Commission for Basic Systems

Sixteenth session

Guangzhou, China

23–29 November 2016

Abridged final report with resolutions, decisions and recommendations

WEATHER CLIMATE WATER

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METEOROLOGICAL
ORGANIZATION

WMO-No. 1183

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GENERAL SUMMARY OF THE WORK OF THE SESSION

1. The president of the Commission for Basic Systems (CBS), Mr Fredrick Branski, opened the sixteenth session of CBS on Wednesday 23 November 2016 at 9:30 a.m. in the Dong Fang Hotel, Guangzhou, China. The Master of Ceremonies, Dr Susan Barrell, vice-president of CBS, invited Dr Guoguang Zheng, Administrator of the China Meteorological Administration and Permanent Representative of China with WMO, Mr Chunsheng Li, Vice Governor of the People's Government of Guangdong Province, Prof Petteri Talaas, Secretary-General of WMO, and Mr Fredrick Branski, president of CBS, to address delegates. Mr David Grimes, President of WMO, and Dr Wenjian Zhang, Assistant Secretary-General of WMO, also participated in the ceremony.

2. The agenda is provided in Appendix 1 to this general summary.

3. The session adopted 2 Resolutions (see Appendix 2 to this general summary), 35 Decisions (see Appendix 3 to this general summary) and 45 Recommendations (see Appendix 4 to this general summary).

4. The list of participants is given in Appendix 5 to this general summary.

5. The Commission elected Mr Michel Jean (Canada) as its president, and Ms Meiyan Jiao (China) as its vice-president.

6. Dr Barrell presented the WMO Gender Policy to the Commission, noting the low level of participation by women in the working structure of the Commission. The Commission requested its Management Group to take full consideration of gender in the structure of the working bodies of the Commission.

7. The Commission noted that several transformational activities were under way in the Commission that may give rise to the need for an extraordinary session, and it requested its Management Group to consider these and, through its president, to make appropriate recommendations to the Executive Council.

8. The Commission decided that its seventeenth session would be held in late 2020.

9. The sixteenth session of the Commission for Basic Systems closed at 4.40 p.m. on 29 November 2016.

APPENDIX 1. AGENDA

1. Organization of the session

1.1 Opening of the session

1.2 Adoption of the agenda for the session

1.3 Consideration of the report on credentials

1.4 Establishment of committees

1.5 Other organizational issues

2. Reports to the Commission

2.1 Report by the president

2.2 Report by the Chairperson of the Open Programme Area Group on Integrated Observing Systems

2.3 Report by the Chairperson of the Open Programme Area Group on Information Systems and Services

2.4 Report by the Chairperson of the Open Programme Area Group on the Data-processing and Forecasting System

2.5 Report by the Chairperson of the Open Programme Area Group on Public Weather Services

2.6 Report by the coordinator on the Group on Earth Observations and the Global Earth Observing System of Systems activities related to WMO

2.7 Report by the coordinator on disaster risk reduction

2.8 Report by the coordinator on capacity development

2.9 Recognition of contributions to the work of the Commission

3. Decisions related to Technical Regulations, associated Guides and guidance material

3.1 Recommendations for the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) and for the *Guide to the WMO Integrated Global Observing System* (in preparation)

3.2 Recommendations for the *Manual on the Global Observing System* (WMO-No. 544) and for the *Guide to the Global Observing System* (WMO-No. 488)

3.3 Recommendations for the *Manual on Codes* (WMO-No. 306)

3.4 Recommendations for the *Manual on the WMO Information System* (WMO-No. 1060) and for the *Guide to the WMO Information System* (WMO-No. 1061) and supporting guides

3.5 Recommendations for the *Manual on the Global Telecommunication System* (WMO-No. 386)

3.6 Recommendations for the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485) and for the *Guide on the Global Data-processing System* (WMO-No. 305)

3.7 Recommendations for the *Guide to Public Weather Services Practices* (WMO-No. 834)

4. Meeting strategic requirements for integrated service delivery and for integrated systems for observing, data processing, forecasting, telecommunications and data management

4.1 Review of decisions of the Seventeenth Congress and the Executive Council related to the Commission and the requirements of WMO President, Members, the technical commissions, regional associations and the United Nations, including those related to the WMO Strategic Plan (2016–2019) and WMO Operating Plan, the Global Framework for Climate Services and other priorities

4.2 Review of strategic drivers impacting on the responsibilities of the Commission

4.3 Emerging trends in big data and their use

4.4 Review of strategy for integrated service delivery and supporting integrated systems

5. Decisions on the work plan for the Commission

5.1 Consideration of discussions by the Executive Council and the Executive Council Working Group on Strategic and Operational Planning on the structure of WMO

5.2 Review of the terms of reference of the Commission

5.3 Review of the terms of reference of the World Weather Watch Programme

5.4 Decisions on the development of the WMO Integrated Global Observing System and the Space Programme

5.4.1 WMO Integrated Global Observing System pre-operational phase key activity areas

5.4.2 WMO Integrated Global Observing System Space Vision for 2040

5.4.3 WMO Integrated Global Observing System Vision 2040

5.5 Decisions on the development of the WMO Information System

5.6 Decisions on the development of the seamless Global Data-processing and Forecasting System

5.7 Decisions on the development of the service delivery including the public weather service

5.8 Decisions on Commission activities to support WMO priority activities

5.9 Decisions on working with regional associations

5.10 Commission working structure

5.11 Future sessions of the Commission

6. Review of previous resolutions and recommendations of the Commission and relevant Executive Council resolutions

7. Election of Officers

8. Any other business

9. Closure of the session

APPENDIX 2. RESOLUTIONS ADOPTED BY THE SESSION

Resolution 1 (CBS-16)

COMMISSION FOR BASIC SYSTEMS MANAGEMENT GROUP

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The *Abridged Final Report with Resolutions of the Fourteenth World Meteorological Congress* (WMO-No. 960), general summary, paragraph 3.1.0.10,

(2) Resolution 26 (Cg-17) – *Technical Regulations* (WMO-No. 49) – Manual on the WMO Integrated Global Observing System "Further decides: (1) That the Commission for Basic Systems … shall act as the lead technical commission for managing changes to the Manual",

(3) Resolution 8 (CBS-15) – Commission for Basic Systems Management Group,

(4) Resolution 7 (CBS-15) – Open programme area groups of the Commission for Basic Systems,

(5) Regulation 33 of the WMO General Regulations (2015 edition),

(6) Resolution 71 (Cg-17) – Preparation of the Strategic and Operating Plans 2020–2023,

Recognizing:

(1) That the effectiveness of the Commission for Basic Systems (CBS) depends to a large extent on the effective management of its activities between sessions,

(2) That a management group would be required to ensure the integration of the programme areas, to prioritize activities, to evaluate the working progress achieved, to coordinate strategic planning, and to decide on necessary adjustments to the working structure during the intersessional period,

Decides:

(1) To re-establish the CBS Management Group with the following terms of reference:

(a) To advise the president on all matters related to the work of CBS on:

(i) Priorities and the planning, coordination, monitoring and evaluation of the work of CBS, its open programme area groups (OPAGs), expert teams and coordinators;

(ii) Provision of the Commission's responses to requests from the Executive Council and Congress relevant to CBS, including input to the WMO Strategic Plan and the Operating Plan, considerations around cooperation between the public and private sectors and the maintenance of National Meteorological and Hydrological Services as the authoritative voices, the review of WMO technical commission structure and processes, emerging data issues and their impacts on the basic systems of WMO, and the monitoring and evaluation of activities relevant to the CBS-related expected results;

(iii) Matters related to collaboration with, and provision of technical advice for, regional associations in support of WMO basic systems;

(iv) Matters related to cooperation and collaboration with other technical commissions in support of other WMO and related international programmes;

(b) To ensure that the work of OPAGs is aligned with, and delivers, the CBS contributions to WMO strategic priorities on the required timescales:

(i) To give special attention to the WMO strategic high-priority areas: disaster risk reduction, Global Framework for Climate Services, WMO Integrated Global Observing System (WIGOS, including the WMO Information System (WIS)), aviation meteorological services, polar and high mountain regions, capacity development, and governance, with specific attention to providing the lead for relevant technical aspects of WIGOS including the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) and for WIS;

(ii) To manage and assess OPAG activities;

(c) To continually review and adjust the working structure and methods of CBS, if needed, to ensure effective, economic and efficient delivery of the outputs of CBS to meet evolving requirements of WMO Members;

(d) To prepare and review operating plans for CBS;

(2) That the composition of the Management Group shall be as follows:

(a) President of CBS (Chairperson);

(b) Vice-president of CBS;

(c) Chairpersons and Co-chairpersons of the four OPAGs;

(d) CBS coordinator on disaster risk reduction.

Note that when needed to advise on matters relevant to CBS, an appropriate person can be invited to attend the CBS Management Group as an associate member.

Note: This resolution replaces Resolution 8 (CBS-15), which is no longer in force.

Resolution 2 (CBS-16)

OPEN PROGRAMME AREA GROUPS OF THE COMMISSION FOR BASIC SYSTEMS

THE COMMISSION FOR BASIC SYSTEMS,

Noting Regulation 33 of the WMO General Regulations (2015 edition),

Considering that there is a need for the continued development and coordination of the:

(1) WMO Integrated Global Observing System (WIGOS), including the surface- and space-based components,

(2) WMO Information System (WIS) and information services,

(3) Data-processing and forecasting systems,

(4) Public weather services,

Decides:

(1) To re-establish the Open Programme Area Group (OPAG) on Integrated Observing Systems with the following terms of reference:

(a) To coordinate all activities related to the surface- and space-based components of the Global Observing System (GOS), which is a major component of WIGOS, in particular the work of the expert, implementation/coordination and inter-programme expert teams and/or rapporteurs established by the Commission for Basic Systems (CBS) under the responsibility of the OPAG, and to liaise and cooperate with other OPAGs, and regional association technical teams;

(b) To inform Members and regional associations of scientific and technical developments on observing technology and techniques of the surface-based and space-based components of GOS;

(c) To evaluate and advise on the comprehensive observational data requirements of the World Weather Watch, the Global Framework for Climate Services and other WMO programmes and international programmes supported by WMO, and to recommend measures to meet those requirements, including coordination of recommendations concerning satellite services, related ground receiving systems and new satellite products;

(d) To improve the utilization of satellite systems by providing guidance on the provision of data products and services from all observation systems, and by assessing the adequacy of related plans for implementation;

(e) To review and advise on the design, implementation and evolution of WIGOS, taking into account established requirements for data as well as cost, capabilities and performance of existing and new observing systems using information received from observing programmes, demonstrations and impact studies;

(f) To review and coordinate monitoring relating to WIGOS and its component systems, including a level of progress against the Implementation Plan for the Evolution of Global Observing Systems and the extent of compliance with WMO regulatory material;

(g) To update regulatory and guidance material on GOS and make recommendations for amendments, in particular to achieve and sustain alignment to the emerging WIGOS regulatory material;

(h) To publicize education and training material and events related to WIGOS;

(i) To monitor and assess progress of the implementation of the current WMO Strategic and Operating Plans on matters related to WIGOS and contribute to the development of the next Strategic and Operating Plans and the related strategic aims of CBS;

(j) To assure adequate exchange of information between WMO and satellite agencies, including the participation in international satellite groups such as the Coordination Group for Meteorological Satellites and the Committee on Earth Observation Satellites;

(k) To coordinate the WMO requirements for radio frequency bands and assignments of radio frequencies to meteorological telecommunications, instruments, sensors, both for operational and research purposes and to liaise with the International Telecommunication Union (ITU) on allocation matters;

(l) To provide the technical lead, with the Commission for Instruments and Methods of Observation, and to contribute to the development and implementation planning of WIGOS and coordinate with the Inter-Commission Coordination Group on the WMO Integrated Global Observing System;

(m) To develop contributions to the activities of the Disaster Risk Reduction Programme;

(n) To contribute to the implementation of the Capacity Development Strategy and the WMO Programme for the Least Developed Countries;

(2) To re-establish the OPAG on Information Systems and Services with the following terms of reference:

(a) To coordinate all activities related to information systems and services, including telecommunications and data management, and in particular the work of the expert and implementation/coordination teams and/or rapporteurs established by CBS under the responsibility of the OPAG, and to liaise and cooperate with the other OPAGs, and regional association technical teams;

(b) To inform Members and regional associations of all relevant developments and requirements relating to telecommunications, data management and the corresponding activities of ITU and the International Organization for Standardization;

(c) To monitor the operation of WIS, to assess the level of implementation of new telecommunication, database and data management techniques as they relate to WMO programmes and other international organizations, and to make proposals regarding the organizational and planning aspects of WIS and the data management functions;

(d) To plan the implementation of and make proposals on the organization, technical and operational aspects of WIS, specifically the Main Telecommunication Network, regional and sub-regional telecommunication networks, as well as meteorological data-collection and distribution systems via environmental observation and communications satellites;

(e) To maintain the existing codes and data representation forms, and develop and implement, as required, data representation forms of meteorological information and products to meet new requirements, including those of WMO programmes and other international organizations;

(f) To monitor progress towards, and take actions to implement, migration to table-driven code forms;

(g) To develop or adjust, as appropriate, meteorological data management functions including database specifications and monitor the effectiveness of these functions;

(h) To update regulatory and guidance material relating to telecommunications and data management;

(i) To publicize education and training material and recommend training events on telecommunications and data-management matters;

(j) To monitor and assess progress of the implementation of the current WMO Strategic and Operating Plans on matters related to telecommunications and data management, and contribute to the development of the next Strategic and Operating Plans and the related strategic aims of CBS;

(k) To lead the development and implementation planning for WIS taking into consideration the needs of WMO programmes;

(l) To contribute to the development and implementation planning of WIGOS and coordinate with the Executive Council Inter-Commission Coordination Group on the WMO Integrated Global Observing System;

(m) To develop contributions to the activities of the Disaster Risk Reduction Programme;

(n) To work with the Global Framework for Climate Services in development and operation of the Climate Services Information System;

(o) To contribute to the implementation of the Capacity Development Strategy and the WMO Programme for the Least Developed Countries;

(3) To re-establish the OPAG on the Data-processing and Forecasting System with the following terms of reference:

(a) To coordinate all activities related to the WMO Global Data-processing and Forecasting System (GDPFS), in particular the work of the expert and implementation/coordination teams and groups established by CBS under the responsibility of the OPAG, and to liaise and cooperate with the other relevant working groups in order to take into consideration emerging requirements by other WMO programmes;

(b) To inform Members and regional associations of technical and scientific developments relating to the forecasting process, and to advise on the implementation of new techniques; and to coordinate organizational and planning aspects of the GDPFS, including the requirements, procedures and practices for designating and maintaining GDPFS centres;

(c) To monitor the performance of the GDPFS and review compliance of its centres against the designated criteria, which include, amongst others, standardized verification of numerical weather prediction (NWP) products, as part of the WMO Quality Management Framework;

(d) To coordinate existing and new requirements stated by Members, and relevant United Nations agencies and international organizations for GDPFS products, and for the production of analysed and forecast data by the GDPFS centres on all timescales;

(e) To provide guidance on the integration of Ensemble Prediction Systems, high-resolution NWP, radar and satellite-based products into core operational forecasting, and on the use and interpretation of meteorological products made available by GDPFS centres, in collaboration with the OPAG on Public Weather Services, the WMO Space Programme and the Commission for Atmospheric Sciences;

(f) To guide the development, outputs and coordination of the operational prediction of sub-seasonal to longer-time scales, and near-term climate prediction, on the basis of the emerging requirements from Regional Climate Centres, Regional Climate Outlook Forums and National Meteorological and Hydrological Services (NMHSs), and in the context of the Climate Services Information System of the Global Framework for Climate Services, in coordination with the Commission for Climatology and the Commission for Atmospheric Sciences;

(g) To arrange for the provision of products and services by designated GDPFS centres within the framework of the Emergency Response Activities (ERA) Programme, and advise on requirements for practical implementations of ERA operational systems and services, in coordination with the OPAG on Public Weather Services Delivery, and in cooperation with and support of relevant United Nations agencies and international organizations;

(h) To coordinate, manage, guide, monitor and implement the Severe Weather Forecasting Demonstration Project (SWFDP) throughout all WMO Regions, in coordination with the OPAG on Public Weather Services, and in liaison with other WMO programmes as appropriate;

(i) To develop and advise on education and training materials related to the Data-processing and Forecasting System and recommend training events as appropriate;

(j) To monitor and assess progress on implementation of the current WMO Strategic and Operating Plans on matters related to the Global Data-processing and Forecasting System and Emergency Response Activities Programmes, and to contribute to the development of the next Strategic and Operating Plans and the related strategic aims of CBS;

(k) To contribute to the activities and work associated with the WMO five strategic high-priority areas, including:

(i) The Global Framework for Climate Services, disaster risk reduction, aviation meteorological services, and capacity development for developing and least developed countries;

(ii) Coordinating, collecting and conveying requirements for the basic systems, including WIGOS and WIS, for the production of GDPFS products, including for severe weather forecasting and warnings through the implementation of the SWFDP, in coordination with the OPAG on Public Weather Services Delivery;

(l) To contribute to implementation of the Capacity Development Strategy and the WMO Programme for the Least Developed Countries;

(4) To re-establish the OPAG on Public Weather Services Delivery with the following terms of reference:

(a) To coordinate all activities related to public weather services, in particular the work of the expert and implementation/coordination teams and/or rapporteurs established by CBS under the responsibility of the OPAG, and to liaise and cooperate with the other OPAGs and regional associations technical teams;

(b) To promote, in coordination with the regional associations, the implementation of the WMO Strategy for Service Delivery by using it to guide implementation at national, regional and global levels;

(c) To coordinate the contribution of the OPAG to such high-priority areas as the Global Framework for Climate Services with particular focus on the User Interface Platform; WIS and WIGOS; disaster reduction and mitigation; and capacity development;

(d) To advise on the emerging requirements of the public weather services community for tailored products generated by GDPFS centres;

(e) To assist NMHSs to strengthen their capabilities to ensure efficient and effective preparation and delivery of warning services through the national public weather services programmes and channels by embedding multi-hazard, multiscale early warning systems within an operational end-to-end service delivery framework;

(f) To promote and support the education and training of the public and other users of NMHS products and services on their use and interpretation, including uncertainty information;

(g) To inform Members and regional associations of, and evaluate, technical and scientific developments relating to the formulation, content, presentation and dissemination of weather information;

(h) To establish education and training requirements related to the delivery of public weather services, in accordance with the competency requirements established by CBS;

(i) To develop and provide to Members guidance material related to all aspects of public weather services;

(j) To develop proposals for increasing the capabilities of Members as regards awareness, preparedness, prevention and response to weather-related disasters, including preparation of memorandums of understanding and standard operating procedures;

(k) To develop proposals for the verification of end-user products, and evaluation of user satisfaction;

(l) To improve procedures for the exchange of severe weather warnings between neighbouring countries;

(m) To monitor and assess progress on the implementation of the current WMO Strategic and Operating Plans on matters related to the Public Weather Services Programme and contribute to the development of the next Strategic and Operating Plans and the related strategic aims of CBS;

(n) To contribute to implementation of the Capacity Development Strategy and the WMO Programme for the Least Developed Countries;

(o) To assist Members, in coordination with other CBS OPAGs as appropriate, in the implementation of impact-based forecast and warning services;

(p) To keep abreast of issues related to social and economic benefits of NMHSs, considering that the socioeconomic outcomes are the ultimate measure of effective service delivery to users;

Decides further:

(1) To designate a coordinator on disaster risk reduction with the following terms of reference:

(a) To coordinate CBS activities, across its relevant OPAGs, related to disaster risk reduction and advise CBS members on activities that will contribute fully to the Disaster Risk Reduction Programme, including relevant enhanced operation of the World Weather Watch;

(b) To provide the CBS Management Group with appropriate information and recommendations concerning the activities of CBS related to disaster risk reduction;

(2) To select:

(a) A. Rea (Australia) as Chairperson and J. Dibbern (Germany) as Co-chairperson of the OPAG on Integrated Observing Systems;

(b) M. dell'Acqua (France) as Chairperson and H. Haddouch (Morocco) as Co-chairperson of the OPAG on Information Systems and Services;

(c) Y. Honda (Japan) and P. Davies (United Kingdom of Great Britain and Northern Ireland) as Co-chairpersons of the OPAG on the Data-Processing and Forecasting System;

(d) G. Fleming (Ireland)as Chairperson and D. Kiktev (Russian Federation) as Co-chairperson of the OPAG on Public Weather Services;

(e) F. Branski (United States of America) as coordinator on disaster risk reduction;

Requests:

(1) The Chairpersons of the OPAGs to act upon matters referred to the OPAG by the president of CBS;

(2) The Chairpersons of the OPAGs and the coordinator on disaster risk reduction to submit a report to CBS not later than three months prior to its next session.

Note: This resolution replaces Resolution 7 (CBS-15), which is no longer in force.

APPENDIX 3. DECISIONS ADOPTED BY THE SESSION

Decision 1 (CBS-16)

ORGANIZATION OF THE SESSION

THE COMMISSION FOR BASIC SYSTEMS,

Having considered the provisional agenda proposed by the president of the Commission for Basic Systems (CBS) on the recommendation of the CBS Management Group,

Approves the provisional agenda;

Approves the report of the representative of the Secretary-General on credentials in accordance with General Regulations 21 to 24;

Adopts the establishment of committees for the duration of the session as:

(1) Coordination Committee:

Chairperson: president

Members: Vice-President, Co-chairpersons of the open programme area groups (OPAGs), Secretary-General's representative, Secretariat staff at the session who are responsible for managing the documents, representative of local organizing committee;

(2) Credentials Committee:

Chairperson: T. Sutherland (British Caribbean Territories)

Members: Zimbabwe;

(3) Committee for the Review of Comments on the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485):

Chairperson: B. Strauss (France)

Members: Canada, China, Germany, Japan, Morocco, New Zealand, the United Kingdom of Great Britain and Northern Ireland and the United States of America;

(4) Committee on the Designation Procedure for Global Data-processing and Forecasting Centres:

Chairperson: Y. Honda (Japan)

Members: Canada, China, Curaçao and Sint Maarten, France, Germany, India, Kenya, the Russian Federation, South Africa, the United Kingdom and the United States;

(5) Nomination Committee:

Chairperson: J.M. de Rezende (Brazil)

Members: Croatia, Morocco, New Zealand and Uganda

Tellers (if required): K. Alder (France), R. Merrouchi (Morocco);

(6) Committee on WMO Information System Centres:

Chairperson: M. dell'Acqua (France)

Members: Benin, Canada, China, Ireland, Italy, Japan, Kuwait, Morocco, New Zealand, Norway, the Republic of Korea, the Russian Federation, the United States and Zimbabwe;

Agrees to the programme of work of the session:

(1) Working hours of the meetings: 9.30 a.m.–12.30 p.m. and 2.30 p.m.–5.30 p.m.;

(2) Arrangement and allocation of agenda items for the session;

Decides to suspend General Regulation 110 for the whole duration of the session to permit rapid processing of documents in accordance with General Regulation 3;

Decides further that, in conformance with General Regulation 112, summarized minutes are not required for the session in view of the technical nature of the discussions;

Adopts for the duration of the session the practice to correct by editorial action, and not by debate in session, documents whose contents are determined solely by administrative procedures;

Notes the agreement, reached by CBS at its extraordinary session in September 2014, that at that and future sessions the practices indicated in paragraph 4.8.3 of the general summary of the *Abridged Final Report with Resolutions of the Executive Council Sixty-fifth Session* (WMO-No. 1118) would be used to make decisions on documents identified as "non-controversial" by the CBS Management Group.

Decision 2 (CBS-16)

REPORTS TO THE COMMISSION

THE COMMISSION FOR BASIC SYSTEMS,

Noting the reports of its president, chairpersons of its open programme area groups, its coordinator on disaster risk reduction and its coordinator on the Group on Earth Observations and Global Earth Observing System of Systems activities related to WMO,

Expresses its satisfaction with the progress made during the intersessional period;

Thanks those Members and experts who delivered the work of the Commission.

Decision 3 (CBS-16)

RECOGNITION OF CONTRIBUTIONS TO THE WORK OF THE COMMISSION

THE COMMISSION FOR BASIC SYSTEMS,

Recognizing that without contributions from Members and individual experts it would not have been able to deliver its work programme for the period 2012–2016,

Acknowledging that 319 individual experts from 54 Members and international organizations had contributed their time, skills and effort to support the work of the Commission for Basic Systems (CBS),

Decides:

(1) To issue certificates of appreciation to 247 experts who have contributed to the work of CBS during the period 2012–2016, of which 26 are female and 221 are male;

(2) To issue certificates of appreciation to 55 experts, of which 6 are female and 49 are male, who have led or in other ways have made especially significant contributions to the work of CBS during the period 2012–2016;

(3) To issue certificates recognizing outstanding contributions to the work of CBS 17 experts, of which 1 is female and 16 are male;

(4) To issue certificates to 54 Members and international organizations recognizing the contribution of their experts to the work of CBS;

Expresses its thanks to all those to whom it has awarded certificates of recognition.

Decision 4 (CBS-16)

BEST PRACTICES FOR ACHIEVING USER READINESS FOR NEW-GENERATION METEOROLOGICAL SATELLITES

THE COMMISSION FOR BASIC SYSTEMS,

Noting Resolution 37 (Cg-17) – Preparation for new satellite systems,

Noting also Decision 32 (EC-68) – Best practices for achieving user readiness for new-generation meteorological satellites,

Noting further that the transition to the operation of new satellite systems enables significant enhancements of products and services delivered by Members,

Acknowledging that the implementation of such new satellite systems in operational schemes has a major impact on user infrastructure, systems, applications and services, and generally requires timely and coordinated actions at the scientific, technical, financial, organizational and educational levels,

Recognizing that new-generation meteorological satellite systems are being implemented or planned to be implemented in the 2016–2021 time frame by China, Japan, the Republic of

Korea, the Russian Federation, the United States of America and the European Organization for the Exploitation of Meteorological Satellites,

Considering the online Satellite User Readiness Navigator portal as a one-stop information resource on the new-generation satellite systems, jointly supported by WMO and satellite operators in the Coordination Group for Meteorological Satellites (CGMS),

Noting that the WMO–CGMS Virtual Laboratory for Education and Training in Satellite Meteorology has focused its 2015–2019 strategy on the development of Members' capacity to use data from new generation satellites,

Recalling that Resolution 37 (Cg-17) requested the Commission for Basic Systems (CBS) to take appropriate actions, in collaboration with satellite operators, in order to raise awareness among Members and to facilitate a seamless transition to the exploitation of the new satellite systems,

Recalling further that the Executive Council at its sixty-eighth session requested CBS to review, revise and adopt the best practices to achieve user readiness for new-generation satellite systems, as per General Regulation 180,

Noting that satellite operators in CGMS adopted the best practices, as far as they apply to the operators, at their 44th meeting in June 2016,

Decides that the best practices specified in the annex to the present decision be endorsed as CBS guidance.

Annex to Decision 4 (CBS-16)

BEST PRACTICES FOR ACHIEVING USER READINESS FOR NEW-GENERATION METEOROLOGICAL SATELLITES

WORLD METEOROLOGICAL ORGANIZATION

Best Practices for Achieving User Readiness for New Meteorological Satellites

Reference User Readiness Project

WMO Space Programme

August 2016

Document change record

Modification	Version	Date	Validation
Initial version	1	06/02/14	
Version after initial IPET-SUP discussions	2	15/06/15	
Version submitted to CGMS-43	3	23/06/15	
Version following CGMS review and further IPET-SUP discussions	4	14/02/16	
Version incorporating comments from IPET-SUP (breakout session at IPET-SUP-2 and subsequent comments) and revised pre-launch checklist from GSICS and CEOS CAL/VAL group	5	29/03/16	
Version with updated Table 1 on new-generation geostationary satellites	6	29/08/16	

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Best Practices for Achieving User Readiness for New Meteorological Satellites

Reference User Readiness Project

1. BACKGROUND

Nearly all geostationary meteorological satellite systems in the world are replaced by a new generation in the 2015-2022 time frame, by Japan, China, the United States of America, the Republic of Korea, the Russian Federation, and EUMETSAT. The new-generation satellites carry advanced imagers providing at least 16 spectral channels and flexible rapid-scan capabilities, with additional innovative payloads, such as lightning mappers and sounders for some of the programmes (see Table 1). Other new-generation systems will be deployed in polar orbit and other orbit types in the coming decade.

Table 1: New-generation meteorological satellites in geostationary orbit 2015-2022 (Status: August 2016)

Satellite	Operator	Launch date	Longitude	Imager	Number of spectral channels	Spatial resolution	Temporal resolution (full disk)	On-board Sounder / Lightning Mapper
Himawari-8*	JMA	7 Dec 2014	140E	AHI	16	0.5-2km	10min	- / -
Electro-L N2*	ROS-HYDROMET	11 Dec 2015	78E	MSU-GS	10	1-4km	15min	- / -
INSAT-3DR	ISRO	2016	74E	IMAGER	6	1-8km	30min	S / -
GOES-R	NOAA	2016	137W	ABI	16	0.5-2km	15min	- / L
Himawari-9	JMA	2016	140E	AHI	16	0.5-2km	10min	- / -
FY-4A	CMA	2016	86.5E	AGRI	14	1-4km	15min	S / L
GOES-S	NOAA	2018	75W	ABI	16	0.5-2km	15min	- / L
Geo-KOMPSAT-2A	KMA	2018	128.2E	AMI	16	0.5-2km	10min	- / -
FY-4B	CMA	2018	105E	AGRI	14	0.5-4km	15min	S / L
MTG-I/S	EUMETSAT	2020-22	9.5E	FCI	16	0.5-2km	10min	S / L

**Himawari-8 and Electro-L N2 are operational; Source: OSCAR/Space (Status: August 2016)*

The new generation of satellites will bring significant enhancements to satellite-based products and services delivered by WMO Members, provided that users can effectively reap their benefits: ingesting the new data types in operational schemes, with overall data volumes one magnitude higher than today, has major impact on user infrastructure, systems, applications and services, and require coordinated action at the scientific, technical, financial, organizational and educational levels. Timely and careful preparation by satellite data users is essential to avoid any disruption of operations upon transition to these new systems, and to

ensure that Members take advantage of the new capabilities effectively, and as early as possible.

The WMO guidelines on user preparation for the new generation of meteorological satellites adopted at CBS-XV in 2012 urges each of the NMHSs and other operational user organizations to:

"Establish a user readiness project focused on the introduction of new satellite data streams into operations (to be initiated ~5 years prior to launch)".

Against this background, the Seventeenth World Meteorological Congress 2015, through Resolution 37 (Cg-17), recommended "to all concerned Members to set up user preparation projects in advance of the launches of new satellite systems, in accordance with the CBS Guidelines for ensuring user readiness for new generation satellites".

One of the main constraints for the planning of a user readiness project is the timely availability of information, specifications, and data and tools used in satellite system development. Therefore, to establish a User Readiness Project, it is important to consider in detail the lifecycle of satellite system development and its relation to the user readiness planning.

It is therefore crucial, that the satellite development entities and operators provide detailed and up-to-date plans for their activities conducted in support of User Readiness Projects. Even though user readiness activities are explicit elements of ongoing satellite system development programmes such as for Himawari-8/9 or GOES-R, satellite operators often do not systematically provide up-to-date planning schedules of deliverables to the user community.

For this reason, the World Meteorological Congress in 2015 also urged "the satellite operators to provide regular and timely updates on their new systems through appropriate means and in particular through inputs to SATURN and OSCAR".

Therefore, the WMO Space Programme has analysed how the typical cycle of satellite system development relates to typical User Readiness Projects, and the outcome of this analysis is a summary of best practices and a generic project schedule. The generic schedule indicates at what time relative to planned launch what information should be available in order to both satisfy the user preparation schedule and respect the constraints of satellite system development.

2. APPLICABILITY

The current document presents, in an integrated manner, Best Practices for User Readiness Projects performed by user organizations (e.g. NHMSs) as well as for satellite development programmes in support to user readiness. The document contains definitions of, and a timeline for, deliverables that should be made available by the satellite development programmes to user readiness projects.

The Best Practices documented here therefore apply to both user organisations (section 3) and satellite operators (section 5).

The primary audiences for this document are members of CGMS and WMO, but the broader user community can equally benefit from the information contained.

3. ACTIVITIES BY USERS TO ACHIEVE READINESS

These activities should be performed by user organizations (e.g. NHMSs) to achieve readiness for new-generation satellites.

3.1 Establishment of a User Readiness Project

It is crucial that planning starts early. This document assumes that users need to prepare for an entirely new generation of satellites, where the User Readiness Project needs to be defined 5 years prior to launch. In particular, it is crucial to:

- Clearly define project outcomes and deliverables;
- Establish clear responsibilities and accountabilities;
- Ensure adequate budget is available for all activities;
- Establish a clear go-live planning for upgraded infrastructure and for new services.

The User Readiness Project needs to address:

- New capabilities as well as improvements of existing capabilities;
- Continuity of operational service provision, including critical path analysis for transition;
- Maximum benefits from existing assets, protection of investment;
- Maximizing value of service at all times during transition;

and must include a detailed assessment of opportunities and risks.

During the execution of the project, special consideration must be given to:

- Need for a dedicated project and project manager (overall accountability is important);
- Maintain contact with satellite operator for up-to-date information;
- Regular communication to key managers and project stakeholders (maintain momentum and counter misinformation);
- Monitor key project milestones and escalate when necessary;
- Ensure management support and buy in is available when needed;
- Manage expectations regarding availability of new products.

3.2 Budgeting and planning

Budgeting and planning is of paramount importance and needs to start early. A new-generation satellite system can be in some cases the driver of significant infrastructure upgrades; performance requirements in terms of data acquisition, storage, network, etc. and should thus be known many years in advance in order to incorporate the necessary upgrades in the long-term evolution and investment plans. Realistic schedule margins and other provisions should be used to avoid planning difficulties, for example due to launch delays.

A main objective for a user organization like an NMHS, is to protect the investment made into existing operational programmes, and to understand early where additional investments are necessary or unavoidable in order to achieve readiness for the new satellite system. Therefore, early information about investment drivers is crucial for budgeting and planning purposes.

3.3 Research & Development

In this context, R&D refers to the phase of activities that prepare the application of new-generation satellite data from the user perspective. This typically includes development of NWP data assimilation methods using the new-generation satellite data where needed, or

development of new or specially tailored products for specific application areas, for instance by centres such as the EUMETSAT Satellite Application Facilities. These activities typically include analysis of the effects of instrument spectral response functions (SRF), field of view (FOV), and the radiative transfer models used to simulate instruments. The planning of such activities depends, to a large extent, on the degree of novelty of the instrument. If it is an upgraded version of an existing series, the lead times can be shortened considerably and some steps (e.g. simulated data) can be dropped completely. For totally new instruments (e.g. MTG-IRS) however, a first-guess SRF can be useful as early as two years before launch date (L-24 months) and for these, simulated data would also be very useful.

3.4 Data handling development and testing

This activity includes design and procurement of new satellite reception systems, as well as upgrades to terrestrial network access (Internet and RMDCN), needed for handling increased data rates. The activity would also encompass upgrades to observational databases, short- and long-term archives, as well as to internal networks and general IT capacity for visualization, monitoring and processing.

It is crucial that the procurement of data handling systems starts early to enable complete testing of all technical and scientific aspects of the processing chain.

3.5 Data processing development and testing

All aspects of the processing software of satellite observations need to be adapted and potentially upgraded to accommodate data from the new satellite. This may include:

- Local processing chain of direct broadcast data into L0 and L1 products;
- Data conversion into intermediate local formats for observations databases and archiving;
- Data monitoring and assimilation into NWP models;
- Processing chain for local generation of higher-level products for specific applications;
- Integration into the operational user environment, including for instance integrated visualization applications (with satellite, radar, surface and altitude observations and model outputs) for forecasters.

For instance, the adaptation of NWP assimilation to the new satellite systems require a long lead time and has specific requirements regarding availability of instrument and product data.

The planning of such activities varies widely according to the needs and capabilities of the user organization (e.g., NMHS).

3.6 Training

Different training subjects and different target groups for training exist and it is important to identify the different categories of needed training as they have different timescales and require different levels of information about the new satellite system. Generic satellite skills and knowledge for operational forecasters recommended by WMO should serve as guidance for framing training activities.

Identified training subjects are:

- Similarities and differences with respect to existing satellites;
- Equipment operation and maintenance;
- Interpretation of L1 data from satellite payload instruments including:
    - Imagery interpretation;

  - Passive sounder data usage;
  - Active instrument usage;
- Use of software tools (for processing, analysis, and assimilation);
- Derived L2 product utilization and interpretation;
- Understanding of data formats and dissemination;
- The physical basis of remote sensing, in particular as it applies to new instruments.

Target groups for training are:

- Trainers (using the "train-the-trainers" approach);
- User readiness project managers;
- Operational forecasters;
- User communities in NWP and other application areas;
- Organizational managers;
- Technical support personnel
- R&D personnel.

The approach for organizing training depends very much on the needs and capabilities of the user organization (e.g., NMHS) and on the organizational relationship between satellite operators and users. With the advancement of e-learning technology, emphasis is clearly shifting from long-term planned classroom training towards "just-in-time-training" based on webinars, self-study online training etc.

The increasing importance of continuing training activities after launch must be emphasized. Training needs to cover critical real weather situations for all seasons and it must be based on the real characteristics of the satellite systems. Emphasis should be given to training formats that can be integrated into ongoing operations, i.e. short training modules for "as it occurs" training of operational forecasters on or between shifts. This approach is for example reflected in the NOAA GOES-R training planning (Figure 1 below), extending baseline training activities until 1-2 years after launch.

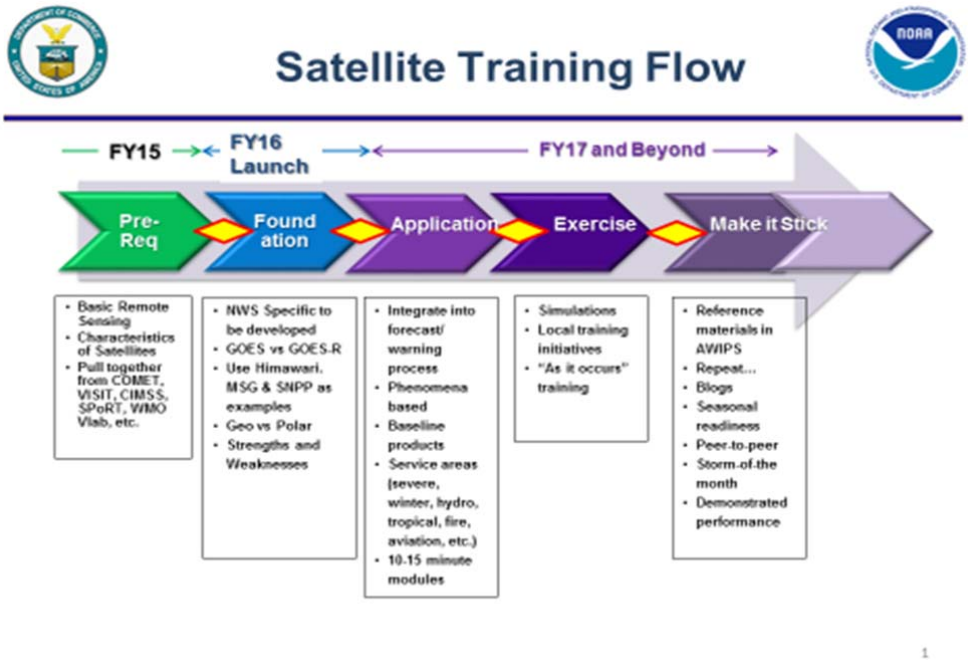

Figure 1: GOES-R Training Plan

The new-generation GEO satellites have strong similarities in instrumentation (e.g., similar spectral, temporal, and spatial resolution of imagers; lightning mappers), and therefore, there are substantial potential benefits to users and to satellite operators in developing common training material and in fostering common development of applications.

The national training programme run by the Australian Bureau of Meteorology VLab training centre to prepare users nationally and in WMO Region V (South-West Pacific) for the effective use of new-generation Himawari-8 data is a good example for assisting user readiness: http://www.virtuallab.bom.gov.au/training/hw-8-training.

In collaboration with the VLab and the COMET/MetEd programme, SATURN now links to online training material on Himawari-8 and GOES-R, in English and Spanish (where available). For example, the COMET/MetEd module "Advanced Himawari Imager (AHI): What's Different from GOES-R ABI" (http://www.meted.ucar.edu/satmet/himawari_ahi/) is very effective in comparing these two imagers, and this module (https://www.meted.ucar.edu/goes_r/abi_es/) explains the GOES-R ABI in Spanish. Translation of more training material is planned and a high priority for WMO and the VLab.

The VLab strategy 2015-2019 places high emphasis on building capacity among WMO Members for understanding and exploiting data from the new-generation satellites. The VLab will play a key role over the coming years in addressing the training needs of meteorologists with regard to the new generation of satellites, and strong support from CGMS members will be required.

3.7 Capacity-building

Capacity-building is vital for ensuring that all WMO Members can maximize their capability to exploit the value of the new generation of satellite data. Such activities can take the form of bilateral NMHS partnerships, regional collaborative mechanisms like the RA I Dissemination Expert Group and the EUMETSAT User Forum in Africa, the RA II WIGOS project on satellite utilization, or major projects providing technical and scientific infrastructure and training for less developed WMO Members (e.g., AMESD and MESA).

Capacity-building should also engage the academic community. It is important to ensure that researchers and students become engaged in scientific activities related to the new instruments, in particular since this will benefit the operational exploitation in the longer term.

3.8 Contributions to Calibration/Validation

Participation of NWP centres in instrument Cal/Val activities have become standard practice both for LEO and GEO satellites. Monitoring of first-guess minus observation (FG-OBS) departures for L1 products are an important contribution to the Cal/Val activities of satellite operators.

4 SATELLITE SYSTEM DEVELOPMENT PHASES

In executing a satellite system development programme, the following activities are typically performed by satellite operators, in cooperation with R&D satellite agencies and industry partners.

The life cycle of space projects is typically divided into 7 phases, as follows:

- Phase 0 – Mission analysis/needs identification
- Phase A – Feasibility
- Phase B – Preliminary Definition
- Phase C – Detailed Definition
- Phase D – Qualification and Production
- Phase E – Utilization
- Phase F – Disposal

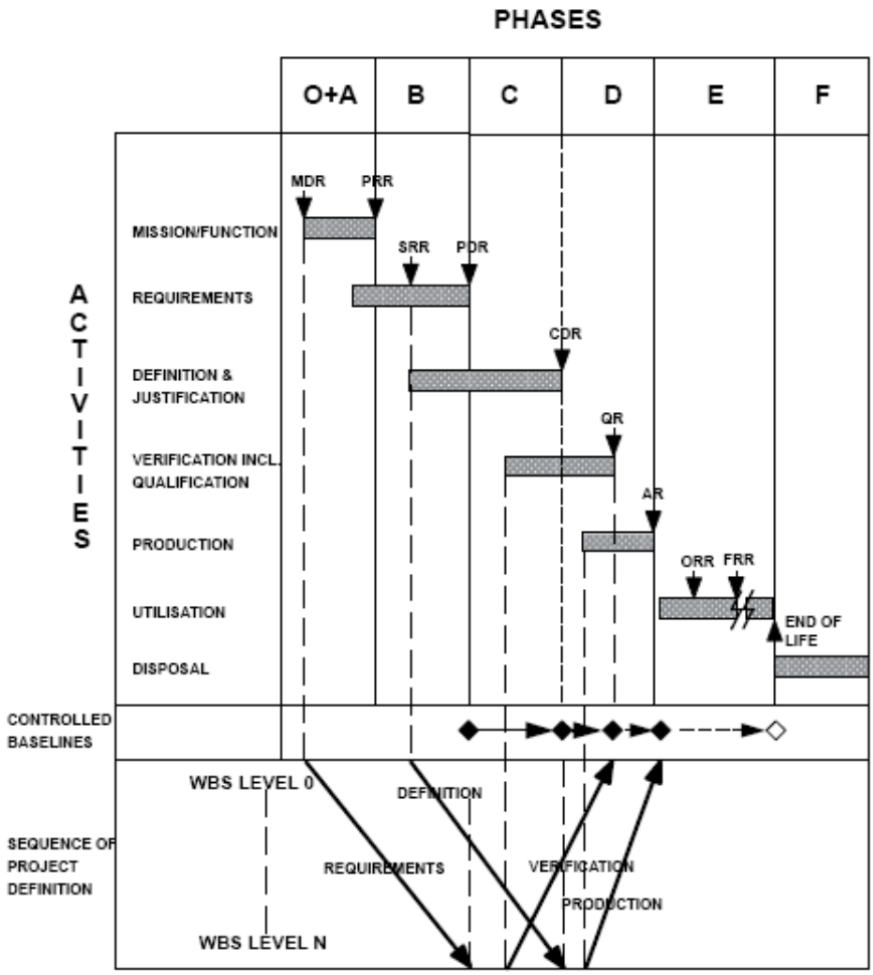

Figure 2: Reference satellite system development lifecycle according to European Cooperation for Space Standardization (ECSS)

Phase C (detailed definition) is concluded with the System Critical Design Review (CDR), at which point the definition of the system (satellite and ground segment) will be complete down to the lowest level, and after which full production (Phase D) of the system will start. If development follows a nominal schedule, the System CDR will take place 3 years before launch. Phase E (utilization) starts with the shipment of the satellite to the launch site and the start of launch preparations, and is subdivided into phase E1 (launch and commissioning), typically lasting until 6-12 months after launch, and phase E2 (routine operations).

The most significant consequence of this lifecycle with respect to the user community is that the system specification and other information made available to the user community before the System CDR (i.e., at the end of Phase C) will be based on requirements, whereas

deliverables based on the real characteristics of the system will only become available after this time, during phase D and E1.

This lifecycle reflects actual experience from MSG and COMS, and also the status and planning for GOES-R and MTG. Variations do exist for specific programmes; for example, the planning for Himawari-8 development was somewhat compressed: the System Critical Design Review was completed in January 2012, only 30 months before the planned launch in summer 2014 (the satellite was successfully launched on 7 October 2014).

5 DELIVERABLES FROM SATELLITE DEVELOPMENT PROGRAMMES TO USER READINESS PROJECTS

This part of the document contains high-level specifications for the different items produced by the Satellite Development Programmes that should be delivered to the User Readiness Projects. The timeline of the deliverables can be found in section 6.

5.1 Instrument pre-launch calibration and characterization

Satellite remote sensing instrument pre-launch calibration and characterization data, being of general interest to the remote sensing data user community, are critical for the production of calibrated and geolocated Level 1 data and their adaptation by NWP and climate applications. The uncertainty, reproducibility, and stability of these data are driven by operational and research remote sensing applications and requirements. For instruments built and/or tested by industry, provision of pre-launch test data to systems engineers, satellite operators, and the remote sensing community are often subject to contractual constraints.

The new generation of satellite instruments employs increasingly complex focal planes, often with two dimensional detector arrays and innovative read-out schemes producing large amounts of data. Despite this increasing instrument complexity, satellite instrument prelaunch testing must still strive to reproduce, as closely as possible, instrument operation in the predicted on-orbit environment. This is also known as “testing as you fly”. The calibration and characterization data produced by this testing ensure that the instrument to be flown is fully understood at launch will meet its performance requirements on-orbit. In order to facilitate proper and efficient use by the international remote sensing community, these data should include the following:

- Channel naming and numbering convention and channel science application(s);
- Spectral Response Function (SRF) (a.k.a. relative or absolute Radiometric Spectral Responsivity (RSR)):
    - channel central frequencies/wavelengths and bandwidths;
    - responsivity versus wavelength as a function of channel (i.e. average) and detector;
- Along-scan and in-track Field of View (FOV)-pixel size or full PSF/MTF;
- Instantaneous Field of Regard/View (IFOR/IFOV) /swath coverage, repeat cycle/orbit configuration;
- Pixel sampling distance/time intervals;
- System level instrument noise (i.e. NEdL, NEdT) as a function of instrument and focal plane temperature and spacecraft voltage;
- Radiometric calibration and characterization:
    - Gain and offset as a function of instrument and focal plane temperature;
    - Polarization sensitivity;
    - Radiometric resolution, dynamic range, linearity, quantization;
    - Response versus scan angle for scanning radiometers;

- Instrument pointing, geometric accuracy and band to band calibration/registration (i.e. geometric performance);
- Expected mission and instrument lifetimes;
- Key parameters of on-board calibrators (i.e. blackbody emissivity and temperature uniformity, solar diffuser spectral Bidirectional Reflectance or Transmittance Distribution Function (BRDF or BTDF) and uniformity);
- Target and realized measurement uncertainties for the above data;
- All the above should indicate the level of maturity of the determination of instrument testing parameter. This is accomplished by identifying if the data were determined using analysis/modelling, demonstration, inspection, or testing at the part, subassembly, subsystem, system or observatory (i.e. spacecraft plus instruments) level.

Prelaunch test data should be provided for the primary, redundant, and all potential cross-strap instrument on-orbit operational configurations.

Mechanisms must be established for providing to users information about events that affect the inflight instrument performance. To address this, GSICS project coordinates the implementation of operational instrument event logs.

5.2 Product specifications

This includes scientific specifications of the product algorithms, detailed specification of formats for dissemination as well as on-demand requests, information on timeliness and expected data volumes, all for both L1 and L2 products.

There is a need for more standardized approach to description of both L1 and L2 products, potentially through the development of standard templates for the product description.

It should be noted that for the online Product Access Guide, see: http://www.wmo.int/pages/prog/sat/documents/SAT-GEN_PAG-concept-v1.0-final.pdf#10, WMO has introduced a standard classification of Level-2 products.

5.3 Data access mechanism specifications

This in particular includes specifications of mechanisms for Direct Broadcast and for DVB-based dissemination. These specifications are required for the procurement of user reception systems.

Systems requirements for Direct Broadcast reception systems, including both antennas, front-end components and computer systems for acquisition and L1 processing need to be available to users in time for starting procurements activities, typically 3 years before launch. The processing systems requirements are becoming increasingly demanding with the complex processing of Direct Broadcast data for the new generation of satellites; the impact on users' systems is significant.

Also required are specifications of other near-real-time dissemination mechanisms employing terrestrial communication, and of offline data access mechanisms, including archive retrieval and other on-demand means.

Where user registration is required for access to products and services, detailed description of the user registration process is required before launch, so that the registration process can be exercised by the users already during the commissioning phase.

5.4 Software tools and test data

L1 pre-processing software is required for the development of the user data processing functions, but in many cases is only available from an operator after Ground Segment acceptance. Any contracts for procurement of data processing systems need to take this need into account, to allow early deliveries.

Software tools can also be developed by experts in the user community, but for a new generation of satellites, these software tools will always depend on L1 processing kernels developed as part of the satellite system development.

Different categories of test data exist, with different life cycles. A universal categorization is not in use, but for the purposes of this document and the SATURN portal, the following terminology is used:

- Synthetic data: No scientific value, but realistic sizes and formats. Used for user dataflow testing;
- Simulated data: Data simulated by forward Radiative Transfer Model (RTM) calculations. Simulated data are used to test processing and visualization tools. These data are produced based on NWP model output, they generally do not contain realistic spatial structure and temporal variability;
- Proxy data: Actual dataset from relevant precursor instruments, e.g., 2.5 min data from Meteosat-10 for MTG-FCI, 1-min super rapid scanning data from GOES for GOES-R ABI, or IASI/AIRS data for FY-4A GIIRS and MTG-IRS. Proxy data are used in early training on capabilities and application areas. It is also possible to use Proxy data to construct test data similar to simulated data by adding RTM simulated data for channels to the ones present in pre-cursor missions or by using interpolation in time and space;
- Pre-operational data: Real satellite data generated as part of the commissioning activities, but before full validation has been completed.

The operators should provide all of these categories of test data, use consistent terminology to describe them, as well as provide software tools for the use of test data, both during pre-launch development and during post-launch commissioning activities.

5.5 Operations plans and schedules

For ensuring user readiness, it is of high importance that both long-term operations plans, as well as routine operations schedules, are made available before the start of routine operations. This includes the following elements:

- Fly-out plan for overall satellite programme, including planning for launches, orbital positions and end-of-life dates, including information about overlap with existing operational satellites;
- Routine operations schedule, including areas of coverage for flexible scanning operational scenarios and information on the process for scenario switching, e.g., activation of Super Rapid Scanning operations for severe storms and tropical cyclone tracking;
- If appropriate, conditions for user input to the operations schedule (e.g. requests for special mode targeted operations);
- Planning for routine spacecraft maintenance activities, like orbital manoeuvres, seasonal spacecraft re-orientation (yaw-flip), instrument decontamination etc.;
- Schedules for activation of LEO direct broadcast where applicable;
- Schedules for routine dissemination for both direct broadcast and re-broadcast via telecommunications satellites.

Details on recommended due-by-dates are provided in the timeline below.

5.6 User Notification and Feedback

It is essential that the satellite operator establish 2-way communications channels to the user community: for providing general and specific information, and to allow users to make enquiries and provide other feedback during the preparations phase. Such channels are also necessary to provide routine user support starting from the commissioning phase and continuing throughout the routine operations phase.

Such communication should include regional satellite user coordination mechanisms (such as the Coordination Group on Satellite Data Requirements for Regions III and IV; RAIDEG), regional user conferences (such as the Asia-Oceania Meteorological Satellite Users Conference) and training events (such as the GOES-R Event Week), as well provide support for enquiries and feedback from individual users.

5.7 Training resources

For new satellite systems, the provision of training material from satellite operators is crucial. Online training resources are of increasing importance, and give the possibility of dynamic adaptation when new information about the satellite and its applications becomes available. It is also essential to capitalize on the contributions of the user community and promote training resources that are made available by user groups. The WMO-CGMS VLab plays a key role in developing and delivering online training material to users worldwide in several languages. An event week on preparing for new-generation satellites was held in November 2015, to which NOAA, EUMETSAT, JMA, CMA, KMA all made contributions (presentations and recordings available at http://www.wmo-sat.info/vlab/next-generation-of-satelliles/); more events of this nature are planned by the VLab.

5.8 Other deliverables

For many applications, it is important to have the set of fundamental constants that have been used to derive satellite data and products, and satellite operators should make this available to users. It is planned to propose a common standard to be used by CGMS operators, e.g., the list published by the US National Institute of Standards and Technology (NIST).

6 TIMELINE FOR THE REFERENCE USER READINESS PROJECT

The table below shows the overall timeline of user preparedness activities, and the planning for the different deliverables from the satellite system development needed to support these activities. Each user deliverable in the reference project has an associated sub-category in SATURN, so that the portal will provide up-to-date links to all deliverables when these become available from the satellite system development.

Time relative to Launch Date ("L")	Satellite System Development: Activities and Milestones	User Readiness Project: Activities and Milestones	Needed Deliverables from Satellite Operators
L-5y (years) -> L-4y	Ground Segment Development Phase C	Initiation of user (e.g., NMHS) readiness project. Initiation of cooperative projects addressing needs of less developed WMO Members.	Overall specifications of user segment, including high-level definition of migration path from existing user segment. Preliminary schedule for deliverables to users.
L-4y -> L-3y	System Critical Design Review	Identification of drivers for investment and running cost. Planning and allocation of human resources and budgets for investments and running costs. Establishment of prioritized data requirements, as clear priorities for current and future products allow the best preparations to be made for establishing data access and delivery capabilities. Initial training on capabilities for trainers and decision-makers.	General description of instruments. General description of NRT dissemination mechanisms. Detailed specifications of L2 and L1 products to be available at start of operations (Day-1 products). Proxy test data. Plans for evolution of products after start of operations (Day-2 products).
L-3y -> L-2y	System Production On-ground characterization of instruments	Design of new reception system. Design of communications network changes, including GTS/RMDCN capacity. Design of new data handling and processing functions. Training on specific application areas, based on proxy data.	Specifications of instruments and their performance, including planned SRFs, noise, FOV size. Simulated test data. Detailed specifications of NRT dissemination mechanisms. Detailed specifications of Direct Broadcast (DB), including frequency and signal characteristics and hardware specifications for antennas, front-end components and computer systems for acquisition and processing of DB data.

Time relative to Launch Date ("L")	Satellite System Development: Activities and Milestones	User Readiness Project: Activities and Milestones	Needed Deliverables from Satellite Operators
			General description of offline data access. Data/product volume estimates. Data/product format definitions. Fundamental constants used in processing. Data access conditions (e.g. licensing, key units, etc.). L1 pre-processing software for DB (preliminary version). Establish and use two-way communication channels for user enquiries.
L-2y -> L-1y	Ground System acceptance	Procurement, installation and acceptance testing of systems. Software design for data processing, including NWP ingest.	Full pre-launch instrument characterization information (including SRFs, noise). Information on radiative transfer models (e.g., RTTOV) that support instruments. Synthetic test data (including L1B data format details, Sat ID, navigation information). Continuous periods test dissemination of synthetic test data. Long-term operations plan. Planning for data exchange to serve global community.
L-1y -> L-6m	Flight readiness of satellite	End-user training (forecasters).	Start of regular updating of plans for launch and commissioning.
L-6m -> L	Operational System Validation and Launch preparations	Data processing software testing (using proxy data). Technical training on reception systems and other	Simulated test data based on pre-launch instrument characterization.

Time relative to Launch Date ("L")	Satellite System Development: Activities and Milestones	User Readiness Project: Activities and Milestones	Needed Deliverables from Satellite Operators
		system elements. Data acquisition system testing (using synthetic data).	L2 data format. Direct Broadcast software package (if DB available). User documentation for dissemination mechanisms and delivered software tools. Routine operations schedule.
L->L+6m	Satellite In-orbit verification Commissioning of L1 products	Full system and software testing (using pre-operational data). Support to operators CAL/VAL activities, in particular through NWP assimilation.	Early dissemination of un-validated L1 data. Early switch-on of Direct Broadcast. Pre-operational L1 data dissemination. In flight characterization of instrument performance. L1 pre-processing software for DB (operational version). Start of routine User Support.
L+6m->L+2y	Commissioning of L2 products	Scientific data exploitation (iterative based on increased understanding of real data). Post-launch training based on real data. Declaration of user operational readiness.	Operational L1 data dissemination, from both old and new satellites (as long as possible, but minimum until L+1y).

Decision 5 (CBS-16)

REPORTING OBSERVATIONS IN BUFR

THE COMMISSION FOR BASIC SYSTEMS,

Recalling that the Commission for Basic Systems (CBS), at its extraordinary session in September 2014, had reviewed progress with migration to table-driven code forms (TDCF) and confirmed the requirement to exchange World Weather Watch information in those representations,

Noting that:

(1) The CBS Management Group had set up a task team to review reporting of upper-air observations in TDCF in response to issues arising from coding practices adopted by centres generating reports,

(2) Reporting regulations for BUFR and CREX in B/C20 and B/C25 of the *Manual on Codes* (WMO-No. 306), Volume I.2 specify how upper-air observations are to be reported,

(3) World Weather Watch monitoring statistics for April 2016 showed that 81% of required surface reports were reported in traditional alphanumeric codes (TACs) and only 58% were reported in BUFR,

(4) In July 2016, the European Centre for Medium-range Weather Forecasts (ECMWF) received BUFR reports from 20% fewer stations than TAC reports,

(5) For 10% of those stations from which reports were received in BUFR by ECMWF, significantly fewer BUFR reports than TAC reports were received,

(6) The Implementation Coordination Team on Integrated Observing Systems in response to recommendations by the Task Team on Table-Driven Code Forms of the Regional Association VI Working Group on Technology Development and Implementation had identified potential to assist migration by involving experts from the Open Programme Area Group on Integrated Observing Systems and by encouraging procurement of appropriate equipment,

Reaffirms:

(1) The requirements expressed in B/C20 and B/C25 for the reporting of upper-air observations;

(2) The importance of completing migration to TDCF;

Urges Members:

(1) To exchange all available reports in correctly formatted TDCF;

(2) To ensure that the availability of reports in TDCF is recorded in the WMO Information System catalogue and in *Weather Reporting* (WMO-No. 9), Volume C1, Catalogue of Meteorological Bulletins;

(3) To provide upper-air observations in TDCF compliant with B/C20 and B/C25 that include the obligation to include within a single report the complete ascent up to the maximum height being reported;

(4) To ensure that any new equipment is capable of handling TDCF and to implement available updates to existing equipment to allow it to process TDCF;

(5) In cases where the Member is still in the process of upgrading its systems and procedures to produce correctly formed reports in TDCF:

(a) To complete the upgrade as rapidly as possible;

(b) To continue to submit reports in TAC until such time as the Member is able to transmit reports in TDCF that are compliant with the appropriate regulations;

(6) To provide experts to assist other Members complete the migration to TDCF;

Urges all regional associations to establish regional working groups for providing training and assistance to Members on the transition to TDCF;

Reminds Members that the TAC are unable to represent WMO Integrated Global Observing System station identifiers, so that Members unable to process TDCF will need to make bilateral arrangements with other Members if they wish to transmit or receive observations from stations that do not have a World Weather Watch station identifier.

Decision 6 (CBS-16)

EXPERIMENTAL IMPLEMENTATION OF FM 92 GRIB (EDITION 3)

THE COMMISSION FOR BASIC SYSTEMS,

Recalling that FM 92-XII General Regularly Distributed Information in Binary Form (GRIB) (GRIB edition 2) took effect from 7 November 2001 (Resolution 4 (EC-LIII)) after two years of experimentation and validation tests,

Recognizing that introduction of GRIB edition 3 would satisfy the existing requirements from broader communities and facilitate their GRIB application,

Decides:

(1) To endorse experimental use of GRIB edition 3 as described in the annex to the present decision;

(2) To use the code identifier FM 92-16 GRIB to identify the constituent components of the version described in the annex to the present decision so that it can be distinguished from later versions;

(3) To review the effectiveness of GRIB edition 3 following a period of use by Members:

(a) To assess feedback from users on its effectiveness;

(b) To modify it to respond to concerns;

(c) To recommend the modified version to the Executive Council for inclusion in the *Manual on Codes* (WMO-No. 306), Volume I.2;

Urges Members to use GRIB edition 3 and provide feedback to the Open Programme Area Group on Information Systems and Services (OPAG-ISS) through their focal point for codes and data representation matters;

Requests OPAG-ISS to gather feedback on the effectiveness of GRIB edition 3 and to provide the revised version, including additions to tables and templates, for further experimental use or adoption by the Executive Council in 2019;

Requests its president to assess whether modifications proposed by OPAG-ISS following the review of use require a vote by correspondence before the revised version is released for experiment or recommended to the Executive Council for adoption;

Authorizes its president, subject to the outcome of any vote by correspondence, to endorse the modified version for experiment or to recommend it to the Executive Council;

Requests the Secretary-General:

(1) To publish on the WMO website as a reference document FM 92-16 GRIB as provided in the annex to the present decision;

(2) To make provision for that version to be available permanently so that archived information recorded in that version may be interpreted correctly.

Annex to Decision 6 (CBS-16)

SPECIFICATION OF FM 92-16 FM 92 GRIB

FM 92–16 GRIB General Representation of fields In Binary

Binary representation of data resulting from an observation or a numerical model simulation of an observable property in a spatial and time domain on a geospatial or celestial reference system

CODE FORM:

SECTION 0	**Indicator Section**
SECTION 1	**Originator Section**
SECTION 2	**Repetitions and Index Section**
SECTION 3	**Time Domain Section**
SECTION 4	**Horizontal Domain Section**
SECTION 5	**Vertical Domain Section**
SECTION 6	**Generating Process Section**
SECTION 7	**Observable Property Section**
SECTION 8	**Data Representation Section**
SECTION 9	**Overlay Section**
SECTION 10	**Data Section**
SECTION 11	**End Section**

(These sections repeated in order if required)

Notes:

(1) GRIB is the name of a binary data representation form for fields resulting from an observation or a numerical model simulation of an observable property in a spatial and time domain on a geospatial or celestial reference system.

(2) Data encoded in GRIB consists of a continuous bit-stream made of a sequence of bytes (1 byte = 8 bits).

(3) A GRIB message is composed of the following sections:

Section	Section Name	Contents

Number		
0	Indicator Section	"GRIB", Master tables version number, total length of message, GRIB edition number.
1	Originator Section	Length of section, section number, local tables version number and information for use of the originator centre.
2	Repetitions and Index Section	Length of section, section number, total number of repetitions, number of distinct repetitions for each repeatable section and optional index.
3	Time Domain Section	Length of section, section number, section unique identifier and description of time domain of the field.
4	Horizontal Domain Section	Length of section, section number, section unique identifier and description of the horizontal domain of the field.
5	Vertical Domain Section	Length of section, section number, section unique identifier and description of the vertical domain of the field.
6	Generating Process Section	Length of section, section number, section unique identifier and description of the process generating the data.
7	Observable Property Section	Length of section, section number, section unique identifier and description of the observable property.
8	Data Representation Section	Length of section, section number, section unique identifier and description of how the data values are represented.
9	Overlay Section	Length of section, section number, section unique identifier and overlay field associating a property to the field. This can be used to indicate the presence or absence of data at each point of the domain by defining a bitmap.
10	Data Section	Length of section, section number, data values in binary format as specified in the data representation section.
11	End Section	"7777"

(4) Sequences of GRIB sections 3 to 10, may be repeated within a single GRIB message. The total number of repetitions is given in section 2. The total number of repetitions is also the number of fields encoded in the GRIB message. Multi-field messages contain more than one field while single field messages contain only one field. A GRIB message shall contain at least one field.

(5) The representation of data by means of a series of bits is independent of any particular machine representation.

(6) Message and section lengths are expressed in bytes.

(7) The content of each section is specified by providing the meaning of bytes numbered progressively starting from one at the beginning of the section.

(8) Sections are composed of Templates, which are specified in terms of Template Components.

(9) Templates Components are sequences of bytes with a specified meaning that can be used in the appropriate Template. In each Template Component bytes are numbered 1, 2, 3 etc., starting at the beginning of the Template Component.

(10) Template Components should be defined to be re-used in different Templates.

(11) Bit positions within bytes are referred to as bit 1 to bit 8, where bit 1 is the most significant and bit 8 is the least significant. Thus, a byte with only bit 8 set to 1 would have the integer value 1.

(12) As used in "GRIB", "International Alphabet No. 5" is regarded as an 8-bit alphabet with bit 1 set to zero.

(13) The IEEE single precision floating point representation occupies 4 bytes and is specified in the standard ISO/IEC 559–1985 and ANSI/IEEE 754–1985 (R1991).

REGULATIONS:

92.1 General

92.1.1 The GRIB code shall be used for the exchange and storage of fields representing an observable property in a geospatial and time domain, which is the result of an observation or a numerical model elaboration.

92.1.2 The beginning and the end of the code shall be identified by 4 bytes coded according to the International Alphabet No. 5 to represent the indicators "GRIB" and "7777" in Indicator section 0 and End section 11, respectively. All other bytes included in the code shall represent data in binary form.

92.1.3 Each section included in the code shall always end on a byte boundary. This rule shall be applied by appending bits set to zero to the section, where necessary.

92.1.4 All bits set to "1" for any value indicates that value is missing. This rule shall not apply to packed data.

92.1.5 Negative values shall be indicated by setting the most significant bit to "1". All integer values are to be considered signed except:

(a) values referring to code and flag tables, which are always unsigned, or

(b) values explicitly declared as unsigned in a note.

92.1.6 When a value V is encoded using a scale factor F and a scaled value V_S the following formula applies:

$$V \times 10^F = V_S$$

92.2 Section 0 – Indicator Section

92.2.1 Section 0 shall always be 16 bytes long. The first 4 bytes of the indicator section shall always be character coded according to the International Alphabet No. 5 as "GRIB".

92.3 Section 1 – Originator Section

92.3.1 The length of the section, in bytes, shall be expressed over the group of the first four bytes, i.e. over the first 32 bits.

92.3.2 The section number shall be expressed in the fifth byte.

92.4 Section 2 – Repetitions and Index section

92.4.1 Regulations 92.3.1 and 92.3.2 shall apply.

92.5 Section 3 – Time Domain section

92.5.1 Regulations 92.3.1 and 92.3.2 shall apply.

92.5.2 The Section Unique Identifier (SUI) shall be expressed in bytes 6 to 7. The SUI is a unique identifier within the message for the section. Repeated sections can just refer back to the first instance by using the same SUI, without the need to explicitly repeat the section in full. In this case, the total length of the repeated section will be 7 bytes.

92.6 Section 4 – Horizontal Domain Section

92.6.1 Regulations 92.3.1, 92.3.2 and 92.5.2 shall apply.

92.6.2 Latitude, longitude and angle values shall be in units of 10^{-6} degree, except for specific cases explicitly stated.

92.6.3 The latitude values shall be limited to the range –90 to 90 degrees inclusive. The orientation shall be north latitude positive, south latitude negative. Bit 1 is set to 1 to indicate south latitude.

92.6.4 The longitude values shall be limited to the range –360 to 360 degrees inclusive. The orientation shall be east longitude positive, west longitude negative. Bit 1 is set to 1 to indicate west longitude.

92.6.5 The latitude and longitude of the first grid point and the last grid point shall always be given for regular grids.

92.7 Section 5 – Vertical Domain Section

92.7.1 Regulations 92.3.1, 92.3.2 and 92.5.2 shall apply.

92.8 Section 6 – Generating Process Section

92.8.1 Regulations 92.3.1, 92.3.2 and 92.5.2 shall apply.

92.9 Section 7 – Observable Property Section

92.9.1 Regulations 92.3.1, 92.3.2 and 92.5.2 shall apply.

92.10 Section 8 – Data Representation Section

92.10.1 Regulations 92.3.1, 92.3.2 and 92.5.2 shall apply.

92.11 Section 9 – Overlay Section

92.11.1 Regulations 92.3.1, 92.3.2 and 92.5.2 shall apply.

92.12 Section 10 – Data Section

92.12.1 Regulations 92.3.1 and 92.3.2 shall apply.

92.12.2 The data shall be packed by the method identified in section 8.

92.13 Section 11 – End section

92.13.1 The end section shall always be 4 bytes long, character coded according to the International Alphabet No. 5 as "7777".

CONTENT OF SECTIONS

Section 0 – Indicator Section

Byte No.	Contents
1–4	GRIB (coded according to the International Alphabet No. 5)
5–6	Reserved
7	Master tables version number (see Code table 0.0 and Note 1–3 in section 1)
8	Edition number (3)
9–16	Total length of GRIB message in bytes (including Section 0)

Section 1 – Originator Section

Byte No.	Contents
1–4	Length of section in bytes
5	Number of section (1)
6–7	Identification of originating/generating centre (see Common Code table C–11)
8–9	Identification of originating/generating subcentre (allocated by originating/generating centre)
10	Local tables version number (see Code table 1.0 and Notes 1-3)
11	Identification of Project (see Code table 1.1)
12	Production status of processed data in this GRIB message (see Code table 1.2)
13–14	Originator Local template number (see Note's 4 and 5)
15–16	Length of originator local template in bytes (see Note 5)
17–nn	Originator Local template (see Note 6)

(nn+1)–(nn+2)	Project Local template number (see Notes 7 and 8)
(nn+3)–(nn+4)	Length of project local template in bytes (see Note 8)
(nn+5)–mm	Project Local template (see Note 9)

Notes:

(1) Local tables shall define those parts of the Master table that are reserved for local use except for the case described in Note 2. In any case, the use of Local tables in messages intended for non-local or international exchange is strongly discouraged.

(2) If master tables version number is 255 then only local tables are in use. The local tables version number must not be zero nor missing, and local tables may include entries from the entire range of the tables.

(3) If local tables version number is zero, master tables version number shall not be zero or missing and only those parts of the tables not reserved for local use may be used.

(4) Originator Local templates are defined and maintained by the Originating Centre.

(5) Originator Local template is optional. If local template is not present, the originator local template number shall be set to missing (all bits set to 1) and the length of local template shall be set to zero.

(6) Originator local template shall be selected using the originator local template number. The originator local templates are maintained and made available to the users by the originating centre.

(7) Project Local templates are defined and maintained by the Originating Centre.

(8) Project Local template is optional. If local template is not present, the project local template number shall be set to missing (all bits set to 1) and the length of project local template shall be set to zero.

(9) Project local template shall be selected using the project local template number. The project local templates are maintained and made available to the users by the project participants.

Section 2 – Repetitions and Index Section

Byte No.	Contents
1–4	Length of section in bytes
5	Number of section (2)
6–7	Total number of repetitions (or total number of fields) (see Note 1)
8–9	Number of distinct sections 3 with length greater than 7 bytes (see Notes 1 and 2)
10–11	Number of distinct sections 4 with length greater than 7 bytes (see Notes 1 and 2)
12–13	Number of distinct sections 5 with length greater than 7 bytes (see Notes 1 and 2)
14–15	Number of distinct sections 6 with length greater than 7 bytes (see Notes 1 and 2)
16–17	Number of distinct sections 7 with length greater than 7 bytes (see Notes 1 and 2)
18–19	Number of distinct sections 8 with length greater than 7 bytes (see Notes 1 and 2)
20–21	Number of distinct sections 9 with length greater than 7 bytes (see Notes 1 and 2)
22–23	Index template number
24–27	Length of Index template in bytes
28–nn	Index template (See Note 3) (see template 2.N, where N is the Index template number given in bytes 22-23)

Notes:

(1) A message with only one field shall have the total number of repetitions and each of the number of distinct sections set to 1.

(2) Two repeated sections shall never be identical. If two sections are identical because they have the same content, one of the two shall be coded with only 7 bytes (empty section with reference) and the SUI shall be coded with the same value of the identical section to which this section refers. Each section will therefore have content in it or refer to another section of the same section number. In the latter case, it will be made only of 7 bytes comprising section length (4 bytes), number of section (1 byte) and Section Unique Identifier–SUI (2 bytes).

(3) The inclusion of an Index template is optional. If index template is not present, the index template number (bytes 22-23) shall be set to missing (all bits set to 1) and the length of index template (bytes 24-27) shall be set to zero.

Section 3 – Time Domain Section

Byte No.	Contents	
1–4	Length of section in bytes (7 or nn)	
5	Number of section (3)	
6–7	Section Unique Identifier (SUI)	
8	Significance of reference date and time (see Code table 3.0)	
9	Type of Calendar (code table 3.1)	Reference date and time
10–13	Year (signed integer according to Reg. 92.1.5)	Reference date and time
14	Month	Reference date and time
15	Day	Reference date and time
16	Hour	Reference date and time
17	Minute	Reference date and time
18	Second	Reference date and time
19–20	Time Domain Template number (see code table 3.2)	
21–nn	Time Domain Template (see template 3.N, where N is the Time Domain Template number given in bytes 19-20)	

Note:

(1) The type of calendar used (byte 9) applies to the entire section including the Time Domain Template.

Section 4 – Horizontal Domain Section

Byte No.	Contents
1–4	Length of section in bytes (7 or nn)
5	Number of section (4)
6–7	Section Unique Identifier (SUI)
8–11	Number of points in the domain
12–13	Horizontal Domain Template number (see Code table 4.0)
14–nn	Horizontal Domain Template (see template 4.N, where N is the Horizontal Domain Template number given in bytes 12-13)

Section 5 –Vertical Domain Section

Byte No.	Contents
1–4	Length of section in bytes (7 or nn)
5	Number of section (5)
6–7	Section Unique Identifier (SUI)
8–9	Vertical Domain Template number (see Code table 5.0)
10–nn	Vertical Domain Template (see template 5.N, where N is the Vertical Domain Template number given in bytes 8-9)

Section 6 – Generating Process Section

Byte No.	Contents
1–4	Length of section in bytes (7 or nn)
5	Number of section (6)
6–7	Section Unique Identifier (SUI)
8–9	Generating Process Template number (see Code table 6.0)
10–nn	Generating Process Template (see template 6.N, where N is the Generating Process Template number given in bytes 8-9)

Section 7 – Observable Property Section

Byte No.	Contents
1–4	Length of section in bytes (7 or nn)
5	Number of section (7)
6–7	Section Unique Identifier (SUI)
8–9	Observable Property Template number (see Code table 7.0)
10–nn	Observable Property Template (see template 7.N, where N is the Observable Property Template number given in bytes 8-9)

Section 8 – Data Representation Section

Byte No.	Contents
1–4	Length of section in bytes (7 or nn)
5	Number of section (8)
6–7	Section Unique Identifier (SUI)
8–11	Number of data values encoded in Section 10
12–13	Data Representation Template number (see Code table 8.0)
14–nn	Data Representation Template (see template 8.N, where N is the Data Representation Template number given in bytes 12-13)

Section 9 – Overlay Section

Byte No.	Contents
1–4	Length of section in bytes (7 or nn)
5	Number of section (9)
6–7	Section Unique Identifier (SUI)
8–9	Overlay Template number (see Code table 9.0)
10–nn	Overlay Template (see template 9.N, where N is the Overlay Template number given in bytes 8–9)

Section 10 – Data Section

Byte No.	Contents
1–4	Length of section in bytes (nn)
5	Number of section (10)
6–nn	Data in a format described by data template 10.X, where X is the Data Template number given in bytes 12–13 of Section 8.

Section 11 – End Section

Byte No.	Contents
1–4	"7777" (coded according to the International Alphabet No. 5)

TEMPLATES USED IN SECTION 3 (TIME DOMAIN SECTION)

Time Domain Template 3.0 – Forecast point in time

Component Code	Component Name
3.0	Forecast point in time

TEMPLATES USED IN SECTION 4 (HORIZONTAL DOMAIN SECTION)

Horizontal Domain Section Template 4.0 – Latitude/longitude regular grid on ellipsoidal planet

Component Code	Component Name
4.0	Ellipsoid of revolution defined with axis lengths
4.1	Latitude/longitude regular grid

Horizontal Domain Section Template 4.1 – Rotated latitude/longitude regular grid on ellipsoidal planet

Component Code	Component Name
4.0	Ellipsoid of revolution defined with axis lengths
4.1	Latitude/longitude regular grid
4.2	Rotation of latitude/longitude coordinate system

Horizontal Domain Section Template 4.2 – Stretched latitude/longitude regular grid on ellipsoidal planet

Component Code	Component Name
4.0	Ellipsoid of revolution defined with axis lengths
4.1	Latitude/longitude regular grid
4.3	Stretching of latitude/longitude coordinate system

Horizontal Domain Section Template 4.3 – Stretched and rotated latitude/longitude regular grid on ellipsoidal planet

Component Code	Component Name
4.0	Ellipsoid of revolution defined with axis lengths
4.1	Latitude/longitude regular grid
4.2	Rotation of latitude/longitude coordinate system
4.3	Stretching of latitude/longitude coordinate system

TEMPLATES USED IN SECTION 5 (VERTICAL DOMAIN SECTION)

Vertical Coordinate Template 5.0 – Vertical level

Component Code	Component Name	Description
5.0	Vertical level	Single level

Vertical Coordinate Template 5.1 – Vertical layer

Component Code	Component Name	Description
5.1	Vertical layer	

TEMPLATES USED IN SECTION 6 (GENERATING PROCESS SECTION)

Generating Process Template 6.0 – Forecast, analysis or observation

Component Code	Component Name	Description
6.0	Process type and identifier	

Generating Process Template 6.1 – Individual ensemble forecast or analysis

Component Code	Component Name	Description
6.0	Process type and identifier	
6.1	Ensemble size	
6.2	Ensemble member	

Generating Process Template 6.2 – Statistical post-processing of all ensemble members

Component Code	Component Name	Description
6.0	Process type and identifier	
6.1	Ensemble size	
6.3	Statistical post-processing of ensemble members	

TEMPLATES USED IN SECTION 7 (OBSERVABLE PROPERTY SECTION)

Observable Property Template 7.0 – Observable property by discipline, category and number

Component Code	Component Name	Description
7.0	Observable property by discipline, category and number	

Observable Property Template 7.1 –Observable Property with units conversion

Component Code	Component Name	Description
7.0	Observable property by discipline, category and number	
7.1	Units conversion	

Observable Property Template 7.2 – Atmospheric chemical or physical constituents

Component Code	Component Name	Description
7.0	Observable property by discipline, category number	
7.2	Chemical or physical constituents	

Observable Property Template 7.3 – Aerosol physical property

Component Code	Component Name	Description
7.0	Observable property by discipline, category number	
7.2	Chemical or physical constituents	
7.3	Aerosol size	

Observable Property Template 7.4 – Aerosol optical property

Component Code	Component Name	Description
7.0	Observable property by discipline, category and number	
7.2	Chemical or physical constituents	
7.3	Aerosol size	
7.4	Radiation wavelength interval	

TEMPLATES USED IN SECTION 8 (DATA REPRESENTATION SECTION)

Data Representation Template 8.0 – Simple packing

Component Code	Component Name	Description
8.0	Simple packing	

Data Representation Template 8.1 –IEEE floating point

Component Code	Component Name	Description
8.1	IEEE floating point	

TEMPLATES USED IN SECTION 9 (OVERLAY SECTION)

Overlay Template 9.0 – Bitmap

Component Code	Component Name	Description
9.0	Bitmap	

COMPONENTS USED IN TEMPLATES OF SECTION 3 (TIME DOMAIN SECTION)

Time Domain Section Template Component 3.0 – Forecast point in time

Byte No.	Contents
1–2	Hours of observational data cut-off after reference time (see Note 1)
3	Minutes of observational data cut-off after reference time
4	Indicator of unit of time range (see Code table 3.3)
5–8	Forecast time in units defined by byte 4

Note:

(1) Hours greater than 65534 will be coded as 65534.

COMPONENTS USED IN TEMPLATES OF SECTION 4 (HORIZONTAL DOMAIN SECTION)

Horizontal Domain Template Component 4.0 – Ellipsoid of revolution defined with axis lengths

Byte No.	Contents
1	Scale factor of length of semi-major axis
2–5	Scaled value of length of semi-major axis (equatorial radius)
6	Scale factor of prime meridian offset
7–10	Scaled value of prime meridian offset (see Note 1)
11	Scale factor of length of semi-minor axis
12–15	Scaled value of length of semi-minor axis (distance from ellipsoid centre to pole)

Horizontal Domain Template Component 4.1 – Latitude/longitude regular grid

Byte No.	Contents
1–4	Ni – number of points along a parallel
5–8	Nj – number of points along a meridian
9–12	Basic angle of the initial production domain (see Note 1)
13–16	Subdivisions of basic angle used to define extreme longitudes and latitudes, and direction increments (see Note 1)
17–20	La1 – latitude of first grid point (see Note 1)
21–24	Lo1 – longitude of first grid point (see Note 1)
25	Resolution and component flags (see Flag table 4.1)
26–29	La2 – latitude of last grid point (see Note 1)
30–33	Lo2 – longitude of last grid point (see Note 1)
34–37	Di – i direction increment (see Notes 1 and 2)
38–41	Dj – j direction increment (see Notes 1 and 2)
42	Scanning mode (flags – see Flag table 4.2)

Notes:

(1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes, and direction increments. For these last six descriptors, the unit is equal to the ratio of the basic angle and the subdivisions number. For ordinary cases, zero and missing values should be coded, equivalent to respective values of 1 and 10^6 (10^{-6} degrees unit).

(2) Direction increments are unsigned and direction of increment is represented in the scanning mode.

Horizontal Domain Template Component 4.2 – Rotation of latitude/longitude coordinates system

Byte No.	Contents
1–4	Latitude of the southern pole of projection
5–8	Longitude of the southern pole of projection
9–12	Angle of rotation of projection

Note:

(1) Three parameters define a general latitude/longitude coordinate system, formed by a general rotation of the sphere. One choice for these parameters is:

(a) The geographic latitude in degrees of the southern pole of the coordinate system, θ_p for example;

(b) The geographic longitude in degrees of the southern pole of the coordinate system, λ_p for example;

(c) The angle of rotation in degrees about the new polar axis (measured clockwise when looking from the southern to the northern pole) of the coordinate system, assuming the new axis to have been obtained by first rotating the sphere through λ_p degrees about the geographic polar axis, and then rotating through $(90 + \theta_p)$ degrees so that the southern pole moved along the (previously rotated) Greenwich meridian.

Horizontal Domain Template Component 4.3 – Stretching of latitude/longitude coordinates system

Byte No.	Contents
1–4	Latitude of the "pole of stretching"
5–8	Longitude of the "pole of stretching"
9–12	Stretching factor

Note:

(1) The stretching is defined by three parameters:

(a) The latitude in degrees (λ, measured in the model coordinate system) of the "pole of stretching";

(b) The longitude in degrees (θ, measured in the model coordinate system) of the "pole of stretching"; and

(c) The stretching factor C in units of 10^{-6} represented as an integer.

The stretching is defined by representing data uniformly in a coordinate system with longitude λ and latitude θ^1, where:

$$\theta^1 = \sin^{-1} \frac{(1 - C^2) + (1 + C^2)\sin\theta}{(1 + C^2) + (1 - C^2)\sin\theta}$$

and λ and θ are longitude and latitude in a coordinate system in which the "pole of stretching" is the northern pole. C = 1 gives uniform resolution, while C > 1 gives enhanced resolution around the pole of stretching.

COMPONENTS USED IN TEMPLATES OF SECTION 5 (VERTICAL DOMAIN SECTION)

Vertical Coordinate Template Component 5.0 – Vertical level

Byte No.	Contents
1	Type of first fixed surface (see Code table 5.1)
2	Scale factor of first fixed surface
3–5	Scaled value of first fixed surface

Vertical Coordinate Template Component 5.1 – Vertical layer

Byte No.	Contents
1	Type of first fixed surface (see Code table 5.1)
2	Scale factor of first fixed surface

3–5	Scaled value of first fixed surface
6	Type of second fixed surface (see Code table 5.1)
7	Scale factor of second fixed surface
8–10	Scaled value of second fixed surface

COMPONENTS USED IN TEMPLATES OF SECTION 6 (GENERATING PROCESS SECTION)

Generating Process Template Component 6.0 – Process type and identifier

Byte No.	Contents
1	Type of generating process (see Code table 6.1)
2	Generating Process Identifier (managed by the originating Centre)

Generating Process Template Component 6.1 – Ensemble size

Byte No.	Contents
1–2	Number of members in ensemble

Generating Process Template Component 6.2 – Ensemble member

Byte No.	Contents
1	Type of ensemble member (see Code table 6.2)
2–3	Member Number

Generating Process Template Component 6.3 – Statistical post-processing of all ensemble members

Byte No.	Contents
1	Type of statistical post-processing of ensemble members (see Code table 6.3)

COMPONENTS USED IN TEMPLATES OF SECTION 7 (OBSERVABLE PROPERTY SECTION)

Observable Property Template Component 7.0 – Observable property by discipline, category and number

Byte No.	Contents
1	Parameter Discipline (see Code table 7.1)
2	Parameter Category (see Code table 7.2)
3–4	Parameter Number (see Code table 7.3)

Observable Property Template Component 7.1 – Units conversion

Byte No.	Contents
1–4	Units conversion scale factor (ucs) (see Note 1)
5–8	Units conversion offset (uco) (see Note 1)

Notes:

(1) Units conversion scale factor (ucs) and offset (uco) shall be used to encode fields in units different from the units reported in table 7.3. If the values encoded in the GRIB message are v_e, the values v in the units provided in table 7.3 shall be: $v = ucs * v_e + uco$.

(2) Encoded as IEEE 32 bits floating point values.

Observable Property Template Component 7.2 – Chemical or physical constituents

Byte No.	Contents
1–2	Atmospheric chemical or physical constituent type (see Common Code table C–14)

Observable Property Template Component 7.3 – Aerosol size

Byte No.	Contents

1	Type of interval for first and second size (see Code table 7.4)
2	Scale factor of first size
3–6	Scaled value of first size in metres
7	Scale factor of second size
8–11	Scaled value of second size in metres

Observable Property Template Component 7.4 – Radiation wavelength interval

Byte No.	Contents
1	Type of interval for first and second wavelength (see Code table 7.4)
2	Scale factor of first wavelength
3–6	Scaled value of first wavelength in metres
7	Scale factor of second wavelength
8–11	Scaled value of second wavelength in metres

COMPONENTS USED IN TEMPLATES OF SECTION 8 (DATA REPRESENTATION SECTION)

Data Representation Template Component 8.0 – Simple packing

Byte No.	Contents
1–4	Reference value (R) (IEEE 32-bit floating-point value)
5–6	Binary scale factor (E)
7–8	Decimal scale factor (D)
9	Number of bits used for each packed value for simple packing, or for each group reference value for complex packing or spatial differencing
10	Type of original field values (see Code table 8.1)
11	Missing value management (see Code table 8.2)
12–15	Primary missing value substitute
16–19	Secondary missing value substitute

Notes:

(1) Management of explicitly missing values is an alternative to bit-map use within Section 6; it is intended to reduce the whole GRIB message size and to provide better performance when decoding data with missing values.

(2) There may be two types of missing value(s), such as to make a distinction between static misses (for instance, due to a land/sea mask) and occasional misses.

(3) As an extra option, substitute value(s) for missing data may be specified. If not wished (or not applicable), all bits should be set to 1 for relevant substitute value(s).

(4) If substitute value(s) are specified, type of content should be consistent with original field values (floating-point - and then IEEE 32-bit encoded-, or integer).

(5) If primary missing values are used, such values are encoded with all bits set to 1 at packed data level.

(6) If secondary missing values are used, such values are encoded with all bits set to 1, except the last one set to 0, at packed data level.

Data Representation Template Component 8.4 –IEEE floating point

Byte No.	Contents
1	Precision (see Code table 8.3)

COMPONENTS USED IN TEMPLATES OF SECTION 9 (OVERLAY SECTION)

Overlay Template Component 9.0 – Bitmap

Byte No.	Contents
1–nn	Bitmap – Contiguous bits with a bit to data point correspondence, ordered as defined in Horizontal Domain Section. A bit set to 1 implies the presence of a data value at the corresponding data point, whereas a value of 0 implies the absence of such a value.

CODE TABLES USED IN SECTION 0 (INDICATOR SECTION)

Code table 0.0 – *GRIB master tables version number*

Code figure	Meaning
0	Experimental
1–254	Future versions
255	Missing. Local tables in use. Valid local tables version number shall be coded.

CODE TABLES USED IN SECTION 1 (ORIGINATOR SECTION)

Code table 1.0 – *GRIB local tables version number*

Code figure	Meaning
0	Local tables not used. Only table entries and templates from the current master table are valid
1–254	Local tables versions used
255	Missing

Code table 1.1 – *International Projects*

Code figure	Meaning
0	Reserved
1	THORPEX Interactive Grand Global Ensemble (TIGGE)
2	Subseasonal-to-Seasonal prediction (S2S)
3–191	Reserved
192–254	Reserved for local use
255	Missing

Code table 1.2 – *Production status of data*

Code figure	Meaning
0	Operational products
1	Operational test products
2	Research products
3–191	Reserved
192–254	Reserved for local use
255	Missing

CODE TABLES USED IN SECTION 3 (TIME DOMAIN SECTION)

Code table 3.0 – *Significance of reference date and time*

Code figure	Meaning
0	Analysis
1	Start of forecast
2	Verifying time of forecast
3	Observation time
4–191	Reserved
192–254	Reserved for local use
255	Missing

Code table 3.1 – *Type of calendar*

Code figure	Meaning	Comments
0	Gregorian	
1	360-day	
2	365-day	Essentially a non-leap year
3	Proleptic Gregorian	Extends the Gregorian calendar indefinitely in the past

4–191	Reserved
192–254	Reserved for local use
255	Missing

Code table 3.2 – *Time domain template number*

Code figure	Meaning
0	Forecast point in time
1–32767	Reserved
32768–65534	Reserved for local use
65535	Missing

Code table 3.3– *Indicator of unit of time range*

Code figure	Meaning
0	Minute
1	Hour
2	Day
3	Month
4	Year
5	Decade (10 years)
6	Normal (30 years)
7	Century (100 years)
8–9	Reserved
10	3 hours
11	6 hours
12	12 hours
13	Second
14–191	Reserved
192–254	Reserved for local use
255	Missing

CODE AND FLAG TABLES USED IN SECTION 4 (HORIZONTAL DOMAIN SECTION)

Code table 4.0 – *Grid definition template number*

Code figure	Meaning
0	Latitude/longitude regular grid on an ellipsoidal planet
1	Rotated latitude/longitude regular grid on an ellipsoidal planet
2	Stretched latitude/longitude regular grid on an ellipsoidal planet
3	Stretched and rotated latitude/longitude regular grid on ellipsoidal planet
4–32767	Reserved
32768–65534	Reserved for local use
65535	Missing

Flag table 4.1 – *Resolution and component flags*

Bit No.	Value	Meaning
1–2		Reserved
3	0	i direction increments not given
	1	i direction increments given
4	0	j direction increments not given
	1	j direction increments given
5	0	Resolved u- and v- components of vector quantities relative to easterly and

		northerly directions
	1	Resolved u- and v- components of vector quantities relative to the defined grid in the direction of increasing x and y (or i and j) coordinates, respectively
6–8		Reserved – set to zero

Flag table 4.2 – *Scanning mode*

Bit No.	Value	Meaning
1	0	Points of first row or column scan in the +i (+x) direction
	1	Points of first row or column scan in the –i (–x) direction
2	0	Points of first row or column scan in the –j (–y) direction
	1	Points of first row or column scan in the +j (+y) direction
3	0	Adjacent points in i (x) direction are consecutive
	1	Adjacent points in j (y) direction is consecutive
4	0	All rows scan in the same direction
	1	Adjacent rows scans in the opposite direction
5	0	Points within odd rows are not offset in i (x) direction
	1	Points within odd rows are offset by Di/2 in i (x) direction
6	0	Points within even rows are not offset in i (x) direction
	1	Points within even rows are offset by Di/2 in i (x) direction
7	0	Points are not offset in j (y) direction
	1	Points are offset by Dj/2 in j (y) direction
8	0	Rows have Ni grid points and columns have Nj grid points
	1	Rows have Ni grid points if points are not offset in i direction
		Rows have Ni–1 grid points if points are offset by Di/2 in i direction
		Columns have Nj grid points if points are not offset in j direction
		Columns have Nj–1 grid points if points are offset by Dj/2 in j direction

Notes:

(1) i direction: west to east along a parallel or left to right along an x-axis.

(2) j direction: south to north along a meridian, or bottom to top along a y-axis.

(3) If bit number 4 is set, the first row scan is as defined by previous flags.

(4) La1 and Lo1 define the first row, which is an odd row.

(5) Di and Dj are assumed to be positive, with the direction of i and j being given by bits 1 and 2.

(6) Bits 5 through 8 may be used to generate staggered grids, such as Arakawa grids (see Part B, GRIB Attachment II).

(7) If any of bits 5, 6, 7 or 8 are set, Di and Dj are not optional.

CODE TABLES USED IN SECTION 5 (VERTICAL DOMAIN SECTION)

Code table 5.0 – *Vertical domain template number*

Code figure	Meaning
0	Vertical level
1	Vertical layer
2–32767	Reserved
32768–65534	Reserved for local use
65535	Missing

Code table 5.1 – Fixed surface types and units

Code figure	Meaning	Unit
0	Reserved	
1	Ground or water surface	–
2	Cloud base level	–

3	Level of cloud tops	–
4	Level of 0 °C isotherm	–
5	Level of adiabatic condensation lifted from the surface	–
6	Maximum wind level	–
7	Tropopause	–
8	Nominal top of the atmosphere	–
9	Sea bottom	–
10	Reserved	–
11	Cumulonimbus (CB) base	m
12	Cumulonimbus (CB) top	m
13–19	Reserved	
20	Isothermal level	K
21–99	Reserved	
100	Isobaric surface	Pa
101	Mean sea level	
102	Specific altitude above mean sea level	m
103	Specified height level above ground	m
104	Sigma level	"sigma" value
105	Hybrid level	–
106	Depth below land surface	m
107	Isentropic (theta) level	K
108	Level at specified pressure difference from ground to level	Pa
109	Potential vorticity surface	K m^2 kg^{-1} s^{-1}
110	Reserved	
111	Eta level	–
112	Reserved	
113	Logarithmic hybrid level	
114	Snow level	Numeric
115–116	Reserved	
117	Mixed layer depth	m
118	Hybrid height level	–
119	Hybrid pressure level	–
120–159	Reserved	–
160	Depth below sea level	m
161	Depth below water surface	m
162	Lake or river bottom	–
163	Bottom of sediment layer	–
164	Bottom of thermally active sediment layer	–
165	Bottom of sediment layer penetrated by thermal wave	–
166	Mixing layer	–
167	Bottom of root zone	–
168–173	Reserved	
174	Top surface of ice on sea, lake or river	–
175	Top surface of ice, under snow cover, on sea, lake or river	–
176	Bottom surface (underside) ice on sea, lake or river	–
177	Deep soil (of indefinite depth)	–
178	Reserved	
179	Top surface of glacier ice and inland ice	–
180	Deep inland or glacier ice (of indefinite depth)	–
181	Grid tile land fraction as a model surface	–
182	Grid tile water fraction as a model surface	–

183	Grid tile ice fraction on sea, lake or river as a model surface	–
184	Grid tile glacier ice and inland ice fraction as a model surface	–
185–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Notes:

(1) The Eta vertical coordinate system involves normalizing the pressure at some point on a specific level by the mean sea level pressure at that point.

(2) Hybrid height level (Code figure 118) can be defined as:

$$z(k) = A(k) + B(k) \times orog$$

(k = 1,...,NLevels; orog = orography; z(k) = height in metres at level k)

(3) Hybrid pressure level, for which Code figure 119 shall be used instead of 105, can be defined as:

$$p(k) = A(k) + B(k) \times sp$$

(k = 1,...,NLevels; sp = surface pressure; p(k) = pressure at level k)

CODE TABLES USED IN SECTION 6 (GENERATING PROCESS SECTION)

Code table 6.0 – Generating *process template number*

Code figure	Meaning
0	Forecast, analysis or observation
1	Individual ensemble forecast or analysis, control and perturbed
2	Statistical post-processing of all ensemble members
3–32767	Reserved
32768–65534	Reserved for local use
65535	Missing

Code table 6.1 – *Type of generating process*

Code figure	Meaning
0	Analysis
1	Initialization
2	Forecast
3	Bias corrected forecast
4	Ensemble forecast
5	Probability forecast
6	Forecast error
7	Analysis error
8	Observation
9	Climatological
10	Probability-weighted forecast
11	Bias-corrected ensemble forecast
12	Post-processed analysis (see Note 1)
13	Post-processed forecast (see Note 1)
14	Nowcast
15	Hindcast
16	Physical retrieval
17	Regression analysis
18–191	Reserved
192–254	Reserved for local use
255	Missing

Note:

(1) Code figures 12 and 13 are intended in cases where code figures 0 and 2 may not be sufficient to indicate that significant post-processing has taken place on an initial analysis or forecast output.

Code table 6.2 – *Type of ensemble member*

Code figure	Meaning
0	Unperturbed high-resolution control forecast
1	Unperturbed low-resolution control forecast
2	Negatively perturbed forecast
3	Positively perturbed forecast
4–191	Reserved
192–254	Reserved for local use
255	Missing

Code table 6.3 – Type of statistical post-processing of ensemble members

Code figure	Meaning
0	Unweighted mean
1	Weighted mean
2	Spread
3	Large anomaly index (see Note 1)
4	Interquartile range (range between the 25th and 75th quantile)
5	Minimum
6	Maximum
7–191	Reserved
192–254	Reserved for local use
255	Missing

Note:

(1) Large anomaly index is defined as {(number of members whose anomaly is higher than 0.5 x SD) – (number of members whose anomaly is lower than –0.5 x SD)} / (number of members) at each grid point, where SD is defined as observed climatological standard deviation.

CODE TABLES USED IN SECTION 7 (OBSERVABLE PROPERTY SECTION)

Code table 7.0 – *Observable property template number*

Code figure	Meaning
0	Observable property by discipline, category and number
1	Observable property with units conversion
2	Atmospheric chemical or physical constituent
3	Aerosol physical property
4	Aerosol optical property
5–32767	Reserved
32768–65534	Reserved for local use
65535	Missing

Code table 7.1 – *Discipline*

Code figure	Meaning
0	Meteorological products
1	Hydrological products
2	Land surface products
3	Space products
4–9	Reserved
10	Oceanographic products

11–191	Reserved
192–254	Reserved for local use
255	Missing

Code table 7.2 – *Parameter category by discipline*

Product discipline 0 – Meteorological products

Category	Description
0	Temperature
1	Moisture
2	Momentum
3	Mass
4	Short-wave radiation
5	Long-wave radiation
6	Cloud
7	Thermodynamic stability indices
8	Kinematic stability indices
9–12	Reserved
13	Aerosols
14	Trace gases (e.g. ozone, CO_2)
15	Radar
16	Forecast radar imagery
17	Electrodynamics
18	Reserved
19	Physical atmospheric properties
20	Atmospheric chemical constituents
21–191	Reserved
192–254	Reserved for local use
255	Missing

Note:

(1) When a new category is to be added to Code table 7.1 and more than one discipline applies, the choice of discipline should be made based on the intended use of the product.

Product discipline 1 – Hydrological products

Category	Description
0	Hydrology basic products
1	Reserved
2	Inland water and sediment properties
3–191	Reserved
192–254	Reserved for local use
255	Missing

Product discipline 2 – Land surface products

Category	Description
0	Vegetation/biomass
1	Agri-/aquacultural special products
2	Transportation-related products
3	Soil products
4	Fire weather products
5–191	Reserved
192–254	Reserved for local use
255	Missing

Product discipline 3 – Space products

Category	Description
0	Reserved
1	Reserved
2	Cloud properties
3	Flight rule conditions
4	Volcanic ash
5	Sea-surface temperature
6–191	Reserved
192–254	Reserved for local use
255	Missing

Product discipline 10 – Oceanographic products

Category	Description
0	Waves
1	Currents
2	Ice
3	Surface properties
4	Subsurface properties
5–190	Reserved
191	Miscellaneous
192–254	Reserved for local use
255	Missing

Code table 7.3 – *Parameter number by product discipline and parameter category*

Note:
(1) By convention, the flux sign is positive if downwards.

Product discipline 0 – Meteorological products, parameter category 0: temperature

Number	Parameter	Units
0	Temperature	K
1	Virtual temperature	K
2	Potential temperature	K
3	Pseudo-adiabatic potential temperature or equivalent potential temperature	K
4–5	Reserved	
6	Dewpoint temperature	K
7	Dewpoint depression (or deficit)	K
8	Lapse rate	K m^{-1}
9	Temperature anomaly	K
10	Latent heat net flux	W m^{-2}
11	Sensible heat net flux	W m^{-2}
12	Heat index	K
13	Wind chill factor	K
14	Reserved	
15	Virtual potential temperature	K
16–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 0 – Meteorological products, parameter category 1: moisture

Number	Parameter	Units
0	Specific humidity	kg kg^{-1}
1	Relative humidity	%
2	Humidity mixing ratio	kg kg^{-1}
3	Precipitable water	kg m^{-2}
4	Vapour pressure	Pa
5–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 0 – Meteorological products, parameter category 2: momentum

Number	Parameter	Units
0	Wind direction (from which blowing)	degree true
1	Wind speed	m s^{-1}
2	u-component of wind	m s^{-1}
3	v-component of wind	m s^{-1}
4	Stream function	m^2 s^{-1}
5	Velocity potential	m^2 s^{-1}
6	Montgomery stream function	m^2 s^{-2}
7–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 0 – Meteorological products, parameter category 3: mass

Number	Parameter	Units
0	Pressure	Pa
1	Pressure reduced to MSL	Pa
2	Pressure tendency	Pa s^{-1}
3	ICAO Standard Atmosphere Reference Height	m
4	Geopotential	m^2 s^{-2}
5	Geopotential height	gpm
6	Geometric height	m
7	Standard deviation of height	m
8	Pressure anomaly	Pa
9	Geopotential height anomaly	gpm
10	Density	kg m^{-3}
11–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 0 – Meteorological products, parameter category 4: short-wave radiation

Number	Parameter	Units
0	Net short-wave radiation flux (surface)*	W m^{-2}
1	Net short-wave radiation flux (top of atmosphere)*	W m^{-2}
2	Short-wave radiation flux*	W m^{-2}
3	Global radiation flux	W m^{-2}

4	Brightness temperature	K
5–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 0 – Meteorological products, parameter category 5: long-wave radiation

Number	Parameter	Units
0	Reserved	
1	Reserved	
2	Reserved	
3	Downward long-wave radiation flux	W m^{-2}
4	Upward long-wave radiation flux	W m^{-2}
5	Net long-wave radiation flux	W m^{-2}
6	Net long-wave radiation flux, clear sky	W m^{-2}
7	Brightness temperature	K
8–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 0 – Meteorological products, parameter category 6: cloud

Number	Parameter	Units
0	Cloud ice	kg m^{-2}
1	Total cloud cover	%
2	Convective cloud cover	%
3	Low cloud cover	%
4	Medium cloud cover	%
5	High cloud cover	%
6	Cloud water	kg m^{-2}
7	Cloud amount	%
8	Reserved	
9	Thunderstorm maximum tops	m
10	Reserved	
11	Cloud base	m
12	Cloud top	m
13	Ceiling	m
14	Non-convective cloud cover	%
15	Cloud work function	J kg^{-1}
16	Convective cloud efficiency	Proportion
17	Reserved	
18	Total column-integrated cloud water*	kg m^{-2}
19	Total column-integrated cloud ice*	kg m^{-2}
20	Total column-integrated condensate*	kg m^{-2}
21	Ice fraction of total condensate	Proportion
22–191	Cloud cover	%
192–254	Reserved for local use	
255	Missing	

Product discipline 0 – Meteorological products, parameter category 7: thermodynamic stability indices

Number	Parameter	Units
0	Parcel lifted index (to 500 hPa)	K

1	Best lifted index (to 500 hPa)	K
2	K index	K
3	KO index	K
4	Total totals index	K
5	Sweat index	Numeric
6	Convective available potential energy	J kg^{-1}
7	Convective inhibition	J kg^{-1}
8	Storm relative helicity	J kg^{-1}
9	Energy helicity index	Numeric
10	Surface lifted index	K
11	Best (4-layer) lifted index	K
12	Richardson number	Numeric
13	Showalter index	K
14	Reserved	
15	Updraught helicity	m^2 s^{-2}
16	Bulk Richardson number	Numeric
17	Gradient Richardson number	Numeric
18	Flux Richardson number	Numeric
19–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 0 – Meteorological products, parameter category 13: aerosols

Number	Parameter	Units
0–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 0 – Meteorological products, parameter category 14: trace gases

Number	Parameter	Units
0	Total ozone	DU
1	Ozone mixing ratio	kg kg^{-1}
2	Total column integrated ozone	DU
3–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 0 – Meteorological products, parameter category 15: radar

Number	Parameter	Units
0	Base spectrum width	m s^{-1}
1	Base reflectivity	dB
2	Base radial velocity	m s^{-1}
3	Vertically integrated liquid water (VIL)	kg m^{-2}
4	Layer-maximum base reflectivity	dB
5	Precipitation	kg m^{-2}
6–8	Reserved	
9	Reflectivity of cloud droplets	dB
10	Reflectivity of cloud ice	dB
11	Reflectivity of snow	dB
12	Reflectivity of rain	dB
13	Reflectivity of graupel	dB

14	Reflectivity of hail	dB
15	Hybrid scan reflectivity	dB
16	Hybrid scan reflectivity height	m
17–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product Discipline 0 – Meteorological products, parameter category 16: forecast radar imagery

Number	Parameter	Units
0	Equivalent radar reflectivity factor for rain	$mm^6\ m^{-3}$
1	Equivalent radar reflectivity factor for snow	$mm^6\ m^{-3}$
2	Equivalent radar reflectivity factor for parameterized convection	$mm^6\ m^{-3}$
3	Echo top	m
4	Reflectivity	dB
5	Composite reflectivity	dB
6–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Note:

(1) Decibel (dB) is a logarithmic measure of the relative power, or of the relative values of two flux densities, especially of sound intensities and radio and radar power densities. In radar meteorology, the logarithmic scale (dBZ) is used for measuring radar reflectivity factor (obtained from the American Meteorological Society *Glossary of Meteorology*).

Product discipline 0 – Meteorological products, parameter category 17: electrodynamics

Number	Parameter	Units
0	Lightning strike density	$m^{-2}\ s^{-1}$
1–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 0 – Meteorological products, parameter category 19: physical atmospheric properties

Number	Parameter	Units
0	Visibility	m
1	Albedo	%
2	Thunderstorm probability	%
3	Mixed layer depth	m
4–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 0 – Meteorological products, parameter category 20: atmospheric chemical constituents

Number	Parameter	Units
0	Mass density (concentration)	$kg\ m^{-3}$
1	Reserved	
2	Mass mixing ratio (mass fraction in air)	$kg\ kg^{-1}$
3	Atmosphere emission mass flux	$kg\ m^{-2}\ s^{-1}$
4	Atmosphere net production mass flux	$kg\ m^{-2}\ s^{-1}$
5	Atmosphere net production and emission mass flux	$kg\ m^{-2}\ s^{-1}$

6–191	Reserved
192–254	Reserved for local use
255	Missing

Product discipline 1 – Hydrological products, parameter category 0: hydrology basic products

Number	Parameter	Units
0	Flash flood guidance (Encoded as an accumulation over a floating subinterval of time between the reference time and valid time)	kg m^{-2}
1	Flash flood runoff (Encoded as an accumulation over a floating subinterval of time)	kg m^{-2}
2	Reserved	
3	Reserved	
4	Snow water equivalent per cent of normal	%
5	Baseflow-groundwater runoff	kg m^{-2}
6	Storm surface runoff	kg m^{-2}
7	Discharge from rivers or streams	m^3 s^{-1}
8	Groundwater upper storage	kg m^{-2}
9	Groundwater lower storage	kg m^{-2}
10	Side flow into river channel	m^3 s^{-1} m^{-1}
11	River storage of water	m^3
12	Floodplain storage of water	m^3
13	Depth of water on soil surface	kg m^{-2}
14	Upstream accumulated precipitation	kg m^{-2}
15	Upstream accumulated snow melt	kg m^{-2}
16–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 1 – Hydrological products, parameter category 2: inland water and sediment properties

Number	Parameter	Units
0	Water depth	m
1	Water temperature	K
2	Water fraction	Proportion
3	Sediment thickness	m
4	Sediment temperature	K
5	Ice thickness	m
6	Ice temperature	K
7	Ice cover	Proportion
8	Land cover (0 = water, 1 = land)	Proportion
9	Shape factor with respect to salinity profile	–
10	Shape factor with respect to temperature profile in thermocline	–
11	Attenuation coefficient of water with respect to solar radiation	m^{-1}
12	Salinity	kg kg^{-1}
13	Cross-sectional area of flow in channel	m^2

14–191	Reserved
192–254	Reserved for local use
255	Missing

Product discipline 2 – Land surface products, parameter category 0: vegetation / biomass

Number	Parameter	Units
0	Land cover (0 = sea, 1 = land)	Proportion
1	Surface roughness	m
2–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 2 – Land surface products, parameter category 4: fire weather products

Number	Parameter	Units
0	Fire outlook	Code table 6.224
1	Fire outlook due to dry thunderstorm	Code table 6.224
2	Haines index	Numeric
3	Fire burned area	%
4	Fosberg index*	Numeric
5	Forest Fire Weather Index (Canadian Forest Service)	Numeric
6	Fine Fuel Moisture Code (Canadian Forest Service)	Numeric
7	Duff Moisture Code (Canadian Forest Service)	Numeric
8	Drought Code (Canadian Forest Service)	Numeric
9	Initial Fire Spread Index (Canadian Forest Service)	Numeric
10	Fire Buildup Index (Canadian Forest Service)	Numeric
11	Fire Daily Severity Rating (Canadian Forest Service)	Numeric
12–191	Reserved	
192–254	Reserved for local use	
255	Missing	

* The Fosberg index denotes the potential influence of weather on a wildland fire. It takes into account the combined effects of temperature, wind speed, relative humidity and precipitation. Higher values indicate a higher potential impact.

Product discipline 2 – Land surface products, parameter category 5: glaciers and inland ice

Number	Parameter	Units
1	Glacier temperature	K
2–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 3 – Space products, parameter category 0: image format products

Number	Parameter	Units
0	Scaled radiance	Numeric
1	Scaled albedo	Numeric
2	Scaled brightness temperature	Numeric
3	Scaled precipitable water	Numeric
4	Scaled lifted index	Numeric
5	Scaled cloud top pressure	Numeric
6	Scaled skin temperature	Numeric

7–191	Reserved
192–254	Reserved for local use
255	Missing

Product discipline 10 – Oceanographic products, parameter category 0: waves

Number	Parameter	Units
0	Wave spectra (1)	–
1	Wave spectra (2)	–
2	Wave spectra (3)	–
3	Significant height of combined wind waves and swell	m
4	Direction of wind waves	degree true
5	Significant height of wind waves	m
6	Mean period of wind waves	s
7	Direction of swell waves	degree true
8	Significant height of swell waves	m
9	Mean period of swell waves	s
10	Primary wave direction	degree true
11	Primary wave mean period	s
12	Secondary wave direction	degree true
13	Secondary wave mean period	s
14	Direction of combined wind waves and swell	degree true
15	Mean period of combined wind waves and swell	s
16	Coefficient of drag with waves	–
17	Friction velocity	$m\ s^{-1}$
18	Wave stress	$N\ m^{-2}$
19	Normalized wave stress	–
20	Mean square slope of waves	–
21	u-component surface Stokes drift	$m\ s^{-1}$
22	v-component surface Stokes drift	$m\ s^{-1}$
23	Period of maximum individual wave height	s
24	Maximum individual wave height	m
25	Inverse mean wave frequency	s
26	Inverse mean frequency of wind waves	s
27	Inverse mean frequency of total swell	s
28	Mean zero-crossing wave period	s
29	Mean zero-crossing period of wind waves	s
30	Mean zero-crossing period of total swell	s
31	Wave directional width	–
32	Directional width of wind waves	–
33	Directional width of total swell	–
34	Peak wave period	s
35	Peak period of wind waves	s
36	Peak period of total swell	s
37	Altimeter wave height	m
38	Altimeter corrected wave height	m
39	Altimeter range relative correction	–
40	10-metre neutral wind speed over waves	m s–1
41	10-metre wind direction over waves	°
42	Wave energy spectrum	$m^2\ s\ rad^{-1}$
43	Kurtosis of the sea-surface elevation due to waves	–

44	Benjamin–Feir index	–
45	Spectral peakedness factor	s^{-1}
46–191	Reserved	
192–254	Reserved for local use	
255	Missing	

* Further information concerning the wave parameters can be found in the *Guide to Wave Analysis and Forecasting* (WMO-No. 702).

Product discipline 10 – Oceanographic products, parameter category 1: currents

Number	Parameter	Units
0	Current direction	degree true
1	Current speed	m s^{-1}
2	u-component of current	m s^{-1}
3	v-component of current	m s^{-1}
4–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 10 – Oceanographic products, parameter category 2: ice

Number	Parameter	Units
0	Ice cover	Proportion
1	Ice thickness	m
2	Direction of ice drift	degree true
3	Speed of ice drift	m s^{-1}
4	u-component of ice drift	m s^{-1}
5	v-component of ice drift	m s^{-1}
6	Ice growth rate	m s^{-1}
7	Ice divergence	s^{-1}
8	Ice temperature	K
9	Module of ice internal pressure*	Pa m
10	Zonal vector component of vertically integrated ice internal pressure	Pa m
11	Meridional vector component of vertically integrated ice internal pressure	Pa m
12	Compressive ice strength	N m^{-1}
13–191	Reserved	
192–254	Reserved for local use	
255	Missing	

* Ice internal pressure or stress (Pa m) is the integrated pressure across the vertical thickness of a layer of ice. It is produced when concentrated ice reacts to external forces such as wind and ocean currents.

Product discipline 10 – Oceanographic products, parameter category 3: surface properties

Number	Parameter	Units
0	Water temperature	K
1	Deviation of sea level from mean	m
2–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 10 – Oceanographic products, parameter category 4: subsurface properties

Number	Parameter	Units
0	Main thermocline depth	m

1	Main thermocline anomaly	m
2	Transient thermocline depth	m
3	Salinity	kg kg^{-1}
4	Ocean vertical heat diffusivity	m^2 s^{-1}
5	Ocean vertical salt diffusivity	m^2 s^{-1}
6	Ocean vertical momentum diffusivity	m^2 s^{-1}
7	Bathymetry	m
8–10	Reserved	
11	Shape factor with respect to salinity profile	–
12	Shape factor with respect to temperature profile in thermocline	–
13	Attenuation coefficient of water with respect to solar radiation	m^{-1}
14	Water depth	m
15	Water temperature	K
16–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Product discipline 10 – Oceanographic products, parameter category 191: miscellaneous

Number	Parameter	Units
0	Seconds prior to initial reference time (defined in Section 1)	s
1	Meridional overturning stream function	m^3 s^{-1}
2	Reserved	
3	Days since last observation	d
4–191	Reserved	
192–254	Reserved for local use	
255	Missing	

Code table 7.4 – *Type of Interval*

Code figure	Meaning
0	Smaller than first limit
1	Greater than second limit
2	Between first and second limit. The range includes the first limit but not the second limit
3	Greater than first limit
4	Smaller than second limit
5	Smaller or equal first limit
6	Greater or equal second limit
7	Between first and second. The range includes the first limit and the second limit
8	Greater or equal first limit
9	Smaller or equal second limit
10	Between first and second limit. The range includes the second limit but not the first limit
11	Equal to first limit
12–191	Reserved
192–254	Reserved for local use
255	Missing

CODE TABLES USED IN SECTION 8 (DATA REPRESENTATION SECTION)

Code table 8.0 – *Data representation template number*

Code figure	Meaning
0	Simple packing

1	IEEE floating point
2–49151	Reserved
49152–65534	Reserved for local use
65535	Missing

Code table 8.1 – *Type of original field values*

Code figure	Meaning
0	Floating point
1	Integer
2–191	Reserved
192–254	Reserved for local use
255	Missing

Code table 8.2 – *Missing value management*

Code figure	Meaning
0	No explicit missing values included within data values
1	Primary missing values included within data values
2	Primary and secondary missing values included within data values
3–191	Reserved
192–254	Reserved for local use
255	Missing

Code table 8.3 – *Precision of floating-point numbers*

Code figure	Meaning
0	Reserved
1	IEEE 32-bit (I=4 in section 7)
2	IEEE 64-bit (I=8 in section 7)
3	IEEE 128-bit (I=16 in section 7)
4–254	Reserved
255	Missing

CODE TABLES USED IN SECTION 9 (OVERLAY SECTION)

Code table 9.0 –*Overlay template number*

Code figure	Meaning
0	Bitmap
1–49151	Reserved
49152–65534	Reserved for local use
65535	Missing

Decision 7 (CBS-16)

REMOVAL OF FM 92-XI EXT. GRIB FROM THE *MANUAL ON CODES* (WMO-No. 306)

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) That the Commission for Basic Systems (CBS) at its twelfth session noted, when FM 92-XII General Regularly Distributed Information in Binary Form (GRIB) (GRIB edition 2)

was adopted, that FM 92-XI Ext. GRIB (GRIB edition 1) was still a valid code and would remain in use, for example, for aviation purposes,

(2) That CBS, at its extraordinary session in November 2006, agreed to the request from the International Civil Aviation Organization (ICAO) to extend the use of GRIB edition 1 for the users of aviation products up to November 2010, because necessary equipment and software for GRIB edition 2 would not be available in all countries by November 2008,

Recognizing that ICAO no longer has requirements to the GRIB edition 1,

Recognizing further that FM 92-XI (GRIB edition 1) may continue to be used for bilateral exchange between Members for some time,

Decides to remove GRIB edition 1 from the *Manual on Codes* (WMO-No. 306), Volume I.2;

Requests the Secretary-General to ensure that the specification of FM 92-XI Ext. GRIB (GRIB edition 1) remains permanently available so that archived data can still be referenced.

Decision 8 (CBS-16)

PROVISIONAL OPERATIONAL IMPLEMENTATION OF DATA REPRESENTATION FOR WMO INTEGRATED GLOBAL OBSERVING SYSTEM METADATA

THE COMMISSION FOR BASIC SYSTEMS,

Recalling Resolution 26 (Cg-17) – *Technical Regulations* (WMO-No. 49) – Manual on the WMO Integrated Global Observing System (WIGOS) that defined the requirements for WIGOS metadata and their exchange between Members,

Recognizing the advantages of using a standard format to exchange WIGOS metadata between Members and to maintain the surface-based observing systems component of the Observing Systems Capability Analysis and Review tool (OSCAR/Surface) using machine-to-machine interfaces,

Acknowledging:

(1) That the WIGOS metadata standard is still under development and that the representation of that standard will need to evolve,

(2) That the data representation for WIGOS metadata has been tested on a limited set of WIGOS metadata records that are unlikely to be completely representative of the variety of WIGOS metadata being created by Members,

(3) The need for technical commissions to carry out a thorough study of the requirement and validate its relevance (*Guidelines on the Preparation and Promulgation of the WMO Technical Regulations* (WMO-No. 1127)) and that in context the word "requirement" corresponds to the "proposed technical standard",

Decides:

(1) To endorse experimental use of the WIGOS metadata data representation in XML as provided in the annex to the present decision for exchange of WIGOS metadata between Members and between Members and OSCAR/Surface;

(2) To reserve the code identifier FM 241 WMDR-XML for the WIGOS metadata data representation in XML and to use the reference FM 241-16 to identify the version described in the annex to the present decision so that it can be distinguished from later versions;

(3) To review the effectiveness of the WIGOS metadata data representation in XML following a period of use by Members:

(a) To assess feedback from users on its effectiveness;

(b) To modify it to respond to concerns;

(c) To recommend the modified version to the Executive Council for inclusion in the *Manual on Codes* (WMO-No. 306), Volume I.3;

Urges Members to use the WIGOS metadata data representation in XML and provide feedback to the Open Programme Area Group on Information Systems and Services (OPAG-ISS) through their focal point for codes and data representation;

Requests OPAG-ISS to gather feedback on the effectiveness of the WIGOS metadata data representation in XML and to provide a revised version for recommendation to the Executive Council in 2019;

Requests its president to assess whether modifications proposed by OPAG-ISS following the review of use require a vote by correspondence before the WIGOS metadata data representation in XML can be recommended to the Executive Council;

Authorizes its president, subject to the outcome of any vote by correspondence, to recommend the modified version to the Executive Council;

Requests the Secretary-General:

(1) To publish the WIGOS metadata data representation in XML as provided in the annex to the present decision on the WMO website as a reference document;

(2) To make provision for that version to be available permanently so that archived information recorded in that version may be interpreted correctly.

Annex to Decision 8 (CBS-16)

REPRESENTATION IN XML OF WMO INTEGRATED GLOBAL OBSERVING SYSTEM METADATA

Make the following changes to the Manual on Codes (WMO-No. 306) Volume I.3.

Add the following entry to the section "FM system of numbering XML markup language application schemas"

FM 241-16 WMDR-XML Data representation for WIGOS metadata. Resolution XX (EC-XX).

Add the following section in sequence of FM number

FM 241: DATA REPRESENTATION FOR WIGOS METADATA

FM 241-16 WMDR-XML WIGOS METADATA REPRESENTATION

241.1 Scope

241.1.1 The WIGOS Metadata Representation (WMDR-XML) shall be used to represent WIGOS metadata for the purpose of machine to machine transfer of WIGOS metadata.

241.1.2 The WMDR-XML is an XML Schema implementation of the WIGOS Standard which describes observations metadata. The scope and content of the WIGOS Application Schema is therefore limited to that which is defined in, Appendix 2.4 - WIGOS Metadata Standard of the Manual on WIGOS (WMO-No. 1160).

241.1.3 The WIGOS Application Schema reuses ISO/TC 211 geographic information standards where appropriate, notably ISO 19156 Observations & Measurements.

241.1.4 Additional data types are reused from ISO 19115 (e.g. CI_ResponsibleParty). An ISO 19136 GML encoding is used.

241.1.5 The encoding has been defined in accordance with the ISO 19109 Rules for Application Schemas.

241.1.6 The core information types (*Feature Types* in ISO terminology) defined in the WIGOS Application Schema are: WIGOSMetadataRecord, ObservingFacility, Equipment, ObservationCollection, Observation, Process and Deployment. Some of these types carry secondary information, for example the Process type is further broken down into Sampling, Processing, Reporting and Deployment types.

241.1.7 Additional information types are defined for logging activities relevant to the observing equipment or facility: FacilityLog, EquipmentLog, ControlCheckReport, MaintenanceReport and EventReport.

241.1.8 Code lists for the WMDR-XML are registered at http://codes.wmo.int and reflect the code tables in the WIGOS Metadata Standard.

241.1.9 The Requirements Classes defined in WMDR-XML are listed in Table 241-1.

Table 241-1. Requirements Classes defined in WMDR-XML

Requirements Classes	
Requirements Class	http://def.wmo/int/wmdr/2016/req/xml-rules
Requirements Class	http://def.wmo/int/wmdr/2016/req/time-encoding
Requirements Class	http://def.wmo/int/wmdr/2016/req/metadata-record
Requirements Class	http://def.wmo/int/wmdr/2016/req/observing-facility
Requirements Class	http://def.wmo/int/wmdr/2016/req/facility-log
Requirements	http://def.wmo/int/wmdr/2016/req/equipment

Class	
Requirements Class	http://def.wmo/int/wmdr/2016/req/equipment-log
Requirements Class	http://def.wmo/int/wmdr/2016/req/observation-collection
Requirements Class	http://def.wmo/int/wmdr/2016/req/observation-segment
Requirements Class	http://def.wmo/int/wmdr/2016/req/deployment
Requirements Class	http://def.wmo/int/wmdr/2016/req/process
Requirements Class	http://def.wmo/int/wmdr/2016/req/sampling
Requirements Class	http://def.wmo/int/wmdr/2016/req/processing
Requirements Class	http://def.wmo/int/wmdr/2016/req/reporting

h241.2 XML Schema for WMDR-XML

241.2.1 Representations of information in WMDR-XML shall declare the XML namespaces listed in Table 241-2 and Table 241-3.

Note: additional namespace declarations may be required depending on the XML elements used within WMDR-XML.

Table 241-2. XML namespaces defined for WMDR-XML

XML Namespace	Default namespace prefix	Canonical location of all-components schema document
http://def.wmo.int/wmdr/2016	**wmdr**	http://schemas.wmo.int/wmdr/1.0rc1

Table 241-3. Other XML namespaces used in WMDR-XML

Standard	XML Namespace	Default namespace prefix	Canonical location of all-components schema document
XML Schema	http://www.w3.org/2001/XMLSchema	xs	
Schematron	http://purl.oclc.org/dsdl/schematron	sch	
XML Linking Language	http://www.w3.org/1999/xlink	xlink	https://www.w3.org/1999/xlink.xsd

Standard	XML Namespace	Default namespace prefix	Canonical location of all-components schema document
ISO 19136:2006 GML	http://www.opengis.net/gml/3.2	gml	http://schemas.opengis.net/gml/3.2.1/gml.xsd
OGC OMXML	http://www.opengis.net/om/2.0	om	http://schemas.opengis.net/om/2.0/observation.xsd

241.3 Virtual typing

Virtual typing is used for OM_Observation. See FM 202 METCE (202.3 Virtual Typing).

241.4 Requirements Class: XML Rules

241.4.1 Requirements class XML Rules contains a set of general rules applicable to the XML encoding. See Table 241-4.

Table 241-4. Requirements class: XML Rules

Requirements Class	
http://def.wmo.int/wmdr/2016/req/xml-rules	
Target Type	Data Instance
Name	XML Rules
Requirement	*XML Well Formed*
	http://def.wmo.int/wmdr/2016/req/xml-rules/well-formed XML encodings of WMDR shall be well formed XML documents (syntactically correct). A well-formed XML document conforms to the XML specification. (https://www.w3.org/TR/REC-xml/)
Requirement	*XML Schema Valid*
	http://def.wmo.int/wmdr/2016/req/xml-rules/xsd-valid XML encodings of WMDR shall validate against the WMDR XML Schema (xsd).

241.5 Requirements Class: Time Encoding

241.5.1 Requirements class Time Encoding contains a set of general rules concerning the encoding of time values in WMDS. See Table 241-5.

Table 241-5. Requirements class: Time Encoding

Requirements Class	
http://def.wmo.int/wmdr/2016/req/time-encoding	
Target Type	Data Instance
Name	Time Encoding

Requirement	*Time Zone Explicit*
	http://def.wmo.int/wmdr/2016/req/time-encoding/time-zone-explicit All times shall be encoded using ISO 8601 time format. A time-zone designator must be supplied for all times. If the time is given as UTC then the time zone designator is 'Z' e.g. *2016-12-25T12:00Z* For times given in a local (non UTC) time the time zone designator shall be expressed as an offset from UTC using plus or minus offsets. For example, the following date times are all the same moment in time: *2016-12-25T10:00**Z** (10am, timezone is UTC)* *2016-12-25T14:00**+04:00** (2pm, timezone is UTC + 4 hours)* *2016-12-25T06:00**-04:00** (6am, timezone is UTC -4 hours)*

241.6 Requirements Class: Metadata Record

241.6.1 This requirements class contains a set of general rules applicable to the XML encoding of the WIGOSMetadataRecord (see Table 241-6). WIGOSMetadataRecord is a container for WIGOS information for the purposes of packaging the information for delivery to, or transfer between, systems.

Table 241-6. Requirements class: Metadata Record

Requirements Class	
http://def.wmo.int/wmdr/2016/req/metadata-record	
Target Type	Data Instance
Name	Metadata Record
Requirement	*Metadata Record Valid*
	http://def.wmo.int/wmdr/2016/req/metadata-record/record-valid XML encodings of WIGOSMetadataRecord shall conform to the XML form for WIGOSMetadataRecord specified in the WMDR XML Schema.

241.7 Requirements Class: Observing Facility

241.7.1 Requirements class Observing Facility contains a set of rules applicable to the XML encoding of ObservingFacility. See Table 241-7.

241.7.2 An ObservingFacility could be a fixed station, moving equipment or a remote sensing platform. The entity ObservingFacility describes the facility and its surrounds. It does not describe the equipment at the facility (systems, sensors etc.); these are described using the Equipment class.

Table 241-7. Requirements class: Observing Facility

Requirements Class	
http://def.wmo.int/wmdr/2016/req/observing-facility	
Target Type	Data Instance
Name	Observing Facility
Requirement	*Observing Facility Valid*
	http://def.wmo.int/wmdr/2016/req/observing-facility/facility-valid XML encodings of ObservingFacility shall conform to the XML form for ObservingFacility specified in the WMDR XML Schema.
Requirement	*Altitude Or Depth*
	http://def.wmo.int/wmdr/2016/req/observing-facility/altitude-or-depth The value for altitudeOrDepth, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsAltitudeOrDepth.
Requirement	*Communication Method*
	http://def.wmo.int/wmdr/2016/req/observing-facility/communication-method The value for communicationMethod, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsDataCommunicationMethod.
Requirement	*Geopositioning Method*
	http://def.wmo.int/wmdr/2016/req/observing-facility/geopositioning-method The value for geopositioningMethod, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsGeopositioningMethod.
Requirement	*Facility Type*
	http://def.wmo.int/wmdr/2016/req/observing-facility/facility-type The value for facilityType, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsFacilityType.
Requirement	*Local Topography*
	http://def.wmo.int/wmdr/2016/req/observing-facility/local-topography The value for localTopography, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsLocalTopography.
Requirement	*Relative Elevation*
	http://def.wmo.int/wmdr/2016/req/observing-facility/relative-elevation The value for relativeElevation, if supplied, shall be taken from the code table

	published online at http://codes.wmo.int/common/wmdsRelativeElevation.
Requirement	*Reporting Status*
	http://def.wmo.int/wmdr/2016/req/observing-facility/reporting-status The value for reportingStatus shall be taken from the code table published online at http://codes.wmo.int/common/wmdsReportingStatus.
Requirement	*Surface Cover*
	http://def.wmo.int/wmdr/2016/req/observing-facility/surface-cover The value for surfaceCover, if supplied, shall be taken from one of the code tables published online at http://codes.wmo.int/common/wmdsSurfaceCoverIGBP http://codes.wmo.int/common/wmdsSurfaceCoverUMD http://codes.wmo.int/common/wmdsSurfaceCoverLAI http://codes.wmo.int/common/wmdsSurfaceCoverNPP http://codes.wmo.int/common/wmdsSurfaceCoverPFT http://codes.wmo.int/common/wmdsSurfaceCoverLCCS.
Requirement	*Surface Cover Classifcation*
	http://def.wmo.int/wmdr/2016/req/observing-facility/surface-cover-classification The value for surfaceCoverClassification shall be taken from one of the code table published online at http://codes.wmo.int/common/wmdsSurfaceCoverClassification
Requirement	*Territory Name*
	http://def.wmo.int/wmdr/2016/req/observing-facility/territory-name The value for territoryName shall be taken from the code table published online at http://codes.wmo.int/common/wmdsTerritoryName.
Requirement	*Topographic Context*
	http://def.wmo.int/wmdr/2016/req/observing-facility/topographic-context The value for topographicContext, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsTopographicContext.
Requirement	*WMORegion*
	http://def.wmo.int/wmdr/2016/req/observing-facility/wmo-region The value for wmoRegion shall be taken from the code table published online at http://codes.wmo.int/common/wmdsWMORegion.

241.8 Requirements Class: Facility Log

241.8.1 Requirements class Facility Log contains a set of rules applicable to the XML encoding of FacilityLog. See Table 241-8.

241.8.2 The purpose of FacilityLog is to capture notable events and extra information about the facility or its surroundings.

Note that events concerning equipment at the facility are to be recorded in the EquipmentLog.

Table 1. Requirements class: Facility Log

Requirements Class	
http://def.wmo.int/wmdr/2016/req/facility-log	
Target Type	Data Instance
Name	Facility Log
Requirement	*Facility Log Valid*
	http://def.wmo.int/wmdr/2016/req/facility-log/facility-log-valid XML encodings of FacilityLog shall conform to the XML form for FacilityLog specified in the WMDR XML Schema.
Requirement	*Facility Log Entries*
	http://def.wmo.int/wmdr/2016/req/facility-log/facility-log-entries Log entries in a FacilityLog shall describe events at the facility and shall conform to the XML form for EventReport in the WMDR XML Schema.

241.9 Requirements Class: Equipment

241.9.1 Requirements class Equipment contains a set of rules applicable to the XML encoding of Equipment. See Table 241-9.

241.9.2 Equipment should be used to describe the equipment (instruments) used to make observations.

241.9.3 Equipment may contain sub-equipment. Note that this is not supported in the 2016 version of OSCAR.

Table 241-9. Requirements class: Equipment

Requirements Class	
http://def.wmo.int/wmdr/2016/req/equipment	
Target Type	Data Instance
Name	Equipment
Requirement	*Equipment Valid*
	http://def.wmo.int/wmdr/2016/req/equipment/equipment-valid XML encodings of Equipment shall conform to the XML form for Equipment

	specified in the WMDR XML Schema.
Requirement	*Equipment Log Entries*
	http://def.wmo.int/wmdr/2016/req/equipment/equipment-log-entries Log entries in an EquipmentLog shall describe control checks or maintenance of the Equipment and shall conform to the XML forms for ControlCheckReport or MaintenanceReport in the WMDR XML Schema.
Requirement	*Geopositioning Method*
	http://def.wmo.int/wmdr/2016/req/equipment/geopositioning-method The value for geopositioningMethod, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsGeopoistioningMethod.

241.10 Requirements Class: Equipment Log

241.10.1 Requirements class Equipment Log contains a set of rules applicable to the XML encoding of EquipmentLog. See Table 241-10.

241.10.2 The purpose of EquipmentLog is to record calibration/control checks and maintenance undertaken on the equipment.

Table 241-10. Requirements class: Equipment Log

Requirements Class	
http://def.wmo.int/wmdr/2016/req/equipment-log	
Target Type	Data Instance
Name	Equipment Log
Requirement	*Equipment Log Valid*
	http://def.wmo.int/wmdr/2016/req/equipment-log/equipment-log-valid XML encodings of EquipmentLog shall conform to the XML form for EquipmentLog specified in the WMDR XML Schema.

241.11 Requirements Class: Observation Collection

241.11.1 Requirements class Observation Collection contains a set of rules applicable to the XML encoding of ObservationCollection. See Table 241-11.

241.11.2 An ObservationCollection contains a coherent set of observations (OM_Observations).

241.11.3 Each ObservationCollection should describe a different observed variable (e.g. humidity, air temperature) from a station/facility.

Table 241-11. Requirements class: Observation Collection

Requirements Class
http://def.wmo.int/wmdr/2016/req/observation-collection

Target Type	Data Instance
Name	Observation Collection
Requirement	*Observation Collection Valid*
	http://def.wmo.int/wmdr/2016/req/observation-collection/collection-valid XML encodings of ObservationCollection shall conform to the XML form for ObservationCollection specified in the WMDR XML Schema.
Requirement	*Application Area*
	http://def.wmo.int/wmdr/2016/req/observation-collection/application-area The value(s) for applicationArea shall be taken from the code table published online at http://codes.wmo.int/common/wmdsApplicationArea.
Requirement	*Program Affiliation*
	http://def.wmo.int/wmdr/2016/req/observation-collection/program-affiliation The value(s) for programAffiliation shall be taken from the code table published online at http://codes.wmo.int/common/wmdsProgramAffiliation.
Requirement	*Representativeness*
	http://def.wmo.int/wmdr/2016/req/observation-collection/representativeness The value for representativeness, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsRepresentativeness.

241.12 Requirements Class: Observation Segment

241.12.1 Requirements class Observation Segment contains a set of rules applicable to the XML encoding of OM_Observation that is referred to as an observation segment in WIGOS. See Table 241-12.

Table 241-12. Requirements class: Observation Segment

Requirements Class	
http://def.wmo.int/wmdr/2016/req/observation-segment	
Target Type	Data Instance
Name	Observation Segment
Requirement	*Observation Feature of Interest*
	http://def.wmo.int/wmdr/2016/req/observation-segment/observation-feature-of-interest XML encodings of OM_Observation (observation segments) in WIGOS shall use O&M Spatial Sampling Features to describe the om:featureOfInterest as a feature with geometry describing the geometric location or range of the observations.

Requirement	*Observation Process*
	http://def.wmo.int/wmdr/2016/req/observation-segment/observation-process XML encodings of OM_Observation (observation segments) in WIGOS shall have use the WIGOS Process type to describe the om:procedure.
Requirement	*Observation Segment Valid*
	http://def.wmo.int/wmdr/2016/req/observation-segment/segment-valid XML encodings of OM_Observation (observation segments) shall conform to the XML form for OM_Observation specified in the ISO 19156 O&M XML schema at http://schemas.opengis.net/om/2.0/observation.xsd.

241.13 Requirements Class: Deployment

241.13.1 Requirements class Deployment contains a set of rules applicable to the XML encoding of Deployment. See Table 241-13.

241.13.2 Deployment describes how the equipment is configured for observations. It is part of Process. One Process may contain multiple deployments for different time periods (e.g. a sensor may be changed warranting a new Deployment description).

Table 241-13. Requirements class: Deployment

Requirements Class	
http://def.wmo.int/wmdr/2016/req/deployment	
Target Type	Data Instance
Name	Deployment
Requirement	*Equipment Valid*
	http://def.wmo.int/wmdr/2016/req/deployment/deployment-valid XML encodings of Deployment shall conform to the XML form for Deployment specified in the WMDR XML Schema.
Requirement	*Exposure*
	http://def.wmo.int/wmdr/2016/req/deployment/exposure The value for exposure, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsExposure.
Requirement	*Instrument Operating Status*
	http://def.wmo.int/wmdr/2016/req/deployment/instrument-operating-status The value for instrumentOperatingStatus shall be taken from the code table published online at http://codes.wmo.int/common/wmdsInstrumentOperatingStatus.

241.14 Requirements Class: Process

241.14.1 Requirements class Process contains a set of rules applicable to the XML encoding of Process. See Table 241-14.

241.14.2 Process has sub-components: Sampling, Reporting, Processing, Deployment.

Table 241-14. Requirements class: Process

Requirements Class	
http://def.wmo.int/wmdr/2016/req/process	
Target Type	Data Instance
Name	Process
Requirement	*Equipment Valid*
	http://def.wmo.int/wmdr/2016/req/process/process-valid XML encodings of Process shall conform to the XML form for Process specified in the WMDR XML Schema.

241.15 Requirements Class: Sampling

241.15.1 Requirements class Sampling contains a set of rules applicable to the XML encoding of Sampling. See Table 241-15.

241.15.2 Sampling describes the sampling used for observations. It is part of the Process.

Table 241-15. Requirements class: Sampling

Requirements Class	
http://def.wmo.int/wmdr/2016/req/sampling	
Target Type	Data Instance
Name	Sampling
Requirement	*Equipment Valid*
	http://def.wmo.int/wmdr/2016/req/sampling/sampling-valid XML encodings of Sampling shall conform to the XML form for Sampling specified in the WMDR XML Schema.
Requirement	*Sampling Strategy*
	http://def.wmo.int/wmdr/2016/req/sampling/sampling-strategy The value for samplingStrategy, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsSamplingStrategy.
Requirement	*Source of Observation*
	http://def.wmo.int/wmdr/2016/req/sampling/source-of-observation The value(s) for sourceOfObservation shall be taken from the code table published online at http://codes.wmo.int/common/wmdsSourceOfObservation.

241.16 Requirements Class: Processing

241.16.1 Requirements class Processing contains a set of rules applicable to the XML encoding of Processing. See Table 241-16.

241.16.2 Processing describes the processing done on observations (post-sampling). It is part of the Process.

Table 241-16. Requirements class: Processing

Requirements Class	
http://def.wmo.int/wmdr/2016/req/processing	
Target Type	Data Instance
Name	Processing
Requirement	*Equipment Valid*
	http://def.wmo.int/wmdr/2016/req/processing/processing-valid XML encodings of Processing shall conform to the XML form for Processing specified in the WMDR XML Schema.
Requirement	*Observing Method*
	http://def.wmo.int/wmdr/2016/req/processing/observing-method The value(s) for observingMethod shall be taken from the code table published online at http://codes.wmo.int/common/wmdsObservingMethod.

241.17 Requirements Class: Reporting

241.17.1 Requirements class Reporting contains a set of rules applicable to the XML encoding of Reporting. See Table 241-17.

241.17.2 Reporting describes how the observations are reported. It is part of the Process.

Table 241-17. Requirements class: Reporting

Requirements Class	
http://def.wmo.int/wmdr/2016/req/reporting	
Target Type	Data Instance
Name	Reporting
Requirement	*Equipment Valid*
	http://def.wmo.int/wmdr/2016/req/reporting/reporting-valid XML encodings of Reporting shall conform to the XML form for Reporting specified in the WMDR XML Schema.
Requirement	*Aggregation Period*

	http://def.wmo.int/wmdr/2016/req/reporting/aggregation-period The value for aggregationPeriod, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsTimeStampMeaning.
Requirement	*Level of Data*
	http://def.wmo.int/wmdr/2016/req/reporting/level-of-data The value for levelOfData, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsLevelOfData.
Requirement	*Reference Time*
	http://def.wmo.int/wmdr/2016/req/reporting/reference-time The value for referenceTime, if supplied, shall be taken from the code table published online at http://codes.wmo.int/common/wmdsReferenceTime.

Add the following section to Appendix B

7. WMDR-XML (DATA REPRESENTATION FOR WIGOS METADATA)

7.1 http://schemas.wmo.int/wmdr/1.0rc1/iwxxm.xsd

Decision 9 (CBS-16)

TERMS OF REFERENCE OF NATIONAL FOCAL POINTS SUPPORTING THE WORK OF THE OPEN PROGRAMME AREA GROUP ON INFORMATION SYSTEMS AND SERVICES

THE COMMISSION FOR BASIC SYSTEMS,

Noting the important role of national focal points in the maintenance of operational procedures and the associated technical regulations, providing the operational channel of communication between Members, the WMO Secretariat and other focal points,

Noting further:

(1) *Technical Regulations* (WMO-No. 49), Volume I – General Meteorological Standards and Recommended Practices,

(2) The *Manual on the WMO Information System* (WMO-No. 1060),

(3) The *Guide to the WMO Information System* (WMO-No. 1061),

(4) The *Manual on the Global Telecommunication System* (WMO-No. 386),

(5) The *Manual on Codes* (WMO-No. 306),

Recalling Resolution 21 (Cg-17) – Procedures for maintaining Manuals and Guides managed by the Commission for Basic Systems,

Recognizing that identification of suitable focal points requires clearly defined terms of reference specifying the areas of responsibility of the focal point,

Decides to adopt the terms of reference for national focal points supporting the work of the Open Programme Area Group on Information Systems and Services (OPAG-ISS) as provided in the annex to the present decision;

Urges Members:

(1) To review their nominated focal points as listed in the Country Profile Data Base (CPDB) or at http://www.wmo.int/pages/prog/www/CBS/Lists_WorkGroups/CBS/cross-cutting relating to the WMO Information System in the light of the terms of reference provided in the annex to the present decision;

(2) To advise the Secretary-General of updates to national focal points via the CPDB portal or by competing and submitting the form available at http://wis.wmo.int/file=1227;

Requests the Secretary-General to maintain the list of focal points and associated e-mail groups to facilitate communication between the focal points and participation in OPAG-ISS expert teams' decision-making processes.

Annex to Decision 9 (CBS-16)

TERMS OF REFERENCE OF NATIONAL FOCAL POINTS SUPPORTING THE WORK OF THE OPEN PROGRAMME AREA GROUP ON INFORMATION SYSTEMS AND SERVICES

National Focal Point on WIS Matters

National or territory focal points on WIS matters are nominated by the Permanent Representatives of Members of WMO. Heads of authorized non-governmental organizations (NGO) contributing to WIS may also nominate a focal point on WIS matters. These focal points provide the operational channel of communication with the WMO Secretariat and with other national WIS focal points.

The terms of reference for the focal points are:

(a) Act as a focal point on all WIS activities within the Member State, territory or NGO;

(b) Monitor and report on the national status of WIS implementation;

(c) Participate in regional or sub-regional WIS coordination and implementation activities;

(d) Arrange for the authorization of national entities or people for access to WIS;

(e) Ensure issues relating to WIS, including the GTS, and World Weather Watch monitoring are directed to the relevant person and followed-up on;

(f) Monitor and participate in the overall maintenance of WIS including CBS OPAG ISS expert teams addressing WIS centre operations, data management and data representation as well as network issues;

(g) Oversee the creation and management of WIS Discovery Metadata for data and products from participating centres;

(h) Assist centre staff in matters relating to WIS, including compliance and functional issues;

(i) Identify and follow-up on training and capacity development needs;

(j) Represent the NMHS in WIS contributions and liaison with other initiatives such as WIGOS and GFCS.

(k) Receive notifications of amendments to the *Manual on WIS* (WMO-No. 1060), the *Guide to WIS* (WMO-No. 1061), the *Manual on the GTS* (WMO-No. 386) and associated Guides, and propagate the information within their State or Territory;

(l) Provide comments on amendments to the *Manual on WIS* (WMO-No. 1060), the *Guide to WIS* (WMO-No. 1061), the *Manual on the GTS* (WMO-No. 386) and associated Guides by the simple procedure, on behalf of the Permanent Representative;

(m) Request amendments to the *Manual on WIS* (WMO-No. 1060), the *Guide to WIS* (WMO-No. 1061), the *Manual on the GTS* (WMO-No. 386) and associated Guides on behalf of the Permanent Representative;

(n) Ensure that the following activities are carried out for WIS centres in the Member State or Territory:

(1) Maintenance of WIS compliance within the centre;

(2) Participation of centres in national and international WIS coordination and implementation activities.

GTS Focal Point

GTS focal points are nominated by the Permanent Representatives of Member countries of WMO that are connected to the GTS. These focal points provide the operational channel of communication with the WMO Secretariat, RTH and GTS focal points.

The terms of reference of the focal points are:

(a) Act as a focal point on all GTS matters within the centre and with its national users;

(b) Manage authorization of reception or transmission of information using the GTS;

(c) Manage subscriptions and access to GTS traffic ensuring compliance with data access and usage policy;

(d) Oversee the creation and management of GTS headers for data and products from the centre;

(e) Ensure data and products published to the GTS from their centre have appropriate WIS discovery metadata already uploaded to the principal GISC;

(f) Coordinate GTS traffic with the RTH(s) to which the centre is attached and the exchange of information through the GTS for national centres;

(g) Arrange for exchange of information between the GTS and national users, including WIS centres;

(h) Ensure issues relating to the GTS and World Weather Watch monitoring are directed to the relevant person and followed-up on;

(i) Monitor, report on and participate in the overall maintenance of the GTS including contributions to CBS expert teams addressing data management and data representation as well as network issues;

(j) Assist staff and users of the centre in matters relating to the GTS, including compliance and functional issues;

(k) Identify and follow-up on training and capacity development needs;

(l) Where a centre operates an RTH, the GTS focal point will also undertake the role of the RTH Focal Point to:

(1) Arrange for the attached GTS centres to initiate, modify and terminate data flows on the GTS, including negotiation of relevant GTS headers, provision of required notices and maintaining operational information held by WMO on the information within the area of responsibility of the RTH;

(2) Monitor and report on the status of RTH operations;

(3) Coordinate the flow of GTS traffic flowing through the RTH, including supporting GISC subscriptions;

(4) Work with the Centre focal points for WIS matters, to ensure that GTS traffic from the attached centres has appropriate WIS Discovery Metadata records.

National Focal Point for Codes and Data Representation Matters

National focal points for codes and data representation matters are nominated by the Permanent Representatives of Member countries of WMO. These focal points provide the operational channel of communication between the WMO Secretariat and Members on codes and data representation issues.

The terms of reference for the focal points are:

(a) To receive notifications of amendments to the *Manual on Codes* (WMO-No. 306), and propagate the information within their State or Territory;

(b) To comment on amendments to the *Manual on Codes* (WMO-No. 306) by the fast-track procedure, on behalf of the Permanent Representative;

(c) To request amendments to the *Manual on Codes* (WMO-No. 306) on behalf of the Permanent Representative;

(d) To support verification of data resulting from migration process;

(e) To communicate with the WMO Secretariat on behalf of the Permanent Representative on issues relating to codes and data representation matters.

Focal Point for WIS Discovery Metadata Matters

Focal points for WIS Discovery Metadata matters are nominated by the Permanent Representatives of Member countries of WMO. These focal points provide the operational channel of communication between the WMO Secretariat and Members on WIS Discovery Metadata issues.

The terms of reference for the focal point are:

(a) To receive notifications of amendments to the *Manual on the WMO Information System* (WMO-No. 1060) concerning WIS Discovery Metadata, and propagate the information within their State or Territory;

(b) To comment on amendments to WIS Discovery Metadata as defined in the *Manual on the WMO Information System* (WMO-No. 1060) by the fast-track procedure, on behalf of the Permanent Representative;

(c) To request amendments to the *Manual on the WMO Information System* (WMO-No. 1060) concerning WIS Discovery Metadata on behalf of the Permanent Representative,

(d) To communicate with the WMO Secretariat on behalf of the Permanent Representative on issues relating to WIS Discovery Metadata;

(e) Assist centres within their Member State or Territory to prepare and maintain WIS Discovery Metadata.

Decision 10 (CBS-16)

AMENDMENTS TO THE GUIDE ON THE IMPLEMENTATION OF THE INTEGRATED WORLD WEATHER WATCH MONITORING

THE COMMISSION FOR BASIC SYSTEMS,

Noting that the *Manual on the Global Telecommunications System* (WMO-No. 386), Attachment I-5, which defines the World Weather Watch (WWW) quantitative monitoring procedures, is supported by the Guide on the Implementation of the Integrated WWW Monitoring (http://www.wmo.int/pages/prog/www/ois/monitor/agm/preparation/procedures/iwm_ImplementationGuide.pdf),

Noting further:

(1) Resolution 26 (Cg-17) – *Technical Regulations* (WMO-No. 49) – Manual on the WMO Integrated Global Observing System (WIGOS), that introduced WIGOS station identifiers,

(2) Recommendations from the Inter-Commission Coordination Group on WIGOS that synoptic stations in the Regional Basic Observing Networks should report hourly,

(3) The formats for gathering statistics listed in the Guide on the Implementation of the Integrated WWW Monitoring do not support WIGOS station identifiers,

Considering that the WIGOS Data Quality Monitoring System will collect statistics on the availability of observations to numerical weather prediction systems and other applications,

Decides:

(1) That a period of parallel operation of the WWW Quantitative Monitoring and the WIGOS Data Quality Monitoring System is required to assess the evolution of the availability of reports from the Global Observing System;

(2) To continue to operate the Integrated WWW Monitoring that gathers statistics four times a year;

(3) To update the Guide on the Implementation of the Integrated WWW Monitoring as shown in the annex to the present decision in order to record statistics on observations from stations that do not have five-character station identifiers;

(4) That all centres participating in the Integrated WWW Monitoring shall provide information on surface synoptic reports for 00 UTC, 06 UTC, 12 UTC and 18 UTC, and on upper air reports for 00 UTC and 12 UTC;

(5) That centres participating in the Integrated WWW Monitoring and in a position to do so should provide information on hourly surface synoptic reports and on upper-air reports whatever their reporting time;

Urges all Members operating Regional Telecommunications Hubs to contribute Integrated WWW Monitoring statistics for the period 1–15 October each year;

Urges all Members operating Regional Telecommunications Hubs on the Main Telecommunications Network to contribute Integrated WWW Monitoring statistics for the periods 1–15 January, 1–15 April, 1–15 July and 1–15 October each year;

Requests the Secretary-General to update the text of the Guide on the Implementation of the Integrated WWW Monitoring as given in the annex to the present decision, to make editorial adjustments as required and to publish the amended version of the Guide.

Annex to Decision 10 (CBS-16)

TEXT OF THE GUIDE ON THE IMPLEMENTATION OF THE INTEGRATED WORLD WEATHER WATCH MONITORING (ENGLISH ONLY)

World Meteorological Organization
Organisation météorologique mondiale

Temps • Climat • Eau

GUIDE ON THE IMPLEMENTATION OF THE INTEGRATED WWW MONITORING

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1. Main features of the IWM

The Integrated WWW Monitoring leads to the integration of the Annual Global Monitoring (AGM) and the Special MTN Monitoring (SMM) into one monitoring scheme. The main features of the IWM are as follows:

1.1 As for the Annual Global Monitoring (AGM), the centres should at least monitor the part of the global dataset for which they are responsible to collect and forward on the GTS:

- National Meteorological Centres (NMCs) should at least monitor data from their own territory;
- Regional Telecommunication Hubs (RTHs) should at least monitor data from their associated NMCs, and possibly from their own Region;
- World Meteorological Centres (WMCs) and RTHs located on the Main Telecommunication Network (MTN) should monitor the complete global dataset.

1.2 ~~As for the AGM, the~~The monitored dataset should include the observations from the stations included from the Regional Basic Synoptic Networks (RBSNs) for ~~the main~~ synoptic hours ~~(00, 06, 12 and 18 UTC)~~ and from the stations included in the Regional Basic Climatological Networks (RBCNs)~~.~~; observations from stations in the RBON (Regional Basic Observing Networks) will be monitored when they are defined. The types of data to be monitored are further detailed in Table A of the Annex.

1.3 The monitored dataset should include the data represented in Traditional Alphanumeric Codes (TAC) and in Table-Driven Code Forms (BUFR, CREX).

1.4 The monitoring periods are: 1-15 January, April, July and October.

1.5 The flow of the monitoring reports is as follows (see Figure 2):

- NMCs prepare quarterly summary reports and send them to their associated RTHs;
- RTHs compile the summary reports received from the NMCs in their zones of responsibility together with their own monitoring summaries and send their quarterly RTH summary reports to the associated RTH on the MTN and the WMO Secretariat;
- RTHs on the MTN participating in the Special MTN Monitoring (SMM) continue sending their raw data to the Secretariat and the other RTHs on the MTN send quarterly RTH/MTN summary reports to the Secretariat

The monitoring reports should be exchanged preferably before the end of the month of monitoring, and not later than the 15th of the following month.

1.6 The analysis of the monitoring reports is expected to be prepared by the RTHs at the Regional level and by the Secretariat at the global level.

2. Changes in the procedures of the monitoring exercises

2.1 There are no changes in the implementation of the SMM. It is expected that the SMM will continue being extended in order to monitor the data exchanged in table-driven code forms.

2.2 The NMCs prepare NMC quarterly summary reports instead of annual AGM reports. The information contained in the AGM reports for the 15 days monitoring period can be used

to prepare these new reports. The NMCs send their quarterly summary reports to the associated RTHs, and not to the WMO Secretariat.

2.3 The RTHS receive the monitoring reports from their associated NMC, compile them into quarterly RTH summary reports, and send them to the associated RTH on the MTN and the WMO Secretariat, instead of sending annual AGM reports.

2.4 The RTHs on the MTN, that do not participate in the Special MTN Monitoring (SMM), send quarterly RTH/MTN summary reports to the Secretariat instead of sending the AGM reports.

2.5 The flow of the monitoring reports before and after the implementation of the IWM are shown in Figures 1 and 2 respectively.

3. Transition from AGM to the IWM

3.1 The AGM reports are replaced by the NMC quarterly summary reports, the quarterly RTH summary reports and the quarterly RTH/MTN reports. The information contained in the AGM reports for the 15 days monitoring period can be used to prepare these new reports. The RTHs can therefore prepare the RTH summary reports from the AGM reports or the NMC quarterly summary reports, and each associated NMC can define with its associated RTH a plan for moving from the transmission to the RTH of the AGM reports to the transmission of the NMC summary reports. This facilitates the phased integration of the AGM into the IWM through a step by step approach at the level of each NMC.

3.2 Once an NMC and its associated RTH prepare the NMC and the RTH quarterly summary reports covering the territory of the NMC for a set of data and that the RTH sends the relevant quarterly summary report to the Secretariat, the NMC and its associated RTH can stop sending the AGM reports covering the territory of the NMC to the Secretariat for that set of data.

3.3 Once an RTH on the MTN sends its RTH/MTN quarterly summary report covering the global dataset to the Secretariat for a set of data, the RTH can stop sending its AGM reports to the Secretariat for that set off data.

3.4 The use of a monitoring application on a PC facilitates the implementation of the IWM at the NMCs, RTHs and RTHS on the MTN. Germany has offered the METDATA Monitoring software for use, free of charge, to WMO and all its Members; the software can be used on a PC to implement the AGM and the IWM.

4. Plans for the implementation of the IWM

4.1 Preparation and exchange of NMC and RTH quarterly summary reports

Each RTH on the MTN should coordinate the development of a plan for the preparation and the exchange of NMC and RTH quarterly summary reports issued from its zone of responsibility:

- The RTH informs its associated NMCs and the WMO Secretariat of its plan for the preparation of its RTH quarterly summary reports for each type of data defined by the abbreviated headings of the bulletins containing the data (see Table A of the Annex).
- The associated NMCs inform the RTH and the WMO Secretariat of their plan for

the preparation of their NMC quarterly summary reports for each type of data defined by the abbreviated headings of the bulletins containing the data (see Table A of the Annex).

- The RTH maintains a table of the planned and effective dates of the implementation of the NMC and RTH quarterly summary reports for each type of data, and posts the updated table on the WMO FTP server (subdirectory …/GTS_monitoring/IWM/RTH_plans/…).

4.2 Preparation and exchange of RTH/MTN quarterly summary reports

Each RTH on the MTN should develop a plan for the preparation and the exchange of its RTH/MTN quarterly summary reports for each type of data and and posts the updated table on the WMO FTP server (subdirectory …/GTS_monitoring/IWM/RTH_plans/…).

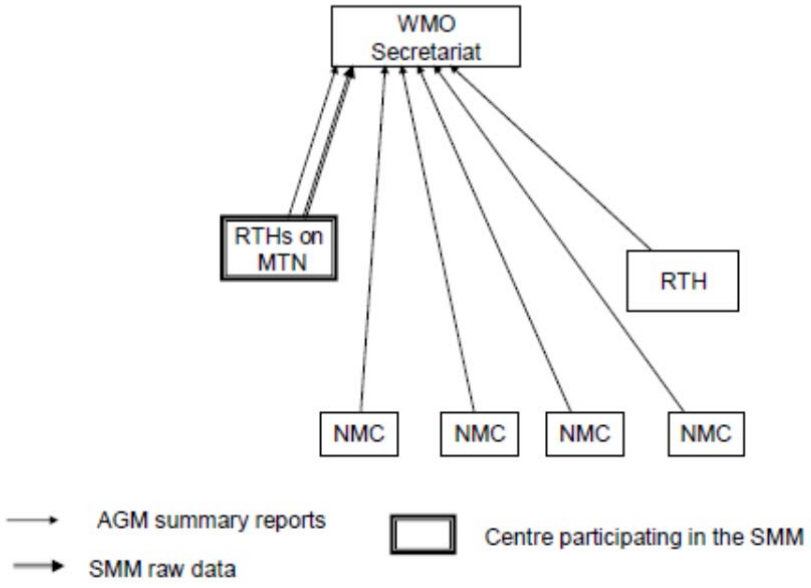

Figure 1 – Flow of monitoring reports before implementation of the IWM

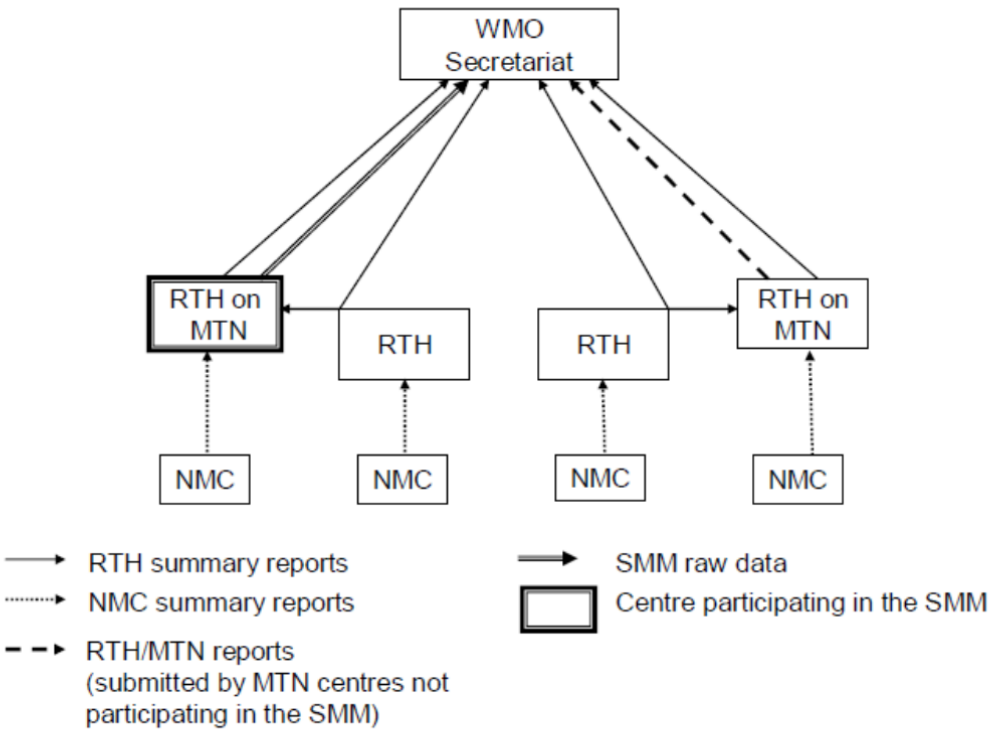

Figure 2 – Flow of monitoring reports after the implementation of the IWM

Annex: Procedures for the preparation and exchange of the IWM quarterly summary reports

1. Introduction

If a monitoring centre experiences difficulties in introducing the format or part of it, this centre is invited to clearly indicate the part of the format, that it could not use, in the field "remarks" of the questionnaire on the implementation of monitoring procedures (see hereunder paragraph 7).

2. Format of directories and sub-directories

CCCC.YYM

||___DMsdsdsMedede.TTT

(a) CCCC.YYM → directory name and extension.

CCCC = Location Indicator of the monitoring centre (e.g. EGRR = RTH Exeter ,

YY = Starting year of the monitoring (e.g. 07 = 2007),

M = Starting month of the monitoring (1 = January, .., 9 = September, A = October, B = November and C = December).

(b) $DM_sd_sd_sM_ed_ed_e.TTT$ → subdirectory name and extension.

D = Type of monitoring (G = global, R = regional, N = national, S = special, B = bilateral etc.);

M_s = Starting month of monitoring (1 = January, …, 9 = September, A = October, B = November and C = December).

d_sd_s = Starting date of monitoring (the date of the month/ M_s);

M_e = Ending month of monitoring (1 = January, …, 9 = September, A = October, B = November and C = December).

d_ed_e = Ending date of monitoring (the date of the month/ M_e);

TTT = Type of files in this subdirectory: DBF for dBase, ASC for ASCII.

Example: EGRR.07A (monitoring carried out by RTH Exeter in October 2007)

||___ GA01A15.TXT - Type of monitoring: global

- Period: from 1 to 15 October

- Type of files under this subdirectory: TXT

3. File names

The file names should be: WYYYY MMd_sd_s d_ed_eCCCCDDP.TTT, with

W	Type of quarterly summary report (N for NMC summary report, R for RTH summary report, G for RTH/MTN summary report)
YYYY	Starting year of the monitoring (e.g. 2007)
MM	Ending month of monitoring (01 for January, …, 12 for December)
d_sd_s	Starting day of monitoring
d_ed_e CCCC	Ending day of monitoring Location indicator (CCCC) of the monitoring centre.
DDP	See Table A
TTT	Type of files, e.g. ASC or TXT for ASCII, DBF for dBase

Table A - DDP

Type of data	DD	Value of **P** according to the form of representation of the monitored data			
		P = A for Traditional Alphanumerical Codes (TAC)		P = B for BUFR	P = C for CREX
Surface observations from fixed	SY	TAC SYNOP	T1 T2* SM, SI,	T1 T2 A1* ISM, ISI,	T1 T2 A1* KSM, KSI,
Radiosonde observations from fixed stations	TT	TEMP	US	IUK, IUS	KUK, KUS
Radiowind observations from fixed stations	PP	PILOT	UP	IUJ, IUW	KUJ, KUW
Climatic observations from fixed surface stations	CL	CLIMAT	CS	ISC	KSC
Surface observations from marine stations	SH	SHIP	SM, SI	ISS	KSS

Radiosonde observations from marine stations	TS	TEMP SHIP	US	IUK, IUS	KUK, KUS
Radiowind observations from marine stations	PS	PILOT SHIP	UP	IUJ, IUW	KUJ, KUW
Buoy observations	BU	BUOY	SS	IOB	KOB
Sea surface and below soundings	BT	BATHY/TESAC/TRACKOB	SO	IOP, IOR, IOS	KOP, KOR, KOS
Aircraft reports	AI	AIREP	UA		
	AM	AMDAR	UD		
	BA			IUA, IUO	KUA, KUO
Observations from wind profilers	BP			IUP	KUP

* The columns T_1 T_2 or T_1 T_2 A_1 of this Table contains the first letters of the abbreviated headings of the bulletins containing the dataset to be monitored

Example: N2007100115KWBCSYA.ASC (SYNOP monitored by WMC/RTH Washington from 1 to 15 October 2007, type ASCII).

4. Format of presentation

Each report shall consist of a number of data lines ~~organised~~ organized into files defined by data type and formatted as given below. All fields would be surrounded by double-quotation marks (") and separated by commas.

5. NMC Quarterly Monitoring

5.1 Format for DD = SY (e.g. TAC SYNOP reports)

Field	Width	Description
1	3	Value of DDP (See Table A) (e.g. SYA)
2	4	International location indicator of the monitoring centre
3	5	WMO station index number
4	2	Synoptic hour of observation (i.e. 00, 01, etc.)
5	2	Number of reports available within 1 hour after the hour of observation
6	2	Total number of reports available after 1 hour after the hour of observation
7	30	WIGOS station identifier

Example: contents of file "N2007100115EBBRSYA.TXT" (October 2007- SYNOP for EBBR)
"SYA","EBBR","06400","00","12","15","0-20000-0-06400"

"SYA","EBBR","06400","12","15","15","0-20000-0-06400"

"SYA","EBBR","06401","00","14","15","0-20000-0-06400"

"SYA","EBBR","06401","06","12","15","0-20000-0-06401"

"SYA","EBBR","06401","12","15","15","0-20000-0-06401"

"SYA","EBBR","06401","18","10","13","0-20000-0-06401"

5.2 Format for DD = TT or PP (e.g. radiosonde observations in BUFR)

Field	Width	Description
1	3	Value of DDP (See Table A) (e.g. TTB)
2	4	International location indicator of the monitoring centre
3	5	WMO station index number
4	2	Synoptic hour of observation (i.e. 00, 06, 12 or 18 UTC)

5	2	Number of reports available within 2 hours after the hour of observation
6	2	Total number of reports available after 2 hours after the hour of observation
7	30	WIGOS station identifier

Example: contents of file "N2007100115EBBRTTB.TXT" (October 2007 – radiosonde observations in BUFR for EBBR)

"TTB","EBBR","06400","00","15","15","0-20000-0-06400"

"TTB","EBBR","06400","12","15","15","0-20000-0-06400"

"TTB","EBBR","06401","00","14","15","0-20000-0-06400"

"TTB","EBBR","06401","06","15","15","0-20000-0-06401"

"TTB","EBBR","06401","12","15","15","0-20000-0-06401"

"TTB","EBBR","06401","18","14","14","0-20000-0-06401"

5.3 Format for DD = CL (e.g. TAC CLIMAT reports)

Field	Width	Description
1	3	Value of DDP (See Table A) (e.g. CLA)
2	4	International location indicator of the monitoring centre
3	5	WMO station index number
4	1	=1 if the report of the previous month is available, =0 otherwise
5	30	WIGOS station identifier

Example: contents of file "N2007100115EBBRCLA.TXT" (October 2007 – September CLIMAT reports for EBBR)

"CLA","EBBR","06400","1","0-20000-0-06400"

"CLA","EBBR","06401","1","0-20000-0-06401"

5.4 Format for DD = SH, TS or PS (e.g. TAC TEMP SHIP reports)

Field	Width	Description
1	3	Value of DDP (See Table A) (e.g.TSA)
2	4	International location indicator of the monitoring centre
3	11	Abbreviated heading TTAAii CCCC of the bulletin
4	2	Synoptic hour of observation (i.e. 00, 01, etc.)
5	5	Number of available bulletins
6	7	Number of available reports

Example: contents of file "N2007100115LEMMTSA.TXT" (October 2007 – TEMP SHIP reports for LEMM)

"TSA","LEMM","USVA01 LEMM","00","22","134"

"TSA","LEMM","USVA01 LEMM","06","24","163"

"TSA","LEMM","USVA01 LEMM","12","25","115"

"TSA","LEMM","USVA01 LEMM","18","88","211"

"TSA","LEMM","USVA13 LEMM","00","33","135"

"TSA","LEMM","USVA13 LEMM","06","45","173"

"TSA","LEMM","USVA13 LEMM","12","34","414"

"TSA","LEMM","USVA13 LEMM","18","10","192"

5.5 Format for DD = BU, BT, AI, AM, BA or BP (e.g. TAC BATHY/TESAC/TRACKOB reports)

Monitoring reports should list the number of bulletins and reports compiled from 2100 to 0259 UTC, 0300 to 0859 UTC, 0900 to 1459 UTC and 1500 to 2059 UTC with one data line per time period. Each data line will contain the ending time of the compiled period rounded up to the nearest hour. For example, data compiled from 2100 to 0259 would be indicated as hour 03.

Field	Width	Description
1	3	Value of DDP (See Table A) (e.g.BTA)
2	4	International location indicator of the monitoring centre
3	11	Abbreviated heading TTAAii CCCC of the bulletin
4	2	Ending time of the compiled period rounded up to the nearest hour
5	5	Number of available bulletins
6	7	Number of available reports

Example: contents of file "N2007100115LFPWBTA.TXT" (October 2007 – BATHY/TESAC/TRACKOB reports for LFPW)

"BTA","LFPW","SSVX01 LFPW","03","24","163"

"BTA","LFPW","SSVX01 LFPW","09","25","115"

"BTA","LFPW","SSVX01 LFPW","15","88","211"

"BTA","LFPW","SSVX01 LFPW","21","22","134"

"BTA","LFPW","SSVX13 LFPW","03","45","173"

"BTA","LFPW","SSVX13 LFPW","09","34","414"

"BTA","LFPW","SSVX13 LFPW","15","10","192"

"BTA","LFPW","SSVX13 LFPW","21","33","135"

6. RTH quarterly monitoring

Four times per year every RTH, including RTHs on the MTN, should provide monitoring reports on the availability of observations within its area of responsibility. The reports should list the number of observations reported as available by the associated NMCs in their quarterly reports compared with the number of observations received at the RTH during the monitoring period. The reports should be sent to the Secretariat and to the RTH's associated RTH on the MTN as quickly as possible, preferably within 10 days.

6.1 Format for DD = SY (e.g. TAC SYNOP reports)

Field	Width	Description
1	3	Value of DDP (See Table A) (e.g. SYA)
2	4	International location indicator of the NMC
3	4	International location indicator of the RTH
4	5	WMO station index number
5	2	Synoptic hour of observation (i.e. 00, 01, etc.)

6	2	Number of reports available at the NMC within 1 hour after the hour of observation
7	2	Total number of reports available at the NMC after 1 hour after the hour of observation
8	2	Number of reports available at the RTH within 1 hour after the hour of observation
9	2	Total number of reports available at the RTH after 1 hour after the hour of observation
10	30	WIGOS station identifier

Example: contents of file "R2007100115LEMMLFPWSYA.TXT"

SYA","LEMM","LFPW","08001","00","12","15","12","15","0-20000-0-08001"

"SYA","LEMM","LFPW","08001","06","15","15","15","15","0-20000-0-08001"

"SYA","LEMM","LFPW","08001","12","14","15","14","15","0-20000-0-08001"

"SYA","LEMM","LFPW","08001","18","8","14","8","13","0-20000-0-08001"

6.2 Format for DD = TT or PP (e.g. radiosonde observations in BUFR)

Field	Width	Description
1	3	Value of DDP (See Table A) (e.g. TTB)
2	4	International location indicator of the NMC
3	4	International location indicator of the RTH
4	5	WMO station index number
5	2	Synoptic hour of observation (i.e. 00, 06, 12 or 18 UTC)
6	2	Number of reports available within 2 hours after the hour of observation
7	2	Number of reports available at the NMC within 2 hours after the hour of observation
8	2	Total number of reports available at the NMC after 2 hours after the hour of observation
9	2	Number of reports available at the RTH within 2 hours after the hour of observation
10	30	WIGOS station identifier

Example: contents of file "R2007100115LEMMLFPWTTB.TXT"
"TTB","LEMM","LFPW","08001","00","15","15","15","15","0-20000-0-08001"

"TTB","LEMM","LFPW","08001","12","15","15","15","15","0-20000-0-08001"

"TTB","LEMM","LFPW","08023","00","14","15","14","15","0-20000-0-08023"

"TTB","LEMM","LFPW","08023","12","12","15","12","15","0-20000-0-08023"

6.3 Format for DD=CL (e.g. TAC CLIMAT reports)

Field	Width	Description
1	3	Value of DDP (See Table A) (e.g. CLA)
2	4	International location indicator of the NMC
3	4	International location indicator of the RTH
4	5	WMO station index number
5	1	=1 if the report of the previous month is available at the NMC, =0 otherwise

6	1	=1 if the report of the previous month is available at the RTH, =0 otherwise
7	30	WIGOS station identifier

Example: contents of file " R2007100115LPMGLFPWCLA.TXT"

"CLA","LPMG","LFPW","08501","1","1","0-20000-0-08501"

"CLA","LPMG","LFPW","08506","1","1","0-20000-0-08506"

"CLA","LPMG","LFPW","08509","1","1","0-20000-0-08509"

6.4 Format for DD = SH, TS or PS (e.g. TAC TEMP SHIP reports)

Field	Width	Description
1	3	Value of DDP (See Table A) (e.g.TSA)
2	4	International location indicator of the NMC
3	4	International location indicator of the RTH
4	11	Abbreviated heading TTAAii CCCC of the bulletin
5	2	Synoptic hour of observation (i.e. 00, 01, etc.)
6	5	Number of bulletins available at the NMC
7	7	Number of reports available at the NMC
8	5	Number of bulletins available at the RTH
9	7	Number of reports available at the RTH

Example contents of file "R2007100115LPMGLFPWTSA.TXT" "TSA","LPMG","LFPW","SMVX01 LPMG","00","24","163","24","163"

"TSA","LPMG","LFPW",SMVX01 LPMG","00","24","163","24","163"

6.5 Format for DD = BU, BT, AI, AM or BA or BP (e.g. AIREP reports)

Monitoring reports should list the number of bulletins and reports compiled from 2100 to 0259 UTC, 0300 to 0859 UTC, 0900 to 1459 UTC and 1500 to 2059 UTC with one data line per time period. Each data line will contain the ending time of the compiled period rounded up to the nearest hour. For example, data compiled from 2100 to 0259 would be indicated as hour 03.

Field	Width	Description
1	3	Value of DDP (See Table A) (e.g.AIA)
2	4	International location indicator of the NMC
3	4	International location indicator of the RTH
4	11	Abbreviated heading TTAAii CCCC of the bulletin
5	2	Ending time of the compiled period rounded up to the nearest hour
6	5	Number of bulletins available at the NMC
7	7	Number of reports available at the NMC
8	5	Number of bulletins available at the RTH
9	7	Number of reports available at the RTH

Example: contents of file "R 2003100115LPMGLFPWAIA.TXT" "AIA","LPMG","LFPW","UAEW01 LPMG","03","24","163","24","163"

"AIA","LPMG","LFPW","UAEW01 LPMG","09","21","152","21","152"

"AIA","LPMG","LFPW","UAEW01 LPMG","15","19","143","19","143"

"AIA","LPMG","LFPW","UAEW01 LPMG","21","20","149","20","149"

7. RTH / MTN quarterly monitoring

In addition to the RTH quarterly monitoring reports produced by every RTH, it is recommended that RTHs on the MTN that do not participate in the SMM also produce a report on all of the data received at their centre and pass these reports to the WMO Secretariat for comparison with other MTN centres. The report should monitor all data of all of the types listed in Table A, that are received at the RTH. The formats and file names of the reports should conform to those defined for the NMC quarterly reports; the first letter of the file names should be "G".

8. Questionnaire on the implementation of the monitoring procedures

As for the AGM, the centres are invited to provide information on the implementation of the monitoring procedures in a file named CCCCQUZ.TXT with the following structure:

Field	Width	Description
1	4	Location indicator (CCCC) of the monitoring centre
2	1	= 1 if the monitoring is automated, = 0 otherwise
3	1	= 1 if the counting of bulletins and reports is performed before quality control, = 0 otherwise
4	1	= 1 if the bulletins and reports are counted only if received or transmitted on the GTS channels, = 0 otherwise
5	1	= 1 if the duplicated bulletins are disregarded, = 0 otherwise
6	1	= 1 if the bulletins including only NIL reports are counted, = 0 otherwise
7	1	= 1 it the bulletins including the indicator COR or CCx are counted in addition to bulletins to be corrected, =0 otherwise
8	1	= 1 if the duplicated reports from fixed stations included in bulletins having the same abbreviated heading are disregarded, = 0 otherwise
9	1	= 1 if the duplicated reports from fixed stations included in bulletins having different abbreviated headings are disregarded, = 0 otherwise
10	1	= 1 if NIL reports are disregarded, = 0 otherwise
11	1	= 1 if reports from fixed stations included in bulletins with the indicator COR or CCx are disregarded to avoid double counting of these reports, = 0 otherwise
12	1	= 1 if all AIREP/AMDAR reports made at different positions during the flight are counted as different reports, = 0 otherwise
13	1	= 1 if the monitoring implemented by using the METDATA monitoring software provided by Germany, = 0 otherwise
14	50	Remarks.

Decision 11 (CBS-16)

DESIGNATION OF GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM CENTRES AGAINST THE NEW CRITERIA / FUNCTIONS AND THEIR INCLUSION IN THE REVISED *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485)

THE COMMISSION FOR BASIC SYSTEMS,

Recalling Recommendation 19 (CBS-16) – Revised *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

Considering the *Manual on the Global Data-processing and Forecasting System*,

Acknowledging the report of the committee established by the session to address the issue around the designation process and criteria,

Noting the interest of some Members, as listed in the annex to the present decision, to have their centres designated and their presentations on their capabilities at the time of the sixteenth session,

Acknowledging with appreciation the quality of the presentations and the demonstration of their new capabilities,

Requests these Members, in order to allow the completion of the designation process defined in the annex to Recommendation 19 (CBS-16), to send to WMO Secretariat the supporting information demonstrating compliance with the designation criteria;

Requests the Secretary-General to remind Members that they are invited to submit requests for new designations of Centres with capabilities corresponding to the new types of centres defined in the Manual, for decision at the sixty-ninth session of the Executive Council.

Annex to Decision 11 (CBS-16)

LIST OF MEMBERS WHO HAVE PRESENTED INFORMATION FOR CENTRE DESIGNATION

Activity / Centres	Member
Regional severe weather forecasting:	
Beijing	China
Wellington	New Zealand
Tokyo	Japan
Pretoria	South Africa
Limited-area deterministic weather prediction:	
Moscow	Russian Federation
Khabarovsk	
Novosibirsk	
Pretoria	South Africa
Rome	Italy
Limited-area ensemble numerical weather prediction:	
Rome	Italy
Non-nuclear emergency response activity:	
Toulouse	France
World Meteorological Centres (WMCs):	
Montreal	Canada
Exeter	United Kingdom
Tokyo	Japan
Beijing	China

ECMWF	ECMWF
Coordination of near-term climate prediction:	
Exeter	United Kingdom
Tropical cyclone forecast verification:	
Shanghai	China
Tokyo	Japan
Wave forecast verification:	
ECMWF (Reading, United Kingdom)	ECMWF

Decision 12 (CBS-16)

PEER REVIEW PROCESS FOR DATA-PROCESSING AND FORECASTING SYSTEM TECHNICAL DOCUMENTS

THE COMMISSION FOR BASIC SYSTEMS,

Recalling Resolution 32 (Cg-XV) – WMO Quality Management Framework,

Noting that an enhanced peer review process for Data-processing and Forecasting System (DPFS) publications would be required before technical documents are admitted for use by Members, as part of the WMO Quality Management Framework,

Noting further that similar peer review processes have been implemented by other technical commissions, for example by the Commission for Hydrology at its thirteenth session,

Adopts the peer review process for the DPFS technical documents as described in the annex to the present decision.

Annex to Decision 12 (CBS-16)

PEER REVIEW PROCESS FOR DATA-PROCESSING AND FORECASTING SYSTEM TECHNICAL PUBLICATIONS

1. INTRODUCTION

With the adoption of the WMO Quality Management Framework, the publications brought out under the technical guidance of the CBS Open Programme Area Group on Data-processing and Forecasting Systems (CBS/OPAG-DPFS) form an essential tool for meeting the objectives of a quality management system (QMS). As such, the publications brought out by CBS/OPAG-DPFS should undergo a comprehensive peer review before they are recommended for adoption as tools for the QMS. The Commission at its sixteenth session adopted the following peer review process.

2. The peer review process

The president of CBS shall appoint the chairperson or the co-chairperson of the CBS/OPAG-DPFS (who are represented at the CBS Management Group), as responsible to oversee the peer review process during an intersessional period (hereafter referred to as the "responsible member"). Technical material related to the scope of CBS/DPFS activities can be submitted to the Commission for publishing as a CBS/DPFS publication by the chairpersons of the CBS/DPFS Expert Teams.

In this regard, the WMO Secretariat should ensure that the technical material is complete, is in a form ready for review, and has been assigned to a category of technical guidance document, i.e. technical notes, guidelines, and other technical guidance metarials. If the report is not considered ready, the Secretariat shall advise the author(s) as to how it might be amended so as to make it suitable for the review process.

Once the technical material is ready for review it should be sent to the responsible member for peer review. The peer review process shall comprise of the following steps:

(a) Selection of reviewers;

(b) Assessment of the report by the reviewers;

(c) Evaluation of the comments from the reviewers;

(d) Publication of the report.

2.1 Selection of reviewers

The responsible member shall determine whether a particular report is ready for review. The responsible member, in consultation with the president of CBS and the WMO Secretariat, should choose at least three reviewers who are experts in the subject matter.

2.2 Assessment of a report by the reviewers

The responsible member will forward to the reviewers the draft document and a copy of the "notes for reviewers", which describes the activities to be undertaken and related process. An agreement with the reviewers should be reached on the time period required for review. The reviewers should be informed that they have the right to remain anonymous, if they so wish.

Reviewers should consider the report from a scientific, technical and editorial point of view and provide their advice, including their views on the suitability of the pre-assigned category of the document.

2.3 Evaluation of the comments from the reviewers

The responsible member together with the Secretariat will evaluate the comments from the reviewers and if needed may forward proposed revisions prepared by the reviewers to the author(s) of the technical material. If appropriate, the author(s) should be requested to elaborate on and comply with the comments of the reviewers. If one or more reviewers wish to see the revised draft, it should be sent to those in question. If, as a result of the review process, the report is considered suitable for publication within the Commission for Basic Systems publication series, the responsible member will recommend its publication to the president of CBS.

2.4 Publication of the document

The president of the Commission for Basic Systems will consider the recommendation when making his or her decision and, when approved (on behalf of the Commission), will coordinate the publication of the document with the WMO Secretariat.

Decision 13 (CBS-16)

GUIDELINES ON METEOROLOGICAL AND HYDROLOGICAL ASPECTS OF SITING AND OPERATION OF NUCLEAR POWER PLANTS, PREVIOUSLY KNOWN AS *TECHNICAL NOTE 170 – METEOROLOGICAL AND HYDROLOGICAL ASPECTS OF SITING AND OPERATION OF NUCLEAR POWER PLANTS* (WMO-No. 550)

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) Decision 60 (EC-68) – Meteorological and hydrological aspects of siting and operation of nuclear power plants,

(2) Resolution 32 (Cg-XV) – WMO Quality Management Framework,

Acknowledging the substantial progress that has been made with the *Guidelines on Meteorological and Hydrological Aspects of Siting and Operation of Nuclear Power Plants*, previously known as *Technical Note 170 – Meteorological and Hydrological Aspects of Siting and Operation of Nuclear Power Plants* (WMO-No. 550), which involves experts from the Commission for Basic Systems (CBS), the Commission for Atmospheric Sciences, the Commission for Climatology, the Commission for Instruments and Methods of Observation, the Joint WMO–IOC Commission for Oceanography and Marine Meteorology, and the International Atomic Energy Agency (IAEA),

Decides to apply the peer review process for Data-processing and Forecasting System technical documents, as described in the annex to Decision 12 (CBS-16) – Peer review process for Data-processing and Forecasting System technical publications, to consolidate comments from CBS;

Requests the Secretary-General to distribute the consolidated version of the *Guidelines on Meteorological and Hydrological Aspects of Siting and Operation of Nuclear Power Plants* to Members for their consideration and comments;

Urges WMO Members and technical commissions concerned to review the draft *Guidelines on Meteorological and Hydrological Aspects of Siting and Operation of Nuclear Power Plants* and provide comments to the WMO Secretariat, as appropriate;

Authorizes the WMO Secretariat to integrate comments from WMO Members, technical commissions concerned and IAEA, and prepare the final consolidated version of the *Guidelines on Meteorological and Hydrological Aspects of Siting and Operation of Nuclear Power Plants*;

Authorizes the president of CBS to endorse the final consolidated version of the "Guidelines on Meteorological and Hydrological Aspects of Siting and Operation of Nuclear Power Plants" for publication;

Requests the Secretary-General to bring these Guidelines to the attention of Members.

Decision 14 (CBS-16)

AMENDMENTS TO THE *GUIDE TO PUBLIC WEATHER SERVICES PRACTICES* (WMO-No. 834)

THE COMMISSION FOR BASIC SYSTEMS,

Recalling that the second edition of the *Guide to Public Weather Services Practices* (WMO-No. 834) was published in 1999, and that to date 27 guidelines focusing on specific aspects of public weather services (PWS) have been published that can be accessed through the web link http://library.wmo.int/opac/index.php?lvl=etagere_see&id=41#.V7LGDoR9670,

Recalling further Decision 93 (EC-68) – Roadmap to an Enhanced Framework for WMO Technical Regulations, requesting the technical commissions, inter alia, to prioritize in their work plans the review and update of relevant parts of the WMO Technical Regulations in accordance with their specific terms of reference,

Acknowledging that the principles in the provision and delivery of PWS, as contained in the Guide, are still largely valid,

Recognizing however that major changes have taken place in the way National Meteorological and Hydrological Services (NMHSs) operate, including the rapid development of technologies that affect every link in the chain that brings weather information to the user; the increasing need to strengthen interaction with various user groups for improved service delivery; the increasing demand for more tailored services and products; and the growing emergence of service providers other than NMHSs,

Having considered that effective service delivery is emerging as a key component in the recognition of credibility of NMHSs, as advocated in the WMO Strategy for Service Delivery, and is being mainstreamed in the work of WMO programmes; that requirements in terms of systems and infrastructure to support service delivery will need to be identified; and that the Competency Framework for PWS Forecasters and Advisors was approved by the Seventeenth World Meteorological Congress and a new section covering general requirements for provision of PWS should be included in the *Guide to Public Weather Services Practices*,

Agrees that there is an urgent need for an in-depth review of the *Guide to Public Weather Services Practices* to include new dimensions related to service delivery and PWS competencies as well as the essence of various guidelines that have been produced by the PWS Programme since the publication of the Guide;

Decides that the *Guide to Public Weather Services Practices* should be completely revised to include broadened responsibility of Members for the routine delivery of services to public and other users, be reviewed and approved by the Commission, and be published prior to the next session of the Commission;

Requests the Secretary-General to facilitate the expeditious revision of the *Guide to Public Weather Services Practices*.

Decision 15 (CBS-16)

EMERGING TRENDS IN INFORMATION AND ITS USE AND THE COMMISSION'S DISCUSSION REGARDING STRATEGIC DRIVERS

THE COMMISSION FOR BASIC SYSTEMS,

Welcoming the valued contribution of Members, during the sixteenth session of the Commission for Basic Systems, to the Technical Conference on Emerging Trends in Information and its Use,

Noting the recommendations and considerations contributed by Members arising from agenda item 4.2 of the sixteenth session of CBS "Review of strategic drivers impacting on the responsibilities of the Commission" and having the benefit of the presence of the Secretary-General and the President of WMO, to whom it conveys its deep appreciation,

Having considered the report of the Technical Conference and the summary of the Commission's discussion regarding strategic drivers, as given in Annex 1 and Annex 3, respectively, to the present decision,

Recognizing:

(1) The emerging issues, opportunities and challenges for Members, and for National Meteorological and Hydrological Services (NMHSs) in particular, right across the data value chain, and the important role of data and information and the associated technologies in many of their activities, from making and sharing observations, to analysis and prediction, to production and dissemination of services, to engaging and interacting with users,

(2) That, when considering adoption of new information sources, from within or external to NMHSs, and new technology solutions, it is important to assess the benefits to be obtained from a service-delivery-focused approach and to consider the entire data value chain,

(3) That while some NMHSs have achieved success in uptake of new technologies and their innovative application, many others do not have the capacity to do so, and need help,

Acknowledging the value of sharing information and, in particular, the importance of practical guidance and support to enable Members to make sound, value-based choices regarding the use of appropriate technology and to build capability,

Acknowledging further that the role of CBS is to support Members in developing and operating the basic systems required to deliver their national mandate, supported by WMO as outlined in the WMO Strategic Plan,

Emphasizing that helping Members derive benefit from the emerging trends in information and its use is a cross cutting issue that will enable them to address national priorities across the value chain,

Decides:

(1) That helping Members address emerging trends in information and its use is a strategic priority of CBS;

(2) That the CBS Management Group will review the recommendations and considerations listed in Annexes 1 and 3 to the present decision, where they are considered to be aligned with the WMO Strategic Plan and the responsibilities, decisions, resolutions or

recommendations of the Commission and ensure that they are included in the work plans of the Commission;

(3) That the Management Group will engage with other technical commissions and technical programmes as appropriate;

(4) To adopt the process outlined in Annex 2 to the present decision that enables the president of CBS to designate a Member-initiated project as a WMO/CBS affiliated project;

(5) That the president, on behalf of CBS, will subsequently review and update the process for, and the status of, the designation of projects;

Encourages Members:

(1) To share concise case studies describing activities related to emerging trends in information and its use;

(2) To refer to the strategic priorities of CBS and action areas listed in Annex 1 to the present decision when considering activities that may be undertaken as WMO/CBS affiliated projects;

(3) To explore innovative approaches to enable organizations from multiple Members to collaborate effectively in delivering WMO/CBS affiliated projects and to engage with the user community to solicit feedback;

(4) To seek, where there are opportunities to do so, to include participation from least developed countries and small island developing States in WMO/CBS affiliated projects;

Requests the Secretary-General to assist the sharing of information on case studies and WMO/CBS affiliated projects and to ensure that similarities and overlaps between projects initiated by Members are identified and that opportunities for further collaboration and information sharing are communicated;

Requests presidents of regional associations to consider the WMO/CBS affiliated projects:

(1) To determine which of those projects meet needs arising within their regional association;

(2) To assist Members from their Region in engaging with these projects;

(3) To bring to the attention of the CBS Management Group where there are gaps and opportunities for projects.

Annex 1 to Decision 15

REPORT ON THE SIXTEENTH SESSION OF THE COMMISSION FOR BASIC SYSTEMS TECHNICAL CONFERENCE ON EMERGING TRENDS IN INFORMATION AND ITS USE

The TECO on “Emerging Trends in Information and its Use” was held on 20-21 November 2016, in Guangzhou, China, in association with the 16th session of CBS. There were 31 presentations, including four keynotes, and 34 posters, which contributed to a very engaging discussion on the many issues raised.

The presentations explored emerging issues, opportunities and challenges for Members, and for NMHSs in particular, right across the data value chain and highlighted the important role of

data and information and the associated technologies in just about every activity they undertake, from making and sharing observations, to analysis and prediction, to production and dissemination of services, to engaging and interacting with users. Significant technological advances are already being integrated within some services, from high performance computing to cloud to Artificial Intelligence (AI) technology, and the innovative use of data, especially 'big data'. This 'big data capability, when taken in conjunction with the multitude of measurements that drive our science, models, knowledge of the environment, forecasting systems and service delivery, provides significant potential for all Members, and reinforces the importance of providing practical guidance and support to build capability, enable sound, value-based choices and prepare members for a more agile future.

The key messages to emerge from the discussion included the following:

- NMHSs need to become more agile in exploring and adopting innovation and new technologies, and to exploit them in engaging with users, in all aspects of their operations and in delivering valued outcomes to end users.
- Exploitation of non-NMHS data, the Internet of Things (IoT) and social media will put a greater emphasis on the importance of partnerships, with the private sector and others.
- While some NMHSs have achieved success in uptake of new technologies and their innovative application, many others do not have the capacity to do so, and need help.
- The data-related issues facing Members in meeting societal needs for meteorological, hydrological and related services, are broader than 'big data'.
- We need to make information and technology choices that reflect the entire data lifecycle/value chain, and not treat each step in isolation, in order to reduce overheads and improve efficiency.
- 'Fit-for-purpose' and 'value-for-money' go hand in hand with ensuring that data-related decision, especially in relation to sourcing observations, are efficient and effective and best serve the mandate of the member and the needs of their users.
- The WMO basic systems, under the guidance of CBS, need to continually evolve to enable Members to remain relevant – e.g. WIS 2.0, WIGOS Vision 2040, future seamless GDPFS, implementation of the SDS.
- Development of common integration and delivery systems and common interfaces that reinforce the 'global and authoritative voice' of WMO would contribute to reinforcing the fundamental mandate and 'trusted brand' of NMHSs in sustained, long-term monitoring and safety of life and property.
- Open data sharing and international data sharing at regional and global level optimises the value of data to all Members, but in promoting the concept, it is necessary to respect national mandates and national choices.
- Cloud is only as good as what we put in it – and it is not free. We need to have a clear idea of how we best leverage cloud storage and cloud computing capabilities.
- With the current pace of technological change, it is no longer realistic for everyone to do everything – we need to consider sharing the task through world-leading science and service collaborations, based on common standards and common operating principles in order to enable interoperability.
- It is important that in empowering Members to meet the challenges and exploit the opportunities of new technology and big data, no Member is left behind.

- NMHSs can demonstrate their leadership through building partnerships with external communities, including volunteers, to access and share data that complements and adds value to the total impact of their service outcomes.

- The global community, including the general public, have a strong desire to make observations and share them – if we don't provide the mechanisms and leadership, via WIGOS, someone else will.

- Crowdsourcing may not deliver direct value for NWP, but there are practical areas where crowdsourced observations and networks can support effective and innovative services e.g. the MeteoFrance vehicle-based IoT project, established in partnership with the Continental tyre company.

- Seamless prediction requires comprehensive earth observations across all domains (cryosphere, ocean, atmospheric chemistry, landscape, etc) and scales (global to urban)

- Ongoing collaboration between NWP and observation communities is essential to ensure that each benefits from advances in the other.

- Just saying we are 'the authoritative voice' is not enough – we have to back it up with effective systems and processes to build trust and confidence.

- Most people don't just want a forecast anymore –they want it when, where, how they choose and they want to know what it means for them, all the way through to the impact they need to worry about (flood, health impact,…) at the scale that matters to them (down to urban-level services).

- There are lots of 'weather' voices out there: how can we, as a community, ensure ours is heard, recognised as authoritative and acted upon?

- As a community in today's world, we have three unique selling points – our global community (standards, data sharing, data processing systems, etc), our basis in science (learning, evolving, improving our outcomes) and our authority in delivering services, especially warnings, that the community can rely on (including our user engagement and our understanding of the areas of impacts).

- The collection of impact data is important, but this data is fundamentally different from operational data. Given the great variety of formats in which data can be provided and the diverse decision support systems, the development of a common approach to the collection and storage of this data to enable briefing of forecasters and later use for warnings verification would be extremely useful. This data will also prove invaluable for deep analytics applications. Finally, the use of the impact information for model/forecast validation, R&D of systems, valuation studies and so on, suggests natural partnership in this endeavour.

- Human aspects of data use and decision-making are important elements in the optimum exploitation of Big Data and further study of these aspects is needed – both the decision-making of forecasters and the decision-making of users and how to optimally link the two.

- Building an impact-based forecast and warnings system helps to provide society with a broader set of information targeted to its needs and at scales where individuals can directly relate to its immediate relevance, and strongly supports the position of the NMHS as the authoritative voice at times of severe weather.

- If NMHSs do not respond to the needs of users in general, and decision-makers in particular, they will lose relevance and weaken their position.

- There may be value in exploring the potential applications for AI technology to enable the smart use of "big meteo data", as the demand for, and skills in, high resolution modelling and ensembles increase.

- Weather stories can be effectively told via social media – but NMHSs need to develop a strategy and provide training to make optimum use of this. Significant policy considerations will need to be addressed (or dealt with) such as how to protect the brand of the NMHS while exploiting technology that allows for the re-posting of information.

- Apparently conflicting requirements of a warning (simple and fast) with individual needs (localised, specific) can be realised by simultaneous use of PUSH and PULL technologies.

- The role of meteorologists and technologists in NMHSs will evolve as a function of evolving user's needs, evolving technologies and the emergence of new environmental challenges.

- The role of other categories of staff, especially observers, will also change as technology and information systems evolve, as automation becomes more prevalent and as diverse data sources are integrated into national observing systems.

- The exponential rate of change of technology is causing disruptions in the work of NMHSs. The 'machine' should not be seen as a threat, but rather as an opportunity; we need to move away from the 'man against the machine' paradigm to the 'man leveraging the machine' paradigm. This is not a technological problem; it is a 'transformation of business' issue.

Some potential actions for CBS consider the following:

- Include all relevant considerations from above in the Evolution of WIS, WIS 2.0.

- Enable the sharing of technology and innovation (e.g. WOW, mPING) – don't reinvent, but where possible re-use, adopt, adapt.

- Promote appropriate collaboration with the private sector – reinforce the authority and mandate of NMHSs while leveraging the skill, agility and resources of the private sector to increase overall societal benefit.

- Take a wide view and ensure that we provide total and inclusive guidance and support to Members – with the aim of ensuring that no Member is left behind.

- Promote sharing of high resolution model products among developing countries; this could possibly be an international cooperation project in CBS, building on WIS2.0 thinking on a distributed cloud-based data sharing platform.

- Embrace the expanding scope of prediction systems, such as those for urban and health predictions, in the context of impact-based forecasts. In all such activities, the full scope of the data lifecycle should be considered, including supporting observations and integration of data from all associated providers.

- Increase the role of World Meteorological Centres in the delivery of regional NWP and Regional WIGOS Centres in the coordination exchange and quality control of data.

- Encourage more cost-benefit studies, across all application areas, to inform effective observing system design and investment proposals, including those made in the context of urban predictions.

- Expand WIGOS to a wider range of observing domains that will better serve the needs of coupled and high resolution models.

- Work towards the development of a systematic approach and structure for the collection, storage and retrieval of impacts-related data in collaboration with other Commissions with similar needs.

- Develop guidance to members on making practical choices – in observations systems, whether data should be bought or sold, choosing partners, engaging with the external/private sector without incurring unreasonable costs nor compromising data sharing, etc. Build on work underway within ICG-WIGOS Task Team on Data and Partnerships.

- Establish and evaluate pilot projects, affiliated with WMO/CBS, on the innovative uptake and application of emerging trends in information and technology (e.g. a common delivery interface, man-plus-machine models, applications of cloud-based computing) and on technology collaboration.

- Review the CBS governance mechanisms to facilitate greater agility in establishing such pilot projects, approval of new solutions, guidance, transition into operation of pilot projects, and sharing of the lessons learnt to enable other Members, particularly LDCs and SIDS, to also benefit.

- Publish and share case studies of successful technological innovation, information systems, partnership approaches, etc – learn from success of others.

- Work together, bilaterally, multilaterally, twinning etc, in the development of projects.

- Examine a wide range of possible partnership models – public and private; with RAs and with other technical commissions and technical programmes.

- Don’t forget that while people get carried away with 'big data', many Members still do not have enough of the right data. Capacity development activities to improve and sustain fit-for-purpose observing systems should remain a priority for CBS.

- Share information on how members are evolving their capabilities and competency models, as new technologies and information sources, including 'big data', influence the role of our people.

- Consider collaboration with WMO Education and Training programme to explore models for ensuring that we consider fully future career structures and opportunities in meteorology, and look for opportunities to include and apply trends in information and technology in education and training solutions.

- Communicate, communicate, communicate.

The TECO concluded by highlighting that emerging trends in information and its use touch on all aspects of the work of WMO Members and that without concerted action and increased agility, by Members and by WMO as a whole, the role of NMHSs in the delivery of services for the safety, security, well-being, and prosperity of its citizens and industries will become increasingly challenged.

The key messages and potential actions outlined above are recommended for the consideration of CBS-16 and inclusion, in specific decisions of the Commission and/or inclusion in the work plans of OPAGs as appropriate.

Annex 2 to Decision 15 (CBS-16)

PROCESS FOR DESIGNATION OF WMO/COMMISSION FOR BASIC SYSTEMS AFFILIATED PROJECTS

Step 1. The lead organisation for the independently-funded candidate Project should express its intent to have the Project designated as a WMO/CBS Affiliated Project through a presentation accessible to all Members facilitated by the Secretariat. The lead organisation shall also submit a letter from the Permanent Representative of their country through the secretariat to the President of CBS and also provide supporting detailed information demonstrating alignment with the WMO Strategic Plan and the responsibilities, decisions, resolutions or recommendations of the CBS.

Step 2. Following consideration of the proposal by the Management Group the president of CBS shall either provide approval for the designation or in case the designation is not recommended, refer it back to the lead organisation with feedback through the Secretariat.

Step 3. Once the Designation has been approved, participants in the Project may recognise the WMO/CBS Affiliation in their communications.

Annex 3 to Decision 15 (CBS-16)

RECOMMENDATIONS AND CONSIDERATIONS FROM THE SIXTEENTH SESSION OF THE COMMISSION FOR BASIC SYSTEMS AGENDA ITEM 4.2 "REVIEW OF STRATEGIC DRIVERS IMPACTING ON THE RESPONSIBILITIES OF THE COMMISSION" HAVING THE BENEFIT OF THE PRESENCE OF THE SECRETARY-GENERAL AND THE PRESIDENT OF WMO

The discussion involved the participation of the Secretary-General and of WMO and the President of WMO. The SG offered his perspective on the future of the organization then a series of questions and comments, including from the President of WMO, followed. The information below captures the essence of the discussion.

Key points of the discussion

- CBS should provide recommendations for a more effective WMO that could be taken forward to Congress;
- RAs should establish clear priorities and action plans which CBS could then evaluate to determine if and how it could help address them;
- There is no formal structure of the working relationship between TCs and RAs. It needs to be taken into account when transforming WMO;
- We need to continue to reduce duplication of responsibilities and work efforts between RAs and TCs. The meeting of PTC/PRA is already a good step;
- Face-to-face meetings are important. However, they may be made more efficient if there is "homework" to be completed before the meeting to facilitate useful and concrete discussions;
- Training by WMO is important. Training on new capability of models is required. Need to make a differentiation between meetings and training or workshops for Members;

- When trying to reduce the length of meetings, care needs to be taken to ensure that in-depth discussions are still possible. Otherwise decisions and outcomes may suffer;
- Three important tenets to consider:
    - Agility
        - We need to be able to respond to rapidly changing operational needs;
        - Much discussion was held at EC last year on the importance for WMO to be responsive to the needs of our international partners;
        - It is very important to examine our working procedures: we can't continue to wait 4 years to get the key decisions within CBS' area of responsibility;
    - Integration
        - We need to examine how we serve our user community and integrate the work that cuts across commissions;
    - Communication
        - We (RAs, TCs and Secretariat) can do a better job selling what we do to Members, stakeholders and our user communities;
        - By sharing as much as possible it will help to not leave anyone behind;
- Request the SG to focus attention on developing countries which do no not meet their users requirements;
- Need to further improve capacity development in developing countries;
- The existence of parallel structures (RAs, TCs, Secretariat) doesn't favour optimal work;
- There is a big investment of manpower (5000+ Experts). Need to find a way to use that resource in an optimal way, this is the challenge;
- WMO stakeholders survey – 120 respondents with the following key results
    - Too many long meetings with minimum results to show;
    - Quality of documents and content not the highest;
    - Need to be more strategic with WMO meeting;
- TCs could conduct a SWOT analysis and find ways to optimise the work of their resources;
- EC-PHORS was established by the President of WMO to engage key stakeholders. This model may have application in other areas;
- Can the structure of TCs include a directors level and high level experts?;
- The Secretariat could possibly support some sort of annual meetings of the commissions and to follow progress so as to inform plans to be set up by Congress. SOP meeting considers multiple options but final decision will come from Members;
- Operational plans could include key players and budgetary resources from external resources. Clear actions plan is necessary;

- Consider an integrated approach and a systematic interface to our work across constituent bodies;
- The SG, could provide a view of the structure from the Secretariat's perspective to which comments could be provided;
- In reducing operational costs, we need to ensure that no one is left behind;
- When choosing OPAG members we need to include experts from developing countries – one way is to have the chair from an advanced country and co-chair form developing countries - this would help with capacity development;
- Major meetings and workshops should be based on priorities;
- When considering all voluntary sources of funding such as those from the Development Agencies, GCF etc., over the last decade can we say that we have a money problem?
- PTC/PRA discussion could be further strengthened and formalized;
- The climate services lead is with RAs with support from TCs;
- The Cg decision process through an integrated operational plan could be better organized. It approves the budget then the plan. First step should be to approve the plan then consider how to organize the budget;
- Need to train Members so that they can address climate services;
- Is there a proliferation of cross participation of TCs? A key issue is optimizing the resources we receive. We must try to maximize value for the funds we receive;
- Place more emphasis on focusing our time on what matters most and all components of WMO need to work together towards those ends;
- Greater visibility of WMO is required in Developing Countries to help them get support from their governments;
- Visits from the President of WMO, the SG and Presidents of Technical Commissions/Associations would of help a great deal in getting support from the governments for developing countries;
- Congress approves our strategic Plan, therefore the work structure should be organized to facilitate its realization;
- CBS can help the integration of WMO activities but how can we get the needs of CBS into the Strategic Plan;
- CBS has the opportunity to develop strategic priorities to support the SP;
- It is a weakness, when we talk resources, to only consider financial resources, failing to recognize the value of our experts' time;
- Need to identify our priorities and gaps and be cognizant of what is happening across the Regions;
- Consider organizing meetings across Regions to address identified issues;
- Many challenges are faced by WMO which needs to adopt best technical and governance structure;

- Governance structure should be adapted to new realities;
- The TCs are an important component structure of the WMO and reduction of overlaps in TCs' activities and increased participation of developing countries should be encouraged;
- Top-down design, through consideration of the Stakeholders survey by the President and SG;
- This is not a cost saving exercise but rather a way to use resources wisely (5000 Experts and 300 Secretariat Staff);
- Introduction of structure should follow a strategy and include an action plan to guide the restructuring;
- The WMO strategic plan is loose. CBS should be more aggressive in helping to set the priorities;
- Need to communicate much better. We are making progress as this week, WMO statement on Climate Change and Green House Gas was consulted by many;
- Cooperation between TCs is good but who sets the priorities…General idea is RAs set the priorities and TCs support;
- 4 years to make decisions is a long stretch. We should be able to reduce the period;
- Need to develop better performance indicators;
- During the last financial plan, gaps were identified but strategic design not addressed at global, regional and national levels;
- The Last Strategic Plan did not capture the strategic design;
- WMO is a regulatory body and it is important to consider when developing the strategic plan;
- We should consider how Congress could reorganize itself.

Some potential actions for CBS to consider:

- CBS to develop a mechanism to strengthen PTC/PRA relationship;
- President of CBS to use every opportunity to visit Developing Countries to help with their visibility with their government;
- Develop strategic priorities to support the SP;
- Contribute to top-down design of the structure of WMO;
- Set more aggressive priorities.

Decision 16 (CBS-16)

RESPONSIBILITIES FOR THE OVERSIGHT AND REVIEW OF THE OBSERVING SYSTEMS CAPABILITY ANALYSIS AND REVIEW TOOL

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) Resolution 23 (Cg-17) — Pre-operational phase of the WMO Integrated Global Observing System,

(2) Resolution 3 (EC-68), re-establishing the Inter-commission Coordination Group on the WMO Integrated Global Observing System (ICG-WIGOS), and particularly the ICG-WIGOS role to coordinate further the development of the WIGOS Information Resource (WIR), with special emphasis on the operational deployment of the Observing Systems Capability Analysis and Review tool (OSCAR) and its databases,

(3) The *Final Report of the Ninth Session of the Implementation–Coordination Team on Integrated Observing Systems (ICT-IOS-9)* (18–21 April 2016), paragraph 8.6,

(4) The *Abridged Final Report with Resolutions and Recommendations of the Extraordinary Session of the Commission for Basic Systems* (WMO-No. 1140), September 2014, and its Annex VIII deciding on the assigned responsibility within the Commission for Basic Systems (CBS) for overseeing and reviewing of OSCAR,

Having considered:

(1) The new working structure of CBS, including the removal of the Inter-Programme Expert Team on WIGOS Framework Implementation, which had assigned responsibilities with regard to OSCAR during the past intersessional period, and the need to assure proper oversight and review of OSCAR,

(2) The role of ICG-WIGOS with regard to guiding the development of the WIGOS pre-operational phase 2016–2019, whereby the further development of the WIGOS Information Resource, with special emphasis on the operational deployment of the databases of OSCAR, is one of the five highest priorities,

(3) The establishment by ICG-WIGOS at its fifth session of a Task Team on OSCAR Development that will be responsible for overall coordination and leadership of OSCAR at the technical level, including liaison with relevant CBS expert teams,

(4) The recommendations of the ICT-IOS with regard to the proposed responsibilities for the oversight and review of WIGOS,

Decides to assign responsibility within CBS for the technical development of OSCAR as detailed in Table 1 of the annex to the present decision.

Annex to Decision 16 (CBS-16)

RESPONSIBILITY FOR THE OVERSIGHT AND REVIEW OF THE OBSERVING SYSTEMS CAPABILITY ANALYSIS AND REVIEW TOOL

TABLE 1: PROPOSED RESPONSIBILITY WITHIN CBS FOR THE OVERSIGHT AND REVIEW OF OSCAR

CBS Team	***Role***	***Reporting to***
ICT-IOS	Lead	ICG-WIGOS
IPET-OSDE	1) Functional requirements with regard to the tools required for the RRR process 2) Review content required for the RRR process including the observational requirements from application areas	ICT-IOS
ET-SAT	Space-based observing systems capabilities (programmatic and technical updates)	ICT-IOS

IPET-SUP	Space-based observing systems capabilities (user assessments)	ICT-IOS
ET-ABO	Aircraft-based observing systems capabilities	ICT-IOS
ET-SBO	Surface-based observing systems capabilities	ICT-IOS
IPET-SWeISS	Space Weather capabilities (surface- and space-based)	ICT-IOS
IPET-OWR[1]	Weather Radar Capabilities	ICT-IOS
C-MAR	Marine meteorological and oceanographic observing systems capabilities	ICT-IOS

[1] Note: IPET-OWR is an Inter-programme Expert Team established jointly by CBS and CIMO with team members from both Commissions, and the team reports to CIMO.

Decision 17 (CBS-16)

OBSERVING SYSTEMS CAPABILITY ANALYSIS AND REVIEW TOOL MAINTENANCE AND RESOURCING

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) *Technical Regulations* (WMO-No. 49), Volume I, Part I – The WMO Integrated Global Observing System,

(2) The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160),

(3) Resolution 2 (EC-68) – Plan for the WIGOS pre-operational phase 2016–2019,

Recalling also the *Final Report of the Ninth Session of the Implementation–Coordination Team on Integrated Observing Systems (ICT-IOS-9)* (18–21 April 2016), paragraph 6.1,

Recalling further:

(1) The obligation of Members, according to the WMO Integrated Global Observing System (WIGOS) Technical Regulations and the WIGOS Manual, to make available internationally, without restriction, those mandatory and conditional (whenever the condition is met) observational metadata that support observations made available internationally,

(2) Decision 30 (EC-68) requesting Members to continue to provide resources, including through the WIGOS Trust Fund and/or seconded experts, to help support the implementation of WIGOS, in particular to assist with the operational deployment of the surface-based observing systems component of the Observing Systems Capability Analysis and Review tool (OSCAR/Surface), and to support the translation of all WIGOS guidance material and user manuals into all official WMO languages, and requesting the Secretary-General to consider allocating resources from the regular budget for the continued development of OSCAR/Surface in order for the system to incorporate adequate provisions for all WIGOS components,

Having considered the recommendations of the ICT-IOS,

Acknowledges:

(1) With appreciation the commitment of Switzerland to help develop, operate and maintain OSCAR/Surface;

(2) The recent successful development and launch of OSCAR/Surface, providing information on surface-based observing capabilities, and its current and expanding role as the repository for the WIGOS metadata of surface-based observing systems;

(3) The key role already played by OSCAR/Requirements and OSCAR/Space in providing information on user requirements for observations and on space-based observing capabilities, respectively, addressing many purposes within WMO activities, including their crucial roles in support the Rolling Review of Requirements process;

(4) The potential for close integration of OSCAR with the developing WIGOS Data Quality Data Monitoring System , which will provide substantial benefits to WIGOS and WMO Members;

(5) The respective roles of the WMO application area focal points and, in particular, the essential role of the OSCAR national focal points, and the WMO Space Programme mechanism for submitting, recording and maintaining information in OSCAR;

(6) The role of the WMO Secretariat with regard to the management of the OSCAR information content;

Recognizes:

(1) The critical importance to WIGOS of OSCAR and its three components: OSCAR/Requirements, OSCAR/Space and OSCAR/Surface, in particular for recording, managing and providing access to WIGOS metadata;

(2) The need to assure continued development of OSCAR in order to keep it compatible with evolving user requirements and observational capabilities;

(3) The need for the Secretariat to maintain the capacity to monitor, update and quality assure the information content of the OSCAR databases, to incorporate feedback from users, and to coordinate and take action according to agreed procedures for keeping such content up to date;

(4) The role of regional associations, National Meteorological and Hydrological Services, space agencies and other partners in providing or facilitating the provision of high-quality required metadata to OSCAR;

Recommends that the Executive Council request the Secretary-General (i) to facilitate maintenance and further development of the three components of OSCAR (OSCAR/Requirements, OSCAR/Space and OSCAR/Surface) and (ii) to actively solicit contributions from Members to this effort, for example in the form of secondments or financial resources to the WIGOS Trust Fund;

Recommends that the Inter-commission Coordination Group on WIGOS investigate the potential for developing and providing a freely available open-source OSCAR-compatible software package that could be implemented at the national level.

Decision 18 (CBS-16)

TRANSLATED VERSIONS OF THE IMPLEMENTATION PLAN FOR THE EVOLUTION OF GLOBAL OBSERVING SYSTEMS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The *Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP)* (WMO Integrated Global Observing System Technical Report No. 2013-4),

(2) Resolution 10 (EC-65) approving Recommendation 6 (CBS-15) on the EGOS-IP,

(3) The *Final Report of the Ninth Session of the Implementation–Coordination Team on Integrated Observing Systems (ICT-IOS-9)* (18–21 April 2016), paragraph 7.1,

Noting with concern the few translation errors contained in the EGOS-IP (Spanish, French),

Acknowledging with appreciation that the EGOS-IP has been translated in five languages,

Acknowledging that due to the status of the document as a technical report it has not been edited by the WMO Secretariat,

Having considered the recommendation of the ICT-IOS, in particular for inviting WMO experts to review and proofread the translated WMO documents,

Invites Commission experts to review the EGOS-IP and notify the Secretariat about the translation errors they may find;

Recognizes the high-level status of the document;

Recommends Members to assist in correcting translation errors in the EGOS-IP by also notifying the Secretariat;

Invites the Secretary-General:

(1) To take appropriate action, and to correct translation errors in the EGOS-IP where known;

(2) To mobilize needed resources for translation of the EGOS-IP into Arabic;

Requests the Open Programme Area Group on Integrated Observing Systems to make sure in due course that the next version of EGOS-IP responding to the Vision of the WMO Integrated Global Observing System Component Observing Systems in 2040, which is under development, will have appropriate status and disclaimer so that it will be edited by the WMO Secretariat.

Decision 19 (CBS-16)

TRAINING ON KEY OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS ISSUES

THE COMMISSION FOR BASIC SYSTEMS,

Noting the *Final Report of the Ninth Session of the Implementation–Coordination Team on Integrated Observing Systems (ICT-IOS-9)* (18–21 April 2016), paragraph 4.5,

Having considered:

(1) The existing mechanisms and processes within WMO for providing training and support to Members, and the need to harmonize actions across those mechanisms and processes,

(2) That capacity development is required to assist Regions to tackle the many and various new initiatives and expectations arising from various programmes and their plans such as the Implementation Plan for the Evolution of Global Observing Systems; the implementation plans for the WMO Information System and the WMO Integrated Global Observing System; the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC; Global Framework for Climate Services aspirations; marine and oceans systems maintenance and development,

(3) The strong need in the Regions for training in some identified key areas,

Endorses a need to enhance training efforts in support of key Open Programme Area Group on Integrated Observing Systems (OPAG-IOS) activities as listed in Part 1 of the annex to the present decision;

Decides to continue to provide training and support for Members in collaboration with regional associations in those identified areas where the Commission for Basic Systems can provide support as listed in Part 2 of the annex to the present decision;

Invites OPAG-IOS experts to contribute to future training efforts as needed;

Further decides to strengthen its interaction with the regional associations by ensuring regional representation to the Commission's expert teams;

Urges the Secretary-General to include the required OPAG-IOS training, as listed in Part 1 of the annex to the present decision, in the WMO Education and Training Programme, and to foster closer collaboration between Secretariat staff having responsibilities for regional programmes and those having responsibilities for scientific and technical programmes where these responsibilities overlap.

Annex to Decision 19 (CBS-16)

LIST OF KEY OPEN PROGRAMME AREA GROUP ON INTEGRATED OBSERVING SYSTEMS ISSUES FOR WHICH TRAINING IS NEEDED AND AREAS WHERE THE COMMISSION FOR BASIC SYSTEMS CAN PROVIDE SUPPORT

1. Key OPAG-IOS Issues for which training is needed:

(a) Major initiatives affecting all Regions and which require support (by order of priority):

(i) Transition to table-driven codes;

(ii) Collection of WIGOS metadata and their submission to OSCAR/Surface;

(iii) Transition to the new system of WIGOS station identifiers;

(iv) Radio frequency protection, with an emphasis on establishing relationships with relevant spectrum authorities at the national level;

(v) Emerging requirements for international exchange of weather radar data, and facilitating such data exchange;

(vi) Definition and implementation of Regional WIGOS Centres;

(vii) Implementation of GCW stations and networks;

(viii) Transition from RBSN/RBCN to RBON;

(b) Areas where there is a need to sustain existing basic observing systems, placing demands on Members and Regions (by order of priority):

(i) Maintaining upper-air programmes with ongoing consumable items;

(ii) Finding the capacity to reactivate silent stations;

(iii) Sustaining technical capabilities to operate and maintain facilities.

2. Areas where CBS can provide support:

(a) Provide training, for example conduct regional workshop;

(b) Continue to provide training and support for those Members and Regions still addressing the transition to TDCF;

(c) Organize inter-regional activities to share experience and best practices, particularly with respect to these major initiatives;

(d) Continue to support Members and Regions to sustain upper-air programmes and reactivate silent stations, particularly in Region I, including assistance in the development of proposals for resource mobilization.

Decision 20 (CBS-16)

IMPROVED SUPPORT OF MEMBERS TO THE IMPLEMENTATION OF MARINE METEOROLOGICAL AND OCEANOGRAPHIC OBSERVING SYSTEMS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Recommendation 18 (CBS-Ext.(2014)) – Support of Members to the implementation of the marine meteorological and oceanographic observing system in support of numerical weather prediction,

(2) *Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP)* (WMO Integrated Global Observing System Technical Report No. 2013-4),

(3) The *Final Report of the Ninth Session of the Implementation–Coordination Team on Integrated Observing Systems (ICT-IOS-9)* (18–21 April 2016), paragraphs 4.3 and 6.7,

Noting also the EUMETNET report: "Derivation of E-SURFMAR related preliminary network design recommendations based on the voluntary studies in the framework of the E-SURFMAR impact study (EMN/STAC9/Doc 13 Ex-Committee-Decision in autumn 2014)",

Considering that marine meteorological and oceanographic observations are not only required by climate monitoring and ocean applications, but also by other WMO applications areas such as numerical weather prediction(NWP),

Acknowledging the routine use of Automated Shipboard Aerological Programme (ASAP) technology by EUMETNET in Regional Association VI for providing upper-air profile data over the North Atlantic because of the positive impact of ASAP data on NWP, and the cost-effectiveness of that technology,

Recognizing the development by the Joint WMO/IOC Commission for Oceanography and Marine Meteorology (JCOMM) of new implementation targets for the ocean observing networks, and the need for Members to contribute to addressing these targets,

Recognizing further the positive contribution and impact of the Aircraft Meteorological Data Relay profile data on NWP, essentially over land,

Considering that ASAP is often the only source of in situ upper-air profile data from large areas of the world oceans,

Requests the Open Programme Area Group on Integrated Observing Systems to consolidate the results of impact studies on ASAP;

Urges Members to work through JCOMM towards contributing to the implementation of marine meteorological and oceanographic observing systems and achieving the implementation targets of ocean observing networks as proposed by JCOMM;

Urges Members in Regions other than Regional Association VI to increase ASAP coverage in the global oceans beyond the North Atlantic to complement other sources of upper-air data.

Decision 21 (CBS-16)

REGIONAL BASIC OBSERVING NETWORK CONCEPT

THE COMMISSION FOR BASIC SYSTEMS,

Recalling Resolution 2 (EC-68) – Plan for the WMO Integrated Global Observing System pre-operational phase 2016–2019,

Recalling further the general WMO Integrated Global Observing System principle of implementing integrated networks serving multiple purposes and application areas,

Recognizing that several new observing systems have been put in operation by National Meteorological and Hydrological Services around the world since the implementation of the Regional Basic Synoptic Network (RBSN) and Regional Basic Climate Network (RBCN), and that data from these observing systems have also proven to be valuable to international partners, where made available,

Recognizing further that an integrated Regional Basic Observing Network (RBON) encompassing the current RBSN and RBCN, as well as new observation types not currently included in these networks, will enable WMO Members to better serve their constituencies through access to more and improved observations,

Acknowledging with appreciation the development of the RBON concept by experts from the Commission for Basic Systems and other technical commissions,

Acknowledging the input already provided by regional associations, technical commissions and partners responsible for WMO co-sponsored and non-WMO observing systems to the development of this concept,

Acknowledging further that regional associations will play a fundamental role in the implementation of the RBON,

Decides to endorse the RBON concept as provided in the annex to the present decision;

Decides further to task the Open Programme Area Group on Integrated Observing Systems (OPAG-IOS) with leading the ongoing development of the RBON concept incorporating feedback from all stakeholders, as provided;

Requests the Secretary-General to bring the RBON concept to the attention of all regional associations for their comments and to incorporate their comments in the RBON concept as it is being further developed;

Requests OPAG-IOS to initiate the development of regulatory material describing the RBON and the obligations of the WMO Members in its implementation, to be included in the next version of the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) that will be submitted to the Eighteenth World Meteorological Congress in 2019, and to coordinate this development with other technical commissions through the Inter-commission Coordination Group on the WMO Integrated Global Observing System;

Invites the regional associations to review and comment on the RBON concept as it is further developed;

Urges its members to actively participate in the further development of the RBON concept.

Annex to Decision 21 (CBS-16)

THE REGIONAL BASIC OBSERVING NETWORK CONCEPT PAPER

1. Preamble

The Regional Basic Synoptic Network (RBSN) and Regional Basic Climatological Network (RBCN)[1] consist of surface stations and upper-air stations designated by the regional associations. They have proven to be highly effective and made valuable regional contributions to the activities of WMO and its Members. The observations from these stations, which are maintained by WMO Members, have been exchanged globally in real-time without restriction. Originally designed to support operational meteorology and climatology, these observations have produced significant benefits across a wide range of applications.

Additional and emerging requirements for observations across diverse application areas are driving the need to redefine the Regional Basic Synoptic and Climatological Networks. New and improved observational technologies provide the opportunity to reassess regional observational strategies. The WIGOS framework calls for a more integrated view of WMO observing systems to serve the needs of multiple application areas. The new Regional Basic Observing Network (RBON) will lead to improved services by delivering more and improved observations to

[1] RBSN and RBCN are defined in the *Technical Regulations* (WMO-No. 49), Volume I, Definitions, and further elaborated in the *Manual on the Global Observing System* (WMO-No. 544), Part III.

stakeholders, and enable the full benefit of regional observing capabilities to be realized. As such, RBON will be a substantive and valuable subset of WIGOS.

Cg-17 decided that the development of WIGOS will continue during its pre-operational phase as one of the WMO strategic priorities in the period 2016-2019, with a focus on the regional and national implementation. As part of the regional WIGOS implementation, the RBON is being introduced to replace the existing RBSN and RBCN networks.

2. Draft concept of Regional Basic Observing Network (RBON)

RBON will be a subset of WIGOS, typically used in combination with space-based and remaining surface-based observing elements of WIGOS in any given application. By design, the RBON will be interoperable with many such remaining observing capabilities. RBON will help to address many, but not all, of the requirements that Members have for WIGOS. Design, execution and management of an RBON will be made in the context of the broader WIGOS.

2.1 Definition of a RBON

2.1.1 In each WMO Region, and in Antarctica, the RBON consists of surface-based meteorological and related observing stations/platforms; it responds to the collective needs of its Members, allowing them to fulfil their mandates and responsibilities in the provision of products and services. The RBON is established and managed by the respective regional associations and the WMO Executive Council (in the case of Antarctica).

2.1.2 The RBON constitutes a selected subset of existing observing systems within WIGOS arising from the Region. The network capabilities will respond to user observational requirements at the national, regional and global levels, identified by the Rolling Review of Requirements (RRR) process[2].

2.1.3 The RBON will operate in support of not only weather forecasting and climate monitoring, but also aiming to address as many as possible of the following WMO application areas:

(a) Global numerical weather prediction (GNWP);
(b) High-resolution numerical weather prediction (HRNWP);
(c) Nowcasting and very short-range forecasting (NVSRF);
(d) Sub-seasonal to longer prediction;
(e) Aeronautical meteorology;
(f) Ocean applications;
(g) Agricultural meteorology;
(h) Climate monitoring (as undertaken through the Global Climate Observing System (GCOS));
(i) Climate applications;
(j) Atmospheric chemistry related application areas.

2.1.4 The RBON will comply with the Principles for observing network design and planning[3], paying particular attention to those aspects of the principles as will be regulated in a new section on the RBON in the Manual on WIGOS.

2.2 The key attributes of the new RBON encompasses (not exclusive):

(a) Requirements for real-time and near-real-time data exchange at the global level;
(b) Requirements for regular updates of WIGOS metadata in the Observing Systems Capability Analysis and Review tool (OSCAR);
(c) Requirements for data exchange in defined WMO formats;

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[2] See the *Manual on WIGOS* (WMO-No. 1160), section 2.2.4 and Appendix 2.3.

[3] See the *Manual on WIGOS* (WMO-No. 1160), section 2.2.2 and Appendix 2.1.

(d) Commitment to operate and maintain the station/platform in the RBON for a minimum of four (4) years;

(e) Requirements for a higher frequency of data (hourly and sub-hourly data) and daily climate summaries;[4]

(f) Requirements for provision of required climate messages;

(g) Requirements for complying with the WIGOS quality management according to the Manual on WIGOS;

(h) Requirements for change management according to the Manual on WIGOS;

(i) Requirements for (Regional) multilateral arrangements for inclusion of systems that cover more than one Region;

(j) Requirements to support as many as possible of the WMO application areas;

(k) Stations/platforms are not limited to those under the responsibility of the National Meteorological and Hydrological Services (NMHSs).

2.3 Process for the selection of stations/platforms into RBON

(a) The regional association (RA) will prioritize the WMO application areas relevant to its Region;

(b) The stations/platforms will be selected so that the RBON observations together with other sources of observations available regionally, including satellite observations, allow horizontal resolution requirements as recorded in OSCAR are met at least at the threshold level;

(c) The stations/platforms will be selected in such a way that at least the threshold, but preferably breakthrough, user observational requirements as recorded in OSCAR for vertical resolution (profile data), observing cycle, timeliness, uncertainty and stability are met;

(d) The selection will be done by the relevant Regional Group designated by the respective RA (e.g., a future possible Regional WIGOS Centre or other dedicated groups) with participation of experts, including users and data providers, from its Members, and well-coordinated with bodies (e.g. JCOMM) governing some of these observing systems;

(e) The proposal for RBON, including an action plan to deal with the identified gaps, will be submitted to the RA session for consideration and adoption through a resolution.

2.4 Criteria for the selection of stations/platforms into RBON

Only those stations/platforms that meet the following requirements can be selected:

(a) Stations/platforms will be capable of exchanging data in real-time or near-real-time on a global level;

(b) Stations/platforms will be capable of exchanging data in the WMO data representation formats (note: other parties may provide a conversion from local to WMO formats);

(c) Stations/platforms recorded in OSCAR will be considered;

(d) Stations/platforms will have a commitment to operate for a minimum of four (4) years;

(e) Stations/platforms will be capable of providing preferably hourly and sub-hourly data;

(f) Stations/platforms will comply with the Regional Quality Assessment;

(g) Change management procedures, including reporting, will be respected.

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[4] Details on frequency of observations depending on the observing system and type of the observation will be specified in the technical regulations.

2.5 Monitoring of RBON

(a) RBON will be monitored against the requirements on a regular basis by one or more recognized global/regional centres, which will identify non-conforming stations/platforms;

(b) Members will respond to any incident management finding within a defined and agreed time frame appropriate to regional capabilities and expectations.

2.6 Management of RBON

(a) The Regional Group will regularly analyse monitoring reports and assist those Members whose stations/platforms do not conform with the regional quality assessment;

(b) Members will inform the Regional Group on action taken to address long-term deficiencies vis-à-vis regional monitoring findings;

(c) Stations/platforms that, in the long-term, do not conform with the defined Regional WIGOS quality standards will be proposed for removal from the RBON and the relevant Members consulted;

(d) In the intersessional period, minor changes in RBON can be authorized by the president of the RA based on the request of the corresponding Permanent Representative if supported by the relevant Regional Group;

(e) Identified gaps in the RBON observing capabilities will be documented and submitted to the RA session and an action plan will be proposed on how to fill the gaps.

2.7 Types of stations/platforms expected to be included in a RBON

According to the classification used in the OSCAR/Surface, the type of station/platform to be included in the RBON could be as follows:

(a) Land (fixed/mobile/on ice);

(b) Sea (fixed/mobile/on ice);

(c) Lake/River (fixed/mobile);

(d) Air (fixed/mobile).

For fixed stations/platforms, a commitment is made to observe at that location, whereas for mobile types the commitment is to assuring the observing programme as a whole to the extent declared.

2.8 Possible candidate stations for a RBON

The stations/platforms currently comprising the Regional Basic Synoptic Networks (RBSN) and the Regional Basic Climatological Networks (RBCN) are the primary candidates for the RBON, and are expected to constitute the backbone of the RBON. Those will be supplemented by other types of stations/platforms, such as weather radars, aircraft-based meteorological stations, wind profilers, lightning detection systems, voluntary observing ships and buoys. These stations/platforms need not necessarily be operated only by NMHSs.

More specifically:

(a) Automatic Weather Stations (AWS) are particularly significant as they provide a convergence of technology which is being used for weather forecasting and climatological requirements;

(b) Conversely, there is a divergence of technologies providing upper-air observations, so RBON will be a composite system of radiosondes, ground-based remote sensing, and the regional observations from aircraft based observing systems (e.g. AMDAR);

(c) Weather radar stations provide observations for which there are new requirements for international exchange, and hence will be an important element of RBON.

3. Further background and reference material for the Regional Basic Observing Network concept

The RBON is a subset of WIGOS stations selected essentially for global exchange, addressing the Vision for the Global Observing System in 2025 and responding to the Rolling Review of Requirements (RRR) and the Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP)(the period up to 2025) (WIGOS Technical Report No. 2013-4) (as listed in Annex).

The RBON complies with the Observing Network Design Principles as defined in the Manual on WIGOS. OSCAR is a key tool for: (i) recording user observational requirements agreed at the global and regional levels; and (ii) for collecting and recording RBON station metadata and their capabilities; hence particularly facilitating monitoring activities, gap analysis, and the planning for the evolution of RBON. Relevant reference material is provided below.

References

1. *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)
2. Vision for the Global Observing System in 2025 (available at http://www.wmo.int/pages/prog/www/OSY/Publications/Vision-2025/Vision-for-GOS-in-2025_en.pdf).
3. WIGOS OND Principles Guidance (under development)
4. Guidance on the RRR process (*Manual on WIGOS*, Appendix 2.3; *Guide to the Global Observing System* (WMO-No. 488), Part II, Observational Data Requirements, 2.3.1)
5. *Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP)* (WIGOS Technical Report No. 2013-4)

Decision 22 (CBS-16)

PRESERVING THE RADIO-FREQUENCY SPECTRUM FOR METEOROLOGICAL AND RELATED ENVIRONMENTAL ACTIVITIES AT THE WORLD RADIOCOMMUNICATION CONFERENCE 2019

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) Resolution 29 (Cg-17) – Radio frequencies for meteorological and related environmental activities,

(2) Decision 36 (EC-68) – Preserving the radio-frequency spectrum for meteorological and related environmental activities at the World Radiocommunication Conference 2019,

Recognizing:

(1) The requirement for the Commission for Basic Systems (CBS) to pursue the continuous review of regulatory and technical matters related to radio frequencies for operational and research meteorological and related environmental activities, and preparation of guidance and information for National Meteorological and Hydrological Services (NMHSs),

in coordination with other technical commissions and stakeholders such as the Coordination Group for Meteorological Satellites,

(2) The successful and effective approach of the Steering Group on Radio Frequency Coordination (SG-RFC) in the three previous World Radiocommunication Conferences (WRC-07, WRC-12 and WRC-15),

(3) The important role of the following two publications in assisting radio-frequency managers and NMHSs to understand the needs of the WMO communities for radio-frequency spectrum allocation and management:

(a) Joint WMO and International Telecommunication Union (ITU) publication: *Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction* (2008 edition) (Geneva, WMO and ITU) presently under review by WMO and ITU experts,

(b) *Guide to Participation in Radio-frequency Coordination* (WMO-No. 1159),

Decides:

(1) To maintain the continuous review of regulatory and technical matters related to radio frequencies in line with Resolution 29 (Cg-17);

(2) To make available to NMHSs and radio-frequency regulators a WMO position paper on the needs of WMO to be considered under the WRC-19 agenda;

(3) To complete, in coordination with ITU, the review of *Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction* (2008 edition);

Requests SG-RFC:

(1) To continue in the preparation for WRC-19, including developing and maintaining a position on the WRC-19 agenda ensuring that such information is made available to national and regional WRC-19 preparation activities;

(2) To complete the update of *Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction* (2008 edition);

Requests the Secretary-General:

(1) To support the urgent work of CBS and SG-RFC as a matter of critical importance, including to maintain the relevant priority and visibility of this activity, in particular as concerns budgetary and personnel decisions, and take effective action to facilitate publishing of the WMO position on the WRC-19 agenda and the WMO/ITU handbook *Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction*;

(2) To bring the present decision to the attention of all concerned, including the ITU Radiocommunication Sector;

(3) To coordinate with ITU on increasing awareness of the WMO position on the WRC-19 agenda and on the use of radio spectrum in the WMO community, including consideration of an ITU/WMO seminar to brief NMHSs and non-NMHS frequency managers on the updated handbook on use of radio spectrum for meteorology;

Authorizes the Secretary-General to make editorial changes to the output of CBS under this decision for the purposes of distribution and publication;

Urges NMHSs to participate in national radio-frequency coordination activities, including presenting the WMO position on the WRC-19 agenda at national and regional frequency management and coordination forums.

Decision 23 (CBS-16)

WMO SUPPORT TO THE NEW GLOBAL CLIMATE OBSERVING SYSTEM IMPLEMENTATION PLAN

THE COMMISSION FOR BASIC SYSTEMS,

Recalling Resolution 39 (Cg-17) which:

(1) Decided to strengthen and to continue the Global Climate Observing System (GCOS) as a programme of WMO as regulated by the 1998 Memorandum of Understanding with partners such as the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization; the United Nations Environment Programme (UNEP) and the International Council for Science (ICSU), and as regulated by new memorandums of understanding agreed by international sponsors,

(2) Recognized the fundamental importance of GCOS to the Global Framework for Climate Services,

(3) Recognized the importance of efficient coordination and interoperability across various component observing systems of GCOS and effective integration of in situ and space-based observations in meeting user needs,

(4) Recognized the unique opportunities for coordinated national and international reliable physical, chemical and biological observation of Essential Climate Variables across the atmospheric, oceanic and terrestrial domains, including hydrological and carbon cycles and the cryosphere, provided through the joint sponsorship of GCOS by WMO, IOC, UNEP and ICSU,

(5) Urged Members to strengthen their national atmospheric, oceanographic and terrestrial climate-observing networks and systems, including networks and systems for the hydrological and carbon cycles and the cryosphere within the framework of GCOS and in support of user needs,

(6) Urged Members to assist developing countries to strengthen their observing networks, to improve their capacity to acquire climate-relevant data, and to enhance their provision of climate services by implementing projects in the 10 GCOS Regional Action Plans, and by contributing to the implementation of the ClimDev Africa Programme and to similar initiatives in other regions,

(7) Urged Members to encourage their National Meteorological and Hydrological Services to provide effective leadership in the preparation of national reports to the United Nations Framework Convention on Climate Change (UNFCCC) on their activities with regard to systematic observation of the global climate system, including the identification of gaps, using revised UNFCCC reporting guidelines on global climate-observing systems that reflect the priorities of the GCOS Implementation Plan and that incorporate reporting on the Essential Climate Variables identified therein,

(8) Urged Members to enhance their support to the GCOS Secretariat, through secondment of experts and through contributions to the Climate Observing System Fund or to specific planning and implementation mechanisms, so as to enable the GCOS Secretariat to

support the full range of implementation agents in its efforts to establish an effectively operating GCOS programme,

Recalling also:

(1) Resolution 23 (Cg-17) that recognized that the WMO Integrated Global Observing System (WIGOS) together with the WMO Information System (WIS) provide the essential infrastructure for acquisition and dissemination of observations, on which the capability of Members to provide critical services to their citizens is built,

(2) Resolution 8 (EC-67) that invites the WMO/IOC/UNEP/ICSU Steering Committee for the Global Climate Observing System, the WMO/ICSU/IOC Joint Scientific Committee for the World Climate Research Programme, the WMO/IOC/UNEP/ICSU Steering Committee for the Global Ocean Observing System, and the Coordination Group for Meteorological Satellites to participate in relevant activities of the Inter-commission Coordination Group on the WMO Integrated Global Observing System and collaborate with WMO on further development and implementation of WIGOS,

(3) Decision 21 (EC-68) that endorsed the GCOS Status Report 2015 as the basis for the new GCOS Implementation Plan,

Recalling further Decision 22 (EC-68) that decided to support the GCOS Implementation Plan review process in asking Members, technical commissions, regional associations and WMO programmes to actively promote the draft plan during the period of the public review, to contribute to it and in requesting them to feed their comments back to the GCOS Secretariat,

Recognizing the need for consistent, coordinated, high-quality climate observations to support the Parties to the UNFCCC in planning adaptation and mitigation, the development of climate science and also to support other multilateral environmental agreements,

Acknowledging that planning and coordinating these observations requires a partnership between those observing in the atmospheric, oceanic and terrestrial domains, covering physical, chemical and biological parameters,

Having considered the document *The Global Observing System for Climate: Implementation Needs* (GCOS-200) (Geneva, WMO),

Having examined the GCOS report *Status of the Global Observing System for Climate* (GCOS-195) (Geneva, WMO),

Observing that there are still gaps in the observations and additional observations are required for vital adaptation planning,

Decides to support Members, as appropriate, in the implementation of the actions identified in the GCOS Implementation Plan and especially those identified in the annex to the present decision, as important components of WIGOS.

Annex to Decision 23 (CBS-16)

ACTIONS IN THE GLOBAL CLIMATE OBSERVING SYSTEM IMPLEMENTATION PLAN[1] OF PARTICULAR INTEREST TO THE COMMISSION FOR BASIC SYSTEMS

1. The GCOS Implementation Plan contains a total of 201 actions, 53 of which are of interest to CBS and are summarized in the three tables below.

2. The actions of interest to CBS have been split into three tables depending on the final objective they will help achieving:

(a) The first table includes actions that contribute to the practical observation systems. Most of these actions are related to network needs, and ensure that observations meet GCOS requirements and that resources for networks are made available. The demand of expanding existing networks is also covered;

(b) The second table includes actions meant to improve users access to the observations, and include actions that promote open data, metadata, discoverability and long term access, and actions that ensure delivery of operational products;

(c) Finally, a third table consists of actions aimed at promoting future improvements to the climate observation system. These actions focus on promoting research activities to develop new approaches, studying the application of new technologies, and designing and planning new networks.

3. General actions are numbered Gxx, actions related to the atmosphere domain Axx, to the ocean domain Oxx and to the terrestrial domain Txx. A complete description of each of these actions and their context can be found in the Implementation Plan.

4. Other actions not listed here may be for GCOS itself, other observing systems or academia. Ocean-related actions are implemented by JCOMM. Actions addressed to the satellite agencies will be brought to the attention of CEOS and CGMS and are also not included in these tables.

Actions to Maintain and Improve Networks

Category	Description	Actions (As approved by the 24th session of the GCOS Steering Committee (GCOS SC-24))
Networks	Ensure sustained resources for networks Ensure observations meet GCOS requirements Expand existing networks	G6 Assisting developing countries to maintain or renovate climate observation systems and to improve climate observations networks G13 Review of ECV observation networks A5 Transition to BUFR A6 Air temperature measurements A13 Implement vision for future of GUAN operation A15 Implementation of GRUAN A20 Increase the coverage of aircraft observations A33 Maintain WMO GAW CO2 and CH4 monitoring networks A36 N2O, halocarbon and SF6 networks/measurements A37 Ozone networks coverage T6 Identify Capacity Development Needs T17 International Soil Moisture Network T19 Maintain and extend the in-situ mass balance network T26 Glacier observing sites T28 Snow-cover and snowfall observing sites T30 Ice sheet measurements T33 Standards and practices for permafrost

[1] The Global System for Climate: Implementation Needs (GCOS-200) (thereafter referred to as "the Implementation Plan") as provided at www.gcos.wmo.int.

Actions to facilitate dissemination of observations and products

Category	Description	Actions
Ensure Open data access and indefinite data storage	Facilitate access to all climate data for all users by fostering open data policies, provision of relevant metadata including discoverability, and ensuring long term access	G15 Open Data Policies G16 Metadata G17 Support to National Data Centres. A1 Near real-time and historical GSN availability A3 International exchange of SYNOP and CLIMAT reports A4 Surface observing stations transition to automatic A8 Provide precipitation data to the Global Precipitation Climatology Centre A9 Submit Water Vapour data A10 National sunshine records into Data Centres A12 Surface Radiation Data into WRDC A17 Retain original measured values for radiosonde data A24 Implementation of archive for radar reflectivities A38 Submission and dissemination of ozone data T5 Develop Metadata T7 Exchange of hydrological data T9 Submit historical and current monthly lake level data T11 Confirm GTN-R sites T13 Establish full scale Global Groundwater Monitoring Information System (GGMS)
Deliver operational products	Deliver required information to users	G22 Implementation of new production streams in global reanalysis G23 Develop coupled reanalysis G24 Improve capability of long-range reanalysis G25 Implementation of regional reanalysis A14 Evaluation of benefits for GUAN A26 Development of methodology for consolidated precipitation estimates A40 Continuity of products of precursors of ozone and secondary aerosols O3 Data Quality O4 Development of climatologies and reanalysis products O12 Gridded ocean current products T29 Integrated analyses of snow T34 Mapping of seasonal soil freeze/thaw T70 Use of Inverse modelling techniques to support emission inventories

Actions to Promote Future Improvements

Category	Description	Actions
Improve observational techniques	Promote R&D activities to develop or demonstrate new or improved approaches Take advantage of new technologies	A23 Measurement of water vapour in the UT/LS A28 In-situ Profile and Radiation T71 Prepare for a carbon monitoring system
Design and plan new observational systems and networks	Plan in cooperation of new ECV products Consider redesign of existing networks	T12 National needs for river gauges T37 Quality of ground-based reference sites for FAPAR and LAI

Decision 24 (CBS-16)

VISION FOR THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM IN 2040

THE COMMISSION FOR BASIC SYSTEMS,

Recalling the *Abridged Final Report with Resolutions of the Sixty-sixth Session of the Executive Council* (WMO-No. 1136), general summary 4.4.7, with the request to the Commission for Basic Systems to lead the development of a "Vision for WIGOS in 2040",

Recalling also the adoption by Resolution 2 (EC-68) of the plan for the WIGOS pre-operational phase 2016–2019, which includes the development of such a Vision,

Recognizing the contributions from the Expert Team on Satellite Systems and the Inter-programme Expert Team on Observing System Design and Evolution in providing initial drafts of the "Vision for WIGOS space in 2040" and the "Vision for WIGOS surface in 2040", respectively,

Acknowledging the contributions made by many technical commission experts, representatives from regional associations and WIGOS partner organizations during two consultation workshops, namely "WIGOS Space 2040" in November 2015, and "WIGOS Surface 2040" in October 2016,

Acknowledging also the current drafts 1.0 of the "Vision for the WIGOS space-based component in 2040" (Part II of the report of the sixteenth session of the Commission for Basic Systems (CBS)), and the draft "Vision for the surface-based components of WIGOS in 2040" (Part II of the report of the sixteenth session of CBS),

Having considered the recommendations of the Implementation–Coordination Team on Integrated Observing Systems (*Final Report of the Ninth Session of the Implementation–Coordination Team on Integrated Observing Systems (ICT-IOS-9)*) with regard to the development of the Vision for the WIGOS component observing systems in 2040,

Notes the work in progress, and commends the Open Programme Area Group on Integrated Observing Systems (OPAG-IOS) for its efforts to develop the drafts of the space- and surface-based parts of the Vision;

Recommends that the current draft of the "Vision for the WIGOS space-based component observing systems in 2040" and the evolving draft "Vision for the WIGOS surface-based components in 2040" be used as the basis for further consultation with Members, satellite operators, and user communities, in line with the roadmap agreed by ICT-IOS;

Recommends that the Inter-commission Coordination Group on the WMO Integrated Global Observing System (ICG-WIGOS) take ownership of the further development of the Vision, including the work necessary for the integration of the two drafts into one coherent Vision document, with a view to have it approved by the Eighteenth Congress in 2019;

Requests OPAG-IOS to contribute to the further development of the Vision according to ICG-WIGOS guidance.

Decision 25 (CBS-16)

WMO INFORMATION SYSTEM SECURITY INCIDENT MANAGEMENT PROCESS

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) That the Commission for Basic Systems (CBS) at its thirteenth session emphasized the increasing security threats to networked systems that National Meteorological and Hydrological Services had to face and the potential impacts to specific sites as well as other interconnected sites, in particular for World Weather Watch systems (*Abridged Final Report with Resolutions and Recommendations of the Thirteenth Session of the Commission for Basic Systems* (WMO-No. 985), general summary 5.2.18),

(2) That the Sixteenth World Meteorological Congress requested CBS to pay particular attention to Internet security and continue to review and update related practices, procedures and guidelines (*Abridged Final Report with Resolutions of the Sixteenth World Meteorological Congress* (WMO-No. 1077), general summary 3.1.2.5),

(3) That the *Guide to Information Technology Security* (WMO-No. 1115) was established and maintained to assist Members in the management of IT security,

Recognizing:

(1) That WMO Members' systems have become increasingly interconnected to facilitate the exchanging of information via private and public networks,

(2) That responsibility for IT security is clearly with organizations operating IT systems,

(3) That information about security incidents needs to be handled with confidentiality and within the governing principles of differing national policies and practices,

Noting the draft security incident process produced by the Open Programme Area Group on Information Systems and Services (OPAG-ISS) and reviewed by the Inter-commission Task Team on the WMO Information System (WIS) (http://wis.wmo.int/file=3004),

Decides that there is a need for a security incident response process that can be used by organizations participating in the operation of WIS;

Requests OPAG-ISS:

(1) To continue the development of a common security incident management process that:

(a) Encourages a centralized and definitive view on security incidents, reduces misinformation and prevents individual Members from undue levels of queries;

(b) Provides a single and definitive national contact point for security incidents that will have the authoritative voice for organizations in that Member, increasing clarity and reducing misinformation;

(c) Accommodates requirements relating to the security incidents of all organizations participating in the operation of WIS;

(2) To provide a recommended process to the CBS Management Group for review and subsequent consideration by the Executive Council at its sixty-ninth session;

Requests the Secretary-General to provide the necessary support to the development and implementation of a common security incident management process;

Urges Members to participate in the development and implementation of a sustainable security incident management process.

Decision 26 (CBS-16)

SYSTEM MONITORING OF THE WMO INFORMATION SYSTEM

THE COMMISSION FOR BASIC SYSTEMS,

Recalling that the Commission for Basic Systems at its extraordinary session in 2014 encouraged the implementation of a pilot WMO Information System (WIS) monitoring system (*Abridged Final Report with Resolutions and Recommendations of the Extraordinary Session of the Commission for Basic Systems* (WMO-No.1140), September 2014, general summary 3.2.13),

Recognizing:

(1) That the Implementation Coordination Team on Information Systems and Services had successfully developed and demonstrated a pseudo-operational prototype WIS Monitoring Common Dashboard at the Global Information System Centres (GISCs) in Beijing and Tokyo, and a prototype dashboard at GISC Brasilia (http://wis.wmo.int/wis-monitor) that do not add to staff workloads in those centres being monitored,

(2) That the proposed WIS monitoring system involves three levels of monitoring: the WIS Common Dashboard for real-time monitoring of the status of WIS traffic flow and services; ad hoc reports on incidents or interruptions to WIS services; and routine biannual reports on system performance,

Decides:

(1) That the prototypes as demonstrated would meet the basic needs identified by the Commission at its extraordinary session in 2014 for monitoring of the WIS infrastructure as a global information system;

(2) That having at least two monitoring sites will ensure operational access to current and recent status of WIS centres;

Requests its Open Programme Area Group on Information Systems and Services:

(1) To make operational at least two WIS Monitoring Common Dashboards;

(2) To propose updates to the *Manual on the WMO Information System* (WMO-No. 1060) TechSpec-15 and associated use cases and guidance in the *Guide to the WMO Information System* (WMO-No. 1061) relating to the WIS Common Dashboard;

(3) To provide standard practice on the WIS Common Dashboard for inclusion in the *Guide to the WMO Information System*;

(4) To support development of an operational WIS monitoring system taking into account the recommendations of relevant expert teams, for example audit, metadata and WIS centres;

Requests the Secretary-General to provide the necessary support to the development and implementation of WIS system monitoring and updates to Manuals and Guides;

Urges Members operating WIS centres:

(1) To make WIS system monitoring operational;

(2) To work with the GISCs to supply the monitoring files in the agreed JSON format for the systems to be included in the common dashboard and reporting.

Decision 27 (CBS-16)

IMPLEMENTATION PLAN OF THE FUTURE SEAMLESS DATA-PROCESSING AND FORECASTING SYSTEM

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) Resolution 11 (Cg-17) – Towards a future enhanced integrated and seamless Data-processing and Forecasting System,

(2) Decision 55 (EC-68) – Implementation of the seamless Data-processing and Forecasting System,

Noting with satisfaction that the work to advance this initiative had been initiated at an expert meeting held in Geneva in February 2016, which was attended by representatives of technical commissions who had developed the draft vision, scope and white paper,

Noting further the development of a draft Data-processing and Forecasting System (DPFS) Imperative, which includes the white paper as an annex, and the draft implementation plan by the Steering Group on the Seamless DPFS, which met in Geneva in November 2016,

Acknowledging that Decision 55 (EC-68) endorsed the vision for the seamless DPFS, as provided in the annex to the present decision, and requested the Steering Group to complete the implementation plan for the process, for consideration by the Executive Council at its sixty-ninth session,

Mindful of the deadline for the submission of the implementation plan to the Executive Council at its sixty-ninth session,

Decides to speed up the process by using the results of the first and second meetings of the Steering Group on the Seamless DPFS (Geneva, February and November 2016, respectively);

Urges the Steering Group to make its first order of priority the completion of the white paper and the development of the implementation plan, which includes a communication plan, for tabling at the sixty-ninth session of the Executive Council;

Urges technical commissions and regional associations to provide their full support in addressing Resolution 11 (Cg-17);

Urges the Secretary-General to provide full support for the realization of this initiative;

Calls upon advanced GDPFS centres to assist the Steering Group with assessment of proof of concept of the seamless DPFS.

Annex to Decision 27 (CBS-16)

VISION FOR THE SEAMLESS DATA-PROCESSING AND FORECASTING SYSTEM AS APPROVED BY THE EXECUTIVE COUNCIL AT ITS SIXTY-EIGHTH SESSION

- The GDPFS will be an effective and adaptable monitoring and prediction system to enable Members and partners in supporting decision-makers to take better-informed decisions.
- The GDPFS will facilitate the provision of impact-based forecasts and risk-based warnings through partnership and collaboration.
- The GDPFS will do so through the sharing of weather, water, climate and related environmental data, products and services in a cost-effective, timely and agile way, with the effect of benefitting all WMO Members, while also reducing the gaps between developed and developing Members.

One may imagine the GDPFS in 2031, 16 years later:

- The overall accuracy of state-of-the-art global prediction models have improved enough to add 1.5 days of overall predictability, if the historical rate of progress of one day per decade is sustained: The goal set by Jule Charney and others when they launched GARP in the 1970s was achieved. Global models have resolutions below 5km, and mesoscale models significantly below 1km, down to a few tens of meters in urban areas for example.
- The sub-seasonal timescales are achieved, ensembles have routinely hundreds of members, shared between many global centres, and forecast products provide accurate and detailed information on such things as closed water budgets over most watersheds, wind, temperature and air quality information in urban street canyons and outwards to the surrounding country side, finely detailed agromet information from hourly cycles to seasonal, precise storm surges and wind damage estimates for cyclone landfall, sea state, including rogue waves, and dangerous shore currents, telecommunications and electricity blackouts from solar eruptions form the surface to satellites orbital heights, toxic algae blooms , pest migrations, etc.
- Most or even all this information are accessible as a public good product to all WMO Members, and their partners, and most of this information is available either in raw format, or directly as impact information. It is disseminated and presented in accordance with user's formats, and using point-to-point or, increasingly, cloud to point communication broadband technologies. It is quality controlled, validated and have metadata information associated, and in the case of forecast information, it is verified. Imbedded in the design of the system is a two-way feedback real-time communication capacity between the provider and the receiver of the data.
- The system has evolved through partnership agreements that allow it to absorb or carry information produced either by the private sector, or by other closely related organizations to the traditional NMHSs.

Decision 28 (CBS-16)

OPEN PROGRAMME AREA GROUP ON THE DATA-PROCESSING AND FORECASTING SYSTEM WORKPLAN

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) Resolution 11 (Cg-17) – Towards a future enhanced integrated and seamless WMO Data-processing and Forecasting System,

(2) Decision 55 (EC-68) – Implementation of the seamless Data-processing and Forecasting System,

(3) The decision of the Commission for Basic Systems (CBS) Management Group, at its meeting in February 2016, to assign the responsibility of the Inter-programme Team on Space Weather Information Systems and Services (IPT-SWeISS) to the Open Programme Area Group on Data-processing and Forecasting Systems (OPAG-DPFS),

Noting with satisfaction that all OPAG working groups (the Implementation Coordination Team, expert teams, task teams, and the Steering Group for the Severe Weather Forecasting Demonstration Project) met before the sixty-eighth session of the Executive Council, to define their workplans for the next intersessional period,

Noting further that OPAG-DPFS is comprised of the following expert teams: Operational Weather Forecast Process and Support, Operational Prediction from Sub-seasonal to Longer-time Scale, Emergency Response Activities, and the recently added IPT-SWeISS,

Considering that the report of the meeting of the ICT of OPAG-DPFS (ICT-DPFS) held in Exeter, United Kingdom of Great Britain and Northern Ireland, from 23 to 27 May 2016, consolidated key activities and milestones, including a set of recommendations to CBS,

Mindful that some of the recommendations were already addressed in Recommendations 19–21 (CBS-16),

Decides to endorse the workplan and the adjusted recommendations of ICT-DPFS (ICT meeting report) as provided in the annex to the present decision;

Invites technical commissions and regional associations to collaborate with OPAG-DPFS for the realization of the objectives;

Requests the Secretary-General to facilitate the work of OPAG-DPFS experts teams.

Annex to Decision 28 (CBS-16)

OPEN PROGRAMME AREA GROUP ON THE DATA-PROCESSING AND FORECASTING SYSTEM KEY OBJECTIVES, MILESTONES AND RECOMMENDATIONS TO THE COMMISSION FOR BASIC SYSTEMS AT ITS SIXTEENTH SESSION

OPAG – DPFS Key Objectives			
1. Implementation of the revised *Manual of the GDPFS* (WMO-No. 485) **2. Working with the Steering Group on Seamless DPFS to develop a Strategy for the future DPFS** **3. Evolution of the DPFS to facilitate implementation of impact-based forecasting and risk-based warnings**			
Expert Teams	**Activities**	**Milestones**	**Recommendation to CBS-16**
ET-OPSLS	• Workshops on Operational Climate Prediction • Guidelines on procedures for generating regional seasonal forecasts • Implementation of sub-seasonal forecasts • Designation of LC-NTCP	Q4, 2017 2018 2019 2017	• Include in the revised *Manual on GDPFS*, the designation criteria for Lead Centre for Near Term Climate Prediction (already included in the new Manual for approval, under Decision 11 (CBS-16)
ET-OWFPS	• Verification methods for high-resolution models • Use of additional observation types for verification • Calibration of model output • Exchange of EPS products • Implications throughout forecast chain for high-resolution NWP including data assimilation • Implementation of new Manual of GDPFS • Impact-based forecasting for land transportation and mega cities • Rolling review of user		• Establish a small TT (working by teleconference) to develop the draft questions/template, for gathering information for the development of the content of the annual report. Production of annual report to be made using CPDB • Collaborate with CAS to develop capabilities for Air Quality forecasting and its future transition to operations. Consideration should be given to the establishment of a Task team on Operational Air Quality to assist with the work • Ensure that the Severe Weather Forecasting Demonstration Project (SWFDP) should continue to take a leading role in exploiting the Cascading Forecasting Process for a wider range of hazards in collaboration with other TCs and projects (e.g. CIFDP, FFGS) • Consider expanding the SWFDP process to cover a wider range of

	requirements • Partnerships to ensure success of integrated service delivery • Impact-based forecasts and risk-based warnings: need for products, interpretation, communication • Cascading forecast process and seamless approach		hazards and applications, and to move towards global coverage. This expansion consideration should include a WMO Multi-Hazard Impacts Programme based on the cascading forecasting process should be considered
ET-ERA	• Migration from fax to e-mail distribution of RSMC products • Develop and test new products as well as Ensemble and Transfer Coefficient Matrix (TCM) methods for atmospheric transport and dispersion modelling • Continue to develop non-nuclear ERA		• Agree to the use of CPDB (Country Profile Database) to capture NMHSs e-mail information that RSMCs can use to notify them for the availability of products issued • Invite Members to provide adequate resources (people) to facilitate the completion of the work related to the development of new products as well as of the Transfer Coefficient Matrix (TCM) methods for atmospheric transport and dispersion modelling

Decision 29 (CBS-16)

FURTHER IMPLEMENTATION OF THE WMO STRATEGY FOR SERVICE DELIVERY

THE COMMISSION FOR BASIC SYSTEMS,

Mindful that delivering essential meteorological, climatological and hydrological services saves lives and livelihoods, improves the quality of life and enhances national economies, and that effective service delivery increases the credibility and support of National Meteorological and Hydrological Services (NMHSs) by governments,

Recalling:

(1) Resolution 2 (Cg-17) – Implementation of the WMO Strategy for Service Delivery,

(2) Decision 42 (EC-68) – Implementation of the WMO Strategy for Service Delivery, through which the Executive Council requested the Commission for Basic Systems (CBS) to identify a mechanism to coordinate and guide the implementation of the Strategy as requested by the Seventeenth World Meteorological Congress (Resolution 2 (Cg-17)) and make proposals in this regard to the joint meeting of presidents of regional associations and presidents of technical commissions in 2017, and to the Executive Council at its sixty-ninth session,

Acknowledging the urgent need for WMO to focus on and assist Members to raise the levels of service delivery by their NMHSs,

Recognizing that while there may be differences in the particular areas of focus of different types of services, and mindful that an important role of NMHSs is to provide forecasts, warnings and advice for the preservation of life and property, a harmonized approach to the accepted principles of high-quality service delivery needs to be adopted, and that in order to provide the required assistance to Members, service delivery as a discipline should be mainstreamed into the activities of WMO,

Recognizing further that there is a need to deliberate on how best to address requirements related to service delivery identified by other work areas of CBS and WMO programmes in order to provide guidance and support to Members on issues related to consistent delivery of operational services,

Agrees that the public weather services (PWS) capabilities of Members need to be upgraded and strengthened on a continuous basis to cope with the optimum delivery of new services, ranging from day-to-day operations to providing guidance informing decision-makers and policymakers on longer timescales;

Considers that collaboration with other technical commissions on establishing mechanisms and structures that promote the fundamentals of good service delivery across all aspects of the work of Members would greatly assist progress in this area;

Decides to endorse and to implement the workplan as provided in the annex to the present decision as likely steps to achieve such a harmonized approach to service delivery;

Urges Members, with the support of the Secretariat, to implement the Strategy as a cross-cutting framework and implement a quality management framework to significantly improve the delivery of weather, climate and hydrological services, thus contributing to more effective outcomes of their key national activities such as PWS, the Global Framework for Climate Services, and disaster risk reduction;

Requests the Secretary-General:

(1) To facilitate and support the achievement of a WMO-wide approach to service delivery as endorsed by CBS;

(2) In view of the enthusiastic response by those Members that have received in-country training piloted by the PWS Programme, to support Members, especially in developing countries and least developed countries, to improve their service delivery levels as defined in the Strategy, through a similar in-country training approach that includes a training mechanism to render the in-country approach scalable.

Annex to Decision 29 (CBS-16)

FURTHER IMPLEMENTATION OF THE WMO STRATEGY FOR SERVICE DELIVERY

Workplan for the improvement of Service Delivery of Members

Mechanisms for promoting the WMO-wide improvement of Service Delivery

Role of CBS, and in particular the OPAG/PWSD

Noting that the WMO Strategy for Service Delivery was developed in consultation with the OPAG/PWSD, and that the mandate for CBS includes "technical guidance on basic infrastructure to support all services" it is evident that CBS, through the OPAG/PWSD, has a role in promoting high-quality service delivery across all areas of WMO responsibility, and not just in Public Weather Services. It is also evident that CBS should respect the mandate of other technical commissions in their own areas of competence, and use mechanisms such as coupled Expert Teams to ensure appropriate coordination. Thus the achievement of a holistic WMO-wide approach to Service Delivery at technical commission level must be via cooperation and collaboration and should start within CBS itself. Mindful of this, CBS-16 agreed that a viable approach to achieving progress could be as follows:

(a) As a first step establish a mechanism within CBS to address the development of a harmonized and joined-up approach to service delivery within the OPAGs of the Commission;

(b) Initiate and conduct informal discussions with representatives of the other technical commissions to examine the possibilities for a concerted approach to this issue;

(c) Work with the presidents of technical commissions (PTC) to define and support a consistent value chain across the Technical Commissions, thereby developing and promoting WMO-wide expert guidance on Service Delivery practices;

(d) From consideration of these options, develop proposals to bring to Congress in 2019 with recommendations as to the best way forward;

(e) Proposals and recommendations on the corresponding realignment of the WMO[1] Programme structure may also need to be developed and brought forward, through the PTC, to the Executive Council for its consideration.

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[1] See Part II of the CBS sixteenth session report "Review of Strategy for Integrated Service Delivery and Supporting Integrated Systems" proposing means for more effective delivery of services related to WMO Programmes.

Decision 30 (CBS-16)

PROVISION OF MULTI-HAZARD IMPACT-BASED FORECAST AND WARNING SERVICES

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) Resolution 2 (Cg-17) – Implementation of the WMO Strategy for Service Delivery,

(2) Resolution 5 (Cg-17) – Public Weather Services Programme,

(3) Resolution 21 (Cg-XV) – Strategy for the Enhancement of Cooperation between National Meteorological and National Hydrological Services for Improved Flood Forecasting,

(4) Decision 5 (EC-68), through which the Executive Council requested the Commission for Basic Systems, in coordination with other technical commissions, to initiate at its sixteenth session (November 2016) as a matter of urgency, through its Open Programme Area Group on Public Weather Services (OPAG-PWS), the preparation of practical guidance materials based on the *WMO Guidelines on Multi-hazard Impact-based Forecast*

and Warning Services (WMO-No. 1150) and the experience gained from the in-country activities, for the step-by-step implementation of multi-hazard impact-based forecast and warning services by National Meteorological and Hydrological Services (NMHSs) as a contribution to the implementation of the WMO Strategy for Service Delivery,

Acknowledging that while much has been done by WMO to build infrastructure and improve modelling capabilities to enhance forecast products, developments in understanding the impacts of hazards have not always matched the improvement in technical capabilities,

Welcoming the acknowledgement by many Members of the importance of improving the understanding of the potential impacts of high-impact and severe meteorological and hydrological events, and that a path that identifies the various stages from weather forecasts and warnings to multi-hazard impact-based forecasts and warnings needs to be laid out,

Recognizing that due to the complex nature of the subject, the best way to demonstrate the steps needed to progress towards impact-based forecasts is through pilot projects and training for implementation by Members,

Agrees that this new area of service delivery by NMHSs needs to be developed on a sustainable and long-term country assistance basis, requiring expertise, resources, patience and persistence, and above all willingness to collaborate and share information and know-how by NMHSs to be built on scoping activities and lessons learnt, and to accelerate assistance to Members on the implementation of multi-hazard impact-based forecasts and warnings;

Considers the key components in the success of impact-based forecasts and warnings as: (1) engagement of stakeholders to establish concrete requirements; (2) integration of social sciences throughout the end-to-end service delivery process; (3) two-way collaboration between research, technology and science communities, and NMHSs, to ensure that user requirements are conveyed and acted upon; and (4) recognition of the fundamental role of partnerships in success of this new way of service delivery;

Decides:

(1) That efforts need to be enhanced for more rapid realization of impact-based forecast and warning services through the development of a strategy for implementation of such services;

(2) That such an implementation strategy should be WMO-wide and applicable to all activities and programmes that have a role in generating impact-based services, with inputs from relevant technical commissions and WMO programmes, as well as stakeholders and development partners that share the interests and concerns of WMO in this subject;

Requests OPAG-PWS:

(1) Through its Expert Team on Impact-Based Forecasting and Risk-Based Warning, to initiate the development of an implementation strategy describing the actionable steps in impact-based forecast and warning services, building on the *WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services*;

(2) To arrange for a review of the PWS Competency Framework to ensure that it adequately addresses those skills required for the delivery of this new service;

Requests the Secretary-General:

(1) To continue with efforts to assist Members with the introduction of methodologies and principles for the implementation of multi-hazard impact-based forecasts and warnings; to ensure that calls for assistance from Members in this regard are responded to

expeditiously and through practical implementation to scale up the projects that have already been initiated to other countries;

(2) To facilitate the timely preparation of an implementation strategy based on the *WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services*, with adequate representation from among stakeholders, in particular disaster response and management agencies, relevant programmes and technical commissions, and WMO development partners with common interest and concern in this area, including the World Bank, to be published by the end of 2017.

Decision 31 (CBS-16)

APPLICATION OF EMERGING TECHNOLOGIES IN THE CONTEXT OF PUBLIC WEATHER SERVICES

THE COMMISSION FOR BASIC SYSTEMS,

Recalling Resolution 5 (Cg-17) – Public Weather Services Programme,

Acknowledging that due to advances in technology and communications, which have revolutionized the way environmental information is collected, integrated, disseminated and shared through multichannel delivery methods, posing significant challenges to National Meteorological and Hydrological Services (NMHSs) in delivering consistent authoritative information, the expectations of users have been raised to such levels that they anticipate such information to be delivered to them when and where they want it, in their preferred formats, and customized to their needs,

Recognizing that the rapid development of technologies such as sophisticated graphical formats, the ability to integrate weather information with other spatial data leading to the need to provide weather information in GIS-compatible formats, mobile apps, web-based services, social networks, automated alerting systems, the Common Alerting Protocol format for warning messages, and its integration into the World Weather Information Service and Severe Weather Information Centre websites, affects every link in the chain that brings weather information to the user and allows the provision of location-specific and tailored weather information for the public, presenting challenges but also opportunities for NMHSs, particularly with respect to the delivery of time-sensitive warning information for public safety,

Recognizing further that other new and emerging technologies such as nowcasting and utilization of big data for monitoring and assessing impacts of severe weather through using crowd-sourced data will have considerable implications for service provision and delivery and will require guidance for Members on their application,

Decides that the Open Programme Area Group on Public Weather Services Delivery, working in collaboration with other efforts within the Commission for Basic Systems (CBS), including the CBS-led review of emerging data issues, and cognisant of related efforts within the Executive Council, will consider and integrate the rapid and efficient application of new and emerging science and technology to improve service delivery in order to meet emerging demands for new products and services in accordance with the WMO Strategic Plan, the thematic areas identified above, and other needs which may yet emerge;

Calls on Members to embrace opportunities offered by new and emerging technologies so as to enable their NMHSs to provide the best possible consistent and authoritative weather information and services to users;

Urges Members to integrate improved science, new technologies and applications to expand decision support services;

Requests the Secretary-General to support the coordination of the efforts of Members in applying these technologies in order to stay agile and to evolve as new technologies mature and older technologies are replaced.

Decision 32 (CBS-16)

ASSESSMENT OF SOCIAL AND ECONOMIC BENEFITS OF METEOROLOGICAL AND HYDROLOGICAL SERVICES

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) Resolution 5 (Cg-17) – Public Weather Services Programme,

(2) Decision 85 (EC-68) – Preparations for an international conference on the socioeconomic benefits of National Meteorological and Hydrological Services – through which the Executive Council endorsed the approach of WMO to organize an international conference on socioeconomic benefits of meteorological and hydrological services as a substantive, focused, time- and cost-efficient, and results-oriented event,

Recognizing that many Members are still in urgent need of:

(1) A clearer demonstration of the necessity of continued support for the observational and data processing infrastructure, and their capacity to provide essential public information, forecast and warning services to their national communities,

(2) More rigorous and widely understood demonstration of the socioeconomic benefits of the services they provide to governments, public and private sectors,

(3) A more systematic basis for prioritizing the use of available funding for infrastructure and service development and improvement,

Noting that a multi-stakeholder conference will bring together government policymakers and political leaders, scientists, including those from social sciences, National Meteorological and Hydrological Services, United Nations partners, development agencies, economists, urban management, private sector investors, users and other stakeholders, to explore how to scale up investment and innovation in weather, climate and hydrological knowledge in order to tackle immediate risks and inform long-term plans and investments,

Noting also the aims and objectives of the conference as endorsed by the Executive Council and provided in the annex to the present decision,

Noting further that the venue of the conference has yet to be identified and that the Executive Council encouraged Members to consider hosting the event in either late 2017 or 2018,

Invites Members of the Commission for Basic Services to actively participate in and contribute to the conference through providing case studies and research that they have undertaken in determining the social and economic benefits of their services to users.

Annex to Decision 32 (CBS-16)

INTERNATIONAL CONFERENCE ON THE SOCIOECONOMIC BENEFITS OF NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES

INVESTING TODAY FOR THE FUTURE WE WANT: LEVERAGING THE BENEFITS OF WEATHER AND CLIMATE SERVICES

Venue and Date to Be Determined

Overview

Weather and climate services* have never been more in demand to protect people, planet and prosperity. Society, technology and the global environment are changing at a remarkable speed, generating new challenges and new opportunities. Shifting climate conditions, accelerating urbanization, rising expectations for safety and security, and a greater need for resilience now require more and better weather, climate, hydrological and related environmental information for effective risk-informed decision-making. The private sector is increasingly playing a role. At the same time, however, meeting the growing demand is complicated, and public budgets are under pressure.

These overarching challenges and opportunities helped fuel the 2030 Agenda for Sustainable Development, the Sendai Framework for Disaster Risk Reduction and the 2015 Paris Agreement on climate change. These agreements will serve as the centrepiece for national and international policymaking over the next 15 years.

Looking forward, demand will only grow. Weather and climate services supplied by National Meteorological and Hydrological Services (NMHSs) and other institutions have a critical role to play in the decades ahead in assisting countries to successfully pursue the Sustainable Development Goals, as well as myriad other priorities. These services will be ever more important to support sustainable growth, to save lives and to promote human well-being on a daily basis and in a cost-effective manner. Studies show that investments in NMHSs infrastructure deliver benefits in the order of 10 to 1.

How, in our rapidly evolving world, can weather and climate service providers best continue to aid countries to manage risk and maximize opportunity? Where, how and when are investments needed to most efficiently realize service benefits?

In response to these developments and questions, WMO and its partners are convening a conference to bring together national, regional and global leaders, stakeholders and experts to discuss how best to leverage the benefits of weather and climate services to address today's and tomorrow's most pressing needs. Sessions will draw on experts from cross-cutting fields such as disaster risk reduction, urban management, climate adaptation and mitigation, and other sectors to look at how weather and climate services can effectively help us reach global goals for food security, public health, sustainable water management, affordable and clean energy and sustainable urbanization.

* Weather, climate, hydrological, marine and other related environmental services

Purpose

The conference will:

- Increase our understanding of how weather and climate services empower countries to address today's most pressing needs
- Create a shared vision of the path forward for delivering high-quality, value-added weather and climate services that help countries manage multiple risks and maximize key opportunities, today and tomorrow, through:
    - impact-based decision support services
    - cutting-edge science and technology
    - multi-hazard early warning systems
    - innovative and sustained climate services
    - gender-sensitive services
- Identify priorities for investment
- Build multi-stakeholder partnerships to develop the needed products and services

Participants

The Conference will bring together policymakers and political leaders from community, national and regional levels, along with other stakeholders such as natural and social scientists, UN partners, development agencies, civil society, business and diverse users.

History

This conference will build on the results of the 2007 *International Conference on Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate and Water Services* in Madrid, Spain. The outcomes of that event, the Madrid Conference Statement as well as the Madrid Action Plan, have served for the past decade as a comprehensive strategy for enhancing the applications and benefits of meteorological and hydrological services around the world. The Statement and Action Plan have guided the efforts of NMHSs to enhance their capacity to respond to the changing needs of society, increasing the utility of services provided to a broad spectrum of users. Case studies and research documenting the benefits of hydrometeorological services can be found in the 2015 WMO/World Bank publication *Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services* (WMO-No. 1153).

Other efforts that will inform the upcoming conference include two recent major works. The first, the 2014 *WMO Strategy for Service Delivery and its Implementation Plan* (WMO-No. 1129), focuses on achieving excellence in the provision and delivery of services. The second, the 2015 *WMO Guidelines on Multi-hazard Impact-based Forecast and Warning Services* (WMO-No. 1150), provides guidance and assistance to NMHSs and their key stakeholders on the design and implementation of a system to inform them of the actual impacts of meteorological and hydrological hazards.

Contributions

WMO is open to financial and in-kind contributions in support of the conference.

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JN 16659

Decision 33 (CBS-16)

EXPERT TEAMS OF THE COMMISSION FOR BASIC SYSTEMS

THE COMMISSION FOR BASIC SYSTEMS,

Having considered the work required by the Commission for Basic Systems (CBS) during the period 2016–2020,

Noting:

(1) New or changed priorities for the work by CBS may arise during the period 2016–2020,

(2) During the period 2012–2016, its teams had made increasing and effective use of collaboration tools including tele- and video-conferencing,

(3) Regulation 33 of the WMO General Regulations (2015 edition),

(4) That disaster risk reduction activities need close coordination between the open programme area groups (OPAGs) and between CBS and other constituent bodies,

Decides:

(1) To establish the expert teams with the terms of reference listed in Annex 1 to the present decision;

(2) In order to assist the CBS coordinator on disaster risk reduction to establish the coordination team with the terms of reference listed in Annex 2 to the present decision;

(3) That the leadership of the expert teams be as listed in Annex 3 to the present decision;

(4) That the expert teams may, at the discretion of their chairperson, organize their work using task teams drawn from a subset of their members to address specific topics;

(5) That chairpersons of CBS OPAGs may, with the endorsement of the president of CBS, establish task teams of limited duration to address specific aspects of the work plan of their OPAG that cannot be delivered by the expert team;

(6) That the CBS Management Group may change the terms of reference of the expert teams, disband expert teams and form new expert teams as required to deliver the work of CBS;

(7) That the membership of expert teams should be drawn from experts nominated by Members and cooperating international organizations;

(8) That nominated experts may be invited to join any team;

Decides that the CBS Management Group Task Team on Migration of Upper-air Reports to Table-driven Code Forms with the terms of reference and membership listed in Annex 4 to the present decision should continue to work by correspondence until it has presented its recommendations to the CBS Management Group;

Requests its Management Group to manage the CBS expert teams to meet the needs of the work of CBS, adjusting the number of teams, their terms of reference and their leadership and membership as required;

Requests its expert teams:

(1) To present their work plans to the CBS Management Group for endorsement;

(2) To organize their work to be efficient, effective and economic, making use of collaborative working tools and tele- or video-conferencing whenever feasible;

Invites cooperating international organizations to contribute to the work of CBS that impacts on their areas of operation;

Urges Members to make experts available to support the work of CBS.

Annex 1 to Decision 33 (CBS-16)

TERMS OF REFERENCE FOR EXPERT TEAMS OF THE COMMISSION FOR BASIC SYSTEMS

Open Programme Area Group on Integrated Observing Systems

Implementation–Coordination Team on Integrated Observing Systems (ICT-IOS)

(a) Contribute to the implementation of the WMO Integrated Global Observing System (WIGOS), in response to WMO Strategic Planning, and guidance from CBS, ICG-WIGOS and in coordination with other relevant WMO Programmes and TCs and provide relevant advice and support to the president of CBS;

(b) Coordinate the work of the OPAG-IOS Expert Teams, Inter-Programme Expert Teams, Steering Groups and Coordinators, provide advice to the work of these groups and report on results to the Commission for Basic Systems; in particular with regard to the Capacity Development Strategy and the WMO Programme for the Least Developed Countries;

(c) In cooperation with CIMO, give guidance to the CIMO IPET on Operational Weather Radar;

(d) Monitor, report and make recommendations regarding the development of the composite observing systems under WIGOS and their capability to meet the requirements of all relevant WMO and co-sponsored programmes; and contribute to the WIGOS priority areas of the pre-operational phase;

(e) Review deficiencies in coverage and performance, including cost-effectiveness, of the existing GOS; make proposals to improve the availability and coverage of data to meet stated requirements; monitor and report on progress in the evolution of the GOS; coordinate with the GCOS implementation activities;

(f) Coordinate and consolidate the development of standardized high quality observing practices and prepare related recommendations;

(g) Coordinate and assess impact studies and provide recommendations and guidance on the evolution of global and regional observing networks;

(h) Oversee and review the development and operation of OSCAR to ensure that it meets the needs of WIGOS;

(i) Contribute to strengthening the collaboration between CBS and the regional associations by increasing engagement with regional experts;

(j) To coordinate, as needed, CBS observations implementation aspects of the GEOSS Implementation Plan and report to the Management Group on activities that can contribute to the development and implementation of GEOSS.

OPAG-IOS Inter-Programme Expert Team on Observing System Design and Evolution (IPET-OSDE)

(a) Under the direction of the Chairperson of the OPAG-IOS, undertake tasks and provide advice on and support for the implementation of the WIGOS framework and the priority activities of the WIGOS pre-operational phase; in particular:

(i) Review and report on the observational data requirements of application areas within the scope of WIGOS;

(ii) Review and report on the capability of both surface-based and space-based systems that are components or candidate components of the evolving observing systems within the scope of WIGOS;

(iii) Carry out the rolling requirements review of application areas leading to Statements of Guidance concerning the extent to which present and planned observing systems meet user requirements for observations;

(iv) Review the implications of the Statements of Guidance concerning the strengths and deficiencies in the existing observing systems and evaluate the capabilities of new observing systems and possibilities for improvements and efficiencies;

(v) Carry out impact studies of real and hypothetical changes to observing systems with the assistance of NWP centres;

(vi) Monitor and report progress against the Implementation Plan for Evolution of Global Observing Systems, based on the "Vision for the GOS in 2025"; identify new actions as necessary, taking into account developments within WIGOS;

(vii) Support ICG-WIGOS in the preparation of a "Vision for the observing system components of WIGOS in 2040";

(viii) Contribute to further elaboration of WIGOS guidance regarding observing network design;

(ix) Promote activities which enhance progress against the Implementation Plan for Evolution of Global Observing Systems;

(x) Oversee and review the following aspects of the development and operation of OSCAR so that it meets the needs of WIGOS and in particular:

(1) Define and maintain the functional requirements for the tools required to support the Rolling Review of Requirements process;

(2) Review the content of OSCAR required to support the Rolling Review of Requirements process, including the observational requirements for application areas, and take prompt action to remedy deficiencies that are identified;

(b) Prepare documents to assist Members, technical commissions, and regional associations, summarizing the results from the above activities;

(c) Provide advice and support to the chairperson of OPAG-IOS, and report on all activities relevant to its Terms of Reference.

Expert Team on Aircraft Based Observing Systems (ET-ABO)

(a) Under the direction of the chairperson of the OPAG-IOS, undertake tasks and provide advice on and support for the implementation of the WIGOS framework and the priority activities of the WIGOS pre-operational phase;

(b) In collaboration with the CIMO Expert Team on Aircraft-based Observations, manage and coordinate the Aircraft Based Observations (ABO) programme, including the development and implementation of the ET-ABO workplan and the budget for the corresponding expenditure of the AMDAR Trust Fund in line with its Terms of Reference;

(c) Provide technical and scientific resources in support of further development of the Aircraft Based Observing System and assist in ABO training and outreach activities, and contribute to the CIMO ET-AO activities;

(d) Oversee and assist in the maintenance, enhancement and optimization of the Aircraft Based Observing System, including the AMDAR observing system, in line with the requirements of Members and the recommendations and actions of the EGOS-IP;

(e) Coordinate the development and maintenance of the ABO quality monitoring system as a component of the WIGOS Data Quality Monitoring System;

(f) Oversee the development and review of OSCAR so that it meets the needs of WIGOS for information concerning aircraft-based observing capabilities;

(g) Coordinate with and report to the work groups of CBS and other technical commissions as appropriate and relevant to the ET-ABO workplan and as directed by the chairperson of the OPAG-IOS;

(h) Provide advice and support to the chairperson of OPAG-IOS, and report on all activities relevant to its Terms of Reference.

Steering Group on Radio-frequency Coordination (SG-RFC)

(a) Under the direction of the chairperson of the OPAG-IOS, undertake tasks and provide advice on and support for the implementation of the WIGOS framework and the priority activities of the WIGOS pre-operational phase;

(b) Review allocations of radio frequency bands and frequency assignments of systems and applications for meteorological activities including their operational requirements (telecommunications, instruments, sensors, etc.) and research purposes, in close coordination with other technical commissions, especially CIMO, and the CBS/OPAG-ISS;

(c) Coordinate with WMO Members, with the assistance of the WMO Secretariat, to:

    (i) Ensure the availability of radio-frequency spectrum to meteorological and other environment monitoring radiocommunication services;

    (ii) Ensure the proper notification and registration of frequency assignments used for meteorological purpose;

    (iii) Identify the future use of the radio-frequency spectrum for meteorological purpose;

(d) Keep abreast of the activities of the Radiocommunication Sector of the International Telecommunication Union (ITU-R), and in particular of the Radiocommunication Study Groups, on radio frequency matters pertaining to meteorological activities, and represent WMO in ITU-R work;

(e) Prepare and coordinate proposals and advice to WMO Members on radio regulation matters pertaining to meteorological activities in ITU Radiocommunication Study Groups, radiocommunication Assemblies (RA), World Radiocommunication Conferences (WRC) and related global and regional preparatory meetings;

(f) Facilitate the cooperation among WMO Members for the use of frequency bands allocated to meteorological and environment monitoring radiocommunication services with respect to:

    (i) Coordination of radio-frequency spectrum use and frequency assignments between countries;

(ii) Sharing the same frequency bands between various radiocommunication services;

(g) Facilitate the coordination of WMO frequency use activities with other international organizations which address radio spectrum management issues, including specialized organizations (e.g. CGMS, the Space Frequency Coordination Group (SFCG)) and regional telecommunication organizations, such as the European Conference of Postal and Telecommunications Administrations (CEPT), the Inter-American Telecommunication Commission (CITEL), the Asia-Pacific Telecommunity (APT), the Regional Commonwealth in the Field of Communications (RCC); the African Telecommunication Union (ATU), and the Arab Spectrum Management Group (ASMG);

(h) Assist WMO Members, upon request, on issues related to the assignment of frequency bands to radiocommunication systems;

(i) Increase the understanding of the role of NMHSs in radio frequency coordination and the importance of the close collaboration with the ITU Radiocommunication Sector (ITU-R) and the Telecommunication Development Sector (ITU-D) in the accomplishment of the WMO priority activities, and in particular review and propose updates to the WMO *Guide to Participation in Radio Frequency Coordination* (WMO-No. 1159), and the WMO/ITU Handbook on the "Use of radio spectrum for meteorology: weather, water and climate monitoring and prediction";

(j) Provide advice and support to the chairperson of OPAG-IOS, and report on all activities relevant to its Terms of Reference.

Expert Team on Surface-based Observing Systems (ET-SBO)

(a) Under the direction of the chairperson of the OPAG-IOS, undertake tasks and provide advice on and support for the implementation of the WIGOS framework and the priority activities of the WIGOS pre-operational phase;

(b) Develop and update relevant elements of the WIGOS Regulatory and Guidance materials, including the Manual and the Guide to the GOS and incorporating WIGOS data quality monitoring system recommendations;

(c) Monitor and assess the status of operational and planned surface-based observing systems and advise how Members could submit related information in OSCAR/Surface;

(d) In collaboration with IPET-OSDE, assess the contribution of current and planned SBO systems to meeting user requirements for all Application Areas;

(e) Contribute to the delivery of those EGOS-IP actions identified as priorities by OPAG-IOS;

(f) Monitor the status of operational networks of SBO systems, promote best practice among WMO Members and provide advice on operational matters;

(g) Oversee the development and review of OSCAR so that it meets the needs of WIGOS for information concerning surface-based observing capabilities;

(h) Provide advice and support to the chairperson of OPAG-IOS, and report on all activities relevant to its Terms of Reference.

Coordinator on Marine Observing Systems (C-MAR)

(a) Under the direction of the chairperson of the OPAG-IOS, undertake tasks and provide advice on and support for the implementation of the WIGOS framework and the priority activities of the WIGOS pre-operational phase;

(b) Collect information on the status of marine (i.e. marine meteorological and oceanographic) observations from the JCOMM approved sources;

(c) Liaise with appropriate JCOMM Expert Teams, Groups, Observation Panels (DBCP, SOT, GLOSS), and associated Programmes (Argo, IOCCP, OceanSITES) to ensure that the

actions from the EGOS-IP are being addressed and that JCOMM Implementation Goals are being considered by the OPAG-IOS;

(d) Liaise with the Rolling Review of Requirements point of contact for Ocean Applications concerning user requirements and gap analysis;

(e) Keep abreast of developments in marine observing systems and advise the chairperson of ICT-IOS on coordinated assessment and implementation developments;

(f) Oversee the development and review of OSCAR so that it meets the needs of WIGOS for information concerning marine meteorological and oceanographic observing systems capabilities;

(g) Provide advice and support to the chairpersons of OPAG-IOS and IPET-OSDE, and report on all activities relevant to their Terms of Reference.

Coordinators on scientific evaluation of impact studies undertaken by NWP centres (C-SEIS)

(a) Under the direction of the chairperson of the OPAG-IOS, undertake tasks and provide advice on and support for the implementation of the WIGOS framework and the priority activities of the WIGOS pre-operational phase;

(b) Prepare and maintain reviews of OSEs, OSSEs and other observational data impact studies undertaken by various NWP centres around the globe and provide information for consideration by the OPAG-IOS;

(c) Organize regular workshops on the Impact of Various Observing Systems on Numerical Weather Prediction and chair the organizing committee;

(d) Provide input to the ICT-IOS and the IPET-OSDE relevant for the evolution of the WIGOS observing system components;

(e) Provide advice and support to the chairperson of OPAG-IOS, and report on all activities relevant to its Terms of Reference.

Expert Team on Satellite Systems (ET-SAT)

(a) Under the direction of the chairperson of the OPAG-IOS, undertake tasks and provide advice on and support for the implementation of the WIGOS framework and the priority activities of the WIGOS pre-operational phase;

(b) Assess and document, in the framework of the WMO Rolling Review of Requirements, the actual and planned capabilities of operational and R&D satellites constituting the space-based component of WIGOS and their adequacy to meet the WMO requirements for satellite data and products. This will be achieved in considering the information provided by participating agencies as well as the outcome of the Coordination Group for Meteorological Satellites (CGMS) and the Committee on Earth Observation Satellites (CEOS), including, for example, the progress of CEOS constellations. The feedback from WMO should be communicated to CGMS and CEOS;

(c) Provide technical advice with respect to both operational and R&D environmental satellites to assist in the implementation of integrated WMO-coordinated observing systems;

(d) Assess progress of R&D and demonstration satellite systems, and identify opportunities and/or problem areas concerning satellite technology and plans;

(e) Oversee the development and review of OSCAR so that it meets the needs of WIGOS for information concerning space-based observing systems capabilities for both programmatic and technical aspects of the systems;

(f) Coordinate with IPET-SUP and other relevant teams on satellite related matters;

(g) Provide advice and support to the chairperson of OPAG-IOS, and report on all activities relevant to its Terms of Reference.

Inter-Programme Expert Team on Satellite Utilization and Products (IPET-SUP)

(a) Under the direction of the chairperson of the OPAG-IOS, undertake tasks and provide advice on and support for the implementation of the WIGOS framework and the priority activities of the WIGOS pre-operational phase;

(b) Monitor the progress of satellite data availability and use by WMO Members, related issues and expectations, with the aim to publish findings and recommendations in a WMO document;

(c) Coordinate with ET-SAT and IPET-OSDE on the evolution of the space-based component of Global Observing Systems;

(d) Initiate and promote activities to improve the availability of operational and R&D satellite data according to user needs, monitor these activities in close coordination with the relevant working groups, regional associations and with WIS activities;

(e) Review present and future R&D satellite data and products including their availability and potential applications, and provide advice with a view to increased utilization by WMO Members;

(f) Review, and assist in addressing, the needs of WMO Members and regional associations for information regarding satellite capabilities and in particular access to and utilization of satellite data and products;

(g) Promote development and harmonization of satellite data and products responding to WMO Members' needs, and develop and update relevant elements of the WIGOS Regulatory and Guidance materials, including the Manual and the Guide to the GOS, and the WIGOS Data Quality Monitoring System;

(h) Keep under review the needs of WMO Members for training in satellite meteorology and related fields, and engage with the Management Group of the Virtual Laboratory for Education and Training in Satellite Meteorology (VLab) to address these needs, towards full utilization of satellite data from operational and R&D satellites, in accordance with the 2015-2019 Virtual Laboratory Training Strategy;

(i) Holding joint and/or overlapping meetings with ET-SAT as appropriate, to facilitate interaction between users and providers of satellite systems, data and products;

(j) Coordinate with ET-SAT with a view to making recommendations and receiving input on matters, such as the exchange, management, and archiving of satellite data and products, radio frequency utilization, as well as education and training and other appropriate capacity-building measures related to the use of satellite data in all WMO Programmes, including support to resource mobilization activities;

(k) Oversee the development and review of OSCAR so that it meets the needs of WIGOS for information concerning user assessments of space-based observing systems capabilities;

(l) Coordinate with WMO technical commissions and Programmes, including co-sponsored programmes, activities related to satellite utilization and products, through ex-officio membership on the Team;

(m) Provide advice and support to the chairperson of OPAG-IOS, and report on all activities relevant to its Terms of Reference.

Inter-Programme Expert Team on Operational Weather Radars (IPET-OWR)

Note: the Terms of Reference for IPET-OWR were approved in Decision 35 (EC-68).

Within the WIGOS framework, under the governance of CIMO and the joint guidance of CIMO and CBS, act as the WMO primary working group on operational weather radars (S, C and X band) with responsibility to:

(a) Develop and propose regulatory and guidance material on:

(i) Standardization of, and regulations and guidance on, systems requirements and specifications, quality control, maintenance and operation, data processing algorithms, data products and data quality monitoring, weather radar composites, and scanning strategies;

(ii) Response to requirements of data users;

(iii) Training and capacity development;

(b) Contribute to development of methods, models and formats for the international exchange of weather radar data and metadata;

(c) Provide advice on network design;

(d) Provide guidance on radio-frequency allocation and protection;

(e) Review and report on potential operational developing and emerging weather radar research and technologies;

(f) Collaborate with other international and regional organizations on relevant matters, particularly including international standards organizations and research bodies and associations;

(g) Collaborate with and respond to the requests of WMO constituent bodies, as appropriate;

(h) Develop and document proposals for the activities of the Inter-Programme Expert Team;

(i) Report on issues, activities and progress to CIMO and CBS.

Open Programme Area Group on Information Systems and Services

Implementation Coordination Team for Information Systems and Services (ICT-ISS)

(a) Assess the implementation aspects at regional and global levels, including sustainability and necessary capacity-building, of the recommendations and proposals developed by the ISS teams;

(b) Review and consolidate the recommendations and proposals developed by the ISS teams with a view to their submission to CBS;

(c) Monitor, assess and take follow-up action on ISS requirements emerging from WMO Programmes and other international programmes/projects supported by WMO, including cross-cutting activities such as GFCS, WIGOS and DRR;

(d) Identify matters requiring the consideration of the OPAG on ISS and develop proposals for tasks and organization of activities;

(e) Advise the technical commissions on information management and data communications issues, especially in respect of the WIS and collaborate with technical commissions to develop and document appropriate standards and practices in information management;

(f) Provide guidance for the ISS teams on requirements and priorities for development of the WIS;

(g) Develop and maintain a strategic plan for the evolution of the WIS and explore and extend WIS functionality to build on new technology and applications to meet the needs of WMO Programmes;

(h) Coordinate the work of the OPAG-ISS related to the implementation and evolution aspects of GEO and ICAO infrastructure, including maintenance of interoperability with GEOSS and SWIM to the benefit of Members;

(i) Develop and maintain procedures for addressing security and incident management events with in WIS.

Expert Team on WIS Centres (ET-WISC)

(a) Review and further develop the technical and operational specifications for the components and interfaces of WIS Centres; develop criteria for interoperability, certification and service quality management of WIS Centres;

(b) Maintain guidance and management procedures for the CBS demonstration and assessment capabilities of candidate GISC and DCPC centres in the framework of the GISC/DCPC demonstration procedure described in the Manual on WIS;

(c) Review and develop the *Manual on WIS* (WMO-No. 1060), the *Guide to WIS* (WMO-No. 1061) and associated informal guidance to better meet the needs of Members;

(d) Maintain WIS competencies related to WIS centre operations and associated training and learning guides; facilitate training on WIS by GISCs and Regional Training Centres;

(e) Review, further develop and oversee routine WIS monitoring activities, including those aspects of monitoring relating to the effectiveness of information exchange on behalf of the WWW and other Programmes, and take action to address issues that are identified by monitoring and auditing;

(f) Review, develop and coordinate recommended practices and guidance on access to, and management of, operational information related to exchange of information through the WIS;

(g) Foster collaboration among WIS centres;

(h) Advise the technical commissions, regional associations and partner organizations on roles, responsibilities and implementation of WIS centres;

(i) Monitor and explore evolving new service monitoring and user management technologies with the aim of improving the efficient operation and usability of WIS;

(j) Raise awareness of Members of the opportunities and risks associated with new service monitoring and user management technologies;

(k) Identify implementation and operational issues requiring the urgent consideration of the OPAG on ISS;

(l) Contribute to the implementation and evolution aspects of GEO and ICAO infrastructure, including maintenance of interoperability with GEOSS and SWIM to the benefit of Members.

Expert Team on Centre Audit/Certification (ET-CAC)

(a) Operate the procedures for technical endorsement of WIS Centres and advise CBS on centres' level of technical compliance with standards and procedures:

    (i) Validate and monitor the conformance of WIS Centres' interfaces to the agreed specifications and practices;

    (ii) Coordinate and organize demonstrations of capabilities of candidate WIS centres as required, including onsite audits of GISCs;

(b) Make recommendations to ICT-ISS regarding continuous improvement of the procedures for certification and periodic assessment of WIS centres;

(c) Advise ICT-ISS on systematic issues identified during certification and assessment activities.

Inter-Programme Expert Team on Codes Maintenance (IPET-CM) (was IPET-DRMM)

(a) Review and maintain the Table-driven Code Forms by defining descriptors, common sequences, data templates and the regulations supporting these, including data representation of regional practices, so they meet the requirements of all Members, WMO Programmes and other concerned international organizations, such as ICAO;

(b) Raise awareness of Members of the opportunities and risks associated with new technologies;

(c) Review and update guidance to Members and technical commissions on data representation, including national practices, and invite, coordinate and assist Members to validate modified or new data representations;

(d) Review, develop and update the *Manual on Codes* (WMO-No. 306), the code tables in the *Manual on WIGOS* (WMO-No. 1160) and associated reference and guidance material as required, and publish these in suitable electronic formats for human and automated use including codes.wmo.int;

(e) Review and develop procedures and guidance to enable the interoperability of metadata and data between WMO standards and formats used within other communities, such as NetCDF, using the WMO Logical Data Model as a tool to achieve this;

(f) Monitor conformance of data exchanged within the WIS and metadata records published to the WIS DAR catalogue with WMO data representation standards for utility and conformance with the guidance and WMO Core Metadata Profile, and develop action plans, including capacity-building, to address issues identified by monitoring;

(g) Review and update the procedures used to maintain WMO data representations, taking into account opportunities presented by the WMO Logical Data Model;

(h) Monitor progress towards, and coordinate actions to implement, migration to Table-driven Codes Forms;

(i) Identify implementation issues requiring the urgent consideration of the OPAG on ISS;

(j) Review and maintain the data designators in abbreviated headings in the *Manual on the GTS* (WMO-No. 386);

(k) Review and maintain the Graphical Representation of Data, Analyses and Forecasts in the attachment to Manual on Codes in cooperation with OPAG-DPFS;

(l) Assist the WIGOS Data Quality Monitoring System (WDQMS) in understanding and dealing with erroneous BUFR messages as and when they are identified by WDQMS;

(m) Contribute to the maintenance of WIS competencies related to use of codes and associated training and learning guides and facilitate training.

Inter-Programme Expert team on Data Representation Development (IPET-DD) (was IPET-MDRD)

(a) Review and further develop the WMO Core Metadata Profile, model driven code forms and WMO standards for metadata and data exchange to meet the needs of Members, WIS, WMO Programmes and cooperating organizations such as ICAO;

(b) Contribute to the review of and recommend updates to the Part D of the *Manual on Codes* (WMO-No. 306) and the *Manual on the WMO Information System* (WMO-No. 1060) and associated reference and guidance material as required, publishing these in suitable electronic forms for human and automated use including codes.wmo.int;

(c) Facilitate proposals to standards development organizations, such as ISO TC 211 and OGC, changes to their respective standards that are required to meet the needs of WIS;

(d) Advise Members, technical commissions and ICG-WIGOS on WIS Discovery Metadata, the model driven code forms and associated application schema and data interoperability issues;

(e) Monitor metadata quality within the WIS DAR Catalogue and take follow-up action to address systematic issues identified;

(f) Identify implementation issues requiring the urgent consideration of the OPAG on ISS;

(g) Monitor and explore evolving data exchange and discovery technologies with the aim of improving the efficient operation and usability of WIS;

(h) Raise awareness of Members of the opportunities and risks associated with new data exchange and discovery technologies;

(i) Contribute to the maintenance of WIS competencies related to use of metadata and new model based data representation and associated training and learning guides and facilitate training.

Expert Team on Communication Techniques and Systems (ET-CTS)

(a) Maintain and develop recommended practices and technical guidance material for data communication techniques and procedures for use in the WIS, with a view to ensuring efficient and safe operations of information systems, and inform members of recent developments in standards bodies, in particular W3C, IETF, ITU and ISO;

(b) Review and further develop the organization and design principles for the WIS data communication and access structure, and coordinate related pilot and implementation projects

(c) Contribute to the development and maintenance of networks-related WIS monitoring;

(d) Review and amend as required the telecommunications components of the *Manual on WIS* (WMO-No. 1060), the *Manual on the GTS* (WMO-No. 386) including the General File Naming Convention, their associated Guides and other guidance material;

(e) Provide guidance on the technical, operational, security, administrative and contractual aspects of data communications services for WIS implementation at national, regional and global levels, including among others satellite telecommunications, managed data communications network services, cloud services and the Internet and coordinating cooperation with other organizations where appropriate to obtain operational benefits;

(f) Review and further develop guidance and practices for planning, implementation and operation of data collection systems for observing systems for NMHSs, including interfaces with observation platforms, methods and data communications protocols;

(g) Monitor the effectiveness of data exchange on the WIS in relation to the expected standards, and take follow-up action, including capacity-building activities, to address issues identified;

(h) Facilitate the interaction between Members and international organizations on telecommunications issues, including ensuring remote communities and areas with limited access to modern communication systems are properly catered for;

(i) Identify implementation issues requiring the urgent consideration of the OPAG on ISS;

(j) Contribute to the maintenance of interoperability with GEOSS and SWIM and liaison with SATCOM to the benefit of Members;

(k) Monitor and explore evolving infrastructure technologies with the aim to improving the efficient operation and usability of WIS;

(l) Raise awareness of Members on the opportunities and risks associated with new infrastructure technologies;

(m) Contribute to the maintenance of WIS competencies related to network and cloud management and the associated training and learning guides and facilitate training.

ICT-ISS Task Team on Information Management (TT-IM)

(a) Collaborate with technical commissions to review available information management practices and develop and document appropriate standards and practices in information management;

(b) Recommend procedures for the long term maintenance and development of standards and best practices related to information management;

(c) Replace the *Guide on World Weather Watch Data Management* (WMO-No. 788) with a new guide on best practices for information management across all WMO Programmes;

(d) Propose updates to incorporate standards and practices for information management under WIS Part C in the *Manual on WIS* (WMO-No. 1060) and *Guide to the W*IS (WMO-No. 1061);

(e) Recommend updates to the WIS competencies related to information management and associated training and learning guides.

ICT-ISS Task Team on Evolution of the WIS (TT-eWIS)

(a) Develop an implementation plan, with schedule and key deliverables, that is in line with the WIS 2.0 strategy and guide implementation of the plan that is approved;

(b) Consolidate stakeholder requirements;

(c) Communicate with stakeholders about the strategy and plan.

Ad hoc Inter-Commission Task Team on WIS (ICTT-WIS)

Note that the Terms of Reference for ICTT-WIS were approved in Decision 38 (EC-68)

(a) Recommend to ICT-ISS a process for making decisions impacting on the management of the capacity of WIS networks, including the process for agreeing that data may be designated as for global exchange (using the "GlobalExchange" keyword in the associated WIS Discovery Metadata record that controls routinely exchange between GISCs and contents of the WIS cache);

(b) Recommend to ICT-ISS an escalation process for resolving issues that result from decisions made through the collaborative mechanisms established between the GISCs;

(c) Propose to ICT-ISS a mechanism for gathering the expectations of technical commissions and regional associations for their requirements of what WIS would provide for them in the 2020s and beyond;

(d) Inform ICT-ISS of the headline services that technical commissions and regional associations expected WIS to provide in the 2020s that could be used to guide the strategy for WIS before the detailed expectations had been gathered.

Open Programme Area Group on Data-Processing and Forecasting Systems

Implementation Coordination Team on Data-Processing and Forecasting System (ICT-DPFS)

(a) Consider the requests and WMO priorities from Cg/EC;

(b) Identify new emerging requirements as a contribution to the implementation of the WMO Strategy for Service Delivery (input required from RAs and other bodies);

(c) Determine how GDPFS Centres can best contribute to fulfil emerging requirements;

(d) Coordinate the implementation of decisions by CBS related to GDPFS and ERA;

(e) Make recommendations to CBS concerning future work;

(f) Review requirements and propose the establishment and activities of Task Teams, including Joint Task Teams;

(g) Recommendations on technical regulations including the implementation of the new Global Data-Processing and Forecasting System Manual and Quality Management Framework;

(h) Recommendation on strategy for future GDPFS.

Expert Team on the Operational Weather Forecasting Process and Support (ET-OWFPS)

(a) Review the *Manual on the GDPFS* (WMO-No. 485) and propose updates as necessary concerning nowcasting to medium-range forecasting to ensure that procedures are adequate;

(b) Review GDPFS and Lead Centres' activities, support their developments and provide guidance as stated in the Manual;

(c) Assess applications for GDPFS status against the designation criteria and make recommendations on designation to CBS;

(d) Review new developments and advances in NWP and related systems, particularly with regard to severe and high impact weather forecasting;

(e) Liaise with relevant WMO Programmes, technical commissions and international organizations as required to advise on requirements for practical implementations in operational systems;

(f) Provide advice to NMHSs on NWP products, including EPS and post-processing, particularly with regard to seamless forecasting of severe and high impact weather;

(g) Monitor and review requirements for observation monitoring by NWP centres in collaboration with WIGOS;

(h) Liaise with the PWS programme to promote and support the use and communication of NWP products, including EPS, available from the GDPFS Centres; develop interpretation guidance to facilitate their use, and encourage feedback on usefulness and application;

(i) Promote and support the education and training of forecasters on the use and interpretation of NWP products, including EPS, and their strengths and weaknesses;

(j) Provide guidance on capacity-building concerning the implementation of operational NWP systems, including verification systems, and/or the use of NWP products.

Inter-programme Expert Team on Operational Predictions from Sub-Seasonal to Longer-Time Scales (IPET-OPSLS)

(a) On the basis of requirements from Regional Climate Centres (RCCs), Regional Climate Outlook Forums (RCOFs) and NMHSs, and in the context of the Climate Services Information System (CSIS) of the Global Framework for Climate Services (GFCS), guide future development, outputs including, for example, the GSCU and coordination of components in the production of LRF. The components include Global Producing Centres (GPCs), Lead Centres for Long-range Forecast Multi-model Ensembles (LC-LRFMME), the Lead Centre for the Standardized Verification System for Long-range Forecasts (LC-SVSLRF) and other relevant bodies generating and providing LRF products;

(b) Support CCl and CBS to collaboratively promote the use of GPC and LC forecast and verification products by RCCs, RCOFs and NMHSs, develop interpretation guidance to facilitate their use, and encourage feedback on usefulness and application;

(c) Support CBS in the implementation of a seamless GDPFS;

(d) Report on production, access, dissemination and exchange of LRF products and provide recommendations for future consideration and adoption by CAS, CCl, CBS, WCRP and other appropriate bodies;

(e) In consultation with relevant experts in CAS and CCl and with the CBS Expert Team on Operational Weather Forecasting Process and Support (ET-OWFPS), review developments in verification scores and practices with a view to updating the Standardized Verification System for Long-range Forecasts (SVSLRF);

(f) Assess applications for GPC status against the designation criteria and make recommendations on designation to CBS;

(g) Review the rules regarding user access to GPC and LC-LRFMME forecasts products;

(h) Review the status of sub-seasonal forecasting activities, and promote the availability and exchange of sub-seasonal forecasts and verification products;

(i) In close collaboration with WCRP, promote international cooperation and research on initialized predictions for timescales longer than seasonal and report on potential for operational predictions to CBS and CCl;

(j) Review the *Manual on the GDPFS* (WMO-No. 485) and propose updates as necessary concerning extended and long-range forecasts.

Expert Team on Emergency Response Activities (ET-ERA)

(a) Review the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485) to ensure that procedures for ERA, both nuclear and non-nuclear, are adequate and meet CBS needs, and propose updates as necessary;

(b) Promote and support the education and training of users on the use and interpretation of ERA products, and their strengths and weaknesses;

(c) Identify and promote technical resources which can assist NMHSs in developing their ERA capabilities for supporting national agencies in their preparedness, planning, response and recovery activities;

(d) Continue to develop and test new products as well as Ensemble and Transfer Coefficient Matrix (TCM) methods for atmospheric transport and dispersion modelling;

(e) Test and improve the collective ability of all RSMCs, the IAEA, CTBTO, the RTH Offenbach and NMHSs in the environmental ERA to fulfil the operational requirements according to adopted standards and procedures stated in the Manual.

Task Team on the Provision of Operational Meteorological Assistance to Humanitarian Agencies (TT-Hum)

The CBS Task Team on the Provision of Operational Meteorological Assistance to Humanitarian Agencies is established under the joint leadership/responsibility of the OPAGs on DPFS and PWS, and in liaison with other relevant technical commissions and Programmes. The CBS Task Team is chaired by the chairperson of the CBS Management Group Coordination Team on Disaster Risk Reduction:

(a) Based on the identified needs and requirements of humanitarian agencies, develop designation criteria and functions for existing GDPFS Centres that could specialize in the development and provision of operational meteorological products and services for mitigating the impacts of meteorological-related hazards;

(b) Develop, in consultation with NMHSs, global and regional operational arrangements that would assist humanitarian agencies and disaster managers in mitigating disasters, taking into consideration the WMO Strategy for Service Delivery and the success of ERA, and provide assistance and support to strengthen NMHSs in this regard;

(c) Assist Members, with or without NMHSs, in developing their capacity for supporting their government and humanitarian agencies in emergency preparedness efforts, including identifying the gaps in current capabilities and the opportunities to realize the benefits of addressing these gaps through close cooperation at regional and national levels. Coordinate with relevant United Nations and international organizations on collecting and responding to their requirements;

(d) Promote and support the education and training of users on the use, interpretation and delivery of meteorological products and services, and their strengths and limitations.

Steering Group on Severe Weather Forecasting Demonstration Project (SG-SWFDP)

Note: Established by CBS-15; members include PWS focal point, representatives of global and regional projects.

(a) Giving guidance and monitoring the further development of existing and new regional projects;

(b) Managing the integration of new components in the SWFDP, including addressing synergies with other WMO Programmes;

(c) Developing recommendations to support the full and sustainable participation of NMHSs, including those from LDCs and SIDSs, in the SWFDP;

(d) Review and make recommendations on the scope of the cascading forecasting process.

Inter-Programme Team on Space Weather Information, Systems and Services (IPT-SWeISS)

Note: these Terms of Reference were approved in Decision 33 (EC-68).

Scope

The responsibility of the Inter-Programme Team on Space Weather Information, Systems and Services (IPT-SWeISS) is to coordinate space weather activities within the WMO Programmes, to maintain linkage with the constituent bodies and their relevant subsidiary groups, to maintain linkage with partner organizations, and to provide guidance to WMO Members. IPT-SWeISS is established under the Commission for Basic Systems (CBS) and the Commission for Aeronautical Meteorology (CAeM) which will provide joint oversight in consultation with each other via their presidents.

Main tasks

(a) Integration of Space Weather observations, through review of space- and surface-based observation requirements, harmonization of space-based sensor specifications, monitoring plans for Space Weather observations;

(b) Standardization and enhancement of Space Weather data exchange and delivery through the WMO Information System (WIS);

(c) Coordinating the development of Space Weather best practices for end-products and services, including, for example, quality assurance guidelines and emergency warning procedures, in collaboration with aviation and other major application sectors;

(d) Encouraging the dialogue between the research and operational space weather communities;

(e) Organization of capacity-building, training and outreach activities towards WMO Members and Space Weather potential users;

(f) Provision of guidance to WMO Members and Programmes on Space Weather matters, and conduct appropriate actions as requested by CBS and CAeM.

Composition

IPT-SWeISS will be composed of members nominated by the relevant technical commissions, selected WMO Members and points of contacts nominated by the regional associations and associate members including representatives of ISES and other partners or major user applications.

IPT-SWeISS members shall cover the various fields of expertise necessary to address space weather matters within WMO and will contribute to the relevant expert teams or other groups of WMO technical commissions including: Commission for Basic Systems (CBS)[1]; Commission for Aeronautical Meteorology (CAeM)[2]; Commission for Instruments and Methods of Observation (CIMO); Commission for Atmospheric Sciences (CAS).

Open Programme Area Group on Public Weather Service Delivery

Implementation–Coordination Team on Public Weather Service Delivery (ICT-PWSD)

(a) Coordinate the implementation of the decisions of Congress, the Executive Council and the Commission for Basic Systems (CBS) with respect to Public Weather Services;

(b) Consult and collaborate to ensure coordination of the work of the Open Programme Area Group (OPAG) on PWSD with that of other CBS OPAGs, technical commissions (TCs), EC working groups, regional associations (RAs) and WMO Programmes and initiatives;

(c) Support a strengthening of partnerships between National Meteorological and Hydrological Services (NMHSs), other agencies and user sectors (e.g., media, health, emergency management) in areas relevant to PWSD;

(d) Through the constituent teams of the OPAG, promote the implementation of the WMO Strategy for Service Delivery in the context of Public Weather Services, and making full use of emerging technologies;

(e) Keep under review the work of the PWSD Expert Teams and coordinate and guide their work programmes;

(f) Continue to encourage and provide guidance to Members to assert the authority of NMHSs as the sole providers of official high-impact weather warnings;

(g) Facilitate the development of guidance and training material to underpin and support those elements of the WMO competency framework relevant to PWS-related activities;

(h) Support and promote excellence in communication as a key enabler of quality service delivery;

(i) Collaborate with development partners and other WMO entities to assist NMHSs in the identification and assessment of societal, economic and environmental benefits of hydrometeorological services;

(j) Continue to promote the awareness and use of guidance documents developed through the work of the OPAG, in collaboration with regional associations, and by other means;

(k) Guide the work of the OPAG to assist Members in developing their capacity to deliver improved services through the use of the best science and emerging technologies.

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[1] Such as the Inter-Programme Expert Teams on Observing System Design and Evolution (IPET-OSDE), on WIGOS Framework Implementation (IPET-WIFI), on Codes Maintenance (IPET-CM), on Data Representation Development (IPET-DD), or the Steering group on Radio-Frequency Coordination (SG-RFC).

[2] Such as the Expert Team on Aviation, Science and Climate (ET-ASC), on Information & Services for Aviation (ET-ISA), on Education, Training and Competencies (ET-ETC).

Expert Team on Service Provision Innovation and Improvement (ET-SPII)

(a) Monitor, evaluate and advise on challenges and opportunities for Public Weather Service Delivery presented by emerging science and technology;

(b) Address the user requirements identified by ET-IMPACT for data provision, management and visualization, through collaboration with OPAG DPFS and other partners as necessary;

(c) Take responsibility for PWS guidance on scientific and technical aspects of Service Delivery improvement, including nowcasting, uncertainty, CAP and mobile/web services;

(d) Provide oversight and coordination of the continuing development of WWIS/SWIC;

(e) Complement and enhance the delivery of user-oriented Public Weather Services, and devise strategies for NMHSs and partners to optimize use and analysis of non-traditional data in forecasting and warning services, using collected examples and use of such data, for example crowd-sourced weather, impact and behavioural data or social media information;

(f) Assist the relevant bodies dealing with cooperation between the public and private sectors in matters relevant to Public Weather Service delivery;

(g) Remain mindful of the PWS needs of LDCs and SIDS when innovating and developing new services, in the spirit of the principle that 'no country is left behind';

(h) Identify experts to advise on technical aspects of Service Delivery improvement as required by the mandate above, specifically in the areas of Big Data and Public-Private Partnerships.

Expert Team on Impact-Based Forecasting and Risk-Based Warning (ET-IMPACT)

(a) Building on the *WMO Guidelines on Multi-hazard Impact-Based Forecast and Warning Services* (WMO-No. 1150), develop an implementation strategy which describes next actionable steps and evolution;

(b) Develop and maintain an expert resource to facilitate activities and projects in the area of Impact-Based Forecasting, including representatives from the social sciences;

(c) Actively promote Impact-Based Forecasting by identifying a network of champions within NMHSs, and by sharing best practices through symposiums, journal papers and communication outlets;

(d) Provide NMHSs with guidance on how to standardize Impact-Based Forecasting messaging protocols and formats (e.g. colour-coding, language, icons, etc.);

(e) Working with external users and stakeholders, technical commissions, regional associations, relevant OPAGs and Programmes of WMO, establish user requirements for service improvements and implement solutions through science and technological innovation;

(f) Evolve current methodologies for verification and evaluation to incorporate a focus on socioeconomic benefits;

(g) Identify skills and relevant training needs for NMHSs and external users associated with wider implementation of multi-hazard impact-based forecast and warning services.

Coordinator on the Competency Framework (C-CF)

(a) Facilitate the development of guidance and training material to underpin and support those elements of the WMO competency framework relevant to activities related to PWS and service delivery.

PWSD Coordinator on Regional Association Liaison (C-RAL)

(a) Consult and collaborate to ensure coordination of the work of the Open Programme Area Group (OPAG) on PWSD with regional associations and their subsidiary bodies.

Annex 2 to Decision 33 (CBS-16)

TERMS OF REFERENCE FOR THE COMMISSION FOR BASIC SYSTEMS MANAGEMENT GROUP COORDINATION TEAM ON DISASTER RISK REDUCTION

The CBS Management Group Coordination Team on Disaster Risk Reduction (CBS-MG-TT-DRR) supports the CBS coordinator on Disaster Risk Reduction. Each Open Programme Area Group (OPAG) is represented on the team by a member of its Implementation Coordination Team. The CBS Management Group Task Team on Disaster Risk Reduction (CBS-MG-TT-DRR) works by correspondence. The chairperson of CBS-MG-TT-DRR is also chair of the Task Team on the provision of meteorological assistance to Humanitarian Agencies (TT-HUM).

(a) Ensure active communication on disaster risk reduction issues between CBS Management Group, the OPAGs, the DRR focal points of regional associations, technical commissions, technical programmes and the EC Working Group on Disaster Risk Reduction, including assistance to the CBS coordinator with the creation of reports to those and to constituent bodies;

(b) Coordinate development, implementation and monitoring of the work plans of the OPAGs in respect of activities related to disaster risk reduction;

(c) Coordinate production proposals from CBS in respect of prioritization and proposal of initiatives or activities, including pilot projects, related to delivering the disaster risk reduction priority in the WMO Strategic Plan 2016–2019 and the WMO Strategy for Service Delivery;

(d) Identify, as it emerges, evolving best practice developed by CBS, other constituent bodies or Members and provide consolidated advice to CBS on its adoption;

(e) Liaising and coordinating with external stakeholders and determining their needs.

Annex 3 to Decision 33 (CBS-16)

LEADERSHIP OF EXPERT TEAMS OF THE COMMISSION FOR BASIC SYSTEMS

Open Programme Area Group on Integrated Observing Systems

Implementation–Coordination Team on Integrated Observing Systems (ICT-IOS)

Chairperson: A. Rea (Australia)

Co-chairperson: J. Dibbern (Germany)

Inter-Programme Expert Team on Observing System Design and Evolution (IPET-OSDE)

Chairperson: E. Andersson (ECMWF)

Co-chairperson: S. Klink (Germany)

Expert Team on Aircraft Based Observing Systems (ET-ABO)

Chairperson: C. Marshall (United States of America)

Vice-chairperson: A. Mouhtadi (Morocco)

Steering Group on Radio-frequency Coordination (SG-RFC)

Chairperson: E. Allaix (France)

Co-chairperson: D. Franc (United States)

Expert Team on Surface-based Observing Systems (ET-SBO)

Chairperson: S. Goldstraw (United Kingdom of Great Britain and Northern Ireland)

Co-chairperson: C. Pei (Ms, China)

Coordinator on Marine Observing Systems (C-MAR)

Coordinator: J. Turton (United Kingdom) (JCOMM ex officio position)

Coordinators on Scientific Evaluation of Impact Studies undertaken by NWP centres (C-SEIS)

Coordinators: S. Boukabara (United States), S. Park (Ms, Republic of Korea)

Expert Team on Satellite Systems (ET-SAT)

Chairperson: J. Kaye (United States)

Co-chairperson: D. Kim (Republic of Korea)

Inter-Programme Expert Team on Satellite Utilization and Products (IPET-SUP)

Chairperson: S. English (ECMWF)

Co-chairperson: X. Fang (China)

Inter-Programme Expert Team on Operational Weather Radars (IPET-OWR)

Note: This is a joint Team managed by CIMO in consultation with CBS, including with regard to nomination of its chairperson and members.

Chairperson: D. Michelson (Canada) [Designated by CIMO in consultation with CBS]

Co-chairperson: [XX, XX] [Designated by CIMO in consultation with CBS]

Open Programme Area Group on Information Systems and Services

Implementation Coordination Team for Information Systems and Services (ICT-ISS)

Chairperson M. dell'Acqua (France)

Co-chairperson: H. Haddouch (Morocco)

Expert Team on WIS Centres (ET-WISC)

Chairperson: X. Li (Ms, China)

Co-chairperson: K. Tsunoda (Japan), M. Francis (United Kingdom)

Expert Team on Centre Audit/Certification (ET-CAC)

Chairperson: K. Alder (New Zealand)

Co-chairperson: L. Wolf (EUMETSAT)

Inter-Programme Expert Team on Codes Maintenance (IPET-CM)

Chairperson: J. Hasegawa (Japan)

Co-chairperson Y. Pelletier (Canada)

Inter-Programme Expert Team on Data Representation Development (IPET-DD)

Chairperson: B. Wilson (Australia)

Co-chairperson: D. Klaric (Ms, Croatia)

Expert Team on Communication Techniques and Systems (ET-CTS)

Chairperson: R. Giraud (France)

Co-chairperson: I. Glaser (Ms, Germany)

ICT-ISS Task Team on Information Management (TT-IM)

Chairperson: D. Schröder (Germany)

Co-chairperson: W. Wright (Australia)

ICT-ISS Task Team on Evolution of the WIS (TT-eWIS)

Chairperson: R. Bunge (United States)

Co-chairperson: J. Tandy (United Kingdom)

Ad hoc Inter-Commission Task Team on WIS (ICTT-WIS)

Chairperson: [XX, XX] To be decided by the Executive Council

Co-chairperson: [XX, XX] To be decided by the Executive Council

Open Programme Area Group on Data-Processing and Forecasting Systems

Implementation Coordination Team on Data-Processing and Forecasting System (ICT-DPFS)

Co-chairperson: Y. Honda (Japan)

Co-chairperson: P. Davies (United Kingdom)

Expert Team on the Operational Weather Forecasting Process and Support (ET-OWFPS)

Chairperson: D. Richardson (ECMWF)

Co-chairperson: J. Wang (Ms, China)

Expert Team on Operational Predictions from Sub-Seasonal to Longer-time Scales (ET-OPSLS)

Chairperson: A. Kumar (United States)

Co-chairperson: C Coelho (Brazil)

Expert Team on Emergency Response Activities (ET-ERA)

Chairperson: A. Muscat (United Kingdom)

Co-chairperson: R. Servranckx (Canada)

Task Team on the provision of operational meteorological assistance to Humanitarian Agencies (TT-Hum)

Chairperson: F. Branski (United States of America)

Steering Group on Severe Weather Forecasting Demonstration Project (SG-SWFDP)

Chairperson I. Sebego (South Africa)

Inter-Programme Team on Space Weather Information, Systems and Services (IPT-SWeISS)

Chairperson: X. Zhang (China) (CAeM)

Co-chairperson: R. Rutledge (United States) (CBS)

Open Programme Area Group on Public Weather Service Delivery

Implementation–Coordination team on Public Weather Service Delivery (ICT-PWSD)

Chairperson: G. Fleming (Ireland)

Co-chairperson: D. Kiktev (Russian Federation)

Expert Team on Service Provision Innovation and Improvement (ET-SPII)

Chairperson: W. Lang (United Kingdom of Great Britain and Northern Ireland)

Co-chairperson M. Li (Ms, China)

Expert Team on Impact-Based Forecasting and Risk-Based Warning (ET-IMPACT)

Chairperson: E. Jacks (United States of America)

Co-chairperson: L.-S. Lee (Hong Kong, China)

Coordinator on the Competency Framework (C-CF)

Coordinator: J. Milton (Ms, Canada)

PWSD Coordinator on Regional Association Liaison (C-RAL)

Coordinator: A. Martis (Curaçao and Sint Maarten) **OR** I. Cacic (Croatia)

Annex 4 to Decision 33 (CBS-16)

COMMISSION FOR BASIC SYSTEMS MANAGEMENT GROUP TASK TEAM ON MIGRATION OF UPPER-AIR REPORTS TO TABLE-DRIVEN CODE FORMS

Terms of Reference

(a) Assist IPET-CM to identify and implement a solution for handling upper air reports that assures the continuing availability of reports from observing sites, and the ability of NWP centres to process the reports, so that the introduction of TDCF upper air reports does not degrade the NWP forecasts, and in particular:

(i) To summarize general issues related to BUFR and requests on how to promote TDCF migration from the viewpoint of NWP centres and report them to IPET-DRMM;

(ii) To advise IPET-CM on a method by which NWP centres report every issue they find in BUFR messages;

(iii) To advise to IPET-CM on the role of NWP centres in the process for checking the quality of BUFR messages;

(b) Coordinate with Members and their Centres to resolve identified problems;

(c) Assess the additional costs to user centres of maintaining their systems to process upper air observations continuing to be being sent in TAC, and assess the costs of accelerating migration of observing systems to produce information in correctly formatted BUFR;

(d) Summarize the benefits of using TDCF in preference to TAC from the perspective of NWP centres.

Membership

Chairperson: Stefan KLINK (EUMETNET)

Weiqing QU (Australia)

Martim MATSCHINSKE (Brazil)

Weihong TIAN (China)

Bruce INGLEBY (United Kingdom)

Kamel REBAI (France)

Yukinari OTA (Japan)

Alexander KATS (Russian Federation)

Adam MAYCOCK (United Kingdom)

Warren TENNANT (United Kingdom)

Richard WEEDON (United Kingdom)

Patricia PAULEY (United States of America)

Decision 34 (CBS-16)

TASK TEAM ON APPROACHES TO TECHNICAL GOVERNANCE

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Regulation 33 of the WMO General Regulations (2015 edition),

(2) Resolution 21 (Cg-17) – Procedures for maintaining Manuals and Guides managed by the Commission for Basic Systems,

Having considered:

(1) The perception that it may be difficult for Members to keep pace with changes regarding advances in technology and new WMO Technical Regulations,

(2) The importance of WMO responding to the needs of its Members with regard to rapid advances in science and technology,

(3) The lack of awareness of existing mechanisms, opportunities and processes to advance the Commission for Basic System's (CBS) work programme,

(4) Increasing challenges for having complex technical regulations and standards approved when some Members do not have the capability to test and implement them,

Decides:

(1) To establish the Task Team on Approaches to Technical Governance with the terms of reference listed in the annex to the present decision;

(2) That the Task Team will be led by:

Chair: J. Tandy (United Kingdom of Great Britain and Northern Ireland)

Co-Chair: [xxx,xxx];

(3) That the Task Team will report to CBS Management Group;

(4) That the Management Group may change the terms of reference of the Task Team or disband it as required to deliver the work of CBS;

(5) That the members of the Task Team will be selected by the Management Group from experts nominated by Members;

(6) That CBS Management Group will prepare recommendations to the Executive Council Working Group on Strategic and Operational Planning in preparation for the sixty-ninth session of the Executive Council and subsequently implement the conclusions;

Requests the Task Team:

(1) To develop and present its work plan to the Management Group for endorsement;

(2) To organize its work to be efficient, effective and economic, making use of collaborative working tools and tele- or video-conferencing whenever feasible.

Annex to Decision 34 (CBS-16)

TERMS OF REFERENCE OF THE COMMISSION FOR BASIC SYSTEMS TASK TEAM ON APPROACHES TO TECHNICAL GOVERNANCE

Working under the guidance of CBS Management Group, the CBS Task Team on Approaches to Technical Governance shall undertake a review of the technical governance within and affecting CBS, and recommend improvements that would allow CBS to address the issues considered in this Decision. In particular, the Task Team shall:

(1) Identify the requirements for effective technical governance within CBS;

(2) Review the technical governance approaches employed within WMO and within other Standards Development Organizations including, but not limited to, the World Wide Web Consortium (W3C), the Open Geospatial Consortium (OGC), the Internet Engineering Task Force (IETF), the International Organization for Standardization (ISO), the International Telecommunications Union (ITU), and the INSPIRE Maintenance and Implementation Group of the European Union;

(3) Identify those areas where the current technical governance approach is considered either effective or ineffective;

(4) Advise the CBS Management Group with regard to issues that may have to be brought to the attention of the Executive Council Working Group on Strategic and Operational Planning to inform that Working Group of the impact of potential changes to the working practices, structures and processes of Technical Commissions being considered;

(5) Propose improvements to the working arrangements of CBS in response to identified shortcomings, and recommend where application of those changes may be applicable.

Decision 35 (CBS-16)

REVIEW OF PREVIOUS RESOLUTIONS OF THE COMMISSION FOR BASIC SYSTEMS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The *Abridged Final Report with Resolutions and Recommendations of the Fifteenth Session of the Commission for Basic Systems* (WMO-No. 1101), general summary 6.1 and 6.2,

(2) Resolutions 1–8 (CBS-15) and Recommendations 1–13 (CBS-15),

(3) Resolutions 1–3 (CBS-Ext.(2014)) and Recommendations 1–24 (CBS-Ext.(2014)),

Having examined its previous resolutions and recommendations still in force,

Decides:

(1) To keep in force the following recommendations:

Recommendation 10 (CBS-XIV);

Recommendation 4 (CBS-15);

Recommendations 3, 8, 14, 17, 22 and 23 (CBS-Ext.(2014));

(2) Not to keep in force the other resolutions and recommendations adopted before the sixteenth session of the Commission for Basic Systems.

APPENDIX 4. RECOMMENDATIONS ADOPTED BY THE SESSION

Recommendation 1 (CBS-16)

MANUAL ON THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM (WMO-No. 1160), SECTION 2, APPENDIX 2.4 AND ATTACHMENT TO APPENDIX 2.4 (THE WIGOS METADATA STANDARD)

THE COMMISSION FOR BASIC SYSTEMS,

Noting that the WMO Integrated Global Observing System (WIGOS) Metadata Standard (WMDS) is the WMO standard for all the observational metadata, as approved by the Seventeenth World Meteorological Congress,

Noting further that the Executive Council at its sixty-eighth session adopted the plan for the WIGOS pre-operational phase (2016–2019), which includes the further development of the WIGOS Information Resource (WIR) with special emphasis on the operational deployment of the Observing Systems Capability Analysis and Review tool (OSCAR),

Recognizing that the OSCAR tool for surface-based observation (OSCAR/Surface) has been developed as an operational tool for the practical implementation of the WMDS by all Members,

Recalling that the "beta" users of OSCAR/Surface during the test phase in 2015 provided many useful comments regarding the metadata elements and their implementation,

Acknowledging the work done by the Inter-commission Coordination Group on Wigos Task Team on WIGOS Metadata in improving and further developing the WMDS, in collaboration with experts from MeteoSwiss and other working bodies of WMO, namely, the Inter-programme Expert Team on WIGOS Framework Implementation, the Inter-programme Expert Team on Satellite Utilization and Products and the Inter-programme Expert Team on Metadata and Data Representation Development,

Recommends that the Executive Council adopt the updated Appendix 2.4 and the attachment to Appendix 2.4 of the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) as provided in the annex to the present recommendation;

Recommends further that the attachment to Appendix 2.4 be extracted from the Manual and processed separately as a stand-alone attachment in order to facilitate frequent updating of its technical content [Comment: similar to Part D of the *Manual on Codes* (WMO-No. 306)], and that the code tables from the current annex to the attachment to Appendix 2.4 be removed and included in the *Manual on Codes*.

Annex to Recommendation 1 (CBS-16)

***MANUAL ON THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM* (WMO-No. 1160)**

SECTION: Cover red

Manual on the WMO Integrated Global Observing System

Annex VIII to the WMO Technical Regulations

SECTION: TitlePage

Manual on the WMO Integrated Global Observing System

Annex VIII to the WMO Technical Regulations

SECTION: ISBN-Long_with_URLs
SECTION: Revision_table

PUBLICATION REVISION TRACK RECORD

TABLE: Revision table

Date	*Part/chapter/ section*	*Purpose of amendment*	*Proposed by*	*Approved by*
	Section 2, Appendix 2.4	Further development of the WIGOS Metadata Standard and OSCAR/Surface	ICG-WIGOS (CBS-16)	
	Section 8	Modifications of the CryoNet station/site concept, of minimum requirements for stations/sites and of the procedure for testing stations/sites	EC-PHORS (CBS-16)	

SECTION: Table_of_contents
SECTION: Pr-Preliminary_pages
Chapter title in running head: INTRODUCTION

INTRODUCTION

General

1. This is the first edition of the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), developed following the decision of the Sixteenth World Meteorological Congress to proceed with the implementation of that System (WIGOS). It was approved by the Seventeenth World Meteorological Congress.

2. The Manual was developed by the Executive Council through its Inter-Commission Coordination Group on WIGOS, specifically its Task Team on WIGOS Regulatory Material. It is the result of a collaborative approach involving all interested technical commissions under the leadership of the Commission for Basic Systems (CBS) and the Commission for Instruments and Methods of Observation (CIMO).

Purpose and scope

3. The Manual is designed:

(a) To specify the obligations of Members in the implementation and operation of WIGOS;

(b) To facilitate cooperation in observations between Members;

(c) To ensure adequate uniformity and standardization in the practices and procedures employed in achieving (a) and (b) above.

4. The Manual is Annex VIII to the *Technical Regulations* (WMO-No. 49) and should be read in conjunction with the four volumes and the set of annexes which together make up the *Technical Regulations*. In particular, the *Manual on the Global Observing System* (WMO-No. 544) will be for some time a companion to the present Manual, but it will eventually disappear as its content is progressively moved into the *Manual on the WMO Integrated Global*

Observing System. Gradually, all technical regulations for all WMO component observing systems will be included under the identity of WIGOS.

5. Members will implement and operate their observing systems in accordance with decisions of Congress, the Executive Council, the technical commissions and regional associations. Where those decisions are technical and regulatory in nature, they will in due course be documented in the Technical Regulations.

6. In essence, the Manual specifies what is to be observed, and what practices and procedures are to be followed in order to meet the relevant observational requirements of Members. These requirements may arise directly at a national level or collectively through WMO Programmes at global or regional levels, and are expressed through the application areas of the Rolling Review of Requirements. A number of other Manuals and Guides provide more practices and procedures on the operation of observing systems including stations and platforms, instruments and methods of observation, and on reporting and management of observations and observational metadata.

7. In the case of hydrological observations, there is not a widely implemented base of global exchange and global standard practices and procedures. *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, provides Members with predominantly recommended practices and procedures. In order to help ensure the quality and comparability of observations within WIGOS, Members making their hydrological observations available through the WMO Hydrological Observing System (WHOS) are requested to comply with the provisions specified within the present Manual. For this reason, a number of provisions that are recommended practices and procedures for hydrology in *Technical Regulations*, Volume III, are listed as standard practices and procedures in the present Manual. It is recognized that it might not be easy for some of the WIGOS standard practices and procedures to be widely and quickly implemented by all Members for their hydrological observations. Nonetheless, Members are urged to make their best efforts to implement the WIGOS standard practices and procedures in the collection and exchange of hydrological observations and to make such observations available through WHOS.

Appendices

8. Appendices are used where a set of provisions on a single topic might, due to their detailed nature and length, otherwise interrupt the flow of the relevant section of the present Manual. Moreover, appendices are used to facilitate the ongoing review and update process by identifying subsections that fall under the responsibility of a particular group.

SECTION: Pr-Preliminary_pages
Chapter title in running head: GENERAL PROVISIONS

GENERAL PROVISIONS

1. The *Technical Regulations* (WMO-No. 49) of the World Meteorological Organization are presented in four volumes:

Volume I – General meteorological standards and recommended practices

Volume II – Meteorological service for international air navigation

Volume III – Hydrology

Volume IV – Quality management

Purpose of the Technical Regulations

2. The Technical Regulations are determined by the World Meteorological Congress in accordance with Article 8 (d) of the Convention.

3. These Regulations are designed:

(a) To facilitate cooperation in meteorology and hydrology among Members;

(b) To meet, in the most effective manner, specific needs in the various fields of application of meteorology and operational hydrology in the international sphere;

(c) To ensure adequate uniformity and standardization in the practices and procedures employed in achieving (a) and (b) above.

Types of Regulations

4. The Technical Regulations comprise *standard* practices and procedures and *recommended* practices and procedures.

5. The definitions of these two types of Regulations are as follows:

The *standard* practices and procedures:

(a) Shall be the practices and procedures that Members are required to follow or implement;

(b) Shall have the status of requirements in a technical resolution in respect of which Article 9 (b) of the Convention is applicable;

(c) Shall invariably be distinguished by the use of the term *shall* in the English text, and by suitable equivalent terms in the Arabic, Chinese, French, Russian and Spanish texts.

The *recommended* practices and procedures:

(a) Shall be the practices and procedures with which Members are urged to comply;

(b) Shall have the status of recommendations to Members, to which Article 9 (b) of the Convention shall not be applied;

(c) Shall be distinguished by the use of the term *should* in the English text (except where otherwise provided by decision of Congress) and by suitable equivalent terms in the Arabic, Chinese, French, Russian and Spanish texts.

6. In accordance with the above definitions, Members shall do their utmost to implement the *standard* practices and procedures. In accordance with Article 9 (b) of the Convention and in conformity with Regulation 128 of the General Regulations, Members shall formally notify the Secretary-General, in writing, of their intention to apply the *standard* practices and procedures of the Technical Regulations, except those for which they have lodged a specific deviation. Members shall also inform the Secretary-General, at least three months in advance, of any change in the degree of their implementation of a *standard* practice or procedure as previously notified and the effective date of the change.

7. Members are urged to comply with *recommended* practices and procedures, but it is not necessary to notify the Secretary-General of non-observance except with regard to practices and procedures contained in Volume II.

8. In order to clarify the status of the various Regulations, the *standard* practices and procedures are distinguished from the *recommended* practices and procedures by a difference in typographical practice, as indicated in the editorial note.

Status of annexes and appendices

9. The following annexes to the *Technical Regulations* (Volumes I to IV), also called Manuals, are published separately and contain regulatory material having the status of *standard* and/or *recommended* practices and procedures:

I *International Cloud Atlas* (WMO-No. 407), Volume I – Manual on the Observation of Clouds and Other Meteors, Part I; Part II: paragraphs II.1.1, II.1.4, II.1.5 and II.2.3; subparagraphs 1, 2, 3 and 4 of each paragraph from II.3.1 to II.3.10; paragraphs II.8.2 and II.8.4; Part III: paragraph III.1 and the definitions (in italics) of paragraph III.2;
II *Manual on Codes* (WMO-No. 306), Volume I;
III *Manual on the Global Telecommunication System* (WMO-No. 386);
IV *Manual on the Global Data-processing and Forecasting System* (WMO-No.485), Volume I;
V *Manual on the Global Observing System* (WMO-No. 544), Volume I;
VI *Manual on Marine Meteorological Services* (WMO-No. 558), Volume I;
VII *Manual on the WMO Information System* (WMO-No. 1060);
VIII *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

These annexes (Manuals) are established by decision of Congress and are intended to facilitate the application of Technical Regulations to specific fields. Annexes may contain both *standard* and *recommended* practices and procedures.

10. Texts called appendices, appearing in the *Technical Regulations* or in an annex to the *Technical Regulations*, have the same status as the Regulations to which they refer.

Status of notes and attachments

11. Certain notes (preceded by the indication "Note") are included in the *Technical Regulations* for explanatory purposes; they may, for instance, refer to relevant WMO Guides and publications. These notes do not have the status of Technical Regulations.

12. The *Technical Regulations* may also include attachments, which usually contain detailed guidelines related to *standard* and *recommended* practices and procedures. Attachments, however, do not have regulatory status.

Updating of the *Technical Regulations* and their annexes (Manuals)

13. The Technical Regulations are updated, as necessary, in the light of developments in meteorology and hydrology and related techniques, and in the application of meteorology and operational hydrology. Certain principles previously agreed upon by Congress and applied in the selection of material for inclusion in the Technical Regulations are reproduced below. These principles provide guidance for constituent bodies, in particular technical commissions, when dealing with matters pertaining to the Technical Regulations:

(a) Technical commissions should not recommend that a Regulation be a *standard* practice unless it is supported by a strong majority;

(b) Technical Regulations should contain appropriate instructions to Members regarding implementation of the provision in question;

(c) No major changes should be made to the Technical Regulations without consulting the appropriate technical commissions;

(d) Any amendments to the Technical Regulations submitted by Members or by constituent bodies should be communicated to all Members at least three months before they are submitted to Congress.

14. Amendments to the *Technical Regulations* – as a rule – are approved by Congress.

15. If a recommendation for an amendment is made by a session of the appropriate technical commission and if the new regulation needs to be implemented before the next session of Congress, the Executive Council may, on behalf of the Organization, approve the amendment in accordance with Article 14 (c) of the Convention. Amendments to annexes to the *Technical Regulations* proposed by the appropriate technical commissions are normally approved by the Executive Council.

16. If a recommendation for an amendment is made by the appropriate technical commission and the implementation of the new regulation is urgent, the President of the Organization may, on behalf of the Executive Council, take action as provided by Regulation 9 (5) of the General Regulations.

Note: A fast-track procedure can be applied for additions to certain codes and associated code tables contained in Annex II (*Manual on Codes* (WMO-No. 306)). Application of the fast-track procedure is described in detail in Annex II.

17. After each session of Congress (every four years), a new edition of the *Technical Regulations*, including the amendments approved by Congress, is issued. With regard to the amendments between sessions of Congress, Volumes I, III and IV of the *Technical Regulations* are updated, as necessary, upon approval of changes thereto by the Executive Council. The *Technical Regulations* updated as a result of an approved amendment by the Executive Council are considered a new update of the current edition. The material in Volume II is prepared by the World Meteorological Organization and the International Civil Aviation Organization working in close cooperation, in accordance with the Working Arrangements agreed by these Organizations. In order to ensure consistency between Volume II and Annex 3 to the Convention on International Civil Aviation – *Meteorological Service for International Air Navigation*, the issuance of amendments to Volume II is synchronized with the respective amendments to Annex 3 by the International Civil Aviation Organization.

Note: Editions are identified by the year of the respective session of Congress whereas updates are identified by the year of approval by the Executive Council, for example "Updated in 2012".

WMO Guides

18. In addition to the *Technical Regulations*, appropriate Guides are published by the Organization. They describe practices, procedures and specifications which Members are invited to follow or implement in establishing and conducting their arrangements for compliance with the Technical Regulations, and in otherwise developing meteorological and hydrological services in their respective countries. The Guides are updated, as necessary, in the light of scientific and technological developments in hydrometeorology, climatology and their applications. The technical commissions are responsible for the selection of material to be included in the Guides. These Guides and their subsequent amendments shall be considered by the Executive Council.

SECTION: Pr-Preliminary_pages
Chapter title in running head: DEFINITIONS

DEFINITIONS

Notes:

1. Other definitions related to observing systems may be found in the *Technical Regulations* (WMO-No. 49), Volume I and the *Manual on the Global Observing System* (WMO-No. 544), Volume I. Definitions are not duplicated between Manuals, hence the importance of consulting all publications.

2. Further definitions may be found in the *Manual on Codes* (WMO-No. 306), the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), Volume I, the *Manual on the Global Telecommunication System* (WMO-No. 386) and other WMO publications.

3. Definitions, terminology, vocabulary and abbreviations used in relation to quality management are those of the International Organization for Standardization (ISO) 9000 family of standards for quality management systems, in particular those identified within *ISO 9000:2015, Quality management systems – Fundamentals and vocabulary*.

The following terms, when used in the present Manual, have the meanings given below.

Accuracy. The extent to which the results of the readings of an instrument approach the true value of the calculated or measured quantities, supposing that all possible corrections are applied.

Acoustic Doppler current profiler (ADCP). Hydroacoustic device to measure the velocity of water over a range of depths in a column using the Doppler effect, with the overall depth of water usually being measured simultaneously.

Acoustic velocity meter. System that uses the difference in travel time of acoustic (ultrasonic) pulses between transducers in a stream to determine the mean velocity on the signal path.

Adaptive maintenance. Modification of an instrument, software or other product, performed after installation to keep it usable in a changed or changing environment.

Bank. (1) Rising land bordering a river, usually to contain the stream within the wetted perimeter of the channel; (2) Margin of a channel on the left-hand (right-hand) side when facing downstream.

Cableway. Cable stretched above and across a stream, from which a current meter or other measuring or sampling device is suspended, and moved from one bank to the other, at predetermined depths below the water surface.

Calibration (rating) tank (Straight open tank). Tank containing still water through which a current meter is moved at a known velocity in order to calibrate the meter.

Catchment area. Area having a common outlet for its surface runoff.

Certification. The provision by an independent body of written assurance (a certificate) that the product, service or system in question meets specific requirements.

Compliance. Adherence to an internal code of conduct where employees follow the principles of one of the Quality Management Standards series (such as the ISO standards) or other internationally recognized practices and procedures. It could also be an external stamp of approval by an accreditation firm when customers or partners request documented proof of compliance.

Confidence level. Probability that the confidence interval includes the true value.

Control. Physical properties of a channel which determine the relationship between stage and discharge at a location in the channel.

Control structures. Artificial structures placed in a stream such as a low weir or flume to stabilize the stage-discharge relation, particularly in the low flow range, where such structures are calibrated by stage and discharge measurements taken in the field.

Co-sponsored observing system. An observing system from which some but not all observations are WMO observations.

Cross-section. Section perpendicular to the main direction of flow bounded by the free surface and wetted perimeter of the stream or channel.

Current meter. Instrument for measuring water velocity.

Current meter, propeller type. A current meter the rotor of which is a propeller rotating around an axis parallel to the flow.

Data archiving. Storage of data on a set of catalogued files which are held in some backup storage medium and not necessarily permanently online.

Data compatibility. The capacity for two systems to exchange data without having to be altered to do so and without any need for changes in data formats.

Data processing. Treatment of observational data until they are in a form ready to be used for a specific purpose.

Data quality objectives. Definition of the type, quality and quantity of primary data and derived parameters required to yield information that can be used to support decisions.

Discharge. Volume of water flowing through a river (or channel) cross-section per unit time.

Drainage basin. See **catchment area**

Elevation. Vertical distance of a point or level, on or affixed to the surface of the ground, measured from mean sea level.

Estuary. Broad portion of a stream near its outlet to a sea, lake or sabkha.

Flood. (1) Rise, usually brief, in the water level of a stream or water body to a peak from which the water level recedes at a slower rate; (2) Relatively high flow as measured by stage height or discharge.

Flood-proofing. Techniques for preventing flood damage in a flood-prone area.

Gauge boards (staff gauge). Graduated vertical scale, fixed to a staff or structure, on which the water level may be read.

Gauge datum. Vertical distance between the zero of a gauge and a certain datum level.

Gauging station. Location on a stream where measurements of water level and/or discharge are made systematically.

GAW Station Information System (GAWSIS). The official catalogue for monitoring sites, platforms or stations operating within the Global Atmosphere Watch (GAW) and related programmes, providing station metadata and serving as the clearing house for unique station identifiers. The GAW Station Information System represents the metadata source for OSCAR for GAW observations.

Hydrograph. Graph showing the variation in time of some hydrological data, such as stage, discharge, velocity and sediment load.

Hydrological forecast. Estimation of the magnitude and time of occurrence of future hydrological events for a specified period and for a specified locality.

Hydrological observation. Direct measurement or evaluation of one or more hydrological elements such as stage, discharge and water temperature.

Hydrological observing station. Place where hydrological observations or climatological observations for hydrological purposes are made.

Hydrological warning. Emergency information on an expected hydrological event that is considered to be dangerous.

Hydrometric station. Station gathering data on one or more parameters of water in rivers, lakes or reservoirs, such as stage, streamflow, sediment transport and deposition, water temperature and other physical or chemical properties of water, and characteristics of ice cover.

Intercomparison. A formalized process to assess the relative performance of two or more systems (observing, forecasting, etc.).

Moving-boat method. Method of measuring discharge which uses a boat to traverse the stream along the measuring section and continuously measure velocity, depth and distance travelled.

Quality. The degree to which a set of inherent characteristics fulfils requirements.

Quality assurance. That part of quality management focused on providing confidence that quality requirements will be fulfilled.

Quality control. That part of quality management focused on fulfilling quality requirements.

Quality management. The coordinated activities that direct and manage an organization with respect to quality.

Rating curve. Curve showing the relation between stage and discharge of a stream at a hydrometric station.

Recession. Period of decreasing discharge as indicated by the falling limb of a hydrograph starting from the peak.

Registration. Certification is very often referred to as registration in North America.

Reservoir. Body of water, either natural or man-made, used for storage, regulation and control of water resources.

River. Large stream that serves as the natural drainage for a basin.

Stage. See ***water level***.

Stage-discharge relation. Relationship between water level and discharge for a river cross-section, which may be expressed as a curve, a table or an equation.

Streamflow. General term for water flowing in a watercourse.

Uncertainty. Estimate of the range of values within which the true value of a variable lies.

Upstream. Direction from which a fluid is moving.

Verification. The process of establishing the truth, accuracy or validity of something.

Water level. Elevation of the free water surface of a water body relative to a datum level.

SECTION: Chapter First

Chapter title in running head: 1. INTRODUCTION TO WIGOS

1. INTRODUCTION TO WIGOS

1.1 PURPOSE AND SCOPE OF WIGOS

1.1.1 The WMO Integrated Global Observing System shall be a framework for all WMO observing systems and for WMO contributions to co-sponsored observing systems in support of all WMO Programmes and activities.

Note: The co-sponsored observing systems are the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS), all joint undertakings of WMO and the

Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the International Council for Science (ICSU).

1.1.2 The WMO Integrated Global Observing System shall facilitate the use by WMO Members of observations from systems that are owned, managed and operated by a diverse array of organizations and programmes.

1.1.3 The principal purpose of WIGOS shall be to meet the evolving requirements of Members for observations.

1.1.4 The interoperability (including data compatibility) of WIGOS component observing systems shall be achieved through their common utilization and application of internationally accepted standards and recommended practices and procedures. Data compatibility shall also be supported through the use of data representation standards.

1.2 WIGOS COMPONENT OBSERVING SYSTEMS

The component observing systems of WIGOS shall comprise the Global Observing System (GOS) of the World Weather Watch (WWW) Programme, the observing component of the Global Atmosphere Watch (GAW) Programme, the WMO Hydrological Observing System (WHOS) of the Hydrology and Water Resources Programme (HWRP) and the observing component of the Global Cryosphere Watch (GCW), including their surface-based and space-based elements.

Note: The above component systems include all WMO contributions to the co-sponsored systems, as well as to the Global Framework for Climate Services (GFCS) and the Global Earth Observation System of Systems (GEOSS).

1.2.1 The Global Observing System of the World Weather Watch

1.2.1.1 The Global Observing System shall be a coordinated system of observing networks, methods, techniques, facilities and arrangements for making observations on a worldwide scale and shall be one of the main components of the World Weather Watch.

1.2.1.2 The purpose of GOS shall be to provide the meteorological observations from all parts of the globe that are required by Member countries for operational and research purposes through all WMO and co-sponsored programmes.

1.2.1.3 The Global Observing System shall consist of: (a) a surface-based subsystem composed of regional basic and other networks of stations and platforms; and (b) a space-based subsystem composed of: (i) an Earth observation space segment; (ii) an associated ground system for data reception, dissemination and stewardship; and (iii) a user segment.

1.2.1.4 The Global Observing System shall comply with the provisions specified in sections 1, 2, 3, 4 and 5.

1.2.2 The Global Atmosphere Watch (observing component)

1.2.2.1 The Global Atmosphere Watch shall be a coordinated system of observing networks, methods, techniques, facilities and arrangements encompassing the many monitoring activities and scientific assessments devoted to the investigation of the chemical composition and related physical characteristics of the atmosphere.

Note: The GAW Programme has six focal areas: ozone, greenhouse gases, reactive gases, aerosols, ultraviolet (UV) radiation and total atmospheric deposition. The GAW stations in addition to measuring one or more of the parameters related to these areas may also measure ancillary variables such as radiation, radio nuclides and persistent organic pollutants.

1.2.2.2 The purpose of GAW shall be to provide data and other information on the chemical composition and related physical characteristics of the background, unpolluted atmosphere, as defined in section 6, from all parts of the globe, in order to reduce environmental risks to society and meet the requirements of environmental conventions, strengthen capabilities to predict the state of climate, weather and air quality, and contribute to scientific assessments in support of environmental policy.

1.2.2.3 The observing component of GAW shall consist of a surface-based system composed of networks for observation of specified variables, complemented by space-based observations.

1.2.2.4 The observing component of the GAW Programme shall be operated in accordance with the provisions specified in sections 1, 2, 3, 4 and 6.

1.2.3 The WMO Hydrological Observing System

1.2.3.1 The WMO Hydrological Observing System shall comprise hydrological observations, initially focusing on water level and discharge.

Note: The composition of WHOS is provided in *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, Chapter D.1.2.

1.2.3.2 The WMO Hydrological Observing System shall expand to include other elements identified through the Rolling Review of Requirements (RRR) (described in section 2.2.4 and Appendix 2.3) at the national, regional and global levels.

1.2.3.3 The purpose of WHOS shall be to provide real-time stream data (both water level and discharge) from participating Members.

1.2.3.4 Members making their hydrological observations available through the WHOS shall comply with the provisions specified in sections 1, 2, 3, 4 and 7.

Note: The *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, the *Guide to Hydrological Practices* (WMO-No. 168), the *Manual on Stream Gauging* (WMO-No. 1044) and the *Manual on Flood Forecasting and Warning* (WMO-No. 1072) provide the necessary information to operate hydrological stations to the prescribed standards.

1.2.4 The Global Cryosphere Watch (observing component)

1.2.4.1 The Global Cryosphere Watch shall be a coordinated system of observing networks, methods, techniques, facilities and arrangements encompassing monitoring and related scientific assessment activities devoted to the investigation of the cryosphere.

1.2.4.2 The purpose of the GCW shall be to provide data and other information on the cryosphere, from the local to the global scale, to improve understanding of its behaviour, interactions with other components of the climate system and impacts on society.

1.2.4.3 The GCW observing network and its standardized core network (CryoNet) shall build on existing observing programmes and promote the addition of standardized cryospheric observations to existing facilities.

1.2.4.4 The observing component of the GCW shall comply with the provisions specified in sections 1, 2, 3, 4 and 8.

1.3 GOVERNANCE AND MANAGEMENT

1.3.1 Implementation and operation of WIGOS

1.3.1.1 Members shall be responsible for all activities connected with the implementation and operation of WIGOS on the territory of their respective countries.

1.3.1.2 Members should, as far as possible, use national resources for the implementation and operation of WIGOS, but, where necessary and if so requested, assistance may be provided in part through:

(a) The WMO Voluntary Cooperation Programme (VCP);

(b) Other bilateral or multilateral arrangements/facilities including the United Nations Development Programme (UNDP), which should be used to the maximum extent possible.

1.3.1.3 Members should participate voluntarily in the implementation and operation of WIGOS outside the territories of individual countries (for example, outer space, oceans and the Antarctic), if they wish and are able to contribute by providing facilities and services, either individually or jointly.

1.3.2 WIGOS quality management

Notes:

1. Within the WMO Quality Management Framework (QMF), WIGOS provides the procedures and practices regarding to the quality of observations and observational metadata that should be adopted by Members in establishing their quality management system for the provision of meteorological, hydrological, climatological and other related environmental observations.

2. Section 2.6 contains detailed provisions for WIGOS quality management.

1.3.3 WIGOS high-level processes

Members should adopt a process-based approach to the management of WIGOS observing systems as described in Attachment 1.1.

SECTION: Chapter
Chapter title in running head: ATTACHMENT 1.1. WIGOS HIGH-LEVEL PROCES…

ATTACHMENT 1.1. WIGOS HIGH-LEVEL PROCESSES

Many of the WIGOS activities may be represented as a series of high-level processes.

The figure below **ELEMENT REF: 1 (Floating object)** provides a schematic description of the processes (horizontal bars), the collaborating entities (columns) and those primarily involved in each process (marked by solid circles). In reality, the processes have more complex interrelationships and sequences than shown by the arrows – the most extreme case being capacity development (including training) which is not shown as a step in the sequence since it provides important inputs to most of the other processes.

ELEMENT 1: Floating object (Automatic)
ELEMENT 2: Picture inline fix size
Element Image: 1160_Att_1_1_Fig_en.eps

END ELEMENT

Schematic representation of WIGOS high-level processes

END ELEMENT

These processes are carried out by Members through one of the following modes of collaboration:

- Data users in application areas: Members collaborate by selectively contributing application experts and information;
- WMO regional associations: Members collaborate by working together in a geographical grouping and by selectively contributing experts for regional teams;
- WMO technical commissions: Members collaborate by selectively contributing technical experts for global teams;
- As individual operators and managers of observing systems, Members directly undertake the relevant WIGOS process(es);
- WMO designated centres for performance monitoring (including lead centres and monitoring centres): individual Members or groups of Members operate a WMO centre designated for performance monitoring.

In the case of WIGOS processes being undertaken by the WMO Secretariat or other entities funded by WMO Programmes, the mode of collaboration is through the overall operation of WMO.

The following example illustrates the relation between the WIGOS high-level processes and the structure of the regulatory material. The standard and recommended practices and procedures relevant to each WIGOS process can be found in section 2, under the following sub-sections:

- Determination of user requirements: 2.1 and 2.2;
- Design, planning and evolution of WIGOS: 2.2;
- Development and documentation of standard and recommended practices and procedures for observing systems: 2.3;
- Implementation of an observing system by owners and operators: 2.3 and 2.4;
- Observing system operation and maintenance including fault management and audit: 2.4;
- Observation quality control: 2.4 and 2.6;
- Observations and observational metadata delivery: 2.4 and 2.5;
- Performance monitoring: 2.4 and 2.6;
- User feedback and review of requirements: 2.2 and 2.6;
- Capacity development (including training): 2.7.

SECTION: Chapter

Chapter title in running head: 2. COMMON ATTRIBUTES OF WIGOS COMPONENT…

2. COMMON ATTRIBUTES OF WIGOS COMPONENT SYSTEMS

2.1 REQUIREMENTS

2.1.1 Members shall take steps to collect, record, review, update and make available their user requirements for observation.

2.1.2 Members shall convey their user observational requirements, for each of the WMO application areas, to the RRR process described under section 2.2.4 and Appendix 2.3.

2.2 DESIGN, PLANNING AND EVOLUTION

2.2.1 General

2.2.1.1 The WMO Integrated Global Observing System shall be designed as a flexible and evolving system capable of continuous improvement.

Note: Factors that drive the evolution of WIGOS component observing systems include technological and scientific progress and cost-effectiveness; changes in the needs and requirements of WMO, WMO co-sponsored programmes and international partner organizations at national, regional and global levels; and changes in the capacity of Members to implement observing systems. It is important to identify the impact on all users before a change is made.

2.2.1.2 Members shall plan and operate their networks in a sustainable and reliable manner utilizing WIGOS standard and recommended practices and procedures, and tools.

Note: Sustainability over at least a ten-year period is recommended; however, this depends on paying sufficient attention to maintenance and operations following the establishment of the network.

2.2.2 Principles for observing network design and planning

2.2.2.1 Observing network design principles

2.2.2.1.1 Members should follow the principles specified in Appendix 2.1 when designing and developing their observing networks.

2.2.2.1.2 Members should conduct network design studies that address national, regional and global scale questions about the optimum affordable mix of components to best satisfy the requirements for observations.

2.2.2.2 Climate monitoring principles of the Global Climate Observing System

Members designing and operating observing systems for monitoring climate should adhere to the principles specified in Appendix 2.2.

Note: Fifty Essential Climate Variables have been identified for GCOS. These are required to support the work of the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC). The Essential Climate Variables cover the atmospheric, oceanic and terrestrial domains, and all are technically and economically feasible for systematic observation. Further information about the Essential Climate Variables can be found in the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* (2010 Update), GCOS-138 (also identified as WMO-TD/No. 1523).

2.2.3 Vision for WIGOS observing systems

Members shall take into account the Vision for the Global Observing System in 2025 when planning the evolution of their observing networks.

Notes:
1. The Vision for the Global Observing System in 2025 provides high-level goals to guide the evolution of the WMO Integrated Global Observing System in the coming decades. The Vision is updated on a multi-year timescale (typically decadal).

2. The Vision for the Global Observing System in 2025 is available at http://www.wmo.int/pages/prog/www/OSY/Publications/Vision-2025/Vision-for-GOS-in-2025_en.pdf.

2.2.4 The Rolling Review of Requirements

Members, both directly and through the participation of their experts in the activities of regional associations and technical commissions, shall contribute to the RRR process and assist the designated Points of Contact for each application area in performing their roles in the RRR.

Note: Appendix 2.3 provides further details on the RRR process.

2.2.5 Observation impact studies

2.2.5.1 Members, or groups of Members within regions, should conduct and/or participate in observation impact studies and related scientific evaluations to address WIGOS network design questions.

2.2.5.2 Members should provide expertise for synthesizing the results of impact studies and making recommendations on the best mix of observing systems to address the gaps identified by the RRR process.

Note: Impact studies involving Observing System Experiments, Observing System Simulation Experiments, Forecast Sensitivity to Observation studies and other assessment tools are used to assess the impact of the various observing systems on Numerical Weather Prediction model analyses and predictions, hence their value and relative priority for addition or retention for these application areas.

2.2.6 Evolution of WIGOS observing systems

2.2.6.1 Members should follow the plans published by WMO for the evolution of WIGOS component observing systems when planning and managing their WIGOS observing systems.

Notes:
1. The planning and coordination of the evolution of WIGOS observing systems is steered by the Executive Council and undertaken by Members individually and through regional associations, technical commissions and relevant steering bodies of WMO co-sponsored observing systems.

2. The current WMO plan for the evolution of WIGOS observing systems was published as the *Implementation Plan for the Evolution of Global Observing Systems* (EGOS-IP) (WIGOS Technical Report No. 2013-4). It contains guidelines and recommended actions to be undertaken by Members, technical commissions, regional associations, satellite operators and other relevant parties in order to stimulate cost-effective evolution of the WMO observing systems and address in an integrated way the requirements of WMO Programmes and co-sponsored programmes.

3. The WMO plan for the evolution of WIGOS observing systems is regularly updated and new versions are published on a multi-year timescale (typically decadal), taking into account the vision for the WIGOS observing systems, the advice of the technical commissions and regional associations concerned, relevant WMO co-sponsored observing systems and international experts in all application areas.

2.2.6.2 Members shall coordinate the activities of organizations within their country, including National Meteorological and Hydrological Services (NMHSs) and other agencies, in addressing relevant actions of the WMO plans for the evolution of WIGOS observing systems.

2.2.6.3 Where Member countries cover small areas and are geographically close or have already established multilateral working relationships, Members should consider a subregional or transboundary river basin approach, in addition to a national one, in WIGOS observing systems planning.

2.2.6.4 In this case, the Members concerned should work in close cooperation to prepare subregional or transboundary river basin reviews of requirements to be used as a basis for detailed planning at that scale.

2.2.7 Monitoring the evolution of WIGOS observing systems

Members should contribute to the monitoring of the evolution of WIGOS observing systems by providing their national progress reports on a yearly basis through nominated national focal points.

Note: The Commission for Basic Systems, in collaboration with other technical commissions, regional associations, and co-sponsored programmes, regularly reviews progress in the evolution of WIGOS observing systems and provides updated guidance to Members thereon.

2.3 INSTRUMENTATION AND METHODS OF OBSERVATION

2.3.1 General requirements

Note: Details are provided in the *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), *Weather Reporting* (WMO-No. 9), Volume D: Information for Shipping, and the *Guide to Hydrological Practices* (WMO-No. 168), Volume I: Hydrology – From Measurement to Hydrological Information.

2.3.1.1 Members should ensure that observations and observational metadata are traceable to the International System of Units (SI) standards, where these exist.

Note: Traceability to the International System of Units (SI) standards is an area where concerted effort is required to increase or improve compliance.

2.3.1.2 Members should employ properly calibrated instruments and sensors that provide observations satisfying at least measurement uncertainties that meet the specified requirements.

Notes:

1. Achievable measurement uncertainty is specified in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.6.5.2, Annex 1.D.

2. A number of operational, financial, environmental and instrumental issues may cause the system to not always satisfy the specified requirements. Annex 1.D (see the column "Achievable measurement uncertainty") provides a list of the achievable and affordable measurement uncertainties which in some cases might not satisfy specified requirements.

2.3.1.3 Members should describe uncertainty of observations and observational metadata as specified in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.6

Notes:

1. The corresponding text from the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.6, will be included as an appendix in a future edition.

2. The definition of uncertainty in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.6, is consistent with international standards approved by the International Committee for Weights and Measures (Comité international des poids et mesures (CIPM)).

2.3.1.4 Members should follow the definitions and specifications for the calculation of derived observations given in the WMO Technical Regulations.

Notes:

1. Further methods provided or referenced by the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) and the *Guide to Hydrological Practices* (WMO-No. 168), Volume I: Hydrology – From Measurement to Hydrological Information, could also be considered.

2. Such derivations can take many forms, for example, statistical processing of average or smooth values, or multivariate algorithm to determine streamflow discharge.

3. The corresponding text from the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) will be included as an appendix in a future edition of the present Manual.

2.4 OPERATIONS

2.4.1 General requirements

Note: Provision 2.4.1.1 of the *Technical Regulations* (WMO-No. 49), Volume I, Part I, applies.

2.4.1.1 WMO observing stations and platforms shall be uniquely identified by a WIGOS station identifier.

Note: The structure of WIGOS station identifiers is specified in Attachment 2.1.

2.4.1.2 Members shall issue WIGOS station identifiers for observing stations and platforms within their geographic area of responsibility that contribute to a WMO or co-sponsored programme and shall ensure that no WIGOS station identifier is issued to more than one station.

Note: Members may issue WIGOS station identifiers for observing stations and platforms within their geographic area of responsibility that do not contribute to a WMO or co-sponsored programme, provided that the operator has committed to providing and maintaining WIGOS metadata.

2.4.1.3 Before issuing a station identifier, Members should ensure that the operator of a station or platform has committed to providing and maintaining WIGOS metadata for that station or platform.

Notes:

1. In circumstances when a WIGOS identifier is required for a station or platform to support a WMO or co-sponsored programme and no Member is in a position to issue one (for example, in Antarctica), the Secretary-General may issue a WIGOS station identifier for that station or platform, provided that its operator has committed to:

   (a) Providing WIGOS metadata;

   (b) Conforming to relevant Technical Regulations.

2. In circumstances where a WIGOS identifier is required for a station or platform to support a WMO or co-sponsored programme and a Member is not able to issue one, the Secretary-General will work with the Member concerned to issue a WIGOS station identifier for that station or platform, provided that its operator has committed to:

   (a) Providing WIGOS metadata;

   (b) Conforming to relevant Technical Regulations.

2.4.1.4 Members shall make available to WMO the updated metadata each time a new station identifier is issued.

2.4.1.5 Members shall operate their observing systems with properly calibrated instruments and adequate observing and measuring techniques.

Notes:

1. Detailed guidance on observing practices of meteorological observing systems and instruments is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8).

2. Detailed guidance on observing practices of hydrological observing systems and instruments is given in the *Guide to Hydrological Practices* (WMO-No. 168), *the Manual on Flood Forecasting and Warning* (WMO-No. 1072) and the *Manual on Stream Gauging* (WMO-No. 1044).

3. Detailed guidance on observing practices of GAW observing systems and instruments is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8).

2.4.1.6 Members should address the requirements for uncertainty, timeliness, temporal resolution, spatial resolution and coverage which result from the RRR process specified in section 2.2.4 and in accordance with the details provided by other sections as appropriate.

2.4.1.7 Members shall ensure that proper safety procedures are specified, documented and utilized in all their operations.

Note: Safety practices and procedures are concerned with ensuring the welfare of staff while promoting overall efficiency and effectiveness of the NMHS and respond to national laws, regulations and requirements for occupational health and safety.

2.4.2 Observing practices

Members should ensure that their observing practices are adequate to comply with user observational requirements.

Note: Observing practices include station operation, data processing practices and procedures, applied calculation rules, documentation on calibration practices and associated metadata.

2.4.3 Quality control

2.4.3.1 Members shall ensure that observations provided through their WIGOS component observing systems are quality controlled.

2.4.3.2 Members shall implement real-time quality control prior to exchange of observations via the WMO Information System.

Notes:

1. Quality control of observations consists in examination of observations at stations and data centres to detect errors so that observations may be either corrected or flagged. A quality control system should include procedures for returning to the source of observations to verify them and to prevent recurrence of errors. Quality control is applied in real-time, but it also operates in non-real-time, as delayed quality control. The quality of observations depends on the quality control procedures applied during acquisition and processing of observations and during preparation of messages, in order to eliminate the main sources of errors and ensure the highest possible standard of accuracy for the optimum use of those observations by all possible users.

2. Quality control in real time also takes place in the Global Data-processing and Forecasting System, prior to the use of meteorological and climatological observations in data processing (i.e. objective analysis and forecasting).

3. Recommended minimum standards of quality control of meteorological and climatological observations at the level of the National Meteorological Centre are given in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), Volume I: Global Aspects, Appendix II-1, Table I. The *Guide on the Global Data-processing System* (WMO-No. 305) should be consulted for more detailed guidance.

4. Recommended practices and procedures for quality control of hydrological observations are given in the *Manual on Flood Forecasting and Warning* (WMO-No. 1072), Chapter 6, and in the *Guide to Hydrological Practices* (WMO-No. 168).

5. Recommended practices and procedures regarding the quality of observations for GAW requirements are formulated in Measurement Guidelines through Data Quality Objectives (see GAW reports at http://www.wmo.int/pages/prog/arep/gaw/gaw-reports.html).

2.4.3.3 Members not capable of implementing these standards should establish agreements with an appropriate Regional Meteorological Centre or World Meteorological Centre to perform the necessary quality control.

2.4.3.4 Members shall also perform quality control of observations on a non-real-time basis, prior to forwarding the observations for archiving.

2.4.3.5 Members should develop and implement adequate quality control processes.

Notes:

1. Quality control processes include (but are not necessarily limited to): (a) validation; (b) cleaning; and (c) monitoring.

2. Further guidance is available in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), the *Guide to Climatological Practices* (WMO-No. 100), the *Guide to Hydrological Practices* (WMO-No. 168), Volume I: Hydrology – From Measurement to Hydrological Information, and the *Guide to the Global Observing System* (WMO-No. 488).

2.4.4 Data and metadata reporting

2.4.4.1 Members shall report and make available observations in the standard formats specified by the *Manual on Codes* (WMO-No. 306).

2.4.4.2 In the case of GAW observations, Members shall report and make available observations in standard formats as advised by GAW data centres, in accordance with the provisions in chapter 6.

Note: Members are to report and make available up-to-date WIGOS metadata as specified in section 2.5.2.

2.4.5 Incident management

2.4.5.1 Members should implement incident management to detect, identify, record, analyse and respond to any incident, in order to restore normal operation of the observing system as quickly as possible, minimizing the negative impact and preventing recurrence.

2.4.5.2 Members shall implement procedures to detect, analyse and respond to system faults and human errors at the earliest stage possible.

2.4.5.3 Members should record and analyse incidents as appropriate.

2.4.6 Change management

2.4.6.1 Members should carefully plan and manage changes to ensure continuity and consistency of observations and record any modification related to the observing system.

Note: This requirement relates to any change in the observing system, including an observing station, observing programme, instruments, methods of observation, and so on.

2.4.6.2 In the event of significant changes in instruments or methods of observation used or the location in which observations are made, Members should ensure a sufficiently long period (to capture all expected climatic conditions) of overlap, with dual operation of old and new systems to identify biases, inconsistencies and inhomogeneities.

2.4.7 Maintenance

2.4.7.1 Members shall ensure that each observing system is rigorously maintained.

2.4.7.2 Members shall perform regular preventive maintenance of their observing systems including their instruments.

Note: Carefully organized preventive maintenance of all system components is recommended to minimize corrective action and to increase the operational reliability of an observing system.

2.4.7.3 Members shall determine the frequency and timing (schedule) of the preventive maintenance taking into account the type of observing system, environmental and climate conditions of the observing site and platform, and the instrumentation installed.

2.4.7.4 Members shall perform corrective maintenance in case of failure of an observing system component as soon as practically possible once the problem has been detected.

2.4.7.5 Members shall employ adaptive maintenance that satisfies the requirements for stability, continuity and consistency of observations through time.

Note: Detailed guidance on maintenance of observing systems and instruments is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), including technical papers on GAW measurements referenced in Part I, Chapter 16; the *Guide to Hydrological Practices* (WMO-No. 168) and the *Manual on Stream Gauging* (WMO-No. 1044).

2.4.8 Inspection

Members shall arrange periodic inspection of their observing systems.

Note: Such inspection could be undertaken directly or remotely, as necessary, to monitor the correct functioning of observing platforms and instruments.

2.4.9 Calibration procedures

2.4.9.1 Members shall ensure that measurement systems and instruments are calibrated regularly in accordance with adequate procedures for each type of system and instrument, as described in the relevant sections of the present Manual.

Notes:

1. Where international or national standards are not available, the basis for calibration is defined or supplied by the manufacturer or by the Scientific Advisory Groups for GAW observations.

2. Detailed guidance on calibration procedures is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), the *Guide to Hydrological Practices* (WMO-No. 168) and the *Manual on Stream Gauging* (WMO-No. 1044).

3. In the GAW Programme, World Calibration Centres perform the audit of the stations and require that every laboratory is traceable to the single network standard.

2.4.9.2 Members shall ensure that the measuring devices they use are:

(a) Calibrated or verified at specified intervals, or prior to use, against measurement standards traceable to international or national standards. Where no such standards exist, the basis used for calibration or verification shall be recorded;

(b) Adjusted or readjusted as necessary, but at the same time safeguarded from adjustments that would invalidate the measurements;

(c) Identified, enabling the calibration status to be determined;

(d) Protected from damage and deterioration during handling, maintenance and storage.

Note: Details regarding hydrological observations are given in *Technical Regulations* (WMO-No. 49), Volume III: Hydrology; guidance is available in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), the *Guide to Hydrological Practices* (WMO-No. 168) and the *Manual on Stream Gauging* (WMO-No. 1044).

2.4.9.3 When the equipment is found not to conform to requirements, the Member shall assess and record the validity of previous measuring results and take appropriate action on the equipment and the products affected.

2.4.9.4 Members shall record and maintain the results of calibration and verification.

2.5. OBSERVATIONAL METADATA

2.5.1 Purpose and scope

Notes:
1. Observational metadata are essential as they enable users of observations to assess their suitability for the intended application, and managers of observing systems to monitor and control their systems and networks. Members benefit from sharing observational metadata which describe quality of observations and provide information about stations and networks used to collect those observations.

2. Discovery metadata, defined in the *Manual on the WMO Information System* (WMO-No. 1060), are concerned with discovering and accessing information, including observations and their observational metadata. Requirements for discovery metadata are specified in the *Manual on the WMO Information System* and are not considered further here.

2.5.1.1 For all WIGOS observations they make available internationally, Members shall record and retain the observational metadata specified as mandatory in the WIGOS Metadata Standard defined in Appendix 2.4.

Notes:
1. The WIGOS Metadata Standard defines a common set of requirements for observational metadata. It includes a detailed list of mandatory, conditional and optional metadata.

2. "Not available", "unknown" or "not applicable" are valid values for many elements of the WIGOS Metadata Standard. These terms assist Members in achieving compliance with the standard, particularly while developing the capability to report actual values.

2.5.1.2 For all WIGOS observations they make available internationally, Members shall record and retain the observational metadata specified as conditional in the WIGOS Metadata Standard (Appendix 2.4) whenever the related condition is met.

2.5.1.3 For all WIGOS observations they make available internationally, Members should record and retain the observational metadata specified as optional in the WIGOS Metadata Standard (Appendix 2.4).

Notes:
1. Further requirements for observational metadata beyond the WIGOS Metadata Standard are stated in the following sections. In the case of GOS, as noted in chapter 5, the *Manual on the Global Observing System* (WMO-No. 544) contains further provisions for GOS metadata.

2. Further guidance on metadata and sound metadata practices, is provided in Guides and specific documentation associated with the individual observing system components.

2.5.2 Exchanging and archiving observational metadata

2.5.2.1 Members shall make available internationally, without restriction, those mandatory and conditional (whenever the condition is met) observational metadata that support observations made available internationally.

2.5.2.2 Members making observations available internationally shall retain and make available, without restriction, observational metadata for at least as long as they retain the observations described by the observational metadata.

2.5.2.3 Members making available internationally archived observations shall ensure that all WIGOS metadata describing the observations remain available, without restriction, for at least as long as the observations are retained.

2.5.2.4 Members making available internationally archived observations should ensure that any additional observational metadata describing the observations remain available, without restriction, for at least as long as the observations are retained.

2.5.3 Global compilation of observational metadata

2.5.3.1 Members shall make available to WMO for global compilation those components of the WIGOS metadata that are specified as mandatory or conditional (whenever the condition is met).

Note: Global compilations of WIGOS metadata are held in several databases. The database of the Observing Systems Capability Analysis and Review tool (OSCAR) of the WIGOS Information Resource (WIR) is the key source of information for WIGOS metadata. Other global compilations of specific components of WIGOS metadata include elements of the GAW Station Information System (GAWSIS), the database of the JCOMM In Situ Observations Programme Support Centre (JCOMMOPS) and others. Purpose and management of WIR and OSCAR are described in Attachment 2.2.

2.5.3.2 For all WIGOS component observing systems they operate, Members shall keep the relevant databases of WMO observational metadata up to date with the required WIGOS metadata.

2.5.3.3 Members shall routinely monitor the content of WIGOS metadata databases and provide feedback to WMO Secretariat on identified discrepancies, possible errors and required changes with respect to the WIGOS component observing systems they operate.

2.5.3.4 Members shall designate their national focal points responsible for making available metadata and monitoring content of WMO observational metadata databases, and inform the Secretariat accordingly.

2.5.3.5 Members delegating to a global or regional entity the responsibility of the national focal point for all or part of the observing networks they operate shall inform the Secretariat accordingly.

2.6 QUALITY MANAGEMENT

Notes:

1. Detailed guidance on how to develop and implement a quality management system (QMS) to ensure and enhance the quality of products and services of NMHSs is provided in the *Guide to the Implementation of a Quality Management System for National Meteorological and Hydrological Services* (WMO-No. 1100).

2. Definitions, terminology, vocabulary and abbreviations used in relation to quality management are those of the ISO 9000 family of standards for quality management systems, in particular *ISO 9000:2015, Quality Management Systems – Fundamentals and vocabulary*.

3. A QMS can be implemented only by the body that has the resources and the mandate to manage the observing system. According to the WMO QMF, Members are urged to follow the standard and recommended practices and procedures associated with implementation of a QMS. In practice, however, it is one or more organizations within the Member country that own and operate observing systems and provide observations and observational metadata, most notably the NMHSs. Therefore, implementation of the WMO QMF relies on the Member making arrangements for such organizations to implement a QMS.

4. In this section, the term "observations" includes also observational metadata.

2.6.1 Scope and purpose of WIGOS quality management

Note: The practices and procedures of WIGOS enable Members to comply with the WMO QMF in relation to the quality of observations.

2.6.2 WIGOS component of the WMO Quality Management Framework

2.6.2.1 Quality policy

2.6.2.1.1 In the establishment and maintenance of WIGOS observing systems, Members should ensure optimum affordable quality for all observations.

2.6.2.1.2 Members should, through a process of continual improvement, pursue effective and efficient management and governance of observing systems.

2.6.2.2 Application of the eight principles of quality management

Members should apply the eight principles of quality management to the implementation of WIGOS, as specified in Appendix 2.5.

2.6.3 WIGOS quality management processes

Note: The processes and roles of various entities are described in Attachment 1.1.

2.6.3.1 Determination and maintenance of user requirements

Note: The WMO RRR process for compiling observation user requirements is described in section 2.2.4 and Appendix 2.3.

2.6.3.2 Development and documentation of observing system standards and recommendations

Through involvement in the work of technical commissions, Members should participate in the development of observing system standard and recommended practices and procedures.

2.6.3.3 Training of personnel and capacity development

Members should ensure appropriate planning and implementation of training and capacity development activities.

2.6.3.4 Performance monitoring

Members should use and respond to the results, advice and reports of designated monitoring centres and any subsequent advice of expert groups.

2.6.3.5 Feedback, change management and improvement

2.6.3.5.1 Members should ensure that inconsistencies and other problems identified by WIGOS Lead and Monitoring Centres are rectified in a timely manner and that a process for their documentation and rectification is implemented and maintained.

2.6.3.5.2 Upon identification or notification of inconsistencies or other problems related to quality of observations, Members should analyse the problem detected and make the necessary improvements to operational practices and procedures so as to minimize the adverse impacts of those problems and prevent their recurrence.

2.6.3.5.3 Members should ensure that changes to operational practices and procedures are accordingly documented.

2.6.4 WIGOS aspects of development and implementation of the quality management system of Members

Note: This section specifies requirements for the integration of WIGOS practices and procedures into the QMS of Members. The requirements are based on the eight clauses of the ISO 9001 Standard. The *Guide to the Implementation of a Quality Management System for National Meteorological and Hydrological Services* (WMO-No. 1100) provides extensive explanatory notes about the eight clauses. The five subsections that follow correspond to the last five of those clauses, providing further details about the elements required in a QMS.

2.6.4.1 General requirements for the content of a quality management system

Members should identify their high-level processes and interactions that lead to the provision of observations.

Note: In addition to WIGOS specific provisions, there are many other general requirements for the content of a QMS that are not unique to WIGOS observations, hence are not repeated here.

2.6.4.2 Requirements related to management and planning

2.6.4.2.1 Members should clearly demonstrate and document their commitment to the integration of WIGOS quality management practices within their QMS.

2.6.4.2.2 Members should carefully identify and routinely review user requirements for observations prior to attempting to meet user needs.

2.6.4.2.3 Members should ensure that their published quality policy is consistent with the WIGOS quality policy.

2.6.4.2.4 Members should establish and indicate the objectives for the observations they intend to provide in the future so as to guide stakeholders, users and clients on the expected evolution of and changes to the observing systems they operate as a contribution to WIGOS.

Note: The objectives referred to in this provision constitute the WIGOS quality objectives.

2.6.4.2.5 Members should appoint a quality manager.

2.6.4.3 Requirements related to resource management

2.6.4.3.1 Members should determine and provide the resources needed to maintain and continuously improve the effectiveness and efficiency of their processes and procedures.

2.6.4.3.2 Members should define the competencies required for staff involved in the provision of observations.

2.6.4.3.3 Members should take steps to rectify any competency shortcomings identified for new or existing employees.

2.6.4.3.4 Members should implement policies and procedures to maintain the infrastructure required for the provision of observations.

2.6.4.4 Requirements related to the provision of observations

2.6.4.4.1 Members should undertake sound planning for the provision of observations.

Note: Such planning includes the following:

(a) Determination and continuous review of user and client requirements;

(b) Translation of user and client requirements into objectives and targets for observations and observing system design;

(c) Initial and ongoing allocation of adequate resources for all aspects of the design, implementation and maintenance processes of observing systems;

(d) Implementation of design processes and activities, including communication strategies and risk management, that will ensure and confirm the development and implementation of observing systems capable of meeting the design objectives and user and client requirements;

(e) Appropriate and ongoing documentation of planning processes and their results.

2.6.4.4.2 Members should identify the users of their observing systems and establish and document users' requirements for observations.

Note: The means for doing this include:

(a) The WMO RRR process, described in section 2.2.4 and Appendix 2.3;

(b) Other processes to establish user requirements within WMO Programmes through the activities of WMO technical commissions;

(c) Regional processes through the activities of WMO regional associations and other multilateral groupings of Members;

(d) National processes.

2.6.4.4.3 Members should have a clear description of the requirements that are agreed upon.

Note: It is important to note the difference between aspirational requirements and agreed requirements. The establishment of requirements provides essential information for the monitoring and measurement of conformance.

2.6.4.4.4 Members should identify and adhere to any statutory or regulatory requirements in relation to the provision of observations.

2.6.4.4.5 Members should design and develop, or otherwise implement, observing systems to satisfy the agreed user requirements.

2.6.4.4.6 Members should use a formal change management process to ensure that all changes are assessed, approved, implemented and reviewed in a controlled manner.

2.6.4.4.7 Members should conduct purchasing in a controlled manner.

Note: Observing systems are highly specialized and often require major expenditure. Staff responsible for purchasing orders or for providing information to suppliers must, therefore, ensure that the information and specifications provided are clear, unambiguous and based on the design objectives and system requirements to enable the delivery of the appropriate products and services. Purchasing in a controlled manner entails the following:

(a) Written specification of all performance requirements for equipment and/or services;

(b) Ensuring that purchasing is subject to a competitive process of more than one candidate for supply of equipment or services;

(c) Assessment of candidates for supply of equipment or services based on merit and suitability for purpose, which can be discerned from:

    (i) Written tendering or quotation of candidates;

    (ii) Experience or reliable anecdotal evidence of past performance;

    (iii) Recommendation of Member or recognized organization or agency;

(d) Documentation of the purchasing process and outcomes.

2.6.4.4.8 Members should include in their QMS the WIGOS provisions covering methods of observation, calibration and traceability, operational practices, maintenance and observational metadata.

2.6.4.4.9 Members should implement practices and procedures which ensure that observations remain accurate.

Note: Observations need to be checked as they must meet the agreed requirements. The methods include automated algorithms, manual inspection and oversight.

2.6.4.5 Requirements for monitoring, performance measurement, analysis and improvement

2.6.4.5.1 Members should use the agreed user requirements for observations (see 2.6.4.4) as a basis for defining and implementing appropriate measures of performance and success.

Note: It is important to gain a clear understanding of how satisfied users are with observations. This requires the monitoring of information on users' perception and on whether their expectations have been met. Surveys are commonly used for this purpose.

2.6.4.5.2 Members should implement activities to gain information on the satisfaction of users of observations.

2.6.4.5.3 Members should ensure that staff are made aware of the methods employed for determining users' perceptions and expectations, and that those methods are applied consistently.

2.6.4.5.4 Members should regularly conduct internal audits of WIGOS processes and procedures and analyse their results as part of the management processes of the observing system.

Note: A detailed explanation of the requirements of the internal audit is provided in the *Guide to the Implementation of a Quality Management System for National Meteorological and Hydrological Services* (WMO-No. 1100), chapter 4, section 4.3, clause 8, requirement 8.2.2.

2.6.4.5.5 Members should monitor the degree of adherence to the defined processes and requirements for producing observations.

Note: Ideally, performance monitoring will be conducted against specific key performance indicators and target levels of performance.

2.6.4.5.6 Members should monitor and measure the suitability and the quality of their observations as they are produced, in order to compare their characteristics with the agreed requirements.

Note: The means to do this include:

(a) The devising, implementation and routine analysis of manually or automatically generated key performance indicators and their associated targets;

(b) Manual inspection and oversight of observational data produced.

2.6.4.5.7 Members should record instances of non-conformity with requirements, and endeavour to rectify problems in a timely manner.

2.6.4.5.8 Members should maintain a documented corrective action procedure relevant to observations.

2.6.4.5.9 Members should specify and implement procedures that describe how non-conforming observations or observational metadata are identified, how they are dealt with, who is responsible for deciding what to do, what action should be taken and what records are to be kept.

Note: A detailed explanation of the requirements for corrective action is provided in the *Guide to the Implementation of a Quality Management System for National Meteorological and Hydrological Services* (WMO-No. 1100), Chapter 4, section 4.3, clause 8, requirements 8.2.3 and 8.2.4.

2.6.4.5.10 Members should analyse monitoring results to detect any performance-related changes, trends and deficiencies and use the results and analyses as input for continual improvement.

Note: Analysing trends and taking action prior to the occurrence of a case of non-conformity helps to prevent problems.

2.6.4.5.11 Members should maintain documented preventive action procedures relevant to observing systems and ensure that staff are aware of and, if necessary, trained in their routine application.

Note: Due consideration might be given to combining the preventive and the corrective action procedures for efficiency, and to simplify the process.

2.6.5 Compliance, certification and accreditation

Note: While WMO encourages the certification of Members' quality management systems by accredited agencies, unless otherwise required of a particular WIGOS component system or subsystem, there is no general regulated requirement for certification of QMS for WIGOS observing systems.

2.6.6 Documentation

2.6.6.1 Members should include the WIGOS quality policy (2.6.2.1) and objectives (2.6.4.2) in their QMS quality manual.

2.6.6.2 Members should include in their QMS documentation those documents that describe the procedures related to WIGOS, including, in particular, those relating to control of non-conforming observations, and corrective and preventive actions.

2.6.6.3 Members should include in their QMS documentation those documents that describe the procedures required to ensure the effective planning, operation and control of their WIGOS processes.

2.6.6.4 Members should include in their QMS documentation those records required by the ISO 9001 standard.

Note: More detailed information on documentation requirements is provided in the *Guide to the implementation of a Quality Management System for National Meteorological and Hydrological Services* (WMO-No. 1100), Chapter 4, section 4.3, clause 4, requirement 4.2.

2.7 CAPACITY DEVELOPMENT

2.7.1 General

2.7.1.1 Members should identify their needs for capacity development in all activity areas of WIGOS.

2.7.1.2 Members should develop plans to meet their capacity development needs.

Note: In addition to national resources allocated to NMHSs, support may be available from other domestic agencies, the WMO regional association concerned, other Members through bilateral or multilateral arrangements, and WMO Programmes (including appropriate technical commissions).

2.7.1.3 Members should establish bilateral and multilateral collaboration (within and beyond their Region) where necessary to address significant capacity development needs.

2.7.1.4 When planning capacity development activities, Members should take a holistic approach considering institutional, infrastructural, procedural and human resource requirements to support both current and continuing needs for installation, operation, maintenance, inspection and training. For this purpose, Members should prepare specific capacity development plans with measurable objectives to enable effective implementation, monitoring and assessment.

Note: Funds to meet these requirements should be planned well ahead, subject to national policies of Members, to assure long-term sustainable networks.

2.7.2 Training

2.7.2.1 Members shall provide adequate training for their staff or take other appropriate actions to ensure that all staff are suitably qualified and competent for the work assigned to them.

Note: This requirement is applied both to initial recruitment or introductory training and to continuing professional development.

2.7.2.2 Each Member should ensure that the qualifications, competencies, skills (and thus training) and numbers of their personnel or other contractors match the range of tasks to be performed.

2.7.2.3 Each Member should inform the staff of their role and how they contribute to the achievement of the quality objectives.

2.7.3 Infrastructural capacity development

Members should regularly review their infrastructure for collecting and making available observations and observational metadata and, as necessary, develop prioritized plans and priorities for capacity development.

SECTION: Chapter
Chapter title in running head: APPENDIX 2.1. OBSERVING NETWORK DESIGN ...

APPENDIX 2.1. OBSERVING NETWORK DESIGN PRINCIPLES

1. Serving many application areas

Observing networks should be designed to meet the requirements of multiple application areas within WMO and WMO co-sponsored programmes.

2. Responding to user requirements

Observing networks should be designed to address stated user requirements, in terms of the geophysical variables to be observed and the space-time resolution, uncertainty, timeliness and stability needed.

3. Meeting national, regional and global requirements

Observing networks designed to meet national needs should also take into account the needs of WMO at the regional and global levels.

4. Designing appropriately spaced networks

Where high-level user requirements imply a need for spatial and temporal uniformity of observations, network design should also take account of other user requirements, such as the representativeness and usefulness of the observations.

5. Designing cost-effective networks

Observing networks should be designed to make the most cost-effective use of available resources. This will include the use of composite observing networks.

6. Achieving homogeneity in observational data

Observing networks should be designed so that the level of homogeneity of the delivered observational data meets the needs of the intended applications.

7. Designing through a tiered approach

Observing network design should use a tiered structure, through which information from reference observations of high quality can be transferred to other observations and used to improve their quality and utility.

8. Designing reliable and stable networks

Observing networks should be designed to be reliable and stable.

9. Making observational data available

Observing networks should be designed and should evolve in such a way as to ensure that the observations are made available to other WMO Members, at space-time resolutions and with a timeliness that meet the needs of regional and global applications.

10. Providing information so that the observations can be interpreted

Observing networks should be designed and operated in such a way that the details and history of instruments, their environments and operating conditions, their data processing procedures and other factors pertinent to the understanding and interpretation of the observational data (i.e. metadata) are documented and treated with the same care as the data themselves.

11. Achieving sustainable networks

Improvements in sustained availability of observations should be promoted through the design and funding of networks that are sustainable in the long-term including, where appropriate, through the transition of research systems to operational status.

12. Managing change

The design of new observing networks and changes to existing networks should ensure adequate consistency, quality and continuity of observations during the transition from the old system to the new.

SECTION: Chapter

Chapter title in running head: APPENDIX 2.2. CLIMATE MONITORING PRINCI…

APPENDIX 2.2. CLIMATE MONITORING PRINCIPLES OF THE GLOBAL CLIMATE OBSERVING SYSTEM

2.2.1 Effective monitoring systems for climate should adhere to the following principles:

(a) The impact of new systems or changes to existing ones should be assessed prior to implementation;

(b) A suitable period of overlap between new and old observing systems is required. This would be a period of dual operation, under the same climatic conditions, of the current and new observing systems, to identify and record any impact of the change;

(c) The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e. metadata) should be documented and treated with the same care as the data themselves;

(d) The quality and homogeneity of data should be regularly assessed as part of routine operations;

(e) Consideration of the need for environmental and climate-monitoring products and assessments, such as the Intergovernmental Panel on Climate Change (IPCC) assessments, should be integrated into national, regional and global observing priorities;

(f) Operation of historically uninterrupted stations and observing systems should be maintained;

(g) Data-poor regions, poorly observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution should be high-priority areas for additional observations;

(h) Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators and instrument engineers at the outset of system design and implementation;

(i) A carefully planned conversion of research observing systems to long-term operations should be promoted;

(j) Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems.

Furthermore, operators of satellite systems for monitoring climate need to:

- Take steps to make radiance calibration, calibration-monitoring and satellite-to-satellite cross-calibration of the full operational constellation a part of the operational satellite system; and

- Take steps to sample the Earth system in such a way that climate-relevant (diurnal, seasonal, and long-term interannual) changes can be determined.

2.2.2 Satellite systems for climate monitoring should adhere to the following specific principles:

(a) Constant sampling within the diurnal cycle (minimizing the effects of orbital decay and orbit drift) should be maintained;

(b) A period of overlap for new and old satellite systems should be ensured that is long enough to determine inter-satellite biases and maintain the homogeneity and consistency of time-series observations;

(c) Continuity of satellite measurements (i.e. elimination of gaps in the long-term record) through appropriate launch and orbital strategies should be ensured;

(d) Rigorous pre-launch instrument characterization and calibration, including radiance confirmation against an international radiance scale provided by a national metrology institute, should be ensured;

(e) On-board calibration adequate for climate system observations should be ensured and associated instrument characteristics should be monitored;

(f) Operational provision of priority climate products should be sustained, and peer-reviewed new products should be introduced as appropriate;

(g) Data systems needed to facilitate user access to climate products, metadata and raw data, including key data for delayed-mode analysis, should be established and maintained;

(h) Use of functioning baseline instruments that meet the calibration and stability requirements stated above should be maintained for as long as possible, even when such instruments exist on decommissioned satellites;

(i) Complementary in situ baseline observations for satellite measurements should be maintained through appropriate activities and cooperation between space agencies and owners of in situ networks;

(j) Random errors and time-dependent biases in satellite observations and derived products should be identified.

APPENDIX 2.3. THE WMO ROLLING REVIEW OF REQUIREMENTS

1. GENERAL

The Rolling Review of Requirements (RRR) compiles information on Members' evolving requirements for observations in the application areas that directly use observations; the extent to which current and planned WIGOS observing systems satisfy those requirements; guidance from experts in each application area on gaps and priorities, in order to tackle the deficiencies and opportunities in WMO observing systems; and plans for the future evolution of WIGOS observing systems.

The application areas are:

1. Global numerical weather prediction (GNWP);
2. High-resolution numerical weather prediction (HRNWP);
3. Nowcasting and very short-range forecasting (NVSRF);
4. Seasonal and interannual forecasting (SIAF);
5. Aeronautical meteorology;
6. Forecasting atmospheric composition
7. Monitoring atmospheric composition
8. Atmospheric composition for urban applications
9. Ocean applications;
10. Agricultural meteorology;
11. Hydrology;
12. Climate monitoring (as undertaken through the Global Climate Observing System (GCOS));
13. Climate applications;
14. Space weather.

Note: A detailed and up-to-date description of the RRR process is available on the WMO website at http://www.wmo.int/pages/prog/www/OSY/GOS-RRR.html.

Observational requirements for WMO polar activities and the Global Framework for Climate Services (GFCS) are also being considered.

An expert is identified for each application area to be the Point of Contact. This expert has a very important role as the conduit to the RRR for input to and feedback from the entire stakeholder community for that application area.

The nominated Points of Contact should coordinate with their application area community (technical commission and WMO Programme or co-sponsored programme, as appropriate) as needed in order to perform the following tasks:

(a) Investigate whether it is appropriate to represent the application area in several sub-applications;

(b) Submit the quantitative user observational requirements to the OSCAR/Requirements database (see http://www.wmo-sat.info/oscar/observingrequirements), review and keep up to date these requirements, and make changes as needed (the Points of Contact are provided with the required access rights);

(c) Produce, review and revise the Statement of Guidance for their application area;

(d) Review how cross-cutting activities (for example, those related to the cryosphere and climate services) are taken into account in the user requirement database and in the Statement of Guidance for the application area.

Note: The user requirements for observations, compiled through the RRR process, are stored and made available by the WIGOS Information Resource (WIR, which includes the OSCAR/Requirement database) as described in detail in Attachment 2.2.

The RRR process consists of four stages, as illustrated in the figure below**ELEMENT REF: 3 (Floating object)**:

1. A review of technology-free (that is, not constrained by any particular type of observing technology) user requirements for observations, within each of the WMO application areas (see section 2.1);

2. A review of the observing capabilities of existing and planned observing systems, both surface- and space-based;

3. A critical review, that is a comparison of requirements with the observing system capabilities;

4. A Statement of Guidance providing a gap analysis with recommendations on how to address the gaps for each application area.

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Schematic representation of the steps included in the RRR process

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2. REVIEW OF USER REQUIREMENTS FOR OBSERVATIONS

Notes:
1. This stage of the RRR is described briefly in section 2.1.

2. Regional associations examine and provide Points of Contact with additional details for the compiled user requirements, taking into account the particular requirements of the Region and transboundary river basin authorities.

3. REVIEW OF CURRENT AND PLANNED OBSERVING SYSTEM CAPABILITIES

Members shall take steps for collecting, reviewing, recording and making available information on current and planned capabilities of observing systems.

Note: Information on observing system capabilities is in the form of metadata and is to be made available for global compilation according to the provisions of section 2.5.

4. THE CRITICAL REVIEW

Note: This WMO Programme activity proceeds with assistance from the Points of Contact of the application areas. It compares the quantitative user observational requirements of each application area with the observing system capabilities.

5. STATEMENTS OF GUIDANCE

Notes:

1. The Statement of Guidance interprets the output of the critical review as a gap analysis and identifies priorities for action: the most feasible, beneficial and affordable initiatives to deal with the identified gaps or shortcomings in WMO observing systems for an application area. This draws on the subjective judgement and experience of the Points of Contact, the experts and other stakeholders they consult within their application area.

2. This stage of the RRR requires the Points of Contact to coordinate with their application area community and stakeholders, as needed, in order to produce, review and revise the Statement of Guidance for the application area.

SECTION: Chapter

Chapter title in running head: APPENDIX 2.4. THE WIGOS METADATA STANDA…

APPENDIX 2.4. THE WIGOS METADATA STANDARD

1. GENERAL

This appendix refers to the WIGOS Metadata Standard, which consists of the set of observational metadata elements to be made available internationally, for the effective interpretation by all observational data users of observations from all WIGOS component observing systems. In this way, metadata users can access important information about why, where and how an observation was made. Metadata also provide information on the processing of the raw data and data quality. Note that WIGOS metadata, which is required from specific components or subsystems, is detailed in sections 3–8.

The table below presents categories (or groups) of metadata, each containing one or more elements. Each element is classified (using the same terminology as ISO) as mandatory (M), conditional (C) or optional (O). In the table, the mandatory elements are shown in bold and the conditional elements in italics.

The definition of each metadata element, together with notes and examples, as well as the explanation of the conditions that apply to the conditional elements are specified in the WIGOS Metadata Standard, contained in the attachment to this appendix.

2. MEMBERS' OBLIGATIONS

Mandatory metadata elements shall always be made available. The content of the corresponding fields shall never be empty: either the metadata "value" or the reason for no-value, shall be made available.

Conditional metadata elements shall be made available when the specified condition or conditions are met, in which case the content of the corresponding fields shall never be empty: either the metadata "value" or the reason for no-value, shall be made available.

Optional metadata elements should be made available, as they provide useful information that can help to better understand an observation. These elements are likely to be important for a particular community, but less so for others.

3. ADOPTION THROUGH A PHASED APPROACH

Making available WIGOS metadata will generate substantial benefits for Members, but developing the capacity to make available these metadata requires a substantial effort on the part of (meta)data providers. To help Members comply with reporting obligations, guidance material will be developed and provided.

Moreover, reporting obligations will be enforced in phases, in order to allow Members sufficient time to develop the capacity to comply. Balancing the effort required to generate and make available individual elements and the need to have this information to make adequate use of observations, implementation will proceed in three phases as shown in the table below. Importantly, the elements required by the end of Phase I are either the mandatory elements contained in *Weather Reporting* (WMO-No. 9), Vol. A, or those of critical importance for the Observing Systems Capability Analysis and Review (OSCAR) tool of the WIGOS Information Resource (WIR), and are considered of benefit for all WMO application areas. Phase II adds elements recognized to be more challenging for Members, but the knowledge of which is still necessary for the adequate use of observations, in particular for assessing quality of observations. Phase III adds the remaining elements specified in this version of the standard.

Elements emerging as being important for specific application areas or observing programmes will be added to the standard as it evolves.

List of elements specified in the WIGOS Metadata Standard, and implementation phases for Members

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Category	*Phase I*	*Phase II*	*Phase III*
	2016	*2017–2018*	*2019–2020*
1. Observed variable	**1-01 Observed variable – measurand (M)**	1-05 Representativeness (O)	
	1-02 Measurement unit (C)		
	1-03 Temporal extent (M)		
	1-04 Spatial extent (M)		
2. Purpose of observation	**2-01 Application area(s) (M)**		
	2-02 Programmes/network affiliation (M)		
3. Station/ platform	*3-01 Region of origin of data (C)*	**3-04 Station/platform type (M)**	**3-05 Station/platform model (M)**
	3-02 Territory of origin of data (C)	3-08 Data communication method (O)	
	3-03 Station/platform name (M)		
	3-06 Station/platform unique identifier (M)		
	3-07 Geospatial location (M)		
	3-09 Station operating status (M)		
4. Environment		4-04 Events at station/platform (O) 4-05 Site information (O)	*4-01 Surface cover (C)*
			4-02 Surface cover classification scheme (C)
			4-03 Topography or bathymetry (C)

			4-06 Surface roughness (O)
			4-07 Climate zone (O)
5. Instruments and methods of observation	**5-01 Source of observation (M)**	5-11 Maintenance party (O)	5-04 Instrument operating status (O)
	5-02 Measurement/observing method (M)	*5-12 Geospatial location (C)*	*5-06 Configuration of instrumentation (C)*
	5-03 Instrument specifications (C)	*5-15 Exposure of instrument (C)*	*5-07 Instrument control schedule (C)*
	5-05 Vertical distance of sensor (C)		*5-08 Instrument control result (C)*
			5-09 Instrument model and serial number (C)
			5-10 Instrument routine maintenance (C)
			5-13 Maintenance activity (O)
			5-14 Status of observation (O)
6. Sampling	6-03 Sampling strategy (O)	**6-05 Spatial sampling resolution (M)**	6-01 Sampling procedures (O)
	6-07 Diurnal base time (C)		6-02 Sample treatment (O)
	6-08 Schedule of observation (M)		**6-04 Sampling time period (M)**
			6-06 Temporal sampling interval (M)
7. Data processing and reporting	**7-03 Temporal reporting period (M)**	7-02 Processing/analysis centre (O)	7-01 Data processing methods and algorithms (O)
	7-04 Spatial reporting interval (C)	7-06 Level of data (O)	7-05 Software/processor and version (O)
	7-11 Reference datum (C)	**7-09 Aggregation period (M)**	**7-07 Data format (M)**
		7-10 Reference time (M)	**7-08 Version of data format (M)**
			7-12 Numerical resolution (O)
			7-13 Latency (of reporting) (M)
8. Data Quality		*8-01 Uncertainty of measurement (C)*	
		8-02 Procedure used to estimate uncertainty (C)	
		8-03 Quality flag (M)	
		8-04 Quality flagging system (M)	
		8-05 Traceability (C)	
9. Ownership and Data Policy	**9-02 Data policy/use constraints (M)**	**9-01 Supervising organization (M)**	
10. Contact	**10-01 Contact (nominated focal point) (M)**		

SECTION: Chapter
Chapter title in running head: APPENDIX 2.4. THE WIGOS METADATA STANDA…

Attachment to Appendix 2.4. WIGOS Metadata Standard

I. PURPOSE AND SCOPE OF WIGOS METADATA

An important aspect of WIGOS (WMO Integrated Global Observing System) implementation is ensuring maximum usefulness of WIGOS observations. Observations without metadata are of very limited use: it is only when accompanied by adequate metadata (data describing the data) that the full potential of the observations can be utilized.

Two complementary types of metadata are required: discovery metadata and interpretation/ description or observational metadata. Discovery metadata facilitate data discovery, access and retrieval. They are WIS metadata and are specified and handled as part of WIS. Interpretation/description or observational metadata enable data values to be interpreted in context. They constitute WIGOS metadata and are the subject of this WIGOS standard for the interpretation metadata required for the effective utilization of observations from all WIGOS component observing systems by all users. The WMO Integrated Global Observing System metadata should describe the observed variable, the conditions under which it was observed, how it was measured, and how the data have been processed, in order to provide users with confidence that the data are appropriate for their application. The Global Climate Observing System(GCOS) Climate Monitoring Principle 2.2.1(c) (see Appendix 2.2) describes the relevance of metadata as follows: "The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e. metadata) should be documented and treated with the same care as the data themselves."

The WMO Integrated Global Observing System observations consist of an exceedingly wide range of data from manual observations to complex combinations of satellite hyper-spectral frequency bands, measured in situ or remotely, from single dimension to multiple dimensions, and those involving processing. A comprehensive metadata standard covering all types of observation is by nature complex to define. A user should be able to use the WIGOS metadata to identify the conditions under which the observation (or measurement) was made, and any aspects that may affect its use or understanding, that is to determine whether the observations are fit for the purpose.

II. WIGOS METADATA CATEGORIES

Ten categories of WIGOS metadata have been identified. These are listed in Table 1 below. They define the WIGOS metadata standard, each category consisting of one or more metadata elements. All of the categories listed are considered to be important for the documentation and interpretation of observations made, and even for their use in the distant future. Hence, the standard currently declares many elements that are clearly not needed for applications focusing on more immediate use of observations. For these applications, such as numerical weather prediction, aeronautical or other transport sector applications and advisories, profiles of the standard may be developed. The categories are in no particular order but reflect the need to specify the observed variable; to answer why, where and how the observation was made; how the raw data were processed; and what the quality of the observation is.

A schematic composition of all categories, containing the individual elements is shown in Figure 1. Note that some of these elements will most likely be implemented using several individual entities (for example, geospatial location will consist of a combination of elements, such as latitude, longitude, elevation or a set of polar coordinates, as well as a reference to the geo-positioning methods used). Chapter VII contains a set of tables detailing all the elements, including definition, notes and examples, obligations and implementation phase. Code tables

enabling users to select from predefined vocabularies to facilitate the application of the WIGOS metadata standard and the exchange of metadata are presented in the *Manual on Codes* (WMO-No. 306).

Table 1: WIGOS metadata categories

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#	*Category*	*Description*
1	Observed variable	Specifies the basic characteristics of the observed variable and the resulting datasets.
2	Purpose of observation	Specifies the main application area(s) of the observation and the observing programme(s) and networks the observation is affiliated to.
3	Station/platform	Specifies the environmental observing facility, including fixed station, moving equipment or remote sensing platform, at which the observation is made.
4	Environment	Describes the geographical environment within which the observation is made. It also provides an unstructured element for additional meta-information that is considered relevant for adequate use of the data and that is not captured anywhere else in this standard.
5	Instruments and methods of observation	Specifies the method of observation and describes characteristics of the instrument(s) used to make the observation. If multiple instruments are used to generate the observation, then this category should be repeated.
6	Sampling	Specifies how sampling and/or analysis are used to derive the reported observation or how a specimen is collected.
7	Data processing and reporting	Specifies how raw data are transferred into the observed variable and reported to the users.
8	Data quality	Specifies the data quality and traceability of the observation.
9	Ownership and data policy	Specifies who is responsible for the observation and owns it.
10	Contact	Specifies where information about the observation or dataset can be obtained.

For example, an observation/dataset may have the following metadata categories associated with it:

- One or several purpose(s) of observation;
- Data processing procedures associated with the instruments;
- Instruments which have been used to make the observation;
- A station/platform to which the instrument(s) belong(s);
- Ownership and data policy restriction;
- Contact.

An instrument output may contribute to observations of one or more variables. For example:

- A four wire humidity probe can produce temperature and humidity, as well as dew point;
- A sonic anemometer does report wind speed, wind direction and can report air temperature;
- A spectrometer can report absorption due to many different chemical species.

An instrument typically will be associated with the categories:

- Instruments and methods of observation;
- Sampling (e.g. 10 Hz samples of air temperature);
- Data processing and reporting (e.g. ceilometer reporting of 10 min statistics of cloud height following processing through sky condition algorithm).

An observed variable may be influenced or characterized by the environment, for example:

- Wind speed (observed variable) on top of a hill (environment);
- River yield (observed variable) characterized by the upstream catchment and land use.

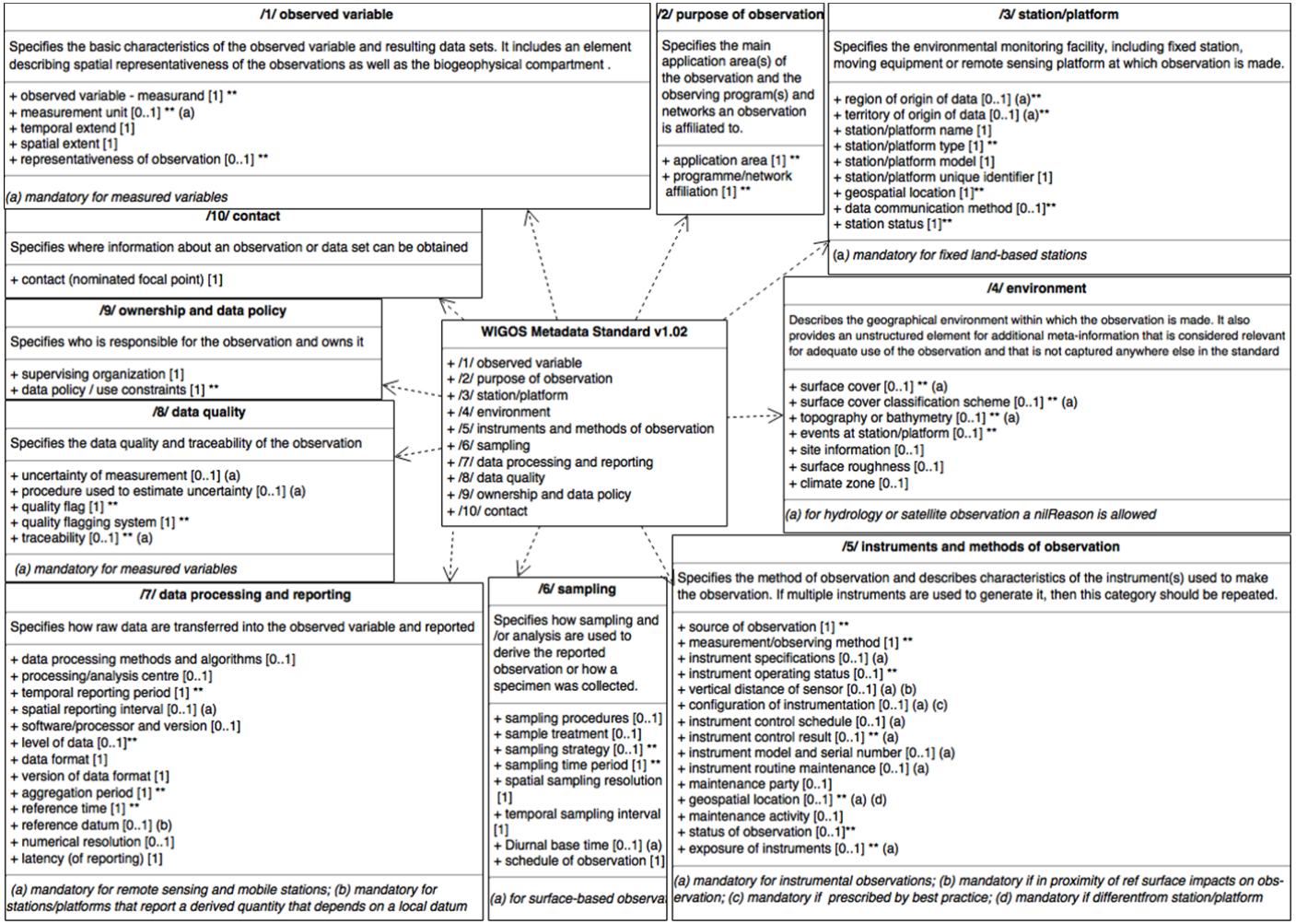

Figure 1. UML diagram specifying the WIGOS Metadata Standard (: code tables expected; [0..1*]: optional or conditional elements. Conditional elements become mandatory if a given condition is met. Conditions are referenced in parentheses. Optional elements**

may be declared mandatory as part of profiling the standard for specific application areas; [1..*]: mandatory elements. These elements must be reported, and if no value is available, a nilReason must be reported, which indicates that the metadata is "unknown", or "not available").

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Table 2. Names and definition of elements

An asterisk (*) denotes the element is required for the WMO Rolling Review of Requirements (RRR) process. A hash sign (#) denotes that it is acceptable to record a "mandatory" element with a value of nilReason (that indicates that the metadata is either "unknown", or "not applicable", or "not available").

TABLE: Table shaded header with lines

Category	*Id*	*Name*	*Definition*	*MCO*	*Phase*
Observed variable	1-01	Observed variable – measurand	Variable intended to be measured or observed or derived, including the biogeophysical context	M*	1
	1-02	Measurement unit	Real scalar quantity, defined and adopted by convention, with which any other quantity of the same kind can be compared to express the ratio of the two quantities as a number [VIM3, 1.9]	C*	1
	1-03	Temporal extent	Time period covered by a series of observations inclusive of the specified date-time indications (measurement history)	M*	1
	1-04	Spatial extent	Typical georeferenced volume covered by the observations	M*	1
	1-05	Representativeness	Spatial extent of the region around the observation for which it is representative	O	2
Purpose of observation	2-01	Application area(s)	Context within, or intended application(s) for which the observation is primarily made or which has/have the most stringent requirements	M*	1

	2-02	Programme/Network affiliation	The global, regional or national Programmes/network(s) that the station/platform is associated with	M	1
Station/platform	3-01	Region of origin of data	WMO Region	C*	1
	3-02	Territory of origin of data	Country or territory name of the location of the observation	C*	1
	3-03	Station/platform name	Official name of the station/platform	M	1
	3-04	Station/platform type	A categorization of the type of observing facility at which an observation is made	M*	2
	3-05	Station/platform model	The model of the monitoring equipment used at the station/platform	M*#	3
	3-06	Station/platform unique identifier	A unique and persistent identifier for an observing facility (station/platform), which may be used as an external point of reference	M*	1
	3-07	Geospatial location	Position in space defining the location of the observing station/platform at the time of observation	M*	1
	3-08	Data communication method	Data communication method between the station/platform and some central facility	O	2
	3-09	Station operating Status	Declared reporting status of the station	M	1
Environment	4-01	Surface cover	The observed (bio)physical cover on the earth's surface in the vicinity of the observation	C	3
	4-02	Surface cover classification scheme	Name and reference or link to document describing the classification scheme	C	3
	4-03	Topography or bathymetry	The shape or configuration of a geographical feature, represented on a map by contour lines	C	3
	4-04	Events at station/platform	Description of human action or natural event at the station or at the vicinity that may influence the observation	O	2

	4-05	Site information	Non-formalized information about the location and its surroundings at which an observation is made and that may influence it	O	2
	4-06	Surface roughness	Terrain Classification in terms of effective surface roughness length	O	3
	4-07	Climate zone	The Köppen-Geiger climate classification scheme divides climates into five main groups (A, B, C, D, E), each having several types and subtypes	O	3
Instruments and methods of observation	5-01	Source of observation	The source of the dataset described by the metadata	M	1
	5-02	Measurement/observing method	The method of measurement/observation used	M#	1
	5-03	Instrument specifications	Intrinsic capability of the measurement/observing method to measure the designated element, including range, stability, precision, etc.	C*#	1
	5-04	Instrument operating status	The status of an instrument with respect to its operation	O	3
	5-05	Vertical distance of sensor	Vertical distance of the sensor from a (specified) reference level such as local ground, or deck of a marine platform at the point where the sensor is located; or sea surface	C*	1
	5-06	Configuration of instrumentation	Description of any shielding or configuration/setup of the instrumentation or auxiliary equipment needed to make the observation or to reduce the impact of extraneous influences on the observation	C#	3
	5-07	Instrument control schedule	Description of schedule for calibrations or verification of instrument	C	3
	5-08	Instrument control result	The result of an instrument control check, including date, time, location, standard type and period of validity	C#	3
	5-09	Instrument model and serial number	Details of manufacturer, model number, serial number and firmware version if applicable	C#	3
	5-10	Instrument routine maintenance	A description of maintenance that is routinely performed on an instrument	C#	3

	5-11	Maintenance party	Identifier of the organization or individual who performed the maintenance activity	O	2
	5-12	Geospatial location	Geospatial location of instrument/sensor	C*	2
	5-13	Maintenance Activity	Description of maintenance performed on instrument	O	3
	5-14	Status of observation	Official status of observation	O	3
	5-15	Exposure of instruments	The degree to which an instrument is affected by external influences and reflects the value of the observed variable	C	2
Sampling	6-01	Sampling procedures	Procedures involved in obtaining a sample	O	3
	6-02	Sample treatment	Chemical or physical treatment of sample prior to analysis	O	3
	6-03	Sampling strategy	The strategy used to generate the observed variable	O*	1
	6-04	Sampling time period	The period of time over which a measurement is taken	M#	3
	6-05	Spatial sampling resolution	Spatial resolution refers to the size of the smallest observable object. The intrinsic resolution of an imaging system is determined primarily by the instantaneous field of view of the sensor, which is a measure of the ground area viewed by a single detector element in a given instance in time	M#	2
	6-06	Temporal sampling interval	Time period between the beginning of consecutive sampling periods	M	3
	6-07	Diurnal base time	Time to which diurnal statistics are referenced	C	1
	6-08	Schedule of observation	Schedule of observation	M	1
Data processing and reporting	7-01	Data processing methods and algorithms	A description of the processing used to generate the observation and list of algorithms utilized to derive the resultant value	O	3

	7-02	Processing/analysis center	Center at which the observation is processed	O	2
	7-03	Temporal reporting period	Time period over which the observable variable is reported	M*	1
	7-04	Spatial reporting interval	Spatial interval at which the observed variable is reported	C*	1
	7-05	Software/processor and version	Name and version of the software or processor utilized to derive the element value	O	3
	7-06	Level of data	Level of data processing	O	2
	7-07	Data format	Description of the format in which the observed variable is being provided	M	3
	7-08	Version of data format	Version of the data format in which the observed variable is being provided	M	3
	7-09	Aggregation period	Time period over which individual samples/observations are aggregated	M	2
	7-10	Reference time	Time base to which date and time stamps refer	M	2
	7-11	Reference datum	Reference datum used to convert observed quantity to reported quantity	C	1
	7-12	Numerical resolution	Measure of the detail in which a numerical quantity is expressed	O	3
	7-13	Latency (of reporting)	The typical time between completion of the observation or collection of the datum and when the datum is reported	M	3
Data quality	8-01	Uncertainty of measurement	Non-negative parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the observation/measurand	C*#	2
	8-02	Procedure used to estimate uncertainty	A reference or link pointing to a document describing the procedures/algorithms used to derive the uncertainty statement	C*#	2

	8-03	Quality flag	An ordered list of qualifiers indicating the result of a quality control process applied to the observation	M#	2
	8-04	Quality flagging system	Reference to the system used to flag the quality of the observation	M#	2
	8-05	Traceability	Statement defining traceability to a standard, including sequence of measurement standards and calibrations that is used to relate a measurement result to a reference [VIM 3, 2.42]	C*#	2
Ownership and data policy	9-01	Supervising organization	Name of organization who owns the observation	M	2
	9-02	Data policy/use constraints	Details relating to the use and limitations surrounding data imposed by the supervising organization	M*	1
Contact	10-01	Contact (Nominated Focal Point)	Principal contact (Nominated Focal Point, FP) for resource	M	1

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III. A NOTE ON SPACE AND TIME

It is important to understand that WIGOS metadata are intended to describe an individual observation or a dataset, i.e. one or several observations, including the where, when, how, and even why the observations were made. As a consequence, references to space and time are made in several places throughout the standard.

Figure 2 illustrates the concepts and terms used to describe the temporal aspects of an observation or dataset, including sampling strategy, analysis, data processing and reporting.

The concepts and terms used to describe spatial aspects (i.e., geospatial location) of observations are even more complex (cf. Figure 3). For example, for ground-based in-situ observations, the spatial extent of the observation coincides with the geospatial location of the sensor, which in most cases will be time-invariant and is normally close to the geospatial location of the station/platform where the observation was made. For a satellite-based lidar system, the situation is quite different. Depending on the granularity of metadata desired, the spatial extent of the individual observation may be an individual pixel in space, the straight line probed during an individual laser pulse, or perhaps an entire swath. In any case, the spatial extent of the observation will not coincide with the location of the sensor. The WIGOS metadata standard therefore needs to take into account such elements as:

1. The spatial extent of the observed variable (e.g. atmospheric column above a Dobson Spectrophotometer) (cf. 1-04);

ELEMENT REF: 5 (Floating object)2. The geospatial location of the station/platform (e.g. radar transmitter/receiver or aircraft position/route) (cf. 3-07);

3. The geospatial location of the instrument (e.g. the anemometer is adjacent to a runway) (cf. 5-05 Vertical Distance and 5-12 geospatial location);

4. The spatial representativeness of the observation (cf. 1-05).

ELEMENT REF: 7 (Floating object)All these are expressed in terms of geospatial location, specifying either a zero-dimensional geographic extent (a point), a one-dimensional geographic extent (a line, either straight or curved), a two-dimensional geographic extent (a plane or other surface), or a three-dimensional geographic extent (a volume).

A station/platform can be:

1. Collocated with the observed quantity as for in situ surface observing station (e.g. an Automatic Weather Station - AWS);

2. Collocated with the instrument but remote to the observed quantity (e.g. radar);

3. Remote from where the instrument may transmit data to the station (e.g. airport surface station where instruments are located across the airport, or a balloon atmosphere profiling station);

4. In motion and travelling through the observed medium (e.g. AMDAR - Aircraft Meteorological Data Relay - equipped aircraft);

5. In motion and remote to the observed medium (e.g. satellite platform).

An instrument can be:

1. Collocated with the observed variable (e.g. surface temperature sensor);

2. Remote to the observed variable (e.g. radar transmitter/receiver);

3. In motion but located in the observed medium (e.g. radiosonde);

4. In motion and remote from the observed quantity (e.g. satellite based radiometer);

5. Located within a standardized enclosure (e.g. a temperature sensor within a Stevenson screen).

ELEMENT 5: Floating object (Automatic)
ELEMENT 6: Picture inline
Element Image: 1160_App_ 2-4_Fig_2_en.eps
END ELEMENT

Figure 2. Graphical representation of temporal elements referenced in WIGOS Metadata categories

END ELEMENT

ELEMENT 7: Floating object (Automatic)
ELEMENT 8: Picture inline fix size
Element Image: 1160_App_ 2-4_Fig_3_en.eps
END ELEMENT

Figure 3. Graphical representation of spatial elements referenced in WIGOS Metadata categories

END ELEMENT

IV. REPORTING OBLIGATIONS FOR WIGOS METADATA

According with the International Organization for Standardization (ISO), the metadata elements are classified as either mandatory (M), conditional (C), or optional (O).

Mandatory metadata elements shall always be made available. The content of the corresponding fields shall never be empty, either the metadata "value" or the reason for no-value, shall be made available.

Most of the elements in this standard are considered **mandatory** in view of enabling adequate future use of observations by all WMO Application Areas. Metadata providers are expected to report mandatory metadata elements, and a formal validation of a metadata record will fail if mandatory elements are not reported. If Members cannot provide all the Mandatory elements the reason for that shall be reported as "not applicable" or "unknown" or "not available". The motivation for this is that knowledge of the reason why a mandatory metadata element is not available provides more information than not reporting a mandatory element at all. In the tables of chapter VII, these cases are indicated with $M^{\#}$.

Conditional metadata elements shall be made available when the specified condition or conditions are met, in which case the content of the corresponding fields shall never be empty, either the metadata "value" or the reason for no-value, shall be made available. For example, the element "Spatial reporting interval" is classified as conditional, because it only applies to remote sensing observations and mobile platforms. Therefore, the elements in this category should be considered mandatory for remote sensing and mobile observing systems but not so for e.g., surface land stations.

Optional metadata elements should also be made available. They provide useful information that can help to better understand an observation. In this version of the standard, very few

elements are considered optional. Optional elements are likely to be important for a particular community, but less so for others.

V. TECHNICAL IMPLEMENTATION AND USE OF THE STANDARD

This document is a semantic standard that specifies the elements that exist and that can be recorded and reported. It does not specify how the information shall be encoded or exchanged. However, the following are likely scenarios and important aspects that may help the reader appreciate what lies ahead.

1. The most likely implementation will be in XML (Extensible Markup Language), in line with the specifications for WIS metadata and common interoperability standards. Regardless of the final implementation, the full metadata record describing a dataset can be envisioned as a tree with the categories as branches off the stem, and the individual elements as leaves on these branches. Some branches may occur more than once, e.g., a dataset may have been generated using more than one instrument at once, in which case two branches for 'instrument' may be required.

2. Not all of the elements specified in this document need to be updated at the same frequency. Some elements, such as position of a land-based station are more or less time-invariant, while others, such as a specific sensor, may change regularly every year. Still other elements, such as environment, may change gradually or rarely, but perhaps abruptly. Finally, elements restricting the application of an observation, e.g., to road condition forecasting, may have to be transmitted with every observation. The implementation of the WIGOS metadata needs to be able to deal with this.

3. Not all applications of observations require the full suite of metadata as specified in this standard at any given time. The amount of metadata that needs to be provided to be able to make adequate use of an observation, for example for the purpose of issuing a heavy precipitation warning, is much less than for the adequate use of even the same observation for a climatological analysis. On the other hand, the metadata needed for near-real-time applications may also need to be provided in near-real-time. This is important to realize, as it makes the task of providing WIGOS metadata much more tractable. The implementation of WIGOS metadata needs to be able to cope with vastly different update intervals, and incremental submission of additional metadata to allow the creation of 'complete' metadata records.

ELEMENT 9: Floating object (Automatic)
ELEMENT 10: Picture inline fix size
Element Image: 1160_App_ 2-4_Fig_4_en.eps
END ELEMENT

Figure 4. Schematic of the relationship of WIS and WIGOS metadata and the scope of the ISO19115 standard (ISO, 2003). The WMO Core is a profile of ISO19115. WIGOS metadata exceed the scope of ISO19115 standard. A possible profile (subset) of WIGOS metadata elements for some specific near-real-time application is also shown.

END ELEMENT

4. Users will want to obtain and filter datasets according to certain criteria/properties as described within each WIGOS metadata record. This functionality requires either a central repository for WIGOS metadata or full interoperability of the archives collecting WIGOS metadata.

How, then can these requirements be met? In the case where observations are clearly only used for some near-real-time application and there is clearly no long-term use or re-analysis application to be expected, a profile of the WIGOS metadata standard may be specified that

declares a specific subset of metadata elements as mandatory. This is depicted schematically in Figure 4.

Importantly, all WIGOS metadata elements (or group of elements) will have to be time-stamped with the time of validity and associated to a unique identifier for a dataset during transmission and for archiving. The specification of time stamps should also include a statement on the use of daylight savings time. Using this approach, increments of a 'full' WIGOS metadata record can be transmitted anytime changes occur and updates are deemed necessary. At the archive, the increments can be added to the existing metadata record for that dataset, establishing the full history of a particular observation with time.

VI. ADOPTION THROUGH A PHASED APPROACH

Making available WIGOS metadata will generate substantial benefits for Members, but developing the capacity to make available these metadata also requires a substantial effort on the part of (meta)data providers. To help Members comply with obligations, guidance material will be developed and provided.

Moreover, obligations will be enforced in phases in order to allow Members sufficient time to develop the capacity to comply. Balancing the effort required to generate and make available the metadata elements, and the need to have this information to make adequate use of observations, implementation will proceed through three phases as shown in Table 3. Importantly, elements required by the end of Phase I are either listed as mandatory elements in WMO-No. 9, Vol. A or are of critical importance for the Observing Systems Capability Analysis and Review (OSCAR) tool of the WIR (WIGOS Information Resource), and are considered of benefit for all application areas. Phase II adds elements recognized to be more challenging for Members, but the knowledge of which is still of rather immediate need for the adequate use of observations, in particular for assessing quality of observations. Phase III adds the remaining elements specified in this version of the standard.

Elements emerging as being important for specific application areas or observing programmes will be added to the standard as it evolves.

Table 3. List of elements specified in the WIGOS Metadata Standard, and implementation phases for Members

TABLE: Table shaded header with lines

Category	*Phase I*	*Phase II*	*Phase III*
	2016	*2017–2018*	*2019–2020*
1. Observed variable	**1-01 Observed variable – measurand (M)**	1-05 Representativeness (O)	
	1-02 Measurement unit (C)		
	1-03 Temporal extent (M)		
	1-04 Spatial extent (M)		
2. Purpose of observation	**2-01 Application area(s) (M)**		
	2-02		

	Programmes/network affiliation (M)		
3. Station/ platform	*3-01 Region of origin of data (C)*	**3-04 Station/platform type (M)**	**3-05 Station/platform model (M)**
	3-02 Territory of origin of data (C)	3-08 Data communication method (O)	
	3-03 Station/platform name (M)		
	3-06 Station/platform unique identifier (M)		
	3-07 Geospatial location (M)		
	3-09 Station operating status (M)		
4. Environment		4-04 Events at station/platform (O)	*4-01 Surface cover (C)*
		4-05 Site information (O)	*4-02 Surface cover classification scheme (C)*
			4-03 Topography or bathymetry (C)
			4-06 Surface roughness (O)
			4-07 Climate zone (O)
5. Instruments and methods of observation	**5-01 Source of observation (M)**	5-11 Maintenance party (O)	5-04 Instrument operating status (O)
	5-02 Measurement/observing method (M)	*5-12 Geospatial location (C)*	*5-06 Configuration of instrumentation (C)*
	5-03 Instrument specifications (C)	*5-15 Exposure of instrument (C)*	*5-07 Instrument control schedule (C)*
	5-05 Vertical distance of sensor (C)		*5-08 Instrument control result (C)*
			5-09 Instrument model and serial number (C)
			5-10 Instrument routine maintenance (C)
			5-13 Maintenance activity (O)

			5-14 Status of observation (O)
6. Sampling	6-03 Sampling strategy (O)	**6-05 Spatial sampling resolution (M)**	6-01 Sampling procedures (O)
	6-07 Diurnal base time (C)		6-02 Sample treatment (O)
	6-08 Schedule of observation (M)		**6-04 Sampling time period (M)**
			6-06 Temporal sampling interval (M)
7. Data processing and reporting	**7-03 Temporal reporting period (M)**	7-02 Processing/analysis centre (O)	7-01 Data processing methods and algorithms (O)
	7-04 Spatial reporting interval (C)	7-06 Level of data (O)	7-05 Software/processor and version (O)
	7-11 Reference datum (C)	**7-09 Aggregation period (M)**	**7-07 Data format (M)**
		7-10 Reference time (M)	**7-08 Version of data format (M)**
			7-12 Numerical resolution (O)
			7-13 Latency (of reporting) (M)
8. Data Quality		*8-01 Uncertainty of measurement (C)*	
		8-02 Procedure used to estimate uncertainty (C)	
		8-03 Quality flag (M)	
		8-04 Quality flagging system (M)	
		8-05 Traceability (C)	
9. Ownership and Data Policy	**9-02 Data policy/use constraints (M)**	**9-01 Supervising organization (M)**	
10. Contact	**10-01 Contact (nominated focal point) (M)**		

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VII. DETAILED SPECIFICATION OF WIGOS METADATA ELEMENTS

An asterisk (*) denotes the element is required for the WMO Rolling Review of Requirements (RRR) process. A hash sign (#) denotes that it is acceptable to record a "mandatory" element with a value of nilReason (that indicates that the metadata is either "unknown", or "not applicable", or "not available"). M = Mandatory, C = Conditional, O = Optional.

CATEGORY 1: OBSERVED VARIABLE

Specifies the basic characteristics of the observed variable and the resulting datasets. It includes an element describing the spatial representativeness of the observation as well as the biogeophysical compartment the observation describe.

TABLE: Table shaded header with lines

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
1-01	Observed variable (measurand)	Variable intended to be measured or observed or derived, including the biogeophysical context	*[ISO19156:2011] NOTE 1:* In conventional measurement theory the term "measurement" is used. However, a distinction between measurement and category-observation has been adopted in more recent work so the term "observation" is used for the general concept. "Measurement" may be reserved for cases where the result is a numeric quantity. *NOTE 2:* The biogeophysical context is expressed in terms of Domain, Subdomain/Matrix, and Layer, and variables are organized hierarchically using these dimensions. Relevant domains, matrices and layers include atmosphere, aerosol, lake, river, ocean, soil, cloud water, aerosol particulate phase, land surface, troposphere, upper troposphere/lower stratosphere, space, etc. *EXAMPLES:*	1-01	M* (Phase 1)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
			In hydrology, this would typically be stage or discharge. Present weather; Air temperature near the surface; CO_2 mixing ratio in the atmosphere		
1-02	Measurement unit	Real scalar quantity, defined and adopted by convention, with which any other quantity of the same kind can be compared to express the ratio of the two quantities as a number [VIM 3, 1.9]	*[VIM 3, 1.9] NOTE 1:* Measurement units are designated by conventionally assigned names and symbols. *[VIM 3, 1.9] NOTE 2:* Measurement units of quantities of the same quantity dimension may be designated by the same name and symbol even when the quantities are not of the same kind. For example, joule per kelvin and J/K are respectively the name and symbol of both a measurement unit of heat capacity and a measurement unit of entropy, which are generally not considered to be quantities of the same kind. However, in some cases special measurement unit names are restricted to be used with quantities of a specific kind only. For example, the measurement unit 'second to the power minus one' (1/s) is called hertz (Hz) when used for frequencies and becquerel (Bq) when used for activities of radionuclides. *[VIM 3, 1.9] NOTE 3:* Measurement units of **quantities of dimension one** are numbers. In some cases these measurement units are given special names, e.g. radian, steradian, and decibel, or are expressed by quotients such as millimole per mole equal to 10^{-3} and microgram per kilogram equal to 10^{-9}. *[VIM 3, 1.9] NOTE 4:* For a given quantity, the short term "unit" is often combined with the quantity name, such as "mass unit" or "unit of mass".	1-02	C* (Phase 1)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
			EXAMPLE: In hydrology, this would typically be m for stage or m^3/s for discharge.		
1-03	Temporal extent	Time period covered by a series of observations inclusive of the specified date-time indications (measurement history)	*NOTE 1*: The Temporal Extent is defined through the begin and end dates of observations. *NOTE 2*: If the data are still being added to, omit the End date (but specify a Begin date). *NOTE 3*: If there are gaps in the data collection (e.g. 1950-1955 then collection resumes 1960-present) then the first date recorded should be the earliest date and the last the most recent, ignoring the gap. *EXAMPLES:* Surface temperature at the station Säntis has been observed since 1 September 1882. The CO_2 record at Mauna Loa extends from 1958 to today. Continuous, 1-hourly aggregates are available from the World Data Centre for Greenhouse Gases for the period 1974-01-01 to 2011-12-31.		M* (Phase 1)
1-04	Spatial extent	Typical spatial georeferenced volume covered by the observations	*NOTE 1*: The spatial extent of an observed quantity can be a zero-, one-, two-, or three-dimensional feature and will be expressed in terms of a series of geospatial locations describing a geometric shape. In the case of space-based observations the spatial coverage should be stated in terms of global (e.g. for LEO, characteristics like swathe width and repeat cycle), disk (GEO), vertical (soundings), etc. *NOTE 2*:	Free text, that could be complemented by one or more	M* (Phase 1)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
			A zero-dimensional geospatial location of an observation implies either an in-situ (point) observation or, by convention, a column-averaged quantity above the specified geospatial location in nadir. One-dimensional geospatial location of an observation implies a distribution/profile of a quantity along a trajectory (e.g., a straight line from the ground up with a given zenith angle). A two-dimensional geospatial location of an observation implies an area or hyper-surface (e.g., a radar image, or a satellite pixel of a property near the surface). A three-dimensional geospatial location of an observation implies a volume-averaged quantity (e.g., a radar pixel in 3D-space). *EXAMPLES:* (i) Air temperature at a surface observing site: Sydney Airport NSW: Lat: -33.9465 N; Lon. 151.1731 E, Alt: 6.0 m above msl; (ii) The projected area or volume of the cone around a particular weather radar with a maximum range of 370 km (radar reflectivity) and 150 km (Doppler); to be expressed as a geometric shape; (iii) 3-dimensional grid of radar pixels; (iv) For infrared and visible imagery by meteorological satellite (sun-synchronous)~~:~~ Global ~~coverage~~; (v) For nadir sounding: atmospheric column above ocean; (vi) NASA Aura satellite (705 km altitude) has a 16-day (233 orbit) repeat cycle; (vii) River discharge by gauge: size and geometric shape of a river Catchment.	URLs	
1-05	Representativeness	Spatial extent of the region around the observation for which it is representative	*NOTE*: The representativeness of an observation is the degree to which it describes the value of the variable needed for a specific purpose. Therefore, it is not a fixed quality of any observation, but results from joint appraisal of instrumentation, measurement interval and exposure against the requirements of some particular application (WMO-No. 8, 2008). Representativeness of an observed value describes the concept that the result of an observation made at a given geospatial location would be compatible with the result of other	1-05	O (Phase 2)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
			observations of the same quantity at other geospatial locations. In statistics, the term describes the notion that a sample of a population allows an adequate description of the whole population. Assessing representativeness can only be accomplished in the context of the question the data [or observations] are supposed to address. In the simplest terms, if the data [or observations] can answer the question, it is representative (Ramsey and Hewitt, 2005). The representativeness of an environmental observation depends on the spatio-temporal dynamics of the observed quantity (Henne et al., 2010). Representativeness of an observation can sometimes be specified quantitatively, in most cases qualitatively, based on experience or heuristic arguments.		

Condition:

{1-02} variables that are measured, rather than classified

CATEGORY 2: PURPOSE OF OBSERVATION

Specifies the main application area(s) of the observation and the observing programme(s) and networks the observation is affiliated to.

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Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
2-01	Application area(s)	Context within, or intended application(s) for which the observation is primarily made or which has/have the most stringent requirements	*NOTE:* Many observations serve more than one purpose, meeting the requirements of various applications areas. In such cases, the application area for which the station or platform was originally established should be listed first.	2-01	M* (Phase 1)
2-02	Program/Network	The global, regional or national	*EXAMPLES:*	2-02	M (Phase 1)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
	affiliation	program/network(s) that the station/platform is associated with	GUAN, AMDAR, GAW, RBSN, WHOS, etc. (full names to be referenced in code table)		

CATEGORY 3: STATION/PLATFORM

Specifies the observing facility, including fixed station, moving equipment or remote sensing platform at which the observation is made.

TABLE: Table shaded header with lines

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
3-01	Region of origin of data	WMO Region	*NOTE:* WMO divides Member countries into six Regional Associations responsible for coordination of meteorological, hydrological and related activities within their respective Regions.	3-01	C* (Phase 1)
3-02	Territory of origin of data	Country or territory name of the location of the observation	*NOTE*: Mandatory for fixed stations, optional for mobile stations *EXAMPLE*: Australia	3-02	C* (Phase 1)
3-03	Station/platform name	Official name of the station/platform	*EXAMPLES*: Mauna Loa, South Pole		M (Phase 1)
3-04	Station/platform type	A categorization of the type of observing facility at	*NOTE*:	3-04	M* (Phase 2)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
		which an observation is made	Code table according to See [INSPIRE D2.8.III.7, 2013]		
3-05	Station/platform model	The model of the monitoring equipment used at the station/platform	*EXAMPLES*: 'Landsat 8' is a platform/station model of 'satellite'; 'Almos Automatic Weather Station (AWS)' is a model of a 'land station'; 'Airbus A340-600' is a model of an 'aircraft'.		M*# (Phase 3)
3-06	Station/platform unique identifier	A unique and persistent identifier for an observing facility (station/platform), which may be used as an external point of reference	*NOTE*: A globally unique identifier assigned by WMO for a station. Where a station has multiple identifiers, there must be a way of recording that they are synonyms. To be defined according to WMO guidelines. *EXAMPLE*: Ship: Call sign		M* (Phase 1)
3-07	Geospatial location	Position in space defining the location of the environmental monitoring station/platform at the time of observation	*NOTE 1*: Required for fixed stations; for stations following pre-determined trajectory (e.g. satellites). *NOTE 2*: The elevation of a fixed terrestrial station is defined as the height above sea level of the ground on which the station stands ("Hha" in WMO Pub. 9 Vol A). *NOTE 3*: The geospatial location can be a zero-, one-, two-, or three-dimensional feature. *NOTE 4*: Geographical coordinates can be specified in decimal degrees. Latitudes are specified with reference to the equator, with positive sign for latitudes north of	11-01 11-02	M* (Phase 1)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
			the equator, and negative sign for latitudes south of the equator. Longitudes are specified with reference to the Greenwich meridian, with positive sign for longitudes east of Greenwich, and negative sign for meridians west of Greenwich. Elevation is a signed number specified in some distance measure (e.g., meters) relative to a reference elevation, with positive sign in the direction away from the Earth centre. *NOTE 5*: The latitudinal and longitudinal positions of a station referred to in the World Geodetic System 1984 (WGS-84) Earth Geodetic Model 1996 (EGM96) must be recorded to a resolution of at least 0.001 decimal degrees (WMO-No. 8, 2008, Part I, Chapter 1, 1.3.3.2).		
			NOTE 6: This element comprises 3 entities, the coordinates (Lat/Long/Alt), the "geopositioning method" (code table 11-01) which produced the coordinates, as well as the "geospatial reference system" (code table 11-02) used. *EXAMPLES:* (i) The station Jungfraujoch is located at 46.54749°N 7.98509°E (3580.00 m a.m.s.l.). The reference system is WGS-84; (ii) Voluntary Observing Ship Route: WMO Regional Association 5, Sub Area 6 (R56); (iii) [geostationary satellite] Meteosat-8 (MSG-1) 3.6°E; (iv) [sun-synchronous satellite] NOAA-19 Height 870 km; Local Solar Time (LST) 13:39; (v) Weather Watch Radar: Warruwi NT -11.6485° N, 133.3800 E, Height 19.1 m amsl; (vi) River discharge gauge: Warrego River at Cunnamulla Weir 28.1000 S,	11-01 11-02	M* (Phase 1)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
			145.6833 E, Height: 180 m amsl.		
3-08	Data communication method	Data communication method between the station/platform and some central facility	*EXAMPLES*: Inmarsat-C, ARGOS, Cellular, Globalstar, GMS(DCP), Iridium, Orbcomm, VSat, landline telephone, mail	3-08	O (Phase 2)
3-09	Station operating status	Declared reporting status of the station	*NOTE:* Refer to the code table.	3-09	M (Phase 1)

Conditions:

{3-01, 3-02}: Mandatory for fixed land-based stations, optional for mobile stations

CATEGORY 4: ENVIRONMENT

Describes the geographical environment within which the observation is made. It also provides an unstructured element for additional meta-information that is considered relevant for adequate use of the observations and that is not captured anywhere else in the standard.

TABLE: Table shaded header with lines

Id	*Name*	*Definition*	*Note or example*	*Code table*	*ItemMCO*
4-01	Surface cover	The observed (bio)physical cover on the Earth's surface in the vicinity of the observation	*NOTE 1:* To be applied to 3 different geographic scales of the vicinity of the observation, namely horizontal radii of <100 m, of 100 m to 3 km, and of 3 km to 100 km. *NOTE 2:*	4-01	C (Phase 3)

Id	*Name*	*Definition*	*Note or example*	*Code table*	*ItemMCO*
			Surface cover or land cover is distinct from land use despite the two terms often being used interchangeably. Land use is a description of how people utilize the land and socio-economic activity – urban and agricultural land uses are two of the most commonly known land use classes. At any one point or place, there may be multiple and alternate land uses, the specification of which may have a political dimension. *NOTE 3:* There are various classification methods for 'land cover'. The MODIS product MCD12Q1 provides 5 different classifications on 500 m resolution grid (https://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table/mcd12q1). These include the IGBP, UMD, LAI/fPAR, NPP and PFT classifications. *NOTE 4:* An alternative approach is the Land Cover Classification System (LCCS) (Di Gregorio, 2005) adopted by the Food and Agriculture Organization of the United Nations. Translation of other systems to LCCS has been explored by Herold et al. (2009). Eight major land cover types are identified during the first, dichotomous classification phase. These are refined in a subsequent so-called Modular-Hierarchical Phase, in which surface cover classes are created by the combination of sets of pre-defined classifiers. These classifiers are tailored to each of the eight major surface cover types. This process can be supported by software (http://www.glcn.org/sof_7_en.jsp) or manually using a field log sheet (http://commons.wikimedia.org/wiki/File:LCCS_field_protokoll.png).		
4-02	Surface cover classification scheme	Name and reference or link to document describing the classification scheme	IGBP, UMD, LAI/fPAR, NPP and PFT, LCCS (recommended implementation as a URI pointing to the code table)	4-02	C (Phase 3)
4-03	Topography or bathymetry	The shape or configuration of a geographical feature, represented on a map by contour lines	*NOTE 1*: Topography shall be formally expressed with the four elements 'local topography', 'relative elevation', 'topographic context', and 'altitude/depth'.	4-03	C (Phase 3)

Id	*Name*	*Definition*	*Note or example*	*Code table*	*ItemMCO*
			NOTE 2: The term 'altitude' is used for elevations above mean sea level. The term 'depth' is used for elevations below mean sea level. *EXAMPLES (can be converted into entries of the code table):* "a ridge at low relative elevation within valleys of middle altitude" "a depression within plains of very low depth"		
4-04	Events at observing facility	Description of human action or natural event at the station or in the vicinity that may influence the observation	*NOTE 1:* This information may be frequently changing (for example ocean debris impacting buoys). *NOTE 2:* The start and end time/date of the event should be included	4-04 or free text or an URL	O (Phase 2)
4-05	Site information	Non-formalized information about the location and its surroundings at which an observation is made and that may influence it	*NOTE:* In hydrology, description and dating of activities occurring in the basin that can affect the observed discharge, e.g., construction of a regulation structure upstream of the gauging location that significantly affects the hydrological regime, inter-basin diversion of water into or from the basin upstream of the gauging location, significant change in consumptive use, surface cover or land use. *EXAMPLES:* maps, plans, photographs, descriptions and other unique site information that is difficult to express in words or that cannot easily be quantified.	Free text and/or URL(s)	O (Phase 2)
4-06	Surface roughness	The Terrain classification in terms of aerodynamic roughness length	*NOTE:* The Terrain classification (Davenport and Wieringa) as mentioned in WMO-No. 8,	4-06	O (Phase 3)

Id	*Name*	*Definition*	*Note or example*	*Code table*	*ItemMCO*
			2008, Updated 2010, Annex to Chapter 5		
4-07	Climate zone	The Köppen climate classification of the region where the observing facility is located	The Köppen-Geiger climate classification scheme divides climates into five main groups (A, B, C, D, E), each having several types and subtypes.	4-07	O (Phase 3)

Conditions:

Either {4-01 and 4-02 and 4-03} or a nilReason="not applicable" must be reported. For hydrology and satellite observations, specifying nilReason is appropriate.

CATEGORY 5: INSTRUMENTS AND METHODS OF OBSERVATION

Specifies the method of observation and describes characteristics of the instrument(s) used to make the observation. If multiple instruments are used to generate the observation, then this category should be repeated.

TABLE: Table shaded header with lines

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
5-01	Source of observation	The source of the dataset described by the metadata	*NOTE:* Refer to the Code table	5-01	M (Phase 1)
5-02	Measurement/observing method	The method of measurement/ observation used	*EXAMPLES:* Temperature can be determined using different principles: liquid in glass; mechanical; electrical resistance; thermistor; thermocouple. Likewise, humidity is determined in AMDAR as a mass mixing ratio. Several chemical variables can be determined using infrared absorption	5-02	M# (Phase 1)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
			spectroscopy. In hydrology, stage would be observed using a staff gauge, electric tape, pressure transducer, gas bubbler, or acoustics. Examples of satellite observation principles: Cross-nadir scanning IR sounder; MW imaging/sounding radiometer, conical scanning, etc. Visual observation of weather, cloud type, etc.		
5-03	Instrument specifications	Intrinsic capability of the measurement/observing method to measure the designated element, including range, stability, precision, etc.	*NOTE 1*: The metadata record can be "not available". *NOTE 2*: Includes the Upper limit of operational range and the Lower limit of operational range. For space-based observations, the channels and their frequencies should be included. *EXAMPLES:* (i) Barometer measurement range 800–1100 hPa (i.e. unsuitable for some mountain ranges, Mt Everest ~300hPa); (ii) Maximum distance a human observer can observe given the topography.	An URL is acceptable in case of space-based observations	C*# (Phase 1)
5-04	Instrument operating status	The status of an instrument with respect to its operation	*NOTE:* To be recorded by data providers for each individual observation.	5-04	O (Phase 3)
5-05	Vertical distance of sensor	Vertical distance of the sensor from a (specified) reference level such as local ground, or deck of a marine platform at the point where the sensor is	*NOTE 1:* The reference surface (generally a surface which will strongly influence the observation) must be specified. *NOTE 2:*		C* (Phase 1)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
		located; or sea surface	Away from center of earth, positive. Negative values indicate position below reference surface. *EXAMPLES:* (i) Air temperature: height of the temperature sensor is 1.50 m above ground surface (station level); (ii) Surface wind: 10.0 m above ground surface (station level); (iii) Soil temperature: 0.50 m below soil surface; (iv) Ship: Visual Obs Height: 22.0 m a.s.l.; (v) Weather Watch Radar: Warruwi AU 24.3 m above ground surface (see 7-07); (vi) Transmissometer 2.55 above runway surface; (vii) Depth of buoy relative to lowest astronomical tide; (viii) Pressure sensor: vertical distance above mean sea level.		
5-06	Configuration of instrumentation	Description of any shielding or configuration/setup of the instrumentation or auxiliary equipment needed to make the observation or to reduce the impact of extraneous influences on the observation	*NOTE:* *An URL could be provided in case of space-based observations.* *EXAMPLES (for surface-based observations):* Shelter, temperature control, etc. Internal volume: [m^3] Aspirated: [Natural/forced/na] Aspiration rate: m^3s^{-1}		$C^{\#}$ (Phase 3)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
			Shielding from: [radiation/precipitation/ wind/etc.]		
5-07	Instrument control schedule	Description of schedule for calibrations or verification of instrument	*NOTE:* *For space-based observations, it applies only to major changes; For very frequent changes on parameters, a specific link to external source should be provided.* *EXAMPLE:* Every year on first week of February		C (Phase 3)
5-08	Instrument control result	The result of an instrument control check, including date, time, location, standard type and period of validity	*NOTE 1:* For the result of control check code table 5-08 is to be used. *NOTE 2:* record even if "not available" *NOTE 3:* Information should contain at least the following elements: Standard type: [International, Primary, Secondary, Reference, Working, Transfer, Travelling, collective] Standard name: [free text] Standard reference: [serial number or equivalent] Within verification limit [Y/N] *NOTE 4*: Can be implemented with a URI pointing to a document containing this information.	5-08	C# (Phase 3)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
			NOTE 5: For space-based observations, it applies only to major changes; for very frequent changes on parameters, a specific link to external source should be provided. *EXAMPLE:* 20140207 15:30 UTC, travelling standard, <name>, <S/N>, field calibration, result: in calibration, validity: 4 years		
5-09	Instrument model and serial number	Details of manufacturer, model number, serial number and firmware version if applicable	*NOTE 1*: Record "not available" NOTE 2: Use the following formats: Instrument manufacturer: [free text] Instrument model: [free text] Instrument serial number: [free text] Firmware version: [free text] *EXAMPLE*: Vaisala PTB330B G2120006		C# (Phase 3)
5-10	Instrument routine maintenance	A description of schedule maintenance that is performed on an instrument	*EXAMPLE*: Daily cleaning of a radiation sensor		C# (Phase 3)
5-11	Maintenance party	Identifier of the organization or individual who performed			O (Phase 2)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
		the maintenance activity			
5-12	Geospatial location	Geospatial location of instrument/sensor	*NOTE 1:* Geographic location of instrument such as airfield anemometer or transmissometer. *NOTE 2:* This element comprises 3 entities, the coordinates (Lat/Long/Alt), the "geopositioning method" (code table 11-01) which produced the coordinates, as well as the "geospatial reference system" (code table 11-02) used. *EXAMPLES:* (i) Melbourne Airport AU (East anemometer) –37.6602 N, 144.8443 E, 122.00 m amsl.; (ii) Relative position of wind sensor aboard ship; (iii) 30 km upstream of river mouth.	11-01 11-02	C* (Phase 2)
5-13	Maintenance Activity	Description of maintenance performed on instrument	*NOTE:* A log of actual maintenance activity, both planned and corrective		O (Phase 3)
5-14	Status of observation	Official status of observation	*NOTE:* A binary flag	5-14	O (Phase 3)
5-15	Exposure of instruments	The degree to which an instrument is affected by external influences and reflects the value of the observed variable	NOTE: The exposure of an instrument results from joint appraisal of the environment, measurement interval and exposure against the requirements of some particular application. Expressed in terms of code table.	5-15	C (Phase 2)

Conditions:

{5-07, 5-08, 5-09, 5-10, 5-15} mandatory for instrumental observations

{5-05} mandatory for instrumental observations and if proximity of reference surface impacts on observation

{5-06} mandatory for instrumental observations and if prescribed by "best practice".

{5-12} mandatory for instrumental observations and if different from station/platform

{5-05, 5-06, 5-10, 5-12, 5-15} A nil Reason = "not applicable" is acceptable for space-based observations.

CATEGORY 6: SAMPLING

Specifies how sampling and/or analysis are used to derive the reported observation or how a specimen is collected.

TABLE: Table shaded header with lines

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
6-01	Sampling procedures	Procedures involved in obtaining a sample	*EXAMPLES*: Temperature measurements are made using a XYZ thermometer and reported results are an average of 10 measurements made in a given hour. Aerosols may be sampled with an inlet with size-cutoff at 2.5 µm and be deposited on a teflon filter. Manual reading of a liquid-in-glass thermometer every three hours. As an exception, an observer may observe the state of the sky from home rather than at the station during night. Rain fall is accumulated during the whole week-end and distributed evenly over these 2 days.	An URL in case of space-based observations	O (Phase 3)
6-02	Sample	Chemical or physical treatment of sample prior to	*EXAMPLES*:		O (Phase 3)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
	treatment	analysis	Homogenization, milling, mixing, drying, sieving, heating, melting, freezing, evaporation.		
6-03	Sampling strategy	The strategy used to generate the observed variable	*EXAMPLES*: Continuous: global radiation, atmospheric pressure, or continuous ozone monitoring with a UV monitor; Discrete: gas chromatographic analysis of carbon monoxide, radar rainfall; Event: grab water samples, flask sampling of air, etc.	6-03 or an URL in case of space-based observations	O* (Phase 1)
6-04	Sampling time period	The period of time over which a measurement is taken	*NOTE:* Includes the sampling time period, plus the meaning of time stamp (11–03).	11-03	M# (Phase 3)
6-05	Spatial sampling resolution	Spatial resolution refers to the size of the smallest observable object. The intrinsic resolution of an imaging system is determined primarily by the instantaneous field of view of the sensor, which is a measure of the ground area viewed by a single detector element in a given instance in time.	*NOTE:* *A representative value (L × L × L), where "L" is a length, is expected, according to the dimension (1-D, 2-D or 3-D), but free text is allowed for the characteristics to be explained.* *EXAMPLES*: The sample is a point in space or a very small volume resembling a point, e.g., a temperature sampled by a thermocouple element: No size to be reported; The sample is a line, either straight (e.g., a line of sight of a DOAS instrument) or curved (e.g., the humidity sampled by an aircraft in flight). The 'length' of the line is to be reported; The sample is an area, either rectangular or of any other shape, e.g., the reach of a radar image. The 'length x length' of the area is to be reported; The sample is a volume, e.g. a water sample or a well-mixed volume of air sampled		M# (Phase 2)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
			by flask. The 'length x length x length' of the volume is to be reported.		
6-06	Temporal sampling interval	Time period between the beginning of consecutive sampling periods	*EXAMPLES:* Surface winds sampled every 0.25 s (frequency 4 Hz) (WMO, 2008); surface winds measured once per hour; Barometric pressure measured once every 6 minutes; water column height measured every 15 seconds; water temperature measured once per hour; For each example, Time stamp indicates "end of period".		M (Phase 3)
6-07	Diurnal base time	Time to which diurnal statistics are referenced	*EXAMPLES:* Rain fall observation is accumulated for 24 hours up until 0700z, the diurnal base time here is 0700z. Daily temperature maxima refer to the period 0600 local time, the diurnal base time here is 0600z.		C (Phase 1)
6-08	Schedule of observation	Schedule of observation	*EXAMPLES:* AMDAR profiling observations are available from Zurich airport between 0600 and 1200 local time; Radio-sondes are collected at a particular station from January to August on weekdays at 0000z and 1200z.	Free text	M (Phase 1)

{6-05, 6-06, 6-07, 6-08} A nil Reason = "not applicable" is acceptable for space-based observations.

CATEGORY 7: DATA PROCESSING AND REPORTING

Specifies how raw data are transferred into the observed variables and reported to the users.

TABLE: Table shaded header with lines

Id	*Name*	*Definition*	*Note or example*	*Code table*	*ItemMCO*
7-01	Data processing methods and algorithms	A description of the processing used to generate the observation and list of algorithms utilized to derive the resultant value	*NOTE*: In hydrology, this would be the equation(s) defining the rating curve and any shifts or corrections applied to the data or the curve. *EXAMPLE:* Radiation correction and calculation of geo-potential height for upper-air soundings.	Free text or an URL	O (Phase 3)
7-02	Processing/analysis center	Center at which the observation is processed.	*EXAMPLES*: Chemical analysis, AMDAR processing center, National Hydrological Service office.		O (Phase 2)
7-03	Temporal reporting period	Time period over which the observed variable is reported	*NOTE:* Includes the temporal reporting interval, plus the meaning of time stamp. *EXAMPLES*: Hourly, daily, monthly, seasonal, event-based, 80 seconds interval during the day, etc. In each case, the meaning, "beginning, "middle", or "end" of period is indicated.	11-03	M* (Phase 1)
7-04	Spatial reporting interval	Spatial interval at which the observed variable is reported	*NOTE*: This is applicable only to remote sensing observations and mobile platforms in general. For most remote-sensing observations, this will be redundant with element 6-05. *EXAMPLES:* (i) An observation from a satellite may be reported with a spatial resolution of		C* (Phase 1)

Id	*Name*	*Definition*	*Note or example*	*Code table*	*ItemMCO*
			10 km x 20 km; (ii) An aircraft may sample every 1 km along its trajectory (cf. 6-05), but may report at a spatial interval of 10 km.		
7-05	Software/processor and version	Name and version of the software or processor utilized to derive the element value	*EXAMPLES*: Avionics version, retrieval algorithm version; MCH Database Management System version 25/10/2013.		O (Phase 3)
7-06	Level of data	Level of data processing	*NOTE*: Pre- or post-processing.	7-06	O (Phase 2)
7-07	Data format[1]	Description of the format in which the observed variable is being provided.	*EXAMPLES*: ASCII, BUFR, NASA AMES, HDF, XML, AMDAR, comma-separated (CSV), tab-separated (.txt), MCH (for interchange)	7-07	M (Phase 3)
7-08	Version of data format[1]	Version of the data format in which the observed variable is being provided.	*EXAMPLES*: FM 12–XIV Ext. SYNOP; FM 42-XI Ext. AMDAR, FM 94-XIV BUFR Version 20.0.0, Radar: ODIM_H5		M (Phase 3)
7-09	Aggregation period	Time period over which individual samples/observations are aggregated	*NOTE:* Includes the aggregation interval, plus the meaning of time stamp. *EXAMPLES*: 5 minute mean, meaning of time stamp is “middle of period”; daily maximum, meaning of time stamp is “end of period”; event based, meaning of time stamp is “beginning of period”.	11-03	M (Phase 2)

Id	*Name*	*Definition*	*Note or example*	*Code table*	*ItemMCO*
7-10	Reference time	Time base to which date and time stamps refer	*NOTE:* The reference time must not be confused with the time zone (which is part of the representation of the time stamp), but indicates what the source of the time stamp is, i.e., to which reference time the time stamps of the observation are aligned. *EXAMPLES*: NIST time server NTP pool project	7-10	M (Phase 2)
7-11	Reference datum	Reference datum used to convert observed quantity to reported quantity	*NOTE 1:* Atmospheric pressure can be reported as (i) Field elevation Pressure (QFE), where the reference datum is the elevation corresponding to the official elevation of the aerodrome; (ii) Atmospheric pressure at nautical height (QNH), where the reference datum is mean sea level and the pressure altitude relationship of the ICAO standard atmosphere is used. Where observed atmospheric pressure cannot be reduced to mean sea level, a station should, by regional agreement, report either the geopotential of an agreed 'constant pressure level' or the pressure reduced to an agreed datum for the station. The level chosen for the station should be reported in this field. (Ref: WMO-No. 8 3.11.1). *NOTE 2:* Hydrology may report a gauge zero which is the gauge height of zero flow.		C (Phase 1)
7-12	Numerical resolution	Measure of the detail in which a numerical quantity is expressed	*NOTE 1*: The resolution of a numerical quantity is a measure of the detail in which the quantity is expressed. It can be expressed as the smallest possible difference between two numbers. It can also be expressed as the number of significant figures of a number, which are those digits that carry meaning contributing to its resolution. *EXAMPLE*:		O (Phase 3)

Id	*Name*	*Definition*	*Note or example*	*Code table*	*ItemMCO*
			If a measurement resolution to four decimal places (0.0001) is given as 12.23 then it might be understood that only two decimal places of resolution are available. Stating the result as 12.2300 makes clear that it is precise to four decimal places (in this case, six significant figures).		
			NOTE 2: The notion of measurement resolution is related but must not be confounded with the uncertainty of an observation. *EXAMPLES*: (i) An anemometer may measure wind speed with a measurement resolution of 0.1 ms^{-1} with a 1 Hz scan rate. Observations may be aggregated to 1-minute values and may be rounded and reported with a (reduced) measurement resolution of 1 ms^{-1}; (ii) A barometer may be capable of measuring atmospheric pressure with a readout resolution of 1 hPa and an uncertainty of 5 hPa (k=2). The data can be reported to the nearest hPa, however, the measurement resolution should be stated as "5 hPa" or "3 significant digits"; (iii) An ocean thermometer measures temperature to 0.0001 °C; (iv) Seawater salinity measured to 0.001 salinity units (derived from conductivity measurements with a resolution of 0.01 Sm^{-1}).		O (Phase 3)
7-13	Latency (of reporting)	The typical time between completion of the observation or collection of the datum and when the datum is reported	(i) For satellite data, the "observation" (e.g. a complete image) can take 20 minutes to generate. Hence the latency would be the time between the completion of the image collection, and when it is available. Typically this can be 2–3 minutes. Some satellite products such as SST can take about 10 minutes of processing until it is available; (ii) A radar volumetric scan can take 6–10 minutes (in Australia), so the latency would be the time between the completion of the scan and when the data is locally available. In Australia, this varies between a few seconds to several minutes depending on delays in data communications;		M (Phase 3)

Id	*Name*	*Definition*	*Note or example*	*Code table*	*ItemMCO*
			(iii) AWS data may have a latency of 1–20 seconds (or considerably more in some places) between the completion of the observation and arrival of the data at a central archive.		

[1] Provided as part of the WIS metadata records

Conditions:

{7-04}: mandatory for remote sensing observations and mobile platforms in general

{7-11}: mandatory for stations/platforms that report a derived observation value that depends on a local datum

CATEGORY 8: DATA QUALITY

Specifies the data quality and traceability of the observation

TABLE: Table shaded header with lines

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
8-01	Uncertainty of measurement	Non-negative parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the observation/ measurand	*NOTE 1:* In principle, an uncertainty statement needs to be reported for each observation, as it can change from observation to observation. If the uncertainty of observations remains virtually constant over time, it is sufficient to report the uncertainty at the beginning of the period and then again when substantial changes of the uncertainty occur. The actual uncertainty statements should be reported with the observations. *NOTE 2:* Complex observations such as gridded satellite imagery may contain large error covariance matrices that are not useful for the purpose of this standard. Such information must be kept with the data, and it is sufficient to report an aggregate		C*[#] (Phase 2)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
			(e.g., mean or median) uncertainty in the metadata. *NOTE 3:* Uncertainty may be expressed, for example, as a standard deviation (or a given multiple of it), or the half-width of an interval having a stated level of confidence. *NOTE 4:* Uncertainty of measurement comprises, in general, many components. Some of these components may be evaluated from the statistical distribution of the results of series of measurements and can be characterized by experimental standard deviations. The other components, which also can be characterized by standard deviations, are evaluated from assumed probability distributions based on experience or other information. *NOTE 5:* It is understood that the result of the measurement is the best estimate of the value of the measurand, and that all components of uncertainty, including those arising from systematic effects, such as components associated with corrections and reference standards, contribute to the dispersion. *NOTE 6:* For space-based observations, the implementation should be taken in a simple way. *EXAMPLE:* A thermometer reading may yield a value of 13.7 °C. A quality assessment of that observation may indicate that it has an expanded uncertainty of +/− 0.3 °C (k=2), where k=2 is a coverage factor corresponding approximately to a confidence interval of 95%.		
8-02	Procedure used to estimate	A reference or link pointing to a document describing the procedures/algorithms used	*NOTE:* Uncertainty is a well-defined term, and guidance material exists to assist in the		

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
	uncertainty	to derive the uncertainty statement	assessment of the uncertainty of observations and a formulation of adequate uncertainty statements. The authoritative source is the "Guide for the Expression of Uncertainty in Measurement" (JCGM 100:2008).		
8-03	Quality flag	An ordered list of qualifiers indicating the result of a quality control process applied to the observation	*NOTE 1:* BUFR code table series 0-33 contains data quality flags/definitions. *NOTE 2:* To be recorded by data providers for each individual observation.	8-03	M# (Phase 2)
8-04	Quality flagging system	Reference to the system used to flag the quality of the observation	*NOTE 1:* At present, there is no single, globally accepted flagging system. The purpose of this element is to make reference to the flagging system used. This reference should either be a URL to a document explaining the meaning of the quality flag, or a link to a code table where this information can be found. *NOTE 2*: The use of the BUFR quality codes listed above is recommended (WMO, 2013a)	8-04	
8-05	Traceability	Statement defining traceability to a standard, including sequence of measurement standards and calibrations that is used to relate a measurement result to a reference [VIM 3, 2.42]	*NOTE 1:* A metrological traceability chain is defined through a calibration hierarchy *[VIM 3, 2.42].* *NOTE 2:* A metrological traceability chain is used to establish metrological traceability of a measurement result *[VIM 3, 2.42].* *NOTE 3:* A comparison between two measurement standards may be viewed as a calibration if the comparison is used to check and, if necessary, correct the quantity value and measurement uncertainty attributed to one of the measurement standards *[VIM 3,*	8-05	C*# (Phase 2)

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
			2.42]. *NOTE 4:* For the statement on traceability, code table 8-05 is to be used. *NOTE 5:* For space-based observations, the implementation should be taken in a simple way.		

Conditions:

{8-01, 8-02 and 8-05} variables that are measured, rather than classified

CATEGORY 9: OWNERSHIP AND DATA POLICY

Specifies who is responsible for the observation and owns it.

TABLE: Table shaded header with lines

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
9-01	Supervising organization	Name of organization who owns the observation	*EXAMPLES:* for satellite operators EUMETSAT, ESA, NOAA, NASA, CMA, RapidEye, ISRO		M (Phase 2)
9-02	Data policy/use constraints	Details relating to the use and limitations surrounding data imposed by the supervising organization	*NOTE:* Only one single use constraint with a value taken from WMO_DataLicenseCode is allowed to ensure unambiguity (WMO, 2013b, p. 51)	9-02	M* (Phase 1)

CATEGORY 10: CONTACT

Specifies where information about an observation or dataset can be obtained.

TABLE: Table shaded header with lines

Id	*Name*	*Definition*	*Note or example*	*Code Table*	*ItemMCO*
10-01	Contact (Nominated Focal Point)	Principal contact (Nominated Focal Point, FP) for resource	*NOTE:* The FP would be able to provide data users with information regarding individual observing platforms and their observations. *EXAMPLES:* Programme or Network Manager, e.g. E-AMDAR Technical Coordinator (TC) has responsibility for data quality of several airlines' fleets, has information on aircraft type/software/known errors etc.		M (Phase 1)

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Chapter title in running head: APPENDIX 2.4. THE WIGOS METADATA STANDA…

SECTION: Chapter
Chapter title in running head: APPENDIX 2.5. THE EIGHT PRINCIPLES OF Q…

APPENDIX 2.5. THE EIGHT PRINCIPLES OF QUALITY MANAGEMENT OF THE WMO QUALITY MANAGEMENT FRAMEWORK APPLIED TO WIGOS

1. User and client focus

Members should identify, document and understand the current and future needs of their users and clients for meteorological, climatological, hydrological, marine and related environmental observations.

Note: The means to achieve this includes participation in and application of the WMO Rolling Review of Requirements (RRR) (see section 2.2.4 and Appendix 2.3).

2. Leadership

Members should clearly define the goals and directions of their observing systems, and create an environment in which staff are encouraged to work towards those goals.

Note: The relevant WMO technical commissions provide technical guidance and leadership for the implementation of WIGOS. They provide information on WIGOS goals and directions, and stimulate the active involvement of technical experts from Member countries.

3. Involvement of experts

Experts from Member countries should be fully involved in the implementation of regulations pertaining to WIGOS quality management.

4. Process approach

Members should adopt a process-based approach to management of observing systems.

5. System approach to management

Members should identify, understand and manage WIGOS observing systems as sets of processes that may be operational, scientific or administrative, with the overall objective of producing the required observation outputs.

6. Continual improvement

Members should ensure that continual improvement is an integral and permanent component of WIGOS observing systems and is implemented through a range of processes and activities that include active participation in the WMO RRR; auditing of observing systems and sites; data quality monitoring and evaluation; and routine consultation with, and review of feedback from, WIGOS users and application areas, primarily through the WMO RRR.

Note: The outcome is the improvement of either the quality of observations or the efficiency of observing systems.

7. Factual approach to decision-making

Members should ensure that decisions, requirements and regulations associated with the design, development, implementation, operation, maintenance and evolution of WIGOS observing systems are based on scientifically, factually and analytically derived information.

Note: The above-mentioned information is available to Members through tools such as the WMO RRR, the WIGOS Information Resource (WIR), the Observing Systems Capability Analysis and Review (OSCAR) tool, and through WMO endorsed planning documents such as the *Implementation Plan for the Evolution of Global Observing Systems* (WIGOS Technical Report No. 2013-4). For further information see section 2.2.4, Appendix 2.1 and Attachment 2.2.

8. Mutually beneficial supplier relationships

Members should participate in, and share with each other and with suppliers, information and results of tests, trials and intercomparisons of instruments and systems, for the mutual benefit of both WIGOS and suppliers.

Note: Suppliers of instruments, systems and related products should be evaluated and selected on the basis of their ability to meet requirements and on the past performance of their products and services.

SECTION: Chapter

Chapter title in running head: ATTACHMENT 2.1. WIGOS STATION IDENTIFIE…

ATTACHMENT 2.1. WIGOS STATION IDENTIFIERS

1. STRUCTURE OF WIGOS STATION IDENTIFIERS

Figure 1 shows the structure of the WIGOS station identifier. The description of each component is given in the table below.

TABLE: Table with lines

WIGOS identifier series	Issuer of identifier	Issue number	Local identifier

Figure 1. Structure of the WIGOS station identifier

Component parts of the WIGOS station identifier

TABLE: Table horizontal lines

Component	*Description*	*Initial range – series 0 (stations)*
WIGOS identifier series	This is used to distinguish between different systems for allocating identifiers. It allows future expansion of the system so that entities do not have to be issued with new identifiers if the structure of the WIGOS identifiers proves unable to meet future requirements. Different values of the WIGOS identifier series may correspond to different structures of the WIGOS identifier. Initial permitted range: 0-14.	0
Issuer of identifier	A number that is used to distinguish between identifiers issued by different organizations. It is allocated by WMO to ensure that only one organization can create a given WIGOS station identifier.	0-65534
Issue number	A number that an organization responsible for issuing an identifier may use to ensure global uniqueness of its identifiers. For example, allocating one issue number for hydrological stations and another for voluntary climate observing stations would enable the managers of the two networks to issue local identifiers independently without needing to check with each other that they were not duplicating identifiers.	0-65534

Local identifier	This is the individual identifier issued for each entity. An organization issuing identifiers must ensure that the combination of issue number and local identifier is unique; in that way global uniqueness is guaranteed.	16 characters

Notes:

1. The structure of WIGOS station identifiers has been designed to be general enough to identify other entities, such as individual instruments; however, this has not yet been implemented.

2. Although the table proposes initial ranges of permitted values of the components that make up a WIGOS identifier, future changes in requirements may result in these ranges being increased. Information technology systems must, therefore, be designed to process identifiers whose components are of arbitrary length. BUFR encodings will need to be prepared for WIGOS identifiers to allow efficient representation and these may use code lists to represent components of the identifier that are shared by many entities. Currently, station identifier = 0.

2. NOTATION FOR THE WIGOS IDENTIFIER

The convention for writing WIGOS identifiers (in the context of WIGOS) is:

<WIGOS identifier series>-<issuer of identifier>-<issue number>-<local identifier>

Here is an example of WIGOS identifier:

TABLE: Table with lines

WIGOS identifier series	Issuer of identifier	Issue number	Local dentifier
0	513	215	5678

which would be written as 0-513-215-5678.

3. REPRESENTING THE WIGOS IDENTIFIER IN CONTEXTS OUTSIDE WIGOS

The following convention should be used to represent the WIGOS identifier outside WIGOS or to show the relationship between the WIGOS identifier and an identifier that has been defined in a different context:

TABLE: Table with lines

int.wmo.wigos	WIGOS identifier	WIGOS supplementary identifier

Figure 2. Structure of an extended WIGOS identifier

Both the int.wmo.wigos and the WIGOS supplementary identifier elements are optional.

int.wmo.wigos

The first component of the extended WIGOS identifier (int.wmo.wigos) allows it to be recognized as a WIGOS identifier when used in contexts where it may be ambiguous as to what type of identifier is being used. This is optional and need not be represented in BUFR, because the entries for the WIGOS identifier provide this information;

WIGOS identifier

The second component (WIGOS identifier) is defined above. Within a WIGOS context it is the only component of the WIGOS identifier that is always required;

WIGOS supplementary identifier

The final component (WIGOS supplementary identifier) is optional and is used to associate identifiers issued using other systems with the WIGOS unique identifier. A single WIGOS identifier may be associated with many WIGOS supplementary identifiers (such as an observing site that is used for both synoptic and aviation reporting), and a WIGOS supplementary identifier may be associated with many WIGOS unique identifiers (such as a World Weather Watch drifting buoy identifier that has been issued to many drifting buoys). In BUFR, this would be indicated by a specific table entry (such as IIiii for World Weather Watch station identifier).

Note: If the above example of WIGOS identifier (0-513-215-5678) was also associated with an identifier (MYLOCATION) issued by another authority, a valid extended WIGOS identifier would be int.wmo.wigos-0-513-215-5678-MYLOCATION.

SECTION: Chapter

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ATTACHMENT 2.2. THE WIGOS INFORMATION RESOURCE

1. PURPOSE

The WIGOS Information Resource (WIR) is a tool designed to provide WIGOS stakeholders (observing network decision-makers, managers, supervisors, implementation coordination groups and observational data users) with all relevant information on the operational status and evolution of WIGOS and its observing components, and their capabilities to meet the user observational requirements of the WMO application areas; the operational requirements of WIGOS, including standard and recommended practices and procedures; and on best practices and procedures used in the WIGOS framework. The WIR serves a number of purposes and brings the following benefits to WMO Members:

(a) General information on WIGOS, its benefits to Members and the impact on Members of addressing WIGOS requirements;

(b) An overall description of the WIGOS component observing systems that are currently in place (list of observing networks, stations, their characteristics (metadata) including information on the observational products they deliver);

(c) Monitoring of the evolution of the observing systems and compare it with the plans in order to ascertain progress;

(d) An outline of existing national and regional plans for evolution of WIGOS component observing systems;

(e) Help for Members and those in charge of designing and implementing observing networks in understanding the requirements for the relevant observing systems, including standard and recommended practices and procedures and user observational requirements, in order for them to make appropriate decisions;

(f) Assistance for Members in identifying observational gaps through critical review and in conducting network design studies, in order for them to address those gaps;

(g) Help for Members in grasping the full potential of the current observing systems, including those operated by partner organizations, with regard to the WMO application areas, in

order to enhance: (a) the scope and availability of observations made by specific observing stations; (b) collaboration; (c) data sharing; and (d) data exchange;

(h) Immediate access for data users to the list of WIGOS component observing systems and a basic set of observational metadata for each (specified by WMO Technical Regulations), with links to the appropriate national databases, where these exist, which contain more detailed information;

(i) Guidance for developing countries on observing network implementation, providing them with tools they can readily use to document their own observing systems (for example, by using the Observing Systems Capability Analysis and Review (OSCAR) tool of the WIR, they would not need to develop a national database);

(j) A mechanism for matching specific needs (capacity building, closing gaps, etc.) with resources (via knowledge sharing, donor contributions, etc.).

Notes:

1. The term observing station refers to any type of observing site, station or platform relevant to WIGOS, whether they are surface-based or space-based, on land, at sea, in a lake, river or in the air, fixed or mobile (including in the air), and making in-situ or remote observations.

2. Gaps are expressed in terms of required space and time resolution, observing cycle, timeliness and uncertainty for the WMO application areas.

2. THE OBSERVING SYSTEMS CAPABILITY ANALYSIS AND REVIEW TOOL

The Observing Systems Capability Analysis and Review tool of the WIR is a key source of information for WIGOS metadata. The surface- and space-based components of OSCAR are intended to record observing platform/station metadata, according to the WIGOS metadata standard described in the present Manual, and to retain a record of the current and historical WIGOS metadata.

3. MANAGEMENT OF THE OBSERVING SYSTEMS CAPABILITY ANALYSIS AND REVIEW

The management of OSCAR (for example, its functional specifications and their evolution) and its components is overseen by the WMO Secretariat in liaison with relevant expert groups and bodies, and in accordance with the WIGOS standards that have been agreed upon and recommended practices and procedures.

4. CONTENT MANAGEMENT OF THE OBSERVING SYSTEMS CAPABILITY ANALYSIS AND REVIEW

The WIGOS metadata are maintained under the authority of the Permanent Representatives with WMO.

The operator of OSCAR will collect feedback from Members on noted discrepancies, possible errors and required changes, so that the information content of OSCAR reflects the reality of the surface- and space-based capabilities of the observing platforms/stations they operate, including instrument and platform/station metadata.

The WMO Secretariat is responsible for coordinating management of the information content of OSCAR, with assistance from designated experts and focal points.

Current information can be found at http://www.wmo.int/oscar.

SECTION: Chapter
Chapter title in running head: 3. ATTRIBUTES SPECIFIC TO THE SURFACE-B…

3. ATTRIBUTES SPECIFIC TO THE SURFACE-BASED SUBSYSTEM OF WIGOS

3.1. REQUIREMENTS

Note: The user observational requirements of WMO application areas are expressed in a technology-free manner, hence they apply to all of WIGOS, not to any specific subsystem. The provisions of section 2.1 apply across all WIGOS subsystems.

3.2. DESIGN, PLANNING AND EVOLUTION

3.2.1 Composition of the surface-based subsystem of WIGOS

3.2.1.1 The WIGOS surface-based subsystem shall be composed of surface stations within the component networks (for example, GOS, GAW, WHOS, GCW).

3.2.1.2 Members should implement elements of the WIGOS surface-based subsystem under the coordination of regional associations when appropriate.

Note: Information regarding the current capabilities of the surface-based subsystem is to be available through the OSCAR tool at http://www.wmo.int/oscar.

3.3. INSTRUMENTATION AND METHODS OF OBSERVATION

3.3.1 General requirements

3.3.1.1 Members shall classify their surface meteorological and climatological observing stations on land.

Note: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.1.2, Annex 1.B, provides guidelines on the classification of surface observing sites on land to indicate their representativeness for the measurement of different variables. The content of Annex 1.B will be included as an appendix in a future edition of the present Manual.

3.3.1.2 Members should locate each observing station at a site that permits instrument exposure against the requirements of the particular application and enables satisfactory non-instrumental observations.

Notes:
1. The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, Annexes 1.B and 1.C provides further guidelines.

2. Requirements for GAW stations are formulated in section 6.

3.3.1.3 Members shall accurately ascertain and refer the position of a station to the World Geodetic System 1984 (WGS-84) and its Earth Geodetic Model 1996 (EGM96).

Notes:
1. Guidelines are provided in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.3.3.2.

2. The WGS-84 is currently not in general use in hydrology. Its description will be included as an appendix in a future edition of the present Manual.

3.3.1.4 Members shall define the elevation of the station.

Note: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.3.3.2(c), provides guidelines on defining the elevation of a station. This material will be included as an appendix in a future edition of the present Manual.

3.3.1.5 If a station is located at an aerodrome, Members shall specify the official elevation of the aerodrome in accordance with the *Technical Regulations* (WMO-No. 49), Volume II, Part II, Appendix 3, 4.7.2.

3.3.1.6 Members operating Regional Instrument Centres should follow the guidelines concerning capabilities and corresponding functions.

Note : The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Annex 1.A, provides guidelines concerning capabilities and corresponding functions for Regional Instrument Centres. This material will be included as an appendix in a future edition of the present Manual.

3.3.1.7 Members operating Regional Marine Instrument Centres should follow the guidelines concerning capabilities and corresponding functions.

Note : The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part II, Chapter 4, Annex 4.A, provides guidelines concerning capabilities and corresponding functions for operating Regional Marine Instrument Centres. This material will be included as an appendix in a future edition of the present Manual.

3.3.2 Requirements for sensors

3.3.2.1 Members shall avoid the use of mercury in their observing systems. Where mercury is still in use, Members shall obey the safety precautions provided.

Note: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 3, 3.2.7, provides safety precautions for the use of mercury. This material will be included as an appendix in a future edition of the present Manual.

3.3.2.2 For inflation of meteorological balloons, Members should prefer helium over hydrogen. If hydrogen is used, however, Members shall obey the safety precautions provided.

Note: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part II, Chapter 10, 10.6.1, provides safety precautions for the use of hydrogen. This material will be included as an appendix in a future edition of the present Manual.

3.3.2.3 Members shall calibrate all pyrheliometers, other than absolute pyrheliometers, by comparison, using the sun as the source, with a pyrheliometer that is traceable to the World Standard Group and has a likely uncertainty of calibration equal to or better than the pyrheliometer being calibrated.

Note: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 7, 7.2.1.4, provides detailed guidelines on calibration of pyrheliometers.

3.3.2.4 Members shall compare, calibrate and maintain barometers according to the guidelines.

Note: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 3, 3.10, provides guidelines on the comparison, calibration and maintenance of barometers. This material will be included as an appendix in a future edition of the present Manual.

3.4. OPERATIONS

3.4.1 General requirements

Members operating surface-based observing systems shall follow the provisions of section 2.4.1.

3.4.2 Observing practices

3.4.2.1 Members shall ensure that the exposure, when applicable, of instruments for the same type of observation at different stations is similar so that observations may be compatible.

3.4.2.2 Members shall determine a reference height for each surface observing station or system.

Note: A reference height is defined as follows:

(a) Elevation of the station: it is the datum level to which barometric pressure reports at the station refer; such current barometric values are termed "station pressure" and are understood to refer to the given level for the purpose of maintaining continuity in the pressure records;

(b) For stations not located on aerodromes: elevation (height above mean sea level) of the ground on which the raingauge stands or, if there is no raingauge, of the ground beneath the thermometer screen. If there is neither raingauge nor screen, it is the average level of terrain in the immediate vicinity of the station, expressed in metres rounded up to two decimals;

(c) For stations located on aerodromes it is an official altitude of the aerodrome.

3.4.3 Quality control

Members operating surface-based observing systems shall follow the provisions of section 2.4.3.

3.4.4 Data and metadata reporting

Members operating surface-based observing systems shall follow the provisions of section 2.4.4.

3.4.5 Incident management

Members operating surface-based observing systems shall follow the provisions of section 2.4.5.

3.4.6 Change management

Members should compare observations from new instruments over an extended interval before the old measurement system is taken out of service or when there has been a change of site. Where this procedure is impractical at all sites, Members should carry out comparisons at selected representative sites.

Notes:

1. This does not apply to all types of station; among the exceptions are hydrological stations.

2. Further details, including the required minimum intervals for such comparison, can be found in the *Guide to Climatological Practices* (WMO-No. 100).

3.4.7 Maintenance

Observing sites and instruments should be maintained regularly so that the quality of observations does not deteriorate significantly between station inspections.

Note: Detailed guidance on maintenance of observing sites, observing systems and instruments is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), the *Guide to Hydrological Practices* (WMO-No. 168) and the *Manual on Stream Gauging* (WMO-No. 1044).

3.4.8 Inspection and supervision

3.4.8.1 Members shall arrange for their surface observing sites, stations and systems to be inspected at sufficiently frequent intervals to ensure that a high standard of observations is maintained, that instruments and all their indicators are functioning correctly, and that the exposure, when applicable, of the instruments has not changed significantly.

Notes:

1. Detailed guidance on the inspection, including frequency, is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part III, Chapter 1.

2. Reference is made to the *Technical Regulations* (WMO-No. 49), Volume II, for provisions on the inspection of aeronautical meteorological stations including its frequency.

3.4.8.2 Members shall ensure that the inspection is performed by qualified and adequately trained staff.

3.4.8.3 When performing inspections, Members should ensure that:

(a) The siting, selection and installation, as well as exposure when applicable, of instruments are known, recorded and acceptable;

(b) Instruments have approved characteristics, are in good order and regularly checked against relevant standards;

(c) There is uniformity in the methods of observation and in the procedure for reduction of observations.

Note: Detailed guidance on inspection and supervision of observing systems and sites is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), which includes guidelines on GAW measurements (see Part I, chapter 16), the *Guide to Hydrological Practices* (WMO-No. 168) and the *Manual on Stream Gauging* (WMO-No. 1044).

3.4.9 Calibration procedures

Members operating surface-based observing systems shall follow the provisions of section 2.4.9.

3.5 OBSERVATIONAL METADATA

Note: Detailed guidance regarding the establishment, maintenance and update of metadata records is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.3.4, and Part III, Chapter 1, 1.9; the *Guide to Climatological Practices* (WMO-No. 100), Chapter 3, 3.3.4; the *Guide to the Global Observing System* (WMO-No. 488), Appendix III.3, and the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, Chapter 10.

Members operating surface-based observing systems shall follow the provisions of section 2.5.

Note: Further provisions specific to the WIGOS component observing systems appear in sections 5, 6, 7 and 8.

3.6. QUALITY MANAGEMENT

Members operating surface-based observing systems shall follow the provisions of section 2.6.

Note: Further provisions specific to the WIGOS space-based subsystem appear in section 4; those specific to the WIGOS component observing systems appear in sections 5, 6, 7 and 8.

3.7. CAPACITY DEVELOPMENT

Members operating surface-based observing systems shall follow the provisions of section 2.7.

Note: Further provisions specific to the WIGOS space-based subsystem appear in section 4; those specific to the WIGOS component observing systems appear in sections 5, 6, 7 and 8.

SECTION: Chapter
Chapter title in running head: 4. ATTRIBUTES SPECIFIC TO THE SPACE-BAS…

4. ATTRIBUTES SPECIFIC TO THE SPACE-BASED SUBSYSTEM OF WIGOS

4.1. REQUIREMENTS

4.1.1 General

Members shall strive to develop, implement and operate a space-based environmental observing system in support of WMO Programmes as described in Attachment 4.1.

Note: The space-based subsystem of WIGOS is established through dedicated satellites, remotely observing the characteristics of the atmosphere, the Earth and the oceans.

4.1.2 Observed variables

This subsystem shall provide quantitative data enabling, independently of or in conjunction with surface-based observations, the determination of variables including but not limited to:

(a) Three-dimension fields of atmospheric temperature and humidity;

(b) Temperature of sea and land surfaces;

(c) Wind fields (including ocean surface winds);

(d) Cloud properties (amount, type, top height, top temperature and water content);

(e) Radiation balance;

(f) Precipitation (liquid and frozen);

(g) Lightning;

(h) Ozone concentration (total column and vertical profile);

(i) Greenhouse gas concentration;

(j) Aerosol concentration and properties;

(k) Volcanic ash cloud occurrence and concentration;

(l) Vegetation type and status, and soil moisture;

(m) Flood and forest fire occurrence;

(n) Snow and ice properties;

(o) Ocean colour;

(p) Wave height, direction and spectra;

(q) Sea level and surface currents;

(r) Sea ice properties;

(s) Solar activity;

(t) Space environment (electric and magnetic field, energetic particle flux and electron density).

Note: Information regarding the current capabilities of the space-based subsystem is available through the OSCAR tool at: www.wmo.int/oscar.

4.1.3 Observing performance requirements

Satellite operators providing observational data to WIGOS shall strive to meet, to the extent possible, the uncertainty, timeliness, temporal and spatial resolution, and coverage requirements of WIGOS as defined in the WIR, based on the Rolling Review of Requirements described in section 2.

Notes:

1. In the present Manual, the term "satellite operators" refers to Members or a coordinated group of Members operating environmental satellites.

2. A coordinated group of Members operating environmental satellites acts jointly to operate one or more satellites through an international space agency such as the European Space Agency or the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT).

3. These requirements are recorded and maintained in the requirements database: http://www.wmo.int/oscar.

4.1.4 Global planning

Satellite operators shall cooperate to ensure that a constellation of satellite systems is planned and implemented to guarantee the continuous provision of space-based observations in support of WMO Programmes.

Note: Collaboration is pursued within the Coordination Group for Meteorological Satellites, which includes all Members operating space-based observation systems in support of WMO Programmes.

4.1.5 Continuity

Satellite operators working together under the auspices of the Coordination Group for Meteorological Satellites or otherwise, should ensure the continuity of operation and of the data dissemination and distribution services of the operational satellites within the subsystem, through appropriate contingency arrangements and relaunch plans.

4.1.6 Overlap

Satellite operators should ensure an adequate period of overlap of new and old satellite systems in order to determine inter-satellite instrumental biases and maintain the homogeneity and consistency of time series observations, unless reliable transfer standards are available.

4.1.7 Interoperability

4.1.7.1 Satellite operators shall achieve the greatest possible interoperability of their different systems.

4.1.7.2 Satellite operators shall make available sufficient technical details about the instruments, data processing, transmissions and dissemination schedules for Members to fully exploit the data.

4.2. DESIGN, PLANNING AND EVOLUTION

Note: The space-based subsystem is composed of:

(a) An Earth observation space segment;

(b) An associated ground segment for data reception, processing, dissemination and stewardship;

(c) A user segment.

4.2.1 Space segment architecture

Note: The overall architecture of the space segment is described in Attachment 4.1. It is defined and evolves in consultation with the Coordination Group for Meteorological Satellites.

It includes:

(a) A constellation of geostationary satellites;

(b) A core constellation of sun-synchronous satellites distributed over three separate orbital planes;

(c) Other operational satellites operated on either sun-synchronous orbits or other appropriate low Earth orbits;

(d) Research and development satellites on appropriate orbits.

4.2.2 Space programme life cycles

Satellite operators shall consider a trade-off between the need for a long series to pay off the development cost and the user learning curve, on one hand, and the need to develop a new generation in order to benefit from state-of-the-art technology, on the other hand.

Notes:

1. The development of an operational satellite programme is conducted in several phases including: definition of user requirements, feasibility assessment at system level, preliminary design, detailed design, development and testing of the subsystems, integration of all subsystems, system testing, launch campaign and on-orbit commissioning. The overall duration of these development phases is typically of the order of 10 to 15 years.

2. The exploitation phase for an operational programme including a series of recurring satellites is typically of the order of 15 years.

4.3. INSTRUMENTS AND METHODS OF OBSERVATION

Notes:

1. Space-based observation relies on a wide range of sensor types, for example, active or passive, operating in various spectral ranges, and with various scanning or pointing modes. Information on the principles of Earth observation from space, the different types of space-based instrument and the derivation of geophysical variables from space-based measurements can be found in the *Guide to Instruments and Methods of Observation* (WMO-No. 8), 2014 edition, Part III, chapter 5.

2. Detailed characteristics of current and planned systems of environmental satellites are available in the satellite module of the OSCAR tool, which is available on line (http://www.wmo.int/oscar/space). It also contains an indication of the main instruments that are relevant for each specific variable observable from space, with their potential performance for the respective variables.

4.3.1 Calibration and traceability

4.3.1.1 Satellite operators shall perform a detailed instrument characterization before launch.

Note: Members must strive to follow the pre-launch instrument characterization guidelines recommended by the Global Space-based Inter-calibration System.

4.3.1.2 After launch, satellite operators shall calibrate all instruments on a routine basis against reference instruments or calibration targets.

Notes:

1. Advantage should be taken of satellite collocation to perform on-orbit instrument intercomparison and calibration.

2. Calibration must be done in accordance with methodologies established and documented by the Global Space-based Inter-calibration System and the Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation.

4.3.1.3 Satellite operators shall ensure traceability to the International System of Units (SI) standards.

Note: The *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* (2010 Update), GCOS-138 (WMO/TD-No. 1523) calls for sustained measurement of key variables from space traceable to reference standards and recommends implementing and evaluating a satellite climate calibration mission.

4.3.1.4 To ensure traceability to the International System of Units (SI) standards, satellite operators shall define a range of ground-based reference targets for calibration purposes.

4.4. SPACE SEGMENT IMPLEMENTATION

4.4.1 Operational satellites on Geostationary Earth Orbit

4.4.1.1 Satellite operators should implement an operational constellation of satellites in geostationary orbit as described in Attachment 4.1.

4.4.1.2 Satellite operators shall ensure that the constellation of satellites in geostationary orbit provides full disc imagery at least every 15 minutes and achieves coverage of all longitudes, throughout a field of view between 60° S and 60° N.

Note: This implies the availability of at least six operational geostationary satellites if located at evenly distributed longitudes, with in-orbit redundancy.

4.4.1.3 Satellite operators should implement rapid-scan capabilities where feasible.

4.4.1.4 For the imagery mission in geostationary orbit, satellite operators should ensure an availability rate of rectified and calibrated data of at least 99% as a target.

4.4.1.5 To meet the essential requirement for continuity of data delivery, satellite operators shall strive to implement contingency plans, involving the use of in-orbit standby flight models and rapid call-up of replacement systems and launches.

4.4.2 Core operational constellation on sun-synchronous low Earth orbits

4.4.2.1 Operators of low Earth orbit (LEO) satellites should implement a core operational constellation of satellites in three regularly distributed sun-synchronous orbits as described in Attachment 4.1.

4.4.2.2 Operators of the core constellation of environmental LEO satellites on three sun-synchronous orbital planes, in early morning, mid-morning and afternoon orbit, shall strive to ensure a high level of robustness to permit the delivery of imagery and sounding data from at least three polar orbiting planes, on not less than 99% of occasions.

Note: This implies provisions for a ground segment, instrument and satellite redundancy, and rapid call-up of replacement launches or in-orbit spares.

4.4.3 Other capabilities on low Earth orbits

Operators of environmental LEO satellites should implement capabilities in appropriate orbits as described in Attachment 4.1.

4.4.4 Research and development satellites

4.4.4.1 Operators of research and development satellites shall consider providing the following observing capabilities:

(a) Advanced observation of the parameters necessary to understand and model the water cycle, the carbon cycle, the energy budget and the chemical processes of the atmosphere;

(b) Pathfinders for future operational missions.

Note: For WMO, the main benefits of research and development satellite missions are:

(a) Support of scientific investigations of atmospheric, oceanic and other environment-related processes;

(b) Testing or demonstration of new or improved sensors and satellite systems in preparation for new generations of operational capabilities to meet WMO observational requirements.

4.4.4.2 Members shall strive to maximize the usefulness of observations from research and development satellites for operational applications. In particular, operators of research and development satellites shall make provisions, where possible, to enable near-real-time data availability to promote the early use of new types of observations for operational applications.

Notes:

1. Although neither long-term continuity of service nor a reliable replacement policy are assured, research and development satellites provide, in many cases, observations of great value for operational use.

2. Although they are not operational systems, research and development satellites have proven to support operational meteorology, oceanography, hydrology and climatology substantially.

4.5 GROUND SEGMENT IMPLEMENTATION

4.5.1 General

4.5.1.1 Satellite operators shall make observational data available to Members through the WMO Information System (WIS) in accordance with the provisions in the *Manual on the WMO Information System* **(WMO-No. 1060). Satellite operators shall inform Members of the means of obtaining these data through catalogue entries and shall provide sufficient metadata to enable meaningful use of the data.**

4.5.1.2 Satellite operators shall set up facilities for the reception of remote-sensing data (and Data Collection System data when relevant) from operational satellites, and for the processing of quality-controlled environmental observation information, with a view to further near-real-time distribution.

4.5.1.3 Satellite operators shall strive to ensure that data from polar-orbiting satellites are acquired on a global basis, without temporal gaps or blind orbits, and that data latency meets WMO timeliness requirements.

4.5.2 Data dissemination

4.5.2.1 Satellite operators shall ensure near-real-time dissemination of the appropriate data sets, as per the requirements of Members, either by direct broadcast via an appropriately designed ground segment, or by rebroadcast via telecommunication satellites.

4.5.2.2 In particular, operators of operational sun-synchronous satellites providing the core meteorological imagery and sounding mission should ensure inclusion of a direct broadcast capability as follows:

(a) Direct broadcast frequencies, modulations and formats should allow a particular user to acquire data from the satellite with a standardized antenna and signal processing hardware. To the extent possible, the frequency bands allocated to meteorological satellites should be used;

(b) Direct broadcast shall be provided through a high data rate stream, such as the High- resolution Picture Transmission (HRPT) or its subsequent evolution, to provide meteorological centres with all the data required for numerical weather prediction (NWP), nowcasting and other real-time applications;

(c) If possible, a low data rate stream should also be provided, such as the Low-rate Picture Transmission (LRPT), to convey an essential volume of data to users with lower connectivity or low-cost receiving stations.

4.5.2.3 Satellite operators shall consider implementing rebroadcast via telecommunication satellites to complement and supplement direct broadcast services and to facilitate access to integrated data streams, including data from different satellites, to non-satellite data and to geophysical data products.

4.5.2.4 Operators of operational geostationary meteorological satellites with rapid-scan capabilities shall strive to provide meteorological centres with data in near-real time as required for nowcasting, NWP and other real-time applications.

4.5.3 Data stewardship

4.5.3.1 Satellite operators shall provide a full description of all processing steps taken in the generation of satellite data products, including algorithms, characteristics and outcomes of validation activities.

4.5.3.2 Satellite operators shall preserve long-term raw data records and ancillary data required for their calibration and reprocessing as appropriate, with the necessary traceability information to achieve consistent Fundamental Climate Data Records.

4.5.3.3 Satellite operators shall maintain Level 1B satellite data archives including all relevant metadata pertaining to the location, orbit parameters and calibration procedures used.

4.5.3.4 Satellite operators shall ensure that their archiving system is capable of providing on-line access to the archive catalogue with a browsing facility, that it provides adequate description of data formats and will allow users to download data.

4.5.4 Data collection systems

4.5.4.1 Satellite operators with a capability to receive data and/or products from Data Collection Platforms (DCP) shall maintain technical and operational coordination under the auspices of the Coordination Group for Meteorological Satellites (CGMS) in order to ensure compatibility.

4.5.4.2 Satellite operators shall maintain a number of "international" DCP channels, which should be identical on all geostationary satellites, to support the operation of mobile platforms moving across all individual geostationary footprints.

4.5.4.3 Satellite operators shall publish details of the technical characteristics and operational procedures of their data-collection missions, including the admission and certification procedures.

4.5.5 The user segment

4.5.5.1 Operators of research and development satellites shall implement capabilities enabling Members to access the data in one of the following ways: by downloading data from server(s) or by receiving data from a rebroadcasting service or a direct broadcast capability.

4.5.5.2 Members shall endeavour to install and maintain in their territory at least one system enabling access to digital data from both LEO and geostationary operational satellite constellations: either a receiver of rebroadcast service providing the required information in an integrated way, or a combination of dedicated direct readout stations.

4.5.5.3 Where appropriate, Members should strive to utilize fixed or moving DCP systems (for example, to cover data-sparse areas) to take advantage of the data-collection and relay capability of the environmental observation satellites.

4.6. OBSERVATIONAL METADATA

For each space-based system they operate, satellite operators shall record, retain and make available observational metadata in accordance with the provisions of section 2.5.

4.7. QUALITY MANAGEMENT

Satellite operators shall include appropriate quality indicators in the metadata for each dataset, in accordance with the provisions of section 2.5.

4.8. CAPACITY DEVELOPMENT

4.8.1 Centres of excellence

Satellite operators, and other Members having the capability to do so, shall provide support to the education and training of instructors in the use of satellite data and capabilities, at specialized Regional Training Centres or other training institutes designated as centres of excellence in satellite meteorology, in order to build up expertise and facilities at a number of regional growth points.

4.8.2 Training strategy

Satellite operators should focus their assistance, to the extent possible, on one or more of these centres of excellence within their service areas and contribute to the Virtual Laboratory for Education and Training in Satellite Meteorology.

Note: The aim of the education and training strategy implemented through the Virtual Laboratory is to systematically improve the use of satellite data for meteorology, operational hydrology, and climate applications, with a focus on meeting the needs of developing countries.

4.8.3 User preparation for new systems

4.8.3.1 In order to facilitate a smooth transition to new satellite capabilities, satellite operators should take steps to prepare users through training, guidance on necessary upgrades of receiving equipment and processing software, and the provision of information and tools to facilitate the development and testing of user applications.

4.8.3.2 In addition to working through the Virtual Laboratory, Members should, as appropriate, exploit partnerships with organizations providing education and training in environmental satellite applications, depending on their specific needs.

4.8.4 Collaboration between users and data providers

4.8.4.1 In order to achieve the most effective utilization of satellite data, Members should pursue close collaboration between users and data providers at a regional level.

4.8.4.2 Working with their regional association, Members should follow systematic steps to document the regional requirements for satellite data access and exchange.

SECTION: Chapter
Chapter title in running head: ATTACHMENT 4.1. CGMS BASELINE FOR THE O…

ATTACHMENT 4.1. CGMS BASELINE FOR THE OPERATIONAL CONTRIBUTION TO THE GOS

(Adopted at the thirty-ninth meeting of the Coordination Group for Meteorological Satellites (CGMS-39) on 6 October 2011)

FUTURE SATELLITE MISSIONS TO BE PERFORMED ON OPERATIONAL/SUSTAINED BASIS

INTRODUCTION

In support of the programmes coordinated or co-sponsored by WMO for weather and climate, CGMS Members plan to maintain the operational capabilities and services described below, that constitute the "CGMS baseline for the operational contribution to the GOS".

While this particular document focuses on missions that are decided and managed in an operational or sustained framework, with a perspective of long-term follow-on, this in no way precludes the importance of other missions undertaken e.g. on a research or demonstration basis. First of all, because today's research and development are the foundation of tomorrow's operational missions. Furthermore, because many missions initiated in an R&D framework for a limited duration are eventually extended well beyond their design life time and provide longstanding support to both scientific and operational activities.

This baseline defines a constellation of geostationary satellites, a core meteorological mission on three sun-synchronous orbits, other missions in sun-synchronous orbits, missions in other Low Earth Orbits, and contains cross-cutting considerations on contingency planning, inter-calibration, data availability and dissemination.

I. CONSTELLATION IN GEOSTATIONARY ORBIT

At least six geostationary satellites shall be operated at evenly distributed locations with in orbit redundancy, and perform the following missions:

(a) Advanced visible and infrared imagery (at least 16 spectral channels, 2km resolution) over the full disc at least every 15 minutes;

(b) Infrared sounding (hyperspectral on some positions);

(c) Lightning detection;

(d) Data collection;

(e) Space environment monitoring.

On selected positions, the following missions shall be performed:

(f) Earth Radiation Budget monitoring;

(g) High spectral resolution UV sounding;

(h) Solar activity monitoring.

II. LEO SUN-SYNCHRONOUS MISSIONS

Operational sun-synchronous satellites shall be operated around three orbital planes in mid-morning ("am", nominally 09:30 descending, 21:30 ascending ECT), afternoon ("pm", nominally 13:30 ascending ECT) and early morning (nominally 05:30 descending, 17:30 ascending ECT) and, as a constellation, shall perform the following missions:

1) Core meteorological mission nominally on three orbital planes:

(i) Multispectral visible and infrared imagery;

(j) Infrared hyperspectral sounding (at least am and pm);

(k) Microwave sounding;

(l) Microwave imagery.

2) Other missions on sun-synchronous orbits:

(m) Wind scatterometry over sea surfaces (at least two orbital planes);

(n) Ocean surface topography by radar altimetry (at least on am and pm orbits, supplemented by a reference mission on a high-precision, inclined orbit);

(o) Radio-occultation sounding (at least am and pm, supplemented by a constellation in specific orbits);

(p) Broadband VIS/IR radiometer for Earth Radiation balance (at least am and pm);

(q) Total Solar Irradiance (at least one);

(r) Contribution to atmospheric composition observations (at least am and pm);

(s) Narrow-band Vis/NIR imagers (at least one sun-synchronous, am spacecraft) for ocean colour, vegetation and aerosol monitoring;

(t) High-resolution multi-spectral Vis/IR imagers (constellation of sun-synchronous satellites, preferably in am);

(u) IR dual-angle view imagery for high-accuracy SST (at least one am spacecraft);

(v) Particle detection and/or electron density (at least am and pm);

(w) Magnetic field (at least am and pm);

(x) Solar activity (at least two missions);

(y) Data collection.

III. OTHER LEO MISSIONS

The following missions shall be performed on an operational basis by Low Earth Orbit satellites on appropriate orbits:

(z) Ocean surface topography by radar altimetry (A reference mission on high-precision, inclined orbit, complementing two instruments on sun-synchronous am and pm orbit);

(aa) Radio-occultation sounding (dedicated constellation of sensors on appropriate orbits).

IV. CONTINGENCY PLANNING

The CGMS baseline is associated with contingency plans for geostationary and polar-orbiting satellite systems, which are detailed in the CGMS Global Contingency Plan[1].

[1] The Global Contingency Plan (http://www.wmo.int/pages/prog/sat/documents/CGMS_Contingency-Plan-2007.pdf) should be updated accordingly. It should indicate that in case of potential gaps on core sun-synchronous missions, absolute priority should be given to observation from mid-morning and early afternoon orbits, in order to maintain the continuity of these datasets.

V. INTER-CALIBRATION

Instruments should be inter-calibrated on a routine basis against reference instruments or calibration sites. The routine and operational inter-calibration and corrections shall be performed in accordance with standards as agreed by the Global Space-based Inter-calibration System (GSICS).

VI. DATA AVAILABILITY AND DISSEMINATION

VI.1. Data open availability with suitable timeliness

All operational environmental observation satellite systems should be designed to ensure the provision of data with suitable timeliness, as appropriate for their intended applications. Data should be preserved for the long term and documented with metadata allowing their interpretation and utilization. The satellite operators should establish dissemination contents and schedules that take into account the data requirements of users. Re-broadcast via telecommunication satellites should complement and supplement direct broadcast services, which allows cost-efficient access to integrated data streams including data from different satellites, non-satellite data and geophysical products. The dissemination systems should utilize all-weather resilient telecommunication means.

VI.2. Direct broadcast for core meteorological missions in LEO

The core meteorological satellite systems in LEO orbits, and other operational observation satellite systems when relevant, should ensure near real-time data dissemination of imagery, sounding, and other real-time data of interest to Members by direct broadcast. Direct broadcast frequencies, modulations, and formats for polar-orbiting satellites should allow a particular user to acquire data from either satellite by a single antenna and signal processing hardware. Direct Broadcast should use allocations in all-weather resilient frequency bands.

VII. NOTE

The present update of the CGMS baseline is adopted in the light of satellite mission plans as they are known in October 2011.

SECTION: Chapter

Chapter title in running head: 5. ATTRIBUTES SPECIFIC TO THE GLOBAL OB…

5. ATTRIBUTES SPECIFIC TO THE GLOBAL OBSERVING SYSTEM OF THE WORLD WEATHER WATCH

Notes:

1. The provisions of sections 1, 2, 3 and 4 are common to all WIGOS component observing systems including the GOS.

2. Provisions specific to the GOS are currently set out in the *Manual on the Global Observing System* (WMO-No. 544), Volume I.

SECTION: Chapter

Chapter title in running head: 6. ATTRIBUTES SPECIFIC TO THE OBSERVING…

6. ATTRIBUTES SPECIFIC TO THE OBSERVING COMPONENT OF THE GLOBAL ATMOSPHERE WATCH

Note: The provisions of sections 1, 2, 3 and 4 are common to all WIGOS component observing systems, including GAW. The provisions in this section are specific to GAW.

6.1. REQUIREMENTS

6.1.1 Members should perform the observations of atmospheric composition and related physical parameters using a combination of surface-based stations and platforms (fixed stations, mobile platforms and remote sensing) and space-based platforms.

6.1.2 Members should use the requirements from the RRR process, particularly in the area of atmospheric chemistry application, in developing their GAW stations.

Notes:

1 The user requirements are reviewed on a regular basis through the RRR process by the Scientific Advisory Groups (SAGs) for each variable, in consultation with the user community and with input from Members. The RRR process is described in section 2.2.4 and Appendix 2.1.

2. Scientific Advisory Groups exist for the six GAW focal areas and their terms of reference are defined by the Commission for Atmospheric Sciences.

6.1.3 Members should follow the Data Quality Objectives specified by the GAW Programme for the individual variables observed.

6.1.4 Members should establish and operate their GAW stations so that they satisfy the station requirements specified in Attachment 6.1.

6.1.5 Members operating GAW stations shall undertake long-term and uninterrupted operation with the stability and continuity of data collection required for the purposes outlined in 6.2.1.

6.2. DESIGN, PLANNING AND EVOLUTION

6.2.1 Members should design, plan and further develop their GAW observing network and stations to address user requirements, in particular those that concern key environmental issues and application areas, including but not limited to the following:

(a) Stratospheric ozone depletion and increase of UV radiation;

(b) Changes in the weather and climate due to human influence on atmospheric composition, particularly changes in greenhouse gases, ozone and reactive gases, and aerosols;

(c) Risk assessment of air pollution and UV on human health and the environment, and issues involving long-range transport of air pollution and its deposition.

6.2.2 Members should contribute observations through operating or supporting suitable platforms at GAW stations and/or through contributing networks.

6.2.3 When doing so, Members shall register their contribution in GAWSIS and submit their observations to the relevant GAW Data Centre.

6.2.4 Members operating a contributing network shall provide a description of the network, register the stations in GAWSIS and provide corresponding metadata.

6.2.5 Members should ensure that the frequency and spacing of the various observations is suited to the temporal and spatial requirements of the specific issues addressed in section 6.2.1.

6.3. INSTRUMENTATION AND METHODS OF OBSERVATION

6.3.1 General requirements of instruments

Members should use recommended types of instruments and methods of observation for variables observed at their stations, and follow further available guidance.

Notes:
1. Guidance is provided in the Standard Operating Procedures (SOPs) and measurement guidelines.

2. Instruments suitable for use at GAW sites are defined by the SAGs for each parameter, in terms of stability, precision and accuracy.

3. Standard Operating Procedures describe the standard approach to operate this kind of instrument.

4. The measurement guidelines describe the standard approach for this kind of measurement regardless of the instrument.

6.3.2 Calibration and traceability

6.3.2.1 Members shall perform calibrations and maintain traceability to the GAW primary standards, where available.

Notes:
1 The GAW primary standard is a single network standard, assigned by WMO for each individual variable. In the case of contributing networks, network observations are traceable to the network standard, which in turn is traceable to the GAW primary standard.

2. Details on calibrations are specified by the SOPs and measurement guidelines.

6.3.2.2 Members should utilize GAW central facilities to sustain the global compatibility of observations.

Note: The GAW central facilities include: Central Calibration Laboratories, World Calibration Centres, Regional Calibration Centres and Quality Assurance/Science Activity Centres.

6.4. OPERATIONS

6.4.1 Monitoring observing system implementation

6.4.1.1 Members shall monitor the operation of GAW stations for which they are responsible and ensure that they follow the relevant procedures for quality assurance and data submission. Members shall seek assistance from central facilities, SAGs and expert teams if operational problems cannot be solved locally.

Note: The procedures to be used in monitoring the operation of GAW are determined within the Commission for Atmospheric Sciences (CAS) in consultation with the participating Members.

6.4.1.2 Members should systematically monitor compliance with GAW regulations, in collaboration with relevant constituent bodies and the Secretariat, in order to identify critical cases of non-compliance (deficiencies) and undertake measures for their timely resolution.

6.4.2 Quality assurance

6.4.2.1 Members should follow specified quality assurance practices and procedures.

Note: Details are given in the GAW SOPs and measurement guidelines and in further documents provided by the SAGs and central facilities.

6.4.2.2 Members shall maintain detailed metadata records in accordance with procedures and practices specified in this Manual.

6.4.2.3 Members should participate in independent evaluations of quality of observations, including intercomparisons and system audits, as appropriate for the observed variables.

6.4.2.4 Members shall permit World Data Centres to perform an independent evaluation of the data quality of their observations.

6.4.3 Data and metadata representation and format

6.4.3.1 Members shall submit their observational data and associated metadata to the relevant GAW World Data Centres for the variables observed at the station within agreed time limits.

6.4.3.2 Members shall use the formats specified by the relevant World Data Centre when submitting their observational data and metadata.

6.5. OBSERVATIONAL METADATA

Note: The general provisions on observation metadata are specified in section 2.5.

6.5.1 Members shall provide metadata associated with instrumentation, site or platform, and calibration history as requested by the World Data Centre for each parameter and by GAWSIS.

6.5.2 Members shall provide such additional metadata as required by GAWSIS and any World Data Centre to which they contribute that are necessary to understand their observations.

6.6. QUALITY MANAGEMENT

Note: The general regulations on quality management are specified in section 2.6.

6.7. CAPACITY DEVELOPMENT

Note: General provisions for capacity development are provided in sections 2.7, 3.7 and 4.7.

6.7.1 Members not capable of implementing required standards should establish agreements with appropriate central facilities or establish partnership with more experienced stations in the form of stations twinning.

Note: In some regions of the world, and for some GAW variables, where there is a clear lack of capacity, Members may be requested to help support a station, or existing stations may be approached to become part of GAW. Such requests and invitations come after approval by the appropriate SAGs.

6.7.2 Members should use the GAW Training and Education Centre (GAWTEC) programme, as available, for capacity-building and staff training in measurement of the specific GAW variables.

SECTION: Chapter
Chapter title in running head: ATTACHMENT 6.1. REQUIREMENTS FOR THE GL…

ATTACHMENT 6.1. REQUIREMENTS FOR THE GLOBAL ATMOSPHERE WATCH STATIONS

1. GENERAL

Essential characteristics of the Global Atmosphere Watch (GAW) regional stations:

(a) The station location is chosen such that, for the variables measured, it is regionally representative and is normally free of the influence of significant local pollution sources;

(b) There are adequate power, air conditioning, communication and building facilities to sustain long-term observations with greater than 90% data capture (i.e. <10% missing data);

(c) The technical support provided is trained in the operation of the equipment;

(d) There is a commitment by the responsible agency to long-term observations of at least one of the GAW variables in the GAW focal areas (ozone, aerosols, greenhouse gases, reactive gases, UV radiation and precipitation chemistry);

(e) The GAW observations made are of known quality and linked to the GAW primary standard;

(f) The data and associated metadata are submitted to one of the GAW World Data Centres (WDCs), typically no later than one year after the observations are made. Changes in metadata, including instrumentation, traceability and observation procedures, are reported to the responsible WDC in a timely manner;

(g) If required, observations are submitted to a designated data distribution system in near-real-time;

(h) Standard meteorological in situ observations, necessary for the accurate determination and interpretation of the GAW variables, are of known quality;

(i) The station characteristics and observational programme are updated in the GAW Station Information System (GAWSIS) on a regular basis;

(j) A station logbook (a record of observations made and of activities that may affect observations) is maintained and used in the data validation process.

1.1 Additional essential characteristics of GAW global stations

In addition to the essential characteristics of regional stations, GAW global stations should fulfil the following requirements:

(a) Measurement of variables in at least three of the six GAW focal areas;

(b) A strong scientific supporting programme with appropriate data analysis and interpretation within the country and, if possible, the support of more than one agency;

(c) Provision of a facility at which intensive campaigns can augment the long-term routine GAW observations and where testing and development of new GAW methods can be undertaken.

2. GAW CONTRIBUTING NETWORKS

The GAW contributing networks provide observations from multiple stations. The stations comprising contributing networks should satisfy the criteria of either regional or global stations taking into account the contributing network regulations (within the contributing network, data submission requirements or standard used can differ from those required for regional and global stations). Where the network standards differ from those of WMO, they must have a confirmed traceability to the WMO standards, where these exist. Data submission regulations for the contributing networks must be at least as stringent as those required within GAW. A station designation as global or regional, if such designation already exists for individual stations, always takes precedence over the designation as contributing station. To be used in global assessments, data from the contributing stations must be submitted to the GAW World Data Centres.

SECTION: Chapter
Chapter title in running head: 7. ATTRIBUTES SPECIFIC TO THE WMO HYDRO…

7. ATTRIBUTES SPECIFIC TO THE WMO HYDROLOGICAL OBSERVING SYSTEM

Note: The provisions of sections 1, 2, 3 and 4 are common to all WIGOS component observing systems, including the WHOS. The provisions of this section are specific to the WHOS.

7.1 REQUIREMENTS

7.1.1 Members shall establish and operate a hydrological observing system according to their national requirements.

7.1.2 Members should also operate their hydrological observing systems to address the requirements of the RRR process, in particular for the hydrology application area.

Notes:
1. A hydrological observing system includes networks of hydrological observing stations, as defined in *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, Chapter D.1.1, which should make observations of the elements described in Chapter D.1.2.

2. Information on hydrological data transmission can be found in the *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, Chapter D.1.4, [D.1.4.]1.2, which states: "Transmission facilities should be organized for the international exchange of hydrological data, forecasts and warnings on the basis of bilateral or multilateral agreement." Further provisions for data transmission and international exchange through the WIS are given in the *Technical Regulations* (WMO-No. 49), Volume I, Part II, the *Manual on the WMO Information System* (WMO-No. 1060) and the *Manual on the Global Telecommunication System* (WMO-No. 386).

7.1.3 Members shall provide on a free and unrestricted basis those hydrological data and products which are necessary for the provision of services for the protection of life and property, and the well-being of all peoples.

7.1.4 Members should also provide, where available, additional hydrological data and products that are required by WMO Programmes and by Members as specified in paragraph 7.1.2.

7.1.5 At the global level, WHOS shall give Members access to near-real time hydrological observations from all Members.

Note: Currently, many Members are making such observations publicly available on the Internet.

7.1.6 Members should provide these sources of observations to the WHOS.

Note: Hydrological observations available through WHOS will initially comprise stage (water level) and discharge. This will likely expand over time to include other elements as identified in the Rolling Review of Requirements at the national, regional and global levels.

7.2 DESIGN, PLANNING AND EVOLUTION

Note: Design, planning and evolution is common to all WIGOS component observing systems.

Members should design and plan their observing network considering the review of the current and planned WHOS capabilities, undertaken as outlined in the RRR as described in section 2.2.4.

7.3 INSTRUMENTATION AND METHODS OF OBSERVATION

7.3.1 General requirements of instruments

7.3.1.1 Members should equip their stations with properly calibrated instruments and should arrange for these stations to follow adequate observational and measuring techniques to ensure that the measurements and observations of the various hydrological elements are accurate enough to address the needs of hydrology and other application areas.

Note: *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, provides that Members should use instruments for measurement of stage (water level) in conformity with the specifications of its annex, section II: Water-level measuring devices.

7.3.1.2 Members should ensure that the uncertainty in the observation of the stage (water level) of rivers, estuaries, lakes and reservoirs does not exceed:

(a) In general, 10 mm at the 95% confidence level;

(b) Under difficult conditions, 20 mm at the 95% confidence level.

Note: Stage (water level) observations are used primarily as an index for computing streamflow discharge when a unique relation exists between stage (water level) and discharge.

7.3.2 Stage and discharge observations from hydrometric stations

Note: *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, provides that Members should establish and operate hydrometric stations for measuring stage (water level), velocity and discharge in conformity with the specifications of its annex, section VI: Establishment and operation of a hydrometric station.

7.3.2.1 Members should ensure that the number of discharge measurements at a stream gauging station are adequate to define the rating curve for the station at all times.

Notes:

1. *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, provides that Members should use the methods for determining the stage-discharge relation (rating curve) of a station as specified in its annex, section VII: Determination of the stage-discharge relation.

2. *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, provides that Members should ensure, when undertaking moving-boat discharge measurements, that equipment and operational procedures are as specified in its annex, section XII: Discharge measurements by the moving-boat method.

7.3.2.2 Members should measure river discharges to an accuracy commensurate with flow and local conditions. Percentage uncertainty of the discharge measurement should not exceed:

(a) In general, 5% at the 95% confidence level;

(b) Under difficult conditions, 10% at the 95% confidence level.

Notes:

1. *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, provides that Members should evaluate the uncertainty in discharge measurements in conformity with the specifications in its annex, section VIII: Estimation of uncertainty of discharge measurements.

2. Discharge measurements are taken to establish and verify the stability of a rating curve. Stage (water level) observations are converted to estimates of discharge using the rating curve on an ongoing basis.

7.3.3 Calibration procedures

Notes:

1. *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, provides that Members should adhere to the specifications of facilities, equipment and procedure for the calibration of current meters as specified in its annex, section I: Calibration of current meters in straight open tanks.

2. *Technical Regulations* (WMO-No. 49), Volume III: Hydrology, provides that Members should ensure that operational requirements, construction, calibration and maintenance of rotating element current meters are as specified in its annex, section IV: Rotating element type current meters.

Members should recalibrate acoustic velocity meters on a routine basis to ensure stability of the calibration, using measurement standards traceable to international or national standards. Where no such standards exist, Members should record the basis used for calibration or verification.

Note: Additional information pertaining to the calibration of instruments can be found in the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, and the *Manual on Stream Gauging* (WMO-No. 1044).

7.4 OPERATIONS

7.4.1 Observing practices

7.4.1.1 Members should collect and preserve their hydrological records.

7.4.1.2 Members should make the necessary arrangements to facilitate the retrieval and analysis of their hydrological observations by automatic data-processing equipment.

7.4.1.3 Where automatic registration is not available, Members should ensure that the observations of elements for hydrological purposes are made at regular intervals appropriate for the elements and their intended purposes.

7.4.1.4 Members should maintain in their archives an up-to-date inventory of their hydrological observations.

7.4.1.5 Members should generally ensure uniformity in time of observations within a catchment area.

7.4.1.6 Members should select the time units used in processing hydrological data for international exchange from the following:

(a) The Gregorian calendar year;

(b) The months of this calendar;

(c) The mean solar day, from midnight to midnight, according to the zonal time, when the data permit;

(d) Other periods by mutual agreement in the case of international drainage basins or drainage basins in the same type of region.

7.4.1.7 For hydrometric stations where data are internationally exchanged, Members should process the following characteristics for each year:

(a) Maximum instantaneous and minimum daily mean values of stages (water levels) and discharge;

(b) Mean daily stages (water levels) and/or mean daily discharges.

7.4.1.8 For rivers under flood conditions or where there are variable controls, Members should make special measurements at intervals frequent enough to define the hydrograph.

7.4.1.9 When sudden and dangerous increases in river levels occur, Members should make and report observations as soon as possible regardless of the usual time of observation, to meet the intended operational use.

7.4.1.10 Members should measure and store stage (water level) observations as instantaneous values rather than averaged values.

7.4.2 Quality control

7.4.2.1 Members should maintain detailed records for each station and for each parameter containing metadata related to the measurements, maintenance and calibration of equipment.

7.4.2.2 Members should perform periodic audits of their stations and collected data.

7.4.2.3 Members should ensure that recorded hydrological observations are converted to a form suitable for archiving and retrieval.

Note: Observations may be initially recorded using various media from paper to electronic digital form. As computer archiving has become a standard practice for most Members, it is advantageous to convert data to the required format early in the process.

7.4.2.4 Members should ensure that their data undergo, at various stages, a range of checks to determine their uncertainty and correctness.

7.4.2.5 With accelerating developments in technology, Members should ensure that data-processing and quality control systems are well-organized and that the relevant staff are trained to understand and use them.

Note: Data are collected and recorded in many ways, ranging from manual reading of simple gauges to a variety of automated data-collection, transmission and filing systems.

7.4.2.6 Members should consider the adoption of a quality management system, as described in section 2.6.

Note: Organizations usually employ an accredited certification agency to provide independent verification.

7.4.2.7 Members should undertake data processing and quality control as described in relevant publications.

Note: Such publications include the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, Chapter 9, the *Manual on Flood Forecasting and Warning* (WMO-No. 1072), Chapter 6, and the *Manual on Stream Gauging* (WMO-No. 1044), Volume II, Chapter 6.

7.4.3 Observations and observational metadata reporting

7.4.3.1 Members should ensure, when providing hydrological information for international purposes, that open text or appropriate code forms are used as specified in bilateral or multilateral agreements.

7.4.3.2 Members should ensure that transmission facilities are organized for the international exchange of hydrological observations on the basis of bilateral or multilateral agreements.

7.4.3.3 In order to make data globally available for real-time exchange and discovery, access and retrieval, Members should report stage and discharge observations in compliance with WIS metadata standards.

Notes:

1. The WMO Information System may also be used for access to hydrological observations not required in real-time.

2. The regulations governing exchanges in international code forms are specified in the Manual on Codes (WMO-No. 306), Volume I.

3. Coded information exclusively for bilateral or multilateral exchange amongst Members may be in other forms by mutual agreement.

7.4.4 Incident management

Note: General provisions for incident management are provided in section 2.4.5.

7.4.5 Change management

Note: General provisions for change management are provided in section 2.4.6.

7.4.6 Maintenance

7.4.6.1 Members should determine the frequency and timing of visits to recording stations on the basis of the length of time that the station can be expected to function without maintenance and the uncertainty requirements of the data.

Notes:

1. There is a relation between the frequency of the visits and the resultant quality of the data collected. Too long a time between visits may result in frequent recorder malfunction and thus in loss of data, while frequent visits are both time consuming and costly.

2. Some data collection devices may suffer a drift in the relationship between the variable that is recorded and that which the recorded value represents. An example of this is a non-stable stage-discharge relationship.

3. Two visits per year are considered an absolute minimum; more frequent visits are recommended to decrease the potential loss of data and/or to avoid data being severely affected by problems such as silting, vandalism or seasonal vegetative growth.

7.4.6.2 Members should schedule periodic visits to the station to recalibrate the equipment or the measurement equations.

7.4.6.3 Members should periodically inspect stations using trained personnel to ensure the correct functioning of instruments.

7.4.6.4 Members should ensure that a formal written inspection is done routinely, preferably each year, to check overall performance of instruments and local observer, if applicable.

7.4.6.5 Members, when routinely inspecting sites, should:

(a) Measure gauge datum to check for and record any changes in levels;

(b) Check the stability of the rating curve and review the relationships between the gauges and permanent level reference points to verify that no movement of the gauges has taken place;

(c) Review the gauging frequency achieved and the rating changes identified;

(d) Undertake a number of maintenance activities as described in sections 7.4.6.8 and 7.4.6.9.

Note: It is vital, for the quality of data, that resources for gauging be allocated and prioritized using rigorous and timely analysis of the probability and frequency of rating changes.

7.4.6.6 Members should ensure that maintenance activities are conducted at data-collection sites at intervals sufficient to ensure that the quality of the data being recorded is adequate.

7.4.6.7 Members should ensure that such activities are conducted by the observer responsible for the sites, if there is one. Members should also ensure that maintenance activities are occasionally performed by an inspector.

7.4.6.8 Members should undertake the following maintenance activities at all collection sites:

(a) Service the instruments;

(b) Replace or upgrade instruments, as required;

(c) Retrieve or record observations;

(d) Perform the recommended checks on retrieved records;

(e) Carry out general checks of all equipment, for example, transmission lines;

(f) Check and maintain the site in accordance with the recommended specifications;

(g) Check and maintain access to the station;

(h) Record, in note form, all of the above activities;

(i) Comment on changes in land use or vegetation;

(j) Clear debris and overgrowth from all parts of the installation.

7.4.6.9 Members should undertake the following maintenance activities at discharge collection sites:

(a) Check the bank stability, as necessary;

(b) Check the level and condition of gauge boards, as necessary;

(c) Check and service the flow-measuring devices (cableways, etc.), as necessary;

(d) Check and repair control structures, as necessary;

(e) Regularly survey cross-sections and take photographs of major station changes after events or changes in vegetation or land-use;

(f) Record, in note form, all of the above activities and their results;

(g) Inspect the area around or upstream from the site, and record any significant land-use or other changes in related hydrological characteristics, such as ice.

Note: Further details are found in the *Manual on Stream Gauging* (WMO-No. 1044).

7.4.6.10 Members should have a well-trained technician or inspector visit stations immediately after every severe flood in order to check the stability of the river section and the gauges. If there is a local observer, Members should train this person to check for these problems and communicate them to the regional or local office.

7.4.6.11 Members should not programme flood gaugings as part of a routine inspection trip because of the unpredictable nature of floods.

7.4.6.12 Members should establish a flood action plan prior to the beginning of the storm or flood season and should specify priority sites and types of data required.

Note: If flood gaugings are required at a site, the preparations would ideally be made during the preceding dry or non-flood season so that all is ready for the annual flood season.

7.4.6.13 Members should consider undertaking the following additional measures if severe flooding is likely:

(a) Upgrade site access (helipad, if necessary);

(b Equip a temporary campsite with provisions;

(c) Store and check gauging equipment;

(d) Protect instrumentation, such as stage recorders, by taking flood-proofing measures.

7.4.6.14 Following the recession of floodwaters, Members should pay particular attention to ensuring the safety and security of the data-collection site and to restoring normal operation of on-site instrumentation.

Note: In some cases, redesign and reconstruction of the site may be required. Such work would ideally take into account information obtained as a result of the flood.

7.4.7 Calibration procedures

Note: Determination of a rating curve is described in section 7.3.2. Calibration procedures for current meters are described in section 7.3.3.

7.5 OBSERVATIONAL METADATA

Notes:

1. Provisions for describing observational metadata, for recording and retaining observational metadata, and for exchanging and archiving observational metadata are provided in section 2.5. These apply to all WIGOS component observing systems including the WHOS. Further provisions specific to WHOS are stated here.

2. The contents of observational metadata are detailed in Appendix 2.4, including WIGOS metadata and other metadata of specific relevance for WHOS.

3. Within an organization or country, a hydrological information system or a station registration file and a historical operation file (as indicated in the *Guide to Hydrological Practices*, WMO–No. 168) or similar repositories may be used as a convenient means to compile a set of metadata about a hydrological station and its observations.

7.5.1 In addition to the provisions in section 2.5, Members should record, retain and make available the WIGOS observational metadata and also the additional observational metadata specified in Appendix 2.4.

7.5.2 Members who use their own station identifiers for hydrological stations should maintain the means to match these with the WMO station identifiers, as specified in section 2.4, Attachment 2.1.

7.5.3 Members should collect and record additional detailed observational metadata identifying the purpose of the station in accordance with provisions in section 2.5.

Note: Further details are found in the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, Chapter 10.

7.6 QUALITY MANAGEMENT

Notes:

1. Provisions for the implementation of quality management in WIGOS are provided in section 2.6. These apply to all WIGOS component observing systems including the WHOS.

2. The WMO Hydrology and Water Resources Programme has developed material on the implementation of the WMO Quality Management Framework in Hydrology and its adoption in national operations. Some Members have achieved compliance with the ISO 9001:2008 standard and examples have been documented to assist other Members.

7.7 CAPACITY DEVELOPMENT

Notes:
1. Provisions for the implementation of capacity development in WIGOS are provided in section 2.7.

2. Whatever the level of technical sophistication of a data-collection authority, the quality of its staff remains its most valuable resource.

7.7.1 Members should undertake careful recruitment, training and management to attain and maintain the appropriate personnel with the most appropriate skill sets.

7.7.2 Members should pursue a carefully structured training programme for all personnel engaged in field and office practices pertaining to data collection because they are in a strong position to influence the quality of the final data.

Note: Formal training ideally will aim at providing both a general course in first principles, plus training modules to teach in-house field and office procedures. All material has to be relevant and current.

7.7.3 Members should provide training classes, follow-up exercises and on-the-job training to field personnel, before they make streamflow and survey measurements using various technologies such as Acoustic Doppler Current Profiler (ADCP) and mechanical current meters.

7.7.4 Members should provide training classes, follow-up exercises, and on-the-job training on data-collection practices and processing of data to increase employee productivity and programme effectiveness.

7.7.5 Members should have appropriate technologies in place, such as hydrological information systems, to allow for streamflow data processing and facilitate the effective and efficient delivery of metadata, data and data products to users.

7.7.6 Members should have an adequate number of stations to meet priority needs and ensure sufficient resources to maintain and operate sites to attain required accuracies and reliability of data for their intended use.

SECTION: Chapter
Chapter title in running head: 8. ATTRIBUTES SPECIFIC TO THE OBSERVING…

8. ATTRIBUTES SPECIFIC TO THE OBSERVING COMPONENT OF THE GLOBAL CRYOSPHERIC WATCH

Note: The provisions of sections 1, 2, 3 and 4 are common to all WIGOS component observing systems including the GCW. The further provisions in this section are specific to the GCW.

8.1 Members should collaborate actively in, and give all possible support to, the development and implementation of the observing component of the Global Cryosphere Watch.

Note: Implementation of GCW encompasses the use of surface- and space-based observations, observing standard and recommended practices and procedures, best practices for the measurement of essential cryospheric variables, and full assessment of error characteristics of in situ and satellite products. The initial focus of CryoNet, the surface-based standardized core observing network, is to promote the addition of cryospheric observations taken in accordance with GCW standard and recommended practices and procedures, guidelines and best practices, at existing sites rather than creating new ones. The development of GCW includes the development of a CryoNet manual and guide.

8.2 Members should encourage partnerships between organizations to coordinate observing, capacity-building and training activities relevant to cryospheric observations, and to assist with the compilation and development of manuals on standard and recommended practices and procedures for cryospheric observation.

8.3 The GCW surface observing network shall comprise a core component, called CryoNet, and contributing stations that are not part of CryoNet.

8.4 The basic component of the CryoNet shall be the CryoNet station.

8.5 A CryoNet station shall measure one or more components of the cryosphere and one or more variables of each component.

Note:

Cryosphere components are: sea ice, freshwater ice, ice sheets, glaciers, icebergs, ice caps, ice shelves, permafrost, seasonally frozen ground, snow, and solid precipitation.

8.6 A CryoNet station shall meet a minimum set of requirements, specified in Appendix 8.1.

8.7 A CryoNet Station shall be either a primary or a reference station.

8.8 A primary CryoNet station shall have a target (intent) of long-term operation and have at least a 4-year initial commitment.

8.9 A reference CryoNet station shall have a long-term operational commitment and long-term (more than 10 years) data records.

Note:

Any primary or reference CryoNet station may have one or more additional attributes:

1. A calibration/validation (Cal/Val) station is used for calibration and/or validation of satellite products and/or (earth system) models, or it has been used for such purposes in the past and it still provides the needed facilities.

2. A research station has a broader research focus related to the cryosphere.

8.10 A GCW station that is not part of CryoNet shall be the GCW Contributing station.

8.11 A GCW Contributing station shall measure at least one variable of at least one cryosphere component.

8.12 A GCW Contributing station shall be a station that provides useful measurements of the cryosphere but does not meet minimum requirements for a CryoNet station, or in some other way does not provide the quality and/or consistency of data required by CryoNet stations.

Notes:

1. For example, where data records may be short or with large gaps. These stations may be in remote, hard to access regions where cryospheric observations are scarce or in regions where they complement other cryospheric measurements. Mobile platforms such as ships, drifting stations and buoys may also be contributing stations.

2. Contributing stations may have the reference attribute.

3. A reference contributing station has a long-term operational commitment and/or long-term (more than 10 years) data records.

8.13 CryoNet shall consist of two different categories of observing sites, Basic Sites and Integrated Sites.

8.14 Basic sites shall monitor single or multiple components of the cryosphere (glaciers, ice shelves, ice sheets, snow, permafrost, sea ice, river/lake ice, and solid precipitation) and shall observe multiple variables of each component.

8.15 Integrated sites shall monitor at least two components of the cryosphere or at least one cryosphere component and one other component of the earth system. Integrated Sites shall promote, through worldwide scientific collaboration, progress in the scientific understanding of the processes that change the cryosphere.

Note: Integrated sites are particularly important for the study of feedbacks and complex interactions between these components.

8.16 Each CryoNet site shall encompass an area larger than a conventional observing station.

8.17 Each CryoNet site shall be comprised of two or more active GCW stations with varying capabilities that shall be operated as a coordinated unit. At least one station shall be a CryoNet station.

8.18 Each CryoNet site shall provide a information describing the research approach and the site management (e.g. cooperation between different partners).

8.19 Each CryoNet site shall meet requirements specified in Appendix 8.1.

Note:

1. A site may encompass several micro-climatological regions or extend over larger altitudinal gradients. Thus, further ancillary meteorological stations are part of a site. Different partners may operate the stations, but they are coordinated through one agency or institute.

2. Typically, sites have a broader research focus related to the cryosphere than stations. Whereas basic sites investigate the cryosphere only, integrated sites aim to provide a better understanding of the cryosphere and/or its linkages to other components of the Earth system, for example, the atmosphere, the hydrosphere, the biosphere, the oceans, soil, vegetation, etc.

8.20 A surface CryoNet station or CryoNet shall meet the minimum requirements specified in Appendix 8.1.

Note:

Contributing stations, which are part of the GCW surface network but not part of CryoNet, do not have the same requirements.

SECTION: Chapter

Chapter title in running head: ATTRIBUTES SPECIFIC TO THE OBSERVING CO…

ATTACHMENT 8.1. MINIMUM REQUIREMENTS FOR INCLUSION OF A GLOBAL CRYOSPHERE WATCH SURFACE MEASUREMENT SITE OR STATION IN CRYONET

I. Minimum requirements for a CryoNet station

1. Meeting Core CryoNet Measurement Requirements: The station shall measure at least one of the variables of one of the cryosphere components (i.e. snow, solid precipitation, lake and river ice, sea ice, glaciers, frozen ground and permafrost). The station location shall be chosen such that cryospheric measurements are representative of the surrounding region, and such representativeness shall be clearly described.

2. Commitment of Operational Continuity: The station shall be active. The responsible agencies shall be committed, to the extent reasonable, to sustaining long-term observations of at least one cryosphere component. There shall be a commitment to continue measurements for a minimum of four (4) years.

3. Metadata Up to Date and Availability: The station metadata, including all metadata describing the station characteristics and observing programme, shall be kept up-to-date and available in the GCW Portal as the interface to the WIGOS Information Resource (WIR).

4. Compliance with Agreed Regulatory Practice: The station observational procedures, the instruments and method of observations, quality control practices, etc., shall follow GCW endorsed regulations, manuals, guides, and, to the extent possible, the recommended best practices.

5. Data and Ancillary Data Freely Available: Data shall be made freely available, and whenever possible in near real-time. In situ ancillary meteorological observations, as required by CryoNet practices shall also be available with documented quality.

6. Competency of Staff: Personnel shall be trained in the operation and maintenance of the station.

II. Requirements for GCW CryoNet site:

1. A site shall comprise at least one CryoNet station.

2. Integrated sites shall have technical supporting staff.

3. Integrated sites shall have training capability.

4. There shall be a long-term financial commitment.

5. Data shall be made freely available, and whenever possible, in (near) real-time.

Recommendation 2 (CBS-16)

MANUAL ON THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM (WMO-No. 1160), SECTION 8

THE COMMISSION FOR BASIC SYSTEMS,

Noting that the observing component of the Global Cryosphere Watch is one of the four component observing systems of the WMO Integrated Global Observing System,

Noting further that the CryoNet concept was revised based on the results of the pre-operational testing of CryoNet,

Recalling Decision 50 (EC-68) by which the Executive Council at its sixty-eighth session decided to endorse the updated CryoNet concept,

Recommends that the Executive Council adopt the updated section 8 of the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) as provided in the annex to Recommendation 1 (CBS-16).

Recommendation 3 (CBS-16)

INITIAL VERSION OF THE *GUIDE TO THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM*

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) *Technical Regulations* (WMO-No. 49), Volume I, Part I – The WMO Integrated Global Observing System,

(2) *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160),

(3) The development of the initial version of the *Guide to the WMO Integrated Global Observing System* by the Inter-commission Coordination Group on the WMO Integrated Global Observing System (ICG-WIGOS) and its editorial board, as provided in the annex to the present recommendation,

(4) The achievements of the Commission for Basic Systems Open Programme Area Group on Integrated Observing Systems and its Inter-programme Expert Team on Observing System Design and Evolution regarding the development of guidance material to address the observing network design principles specified in the *Manual on the WMO Integrated Global Observing System*, Appendix 2.1, as provided in section 5 of the annex to the present recommendation,

Noting further:

(1) That the Executive Council at its sixty-eighth session requested:

(a) The Secretary-General to submit the document to the sixteenth session of the Commission for Basic Systems (November 2016) for its review and endorsement,

(b) ICG-WIGOS to further develop and enhance the *Guide to the WMO Integrated Global Observing System* with additional material as it becomes available,

(2) That Executive Council at its sixty-eighth session invited Members:

(a) To use the *Guide to the WMO Integrated Global Observing System* in their implementation of the relevant technical regulations,

(b) To provide feedback to the Secretary-General on how to improve subsequent versions of the Guide,

Recommends that the Executive Council adopt the initial version of the *Guide to the WMO Integrated Global Observing System* and that the Council ensure that it be made available to Members in all WMO official languages;

Requests the Secretary-General:

(1) To publish the specification of the binary universal form for the representation of meteorological data (BUFR) code table entries that support WIGOS station identifiers on the WMO web site in advance of their formal approval through the fast track procedure;

(2) To maintain Weather Reporting (WMO-No. 9) and the associated 5-digit WMO station identifiers until the Nineteenth World Meteorological Congress, when Members have received training and have had sufficient time to transition to the new WIGOS station identifiers.

Annex to Recommendation 3 (CBS-16)

INITIAL *GUIDE TO THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM* (VERSION 0.5)

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5. OBSERVING NETWORK DESIGN

INTRODUCTION

General

This is the first edition of the *Guide to the WMO Integrated Global Observing System* (WMO-No. XXXX), developed following the Seventeenth World Meteorological Congress' decision for WIGOS to proceed in a Pre-operational Phase (2016-2019), decision to publish WIGOS-related regulatory material in the *Technical Regulations* (WMO-No. 49), Volume I, Part I – WIGOS and its new Annex VIII: *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), and request that a set of guidelines incorporated in an initial Guide to WIGOS be provided to WMO Members by 1 July 2016 and progressively revised and enhanced through the WIGOS Pre-operational Phase. In essence, the *Technical Regulations* (WMO-No. 49), Volume I, Part I – WIGOS and *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) specify where, when, what and how is to be observed in order to meet the relevant observational requirements of Members.

This initial Guide to WIGOS aims to assist Members to comply with a number of new regulations which come into effect on 1 July 2016. It was developed by the Secretariat, in particular the WIGOS Project Office, with input from technical experts of the Executive Council's Inter-commission Coordination Group on WIGOS (ICG-WIGOS) task teams and the lead technical commissions (CBS and CIMO).

Purpose and Scope

This initial version of the Guide provides material relevant to some of the new WIGOS-related regulations. The topics cover the new system of WIGOS station identifiers, the new requirements to record and make available metadata as specified in the WIGOS metadata standard, the new OSCAR (Observing Systems Capability Analysis and Review) tool to be used by Members to submit metadata for WMO global compilation, and the new Observing Network Design Principles.

Further content is in preparation and will be included in future versions. The next version is planned for 2017. Future versions of this guide will provide detailed guidance and technical guidelines on how to establish, operate and manage WIGOS component observing systems to make observations in compliance with the regulations of the *Technical Regulations* (WMO-No. 49), Volume I, Part I – WIGOS and *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160). Future versions of the Guide will explain and describe WIGOS practices, procedures and specifications and will be aimed at assisting the technical and

administrative staff of National Meteorological and Hydrological Services responsible for the networks of observing stations in preparing national instructions for observers.

The Guide should be used in conjunction with the many other relevant WMO guides, technical documents and related publications which complement each other. The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) is the authoritative reference for all matters related to instrumentation and methods of observation. It should be consulted for more detailed descriptions and best practices. The subsequent step of how observations are to be encoded and reported is specified in the *Manual on Codes* (WMO-No. 306).

The *Guide to the Global Observing System* (WMO-No. 488) is the authoritative reference for all matters related to the GOS.

List of relevant and related publications

The development of this Guide is taking a "thin layer" approach, meaning it aims only to publish additional and new material which complements the existing material in existing Guides. All guidance material relating to observing systems in any of the WMO Guides or Manuals is effectively WIGOS guidance material.

Here is the list of the publications relevant and related to the *Guide to WIGOS*. The most relevant are indicated by an asterisk (*) following the publication name. Publications are also referenced within sections of this initial Guide where there is a very specific point to be highlighted. All these publications are available at http://library.wmo.int/opac/index.php. The search can be done either using "WMO/No." or "WMO/TD-No." where the corresponding number of the publication is used.

Technical Regulations, Volumes I - IV (WMO-No. 49) *

I. Manuals:

1. Manual on Codes – International Codes (WMO-No. 306), Volume I.1: Part A – Alphanumeric Codes (2011 edition updated in 2015)
2. Manual on Codes - International Codes (WMO-No. 306), Volume I.2: Part B and Part C (2011 edition updated in 2015)
3. Manual on the Global Telecommunication System (WMO-No. 386), Volume I (2011 edition updated in 2013)
4. International Cloud Atlas (WMO-No. 407), Volume I (1975 edition) *
5. International Cloud Atlas (WMO-No. 407), Volume II (1987 edition) *
6. Manual on the Global Data-Processing and Forecasting System (WMO-No. 485) (2010 edition updated in 2015)
7. Manual on the Global Observing System (WMO-No. 544), Volume I (2010 edition updated in 2015) *
8. Manual on Marine Meteorological Services (WMO-No. 558) (2012 edition)
9. Manual on the Implementation of Education and Training Standards in Meteorology and Hydrology: Volume I – Meteorology (WMO-No. 1083) (2012 edition)
10. Manual on the WMO Information System (WMO-No. 1060) (2012 edition updated in 2015)
11. Manual on the WIGOS (WMO-No. 1160) *

II. Guides:

1. Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8) (2014 edition) *
2. Guide to Climatological Practices (WMO-No. 100) (2011 edition) *
3. Guide to Agricultural Meteorological Practices (WMO-No. 134) (2010 edition updated in 2012)
4. Guide to Hydrological Practices (WMO-No. 168), Volume I (2008 edition) *
5. Guidelines for the Education and Training of Personnel in Meteorology and Operational Hydrology, Volume I: Meteorology (WMO-No. 258) (2002 Edition)

6. Guidelines for the Education and Training of Personnel in Meteorology and Operational Hydrology, Volume II: Hydrology (WMO-No. 258) (2003 Edition)
7. Guide on the Global Data-Processing System (WMO-No. 305) (1993 edition)
8. Guide to Marine Meteorological Services (WMO-No. 471) (2001 edition)
9. Guide to the Global Observing System (WMO-No. 488) (2010 edition updated in 2013) *
10. Guide to the Quality Management System for the Provision of Meteorological Service for International Air Navigation (WMO-No. 1001) (2011 edition)
11. Guide to the Implementation of a Quality Management System for National Meteorological and Hydrological Services (WMO-No. 1100) (2013 edition)
12. Guide to the WMO Information System (WMO-No. 1061) (2013)

III. Technical documents/technical notes:

1. Baseline Surface Radiation Network (BSRN), Operations Manual (WCRP-121, WMO/TD-No. 1274) (2005)
2. Global Atmosphere Watch Measurements Guide (WMO/TD-No. 1073) (2001)
3. Guide to the GCOS Surface Network (GSN) and GCOS Upper-Air Network (GUAN) (WMO/TD-No. 1558) (GCOS-144) (2010 Update of GCOS-73)
4. International Meteorological Tables (WMO-No. 188, TP 94) (1966) *
5. Manual on sea level measurement and interpretation, Volume IV (WMO/TD-No. 1339) (Update to 2006)
6. Note on the standardization of pressure reduction in the International Network of Synoptic stations (WMO-No. 154, TP 74) (1964)
7. WMO Global Atmosphere Watch (GAW) Strategic Plan: 2008-2015 - A contribution to the Implementation of the WMO Strategic Plan: 2008-2011 (WMO/TD-No. 1384) (revised in 2007) *

IV. Guidelines and other related publications:

1. Aircraft Meteorological Data Relay (AMDAR) Reference Manual (WMO-No. 958) (2003)
2. GAW Reports
3. GCOS Upper-Air reference Network (GRUAN) – Manual (WIGOS Technical Report No. 2013-02, GCOS-170) (2013)
4. GCOS Upper-Air reference Network (GRUAN) – Guide (WIGOS Technical Report No. 2013-03, GCOS-171) (2013)
5. Hydrology and Water Resources Programme (HWRP) Manuals
6. JCOMM Catalogue of Practices and Standards (Manuals and Guides, Observation Standards, such as IOC Manuals and Guides)
7. Marine Meteorology and Oceanography Programme Publications and Documents
8. Sixth WMO Long-term Plan (2004–2011) (WMO-No. 962) (Updated in 2004)
9. Guidelines for the Education and Training of Personnel in Meteorology and Operational Hydrology – Volume I. Meteorology (WMO-No. 258) (2002)
10. Guidelines for the Education and Training of Personnel in Meteorology and Operational Hydrology – Volume II. Hydrology (WMO-No. 258) (2003)

Organization of the Guide

The Guide, when completed, will for ease of reference follow as closely as possible the same structure as used in Volume I Part I – WIGOS of the *WMO Technical Regulations* (WMO-No. 49) and the *Manual on the WIGOS* (WMO-No. 1160). That structure consists of eight sections.

Sections 1 and 2 apply to the all of WIGOS component observing systems. Section 3 provides further information applicable to the surface based sub-system of WIGOS while Section 4 provides further information applicable to the space based sub-system of WIGOS. Sections 5 - 8 (system specific sections) provide further information relevant to the Global Observing System of the World Weather Watch (Section 5), the Global Atmosphere Watch (Section 6),

the WMO Hydrological Observing System (Section 7), and the Global Cryosphere Watch (Section 8), respectively.

When using future versions of the Guide, readers are strongly encouraged to consult all of the relevant Sections recognizing the way in which the Sections build upon each other.

The organization of this initial Guide is extremely abbreviated. Only the first section "Introduction to WIGOS" will remain in the same form in future versions. Other material is, for convenience, presented as sections 2 to 5 in this initial Guide but will become sub-sections in future versions.

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1. INTRODUCTION TO WIGOS

1.1 PURPOSE AND SCOPE OF WIGOS

It is specified in the *Technical Regulations* (WMO-No. 49), Volume I, Part I – WIGOS and *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) that the WMO Integrated Global Observing System (WIGOS) is a framework for all WMO observing systems and for WMO contributions to co-sponsored observing systems in support of all WMO Programmes and activities.

1.2 WIGOS COMPONENT OBSERVING SYSTEMS

The component observing systems of WIGOS are the Global Observing System (GOS) of the World Weather Watch Programme, the observing component of the Global Atmosphere Watch (GAW) Programme, the WMO Hydrological Observing System (WHOS) of the Hydrology and Water Resources Programme and the observing component of the Global Cryosphere Watch (GCW), including their surface-based and space-based components.

The above component systems include all WMO contributions to the co-sponsored systems, to the Global Framework for Climate Services (GFCS) and to the Global Earth Observation System of Systems (GEOSS). The co-sponsored observing systems are the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS), all joint undertakings of WMO and the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the International Council for Science.

1.3 GOVERNANCE AND MANAGEMENT

Implementation and operation of WIGOS

The implementation of WIGOS is an integrating activity for all WMO and co-sponsored observing systems: it supports all WMO Programmes and activities. The Executive Council and regional associations, supported by their respective working bodies, have a governing role in the implementation of WIGOS. Technical aspects of WIGOS implementation are guided by the technical commissions, with leadership provided through the Commission for Basic Systems and the Commission for Instruments and Methods of Observation.

The WIGOS framework implementation phase occurred in the period 2012-2015. Implementation plans and activities followed a structure based on ten Key Activity Areas which are listed below and represented schematically in Figure 1:

(a) Management of WIGOS implementation;

(b) Collaboration with the WMO co-sponsored observing systems and international partner organizations and programmes;

(c) Design, planning and optimized evolution;

(d) Observing System operation and maintenance;

(e) Quality Management;

(f) Standardization and interoperability;

(g) The WIGOS Information Resource;

(h) Data discovery and availability (of data and metadata);

(i) Capacity development;

(j) Communications and outreach.

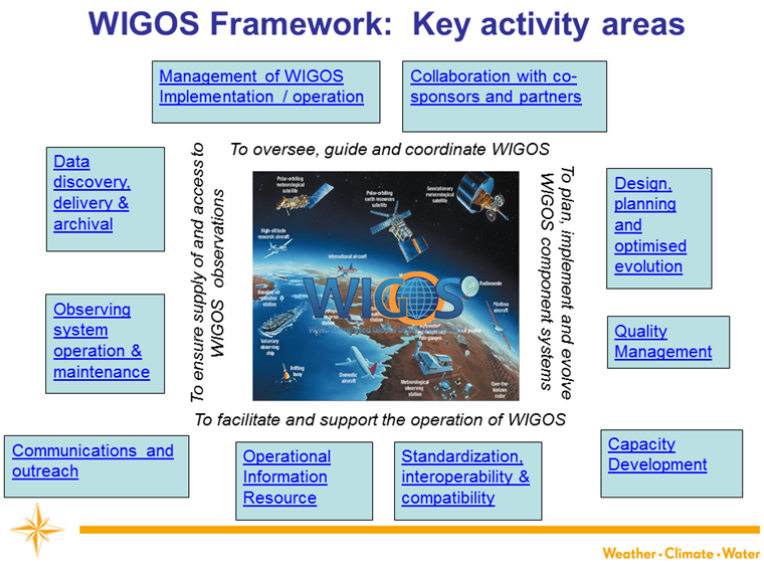

Figure 1: Ten Key Activity Areas for WIGOS framework implementation and the relation between them.

Building on the WIGOS framework, the five priority areas of the WIGOS Pre-operational Phase are being addressed in the period 2016-2019 and are supporting the delivery of WMO's strategic priorities. The five priority areas are listed below and represented schematically in Figure 2:

(1) National WIGOS implementation;

(2) WIGOS regulatory and guidance material;

(3) WIGOS Information Resource;

(4) WIGOS Data Quality Monitoring System;

(5) Regional WIGOS Centres.

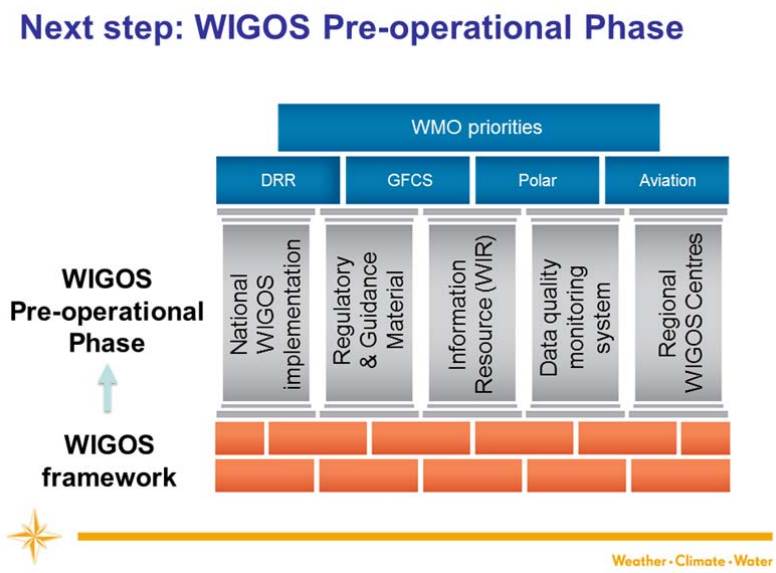

Figure 2: The five priority areas of the WIGOS Pre-operational Phase, building on the WIGOS framework and supporting the delivery of WMO's strategic priorities.

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2. WIGOS STATION IDENTIFIERS

http://wis.wmo.int/page=WIGOS-Identifiers

WIGOS Identifiers

This page provides information about WIGOS Identifiers.

System of WIGOS identifiers

The system of WIGOS identifiers is defined in Attachment 2.1 of the Manual on WIGOS.

The structure of a WIGOS Identifier is:

WIGOS Identifier Series (number)	Issuer of Identifier (number)	Issue Number (number)	Local Identifier (characters)

Only WIGOS Identifier Series 0 has been defined. This series is used to identify observing stations.

Advice for users of WIGOS Identifiers

WIGOS Identifiers do not have meaning in themselves. Users must not interpret any patterns they see in WIGOS Identifiers; for WIGOS station identifiers users should use OSCAR/Surface to look up the metadata for the station associated with the WIGOS station identifier.

Recording the WIGOS station identifier in observation reports (in the standard WMO reporting formats)

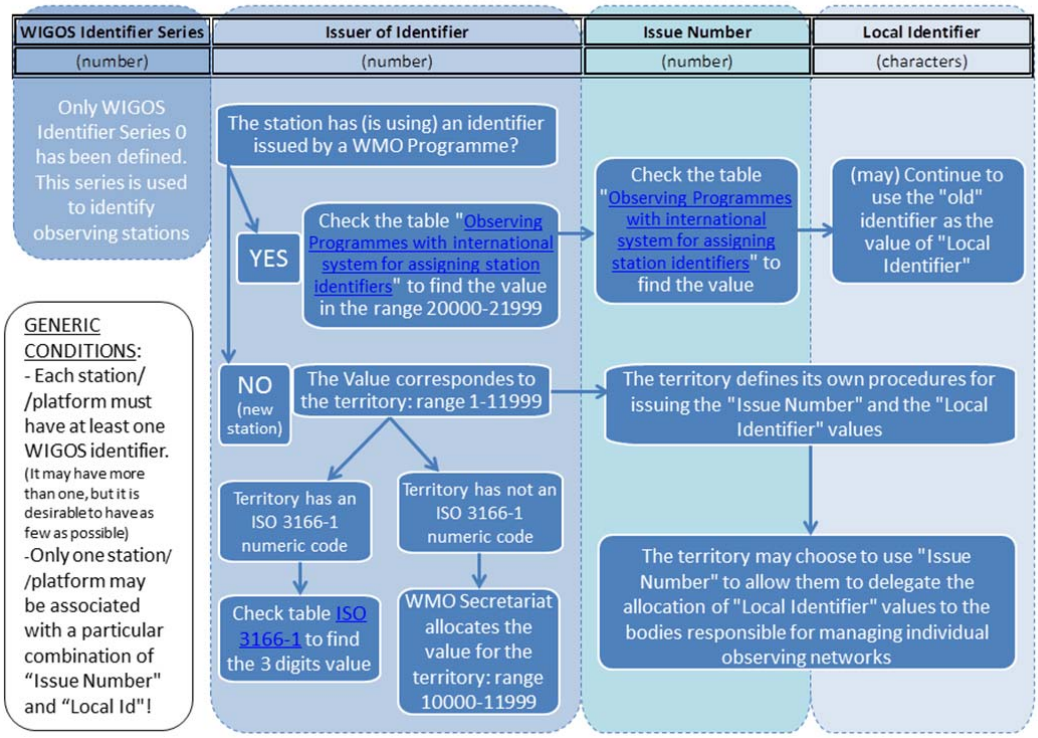
WIGOS station identifiers cannot be represented in the Traditional Alphanumeric Code forms such as FM-12 SYNOP or FM-35 TEMP. The Table Driven Code Form equivalents have to be used (FM-94 BUFR or FM-95 CREX, or, in the future, model driven code forms). Further information on representing the WIGOS station identifier in BUFR/CREX is available from section WIGOS-ID-BUFR.

Centres that are unable to process table driven code forms will not be able to access the reports from stations that only have WIGOS station identifiers.

Advice for people responsible for allocating WIGOS Identifiers

Fundamentals

All observing stations must be associated with at least one WIGOS station identifier. A WIGOS station identifier may only be associated with one observing station. If you need additional help after reading this guidance, please contact the Secretariat at wigos-help@wmo.int.



Assigning WIGOS Identifiers to observing stations

Each observing station must have at least one WIGOS station identifier associated with it. The station identifier(s) associate the station with its WIGOS metadata.

Observing stations that had been allocated with station identifiers by a WMO Programme before the introduction of WIGOS station identifiers (that is before 1 July 2016) may continue to use those identifiers, and are not required to have additional identifiers created for them. For these observing facilities, the WIGOS station identifier can be deduced from the pre-existing identifier using the tables in the section "Issuer of Identifier" below. Further, should the station take on new responsibilities (such as an aviation station starting to report World

Weather Watch synoptic information), the WIGOS identifier can also be used in that new context, even though it was derived from a station identifier associated with a different programme (in this example the synoptic report could use the WIGOS station identifier derived from the ICAO aerodrome indicator).

Although it is possible for an observing station to be associated with more than one WIGOS station identifier, it is desirable to associate as few identifiers as possible with an observing station. Therefore, **if an observing station is already associated with a WIGOS identifier, or is associated with an identifier issued by a WMO or partner programme, an additional WIGOS station identifier *should not* be issued.**

WIGOS Identifiers for observing stations

The following table lists the values of *Issuer of Identifier* that have been allocated for use.

Issuer of Identifier

Range of *Issuer of Identifier*	**Category of issuer**	**Method of allocating**	**Procedures for issuing *Issue Number* and *Local Identifier***
0	Reserved for internal use by OSCAR	OSCAR allocates the value.	Determined by OSCAR.
1-9999	Member State or territory for which there is an ISO 3166-1 numeric country code	ISO 3166-1 three digit numeric country code (by convention leading zeroes are not shown in WIGOS Identifiers). See ISO web site and click on "Officially assigned codes" (on the left of the screen).	Issuer identifies its own procedures. Further guidance is available in the section "Guidance on recommended practices for the allocation of 'issue number' and 'local identifier' for Member states and territories that have an 'issuer of identifier' allocated to them".
10000-11999	Member State or territory for which there is no ISO 3166-1 numeric country code	WMO Secretariat allocates an available number on request.	Issuer identifies its own procedures. Further guidance is available in the section "Guidance on recommended practices for the allocation of 'issue number' and 'local identifier' for Member states and territories that have an 'issuer of identifier' allocated to them".
12000-19999	Reserved for future use	To be determined.	To be determined.
	Identifiers in the ranges 20000-21999 and 22000-39999 are intended only to be used to allocate WIGOS identifiers for observing facilities that had one or more pre-existing identifiers.		
20000-21999	WMO Secretariat for identifiers associated with WMO Programmes	Details are provided in the section "Allocation of 'issuer of identifier' for station identifiers associated with WMO Programmes".	Details are provided in the section "Allocation of 'issuer of identifier' for station identifiers associated with WMO Programmes".
22000-39999	WMO Secretariat for identifiers associated with programmes of	Details are provided in the section "Allocation of 'issuer of identifier' for station identifiers associated with WMO co-	Details are provided in the section "Allocation of 'issuer of identifier' for station identifiers associated with WMO co-sponsored programmes".

	Partner organizations	sponsored programmes".	
40000-65534	Reserved for future use	To be determined.	To be determined.
65535	Missing value (reserved value in Table Driven Code Forms)		

WIGOS-ID-BUFR

REPRESENTING THE WIGOS STATION IDENTIFIER IN WMO STANDARD CODE FORMS

Constraints in reporting WIGOS station identifiers

Traditional Alphanumeric Code Forms (TAC) cannot represent WIGOS station identifiers. As a consequence, observations can only be exchanged in TAC if the observing facility has been allocated a conventional World Weather Watch station identifier. Observation facilities that have not been allocated a World Weather Watch station identifier must exchange their observations using the Table Driven Code Forms.

Reducing ambiguity through systematic use of WIGOS station identifiers

An observing facility may have several WIGOS station identifiers associated with it. Using OSCAR, it is possible to discover all the WIGOS station identifiers associated with that facility. In theory, this allows any of the possible WIGOS identifiers to be used in a report of an observation, but in practice doing so would result in a large overhead for all users of the observation. A disciplined approach to using WIGOS station identifiers in a report will reduce the work for end users.

Choosing which WIGOS station identifier to use

Using the following practices makes it easier for users of observation reports to link observations from a single observing facility:

1. Use the same WIGOS identifier for all reports of the same type from that observing facility. *For example, always use the same identifier for surface synoptic reports*;
2. Use the WMO Programme station identifier that is associated with the type of observation being reported if there is one. *For example a WIGOS station identifier associated with the World Weather Watch land station identifier would be used for surface synoptic reports*;
3. There is no requirement to introduce new WIGOS station identifiers if the observing facility already has a WIGOS station identifier. *For example, whatever type of observation is reported, if the facility has a WIGOS identifier derived from a World Weather Watch station identifier, then that WIGOS identifier may be used for reporting any type of observation - but, following the first practice, different types of report might use different pre-existing identifier*.

Messages containing only reports from stations that had a pre-existing station identifier for the type of report being exchanged

In many cases, such as for surface observations from World Weather Watch land stations made at stations that existed before the introduction of WIGOS station identifiers, no change is needed to report from those stations in BUFR or CREX. The existing identifier should be reported as in the past.

It is good practice also to report the WIGOS station identifier.

Messages containing reports from stations that did not have a pre-existing station identifier for the type of report being exchanged

New observing facilities, or those reporting new types of observation, will need to report the full WIGOS station identifier. BUFR and CREX messages that include reports from stations that do not have a pre-existing station identifier appropriate to that type of report have to include the BUFR/CREX sequence 3 01 150 to represent the WIGOS station identifier.

If there is no pre-existing identifier, the value for the station identifier in the standard sequence for the data should be set to "missing".

Reporting the WIGOS station identifier in a BUFR/CREX message

When constructing a BUFR or CREX message that refers to WIGOS station identifiers the sequence 3 01 150 shall appear in the message before the sequence describing the information from those stations.

That is, the message contents should be in the order:
< sequence for the WIGOS station identifier (3 01 150)>
< sequence for the data being reported>

Reporting the WIGOS station identifier if the reporting environment can only handle Traditional Alphanumeric Codes

It is not possible to represent full WIGOS station identifiers in Traditional Alphanumeric Codes. In some circumstances it may be necessary to report internationally observations from stations that did not have a pre-existing World Weather Watch station identifier and for which the technical environment only support the traditional alphanumeric codes.

The recommended approach in this case is to agree a national practice that meets the local technical constraints to identify the observing station in reports (or a bilateral practice where a bilateral arrangement is used to translate TAC to TDCF for international exchange). These national reports must be converted to table driven code format before international exchange; the conversion must include a translation from the method of identifying the station used in the national report to the WIGOS station identifier for that station. Extreme care must be taken to ensure that the national report is not distributed internationally.

Examples of a possible national practice for a surface synoptic report might be to use five alphabetic characters for the identifier, or a numeric identifier in the range 99000 to 99999 (only two identifiers in that range, 99020 and 99090, were recorded in WMO No. 9 Volume A in April 2016). A look-up table from that identifier to the WIGOS station identifier would allow the translating centre to insert the WIGOS station identifier.

The situation is more complex for upper-air reports. In this case, the WMO Secretariat should be asked for assistance.

WIGOS-Id-Country

GUIDANCE ON RECOMMENDED PRACTICES FOR THE ALLOCATION OF 'ISSUE NUMBER' AND 'LOCAL IDENTIFIER' FOR MEMBER STATES AND TERRITORIES THAT HAVE AN 'ISSUER OF IDENTIFIER' ALLOCATED TO THEM.

Principles to guide allocation of station identifiers

1. Issuers of identifiers are responsible for guaranteeing that no two observing facilities share the same station identifier. Note that the structure of WIGOS station identifiers guarantees that issuers of identifiers cannot create station identifiers that have already been allocated by another issuer of identifier.
    1. Issuers of identifiers may choose to use the *Issue Number* to allow them to delegate the allocation of *Local Identifier* to other organizations responsible for managing individual observing networks. Issuing each organization with a different *Issue*

Number will allow those organizations to allocate "Local Identifiers" for their observing facilities.

2. The issuer of identifiers has to record which *Issue Numbers* have ever been allocated, and which organization is responsible for managing *Local Identifiers* for each.

2. An organization issuing a *Local Identifier* must ensure that no two observing facilities share a WIGOS station identifier.
   1. An organization that is responsible for allocating both *Issue Numbers* and *Local Identifiers* must ensure that no two observing facilities have the same combination of *Issue Number* and *Local Identifier*. If the organization is only responsible for allocating *Local Identifiers* then it is sufficient for that organization to ensure that it does not issue the same *Local Identifier* to the more than one observing facility.
   2. The organization must maintain a record of the *Local Identifiers* (and *Issue Numbers*) that it has issued (it may choose to use OSCAR for this).
      1. The body may choose to use an existing national identifier for the observing facility as the *Local Identifier*. Doing so in a systematic way may decrease the administrative load for the body.
      2. Historically, station identifiers may have been re-used when observing facilities closed and new ones opened. If the organization has been allocated a range of *Issue Numbers*, the organization may wish to consider using different *Issue Numbers* to distinguish between the different locations, allowing the *Local Identifier* to retain the link to the identifier that was used while the observing facility was open at a location.
      3. Although a single WIGOS station identifier must not be issued to more than one observing facility, it is permitted for a station to have more than one WIGOS station identifier associated with it. For example, although all observing facilities with pre-existing World Weather Watch (WWW) station identifiers have a WIGOS station identifier based on the WWW identifier, the organization may wish to create a new identifier that is linked to a national numbering scheme.
      4. The WIGOS station identifier for a closed observing facility must not be re-used unless the observing facility reopens.
   3. The organization responsible for allocating the WIGOS station identifier should ensure that the operator of the observing facility has committed to providing and maintaining WIGOS metadata for that observing facility.
      1. Stations may have more than one WIGOS station identifier. In this case, the organization issuing the *Local Identifier* should associate all these identifiers with the same WIGOS metadata record so that only one WIGOS metadata record needs to be maintained. OSCAR will provide tools to document this linkage.
      2. If the location of a fixed observing facility is moved, the organization should consider whether it should be issued a new WIGOS station identifier, the WIGOS metadata updated to state that the observing facility at the previous position has closed, and a new WIGOS metadata record created for the new location. The organization must use meteorological judgement on the impacts of the change in deciding whether to retain the WIGOS station identifier or to issue a new one. A move of a few metres is unlikely to be significant, but a move to the opposite side of a mountain would be treated as a new station. Note: the structure of the WIGOS station identifier means that the range of WIGOS station identifiers is, for practical purposes, unlimited. This removes the need to re-use WIGOS station identifiers.

3. Search Oscar/Surface for the proposed WIGOS station identifier before issuing the identifier to make sure that it has not already been allocated.

4. Organizations are strongly advised to document their procedures for allocating WIGOS station identifiers in their Quality Management System.

Specifying the *local identifier*

The *local identifier* may be up to 16 characters long. It must not contain blanks (and any blanks added to the end of the identifier by IT systems must be ignored). The ”local identifier” may contain only lower case Latin letters, upper case Latin letters, numbers or the characters - (dash) _ (underscore) or . (full stop/period).

Leading zeroes in *local identifier* are significant and must be treated as part of the character string. (Note that this differs from the treatment of leading zeroes in the numerical *issuer of identifier* and *issue number* parts of the WIGOS identifier that are omitted from the WIGOS station identifier.)

Examples

Example 1

1. Consider a Member State that has observing systems managed by many different organizations, including the National Meteorological Service (NMS), the National Hydrological Service (NHS) and the National Transport Department (TD). Each of these organizations is independent, and each has its existing conventions for labelling observing facilities. For example, the Meteorological Service uses WMO World Weather Watch station identifiers for its synoptic network, its own numbering system for other weather observing facilities, and another numbering system for its climate observing facilities.
2. In this situation, the Member (as issuer of identifiers) might choose to use the following convention for assigning WIGOS station identifiers. In all cases, the *Local Identifier* must not be re-issued (with the same *Issue Number*) if an observing facility is closed.

Issue Number	**Interpretation of *Issue Number***	***Local Identifier***
1	NMS synoptic observing facility	WMO World Weather Watch station identifier (as characters with leading zero if necessary to make it 5 digits long). Initially, to ensure that plotting software can display the local identifier, the Member chooses to limit the length of Local Identifiers to 5 digits, and to assign new WIGOS stations identifiers that lie outside the block of identifiers allocated to the Member by the World Weather Watch.
2	NMS other weather observing facility	Existing national station identifier (as characters with leading zero if necessary). The local identifier for a new observing facility is created using the existing procedures for national station identifiers.
3	NMS climate observing facility	Existing climate station identifier (as characters, without leading zeroes because that was the convention for writing down climate observing facility identifiers in the past). New observing facilities are allocated identifiers using the existing practices.
100-200	Used by NHS for allocating identifiers for their observing facilities. The NHS allocates one number for each of their regions. The NHS is organized according to river basins, and it uses its range of *Issue Numbers* to sub-delegate allocation of *Local Identifiers* to	The NHS uses their existing river basin observing facility numbering system.

	each river basin authority.	
1000-10000	Used by the TD for allocating their observing facility identifiers. Their management procedures number the observing facilities by their distance in metres from the end of the road that is closest to the national capital. Each *Issue Number* corresponds to one road.	Distance of observing facility from the end of the road that is closest to the national capital.

Example 2

1. A Member has implemented a national system for managing its national assets, and each observing facility has to be registered on this system and as a consequence has been allocated an asset number that is used by the Member to track all information about that observing facility. Some of these assets are mobile platforms (such as moored buoys). Disposable observing platforms (such as radiosondes) are associated with the asset number of their base station.
2. The Member wishes to align their WIGOS station identifiers with its national asset management system. It choose to use the national asset number as the *Local Identifier*. The Member is concerned that they will move assets from one location to another, so using the asset number alone as the WIGOS station identifier would not result in misleading WIGOS metadata histories. In consequence, the Member uses the *Issue number* to record changes in location. Because they wish to record past positions as well, they decide initially to use an *Issue Number* of 10000 and to increment it for an asset every time that asset is re-deployed. They use *Issue Number*s less than 10000 to record historical positions for that asset.

WIGOS-Id-WMOProg

WIGOS IDENTIFIERS - ALLOCATION OF ISSUER OF IDENTIFIER FOR STATION IDENTIFIERS ASSOCIATED WITH WMO PROGRAMMES

The table defines the value of *Issuer of identifier* in the range 20000-21999 to be used for WIGOS station identifiers. This range is used to ensure that observing facilities that had pre-existing station identifiers can be allocated a WIGOS station identifier in a way that retains an association with the pre-existing identifier. Any new observing facility will be given an identifier within the range allocated to the Member operating the observing facility.

Observing Programmes with an international system for assigning station identifiers

Issuer of Identifier	Category of station identifier	Method of allocating *Issue Number*	Method of allocating *Local Identifier*
20000	World Weather Watch land station with sub-index number (SI) = 0	0: station defined in WMO-No. 9 Volume A on 1 July 2016. Any other positive number: to distinguish between different observing facilities that used the station identifier in the past.	Use the block number (II) and the station number (iii) as a single five digit number IIiii (with leading zeroes). **Example:** station 60351 would be represented by 0-20000-0-60351
20001	World Weather Watch land station with sub-index number (SI) = 1	0: station defined in WMO-No. 9 Volume A on 1 July 2016.	Use the block number (II) and the station number (iii) as a single five digit number IIiii (with leading zeroes).

		Any other positive number: to distinguish between different observing facilities that used the station identifier in the past.	**Example:** upper air station 57816 would be represented by 0-20001-0-57816
20002	World Weather Watch Marine Platform (moored or drifting buoy, platform, etc.)	0 - platform for which the identifier was in use on 1 July 2016. Any other positive number - to distinguish between different platforms that used the same identifier at different times.	Use the region/platform number combination $A_1b_wn_bn_bn_b$ **Examples:** the data buoy 59091 would be represented by 0-20002-0-59091. The World Weather Watch list of data buoys lists two buoys with identifier 13001. The buoy most recently used at the time WIGOS station identifiers were introduced is allocated 0-20002-0-13001 and the second is issued identifier 0-20002-1-13001 (note - the *Issue Number* is different from that for the first buoy).
20003	Ship identifier based on ITU call sign.	0 - ship allocated the identifier more recently on 1 July 2016. Any other positive number - to distinguish between different ships that used the same ship identifier at different times.	Ship call sign. **Example:** the (now obsolete) weather ship C7R would be represented by 0-20003-0-C7R.
20004	Ship Identifier - issued nationally	0 - ship allocated most recently on 1 July 2016. Any other positive number: to distinguish between different ships that used the same ship identifier at different times.	Ship identifier. **Example:** the fictitious shop *XY123AB* would be represented by 0-20004-0-XY123AB
20005	AMDAR aircraft identifier	0 - aircraft most recently issued the identifier on 1 July 2016. Any other number: to distinguish between different aircraft that used the same aircraft identifier at different times.	Aircraft identifier. **Example:** aircraft EU0246 would be represented by 0-20005-0-EU0246.
20006	ICAO airfield identifiers	0 - airfield most recently allocated the	ICAO airfield identifier.

		identifier on 1 July 2016. Any other positive number: to distinguish between airfields that used the same airfield identifier at different times.	**Example:** Geneva airport (LSSG) would be represented by 0-20006-0-LSGG.
20007	Ship IMO number (*hull number*)	0 - ship to which the IMO number was most recently allocated on 1 July 2016. Any other positive number: to distinguish between ships that used the same IMO identifier at different times.	Ship identifier. **Example:** ship 9631369 would be represented by 0-20007-0-9631369.
20008	Global Atmosphere Watch Identifier	0 - station to which the GAW identifier was most recently allocated on 1 July 2016.	Three character GAW identifier. **Example:** Jungfraujoch JFJ would be represented by 0-20008-0-JFJ.
20009	WMO Satellite Programme	0	Three digit satellite identifier with leading zeroes (recorded in Common Code Table C-7 of WMO-No. 306, Manual on Codes Volume I.1) **Example:** METEOSAT 10 (with identifier 057) would be represented by 0-20009-0-057.
20010	WMO Weather Radar	0	Unique key used to cross-reference information about a single radar within the WMO radar database (note: this key was not previously published) **Example:** Station with record number 121 would be represented by 0-20010-0-121.
20011-21999	Reserved for future use.	To be determined.	To be determined.

Observing Programmes that did not have a systematic international system for station identification

The following observing programmes did not have a pre-existing international system for assigning station identifiers and have not been allocated *Issuer of Identifier*s. Members operating the stations supporting these observing programmes should allocate WIGOS identifiers using their national system.

Sea level network. In the past, station identifiers have been issued according to national conventions. In cases where the identifier of another WMO Programme has been used (for example a land station identifier), the WIGOS identifier corresponding to that identifier should be used.

Tsunamimeter network. In the past, station identifiers have been issued according to national conventions. In cases where the identifier of another WMO Programme has been used

(for example a land station identifier), the WIGOS identifier corresponding to that identifier should be used.

WIGOS-Id-Partner

WIGOS IDENTIFIERS - ALLOCATION OF 'ISSUER OF IDENTIFIER' FOR STATION IDENTIFIERS ASSOCIATED WITH WMO CO-SPONSORED PROGRAMMES

This section defines the value of *Issuer of identifier* to be used for WIGOS Identifiers that have Issuer of Identifier in the range 22000-39999.

Note: no *Issuer of Identifier* in this range has been issued.

Issuer of Identifier	Category	Issue Number	Local Identifier
22000-39999	Identifiers for marine systems administered through JCOMMOPS. *Note: JCOMMOPS coordinates some marine observing systems to avoid technical incompatibilities.*	Determined by JCOMMOPS	Determined by JCOMMOPS.
22001-39999	Reserved for future use.	To be determined.	To be determined.

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3. WIGOS METADATA

1. INTRODUCTION

The availability of WIGOS metadata is essential for the effective planning and management of WIGOS observing systems. These metadata are essential for the Rolling Review of Requirements process and similar activities at national level.

The metadata is also essential for the utilization of WIGOS observations. These metadata are interpretation/description or observational metadata – information that enables data values to be interpreted in context and permit the effective utilization of observations from all WIGOS component observing systems by all users.

The WMO Information System (WIS) is the single coordinated global infrastructure responsible for the telecommunications and data management functions. WIS enables: (i) the routine collection and dissemination service for time-critical and operation-critical data and products; (ii) Data Discovery, Access and Retrieval service; and (iii) the timely delivery service for data and products. WIGOS metadata gives insight into the conditions and methods used to make the observations which are distributed through the WIS.

WIGOS metadata describes the station/platform where the observation was made, the system(s) or network(s) it contributes to, the instruments and methods of observations utilized and the observing schedules in order to support planning and management of WIGOS observing systems.

WIGOS metadata also describes the observed variable, the conditions under which it was observed, how it was measured or classified, and how the data has been processed, in order to provide the users with confidence that the use of the data are appropriate for their application. GCOS (Global Climate Observing System) Climate Monitoring Principle No. 3 describes the relevance of metadata as:

> "The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e. metadata) should be documented and treated with the same care as the data themselves."

Metadata can be static, for example the exposure of an instrument at a fixed station. Metadata can change with every observation, for example the location of a mobile station, in which case it should be reported with the observations to which it applies.

The WIGOS Metadata Standard (WMDS) specifies the metadata elements that exist and that are to be recorded and made available. It has been implemented in OSCAR/Surface (OSCAR stands for Observing Systems Capability Analysis and Review) which is the WMO's official authoritative repository of metadata on surface-based meteorological, climatological, hydrological and other related environmental observations that are required for international exchange. OSCAR/Surface is one of the components of the WIGOS Information Resource (WIR).

Observational metadata are to be submitted to, and maintained in OSCAR/Surface by WMO Members and in OSCAR/Space by relevant WMO Members according to the provisions of the Manual on WIGOS. Metadata from a number of co-sponsored observing systems are also maintained in OSCAR. OSCAR/Surface replaces and significantly extends the WMO Publication No. 9, Volume A, Observing Stations and the WMO Catalogue of Radiosondes, which is now obsolete. This highlights the much wider scope of all the WIGOS component observing systems.

This document provides guidance on recording metadata related to surface-based observations and submitting those to OSCAR/Surface.

1.1. Key terminology

Term	***Description***
Observing station/platform	A place where observations are made; this refers to all types of observing station and platform, whether surface-based or space-based, on land, sea, lake or river, or in the air, fixed or mobile, and making in-situ or remote observations [this definition is from the *Technical Regulations* (WMO-No. 49), Volume I – General Standards and Recommended Practices (2015 edition), PART I. The WMO Integrated Global Observing System]. In many contexts this is abbreviated to "station".
Observing Facility	This is an alternative term for a place where observations are made and equivalent to the term Observing station/platform.
Site	This is also a term for a place where observations are made. However, it is generally used when taking into account the environmental conditions of the location.
Observation	Evaluation of one or more elements of the physical environment [this definition is from the *Technical Regulations* (WMO-No. 49), Volume I – General Standards and Recommended Practices (2015 edition), PART I. The WMO Integrated Global Observing System]. Note: It is the act of measuring or classifying the variable. The term is also often used to refer to the data resulting from the observation, even though the term "observational data" is defined as to be the result of an observation [this definition is also from the *Technical Regulations* (WMO-No. 49), Volume I – General Standards and Recommended Practices (2015 edition), PART I. The WMO Integrated Global Observing System].
Measurand	Quantity intended to be measured [this definition is from JCGM 200:2012].

	Note: generally it is a result of a measurement from an instrument.
(Observed) Variable	Variable intended to be measured (measurand) or observed or derived, including the biogeophysical context [this term is specified in the WIGOS Metadata Standard].
Observational Metadata	Descriptive data about observational data: information that is needed to assess and interpret observations or to support design and management of observing systems and networks [this definition is also from the *Technical Regulations* (WMO-No. 49), Volume I – General Standards and Recommended Practices (2015 edition), PART I. The WMO Integrated Global Observing System].
Observing domain	The component of the Earth system which is being observed: atmospheric (over land, sea, ice), oceanic and terrestrial.
Observing (or observation) system	A coordinated system of methods, techniques and facilities for making observations using one or more sensors, instruments or types of observation at one or more stations and platforms, acting together to provide a coordinated set of observations [this definition is also from the *Technical Regulations* (WMO-No. 49), Volume I – General Standards and Recommended Practices (2015 edition), PART I. The WMO Integrated Global Observing System].
Observing Network	One or more sensors, instruments or types of observation at more than one station or platform, acting together to provide a coordinated set of observations [this definition is from the Technical Regulations (WMO-No. 49), Volume I – General Standards and Recommended Practices (2015 edition), PART I. The WMO Integrated Global Observing System].

The following abbreviations appear throughout the text:

WIGOS - WMO Integrated Global Observing System

WIS - WMO Information System

1.2. Managing WIGOS metadata in accordance with the WMDS

1.2.1. Identification of functions and responsibilities

The following generic national functions and responsibilities need to be fulfilled:

(a) Network Metadata Manager – responsible for keeping network observational metadata up-to-date, correct, quality controlled and complete;
(b) Observational Metadata Manager – responsible for encoding and transmitting WIGOS Metadata, ensuring that metadata meets the WMDS;
(c) Station/platform Metadata Maintainer – responsible for recording and maintaining metadata for the Station/platform.

The above labels might not be used but the relevant functions need to be fulfilled.

1.2.2. Using the OSCAR/Surface tool

The key WMO tool to assist the above functions is the OSCAR Surface-based Capabilities database.

The WMDS will be implemented in three phases over a five year period (2016-2020). In practice this will be done through using the OSCAR/Surface tool, which means that Members must transfer their WIGOS metadata, either in near-real-time or less frequently, to OSCAR/Surface for the observations they exchange internationally. All prescribed metadata are

to be collected and stored by Members. Moreover, OSCAR/Surface contains a few additional metadata fields, not explicitly specified in the WMDS, e.g., population density or climate zone, amongst others. Members should include as many of the additional fields as possible in OSCAR/Surface.

Note that OSCAR/Surface provides a manual interface for submission of metadata. This interface is accessed through the internet using any Web browser. It is intended that machine to machine submission of metadata will be possible in the future; the guidance for exchanging WIGOS metadata in this way will be developed as soon as the XML schema is finalized.

Further guidance on using OSCAR/Surface is provided in section 4 of this initial Guide.

2. GENERAL GUIDANCE ON WIGOS METADATA

WIGOS metadata standard is an observation focused standard. However, typically observations are grouped in terms of the observing station/platform where one or more sensors or instruments are located.

The following metadata elements of the WMDS are mandatory for the first phase of its implementation (2016). The numbers refer to the elements in the WMDS and the numbers in brackets refer to sub-sections of this chapter:

- 1-01 Observed variable (measurand) (2.2)
- 1-03 Temporal extent (2.1)
- 1-04 Spatial extent (2.2)
- 2-01 Application area(s) (2.2)
- 2-02 Programmes/network affiliation (2.1 & 2.2)
- 3-03 Station/platform name (2.1)
- 3-06 Station/platform unique identifier (2.1)
- 3-07 Geospatial location (2.1)
- 3-09 Station/platform status (2.2)
- 5-01 Source of observation (2.2)
- 5-02 Measurement/observing method (2.2)
- 5-03 Instrument specifications (2.2)
- 6-07 Diurnal base time (2.2)
- 6-08 Schedule of observation (2.2)
- 7-03 Temporal reporting period (2.2)
- 9-02 Data policy/use constraints (2.2)
- 10-01 Contact (nominated focal point) (2.3)

Note: each time the number in format x-yy appears, it refers to the number of the metadata element in WMDS. Where a metadata element is mentioned without this number, it means it is not part of the WMDS.

The following metadata elements of the WMDS are mandatory when relevant conditions are met (referred to as Conditional elements) for the first phase of implementation (2016) – the references below refer to the following sub-sections:

- 1-02 Measurement unit (2.2)
- 3-01 Region of origin of data (2.1)
- 3-02 Territory of origin of data (2.1)
- 5-05 Vertical distance of sensor (2.2 and 3.1.1)
- 7-04 Spatial reporting interval (-)
- 7-11 Reference datum (3.1.1)

Another metadata element (6-03 Sampling strategy), of the WMDS has optional status during phase 1 (2016).

All other elements of the WMDS are to be implemented in phase 2 (2017-18) or 3 (2019-20), however a Member may optionally make these elements available before then.

In OSCAR/Surface, metadata are assembled under the following five headings.

2.1. Station characteristics

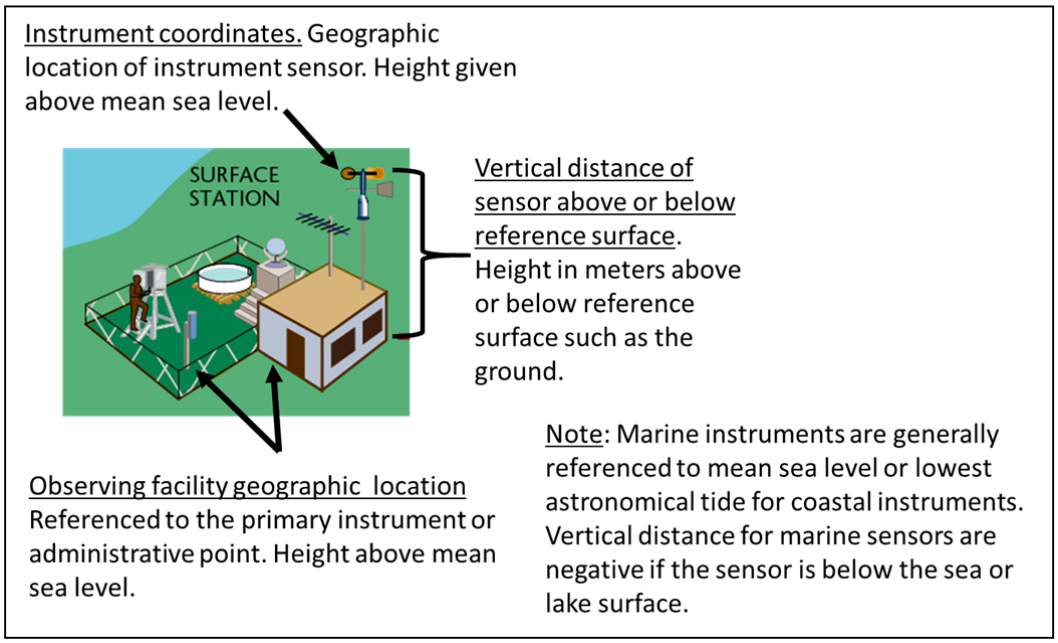
The metadata element that uniquely identifies the station/platform is the WIGOS identifier (3-06 Station/platform unique identifier). This heading contains the basic information of the station/platform, such as Station Name (3-03 Station/platform name), Date established (1-03 Temporal extent) and Station/platform Type (3-04), together with the WMO Region (3-01 Region of origin of data), its Country/territory (3-02 Territory of origin of data), its Coordinates (Latitude, longitude, Elevation, Geopositioning method) (3-07 Geospatial Location) and Time zone, as well as a description of the relevant environmental characteristics of the Station/platform and its surrounds (Climate zone, Predominant surface cover (4-01 Surface cover), Surface roughness, Topography or bathymetry (4-03), Population in 10km / 50km).

Other complementary information is listed here in Station URL (acronym for Uniform Resource Locator, a reference/address to a resource on the Internet), Other link and also in the Site information element (4-05) which may include images (photos) of the Station/platform. The official Program/network affiliations (2-02) for the station are also listed here.

The following fields in OSCAR/Surface are not metadata elements of the WMDS: Time zone, Climate zone, Surface roughness, Population, Station URL and Other link.

2.1.1 Station coordinates

The method to specify station coordinates (3-07 Geospatial Location) is described in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, section "1.3.3.2 Coordinates of the station".



2.2. Observations / Measurements

Each observation or measurement is described succinctly in terms of the following elements, which are grouped in OSCAR/Surface under the heading "Observations / Measurements": variable (1-01 Observed variable), unit (1-02 Measurement unit), analytical methods (5-02 Measurement/observing method), Programs/network affiliations (2-02), which includes

Status (3-09 Station Operating Status), Application Areas (2-01), Source of observation (5-01), geometry (1-04 Spatial extent) and Data policy/Use constraints (9-02).

Under each variable and for each data series segments that may be present the information is structured under "schedule" and "instruments". Under "schedule" the following metadata elements are listed: Temporal reporting interval (7-03 Temporal reporting period), Diurnal base time (6-07) and Schedule (6-08) (Month From-To; Weekday From-To; Hour From-To). Under "Instruments" the following metadata elements are listed: Manufacturer (5-03 Instrument specifications), Model (5-09 Instrument Model and serial number), Configuration (5-06), Serial number (5-09), QA/QC schedule (5-07 Instrument control schedule), Firmware version (5-03 Instrument specifications), Use since, Use till, Coordinates (5-12 Geospatial Location: Latitude, Longitude, Elevation), Geo-positioning method (code table 11-01 of the WMDS), Distance from reference surface (5-05 Vertical distance of sensor), Status (5-14 Status of observation), Status From, To, Maintenance periods: Description (5-13 Maintenance Activity), party (5-11 Maintenance party) and date (5-08 Instrument control result).

Some other metadata elements are included under this heading of OSCAR/Surface, which are not required for phase 1: Latency (of reporting 7-13), Sampling procedures (6-01) and Representativeness (1-05). Also included are the following elements which are not part of the WMDS: Near Real Time, Near Real Time URL and Last updated.

Often, multiple observations are associated with a single Station/platform. Observations at a Station/platform are listed in alphabetical order. A future requirement is that the Observations can be grouped according to observing domain or sub-domain.

2.2.1 Instrument coordinates

A method similar to the one referred to in section 2.1.1 should be followed for the coordinates of individual instruments (5-12 Geospatial Location). If the instruments are located in a single observing point, the Station/platform coordinates may be used as an approximation. Where necessary, the actual geospatial location of the instrument (sensing component) is recorded according to the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), section "1.3.3.2 Coordinates of the station". Additionally the height or depth of the instrument above or below its reference surface is recorded where appropriate.

2.3. Station Contacts

The details of the station contacts (10-01 Contact – Nominated Focal Point) are recorded. This may include functions, such as the station or network manager, data or metadata holder, or the organization responsible for the data policy.

2.4. Bibliographic references

Where the data series or segment, or methods relating to the data series or segments, have been previously published or referenced, e.g. nationally or on the Internet, they are recorded in this section. OSCAR/Surface allows for the upload of documents. There is no direct correspondence between this section and any particular metadata element of the WMDS.

2.5. Documents

This section provides access to documents concerning the Station/platform or the observed variables. These may include correspondence, instrument calibration certificates, and network descriptions and so on. This section may be related with element 4-05 Site information and can be regarded as an historic archive of complementary documentation on the changes in the Station/platform, its instruments and conditions of observation.

3. SPECIFIC GUIDANCE FOR DIFFERENT TYPES OF STATIONS/PLATFORMS

While the guidance provided in chapter 2.1 is intended to be useful for Members managing metadata of any type of Station/platform, the following section is intended to provide additional guidance relevant to specific types of Stations/platforms.

The WMDS identifies a Station/platform and has a direct (one to many) relationship to the observations.

Station characteristics such as a climate zone, surface cover or surface roughness (currently not in the WMDS, but implemented in OSCAR/Surface) should refer to the Station/platform geospatial location (3-07). For example, surface cover is generally most applicable to observations such as surface air temperature, humidity, irradiance and precipitation. Surface roughness is not applicable to lake/rivers observations.

The Geospatial location of the Station/platform should identify the reference location of that Station/platform. The geographic coordinates of the instruments are specified separately for each instrument of the Station/platform. The guidance for different types of Stations/platforms is specified in the following sections.

A change of coordinates should always reflect a physical re-location of the Station/platform and/or instrument. The historical coordinate values of the Station/platform location should be retained.

3.1 Stations/platforms on land

This section describes the metadata aspects related to the main types of observations made on land. It is structured in accordance to the geometry (1-04 Spatial extent - point, profile or volume) and to the technology (in situ or remote sensing) used for the observations.

The geospatial location (3-07) of the Station/platform may refer to the observation which has existed for the longest period of time, or it may be related to the administrative point, or to the primary application area (2-01). The coordinates should be centred over the instrument and the ground elevation should be the natural (undisturbed) surface of the ground.

Stations/platforms on land include observations which are made at a fixed position in relation to the land surface, a mobile observation on land or those which transfer their data to a facility on land. These facilities may be close to land (such as a wharf or on a pylon grounded in the earth).

A mobile station may remain in a fixed location during a period of observations, or may be mobile during the observation.

3.1.1 Surface in-situ observations

The observations of the variables in a surface in-situ observing station, such as wind speed/direction, air temperature, relative humidity, atmospheric pressure, precipitation, present weather, cloud, etc., by the instruments/observer located at this station are described individually. Although such observations are made as in situ observation in a station, they should represent an area surrounding the station depending on the environmental exposure conditions of the instrument.

Some instruments may measure more than one observed variable at the same time. Each observed variable should be described and the common instrument may be identified through a common serial number. Examples of such instruments include some humidity probes (reporting humidity and temperature), some sonic anemometers (may report wind speed, wind

direction, virtual air temperature) and so-called “all-in-one” instruments (e.g. reporting temperature, humidity, wind speed, wind direction and pressure).

Surface in situ refers to observations made near the surface of the Earth, over land, such as Automatic Weather Stations (AWS) and Manual Weather Stations. The simplest station may make only one observation (e.g. rainfall), while others may include observations of several variables, such as air temperature, humidity, wind, soil temperature, rainfall intensity and amount, etc.

The following conditional elements of the WMDS are mandatory for fixed stations, for the first phase of the implementation of WMDS:

3-01 - Region of origin of data,

3-02 - Territory of origin of data,

5-05 - Vertical distance of the sensor from a (specified) reference level such as local ground, or deck of a marine platform at the point where the sensor is located; or sea surface,

7-11 - Reference datum - for derived observations that depend on a local datum.

3.1.2 Upper-air in situ observations

Upper-air in situ observations primarily includes observations which are made using instrumentation attached to meteorological balloons (i.e. radiosondes), or unmanned aerial vehicles (UAV, also called drone). Also the balloon tracking for the calculation of winds (i.e. by radar, radio-theodolite) is regarded as an upper-air in situ observation. In the case of radiosondes the measurement, often referred to as a sounding, delivers a complete profile from the launch point to balloon burst. To ensure the timely availability, to the data users, the sounding is often split into several messages but the same metadata is included in all parts of the transmitted messages. Observations such as those made by dropsondes, rockets and by using kites are also included in this category but specific guidance for these systems will be included in a later release of the metadata standard.

The majority of the metadata for these systems are also incorporated within the WMO defined BUFR message and are reported along with the data for each sounding. Because without these metadata the observations are meaningless the Station/platform Metadata Maintainer and the Network Metadata Manager must ensure that the transmitted metadata are valid and accurate for each reported sounding. To prevent any confusion the metadata reported in BUFR messages must be fully consistent with the WMDS elements and with the information that is inserted into OSCAR.

It is common that the launch point of the balloon has different geospatial coordinates than the Station/platform and this can make a significant impact on the data users. It is important that both sets of geospatial coordinates are included in the Station/platform metadata database, and that the coordinates incorporated in the BUFR messages is for the balloon launch location. Element 5-12 Geospatial location, of instrument, is related to this, while element 3-07 Geospatial location, of station, refers to the main facility. Note that element 5-12 Geospatial location of instrument is an element of the phase 2 of implementation.

Many radiosonde systems no longer include a pressure sensor, and thus the pressure and geopotential height is derived from the Global Navigation Satellite Systems (GNSS) altitude. The atmospheric pressure can be derived artificially from an estimate of status of the atmosphere based on WMO recommended calculus or by using the static predefined International Standard Atmosphere (ISA). The metadata defining the source of the pressure and geopotential height measurements is mandatory and shall be included in every BUFR

message. This relates to element 7-01 of WMDS, Data-processing methods and algorithms, which is optional for phase 3 of implementation.

3.1.3 Weather Radar observations

Weather radars are active remote sensing observing systems to make real-time and high resolution observations from a large scale area (up to a radius of 250 km). The weather radar observations have been made particularly for the detection of the precipitation, hydrometeor classification and quantitative precipitation estimation. Doppler wind speed and direction can also be reported from some weather watch radars. Radar Station/platform coordinates, height of the location, tower height, frequency, polarization, scanning parameters and other characteristics of weather radar observations are metadata elements contained in the WMO Radar Database (WRD - http://wrd.mgm.gov.tr). Members should continue to collect and supply/update the metadata about their weather radars to the WRD (managed by the Turkish State Meteorological Service). The metadata regarding weather radars are transferred from the WRD to the OSCAR/Surface by machine-to-machine procedures. Radar metadata cannot be edited manually in OSCAR/Surface.

3.1.4 Other surface-based remote sensing observations

Other surface-based remote sensing includes all observations, excluding weather radars, which are made using remote sensing instrumentation located at a fixed station. These systems are wide ranging in their methods of observation, but primarily result in a measurement profile representative of the atmosphere above the sites. Examples of systems in this category are wind profiling radars, lidars, sodars, radiometers, ground-based GNSS receivers, HF Radar. So, both active and passive remote sensing technologies are considered here.

The majority of the metadata regarding these systems are incorporated within the WMO defined BUFR message and thus are only reported along with the data for each sounding. The Station/platform Metadata Maintainer and the Network Metadata Manager must ensure that the transmitted metadata are valid and accurate for each reported sounding.

These systems often use advanced flagging techniques to identify measurements that do not meet the data quality criteria and it is mandatory to include this information within the metadata that is transmitted with each message. This relates to elements 8-01 to 8-05 of WMDS (Data quality) which are mandatory/conditional for phase 2.

3.2 Stations/platforms on the sea surface

Sea surface observations are taken from a variety of stations/platforms. These include moored buoys, drifting buoys, ships and off-shore installations. Also terrestrial based (on shore) high-frequency radars (surface current direction and speed) can be entered as such. Variables most commonly measured are air temperature, atmospheric pressure, humidity, wind direction and speed, sea surface temperature, wave height, wave period, wave direction, sea-level altitude, current speed and direction and salinity.

Ship observations typically include air and sea water temperature, atmospheric pressure, humidity, wind direction and speed. These are commonly measured automatically. Manual ship observations also include wave height, wave period, wave direction, ceiling (cloud cover) and visibility.

Sea surface observations are also being made at autonomous surface vehicles (ASVs). These are propelled by wind and/or wave action and measure air temperature, atmospheric pressure, humidity, wind direction, wind speed, sea surface temperature and sea surface salinity.

Buoy positions are reported at the time of observation by the organization that operates the platform. Ship positions are also reported at the time of observation however many vessels do not report their actual identity due to economic considerations. Autonomous vehicles report their position obtained at the time of observations. The observations are reported under the ownership of the organization that is remotely controlling the vehicle(s).

3.3 Airborne stations/platforms

Airborne observations refer to measurements resulting in one or more meteorological variables along with the required metadata. These observations are made at a particular pre-scheduled intervals in space and time, so at a series of locations (in three dimensional space). In practice these observations are carried out on board of aircraft to be called Aircraft Based Observation station/platform (ABO). These series of observations deliver profiles near aerodromes or series of equidistant observations at constant altitude.

In general, data is reported by three categories of ABO stations/platforms using different data relay systems. Examples are:

- WMO ABO - AMDAR (Aircraft Meteorological DAta Relay) - aircraft providing meteorological data according to WMO standards and specifications,
- ICAO ABO - ADS-C (Automatic Data Surveillance Contract) - aircraft providing data under regulations and co-operative arrangements with ICAO,
- Other ABO - Data derived from observing systems on aircraft not being controlled by WMO or ICAO (so called 3rd party data). Data availability is dependent on NMHS arrangements with the data provider as to whether data can be ingested to WIS, taking into account requirements stated in the Technical Regulations.

The ABO data requires that Network Metadata Managers maintain a database of metadata relating to aircraft models and types, information on sensors and software for processing the data. There will also be a requirement for airport positional metadata with regards to initiating and terminating of profiles.

[Reference: WIGOS Manual and the AMDAR Reference Manual (WMO-No. 958), to be replaced by the Guide on Aircraft Based Observations.]

3.4 Stations/platforms underwater

Underwater observations can be obtained in a number of ways. These include thermistor strings and devices attached to inductive cabling, expendable bathythermographs (XBTs), acoustic doppler current profiler (ADCP), ARGO floats and conductivity, temperature and depth (CTD) devices. Bottom mounted water pressure sensors are used to measure variations in the water column which are indicative of a low amplitude wave (tsunami) generated by an underwater disturbance (seismic activity). A new technology, profiling gliders, are unmanned underwater vehicles (UUVs) and are becoming more widespread in their employment.

The variables that are observed by these devices include water temperature, water pressure, salinity, current direction and speed, fluorescence and dissolved oxygen. All of these variables are measured at depth – as deep as the sensors or gliders are located.

The underwater observations obtained from moored buoys use the position of the buoy itself and are reported by the organization that operates the buoy. XBT's positions are made at the point of launch and are reported by the launch vehicle (ship or aircraft). ADCPs and CTDs are usually moored at a specific location which is reported at the time of observation by the

organization that is operating the device. ARGO float positions are reported at the time of observation by the organization that is operating the device. UUVs observations are reported using the position of the vehicle when it begins its subsurface excursion and are reported by the organization piloting the vehicle.

3.5 Stations/platforms on ice

Note: specific guidance for Stations/platforms on ice is under development.

3.6 Stations/platforms on lakes/rivers

Records of lake/river gauge height or stage and river discharge are fundamental to the management of water resources, understanding of streamflow variability in time and space and calibration of hydrological models used in streamflow and flood forecasting. Gauge heights can be measured in various ways, such as direct observation of a staff gauge, or by automatic sensing through the use of floats, transducers, gas-bubbler manometers and acoustic methods. River flows are generally computed through conversion of a record of stage to discharge, using an empirically derived rating conversion curve or other hydraulic models. General stream-gauging procedures are recommended in the *Manual on Stream Gauging Volume I – Fieldwork and Volume II - Computation of Discharge* (WMO-No. 1044).

3.7 Satellites

Satellite observations provide information from all areas of the world. These observations provide information on surface characteristics as well as atmospheric conditions depending on the instrument type. Essential information about satellites are orbit and type of orbit (geostationary or polar orbiting) including height of the satellite, local observation intervals, types of technologies applied (active/passive, optical/microwave, imager/sounder,) including instrument characteristics (bands measured, footprint, measurement approach like scanning versus push broom or similar, swath size if applicable, return period, etc.).

Meteorological satellites usually transport a variety of different instruments, each mounted for specific applications required by a diverse user community. In fact, due to this variety of instruments, the specific observation programme chosen, the related metadata have a different nature then with the classical surface based observations (see the *Guide to Instruments and Methods of Observation* (WMO-No. 8), 2014 edition). As a consequence, metadata for satellite observations are collected as a separate database, OSCAR/Space.

4. MAKING WIGOS METADATA AVAILABLE TO WMO USING OSCAR/SURFACE

FINDING INFORMATION IN OSCAR/SURFACE

How to navigate the portal

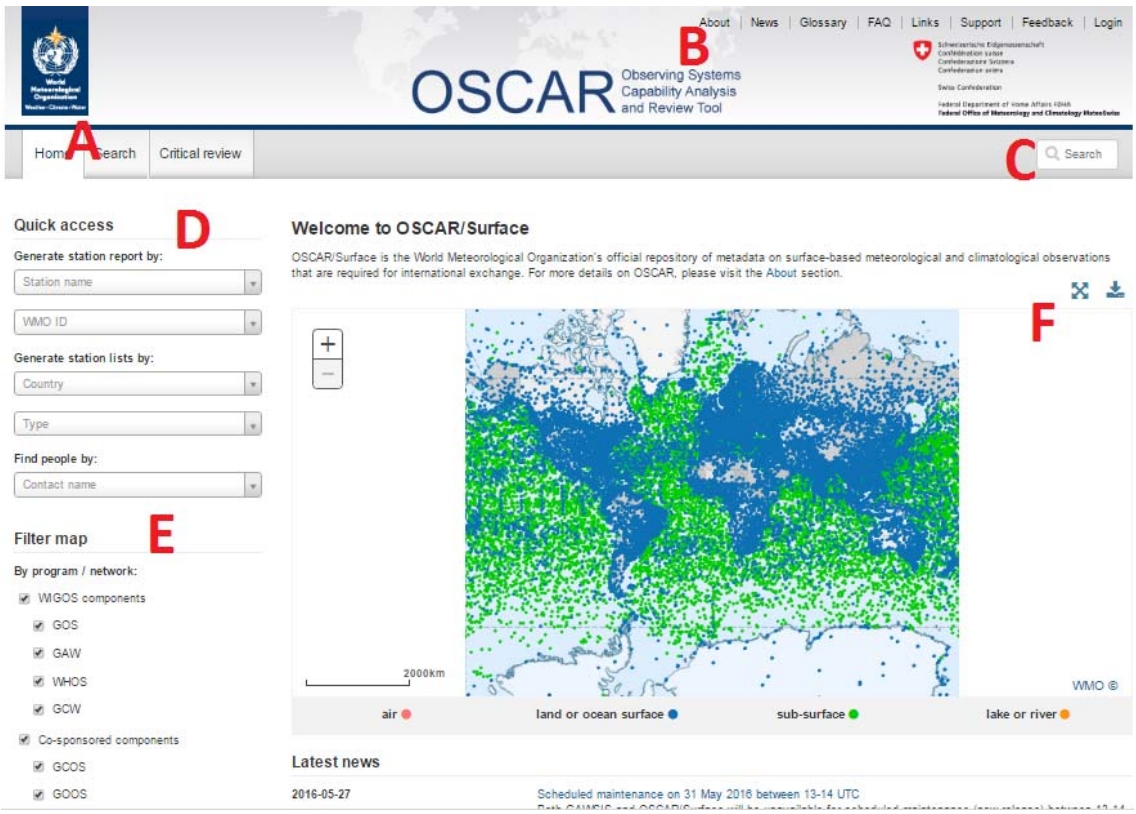


Figure 1 Front page of OSCAR/Surface

The home page of OSCAR/Surface, Figure 1, has been labelled with large red letters, A – F for the purpose of describing the various functionalities of the website. Each letter corresponds with a different functionality as follows.

A. The Home, Search, and Critical Review tabs

The Home tab allows for navigation to the OSCAR/Surface home page at all times. This functionality is also replicated by clicking on the OSCAR logo in the upper right of the page.

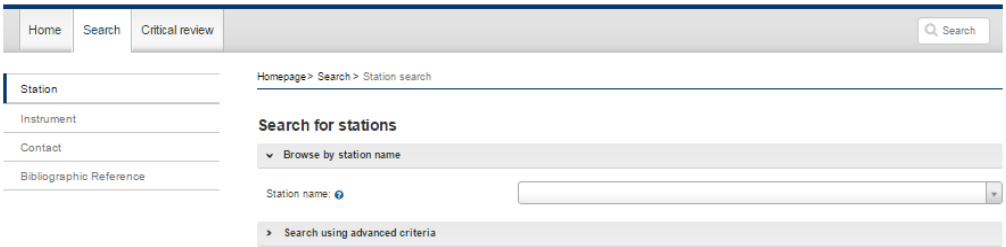


Figure 2 Search Tab

The Search tab brings you to the search functionality page, Figure 2, that allows for queries to the information stored in OSCAR/Surface in a variety of ways:

- Search for Station – searching by observing station attributes;
- Search for Instruments – searching by the instrument attributes within an observing station;
- Search for Contact (Figure 16) – searching an address book of observing system owners or points of contacts;
- Search for Bibliographic reference (Figure 18) – searching the records of peer reviewed articles that were published.

The Critical Review tab is currently not activated as the Critical Review functionality will be implemented at a later stage.

B. This section in the upper right corner of the webpage in Figure 1 houses the links to pages for:

a. About OSCAR/Surface – Information about the development and history of OSCAR/Surface;
b. News – An archive of the "Latest news" updates related to OSCAR/Surface;
c. Glossary – list of commonly used terms in WIGOS and OSCAR/Surface;
d. Frequently asked questions (FAQs) – list of useful questions for the users of OSCAR/Surface;
e. Links – list of useful links relating to WIGOS and observing systems;
f. Support – A form requesting contact information from the user and a comments section to capture the user's request to be submitted to the OSCAR/Surface support and operations team;
g. Feedback – A form for submitting feedback to the OSCAR/Surface development team;
h. Login- The permissions controlled access to edit the data contained in OSCAR/Surface.

C. Search – This text box allows for a quick text search across the description, title, name, and address

The results are returned in a drop down menu, as shown in Figure 4, arranged by categories:

a. Search by station; and
b. Search for contacts.

In the right corner of each category, the user may access all the search results by clicking on the "View all>>" link associated with the three categories.

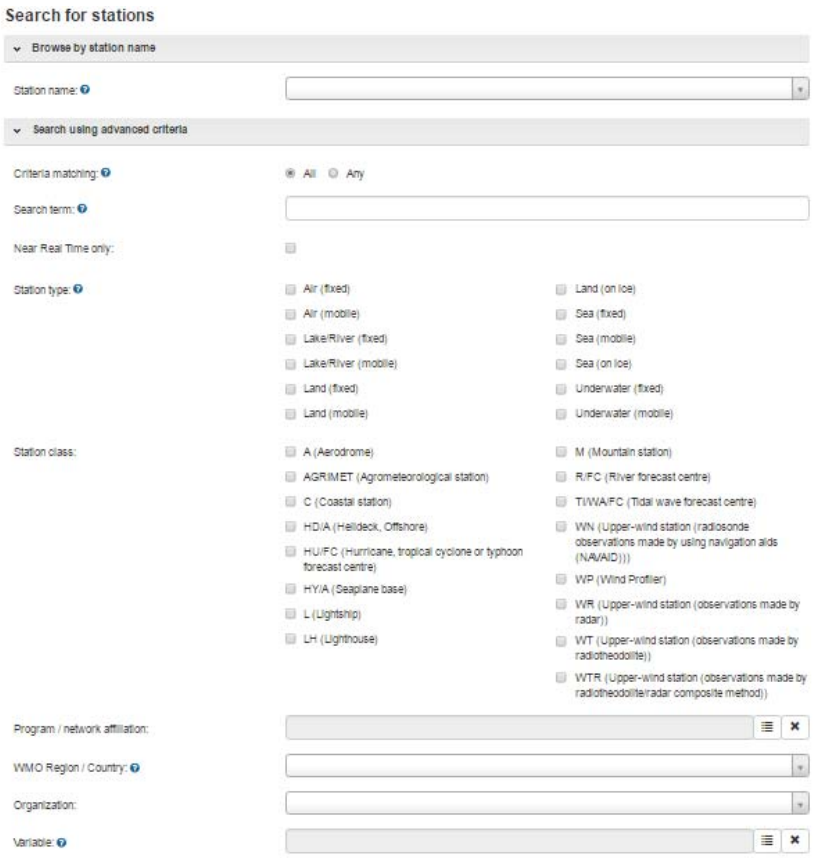


Figure 3: The station search screen

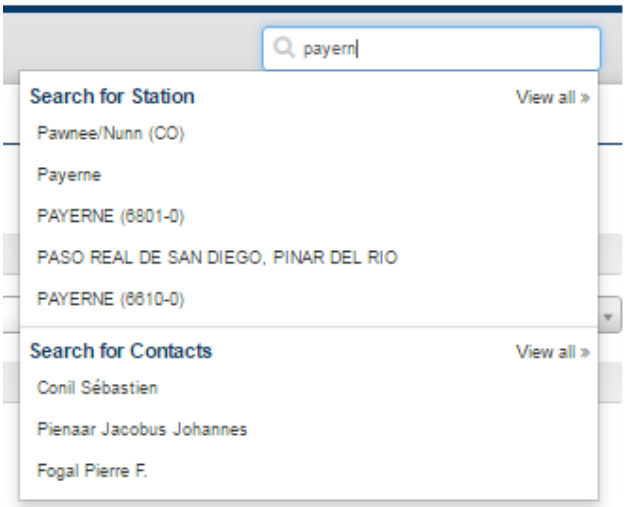


Figure 4 Quick Search results

D. Quick access

The quick access section allows for searches by station name and WMO ID (under "Generate station report by:") to retrieve/view the station's detailed information. Under "Generate station lists by:" there is also the capability to generate a list of all stations (named "report" in OSCAR/Surface) within a particular country and for a station type. There is a quick search for

contact names (under "Find people by:") as well as that generates a report with the full contact information stored within OSCAR/Surface.

E. Filter map

The filter map functionality allows for the display of world-wide stations on the map. By default, all WIGOS component observing systems and other components/networks are selected, however, the user is able to remove check marks from components to view only those stations affiliated with the selected programmes.

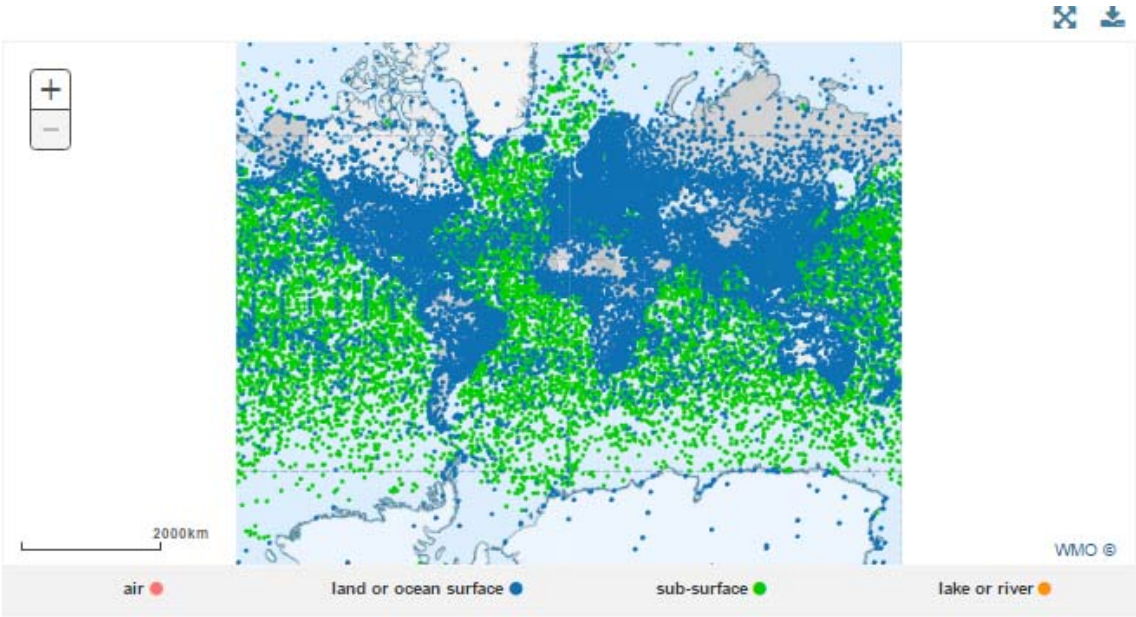


Figure 5 Map Interface

F. Map interface and download

Figure 5 shows the map plotting the observing stations in OSCAR/Surface coloured by the categories "air", "land or ocean surface", "sub-surface" and "lake or rivers". The map interface allows for the selection of individual stations by clicking on a station on the map. The user is able to zoom in/out using the "+/-" buttons on the upper left section of the map, or double click on any open spaces in the map. The mouse can also be used to move the map to the appropriate location of interest. Once the desired area is displayed, the user has the option to click on an individual station to generate a report of that station's information or choose to download the map in various formats for offline display purposes. The download functionality is accessible via the icon in the upper right section above the map (Figure 5) and allows for an image export as a PNG, JPG, GIF, and EPS, and also allows for the station location information to be downloaded in the KML format for use in Google Earth.

How to Search for Stations

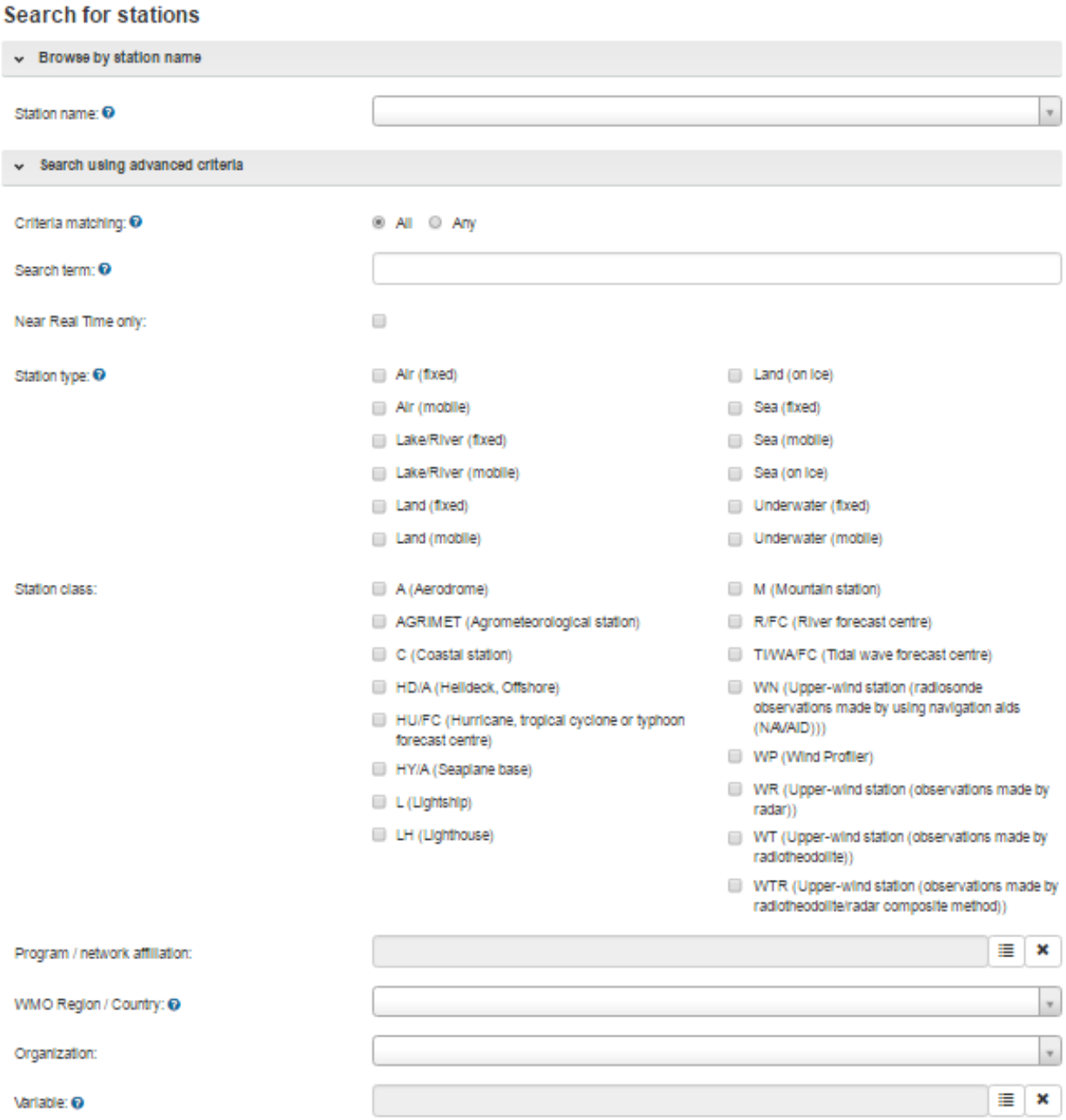


Figure 6: Search for Stations

The search for Stations, via the "Search" tab (see the previous section on Finding information in OSCAR/Surface) stored in OSCAR/Surface, as shown in Figure 6, **Error! Reference source not found.**is available for users with prior knowledge of the Station name via a drop down menu under the button "Browse by station name". Alternatively, other criteria may be used to narrow the results to probable stations meeting those attributes. These search criteria are available under the option "Advanced search":

- A "Search term" corresponding to a partial recall of the station's name;
- The periodicity of the data being "Near real-time" or not, which is searched by checking the box for "Near real-time" stations;
- The "Station Type" which is a categorization of the type of station at which an observation is made;
- The "Station class", which corresponds to the most frequently used attributes of the Volume A codelist for Observing Remarks;
- The "Programme/Network Affiliation" – a menu of WMO Programmes are provided via the button and allows for the selection of one or more WMO Programmes for listing. The "X" button allows for the selections to be removed from the search criteria;
- The "WMO Region/Country" – Corresponds to the various WMO regional associations (RAs), I-VI and the Members within each RA;
- The "Organization" – corresponding to the comprehensive list of supervising organizations for all stations in OSCAR/Surface;
- The "Variable" – clicking on the second button, from the right, opens a menu that allows to select one or more variables from the following domains:
    - Atmosphere,
    - Earth,
    - Ocean,
    - Outer Space , and
    - Terrestrial,

each with their own subcategories to further refine the search as detailed as the actual physical variable being measured.

Search for Stations- expanded

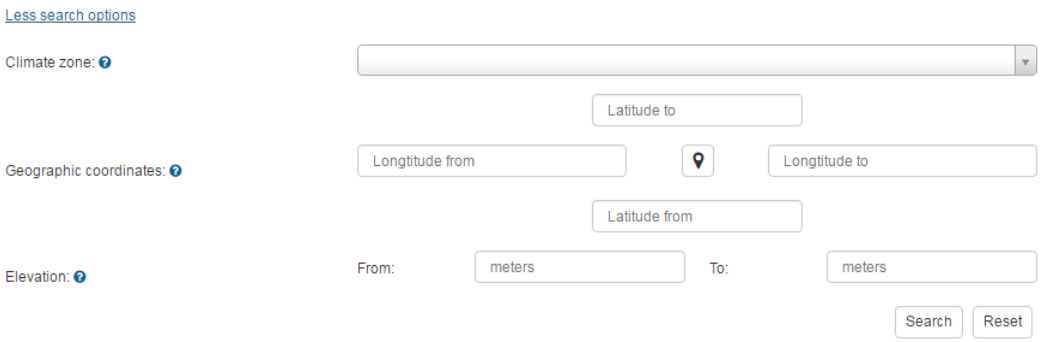


Figure 7 Search for Stations- expanded

There are additional options for searching by Stations, as shown in Figure 7 that are accessible by clicking on the "More Search Options" hyperlink. This reveals the options:

- Search by Climate zone – A climate zone can be selected from a drop down menu with a list of the Koppen classification types;

- Search by Geographic Coordinates – There are text boxes that allow the selection of a geographic range as "Longitude from" to "Longitude to", as well as "Latitude from" to "Latitude to". It is possible to only insert a single value here. For example, inserting 66 into "Latitude from" will show stations roughly above the polar circle. Only numerical entries are valid for these boxes. Attempts to enter text and submit the search will result in an error dialog with the message "The submitted data is invalid. Please look for the red widget in the sections for more information." Also noteworthy is the icon in Figure 8 in the middle of the text boxes, that allows the user to manual draw a box around the region of interest (Figure 9).

Figure 8 Geographic coordinates search

Figure 9 Drag and draw selection

- Search by Elevation- the elevation range of the stations can be entered in meters in the text boxes.

At the bottom of the page, there are two buttons: the "Search" one to submit the search criteria and the "Reset" button to clear all prior entries.

How to find specific observing systems, such as Radars, Wind Profilers, Radiosondes etc.

One way to find stations by observation technology is to search by "network affiliation". Another way is to use the "station class". As with all information in OSCAR/Surface, the

accuracy of the search results depends heavily on the quality of the metadata inserted into the system. The table below lists how to find commonly searched observing technologies.

Technology	Search by
Radars	Network affiliation "WRO" (under WIGOS/GOS/GOS_Other_Elements)
Wind Profilers	Station class "WP"
Radiosondes	Network affiliation "RBSN(T), or Network affiliation "RBSN(S/T) under WIGOS/GOS/GOS_Surface_Networks/RBSN) Or: Station class "WN"

Station report details

This is the result of a station search (or "report" as named in OSCAR/Surface) which displays all station details (Figure 10), including the history of changes, as documented in OSCAR/Surface. The station report is organized into the following five sections: "Station characteristic", "Observations/Measurements", "Contacts", "Bibliographic references" and "Documents", which can be expanded by clicking on the respective buttons.

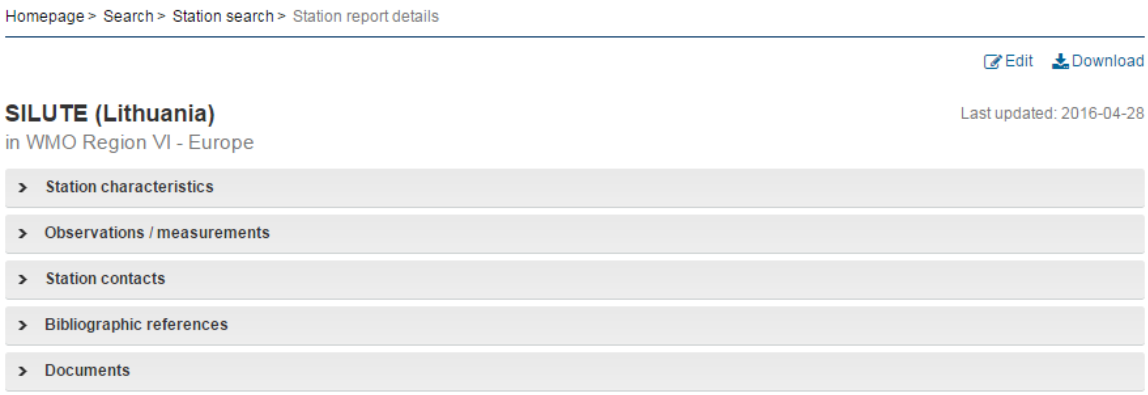


Figure 10: The main sections of the station report

Station characteristics

The station characteristics section (Figure 11) gives an overview of the general situation of the station, such as country it is located in, coordinates, WMO identifiers and terrain properties. All changes that are inserted in OSCAR/Surface are recorded and can be shown when expanding the field in question, as shown in Figure 11.

Coordinates: 46.8129081726°N, 6.943500042°E, 490m

Latitude	Longitude	Ground elevation	Geopositioning method	From
46.8129081726°N	6.943500042°E	490m		2013-04-03

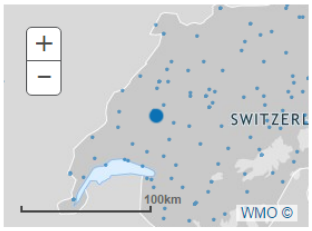
Figure 11: The table in the station characteristics section of the station report shows the history of changes to this station's location together with the date of change. (Here only one position is recorded)

Payerne (Switzerland)
in WMO Region VI - Europe

Last updated: 2013-04-03

Station characteristics

Station name:	Payerne
Station alias:	
Date established:	1968-09-20
Station type:	Land (fixed)
Station class(es):	
WMO index No:	0-20008-0-PAY
WMO region:	VI - Europe
Country / Territory:	Switzerland
Coordinates:	46.8129081726°N, 6.943500042°E, 490m



Latitude	Longitude	Ground elevation	Geopositioning method	From
46.8129081726°N	6.943500042°E	490m		2013-04-03

Time zone:	UTC+1
Climate zone:	Warm temperate climate, fully humid, warm summer
Station URL:	www.meteoswiss.admin.ch/web/en/weather/ozone_layer.html
Other link (URL):	
Predominant surface cover:	
Surface roughness:	
Topography or bathymetry:	

Figure 12: Station characteristics

WIGOS Station identifier

Stations are identified by the WIGOS station identifier (WIGOS ID) in OSCAR/Surface. WIGOS IDs are the official WMO identifiers and have to be used for all WMO stations from July 2016 on. Please see the official WIGOS ID documentation for more details.

An initial WIGOS identifier was created for each station and initially imported into OSCAR/Surface. For stations formerly in Volume A, the WIGOS ID is based on the station identifier allocated to the station by the country in Volume A. In case of Radar, GAW or JCOMMOPS stations, it is based on the identifier used in these systems. This identifier should not be changed, as it provides a historic reference. Please contact the administrator if you think that this identifier should be changed nevertheless.

Station class(es):	
WMO index No:	0-20000-0-12497
WMO region:	VI - Europe
Country / Territory:	Poland

Figure 13: WIGOS station identifier: The identifier 0-20000-0-12497 is based on the indexNbr 12497 allocated to it in Volume A. The first "0" indicates that the identifier

represents a station, "20000" is an issuer range allocated to WMO Programmes or networks, whereas the third "0" is the "issuer number".

Multiple identifiers can be attached to a station to reflect affiliation with different networks or programmes. For this the dialogue "programs / network affiliations" can be used. The programme or network in which the identifier is used must also be specified.

Programs / network affiliation:

Program / network affiliation	Program specific ID	Current recorded status	Declared status	From	To	Status
GOS		Operational	Operational	1951-01-01		Approved
CLIMAT(C)		Operational	Operational	1951-01-01		Approved
RBCN		Operational	Operational	1951-01-01		Approved

Figure 14: Additional identifiers can be added under "programs/network affiliations"

Observations/measurements

This section shows all observations, past and present, that are/were taken at the station, together with details about the instrument used, data processing applied and the observation schedule. If the observations are made under a Programme/network, this affiliation and the identifier used are also displayed here.
Observations are structured as "data series" and "segments".

Attributes such as data format and the data processing centre are recorded at the level of the data-series whereas observing schedule and instrument used are stored in data-segments.

Major changes to the properties of a data-series or data-segment may warrant closing the current one and adding a new one instead of simply recoding a change in the current one. This is the case when the characteristics of series or segment were changed to such an extent that it is no longer continuous. The user may then decide to create a new data series or data segment based on the following concept and example:

What is the difference between a data-series and a data segment?

A data-series represents the entirety of observations of the same variable taken at this station.

A segment is a sub-set of these observations, and represents those that were taken without major interruption and under roughly the same conditions.

Example: The sampling method and observing schedule of a pressure observation are changed to 10 minutes and 30 minutes respectively, from 30 and 60 minutes on 1/1/2016. The current segment is closed (end date 31/12/2015) and a new one with the new observing schedule created. The segment remains part of the same pressure data-series.

Observations / measurements

Air temperature (at specified distance from reference surface) - [Method: (unknown / unspecified)]

Variable:	Air temperature (at specified distance from reference surface)
Variable unit:	(unknown)
Analytical method:	(unknown / unspecified)
Programs / network affiliation:	Name EMEP (from 1968-09-20)
Source of observation:	(unspecified)
Geometry:	(unspecified)
Near Real Time:	No
Data centre:	EMEP
Data policy / use constraints:	(unspecified)
Last updated:	On 2016-04-28

Data series segments

From 1993-04-07 to 1993-12-20

Observations made:	From: 1993-04-07 To: 1993-12-20
Data submission:	From: 1993-04-07 To: 1993-12-20
Level of data:	Level II
Data URL:	http://ebas.nilu.no/DataSets.aspx?stations=CH0002R&InstrumentTypes=aws&components=temperature&matrices=met&fromDate=1993-04-07&toDate=1993-12-20

Schedule

Monday to Sunday , 00:00 to 23:00 , every 1 day (d)

Figure 15: Observations/measurements section of station

Station contacts, Bibliographic references and Documents.

These three sections list station contacts, references and the available documents with further information on the station. Station contacts include various roles, such as operators, national focal points, maintenance technicians etc.

How to Search for Contacts

The search for contacts functions as a searchable directory of station owners or Points of Contact (POCs). Figure 16 shows the options to search by name, either by entering the text or using the drop-down menu to browse the entries, and the more advanced search using the Contact's country and the variables being measured at the station.

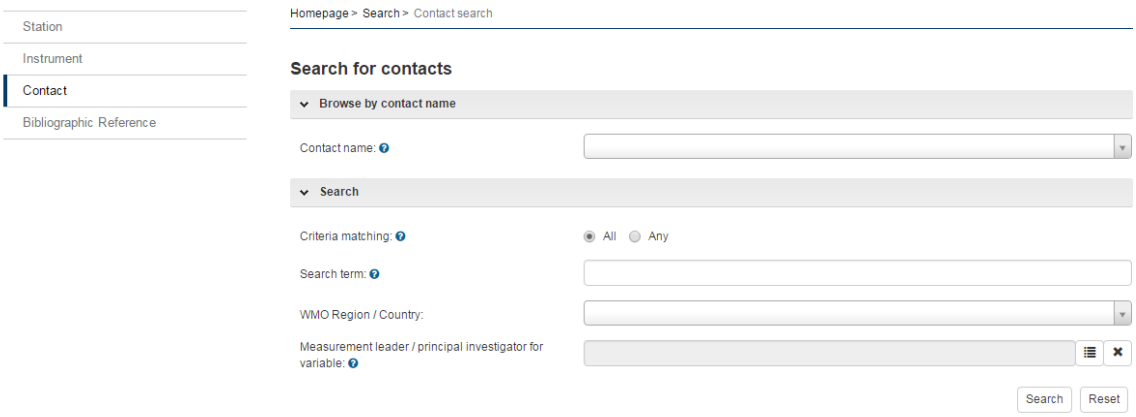


Figure 16 Search for Contacts

How to identify the National Focal Point for OSCAR/Surface of a country?

In order to find the OSCAR/Surface National Focal Point, list all contacts of the country you are interested using the "search for contacts" detailed search criteria "WMO Region/country". Then examine the contacts role attributes. The roles of a contact are revealed when clicking on the person.

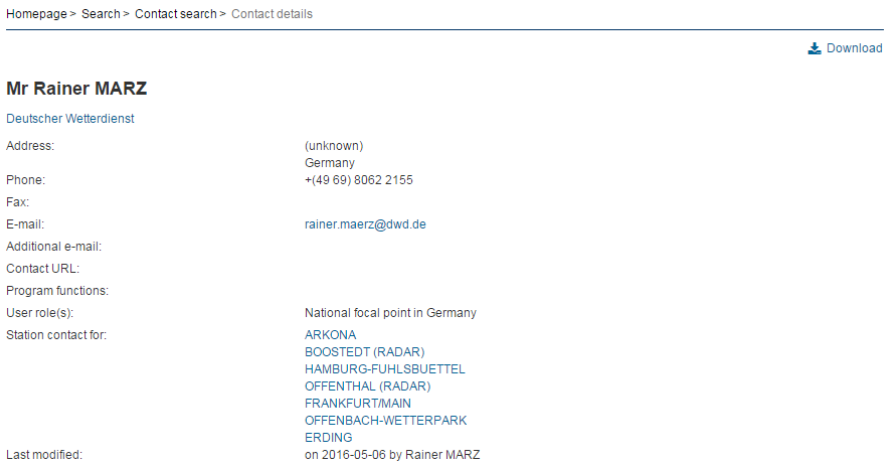


Figure 17: Detailed attributes of a contact in OSCAR/Surface

How to Search for Bibliographical Reference

Another function in OSCAR/Surface is the ability to locate any citations input for the station. If the user knows the Author's name or the year of the publication, the search can return the stored references (Bibtex) corresponding to the matches. A keyword search allows for a wider search of the text of the citation, as shown in Figure 18.

Figure 18 Search for Bibliographic References

How to Search for Instruments

OSCAR/Surface stores the instrument metadata according to the WIGOS metadata standards. As such, a user is able to query the data for Manufacturer, Model, Serial number, and Period of observation in order to find … Figure 19 shows the further search options available by clicking on the "More search options" link, which reveals criteria for the Variable, Programme/Network affiliation, Organization, RA or Country of the instrument's location, Climate zone, geographic coordinates, and elevation.

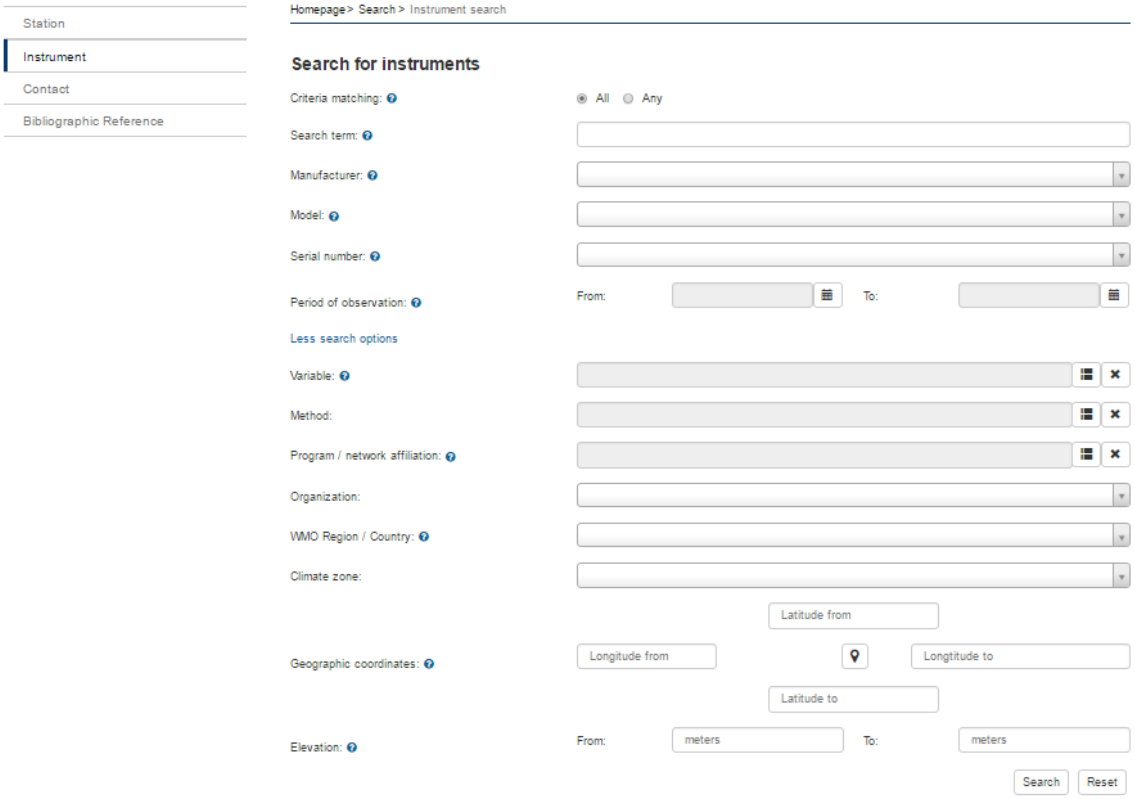


Figure 19 Search for Instrument - expanded

CHANGING INFORMATION IN OSCAR/SURFACE

The authorization and access control module in OSCAR/Surface

Only authorized users can change information in OSCAR/Surface. The administrator, working at the WMO Secretariat, creates the login for the National Focal Point (NFP) for the countries upon receipt of a nomination from the Permanent Representative. National Focal Points can in turn create additional users and associate them with stations, associated with their country. National Focal Points have the right to edit all stations in their associated country, whereas other users can only edit stations they are directly associated with, as well as create new stations. The table below details the access rights.

Role	Create Station	Edit station	Create user
Admin	all	all	All
NFP	For their country	All in their country	For their country
Contact	For their country	Only own stations	For their country
Network focal point	all	Of own network	For their country

Table 1: User and role access rights

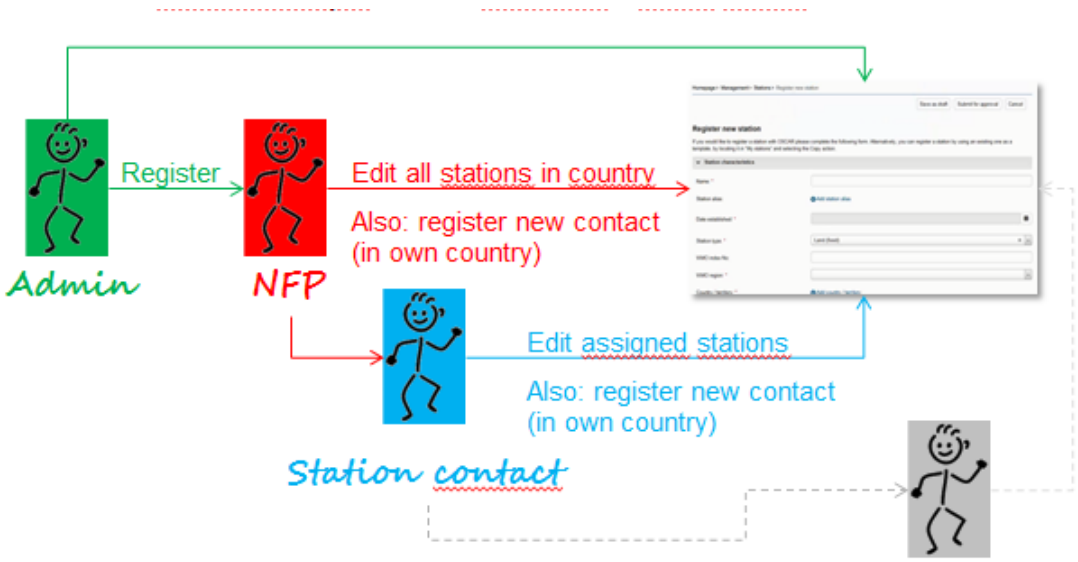


Figure 20: Access and role model in OSCAR/Surface

Having editing rights to a station, a NFP, or regular contact can add additional contacts to a station. This then grants them editing rights to this station.

How to Log-on to OSCAR/Surface and register a new user

The log-on or user registration procedure is needed in order to change information in OSCAR/Surface and therefore not required for searching information. The registration only has to be completed once to associate the authorized e-mail of a National Focal Point or Station contact with the OSCAR/Surface system and the Electronic Identity and Access Management

system used by OSCAR/Surface. Having completed this procedure, it suffices to supply username and password to log-on to OSCAR/Surface.

Figure 21: Accessing the log-on and register new user functionality of OSCAR/Surface

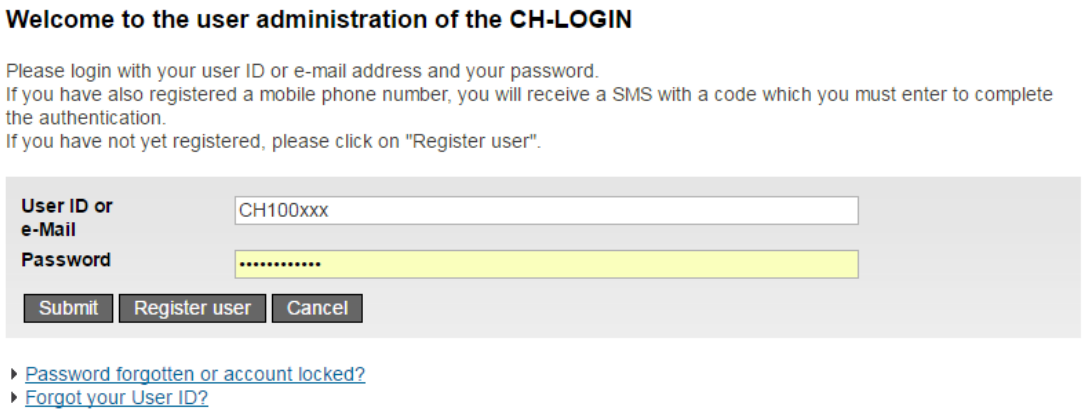
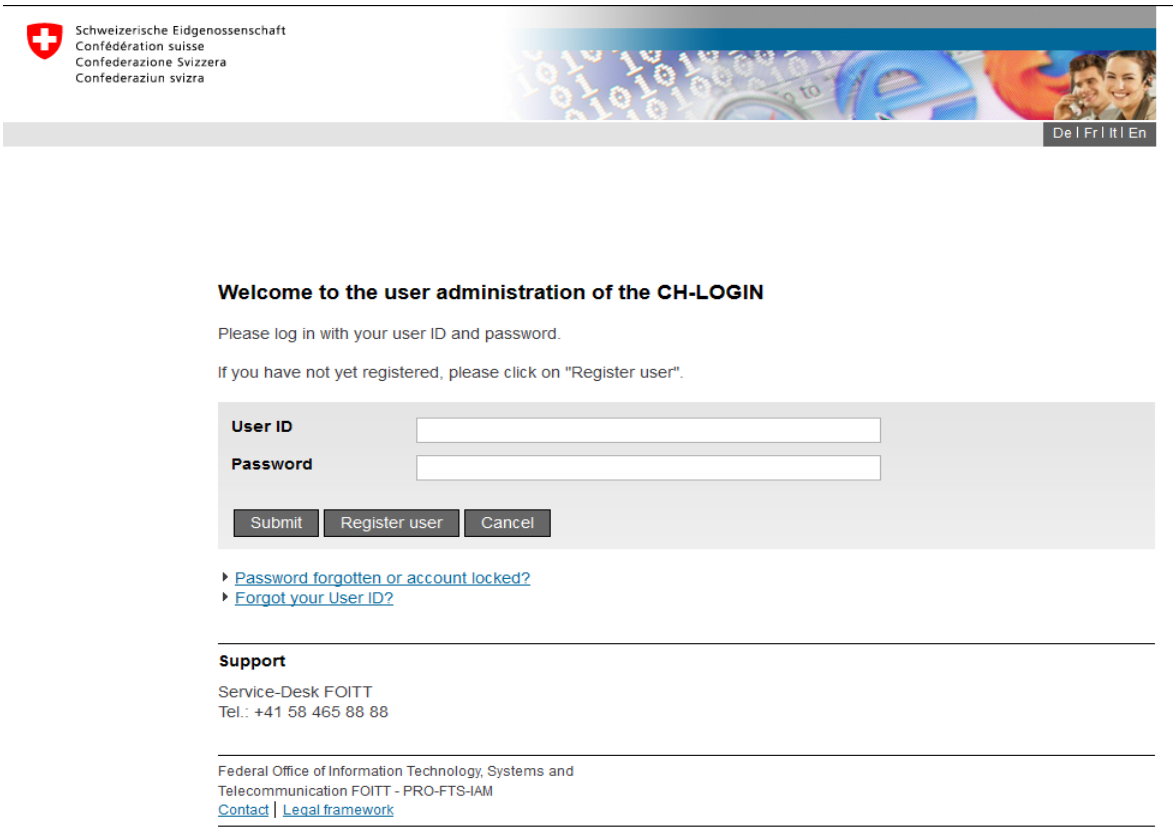


Figure 22: Supplying username and password from previous user registration in order to log-on to OSCAR/Surface or registering a new user



You can register as a user in 6 steps

User registration, step 1: e-mail address entry

Please enter a valid e-mail address and the CAPTCHA displayed and then click on "Next".
You can request a new CAPTCHA by clicking on "New CAPTCHA".
Your e-mail address will be validated in the next step.

CAPTCHA breakables

CAPTCHA text

E-mail address

Next | New CAPTCHA. | Quit

User registration, step 2: e-mail address validation

An e-mail with a validation code has been sent to the e-mail address shown. Please enter this code below and then click on "Next".
Use the "Back" button to return to step 1 where you can re-enter an e-mail address.

E-mail address testing@wmo.int

Validation code

Next | Quit | Back

User registration, step 3: mobile phone number entry (optional)

If you have a mobile phone, please enter this phone number now. This number can be used for advanced authentication.
If you wish to continue without entering a mobile phone number, please leave this field empty and click on "Continue without mobile phone".

Mobile phone number

Next | Quit | Continue without mobile phone

User registration, step 5: user information

Please enter your full name. To register, you must read and accept the terms of use.

User ID auto-generated

Surname Cappelletti

First name Lucia

Organisation Please leave blank

Notes

Show terms of use

☑ I accept the terms of use

Next | Quit

User registration, step 6: set user password

Please select a password that meets the criteria outlined below and then click on "Next".

Enter password

Confirm password

The new password must meet the following criteria:

- length of at least 8 characters
- contain at least 1 uppercase letter
- contain at least 1 lowercase letter
- contain at least 2 non-alphabetic characters (eg numbers, special characters)

Please also note that the new password must be different from the previous passwords.

Next Quit

User registration: you have successfully registered.

You have successfully registered. One user has been issued the user name below.

Registration was successful

Just as a reminder, please make a note of your user ID CHA1000105

Next

Access not possible

You do not have the access rights for this application. This can be due to the following reasons:

1. **This ist the first time you want to access this application. Please click the "Request access" button and follow the directions.**
2. **If you already requested access to this application, the following steps might help:**
   - **wait until you receive the e-mail that confirms you have access.**
   - **click the "New login" button and select a different login method because the previously selected login method was not accepted by the application.**

New login Request access

Request access, step 1: user information

Your user information is shown in this step. If necessary, complete your full name. You can add further information in the remarks field. You have to accept the terms of use in order to request access.

Surname	Cappelletti
First name	Lucia
Organisation	bitte leer lassen
Notes	
Your ID or passport number (if available)	n/a

Show terms of use

☑ I accept the terms of use

Next Quit

Request access: request submitted successfully

You now have access to the requested application.
The new access rights will be active after you login again to the application. Please logoff by clicking the "Back to application" button.

Your request for access to the application 'OSCAR' was successfully submitted.

Back to application

Welcome to the user administration of the CH-LOGIN

Please log in with your user ID and password.

If you have not yet registered, please click on "Register user".

User ID	CHA1000105
Password	••••••••••••••••

Submit Register user Cancel

- Password forgotten or account locked?
- Forgot your User ID?

How to create a new station

Once you are logged on to OSCAR/Surface, the Management console appears in the main menu. The “register new station” dialogue can be reached from there. Use this form to create a new station in OSCAR/Surface.

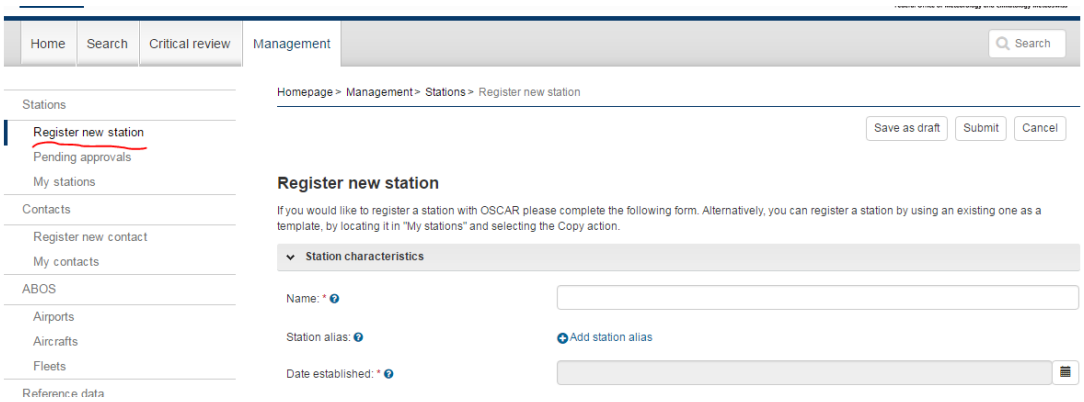


Figure 23: Register new station form in Management console

The dialogue is separated into the same five sections as the "station report" page, each of which allows to edit the elements corresponding to that category. Some elements, such as the name of the station, are mandatory and the station cannot be saved unless all mandatory elements have been provided. Should incomplete information be supplied, an error message is shown upon saving, indicating that some elements are missing. The missing fields and section headers are then also coloured in red. However, it is possible to save the station as draft to save the information so far supplied for later editing.

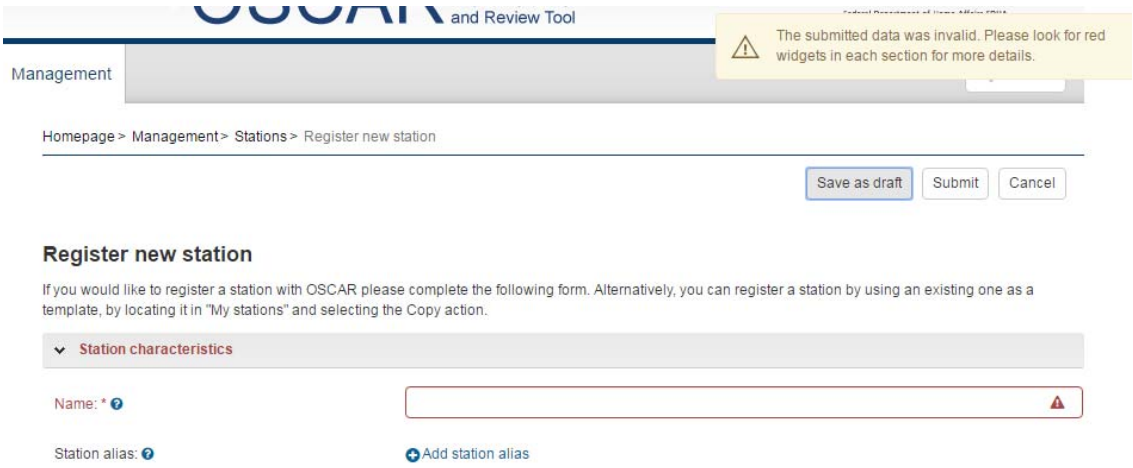


Figure 24: Missing fields are shown in red and error message indicating missing fields

Saving a station as draft

When saving a station as draft, it is not publicly visible. To continue editing, find the station in the list of "my stations" and continue editing. Note that once a station is published, an edit can no longer be saved as draft, as the station is already public.

Inputting historic information

The history of changes of almost all information in OSCAR/Surface is stored to be able to better understand the station history and development of capabilities over time. Therefore, all such fields have a date input field, in addition to the actual field capturing the information. When completing such a field, the date at which the change actually occurred should be indicated. For example, a change of instrument in a station may only be documented in OSCAR/Surface after the technician in the field has completed the work. In this case, the date when the instrument changed, and not the date when the information is input into the system, should be indicated here.

Figure 25: Date field enabling the date when a change occurred to be captured

Multipurpose station concept / duplicate stations

OSCAR/Surface is observation centric and focuses on documenting the observations made. The concept of a station in OSCAR/Surface is mainly used for describing the physical environment in which the observations take place. Therefore, it is possible that multiple traditional stations that report with different identifiers to various observing programmes are grouped together in OSCAR/Space as a single station, each observation being affiliated to an observing programme with its own identifier. At the same time physically identical stations may have initially been imported as separate stations into OSCAR/Surface. It is the responsibility of the station operator to decide whether stations should be represented as separate entities in the system.

Network affiliations and approval

In order to indicate that a station is part of a specific observing programme, the corresponding data-series can be *affiliated* with a list of WMO and related programmes. This can be done from the observations/measurements screen by editing the data-series and selecting the programmes/affiliations sub-form. In some cases, joining the programme may be subject to approval. In this case, the programme focal point will receive an automatic e-mail asking for approval of the request. While the approval process in not completed, the affiliation will show as "pending".

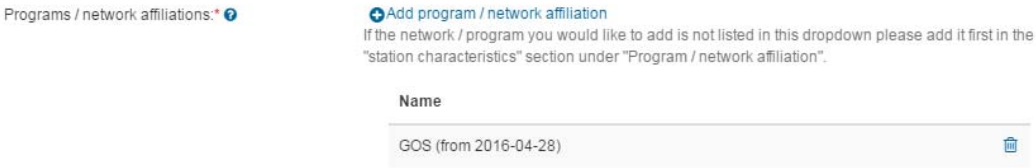


Figure 26: Affiliating a data-series with a network

How to edit an existing station

The edit menu can be reached by clicking on the "edit" button which is shown if the logged on user has editing rights to the station. To get to the station report any of the quick access, search or map filter methods can be used.

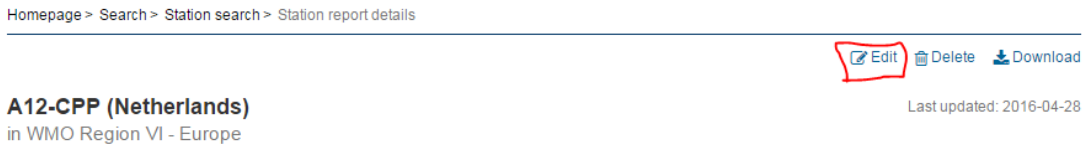


Figure 27: The edit station button on the station report is shown when the user has editing rights

Editing the station is then done using the same form as the "register new station", except that most of the fields are already populated. Remember that the date of a change must be documented in OSCAR/Surface, too, as described above.

Why can I not save my edits?

When saving a change to a station it can happen that the system refuses to save the change because of missing information. However, the missing information has nothing to do with the change just made. This is because the information that was initially imported into the system is still incomplete and an edit not completing it therefore fails.

Another reason why an edit cannot be saved is an internal error in the system. In this case, a red notification is shown, and the station is still in editing mode. In such a case, it is worthwhile checking whether the changes have been applied to the database or not. This can be done for example by opening the station report in another window, while keeping the current one open. If the changes have been submitted, the current windows can be closed. Otherwise try saving again after a short while.

Session timeout

The session is closed after xx minutes of inactivity. Therefore, when making lengthy changes with long pauses between edits, is it recommendable to keep a second window open to check if the session is still alive before saving the edits. In case the session is no longer active, logon again in the second window before saving the change.

Editing Radars or JCOMM stations

OSCAR/Surface also contains information that is regularly imported from external portals; the stations maintained by JCOMMOPS as well as the Weather Radar Database operated by the Turkish Meteorological Service. Therefore changes to these stations have to be made in the respective portals and cannot be done in OSCAR/Surface directly.

How to copy a station

To copy a station, locate the station in the "my stations" screen. From there it is possible to copy it using the "copy" icon on the right. The new station will be opened as the "edit" screen. Only relevant attributes are copied.

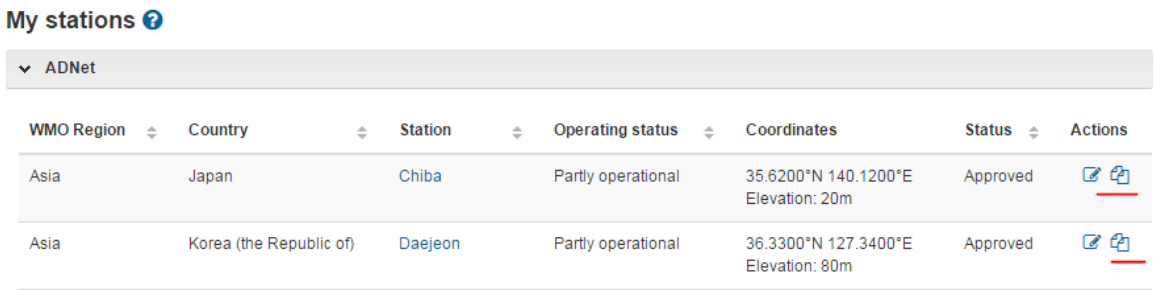


Figure 28: The copy action in the "my stations" screen

How to delete a station

Only an administrator can delete stations. Please use the contact form to notify the administrator that a station should be deleted. The reason why stations cannot be deleted in OSCAR/Surface is that the record of the station should be documented in the system even though the station is no longer active. Therefore, rather than deleting the station it is more appropriate in most cases to set the end date of the data-series and set the reporting status to "closed". Stations created for testing purposes can be removed by the administrator.

How get help and to report bugs

There is a contact form in OSCAR/Surface that can be used to both get help and also to report bugs or request new features. Requests submitted to this form are tracked and jointly addressed by the OSCAR/Surface operating team and the WMO Secretariat.

How can I make mass changes / Is there an API / How can I synchronize my existing database with OSCAR/Surface?

OSCAR/Surface will provide a Machine2Machine (M2M) API that can be used to batch import stations as well as making mass changes to information in the system. The details of this interface are currently being specified and will be available in the next release.

Annex I – List of fields in OSCAR/Surface screen

The list of fields will be provided in the next version of this Guide. In order to get an overview of the information fields needed to complete a station, you can try creating a "dummy" station which is saved as a draft or not saved at all, using the "register new station" dialogue. This allows browsing through all forms and fields required for creating a new station.

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5. OBSERVING NETWORK DESIGN

5.1 INTRODUCTION

Observing Network Design (OND) Principles are provided in the *Manual on WIGOS*, paragraph 2.2.1, Appendix 2.1 (WMO-No. 1160). The purpose of this section is to provide guidance on the interpretation and implementation of the OND Principles. The 12 Observing Network Design (OND) Principles are short and therefore abstract. National Meteorological and Hydrological Services (NMHSs) designing and evolving their observing system networks will need more concrete guidance on how to respond to these principles. This document provides for each OND Principle a set of more concrete guidelines or recommendations.

Explanation of terms – see annex to this section. For the purpose of generalizing certain Observing Network Design guidelines and recommendations abstract or conceptual terms and definitions, for example 'integrated station network' are used sometimes. Explanation of such abstract terms can be found in the Annex 'Explanation of terms'.

Some recommendations apply across several OND Principles. For ease of interpretation, these points are repeated wherever applicable. Their appearance on multiple occasions is therefore intentional.

Scope – generic guidance appropriate to all or many observing systems. In this document in some cases rather abstract terms are used such as 'network design' or 'observing networks'. Sometimes these definitions –although rather abstract- have their origin in a specific area of meteorological observations, e.g. in ground-based observing. The terms 'network design' and 'observing networks' are regularly used and accepted when describing the process of creating a network of ground-based observing sites in a country and thereby considering aspects like

appropriate distance between stations, other siting conditions or frequency of observing. Also in the area of space-based observations the term 'network design' can be used and the term is already used in the corresponding community. However, this connotation hasn't yet been adopted generally. So, it is important to recognize that many guidelines and recommendations in this document –when referring to, for example 'network design' or 'observing networks' – are not necessarily restricted to ground-based observations but should be applied to all observing systems.

5.2GUIDANCE ON THE OBSERVING NETWORK DESIGN PRINCIPLES

Note: For convenience, the description of the OND Principles is reproduced in brackets and italic under the name of each principle.

PRINCIPLE 1. – SERVING MANY APPLICATION AREAS

(Observing networks should be designed to meet the requirements of multiple application areas within WMO and WMO co-sponsored Programmes)

Note: A WMO Application Area is an activity involving primary use of observations, in a chain of activities that allow National Meteorological Services or other organizations to render services contributing to public safety, socioeconomic well-being and development in their respective countries, in a specific domain related to weather, climate and water. The concept of a WMO Application Area is used in the framework of the WMO Rolling Review of Requirements (RRR[1]) for observations and describes a homogeneous activity for which it is possible to compile a consistent set of observational user requirements agreed by community experts working operationally in this area.

1. When designing observing networks, the needs of WMO Application Areas, as documented in the Manual on WIGOS, should be taken into account. In particular, see the WIGOS Rolling Review of Requirements (RRR) process, the WIGOS database of user requirements for observations (OSCAR/Requirements) and the Statements of Guidance (http://www.wmo.int/pages/prog/www/OSY/GOS-RRR.html#SOG) for all Applications Areas. As an example, the design of observing networks implemented primarily in support of Application Areas for operational weather forecasting should also take into account the needs of other Applications Areas such as climate monitoring.

2. Where practicable, observing networks should be designed and operated in such a way that the needs of multiple applications are addressed. It is acknowledged that different applications have different, and sometimes conflicting, requirements; when an observing network is implemented primarily to serve the needs of one application, compromises may be needed in its ability to serve others. Nevertheless the requirements of other applications should be actively considered during network design.

3. As part of the management of an observing network, a user consultation procedure should be implemented through which the requirements of different Application Areas can be ascertained, considered and analyzed simultaneously. (See also section 2.)

4. In order to respond to the needs of its Programmes, WMO engages in partnerships with other bodies responsible for observations through co-sponsored programmes – see the Preamble to the Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP: http://www.wmo.int/pages/prog/www/OSY/gos-vision.html#egos-ip). These partnerships should be taken into account when designing observing networks.

[1] The Rolling Review of Requirements is described in WMO-No. 1160, *Manual on WIGOS*, paragraph 2.2.4

5. Partnerships with other organizations (e.g. involved in road transportation, electric power generation, etc.), including partner organizations responsible for observations, should be exploited through the integrated and multi-purpose design of observing networks, in order to achieve synergies between networks and/or domains and improved cost-effectiveness.

PRINCIPLE 2. – RESPONDING TO USER REQUIREMENTS

(Observing networks should be designed to address stated user requirements, in terms of the geophysical variables to be observed and the space-time resolution, uncertainty, timeliness and stability needed)

Note: User requirements for observations are documented and quantified in the Observing System Capability Analysis and Review tool (OSCAR/Requirements). The user requirements as stated in OSCAR are "high-level" in the sense that they are not intended to capture all the detailed requirements that must be taken into account when designing a specific observing system. The requirements in OSCAR/Requirements should therefore be taken into account but they are not sufficient to provide a full description of the observing system requirements.

1. User communities should be involved in observing network design. In order to ensure observing networks respond to the key needs of the user communities, detailed decisions about observing network design should include a consultation stage with appropriate Application Area representatives. A procedure should be implemented to allow a documented collection and synthesis of detailed user requirements.
2. Members should take into account the Actions in the Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP) as well as the gap analyses from the RRR Statements of Guidance (SoGs) for all Application Areas when designing their observing networks.
3. Taking into account observational user requirements specified in OSCAR, together with additional regional requirements that may not be specified in OSCAR, and national requirements, Members should conduct further studies to assess feasibility of addressing them with existing technology, taking resources and cost-effectiveness into account. (See also section 5.)
4. Observational data should be processed to a level (e.g. raw instrument data or calibrated instrument data or retrieved geophysical variable) to be established in consultation with users. This should include agreement on quality control, formats, etc. The appropriate level of processing will vary according to the user communities' needs and to the intended applications. Appropriate resources should be allocated to these data processing requirements. Also, where supported by user requirements, appropriate resources should be allocated to archiving the raw data and metadata, such that data can be reprocessed at a later date.

PRINCIPLE 3. – MEETING NATIONAL, REGIONAL AND GLOBAL REQUIREMENTS

(Observing networks designed to meet national needs should also take into account the needs of WMO at the regional and global levels)

1. National observing networks are designed and established by Members primarily to respond to their own national needs/requirements and in many cases in agreement with other Members and in accordance with WMO regulatory and guidance material. However, when implementing these national networks, Members should take into account the requirements for global and regional applications. For example, Members should consider small additional commitments or adjustments (e.g. in terms of data storage, data policy, availability, exchange and documentation) to make data useful to other Members.
2. WIGOS regulations should be adopted for observing networks that are implemented primarily to respond to national needs.

3. National procedures through which national user requirements are collected and assessed (see section 2.1) should be designed in such a way that regional and global requirements can be addressed simultaneously.
4. For each national network/site, a network/site definition document should be maintained containing information on:
    a. planned observing capabilities of the network/site,
    b. target performances,
    c. user requirements to which the network/site is responding.

PRINCIPLE 4. – DESIGNING APPROPRIATELY SPACED NETWORKS

(Where high-level user requirements imply a need for spatial and temporal uniformity of observations, network design should also take account of other user requirements, such as the representativeness and usefulness of the observations)

1. In general, the composite observing network should be designed in such a way that it delivers basic observations that are quasi-uniform in space for observed variables, and resulting from an analysis of the 3D resolution requirements provided in OSCAR. Gaps should be assessed in accordance with the *Manual on WIGOS* (WMO-No.1160). (See also section 5 for guidance on composite network design.)
2. However, for some Application Areas, the representativeness of observations may be a more important design driver than spatial and temporal homogeneity. In such cases, the density of an observing network should be adjusted according to variability of the observed phenomena in a given region, such as to address the need for greater density of some observations in mountainous and coastal areas where steep gradients in geophysical variables exist. Also, observing networks should be designed with spatial and temporal spacing such that severe, extreme and high-impact events, often of short duration, are captured, and such that climate-relevant changes (e.g. diurnal, seasonal and long-term inter-annual) can be resolved.
3. When considering priorities for additional observations, attention should be given to: data-sparse regions and domains, poorly observed variables, regions sensitive to change, and regions which experience environmental phenomena that place populations at risk. As these are not always located within the territory of the country needing the observations, this creates a need to acquire observations in areas outside the territory of the funding nation or group of nations (e.g. EUMETNET funding of E-ASAP, GCOS Cooperation Mechanism).
4. Observing networks should be designed taking into account measurements and gaps of other systems in the vicinity, e.g. measurements using the same technology in neighbouring countries, or measurements from networks using different technologies, both surface-based and space-based.
5. Surface-based observations have to be representative for specific applications. Sites representative of local features should be generally avoided (e.g. on steep slopes, in hollows, in proximity to pronounced features such as buildings, topographical influences, ridges) unless sited for a specific purpose and application.
6. Non-NMHS observations can provide valuable measurements for filling in observational gaps. In many areas these may be the only available observations, particularly for elements requiring higher density measurements such as precipitation and extreme events such as hail, wind storms, etc. NMHSs should investigate collaborations with others within their country in order to complement existing networks, to share resources and to address gaps. For observations of this type, special attention should be given to possible data-policy issues, and the guidance given in section 3.1 should be followed.
7. Where possible, objective tools should be used to assess the impact and benefit of observations, including demonstration of the impact of observation density. Such tools (e.g. Observing System Experiments, Observing System Simulation Experiments,

Forecast Sensitivities to Observations) exist in NWP and are well-proven. The development of equivalent tools for other Application Areas is encouraged.

PRINCIPLE 5. – DESIGNING COST-EFFECTIVE NETWORKS

(Observing networks should be designed to make the most cost-effective use of available resources. This will include the use of composite observing networks)

1. Observing networks should be designed using the most appropriate and cost-effective technologies or combinations of technologies. Guidance documents from CIMO and other technical commissions on existing technology should be consulted. For example, reference can be made to the *Guide to Climatological Practices* (WMO-No. 100), Chapter 2, 2.5; the *Guide to Agricultural Meteorological Practices* (WMO-No. 134) Chapter 2, 2.2.4, 2.4.1.11.3; and the *Guide to the Global Observing System* (WMO-No.488), Part III, 3.1.
2. Developments to observing networks should, where possible, build on and lead to consolidation of existing sub-networks, capitalizing on both existing and new technology, and integrating new networks into existing WIGOS capabilities.
3. The observing network should evolve in response to changing user requirements. Designs should be sufficiently flexible to allow for incremental expansion, or contraction, without the need for complete network re-design.
4. Partnerships with other organizations responsible for observations should be established or maintained in order to build on potential synergies, share costs and provide more cost-effective multi-purpose networks. Other organizations may include WMO partners (see the Preamble to the Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP) (http://www.wmo.int/pages/prog/www/OSY/gos-vision.html#egos-ip)) or national governmental and non-governmental organizations.
5. Observing network design should, where possible, be based on the results from scientific studies which assess the impact, importance and value of the observations for the applications to which they contribute. Complementary impact-per-cost studies should also be conducted in order to address the cost-effectiveness of various possible observing systems when designing networks.
6. Spaced-based and surface-based observing networks should be designed and operated in such a way that they are complementary, with appropriate activities and cooperation between the communities responsible for these networks, to ensure that observations from each network are used to enhance the impact and effectiveness of each other.
7. Observing networks should be designed taking into account measurements available from other networks in the vicinity including in neighbouring countries, or measurements from networks using different technologies.
8. To optimize benefits within a Member's own territory, an effective observing network may require investment outside the Member's territory. This may be realized through, for example, regional collaboration.
9. Network design may include the need for visual/manual observations and observations of phenomena not necessarily well detected/identified by automated systems or because manual observations are more cost-effective.

For space-based observing systems

10. Space-based observing systems that continue to meet calibration and stability requirements may remain cost-effective for longer than their expected/designed life-time. Operators should consider continuing to operate such systems at a lower level of maintenance after the designed life-time.

PRINCIPLE 6. – ACHIEVING HOMOGENEITY IN OBSERVATIONAL DATA

(Observing networks should be designed so that the level of homogeneity of the delivered observational data meets the needs of the intended applications)

1. Only observing technologies with adequately characterized performance should be deployed, to ensure that levels of observational quality consistent with user requirements are attained.
2. Observing networks should be operated to meet agreed performance targets.
3. Observing networks and stations should be assessed regularly and using objective criteria to ensure that the desired performance standards are being met.
4. As part of routine operations, the quality and homogeneity of data should be regularly assessed through an ongoing programme to monitor performance of the network. This may include both automated and manual checks.
5. A comprehensive monitoring of data availability, timeliness and quality should be implemented. For appropriate observation types, this should include monitoring against NWP short-range forecasts. Monitoring should also be implemented to help detect various types of errors, for example, non-timely or missing data, improperly coded observations, and grossly erroneous measurements.
6. Monitoring results may be made available in different ways, for example, via web portals, regular reports (visualization of overall performance statistics) or fault reports (focus on detected errors at specific sites).
7. When station relocations or instrument upgrades are made, a sufficient period of overlap between the old and new systems, considering the targeted Application Areas, should be made whenever practicable. (See also the section on OND Principle number 12 below.)
8. The availability of complete metadata is essential to assess the homogeneity of observations. (See also Section 10.)
9. For many applications including climate monitoring, it is important that calibration, calibration-monitoring and inter-calibration are designed as part of observing network. For (near) real-time applications, it is important that calibration information is made available in (near) real-time. It is also important that raw data are archived, in order that they can be reprocessed at a later date to improve their homogeneity.
10. Intercomparisons and validation of observations made using different technologies should be undertaken in order to improve understanding of observational uncertainty or relative performances (bias, standard deviation, gross errors).
11. Whilst some non-NMHS observations may be collected using non-standard formats, where possible, all observations should be disseminated using standard quality rules, standard formats and according to standard dissemination procedures.
12. Observations should be disseminated in such a way that the quality and provenance of the original measurement is retained.
13. Members should give a high priority to maintaining the operations of observing stations/sites/systems that have long-term data series, especially for climate applications.
14. For climate monitoring applications, surface-based stations should be sited in locations that are least likely to be impacted by changes through time in the natural or man-made environment.

PRINCIPLE 7. – DESIGNING THROUGH A TIERED APPROACH

(Observing network design should use a tiered structure, through which information from reference observations of high quality can be transferred to other observations and used to improve their quality and utility)

Note: In addition to improving the quality and utility of observations, this approach to design will also lead to improvements in the understanding of the quality of the observations.

1. The tiered approach should include, as a minimum, a sparse network of reference stations (e.g., GRUAN) from which other stations can be benchmarked. Reference

stations should be calibrated to SI or community-accepted traceable standards with fully quantified uncertainties, have the highest level of robustness (e.g. duplicate or triplicate sensors of key variables such as temperature and precipitation), be well sited in locations least affected by urbanization and other non-climatic influences, have regular maintenance and replacement cycling of instruments, the highest standard of metadata collection including photo documentation, and continuous monitoring of system performance to resolve instrument and environmental issues as they arise.

2. Stations such as the "baseline" networks of GCOS (GSN, GUAN) can form an intermediate data layer, with quality between that of Reference stations and the larger comprehensive network of observing stations[2].
3. In the field of space-based observing, satellite redundancy should be used whenever appropriate to ensure the reliability of data provision from certain orbits. With regards to ground-based observations even at non-reference stations, instrument redundancy should be used whenever appropriate to ensure the reliability of the observation and measurement accuracy.
4. In addition to geostationary and low-Earth orbit sun-synchronous constellations, space-based observing networks should include high eccentricity orbits to permanently cover the Polar Regions, low or high-inclination low-Earth orbiting satellites for comprehensive sampling of the global atmosphere and lower-flying platforms such as short-life nanosatellites as gap fillers.
5. A network of other NMHS or non-NMHS stations can be interspersed with a subset of high quality stations for more complete coverage.
6. Network design should include consideration of skills and training needed for staff, which is expected to be different at different levels in the tiered structure. Expertise of staff at Reference stations should be used to provide guidance to other parts of the network.

PRINCIPLE 8. – DESIGNING RELIABLE AND STABLE NETWORKS

(Observing networks should be designed to be reliable and stable)

1. The design and implementation of observing networks should ensure that standard operating procedures and practices are followed, including appropriate maintenance and calibration procedures.
2. Data quality objectives should be defined for each network. Decisions will need to be made regarding the level of quality control to be applied. Fully automatic quality control with no manual assessment may be the most cost-effective but in some cases may result in a lower level of quality.
3. Station site/satellite orbit selection criteria should be based on the purpose and tier of the network. Criteria associated with length of time the station/satellite will be operated, available energy sources, data transmission options, and factors associated with homogeneity and the local environment should be considered.
4. Training should be commensurate with the network tier. A basic network consisting of manual observations should focus on sound observing techniques and methods for data recording and dissemination. For automated networks, training should focus to a greater degree on maintenance and operation of instruments and automatic data collection methods. Operation of reference networks will require the greatest level of training and higher standards for calibration, inspection, maintenance and management.
5. Observing networks, both ground-based stations and space-based systems, and their telecommunications should be designed to be robust against exposure to severe weather, hydrological, climate and other environment conditions (e.g. geomagnetic storms, space-debris in case of satellites).

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[2] See GAIA-CLIM Report / Deliverable D1.3, Gap analysis for integrated atmospheric ECV climate monitoring: Report on system of systems approach and rationale – http://www.gaia-clim.eu/workpackagedocument/d13-report-system-systems-approach-adopted-and-rationale

6. A combination of standard and backup power sources (e.g. sustainable such as solar, water and wind for ground-based stations and other appropriate source for satellites) should be used, whenever possible, to better ensure uninterrupted operation of observing platforms in all environmental conditions.
7. When possible, data should be made available to global collection centres where data monitoring can be performed and feedback provided in near real-time regarding data quality, including frequency and character of observational errors, reporting percentages, completeness and timeliness.
8. Monitoring procedures described under Section 6 should also help in assessing the current and long-term reliability and stability of networks.
9. The functioning of the operations of an observing network and its components should be monitored and supported by incident/fault management, in order improve reliability and stability of a network.
10. For the purpose of climate monitoring, special attention should be given to maintaining stations/satellite orbits with long, historically-uninterrupted records and to maintaining their homogeneity in location, instrumentation, and observing procedures.
11. Parallel long-term (e.g. on site) data storage should be designed to augment real-time dissemination which will help ensure original observations are preserved (e.g. on site) to allow for the higher level of quality and completeness required for climate applications.
12. Station sites/satellite orbits should be selected in areas least likely to be impacted by factors such as new construction that will force station relocations.

PRINCIPLE 9. – MAKING OBSERVATIONAL DATA AVAILABLE

(Observing networks should be designed and should evolve in such a way as to ensure that the observations are made available to other WMO Members, at space-time resolutions and with a timeliness that meet the needs of regional and global applications)

1. Data availability gaps with respect to the stated user requirements must be addressed. Members should: (i) make efforts to collect and disseminate observations that are made but not currently collected centrally; (ii) exchange existing data internationally in accordance with the *Manual on WIGOS* (WMO-No. 1160); and (iii) improve data timeliness.
2. Mechanisms should be established to minimize the loss of existing observational data and to promote the recovery of historical records for climate applications.
3. Multiple and overlapping methods of dissemination (e.g. through multiple routes) that comply with the Technical Regulations should be used to improve continuity of data delivery to users.
4. Cloud concepts and other methods for expanding telecommunications capacities should be considered for managing the rapid growth in data volumes of 2D- and 3D-scanning remote-sensing observing systems (e.g. satellites and Radars).
5. To facilitate data availability and access, WMO-defined standard data formats should be used for data exchange.

For climate applications

6. All raw data and agreed subsets of processed data should be collected into a documented and permanent data and metadata record following common standards (e.g., GCOS-143) and archived in a World Data Centre or other recognized data centre.
7. A sustained operational capability is required, to produce and maintain the archived data record throughout and after the life of the observing network.
8. Resources should be allocated to ensure appropriate reprocessing of observational data to respond to the needs of climate applications.

PRINCIPLE 10. – PROVIDING INFORMATION SO THAT THE OBSERVATIONS CAN BE INTERPRETED

(Observing networks should be designed and operated in such a way that the details and history of instruments, their environments and operating conditions, their data processing procedures and other factors pertinent to the understanding and interpretation of the observational data (i.e. metadata) are documented and treated with the same care as the data themselves)

1. Metadata practices should adhere to the WIGOS Metadata Standard as specified in the *Manual on WIGOS* (WMO-No. 1160).
2. Members should follow standard procedures to collect, check, share and distribute the WIGOS metadata that are required for international exchange, to ensure appropriate homogeneous use of the observational data, and knowledge of their quality and traceability; additional WIGOS metadata should be recorded by Members and be made available on request.
3. Station metadata should be created at the time of network installation and updated regularly to include information such as station location, the surrounding environment, instrumentation type and calibration metrics, observing practices, and maintenance. Whenever possible photographic images of the station and environment should be made and archived annually.
4. WIGOS metadata should be updated whenever changes occur, including changes in sheltering and exposure, changes in mean calculations, observation hours, land-use changes, new types of instruments, changes in quality control, homogenization and data recovery procedures.
5. Wherever possible, users should be given advance notice of changes in instruments and data processing.

PRINCIPLE 11. – ACHIEVING SUSTAINABLE NETWORKS

(Improvements in sustained availability of observations should be promoted through the design and funding of networks that are sustainable in the long-term including, where appropriate, through the transition of research systems to operational status)

Note: In this context, "sustainable" means that the network can be maintained in the medium- to long-term. This is desirable for most operational applications and is required for climate monitoring. Requirements for systems to be robust and for their data to be of appropriate quality are discussed in other sections.

1. Some research-based systems, where appropriate, mature and cost-effective, should evolve to a status of secure long-term funding, while maintaining or improving the availability and quality of the observations.
2. The transition of research observing systems or new observing technologies to long-term operations requires careful coordination between data providers and users (both research and operational users).
3. Members should ensure that their funding for the sustained networks remains sufficient in the longer term taking into account the required evolutions and changes (e.g. technology). (See also section 12.)
4. Transition of research-based observing systems or new observing technologies to long-term operations should include the design of robust and maintainable systems that assure appropriate data collection, quality control, archive and access.
5. Members should take steps to make pre-operational data available to users on a best efforts basis to facilitate early uptake and adoption of the new data, once operational.
6. Written agreement for operational collection and archive of observations should be made with a recognized archive centre.
7. When selecting sites/stations/satellite orbits, network planners and administrators

should consider locations that can be secured through long-term agreements (e.g. leases or ownership for ground-based observing sites).

8. Other useful guidance materials are available in the GAIA-CLIM Report/Deliverable D1.3, Gap analysis for integrated atmospheric ECV climate monitoring: Report on system of systems approach and rationale[2].

PRINCIPLE 12. – MANAGING CHANGE

(The design of new observing networks and changes to existing networks should ensure adequate consistency, quality and continuity of observations during the transition from the old system to the new)

Note: When considering which changes might be consistent with WMO strategy, reference should be made to the Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP) (http://www.wmo.int/pages/prog/www/OSY/gos-vision.html#egos-ip).

1. The impact of new systems or changes to existing systems on user applications should be assessed prior to implementation taking into account observational user requirements of all Application Areas.
2. A suitable period of overlap for new and old observing systems is required (i.e. parallel observations) to maintain the homogeneity and consistency of observations in time.
3. Test-beds and pilot projects are required through which new systems can be tested and evaluated, and guidelines for operational transition (including the production and dissemination of the necessary new metadata) developed.
4. The objective tools demonstrating the impact and benefit of observations for certain Application Areas should be used, where possible, to support change management. (See also section 4.)

For climate applications

5. To avoid gaps in the use of the long-term record, continuity of key measurements should be ensured through appropriate strategies.
6. When a period of overlap between old and new systems is not possible, other methods such as paired observations (co-location of original and new instrumentation) should be used.
7. When introducing a change, efforts should be made to retain as many similarities as possible between the old and new system (e.g. similar site exposure for ground-based systems, similar orbital position for space-based systems, similar procedures, instruments and sensors).

ANNEX TO PARAGRAPH 5: EXPLANATION OF TERMS RELATED TO OBSERVING NETWORK GUIDANCE

Note: formal definitions of terms are published in Technical Regulations *(WMO-No. 49) rather than in guides.*

An *integrated station network* consists of multipurpose stations and/or stations of the different types in the same geographical area, which is applying the agreed WMO practices.

A *tiered network* is a network designed in accordance with (or following) an industry standard hierarchical network model.

Third parties are persons or organizations who are not a party to a contract or a transaction, but have an involvement. The third party normally has no legal rights in the matter, unless the contract was made for the third party's benefit.

Recommendation 4 (CBS-16)

REVISED *MANUAL ON THE GLOBAL OBSERVING SYSTEM* (WMO-No. 544) AND *GUIDE TO THE GLOBAL OBSERVING SYSTEM* (WMO-No. 488)

THE COMMISSION FOR BASIC SYSTEMS,

Noting the recent finalization within the Implementation–Coordination Team on Integrated Observing Systems (ICT-IOS) of draft new regulatory material for the *Manual on the Global Observing System* (WMO-No. 544), Volume I – Global Aspects,

Noting further the finalization within ICT-IOS of updated draft guidance material for the *Guide to the Global Observing System* (WMO-No. 488),

Having considered the proposed amendments, which respond to the WMO Integrated Global Observing System (WIGOS) call for increased global standardization of observing technologies and techniques, and address, in particular:

(1) WIGOS station identifiers,

(2) Automatic weather station systems,

(3) Aircraft meteorological stations,

(4) Radar wind profiler stations,

(5) Weather radar stations,

(6) The Voluntary Observing Ships scheme,

Recommends the Executive Council:

(1) To amend the *Manual on the Global Observing System*, Volume I, Global Aspects, as detailed in Annex 1 to the present recommendation;

(2) To amend the *Guide to the Global Observing System*, as detailed in Annex 2 to the present recommendation.

Annex 1 to Recommendation 4 (CBS-16)

AMENDMENTS TO THE *MANUAL ON THE GLOBAL OBSERVING SYSTEM* (WMO-No. 544), VOLUME I, GLOBAL ASPECTS

SECTION: Cover red
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Manual on the Global Observing System

Volume I – Global Aspects

Annex V to the WMO Technical Regulations

SECTION: TitlePage

Manual on the Global Observing System

Volume I – Global Aspects

Annex V to the WMO Technical Regulations

SECTION: ISBN-long
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PUBLICATION REVISION TRACK RECORD

TABLE: Revision table

Date	*Part/chapter/ section*	*Purpose of amendment*	*Proposed by*	*Approved by*

SECTION: Table_of_contents
SECTION: Pr-Preliminary_pages

INTRODUCTION

Purpose and scope

1. The Manual is designed:

(a) To facilitate cooperation in observations between Members;

(b) To specify obligations of Members in the implementation of the World Weather Watch (WWW) Global Observing System (GOS);

(c) To ensure adequate uniformity and standardization in the practices and procedures employed in achieving (a) and (b) above.

2. The first edition of the *Manual on the Global Observing System* was issued in 1980 in accordance with the decisions of the Seventh World Meteorological Congress. Since then it has undergone a number of revisions and amendments. The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) will eventually replace the present Manual entirely, and the transfer process begians with theis 2015 edition – some of its provisions have been removed and are now incorporated into the *Manual on the WMO Integrated Global Observing System*. For now these two Manuals are companion documents and must be read together. In particular, the provisions of the *Manual on the WMO Integrated Global Observing System* apply to all component observing systems, including the GOS.

3. This Manual is composed of Volumes I and II, which contain the regulations for the global and regional aspects of the System, respectively. The regulations stem from recommendations of the Commission for Basic Systems and resolutions of regional associations, as well as from decisions taken by Congress and the Executive Council.

4. Volume I of the Manual – Global Aspects – has regulatory status and is referred to as Annex V to the *Technical Regulations* (WMO-No. 49).

5. Volume II of the Manual – Regional Aspects – does not have regulatory status.

6. In essence, the Manual specifies what is to be observed where and when in order to meet the relevant observational requirements of Members. The *Guide to the Global Observing System* (WMO-No. 488) provides detailed guidance on how to establish, operate and manage networks of stations to make these observations. While some regulatory material concerning instruments and methods of observation is contained in a special short section of the Manual, a full description of how and with what observations are made is contained in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8). The *International Cloud Atlas* (WMO-No. 407) describes the classification of clouds. The subsequent step of how observations are to be reported and encoded is specified in the *Manual on Codes* (WMO-No. 306). Further guidance on observations for special applications is given in WMO publications such as the *Guide to Meteorological Observing and Information Distribution Systems for Aviation Weather Services* (WMO-No. 731), *Guide to Marine Meteorological Services* (WMO-No. 471), *Guide to Climatological Practices* (WMO-No. 100), *Guide to Agricultural Meteorological Practices* (WMO-No. 134) and various publications of the Global Atmosphere Watch Programme.

SECTION: Pr-Preliminary_pages

GENERAL PROVISIONS

1. The *Technical Regulations* (WMO-No. 49) of the World Meteorological Organization are presented in four volumes:

Volume I – General meteorological standards and recommended practices
Volume II – Meteorological service for international air navigation
Volume III – Hydrology
Volume IV – Quality management

Purpose of the Technical Regulations

2. The Technical Regulations are determined by the World Meteorological Congress in accordance with Article 8 (d) of the Convention.

3. These Regulations are designed:

(a) To facilitate cooperation in meteorology and hydrology among Members;

(b) To meet, in the most effective manner, specific needs in the various fields of application of meteorology and operational hydrology in the international sphere;

(c) To ensure adequate uniformity and standardization in the practices and procedures employed in achieving (a) and (b) above.

Types of Regulations

4. The Technical Regulations comprise *standard* practices and procedures and *recommended* practices and procedures.

5. The definitions of these two types of Regulations are as follows:

The *standard* practices and procedures:

(a) Shall be the practices and procedures that Members are required to follow or implement;

(b) Shall have the status of requirements in a technical resolution in respect of which Article 9 (b) of the Convention is applicable;

(c) Shall invariably be distinguished by the use of the term *shall* in the English text, and by suitable equivalent terms in the Arabic, Chinese, French, Russian and Spanish texts.

The *recommended* practices and procedures:

(a) Shall be the practices and procedures with which Members are urged to comply;

(b) Shall have the status of recommendations to Members, to which Article 9 (b) of the Convention shall not be applied;

(c) Shall be distinguished by the use of the term *should* in the English text (except where otherwise provided by decision of Congress) and by suitable equivalent terms in the Arabic, Chinese, French, Russian and Spanish texts.

6. In accordance with the above definitions, Members shall do their utmost to implement the *standard* practices and procedures. In accordance with Article 9 (b) of the Convention and in conformity with Regulation 128 of the General Regulations, Members shall formally notify the Secretary-General, in writing, of their intention to apply the *standard* practices and procedures of the Technical Regulations, except those for which they have lodged a specific deviation. Members shall also inform the Secretary-General, at least three months in advance, of any change in the degree of their implementation of a *standard* practice or procedure as previously notified and the effective date of the change.

7. Members are urged to comply with *recommended* practices and procedures, but it is not necessary to notify the Secretary-General of non-observance except with regard to practices and procedures contained in Volume II.

8. In order to clarify the status of the various Regulations, the *standard* practices and procedures are distinguished from the *recommended* practices and procedures by a difference in typographical practice, as indicated in the editorial note.

Status of annexes and appendices

9. The following annexes to the *Technical Regulations* (Volumes I to IV), also called Manuals, are published separately and contain regulatory material having the status of *standard* and/or *recommended* practices and procedures:

I *International Cloud Atlas* (WMO-No. 407), Volume I – Manual on the Observation of Clouds and Other Meteors, Part I; Part II: paragraphs II.1.1, II.1.4, II.1.5 and II.2.3; subparagraphs 1, 2, 3 and 4 of each paragraph from II.3.1 to II.3.10; paragraphs II.8.2 and II.8.4; Part III: paragraph III.1 and the definitions (in italics) of paragraph III.2;
II *Manual on Codes* (WMO-No. 306), Volume I;
III *Manual on the Global Telecommunication System* (WMO-No. 386);
IV *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), Volume I;
V *Manual on the Global Observing System* (WMO-No. 544), Volume I;
VI *Manual on Marine Meteorological Services* (WMO-No. 558), Volume I;
VII *Manual on the WMO Information System* (WMO-No. 1060);
VIII *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

These annexes (Manuals) are established by decision of Congress and are intended to facilitate the application of Technical Regulations to specific fields. Annexes may contain both *standard* and *recommended* practices and procedures.

10. Texts called appendices, appearing in the *Technical Regulations* or in an annex to the *Technical Regulations*, have the same status as the Regulations to which they refer.

Status of notes and attachments

11. Certain notes (preceded by the indication "Note") are included in the *Technical Regulations* for explanatory purposes; they may, for instance, refer to relevant WMO Guides and publications. These notes do not have the status of Technical Regulations.

12. The *Technical Regulations* may also include attachments, which usually contain detailed guidelines related to *standard* and *recommended* practices and procedures. Attachments, however, do not have regulatory status.

Updating of the *Technical Regulations* and their annexes (Manuals)

13. The *Technical Regulations* are updated, as necessary, in the light of developments in meteorology and hydrology and related techniques, and in the application of meteorology and operational hydrology. Certain principles previously agreed upon by Congress and applied in the selection of material for inclusion in the *Technical Regulations* are reproduced below. These principles provide guidance for constituent bodies, in particular technical commissions, when dealing with matters pertaining to the *Technical Regulations*:

(a) Technical commissions should not recommend that a Regulation be a *standard* practice unless it is supported by a strong majority;

(b) *Technical Regulations* should contain appropriate instructions to Members regarding implementation of the provision in question;

(c) No major changes should be made to the *Technical Regulations* without consulting the appropriate technical commissions;

(d) Any amendments to the *Technical Regulations* submitted by Members or by constituent bodies should be communicated to all Members at least three months before they are submitted to Congress.

14. Amendments to the *Technical Regulations* – as a rule – are approved by Congress.

15. If a recommendation for an amendment is made by a session of the appropriate technical commission and if the new regulation needs to be implemented before the next session of Congress, the Executive Council may, on behalf of the Organization, approve the amendment in accordance with Article 14 (c) of the Convention. Amendments to annexes to the *Technical Regulations* proposed by the appropriate technical commissions are normally approved by the Executive Council.

16. If a recommendation for an amendment is made by the appropriate technical commission and the implementation of the new regulation is urgent, the President of the Organization may, on behalf of the Executive Council, take action as provided by Regulation 9 (5) of the General Regulations.

Note: Detailed procedures for amending the *Manual on the GOS* and other Manuals that are the responsibility of CBS are provided in Annex 1 of Resolution 12 (EC-68), to be incorporated into the WMO *Technical Regulations* (WMO-No. 49) Volume 1 as Appendix E, in accordance with Resolution 21 (Cg-17). These procedures include simple (fast-track) procedures which may be used for amendments to designated technical specifications in the *Manual on the GOS*. However there are no such designations in this 2017 update. ~~A fast-track procedure can be applied for additions to certain codes and associated code tables contained in Annex II (*Manual on Codes* (WMO-No. 306)). Application of the fast-track procedure is described in detail in Annex II.~~

17. After each session of Congress (every four years), a new edition of the *Technical Regulations*, including the amendments approved by Congress, is issued. With regard to the amendments between sessions of Congress, Volumes I, III and IV of the *Technical Regulations* are updated, as necessary, upon approval of changes thereto by the Executive Council. The *Technical Regulations* updated as a result of an approved amendment by the Executive Council are considered a new update of the current edition. The material in Volume II is prepared by the World Meteorological Organization and the International Civil Aviation Organization working in close cooperation, in accordance with the Working Arrangements agreed by these Organizations. In order to ensure consistency between Volume II and Annex 3 to the Convention on International Civil Aviation – *Meteorological Service for International Air Navigation*, the issuance of amendments to Volume II is synchronized with the respective amendments to Annex 3 by the International Civil Aviation Organization.

Note: Editions are identified by the year of the respective session of Congress whereas updates are identified by the year of approval by the Executive Council, for example "Updated in 2012".

WMO Guides

18. In addition to the *Technical Regulations*, appropriate Guides are published by the Organization. They describe practices, procedures and specifications which Members are invited to follow or implement in establishing and conducting their arrangements for compliance with the Technical Regulations, and in otherwise developing meteorological and hydrological services in their respective countries. The Guides are updated, as necessary, in the light of scientific and technological developments in hydrometeorology, climatology and their applications. The technical commissions are responsible for the selection of material to be included in the Guides. These Guides and their subsequent amendments shall be considered by the Executive Council.

SECTION: Chapter
Chapter title in running head: PART I. GENERAL PRINCIPLES REGARDING TH…

PART I. GENERAL PRINCIPLES REGARDING THE ORGANIZATION AND IMPLEMENTATION OF THE GLOBAL OBSERVING SYSTEM

1. PURPOSE OF THE GLOBAL OBSERVING SYSTEM

1.1 The purpose of the Global Observing System shall be to provide, from all parts of the globe and from outer space, high-quality standardized observations of the state of the atmosphere, land and ocean surface for the preparation of weather

analyses, forecasts and warnings and for other applications in support of WMO Programmes and related environmental programmes of other organizations.

1.2 The GOS should provide supplementary observations required internationally for special purposes, provided this does not obstruct the achievement of the primary purposes of the World Weather Watch.

2. ORGANIZATION AND DESIGN OF THE GLOBAL OBSERVING SYSTEM

2.1 The GOS shall be organized as part of the WWW, in conjunction with the Global Data-processing and Forecasting System and the Global Telecommunication System (GTS).

2.2 The GOS shall be constituted as a coordinated system of methods, techniques and facilities for making observations on a worldwide scale and as one of the main components of the WWW, taking into account to the extent feasible the requirements of other international programmes.

2.3 The GOS shall consist of facilities and arrangements for making observations at stations on land and at sea, from aircraft, from environmental observation satellites and other platforms.

2.4 For convenience in the planning and coordinating of the system, taking into account various criteria for observational data requirements, the GOS shall be considered as composed of three levels: global, regional and national.

2.5 The GOS shall be designed as a flexible and developing system capable of continuous improvement, on the basis of the latest achievements of technological and scientific progress and in accordance with changing requirements for observational data.

2.6 The planning and coordination of the GOS shall be realized through recommendations of the Commission for Basic Systems and approved by the Executive Council, in consultation and coordination with Members, regional associations and other technical commissions concerned.

2.7 The GOS shall consist of two subsystems: the surface-based subsystem and the space-based subsystem.

2.8 The GOS surface-based subsystem shall be composed of surface synoptic land and sea stations, upper-air synoptic stations, climatological stations, agricultural meteorological stations, aircraft meteorological stations, aeronautical meteorological stations, research and special-purpose vessel stations and special stations as detailed in Part III, paragraph 1 (a) to (h) of this Manual.

2.9 The main elements of the GOS surface-based subsystem shall consist of networks of surface synoptic stations on land and at sea, ~~and~~ upper-air stations, ~~and~~ aircraft meteorological stations, radar wind profiler stations and weather radar stations, as detailed in Part III, paragraph 1 (a) to (~~c~~e) of this Manual.

2.10 Other elements of the GOS surface-based subsystem shall consist of aeronautical meteorological stations, climatological stations, agricultural

meteorological stations, research and special-purpose vessel stations and special stations as listed in Part III, paragraph 1 (f~~d~~) to (l~~h~~) of this Manual.

2.11 The GOS space-based subsystem shall comprise satellites of three types: operational low Earth orbit and operational geostationary satellites and research and development satellites.

3. IMPLEMENTATION OF THE GLOBAL OBSERVING SYSTEM

3.1 Countries themselves are responsible for all activities connected with the implementation of the GOS on their individual territories and should fund them, to the extent possible, using national resources.

3.2 Implementation of the GOS on the territory of developing countries should be based on the principle of the utilization of national resources but, where necessary and so requested, assistance may be provided in part through:

(a) The WMO Voluntary Cooperation Programme;

(b) Other bilateral or multilateral arrangements, including the United Nations Development Programme, which should be used to the maximum extent possible.

3.3 Implementation of the GOS in regions outside the territories of individual countries (for example, outer space, oceans, the Antarctic) should be based on the principle of voluntary participation of countries that desire and are able to contribute by providing facilities and services, either individually or jointly from their national resources, or by having recourse to collective financing. The assistance sources described in 3.2 above may also be used.

3.4 In the implementation of the GOS, maximum use should be made of existing arrangements, facilities and personnel.

Note 1. The setting up and operation of the new and improved facilities and services require a considerable amount of scientific research, development engineering, coordination of procedures, standardization of methods and implementation coordination.

Note 2. The further development of the GOS is an important feature of the WWW plan that provides for:

(a) Continued development of the GOS as a cost-effective composite system comprising operationally reliable surface-based and space-based (satellite) subsystems. It is expected that, within the surface-based subsystem, new systems measuring both large and local scales of atmospheric phenomena will be deployed operationally on a wider scale. Increasing use will be made of the rapidly growing fleet of aircraft with automated observing and reporting systems to observe data at cruising levels and during ascent and descent. Radar wind profilers will play an important role in upper-air networks. International exchange of weather radar observational data will enhance Members' ability to provide services for the good of all. Mobile sea stations will continue to be the main source for surface synoptic observations over the oceans. Through increased use of automatic observing and (satellite) transmission equipment, the quality and quantity of the data will increase. The number of ships equipped with automated upper-air sounding facilities (as part of the Automated Shipboard Aerological Programme) will increase and the deployment of more cost-effective systems will be accelerated. Drifting buoys, deployed outside the main shipping routes, will continue to supply surface atmospheric and oceanographic parameters from the data-void ocean areas. It is also expected that the operational space-based subsystem will include a new generation of polar-orbiters and geostationary satellites with improved and new sensing systems.

(b) Coordination, integration and sustainability of composite surface- and space-based subsystems and development of observing networks that are adaptable to changing requirements. This will include the planning for a new composite upper-air observing system making the most effective use of new and emerging technology, in order to develop a cost-effective, truly global system with the density of in situ observations required for operational purposes as well as to complement and calibrate observations from satellites. The new composite system will utilize a range of technologies and techniques, some of which require long-term development efforts to become operational. New technology should be introduced as and when proven and must be consistent with existing systems and supporting structures.

(c) Development of new strategies to facilitate closer cooperation between Meteorological Services and research programmes so that the available observing systems and programmes can be of use to operational meteorology and the research community.

(d) Exploration of new ways for Members to contribute to the GOS, including joint funding and innovative arrangements to ensure adequate observations in remote and data-sparse areas.

3.5 Existing elements of the GOS, as defined in Part III, shall not be removed before the reliability of a new element has been proven, and relative accuracy and representativeness of the observational data have been examined and found acceptable.

SECTION: Chapter
Chapter title in running head: PART II. REQUIREMENTS FOR OBSERVATIONAL...

PART II. REQUIREMENTS FOR OBSERVATIONAL DATA

EDITORIAL NOTE: NO CHANGES ARE PROPOSED TO PART II.

THE ENTIRE TEXT OF THIS PART HAS BEEN EXCISED FOR THE SAKE OF BREVITY.

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SECTION: Chapter
Chapter title in running head: PART III. SURFACE-BASED SUBSYSTEM

PART III. SURFACE-BASED SUBSYSTEM

1. COMPOSITION OF THE SUBSYSTEM

The main elements of the surface-based subsystem shall be:

(a) Surface synoptic stations:

(i) Land stations:

- **Manned surface stations;**
- **Automatic surface stations;**[3]

(ii) Sea stations:

- **Fixed sea stations:**
  - **Ocean weather stations;**
  - **Lightship stations;**
  - **Fixed platform stations;**
  - **Anchored platform stations;**
  - **Island and coastal stations;**
- **Mobile sea stations:**
  - **Voluntary observing ship stations**

- Selected ship stations;
- Selected AWS ship stations;
- VOSClim (VOS Climate) ship stations;
- VOSClim (VOS Climate) AWS ship stations;
- Supplementary ship stations;
- Supplementary AWS ship stations;
- Auxiliary ship stations;
- Auxiliary ship AWS stations;
- Ice-floe stations;
- Automatic sea stations:[1]
  - Fixed sea stations;
  - Lightship stations;
  - Mobile sea stations;
  - Drifting buoy stations;
  - Moored buoy stations;

(b) Upper-air synoptic stations:

- Rawinsonde stations;
- Radiosonde stations;
- Radiowind stations;
- Pilot-balloon stations;

(c) Aircraft meteorological stations;

(d) Radar wind profiler stations;

(e) Weather radar stations;

other elements of the subsystem shall be:

(f~~d~~) Aeronautical meteorological stations;

(g~~e~~) Research and special-purpose vessel stations;

(h~~f~~) Climatological stations;

(i) Global Climate Observing System Surface Network stations;

(j) Global Climate Observing System upper-air stations;

(k~~g~~) Agricultural meteorological stations;

(l~~h~~) Special stations, which include:

- ~~(i) Weather radar stations;~~
- (i~~i~~) Radiation stations;
- (ii~~i~~) ~~Wind profilers~~Other remote-sensing profiler stations;
- (iii~~v~~) ~~Atmospherics~~ Lightning ~~detection~~ location stations;
- (iv) Meteorological reconnaissance aircraft stations;
- ~~(vi) Meteorological rocket stations;~~

(vii) Global Atmosphere Watch stations;

(viii) Planetary boundary-layer stations;

(vix) Tide-gauge stations.

Note 1. Definitions of stations listed above will be found in the appendix to this Manual.

Note 2. Any station may fall under more than one of the above categories.

Note 3. Observations from automatic surface synoptic stations on land or at sea may be asynoptic when collected via satellite.

2. IMPLEMENTATION OF ELEMENTS OF THE SUBSYSTEM

2.1 Networks of observing stations

2.1.1 General

2.1.1.1 Three types of networks of observing stations – global, regional and national, to meet the three levels of requirements for observational data – shall be established.

2.1.1.2 The networks should be interdependent, with selected stations of the national networks within a Region comprising the corresponding regional network, and with selected stations of the regional networks forming the global network. Therefore, a station of the global network should be part of a regional network and a national network.

2.1.1.3 The frequency and spacing of the observations should be adjusted to the physical scales of the meteorological phenomena to be described.

Note: See the *Guide to the Global Observing System* (WMO-No. 488), Figure II.1.

2.1.2 Global networks

2.1.2.1 A global synoptic network shall be established, based upon the Regional Basic Synoptic Networks (RBSNs).

Note: See 2.1.3 below.

2.1.2.2 The observing programme of the global synoptic network should provide meteorological data which have the necessary accuracy, and spatial and temporal resolution, to describe the state of temporal and spatial changes in the meteorological phenomena and processes occurring on the large and planetary scales.

Note: Guidance as to the determination of requirements for accuracy and time and spatial resolution of the observational data is given in the *Guide to the Global Observing System* (WMO-No. 488).

2.1.2.3 The global synoptic network should be as homogeneous and as uniform as possible, and observations should be made at the main standard times of observation.

2.1.2.4 Members should implement and sustain the Global Climate Observing System (GCOS) Surface Network (GSN) – the global baseline network of some 1 000 selected surface observing stations established to monitor daily global and large-scale climate variability.

2.1.2.5 Members should implement and sustain the GCOS Upper-air Network (GUAN) – the global baseline network of about 170 selected upper-air stations established with relatively homogenous distribution to meet requirements of GCOS.

2.1.2.6 Members should also establish and sustain the GCOS Reference Upper-air Network (GRUAN) of about 30 to 40 selected upper-air stations, to provide long-term high quality

climate records, to constrain and calibrate data from more spatially-comprehensive global observing systems (including satellites and current radiosonde networks), and to fully characterize the properties of the atmospheric column.

2.1.3 Regional networks

2.1.3.1 Regional networks shall be established in relation to the regional requirements.

Note: Regional associations are responsible for the determination and coordination of the composition of these networks within the general framework established by the Commission for Basic Systems.

2.1.3.2 Regional Basic Synoptic Networks of both surface and upper-air stations and Regional Basic Climatological Networks (RBCNs) of climatological stations shall be established to meet the requirements laid down by the regional associations.

Note 1. The regional associations will review their plans regularly, in order to ensure that they meet any new international requirements.

Note 2. Details of known regional requirements are given in Volume II of this Manual.

2.1.3.3 Together, the RBSNs shall form the main part of the global surface-based synoptic network.

2.1.3.4 Members shall implement the RBSNs.

2.1.3.5 The horizontal spacing of observing stations and the frequency of their reporting should be in accordance with the requirements laid down in Part II above and in Volume II of this Manual.

2.1.4 National networks

National networks shall be established by Members to satisfy their own requirements. When implementing these national networks, Members shall take into account the need to participate in, and form part of, the global and regional networks.

Note: A complete list of all surface and upper-air stations in operation which are used for synoptic purposes is given in *Weather Reporting* (WMO-No. 9), Volume A – Observing Stations.

2.2 Observing stations

2.2.1 General

2.2.1.1 The implementation and operation of each of the above elements should be in accordance with decisions of Congress, the Executive Council, the technical commissions and regional associations concerned.

Note: These decisions are reflected in the *Technical Regulations* (WMO-No. 49) and its annexes, for example this Manual and the *Manual on Codes* (WMO-No. 306), and in other relevant WMO publications such as the *Guide to the Global Observing System* (WMO-No. 488) and the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), which set forth the technical and meteorological aspects in detail.

2.2.1.2 In implementing the GOS surface-based subsystem, Members should ensure that the observing system meets the subsystem requirements.

2.2.1.3 In implementing the surface-based subsystem, Members should strive to meet the provisions of the decisions indicated in 2.2.1.1 above as closely as possible, in particular as regards the main elements of the surface-based subsystem.

2.2.1.4 Each station shall be uniquely identified by a WIGOS station identifier.

Note: Further regulations and notes relating to station identifiers are to be found in sections 2.4.1.1 to 2.4.1.4 of the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

2.2.1.5~~4~~ Each station should be located at a site that permits correct exposure of the instruments and satisfactory non-instrumental observations.

2.2.1.6~~5~~ In general, observing stations shall be spaced at an interval and observations shall be taken frequently enough to provide an accurate description of the atmosphere for those who use the observations for their intended purpose.

2.2.1.7~~6~~ If in certain desert and other sparsely populated areas it is not possible to establish networks with the recommended densities, networks with densities as near as possible to those recommended should be established. Special efforts should be made to establish an adequate network in such areas when they border a populated area or are traversed by a regularly used air route.

2.2.1.8~~7~~ Asynoptic observations should be taken when necessary to complement observations from the synoptic networks and in a manner which increases the overall observational spatial or temporal density.

2.2.1.9~~8~~ Observations should be taken in areas where special phenomena are occurring or are expected to develop. As many meteorological elements of standard observations as possible should be reported. Information should be communicated in real time.

Note: Drifting buoys and aircraft may also report at asynoptic times.

2.2.1.10~~9~~ Members shall ensure that a record of all surface and upper-air observations is made and preserved.

2.2.2 Operation of Automatic Weather Station (AWS) systems

Note 1. This section contains provisions for the operation of AWS systems in support of their contribution to the Global Observing System and to WIGOS. It is structured so as to anticipate the eventual integration of the material into the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

Note 2. The provisions of this section 2.2.2 are specific to AWS systems. They must be read in conjunction with further provisions throughout Part III as well as the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) with which AWS operated by Members are to comply.

Note 3. The provisions in this section are directed to Members that operate AWS and provide data to the WMO Information System (WIS).

Note 4. Guidance on making measurements using AWS can be found in *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part II, Chapter 1.

Note 5. Guidance on network planning and site selection in relation to AWS can be found in the *Guide to the Global Observing System* (WMO-No. 488), Part III, Section 3.2.1.4.

General Requirements

2.2.2.1 Members shall establish and operate an AWS network to meet national, regional and global requirements for observations.

Note 1. General provisions for equipment and methods of observation for meteorological stations, including AWS stations, are given in section 3.1.

Note 2. Further guidance on the operation of AWS networks in support of the surface-based subsystem of the GOS are provided in *Guide to the Global Observing System* (WMO-No. 488) Part III, Section 3.1.4.3.

2.2.2.2 Members should ensure that observations from AWS, as a minimum, meet the minimum requirements for all Application Areas that the station is associated with.

Note 1. Further discussion of requirements for observations is located in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) section 2.2.4 and Appendix 2.3. Requirements for observational data are also described in the *Guide to the Global Observing System* (WMO-No. 488), Part II.

Note 2. It is recommended that Members designate an AWS network manager to be responsible for ensuring that the network addresses user requirements on an ongoing basis, through a review process that takes into consideration WIGOS requirements.

Note 3. The Guide to the Global Observing System (WMO-No. 488), Part III, Appendix III.2, Basic set of variables to be reported by standard automatic weather stations for multiple users, offers guidance to Members on variables that are recommended to be reported from an AWS so as to meet minimum requirements in several areas.

Note 4. The *Guide to the Global Observing System* (WMO-No. 488), Appendix III.1, Functional Specifications for Automatic Weather Stations, provides information on measurement performance requirements for a range of variables associated with various WMO Application Areas.

2.2.2.3 Members should ensure that staff are trained to the appropriate level of competency for operation and maintenance of their AWS.

Note: Guidance on the training of instruments specialists is provided within the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part III, Chapter 5.

2.2.2.4 Members should document the methods and procedures employed in the operation of their AWS.

Note: Such documentation is necessary to meet requirements of some Application Areas for observations traceability and comprises several aspects including metadata management, quality management, maintenance, change management, incident management, inspection and calibration. Further provisions and guidance on documentation practices are available in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 2.6.6 and the *Guide to the Global Observing System* (WMO-No. 488), Part III, Section 3.2.1.4.

Observing Practices

2.2.2.5 Observation reports shall have a time stamp indicating the time of measurement with a minimum temporal resolution of 1 minute with respect to UTC.

Quality Control

Note 1. The importance of and requirements for Members to implement quality control procedures are given in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) section 2.4.3. Further elaboration on best practice in quality control of AWS observational data is described in the *Guide to the Global Observing System* (WMO-No. 488), Part VI and in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part III and Part II, section 1.3.2.8. For AWS observations, it is important that appropriate quality control procedures are applied at all stages of data processing and message generation.

Note 2. Quality control of AWS systems incorporates aspects of the system design and operation including the following core elements as a minimum:

- Siting and exposure of systems and sensors;
- Calibration and verification of systems and sensors;
- System and network maintenance;
- Incident management;
- Data quality control.

Data & Metadata Reporting

2.2.2.6 Members shall make and report observations from AWS a minimum of eight times per day at the main and intermediate times.

Note: WMO standard Table Driven Code Forms (such as BUFR) are to be used for international exchange of surface observations in accordance with the *Manual on Codes – International Codes* (WMO-No. 306).

2.2.2.7 Members should make and report observations from AWS at least hourly.

Note 1. Observations generated routinely should be reported at uniform intervals aligned to the UTC hour.

Note 2. Observations may be required to be reported more frequently when endeavouring to meet requirements for specific application areas such as high resolution NWP and nowcasting. In such cases, it is recommended that Members report these observations to the WIS.

2.2.2.8 Members that report AWS observations to the WIS shall maintain a copy of all reported AWS observations and associated metadata.

Note 1. Non-destructive storage of observations is important such that data and metadata quality and information content are not altered.

Note 2. More information on data processing is provided in the *Guide to the Global Observing System* (WMO-No. 488) Part V, Reduction of Level I Data, and on data sampling in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part III, Chapter 2, Sampling Meteorological Variables.

Note 3. The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) section 2.5 contains provisions for Members to maintain and provide required metadata in relation to all observations including operational AWS. Some specific requirements for the calculation and reporting of some meteorological observations are given in Part III, Section 3.3.

Incident Management

Note: The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 2.4.5 contains provisions for Members in relation to the management of incidents which interrupt the normal operation of their observing systems by reducing availability and/or quality of observational data.

2.2.2.9 Members who exchange AWS observations shall detect and report major incidents to international recipients of observational data and advise of their resolution in accordance with the Incident Management Systems under WIGOS.

Note 1. Some incidents, such as those related to internal factors, may be detected automatically and reported without delay to international recipients of observational data. Other incidents may be detected with delay or through periodic checks and reported accordingly. Automatic incident detection can be performed using either built-in test equipment or external monitoring systems. A centralized system can be used for monitoring the performance and health of AWS systems and networks.

Note 2. It is important to take corrective action in response to incidents as soon as possible, including their analysis and recording.

2.2.2.10 Members who exchange AWS observations should include information about incidents in the metadata that they record and make available.

Change Management

Note: The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 2.4.6 contains provisions for Members in relation to change management associated with all observing systems, including AWS.

2.2.2.11 When making changes to AWS, Members should plan carefully to avoid or minimize impact on observational data availability and quality.

Note: An important aspect of such careful planning is to have clear roles and responsibilities for each given change.

2.2.2.12 When making changes to AWS systems and networks, Members should notify stakeholders and observational data users in advance, both national and international, record and document such changes and update relevant metadata records.

Note 1. These notifications include information on the expected impacts and the time period over which the change will take place and, importantly, when the period of change is complete. A future standard mechanism and format for such notifications will be useful.

Note 2. The record of changes includes the nature and characteristics of the change, the date and time of implementation and the reason that the change is being made.

Note 3. The relevant metadata includes both national and international metadata records pertaining to the AWS system and site.

2.2.2.13 In making changes to observing systems, Members should plan and make provision for requirements for periods of overlapping observations.

Note: For climatological stations in particular there may be a requirement to undertake a period of overlap as detailed in *Guide to the Global Observing System* (WMO-No. 488), Part III, Section 3.7.4 and this is particularly pertinent when the establishment of an AWS system replaces manual observations.

Maintenance

Note: The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 2.4.7 contains provisions for Members in relation to the maintenance of all observing systems, including AWS systems.

2.2.2.14 Members who operate AWS shall develop, implement and document policy and procedures for routine maintenance of the system.

Note 1. The purpose of the policy and procedures is to ensure the requirements and standards for operational performance and observational data quality are met.

Note 2. The complete AWS system incorporates hardware, software, telecommunications and ancillary systems. Where possible and practical, the maintenance programme is to be based on relevant manufacturer specifications and guidelines.

Note 3. Routine site maintenance is conducted so as to ensure the ongoing representativeness of the site and the measured variables in accordance with the requirements of the Application Areas that the AWS observations support.

Note 4. Further guidance on maintenance of AWS networks is in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part II, Chapter 1, Section 1.6.

Note 5. Routine maintenance should be planned so as to minimize any impact on the making and reporting of observations, particularly during critical weather times and situations.

2.2.2.15 Members shall perform corrective maintenance as soon as practically possible after an issue with an AWS system has been detected.

Note: Typically, it is through monitoring and/or incident management that an issue is detected and responsive maintenance is triggered. The assessment of what is practically possible may take into account the severity of the issue.

2.2.2.16 Members who operate AWS should, where appropriate, implement and perform maintenance tasks remotely.

Note: Remote maintenance cannot replace on-site maintenance for many tasks, but the ability to perform some tasks remotely can contribute to preventive maintenance practices helping to achieve higher overall system uptime and quality of operation.

2.2.2.17 Members who operate AWS shall ensure that they have sufficient numbers of competent staff to meet all maintenance requirements and responsibilities.

2.2.2.18 Members who exchange AWS observational data should record and report details of corrective and preventive maintenance completed in accordance with the WIGOS metadata standard.

Note 1. The requirements to retain and make available metadata, and the specification of the WIGOS metadata standard, are provided in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) section 2.5 and Appendix 2.4 with further elaboration in the *Guide to the WMO Integrated Global Observing System* (WMO-No. xxxx).

Note 2. Any planned or responsive maintenance which has or is expected to reduce the normal AWS data availability and/or quality is to be treated in the same manner as an incident, by following provisions 2.2.2.9 and 2.2.2.10 above.

2.2.2.19 Members should either flag, remove or not report, as appropriate, observational data that is adversely impacted by maintenance activities.

Inspection & Supervision

2.2.2.20 Members shall define and establish functions and responsibilities for inspection and supervision of their AWS.

Note 1. The objective of inspection and supervision is to determine whether the AWS and its sensors are functioning correctly (within performance tolerances) and, if not, to understand the deviations and initiate a response.

Note 2. Remote monitoring and diagnostic systems can significantly increase the effectiveness of inspection and supervision activities.

Note 3. The general provisions for inspection and supervision provided within the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 3.4.8 apply to all surface-based systems, including AWS systems.

2.2.2.21 Members who report AWS observational data to the WIS shall record and report inspection results in accordance with the WIGOS metadata standard.

2.2.2.22 Members that report AWS observations to the WIS shall inspect their AWS at least once every two years.

Note 1. It is recommended that the frequency of inspections should be adequate to ensure a high probability of detection of issues that might impact on the integrity and quality of observational data.

Note 2. For further guidance on inspection processes and standards see *Guide to the Global Observing System* (WMO-No. 488) Part III, Section 3.1.3.8.

Calibration Procedures

2.2.2.23 Members shall define and establish functions and responsibilities for the calibration of their AWS and its sensors, giving consideration to the manufacturer guidelines.

Note 1. The objective of calibration is to constrain AWS components and sensors to operate within performance tolerances given by the supplier and to meet defined user requirements.

Note 2. Recalibration or replacement of sensors is to be undertaken as soon as possible after detecting that tolerances for field verifications are exceeded.

2.2.2.24 Members should ensure that, when possible, AWS field sensors and travelling standards are traceable to the relevant primary international standard.

2.2.2.25 Members who report AWS observations to the WIS should record and report details of calibrations or field verifications in accordance with the WIGOS metadata standard.

Note 1. Any calibration or verification activity which has or is expected to reduce availability and/or quality of AWS observations is to be treated in the same manner as an incident, by following provisions 2.2.2.9 and 2.2.2.10 above.

Note 2. It is recommended that, for those sensors for which it is possible and appropriate, the periodic comparison of AWS sensors with travelling standards should be performed and recorded in accordance with the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part III, Chapter 1, Section 1.7.

2.3 Surface synoptic stations

2.3.1 General

2.3.1.1 Surface synoptic stations may be manned or partly or fully automated and shall include land stations and fixed and mobile sea stations which conduct synoptic observations.

2.3.1.2 Each synoptic station shall be located so as to give meteorological data representative of the area in which it is situated.

2.3.1.3 The main standard times for surface synoptic observations shall be 0000, 0600, 1200 and 1800 UTC.

2.3.1.4 The intermediate standard times for surface synoptic observations shall be 0300, 0900, 1500 and 2100 UTC.

2.3.1.5 Atmospheric pressure observations should be made at exactly the standard time while the observation of other meteorological elements should be made within the 10 minutes preceding the standard time.

2.3.1.6 Every effort should be made to obtain surface synoptic observations four times daily at the main standard times, with priority being given to the 0000 and 1200 UTC observations, which are required for global exchanges.

2.3.1.7 Additionally, Members should endeavour to obtain surface synoptic observations at the intermediate standard times and, furthermore, at regular hourly intervals.

2.3.1.8 When it is difficult, for any reason, to provide sufficient staff for 24-hour operations, partially or fully automated stations should complement or replace manned surface stations, including those in the basic synoptic network, to provide observations at least at the main standard times.

2.3.2 Land stations

General

2.3.2.1 Each synoptic station on land shall be uniquely identified by a WIGOS station identifier.

Note: Requirements relating to station identifiers are at 2.2.1.4. Some of the now-expired identification requirements for synoptic stations are reproduced here because they may be adopted by an "issuer of identifiers" as a convention to be followed in defining "local identifiers" for new stations:

> ~~2.3.2.1~~ "A synoptic station on land shall be identified by a station index number assigned by the Member concerned, from within the allocations made to that Member, in compliance with the scheme prescribed in the *Manual on Codes* (WMO-No. 306). Before issuing a station index number, Members should ensure that the operator of the station or platform has committed to complying with the relevant Technical Regulations.
>
> ~~Note: If a station is outside the geographical territory of any Member, or if the relevant Member is not able to assign a number, the Secretary-General may assist in the process of assigning a number.~~
>
> ~~2.3.2.2~~ When a Member establishes a synoptic station on land it shall send the following information to the Secretariat at least two months before the station becomes operational:
>
> (a) Name, and where appropriate, station index number (stating whether the station is automatic or manned and, if both, the type of each);
>
> (b) Geographical coordinates in degrees, minutes and integer seconds of arc and elevation of the station, in metres (up to two decimals) above mean sea level;

(c) Geopotential of the datum level in whole metres to which the pressure is reduced, or the reference isobaric surface the geopotential of which is reported;

(d) Times at which synoptic observations are made and reported;

(e) Topographical situation;

(f) Any other information required for completion of the entries in *Weather Reporting* (WMO-No. 9), Volume A – Observing Stations.

~~Note:~~ Information on the accurate specification of the geographical coordinates and elevation of a station is provided in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.3.3.2.

~~2.3.2.3~~ Members shall send any necessary amendments to the information supplied under 2.3.2.2 (a) – (f) above to the Secretariat as soon as possible.

~~2.3.2.4~~ The Secretariat should be notified of any changes of the index numbers of synoptic stations included in the international exchanges at least six months before they take effect.

~~2.3.2.5~~ Each Member should publish a description of each of its synoptic stations in accordance with the provisions of the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

~~2.3.2.6~~ All changes in the station index number of a synoptic station shall take effect on 1 January or 1 July.

~~2.3.2.7~~ Each Member of WMO shall designate a national focal point to communicate with the Secretariat on matters regarding the contents of *Weather Reporting* (WMO-No. 9), Volume A – Observing Stations. The national focal point shall be authorized to act in this capacity on behalf of the Permanent Representative concerned."

Location and composition

2.3.2.~~8~~2 Surface land stations, including those in the RBSN, should be spaced at intervals not exceeding the minimum horizontal resolution required by applications areas supported by the network and as described in the Rolling Review of Requirements Process and the Observing Systems Capability Analysis and Review Tool (OSCAR) database.

Note: As a general rule, during the first decade of the twenty-first century, the interval was not supposed to exceed 250 km (or 300 km in sparsely populated areas).

2.3.2.~~9~~3 Surface synoptic observations recorded at a manned synoptic land station shall consist of observations of the following meteorological elements:

(a) Present weather;

(b) Past weather;

(c) Wind direction and speed;

(d) Cloud amount;

(e) Type of cloud;

(f) Height of cloud base;

(g) Visibility;

(h) Air temperature;

(i) Humidity;

(j) Atmospheric pressure;

together with such of the following meteorological elements as are determined by regional association resolutions:

(k) Pressure tendency;

(l) Characteristic of pressure tendency;

(m) Extreme temperature;

(n) Amount of precipitation;

(o) State of ground;

(p) Direction of cloud movement;

(q) Special phenomena.

2.3.2.~~10~~4 A surface synoptic observation at an automatic land station shall consist of observations of the following meteorological elements:

(a) Atmospheric pressure;

(b) Wind direction and speed;

(c) Air temperature;

(d) Humidity;

(e) Precipitation, yes or no (at least in tropical areas);

together with the following additional meteorological elements, which should be included if possible:

(f) Amount of precipitation;

(g) Intensity of precipitation;

(h) Visibility;

(i) Optical extinction profile (height of cloud base);

(j) Special phenomena.

Note 1. The set of automatic weather station metadata required for operational purposes is presented in Attachment III.1.

Note 2. Height of cloud base and cloud extent can be derived directly from the optical extinction profile without further measurement, using one-minute time series.

Frequency and timing of observations

2.3.2.~~11~~5 At synoptic land stations surface synoptic observations should be made and reported eight times per day (at the main and intermediate standard times) in extratropical areas, and four times per day (at the main standard times) in the tropics.

2.3.2.~~12~~6 At a (manned or automatic) land station, surface synoptic observations shall be made and reported at least at the main standard times.

2.3.3 Sea stations

General

2.3.3.1 When more economical means are not available, ocean weather stations and some other fixed sea stations should provide essential and detailed meteorological and oceanographic data from critical locations or ocean areas.

Note 1. These stations, in fulfilling this role, form an integral part of regional and national networks.

Note 2. Fixed sea stations also provide reference-level data and a basis for calibration of soundings by remote sensing from satellites and are thus important in the analysis of phenomena on a large or planetary scale.

Note 3. The WIGOS station identifier of a~~A~~ fixed sea station other than an ocean weather station or a moored buoy may be identified by a station index number following the convention of 2.3.2.1 if considered to be in the same category as a land station.

2.3.3.2 Members shall recruit, as mobile ship stations, as many ships as possible that traverse data-sparse areas and regularly follow routes through areas of particular interest.

2.3.3.3 Members concerned shall provide the Secretariat, not later than 1 March each year, with a list of their selected and supplementary ship stations in operation at the beginning of the year, or shall provide any necessary amendments to their previous list – giving the name, call sign and route or route designator of each ship.

2.3.3.4 Members shall include in the lists of selected and supplementary ship stations information on the method of obtaining sea-surface temperature; on the types of barometer, psychrometer, barograph, radio equipment and other instruments aboard the ship; and radiowatch hours.

2.3.3.5 Members should consider using fixed or mobile automatic sea stations or drifting buoy stations in the data-sparse areas.

Note: These stations are located on fixed or mobile ships, fixed or anchored platforms, and drifting platforms and ice floes.

Location and composition

2.3.3.6 Each fixed sea station should be located so as to provide data which are representative of the marine area. As a minimum, observations should be taken at the main synoptic times. The observations should include as many meteorological elements of a full synoptic report as possible.

2.3.3.7 Members should establish, either individually or jointly, ocean weather stations or other suitable observing facilities in ocean areas where there are large gaps in the global network.

Note: Information describing the stations should be sent to the Secretariat, as for synoptic land stations (see paragraph 2.3.2.2).

2.3.3.8 In its recruitment programme, each Member should aim for its mobile sea stations to contribute as much as possible to the attainment of an adequate density of observations in all oceanic areas.

Note: An adequate density of surface reports in oceanic areas is one per 250 km.

2.3.3.9 It shall be possible to determine the position of a fully automated mobile sea station.

2.3.3.10 At ocean weather stations, a surface synoptic observation shall consist of observations of the following elements:

(a) Present weather;

(b) Past weather;

(c) Wind direction and speed;

(d) Cloud amount;

(e) Type of cloud;

(f) Height of cloud base;

(g) Visibility;

(h) Air temperature

(i) Humidity;

(j) Atmospheric pressure;

(k) Pressure tendency;

(l) Characteristic of pressure tendency;

(m) Ship's course and speed;

(n) Sea-surface temperature;

(o) Direction of movement of waves;

(p) Wave period;

(q) Wave height;

(r) Sea ice and/or icing of ship superstructure, when appropriate;

(s) Special phenomena.

2.3.3.11 At a selected ship station, a surface synoptic observation should consist of observations of elements (a) to (r) in 2.3.3.10 above.

2.3.3.12 At a supplementary ship station, a surface synoptic observation should consist of observations of elements (a) to (i) and (r) in 2.3.3.10 above.

2.3.3.13 At an auxiliary ship station, a surface synoptic observation should consist of observations of elements (a) to (d), (g), (h), (j) and (r) in 2.3.3.10 above.

2.3.3.14 At lightships, manned platforms, and coastal and island stations, a surface synoptic observation should consist of observations of elements (a) to (r), with the exception of (m), in 2.3.3.10 above.

2.3.3.15 At a fixed automatic sea station, surface synoptic observations shall consist of observations of the following elements:

(a) Atmospheric pressure;

(b) Wind direction and speed;

(c) Air temperature;

(d) Sea-surface temperature;

In addition to the elements listed above, a surface synoptic observation made at a fixed automatic sea station should include, if possible, the following elements:

(e) Precipitation, yes or no (especially in tropical areas);

(f) Waves.

2.3.3.16 At a drifting automatic sea station (drifting buoy), a surface synoptic observation should consist of as many as possible of elements (a) to (d), and (f), in 2.3.3.15 above.

Note: The position of the drifting buoy shall also have to be determined.

2.3.3.17 Members should endeavour to equip mobile ships to make subsurface observations.

Note: Guidance on steps to be taken while recruiting a selected, supplementary or auxiliary observing ship; on the organization needed to collect ships' weather reports; and on the use of marine meteorological logs on board ships is contained in the *Guide to Marine Meteorological Services* (WMO-No. 471).

Frequency and timing of observations

2.3.3.18 At ocean weather stations, surface synoptic observations shall be made and reported at least four times per day at the main standard times (and preferably also at the intermediate standard times, and ideally hourly).

2.3.3.19 At lightship stations, fixed and anchored platform stations, and automatic sea stations, surface synoptic observations shall be made and reported at least four times per day at the main standard times.

2.3.3.20 At mobile sea stations, surface synoptic observations should be made and reported at least four times per day at the main standard times.

2.3.3.21 When operational difficulties on board ship make it impracticable to make a surface synoptic observation at a main standard time, the actual time of observation should be as near as possible to the main standard time.

2.3.3.22 Whenever storm conditions threaten or prevail, surface synoptic observations should be made and reported from mobile sea stations more frequently than at the main standard times.

2.3.3.23 When sudden and dangerous weather developments are encountered at sea stations, surface observations should be made and reported as soon as possible without regard to the standard observation times.

Note: For specific instructions relative to the furnishing by ships of special reports, in accordance with the International Convention for Safety of Life at Sea, see *Weather Reporting* (WMO-No. 9).

2.3.3.24 Members should arrange for timely transmission of observations.

Note: Details of observing and reporting programmes are given in the *Guide to Marine Meteorological Services* (WMO-No. 471), Chapter 5. In case of difficulties resulting from fixed radiowatch hours on board single-operator ships, the procedures set out in the *Manual on the Global Telecommunication System* (WMO-No. 386), Volume I – Global Aspects, Part I, Attachment I-1, should be followed.

2.4 Upper-air synoptic stations

General

2.4.1 Upper-air synoptic stations shall be ~~identified as provided under 2.3.2.1 to 2.3.2.6 above~~ uniquely identified by a WIGOS station identifier.

2.4.2 The standard times of upper-air synoptic observations shall be 0000, 0600, 1200 and 1800 UTC.

2.4.3 As upper-air data from the ocean areas are particularly sparse, Members should give consideration to equipping suitable ships to make soundings and, if possible, to measure upper winds.

2.4.4 In the tropics, priority should be given to upper-wind observations.

2.4.5 Upper-air stations making observations of pressure, temperature, humidity and wind should be spaced at intervals not exceeding the minimum horizontal resolution required by applications areas supported by the network and as described in the Rolling Review of Requirements Process and the OSCAR database.

Note: As a general rule, during the first decade of the twenty-first century, the interval was not supposed to exceed 250 km (or 1 000 km in sparsely populated and ocean areas).

Location and composition

2.4.6 An upper-air synoptic observation shall consist of observations of one or more of the following meteorological elements:

(a) Atmospheric pressure;

(b) Air temperature;

(c) Humidity;

(d) Wind direction and speed.

Frequency and timing of observations

2.4.7 At upper-air synoptic stations, the frequency of synoptic observations should be four per day, and these should be made at the standard times of upper-air synoptic observations.

2.4.8 At upper-air synoptic stations, upper-air observations shall be made and reported at least at 0000 and 1200 UTC.

2.4.9 At ocean weather stations, upper-air synoptic observations should comprise rawinsonde observations at 0000 and 1200 UTC and/or radiowind observations at 0600 and 1800 UTC.

2.4.10 The actual time of regular upper-air synoptic observations should be as close as possible to (H-30) and should not fall outside the time range (H-45) to H.

Note: The actual time of a pilot-balloon observation may deviate from the range indicated above if such deviation is expected to enable wind observations to considerably greater heights.

2.4.11 In areas where it is not possible to meet the frequency requirements mentioned above, every effort should be made to obtain at least the following observations:

(a) Upper-air observations from the RBSNs and other networks of stations on land and at sea, twice daily, at 0000 and 1200 UTC;

(b) In the tropics, at stations where two complete radiosonde/radiowind observations are not made, priority should be given to the implementation of one complete radiosonde/radiowind observation and one radiowind observation daily.

2.5 Aircraft meteorological stations

Note: The structure of section 2.5 now departs from the standard structure which comprised sub-sections "General", "Location and composition" and "Frequency and timing of observations". This is a transitional step towards the eventual migration into the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

General

Note 1: An Aircraft Meteorological Station is defined in *Technical Regulations* (WMO-No. 49) Volume I – General Standards and Recommended Practices as a "Meteorological Station situated aboard an aircraft", where a Meteorological Station is defined as a "Place where meteorological observations are made with the approval of the WMO Member or Members concerned."

Note 2: Mandatory requirements for provision of observations from aircraft are in *Technical Regulations* (WMO-No. 49) Volume II – Meteorological service for international air navigation. The following provisions are to be read in conjunction with that material.

2.5.1 Members should arrange for meteorological observations to be made and reported by aircraft of their national registry.

Note 1. This provision applies to aircraft operating both on national and international air routes and whilst in all phases of flight.

Note 2. In general, three categories of aircraft-based observations (ABO) are described within the *Guide to Aircraft-Based Observations* (WMO-No. xxxx), which Members should consider utilizing:

i. WMO Aircraft-Based Observations;

ii. ICAO Aircraft-Based Observations;

iii. Other Aircraft-Based Observations.

WMO ABO are derived from aircraft-based observing systems operated by WMO Members in collaboration with cooperating airlines, in which requirements for ABO are specified by WMO and its Members so as to meet meteorological needs.

ICAO ABO are observations derived from ICAO regulated Aircraft Observations, which are made available to WMO and its Members under the provisions of ICAO as set out within the *Technical Regulations* (WMO-No. 49) Volume II – Meteorological service for international air navigation.

Other ABO are those observations that are derived from aircraft-based observing systems operated by other entities. In this case, while Members do not define specifications for the operation of the observing system, they are urged to ensure that the observations are fit for purpose.

Note 3. It is recommended that Members collaborate with their civil aviation authorities regarding compliance with ICAO requirements for the provision of Aircraft Reports in support of International Air Navigation, as defined in the *WMO Technical Regulations* (WMO-No. 49), Volume II — Meteorological Service for International Air Navigation, Part 1. This includes the forwarding of Aircraft Reports by civil aviation authorities to ICAO World Area Forecast Centres (WAFCs) on the Aviation Telecommunications Network so that they can subsequently be made available to WMO Members on the WIS.

2.5.2 Members should participate in the WMO Aircraft Meteorological DAta Relay (AMDAR) observing system.

Note: Guidance on AMDAR programme development and operation is provided in the *Guide to Aircraft-Based Observations* (WMO-No. xxxx) Section 2.1, AMDAR Observing System Development and Operation.

Requirements

2.5.3 Members should meet the WMO Integrated Global Observing System (WIGOS) requirements for aircraft-based observations.

Note 1. WIGOS requirements for upper-air observations (including those for aircraft-based observations) are to be found in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

Note 2. It is recommended that aircraft-based observations consist of at least the following variables, with desirable and optional variables as indicated:

- (static) air temperature;
- wind speed;
- wind direction;
- pressure altitude;
- latitude;
- longitude;
- time of observation;
- turbulence: mean, peak and event-based Eddy Dissipation Rate (EDR) – desirable;
- geometric altitude – desirable;
- humidity – desirable;
- icing – desirable;
- turbulence: derived equivalent vertical gust (DEVG) – optional.

Note 3. For more details and further requirements on the measurement processes and data processing associated with these and additional optional variables, see [REF WMO AMDAR Onboard Software Functional Requirements Specifications, CIMO IOM Report No. 115, Chapter 3].

Note 4. For more detailed guidance on the provision of aircraft-based observations in support of requirements for upper air observations, see Guide to Aircraft-Based Observations (WMO-No. xxxx) Section 1.5.

2.5.4 In the operation of AMDAR observing systems, Members should consult and adhere to WMO specifications and best practice.

Note: Some relevant specifications and guidance on practices include:

- *Guide to Aircraft-Based Observations* (WMO-No. xxxx);
- The AMDAR Onboard Software Functional Requirements Specifications, which provides a standard for the meteorological functionality of AMDAR software applications and air-ground data formats;
- The ARINC Data Link Ground System Standard and Interface Specification (DGSS/IS) [REF ARINC 620], which provides a specification of the Meteorological Report;
- *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part II, Chapter 3.

2.5.5 Members that operate AMDAR observing systems, shall include in their AMDAR observations air temperature, wind speed, wind direction, pressure altitude, latitude, longitude and time of observation.

2.5.6 Members that operate AMDAR observing systems, should include measurement of humidity or water vapour turbulence and icing as additional components of AMDAR observations.

Observations Data Management

2.5.7 Members who make available aircraft-based observations to the WIS shall ensure they have the authority to do so from the observational data owner.

2.5.8 Members who make available aircraft-based observations to the WIS should retain a copy of all such observations.

Note: The purpose of this record is to assist observations management functions. In some cases retention of raw or high resolution observational data, from which the reports were derived, may be helpful. dataset management and services are not regulated in this document.

2.5.9 Members shall make available observational metadata relevant to the aircraft-based observations they report to the WIS.

Note 1: More details on Data Management Aspects are available in the *Manual on the Global Data-Processing and Forecasting System* (WMO-No. 485) Vol. 1, Global Aspects, Part III.

Note 2: More information on data processing and data levels is provided in the *Guide to the Global Observing System* (WMO-No. 488) Part V, Reduction of Level I Data.

Note 3: More detailed guidance on aircraft-based observational data management can be found in *Guide to Aircraft-Based Observations* (WMO-No. xxxx) Section 1.9.

Quality Management

2.5.10 Members that receive, process and transmit aircraft-based observations to the WIS shall as a minimum comply with the WMO requirements for quality control of these data.

Note 1. Requirements for quality control are defined within:

- The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Sections 2.6 and 3.6;
- The *Manual on the Global Data-Processing and Forecasting System* (WMO-No. 485) Part II, Annex II.1, Minimum Standards for Quality Control of Data for Use in the GDPFS.

Note 2. Further information on quality control of aircraft-based observational data, can be found in the *Guide to Aircraft-Based Observations* (WMO-No. xxxx) Section 1.8 and Annex I, Guidance on Quality Control of Aircraft-Based Observations.

2.5.11 WMO Members who make available aircraft-based observations to the WIS shall develop and implement policy and procedures for quality monitoring and quality assessment of such observations.

Note 1: Further information on quality monitoring of aircraft-based observational data, can be found in the *Guide to the Global Observing System* (WMO-No. 488) Chapter 3.4, Annex II, Guidance on Quality Monitoring of aircraft-based Observational Data.

Note 2: It is recommended that Members ensure that aircraft-based observing systems operated in collaboration with partner airlines and other operators, comply with all practices and guidance that impact on observational data quality provided in the *Guide to Aircraft-Based Observations* (WMO-No. xxxx) Section 2.

2.5.12 Members who make available aircraft-based observations to the WIS shall develop procedures for the analysis of and response to available monitoring informat:

Note 1. Responses include taking prompt and appropriate corrective action for systematic observing system defects and issues identified that adversely affect the quality of aircraft-based observations transmitted on the WIS. Such responses can be facilitated by WMO Focal Points on Aircraft-Based Observations.

Note 2. A key source of advice on aircraft-based observational data quality is from the WMO Lead Centre on Aircraft-Based Observations or from other WMO Members.

Note 3. The WMO Lead Center on Aircraft Data undertakes quality monitoring of aircraft-based observations and makes available monitoring information to WMO Members on the WMO website.

Note 4. More detailed guidance on aircraft-based observations and observing systems quality management can be found in the *Guide to Aircraft-Based Observations* (WMO-No. xxxx) Section 1.7 and Annex II.

2.5.13 Members who operate AMDAR observing systems shall ensure that on-board data quality control processing is applied in accordance with WMO specifications and best practice.

Note: Specifications for on-board data quality control processing are described in the AMDAR Onboard Software Functional Requirements Specification [RFF, AOSFRS].

Provision of Aircraft-Based Observations on the WIS

2.5.14 Members that receive and process aircraft-based observational data from any source, including AMDAR, ICAO aircraft observations and other aircraft-based observing systems shall make such data available to the WIS in accordance with WMO regulations.

Note 1. Relevant regulations may be found in:

- *Technical Regulations* (WMO-No. 49) Volume II – Meteorological service for international air navigation;
- *Manual on the Global Telecommunication System* (WMO-No. 386);
- *Manual on Codes* – International Codes (WMO-No. 306).

Note 2. Guidance on the encoding and provision of aircraft-based observation to the WIS can be found in the *Guide to Aircraft-Based Observations* (WMO-No. xxxx) Section 1.9 and Annex III.

2.5.15 Members who make available aircraft-based observations to the WIS shall ensure that they have the capacity to identify and remove poor quality data from transmission on the WIS until such time as the data quality is restored.

Observational Metadata Requirements and Management

2.5.16 Members that receive, process and make available to the WIS aircraft-based observational data from any source shall ensure that they maintain a database of related metadata.

Note: Relevant metadata includes that relating to the following observational aspects and elements of their observational data:

- Models and types of aircraft;
- When and where possible, onboard sensors and their siting, calibration and operational issues and faults;
- Specific software and algorithms used to process data to generate the reported variables;
- Metadata related to quality control processes, data communication practices, data processing and delivering centres.

2.5.17 Members that make available aircraft-based observations to the WIS shall maintain and provide the related, internationally required metadata.

Note 1: Specific details of relevant metadata can be found in the *Guide to Aircraft-Based Observations* (WMO-No. xxxx) Annex IV Guidance on Aircraft-Based Observations Metadata Maintenance and Provision].

Note 2: General provisions for the requirements for provision of observational metadata can be found in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 2.5.

Note 3: More detailed guidance on aircraft-based observational metadata management can be found in the *Guide to the Global Observing System* (WMO-No. 488) Chapter 3.4, Section 1.10

Maintenance and Incident and Change Management

Note: General provisions which apply to the management of incidents and changes in Members' aircraft-based observing systems are within the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)

Sections 2.4 and 3.4 and within the *Manual on the Global Telecommunication System* (WMO-No. 386) Part II, Chapter 5.

2.5.18 Members should ensure that changes to the programme or schedule of reporting of aircraft-based observations on the WIS are planned and notified in advance.

Note 1: Recommended practices in relation to reporting and recording of such incidents within aircraft-based observational metadata are provided within the *Guide to Aircraft-Based Observations* (WMO-No. xxxx) Annex IV.

Note 2: It is recommended that Members establish and document suitable policy and procedures for the management of incidents associated with the operation of aircraft-based observing systems.

Note 3: One aim of such procedures is to ensure that incidents adversely affecting the quality or timeliness of aircraft-based observations are rectified in a timely manner.

Note 4: It is recommended that Members report such incidents to the relevant WMO Lead Centre~~r~~ on Aircraft Observations and to WMO Focal Points on aircraft-based Observations through the relevant communications channels.

2.5.19 Members who make available aircraft-based observations to the WIS shall, in collaboration with their operating partners, develop policy and procedures for the detection, advisement and timely rectification of issues and errors that adversely affect the quality of observations.

2.5.20 Members who make available aircraft-based observations to the WIS shall develop, implement and document plans, policy and procedures for routine maintenance of their aircraft-based observing systems.

Note 1: Such plans will ensure standards for operational performance are maintained.

Note 2: Plans and procedures for routine maintenance should include provisions for maintenance of all aircraft-based observing system components and sensors, related infrastructure and materials.

Note 3: Maintenance documentation and related metadata should be made available to relevant users and stakeholders.

2.5.21 Members should utilize a centralized system for the monitoring of the status and health of aircraft-based observing systems as an integrated component of their maintenance regime.

Note: An example of such a centralized system is a computer system designed and established to receive, monitor and report on automatically generated information and data pertaining to the aircraft-based observing system operation and performance. The functions of such a system might include: (1) automated analysis of quality monitoring and data quality control reports and the raising of alarms or flags based on criteria; (2) alerting for changes in data availability; and (3) monitoring and event-based alerting related to operational computer and communications systems performance.

~~**2.5.1 Each Member shall arrange for observations to be made by aircraft of its registry operating on international air routes and for the recording and reporting of these observations.**~~

~~Note: Further information on aircraft observations and reports may be found in the *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation, Part I, 5.~~

~~**2.5.2 Members accepting responsibility for collecting aircraft reports for synoptic purposes shall promptly make these available, in agreed code forms, to other Members.**~~

~~2.5.3 Members should give special consideration to the use of an automated aircraft meteorological observing and reporting system.~~

~~2.5.4 Aircraft reports shall, at a minimum, satisfy the requirements of International Air Navigation (for details see the *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation, Part I, 5).~~

~~Location and composition~~

~~2.5.5 The following aircraft observations shall be made:~~

~~(a) Routine aircraft observations during en-route and climb-out phases of the flight; and~~

~~(b) Special and other non-routine aircraft observations during any phase of the flight.~~

~~2.5.6 Routine air reports shall contain the following meteorological elements:~~

~~(a) Air temperature;~~

~~(b) Wind direction and speed;~~

~~(c) Turbulence;~~

~~(d) Aircraft icing;~~

~~(e) Humidity (if available).~~

~~In addition, reports of any volcanic activity observed by the flight crew shall be included.~~

~~2.5.7 Special aircraft reports shall be made whenever any of the following conditions are observed:~~

~~(a) Severe turbulence;~~

~~(b) Severe icing;~~

~~(c) Severe mountain wave;~~

~~(d) Thunderstorms, with or without hail, that are obscured, embedded, widespread or in squall lines;~~

~~(e) Heavy duststorms or heavy sandstorms;~~

~~(f) Volcanic ash clouds;~~

~~(g) Pre-eruption volcanic activity or a volcanic eruption;~~

~~In addition, in the case of transonic and super-sonic flights:~~

~~(h) Moderate turbulence;~~

~~(i) Hail;~~

~~**(j) Cumulonimbus clouds.**~~

~~2.5.8 Routine aircraft observations should be made at the designated air traffic services/meteorological (ATS/MET) reporting points.~~

~~Note: Lists of designated ATS/MET reporting points are prepared by and available from International Civil Aviation Organization Regional Offices.~~

~~**Frequency and timing of observations**~~

~~2.5.9 When automated observing and reporting systems are available, routine observations should be made every 15 minutes during the en-route phase and every 30 seconds during the first 10 minutes of the flight.~~

~~**2.5.10 When voice communications are used, routine observations shall be made during the en-route phase in relation to those air traffic services reporting points or intervals:**~~

~~**(a) At which the applicable air traffic services procedures require routine position reports; and**~~

~~**(b) Which are those separated by distances corresponding most closely to intervals of one hour of flying time.**~~

~~**2.5.11 Observations shall be made by all aircraft of meteorological conditions encountered during the take-off or approach phases of flight which were not previously reported to the pilot-in-command and which in his or her opinion are likely to affect the safety of other aircraft operations.**~~

~~**2.5.12 Observations shall also be made by aircraft:**~~

~~**(a) If a meteorological office providing meteorological service for a flight makes a request for specific data; or**~~

~~**(b) By agreement between a Meteorological Authority and an operator.**~~

2.6 Radar wind profiler stations

Note 1: The structure of this section 2.6 departs from the standard structure used to regulate other elements of the surface-based subsystem of the GOS. This is a transitional step towards the eventual migration of this regulatory material to the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

Note 2: Wind profile observations can be determined by a range of other types of systems, such as Doppler lidars, Doppler sodars, and Doppler weather radars. A general description of surface based profiling techniques and systems is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part II, Chapter 5.2 and on radar wind profilers in particular in section 5.2.2.

2.6.1 General Requirements

2.6.1.1 Members should consider the establishment of radar wind profiler (RWP) stations as an element of their network of upper-air stations.

Note: Each RWP station is to be uniquely identified by a WIGOS station identifier, following the provisions in Attachment 2.1 to Chapter 2 of the Manual on the *WMO Integrated Global Observing System* (WMO-No. 1160).

2.6.1.2 Members who operate RWPs shall comply with national regulations for the use of radio frequencies.

Note 1: Extensive information about the use of radio frequencies is available in the Handbook on the Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction (ITU/WMO, 2008) noting that Resolution 217 of the World Radiocommunication Conference 1997 (WRC-97) is the basis for frequency allocation for RWP. Further information is provided in the *Guide to Participation in Radio-frequency Coordination* (WMO-No. 1159).

Note 2: Physical constraints on selecting systems are described in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) section 5.2. The vertical range of a radar wind profiler is strongly related to the operating frequency.

2.6.1.3 Members who operate RWP shall make horizontal wind vector observations.

2.6.1.4 Members who operate RWP should make vertical wind component observations.

Note 1: Further information about the observations made by RWP, and accuracy requirements, is provided in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8).

Note 2: RWP operations may pose safety hazards to operators and maintenance personnel, so the requirement to ensure proper safety procedures (see *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) section 2.4.1.7) is particularly relevant. Typically, safety hazards for RWP include electrical shock hazard, RF radiation hazard, high noise hazard (for systems equipped with RASS), tripping hazard, lifting hazard, electrostatic discharge hazard and may additionally include high voltage and radiation exposure.

2.6.2 Observing Practices

Note: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part II, Chapter 5.2.2, provides guidance on RWP observing practices. Relevant considerations include techniques and system characteristics, and site selection to optimally contribute to the upper-air network.

2.6.2.1 Members shall operate their RWP continuously so as to acquire and provide horizontal winds at time intervals not exceeding 60 minutes.

Note: Data acquisition at shorter time intervals, for example every five or ten minutes, may be preferable or required depending on user requirements and applications that the observations are intended to support. Users must then be cautious about a potential degradation of data quality under certain atmospheric conditions.

2.6.2.2 Members who operate RWP should maximize the quality of the acquired observational data.

Note: Range and velocity aliasing errors can be completely avoided if data sampling is properly set up. Also, clutter needs to be filtered and interference contamination needs to be minimised by suitable data processing techniques. Further information is provided in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8).

2.6.2.3 Members should retain a copy of all RWP observations they report to the WIS.

Note: Non-destructive storage of observations is important such that data and metadata quality and information content are not altered.

2.6.3 Quality Control

Note 1: The importance of and requirements for Members to implement quality control procedures are given in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) section 2.4.3. For RWP it is important that appropriate quality control procedures are applied at all stages of signal and data processing.

Note 2: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part II, Chapter 5.2.2, provides some guidance on quality control for radar wind profiler observations. To the extent possible the procedures are to operate automatically in real-time and enable the characterization of data quality, and be part of a quality assurance programme which, at a minimum, also includes system and test equipment calibration, hardware and software maintenance, technical instructions and reporting.

2.6.3.1 Members who operate RWP shall implement practices and procedures for frequent routine monitoring of the quality of their RWP observations.

Note: It is recommended that RWP observational data quality monitoring be based on frequent and ongoing comparison with a reliable reference standard. A commonly used method relies on the use of "observation minus background" statistics from Numerical Weather Prediction (NWP) output. Comparison may also be made with co-located upper-air wind measurements from other observing systems if available.

2.6.4 Data and Metadata reporting

2.6.4.1 Members who operate RWP should make RWP observational data available via the WMO Information System.

Note 1: WMO standard RWP BUFR codes are to be used for international exchange.

Note 2: The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 2.4.4 contains provisions for Members to maintain and provide required metadata in relation to all observations including operational RWP. While it is desirable that real-time metadata such as data quality be provided together with the observations to which they apply, the feasibility of reporting codes places a limit on what can be accommodated.

2.6.5 Incident Management

Note: The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 2.4.5 contains provisions for Members in relation to the management of incidents which interrupt the normal operation of their observing systems by reducing availability and/or quality of observational data.

2.6.5.1 Members who exchange RWP observations shall detect and report major incidents to international recipients of observational data and advise of their resolution in accordance with the Incident Management Systems under WIGOS.

Note 1: Some incidents, such as those related to internal factors, may be detected automatically and reported without delay to international recipients of observational data. Other incidents may be detected with delay or through periodic checks and reported accordingly. Automatic incident detection can be performed using either built-in test equipment or external monitoring systems. A centralized system can be used for monitoring the performance and health of RWP systems and networks.

Note 2: It is important to take corrective action in response to incidents as soon as possible, including their analysis and recording.

2.6.5.2 Members who exchange RWP observations should include information about incidents in the metadata that they record and make available

2.6.6 Change Management

Note: The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 2.4.6 contains provisions for Members in relation to change management associated with all observing systems, including radar wind profilers.

2.6.6.1 When making changes to radar wind profiler systems, Members should plan carefully to avoid or minimize impact on observational data availability and quality.

Note: An important aspect of such careful planning is to have clear roles and responsibilities for each given change.

2.6.6.2 When making changes to radar wind profiler systems and networks, Members should notify stakeholders and observational data users in advance, both national and international, record and document such changes and update relevant metadata records.

Note 1: These notifications include information on the expected impacts and the time period over which the change will take place and, importantly, when the period of change is complete. A future standard mechanism and format for such notifications will be useful.

Note 2: The record of changes includes the nature and characteristics of the change, the date and time of implementation and the reason that the change is being made.

Note 3: The relevant metadata includes both national and international metadata records pertaining to the observing system and site.

2.6.7 Maintenance

Note: The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 2.4.7 contains provisions for Members in relation to the maintenance of all observing systems, including radar wind profilers.

2.6.7.1 Members who operate radar wind profilers shall develop, implement and document policy and procedures for routine maintenance of the radar wind profiler system.

Note 1: The purpose of the policy and procedures is to ensure the requirements and standards for operational performance and observational data quality are met.

Note 2: The complete radar wind profiler system incorporates hardware, software, telecommunications and ancillary systems. Where possible and practical, the maintenance programme should be based on relevant manufacturer specifications and guidelines.

2.6.7.2 Members shall perform responsive maintenance as soon as practically possible after an issue with their radar wind profiler system has been detected.

Note: Typically, it is through monitoring and/or incident management that an issue is detected and responsive maintenance is triggered. The assessment of what is practically possible may take into account the severity of the issue.

2.6.7.3 Members who operate radar wind profilers should, where appropriate, implement and perform maintenance tasks remotely.

Note: Remote maintenance cannot replace on-site maintenance for many tasks, but the ability to perform some tasks remotely can contribute to preventive maintenance practices helping to achieve higher overall system uptime and quality of operation.

2.6.7.4 Members who operate radar wind profilers should maintain their sites to minimize the effect on the system by external factors (for example blockage by vegetation).

2.6.7.5 Members who operate radar wind profilers shall ensure that they have sufficient numbers of competent staff to meet all maintenance requirements and responsibilities.

2.6.7.6 Members who exchange radar wind profiler observational data should record and report details of corrective and preventive maintenance completed in accordance with the WIGOS metadata standard.

Note 1: The requirements to retain and make available metadata, and the specification of the WIGOS metadata standard, are provided in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) section 2.5 and Appendix 2.4 with further elaboration in the *Guide to the WMO Integrated Global Observing System* (WMO-No. xxxx)

Note 2: Any planned or responsive maintenance which has or is expected to reduce the normal radar wind profiler data availability and/or quality is to be treated in the same manner as an incident, by following provisions 1.5.1 and 1.5.2.

2.6.8 Inspection and Supervision

2.6.8.1 Members shall define and establish roles and responsibilities for inspection and supervision of their RWP.

Note 1: The objective of inspection and supervision is to determine whether the RWP is functioning correctly (within performance tolerances) and, if not, to understand the deviations and initiate a response.

Note 2: Remote monitoring and diagnostic systems can significantly increase the effectiveness of inspection and supervision activities.

Note 3: The general provisions for inspection and supervision provided within the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 3.4.8 apply to all surface-based systems, including RWP systems.

2.6.8.2 Members who exchange RWP observational data shall record and report inspection results in accordance with the WIGOS metadata standard.

2.6.9 Calibration Procedures

2.6.9.1 Members shall define and establish roles and responsibilities for the calibration of their RWPs, giving consideration to the manufacturer guidelines.

Note: The objective of calibration is to constrain RWP to operate within performance tolerances given by the supplier and to meet defined user requirements.

2.6.9.2 Members who exchange RWP observational data shall record and report details of calibrations in accordance with the WIGOS metadata standard.

Note 1: Relevant calibration details, in the case of the spaced antenna method of wind determination, would include the statistical bias correction applied.

Note 2: Any calibration activity which has or is expected to reduce the normal radar wind profiler data availability and/or quality is to be treated in the same manner as an incident, by following provisions 1.5.1 and 1.5.2.

2.7 Weather radar stations

Note 1: The structure of this section 2.7 departs from the standard structure used to regulate other elements of the surface-based system of the GOS. This is a transitional step towards the eventual migration of this regulatory material to the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

Note 2: A general description of weather radars is given in the *Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8)*, Part II, Chapter 9 (see 9.1).

2.7.1 General Requirements

2.7.1.1 Members should establish a network of weather radar stations either nationally or in combination with other Members.

Note: Each weather radar station is to be uniquely identified by a WIGOS station identifier (See provision 2.4.1.1 in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

2.7.1.2 Members who operate weather radars shall comply with national regulations for the use of radio frequencies

Note: Extensive information about the use of radio frequencies is available in the Handbook on the Use of Radio Spectrum for Meteorology: Weather, Water and Climate Monitoring and Prediction (ITU/WMO, 2008) and also the *Guide to Participation in Radio-frequency Coordination* (WMO-No.1159).

2.7.1.3 Members that operate weather radars shall operate radars capable of transmitting and receiving horizontally polarised signals.

2.7.1.4 Members that operate weather radars should operate radars capable of transmitting and receiving both horizontally and vertically polarised signals.

Note: Such radars are generally known as dual-polarisation or polarimetric radars.

2.7.1.5 Members shall ensure their weather radars provide observations of the radar reflectivity factor.

Note: Radar reflectivity is related to precipitation intensity, and may also be generated by non-meteorological phenomena.

2.7.1.6 Members should ensure their single-polarisation weather radars provide the following observations:

Radial velocity

Spectral width

2.7.1.7 Members should ensure their weather radars with dual-polarisation capability provide the following observations:

Differential reflectivity

Cross-polar correlation

Differential phase

Specific Differential Phase

Note 1: Further information about the observations made by weather radars, and accuracy requirements, is provided in the *Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8)* Part II, Table 9.2.

Note 2: Weather radar operations may pose safety hazards to operators and maintenance personnel as well as the surrounding community, so the requirement to ensure proper safety procedures (see *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) section 2.4.1.7) is particularly relevant. Typically, on-site safety hazards for weather radars include high voltage, radiation exposure, working in confined spaces, heavy moving components, climbing and working at heights. Further information is available in the *Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8)* Part II, 9.8.

2.7.2 Observing Practices

Note: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part II, Chapter 9, provides guidance on weather radar observing practices related to site selection (9.8.1), optimizing radar characteristics (9.6.8), understanding error sources (9.9 and Figure 2), and meteorological applications (9.10) and products (9.11).

2.7.2.1 Members who operate weather radars should make available observations at least every 15 minutes.

Note 1. Higher temporal-frequency observations acquisition, for example every five or ten minutes, may be preferable depending on the user requirements and the applications supporting them.

Note 2. It is recognized that Members may have seasonal differences in operation of weather radars. The above recommended reporting frequency applies during those periods when the radar is in operation.

Note 3. Requirements to make available metadata in relation to all observations, including weather radar observations, are in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) section 2.5.

2.7.2.2 Members should retain a copy of all weather radar observations they report to the WIS.

Note: Non-destructive storage of observations is important such that data and metadata quality and information content are not altered.

2.7.3 Quality Control

Note 1. The importance and requirement for Members to implement quality control procedures are in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) section 2.4.3. In relation to weather radars the procedures will improve both qualitative and quantitative uses of weather radar observations.

Note 2. The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part II, Chapter 9, provides some guidance on quality control for weather radar observations. To the extent possible the procedures are to include quality control of both internal and external factors, and enable the characterization of data quality and the inclusion of a record of the quality control methods with the observations they were applied to.

2.7.4 Data and Metadata Reporting

Note: The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 2.4.4 contains provisions for Members to maintain and provide required metadata in relation to all observations including operational weather radar.

2.7.4.1 Members who operate weather radars should make weather radar observational data available for international exchange.

Note: A standard WMO data format is under development that will ensure real-time weather radar observational data and metadata are able to be represented non-destructively.

2.7.4.2 Members who exchange observational data shall provide real-time metadata together with the observational data to which they apply.

Note 1. Key amongst such metadata is information on quality and it should accompany as closely as possible the observational data to which it applies.

Note 2. It is recommended that such metadata include information on calibration, timing, beam pointing, and other system settings.

2.7.4.3 Members who exchange weather radar observational data shall provide the associated non-real-time metadata to the WMO Radar Database.

Note: Members are strongly urged to provide non-real-time metadata to the WMO Radar Database for all of their weather radars, including those from which observational data are not exchanged.

2.7.5 Incident Management

Note: The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 2.4.5 contains provisions for Members in relation to the management of incidents which interrupt the normal operation of their observing systems by reducing availability and/or quality of observational data.

2.7.5.1 Members who exchange weather radar observational data shall detect and report major incidents to international recipients of observational data and advise of their resolution in accordance with the Incident Management Systems under WIGOS.

Note 1: Some incidents, such as those related to internal factors may be detected automatically and reported without delay to international recipients of observational data. Other incidents may be detected with delay or through periodic checks and reported accordingly. Automatic detection is facilitated through the use of built-in test equipment and/or external monitoring systems.

Note 2: As stated in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), section 2.4.5.2, it is important to take corrective action in response to incidents as soon as possible, including their analysis and recording.

2.7.5.2 Members who exchange weather radar observations should report incident information within the metadata that they report in real-time.

Note: A standard WMO data format is under development that will ensure such incident information allows identification of observational data which have been negatively impacted, and also any additional quality control which has been applied to the observational data as a result of the incident. This will assist incident awareness and management.

2.7.6 Change Management

2.7.6.1 When making changes to weather radars and systems, Members should plan carefully to avoid or minimise impact on observational data availability and quality.

Note: An important aspect of such careful planning is to have clear roles and responsibilities for each given change.

2.7.6.2 When making changes to weather radar systems and networks, Members should notify stakeholders and observational data users in advance, both national and international, record and document such changes and update relevant metadata records.

Note 1: These notifications include information on the expected impacts and the time period over which the change will take place and, importantly, when the period of change is complete. A future standard mechanism and format for such notifications will be useful.

Note 2: The record of changes includes the nature and characteristics of the change, the date and time of implementation and the reason that the change is being made.

Note 3: The relevant metadata includes both national and international metadata records pertaining to the observing system and site.

2.7.7 Maintenance

Note: The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) Section 2.4.7 contains provisions for Members in relation to the maintenance of all observing systems, including weather radars and the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part II, Chapter 9 (see 9.7.1), provides guidance on weather radar maintenance.

2.7.7.1 Members who operate weather radars shall develop, implement and document policy and procedures for routine maintenance of the weather radar system.

Note: Such policies and procedures will ensure requirements and standards for operational performance and observational data quality are met.

2.7.7.2 In relation to preventive maintenance activities, Members shall give attention to all components that comprise the complete weather radar system, with consideration given to manufacturer guidelines.

2.7.7.3 Members shall perform responsive maintenance as soon as practically possible after an issue has been detected with their weather radar system(s).

Note: Typically, it is through monitoring and/or incident management that an issue is detected and responsive maintenance is triggered. The assessment of what is practically possible may take into account the severity of the issue.

2.7.7.4 Members who operate weather radars should, where appropriate, implement maintenance tasks remotely.

Note: Remote maintenance cannot replace on-site maintenance for many tasks, but the ability to perform some tasks remotely can contribute to preventive maintenance practices helping to achieve higher overall system uptime and quality of operation.

2.7.7.5 Members who operate weather radars should maintain their sites to minimize the effect on the radar system by external factors (for example blockage by vegetation).

2.7.7.6 Members shall ensure that they have sufficient numbers of competent staff to meet all maintenance requirements and responsibilities.

2.7.7.7 Members who exchange weather radar observational data shall record and report details of corrective and preventive maintenance completed in accordance with the WIGOS metadata standard.

Note 1: The requirements to retain and make available metadata, and the specification of the WIGOS metadata standard, are provided in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) section 2.5 and Appendix 2.4 with further elaboration in the *Guide to the WMO Integrated Global Observing System* (WMO-No. xxxx)

Note 2: Any planned or responsive maintenance which has or is expected to reduce the normal weather radar observational data availability and/or quality is to be treated in the same manner as an incident, by following provisions 2.7.5.1 and 2.7.5.2.

2.7.8 Inspection and Supervision

2.7.8.1 Members shall define and establish roles and responsibilities for inspection and supervision of their weather radars.

Note 1: The objective of inspection and supervision is to determine whether the weather radar system is functioning correctly (within performance tolerances) and, if not, to understand the deviations and initiate a response.

Note 2: Remote monitoring and diagnostic systems can significantly increase the effectiveness of inspection and supervision activities.

2.7.8.2 Members who exchange weather radar observational data shall record and report inspection results in accordance with the WIGOS metadata standard.

2.7.9 Calibration Procedures

Note: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part II, Chapter 9 (see 9.7.2), provides guidance on weather radar calibration.

2.7.9.1 Members shall define and establish roles and responsibilities for the calibration of their weather radar systems, giving consideration to the manufacturer guidelines.

Note: The objective of calibration is to constrain weather radar systems to operate within performance tolerances given by the supplier and to meet defined user requirements. WMO-No. 8, Part II, Chapter 9, Table 9.4 contains indicative accuracy requirements.

2.7.9.2 Members shall ensure that they have sufficient numbers of competent staff to meet all calibration requirements and responsibilities.

2.7.9.3 Members who exchange weather radar observational data shall record and report details of calibrations in accordance with the WIGOS metadata standard.

Note 1: Relevant details include calibration variables and their settings or levels, and the terms of the weather radar equation along with the calibration constant

Note 2: Reporting of calibrations is to be done with the observational data to which they apply, in accordance with provision 2.7.4.2

Note 3: Any calibration activity which has or is expected to reduce the normal weather radar observational data availability and/or quality is to be treated in the same manner as an incident, by following provisions 2.7.5.1 and 2.7.5.2

2.~~6~~8 Aeronautical meteorological stations

General

2.~~6~~8.1 Members should establish an adequate network of aeronautical meteorological stations to meet the requirements of aviation.

Note: Detailed information on aeronautical meteorological stations, observations and reports is given in the *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation, Part I, 4.

2.~~6~~8.2 The data relating to the elevation of an aeronautical meteorological station on land shall be specified in whole metres.

~~2.6.3~~ Note: The WIGOS station identifier of ~~A~~an aeronautical meteorological station on land may follow the convention of 2.3.2.1.~~shall be identified by a station index number assigned by the Member concerned in compliance with the scheme prescribed in the *Manual on Codes* (WMO-No. 306), Volume I (Annex II to the *Technical Regulations* (WMO-No 49)).~~

2.~~6~~8.3~~4~~ If a change of index number of an aeronautical meteorological station on land, the reports of which are included in international exchanges, is necessary, such change should be made effective on 1 January or 1 July.

Location and composition

2.~~6~~8.4~~5~~ Aeronautical meteorological stations shall be established at aerodromes and other points of significance for international air navigation.

2.~~6~~8.5~~6~~ Aeronautical observations should consist of the following meteorological elements:

(a) Surface wind direction and speed;

(b) Visibility;

(c) Runway visual range, when applicable;

(d) Present weather;

(e) Cloud amount, type and height of base;

(f) Air temperature;

(g) Dew point temperature;

(h) Atmosphere pressure (QNH and/or QFE);

(i) Supplementary information.

Note: For further information on what is to be reported under "supplementary information", see the *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation, Part I, 4.6.8.

Frequency and timing of observations

2.~~6~~8.~~6~~7 Routine observations shall be made at intervals of one hour or, if so determined by regional air navigation agreement, at intervals of one half-hour. Special observations shall be made in accordance with criteria established by the Meteorological Authority in consultation with the appropriate Air Traffic Services Authority.

2.~~7~~9 Research and special-purpose vessel stations

General

2.~~7~~9.1 Members operating research and special-purpose vessels should do their utmost to ensure that all such vessels make meteorological observations.

Location and composition

2.~~7~~9.2 In addition to as many as possible of the meteorological elements of surface and upper-air observations, subsurface temperature observations, down to the thermocline, should also be made and transmitted (in real time), in accordance with the procedures agreed between WMO and the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization.

Frequency and timing of observations

2.~~7~~9.3 In addition to meeting requirements for research, special-purpose vessels should, when possible, make surface and upper-air observations that meet and supplement basic synoptic requirements.

2.~~8~~10 Climatological stations

General

2.~~8~~10.1 Each Member shall establish in its territory a network of climatological stations.

2.~~8~~10.2 The network of climatological stations should give a satisfactory representation of the climate characteristics of all types of terrain in the territory of the Member concerned (for example, plains, mountainous regions, plateaux, coasts and islands).

2.~~8~~10.3 Each Member shall establish and maintain at least one reference climatological station.

2.~~8~~10.4 Each Member shall establish and maintain an up-to-date directory of the climatological stations in its territory, giving the standard metadata specified in the *Manual on the WMO Integrated Global Observing System* **(WMO-No. 1160), including at least the following information for each station:**

(a) Name and geographical coordinates;

(b) Elevation;

(c) A brief description of the local topography;

(d) Category of station and details of observing programmes;

(e) Exposure of instruments, including height above ground of thermometers, raingauges and anemometers;

(f) A station history (date of beginning of records, changes of site, closure or interruption of records, changes in the name of the station and important changes in the observing programme);

(g) The name of the supervising organization or institution;

(h) The datum level to which atmospheric pressure data of the station refer.

2.~~8~~10.5 The data relating to the elevation of a climatological station should be specified to the nearest metre.

Note: Information on the accurate specification of the geographical coordinates and elevation of a station is provided in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, 1.3.3.2.

Location and composition

2.~~8~~10.6 Each climatological station should be located and set up so that it will be able to operate continually for at least 10 years, and so that the exposure will remain unchanged over a long period, unless it serves a special purpose that justifies its functioning for a shorter period.

2.~~8~~10.7 Each reference climatological station should have adequate and unchanging exposure that allows observations to be made in representative conditions. The surroundings of the station should not alter over time to such an extent that they affect the homogeneity of the series of observations.

2.~~8~~10.8 At a principal climatological station, observations shall be made of all or most of the following meteorological elements, where appropriate:

(a) Weather;

(b) Wind direction and speed;

(c) Cloud amount;

(d) Type of cloud;

(e) Height of cloud base;

(f) Visibility;

(g) Air temperature (including extreme temperatures);

(h) Humidity;

(i) Atmospheric pressure;

(j) Precipitation amount;

(k) Snow cover;

(l) Sunshine duration and/or solar radiation;

(m) Soil temperature.

2.~~8~~10.9 At a principal climatological station, soil temperature should be measured at some or all of the following depths: 5, 10, 20, 50, 100, 150 and 300 cm.

2.~~8~~10.10 At an ordinary climatological station, observations shall be made of extreme temperatures and amount of precipitation and, if possible, of some of the other meteorological elements listed in 2.~~8~~10.8 above.

2.~~8~~10.11 At an automatic climatological station, records should be made of meteorological elements selected from those in 2.~~8~~10.8 above.

Frequency and timing of observations

2.~~8~~10.12 Each Member should arrange for observations at all climatological stations to be made at fixed times, according to either UTC or Local Mean Time, which remain unchanged throughout the year.

2.~~8~~10.13 When two or more observations are made at a climatological station, they should be made at times that reflect the significant diurnal variations of the climatic meteorological elements.

2.~~8~~10.14 When changes are made to the times of climatological observations in a network, simultaneous observations should be carried out at a skeleton network of representative stations at the old times of observation and at the new ones, for a period covering the major climatic seasons of the area.

2.~~9~~11 Global Climate Observing System Surface Network stations

In implementing the observing programme at GCOS Surface Network (GSN) stations, Members should adhere to the GCOS Climate Monitoring Principles adopted by Resolution 9 (Cg-XIV). In particular, they should comply with the following best practices:

(a) Long-term continuity should be provided for each GSN station: this requires resources, including well-trained staff, and minimal changes in location. Any significant changes in instrumentation or station location should be managed so as to avoid the introduction of inhomogeneities into the measurement record. This may require that old and new instruments be operated simultaneously for a sufficient period of overlap (at least one, but preferably two years) to enable systematic biases between old and new measurement systems to be derived;

(b) CLIMAT data should be accurate, and provided in a timely manner: CLIMAT reports should be transmitted by the fifth day of the month (and no later than the eighth day of the month);

(c) Rigorous quality control of the measurements and their message encoding should be exercised: CLIMAT reports require quality control not only of the measurements themselves, but also of their message encoding to ensure their accurate transmission to national, regional and world centres. Quality-control checks should be made on site and at a central facility designed to detect equipment faults at the earliest stage possible. The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part IV, Chapter 3, provides the appropriate recommendations;

(d) The site layout should follow the recommendations in the *Guide to the Global Observing System* (WMO-No. 488);

(e) The site and instruments should be inspected regularly and maintained according to WMO recommended practices. To obtain homogeneous datasets, maintenance should be carried out as documented in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8);

(f) A national plan should be developed to archive daily data from GSN stations for climate and climate research purposes: the archive should include both observations and observational metadata pertaining to each climate station, as specified in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160);

(g) Detailed metadata and historical climate data for each GSN station should be provided: a GSN Data Centre should have an up-to-date digital copy of the historical climate data and all types of metadata for GSN stations. A current copy of the long-term series of data and metadata from GSN stations should be made available.

2.~~10~~12 Global Climate Observing System upper-air stations

2.~~10~~12.1 Global Climate Observing System Upper-air Network stations

In implementing observing programmes at GCOS Upper-air Network (GUAN) stations, Members should adhere to the GCOS Climate Monitoring Principles adopted by Resolution 9 (Cg-XIV). In particular, they should comply with the following best practices:

(a) Long-term continuity should be ensured at each GUAN station: this requires resources, including well-trained staff, and minimal changes in location. Changes in instrumentation must be managed in such a way that no systematic bias is introduced into the measurement time series. This may be accomplished by ensuring a sufficient period of overlap, with observations being made using both old and new measurement systems (perhaps as much as a year), or by making use of the results of instrument intercomparisons made at designated test sites;

(b) Soundings should preferably be made at least twice per day and should reach as high as possible, noting the GCOS requirements for ascents up to a minimum height of 30 hPa. Since climate data are needed in the stratosphere to monitor changes in the atmospheric circulation and to study the interaction between stratospheric circulation, composition and chemistry, every effort should be made to maintain soundings regularly up to a level as high as 5 hPa where feasible, noting the above GCOS requirements;

(c) Rigorous quality control should be exercised at each GUAN site: periodic calibration, validation and maintenance of the equipment should be carried out to maintain the quality of the observations;

(d) Basic checks should be made before each sounding to ensure accurate data: the accuracy of a radiosonde's sensors should be checked in a controlled environment immediately before the flight. Checks should also be made during and/or at the end of each sounding to ensure that incomplete soundings or soundings containing errors are corrected before transmission;

(e) Back-up radiosondes should be released in cases of failure: in the event of failure of a sounding instrument or incomplete sounding resulting from difficult weather conditions, a second release should be made to maintain the record from the GUAN station;

(f) Detailed metadata for each GUAN station should be provided: the batch identifier on the radiosondes should be logged for each flight, so that faulty batches can be identified and the data amended or eliminated from the climate records, if necessary. Up-to-date records of metadata in a standard format should be provided to the GUAN Data Centre. Both the corrected and uncorrected upper-air observation should be archived. Climate

change studies require extremely high stability in the systematic errors of the radiosonde measurements;

(g) To achieve suitable global coverage, Members should consider operating stations outside of national boundaries.

2.~~10~~12.2 Global Climate Observing System Reference Upper-air Network stations

Observing programmes contributing to the GCOS Reference Upper-air Network (GRUAN) must undergo the GRUAN site assessment and certification process. In particular, GRUAN sites shall comply with the following best practices:

(a) To ensure that GRUAN measurements meet their design criteria and serve the needs of the climate-monitoring community, long-term continuity of measurement series should be ensured at each GRUAN site: this requires resources including well-trained staff, long-term funding and support for replacement of aging measurement systems;

(b) Robust change management protocols shall be implemented to ensure the long-term homogeneity of the measurement series at GRUAN sites. Changes to measurement systems shall not be made without advanced notification to the GRUAN Lead Centre;

(c) Sufficient raw and metadata shall be collected at contributing sites to permit the processing of measurements, at a centralized processing facility, into a reference measurement. This requires, at least, that the uncertainty of the measurement (including corrections) has been determined, the entire measurement procedure and set of processing algorithms are properly documented and accessible, and that every effort has been made to tie the observations to an internationally accepted traceable standard. Sufficient metadata must also be collected and archived to allow reprocessing of the data at any future date;

(d) In addition to ensuring long-term homogeneity of measurement series at each site within the network, sites shall also be operated in such a way that homogeneity of measurements across the network will ensure that significant site-specific differences between GRUAN data and co-located measurements do not result from the GRUAN data products;

(e) GRUAN sites shall perform regular traceable pre-launch ground checks for balloon-borne systems and record the results. Other instruments which provide vertical profiles extending from the surface require regular checks to assure correct operation;

(f) GRUAN sites shall provide redundant reference observations of the essential climate variables selected for measurement at the site at intervals sufficient to validate the derivation of the uncertainty in the primary measurement;

(g) To achieve suitable global coverage, Members should consider operating stations outside of national boundaries.

Note: The mandatory practices required of GRUAN sites, as detailed in the *GCOS Reference Upper-Air Network (GRUAN) Manual* (GCOS-170, WIGOS Technical Report No. 2013-02), reflect GRUAN's primary goal of providing reference-quality observations of the atmospheric column while accommodating the diverse capabilities of sites within the network. However, certification of measurement programmes at a GRUAN site goes beyond considering the extent to which the site adheres to the mandatory practices outlined in the GRUAN Manual and considers the added value that the site brings to the network. The added value is assessed by experts forming the Working Group on the GCOS Reference Upper-air Network, whose judgement is guided by considerations 8.17 to 8.26 in the GRUAN Manual. The GRUAN Manual is supplemented by a more detailed *GCOS Reference Upper-Air Network (GRUAN) Guide* (GCOS-171, WIGOS Technical Report No. 2013-03) which provides guidelines on how the protocols detailed in the GRUAN Manual might be achieved, and by a series of technical documents available from the GRUAN website at http://www.gruan.org.

2.~~11~~13 Agricultural meteorological stations

General

2.~~11~~13.1 Each Member should establish in its territory a network of agricultural meteorological stations.

2.~~11~~13.2 The density of the network of each category of agricultural meteorological station should permit the delineation of weather parameters on the scale required for agrometeorological planning and operation, taking into account the agricultural features of the country.

2.~~11~~13.3 Each Member should maintain an up-to-date directory of the agricultural meteorological stations in its territory, giving the standard metadata specified in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), including at least the following information for each station:

(a) Name and geographical coordinates;

(b) Elevation;

(c) Brief description of the local topography;

(d) Natural biomass, main agrosystems and crops of the area;

(e) Types of soil, physical constants and profile of soil;

(f) Category of station, details of observing programme and reporting schedule;

(g) Exposure of instruments, including height above ground of thermometers, raingauges and anemometers;

(h) Station history (date of beginning of records, changes of site, closure or interruption of records, changes in the name of the station and important changes in the observing programme);

(i) Name of the supervising organization or institution.

Location and composition

2.~~11~~13.4 Each agricultural meteorological station should be located at a place that is representative of agricultural and natural conditions in the area concerned, preferably:

(a) At experimental stations or research institutes for agriculture, horticulture, animal husbandry, forestry, hydrobiology and soil sciences;

(b) At agricultural and allied colleges;

(c) In areas of present or future importance for agricultural and animal husbandry;

(d) In forest areas;

(e) In national parks and reserves.

2.~~11~~13.5 At an agricultural meteorological station, the observing programme should, in addition to the standard climatological observations, include some or all of the following:

(a) Observations of physical environment:

(i) Temperature and humidity of the air at different levels in the layer adjacent to the ground (from ground level up to about 10 metres above the upper limit of prevailing vegetation), including extreme values of these meteorological elements;

(ii) Soil temperature at depths of 5, 10, 20, 50 and 100 cm and at additional depths for special purposes and in forest areas;

(iii) Soil water (volumetric content) at various depths, with at least three replications when the gravimetric method is used;

(iv) Turbulence and mixing of air in the lower layer (including wind measurements at different levels);

(v) Hydrometeors and water-balance components (including hail, dew, fog, evaporation from soil and from open water, transpiration from crops or plants, rainfall interception, runoff and water table);

(vi) Sunshine, global and net radiation as well as the radiation balance over natural vegetation, and crops and soils (over 24 hours);

(vii) Observations of weather conditions causing direct damage to crops, such as frost, hail, drought, floods, gales and extremely hot, dry winds;

(viii) Observations of damage caused by sandstorms and duststorms, atmospheric pollution and acid deposition as well as forest, bush and grassland fires;

(b) Observations of a biological nature:

(i) Phenological observations;

(ii) Observations on growth (as required for the establishment of bioclimatic relationships);

(iii) Observations on qualitative and quantitative yield of plant and animal products;

(iv) Observations of direct weather damage on crops and animals (adverse effects of frost, hail, drought, floods, gales);

(v) Observations of damage caused by diseases and pests;

(vi) Observations of damage caused by sandstorms and duststorms and atmospheric pollution, as well as forest, bush and grassland fires.

Frequency and timing of observations

2.~~11~~13.6 Observations of a physical nature should be made at the main synoptic times. Observations of a biological nature should be made regularly or as frequently as significant changes occur, and should be accompanied by meteorological observations.

2.~~12~~14 Special stations

2.~~12~~14.1 General

2.~~12~~14.1.1 In addition to the stations discussed previously, Members should establish special stations.

Note: In some cases, these special stations are collocated with surface or upper-air stations of the RBSNs.

2.~~12~~14.1.2 Members should cooperate in the establishment of special stations for particular purposes.

2.~~12~~14.1.3 Special stations shall include:

~~(a) Weather radar stations;~~

(~~b~~a) Radiation stations;

(~~c~~b) Other remote-sensing~~Wind~~ profiler stations;

(~~d~~c) ~~Atmospherics detection~~Lightning location stations;

(~~e~~d) Meteorological reconnaissance aircraft stations;

~~(f) Meteorological rocket stations;~~

(~~g~~e) Global Atmosphere Watch stations;

(~~h~~f) Planetary boundary-layer stations;

(~~i~~g) Tide-gauge stations.

~~2.12.1.4 A special station should be identified by its name, geographical coordinates and elevation.~~

~~2.12.2 Weather radar stations~~

~~General~~

~~2.12.2.1 Members should establish an adequate network of weather radar stations, either nationally or in combination with other Members of the Region or Regions, in order to secure information about areas of precipitation and associated phenomena and about the vertical structure of cloud systems, for operational meteorology, hydrology, climatology and research.~~

~~Location and composition~~

~~2.12.2.2 Weather radars shall be located in such a manner as to minimize interference from surrounding hills, buildings and electro-magnetic sources, so as to provide good coverage of population centres; geographic features affecting stream and river flows; and major thoroughfares and other facilities of importance.~~

~~Frequency and timing of observations~~

~~2.12.2.3 As a minimum, observations should be taken and reported at hourly intervals. Observations should be more frequent when heavy convective activity or heavy widespread precipitation is occurring.~~

2.~~12~~14.~~3~~2 Radiation stations

General

2.~~12~~14.~~3~~2.1 Members should establish at least one principal radiation station in each climatic zone of their territory.

2.~~12~~14.~~3~~2.2 Members should maintain a network of radiation stations of sufficient density for the study of radiation climatology.

2.~~12~~14.~~3~~2.3 Each Member should maintain an up-to-date directory of the radiation stations in its territory, including ordinary and principal stations, giving the following information for each station:

(a) Name and geographical coordinates in degrees and minutes of arc;

(b) Elevation, in whole metres;

(c) Brief description of local topography;

(d) Category of station and details of the observing programme;

(e) Details of radiometers in use (type and serial number of each instrument, calibration factors, dates of any significant changes);

(f) Exposure of radiometers, including height above ground, details of the horizon of each instrument and nature of the surface of the ground;

(g) Station history (date of beginning of records, changes of site, closure or interruption of records, changes in the name of the station and important changes in the observing programme);

(h) Name of the supervising organization or institution.

Location and composition

2.~~12~~14.~~3~~2.4 Each radiation station shall be located, to the extent possible, to benefit from adequate exposure that permits observations to be made in representative conditions.

Note: The exposure and surroundings of the stations should not alter over time to such an extent as to affect the homogeneity of the series of observations.

2.~~12~~14.~~3~~2.5 At principal radiation stations, the observing programme should include:

(a) Continuous recording of global solar radiation and sky radiation, using pyranometers of the first or second class;

(b) Regular measurements of direct solar radiation;

(c) Regular measurements of net radiation (radiation balance) over natural and crop soil cover (made over a 24-hour period);

(d) Recording of duration of sunshine.

Note: The terminology of radiation qualities and measuring instruments and the classification of pyranometers is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 7.

2.~~12~~14.~~3~~2.6 At ordinary radiation stations, the observing programme should include:

(a) Continuous recording of global solar radiation;

(b) Recording of duration of sunshine.

2.~~12~~14.~~3~~2.7 Pyrheliometric measurements shall be expressed in accordance with the World Radiometric Reference.

Frequency and timing of observations

2.~~12~~14.~~3~~2.8 When automatic recording is not available, measurements of direct solar radiation should be made at least three times a day, provided the sun and the sky in the vicinity are free from cloud, corresponding to three different solar heights, one of them being near the maximum.

2.~~12~~14.~~3~~2.9 During clear-sky conditions, measurements of long-wave effective radiation should be made every night, one of them being made soon after the end of the evening civil twilight.

2.~~12~~14.~~4~~3 ~~W~~Other remote-sensing~~ind~~ profiler stations

General

2.~~12~~14.~~4~~3.1 Members should consider the establishment of ~~wind~~ other remote-sensing profilers.

Note: In addition to radar wind profilers, addressed in section 2.6, a range of other remote-sensing technologies are being used to collect wind and thermal profiles of the atmosphere. Chapter 5, section 5.2 of the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part II, provides further information about acoustic sounders (sodars), radio acoustic sounding systems, microwave radiometers, laser radars (lidars) and the Global Navigation Satellite System (GNSS). Doppler weather radars may also be used to derive wind profiles.

Location

2.~~12~~14.~~4~~3.2 ~~Wind profiler stations should be located so as to measure wind profiles in the troposphere.~~ The location and spacing of stations should be consistent with the requirements for the observations.

2.~~12~~14.~~5~~4 ~~Atmospherics detection~~Lightning location stations

General

2.~~12~~14.~~5~~4.1 Members should consider acquiring observations from lightning location systems~~Members should establish atmospherics detection stations~~.

Note: A detailed description of ~~M~~methods in use ~~are described~~is provided in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part II, Chapter ~~6~~7. A surface-based sensor at a single station can detect the occurrence of lightning, but cannot be used to locate it on an individual flash basis. A network of stations is needed for accurate lightning location.

Location and composition

2.~~12~~14.~~5~~4.2 ~~Atmospherics (spherics) detection stations should be located so as to measure this phenomenon in areas of frequent convective activity.~~ The spacing and number of ~~ground~~ stations should be ~~determined based on~~consistent with the technique used, and the desired coverage, detection efficiency and accuracy of location.

Frequency and timing of observations

2.~~12~~14.~~5~~4.3 Continuous monitoring by the station should be maintained~~, with an indication of direction and distance, at about 10-minute intervals~~.

2.~~12~~14.~~6~~5 Meteorological reconnaissance aircraft stations

General

2.~~12~~14.~~6~~5.1 Members are encouraged to organize and communicate, either individually or jointly, routine and special aircraft weather reconnaissance flights.

Location and composition

2.~~12~~14.~~6~~5.2 Aircraft reconnaissance facilities should be located near prevalent storm tracks in data-sparse areas. Reconnaissance flights should be initiated in locations where additional observational information is required for the investigation and prediction of developing or threatening storms.

2.~~12~~14.~~6~~5.3 Meteorological reconnaissance flight observations should include:

(a) Altitude and position of aircraft;

(b) Observations made at frequent intervals during a horizontal flight at low level;

(c) Observations made during flights at higher levels, as near as possible to standard isobaric surfaces;

(d) Vertical soundings, either by aircraft or by dropsonde.

2.~~12~~14.~~6~~5.4 The meteorological elements to be observed during meteorological reconnaissance flights should include:

(a) Atmospheric pressure at which the aircraft is flying;

(b) Air temperature;

(c) Humidity;

(d) Wind (type of wind, wind direction and speed);

(e) Present and past weather;

(f) Turbulence;

(g) Flight conditions (cloud amount);

(h) Significant weather changes;

(i) Icing and contrails.

Note 1. For detailed guidance regarding observations made during meteorological reconnaissance flights, see the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8).

Note 2. Type of wind refers to how the wind was determined and whether it was a mean or a spot wind.

Frequency and timing of observations

2.~~12~~14.~~6~~5.5 Reconnaissance flights should be scheduled in response to requirements for data from data-sparse areas, or in response to special phenomena.

2.~~12~~14.~~6~~5.6 Flight times and frequency should be selected so that reconnaissance information supplements upper-air information.

~~***2.12.7 Meteorological rocket stations***~~

~~**General**~~

~~2.12.7.1 Members are encouraged to establish meteorological rocket stations.~~

~~Note: When establishing and operating these stations, appropriate safety precautions are considered necessary and need to be coordinated with the relevant air traffic control authorities.~~

~~**Location and composition**~~

~~2.12.7.2 Members establishing rocket stations should coordinate their locations through WMO so that continuous networks can be maintained. Meteorological elements to be measured include:~~

~~(a) Wind direction and speed;~~

~~(b) Air temperature;~~

~~(c) Solar radiation;~~

~~(d) Electrical variables;~~

~~(e) Minor chemical constituents.~~

~~**Frequency and timing of observations**~~

~~2.12.7.3 The frequency and timing of launches should be coordinated, because of cost, among Members concerned, to allow simultaneous sampling at rocket network stations. Information on launches should be communicated to the Secretariat.~~

2.~~12~~14.~~8~~6 Global Atmosphere Watch stations

Note: Technical regulations relating to the observing component of the Global Atmosphere Watch (GAW) are contained in the *Technical Regulations* (WMO-No. 49), Volume I – General Standards and Recommended Practices, Part I – WMO Integrated Global Observing System, and in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160). Further information on GAW stations is contained in the GAW Station Information System at http://gaw.empa.ch/gawsis/ as well as the appropriate GAW technical publications, and the *Guide to the Global Observing System* (WMO-No. 488).

2.~~12~~14.~~9~~7 Planetary boundary-layer stations

General

2.~~12~~14.~~9~~7.1 Members should establish an adequate network of stations for making measurements in the planetary boundary layer.

Location and composition

2.~~12~~14.~~9~~7.2 Members should, whenever possible, provide a capability to obtain detailed knowledge of the profiles of temperature, humidity, pressure and wind in the lowest 1 .

Note 1. This information is required in the study of diffusion of atmospheric pollution, the transmission of electromagnetic signals, the relation between free-air variables and boundary-layer variables, severe storms, cloud physics, convective dynamics, etc.

Note 2. The required accuracy and height intervals of measurements of several variables depend upon the nature of the problems under study.

Note 3. Some of the vertical and horizontal sounding systems which could be applied to specific problems for limited periods in a variety of locations are described in the *Guide to the Global Observing System* (WMO-No. 488).

2.~~12~~14.~~10~~8 Tide-gauge stations

General

2.~~12~~14.~~10~~8.1 Members should establish an adequate network of tide-gauge stations along coasts subject to storm surges.

Location and composition

2.~~12~~14.~~10~~8.2 Gauges should be placed in a manner that allows determination of the full range of water heights.

Frequency and timing of observations

2.~~12~~14.~~10~~8.3 Observations of tide height should be made at the main synoptic times, 0000, 0600, 1200 and 1800 UTC. In coastal storm situations, hourly observations should be made.

3. EQUIPMENT AND METHODS OF OBSERVATION

Note: The *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) is the authoritative reference for all matters related to methods of observations. It should be consulted for more detailed descriptions.

3.1 General requirements for meteorological stations

3.1.1 All stations shall be equipped with properly calibrated instruments to allow for observations and measurements to be made using sufficiently advanced techniques so that the measurements and observations of the various meteorological elements are accurate enough to meet the needs of synoptic meteorology, aeronautical meteorology, climatology and other meteorological disciplines.

Note: For detailed guidance on instruments and methods of observation, see the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) and *Weather Reporting* (WMO-No. 9), Volume D – Information for Shipping.

3.1.2 To satisfy data requirements, primary data from surface-based instruments and observing systems shall be converted into meteorological variables.

3.1.3 The exposure of instruments for the same type of observation at different stations shall be similar in order that observations may be compatible.

3.1.4 A reference height shall be established at each meteorological station.

3.1.5 In order to ensure maintenance of a high standard of observations and the correct functioning of instruments, stations shall be inspected periodically.

3.1.6 Station inspections should be carried out by experienced personnel and should ensure that:

(a) The siting and exposure of instruments are known, recorded and acceptable;

(b) Instruments have approved characteristics, are in good order and regularly verified against relevant standards;

(c) There is uniformity in the methods of observation and in the procedure for reduction of observations;

(d) The observers are competent to carry out their duties.

3.1.7 All synoptic land stations should be inspected at least once every two years.

3.1.8 Agricultural meteorological and special stations should be inspected at least once every year.

3.1.9 Principal climatological stations should be inspected at least once every year; ordinary climatological and precipitation stations should be inspected at least once every three years. If possible, relevant inspections should occasionally be carried out during the winter season.

3.1.10 Automatic weather stations should be inspected not less than once every ~~six months~~two years.

3.1.11 At sea stations, barometers should be checked at least twice a year with reference to a standard barometer.

3.2 General requirements for instruments

3.2.1 Meteorological instruments should be reliable and accurate.

Note: It is mandatory for Members to avoid the use of mercury in their instruments or, where mercury is still in use, to obey safety precautions. See the Manual on the WMO Integrated Global Observing System (WMO-No. 1160) section 3.3.2.1.

3.2.2 Instruments in operational use shall be periodically compared directly or indirectly with the relevant national standards.

3.2.3 Where automated instrument systems are employed, reference (or check) values of variables shall also be measured, taking into consideration criteria for the allowed difference between the reference and compared instruments as well as the appropriate minimum time interval between comparisons.

3.2.4 At reference climatological stations, any change in instrumentation should be such as not to decrease the degree of accuracy of any observations as compared with the earlier observations, and any such change should be preceded by an adequate overlap (at least two years) of older and newer instrumentation.

3.2.5 Unless otherwise specified, instruments designated as regional and national standards should be compared by means of travelling standards at least once every five years.

3.2.6 In order to control effectively the standardization of meteorological instruments on a national and international scale, a system of national and regional standards, as adopted by WMO, shall be applied in the GOS.

Note: (See the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1.)

3.3 Surface observations

3.3.1 General

3.3.1.1 Observations should be made in such a way that:

(a) A representative temporally smoothed value of the variable can be found in the vicinity of the station;

(b) All representative extreme values (or other indicators of dispersion) can be determined, if required;

(c) All synoptic-scale discontinuities (such as fronts) can be identified as soon as possible after an observation is made.

3.3.1.2 To satisfy these requirements, observational methods should be selected so as to achieve:

(a) Suitable temporal and/or spatial samples of each variable;

(b) A justifiable accuracy for the measurement of each variable;

(c) A representative observation height above the ground.

3.3.1.3 To avoid the effect of small-scale fluctuations, the meteorological variable should be sampled continuously or repeatedly over a suitable time in order to obtain both representative mean and extreme values. Alternatively, instruments with a suitable lag or damping effect should be used to eliminate or substantially reduce high-frequency noise.

3.3.1.4 The averaging time should be short compared with the temporal scale of such discontinuities as fronts or squall lines, which usually delineate air masses with different characteristics whilst removing the effects of small-scale disturbance. For example, for synoptic purposes, an average taken over 1 to 10 minutes will suffice for the measurement of atmospheric pressure, air temperature, humidity, wind, sea-surface temperature and visibility.

3.3.1.5 Instrumental readings shall be corrected and reduced as appropriate.

3.3.2 Atmospheric pressure

3.3.2.1 Barometric readings shall be reduced from local acceleration of gravity to standard (normal) gravity. The value of standard (normal) gravity (gn) shall be regarded as a conventional constant.

gn = 9.806 65 m s^{-2}

3.3.2.2 The hectopascal (hPa), equal to 100 pascals (Pa), shall be the unit in which pressures are reported for meteorological purposes.

Note: One hPa is physically equivalent to one millibar (mb) and thus no changes are required to scales or graduations made in mb in order to read them in hPa.

3.3.2.3 Atmospheric pressure shall be determined by a suitable pressure measuring device. The uncertainty of such a device is specified in the *Guide to Meteorological Instruments and Methods of Observation* **(WMO-No. 8), Part I, Chapter 1, Annex 1.E.**

3.3.2.4 In order for mercury barometer readings made at different times and at different places to be comparable, the following corrections should be made:

(a) Correction for index error;

(b) Correction for gravity;

(c) Correction for temperature.

Note: It is mandatory for Members to avoid the use of mercury in their instruments or, where mercury is still in use, to obey safety precautions. See the Manual on the *WMO Integrated Global Observing System* (WMO-No. 1160) section 3.3.2.1 and the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part I, Chapter 3, 3.2.7.

3.3.2.5 Whenever it is necessary to compute the theoretical local value of the acceleration due to gravity, each Member shall follow the procedure given in the *Guide to Meteorological Instruments and Methods of Observation* **(WMO-No. 8), Part I, Chapter 3, Annex 3.A.**

3.3.2.6 Atmospheric pressure at a station shall be reduced to mean sea level, except at those stations where regional association resolutions prescribe otherwise.

3.3.2.7 The results of comparisons of national and regional reference standard barometers shall be reported to the Secretariat for communication to all Members concerned.

3.3.2.8 Regional comparisons of national standard barometers with a regional standard barometer shall be arranged at least once every 10 years.

3.3.2.9 Reference standards for comparison purposes may be provided by a suitable pressure measuring device that, generally, shall be of the highest metrological quality available at a given location (or in a given organization), and to which measurements made there are traceable.

3.3.2.10 In calibration against a standard barometer whose index errors are known and allowed for, tolerances for a station barometer stated in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 3 should not be exceeded.

3.3.3 Air temperature

3.3.3.1 One of the following three main types of thermometer shall be used:

(a) Liquid-in-glass thermometer;

(b) Resistance thermometer;

(c) Thermocouples.

All temperature shall be reported in degrees Celsius.

3.3.3.2 An instrument height of between 1.25 and 2.0 m above ground is considered satisfactory to obtain representative air temperature measurements.

Note: At a station where considerable snow cover may occur, a greater height is permissible or, alternatively, a moveable support can be used allowing the thermometer housing to be raised or lowered in order to maintain the correct height above the snow surface.

3.3.3.3 Thermometer screens should be constructed to minimize radiation effects and at the same time allow free influx and circulation of air.

3.3.3.4 Thermometers should be checked against a reference standard instrument every two years.

Note: The required uncertainties are given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 1, Annex 1.E.

3.3.3.5 For psychrometric purposes, thermometers shall be read to at least 0.1 °C.

3.3.4 Humidity

Note: Definitions and specifications of water vapour in the atmosphere are given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 4, Annex 4.A.

3.3.4.1 In surface observations, at temperatures above 0 °C values of humidity should be derived from the readings of a psychrometer or other instrument of equal or better accuracy.

3.3.4.2 If forced ventilation of psychrometers is used the airflow past the thermometer bulbs should be between 2.5 m s^{-1} and 10 m s^{-1}.

3.3.4.3 In surface observations the height requirements for humidity measurements shall be the same as for air temperature measurements.

3.3.5 Surface wind

3.3.5.1 The exposure of wind instruments over level, open terrain shall be 10 metres above the ground.

Note: Open terrain is defined as an area where the distance between the anemometer and any obstruction is at least 10 times, but preferably 20 times, the height of the obstruction.

3.3.5.2 At aeronautical stations the wind sensors should be exposed to provide measurements representative of conditions 6 to 10 metres above the runway at the average take-off and touch-down points.

3.3.5.3 Wind speed should be measured to the nearest unit (metres per second, kilometres per hour or knots), and should represent, for synoptic reports, an average over 10 minutes or, if the wind changes significantly in the 10-minute period, an average over the period after the change.

Note: In observations used at an aerodrome for aircraft taking off and landing, the averaging period is two minutes and the speed is reported in metres per second, kilometres per hour or knots (with an indication of the unit used).

3.3.5.4 Wind direction should be measured in degrees and reported to the nearest 10 degrees and should represent a scalar average over10 minutes or, if the wind changes significantly in the 10-minute period, an average over the period after the change.

3.3.5.5 "Calm" should be indicated when the average wind speed is less than 0.5 m s^{-1}. The direction is not measured for synoptic purposes in this case.

3.3.5.6 In the absence of an anemometer, the wind speed may be estimated using the Beaufort scale.

Note: The Beaufort scale is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 5.

3.3.5.7 At sea stations, in the absence of an appropriate instrument, the wind speed may be estimated by reference to the Beaufort scale and the wind direction by observing the motion of sea waves.

3.3.6 Clouds

3.3.6.1 For all cloud observations, the tables of classification, definitions and descriptions of general species and varieties of clouds as given in the *International Cloud Atlas* (WMO-No. 407), Volume I – Manual on the Observation of Clouds and other Meteors (Annex I to the *Technical Regulations* (WMO-No. 49)), shall be used.

3.3.6.2 Height of cloud base should preferably be determined by measurement.

3.3.7 Weather

Note: See the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 14, paragraph 14.2.

3.3.8 Precipitation

3.3.8.1 The amount of precipitation shall be the sum of the amounts of liquid precipitation and the liquid equivalent of solid precipitation.

3.3.8.2 Daily amounts of precipitation should be measured to the nearest 0.2 mm and, if feasible, to the nearest 0.1 mm. Daily measurements of precipitation should be made at fixed times.

3.3.8.3 The design and exposure of a raingauge should be such as to minimize the effects of wind, evaporation and splashing, these being the most frequent sources of error.

Note: In general, objects should not be closer to the gauge than a distance twice their height above the gauge orifice.

3.3.9 Sea-surface temperature

The method used at manned sea stations for measuring sea-surface temperature shall be entered in the relevant meteorological logbook.

3.3.10 Waves

When separate wave systems are clearly distinguishable, each of them should be recorded.

3.3.11 Radiation

The comparison of radiation instruments on a regional or a global level should be performed at least once every five years. The calibration of radiation instruments should be checked and these should be recalibrated, if necessary, at least once a year against existing standards.

Note: For details of calibration of other radiation sensors, refer to the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapter 7.

3.3.12 Soil temperature

3.3.12.1 Measurements should be made to detect diurnal variations of soil temperature at depths of 5, 10, 20 and, in some cases, 50 cm.

3.3.12.2 Soil surface temperature measurements are recommended for special purposes.

3.3.13 Soil moisture

3.3.13.1 Gravimetric estimation of soil moisture should be taken as the average of at least three samples from each depth.

3.3.13.2 Gravimetric water content should be expressed as the grams of soil moisture contained in a gram of dry soil.

3.3.14 Evapotranspiration

Observations of evapotranspiration should be representative of the plant cover and moisture conditions of the general surroundings of the station. Separate statements of evapotranspiration from irrigated areas should be provided.

3.3.15 Evaporation

3.3.15.1 Evaporation should be measured by means of evaporation tanks. The design and exposure of the evaporation tanks should ensure the required comparability of observations.

3.3.15.2 Water temperature and wind run records should be taken at each observation.

3.3.15.3 The amount of evaporation should be read in millimetres.

3.3.16 Sunshine duration

The threshold value for bright sunshine should be 120 W m^{-2} of direct solar irradiance.

3.4 Upper-air observations

3.4.1 At upper-air synoptic stations, atmospheric pressure, temperature and humidity (PTU) observations shall be made by means of a radiosonde attached to a fast-ascending free balloon.

Note: For detailed guidance on the radiosonde and balloon techniques, see the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part I, Chapters 12 and 13.

3.4.2 Computations of upper-air observations shall be based on the relevant definitions of physical functions and values of constants given in the *Technical Regulations* (WMO-No. 49), Volume I – General Meteorological Standards and Recommended Practices, Appendix A.

3.4.3 At an upper-air synoptic station, upper-wind observations should be made by tracking of the fast-ascending free balloon by electronic means (such as radio theodolite, radar or NAVAID).

Note: At stations where the skies are generally clear, upper winds may be determined by optical tracking of a balloon.

3.4.4 Each upper-air station should have an appropriate manual of instructions.

3.4.5 Each upper-air synoptic station shall promptly report any changes of the types of radiosonde and windfinding systems in operational use to the Secretariat for communication to all Members, at least on a quarterly basis.

3.4.6 International comparisons of widely used radiosonde types shall be made at least once every four years.

3.4.7 New radiosonde types should be compared with sondes accepted as having the most stable and accurate performance before adoption for operational use.

3.4.8 At a meteorological reconnaissance aircraft station, electronic means (NAVAID) should be used when a vertical profile of upper winds is to be determined by means of a dropsonde.

SECTION: Chapter
Chapter title in running head: PART III. SURFACE-BASED SUBSYSTEM

ATTACHMENT III.1. AUTOMATIC WEATHER STATION METADATA REQUIRED FOR OPERATIONAL PURPOSES

Note: The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) specifies the WIGOS Metadata Standard defined in Appendix 2.4 for all WMO Integrated Global Observing System (WIGOS) observations. This attachment provides further details relevant only to automatic weather stations.

A metadata database should provide detailed information to enable users to gain adequate background knowledge about the station and observational data, together with updates due to changes that occur.

Major database elements include the following:

(a) Network information;
(b) Station information;
(c) Individual instrument information;
(d) Data-processing information;
(e) Data handling information;
(f) Data transmission information.

Station information

There is a great deal of information related to a station’s location, local topography, etc. Basic station metadata include:

(a) Station name and index number(s);
(b) Geographical coordinates;
(c) Elevation above mean sea level;
(d) Types of soil, physical constants and profile of soil;
(e) Types of vegetation and condition;
(f) Local topography description;
(g) Type of automatic weather station, manufacturer, model, serial number;
(h) Observing programme of the station: parameters measured, reference time, times at which observations/measurements are made and reported;
(i) The datum level to which atmospheric pressure data of the station refer.

Individual instrument information

(Information related to sensors installed at the station, including recommended, scheduled and performed maintenance and calibration)

Metadata provided should be:

(a) Sensor type, manufacturer, model, serial number;
(b) Principle of operation, method of measurement/observation, type of detection system;
(c) Performance characteristics;
(d) Unit of measurement, measuring range;
(e) Resolution, accuracy (uncertainty), time constant, time resolution, output averaging time;
(f) Siting and exposure: location, shielding, height above ground (or level of depth);
(g) Data acquisition: sampling interval, averaging interval and type;
(h) Correction procedures;
(i) Calibration data and time of calibration;
(j) Preventive and corrective maintenance: recommended/scheduled maintenance and calibration procedures, including frequency, procedure description;
(k) Results of comparison with travelling standard.

Data-processing information

For each individual meteorological element, metadata related to processing procedures include:

(a) Measuring/observing programme: time of observations, reporting frequency, data output;
(b) Data-processing method/procedure/algorithm;
(c) Formula to calculate the element;
(d) Mode of observation/measurement;
(e) Processing interval;
(f) Reported resolution;
(g) Input source (instrument, element, etc.);
(h) Constants and parameter values.

Data handling information

Metadata elements of interest include:

(a) Quality control procedures/algorithms;
(b) Quality control flags definition;
(c) Constants and parameter values;
(d) Processing and storage procedures.

Data transmission information

The transmission-related metadata of interest are:

(a) Method of transmission;
(b) Data format;
(c) Transmission time;
(d) Transmission frequency.

SECTION: Chapter
Chapter title in running head: PART IV. SPACE-BASED SUBSYSTEM

PART IV. SPACE-BASED SUBSYSTEM

Note: Regulations applicable to the space-based subsystem of the GOS are contained in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

SECTION: Chapter
Chapter title in running head: PART V. QUALITY CONTROL

PART V. QUALITY CONTROL

Note: Provisions for quality control of all WIGOS observations, including GOS observations, are contained in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

SECTION: Chapter
Chapter title in running head: APPENDIX. DEFINITIONS

APPENDIX. DEFINITIONS

The following terms, when used in this Manual, have the meanings given below. Composite terms have not been defined in this section when their meanings can easily be deduced from those of the elements constituting them. For example, the meaning of the term "synoptic land station" can be constructed logically from the meaning of the terms "synoptic station" and "land station". Other definitions can be found in the *Manual on Codes* (WMO-No. 306), *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), *Manual on the Global Telecommunication System* (WMO-No. 386) and other WMO publications.

Many terms used in this Manual are defined in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) and are not repeated here.

A. METEOROLOGICAL OBSERVING FACILITIES AND RELATED SERVICES

Aeronautical meteorological station: A station designated to make observations and meteorological reports for use in international air navigation.

Agricultural meteorological station: A station that provides meteorological and biological information for agricultural and/or biological applications. Agricultural meteorological stations are classified as follows:

– Principal agricultural meteorological station: A station that provides detailed simultaneous meteorological and biological information and where research in agricultural meteorology is carried out. The instrumental facilities, the range and frequency of observations in both meteorological and biological fields, and the professional personnel are such that fundamental investigations into agricultural meteorological questions of interest to the countries or Regions concerned can be carried out.

– Ordinary agricultural meteorological station: A station that provides, on a routine basis, simultaneous meteorological and biological information and may be equipped to assist in research into specific problems; in general the programme of biological or phenological observations for research will be related to the local climatic regime of the station.

- Auxiliary agricultural meteorological station: A station that provides meteorological and biological information. The meteorological information may include such items as soil temperature, soil moisture, potential evapotranspiration, detailed information on the very lowest layer of the atmosphere; the biological information may cover phenology, onset and spread of plant diseases, etc.

- Agricultural meteorological station for specific purposes: A station set up temporarily or permanently that provides meteorological data for specific agricultural purposes.

Aircraft Communication Addressing and Reporting System (ACARS): Automated aviation meteorological data collection system from aircraft fitted with appropriate software packages. Similar in function to ASDAR.

Aircraft Meteorological Data Relay (AMDAR): The collective name for the automated aviation meteorological data collection systems called ASDAR and ACARS from aircraft fitted with appropriate software packages.

Aircraft to Satellite Data Relay (ASDAR): Automated aviation meteorological data collection system from aircraft fitted with appropriate software packages. Similar in function to ACARS.

Anchored platform station: An observing station on a platform anchored in deep water.

Atmospherics detection station: A station contributing observations to an atmospheric detection system.

Atmospherics detection system: An instrumental system consisting of a number of stations for the detection and location of atmospherics.

Automated aircraft meteorological system: A series of devices integrated into the instrumentation of an aircraft, which records and/or transmits observations automatically.

Automatic weather station (AWS): Meteorological station at which observations are made and transmitted automatically.

Auxiliary ship station: A mobile ship station, normally without certified meteorological instruments, that transmits reports in code form or in plain language, either as routine or on request, in certain areas or under certain conditions.

Climatological station: A station whose observations are used for climatological purposes. Climatological stations are classified as follows:

- Reference climatological station: A climatological station the data of which are intended for the purpose of determining climatic trends. This requires long periods (not less than 30 years) of homogeneous records, where human-induced environmental changes have been and/or are expected to remain at a minimum. Ideally, the records should be of sufficient length to make possible the identification of secular changes of climate.

- Principal climatological station: A climatological station at which hourly readings are taken, or at which observations are made at least three times daily in addition to hourly tabulation from autographic records.

- Ordinary climatological station: A climatological station at which observations are made at least once daily, including daily readings of extreme temperature and of amount of precipitation.

- Climatological station for specific purposes: A climatological station established for the observation of a specific element or elements.

Coastal station: A station on a coast that may be able to make some observations of conditions at sea.

Drifting automatic sea (drifting buoy) station: A floating automatic station that is free to drift under the influence of wind and current.

Environmental data buoy station: A fixed or drifting buoy which records or transmits environmental and/or marine data.

Environmental observation satellite: An artificial Earth satellite providing data on the Earth system which are of benefit to WMO Programmes.

Note: These data support a variety of disciplines including, but not limited to, meteorology, hydrology, climatology, oceanography, climate and global change related disciplines.

Fixed platform station: An observing station on a platform at a fixed site in shallow water.

Fixed sea station: An ocean weather ship or a station situated on a lightship, a fixed or anchored platform, a small island or in certain coastal areas.

Global Climate Observing System Reference Upper-Air Network (GRUAN) station: An upper-air station included in the network of stations specially selected and certified to provide long-term high-quality climate records.

Global Climate Observing System Surface Network (GSN) station: A land station included in the specially selected network of stations to monitor daily and large-scale climate variability on a global basis.

Global Climate Observing System Upper-Air Network (GUAN) station: An upper-air station included in the specially selected global baseline network of upper-air stations to meet the requirements of the Global Climate Observing System.

Global Data-processing and Forecasting System (GDPFS): The coordinated global system of meteorological centres and arrangements for the processing, storage and retrieval of meteorological information within the framework of the World Weather Watch.

Global Telecommunication System (GTS): The coordinated global system of telecommunication facilities and arrangements for the rapid collection, exchange and distribution of observational and processed information within the framework of the World Weather Watch.

Ice-floe station: An observing station on an ice floe.

Island station: A station on a small island on which conditions are similar to those in the marine environment and from which some observations of conditions at sea can be made.

Land station: An observing station situated on land.

Lightship station: A surface synoptic station situated aboard a lightship.

Meteorological element: Atmospheric variable or phenomenon which characterizes the state of the weather at a specific place at a particular time (see Section B below).

Meteorological reconnaissance aircraft station: A meteorological station on an aircraft equipped and assigned for the specific purpose of making meteorological observations.

Meteorological reconnaissance flight: An aircraft flight for the specific purpose of making meteorological observations.

Meteorological rocket station: A station equipped to make atmospheric soundings using rockets.

Mobile sea station: A station aboard a mobile ship or an ice floe.

National Meteorological Centre (NMC): A centre responsible for carrying out national functions including those under the World Weather Watch.

Ocean weather station: A station aboard a suitably equipped and staffed ship that should remain at a fixed sea position and that makes and reports surface and upper-air observations, and may also make and report subsurface observations.

Ozone sounding station: A station at which observations of atmospheric ozone are made.

Pilot-balloon observation: A determination of upper winds by optical tracking of a free balloon.

Pilot-balloon station: A station at which upper winds are determined by optical tracking of a free balloon.

Planetary boundary layer: The lowest layer in the atmosphere, usually taken to be up to 1 500 m, in which meteorological conditions are affected significantly by the Earth's surface.

Planetary boundary-layer station: A station equipped to provide detailed meteorological data on the planetary boundary layer.

Precipitation station: A station at which observations of precipitation only are made.

Radar wind profiler observation: A vertical profile of the horizontal wind vector and under some conditions the vertical wind component, determined by transmitting radar signals and analysing the reflected information contained in the backscattered electromagnetic wave using system-specific data processing techniques.

Radar wind profiler station: A surface-based station at which radar wind profiler observations are made.

Radar wind profiler system: A system that makes radar wind profiler observations.

Note: The system includes observational data processing and telecommunications hardware and software, documentation, monitoring, maintenance, and certain facilities and support capabilities such as power supply and air conditioning, together with the human expertise and resources required to operate and manage all of these components.

Radiation station: A station at which observations of radiation are made.

– Principal radiation station: A radiation station the observing programme of which includes at least the continuous recording of global solar radiation and of sky radiation and regular measurements of direct solar radiation.

– Ordinary radiation station: A radiation station whose observing programme includes at least the continuous recording of the global solar radiation.

Note: The terminology of radiation quantities and measuring instruments is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8).

Radiosonde observation: An observation of meteorological elements in the upper air, usually atmospheric pressure, temperature and humidity, by means of a radiosonde.

Note: The radiosonde may be attached to a balloon, or it may be dropped (dropsonde) from an aircraft or a rocket.

Radiosonde station: A station at which observations of atmospheric pressure, temperature and humidity in the upper air are made by electronic means.

Radiowind observation: A determination of upper winds by tracking of a free balloon by electronic means.

Radiowind station: A station at which upper winds are determined by the tracking of a free balloon by electronic means.

Rawinsonde observation: A combined radiosonde and radiowind observation.

Rawinsonde station: A combined radiosonde and radiowind station.

Reference level data: Data for a specified level, normally 1 000 hPa, which enable absolute heights to be ascribed to satellite temperature-sounding data.

Regional Basic Climatological Network (RBCN): A network composed of climatological stations within a WMO Region with a specified observational programme, which is a minimum regional requirement to permit Members to fulfil their World Weather Watch responsibilities, and also serves as a target list for WWW monitoring of climatological data.

Regional Basic Synoptic Network (RBSN): A network composed of synoptic stations within a WMO Region with a specified observational programme, which is a minimum regional requirement to permit Members to fulfil their World Weather Watch responsibilities and in the application of meteorology.

Regional Meteorological Centre (RMC): A centre of the Global Data-Processing and Forecasting System which has the primary purpose of issuing meteorological analyses and prognoses on a regional scale.

Regional Specialized Meteorological Centre (RSMC): A centre of the Global Data-processing and Forecasting System that has the primary purpose of issuing meteorological analyses and prognoses on a regional scale for a specified geographical area or of providing products and related information in a designated field of activity specialization.

Research and special-purpose vessel station: A vessel making voyages for research or other purposes, which is recruited to make meteorological observations during the voyages.

Sea station: An observing station situated at sea.

Selected ship station: A mobile ship station that is equipped with sufficient certified meteorological instruments for making observations and that transmits the required observations in the appropriate code form for ships.

Special report: A report made at a non-standard time of observation when specified conditions or changes of conditions occur.

Special station: A station for a special purpose as specified in Part III, paragraph 1, of this Manual.

Standard time of observation: A time specified in this Manual for making meteorological observations.

Note: The term Coordinated Universal Time (UTC) is used in this Manual.

Supplementary ship station: A mobile ship station that is equipped with a limited number of certified meteorological instruments for making observations and that transmits the required observations in an abbreviated code form for ships.

Surface observation: A meteorological observation, other than an upper-air observation, made from the Earth's surface.

Surface station: A surface location from which surface observations are made.

Synoptic observation: A surface or upper-air observation made at a standard time.

Synoptic station: A station at which synoptic observations are made.

Tide-gauge station: A station at which tidal measurements are made.

Upper-air observation: A meteorological observation made in the free atmosphere either directly or indirectly.

Upper-air report: A report of an upper-air observation.

Upper-air station: A surface location from which upper-air observations are made.

Upper-wind observation: An observation at a given height or the result of a complete sounding of wind direction and speed in the atmosphere.

Weather radar observation: Evaluation of atmospheric characteristics obtained by transmitting electromagnetic waves (radar signals) and analysing the reflected information from the targets in the sample volume.

Note: ___Such evaluation is typically repeated over a sequence of samples, as determined by the scan strategy, and reported as a spatially continuous dataset.

Weather radar station: a surface-based station at which weather radar observations are made.

Weather radar system: a system that makes weather radar observations.

Note: ___The system includes observational data processing and telecommunications hardware and software, documentation, monitoring, maintenance, and certain facilities and support capabilities such as power supply and climate control, together with the human expertise and resources required to operate and manage all of these components.

~~Weather radar station: A station making observations by weather radar.~~

World Meteorological Centre (WMC): A centre of the Global Data-Processing and Forecasting System which has the primary purpose of issuing meteorological analyses and prognoses on a global scale.

World Weather Watch (WWW): The worldwide, coordinated, developing system of meteorological facilities and services provided by Members for the purpose of ensuring that all Members obtain the meteorological and other environmental information they require both for operational work and for research. The essential elements of the World Weather Watch are the:

– Global Observing System (GOS);

– Global Data-processing and Forecasting System (GDPFS);

– Global Telecommunication System (GTS).

B. METEOROLOGICAL ELEMENTS AND OTHER OBSERVED VARIABLES

Aerosol: Substances, divided into solid particles or liquid droplets, held in suspension in the atmosphere.

Air temperature: The temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation.

Aircraft icing: Formation of ice, rime or hoar frost on an aircraft.

Atmospheric pressure: Pressure (force per unit area) exerted by the atmosphere on any surface by virtue of its weight; it is equivalent to the weight of a vertical column of air extending above a surface of unit area to the outer limit of the atmosphere.

– Pressure tendency: Character and amount of a station pressure change over three hours (over 24 hours in tropical regions).

– Characteristic of pressure tendency: Shape of the curve recorded by a barograph during the three-hour period preceding an observation.

Cloud: A hydrometeor consisting of minute particles of liquid water or ice, or of both, suspended in free air and usually not touching the ground.

– Cloud amount: The fraction of the sky covered by the clouds of a certain genus, species, variety or layer; or by a combination of clouds.

– Height of cloud base: Height above the surface of the Earth of the base of the lower cloud layer, when its amount exceeds a specific value.

– Direction and speed of cloud movement: Direction from which the cloud is coming and the horizontal component of its speed.

– Cloud type (classification): Type or variety of cloud as described and classified in the International Cloud Atlas.

Contrail: Cloud which forms in a wake of an aircraft when the air at flight level is sufficiently cold and moist.

Dew point: Temperature to which a volume of air must be cooled at constant pressure and constant moisture in order to reach saturation.

Humidity: Water vapour content of the air.

Precipitation: Hydrometeor consisting of a fall of an ensemble of particles. The forms of precipitation are: rain, drizzle, snow, snow grains, snow pellets, diamond dust, hail and ice pellets.

Precipitation chemistry: Nature and amount of the impurities dissolved or suspended in the precipitation.

Sea ice: Any form of ice found at sea which has originated from the freezing of sea water.

Sea-surface temperature: Temperature of the surface layer of the sea.

Soil moisture: Moisture contained in that portion of the soil which lies above the water table, including the water vapour contained in the soil pores.

Soil temperature: Temperature observed at different depths in the soil.

Solar radiation: Radiation emitted by the sun, sometimes called short-wave radiation, with wavelengths between 290 nm and about 4 000 nm.

State of ground: The characteristics of the surface of the ground, especially resulting from the effect of rain, snow and temperatures near freezing point.

Sunshine duration: The sum of the time, during a given period, for which the direct solar irradiance exceeds 120 W m^{-2}.

Turbidity: Reduced transparency of the atmosphere to radiation (especially visible) caused by absorption and scattering by solid or liquid particles other than clouds.

Turbulence: Random and continuously changing air motions which are superposed on the mean motion of the air.

Upper wind: The wind speed and direction at various levels in the atmosphere, above the domain of surface weather.

Visibility: Greatest distance at which a black object of suitable dimensions can be seen and recognized against the horizon sky during daylight or could be seen and recognized during the night if the general illumination were raised to the normal daylight level.

Wave height: The vertical distance between the trough and crest of the wave.

Wave period: Time between the passage of two successive wave crests past a fixed point.

Waves, direction of movement of: Direction from which the waves arrive at a given point.

Weather: State of the atmosphere at a particular time, as defined by the various meteorological elements.

– Present weather: Weather existing at a station at a time of observation.

– Past weather: Predominant characteristic of the weather which existed at an observing station during a given period of time.

Wind direction: Direction from which the wind blows.

Wind speed: Ratio of the distance covered by the air to the time taken to cover it.

Note: A more detailed list of geophysical parameters used to state observational data requirements and their associated definitions is contained in the *Guide to the Global Observing System* (WMO-No. 488).

SECTION: BC-Back_cover

Annex 2 to Recommendation 4 (CBS-16)

AMENDMENTS TO THE *GUIDE TO THE GLOBAL OBSERVING SYSTEM* (WMO-No. 488)

Guide to the Global Observing System

WMO-No. 488

PUBLICATION REVISION TRACK RECORD

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INTRODUCTION

EDITORIAL NOTE: NO CHANGES ARE PROPOSED TO THIS SECTION.
THE TEXT HAS BEEN OMITTED FOR THE SAKE OF BREVITY.

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PART I

PURPOSE, SCOPE, REQUIREMENTS AND ORGANIZATION OF THE GLOBAL OBSERVING SYSTEM

EDITORIAL NOTE: NO CHANGES ARE PROPOSED TO THIS SECTION.
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PART II

OBSERVATIONAL DATA REQUIREMENTS

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PART III

THE SURFACE-BASED SUBSYSTEM

EDITORIAL NOTE: NO CHANGES ARE PROPOSED TO SUB-SECTIONS 3.1 to 3.2.1.2.5 INCLUSIVE.
THE TEXT HAS BEEN OMITTED FOR THE SAKE OF BREVITY.

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3.2.1.2.6 *Station identification*

All stations which contribute to WMO observing systems are to be uniquely identified by a WIGOS station identifier. Further information about WIGOS station identifiers is in the *Manual on WIGOS* (WMO-No. 1160) section 2.4.1 and Attachment 2.1, as well as the *Guide to WIGOS* (WMO-No. xxxx). As indicated in the *Manual on the Global Observing System* (WMO -No. 544) section 2.3.2, some of the now-expired identification requirements for synoptic stations are reproduced here because they may be adopted by an "issuer of identifiers" as a convention to be followed in defining "local identifiers" for new stations:

A surface station included in the regional basic synoptic network shall be identified by a station index number assigned by the relevant Member in compliance with the scheme set out in the

Manual on Codes (WMO-No. 306), Volume I.1, Part A. The list of station index numbers, observing programmes and other relevant information is published by the WMO Secretariat in Weather Reporting (WMO-No. 9), Volume A – Observing stations.

Each Member operating synoptic stations is required to provided the WMO Secretariat with the necessary information for this purpose in compliance with the regulations laid down in the Manual on the Global Observing System (WMO -No. 544), Volume I, Part III, 2.3.2.

Each Member should keep an up-to-date list, or directory, of the synoptic stations on its territory, providing the following information for each station:

(a) Name, and where appropriate, station index number;

(b) Geographical coordinates in degrees, minutes and integer seconds of arc;4

(c) Elevation of the station in metres (up to two decimals) above mean sea level;4

(d) Geopotential of the datum level in whole metres to which the pressure is reduced, or the reference isobaric surface the geopotential of which is reported;

(e) Category of the station and observing programme;

(f) Times at which synoptic observations are made and reported;

(g) Brief description of surrounding topography;

(h) Instrument exposure, in particular height above ground of thermometers, rain-gauges and anemometers;

(i) Station history: date regular observations were initiated, transfers, interruptions in observations, name changes and any substantial changes made to the observing programme;

(j) Name of supervising organization or institution;

(k) Any other information required for completion of the entries in Weather Reporting (WMO-No. 9), Volume A – Observing stations.

EDITORIAL NOTE: NO CHANGES ARE PROPOSED TO SUB-SECTIONS 3.2.1.2.7 to 3.2.1.3.2.3 INCLUSIVE.
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3.2.1.3.3 ***Mobile sea stations***

3.2.1.3.3.1 ***Voluntary Observing Ship stations*** ~~**Selected, supplementary and auxiliary ships**~~

The international scheme by which ships are recruited for making and transmitting meteorological information is called the WMO Voluntary Observing Ships' Scheme (VOS). Mobile sea stations of the VOS are composed of selected ship stations, selected AWS ship stations, VOSClim (VOS Climate) ship stations, VOSClim AWS ship stations, supplementary ship stations, supplementary AWS ship stations, auxiliary ship stations, and auxiliary AWS ship stations ~~and ice-floe stations (the latter is discussed in 3.2.1.3.4)~~. ~~Mobile~~ VOS ships are one of the main sources of surface observations over the oceans. The *Manual on the Global Observing System* (WMO-No. 544), Volume I, specifies that Members shall recruit as many mobile ships that traverse data-sparse areas and/or regularly follow routes through areas of particular interest as possible. ~~The international scheme by which ships are recruited for making and transmitting meteorological information is called the WMO Voluntary Observing Ships Scheme. Relevant standards and recommended practices and procedures are contained in the *Guide to Marine Meteorological Services* (WMO-No. 471)~~.

In accordance with the *Technical Regulations* (WMO-No. 49), each Member shall arrange for the recruitment of ships which are on the national register of that Member as mobile ship stations. By fulfilling this obligation, each Member contributes to the common objective of obtaining sufficient coverage of

meteorological observations over the sea. Uniform coverage is desirable, albeit difficult to achieve, owing to large differences in the density of shipping traffic over the oceans that is comparatively greater in the northern hemisphere. Consequently, greater attention should be given to the recruitment of voluntary observing ships which operate in the tropics or in the southern hemi- sphere. To meet international meteorological requirements for data density over the oceans, successive plans under the World Weather Watch have shown the need for maintaining or increasing the number of voluntary observing ships.

Relevant standards and recommended practices and procedures are contained in Appendix III.4

~~The ships engaged in the WMO Voluntary Observing Ships Scheme are classified as follows:~~

~~(a)Selected ship stations;~~
~~(b)Supplementary ship stations;~~
~~(c)Auxiliary ship stations.~~

For details, please refer to *International Meteorological Vocabulary* (WMO-No. 182), the *Manual on the Global Observing System* (WMO-No. 544), Part III, 2.3.3.12– 2.3.3.14) and Technical Report No. 4, *The Voluntary Observing Ships Scheme—A Framework Document* (WMO/TD-No. 1009).

~~A selected ship station is a mobile ship station which is equipped with sufficient certified meteorological instruments for making surface observations and which transmits weather reports in the full SHIP code form.~~

~~A supplementary ship station is a mobile ship station with a limited number of certified meteorological instruments for making surface observations. It transmits weather reports in an abbreviated SHIP code form. (See 2.3.3.13 of the *Manual on the Global Observing System* (WMO-No. 544), Volume I, Part III.)~~

~~An auxiliary ship station is a mobile ship station, normally without certified meteorological instruments, which may transmit reports in a reduced code form in plain language as a routine or on request, in certain areas or under certain conditions. (See 2.3.3.14 of the *Manual on the Global Observing System* (WMO-No. 544), Volume I, Part III.)~~

~~Meteorological Services in many countries are generally required to provide more detailed information on the weather and sea conditions in coastal areas. Some Services have successfully recruited ships of local companies to make and transmit observations during their voyage from harbour to harbour along the coast. Such ships may be recruited as supplementary or auxiliary ships. Their observations have been found to be of great value everywhere.~~

~~3.2.1.3.3.2 Criteria for recruitment of voluntary observing ships~~

~~Several criteria can be used to decide whether a particular ship should be recruited as a selected, supplementary or auxiliary ship to meet national and international needs. The following points should be explored: whether all the necessary instruments can be installed, whether the ship's officers will have time to record and transmit the observations and whether the necessary regular contact can be established for the receipt of meteorological log-books. Generally, shipowners and masters are very cooperative in these matters; it is, however, advisable that these~~

~~questions be thoroughly discussed at the recruiting stage. At the same time, the meteorological authorities must decide whether the standard duties of navigation and radio officers would leave them sufficient time to conduct and transmit the observations.~~

~~Countries may also recruit ships of foreign registry with a view to obtaining a sufficient number of observations from the oceans. This is sometimes done by arrangement between the Meteorological Services of two countries in cases where the home port of certain ships is situated in other than the recruiting country. Selected or supplementary ships thus recruited should, however, visit the ports of the recruiting country often enough to permit regular contact. In order to avoid the entry of duplicate data into the international archiving system, meteorological log-books from ships registered in a foreign country should be produced and stored through appropriate arrangements with the Meteorological Service of the country of registry. When a ship of foreign registry is recruited, the Member in whose country the ship is registered should be notified, unless a port in the country of the Member that recruits the ship is considered to be its home port.~~

~~No prior arrangements are required with the Meteorological Service of the country of registry for the recruitment of an auxiliary ship.~~

~~The recruitment of voluntary observing ships is the responsibility of each Member participating in the scheme, and for this purpose Members should establish a suitable organizational unit. Shipping agencies should be contacted to enlist their cooperation. Appropriate measures should also be taken for the provision of instruments, instruction material and other necessary documents to ships, for the collection and examination of ships log-books for visits to ships and for the various financial questions involved. A special officer within this national unit should be made responsible for ship recruitment.~~

~~3.2.1.3.3.3 Information relating to ships participating in the WMO Voluntary Observing Ships Scheme~~

~~(a) International list of selected, supplementary and auxiliary ships~~

~~This list is an important source of marine data that is used for various purposes all over the world. In analysing these data, Meteorological Services should be aware of the type of instrumentation on board a given ship, or of a particular observing method when several methods are generally in use. For this purpose WMO issues the annual *International List of Selected, Supplementary and Auxiliary Ships* (WMO-No. 47) on the basis of information supplied by Members in accordance with 2.3.3.3 and 2.3.3.4 of the *Manual on the Global Observing System* (WMO-No. 544), Volume I, Part III. This publication contains particulars for each ship such as:~~

~~Recruiting country;~~

- ~~(a) Metadata format version;~~
- ~~(b) Date of report preparation;~~
- ~~(c) Name of ship;~~
- ~~(d) Country of registration;~~
- ~~(e) Call sign or WMO number;~~
- ~~(f) International Maritime Organization number;~~
- ~~(g) Vessel type;~~

(h) Vessel digital image;
(i) Ship characteristics (length, moulded breadth, freeboard, draught, cargo height, distance of bridge from bow);
(j) Area or routes which the ship normally plies;
(k) Type of barometer;
(l) Type of thermometer;
(m) Thermometer exposure;
(n) Type and exposure of hygrometer or psychrometer;
(o) Method of obtaining sea-surface temperature;
(p) Various other meteorological instruments used aboard the ship;
(q) Height, in metres, of the instruments above (or below, e.g. for sea-surface temperature) the maximum Summer load line;
(r) Height, in metres, of the anemometer above the maximum Summer load line and above the deck on which it is installed.

The International List of Selected, Supplementary and Auxiliary ships (WMO-No. 47) should be updated regularly, owing to the frequent changes in the international merchant shipping fleet and in the recruitment of auxiliary ships, in particular. As a rule, Members are required to provide on a quarterly basis, namely by 15 January, 15 April, 15 July and 15 October each year, to the WMO Secretariat a complete list of their selected, supplementary and auxiliary ships that were in operation at the end of the quarter in question. This information can also be given in the form of amendments to the list for the preceding year.

(b) Logistics

Some advice on how to handle the recruitment and operation of mobile ship observations through a national unit is given above. In addition, in larger ports, a port meteorological officer should be appointed to liaise directly with the ships' officers. This is often necessary in order to provide the latter with manuals and other documents, inspect the instruments on board, collect the log-books, or the data from the electronic log-books and to take any necessary corrective action. Port meteorological officers play a very important role and the efficiency of the Voluntary Observing Ships Scheme is heavily dependent on them. Their duties are set out in detail in the *Guide to Marine Meteorological Services* (WMO-No. 471).

(c) Meteorological log-books

The recording of observations in a meteorological log-book or electronic log-book is obligatory for selected and supplementary ships and recommended for auxiliary ships. The layout of log-books is a national responsibility. An example of a log-book is given in Figure III.3. Log-books should contain clear instructions for entering observations. It is useful, for example, to indicate by shading those columns which are meant for entries to be transmitted as part of the weather report. To facilitate the supply of meteorological log-books to ships which do not regularly call on their home ports, port meteorological officers in various ports keep a stock of log-books of different National Meteorological Services. In addition, they may keep stocks of observing and coding instructions in different languages.

(d) Communications

Weather reports from mobile ship stations should be transmitted to a coastal radio station as soon as possible after the time of observation; hence the meteorological report, as soon as it is made on board ship, should be handed to the ship's radio

~~officer without delay so that it can be cleared to shore as rapidly as possible. Regulations for the transmission of weather reports from mobile ship stations to designated coastal radio stations are given in the *Manual on the Global Telecommunication System* (WMO-No. 386), Volume I, Part I, Attachment I–1. The relevant procedures are reproduced below for ready reference. Weather reports from mobile ship stations should be transmitted without special request from the ship to the nearest coastal radio station situated in the zone in which the ship is navigating. If it is difficult to contact promptly the nearest radio station in the zone in which the ship is navigating owing to radio propagation conditions or other circumstances, the weather messages should be cleared by following the procedures in the order given below:~~

- ~~(a) Transmission to any other coastal radio station in the zone in which the ship is navigating;~~
- ~~(b) Transmission to any coastal radio station in an adjacent zone within the same Region;~~
- ~~(c) Transmission to any coastal radio station in any other zone within the same Region;~~
- ~~(d) Transmission to a coastal radio station in an adjacent zone in a neighbouring Region or, failing that, to any other station in a neighbouring Region;~~
- ~~(e) Transmission to another ship or an ocean weather station with the function of or willing to act as a relay station.~~

~~Maritime mobile radio systems used for ship-to-shore communications as above can cause problems, for various reasons of a technical nature, in the collection of ships' weather reports for subsequent distribution over the Global Telecommunication System. The use of new communication techniques, especially through satellites, offers a promising solution to these problems. Special mention may be made of the system known as INMARSAT, designed for full communication capability for public ship-to-shore communication. The use of this system has, however, important technical and financial implications for National Meteorological Services, and WMO has been studying them. Other satellite data telecommunication systems are now also being used in a cost-effective way.~~

~~(c)Personnel and training~~

~~An essential step in recruiting voluntary observers for ships' observations is to obtain the permission of the owner and the master of the ship. When this has been done and the observer(s) identified, the port meteorological officer provides instructions in the following areas:~~

- ~~(a) General care of instruments;~~
- ~~(b) Exposure and reading of hygrometer and psychrometer;~~
- ~~(c) Obtaining sea-water temperatures;~~
- ~~(d) Cloud observations;~~
- ~~(e) Use of WMO codes;~~
- ~~(f) Coding and transmission of observations.~~

~~Once a ship has been recruited, the port meteorological officer should endeavour to visit it at least every three months to check instrument accuracy and renew supplies of forms and documents, for example, codes and regulations. The officer should take the opportunity to foster an interest in meteorology in the crew members~~

~~**concerned and explain to them the mutual value of accurate weather information to seafarers and meteorologists.**~~

3.2.1.3.3.2 ~~3.2.1.3.4~~ *Ice-floe stations*

(a) General

An ice-floe station is generally a part of a scientific base on a large ice floe drifting in the polar regions. Such stations make an important contribution to the network in data-sparse polar regions. Members, individually or jointly, should arrange for meteorological observations from large ice floes whenever possible, either as part of the programme of a scientific base or as an automatic station. In the case of a joint undertaking, one National Meteorological Service should have the responsibility for the station's scientific and technical standards.

(b) dentification

Identification of ice-floe stations shall be the same as for ships.

(c) Communications

Ice-floe stations should have two-way radio connections or automatic transmission via satellite. In the polar regions, only polar-orbiting satellites can be used. The ARGOS system operated with some of the US satellites offers this possibility, and the use of the Doppler effect in the receiver signals makes it possible to locate the station fairly accurately. Using polar-orbiting satellites as a means of communication may give a synoptic reporting times.

(d) Personnel and training

A sufficient number of the staff on the ice-floe base must have adequate training for taking all the required observations in accordance with WMO regulations. At least one trained technician should be available to operate and maintain the instruments and be responsible for the supply of expendables and back-up equipment. The staff must also include personnel to operate the communications system.

EDITORIAL NOTE: NO CHANGES ARE PROPOSED TO SUB-SECTIONS 3.2.1.4 to 3.3.3.4 INCLUSIVE. THE TEXT HAS BEEN OMITTED FOR THE SAKE OF BREVITY.

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3.4 AIRCRAFT METEOROLOGICAL STATIONS

An Aircraft Meteorological Station is defined in the *Technical Regulations* (WMO-No. 49) Volume I – General Meteorological Standards and Recommended Practices[REF WMO Technical Regulations, Volume I] as a "Meteorological Station situated aboard an aircraft", where a Meteorological Station is a "Place where meteorological observations are made with the approval of the WMO Member or Members concerned". Meteorological observations from an Aircraft Meteorological Station (aircraft-based observations) are to be made for both aviation and meteorological purposes by aircraft operating on national and international air routes. The making of such observations is regulated by both WMO and the International Civil Aviation Organization (ICAO) within the *Technical Regulations* (WMO-No. 49) [Ref. WMO-No. 49, Technical Regulations, Volumes I1 and II2]. More specifically, detailed provisions for the making of such observations and requirements for their provision on the WMO Information System (WIS) can be found in the *Manual on the Global Observing System* (WMO-No. 544), Volume I [Ref. Manual on the GOS, Part III Section 2.5, Aircraft Meteorological Stations].

Further guidance on aircraft based observations can be found in the [Ref. *Guide to Aircraft-Based Observations* (WMO-No. xxxx)]. Members should utilize this guide as a source of information on best practice in relation to the implementation and operation of Aircraft Meteorological Stations and the provision of ABO on the WIS within three categories:

1. WMO Aircraft-Based Observations;

2. ICAO Aircraft-Based Observations;

3. Other Aircraft-Based Observations.

WMO Aircraft-Based Observations are derived from aircraft-based observing systems operated by WMO Members in collaboration with their national or other partner airlines, in which requirements for aircraft-based observations are specified by WMO and its Members so as to meet meteorological needs.

ICAO Aircraft-Based Observations are observations derived from ICAO regulated Aircraft Observations, which are made available to WMO and its Members under the provisions of ICAO as set out within the *Technical Regulations* (WMO-No. 49) Volume II – Meteorological service for international air navigation[WMO Technical Regulations, Volume 2].

Other Aircraft-Based Observations are those observations derived from aircraft-based observing systems operated by other entities. In this case, while Members do not define specifications for the operation of the observing system, they are urged to ensure that the observations are fit for purpose.

As at 2016, the WMO Aircraft Meteorological Data Relay (AMDAR) observing system is the chief source of aircraft-based observations on the WIS. A detailed description of the AMDAR system and recommendations on its implementation and operation by Members are contained within the [Ref. *Guide to Aircraft-Based Observations* (WMO-No. xxxx).

~~3.4.1~~ ~~***General***~~

~~**An aircraft meteorological station is an aircraft in flight from which meteorological data are obtained by utilizing instruments and equipment installed for navigational purposes. The measured data can be supplemented by the observation of visual, weather phenomena and by subjective or objective assessments of turbulence and icing. When compiled into reports, they constitute a vital part of the global database. The reports are of particular value over areas where other upper-air data are scanty or lacking. They can provide information on atmospheric phenomena such as wind, temperature and turbulence along horizontal and vertical profiles on a much smaller scale than do other routine observing systems. Thus, they also constitute a valuable source of information for the issuing of reports on significant weather phenomena and for special investigations and research. The collection and evaluation of post-flight reports is also an invaluable data source. Subject to timely receipt, processing and dissemination, they can be of use for forecasting purposes.**~~

~~**Over recent years it has become evident that valuable meteorological data can be obtained from large areas of the world by collecting data from aircraft fitted with appropriate software packages. To date the predominant sources of automated aviation data have been from aircraft-to-satellite data relay (ASDAR), and more recently, from aircraft equipped with aircraft communication addressing and reporting systems (ACARS).**~~

~~Aircraft communication addressing and reporting systems (ACARS) transmit data between aircraft and ground stations via radio and satellite communication systems. Such systems offer the potential for a vast increase in the provision of aircraft observations of wind, temperature and humidity.~~

~~The various systems – ASDAR, ACARS – are collectively named AMDAR, which stands for aircraft meteorological data relay. They are making an increasingly important contribution to the observational database of the World Weather Watch of the World Meteorological Organization. It is envisaged that AMDAR data will inevitably supersede manual air reports (AIREP).~~

~~AMDAR systems operate on aircraft which are equipped with sophisticated navigation and other sensing systems. There are sensors for measuring air speed, air temperature and air pressure. Other data relating to aircraft position, acceleration and orientation are available from the aircraft navigation system. The aircraft also carry airborne computers for the flight management and navigation systems, by which navigation and meteorological data are computed continuously and made available to the aircrew at the flight deck.~~

~~In AMDAR systems, the data are further processed and fed automatically to the aircraft communication system for transmission to the ground, or alternatively, a dedicated processing package can be used on the aircraft to access raw data from the aircraft systems and independently derive the meteorological variables. In addition, these facilities are used to compile and transmit meteorological reports in real time. The messages contain wind speed and direction, air temperature, altitude, a measure of turbulence and the aircraft position.~~

~~The source data for meteorological observations require significant correction and complex processing to yield meteorological measurements representative of the free airstream in the vicinity of the aircraft. Although the data processing involved is complex, errors in reported wind and temperatures are comparable with those of radiosonde systems. AMDAR observations can thus provide high-quality single-level data in cruise and detailed profile data up to cruise levels.~~

~~AMDAR observations where made can meet the resolution and accuracy requirements for global numerical weather prediction. Observations are restricted from commercial aircraft to specific air routes at cruise level and profile data are only available on climb or descent in the terminal areas. AMDAR observations are not made at standard times, and significant gaps in observations arise owing to the normal flight scheduling.~~

~~AMDAR profiles can be very useful for local airfield forecasting and are available during flight operations. This can be especially important during severe storm events.~~

~~For further details concerning AMDAR, please refer to the *Aircraft Meteorological Data Relay (AMDAR) Reference Manual* (WMO-No. 958).~~

~~*3.4.2 Instrumentation and data processing*~~

~~The type of sensors used and their siting on board the aircraft are determined by the manufacturers and depend on the type of aircraft. For details concerning instruments, measurement and data processing on board aircraft, reference should be made to~~

~~Chapter 3, Part II, of the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8).~~

~~*3.4.3* *Site selection*~~

~~The selection of observing sites is prescribed by the reporting procedures promulgated by the International Civil Aviation Organization and national aviation authorities. See [C.3.1.] 5, Volume II, *Technical Regulations* (WMO-No. 49). These generally lead to an accumulation of data at reporting points fixed at intervals of 10° longitude or latitude along major air routes, with most altitudes being between the upper standard pressure levels, 300 hPa and 150 hPa.~~

~~Observations related to specified weather phenomena should be made wherever these phenomena are encountered.~~

~~Data obtained automatically during ascent or descent are related to the predetermined pressure increments and refer to the vicinity of the aerodrome of departure or arrival. However, owing to the geographical separation of sectors used for approach and take-off and to the differences in descent and climb rates, systematic differences are to be expected.~~

~~*3.4.4* *Observing and reporting procedures*~~

~~The observational data requirements to support international air navigation are contained in Volume II of the *Technical Regulations* (WMO-No. 49). Details on the frequency and time of observations are given in 2.5.5 and 2.5.11, Volume I, Part III of the *Manual on the Global Observing System* (WMO-No. 544).~~

~~*3.4.5* *Communications*~~

~~ASDAR data are transmitted from the host aircraft via the International Data Collection System on board the Meteorological Geosynchronous Satellite System (METEOSAT, GOES-E, GOES-W, GMS).~~

~~Ground stations are located in the USA, Japan and Europe where the received data are encoded into WMO AMDAR code and injected into the Global Telecommunication System.~~

~~The standards for aircraft VHF data-links have been established for ACARS and adopted by SITA (AIRCOM), ARINC, Air Canada (ACARS) and Japan (AVICOM). These five compatible systems provide coverage over most of the land areas of the globe through a network of remote ground stations.~~

~~Airlines operating international routes have contacts with appropriate service providers; for instance transatlantic operations require contracts with SITA, ARINC and ACARS. ACARS/AIRCOM is used mainly for automation of key airline applications such as maintenance, engine monitoring, flight operations and logistics support. Meteorological data are readily attached to down-linked messages and can be controlled by ground command or on-board programming. The data formats for down-linking meteorological reports through ACARS/AIRCOM are not standardized globally.~~

~~*3.4.6 Personnel and training*~~

~~**Making meteorological measurements and observations on board the aircraft is a part of pilots' training in which National Meteorological Services should cooperate as far as possible.**~~

~~*3.4.7 Quality standards*~~

~~**For safety reasons, operators generally apply very high quality standards for measurements and reports. The quality of air reports has been found to be comparable with radiosonde data. For a single level, the reports are much more accurate than satellite wind and temperature data.**~~

~~**Systematic errors noticed during the evaluation of observations received at meteorological offices need to be identified; the malfunctioning unit should be located if possible, and the operator notified.**~~

~~**Procedures should be developed by the National Meteorological Services together with national airlines for continuously monitoring adherence to established reporting procedures, the quality of the reports and the adequacy of dissemination methods.**~~

EDITORIAL NOTE: NO CHANGES ARE PROPOSED TO SUB-SECTIONS 3.5 to 3.9.2.8.8 INCLUSIVE. THE TEXT HAS BEEN OMITTED FOR THE SAKE OF BREVITY.

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EDITORIAL NOTE: NO CHANGES ARE PROPOSED TO APPENDICES III.1 to III.3 INCLUSIVE. THE TEXT AND TABLES HAVE BEEN OMITTED FOR THE SAKE OF BREVITY.

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EDITORIAL NOTE: THE CONTENT OF THE FOLLOWING APPENDIX WAS PREVIOUSLY CHAPTER 6 OF THE GUIDE TO MARINE METEOROLOGICAL PRACTICES, WHICH HAS BEEN MODIFIED EDITORIALLY TO FIT THE GUIDE TO THE GOS.

APPENDIX III.4

THE WMO VOLUNTARY OBSERVING SHIPS' SCHEME

1 Introduction

Note: This Appendix was originally structured as Chapter 6 of the WMO *Guide to Marine Meteorological Services* (WMO-No. 471).

The international scheme under which ships plying the various oceans and seas of the world are recruited for taking and transmitting meteorological observations is known as the WMO Voluntary Observing Ships' Scheme. The forerunner of the scheme dates back to 1853, the year in which delegates of 10 maritime countries came together at a conference in Brussels, on the initiative of Lieutenant Matthew F. Maury, then director of the US Navy Hydrographic Office, to discuss the establishment of a uniform system for the collection of meteorological and oceanographic data from the oceans and their use for the benefit of shipping. In the twentieth century, the system was recognized in the *International Convention for the Safety of Life at Sea (SOLAS)as amended*, which specifies in Regulation 5 of Chapter V — Safety of navigation — that 'the Contracting Governments undertake to encourage the collection of meteorological data by ships at sea and to arrange for their examination, dissemination and exchange in the manner most suitable for the purpose of aiding navigation'.

Voluntary observing ships make a highly important contribution to the Global Observing System of the World Weather Watch. They also contribute substantially to the IOC-WMO-ICSU-UNEP Global Climate Observing System (GCOS), and the IOC-WMO-ICSU-UNEP Global Ocean Observing System (GOOS). Relevant standard and recommended practices and procedures are contained in Volume I, Part III, Section 2.3.3 of the *Manual on the Global Observing System* (WMO-No. 544). Although new technological means, such as satellites and automated buoys, are used to gather data from the oceans, voluntary observing ships continue to be the main source of oceanic meteorological information.

From the beginning of such activity shipping has assisted in the scientific exploration of the oceans, as well as in the development of suitable measuring techniques for use by shipborne observers. Nowadays, the cooperation of voluntary observing ships is sought in each of the large-scale scientific experiments conducted by special research vessels in order to furnish the additional data needed for complete analyses of environmental conditions. In addition, the participation of these ships is regularly requested in technical studies and investigations concerning observing methods, such as the measurement of sea-surface temperature, precipitation and wind.

2 Classification of voluntary observing ships

2.1 Types of surface synoptic sea stations

Meteorological observing stations include surface synoptic sea stations of different types. Since this Appendix of the *Guide* emphasizes the mutual collaboration between marine users and meteorologists regarding the making of marine meteorological observations from voluntary observing ships, only the activities of Meteorological Services with regard to voluntary observing ship stations are described in the following paragraphs. There are eight types of mobile ship stations engaged in the WMO Voluntary Observing Ship Scheme, namely:

(a) Selected ship stations;

(b) Selected AWS ship stations;

(c) VOSClim (VOS Climate) ship stations;

(d) VOSClim (VOS Climate) AWS ship stations;

(e) Supplementary ship stations;

(f) Supplementary AWS ship stations;

(g) Auxiliary ship stations; and.

(h) Auxiliary AWS ship stations.

The types of observation normally made by each of these types of ship stations is shown in Table 1 below.

2.2 Selected ship station

A mobile ship station equipped with sufficient certified meteorological instruments for making observations, transmits regular weather reports and enters the observations in a meteorological logbook. A Selected ship should have at least a barometer, a thermometer to measure SST, a psychrometer (for air temperature and humidity), a barograph and possibly an anemometer. Selected ships constitute the large majority of voluntary observing ships.

2.3 Selected AWS ship station

A mobile ship station equipped with an Automatic Weather Station (AWS) system comprising certified meteorological instruments to measure at least at least air pressure, pressure change, temperature and humidity. Optional sensors would include wind speed and direction and sea temperature measurement. The AWS may or may not have the facility for manual input of the visual elements, and transmit reports at least three hourly or more frequently. The AWS should have the facility to log the data.

2.4 VOSClim (VOS Climate) ship station

A mobile ship station equipped with sufficient certified meteorological instruments for making observations, transmits regular and timely weather reports, enters the observations in an International Maritime Meteorological Tape (IMMT) compliant electronic logbook and has a proven record of providing high quality observations. A VOSClim ship should have at least a barometer, a thermometer to measure SST, a psychrometer (for air temperature and humidity), a barograph and possibly an anemometer. The full range of metadata must be maintained in WMO-No. 47, the full suite of digital images, sketches and drawings must be available, and the delayed-mode IMMT data must be submitted to the Global Collecting Centres (GCCs) according to the procedures described in Chapter 3 of of WMO-No. 471, *Guide to Marine Meteorological Services*. It is highly desirable for a VOSClim ship to be inspected at less than six monthly intervals.

2.5 VOSClim (VOS Climate) AWS ship station

A mobile ship station equipped with an AWS system comprising certified meteorological instruments to measure at least air pressure, pressure change, temperature and humidity. Optional sensors would include wind speed and direction and sea temperature measurement. The AWS may have a facility for manual input of the visual elements, and transmit reports at least three hourly or more frequently. The AWS must have the facility to log the data including the additional IMMT delayed-mode VOSClim groups. The full range of metadata must be maintained in WMO-No. 47, the full suite of digital images, sketches and drawings must be available, and the delayed-mode IMMT data must be submitted to the GCCs according to the procedures described in Chapter 3 of of WMO-No. 471, *Guide to Marine Meteorological Services*. It is highly desirable for a VOSClim ship to be inspected at less than six monthly intervals.

2.6 Supplementary ship station

A mobile ship station equipped with a limited number of certified meteorological instruments for making observations. It transmits regular weather reports and enters the observations in a meteorological logbook.

2.7 Supplementary AWS ship *station*

A mobile ship station equipped with an AWS system comprising a limited number of certified meteorological instruments and reporting regularly.

2.8 Auxiliary ship station

A mobile ship station normally without certified meteorological instruments, which transmits in a reduced code form or in plain language, either on a routine basis or on request, in certain data sparse areas and under certain conditions.

2.9 Auxiliary AWS ship station

A mobile ship station equipped with an AWS system comprising non-certified meteorological instruments and reporting regularly.

2.10 International list of selected, VOSClim, supplementary and auxiliary ships

Selected, Selected AWS, VOSClim, VOSClim AWS, Supplementary, Supplementary AWS, Auxiliary and Auxiliary AWS ship stations constitute an important source of marine data. In analysing these data, Meteorological Services should be aware of the type of instrumentation onboard a given ship, or the particular method of observation when several methods are generally in use. To this end WMO compiled the International List of Selected, VOSClim, Supplementary and Auxiliary Ships (WMO-No. 47) which is kept up to date through information supplied by Members, and for each ship. For this purpose WMO issues the annual *International List of Selected, Supplementary and Auxiliary Ships* (WMO-No. 47) on the basis of information supplied by Members in accordance with 2.3.3.3 and 2.3.3.4 of the *Manual on the Global Observing System* (WMO-No. 544), Volume I, Part III. The information contained covers such particulars as:

(a) Recruiting country;

(b) Metadata format version;

(c) Date of report preparation;

(d) Name of ship;

(e) Call sign;

(f) Vessel type;

(g) Vessel dimensions;

(h) Area or routes the ship normally plies;

(i) Type of barometer;

(j) Type of thermometer;

(k) Exposure of thermometer;

(l) Type of hygrometer or psychrometer;

(m) Exposure of hygrometer or psychrometer;

(n) Method of obtaining sea surface temperature;

(o) Type of barograph;

(p) Various other meteorological instruments used aboard the ship;

(q) Types of radio equipment, including INMARSAT;

(r) Height of barometer, in metres, measured from maximum load line;

(s) Height of anemometer, in metres, measured from maximum load line; and,

(t) Depth of sea temperature measurement.

(u) Ships routes

(v) Satellite transmission system

(w) Make and model of AWS system

(x) Name and version of electronic logbook software

The *International List of Selected, VOSClim, Supplementary and Auxiliary Ships* needs to be regularly updated (see the *Manual on the Global Observing System*, Volume I, Part III, paragraph2.3.3.3) because of frequent changes in the international merchant fleet and changes in the recruitment of observing ships. Members are asked to provide to the WMO Secretariat at least every quarter, but preferably every month, updates of their list of Selected, VOSClim, Supplementary and Auxiliary ships, as an email attachment in approved format. This is the most efficient means of keeping the master list updated, as no retyping is required. The Secretariat makes available the master list through its web page (http://www.wmo.int/pages/prog/www/ois/pub47/pub47-home.htm).

Furthermore, a new overarching standard for collecting and making available metadata is being implemented for all WMO observing systems. More information is in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) and the *Guide to the WMO Integrated Global Observing System* (WMO-No. xxxx).

3 Recruitment of voluntary observing ships

3.1 Requirement to recruit ships

The recruitment of voluntary observing ships is the responsibility of each Member participating in the scheme.

Each Member shall recruit as mobile ship stations as many ships as possible that traverse data-sparse areas and regularly follow routes through areas of particular interest. In fulfilling this obligation, each Member contributes to the common objective of obtaining sufficient coverage of meteorological observations over the sea. While a uniform coverage of the oceans is desirable, this is difficult to achieve in view of the large differences in the density of shipping traffic. This traffic is comparatively dense in the northern hemisphere, but this is not the case in the tropics or in the southern hemisphere. Consequently, greater attention should be given to the recruitment of voluntary observing ships in these areas. Monthly maps showing the density of observations received from ships are available from JCOMMOPS (http://wo.jcommops.org/cgi-bin/WebObjects/JCOMMOPS.woa/wa/map?type=GTSM_VOS).

Meteorological Services in many countries are required to provide more detailed information of the weather and sea conditions in coastal areas. Some services recruit ships of local shipping companies to make and transmit observations during their voyage from harbour to harbour along the coast. Their observations have been widely recognized as being of great value.

3.2 Criteria for recruitment

Several criteria can be used in deciding whether a particular ship should be recruited as a Selected, Selected AWS, VOSClim, VOSClim AWS, Supplementary, Supplementary AWS, Auxiliary or Auxiliary AWS ship, to satisfy national and international needs. Questions which should be examined are whether all the necessary instruments can be installed with adequate exposure, whether the ship's officers will have the time available for recording and transmitting the observations and whether the necessary regular contact can be established for training the observers and for the receipt of electronic or hardcopy logbook data. Ship owners and masters are generally very cooperative in these matters; however, it is advisable that these questions be thoroughly discussed at the recruiting stage. In all cases observations should never be undertaken if they will impair the safe navigation of the recruited ship.

Contrary to the early days of the VOS Scheme ships are now registered in a variety of different countries. Ships registered in ports outside those of the recruiting country are

therefore commonly recruited, although it is advisable to contact the Meteorological Service of the flag state beforehand and to check that the ships hasn't already been recruited by reference to WMO-No. 47. Care should be taken to ensure that duplicate recruitment is avoided. Selected or supplementary ships thus recruited should, however, visit the ports of the recruiting country often enough to permit regular contact.

Members should establish a suitable organizational structure for the maintenance of their marine networks and for the recruitment of voluntary observing ships. It will often be necessary to contact shipping companies, managers and shipping agencies to enlist their cooperation by arranging visits to ships and the provision of instruments. Port Meteorological Officers play a large role in the recruitment of ships. Appropriate measures should also be taken for the provision of instruments, instruction material and other necessary documents to ships, for the collection and examination of ships log-books for visits to ships and for the various financial questions involved. A special officer within this national unit should be made responsible for ship recruitment.

Complaints about meteorological observations from a particular observing ship should be directed to the Member with which the ship is registered. If the ship was recruited by another Member, the Member receiving the complaint should forward it to the Member concerned.

No prior arrangements are required with the Meteorological Service of the country of registry for the recruitment of an auxiliary ship or auxiliary AWS ship.

3.3 Personnel and training

An essential step in recruiting voluntary observers for ships' observations is to obtain the permission of the owner and the master of the ship. When this has been done and the observer(s) identified, the port meteorological officer provides instructions in the following areas:

(a) General care of instruments;

(b) Exposure and reading of hygrometer and psychrometer;

(c) Obtaining sea-water temperatures;

(d) Use of WMO codes;

(e) Coding and transmission of observations.

Once a ship has been recruited, the port meteorological officer should endeavour to visit it at least every three months to check instrument accuracy and renew supplies of forms and documents, for example, codes and regulations. The officer should take the opportunity to foster an interest in meteorology in the crew members concerned and explain to them the mutual value of accurate weather information to seafarers and meteorologists.

4 Meteorological observations from ships

4.1 Danger messages

The International Convention for the Safety of Life at Sea (SOLAS), 1974, in its Regulation 31, Chapter V, concerning the safety of navigation, specifies that ship masters are obliged to issue a danger message when a ship meets with objects or conditions which are of direct danger to navigation. As far as meteorological phenomena are concerned, danger messages should contain information on dangerous ice, tropical storms, encounters sub-freezing air temperatures associated with gale force winds causing severe ice accretion on superstructures,

or winds of force 10 or above on the Beaufort scale for which no storm warning has been received.

Details concerning the contents of danger messages and their transmission are described in Regulation 32 of Chapter V of the *International Convention for the Safety of Life at Sea*. The information given in these messages directly serves the safety of navigation. Those containing meteorological information are of vital importance to Meteorological Services for the preparation of weather and sea bulletins.

4.2 Surface observations

4.2.1 CONTENT OF SURFACE OBSERVATIONS FROM SHIPS

The elements observed by the various types of voluntary observing ship are shown in Table 1.

Table 1

Observations made by mobile ships stations

	Selected	*Selected AWS*	*VOSClim*	*VOSClim AWS*	*Supplementary*	*Supplementary AWS*	*Auxiliary*	*Auxiliary AWS*
Present and past weather	*x*		*x*		*x*		*x*	
Wind direction and speed	*x*		*x*		*x*		*x*	
Cloud amount	*x*		*x*		*x*		*x*	
Cloud type and height of base	*x*		*x*		*x*			
Visibility	*x*		*x*		*x*		*x*	
Temperature	*x*	*x*	*x*	*x*	*x*		*x*	
Humidity (dew point)	*x*	*x*	*x*	*x*				
Atmospheric pressure	*x*	*x*	*x*	*x*	*x*	*x*	*x*	
Pressure tendency	*x*	*x*	*x*	*x*				
Ship's course and speed	*x*	*x*	*x*	*x*				
Sea temperature	*x*		*x*					
Period and height of wind waves	*x*		*x*					
Direction, period and height of swell	*x*		*x*					

Sea-ice and/or icing (if appropriate)	x		x		x		x	
Special phenomena (if appropriate)	x		x					
Max height of deck cargo above the SLL	-	-	x	x	-	-	-	-
Height difference from the SLL to the water line	-	-	x	x	-	-	-	-
Course of ship over ground	-	-	x	x	-	-	-	-
Ship's ground speed	-	-	x	x	-	-	-	-
Ship's heading	-	-	x	x	-	-	-	-

x = mandatory

4.2.2 PROGRAMME FOR SURFACE OBSERVATIONS ON BOARD SHIPS

The basic programme for making surface observations on board ships consists of the following procedures:

(a) Synoptic observations should be made at the main standard times: 0000, 0600, 1200 and 1800 UTC. When additional observations are required, they should be made at one or more of the intermediate standard times: 0300, 0900, 1500 and 2100 UTC;

(b) While taking observations, atmospheric pressure should be read at the exact standard time, the observation of other elements being made within the ten minutes preceding the standard time;

(c) When operational difficulties on board ship make it impracticable to make the synoptic observation at a main standard time, the actual time of observation should be as near as possible to the main standard times. In special cases, the observations may even be taken one full hour earlier than the main standard time, i.e. at 2300, 0500, 1100 and 1700 UTC. In these cases the actual time of observation should be indicated; however, these departures should be regarded only as exceptions;

(d) When sudden or dangerous weather developments are encountered, observations should be made for immediate transmission without regard to the standard times of observation (see paragraph 4.1 above for obligations under the *International Convention for the Safety of Life at Sea*);

(e) In accordance with SOLAS Chapter V regulation 32, when a master has reported a tropical cyclone or other dangerous storm, it is desirable but not obligatory, that further observations be made and transmitted hourly, if practicable, but in any case at intervals of not more than 3 hours, so long as the ship remains under the influence of the storm Meteorological Services may also request more frequent observations for storm warnings, particularly for tropical cyclones, and special observations may also be requested for search and rescue operations or other safety reasons;

(f) When required for scientific studies supplementary observations should be made at intermediate standard times, subject to non-interference with navigation duties;

(g) Ships' officers should be encouraged to continue taking and reporting observations while the ships are in coastal waters, provided it does not interfere with their duties for the safety of navigation;

4.2.3 OBSERVATION OF SEA AND SWELL

The distinction between two separate wave trains and particularly the distinction between sea and swell can be difficult for an inexperienced observer. Sea waves are systems of waves observed at a different place than within the wind field producing the waves. Swell waves are systems of waves observed at a point remote from the wind field which produced the waves, or observed when the wind field which generated the waves no longer exists.

The distinction between sea and swell can be made on the basis of one of the following criteria:

Wave direction — if the mean direction of all waves of more or less similar characteristics differs 30° or more from the mean direction of waves of different appearance, then the two sets of waves should be considered to belong to separate wave systems.

Appearance and period — when typical swell waves characterized by their regular appearance and long-crestedness arrive approximately, i.e. within 20°, from the direction of the wind, they should be considered as a separate wave system if their period is at least four seconds greater than the period of the larger waves of the existing sea.

More guidance on the observation of waves and swell, as well as the observation of sea ice, can be found in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part II, Chapter 4, Marine observations.

4.3 Upper-air observations

In the past very few mobile ship stations were equipped for making upper-air synoptic observations. An automated means of making upper-air soundings from a merchant ship has now been developed under the Automated Shipboard Aerological Programme (ASAP). The balloon is filled with helium and released by a ship's officer. After launch, the observations are automatically received, encoded, and transmitted to the NMS.. However, the number of ships making upper-air observations is still small and mostly concentrated in the North Atlantic.

An upper-air synoptic observation consists of one or more of the following elements:

(a) Atmospheric pressure;

(b) Air temperature;

(c) Humidity; and,

(d) Wind speed and direction.

The standard times of upper-air synoptic observations are 0000, 0600, 1200 and 1800 UTC, although most ASAP ships report only two times per day. The actual launch time of regular upper-air synoptic observations is about 60 minutes before these standard times to provide sufficient reserves for re-launches as well as delayed satellite transmissions.. The actual time of a balloon observation may deviate from this time range if wind observations at considerably greater heights can be achieved.

In the basic programme of upper-air soundings from mobile ships the general objective is to obtain reports from positions which are not more than 1000 km apart and the observations are typically required at 0000 and 1200 UTC. These observations are to be coordinated within the framework of an international programme to ensure that data are obtained from those parts of the oceans where upper-air data are most needed. Members establishing a programme of upper-air observation on board voluntary observing ships are required to complete the ASAP section of the national SOT Annual Report.

4.4 Sub-surface observations

Selected ships may also be equipped to make bathythermograph observations during ocean crossings. The use of an expendable bathythermograph (XBT) does not oblige the ship to reduce speed or make course alterations. All arrangements for this type of observation are made within the framework of the JCOMM Ship Observations Team (SOT) and its Ship of Opportunity Programme (SOOP).

Procedures for the collection and exchange of BATHY and TESAC (temperature, salinity and current) observations are specified in the *Guide to Operational Procedures for the Collection and Exchange of JCOMM Oceanographic Data* (IOC/WMO *Manuals* and *Guides* No. 3) and the WMO *Manual on the Global Telecommunications System*, Volume 1, Part 1, Attachment I-1 (WMO-No. 386). The preferred times for BATHY and TESAC observations are 0000, 0600, 1200 and 1800 UTC. However observations taken at any time are useful and should be transmitted.

4.5 Special observations

In relation to international programmes of scientific or economic significance, observations of a special nature are needed from ships at sea and WMO is requested to assist through its Voluntary Observing Ships' Scheme. One such example is the request for observations on locust swarms in the seas around Africa, the Arabian Peninsula, Pakistan and India. This programme, which is of great importance to the agricultural economy in the countries concerned, is described in Annex A of this Chapter.

Another example is the report of freak waves. A freak wave is defined as a wave of very considerable height preceded by a deep trough. It is the unusual steepness of the wave which makes it dangerous to shipping. Favourable conditions for the development of freak waves seem to be strong current flows in the opposite direction to a heavy sea and especially when this occurs near the edge of the continental shelf. The reports may contribute to a mapping of these particularly dangerous areas and to a better understanding of the phenomenon. Guidelines covering the content and form of the report and the forwarding arrangements are described in Annex B of this Chapter (see also Chapter 3, paragraph 3.3.1 of WMO-No. 471, *Guide to Marine Meteorological Services*).

Sea-surface currents are also subject to special observation. These data are derived from measurement of ships' set and drift and form the basis for consideration of the ocean surface current circulation. They are of value to research and climatic studies and are collated by the International Surface Current Data Centre (ISCDC) in the United Kingdom which sends a copy of the stored data to the World Data Centres for Oceanography. In order to improve this database, all vessels are encouraged to obtain and supply such data on a voluntary basis. Details of the form of the report and the forwarding arrangements are given in Annex C of this Chapter (see also Chapter 3, paragraph 3.3.2 of WMO-No. 471, *Guide to Marine Meteorological Services*).

4.6 Coding of observations

Ships' observations are coded in the international meteorological codes published in the *Manual on Codes*, Volume I (WMO-No. 306). The various code forms are given code names which are sometimes included in the heading of the ship's report. In all cases, however, a 4-letter identification group is used (see code 2582 in the Manual on Codes). The identification groups normally used by ships are shown in Table 2.

Table 2

Identification groups of codes reported by SHIPS

Code name	*Identification group(s)*	*Content of the code*
SHIP	BBXX	Surface report from a sea station
PILOT SHIP	QQAA, QQBB, QQCC, QQDD	Upper-wind report from a sea station; Parts A, B, C, D respectively
TEMP SHIP	UUAA, UUBB, UUCC, UUDD	Upper-level pressure, temperature, humidity and wind report from a sea station; Parts A, B, C, D respectively
BATHY	JJVV	Bathythermal observation
TESAC	KKYY	Observation of temperature, salinity and current from a sea station
TRACKOB	NNXX	Report of a marine surface observation along a ship's track
BUFR	BUFR	Binary Universal Form for the Representation of meteorological data (specific sequences and/or templates should be used for specific ship reports)
CREX	CREX	Character form for the Representation and EXchange of data (specific sequences and/or templates should be used for specific ship reports)

4.7 Electronic Meteorological logbooks

The manual coding of shipboard observations has been greatly aided by the use of electronic logbook software and by the increased availability of satellite communications on merchant ships. Observations are taken manually in the traditional way and then entered into a dedicated software program loaded onto a personal computer. This may be in the form of a laptop provided by a National

Meteorological Service (NMS), or by installing the software on a ship's computer (with the permission of the shipowner). The computer program then:

(a) Provides screen prompts to assist with data entry;

(b) Calculates the true wind, MSL pressure and dew point;

(c) Checks the validity of some data, e.g. month in range 1–12, observations near climatological extremes;

(d) Allows the real-time observation in SHIP code to be downloaded to a floppy disk or USB device so that it can then be transferred to the ships Inmarsat system for transmission to the Meteorological Service; because most ocean going ships are required to carry INMARSAT-C equipment, the floppy disk can usually be placed in the INMARSAT terminal and the observation can be transmitted without rekeying. However some ships Inmarsat equipment may not have this facility, in which case the data will need to be transcribed;

(e) Automatically formats and stores the observation in IMMT format (referred to in Chapter 3, paragraph 3.2.7 of WMO-No. 471, *Guide to Marine Meteorological Services*), which can be subsequently downloaded to floppy disk or USB. These data are usually collected by a Port Meteorological Officer at the time of inspection, or emailed directly from the ship to the NMS when email is available.

5 On-board meteorological instrumentation

5.1 General

Full guidance on the basic meteorological instruments suitable for use onboard ships making observations under the Voluntary Observing Ships Scheme, together with advice on methods of observations, is provided in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Part II, Chapter 4, Marine observations.

Experience shows that certain features of these meteorological instruments onboard ships require constant attention. The following comments emphasize where special care should be paid and are fully complementary to the general guidance in the above-mentioned *Guide*.

5.2 Instruments measuring atmospheric pressure

Note: It is mandatory for Members to avoid the use of mercury in their instruments or, where mercury is still in use, to obey safety precautions. See the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) section 3.3.2.1 and the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8) Part I, Chapter 3, 3.2.7.

Aneroid barometers, precision aneroid barometers and digital barometers are commonly used on VOS to measure atmospheric pressure. These instruments are subject to drift and require regular checking by a PMO using a Transfer Standard Barometer, preferably at intervals not exceeding three months. A permanent record of all such checks should be maintained by the PMO, with a copy attached to the barometer showing the date of the check, and the ambient temperature and pressure.

Some aneroid (dial type) barometers are set to indicate Mean Sea Level pressure when they are installed on the ship. Other aneroid barometers, precision aneroid barometers and digital barometers require correction to Mean Sea Level. The barometer height can vary significantly with the loading of the ship, so the barometer

correction table for height needs to provide a range of height reduction constants. The draught of very large tankers can vary by as much as 10 metres between a sea-going ballast condition and a fully-loaded condition. If the barometer elevation is great, air temperature may also have to be taken into consideration when preparing reduction tables. At all times the limit of accuracy of the applied reduction should be kept within 0.2 hPa.

The correction of the barometer to Mean Sea Level may be made manually by use of correction tables, or in the case of ships using electronic logbook software, computed by the software.

Barographs used on board ships should be supplied with an efficient built-in damping device and the instrument should be mounted on shock-absorbing material in a position where it is least likely to be affected by concussion, vibration or movement of the ship. The best results are generally obtained from a position as close as possible to the centre of flotation. The barograph should be installed with the pen arm oriented athwart-ship to minimize the risk of its swinging off the chart.

5.3 Instruments measuring wind speed and direction

In order that wind reports from ships equipped with instruments are comparable with estimated winds and wind reports from land stations, anemometer readings should be averaged over 10 minutes. It is difficult to estimate 10-minute means by watching the dial of an anemometer. An overestimation of more than 10 per cent is not uncommon. It is therefore preferable that the instrument read-out used for reporting wind velocities be automatically averaged over 10 minutes. If such read-outs are not available, careful instructions should be given in order to avoid overestimation.

Due to the flow distortion caused by superstructure, masts and spars, the site of the anemometer sensor has to be carefully selected, preferably as far forward and as high as possible, ideally on the foremast if this is possible. Wind speed also needs to be corrected for effective height (For further information see *Wind Measurements Reduction to a Standard Level*; R.J. Shearman and A.A. Zelenko (MMROA Report No. 22, WMO/TD-No. 311).

Any anemometer mounted on a ship measures the movement of air relative to the ship and it is essential that the true wind be computed from the relative wind and the ship’s velocity. A simple vector diagram may be used, although in practice this can be a frequent source of error. Special slide rules and hand computers are available and programs can be installed on small digital computers.

5.4 Instruments measuring temperature and humidity

Temperature and humidity observations should be made by means of a psychrometer with good ventilation and exposed in the fresh airstream on the windward side of the bridge. Many countries use a louvred screen and secure on each side of the vessel, so that the observation can be made on the windward side. The muslin and wick fitted to a wet-bulb thermometer in a louvred screen should be changed at least once a week, and more often in stormy weather, and the water bottle filled.

Automated or distant-reading thermometers and hygrometers should be sited in a well-ventilated and exposed screen with good radiation protection and placed as far as possible from any artificial source of heat. It is advisable to compare the readings with standard psychrometer observations at the windward side of the bridge at regular intervals, particularly when new types of equipment are introduced.

5.5 Instruments measuring sea temperature

It is important that the temperature of the uppermost thin film of water (measured by infra-red radiometers) should be distinguished from the temperature of the underlying mixed layer. It is the representative temperature of the mixed layer which should be reported by voluntary observing ships.

The 'bucket' instrument method is the simplest and probably the most effective method of sampling this mixed layer, but unfortunately the method can only really be used on board vessels with low freeboards and moving slowly. Other methods are:

(a) Intake and tank thermometers, preferably with distant reading display and used only when the ship is moving;

(b) Hull-attached thermometers located forward of all discharges;

(c) Trailing thermometers;

(d) Infra-red radiometers.

These instruments are described in Part II, Chapter 4 of the *Guide to Meteorological Instrument and Methods of Observation* (WMO-No. 8).

6 Transmission of ship's observations to the shore

6.1 General guidance

Weather reports from mobile ship stations should be transmitted to a coastal radio station as soon as possible after the time of observation; hence the meteorological report, as soon as it is made on board ship, should be handed to the ship's radio officer without delay so that it can be cleared to shore as rapidly as possible. Regulations for the transmission of weather reports from mobile ship stations to designated coastal radio stations are given in the *Manual on the Global Telecommunication System* (WMO-No. 386), Volume I, Part I, Attachment I–1. The relevant procedures are reproduced below for ready reference. Weather reports from mobile ship stations should be transmitted without special request from the ship to the nearest coastal radio station situated in the zone in which the ship is navigating. If it is difficult to contact promptly the nearest radio station in the zone in which the ship is navigating owing to radio propagation conditions or other circumstances, the weather messages should be cleared by following the procedures in the order given below:

(a) Transmission to any other coastal radio station in the zone in which the ship is navigating;

(b) Transmission to any coastal radio station in an adjacent zone within the same Region;

(c) Transmission to any coastal radio station in any other zone within the same Region;

(d) Transmission to a coastal radio station in an adjacent zone in a neighbouring Region or, failing that, to any other station in a neighbouring Region;

(e) Transmission to another ship or an ocean weather station with the function of or willing to act as a relay station.

Maritime mobile radio systems used for ship-to-shore communications as above can cause problems, for various reasons of a technical nature, in the collection of ships' weather reports for subsequent distribution over the Global Telecommunication System. The use of new communication techniques, especially through satellites, offers a promising solution to these problems. Special mention may be made of the system known as INMARSAT, designed for full communication capability for public ship-to-shore communication. The use of this system has, however, important technical and financial implications for National Meteorological Services, and WMO has been studying them. Other satellite data telecommunication systems are now also being used in a cost-effective way.

6.2 INMARSAT

Ship reports can be readily transmitted to an Inmarsat Land Earth Station (LES) which has been authorized to accept these reports. Such reports should always be sent via Special Access Code 41 to ensure that they are automatically routed to the Meteorological Service and that no cost is incurred to the ship The NMS of the country operating the LES pays the cost. There are a number of such LESs in each satellite footprint and they are listed, together with the area from which they will accept reports in WMO-No. 9, Volume D, Part B, Coastal Radio Stations Accepting Ships' Weather Reports. To place a limit on the costs incurred by an NMS, a LES may be authorized to accept reports only from ships within a designated area of ocean. These limits should be drawn to the attention of the relevant ship's officers when recruiting a ship under the Voluntary Observing Ships Scheme.

An increasing number of ships are now willing to use their Inmarsat systems to send their weather reports by email direct to the Meteorological Services. In such cases however the cost of the transmission will be incurred by the shipowner, so it must be ensured that they are willing to accept such costs. In addition the Meteorological Service will need to establish a secure system for the receipt and routing of the reports through their message switching systems.

6.3 Service Argos

Service Argos is a system for receipt of data from automatic weather stations by orbiting satellites, and has been used for many years to collect data from drifting buoys and profiling floats. The data are sent from the satellite to ground stations for processing and distribution on the GTS.

6.4 Other satellite data telecommunication providers

There are now private satellite data telecommunication service providers that offer the possibility to collect ship observations via specific satellite systems (e.g. Iridium). The data can be transmitted in free format to shore, and the Member recruiting the ship should be responsible for converting the raw data to geo-physical units, and applying the necessary quality control procedures before the dissemination of the data over the GTS.

7 Distribution of ships' weather reports over the GTS

Ship weather reports received at an NMC from INMARSAT Land Earth Stations (LES) and coastal radio stations should be assembled into meteorological bulletins and transmitted over the GTS with minimum delay. Some Centres transmit a bulletin of available ship weather reports every 15 minutes. Because ship weather reports are a vital input to a variety of forecast models runs it is important the data from different parts of the world is received with minimum delay.

8 Meteorological logbooks for ships

8.1 Layout

The recording of observations in permanent form is obligatory for selected, VOSClim and supplementary ships and recommended for auxiliary ships. Although most ships now use electronic logbooks for compiling their observations, a small number of ships still record their observations in a hardcopy meteorological logbook. The layout of logbooks is a national responsibility. Generally, the order of parameters recorded in the logbook follows the order of elements in the WMO SHIP code format. Thus the logbook can be used both for recording the synoptic weather report which is to be transmitted and to include additional information required for climatological purposes. For the latter use, the entries are subsequently transferred on to IMMT format (see Chapter 3, paragraph 3.2.7 and Annex 3.C of WMO-No. 471, *Guide to Marine Meteorological Services*).

Logbooks should contain clear instructions for entering observations. Code books or code cards should also be provided, along with logbooks, for ready reference and to help correct wrong entries as necessary. It is useful to mark in the logbook those columns which are earmarked for entries to be transmitted as part of the weather report. In some national logbooks, these columns are lightly shaded or coloured and in others they are inserted in a special frame. Space is often also provided in logbooks to enter the various readings used to compute a meteorological element such as air pressure reduced to sea-level, or actual wind derived from a measured apparent wind and the ship's movement. This will enable a check of the computations carried out on board ship for subsequent quality control of the data during processing for climatological purposes.

To facilitate the supply of meteorological log-books to ships which do not regularly call on their home ports, port meteorological officers in various ports keep a stock of log-books of different National Meteorological Services. In addition, they may keep stocks of observing and coding instructions in different languages.

Ships should be requested to return a completed logbook to the Meteorological Service or PMO which has recruited the ship. The period covered by a logbook should

ideally not be more than three months, so that the delay in entering the observations in the climatological system is not too great.

Logbooks should be returned with information regarding the ship, the instruments used and other details of a general nature, and space should accordingly be provided for these entries. The name of the master, the observers and the radio officer (if carried) should also be included, particularly if an Award system exists in the country where the ship has been recruited.

8.2 Supply and return

The observations made by VOS using electronic logbook software, are archived by the programme and need to be downloaded by PMOs at regular intervals. Some VOS still use hard copy logbooks, so PMOs need to issue these ships with the required stationery and collect the completed logbooks. The completed paper logbooks and the electronic data are generally considered to be the property of the NMS which has recruited the ship.

The NMS should archive the paper and electronic logbook data and submit it to the Global Collecting Centres (GCCs) under the Marine Climatological Summaries Scheme (MCSS).

In order to avoid the entry of duplicate data into the international archiving system, meteorological log-books from ships registered in a foreign country should be produced and stored through appropriate arrangements with the Meteorological Service of the country of registry.

8.3 Scrutiny of entries

However clear the instructions relating to entering observations in a logbook, there is always the possibility of errors occurring in entries to a logbook. Completed logbooks must therefore be scrutinized upon receipt and obvious errors corrected. It is of great importance that recurrent types of errors be brought to the attention of the observers concerned so that any misinterpretation of the instructions or erroneous practices in reading instruments or making entries can be corrected. When the logbooks are received by the Port Meteorological Officer, a first check should be made as soon as possible to permit a personal conversation with the appropriate ship’s officers. Such conversations or written responses commenting on logbooks which have been received constitute an important element of the continuous training of shipborne observers. Without this feedback ship officers would soon become uncertain as to the quality of their work or the implementation of certain observing or coding procedures and, with the inevitable waning of interest, the quality of their observations may deteriorate.

Ships’ officers often include questions on coding matters or on any special phenomena observed by them in the ‘remarks’ column of the logbook. Response to these questions is important, as this falls within the same spirit of maintaining interest in meteorological work. Some countries have instituted special periodicals for meteorological observers on board their ships in which these questions are discussed and explained (see paragraph 11 below).

9 Port Meteorological Officers (PMOs)

In recruiting voluntary observing ships and assisting them in their meteorological work, direct contact with ships' officers is often needed to provide them with instructive material and other documents, to inspect meteorological instruments on board ships, to collect completed hardcopy logbooks and to download log files from electronic logbooks, and to provide feedback on the quality of their observations. For this purpose, Port Meteorological Officers (PMOs), ideally with seagoing experience, should be appointed at the main ports routinely visited by observing ships. PMOs play a very important role and the efficiency of the Voluntary Observing Ships Scheme is heavily dependent on them.

PMOs are representatives of the Meteorological Service of the country as far as the local contact with maritime authorities is concerned. The role of PMOs is a very important one and the efficiency of the voluntary system of ships' observations often depends on the initiative displayed by these officers. They are in a good position to discuss with ships' officers any problems they have encountered and offer suggestions, bring to their attention any changes in procedures that may have taken place and give them the latest information which they may wish for. Opportunity should also be taken to explain various meteorological and/or oceanographic programmes whenever observations are specially needed from ships. Meteorological instruments on board ships should be checked and other advice or assistance in meteorological matters should be given by PMOs upon request by the master of any ship.

PMOs should also report to the meteorological authorities in their country if the meteorological work carried out on board the ship has not been entirely satisfactory. Members should immediately respond to these reports; when they concern the work carried out under the authority of another Member, the latter should be informed. If action has to be taken following complaints this can best be done through the PMOs who can play a very important role by a tactful approach to the masters and, if constructive criticism is expressed in positive terms, goodwill can be maintained all round.

The scope of the work of PMOs depends largely on the importance of the marine traffic in the particular area served. Before deciding to establish a PMO in a given port, a study must be made of the various services which should be provided. As marine activities develop, a review should be made from time to time to see whether new services should be provided. Guidelines for organizing PMO activities are given in Annex D of this Chapter, and are also available on the VOS website (http://www.bom.gov.au/jcomm/vos/). A list of PMOs with their addresses and telephone numbers is available on the JCOMM website (http://www.jcomm.info/pmos).

10 Incentive programme for voluntary observing ships

In recognition of the valuable work done by ships' officers in taking and transmitting meteorological observations and as an incentive to maintaining a high standard of observation many maritime countries have established a national award or certificate system. These systems vary greatly from country to country; in some countries the ships receive the awards, while in other countries awards are made to the individual masters or officers. Sometimes recognition for the meteorological work done on board ships is given in the form of books, charts and other documents presented to the ship.

Members are encouraged to continue the practice of issuing national awards or certificates to Selected, VOSClim, Supplementary and Auxiliary ships recruited by them, or to the ships' personnel, as a sign of their participation in the WMO Voluntary Observing Ships' Scheme.

In addition to national award schemes, the JCOMM Ship Observations Team has produced a "Certificate of Appreciation" that can be issued by Meteorological services to participating observing ships

11 Marine meteorological publications produced by National Services for seafarers and marine observers

A number of National Meteorological Services in maritime countries publish magazines directed to the masters and officers of ships participating in the WMO Voluntary Observing Ships' Scheme. Although content and format differ widely, all these periodicals have two goals in common: first to stress the importance of ships' participation in the marine observing programme and second to offer timely marine meteorological information of interest. A list of these periodicals is given in Annex E of this Chapter.

Among the material included in these periodicals are:

(a) Incidents where ships' observations proved particularly useful;

(b) Commendations on active participation in the WMO Voluntary Observing Ship Scheme;

(c) Hints on observing practices;

(d) Changes in broadcast schedules of weather and sea bulletins or radiofacsimile broadcasts;

(e) Articles on important weather features of particular ocean areas.

Members are encouraged to produce such periodicals and supply them to voluntary marine observers.

ANNEX A

LOCUST REPORTS FROM SHIPS

(Reference: paragraph 4.5)

Members concerned should instruct reporting ships, regardless of their nationality, operating in the seas around Africa, the Arabian Peninsula, Pakistan and India, to send by radio, and in plain language, reports on any locusts seen to the Food and Agriculture Organization of the United Nations (FAO) in Rome Telex 610181 FOODAGRI. Costs are paid by the FAO.

Each locust report should contain the following elements:

(a) Date and time (specifying UTC or zone time) when locusts first seen;

(b) Latitude and longitude, if possible to nearest minute, where locusts first seen;

(c) Time and position at which locusts last seen;

(d) Whether *isolated locusts* (seen in flight singly), *locust group*(s) (flying locusts seen intermittently in numbers), *swarm* (flying locusts seen continuously in numbers, over a period of at least a minute), *dense swarm* (obscuring part of horizon or

other background), *locusts appearing on board* or *floating dead locusts* (isolated, groups or swarms);

(e) Colour of locusts (yellow, pink, grey);

(f) Wind direction and speed.

Details of such reports should be entered in the ship's meteorological logbook or recorded in the ships electronic logbook, even when it has not been possible to send a radio report.

ANNEX B

GUIDELINES FOR REPORTING OF INFORMATION ON FREAK WAVES AND FOR RECORDING IN METEOROLOGICAL LOGBOOKS, AND AN EXAMPLE OF A SPECIAL LOG SHEET

(Reference paragraph 4.5)

(i) Guidelines

It is recommended that the following information be recorded in meteorological logbooks:

(1) *Information on freak waves*

Date: _____ Time: _____ Ship's position

....

Full description of freak wave (including height and horizontal distance between crest and trough, if possible)

Weather condition: .....

State of sea: .....

Any other factors that may have influenced the state of sea: .....

Any damage sustained by ship: .....

(2) *Information to be attached to freak wave reports by National Meteorological Centres:*

Ship's name: .....

Gross registered tonnage: .....

Ship's radio call-sign: .....

FREAK WEATHER REPORT

A freak wave may be defined as a wave of very considerable height, ahead of which there is a deep trough. Thus it is the unusual steepness of the wave which is its outstanding feature and which makes it dangerous to shipping.

ss/mv .....

Call sign .....

Gross tons .....

Date ..... Time .....GMT

Ship's position.....

DESCRIPTION OF FREAK WAVE

Height .....m Direction if known .....

Horizontal distance between crest and trough .....m

Depth of water .....m (either by sounding or from chart)

Remarks .....

WEATHER CONDITIONS

Wind direction ..... Wind speed .....knots

Any other weather factor applicable .....

.....

STATE OF SEA

Sea waves: Height .....m Period .....sec

Swell waves: Direction ..... Period ..... sec Height .....m

Any other factor that may have influenced stat of sea (tide, currents, etc.) .....

.....

DAMAGE TO SHIP (if any) .....

Signature of Observer .....

Signature of Master .....

ANNEX C

GUIDELINES FOR THE OBSERVATION AND RECORDING OF SEA CURRENT DATA ON BOARD SHIP, AND AN EXAMPLE OF A SPECIAL LOG SHEET

(Reference paragraph 4.5)

(i) Guidelines

1. *Introduction*

The knowledge which we now possess regarding surface currents in the world seas is, for the most part, based on information from current observations taken on board ships.

The systematic collection of surface current information had already begun in the middle of the nineteenth century. The famous Lieutenant Matthew F. Maury of the US Navy was one of the first who saw the importance of gathering wind and current data from ship logbooks. In 1845, he published the first of a series of 'Wind and current charts'.

For constructing current charts, as many observations as possible are required, covering many years. As the variability of local currents can be examined only on the basis of a large number of observations, and as the number needed has not been reached for any place at sea, there is still a great need of current observations, especially from areas less frequented by ships outside the major shipping lanes. More observations are also needed to establish, year to year, variations in currents, as some of these are of great significance for marine science, e.g., the El Niño. The only way of obtaining enough observations is by the cooperation of voluntary observers.

By making and reporting observations of currents experienced, the seaman not only gains practical knowledge himself, but benefits shipping generally by adding to our statistical knowledge, so that up-to-date information can be published.

2. *Methods of ocean-current observations and some definitions*

The method of making current observations is to calculate the difference between the dead reckoning (DR) position of the ship after making due allowance for leeway and the position by a reliable astronomical, land, radio, radar, electronic or satellite fix. The result is the set and drift over the ocean floor experienced by the ship during the interval since the previous reliable fix was obtained, and applies to a mean depth of about half the ship's draught.

The *sea of current* is the direction in which it acts; that is the direction toward which it flows. So, the current set is from the DR position to the fix.

The d*rift of a current* is the distance measured in nautical miles from the DR position to the fix.

The *leeway* is the angular difference between the ship's course and the ship's direction of movement through the water (i.e., the direction shown by the wake). Leeway occurs when a ship is subjected by the wind to a pressure from a beam. The angle is rarely more than a few degrees, but there is a considerable loss of accuracy in the observation of the current if a realistic allowance is not made for leeway.

The *"FROM" position* is the true position at the beginning of the stretch over which the current is calculated.

The *"TO" position* is the true position at the end of the stretch over which the current is calculated.

The *dead reckoning (DR) position* is the position of the ship determined by applying to the last well-determined position (the "FROM" position), the run that has since been made, using only the true courses steered (corrected for leeway, if necessary) and the distance run, as determined by log or engine revolutions, *without considering current*. It is important that the true course is corrected for the influence of the wind, so that the difference between the DR position and the true fix is caused only by the current.

3. *The calculation*

The calculation is done in two steps and is based on the following data:

First step — Calculation of the DR position:

Data: (*a*) Position FROM;

(*b*) Course(s) steered, corrected for possible wind influence without considering current;

(*c*) The distance, calculated from speed and time, run along each of the course lines without considering current.

Second step — Calculation of the current:

Data: (*a*) DR position;

(*b*) Position TO.

It is possible to do both calculations by computer. In this case, it is necessary that all three data for the first step and also the position TO are entered in the logbook by the observer.

The advantages of doing the calculation by computer are that the extra work involved for the observers on board is avoided and that errors in the calculation are practically eliminated. A disadvantage, however, is that errors in the basic data cannot be discovered and this inevitably leads to incorrectable faulty results. On the other

hand, the observer is in a position to check the basic data for possible mistakes; also, he can check if the data are reliable enough for current calculation.

Calculation by computer therefore means an increased responsibility of the observer for entering the basic data correctly and for their reliability. For this reason, it is advisable to always enter the data carefully, and then, to check them.

However, in many cases, the officer will wish to calculate the current for his own interest and use, and this is to be encouraged. When the current is calculated on board, it should be entered in the logbook, along with the data from which it was calculated.

4. *The observation*

The following notes are intended to give practical guidance on the ways in which the most useful observations of currents can be made. The usefulness of an observed current depends largely on its representativeness and its accuracy. Nevertheless, an observation which might normally be rejected as being unlikely to have the desired accuracy might still be of value if it came from an area of sparse shipping, i.e., one about whose currents little was known. The observation of currents is particularly desirable in such areas.

The representativeness and accuracy of current observations are discussed below in more detail:

(a) Representativeness of observed currents

Ideally, each observation would represent a single current. In practice though, an observation is made over a distance over which there is likely to be some variation in current. An observation is not required if it is likely to incorporate currents from two different systems. In particular, it is desirable to interrupt an observation when passing a cape, a strait or a current rip, as they are likely to form boundaries between different current systems. Also, observations should not be made with the distance between FROM and TO positions, in excess of about 500 nautical miles or with the time interval between these positions in excess of about 24 hours. Observations should not be made where there are tidal influences, e.g., on coastal passages;

(b) Accuracy of fixes

The accuracy of current observations depends largely on the accuracy of the two fixes. In general, fixes accurate to within two nautical miles are required. Observations based on noon (sun) positions, derived by running fix, usually have less than the desired accuracy; the accuracy of such fixes depends on a due appreciation of the currents experienced — the very element we are trying to determine. On the other hand, the fixes derived from observing two or more planets or stars at twilight, are likely to be very suitable for calculating currents. When suitable equipment is available, fixes by such accurate methods as satellite navigation or OMEGA give especially useful current observations;

(c) Course

The true course, corrected for compass error, must be used. An error in the DR position, due to an incorrect course, has a direct influence on the current calculation. Therefore, the course must be corrected for leeway, whenever necessary. Estimating the correction for wind is not simple and can only be made by experience. However, at a meteorological service receiving current observations, it is hardly possible to make such corrections, because they are so very dependent on the type of ship and on its draught. If estimation of the leeway is impossible, for example, because of stormy weather, no current observation should be made.

When, for some reason, the ship is stopped, it is also better to make no current observation if the wind is more than Beaufort force 3;

(d) Speed

It is of great importance that the speed of the ship *through the water* is known as accurately as possible. An electronic type of log is especially useful. With other, more common, types of log, the speed cannot be determined so precisely and a compromise between log distance and distance by engine revolutions, making due allowance for slip, possibly gives the best results. The slip depends on several factors (such as draught, loading conditions, sea and swell and the time elapsed since the ship was in dry dock), but some of their effects are often hard to determine;

(e) Changes in course and speed between the FROM and TO positions

Between the FROM and TO positions, it is possible for the course to have been changed one or more times; also, it can happen that different corrections for leeway must be applied over a distance sailed with a constant course. In such circumstances, the distance is divided into parts, each with a constant course and speed through the water. If the current is not calculated on board, but later by computer for each part, each distance must be determined from speed and time noted in the logbook. More than three parts are not acceptable;

(f) Period between FROM and TO positions

The main considerations are that the period should be long enough for the current to have a measurable effect, yet short enough to make it unlikely that any large variation in current would have occurred over the distance covered. Thus, the desirable period depends on the accuracy of available navigational data. Exceptionally, with very accurate data, e.g., satellite fixes and speed through the water measured by electronic log, the current might justifiably be measured over a period as short as one or two hours. Also, when coasting, a period of a few hours between two shore fixes may be taken. Usually, however, a longer period is desirable and a period of about 12 hours between stellar fixes, determined at dusk and at dawn, for instance, would be very suitable. A period of about 24 hours is necessary when the only positions determined have been by running fix, e.g., noon (sun) positions, but such observations are barely acceptable. Observations from still longer periods are not acceptable. Since observations of current should be independent, period of observation should not overlap.

ANNEX D

GUIDELINES FOR ORGANIZING PORT METEOROLOGICAL OFFICER (PMO) ACTIVITIES

(Reference paragraph 9)

1. Introduction

The functions of a Port Meteorological Officer (PMO) cover seven broad areas:

(a) Recruitment of ships to take part in the Voluntary Observing Ships' Scheme;

(b) Regular liaison with recruited ships to ensure the highest standard of observations;

(c) Collection of completed ships' meteorological logbooks and data from Electronic logbooks;

(d) Act as an interface between the meteorological service and the marine community;

(e) In large ports act as a focus for the provision of meteorological services in the port;

(f) Assist with arranging deployment of drifting buoys and profiling floats;

(g) Inspection of ships fitted with upper-air radiosonde equipment, an AWS system, or XBT equipment.

1.1 Personnel requirements

Each maritime Member of WMO should endeavour to appoint PMOs with maritime experience at its main ports. Their maritime experience enables them to communicate effectively with the ship's master and other officers. They should also have experience in, and knowledge of, meteorology, theoretical as well as practical. Knowledge of the English language would be an advantage, as most ships' officers whose mother tongue is not English are able to express themselves in this language. The necessary training of PMOs is described in the Manual on Marine Meteorological Services, Part IV, Section 3.

1.2 Location of the office of a Port Meteorological Officer

The office of the PMO should preferably be situated in the centre of the harbour area. This allows the maximum of ships to be visited and facilitates visits by observers from voluntary ships to the PMO's office and gives them access to meteorological information. The PMO will need appropriate transport for instruments and supplies to ships as required.

2. Duties of a Port Meteorological Officer

2.1 Recruitment of observing ships

2.1.1 MERCHANT SHIPPING

Recruiting of observing ships should be in the hands of the PMOs, but subject to overall guidance from the relevant section of the NMS. A worldwide distribution of observing ships is the objective to attain and every effort should be made to recruit ships which operate in data-sparse areas, e.g. the oceans of the southern hemisphere.

PMOs often prioritize the recruitment of ships which are registered in their own country, but ships of other registry are commonly considered for recruitment if they are regular callers and if the PMO considers that they would make a useful addition to the voluntary observing fleet.

Points to be considered when recruiting ships are:

(a) Willingness of masters and officers to carry out the voluntary weather observing and to submit reports throughout the voyage;

(b) Suitability of the ship to carry and care for the instruments.

Permission to recruit a ship should, whenever possible, be obtained from the ship owners or managers, usually through the marine superintendent of the company and from the master. It is recommended that only a verbal undertaking by a ship's master to carry out the work of an observing ship should be obtained. This service is voluntary, and it is therefore not desirable to create the impression that a formal binding contract will be imposed.

When a ship agrees to participate (or volunteer) in the scheme, the PMO equips the ship with the necessary instruments and stationery. This needs to be done quickly as many ships do not spend much time in port. A list of the instruments issued to the ship should be recorded along with the metadata required for WMO-No. 47 by the PMO.

If calibrated NMS instruments are available the ship should be recruited as a Selected or a VOSClim ship. If available, E-logbook software should be installed and training given on how to prepare observations.

Suggested lists of instruments and stationery for the various types of observing ships are as follows:

Selected and VOSClim ships

- One suitably certificated precision or digital barometer;
- One barograph (unless the digital barometer includes a tendency display);
- One whirling pyschrometer OR two screens and two sheathed thermometers (1 air, 1 wet bulb) for each screen, plus two spares OR a suitable digital electronic device to measure temperature and humidity;
- Two sea thermometers and suitable sea buckets (if that bucket method is to be used for measuring sea-surface temperature);
- Electronic logbook software (or hardcopy meteorological logbooks);
- Barograph charts;
- Plotting charts;
- Code and decode information (usually in the form of a code card);

State of sea card or booklet;

Cloud types for observers booklet;

Reduction to mean sea level card (for ships where the pressure height correction isn't automatically applied by the electronic logbook software);

Dew-point tables (for ships that aren't equipped with electronic logbook software).

Supplementary ships:

One suitably certificated precision or digital barometer;

One whirling pyschrometer OR two screens and two sheathed thermometers (1 air, 1 wet bulb) for each screen. plus two spares OR a suitable digital electronic device to measure temperature and humidity;

Electronic logbook software (or hardcopy meteorological logbooks);

Code and decode information (usually in the form of a code card);

State of sea card or booklet;

Cloud types for observers booklet;

Reduction to mean sea level card (for ships where the pressure height correction isn't automatically applied by the electronic logbook software.

Auxiliary ships:

Aneroid barometer correction card;

Code and decode information (usually in the form of a code card);

Electronic logbook software (or hardcopy meteorological logbooks);

State of sea card or booklet;

Cloud types for observers booklet.

Ships' officers should be asked to keep the Meteorological Service's instruments in good and clean condition. The position for the barometer in a ship's chart room should be chosen with care in consultation with the master. It should be as safe as possible from accidental damage, in a good light and clear of artificial heating. Advice should be given as to the best exposure for the thermometer screen if issued under differing conditions. The screen should be kept white. Special attention should be drawn to the care required in ensuring accurate sea temperature observations.

PMOs should ensure that observing officers understand the importance of reading wet and dry bulb temperatures in any one observation to the same degree of precision. All temperatures are required to be read to the nearest tenth of a degree. When this is not possible and the temperatures are read to the nearest whole degree, the tenth figure is reported as a solidus and not by a zero.

Subject to financial constraints, ships under construction may be supplied with distant reading equipment. PMOs should inform their headquarters of any ships being built in their area which would be suitable, and their respective owners and marine superintendents could then be approached by headquarters with a view to installing the necessary cabling and equipment during the construction. When the necessary agreements and financial approvals with the shipowners or managers have been obtained, the PMO should be informed. He should then arrange to visit the ship with a technician if necessary to discuss the siting and installation of the instruments.

It is of the greatest importance that the PMO's initial guidance and instruction to newly-recruited ships officers should be as thorough and complete as possible. This will immediately ensure a uniformity in observing technique.

2.1.2 Fishing vessels and small craft

To help extend the collection of marine meteorological data small craft fitted with good communication equipment may be supplied with instruments or they may be recruited as non-instrumental observing ships and requested to report surface weather conditions, whenever possible. They become auxiliary ships under the Voluntary Observing Ships' Scheme.

Large fishing vessels and yachts can supply most valuable meteorological information from important areas from which there are normally very few ships' weather reports.

In ports from which fishing vessels and large yachts sail, the PMOs should do all that is possible to encourage and interest the owners and captains in marine meteorology. The

captains should be assured of the usefulness to forecasting centres of their voluntary weather reports.

2.2 Visits to ships

Visits and inspections are primarily intended to be occasions for giving encouragement and guidance to marine observers and for thanking them for their work, but they are also the occasion of checking on the continued accuracy of the instruments. Observing ships should, if possible, be visited at intervals of no more than three months and a report made on their instruments. A point to remember when visiting ships is that all the facilities being made available to the visitor are at the discretion and invitation of the ship's staff.

At each inspection any defective National Meteorological Service instruments should be replaced and a receipt should, if possible, be obtained from the master or his senior officer for all instruments issued.

The barometer is probably the most important instrument for weather observing. The reading should be checked by comparison with a PMO's Transfer Standard Barometer, such as a Vaisala digital barometer.

The barometer should be withdrawn from a ship if the difference from the Transfer Standard barometer exceeds 0.3 hPa.

It is recommended that a record card is kept for each barometer issued to a ship. On the card is recorded the difference between the barometer and the Transfer Standard barometer. The difference, however small, should always be entered on a form, so that an accurate record can be kept of the behaviour of each barometer. Plus or minus signs should be used to indicate high or low differences: the plus sign when the ship's barometer is reading higher than the Transfer Standard and the minus sign when the barometer is lower than the standard.

Distant reading equipment, if fitted aboard ships, should be checked at each inspection.

Hand anemometers, if issued to ships, should be returned to the NMS once a year for recalibration and a replacement issued.

In making out reports on instruments, care should be taken to distinguish between Meteorological Service instruments and the ship's own instruments. Where the ship's own instruments are used for observing, the PMO should record this on the visit form. This is necessary to avoid confusion between the property of the NMS and that of the owners or officers.

A standard inspection form should be used for each visit. Space should be available on this form for recording, for example:

(a) Any replacement of instruments;

(b) Any instruments which are the property of the ship's owners or officers;

(c) Any instruments supplied by other authorities e.g. XBTs, plankton recorders, which affect the appropriate entry to the *International List of Selected, VOSClim, Supplementary and Auxiliary Ships* (WMO-No. 47);

(d) Any metadata required by WMO-No. 47 (unless this data is collected using the ships electronic logbook).

The inspection report should be forwarded to the relevant section of the NMS as soon as possible after the inspection.

On visiting an observing ship, the PMO should ascertain that the necessary hardcopy logbooks (if applicable) and stationery are on board and are up-to-date. The ship's officers should be encouraged to understand the international meteorological codes and be familiar with the procedures to be carried out in transmitting weather messages to the meteorological centres ashore.

Courtesy visits should, if possible, be made to voluntary observing ships of other nations when they are in local ports and advice and assistance given as necessary.

2.2.1 WITHDRAWAL OF INSTRUMENTS

It should be the duty of the PMO to recover instruments from ships which cease to observe. When ships cease observing for any reason, the fact should be recorded. PMOs should watch the shipping papers and journals to ascertain, among others, ship sales and change of registry and if these take place abroad they should consider requesting the assistance of the PMO in the relevant country and port.

On receipt of this information, the ship's name will be removed from the national fleet list in the relevant NMS.

When withdrawing instruments care should be taken that instruments which are not the property of the NMS are not included.

2.3 Collection of ships' hardcopy meteorological logbooks

When completed, ships normally return their hardcopy meteorological logbooks to the NMS, but some may prefer to hand it to a PMO. The latter should see the meteorological logbook of all visiting ships and, if it is full or nearly full, they should forward it to the relevant section of their NMS as soon as possible after collection.

It is important to return completed logbooks from observing ships. When visiting observing ships, a PMO should therefore ascertain that the logbooks have been returned. If the book in current use has been started more than six months previously it should be withdrawn and the officers asked to start a new one. PMOs should take the opportunity, whenever possible, to give any advice as to the method of writing up the logbooks.

PMOs should make a special point of visiting observing ships' crews who appear to have difficulties in completing their logbooks and ascertaining the cause.

2.4 General liaison with ships

A PMOs first duty is the care and supervision of the work of voluntary marine observers and they should give encouragement to the applications by the merchant marine generally of marine meteorology to safe and efficient navigation, comfort of passengers and the care of cargo.

A PMO is the channel use to communicate advice, instruction and correction to marine observers and also the gratitude of the meteorological departments responsible for coordinating the work. Thus a complimentary call by these officers upon the master and officers of a ship should be regarded as more valuable than a letter or e-mail, but a complimentary card should be left if it was not possible to see the master.

PMOs should make themselves familiar with the current international meteorological codes for ships in order to be able to explain it to the masters and officers of the voluntary observing fleet.

Advice and encouragement to voluntary observing officers should be given at every opportunity during visits and, for example, through the medium of any national marine meteorological publications aimed at the voluntary observing ships.

Every encouragement should be given to marine observers and others interested in marine meteorology, to contribute papers or remarks on pertinent subjects, for publication in meteorological journals. Special attention should be directed to the pages, where provided, in the meteorological logbooks for 'additional remarks'. Masters and officers should be encouraged to write descriptions of their experiences not only as regards weather, but of all subjects of scientific interest. It is important that PMOs should maintain contact with their national navigation schools and colleges and give them any advice and assistance they may require.

PMOs of a Meteorological Service should remember that it is their duty to secure by the voluntary service of ships' officers the best possible information on meteorological conditions at sea, but it is also desirable to avoid imposing a workload which may interfere with or adversely affect the main duties of a ships' officer to become, if excessive, detrimental to his or her main duties.

PMOs should make themselves thoroughly familiar with the scheme of communication for observing ships' routine weather reporting. They should give every encouragement and all necessary advice and instruction to observing ships.

Attention should be drawn to the Special Access Code 41 procedures for ships fitted with INMARSAT. Addressed telexes to Meteorological Services without the code 41+ procedures are chargeable to the ship.

PMOs should explain the use of radio weather bulletins, gale, storm and tropical cyclone warnings issued specially for shipping, and which radio weather bulletins, including facsimile broadcasts are the most suitable for masters and officers. They should be familiar with Meteorological Maritime Safety Information (MSI) broadcasts such as SafetyNet and Navtex

forecasts and warnings. Information on this the other meteorological services available to mariners should also be given to navigation schools .

PMOs should try to keep in touch with the management and marine superintendent of shipping companies with offices in their area and make regular visits to them.

2.5 Provision of port meteorological services

Shipping, fishing and other marine interests should be informed on how weather forecasts can readily be obtained in the port. They should also be kept informed of all meteorological services available to mariners.

Weather information useful to shipping, fishing or small craft should, if possible, be available at the Port Meteorological Office and details made available of marine forecast products that are available over the Internet. In large ports with a network of automatic weather stations the latest observations may be displayed electronically at the PMO's office (see Chapter 5 for more information on services in ports).

As the first point of contact by ships' officers on meteorological matters, the PMO may be asked for more specific technical information, e.g. on cargo ventilation. If the PMO is unable to answer the query himself, he should transmit it to the appropriate section of the Meteorological Service and ensure that a prompt reply is made.

ANNEX E

MARINE METEOROLOGICAL PUBLICATIONS PRODUCED BY NATIONAL SERVICES AND INTERNATIONAL ORGANIZATIONS OF INTEREST TO SEAFARERS AND MARINE OBSERVERS

(Reference: paragraph 11)

Title of Publication	*Editions per year*	*Country of origin*	*Language*
Boletín Climático Marino	3	Cuba	Sp.
Météo le magazine	4	France	F
Guide de l'Observateur Météorologiste en Mer	1	France	F
Der Wetterlotse	6	Germany	German
Newsletter V.O.S. from Hong Kong, China	2	Hong Kong, China	E
Ship and Maritime Meteorology (Fune to Kaijou Kishou)	3	Japan	Japanese
Meteorological Information bulletin Maritime	4	Netherlands	Dutch and English
Monthly Weather Summary	12	Qatar	E
IMO News	4	United Kingdom	E
Mariners Weather Log	4	United States	E
Storm Data	12	United States	E
WMO Bulletin	4	Switzerland	E, F, R, Sp.

PART IV

THE SPACE-BASED SUBSYSTEM

EDITORIAL NOTE: NO CHANGES ARE PROPOSED TO THE REMAINDER OF THE GUIDE.

PARTS IV TO VIII AND THE ANNEX OF ACRONYMS HAVE BEEN OMITTED FOR THE SAKE OF BREVITY.

Recommendation 5 (CBS-16)

SATELLITE SKILLS AND KNOWLEDGE FOR OPERATIONAL METEOROLOGISTS

THE COMMISSION FOR BASIC SYSTEMS,

Recalling the request of the Sixteenth World Meteorological Congress to technical commissions to assign high priority to the development of job competency standards within the area of responsibility of each of the commissions,

Recognizing that the levels of skill and knowledge of operational meteorologists related to satellite data do not match the needs of many Members,

Noting that the proposed guidance document "Satellite Skills and Knowledge for Operational Meteorologists", annex to the present recommendation, developed within the WMO–Coordination Group for Meteorological Satellites Virtual Laboratory for Education and Training in Satellite Meteorology, describes the underpinning skills supporting the WMO competency areas that relate to the use of satellite data by operational meteorologists,

Stresses that the guidance document should be used in conjunction with addressing the WMO qualification and competency definitions, for example to assist trainers in developing appropriate learning objectives for satellite-related elements of their courses;

Recommends that the proposed "Satellite Skills and Knowledge for Operational Meteorologists" be endorsed, and that it be linked to, or included in, the forthcoming *Guide on Competency* under development by the WMO Education and Training Programme.

Annex to Recommendation 5 (CBS-16)

SATELLITE SKILLS AND KNOWLEDGE FOR OPERATIONAL METEOROLOGISTS

W O R L D M E T E O R O L O G I C A L O R G A N I Z A T I O N

Satellite Skills and Knowledge for Operational Meteorologists

WMO Space Programme

July 2016

SATELLITE SKILLS AND KNOWLEDGE FOR OPERATIONAL METEOROLOGISTS

Summary

This document describes the underpinning skills that support the WMO Competencies that relate to the use of satellite data by operational meteorologists. The skills are:

1. Identify surface features;
2. Identify cloud types and their characteristics;
3. Identify and interpret broad scale, synoptic and mesoscale systems;
4. Identify and interpret atmospheric phenomena;
5. Interpret derived fields and derived products;
6. Identify and interpret oceanic features and systems.

Meteorologists in different locations or performing different job tasks will have access to different satellites with their particular characteristics and to various display and manipulation systems and tools. They will also be dealing with a variety of local meteorological systems and phenomena.

The focus of this document is on meteorological forecasting. Other uses of satellite data, for example, research, oceanography, hydrology, climatology and other specialist areas, will be considered separately in other documents.

The skills definition was developed by the WMO-CGMS Virtual Laboratory for Education and Training in Satellite Meteorology (VLab) to make it quicker and easier for training centres to develop learning objectives that relate to the WMO Competencies.

How to use this document

This document specifies the satellite interpretation skills required of a meteorological forecaster. It does not specify how satellite meteorology should be taught or the order in which it should be taught. This will vary according to many various circumstances, including the particular job tasks required; whether it is taught as part of a short course, a full initial course or independent learning; and, whether it is a separate subject, integrated with other data sources and theory as part of a meteorological systems approach, or a combination by initially teaching background satellite theory followed by an integrated systems approach.

Background

The interpretation of satellite imagery is not an end in itself but is an element of the competent forecaster's toolbox.

The WMO-CGMS VLab is a global network of specialized training centres and meteorological satellite operators working together to improve the utilization of data and products from meteorological and environmental satellites. The WMO Competencies for operational meteorologists and hydrologists and the qualifications for meteorologists and meteorological technicians provide a basis for the VLab training that targets operational meteorologists.

The application of satellite data and satellite skills and knowledge supports the WMO Competencies for Operational Meteorology and Hydrology. These require the competent meteorologists to “Analyse and monitor continually the evolving meteorological and/or hydrological situation”, “Forecast meteorological and hydrological phenomena and parameters” and effectively communicate the information to the users.

As these skills support the high level competencies, this document designates the satellite interpretation requirements as contributing or enabling skills rather than as competencies in their own right.

Trainers who want their courses to be aligned to the qualifications and competencies can use this document to more quickly develop appropriate learning objectives for the satellite related elements of their courses. Of course this document should be used in conjunction with the

qualification (WMO-No. 1083[1]) and WMO competency definitions[2].

Operational meteorologists can use the document to calibrate the breadth and depth of the underlying knowledge and skills with respect to the application of satellite data.

The performance requirements that support these skills and knowledge will be based on the particular context of the organization, its service requirements and available satellite data. This document covers the full range of possible skills and knowledge requirements. Any individual will require only a subset of these, according to their job requirements.

In addition to the general competencies of a meteorological forecaster, the following conditions and background skills and knowledge will apply.

General conditions

- Imagery includes still and animated (looped) imagery single and multiple channels and combinations of channels, including RGB displays, derived quantitative products (processed satellite data blended with NWP data) and synthetic satellite imagery from numerical model predictions;
- Satellites include geosynchronous and polar orbiting satellites with passive and active sensing;
- Satellite interpretation is not undertaken in isolation but occurs within the context of all other observations, guidance and situational awareness;
- Systems, features and phenomena of interest will be dependent on the required forecasting tasks and location.

Access, selection, display and manipulation of satellite data

The forecaster will be able to:

- Access data from geostationary and polar orbiting satellites;
- Select the most appropriate channels, combinations of channels and products for the task at hand;
- Display and manipulate the imagery as individual or combined channels, singly or with animation;
- Apply enhancements to imagery;
- Access and display derived data.

Characteristics, limitations and possible errors in the satellite data

The forecaster will take into account factors affecting data quality and characteristics, including:

- Satellite resolution (time, horizontal, vertical), channel;
- Position of the satellite sub-point – resolution, parallax errors;
- Time of scan for different parts of the image and latency of delivery;
- Satellite sensitivities, precision, accuracy and wavelength characteristics;
- Variations due to sun angle.

Skill 1: Identify surface features

Description

Identify geographical features, surface characteristics and conditions.

[1] http://library.wmo.int/pmb_ged/wmo_1083_en.pdf

[2] http://www.wmo.int/pages/prog/dra/etrp/competencies.php

Performance components

1. Identify terrain and geographical features:
    - Discriminate between land and water (oceans, seas, lakes, rivers, inlets)
    - Distinguish mountainous from low lying regions
    - Differentiate natural vs human modified areas
2. Identify surface characteristics and conditions, including dry/wet, different vegetation types and clear areas, sand and desert:
    - Identify vegetation free areas and vegetation types. Identify different types of desert surface e.g. sand, desert pavement
    - Identify areas of recent burning
    - Identify hotspots (fires, volcanic activity etc.)
    - Identify areas of recent volcanic ash cover
    - Identify areas of flooding
3. Identify snow/ice cover and analyse its extent:
    - Discriminate between cloud and snow
    - Identify frozen rivers and lakes

Skills, techniques and knowledge requirements

- Infrared and visible channels
- Multi-channel RGB products (Natural Colour RGB, Day Microphysics RGB, Microphysics RGB, Snow RGB, Dust RGB)[3]
- Derived products (Land SAF, etc.)

Skill 2: Identify cloud types and their characteristics

Description

Identify cloud types and features including height and temperature of tops, thickness and microphysics.

Performance components

1. Identify stratiform, cumuliform and cirriform cloud regions and individual cloud types and their characteristics;
2. Identify Cumulonimbus clouds, their intensity, organization and stage of development;
3. Identify fogs and discriminate between fog and low cloud;
4. Identify contrails and ship trails;
5. Deduce cloud top heights based on brightness temperatures, surface observations and sounding data (observed, satellite derived and numerical models);
6. Identify clouds made of water droplets, ice particles or a mixture;
7. Discriminate between clouds with small or large cloud particles.

Skills, techniques and knowledge requirements

- Cloud types and characteristics (thick, thin, multi-layered, developing, decaying) based on texture, brightness, brightness temperature and synoptic and mesoscale context;
- Brightness temperatures, contamination from higher levels;

[3] Recommended WMO standards for RGB products are provided in http://www.wmo.int/pages/prog/sat/documents/RGB-WS-2012_FinalReport.pdf

- Fog and Night Microphysics RGB products, shadows on visible imagery and animation to identify valley fogs as well as meteorological situational awareness and surface and aircraft observations;
- RGB products and/or microphysical parameters to identify clouds composed of different phases and clouds with small or large cloud particles[4];
- Infrared, water vapour and visible imagery (including high resolution visible channel).

Skill 3: Identify and interpret broad-scale, synoptic and mesoscale systems

Description

Identify, locate and interpret broad scale, synoptic and mesoscale atmospheric systems, their characteristics, strength and stage of evolution and deduce atmospheric dynamical and thermodynamical properties.

Performance components

For each system, select and apply conceptual models to locate and identify the system, its orientation, strength and stage of evolution, including precursor signatures, taking into account departures from climatological or idealised models. (Categories are not exclusive and some features relate to more than one category.)

Note that a full analysis or prediction involves all available data and guidance and is a higher order competency. Thus, the satellite interpretation task is not an end in itself but, in conjunction with other data, contributes to this higher level task.

1. Broad-scale systems and features:
    - Intertropical convergence zones, monsoon and trade wind regimes;
    - Westerly regimes with embedded cyclones and anticyclones;
    - Polar easterlies and systems;
    - Broad scale waves;
    - Zonal, meridional flows, mobile and blocking systems;
    - Upper and low level circulations.
2. Synoptic scale systems and features:
    - Anticyclones;
    - Cyclones, tropical cyclones and lows, subtropical, mid-latitude and polar lows, at upper and lower levels;
    - Jet streams, convergence and frontal zones, conveyor belts, dry slots;
    - Troughs, ridges and cols, deformation axes, waves;
    - Cloud regions – stratiform, stratocumulus, cumulus (cold outbreaks, trade cumulus), cloud bands and cloud shields;
    - Cold pools and thermal shear.
3. Mesoscale systems and features:
    - Local thermal and topographic circulations including land and sea breezes, katabatic and anabatic winds, foehn winds, mountain waves, banner clouds, island and peninsula effects (including Karman Vortices and v-shaped wave clouds), heat lows and troughs;

[4] Recommended WMO standards for RGB products are provided in http://www.wmo.int/pages/prog/sat/documents/RGB-WS-2012_FinalReport.pdf.

- Convective cells and cloud systems (including pulse convection, multicells, supercells, squall lines, mesoscale convective complexes and systems) and associated mesoscale features including outflow boundaries and storm top features;
- Convergence lines (mesoscale boundaries and interactions, dry lines, cloud streets);
- Low level jets;
- Gravity waves and bores.

Skills, techniques and knowledge requirements

- Detailed conceptual models of each atmospheric system;
- Dvorak tropical cyclone enhancement and techniques for tropical cyclone intensity;
- RGB products (Airmass RGB, Microphysics RGB etc.) [5];
- Infrared, water vapour and visible imagery (including high resolution visible channel).

Skill 4: Identify and interpret atmospheric phenomena

Description

Identify and interpret atmospheric phenomena, their characteristics, strength and stage of evolution.

Performance components

For each phenomenon, locate and identify it and determine its strength, characteristics and, when appropriate, stage of evolution.

Note that a full analysis or prediction involves all available data and guidance and is a higher order competency. Thus, the satellite interpretation task is not an end in itself but, in conjunction with other data, contributes to this higher level task.

Phenomena include:

- Dust and sand storms and plumes and areas of raised dust;
- Fires and smoke;
- Precipitation types and amounts;
- Volcanic ash particulates and chemical emissions;
- Aerosol and particulate pollution;
- Features indicating regions of clear air turbulence.

Skills, techniques and knowledge requirements[6]

- Dust, and sand storms:
  - Conditions - detect dust over land and water, night and day
  - Discriminate between dust, cloud, smoke and desert surfaces
  - Dust RGB products
- Fires and smoke:
  - Locate fires and their movements

[5] Recommended WMO standards for RGB products are provided in http://www.wmo.int/pages/prog/sat/documents/RGB-WS-2012_FinalReport.pdf.

[6] Recommended WMO standards for RGB products are provided in http://www.wmo.int/pages/prog/sat/documents/RGB-WS-2012_FinalReport.pdf.

- Pollution:
  - Pollutants include SO_2, NO_2, etc.
- Volcanic ash

  Identify and analyse in particular:
  - Volcanic emissions including ash, SO_2
  - Determine the areal extent of the ash cloud, its height and its temporal evolution
  - Volcanic Ash RGB
- Precipitation:
  - Precipitation type (convective, stratiform and deep versus shallow precipitation) using satellite channels including microwave channel data
- Other aerosols:
  - Use the Airmass RGB to identify ozone rich regions in the middle and upper atmosphere
- Clear Air Turbulence (CAT):
  - Identify CAT signatures using water vapour channels, synthetic satellite imagery

Skill 5: Interpret derived fields and derived products

Description

Interpret fields and parameters and compare/contrast them with information from other observational data.

Performance components

Interpret fields and parameters in order to integrate them with other data, observations and guidance as input to analysis and diagnosis.

Derived fields include:

- Surface temperatures;
- Vertical temperature and moisture profiles;
- Atmospheric winds;
- Cloud type, cloud top temperature;
- Total and liquid precipitable water;
- Vegetation and fire danger indices, soil moisture.

Skills, techniques and knowledge requirements

- Strengths and weaknesses of satellite derived products/fields;
- Image interpretation - both single channel, RGB products[7] and derived products;
- Satellite data in combination with derived products;
- Knowledge of other sources of observational data, e.g. surface-based observations, radiosonde data, and radar products.

[7] Recommended WMO standards for RGB products are provided in http://www.wmo.int/pages/prog/sat/documents/RGB-WS-2012_FinalReport.pdf.

Skill 6: Identify and interpret oceanic features and systems

Description

Identify and interpret oceanic features and systems relevant to meteorological forecasting. (Note that oceanographers would require more extensive skills that are not covered here.)

Performance components

1. Interpret sea surface temperature fields and their characteristic broad scale, synoptic and mesoscale patterns;
2. Interpret near surface wind data;
3. Identify and interpret sea state data and relate this to wave height and swell;
4. Identify and interpret oil slicks and their evolution;
5. Identify and interpret areas of sun glint and dark zones;
6. Identify and interpret sea-ice, its extent, movement and characteristics (young and old sea ice, sea ice undergoing ablation and containing melt ponds);
7. Identify and interpret ocean currents and eddies and regions of ocean upwelling.

Skills, techniques and knowledge requirements

- Sea surface temperature limitations, including cloud cover, skin temperature, deeper temperatures;
- Sea surface wind detection (scatterometer), including wind direction ambiguities, wind speed inaccuracies, rain effects;
- Sea state measurement limitations and errors based on active microwave sensors and aperture radar. Sea ice detection methods using microwave sensors, synthetic aperture radar and multispectral radiometers. MODIS Sea Ice algorithm;
- Relationship between sun glint, dark zones and ocean surface conditions;
- Sun glint and high cloud characteristics;
- Sea ice and cloud characteristics.

Acknowledgements

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Recommendation 6 (CBS-16)

NEW *GUIDE TO AIRCRAFT-BASED OBSERVATIONS*

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Recommendation 15 (CBS-Ext.(2014)) – Procedures for maintaining Manuals and Guides managed by the Commission for Basic Systems,

(2) The *Manual on the Global Observing System* (WMO-No. 544), Volume I, Part III, section 2.5 – Aircraft meteorological stations,

(3) The *Guide to the Global Observing System* (WMO-No. 488), Part III, section 3.4, Aircraft meteorological stations,

Noting further the growth over the past several decades of the Aircraft Meteorological Data Relay (AMDAR) observing system and the volume of aircraft-based observations on the Global Telecommunications System (GTS) that contribute to the significant positive impact on meteorological, forecasting and other applications as a critical component of the Global Observing System (GOS), the WMO Integrated Global Observing System (WIGOS) and the World Weather Watch (WWW),

Recognizing:

(1) The need for extensive guidance on aircraft-based observations and the AMDAR observing system, as a component of WWW, WIGOS and the GOS,

(2) The urgent requirement to revise and update guidance on aircraft-based observations and the AMDAR observing system,

(3) That many WMO Members either operate AMDAR observing systems, or contribute aircraft-based observations on the GTS, or both,

Noting that complementary technical regulations and guidance on aircraft meteorological stations are recommended to be adopted under Recommendation 4 (CBS-16) – Revised *Manual on the Global Observing System* (WMO-No. 544) and *Guide to the Global Observing System* (WMO-No. 488),

Recommends the following draft resolution to the Executive Council: Draft Resolution XX.XX(X) (EC-69) — New *Guide to Aircraft-Based Observations* (see annex to the present recommendation).

Annex to Recommendation 6 (CBS-16)

DRAFT RESOLUTION XX.XX(X) (EC-69)

NEW *GUIDE TO AIRCRAFT-BASED OBSERVATIONS*

THE EXECUTIVE COUNCIL,

Noting Recommendation 4 (CBS-16) – Revised Manual on the GOS and Guide to the GOS,

Noting Recommendation 6 (CBS-16) – New Guide to Aircraft-Based Observations,

Decides to adopt the Guide to Aircraft-Based Observations as formal guidance on regulations for Members in replacement of WMO-No. 958, the AMDAR Reference Manual, and as detailed in the annex to this Resolution;

Requests the Secretary-General:

(1) To arrange for its publication as a WMO numbered guide;

(2) To bring this resolution to the attention of Members;

(3) To mobilize resources for translation into the official languages of WMO;

Invites Members to contribute to the translation of the Guide, noting that this Guide was not included in the list of publications for production from the regular budget during the seventeenth financial period (Resolution 58 (Cg-17)).

_____

Annex: 1

Annex to draft Resolution XX.XX(X) (EC-69)

(This annex is available in English only)

NEW GUIDE TO AIRCRAFT-BASED OBSERVATIONS

WORLD METEOROLOGICAL ORGANIZATION

Guide to Aircraft-Based Observations

COMMISSION FOR BASIC SYSTEMS

Expert Team on Aircraft-Based Observing Systems

Sub-Group on Regulatory Material

DRAFT VERSION 10

27 September 2016

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1. Aircraft-Based Observations

1.1 Introduction

In the context of this guide, aircraft-based observations (ABO) are defined as a set of measurements of one or more meteorological variables, along with the required observational metadata, made at a particular time or according to a defined schedule at a location or series of locations in three dimensional space from an aircraft platform (Aircraft Meteorological Station). Such observations might be made or obtained from commercial passenger, military, private business, unmanned or other aircraft, utilizing either existing or purpose-deployed sensors, systems and/or avionics software.

Ideally and whenever possible, ABO should be made so as to best meet or contribute to the meeting of meteorological requirements for upper-air data as defined in [REF section 1.5.1].

The thousands of aircraft flying through the atmosphere every day offer an efficient and cost-effective way to gather meteorological information. In the case of the majority of modern aircraft, the aircraft's sensors, while flying, measure air temperature, wind speed and direction, air pressure and other variables of the atmosphere as this information is necessary for the aircraft's navigation systems and aircraft performance monitoring. While these data are used as input to a range of on-board applications supporting flight operation, they are also often automatically transmitted over the aircraft communications system to the airline for performance monitoring by the operator's technical division. In the case of the Aircraft Meteorological DAta Relay (AMDAR) observing system, the meteorologically relevant information can be accessed by a specific software package (AMDAR On-board Software, AOS) for the production of ABO.

In some cases where a sensor or an appropriate communication system is unavailable (e.g. for the measurement of water vapour and humidity), the installation of equipment from commercial manufacturers, including additional sensors and communications facilities, may be required. However, the WMO AMDAR system relies predominantly on the innate aircraft sensors and avionics and communications systems.

Collaboration and cooperation between National Meteorological and Hydrological Services (NMHS) and meteorological service providers, airlines and the aviation industry for the provision of ABO will result in significant positive benefits to the meteorological community, the Air Transport Industry (ATI) and aeronautical agencies – see [REF section 1.4].

In addition to the aircraft-based observations provided by the WMO AMDAR observing system, there are several other sources of aircraft-based observations that Members should endeavour to obtain, maintain and provide, including those able to be made available by commercial airlines acting in accordance with the International Civil Aviation Organization (ICAO) and national Air Traffic Management (ATM) regulations and guidance.

In this guide, the words "shall" and "should" are intended to have their literal meaning in English and do not imply or indicate regulatory status for WMO Members. In general, the guide provides recommended practices and procedures only, unless directly referencing provisions from other WMO Technical Regulations as indicated.

1.2 History and Background

The history of the use of the aircraft platform as a meteorological observing system dates back to the late 1910s when so called meteographs were mounted to the wings of early military biplane aircraft. A meteograph made recordings of air pressure, air temperature and humidity. The data

were used for tracking layers of air in the higher atmosphere. Once or twice per day pilots flew pre-defined tracks for 1 hour, up to 5000 to 6000 meters in altitude.

Aircraft soundings were discontinued in the early 1940s with the advent of the balloon-borne radiosondes.

The use of modern navigation and communication systems in the 1960s and 1970s sparked renewed interest in the use of aircraft to measure and report meteorological data. Automated Weather Observations by aircraft were first used to relay wind and temperature data in support of the Global Weather Experiment FGGE[1] (1978-1979). One of the instruments contributing to the FGGE dataset was a newly developed automated weather observing system installed in aircraft. This (prototype) ASDAR (Aircraft-to-Satellite DAta Relay) system provided wind and temperature information from different levels of the atmosphere. The information was transmitted through the Geostationary Meteorological Satellite System for transmission on the WMO Global Telecommunication System (GTS).

A consortium of 10 WMO Members funded the industrial development of the next generation ASDAR equipment which was operational in the period 1991-2007. The development phase was supervised by the Consortium for ASDAR Development (CAD). For support of the operational phase the CAD was transformed into the Operational Consortium for ASDAR Participants (OCAP). The OCAP managed a Trust Fund for the financial support of the ASDAR operations and expansion, and for contracting a Technical Coordinator.

The advent of flight computers in modern aircraft allowed an alternative approach to ASDAR by tapping the data from innate systems and instruments on the aircraft. In addition to alleviating the requirement to fit aircraft with expensive, purpose-built hardware, this approach made it possible to retrieve valuable atmospheric information and transmit it in (near) real-time using the aircraft communications system through the installation of a dedicated software package only. This new approach was named AMDAR and is now an operational component system within the Aircraft-based Observing (ABO) System in support of the WMO Global Observing System (GOS). Its description and requirements for operation are provided below in [REF section 2.1].

1.3 Description of Aircraft-Based Observations Guidance

Aircraft-based observations are to be made by aircraft operating on national and international air routes. The provision of such observations for both aviation and meteorological purposes and applications is regulated by both WMO and the International Civil Aviation Organization (ICAO) and described in WMO-No. 49, Technical Regulations, Volumes 1 and 2. The material in this guide is provided for WMO Members to supplement the regulations provided within [REF WMO No. 544, Manual on the GOS, Part III, Section 2.5, Aircraft Meteorological Stations] and within [REF WMO-No. 488, Guide to the GOS, Part III, Section 3.4].

Additionally, the Aircraft-Based Observing System is a sub-system of the WMO Integrated Global Observing System (WIGOS), of which the GOS is a component system, and so Members are required to comply with [REF WMO-No. 1160, Manual on WIGOS] in the operation of their aircraft-based observing systems.

For the purpose of this guide a distinction is made between three categories of aircraft-based observations:

1. WMO Aircraft-Based Observations
2. ICAO Aircraft-Based Observations

[1] FGGE: First GARP (Global Atmospheric Research Program) Global Experiment.

3. Other Aircraft-Based Observations

WMO Aircraft-Based Observations are derived from aircraft-based observing systems operated by WMO Members in collaboration with their national or other partner airlines, in which requirements for aircraft-based observations are specified by WMO and its Members so as to meet meteorological needs.

ICAO Aircraft-Based Observations are observations derived from ICAO regulated Aircraft Observations, which are made available to WMO and its Members under the provisions of ICAO as set out within Technical Regulations (WMO-No. 49) Volume II – Meteorological service for international air navigation.

Other Aircraft-Based Observations are those observations derived from aircraft-based observing systems operated by other entities. In this case, while Members do not define specifications for the operation of the observing system, they are urged to ensure that the observations are fit for purpose.

Each of these sources of ABO is described in detail in [REF Section 1.6 below]. Section 1 of this guide provides information on ABO data sources and guidance on how the data should be managed by Members. Section 2 provides information on the systems that produce these data and, in the case of the AMDAR observing system, guidance on its implementation, operation and maintenance.

The WMO AMDAR observing system is currently the chief source of ABO and its description and operational guidance will form the main contribution to the guide.

1.4 Benefits of Aircraft-Based Observations

The great benefit of aircraft-based observations and AMDAR data in particular to meteorology, is the fact that the data are derived according to specific meteorological requirements, so that the meteorological parameters measured are reported at a high frequency during the take-off and landings of participating aircraft. What this means is that the aircraft provides a "meteorological snapshot" of the atmosphere on a vertical trajectory at positions crucial for aeronautical operations and at a frequency that provides a suitable vertical resolution of meteorological variables measured. Vertical profiles derived from aircraft-based observations should be considered as being very similar in character and application as those derived from meteorological radiosondes. There are three elements of the AMDAR observing system which make it especially valuable for forecasting applications, including aeronautical meteorology:

1. AMDAR wind and temperature observations have been shown to have data quality (i.e. accuracy or uncertainty of measurement) equivalent to that of radiosondes;
2. The measurement sensors and systems on the aircraft are able to produce this accurate data at a very high rate or frequency of measurement, thus providing very fine detail within the vertical profiles (in particular at the lower altitudes); and
3. Owing to the frequency at which aircraft are landing and taking off from airports, these vertical profiles can be produced on a 1 to 3-hourly-basis at many airport locations.

In addition to the vertical profiles at take-off and landing, the aircraft provide data at selected time intervals during flight at cruise level at around 10,000 to 12,000 metres.

These features of the AMDAR observing system have led forecasters to provide testimony that these data are very valuable and useful, providing significant improvement to applications for monitoring and prediction of weather systems and phenomena such as:

- Surface and upper-air forecasts of wind and temperature;
- Thunderstorm genesis, location and severity;

- Wind shear location and intensity;
- Low cloud formation, location and duration;
- Fog formation, location and duration;
- Turbulence location and intensity;
- Jet stream location and intensity;
- Precipitation type, amounts and rates; and
- Conditions leading to aircraft icing.

Modern numerical weather prediction (NWP) systems are able to precisely quantify the benefits of aircraft-based observations, resulting in the conclusion that, in many, if not most cases, these observations are second only to high-volume satellite data in positive impact on NWP improved forecasting skill and error reduction. AMDAR and other aircraft-based observations generally provide an improvement in forecasting ability, through a reduction in NWP forecast error, of up to 10-20% over the first 24 hours of the forecast period. Recent studies with the High Resolution Rapid Refresh model in the United States of America have also demonstrated a large positive impact on model error reduction and that AMDAR data are the most significant contributor to that model's forecast skill.

A study[2] in 2014 provided information on the cost-effectiveness of the AMDAR observations relative to all other data sources used in global NWP systems. When cost estimates for each observing system were included the authors concluded that ABO observations have the largest impact per unit cost.

For more detailed information on the benefits and impact of ABO and AMDAR data, see WMO [REF WIGOS Technical Report 2014-2, The Benefits of AMDAR to Meteorology and Aviation] and the WMO website[3]

1.5 Requirements

1.5.1 Requirements for Upper Air Data

The WMO requirements for upper-air observations are maintained and specified under the WMO Rolling Review of Requirements (RRR) process[4] which is described in detail in the [REF Manual on WIGOS, section 2.2.4 and Appendix 2.3].

The RRR defines observational data requirements for WMO Application Areas, which are based on the Statement of Guidance (SoG) documents available for each Application Area and expressed in terms of space/time resolution, uncertainty, timeliness, etc., for each of the required observed variables, independent of the observing technology.

The application areas most relevant to ABO and AMDAR are Global NWP, High Resolution NWP and Aeronautical Meteorology. The requirements are defined for the variables atmospheric pressure, air temperature, wind (horizontal) and specific humidity. ABO data are also useful for most of the other application areas.

More information on the requirements for upper air observations from the AMDAR observing system is provided in [REF Section 2.1.1].

1.5.2 Requirements for Aircraft-Based Observations

[2] Eyre, J. and R. Reid, July 2014: Cost-benefit studies of observing systems. Forecasting Research Technical Report No: 593. Met Office, Exeter, United Kingdom, 11pp.
[3] See: http://www.wmo.int/pages/prog/www/GOS/ABO/data/ABO_Benefits.html.
[4] See: http://www.wmo.int/pages/prog/www/OSY/GOS-RRR.html.

In addition to complying with the regulations and guidance as referenced in [REF Section 1.3], Members should also endeavour to meet the following requirements and practices:

- Observations should meet the WMO requirements for upper-air observational data as referred to in [REF section 1.5.1].
- Agreements should be made with operators of other ABO systems and data owners to ensure that data can be transmitted on the WIS in accordance with [REF WMO Resolution 40].
- Observational data should be managed in accordance with [REF sections 1.7 to 1.11].
- AMDAR observing systems should be operated in accordance with [REF section 2.1].

It is recommended that aircraft-based observations consist of at least the following variables, with desirable and optional variables as indicated:

- (static) air temperature
- wind speed
- wind direction
- pressure altitude
- latitude
- longitude
- time of observation
- turbulence: mean, peak and event-based Eddy Dissipation Rate (EDR) - desirable
- geometric altitude - desirable
- humidity - desirable
- icing - desirable
- turbulence: derived equivalent vertical gust (DEVG) - optional

For more details and further requirements on the measurement processes and data processing associated with these and additional optional variables see [REF AMDAR Onboard Functional Requirements Specification (AOSFRS), CIMO IOM report No. 115, Chapter 3].

For more details on instruments and methods of observation associated with aircraft-based observations, see [REF CIMO Guide, Part II, Chapter 3].

In addition to meeting requirements for measurement resolution and accuracy of reported variables, aircraft-based observations should be made so as to best meet temporal and spatial and also timeliness requirements for provision of vertical profiles and horizontal observations of variables, which are taken as the participating aircraft are ascending and descending and in level flight respectively.

For more details on requirements for observations in support of WIGOS and the WMO World Weather Watch Programme, see [REF Manual on WIGOS, Section 2.5].

For more detailed guidance on the provision of aircraft-based observations in support of requirements for upper-air observations, see [REF Guide to the GOS, Chapter 3.4, Section 1.5].

More specific details regarding the configuration of systems so as to most optimally meet requirements for upper-air data are provided in [REF Chapter 2].

1.6 Sources of Aircraft-Based Observations

Sources of ABO can be categorized in terms of a range of different aspects and functions including:

- The system that provides the ABO;
- Which entity or organization is responsible for its regulation or provision;
- How measurements and reports are generated (including whether they are produced automatically/routinely or manually/non-routinely);

- Measurements are obtained from on board sensors installed for the primary functions of the aircraft (innate), or from sensors purposely installed for meteorological observations (additional);
- The communications systems used for air-to-ground relay;
- Whether or not the downlink message always contains meteorological information;
- The format used for air-to-ground downlink;
- The entity responsible for processing the reports on the ground; and
- The format used for provision to the WIS.

An overview of the various ABO data sources and systems is shown in [REF Table 1].

System / Type	Regulator / Provider	Auto / Manual	Sensors	Comms	Met. Information	Air-Ground Format	Responsible for Ground Processing	Responsible for WIS provision	Preferred WIS Format
AMDAR	WMO	Auto	Innate to aircraft[5]	ACARS	Always	AMDAR	NMHS	NMHS	BUFR[6]
AIREP	ICAO	Auto & Manual	Innate & pilot (from cockpit display and subjective)	ACARS	Always	AIREP	MOW or WAFC	WAFC	BUFR[7]
PIREP[8]	National Civil Aviation Authority	Manual	Innate & pilot (from cockpit display and subjective)	VHF radio / ACARS	Always	PIREP	MOW or WAFC	WAFC	BUFR[9]
ADS-C	ICAO	Auto	Innate to aircraft	ACARS	Optional	ICAO Aircraft Report	MOW or WAFC	WAFC	BUFR[10]
Mode-S	ICAO	Auto	Innate to aircraft	L-Band (SSR[11])	Derived	ICAO Aircraft Report	ATC / NMHS	NMHS	BUFR
TAMDAR	Other (External)	Auto	Additional	Satellite	Always	TAMDAR	PAC[12]	NMHS	BUFR
AFIRS	Other (External)	Auto	Innate to aircraft and/or additional	Satellite	Optional	AFIRS	FLYHT	NMHS	BUFR

Table 1: Sources of aircraft-based observations

Note that, as of November 2014, Members are required to have ceased provision of data to the WIS in character based codes in favour of the WMO Binary Universal Form for the Representation of meteorological data (BUFR).

[5] An additional sensor is required for measurement of humidity.

[6] AMDAR ABO have historically been submitted also in WMO FM42 format however, since Nov 2014, WMO no longer supports character-based formats.

[7] AIREPs have historically been submitted also in WMO FM41 format, however, since Nov 2014, WMO no longer supports character-based formats.

[8] PIREP is a special type of Aircraft Report developed for use over United States and Canada airspace and is not an ICAO regulated report.

[9] PIREPs have historically been transmitted on the GTS also in FM41 format, however, since Nov 2014, WMO no longer supports character-based formats.

[10] Observations from ADS-C have historically been submitted also in WMO FM41 format, however, since Nov 2014, WMO no longer supports character-based formats.

[11] SSR = Secondary Surveillance Radar.

[12] PAC = Panasonic Avionics Corporation.

1.6.1. WMO Aircraft-Based Observations

WMO aircraft-based observations are defined as meteorological observations made from an aircraft platform under cooperation and/or commercial arrangement between aircraft operators or their agents with WMO Member NMHSS, meeting prescribed WMO standards and requirements for reporting and quality and transmitted by Members on the WIS. These observations are to be made in accordance with WMO regulations within [REF WMO No. 49, Volume 1], including its Annexes.

1.6.1.1 AMDAR Aircraft-Based Observations

The global AMDAR observing system was initiated by the World Meteorological Organization (WMO) and its Members. National and regional AMDAR programmes are operated by WMO Member NMHSs in cooperation and collaboration with their partner commercial airlines.

The AMDAR programme is an integrated component of the WMO Global Observing System and the WMO Integrated Global Observing System, which is defined and maintained under the World Weather Watch Programme [REF Manual on the WIGOS, Chapter 7].

A technical description of aircraft-based sensors and the methods for deriving meteorological observations from them can be found within the Guide to Meteorological Instruments and Methods of Observations, [REF WMO-No. 8, Part II, Chapter 3].

The WMO AMDAR observing system operates under a cooperative arrangement between airlines and NMHSs. The system, as depicted below in [REF Figure 1], collects the following meteorological data from commercial aircraft for global distribution to the NMHS on the WIS:

- High resolution[13] vertical profiles of air temperature, wind speed and direction on aircraft ascent and descent;
- Regular near-real-time reports (e.g. every 5-10 minutes) of meteorological variables while the aircraft is en-route at cruise level;
- Accurate measurement of coordinates (time, latitude, longitude and pressure altitude);
- If available, measurement of turbulence as EDR (Eddy Dissipation Rate) and/ or DEVG (Derived Equivalent Vertical Gust); and
- Water vapour or humidity (from suitably equipped[14] aircraft).

See section 2.1 for a detailed description of the AMDAR system and requirements and guidance relating to (ground) infrastructure and programme development, operation and maintenance.

1.6.1.2 Data Reception and Processing

AMDAR observations should be received and processed by the Member's NMHS before reformatting into BUFR for provision to the WIS.

In some cases, AMDAR observations may be processed by one Member on behalf of one or more others under bilateral or multilateral arrangement and agreement. In the interests of programme efficiency and capacity development, WMO strongly encourages such collaboration.

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[13] Vertical resolution of around 100 metres in the lower troposphere (to 700 hPa) and temporal resolution of up to around 1 profile per hour depending on fleet size and configuration for reporting and AMDAR fleet traffic at individual airports.

[14] The Water Vapor Sensing System, WVSS-II, is a specialized sensor designed for use in aviation which has undergone extensive testing and operational evaluation by WMO Member NMHS and is currently the only sensor deemed to be capable of meeting operational and performance requirements for use with AMDAR [REF WMO AOSFRS, Appendix C2].

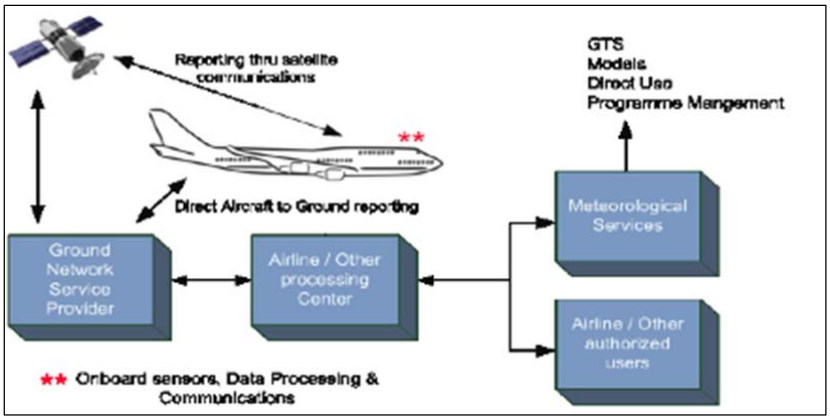


Figure 1. Simplified overview of the AMDAR observing system.

To facilitate such efficiencies Members should ensure that AMDAR observations are provided in a WMO standard (air to ground) format as described in [REF Section 2.1.2.3].

Members should undertake prescribed minimum quality control of aircraft-based observations prior to their provision to the WIS as described in [REF Section 1.8 and Annex I].

1.6.1.3 Provision of Observations to the WIS

Members should provide AMDAR to the WIS in accordance with [REF WMO Resolution 40] and in accordance with the referenced provisions and recommended practices in [REF Section 1.9 and Annex III]

1.6.1.4 Maintenance and Provision of Metadata

Members should maintain a record of AMDAR observational metadata in accordance with the referenced provisions and recommended practices in [REF Section 1.10 and Annex IV].

1.6.1.5 Monitoring and Quality Assessment

Members should undertake routine monitoring and quality assessment of AMDAR observational data in accordance with the referenced provisions and recommended practices in [REF Section 1.8 and Annex II].

Members should ensure that changes to the programme or schedule of reporting of aircraft-based observations on the WIS are planned and notified in advance.

1.6.2 ICAO Aircraft-Based Observations

1.6.2.1 ICAO Aircraft Reports

Several sources of ICAO aircraft-based observations are to be made available to WMO Members under the regulations of ICAO governing its Contracted States. The requirements for the making of aircraft observations and the provision of aircraft reports (air-reports) are discussed and defined in [REF ICAO Annex III, Ch. 5 and Doc. 8896, Ch. 7].

Note: The detailed descriptions and provisions for ICAO aircraft observations are not provided in full within this Guide. The reader is referred to the ICAO and/or WMO publications as indicated.

From [REF ICAO Doc. 8896, Ch. 7]:

> A report consisting of a position report and of meteorological information is called a “routine air-report”. (It may also contain operational information.) Reports containing special aircraft observations are called “special air-reports” and, in most cases, constitute a basis for the issuance of SIGMETs.

Routine air-reports are to be made by aircraft with air-ground data link when air-ground data link is used and Automatic Dependent Surveillance (ADS) or Secondary Surveillance Radar (SSR) Mode-S is being applied. Reports are to be made by such aircraft at 15-minute intervals during their en-route phase and every 30 seconds during the climb-out phase for the first 10 minutes of the flight.

A brief description of the ADS and SSR systems that can be used to generate air-reports of various content is provided within [REF section 2.2].

Routine and Special Reports (AIREPs) from an aircraft are prepared during flight in conformity with requirements for position, and operational and/or meteorological reporting as described below in [REF section 1.6.2.1].

From [REF ICAO Doc. 8896, Ch. 7, section 7.7]:

> 7.7.1 Basic Principles: Air traffic services and meteorological authorities must establish appropriate arrangements to ensure that routine and special air-reports reported to ATS units by aircraft in flight are transmitted without delay to the World Area Forecast Centres (WAFCs) and to the associated Meteorological Watch Offices (MWO).
>
> 7.7.3 Additional exchange of air-reports beyond WAFCs: Air-reports exchanged beyond WAFCs are considered as basic meteorological data and therefore their further dissemination is subject to WMO provisions.

While the ICAO ABO derived from AIREPs are made available as basic data to WMO Members for their use in the provision of their mandated services and applications, the primary purpose of these observations are for the applications of Air Traffic Services, MWOs and WAFCs.

Regulations and guidance for WMO Members on the reception, provision to the WIS and management of ICAO ABO are provided in WMO-No. 386, Manual on the GTS, Vol. I, Part I, Section 2.7]. These regulations state that:

> Collecting centres designated in the ICAO Regional Air Navigation Plans for the collection of aircraft weather reports shall send all available aircraft weather reports to the NMC situated in the respective country or to other meteorological centres designated by agreement between the aeronautical and meteorological authorities concerned.
>
> RTHs shall collect the aircraft weather reports from the NMCs in their respective zones of responsibility.

Provisions for ICAO ABO are regulated at the highest level in [REF WMO-No. 49 Technical Regulations, Volume 2, Meteorological Service for International Air Navigation, Part I, Section 5, Aircraft Observations and Reports and Part II, Appendix 4], also published by the International Civil Aviation Authority (ICAO) and described in [REF ICAO Annex 3 to the Convention on International Civil Aviation].

Requirements in terms of (mandatory) standards and recommended practices are stated in WMO-No. 49, Vol. 2/ICAO Annex 3, Appendix 4, "Technical Specifications Related to Aircraft Observations and Reports".

Details on data processing and delivery can be found in the following ICAO documents:

- ICAO Doc 4444 PANS/ATM, Air Traffic Management, (see paragraph 4.12 REPORTING OF OPERATIONAL AND METEOROLOGICAL INFORMATION)
- ICAO Doc 8896, Manual of Aeronautical Meteorological Practice (see Chapter 7, AIRCRAFT OBSERVATIONS AND REPORTS)
- ICAO 9377, Manual on Coordination between Air Traffic Services, Aeronautical Information Services and Aeronautical Meteorological Services (see 4.2 REPORTS OF AIRCRAFT OBSERVATIONS RECEIVED IN ATS UNITS)

Based on these provisions, it is clear that NMCs Washington and London are currently responsible for the initial collection of AIREPs from WAFCs and for their provision to WMO Members.

At the current time, meteorological information from Aircraft Reports can be considered to be a supplementary source of aircraft-based observations that assist in meeting the requirements of WMO Members for upper-air observations – see [REF Section 1.5]. However, In most countries, these Aircraft Reports are either not being made or are not being made available to WAFCs in accordance with ICAO provisions. Members should therefore liaise with their civil aviation authorities to ensure that Aircraft Reports are made and that they are then sent to WAFCs so as to be made available to the WIS as aircraft-based observations.

Beyond the provisions that are made in the WMO and ICAO documents above for the derivation of ABO from AIREPs, the additional derivation of ABO from these and other national Air Traffic Management systems and sources is essentially a matter between WMO Members and their respective civil aviation authorities. In the event that such additional ABO data are able to be made available to NMHSs, they should remain subject to [REF WMO Resolution 40] and the requirements for provision of such data to the WIS as described in [REF section 1.8].

For example, the derivation of ABO from PIREPs (described below) and high resolution ADS-B or Mode-S systems, described below in [REF section 2.2] are not regulated under ICAO provisions outlined above.

1.6.2.2 Other National Aviation Aircraft Reports

Pilot Reports

A Pilot Report (PIREP) is a routine or urgent report of actual weather conditions encountered by an aircraft in flight. This information is usually relayed by radio to the nearest ground station, but other options (e.g. electronic submission) also exist in some regions. The message would then be encoded and relayed to other weather offices and air traffic service units. At a minimum the PIREP must contain a header, aircraft location, time, flight level, aircraft type and one other field. The provision of PIREPs by aircraft is regulated in accordance with national requirements and is not subject to regulation by ICAO.

Information on the origins or PIREPs are difficult to find but the requirements, content and other details should be available from the relevant civil aviation authority. In the United States, the requirements for PIREPs are issued as a directive[15] and documented within the Federal Aviation Administration (FAA) [REF Aeronautical Information Manual[16], section 7-1-20].

While PIREPs should essentially be treated in the same way as AIREPs, subject to the same quality control and reported to the WIS in the same way, it is preferred that they are able to be distinguished from other ABO sources, including AIREPs.

1.6.2.3 Format and Content of Air-reports

[15] See: http://www.srh.noaa.gov/msd/sram/directives/10-804.pdf
[16] https://www.faa.gov/air_traffic/publications/media/aim_basic_4-03-14.pdf

The meteorological content of routine air-reports transmitted via air-to-ground data link is provided in [REF ICAO Doc. 8896, Table 7-3], as shown below.

Table 7-3. Meteorological content of routine air-reports transmitted via air-ground data link
(All the reports include information on the position of the aircraft in four dimensions.)

ADS and SSR Mode S not being applied	*ADS or SSR Mode S being applied*
Air temperature	Wind direction
Wind direction	Wind speed
Wind speed	Wind quality flag
Turbulence	Air temperature
Aircraft icing	Turbulence (if available)
Humidity (if available)	Humidity (if available)

Criteria for Reporting

When air-ground data link is used, the wind direction, wind speed, wind quality flag, air temperature, turbulence and humidity included in air-reports shall be reported in accordance with the following criteria.

- Wind direction: The wind direction shall be reported in terms of degrees true, rounded to the nearest whole degree.
- Wind speed: The wind speed shall be reported in metres per second or knots, rounded to the nearest 1 m/s (1 knot). The units of measurement used for the wind speed shall be indicated.
- Wind quality flag: The wind quality flag shall be reported as 0 when the roll angle is less than 5 degrees and as 1 when the roll angle is 5 degrees or more.
- Air temperature: The air temperature shall be reported to the nearest tenth of a degree Celsius.
- Turbulence: The turbulence shall be reported in terms of the cube root of the eddy dissipation rate (EDR). For further details, see [REF Annex 3, App. 4, par. 2.6].
- Humidity: The humidity shall be reported as the relative humidity, rounded to the nearest whole per cent.

Note: The ranges and resolutions for the meteorological elements included in air-reports are shown in [ICAO, Annex 3, Appendix 4,Table A4-3].

The AIREP format is described in more detail in [REF Annex III].

1.6.2.4 Provision of Observations to the WIS

Members must provide aircraft-based observations derived from ICAO air-reports to the WIS in accordance with the referenced provisions above in [REF section 1.6.2.1] and those in [REF sections 1.8 and 1.9]. Members should also follow recommended practices described in [REF and Annexes I and III].

1.6.2.5 Maintenance and Provision of Metadata

Members should maintain a record of observational metadata for ICAO ABO in accordance with the referenced provisions and recommended practices in [REF section 1.10 and Annex IV].

1.6.2.6 Monitoring and Quality Assessment

Members should undertake routine monitoring and quality assessment of ICAO ABO in accordance with the referenced provisions and recommended practices in [REF section 1.8 and Annex II].

For details on systems that generate ICAO aircraft reports, see section 2.2

1.6.3. Other Aircraft-Based Observations

Aircraft-based observations are also available through commercial manufacturers and system operators. Such systems are distinct from the AMDAR system in that the collaboration is between the NMHS and a Third Party commercial entity, rather than between the NMHS and the airline and/or the national civil aviation organization.

Such Third Parties currently include:

- Panasonic Avionics Corporation under its Weather Solution Program manufactures and deploys the Tropospheric Airborne Meteorological Data Reporting (TAMDAR) sensing system, a device designed to collect and transmit weather and other data during the flight of an aircraft.
- FLYHT Aerospace Solutions Ltd. manufactures the Automatic Flight Information and Reporting System (AFIRS), which interfaces with the aircraft flight data, processes and stores it and transmits it over the Iridium global satellite network.

Both systems provide downlink, voice and text communications and flight-following features as services to the client airline.

Both companies provide a centralized data processing centre at which the data is received, processed and routed to the airline and data subscribers.

In the case of TAMDAR, meteorological sensors are deployed as components of the TAMDAR probe so that some observations of meteorological parameters are made independently from the aircraft. These data are openly shared back with the host airline. With the airline's permission, a host airline's data may also be shared with other participating fleets.

The TAMDAR and AFIRS systems and their operation are briefly described in [REF Section 2.3.3].

1.6.3.1 Data Policy and Agreements with Data Providers

It is critically important that Members are aware of the methods of measurement and observation that are employed by the Third Party in operation of the observing system from which the aircraft-based observations are derived – in particular those aspects that impact on reliability and quality of the data source.

It is important to understand that Third Party ABO data providers are generally commercial entities and so they operate their systems and provide their services and products in the expectation that they will receive a return on their investment. In some cases, the collection of meteorological data may be considered to be a secondary or tertiary revenue stream for the operator and the primary source may be the service provided to the airline. In any case, the business case for provision of meteorological data to the NMHS still holds. This fact should be utilized in negotiating with the two parties, the Third Party data provider and the airline, for the provision of ABO. The stronger the business case and the more the NMHS can do to offset the cost of the ABO data through the provision of improved meteorological services to the airline, the greater the likelihood that a lower cost contract or agreement can be negotiated by the NMHS.

1.6.3.2 Provision of Observations to the WIS

Members should ensure that the formation of a contract or agreement with the service provider for the provision of Third Party ABO data allows the data to be transmitted to the WIS in accordance with [REF WMO Resolution 40].

Members should provide Third Party data derived from other aircraft-based observing systems to the WIS in accordance with the referenced provisions and recommended practices in [REF sections 1.8 and 1.9 and Annexes I and III].

1.6.3.1.3 Maintenance and Provision of Metadata

Members should maintain a record of observational metadata for other aircraft-based observing systems in accordance with the referenced provisions and recommended practices in [REF section 1.10 and Annex IV].

1.6.3.1.4 Monitoring and Quality Assessment

Members should undertake routine monitoring and quality assessment of Third Party aircraft-based observational data in accordance with the referenced provisions and recommended practices in [REF section 1.8 and Annex II].

1.7 Observational Data Management

The entities functions and practices described in this section together with the data and quality management practices undertaken by Members and described in [REF sections 1.8, through to 1.11] form the overall ABO Data Management system. Within the data management system, the monitoring and improvement of the quality chain is a leading theme, i.e. improvement follows from evaluation, research and ongoing development of the data processing and production chain. For aircraft-based observations, including aircraft derived data from ICAO ABO; this chain is a relatively complex system because of the many data processing operations and autonomous data switches involved. This complex data management and distribution system can be described as a system of entities that each undertake a number of tasks, activities and practices to support observational data management, starting from initial variable measurement on the aircraft platform through to the delivery of data products to data users.

[REF Figure 2] below shows the Proposed Aircraft Observations Global Data Management Framework that was first developed at the WMO AMDAR Panel Aircraft Observing System Data Management Workshop, Geneva, Switzerland, June 2012 and later updated by the WMO Expert Team on Aircraft Based Observing Systems (Session 2, December 2015). While many of the elements of this proposed system are not yet in place, including the ABO Data Centre and the framework for metadata management, it provides an aspirational focus for the future to support improved ABO data management.

While this figure does not depict the data management framework for Other ABO and aircraft-based observing systems as described in [REF sections 1.6.3 and 2.3], these data should be managed under a similar data management framework.

The important entities functions, roles and practices depicted in the figure are described below.

Aircraft Observing Platforms

A range of aircraft platforms as described below in [REF section 2] routinely obtain measurements from dedicated sensors, which are processed and controlled and combined with static and dynamic metadata to form observations, which are then dispatched by communications system to the ground based on a programmed schedule of reporting.

Aviation Data Service Providers

Reports of observations (ABO) are provided by Aviation Data Service Providers (Av. DSP) that are responsible for maintaining air-ground and ground-ground communications network in support of the Aviation Communications Addressing and Reporting System (ACARs), delivering reports to airlines, Air Traffic Management (ATM) and ABO Data Processing Centres (DPCs). In some cases, an arrangement between airlines and NMHSs is made for airlines to deliver AMDAR data to the ABO DPC.

World Area Forecast Centres

ICAO World Area Forecast Centres (WAFCs) operated by WMO Members provide weather services in support of air navigation requirements and are responsible for the collection of ICAO Aircraft Reports, which are then made available to the WIS as described in [REF section 1.6.2].

Airlines

Airlines of ICAO Contracted States are responsible for meeting the regulations of ICAO for the provision of Aircraft Reports. Airlines providing ABO in partnership with Members are responsible for the delivery of ABO to DPCs under the terms of agreements put in place between the parties and as described in detail in [REF section 2.1.3.1.2]. Airlines should also be responsible for the provision of required aircraft metadata in support of ABO quality management and meteorological applications that require such information.

ABO Data Processing Centres

ABO DPCs are operated by NMHSs and may undertake ABO DPC responsibilities and functions in support of one or more national ABO programmes. ABO DPCs have responsibility for:

- The reception, processing, quality control and archival of ABO and its transmission on the GTS;
- The reception, processing and maintenance of metadata and its relay to OSCAR;
- Optimization of ABO data, in particular the management of data optimization systems supporting AMDAR observing systems as described in [REF section 2.1.2.2 and Annex V]; and
- In some cases, the provision of data display or visualisation functionality in support of ABO programme management.

Third Party ABO Data Processing Centres

Third Party ABO Data Processing Centres (3P DPCs) are centres that undertake DPC functions on behalf of and in agreement with a NMHS or region. Generally, such centres should not be responsible for provision of ABO to the WIS, which should be maintained as a WMO Member responsibility.

ABO National Meteorological Service

An ABO National Meteorological Service (NMS) is a WMO Member that receives and uses ABO and may or may not contribute ABO through the services or functions of a partner DPC. In the case of the former, the ABO NMS should take responsibility for the provision of required partner or national airline metadata.

Observing System Capabilities Analysis and Review System

The WMO Observing System Capabilities Analysis and Review (OSCAR) system is the repository for all ABO metadata. Members will be responsible for ensuring that ABO metadata is obtained from national airlines and provided to OSCAR in accordance with the requirements described in [REF section 1.10 and Annex IV].

ABO Data Monitoring Centre

WMO ABO Data Monitoring Centres (DMCs) are responsible for monitoring of ABO data and may undertake a global or regional data monitoring role. The requirements of DPCs are specified in Annex II. ABO DMCs will be designated by CBS.

ABO Lead Centre

WMO Global and regional ABO Lead Centres (LCs) are responsible for the monitoring and management of ABO and associated data quality issues. ABO LCs will be designated by CBS. The requirements of ABO LCs are specified in Annex II.

ABO Data Centre

WMO ABO Data Centres will be responsible for the reception, management and maintenance of all ABO data which is expected to include the following functions:

- Reception and database storage of all ABO transmitted on the GTS;
- Maintenance of quality monitoring data and information on ABO data quality issues; and
- Provision of interface to the ABO database and secured provision to WMO Members.

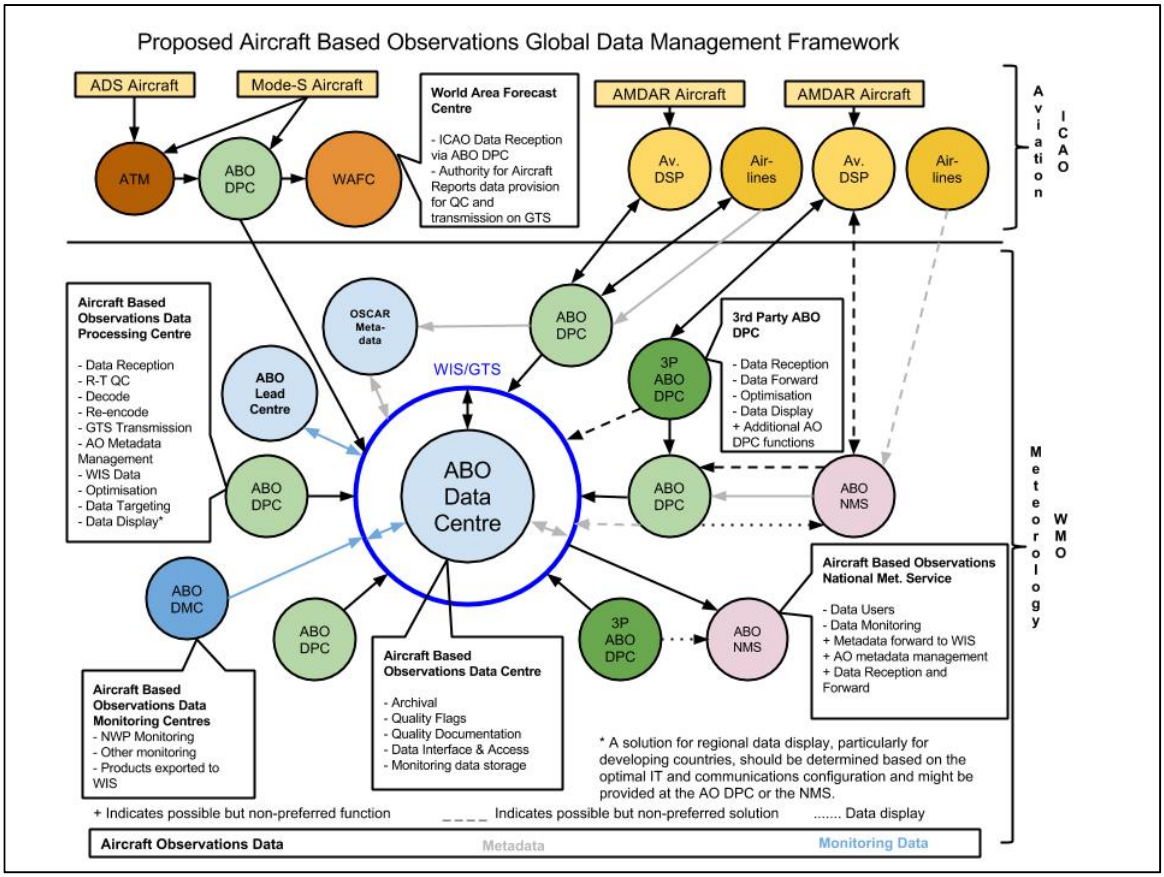


Figure 2: Proposed Aircraft Observations Data Management Framework

1.8 Quality Management

The Manual on WIGOS provides the over-arching framework for quality management for all WIGOS component observing systems and sub-systems. Members that receive, process and provide aircraft-based observations to the WIS must comply with all the relevant general provisions in the Manual on WIGOS for quality control of their aircraft-based observing systems and quality management of their observational data.

In particular, Members should ensure that they are compliant with the provisions for quality management within [REF Manual on WIGOS, Sections 2.6 and 3.6, Manual on GDPFS, Part II, Annex II.1 and the Manual on the GOS, Part V Quality Control].

Members must adhere to the provisions made in relation to quality management of aircraft-based observations and systems as made within the [REF Manual on the GOS, Part III, Chapter 2.5, Aircraft Meteorological Stations].

1.8.1 Member Quality Management System

Members who make available aircraft-based observations to the WIS should ensure that their Quality Management System (QMS) incorporates the required procedures, practices and documentation necessary to maintain their aircraft-based observational data at prescribed quality standards. This should include the recommended quality management practices described in this guide.

1.8.2 Aircraft-Based Observations Quality Management

1.8.2.1 Aircraft Based Observing System Quality Control

Members that operate AMDAR and other aircraft-based observing systems in collaboration with partner airlines and aircraft operators should ensure compliance with all practices and guidance that impact on observational data quality provided in [REF Section 2].

1.8.2.2 Aircraft-Based Observations Data Quality Management

A broad and basic depiction of the data flows and quality management processes in place at the national and international level that impact significantly on the quality of aircraft-based observations is provided below in [REF Figure 3].

Members should ensure that each of the following elements and functions are addressed in establishing a national or regional framework for the management of aircraft-based observational data quality:

1. A person (or persons) should be appointed to the role of aircraft-based observations Programme Manager (PM) – in most cases, this person will also serve as the WMO/CBS Focal Point on Aircraft-Based Observations. See [REF Section 1.12]. The ABO PM should be responsible for:
    a. Establishing that airline partners meet national and international requirements and standards for ABO provision as outlined within this guide.
    b. Obtaining and acting upon feedback on data quality issues including those provided by the Quality Evaluation Centre.
    c. Obtaining and acting upon changing or new requirements that impact upon the programme.
    d. Establishing and maintaining a feedback mechanism with ABO data providers on ABO data quality.
2. A facility should be established for the reception and quality control of aircraft-based observations. See [REF Section 1.8.2.2.1].
3. A Quality Evaluation Center (QEC) should be made responsible for continuously monitoring and analysing the quality of the aircraft-based observations. The QEC should receive and utilize feedback on ABO data quality from various sources including national, regional and global data users and the WMO/CBS Lead Center on Quality Monitoring of Aircraft Observations. See [REF Section 1.8.2.2.2].
4. A mechanism should be established to ensure that the national ABO programme accommodates the on-going and changing requirements of national and international data users.

1.8.2.2.1 Data Quality Control Practices

Members that receive process and provide aircraft-based observations to the WIS must as a minimum comply with the requirements for quality control of these data as defined within the following manuals:

- [REF Manual on GDPFS, Part II, Annex II.1, Minimum Standards for Quality Control of Data for Use in the GDPFS]
- [REF Manual on the GOS, Part V, Quality Control]

Members that receive, process and provide aircraft-based observations to the WIS should comply with the observational data quality control recommended practices within [Annex I, Guidance on Quality Control of Aircraft-based Observational Data].

1.8.2.2.2 Quality Monitoring and Improvement

WMO Members that receive, process and provide aircraft based observations to the WIS should develop and implement policy and procedures for quality monitoring and quality assessment of aircraft-based observations so as to continuously assure the quality of such observations provided to the WIS.

Members that receive process and provide aircraft-based observations to the WIS should comply with the observational data quality control practices within [REF Annex II, Guidance on Quality Monitoring of Aircraft-Based Observations].

The WMO Lead Centre on Aircraft Data is responsible for quality monitoring of aircraft-based observations and the dissemination of monitoring information to WMO Members.

The World Meteorological Centre, Washington, has the role as Lead Centre for Aircraft Data with the data monitoring processes carried out by the US National Weather Service, National Centres for Environmental Prediction, Central Operations.

Current requirements for the monitoring of aircraft data by monitoring centres (Regional Specialised Meteorological Centres - RSMCs) are defined in [REF the Manual on the Global Data-Processing and Forecasting System, GDPFS Part II, Attachment 9, Section 5 on Aircraft Data].

Members that receive, process and provide aircraft-based observations to the WIS should utilize the quality monitoring information available from the WMO/CBS Lead Center for Quality Monitoring of Aircraft Observations as described in [Annex II, Guidance on Quality Monitoring of Aircraft-based Observational Data] as an integrated component of their quality monitoring practices.

Members that receive, process and provide aircraft-based observations to the WIS should appoint a representative from their organization to take on the role of the national WMO Focal Point on Aircraft-based Observations. The focal point is responsible for receiving, utilizing and acting upon information from WMO or other Members relating to the quality of their aircraft-based observations. This will include the timely rectification of related faults and errors and, when required, the removal of such data from provision on the GTS until such time as faults are rectified.

1.9 Provision of Aircraft-Based Observations to the WIS

Members must adhere to the provisions made in relation to provision of aircraft-based observations as made within the [REF Manual on the GOS, Part III, Chapter 2.5, Aircraft Meteorological Stations].

Members that receive, process and provide to the WIS aircraft-based observations from any source, including AMDAR, ICAO aircraft observations and other aircraft-based observing systems should do so in accordance with [REF WMO Resolution 40] and in accordance with the guidance provided in [REF Annex III, Guidance on Encoding of Aircraft-based Observational Data for Transmission on the WIS].

Members must ensure that each aircraft reporting aircraft-based observations to the WIS is designated with a unique national aircraft identity in accordance with the requirements established in [Annexes III and IV].

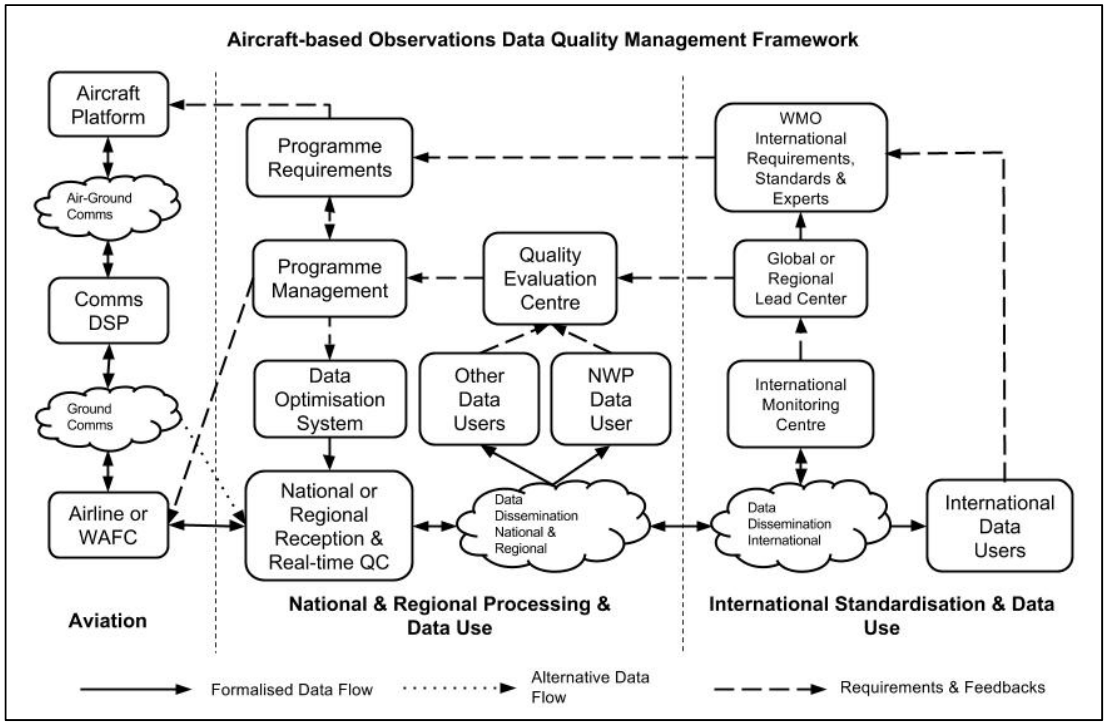


Figure 3: Aircraft-Based Observations Data Quality Management Framework.

Members should ensure that, on receipt of advice from the relevant WMO Lead Center on aircraft observations or from other WMO Members, that particular aircraft-based observations are errant or of poor quality, they have the capacity to remove or “blacklist” such data from further providing to the WIS until such time as the data quality is restored.

1.10 Observational Metadata Requirements and Management

Observational metadata refers to all types of metadata necessary to interpret the (sets of) observational data.

Members that receive and process aircraft-based observational data from any source should ensure that they maintain a database of metadata related to the following observational aspects and elements of their observational data:

- Models and types of aircraft;
- On-board sensors and their siting and calibration, maintenance issues and calibration (where available and when able to be provided);
- Specific software and algorithms used to process data to generate the reported variables; and
- Metadata related to quality control processes, data communication practices, data processing and delivering centres.

Members should maintain and provide internationally required metadata relating to their aircraft-based observational data in accordance with both the provisions and recommended practices within:

- [REF WMO-No. 1160, Manual on WIGOS, Section 2.5 and Appendix 2.4].
- [REF Manual on the GOS, Section Part III, Chapter 2.5, Aircraft Meteorological Stations].
- [REF Annex IV Guidance on Aircraft-Based Observations Metadata Maintenance and Provision].

1.11 Operations, Maintenance, Incident Management and Change Management

Maintenance consists of the routine processes and procedures that ensure that infrastructure and equipment, upon which the quality and reliability of observing system outputs depend, are planned and implemented.

Members must ensure that they operate and manage incidents and changes related to their aircraft-based observing systems in accordance with the general provisions within:

- [REF Manual on the WIGOS, Sections 2.4 and 3.4].
- [REF Manual on the GOS, Part III, Chapter 2.5, Aircraft Meteorological Stations].
- [Manual on the GTS, Part II, Chapter 5].

Members who make available aircraft-based observations to the WIS must in collaboration with their partner airlines, develop and agree on policy and procedures for the detection, advisement and rectification of issues and errors associated with the quality and operational performance of airline sensors, systems and infrastructure upon which their aircraft-based observing systems depend.

Members should ensure that changes to the programme or schedule of reporting of aircraft-based observations on the WIS are planned and notified in advance.

The [REF Manual on the GTS, Part II], states that:

> **5.1 Responsibility for notification of amendments**
>
> Information for WMO publications shall be kept current. Notification of amendments shall be sent to the Secretariat at least two months in advance of the effective date of the change.

In practice and for the purpose of fulfilling the above requirement in relation to the operation of their aircraft-based observing systems, Members should do the following to report changes to aircraft-based observations programmes:

1. Provide a written description of the change to be made within a METNO as described in the Manual on the GTS.
2. Provide a written description of the change to be made by e-mail to: gos@wmo.int or via the Contact Form at: http://www.wmo.int/pages/prog/www/OSY/form_enOBS.php.
3. Update national and internationally required metadata as described in [section 1.10 and Annex IV].

1.12 International and Regional Planning and Capacity Development

1.12.1 WMO Aircraft-Based Observations programme

In order to coordinate and promote the development of aircraft-based observations and national (and regional) AMDAR programmes, the WMO Executive Council decided at its forty-ninth session in 1997 to establish a WMO Panel on AMDAR, composed of WMO Members that operated, or intended to operate, national AMDAR programmes. In 1998 the AMDAR Panel took over the responsibilities for the operation of AMDAR, the remaining ASDAR units and the AMDAR Trust Fund.

At its sixteenth session (2003), the World Meteorological Congress agreed with a recommendation made by the WMO Commission for Basic Systems (CBS) that AMDAR should become fully integrated into the WMO World Weather Watch (WWW) Programme. In 2007, at its seventeenth session, Congress paved the way for the AMDAR observing system to become a recognized, operational component of the WWW Global Observing System.

At its 15th annual session (2012) the WMO AMDAR Panel agreed that all was in place within WMO and its Technical Commissions to formally hand over full responsibility for the AMDAR observing system and the AMDAR Trust Fund, and for the Panel to cease its activities.

The international Aircraft-Based Observations Programme (ABOP – not an officially designated WMO Programme), which includes AMDAR, is now supported by an Expert Team on Aircraft Based Observing Systems (ET-ABO) within CBS and also an Expert Team on Aircraft-Based Observations (ET-AO) within the Commission for Instruments and Methods of Observation (CIMO).

The tasks and activities of the two Expert Teams include the provision of programmatic and technical support for development, enhancement and maintenance of all aircraft-based observing systems and for management of international standards and practices associated with aircraft-based observations.

Figure 4 below represents the current governance and programmatic management of aircraft-based observations within WMO.

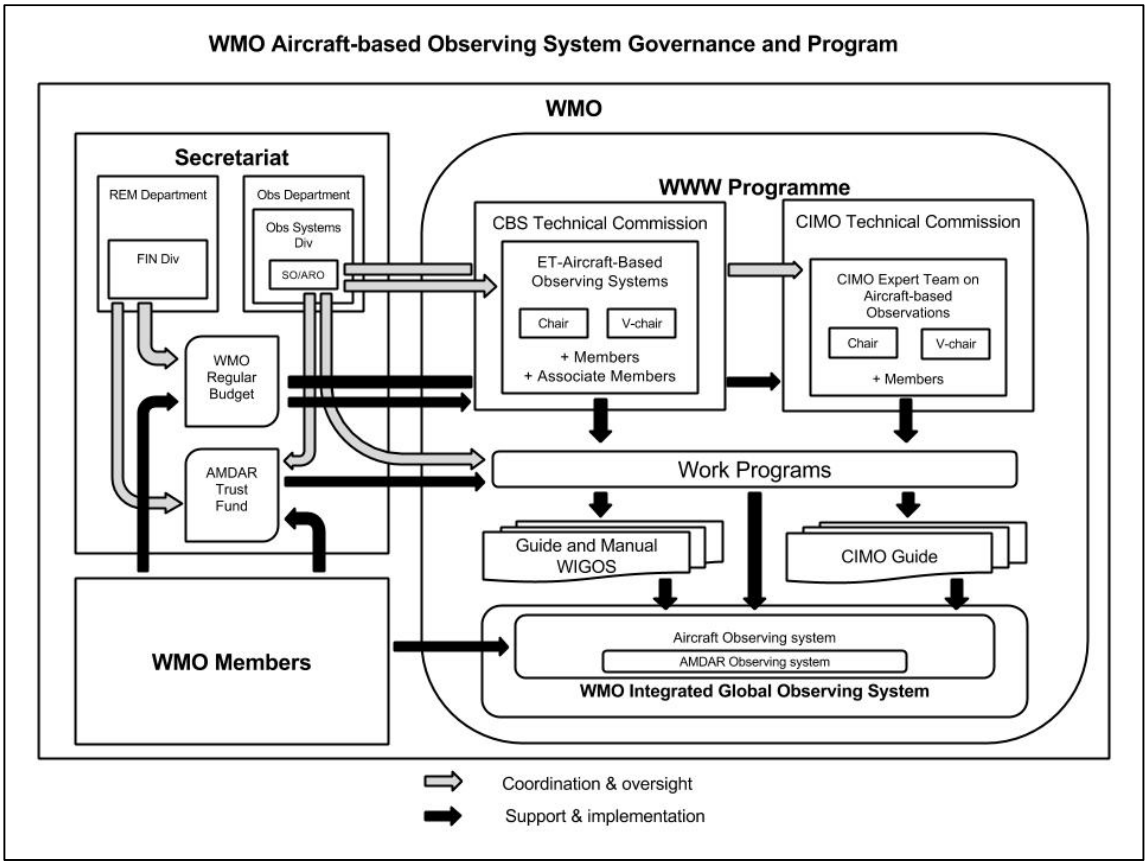


Figure 4: Aircraft-based Observing System Governance and Programmatic Structure.

1.12.2 Projects and Development

Under the ABOP, WMO Technical Commissions have instigated a regional approach to aircraft-based observations development in collaboration with WMO Regional Associations (RAs) and its Members. The ABOP intends to assist RAs in developing and maintaining ABOP Regional Implementation Plans (A-RIPs) in each of the six WMO Regions. These A-RIPs are based on and in line with the relevant actions of the [REF CBS Implementation Plan for Evolution of Global Observing Systems (EGOS-IP), WMO Technical Report No. 2013-4]. An important role in this process is assigned to the WMO National Focal Points for Aircraft-Based Observations nominated by the Members. The Focal Points are listed in the WMO Country Profile Data Base[17].

[17] https://www.wmo.int/cpdb/

While AMDAR is now a mature and stable operational observing system, there are many developments and enhancements underway or planned that are expected to improve the benefits of the system, the use of its observational data products and its operational coverage:

1. Development of new programmes that will improve global upper-air data coverage over currently data-sparse areas including:

- Regions I and III
- Eastern Europe
- Western Asia
- The Southwest Pacific
- Central and South America
- The Middle East

2. Implementation of water vapour measurement as a component of the AMDAR Observing System.

3. Implementation of turbulence monitoring and reporting.

4. Implementation of icing monitoring and reporting.

5. Wider implementation of ground-based AMDAR Data Optimization.

6. Wider integration of AMDAR standards and protocols into the avionics and aircraft manufacturing process.

7. Implementation of routine data targeting in support of weather systems monitoring and prediction.

WMO Members should provide support for the continued development and enhancement of the ABOP through the following actions:

- Continue financial support to the AMDAR Trust Fund in line with the relevant World Meteorological Congress resolutions.
- Contribute staff resources to the membership of relevant WMO Technical Commission and Regional Association work teams and groups.
- Endeavour to obtain and provide aircraft-based observations on the WIS.
- Endeavour to develop and maintain operational AMDAR observing systems in line with national, regional and global requirements.

1.12.3 Training and Outreach

1.12.3.1 Training Requirements

Members should ensure that staff members are adequately trained for competency in the following areas of operational practices relating to aircraft-based observations and the operation of AMDAR programmes:

- Interaction and negotiation with aviation representatives and contact persons for collaboration on aircraft-based observations and AMDAR programme participation.
- Specification of technical and functional requirements for AMDAR observing system planning and design.
- Information Technology (IT) skills supporting data communications and data processing systems infrastructure development and maintenance.
- Data monitoring and scientific and meteorological data analysis.
- Systems and data quality management.

For further information in relation to capacity development of AMDAR, refer to [REF section 2.1.4, Capacity Development].

1.12.3.2 Outreach

It is critical to the maintenance and continued development of the AMDAR observing system that the interests of Members are represented and promoted to the important stakeholders, e.g. relevant sections within the NMHS concerned, ATI organizations, aeronautical associations and associated forums.

WMO and the Aircraft-Based Observations programme (ABOP) promote aircraft-based observations and the AMDAR observing system through a range of activities:

- Maintaining the ABO and AMDAR areas of the WMO website [REF see: http://www.wmo.int/pages/prog/www/GOS/ABO/index_en.html];
- Publishing the WMO AMDAR Newsletter and maintaining the News and Events website [REF see: http://www.wmo.int/amdar-news-and-events/];
- Maintaining statistical reports and quality monitoring information on the WMO website [REF see: http://www.wmo.int/pages/prog/www/GOS/ABO/ABO_Data.html]
- Developing and maintaining guidance on the benefits and business case for aviation and airline collaboration on aircraft-based observations [REF see: http://www.wmo.int/pages/prog/www/GOS/ABO/AMDAR/resources/index_en.html]
- Cooperating actively with airlines and other relevant organizations and participating in aviation-related bodies, e.g. Airlines Electronic Engineering Committee (AEEC).

1.12.3.3 Publications

The WMO Technical Commission expert teams on aircraft-based observations support the revision and production of technical and scientific studies relevant to aircraft-based observations, observing systems and their related technologies. See [REF Annex VIII] for a list of important references.

1.12.3.4 Focal Points

Members should nominate WMO Focal Points on Aircraft-Based Observations who can liaise with WMO Technical Commissions, WMO Lead Centres and fellow focal points on matters related to aircraft-based observations and AMDAR. WMO Focal Points on Aircraft-Based Observations are listed in the WMO Country Profile Data Base.

2. Aircraft-based Observing Systems

2.1. AMDAR Observing System Development and Operation

Aircraft Meteorological DAta Relay (AMDAR) is the World Meteorological Organization (WMO) meteorological observing system that facilitates the fully automated collection and transmission of weather observations from commercial aircraft. The AMDAR programme is an integrated component of the WMO Global Observing System (GOS) of the World Weather Watch (WWW) Programme [REF http://www.wmo.int/pages/prog/www/index_en.html]. The system is operated by WMO Member NMHs in collaboration and cooperation with partner airlines and has grown rapidly and continuously since the early 1990s.

While the AMDAR programme is currently (early 2016) served by a worldwide fleet of over 4000 aircraft contributing around 700,000 high quality upper-air observations per day, there are still many areas of the world with little or no AMDAR coverage. WMO and CBS urge Members to work towards improving upper-air coverage of the GOS by developing new, and expanding existing national and regional AMDAR programmes.

[REF Figure 1, section 1.6.1.1] provides a general overview of the AMDAR system in which on-board sensors, computers and communications systems collect, process, format and transmit the data to ground stations via satellite and VHF links. The transmission of this data to the ground is

accomplished through use of the aircraft's ACARS (Aircraft Communications Addressing and Reporting System) system. Once on the ground, the data is processed and provide to the WIS for global use by NMHS and other authorized users.

The primary dataset of AMDAR data includes: the time of observation and the aircraft position in three dimensional space, wind speed and direction, ambient temperature and, where available occasionally turbulence information. Additional parameters include humidity measurement, requiring the deployment of a water vapour measurement (WVM) sensor and turbulence requiring the implementation of the calculation and reporting a supplementary metric, the Eddy Dissipation Rate (EDR).

See [REF section 1.9] for details on reporting AMDAR data on the WIS.

2.1.1 Requirements and Planning

When considering developing or participation in an AMDAR programme the NMHS should ensure planning and availability of resources to fulfil the following requirements:

- Members must comply with the provisions within the [REF, Manual on the GOS, Section Part III, Chapter 2.5, Aircraft Meteorological Stations].
- Members should ensure that WMO requirements for upper-air data will be met (see [REF Section 1.5.1]).
- Member should ensure compliance with relevant standards:
    - The AMDAR On-board Software Functional Requirements Specifications [REF AOSFRS] provides a standard for the meteorological functionality of AMDAR software applications and air-ground data formats.
    - The AEEC Data Link Ground System Standard and Interface Specification (ARINC 620, Supplement 8) [REF ARINC 620], providing a specification of the Meteorological Report versions 1 to 6 uplink and downlink messages supporting AMDAR data delivery under the ACARS protocols.
    - WMO-No. 8, [REF CIMO Guide, Part II, Chapter 3].
- Members should comply with [REF WMO Resolution 40].
- Members should comply with the requirements for the operation of an AMDAR programme as provided below in [REF section 2.1.3].
- Members should comply with requirements for quality management of AMDAR data as provided in [REF Section 1.8].
- Members should comply with requirements for data quality control of AMDAR observations as provided in [REF Annex I].
- Members should comply with requirements for the provision of AMDAR data to the WIS as provided in [REF Section 1.9].
- Members should comply with requirement for the management and provision of AMDAR metadata as provided in [REF Section 1.10].

When considering and planning for the development and implementation of a national AMDAR programme with one or more partner airlines, it is necessary for NMHSs to address each of the following basic topics and requirements:

- Assessment of national, regional and global requirements for upper-air data including requirements for measurement of humidity;
- Assessment of the capabilities and potential coverage of national airlines;
- Obtaining airline contacts and commencing negotiations with the airline(s);
- Building a business case for airline participation;
- AMDAR programme cost considerations;
- Contracts and agreements between NMHSs and airline(s);
- Design and implementation of the AMDAR system; and
- Data display and use.

2.1.1.1 Assessment of requirements for upper-air observations

Before commencing the development of an AMDAR programme the requirements of upper-air data users and applications areas, including national, regional and global, should be gathered and consolidated. These requirements should be assessed against the capabilities of the current national composite upper-air observing system and the ability of an AMDAR programme to fill gaps and/or to provide an efficiency dividend. Upper-air observing systems that might be considered in such an analysis are radiosondes, radar wind profilers, polar orbiting and geostationary satellites and other ground-based remote-sensing systems.

The national aspects of such an analysis can be undertaken only by each NMHS individually in consideration of both the current configuration of the composite upper-air observing system and its likely future evolution.

An obvious consideration is that the AMDAR programme coverage is fully dependent on the flight schedule and coverage of the potential participating airlines. Flight schedules can vary from day to day, week to week, month to month and seasonally depending on customer demand and other airline-dependent factors.

Given the international operations (i.e. regional and long-haul international flights) of many airline operators, it is also important to take into consideration that the AMDAR programme, by its nature, offers the opportunity to collaborate with regional and international NMHS partners to share and optimize the efficiency and coverage that can be provided. It is highly recommended that Members consider the various WIGOS and aircraft-based observations regional implementation plans for their respective Regional Association. This may provide the opportunity to collaborate on a regional basis, including the possibility to share costs associated with establishment and operation of the necessary infrastructure (e.g. ground-based data processing systems), resources and data processing.

2.1.1.2 Requirements for Humidity Measurement

It is possible to equip aircraft with instrumentation for high quality observations of atmospheric humidity during all phases of flight. This greatly increases the value of the meteorological information collected by an AMDAR programme. The benefits and cost considerations of this equipment are described in detail in the WIGOS Technical Report 2014-1, *The Benefits of AMDAR to Meteorology and Aviation* mentioned above.

The WIGOS Technical Report 2015-1, August 2015, *Impact and Benefits of AMDAR Temperature, Wind and Moisture Observations in Operational Weather Forecasting*, was commissioned by the WMO Aircraft Based Observations Programme (ABOP) and is an amalgamation and extension of two papers that were to be published in the Bulletin of the American Meteorological Society (BAMS). The report provides a comprehensive revision and summary of the impacts of AMDAR aircraft-based observations of air temperature and wind over the past decade and a comprehensive analysis and assessment of data quality of water vapour observations derived from the United States MDCRS/AMDAR/WVSS-II program.

Members should consider requirements for humidity measurement as a component of their AMDAR programme and endeavour to include this observation capability in new and existing AMDAR programmes. While this does require the addition of equipment to the designated aircraft, that process is well defined and leads to a significantly greater benefit to a national or regional AMDAR programme.

2.1.1.3 Assessment of national airlines capabilities and coverage

Potential operators of a national or regional AMDAR programme should start with a preliminary assessment of the national airlines' aircraft fleets and analysis of the operational routes serviced by

the airlines. In the case where a national airline does not exist, other commercial airlines operating within the nation or region may be considered.

The overall aim of the survey and analysis of the national airlines should be to determine what coverage might be obtained by equipping one or more fleets of aircraft types and which combination of airlines and aircraft fleets most efficiently provides the optimal coverage that best meets established requirements for upper-air data.

Generally detailed information on the airline's fleets and the flight routes that they operate can be found on the airline's website. If not, then it will be necessary to establish direct contacts within the airline (see section below) to obtain this information.

The following aspects and questions regarding the airline especially require consideration:

- Of prime importance is whether the airline and aircraft have ACARS (communications) capability, which enables the near-real-time automated reporting functionality required for AMDAR.
- Which types of aircraft does the airline operate and which routes does each aircraft type tend to fly?
- Of these types, which fly domestic routes and which fly internationally?
- What is the age of the aircraft? The more modern the aircraft, the more likely they will be able to accommodate an AMDAR software application. Note that it will be necessary to determine exactly which avionics the aircraft have and whether or not they will support an AMDAR software application.
- Which airports does each airline and aircraft fleet service routinely?
- Based on the airline flight schedules, how many vertical profiles per day at each airport are likely to be obtained through equipping the different aircraft types?
- Is the airline well established, stable and likely to continue operation well into the future?
- Does the airline have a strong maintenance division? While this is not crucial and, in fact, there are many airlines outsourcing their maintenance operations, it is certainly beneficial to be able to liaise directly with technical staff and engineers within the airline who will understand the engineering aspects of aircraft maintenance and monitoring via avionics systems.

Once the initial analysis of national airlines has been undertaken, it is then necessary to make a more firm determination on whether or not the airlines and aircraft have the required technical capabilities. This can be done by asking the airline to complete a questionnaire, the Airlines AMDAR Compatible Systems Survey that is available from the WMO AMDAR Resources website[18]. Once the survey has been completed it should be returned to the WMO Secretariat, for analysis and for providing further advice regarding AMDAR software.

The survey should be completed before the airline has agreed to participate in the AMDAR programme and will be necessary to identify the on-board avionics type and capabilities, which will determine the suitability and requirements for AMDAR on-board software, see [REF Section 2.1.2.3 and Annex VI] below.

For a global summary of airlines operating AMDAR suitable aircraft, highlighting those that have been targeted by WMO to contribute to extending global AMDAR coverage, it is also recommended to consult the WMO report, *AMDAR Coverage & Targeting for Future Airline Recruitment, February 2013*[19]

[18] http://www.wmo.int/pages/prog/www/GOS/ABO/AMDAR/resources/index_en.html
[19] Available from: http://www.wmo.int/pages/prog/www/GOS/ABO/AMDAR/resources/AMDAR_Coverage_Recruitment_Study.html

2.1.1.4 Obtaining airline contacts and commencing negotiations

Once it has been confirmed that one or more national airlines operate aircraft that might be suitable for contributing to the WMO AMDAR programme and the upper-air data requirements, the NMHS should seek to establish some key contacts within the airline so as to be able to begin negotiations and present a business case to the airline for participation in the programme. [REF Table 1] below provides the various recommended airline personnel that might be strategic contacts to make and maintain so as to assist, provide information and/or negotiate with in relation to the establishment of an AMDAR programme.

Airline Contact	Role in the Airline	Role in AMDAR Programme Development and or Operation	Comment
Airline CEO or other senior executive officer	Executive manager and high level decision-maker	• May understand the impact of weather on airline operations. • May be a recipient of the business case for programme participation. • May provide initial, high-level decision on airline involvement in the programme.	• Unlikely to be involved in detailed negotiations. • Unlikely to be involved in ongoing aspects of the programme.
Chief Pilot	Senior representative of pilots to airline executive and is influential in airline decision-making, particularly in relation to those aspects of flight operations and safety	• Will understand the impact of weather on airline operations and efficiency, including fuel usage. • May provide influence on high-level decision on airline involvement in the programme. • May be a recipient of the business case for programme participation. • May provide a link to flight operations aspects of the programme.	• May be involved in the initial negotiations. • Unlikely to be involved in ongoing aspects of the programme.
Flight Operations Manager	Manager of all aspects of aircraft flight operations and is often the contact that liaises with NMHSs for weather services.	• Will understand the impact of weather on airline operations and efficiency, including fuel usage. • May provide a link to aircraft maintenance and engineering areas of the airline.	• May be involved in the initial negotiations and also the ongoing aspects of the programme. • Often is the first airline contact made by the AMDAR programme manager due to the weather services link.
Avionics and Maintenance Engineering	Responsible for airline aircraft and avionics maintenance.	• Will be involved in determining avionics capabilities. • Will be responsible for AMDAR software integration.	• Can be a useful first-up contact but usually defers to other airline managers regarding participation in the programme and its benefit to the airline.

Table 1: Airline contacts and their roles and associations with the AMDAR programme.

Once a suitable group of airline contacts has been established, the NMHS should start negotiations with the airline management in order to convince them of the benefits of participation in the programme and assist in the development of a business case for airline participation. The ultimate goal is to reach agreement on the various programme parameters, including AMDAR fleet size and configuration, AMDAR software development and integration, implementation and ongoing costs and other factors associated with the design of the AMDAR system as describe in detail in [REF Section 2.1.2].

2.1.1.5 Building a business case for airline participation

Of critical importance in the process of convincing the airline to participate in the AMDAR programme is the development of a business case. The NMHS should clearly establish the business relationship between the provision of the AMDAR data, the expected improvement in weather forecasting skill and the resulting positive impact on the services to aviation able to be made by the NMHS. It should be made clear that this will lead to improved, more efficient and safer flight operations, reduction in airline costs (e.g. reduced fuel consumption) and increased airline customer satisfaction based on the airline demonstrating concern and being willing to assist in mitigation of environmental issues related to activities in the aviation industry.

For more detailed information on the benefits and impact of AMDAR observation that can be used in developing a business case, see WMO WIGOS Technical Report 2014-1, *The Benefits of AMDAR to Meteorology and Aviation*[20].

Other important considerations for inclusion and explanation in the airline business case are the following:

- It should be emphasized that the AMDAR software module, once installed and operational, will have no impact on the aircraft operations. The AMDAR software is tested and certified to ensure seamless and safe integration into the avionics, such as ACMS or its equivalent.
- The AMDAR observations, collected and pre-processed by the AMDAR software, are interleaved with the routine aircraft-to-ground data flow and communications over the ACARS system.
- The airline may argue that the AMDAR data provided to the NMHS improves weather services generally, which benefits all airlines. While this is true, it should be emphasized that there are at least two benefits participating airlines have over non-participating airlines:
    - The performance of on-board sensor(s) providing data to the AMDAR software, which are integral to the operation and performance of the aircraft, are monitored for quality control reasons as a result of the provision of AMDAR data to the NMHS. The NMHS can therefore provide a complimentary service to the airline to inform them if and when a sensor is errant or out of calibration;
    - The impact of AMDAR is generally greatest where and near to where the AMDAR observations are made and reported and so, the improvement to weather forecasting skill would be expected to be most pronounced for those routes the participating airline operates and provides data for;
    - In the near future, the ABOP expects to establish a Global Data Centre for Aircraft-Based Observations, for which participating airlines would have access to, and be able to utilize for fight operations and other applications that might enhance their business; and
    - The airline can promote its participation in the programme, demonstrating its commitment to improved airline operational performance and service to the nation through a partnership with the NMHS. As a result, it will likely generate greater satisfaction and loyalty from those customers that appreciate the airline's endeavours to

[20] Available at: http://www.wmo.int/pages/prog/www/GOS/ABO/AMDAR/publications/Benefit_of_AMDAR_Data_to_Meteorology_and_Aviation.pdf

reduce its impact on the environment and support the NMHS in improving forecasting services for the nation.

2.1.1.6 AMDAR programme cost considerations

The costs for the development and operation of an AMDAR programme are highly dependent on the size and complexity of the programme. They also depend on the relationship established between the NMHS and the airline and the extent to which the airline perceives or quantifies the benefits based on the business case for AMDAR programme participation.

Generally, AMDAR programmes have been and should be established between NMHSs and their partner airlines under the understanding and agreement that the mutual benefits dictate that the NMHS should pay no more than the incremental costs of establishing and operating the programme.

A costing model for comparing the estimated costs associated with operating an AMDAR programme with those of a radiosonde programme was developed and the results are available in Annex 5 of WIGOS Technical Report 2014-1, *The Benefits of AMDAR Data to Meteorology and Aviation.*

In summary, the programme costs are largely dependent on the following factors:

- The communications solutions adopted in cooperation with the airline;
- The contractual arrangements between the particular airline and its data service provider (DSP);
- The size of the AMDAR fleet and the volume of AMDAR data generated by the fleet;
- The extent to which data optimization methods are deployed and utilized;
- The extent to which the airline perceives and quantifies the benefits of participating in the programme; and,
- The extent to which the airline itself is willing to contribute (financially) to the programme.

The following costs have to be considered:

- Development and infrastructure costs:
  - AMDAR on-board software.
  - Software integration and rollout.
  - Communications infrastructure.
  - Data processing and quality management development.
  - Data optimization system.
- On-going operational costs:
  - Data communications costs.
  - Aircraft system utilization costs.
  - Maintenance cost for the AMDAR on-board software and the required ground-based infrastructure and software.

2.1.1.7 Contracts and agreements between NMHS and airlines

It is very important that an agreement, contract or Memorandum of Understanding (MoU) is established between the NMHS and each participating airline for the operation of the national or regional AMDAR programme. Such a document should outline the terms and conditions agreed upon to cover at least the following aspects of the programme operation:

- The time period for operation of the agreement and the programme, including an arrangement for contract or agreement termination.
- The number of aircraft to be equipped with AMDAR software for reporting AMDAR data at an agreed frequency of reporting.
- Costs payable to the airline by the NMHS.
- Requirements for the airline to ensure data supply and quality.

- Requirements for the NMHS to report to the airline any issues or faults associated with AMDAR software performance and data quality.
- The terms and conditions, including liabilities and the rights of the NMHS and 3rd parties (e.g. NMHS clients) covering use of the AMDAR data, which may desirably include ownership (i.e. jointly with the airline) of the associated meteorological data upon reception. It is critical that this aspect of the agreement at least allows AMDAR data to be distributed to the WIS and used by WMO Members according to [REF WMO Resolution 40].
- Third Party liabilities associated with operation of the programme and AMDAR data use:
  - The NMHS should seek to ensure that the agreement precludes the NMHS from being liable for any damages (including Third Party claims) associated with any aspect of the aircraft operation (this must be the airline's responsibility); and,
  - The agreement should preclude the airline being liable for damages (including Third Party claims) associated with any aspect of data use by the NMHS and its data users and clients (this should be the NMHS's responsibility).

- Ownership and Intellectual Property (IP) rights. The agreement might stipulate that:
  - If appropriate and, depending on which party contributed resources to its development, the NMHS has ownership of the AMDAR on-board software.
  - If the airline claims ownership of the AMDAR on-board software, it should be agreed that this software would be made available for implementation in aircraft of other airlines under a non-exclusive and free licence for use.
  - WMO and/or the NMHS have rights over the IP associated with the specification of the AMDAR on-board software.

Important Notes:

The arrangement of contracts and agreements can be a complex process and such documents must be consistent and in keeping with both national and international laws and legislation. For this reason, it is highly recommended that Members consult with either their own or hired legal staff to assist in this process and ensure that any agreement or contract developed is compliant with the law and does not unknowingly or otherwise disadvantage any parties to the agreement.

In many cases, national laws prevent contracts from the waiving of Third Party liabilities. In such cases, it is critical to undertake a risk assessment and ensure that each party has developed and implemented appropriate mitigation strategies for any risks associated with the operation of the programme.

If requested, WMO may be able to assist in the process of developing an agreement or contract between a NMHS and an airline for operation of an AMDAR programme.

2.1.2 Design and Implementation of the AMDAR system

When commencing a new AMDAR programme, many requirements must be taken into consideration regarding the design, development and the implementation of the system.

In designing and implementing the AMDAR system, the NMHS must consider all components of the AMDAR system shown in [REF Figure 1] above.

The following are the major system elements to be addressed for design, development and implementation:

1. Regional and international design considerations;
2. Requirements for measurement of humidity, including sensor installation and maintenance;
3. Configuration and optimization;
4. AMDAR on-board software development and implementation;
5. Air-to-ground communications;
6. Ground-based communications and data processing infrastructure;

7. Delivery to data users; and
8. Data quality management and monitoring.

2.1.2.1 Regional and international design considerations

There are two international aspects of an AMDAR programme design that might be taken into consideration before designing and implementing an AMDAR programme and system. These are:

1. International AMDAR data sharing and optimization opportunities; and
2. International cooperation on AMDAR system infrastructure.

Many national airlines operate internationally and, therefore, may be capable of producing valuable AMDAR data both within and outside national boundaries. This has implications for two aspects of the AMDAR programme. Firstly, if a national airline is not yet ready to participate in the AMDAR programme, it might be possible to provide AMDAR data over or within that country generated by another operational national AMDAR programme. Through a bilateral arrangement, the recipient NMHS would cover the incremental costs to the operational AMDAR programme for providing that data. Secondly, when it comes to the roll-out of the AMDAR fleet to be made operational, it is worth considering equipping a combination of domestic, regional and international aircraft fleets, which, when combined with suitable configuration or optimization (see below) would allow a more comprehensive national and regional coverage. This would have several advantages including an even greater impact on national, regional and global NWP and the opportunity for collaboration and data cost sharing with other NMHSs.

The second above consideration may lead to significant opportunities for reducing the costs associated with AMDAR system infrastructure. The international aspect of airline operations and communications and the fact that the AMDAR programme relies on using standardized aviation and meteorological communications protocols (i.e. AEEC ACARS and WMO BUFR), makes it possible that AMDAR data can be received and processed by dedicated regional data processing hubs. This offers the opportunity for international and regional collaboration and efficiency dividends in relation to the development of AMDAR programme infrastructure.

Examples of regional cooperation in AMDAR are:

- The E-AMDAR programme (14 airlines, supported by 31 member states) providing supplementary global data outside the EUMETNET[21] domain through bilateral agreements and as a contribution to the WMO World Weather Watch Programme;
- The US MDCRS programme (7 airlines), providing data outside the United States domestic airspace over central and South America; and,
- AMDAR data cost-sharing between Australia and New Zealand.

Cooperative arrangements are strongly encouraged by WMO and can be facilitated through supportive actions within WMO Regional Associations (see: REF Section 1.10 above) and communication between the national WMO Aircraft-Based Observations Focal Points.

Under the WMO Aircraft-Based Observations Programme (ABOP), Regional Implementation Plans for AMDAR have been developed as a component of the WIGOS Regional Implementation Plans.

2.1.2.2 Network Configuration and Optimization

Before the development of the AMDAR on-board software (AOS), it is necessary to consider the likely size of the potential national AMDAR fleet and how data production will be configured and controlled. The AOS contains software configuration parameters and functions for optimizing reporting based on geographical area, airport identification or time. The default configuration of the

[21] http://www.eumetnet.eu/

software should be discussed with the software developer and specified before the software is developed and released.

When limited to the AOS configurable optimization functionality only, AMDAR systems and programmes can still have high redundant data levels (up to and more than 50% for large programmes). Given the significant communications costs associated with the AMDAR system, the AOS has been specified and developed to respond to "uplink commands", transmitted through the ACARS system. Some AMDAR Programmes have made use of this AMDAR software functionality by developing and implementing ground-based AMDAR Data Optimization Systems (ADOS). Based on flight plans between so called “airport pairs” (departure and destination locations) these systems are able to determine the potential AMDAR data that might be produced during a set period of time e.g. one hour. If data is already available or scheduled to be produced during the period by another AMDAR aircraft, the ADOS will automatically compile and send uplink commands to the aircraft in order to reconfigure the reporting configuration of the AOS and thus avoid the production of redundant data not required for meteorological service provision. Such AMDAR Data Optimization Systems have demonstrated the capability to reduce the communications costs associated with the AMDAR system by 50% or more, while not adversely impacting useful data coverage.

AMDAR Data Optimization Systems have been implemented in the E-AMDAR and Australian AMDAR Programmes. Commercial service providers (Rockwell Collins/ARINC, SITA) have started to develop optimization systems which can also be used for AMDAR data optimization.

For national AMDAR Programmes with fleet sizes of the order of 50 or more aircraft, it is recommended that AMDAR Data Optimization Systems be implemented as a component of the systems infrastructure.

In addition to reducing costs and data redundancy, AMDAR Data Optimization Systems also offers the capability of altering and adjusting data observations output based on short-term requirements. Potential applications include the targeting of additional AMDAR data for severe synoptic or other scale weather system monitoring and prediction, or mitigating coverage loss during airline strikes or system outages that impact on data output.

Further information and guidance on the requirements for development and utilization of an AMDAR Data Optimization System can be found in [REF Annex V, Guidance on AMDAR Observing System Data Optimization].

2.1.2.3 AMDAR on-board software (AOS) development and implementation

The role of the AOS is to facilitate the functions and the required system interfaces of the on-board AMDAR system. The primary functions of the AOS are:

1. Interface to a variety of innate aircraft avionics equipment;
2. Perform initial quality checks on the input data;
3. Perform calculations upon the input data to derive required meteorological variables;
4. At set intervals, process collected data into standard output messages for transmission to ground stations; and,
5. Accept and process inputs, allowing users to alter the AOS behaviour by manual or uplink command re-configuration.

Given that the full functionality of AOS is relatively computationally complex and demanding, the AMDAR system relies on and is usually best employed in modern commercial aircraft, equipped with the necessary avionics, data computers and communications systems.

The current AMDAR Observing System relies on the communications protocols defined for the Aircraft Communications Addressing and Reporting System (ACARS), which are specified within the standards of the Aeronautical Airlines Electronic Engineering Committee (AEEC).

WMO currently specifies and maintains two meteorological standards for AMDAR On-board Software:

1. The AMDAR On-board Software Functional Requirements Specification (AOSFRS), which supersedes the ACARS AMDAR ACMS (AAA) specification series (versions 1 to 3).
2. The "ARINC 620" AMDAR On-board Software versions 1 through 6 defined within the AEEC 620-8 Data Link Ground System Standard and Interface Specification (DGSS/IS), which is maintained by the AEEC Data Link Systems Sub-committee. Within the specification, AMDAR reporting formats and functionality are defined through the definition of the Meteorological Report.

The AOSFRS and the ARINC 620 specifications both rely on the basic DGSS/IS ACARS protocols. The specifications or their URL references are provided from the AMDAR Resources Area[22].

The NMHS and the Airlines will need to reach agreement on the terms and conditions for any software development that is required to be undertaken and whether there will be a requirement for the involvement of a third-party applications developer. The AOS will generally be required to undergo testing and certification with the avionics manufacturer to ensure that it complies with requirements and does not interfere with or adversely affect existing and standard applications.

Further information and guidance on the AMDAR on-board software development can be found in [REF Annex VI, Guidance on AMDAR On-board Software Development].

Flight testing

Once AOS software has been developed, it should be tested operationally to ensure its correct functionality and performance, including message format, response to uplink commands, correct software configuration and quality of the AMDAR data produced. Arrangements to conduct flight testing on one or more aircraft over a suitable period of time (e.g. 1-2 weeks) should be made with the airline and the AOS developer in advance and, if necessary, include a process to correct any software defects or bugs. Such testing can be undertaken at ground-testing facilities or from the ground during aircraft maintenance but it is recommended to also examine and analyse the AMDAR data received from a series of operational flights very carefully before the full AOS roll out occurs and before AMDAR data is provided to the WIS. The flight testing process and data analysis should involve a number of checks including (as a minimum):

- Comparing temperature, wind and other meteorological data with co-located radiosonde or NWP data.
- Validating spatial and temporal coordinates.
- Ensuring compliance with the (latest) WMO AMDAR BUFR specification FM 94.

Experts from the Aircraft-Based Observations Programme can assist and provide technical advice in relation to AOS specification, development and testing.

Software Rollout

Once the AOS and the data quality have been tested, and the AMDAR data processing system is operationally implemented, the airline can be requested to install the software across the entire

[22] http://www.wmo.int/pages/prog/www/GOS/ABO/AMDAR/resources/index_en.htm

proposed AMDAR fleet. This will usually occur during standard aircraft maintenance checks and processes so as to minimise costs and disruption to airline operations.

2.1.2.4 Air to ground communications

The primary system that supports communications for the global aviation industry is called the Aircraft Communication Addressing and Reporting System (ACARS). The aeronautical communications infrastructure that supports air-to-ground communications of ACARS is normally provided by one of the two major aviation Data Service Provider (DSP) companies, e.g. ARINC and SITA[23]. Independent communications companies are operating similar aviation services (Japan, China, Thailand and Brazil) and are linked to the ground-based component of the global services provided by ARINC and SITA. Both companies provide two-way communications based on VHF, HF and satellite systems. Airlines will usually have a contract with one or more of these companies to guarantee global communications services for their own commercial operational purposes.

On-board avionics applications require air-to-ground communications via ACARS utilizing both VHF and satellite communications systems for global coverage. AMDAR software applications are however generally configured to use only the VHF communications channel for data delivery. This can mean that en-route reports, compiled over locations where VHF coverage is not available, will be delayed by several hours on long-haul international flights.

The downlinked AMDAR data are received by the ground reception system of the DSP and routed to the airline. Data can then either be routed by the airline to the NMHS or, in some cases, in agreement with the airline, the data can be routed directly to the NMHS by the DSP in parallel. Both approaches would usually require the establishment of hardware and software systems within the NMHS to which the data is routed using an Internet transfer protocol such as, for example, TCP/IP or FTP. In the latter case the NMHS will need to negotiate a contract with the DSP for providing the service.

In both cases the data will be received in a Type-B ACARS message format. The NMHS will have to develop a ground processing system for receiving, de-coding and quality checking the data before re-formatting them into a bulletin for operational use and distribution to the WIS.

2.1.2.5 Ground-based reception and processing

It is the responsibility of the NMHS to ensure that the necessary ground-based processing system for AMDAR data is developed, implemented and made operational by the time the airline(s) commence producing data.

The data acquisition and processing system is normally located in the NMHS and is required to:

1. Receive the data (most usually delivered as a Type B ACARS message, for which the format can be obtained from the relevant software specification – [REF AOSFRS] or [REF ARINC 620]);
2. Decode the data;
3. Conduct rudimentary data quality checks (range, rates of change, observations consistency, etc. - see [REF Annex I - Guidance on Quality Control of Aircraft-based Observational Data]; and
4. Reformat the data into acceptable messages/bulletins for operational use within the NMHS and for exchange on the WIS – see [REF Annex III - Guidance on Encoding of Aircraft-based Observational Data for Transmission on the WIS].

[23] Although a new operational system has recently been developed based on the low earth orbiting satellite system IRIDIUM and may also be an optional consideration.

2.1.2.6 Planning for Water Vapour Measurement in the ABO Network

The addition of Water Vapour Measurement (WVM) should also be evaluated in the planning of an ABO Network, as that enables the network to include observations of all basic meteorological parameters as provided by radiosondes. WVM can be accomplished with the addition of an appropriate water vapour sensor to some or all of the aircraft participating in the ABO programme. This requires a relatively minor modification to the aircraft for sensor installation, which is typically installed by the airline partner's maintenance team. The sensor must also be certified for use on specific aircraft types by the governing aviation regulatory body for the nation or region (e.g. FAA, EASA, CAAC, etc.) This process, known as a Supplemental Type Certification (STC), is explained on the WMO AMDAR website.

The Water Vapor Sensing System (WVSS-II) is a specialized sensor designed specifically for aviation use in AMDAR. It has undergone extensive performance testing and operational evaluation by WMO Member NMHSs in collaboration with the WMO AMDAR Programme. It has been certified for use on multiple aircraft types in the US and Europe. WVSS-II is currently the only sensor deemed to be capable of meeting operational and performance requirements for use with AMDAR [REF WMO AOSFRS, Appendix C2]. A WMO IOM document regarding the performance of WVSS-II has been drafted and is expected to be finalized in 2016.

As at February 2016, there are 141 WVSS-II equipped aircraft reporting WVM within the AMDAR programme globally. The US AMDAR programme operates 133 equipped aircraft and the E-AMDAR programme operates 8 equipped aircraft. Both regions are continuing to expand their implementations of WVM with WVSS-II. WVM data is currently used in various NWP models and recent studies have indicated this addition provides a significant benefit to model performance. [Ref Benjamin, NOAA; AMS 2016[24] and Ingleby, ECMWF; AMS 2016[25]]

While it is recommended to start a WVM program after standard AMDAR operations have begun, reaching agreement for this addition will take time and it is best to commence discussions on this aspect with the airline early. Factors that should be considered when implementing WVM are:

- Whenever possible, consideration should be given to airline partners that operate aircraft types which already have a sensor certification for the area. This will reduce the need to go through a lengthy certification process, which can take close to a year to complete, depending on many factors.
- The aircraft onboard software must be adapted to accommodate the addition of the new sensor.
- The ground-based processing center must accommodate the new data type, including quality controls, data formatting, and management of metadata.
- While ideally all aircraft in the ABO network would be equipped to report WVM, realistically only a percentage of the fleet will typically be equipped. That percentage would be determined by the anticipated frequency and locations those aircraft are expected to operate. Consideration must be given to the fact that an airline will always have a small percentage of their aircraft fleet out of service for maintenance at any one time. Therefore a sufficient number of aircraft must be equipped to ensure WVM data is always available to support NMHS data needs.
- The sensor is typically installed during a scheduled aircraft "heavy maintenance" check. This is a routine aircraft maintenance that typically lasts for one or two months, depending on local practice. Experience shows that installation is easily accomplished during this period without impact to other airline maintenance activities. Since this maintenance is only

[24] Observation Sensitivity Experiments with the Hourly Rapid Refresh Using Hybrid-Ensemble/Variational Data Assimilation – Benjamin, 2016 AMS Annual Meeting

[25] Extra aircraft data including humidity: ECMWF evaluation of quality and impact - Ingleby; 2016 AMS Annual Meeting

done on each aircraft approximately every two years, it may take time to get the planned number of aircraft equipped with the sensor.

- While sensor performance has proven to be stable for as many as six years or more, it is recommended that a store of spare sensors of at least 5% of the installed fleet should be maintained. This will allow the most effective maintenance program and not cause undue impact to the partner airline. Maintenance of the sensor unit has proven to be very infrequently required and, when it is necessary, the unit can be replaced within a matter of hours.

2.1.3 Operations

2.1.3.1 General Requirements

Responsibilities of Members

Members should ensure that their AMDAR system is operated in accordance with the following general requirements:

- Put in place agreements with partner airlines to ensure that they undertake those responsibilities identified in [REF Section 2.1.3.1.2 below] and so that aircraft-based observations generated by the programme can be made available to all WMO Members on the WMO Information System in accordance with the requirements of WMO Resolution 40.
- In consultation with airline partners, configuration of AMDAR On-board Software (AOS) in accordance with requirements for upper air data and aircraft-based observations (see [REF Section 1.5]).
- If implemented and utilized as a component of the AMDAR system, ensure correct configuration and operation of the ground-based optimization systems in consultation with airline partners.
- Processing and management of AMDAR messages and observational data received from partner airlines - see [REF Sections 1.7, 1.8, and 2.1.3.3].
- Reporting of aircraft-based observations and metadata in accordance with national, regional and international requirements and for provision of such data on the WMO Information System - see [REF Sections 1.9, 1.10, 2.1.3.4 and 2.1.3.5].
- Monitoring of operational systems and AMDAR data (see [REF Sections 1.8 and 2.1.3.3 and Annex II].
- Management of incidents, including the identification and rectification of defects - see [REF Section 2.1.3.7].
- Maintenance of the observing system components - see [REF Sections 1.11 and 2.1.3.9].
- Planning, implementation and documentation of changes in the operational practices and procedures of the observing system - see [REF Sections 1.11 and 2.1.3.8].

Responsibilities of Partner Airlines

Partner airlines have several responsibilities to facilitate and support the planning and operation of an AMDAR Programme and these responsibilities should be negotiated in a formal agreement as described in [REF Section 2.1.3.1.1]. They include:

- Assist in developing AMDAR On-board Software as needed, see [REF Section 2.1.2.3].
- Develop documentation to support AMDAR On-board Software installation and maintenance.
- Assist in flight testing of the software, see [REF Section 2.1.2.3.1].
- Implement the software in avionics systems through roll-out on the selected fleet(s), see [REF Section 2.1.2.3.2].
- Arrange for air to ground communication of AMDAR data to the NMHS, see [REF Section 2.1.2.4].
- Facilitate contacts between NMHS and Data Service Provider(s) as needed, see [REF Section 2.1.2.4];
- Assist in setting up ground-based data transmission as needed, see [REF Section 2.1.2.5];

- Allow the NMHS the use or ownership of data for Member mandated purposes in accordance with [REF WMO Resolution 40];
- Ensure that updates to avionics systems do not disable or adversely affect AMDAR operation;
- Provide required operational metadata; see [REF Sections 1.10 and 2.1.3.5];
- Rectify sensor issues as soon as possible within operational constraints;
- Inform about planned operational changes, e.g. flight schedules and routes, fleet configurations or renewals and other issues that could influence AMDAR data provision; and
- Agree on operational programme costs, see [REF section 2.1.1.5].

Responsibilities of Other Partners

NMHS and airlines may have to contract a data service provider (DSP) for the transmission of AMDAR data from the aircraft to the ground and from the airline's data processing infrastructure to the NMHS. The contract should:

- Guarantee the highest possible reliability of the transmission infrastructure operated by the DSP, see [REF sections 2.1.2.4 and 2.1.2.5];
- Include a feedback mechanism to inform the NMHS and the airline about any planned changes or incidental issues that will disrupt the data transmission; and
- Define back-up solutions needed to prevent or minimize the duration of disruption in data provision.

2.1.3.2 Observing Practices

Reporting Configuration

Observing Frequency

Members should be responsible, in collaboration with partner airlines, for ensuring that AMDAR on-board software (AOS) is configured optimally so as to best meet requirements for upper-air data and aircraft-based observations as described in [REF Section 1.5].

As described in [REF Section 2.1.2.3], the primary standard for AOS is the AMDAR On-board Software Functional Requirements Specification (AOSFRS), maintained by WMO [REF AOSFRS]. The AOSFRS provides the functional and meteorological requirements for AOS that also should underpin any applications that adhere to the uplink and downlink message formats associated with the AEEC ARINC 620-8 Meteorological Report.

Depending on the degree of configurability of the AOS that has been implemented (see [REF section 2.1.2], Members should collaborate with partner airlines to ensure that the AOS reporting configuration is established and maintained so as to best meet the default reporting regime defined within the AOSFRS as a minimum.

The AOS should be used to configure and determine both the frequency of reporting during the various phases of flight, see [REF Figure 4] and also over which geographical areas and locations the observations are to be made and reported.

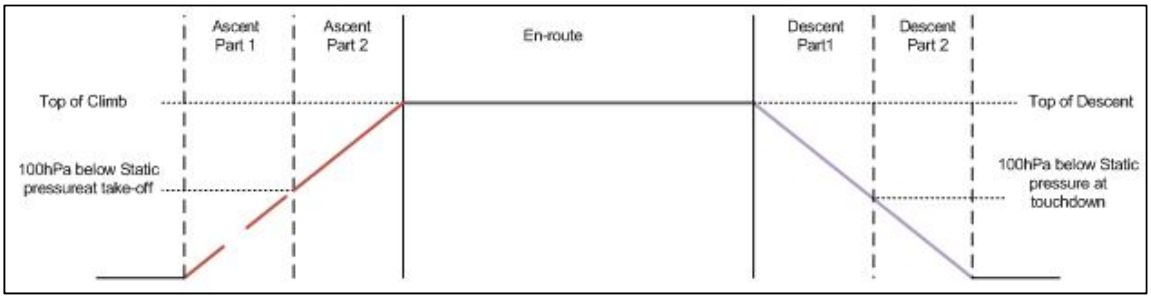


Figure 4, AMDAR Flight Phases.

The reporting frequency during the ascent, en-route and descent phases of a flight should be in accordance with the AOSFRS as a minimum, either based on air pressure level specification (vertical resolution) or on a time-based specification (temporal resolution) – see [REF Figure 5].

	PRESSURE BASED SCHEME	TIME BASED SCHEME
ASCENT PART 1	5 OR 10 hPa INTERVALS FOR FIRST 100 hPa (DEFAULT 10 hPa)	3 T0 20 SECS INTERVALS (DEFAULT 6) FOR 30 TO 200 SECS (DEFAULT 90)
ASCENT PART 2	25 OR 50 hPa INTERVALS ABOVE FIRST 100 hPa (DEFAULT 50 hPa)	20 TO 60 SECS INTERVALS (DEFAULT 20) FOR 490 TO 1050 SECS (DEFAULT 510)
EN-ROUTE	1 TO 60 MINUTES INTERVAL (DEFAULT 7 MINUTES)	
DESCENT PART 1	25 TO 50 hPa INTERVALS FROM TOD TO LAST 100 hPa (DEFAULT 50 hPa)	20 TO 60 SECS INTERVAL (DEFAULT 40) FROM TOD TO TOUCHDOWN
DESCENT PART 2	5 OR 10 hPa INTERVALS FOR LAST 100 hPa (DEFAULT 10 hPa)	

Figure 5. AMDAR Observing Intervals by Flight Phase.

Reporting Location and Optimization

Ideally vertical profiles of AMDAR observations at airports would be equally spaced (both geographically and temporally) and configured or optimized so as to best meet requirements associated with the relevant WMO Application Areas for which the AMDAR network has been established to address (see [REF Section 1.5]). For example, the AMDAR network might be configured and optimized so as to endeavour to meet the requirements for provision of upper-air data or Global NWP. However, in reality and in practice, the ideal data output necessary to meet the precise requirements is very difficult to attain. Airports are located where they are to meet requirements for transport of people and goods. In some areas they are closer to each other, so that observations at all locations would be surplus to requirements, whereas, in sparsely populated areas, there are longer distances between airports and requirements for observations are not able to be fully met. Furthermore, an airline participating in an AMDAR programme might not service all airports needed to deliver the required horizontal coverage of vertical profiles.

The geographical production of observations by the AOS can be controlled through two mechanisms ideally available within the AOS application and as defined within the AOSFRS standard. Firstly geographical boxes can be defined and set either to report or supress observations. Secondly, a list of airports can be defined and set either to report or suppress vertical profiles. Members should collaborate with airline partners to ensure that these configurations are established and maintained so as to best meet the requirements for horizontal resolution of reporting of both vertical profiles and en-route AMDAR observations.

Ground-based Data Optimization Configuration

Once the AOS is configured and activated, the aircraft will make observations and send reports in the same way during each flight. The default AOS configuration settings can be changed but that requires either a manual intervention, usually by the airline, or, if the software has the required functionality, through the sending of configuration change uplink commands to each aircraft in the fleet. As a result, and depending on the number of aircraft in the AMDAR fleet and their flight schedules, the permanent default configuration may result in the collection of more data than required at certain airports or along certain routes. These redundant data may be up to fifty percent or more of the total volume of AMDAR data collected and can result in unnecessarily high communications costs for the NMHS. This issue can be alleviated or resolved through the development and employment of a ground-based data optimization system. More details on the development and implementation of an optimization system is provided in [REF section 2.1.2.2 and in Annex V].

If Members employ an optimization system, they should:

- Configure or arrange for configuration of the system to ensure that they optimally meet requirements for provision of aircraft-based observations as described in [REF section 1.5];
- Collaborate and cooperate with regional Members and other AMDAR programmes to endeavour to optimize regional and global coverage of aircraft-based observations outside and beyond national borders - see [REF sections 1.12 and 2.1.2.2].

2.1.3.3 Quality Management

General requirements and provisions for management of the quality of aircraft-based observations are provided in [REF section 1.8]

Data Quality Control

Onboard data processing

Quality control processing should be applied to AMDAR observational data variables in accordance with the data validation procedures as specified in the AMDAR Onboard Software Functional Requirements Specification (AOSFRS) [REF, AOSFRS].

Ground-based Data Processing

Members should apply the relevant quality control procedures to AMDAR data after reception in the processing center.

Data monitoring and quality assessment

WMO Members should develop and implement policy and procedures for quality monitoring and quality assessment of AMDAR observations made by their AMDAR programme.

The WMO Lead Center on Aircraft Data is responsible for quality monitoring of aircraft-based observations and the dissemination of monitoring information to WMO Members.

The World Meteorological Centre, Washington, has the role as Lead Centre for Aircraft Data with the data monitoring processes carried out by the US National Weather Service, National Centres for Environmental Prediction, Central Operations.

At the current time, aircraft and AMDAR data monitoring is limited to the compilation and notification of monthly Numerical Weather Prediction (NWP) comparison reports that are available online from: NCEP Central Operations, Quality Assessment Project: http://www.nco.ncep.noaa.gov/pmb/qap/

Members should use the monitoring information and reports provided by the WMO Lead Center for Aircraft Data as an integrated component of the quality management operations of their AMDAR programme.

Members should consider the development and implementation of additional monitoring procedures for AMDAR observational data, which might include:

- Use of statistics and diagnostic results from their AMDAR quality control procedures (see [REF Section 1.7.2.1 and Annex I]).
- Use of the monitoring results of other WMO Member monitoring Centres.
- Use of AMDAR information available at the Global Data Centre for Aircraft-Based Observations (GDC-ABO).
- Inter-comparison of AMDAR observations with NWP fields.

- Inter-comparison of AMDAR observations with other sources of upper-air observations, for example radiosonde data.
- Monitoring diagnostics developed and based on other data analysis techniques such as:
    - Temporal consistency/gradient checks;
    - Spatial consistency/gradient checks;
    - Aircraft inter-comparison;
    - Aircraft apparent velocity checks.

Members should develop procedures for the analysis of available monitoring information and take prompt and appropriate corrective action (see [REF 2.1.3.6]) for systemic defects and issues identified that adversely affect the quality of AMDAR observations provided to the WIS.

Detailed guidance on quality monitoring and analysis of aircraft-based observational data is provided in [REF Annex II].

2.1.3.4 Data Management and Reporting

Members should develop policy and procedures for the management of their AMDAR observations in accordance with the provisions defined above and in [REF Sections 1.7, 1.8 and 1.9].

2.1.3.5 Metadata Management and Reporting

Members that provide AMDAR observations to the WIS, must provide their AMDAR metadata in accordance with the provisions in the [REF Manual on WIGOS, sections 2.5, 3.5 and Appendix 2.4].

Members should manage and report their AMDAR metadata in accordance with the provisions and recommended practices referenced and provided in [REF Section 1.10 and Annex IV].

2.1.3.6 Systems Operations and Management

An operational AMDAR system will have several important communications and data processing components, which may include one or more of:

- A networked data reception computer or server that receives AMDAR data from the aviation Data Service Provider (DSP), airline or other data provider entity.
- A message switching[26]/routing computer or server.
- A data processing computer system.
- A data archival or database computer system.
- If optimization/uplinking is implemented, a networked computer or server that compiles and sends AMDAR uplink commands to the aviation DSP or airline.

Members should ensure that they develop and implement a policy, plans and procedures for each of the AMDAR component systems so as to ensure that their operations are maintained and assured at the highest possible level of availability and in order to meet both national and international requirements for the continuous and uninterrupted provision of AMDAR observational data.

Members should ensure that systems management policy and procedures includes suitable provisions for such measures as:

- Computer system redundancy.
- System fault and maintenance switch-over.
- Message and data buffering, archiving and backup.
- Database mirroring or replication.
- Computer hardware, operating system and applications software maintenance.

[26] Message switching is a network switching technique in which data is routed in its entirety from the source node to the destination node.

2.1.3.7 Incident Management

An incident is an unplanned interruption or reduction in the quality of a service or product. Incident Management is the undertaking of procedures and actions in response to such incidents and includes as a minimum their reporting, rectification and documentation.

The objectives of Incident Management procedures are to:

- Recover and return as quickly as possible to normal service production and minimize the negative impact for data users.
- Ensure that the highest possible levels of service quality and availability are maintained.

Examples of incidents that will have a negative effect on the production of AMDAR data are:

- Operational computer system outage or malfunction.
- Malfunction of e.g. a temperature sensor of an aircraft.
- Industrial actions by airline staff (usually announced a few days in advance).
- Unplanned grounding of a number of aircraft for meteorological, environmental, technical or operational reasons.
- Updates of avionics software that disturbs the proper functioning of the onboard AMDAR software.

Members should ensure that suitable policy and procedures for the management of incidents are developed, documented and maintained by staff responsible for the operation of the aircraft-based observations programme. Such procedures should ensure that incidents adversely affecting the quality or timeliness of AMDAR observations are rectified in a timely manner.

Members should ensure that incidents, particularly those that impact on data quality or availability, are documented, recording the nature of the incident, the corrective action taken and the times and dates of occurrence and rectification.

Members should in collaboration with their partner airlines, develop and agree on policy and procedures for incident management associated with any additional AMDAR-related, airline-operated equipment or sensors, in accordance with the requirements specified by the manufacturer. This will include, for example, provisions for WVSS humidity sensor replacement in the event of quality or operational failure.

It is recommended that Members report such incidents to the relevant WMO Lead Center on Aircraft Observations and to WMO Focal Points on Aircraft-Based Observations through the relevant communications channels.

2.1.3.8 Change Management

Change management involves the planning, defining and implementing of new or modified procedures and/or technologies, either out of necessity or so as to take advantage of opportunities that lead to improvement or greater efficiency in operations.

In contrast to incident management, change management is a planned and managed process that will influence programme operations for a predictable or known time and might change or even reduce the programme's capability to produce data as normal. Examples of such changes are:

- An airline stops serving a certain geographical area that is part of the current AMDAR programme.
- An airline retires a certain aircraft type within its fleet.
- The AMDAR onboard software needs to be replaced by an updated version.
- The AMDAR programme changes to using a different data format for provision of data to the WIS

It is recommended that Members should, through the relevant communications channels, report and advise the relevant WMO Technical Commissions, WMO Lead Center on Aircraft Observations and WMO Focal Points on future plans for changes to their operational aircraft-based observing system.

2.1.3.9 Maintenance

Maintenance consists of the routine processes and procedures that ensure that infrastructure and equipment upon which the quality and reliability of observing system outputs depend, are planned and implemented.

Members must as a minimum maintain their AMDAR observing system in accordance with the provisions in [REF Manual on the GOS, Sections 2.4.7 and 3.4.7] and [REF section 1-11].

Maintenance of the aircraft, its sensors and avionics hardware and software is considered to be the responsibility of each cooperating airline. Similarly for the airline's ground processing system when the AMDAR data is passed through that system to the NMHS.

Members should in collaboration with their partner airlines, develop and agree on policy and procedures for the detection, advisement and rectification of issues and errors associated with the quality and operational performance of aircraft sensors, systems and infrastructure upon which their AMDAR observing system depends.

Members should in collaboration with their partner airlines, develop and agree on policy and procedures for the maintenance and/or calibration of any additional AMDAR-related operational equipment or sensors in accordance with the requirements specified by the manufacturer.

AMDAR Onboard Software Maintenance

Members should plan and budget for maintenance of AOS software and endeavour to comply with the [REF AOSFRS].

The NMHS is responsible for the maintenance of its ground based infrastructure necessary for receiving, processing and distributing the AMDAR data and for the monitoring of the quality of the data and products.

2.1.4 Capacity Development and Outreach

WMO and its Members maintain the work programme of the CBS and CIMO Expert Teams, which includes activities for training and outreach related to the technical development and implementation globally of the AMDAR programme and the use and management of AMDAR data. The work programme is supported by the WMO AMDAR Trust Fund. Members should contribute to the AMDAR Trust in line with [REF WMO Cg-17, Resolution 22, Global Observing System], which urges Members: *(4) To continue providing contributions to the AMDAR Trust Fund for the support of technical developments and capacity-building related to AMDAR*.

2.1.4.1 Regional AMDAR Workshops

AMDAR workshops may be initiated under an agreement between WMO and a hosting WMO Member. Agreement on the hosting of such workshops shall be based on the General Terms & Conditions for Hosting a WMO Regional Workshop on AMDAR as maintained by CBS and the WMO Secretariat. The purpose of workshops is not only to assist Members in the planning and commencement of new AMDAR programmes but also to stimulate wider and collaborative development of AMDAR in the region.

The workshop programme covers presentations made by the WMO Secretariat and invited AMDAR experts and discussions on the various aspects of planning, implementation and operation of an AMDAR programme. The programme also includes presentations highlighting the benefits of AMDAR data to meteorology and to aviation.

Workshops have been held in the following countries:

Toronto, Canada, September 2002 for Northern America

Dakar, Senegal, November 2002 for ASECNA

Pretoria, South Africa, October 2003 for the South African Society for Atmospheric Sciences (SASAS)

Budapest, Hungary, December 2004 for Central and Eastern Europe

Bucharest, Romania, November 2007 for South-East European countries

Kuala Lumpur, Malaysia, November 2008 for South-East Asia

Mexico City, Mexico, November 2011 for Latin America

Nairobi, Kenya, June 2015 for South, Central and Eastern Africa

Casablanca, Morocco, December 2015 for Northern and Western Africa

Panama City, Panama, August, 2016 for Central and South America

2.1.4.2 On-line interactive training course

An on-line Learning Module on AMDAR, "Introduction to Aircraft Meteorological Data Relay (AMDAR)" is available to WMO Members through the COMET Program of the University Corporation for Atmospheric Research (UCAR).

The content is organized into three sections, focused on the meteorological applications of AMDAR, the aviation applications of the data, and additional information about the systems and requirements for AMDAR implementation. Several experts offer interviews describing examples of AMDAR use in numerous meteorological and aviation applications.

The intended audience for the module includes meteorological service managers and providers, observational development groups, the aviation industry, and others interested in benefiting from an aircraft-based observing system in their region. With its broad scope, the lesson should appeal to anyone interested in learning more about the AMDAR programme, the observations it provides, and how the data are used.

The Learning Module on AMDAR can be found as part of the COMET's MetEd freely accessible collection of learning resources for the geoscience community. Among these resources is also the module on volcanic ash describing impacts to aviation, climate, maritime operations and society and includes training for forecasters.

The COMET learning resources can be accessed at [REF http://www.comet.ucar.edu] under the MetEd heading. The user needs to register and set up an account (no cost).

2.1.4.3 WMO AMDAR website

WMO maintains an AMDAR website: [REF http://www.wmo.int/amdar] providing information on the AMDAR Observation System, including data statistics, AMDAR Resources, and information on the various national and regional AMDAR programmes. The site also provides access to the News, Events and e-mail groups.

2.1.4.4 Newsletter

The WMO AMDAR Newsletter is published twice a year and contains information on the WMO global AMDAR observing system, aircraft-based observations and the work of the Aircraft-Based Observations Programme, supported by the relevant expert teams of the WMO Technical Commissions, CBS and CIMO: [REF https://sites.google.com/a/wmo.int/amdar-projects-and-collaboration/email-groups/newsletters-and-news].

2.2 ICAO ABO Systems

Note: Some of the information in this section is derived from material from the [REF Final report of the EUMETNET ADD FS ET on the feasibility to initiate a new EUMETNET activity for aircraft derived observations, October 2, 2015, version 1.0], with the permission of the EUMETNET observations program.

2.2.1 ADS-C (FANS-1/A)

ADS (Automatic Dependent Surveillance) is a specific application of ACARS that broadcasts or responds to a request to provide Aircraft Reports (Air-reports), which contain position, altitude, vector and other information from the aircraft for use by an Air Navigation Service Providers (ANSP), other aircraft or other Air Traffic Management entities.

An application of the system is "addressed" or "contract" ADS: ADS-C. The data is transmitted based on an explicit contract between an ANSP and an aircraft. This contract may be a demand contract, a periodic contract, an event contract and/or an emergency contract. ADS-C is most often employed in the provision of air traffic management over transcontinental or transoceanic areas which see relatively low traffic levels.

The ANSP initiates the request for the required ADS-C report and the ADS-C system (Future Air Navigation System, FANS) automatically responds with no intervention required on the part of the pilot. The generated ADS reports are addressed and sent to the requesting ANSP. For more details see [REF ICAO Doc. 4444, Ch.13].

The ANSP may use an ADS-C report for a variety of purposes. These include:

- Establishing and monitoring of traditional time-based separation minima;
- Establishing and monitoring of distance-based separation standards;
- Flagging waypoints as ‘overflown’;
- Updating estimates for downstream waypoints;
- Route and level conformance monitoring;
- Updating the display of the ADS-C position symbol, and the associated extrapolation;
- Generating (and clearing) alerts;
- Generating (and clearing) ADS-C emergencies;
- Updating meteorological information; and
- Updating other information in the flight plan held by the ANSP.

The content of ADS-C Air-reports is contained in ICAO Annex 3, Appendix IV as described above in [REF section 1.6.2]. In routine as well as in special air-reports the meteorological information is transmitted in a separate assigned data block. In accordance with [REF ICAO Doc 4444 and Doc 8896], the ADS-C reports containing a meteorological information block are relayed without delay to the WAFCs for further exchange as basic data to WMO.

The aircraft system sends specific aircraft data in different groups of an ADS-C report. Each group contains different types of data. An ADS-C event report contains only some of the groups, which are fixed. The ADS-C periodic report can contain any of the ADS-C groups, which the ATSU specifies in the contract request. The ADS-C report groups consist of:

- Basic group;
- Flight identification group;
- Earth reference group;
- Air reference group;
- Airframe identification group;
- Meteorological group;
- Predicted route group;
- Fixed projected intent group;
- Intermediate projected intent group.

For further details on ADS-C see [REF ICAO Doc. 2411, GOLD, ICAO Doc 4444 PANS-ATM and ICAO Doc. 8896].

For more detail on the requirements for provision of meteorological data from ADS-C, see [REF sections 1.6.2, 1.7, 1.8, 1.9, 1.10 and Annex III].

2.2.2 ADS-B

Automatic Dependent Surveillance – Broadcast (ADS–B) is a cooperative surveillance technology, regulated by ICAO, in which an aircraft determines its position via satellite navigation and periodically broadcasts it, enabling it to be tracked. The information can be received by air traffic control ground stations as a replacement for secondary radar. It can also be received by other aircraft to provide situational awareness and allow self-separation.

ADS–B is "automatic" in that it requires no pilot or external input. It is "dependent" in that it depends on data from the aircraft's navigation system. ADS-B is always “on” and requires no operator intervention. It continuously broadcasts aircraft position and other data to any aircraft, or ground station equipped to receive ADS-B and can therefore replace or supplement radar as the primary surveillance method for controlling aircraft worldwide.

The system has two services: ADS-B Out and ADS-B In.

"ADS-B Out" periodically broadcasts information about each aircraft, such as identification, current position, altitude, and velocity, through an onboard transmitter. ADS-B Out provides air traffic controllers with real-time position information that is, in most cases, more accurate than the information available with current radar-based systems. With more accurate information, ATC will be able to position and separate aircraft with improved precision and timing.

"ADS-B In" is the reception by aircraft of ADS-B data such as direct communication from nearby aircraft. The ground station broadcast data is typically only made available in the presence of an ADS-B Out broadcasting aircraft, limiting the usefulness of purely ADS-B In devices.

The ADS-B system has three main components:

1) Ground infrastructure - a receiving subsystem that includes message reception and report assembly functions at the receiving destination: e.g., other airplanes, vehicle or ground system;
2) Airborne component – a transmitting subsystem that includes message generation and transmission functions at the source, i.e. the aircraft; and
3) Operating procedures - the transport protocol; e.g., VHF (VDL mode 2 or 4),1090ES, or 978 MHz UAT*;

(*UAT Universal Access Transceiver)

The system relies on two avionics components: a high-integrity GPS navigation source and a datalink (ADS-B unit). The format of extended squitter (ES), see [ICAO Annex 10, Volumes III and IV] messages has been codified by ICAO in [REF ICAO Doc. 8971].

The ADS-B ES message (112 bits), as depicted below in [REF figure 2.2.1], includes a 56 bit data field used to carry ADS-B information.

Figure 2.2.1

At present no meteorological information is directly available from ADS-B (Extended Squitter, EHS), other than information triggered by MODE-S MRAR (see below in [REF 2.2.3]). However, certain ADS-B data contents, when combined with a selection of Mode-S parameters, allow the derivation of wind and temperature information as described below.

2.2.3 Secondary Surveillance Radar Mode-S

Mode-S is a Secondary Surveillance Radar[27] process that allows selective interrogation of aircraft according to the unique 24-bit address assigned to each aircraft. Recent developments have enhanced the value of Mode-S by introducing Mode-S EHS (Enhanced Surveillance). Mode-S employs airborne transponders to provide altitude and identification data, with ADS-B adding global navigation data typically obtained from a GPS receiver. The position and identification data supplied by Mode-S/ADS-B broadcasts are available to pilots and air traffic controllers.

Mode-S/ADS-B data updates rapidly, is very accurate and provides pilots and air traffic controllers with common air situational awareness for enhanced safety, capacity and efficiency. Further, it can provide a cost-effective solution for surveillance coverage in non-radar airspace.

Mode-S transponder equipped aircraft must also incorporate an Aircraft Identification feature to permit flight crew to set the Aircraft Identification, commonly referred to as Flight ID, for transmission by the transponder. The Aircraft Identification transmission must correspond with the aircraft identification specified in item 7 of the ICAO flight plan, or, when no flight plan has been filed, the aircraft registration. Aircraft equipped with Mode-S having an aircraft identification feature shall transmit the aircraft identification as specified in Item 7 of the ICAO flight plan or, when no flight plan has been filed, the aircraft registration.

In addition to the downlinking of Aircraft Identification, which is a prerequisite for Mode-S Elementary Surveillance (ELS), other specified downlink parameters (DAPs) may be acquired by the ground system to meet the requirements of Mode-S Enhanced Surveillance (EHS).

The Mode-S system requires each interrogator to have an Identifier Code (IC), which can be carried within the uplink and downlink transmissions (1030/1090 MHz). Responding aircraft transponder identification is achieved by acquiring the unique ICAO 24-bit aircraft address.

Further information on Mode-S operation for aviation can be found in ICAO Doc. 9688.

2.2.3.1 Derivation of Meteorological Data from Mode-S and ADS-B

Mode-S MRAR

Mode-S MRAR data contains wind and temperature observations, measured/calculated by the aircraft (see table below).

[27] See: http://www.skybrary.aero/index.php/Transponder

Data type	Resolution	Unit
Mode-A slant position (range)[7]	1/256	Nm
Mode-A slant position (azimuth)	$360/2^{16}$	Degrees
Position from ADS-B	~5	m
wind speed	1	Knot
Wind direction	180/256	Degrees
Static air temperature	0.25	°C
Average static pressure	1	hPa
Turbulence	4 levels	nil/light/moderate/severe
Humidity	100/64	%

Turbulence and humidity are not (always) available. The quality of the EHS MRAR wind and temperature information is comparable to the quality of AMDAR wind and temperature data. The quality is however dependent on the aircraft type, and is in general good when from commercial passenger aircraft (table below), while biased temperatures are observed when from small business/private aircraft (Strajnar et al., 2015).

ADS-B ES Data Content

[REF Table 2.2.1] below provides a brief description of the ADS-B message content.

Message type	Downlink Format	Data Content
ADS-B ES (112 bits)	DF17	Airborne position Surface position Extended squitter status Aircraft type and ID Airborne velocity

Table 2.2.1

Mode-S EHS data does not contain onboard generated meteorological information. However, by combining certain parameters from the Mode-S EHS DAB set and from the ADS-B data elements from the Downlink Format, wind and temperature information can be derived.

From a selection of Mode-S EHS Downlink Aircraft Parameters (DAPs) [REF EUROCONTROL, Mode-S Harmonisation of the Transition Arrangements for State Aircraft, List of DAPs for EHS Capability] and ADS-B ES parameters it is possible to derive good quality wind speed and direction and moderate quality air temperature (see [REF Table 2.2.2] below) at very high temporal frequency (up to 2-second reports).

Meteorological parameter	Presence	Observed	Quality	Accuracy wrt. NWP model
Wind speed	Derived	All aircraft	Good	2-2.5 m/s
Wind direction	Derived	All aircraft	Good	10-15 degrees
Temperature	Derived	All aircraft	Moderate	2K

Table 2.2.2

Mode-S EHS data transmission requires active interrogation from am ATC radar and can only be done by an authorized body, e.g. the ATC. The response transmission of the aircraft can be received using a local ADS-B/Mode-S receiver. The frequency of interrogation is dependent on the application and is generally between 4 to 20 seconds.

Aircraft compliant with Mode-S EHS provide the basic functionality features of Mode-S ELS supplemented by eight DAPs, provided either via a basic DAP set or an alternative DAP set, depending respectively on the absence or presence of the Track Angle Rate parameter.

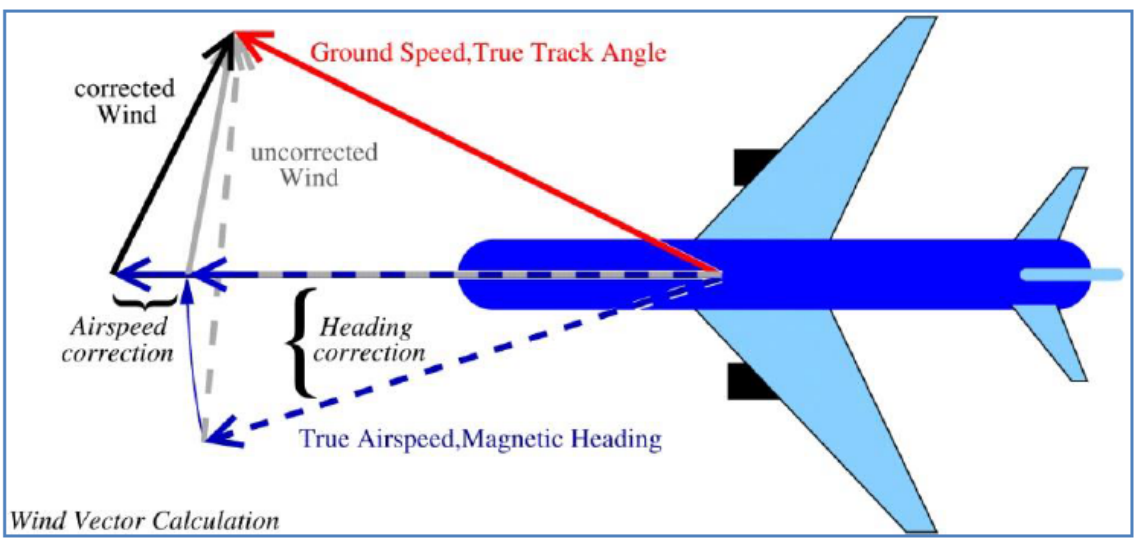
Table 2.2.3 provides an overview of the Mode-S EHS DAP sets.

BDS Register	Basic DAP Set (if track Angle Rate is available)	Alternative DAP Set (if Track Angle Rate is not available)
BDS 4,0	Selected Altitude	Selected Altitude
BDS 5,0	Roll Angle	Roll Angle
	Track Angle Rate	
	True Track Angle	True Track Angle
	Ground Speed	Ground Speed
		True Airspeed (provided if Track Angle Rate is not available)
BDS 6,0	Magnetic Heading	Magnetic Heading
	Indicated Airspeed (IAS) / Mach no. (Note: IAS and Mach no. are considered as 1 DAP (even if technically they are 2 separate ARINC labels). If the aircraft can provide both, it must do so).	Indicated Airspeed (IAS) / Mach no. (Note: IAS and Mach no. are considered as 1 DAP (even if technically they are 2 separate ARINC labels). If the aircraft can provide both, it must do so).
	Vertical Rate (Barometric rate of climb/descend or baro inertial)	Vertical Rate (Barometric rate of climb/descend or baro inertial)

Table 2.2.2

If the magnetic heading has been corrected to true north and corrections have been applied for the airspeed, the correct wind vector can be calculated, resulting in good quality wind speed and wind direction information.

Figure Y provides an understanding how these corrections provide the high quality wind information.



Mode-S EHS air temperature is derived using the measurements of the downlinked Mach number and airspeed. The airspeed is not an observation provided by the aircraft, but derived from the measured Mach number (pitot probe) and temperature. The mach number is the quotient of the airspeed and the speed of sound, and that is dependent on the temperature. Comparison between NWP temperatures and Mode-S EHS temperatures reveal that a temperature correction will be needed for each aircraft, flight phase and time, resulting in a decrease of the standard deviation. The quality of Mode-S EHS temperatures are therefore considered as moderate (table below).

Further information on the derivation of meteorological data from Mode-S can be found in the [REF CIMO Guide, Part III, Chapter 3.4].

Further information and reference on derived aircraft-based observations can be found online at [REF the Royal Netherlands Meteorological Institute website, Mode-S EHS research, http://mode-s.knmi.nl/].

2.3 Other ABO Systems

2.3.1 Introduction

As described in [REF Section 1.6.3], Members are able to receive aircraft-based observations (ABO) from other Third Party sources. This section describes or provides references for descriptions of the systems currently known to and utilized by WMO Members.

Data from 3rd part sources should be processed and provided to the WIS in accordance with the guidance provided within [REF 1.6.3 and Annexes I and III].

2.3.2 TAMDAR

Tropospheric Airborne Meteorological Data Reporting (TAMDAR[28]) is a commercially developed, deployed and operated system that obtains and sells meteorological data derived from the predominantly aircraft-independent sensing and communications probe. Unlike the WMO AMDAR observing system, emphasis has been placed on equipping primarily regional air carriers, as their flights tend to: (i) service more remote and diverse locations; and (ii) be of shorter duration, thereby producing more daily vertical profiles and remaining in the boundary layer for longer durations. Although TAMDAR is fully functional and regularly operates above 40,000 ft, the aircraft that typically host the sensor often cruise below 25,000 ft.

TAMDAR collects measurements of relative humidity (RH), pressure, temperature, winds, icing, and turbulence, along with the corresponding location, time, and geometric altitude from a built-in GPS. These data are relayed via satellite in real-time to a ground-based network operations centre, where in-line quality control procedures are performed prior to distribution. The overall humidity and temperature data quality is similar to radiosondes (REF Gao et al., 2012). The wind observations are derived in a similar fashion as typical AMDAR winds, using aircraft heading and true airspeed (TAS), and the ground track vector, which is provided by the internal GPS unit.

The TAMDAR sensor samples on a pressure-based interval on ascent and descent, and a time-based interval in cruise, which also varies with altitude from 3 min at lower altitudes to 7 min at higher altitudes. At present, on ascent and descent, the sensor reports every 10 hPa, however this can be adjusted remotely in real time down to 1 hPa (~30 ft) depending on the rate of ascent and descent. During cruise, if any metric changes above a set threshold, the sensor will send a custom report, so turbulent flights through the cloud tops will generate far more observations than a higher-altitude cruise in clear skies.

Under the NOAA Great Lakes Field Experiment in the 1990s, NOAA collaborated with (then) AirDat LLC for the provision of aircraft-based observations derived from a large fleet of participating aircraft from several airlines operating in the Great Lakes area of the United States. Under this cooperation, TAMDAR data were made available on the GTS and several impact assessments were undertaken by NOAA which attests to the quality and utility of TAMDAR data for both NWP and other forecasting applications.

The TAMDAR system is described in more technical detail in [REF CIMO Guide No 8 Part II, Chapter 3].

[28] See: http://www.airdat.com/technology/tamdar-sensor-network/

2.3.3 AFIRS

FLYHT Aerospace Solutions Ltd has developed the Automated Flight Information Reporting System (AFIRS[29]) avionics system which provides client airlines with global flight tracking and aircraft performance monitoring with voice and data communications using the Iridium global satellite network. The AFIRS system also supports ACARS protocols such as OOOI (Out Off On In) messaging.

AFIRS interfaces to the aircraft flight data computer to obtain high frequency flight data for processing and dispatch via short-burst downlink messaging over the satellite network. It supports an AMDAR-like functionality that allows meteorological data to be downlinked in a suitable format, e.g. text delimited.

FLYHT has collaborated with at least one NMHS for the provision of good quality ABO data which has been made available to the WIS.

2.3.4 IAGOS

The In-service Aircraft for a Global Observing System (IAGOS) program[30] is a European Research Infrastructure and builds on the scientific and technological experience gained within the research projects MOZAIC (Measurement of Ozone and Water Vapour on Airbus in-service Aircraft and CARIBIC. It provides a data base for users in science and policy, including near real-time data provision for weather prediction, air quality forecasting and for assimilation in climate models. IAGOS cooperates with several airlines for quasi-continuous measurements. Six aircraft are currently (end of 2015)equipped with an IAGOS instrument package. The ultimate goal of IAGOS is to equip 20 long-range aircraft of internationally operating airlines with IAGOS equipment for continuous operational deployment.

The IAGOS aircraft-to-ground communication system and WMO BUFR template was developed based on the AMDAR system, which allows the data to be received and processed by standard ABO infrastructure. For details see on the BUFR formats see [REF Annex III].

IAGOS contributes to the IGAS[31] (IAGOS for the GMES Atmospheric Service) project, which is aiming to provide data streams in both near-real-time and delayed mode to the Copernicus Atmospheric Service. The WMO GAW32 is partner in IGAS.

2.3.5 CARIBIC

The Civil Aircraft for the Regular Investigation of the Atmosphere Based on an Instrument Container (CARIBIC) is a research aircraft-based observing system in which detailed and extensive measurements are made during long distance flights. An airfreight container with automated scientific apparatus is deployed, which is connected to an air and particle (aerosol) inlet underneath the aircraft. The container is installed in a Lufthansa Airbus A340-600. It has a system for collecting air samples and has been operational since December 2004. These air samples are analysed in the laboratory.

The CARIBIC project is to be integrated into the IAGOS program.

More information is available at the CARABIC website[33].

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[29] See: http://flyht.com/products/
[30] See: http://www.iagos.org/
[31] See: http://www.igas-project.org/index.php/ProjectInfo/ProjectInformation
[32] See: http://www.wmo.int/pages/prog/arep/gaw/gaw_home_en.html
[33] See: http://www.caribic-atmospheric.com/

Annex I - Guidance on Quality Control of Aircraft-Based Observations

Background

This document provides guidance for the operational quality control (QC) of aircraft-based meteorological observations received from an aircraft platform. While likely generally applicable to most aircraft-based observing systems, it is expected that the data QC practices will be applied to data derived from Member AMDAR observing systems see [REF Sections 1.6.1 and 2.1] and also similar data derived from ICAO aircraft observations [REF see Section 1.6.2].

In addition to the data QC checks specified in this document, Members should also ensure that their QC systems for aircraft-based observations meet the more general provisions for quality control of data as specified in [REF Section 1.8].

The data quality control checks specified in this document are for application in ground-based systems, to be applied to observations received from the aircraft-based observing system prior to transmission on the WMO Information System.

For quality control requirements and checks for application within on boards systems, see [REF Section 2.1.3.3].

For provisions for quality monitoring of aircraft-based observations, see [REF Appendix II].

For general provisions for incident change Management, see [REF Section 1.11].

Basic Data Quality Control Checks

Members should apply the following basic data quality control checks on the meteorological variables of their aircraft-based observations:

1. Range Check
2. Static Value Check
3. Temporal Variation Check

Range Check

The Range Check tests whether a value lies within the allowable range as specified for each variable within [REF Table 1] below.

Algorithm

IF v_i < lower value of Range THEN v_i is erroneous

IF v_i > upper value of Range THEN v_i is erroneous

Variables Applied to

The Range Check should be applied to all variables within [REF Table 1] below.

Check Failure Action

- A value outside of the range should be flagged as erroneous and not submitted to the WIS.
- If the erroneous variable is a temporal or spatial coordinate, then all variables in the observation should be flagged as erroneous and the observation should not be submitted to the WIS.
- If the behaviour persists for consecutive flights, the aircraft should be black-listed from provision to the WIS until rectified and the airline notified.

Static Value Check

The Static Value Check tests whether values of particular variables are not varying temporally, as they should, from one observation to the next, usually indicating that the variable is not being updated in the on board data computer.

Algorithm

for each valid v_t , calculate: $\Delta v = v_t - v_{t+\Delta t}$

where v_t is the value of v at time t and $v_{t+\Delta t}$ is the value of v at time $t + \Delta t$

IF Δv is continuously zero* then apply Check Failure Action

* Continuously zero means that the value of Δv remains zero for each consecutive check and for an extended period of time.

Notes:

- Check Failure Action should only be applied if the check is failed for at least 5 consecutive checks.

Variables Applied to

The Static Value Check should be applied to the variables indicated within [REF Table 1] below.

Check Failure Action

- Every value in the series of checks that have been failed and every value for the remainder of the flight for which the observations are derived should be flagged as erroneous and not submitted to the WIS.
- If subsequent manual checks reveal that the error ceased to occur, then non-errant data can be flagged as good quality.
- If the erroneous variable is a temporal or spatial coordinate, then all variables for all observations for which the checks have been failed should be flagged as erroneous and all observations for the remainder of the flight should not be submitted to the WIS.
- If the behaviour persists for consecutive flights, the aircraft should be black-listed from provision to the WIS until rectified and the airline notified.

Temporal Variation Check

The Temporal Variation Check calculates the difference between consecutive values of variables and tests whether the difference exceeds a threshold value, indicating a likely error in one, the other or both values.

Variables Applied to

The Temporal Variation Check should be applied to the variables indicated within [REF Table 1] below.

Algorithm

for each valid v_t, calculate: $\Delta v = v_t - v_{t+\Delta t}$

where v_t is the value of v at time t and $v_{t+\Delta t}$ is the value of v at time $t + \Delta t$

IF $\Delta v > T$ then apply Check Failure Action

where T is the threshold value from [REF Table 1] below.

Check Failure Action

- If v_t is validated by previous checks, value $v_{t+\Delta t}$ should be flagged as erroneous and not submitted to the WIS. If v_t has not been validated, both values should be flagged as erroneous and not submitted to the WIS.

- If the erroneous variable is a temporal or spatial coordinate, then all variables for all observations for which the checks have been failed should be flagged as erroneous and all observations for the remainder of the flight should not be submitted to the WIS.
- If the behaviour persists for consecutive flights, the aircraft should be black-listed from provision to the WIS until rectified and the airline notified.

Specific Variable and Special Data Quality Checks

Members should apply the following specific and special data quality control checks to their aircraft-based observations:

Apparent Aircraft Velocity Check

The Apparent Aircraft Velocity Check tests the validity of spatial and temporal coordinates of consecutive observations by calculating an "apparent velocity" at which the aircraft has travelled over the period of time between observations. The apparent aircraft velocity can be approximated by applying a calculation which is a function of the latitude, longitude and time coordinates of the observations.

Algorithm

Calculate the distance (D) in kilometres between the two latitude & longitude coordinates, $[\mathrm{Lat}_1, \mathrm{Lon}_1]$ and $[\mathrm{Lat}_2, \mathrm{Lon}_2]$ using the "Haversine Formula":

$$\mathrm{D} = \mathrm{R} * \mathrm{c}$$

Where:

$\mathrm{R} = 6371$ Is an approximation to the average radius of the earth in km;

$$\mathrm{c} = 2 * \mathrm{atan2}(\sqrt{\mathrm{a}}, \sqrt{(1-a)})$$

$$\mathrm{a} = \sin\left(\frac{\mathrm{dLat^r}}{2}\right) * \sin\left(\frac{\mathrm{dLat^r}}{2}\right) + \cos(\mathrm{Lat_1^r}) * \cos(\mathrm{Lat_2^r}) * \sin\left(\frac{\mathrm{dLon^r}}{2}\right) * \sin\left(\frac{\mathrm{dLon^r}}{2}\right)$$

$$\mathrm{dLat}^r = \mathrm{rad}(\mathrm{Lat}_2 - \mathrm{Lat}_1),\ \mathrm{dLon}^r = \mathrm{rad}(\mathrm{Lon}_2 - \mathrm{Lon}_1)$$

$$\mathrm{Lat_1^r} = \mathrm{rad}(\mathrm{Lat}_1),\ \mathrm{Lat_2^r} = \mathrm{rad}(\mathrm{Lat}_2)$$

rad() is a function for the angular conversion of degrees to radians

Calculate: $V_A = \frac{\mathrm{D}}{\Delta \mathrm{t}}$

Where: $\Delta\mathrm{t}$ is the time difference between observations in hours.

IF : $\mathrm{V_A} > \mathrm{V^T}$ then apply Check Failure Action

Where: $\mathrm{V^T}$ is an appropriate maximum aircraft velocity threshold for the aircraft.

Note: It is recommended that for Boeing, Airbus and similar performing jet aircraft, this value might be universally set to 1250 km/h. However, based on sound reasoning or scientific analysis, varying thresholds may be adopted for particular aircraft types and performance.

Check Failure Action

- All values corresponding to $[\mathrm{Lat}_2, \mathrm{Lon}_2]$ and all subsequent observations should be flagged as erroneous and not submitted to the WIS.
- If the behaviour persists for consecutive flights, the aircraft should be black-listed from provision to the WIS until rectified and the airline notified.

Additional Data Quality Control Checks

Members may elect to apply the following additional data quality control checks on the meteorological variables of their aircraft-based observations:

1. Numerical Weather Model Comparison Check
2. Radiosonde Comparison Check
3. Vertical Spatial Check
4. Horizontal Spatial Check

It should be noted that such checks should be applied as part of the data QC process only if they do not have significant impact on latency of provision of data to the WIS. See [REF Section 1.5] on requirements for aircraft-based observations. In the case that such checks do severely and adversely impact data latency, consideration should be given to applying such checks as a component of the quality monitoring and quality assessment process only – see [REF Annex II].

Numerical Weather Model Comparison Check

The Numerical Weather Model Comparison Check tests whether a value is consistent with the comparative value derived from the output of a NWP model.

Algorithm

IF $|v_i - v_i^N| > T$ THEN v_i is erroneous

Where v_i^N is the NWP value interpolated and derived as necessary from the NWP model output; T is the threshold value, which may be a function of a number of parameters including the variable being compared, the observation altitude, etc.

Notes:

- The NWP comparison value should, if possible, be derived from the first guess field of the model output.
- The values of T should be determined in consultation with NWP experts and based on the results of comparison statistical analysis.
- The values of T should be such that loss of valid data is prevented or minimised.

Variables Applied to

The Numerical Weather Model Comparison Check should be applied to meteorological variables.

Check Failure Action

- Erroneous values should be flagged and not submitted to the WIS unless the BUFR encoding process makes provision for the setting of aircraft-based observations data quality flags and the value is appropriately flagged.
- If the behaviour persists for consecutive flights, analysis should be undertaken and, if appropriate, the aircraft should be black-listed from provision to the WIS until rectified and the airline notified.

Radiosonde Comparison Check

The Radiosonde Comparison Check tests whether a value is consistent with the comparative value derived from a co-located radiosonde vertical profile.

Algorithm

IF $|v_i - v_i^R| > T$ THEN v_i is erroneous

Where v_i^R is the value from the collocated radiosonde profile, interpolated and derived as necessary; T is the threshold value, which may be a function of a number of parameters including the variable being compared, the observation altitude, etc.

Notes:

- The radiosonde comparison value should be logarithmically interpolated to the aircraft observation value altitude.
- The values of T should be determined based on the results of comparison statistical analysis.
- Comparisons should be made only when the observing systems are suitably collocated, which will usually be when the radiosonde system is located at the airport where the aircraft is ascending or descending.
- Comparison pairs should be derived with a maximum temporal separation of 60 minutes and a maximum horizontal spatial separation of 60km.

Variables Applied to

The Radiosonde Comparison Check should be applied to meteorological variables.

Check Failure Action

- Erroneous values should be flagged and not submitted to the WIS unless the BUFR encoding process makes provision for the setting of aircraft-based observations data quality flags and the value is appropriately flagged.
- If the behaviour persists for consecutive flights, analysis should be undertaken and, if appropriate, the aircraft should be black-listed from provision to the WIS until rectified and the airline notified.

Table 1 – Aircraft-based observations variables and QC test information.

Variable	Unit	Range	Apply Static Value Check (Y/N)	Apply Temporal Variation Check (Y/N)	Temporal Variation Check Threshold
Pressure Altitude	Foot (ft) Meter (m)	-1000 to 50000 -330 to 17000	Y	Y	5000 ft/min
Static Air Temperature	^{o}C	-99 to 99	Y	Y	20C degs/min
Wind Direction	^{o} from true N	1 to 360	Y	Y	180 deg/min
Wind Speed	Knot (kt) m/sec	0 to 800 0 to 400	Y	Y	50 kts/min
Latitude	Degree:minute	90,00S to 90,00N	N	Y	30 mins/min
Longitude	Degree:minute	180,00E to 180,00W	N	Y	300 mins/min
Time (UTC)	Hour:Minute:Second	00:00:00 to 23:59:59	Y	N	N/A
Turbulence (g)	g	-3 to 6	Y	N	N/A
Turbulence (DEVG)	ms^{-1}	0 to 20	Y	N	N/A
Turbulence (EDR)	$m^{2/3}s^{-1}$	0 to 1	Y	N	N/A
Humidity (RH)	%	0 to 100	Y	N	N/A

Humidity (dew pt)	^{o}C	-99 to +49	Y	N	N/A
Humidity (mixing ratio)	gram/kg	0 to <100	Y	N	N/A

Annex II - Guidance on Quality Monitoring of Aircraft-Based Observations

Note: This Annex is still under development and review. Parts of it will be considerably revised prior to publication.

Background

This annex provides guidance for the operational quality monitoring (QM) and quality evaluation (QE) of aircraft-based meteorological observations received from an aircraft platform. While likely generally applicable to most aircraft-based observing systems, it is expected that the practices will be applied to data derived from Member AMDAR observing systems see [REF Sections 1.6.1 and 2.1] and also similar data derived from ICAO aircraft observations see [REF Section 1.6.2].

In general the quality monitoring system for aircraft-based observations will be consistent with, and should be regarded as a component of the WIGOS Data Quality Monitoring System (WDQMS). The figure below depicts the general framework for the WDQMS.

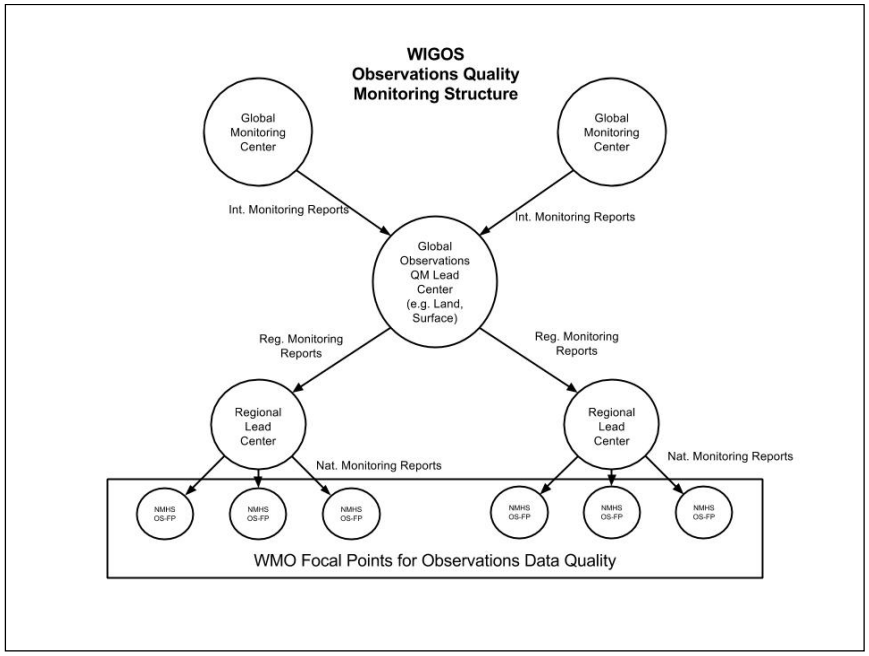

Figure 1: The WIGOS Observations Quality Monitoring Structure, supporting the WIGIOS Data Quality Monitoring System.

For the purposes of this guide, quality monitoring is defined as practices and procedures and the production of reports and diagnostics that allow the quality of aircraft-based observations to be assessed. Quality evaluation is defined as the use or application of quality monitoring reports and information and analysis techniques and tools to analyse and assess the quality of aircraft-based observations, investigate and isolate systemic issues and make recommendations for improvements to operational practices. These aspects of ABO quality management are depicted in [REF Figure 2, Aircraft-Based Observations Data Quality Management Framework in section 1.8.2.2], in [Figure 2] below which provides a more detailed depiction of the regional and national framework that should be established to support ABO quality evaluation at the programme level.

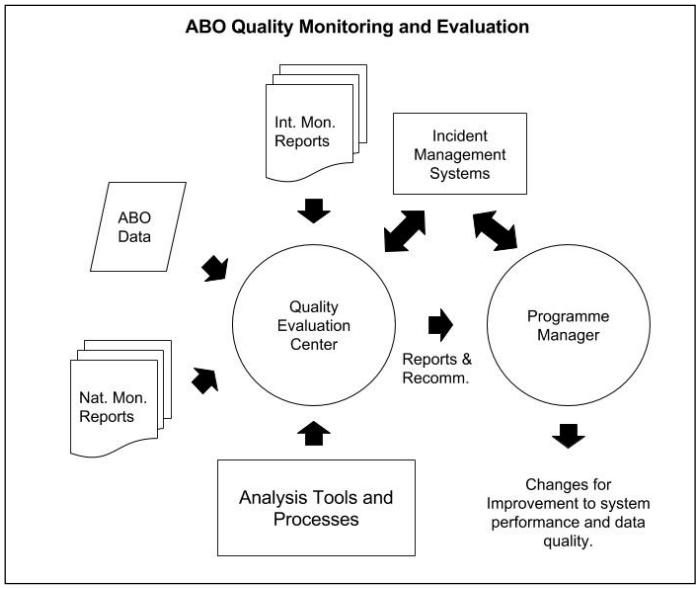

Figure 2: Information, tools and practices supporting the quality evaluation process for aircraft-based observations.

Quality Monitoring Practices

Data quality monitoring practices should focus on the measurement of the performance of the system against a set of targets, defined for the functional specifications of the ABO or AMDAR system:

1. Performance figures in terms of quantities, for example, number of observations provided for a specific area and period, stated by the system management and confirming the on-board observing programmes.
2. Quality indicators of the physical quantities and variables providing a measurement of uncertainties, usually in the form of systematic (average difference with respect to a reference, commonly referred to as bias) and (number or percentage of) incidental (gross) errors.
3. Quality indicators for metadata, essential for the interpretation and use of the data (timestamp, horizontal and vertical positions, flight phase) and other information, necessary for appropriate data management (like aircraft identification) and usefulness (timeliness).
4. Results of data quality control processes, including error and consistency checking of bulletin formatting and the detection and elimination of duplicate observations.

Requirements for WMO Global & Regional NWP Quality Monitoring Centres

The general description and requirements for WMO designated Global and Regional Monitoring and Evaluation are described in [REF Section 1.8.2].

The following specifications are applicable for both designated Global and Regional Monitoring Centers for ABO but may be used and applied by any NWP monitoring center.

The reports produced by NWP monitoring centers should be made available by e-mail to WMO Focal Points on Aircraft-Based Observations.

The reports produced by NWP monitoring centers will be made available to WMO Members and maintained or archived.

The current requirements for monthly monitoring of aircraft-based observations by WMO global NWP quality monitoring centres are defined in the [REF Manual on the Global Data Processing and Forecasting System, WMO-No. 485, Volume I, Part II, Attachment II.9], Procedures and

Formats for the Exchange of Monitoring Results[34]. The procedures for Aircraft Data are given in Section 5.

The procedures in the Manual on the GDPFS are considered to be minimal and somewhat limited in terms of serving the modern requirements of aircraft-based observations programme operators and data users. They provide requirements for monitoring of air temperature and wind only.

The following specification of requirements are the new procedures recommended for adoption by WMO designated and other global NWP quality monitoring centres for aircraft-based observations and it is expected they will supersede and replace the requirements provided in the Manual on the GDPFS.

Automated Monitoring Reports

Daily Availability Monitoring Report of Aircraft-Based Observations

WMO Global NWP Quality Monitoring Centres should undertake monitoring of the availability of aircraft-based observations and compile and provide a daily report that lists significant changes in the quantity or volume of aircraft-based observations reported to the WIS.

The ABO Availability Report should:

- Be limited to the provision of information that isolates errors or issues with a low probability of false alarm and according to the criteria below;
- Be made available automatically by e-mail to all focal points for operational aircraft-based observations programme managers for the previous UTC day as soon after 0000 UTC as possible;
- Isolate those aircraft whose recent availability of observations over the past 3 days various significantly from its availability of observations over the preceding 7 days;
- Be provided in the format described within Attachment I.

Criteria for the inclusion of aircraft in the reports are based on the following. An aircraft is Suspect if:

- TAd1NA = 0 AND Percentage(TAd3ND,TAd7ND) < 30
- OR Percentage(TAd3ND, TAd7ND) > 200
- OR MRd1NA=0, AND Percentage(MRd3ND,MRd7ND) < 30
- OR Percentage(MRd3ND,MRd7ND) > 200

Where: Percentage(x,y) is the value of x expressed as a percentage of y.

Based on Attachment I, the suggested report content is shown below:

```
[HEADER]

Report Name:Aircraft-Based Observations Daily Availability Report

Issuing Center: [Name of Center]

Report Period of Validity:[hh:mm dd-mm-yyyy to hh:mm dd-mm-yyyy]

Location of Monitoring Site:[Internet address]

ID: Aircraft identity

[Field Header:Field Description]

[etc]

[/HEADER]
```

[34] Available online here: http://www.wmo.int/pages/prog/www/DPS/Monitoring-home/mon-procedures.htm

```
[DATA]

ID; SUS_L; TAd3ND; TAd7ND; MRd3ND; MRd7ND

[etc]

[/DATA]
```

Daily 10-Day-Moving Monitoring Report of Aircraft-Based Observations NWP Comparison

WMO Global NWP Quality Monitoring Centers should undertake monitoring of aircraft-based observations so as to provide two daily quality monitoring reports to observing system programme managers by e-mail.

These QM reports should consist of:

1. TA and MR Daily 10-Day-Moving Window NWP Comparison
2. Wind Daily 10-Day-Moving Window NWP Comparison

These QM reports should be:

- Limited to the provision of information that isolates errors or issues with a low probability of false alarm and according to the criteria below;
- Made available automatically by e-mail to all focal points for operational aircraft-based observations programme managers for the previous UTC day as soon after 0000 UTC as possible;
- Provide a 10-day, moving window of monitoring statistics for the current and prior 9 days; and
- Provided in the format described within Attachment I.

Criteria for the inclusion of aircraft in the reports are provided in Attachment II.
Based on Attachment I, the suggested report content is shown below for the TA and MR Daily 10-Day-Moving Window NWP Comparison:

```
[HEADER]

Report Name:Aircraft-Based Observations Daily NWP Comparison Check

Issuing Center: [Name of Center]

Report Period of Validity:[yyyy-mm-dd hh:mm to yyyy-mm-dd hh:mm]

Comparison Standard:[Model Identity; Model field used for comparison]

Variables:[Air Temperature and Humidity]

Location of Monitoring Site:[Internet address]

ID: Aircraft identity

[Field Header:Field Description]

[etc]

[/HEADER]

[DATA]

ID; SUS_L; TAd1NA; TAd1NC; TAd1NR; TAd1NG; TAd1MB; TAd1SD; TAd1NA; TAd9NC;
TAd9NR; TAd9NG; TAd9MB; TAd9SD; MRd1NA; MRd1NC; MRd1NR; MRd1NG; MRd1MB; MRd1SD;
MRd1NA; MRd9NC; MRd9NR; MRd9NG; MRd9MB; MRd9SD

[etc]
```

```
[/DATA]
```

Based on Attachment I, the suggested report content is shown below for the Winds Daily 10-Day-Moving Window NWP Comparison:

```
[HEADER]

Report Name:Aircraft-Based Observations Daily NWP Comparison Check

Issuing Center: [Name of Center]

Report Period of Validity:[ yyyy-mm-dd hh:mm to yyyy-mm-dd hh:mm]

Comparison Standard:[Model Identity; Model field used for comparison]

Variables:[Wind speed, wind direction and wind vector difference]

Location of Monitoring Site:[Internet address]

ID: Aircraft identity

[Field Header:Field Description]

[etc]

[/HEADER]

[DATA]

ID; SUS_L; WSd1NA; WSd1NC; WSd1NR; WSd1NG; WSd1MB; WSd1SD; WSd1NA; WSd9NC;
WSd9NR; WSd9NG; WSd9MB; WSd9SD; WDd1NA; WDd1NC; WDd1NR; WDd1NG; WDd1MB; WDd1SD;
WDd1NA; WDd9NC; WDd9NR; WDd9NG; WDd9MB; WDd9SD; WMd1NA; WMd1NC; WMd1NR; WMd1NG;
WMd1WVRMS; WMd9NA; WMd9NC; WMd9NR; WMd9NG; WMd9WVRMS

[etc]

[/DATA]
```

Monthly Monitoring of Aircraft-Based Observations

WMO Global NWP Quality Monitoring Centers should undertake monitoring of aircraft-based observations so as to provide two monthly quality monitoring reports to observing system programme managers by email.

These QM reports should be:

1. TA and MR Monthly NWP Comparison
2. Winds Monthly Comparison

- Contain results for all aircraft providing data to the WIS;
- Made available automatically by e-mail to all focal points for operational aircraft-based observations programme managers for the previous UTC month as soon after 0000 UTC of the first day of the new month as possible;
- Sorted so as to provide suspect records first, followed by non-suspect records, grouped by programme.
- Provided in the format described within Attachment I.

Criteria for the designation of aircraft as suspect are provided in Attachment II.
Based on Attachment I, the suggested report content is shown below for the TA and MR Monthly NWP Comparison:

```
[HEADER]

Report Name:Aircraft-Based Observations Monthly NWP Comparison
```

```
Issuing Center: [Name of Center]

Report Period of Validity:[ yyyy-mm-dd hh:mm to yyyy-mm-dd hh:mm]

Comparison Standard:[Model Identity; Model field used for comparison]

Variables:[Air Temperature and Humidity]

Location of Monitoring Site:[Internet address]

ID: Aircraft identity

[Field Header:Field Description]

[etc]

[/HEADER]

[DATA]

ID; SUS; SUS_L; TAplNA; TAplNC; TAplNR; TAplNG; TAplMB; TAplSD; TApmNA; TApmNC;
TApmNR; TApmNG; TApmMB; TApmSD; TAphNA; TAphNC; TAphNR; TAphNG; TAphMB; TAphSD;
MRplNA; MRplNC; MRplNR; MRplNG; MRplMB; MRplSD; MRpmNA; MRpmNC; MRpmNR; MRpmNG;
MRpmMB; MRpmSD; MRphNA; MRphNC; MRphNR; MRphNG; MRphMB; MRphSD

[etc]

[/DATA]
```

Based on Attachment I, the suggested report content is shown below for the Winds Monthly NWP Comparison:

```
[HEADER]

Report Name:Aircraft-Based Observations Monthly NWP Comparison

Issuing Center: [Name of Center]

Report Period of Validity:[ yyyy-mm-dd hh:mm to yyyy-mm-dd hh:mm]

Comparison Standard:[Model Identity; Model field used for comparison]

Variables:[ Wind speed, wind direction and wind vector difference]

Location of Monitoring Site:[Internet address]

ID: Aircraft identity

[Field Header:Field Description]

[etc]

[/HEADER]

[DATA]

ID; SUS; SUS_L; WSplNA; WSplNC; WSplNR; WSplNG; WSplMB; WSplSD; WSpmNA; WSpmNC;
WSpmNR; WSpmNG; WSpmMB; WSpmSD; WSphNA; WSphNC; WSphNR; WSphNG; WSphMB; WSphSD;
WDplNA; WDplNC; WDplNR; WDplNG; WDplMB; WDplSD; WDpmNA; WDpmNC; WDpmNR; WDpmNG;
WDpmMB; WDpmSD; WDphNA; WDphNC; WDphNR; WDphNG; WDphMB; WDphSD; WMplNA; WMplNC;
WMplNR; WMplNG; WMplWVRMS; WMpmNA; WMpmNC; WMpmNR; WMpmNG; WMpmWVRMS; WMphNA;
WMphNC; WMphNR; WMphNG; WMphWVRMS

[etc]

[/DATA]
```

Requirements for WMO Lead Centres on Aircraft-Based Observations

WMO Lead Centers on Aircraft-Based Observations should provide the following functions and services to assist WMO Members in the quality management of their aircraft-based observing systems:

1. Receive process, archive and analyse monitoring reports from designated WMO Global and Regional Monitoring Centers for ABO.

2. Ensure WMO Focal Points on ABO receive monitoring reports and act upon issues arising from them.

3. Develop, implement and maintain an Incident Management System to record and manage faults or issues raised through the monitoring and quality evaluation processes.

4. Provide technical advice to assist Members in rectifying quality issues associated with their aircraft-based observing systems.

5. Establish and maintain an online facility that provides the suite of quality monitoring information and tools as described in Attachment III.

6. Compile an annual report to the Commission for Basic Systems/OPAG-IOS on the performance of the ABO system and the ABO quality monitoring system, high-lighting any important issues.

Requirements for Quality Monitoring and Quality Evaluation by Members

Quality Evaluation Information, Tools and Practices

The quality evaluation process for ABO can be described in terms of the structure and the related processes and practices that are depicted within Figure 2 above.

The quality evaluation centre (QEC) should be staffed by a suitable number of scientific officers that have:

1. A detailed understanding of the ABO system and its operation;

2. Scientific knowledge of metrological science and skills in scientific data analysis;

3. Skills and knowledge in quality management, systems incident management and report writing.

The QEC should have access to information and data that supports the quality evaluation processes. These include as a minimum:

1. Convenient access to the relevant available automated and other global, regional and national monitoring reports;

2. Access to the ABO data generated by the ABO system in a form that allows flexible and rapid rendering of the data for analysis, comparison, plotting, etc. A relational database storage of historical data (at least 2 years) is ideal.

3. Access to data analysis applications and tools, for example and as a minimum, a spreadsheet application with mathematical, mapping and graphical tools.

The QEC should utilize the incident management system of the organization for the registering and maintenance of errors and issues identified in the quality evaluation process.

The QEC should utilize the results of quality evaluation practices and results to identify systemic issues that might be addressed through the improvement of the ABO system operation through modification or changes to processes and procedures.

Results of quality evaluation analyses and resulting changes to the observing system should be notified, recorded and documented in line with national, regional and WMO quality management requirements and practices.

As a minimum, routine quality monitoring and quality evaluation practices and procedures undertaken by Member Quality Managers and Quality Evaluation Centers, should consist of the following:

- The production and use of outputs and reports of national programme data quality control processes (see [REF Annex I]).
- The reception and use of QM reports provided by WMO designated Lead Centres and WMO Monitoring Centres.
- The reception and use of reports provided by other global or regional monitoring Centres.
- The routine production and scrutiny of national QM reports.
- Routine analysis of all available QM outputs and reports.
- Initiation and completion of relevant incident management procedures for identified data quality errors and issues, including as a minimum:
    - Blacklisting of errant aircraft from reporting to the WIS;
    - Documentation and update of relevant metadata for recording of issues and errors;
    - Notification to data users and application areas;
    - Compliance with national, regional and global incident management systems operation and maintenance.
- Initiation and completion of relevant system and practice improvements required to rectify systemic errors or issues associated with or causing data quality issues.

Attachment I – Recommended Format for ABO Quality Monitoring Reports

It is proposed that ABO quality monitoring reports should conform to the following specification, providing a format that is both machine and human readable.

ABO monitoring reports should have the following features and properties:

- The reporting files should be provided as a text file with two distinct information blocks of Semicolon Separated Values (SSV).
- The reporting files should consist of a Header block and a Data block.
- The Header block should consist of at least one line of SSV information between the Header block markers: [HEADER][/HEADER].
- Each SSV in the report Header should consist of a Header Value Name and a header value separated by a colon: Header Value Name:header value. For example: Report Name: Daily Global Aircraft Observations QM Report

- Each line of the Header should end with a carriage return and line feed.
- The Data block should consist of at least two lines of SSV information between the Data block markers: [DATA][/DATA].
- The first line of the Data block should be a line of SSV information that contains the Field Headers of the data submitted within the Data block.
- Each line of the Data block should provide a SSV for each of the fields corresponding to the Field Headers provided in the Header block.
- Each line of the Data block should end with a carriage return and line feed.

```
[HEADER]
Header Value Name:header value;Header Value Name:header value;…
Header Value Name:header value;Header Value Name:header value;…
…
 [/HEADER]
[DATA]
Field Header 1; Field Header 2; Field Header 3;…
Field 1 value;Field 2 value;Field3 value;…
Field 1 value;Field 2 value;Field3 value;…
…
[/DATA]
```

Reported monitoring parameter Field Headers are listed below and will take the form VcX, where:

V is the variable indicator (e.g. TA = air temperature)

c is the category indicator (e.g. pl = low pressure category)

X is the statistic indicator (e.g. NA = number of available values)

e.g. TAplNA = number of air temperature values available in the low pressure category.

Non-statistical Field Headers	Description
ID	Aircraft identity (e.g. AU0001)
SUS	Suspect flag: Y = aircraft is flagged as suspect; N or no value = aircraft is not suspect
SUS_L	List (space delimited) of one or more Field Headers for which the aircraft has breached the criteria for being Suspect. Empty if not SUS. E.g. a value of “TAplNG TApmNG” would indicate that the aircraft was deemed suspect based on the number of gross errors for the LOW and MED pressure level categories for air temperature.

Field Headers For Statistical Parameters

Field Header Variable Indicator	Description
TA	Air temperature
WS	Wind speed
WD	Wind direction
WM	Wind vector difference magnitude
WU	Wind u component

WV	Wind v component
RH	Relative Humidity
MR	Water mixing ratio
RT	Report time
LA	Latitude
LO	Longitude
AS	Aircraft apparent speed

Field Header Category Indicator	Description
pl	In the low (altitude) pressure category
pm	In the mid (altitude) pressure category
ph	In the high (altitude) pressure category
d1	Calculated over 1 day
d3	Calculated over 3 days
d7	Calculated over 7 days (prior to the d3 category)
d9	Calculated over 9 days (prior to the d1 category)
ru	Range upper
rl	Range lower

Field Header Statistic Indicator	Description
NA	number of values available
NC	number of values compared
NR	number of values rejected
NG	number of values with gross errors against criteria
ND	daily average number of values available
SD	standard deviation of differences
MD	mean of differences (bias)
RMS	root mean square of differences
WVRMS	RMS of the magnitude of the wind vector difference
NZ	number of zero values

Attachment II – Criteria for the selection of aircraft having suspect observations

Note: This Attachment is still under development and review. It will be considerably revised prior to publication.

Variable	Unit	Report	% Gross Error	Minimum NC			Gross Error Difference			Mean Difference			RMS		
Pressure Levels			ALL	LOW	MID	HIGH	LOW	MID	HIGH	LOW	MID	HIGH	LOW	MID	HIGH
Air Temperature	Deg. C	Monthly	2	20	50	50	15.0	10.0	10.0	3.0	2.0	2.0	4.0	3.0	3.0
		Daily	2	20	50	50	15.0	10.0	10.0	3.0	2.0	2.0	4.0	3.0	3.0
		9-day	2	20	50	50	15.0	10.0	10.0	3.0	2.0	2.0	4.0	3.0	3.0
Wind Speed	m/s	Monthly	2	20	50	50	30.0	30.0	40.0	3.0	2.5	2.5	10.0	8.0	10.0
		Daily	2	20	50	50	30.0	30.0	40.0	3.0	2.5	2.5	10.0	8.0	10.0
		9-day	2	20	50	50	30.0	30.0	40.0	3.0	2.5	2.5	10.0	8.0	10.0
Wind Direction	Degrees	Monthly	2	20	50	50	90.0	90.0	90.0	10.0	10.0	10.0	50.0	50.0	50.0
		Daily	2	20	50	50	90.0	90.0	90.0	10.0	10.0	10.0	50.0	50.0	50.0
		9-day	2	20	50	50	90.0	90.0	90.0	10.0	10.0	10.0	50.0	50.0	50.0
Wind Vector Difference	m/s	Monthly	2	20	50	50	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
		Daily													
		9-day													
Humidity	% humidity	Monthly													
		Daily													
		9-day													

Note:

- The pressure level categories are:
  low: surface to 701 hPa
  mid: 700 to 301 hPa
  high: 300 hPa and above.

Attachment III – WMO Lead Centers on Aircraft-Based Observations Online Facilities Requirements

WMO Global or Regional Lead Centers on Aircraft-Based Observations should establish the following facilities to support quality monitoring and evaluation functions of Members.

1. Establishment and maintenance of a database of ABO data and NWP comparison statistics received from monitoring centres (at least 7 months of high resolution data and at least 2 years of daily resolution data from multiple monitoring centers) to support the server-side derivation and delivery of tabular and graphical information and diagnostics for the following parameters:
    a. Air Temperature (with NWP comparisons)
    b. Wind speed (with NWP comparisons)
    c. Wind direction (with NWP comparisons)
    d. Wind vector difference magnitude (with NWP comparisons)
    e. Humidity (with NWP comparisons)
    f. Turbulence
    g. Icing
    h. Pressure altitude
    i. Observation time
    j. Latitude
    k. Longitude

    The database should also support the flagging of data and the display of data based on the following quality checks carried out by the system in accordance with Annex I:

    a. Numerical Weather Model Comparison Check
    b. Range Check
    c. Static Value Check
    d. Temporal Variation Check
    e. Apparent Aircraft Velocity Check
2. Provision of the following graphical diagnostics for the above parameters:
    a. For individual aircraft, time series graph of ABO values and differences (high and low temporal resolution) with following configurable features:
        i. Time averaging (day, number of days, week, month, year)
        ii. Overlay of up to 50 aircraft
3. Provision (online viewing and downloading) of the following tabulated data for the above parameters:
    a. For individual or selectable set of aircraft, provide statistical reports constructed and generated based on the set of parameters (1 above), related flags and statistical formulations of parameter values as below:
        i. Values
        ii. Mean
        iii. Standard deviation
        iv. RMS
        v. Count

Annex III - Guidance on Encoding of Aircraft-based Observational Data for Transmission on the WIS

Introduction

The full aircraft-based observing system, of which the AMDAR observing system is a component system, comprises the end-to-end system of processes and practices, starting from measurement by aircraft sensors right through to the delivery of the data to data users. On the aircraft, Aircraft Data Computers (ADC) obtain, process and format data from onboard sensors. These observational data will be down linked together with metadata from the aircraft to the ground station and will, particularly in the case of AMDAR and ICAO Aircraft Reports, conform to standardized code formats used for telecommunications practices. Once on the ground the data are usually relayed to the National Meteorological and Hydrological Services (NMHSs), most often via the participating airline or an aviation authority, and other authorized users as shown within [REF Figure 1, section 1.6.1]. Data received at these data processing centers are decoded and undergo basic quality control checks before being reformatted for distribution to data users both internal to the NMHS and externally to other NMHSs via the WMO Global Telecommunication System (GTS). AMDAR data formats as used for the AMDAR Onboard Software (AOS) are described in the [REF AMDAR Onboard Software Functional Requirements Specification (AOSFRS), version 1.1 (WMO IOM-report 115, 2014)]. Other ABO data formats are described in [REF section 1.6 of this guide.

This Annex describes the detailed procedures for recompiling ABO data into encoded data and associated metadata for international distribution on the WMO Global Telecommunications System (GTS).

A general description of GTS messages and the process for assembling them is provided below.

More general requirements for provision of ABO on the GTS are provided within [REF section 1.9].

ABO Data Requirements

The data and observational metadata listed below are required to compile an aircraft-based observation within a report for automatic relay to a ground processing system and data distribution network. The data are derived from the aircraft sensor and navigation data acquisition system and further processed on board as required and as appropriate. At least the following observations variables and metadata shall be provided, if available, for each observation:

Observation Metadata:

Aircraft specific identification

1 Aircraft identifier (WMO Aircraft Registration Number)[1]

Positional information (related to a single level observation):

2 Latitude

3 Longitude

4 Pressure altitude (flight level)[2]

---

[1] See note 1 within [REF Attachment 1].

[2] Pressure altitude is a measure of height relative to the standard datum pane of 1013.25 hPa (see Manual on Codes – WMO-No. 306 Vol I.1 part A). In fact pressure altitude is the indicated height with an altimeter setting of 1013.25 hPa according to the International Standard Atmosphere (ISA). The standard atmosphere assumes a linear decrease in temperature with height of 6.5°C per kilometre up to 11 kilometres, and a mean sea level temperature and pressure of 15°C and 1013.25 hPa, respectively. From 11 kilometres to 20 kilometres the temperature is assumed constant at -56.5°C. Because the variable Flight Level

Timestamps (related to a single level observation)

5 Day and time of observation

Other metadata

6 Phase of flight

7 Observation number (optional)

Observation Variables:

8 Air temperature (Static air temperature)

9 Humidity (mixing ratio)

10 Wind vector, expressed as

a. wind direction

b. wind speed

11 Maximum wind speed during level flight

12 Turbulence (Eddy Dissipation Rate, EDR)

13 Icing

Introduction to Message Reporting

The WMO Information System (WIS) is the framework covering the coordinated global infrastructure responsible for the telecommunications and data management functions. The architecture enables exchange of observational data. Coded messages are used for the international exchange of meteorological information comprising observational data provided by the WWW Global Observing System that also includes aircraft-based and derived observations. All these messages are disseminated over the WMO Global Telecommunication System (GTS) linking regional and national telecommunication hubs located at meteorological centres. The encoded messages are composed of a set of Code Forms and Binary Codes and are usually called bulletins. Two types of WMO Code Forms are currently in practice, one code form that consists of binary values (in a Table Driven Codes Format, TDCF) and the other based on alphanumerical characters. Codes with observations that are encoded in the binary format are called BUFR (FM 94–XIV, “Binary Universal Form for the Representation of meteorological data”). For alphanumeric codes there are the so-called *Traditional Alphanumercial Codes* (TAC), primarily developed for historic communications facilities like telex, and a modern alternative, called CREX, based on a similar TDCF like BUFR (CREX: “Character form for the Representation and EXchange of data”). However, the WMO Commission for Basic Systems (CBS) has decided, and it has been approved that, from 11 November 2014, it is mandatory to use only the BUFR code, TAC would no longer be supported and transition from TAC to BUFR by Members should have been completed. Although TAC was phased out already in 2014, it is still in practice by some Members but will end when their transition to BUFR is completed. CREX is intended to be used as an interim solution for those Members, who are not yet able to fully transition to use of BUFR. Because of the limited relevance today of these WMO alphanumeric codes (TAC and CREX), only limited details are given here. For detailed description of TAC (e.g. code format FM42, ‘AMDAR’) and CREX it is recommended to consider the *Manual on Codes* (WMO-No. 306) and the WMO Codes website at: http://wis.wmo.int/ManCodes.

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equals Pressure altitude, altitude may be reported as Flight Level as well. Note that for observations below the level of 1013.25 hPa, Pressure Altitude or Flight Level shall be reported as negative values.

Apart from the recommended WMO code forms, another alphanumeric code form representing aircraft data is still disseminated over the GTS. These reports are generated and delivered by ICAO entities. To avoid duplications, ensure adequate data quality control and stimulate standardized coding, it has been recommended that, in compliance with ICAO regulations, only the two WAFC ("WAFC Washington" (Kansas) and "WAFC London" (Exeter)) may transmit or authorize the transmission of ICAO derived ABO messages (bulletins) on the GTS for global distribution (for more information see [REF section 1.6.2, 1.7, 1.8 and 1.9]. It is expected that national civil aviation authorities should comply with ICAO provisions to ensure that ICAO Aircraft Reports are sent to one or other of the WAFCs for this purpose.

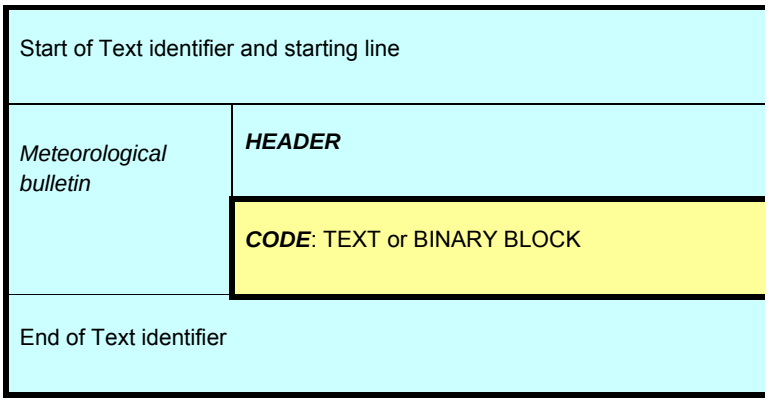
More details on the responsibilities related to data distribution over the GTS can be found in the *Manual on the GTS* (WMO-No. 386).

A bulletin might consist of a batch of (single level) observations from a single aircraft or observations from several aircraft. So a bulletin may contain one or more encoded reports or messages and one or more observations, but usually contains codes with the same format. For economic reasons it is common practice to collect codes within certain time intervals before dissemination as a bulletin. This interval however should be as short as possible to reduce data latency. It also is desirable to batch data in specific geographical regions. This will allow switching centres to direct data to appropriate users without the need to sort or filter individual observations.

Format used for meteorological messages

A meteorological message consists of one single meteorological bulletin. The lay-out of a message is formatted as follows:

Meteorological Message



As shown in this figure, the observational information is contained in the text or binary block. This block (i.e. the contents of the bulletin) is preceded by a start of text line and a heading and followed by an end-of-message identification. The bulletin itself consists of a header and a text/binary block. In practice the combination of Start-of-text line, header and end-of-text as shown above are regarded as the 'envelope' of the message. Information on this envelope relates to the origin of the message. It is common practice, but not always the case, that the message is generated by the same centre as the text/binary block is generated.

Description of the bulletin header

The header is formatted as follows:

$T_1T_2A_1A_2$ii CCCC YYGGgg (BBB)

Where:

T_1T_2 are the data type and/or form designators.

- For binary code messages T_1=**I**, for alphanumeric messages encoding upper-air data T_1 = **U**. For upper-air data encoded binary, T_2 = **U**.
- For upper-air alphanumeric encoded data, and T_2 = **A** or **D** in case of aircraft reports, where T_2 = **A** is used for FM41 (CODAR) or ICAO AIREP encoded data and T_2= **D** for FM42 (AMDAR) encoded data. (Note that both FM41 (CODAR) and FM42 (AMDAR) are now considered obsolete.)

A_1A_2 are geographical and/or data type designators (the first observation in the bulletin prevails).

- For Binary encoded data (*i.e.* with T_1T_2 = **IU**), A_1 = **A** for single level observations (both automatic and manual observed, *i.e.* both AMDAR and AIREP) and A_1 = **O** for profiles of AMDAR related aircraft observations in ascending or descending flight phase[3]. A_2 indicates the geographical region appropriate for the observations.

Note: A distinction between AMDAR and AIREP can only be made using the Data Category/subcategory values in section 1 of the BUFR message itself, as documented in the [REF Manual on Codes (WMO-No. 306), Vol. I.2, Common Code Table C13: Data sub categories of *categories defined by entries in BUFR Table A*]*;* see also [REF Manual on the GTS, WMO-No. 386, Vol. I, Part II, Attachment II.5, *Table C6*].

The appropriate geographical region indicator A_2 is defined in the [REF Manual on the GTS, WMO-No. 386, Vol. I, Part II, Attachment II.5, Table C3, Geographical area designator A_2], and presented in the following tables (figure 1) and figure 2:

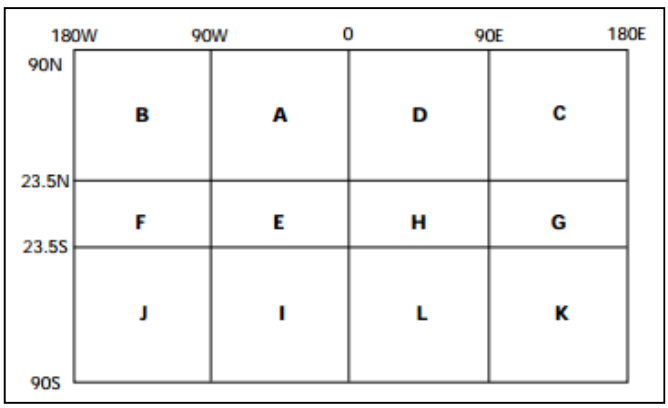


Figure 1

Designator	Geographical area		Designator	Geographical area	
A	0° – 90°W	northern hemisphere	I	0° – 90°W	southern hemisphere
B	90°W –180°	northern hemisphere	J	90°W – 180°	southern hemisphere
C	180° – 90°E	northern hemisphere	K	180° – 90°E	southern hemisphere
D	90°E – 0°	northern hemisphere	L	90°E – 0°	southern hemisphere
E	0° – 90°W	tropical belt	N	Northern hemisphere	
F	90°W – 180°	tropical belt	S	Southern hemisphere	
G	180° – 90°E	tropical belt	T	45°W – 180°	northern hemisphere
H	90°E – 0°	tropical belt	X	Global area (area not definable)	

Figure 2

[3] BUFR template or common sequences [3 11 008] and [3 11 009] (Aircraft ascent/descent profile) may be used for reporting AMDAR profiles. However it is recommended to report sets of single level observations according to BUFR template [3 11 010] (BUFR template for AMDAR, version 7)

Notes:

1. If the BUFR bulletin contains data from several aircraft flying in different sectors of the globe, X should be coded 'X'.

2. The tropical belt is defined to be within 23.5° N and 23.5° S.

3. A_1A_2 (for TAC) or A_2 (for BUFR) indicate geographical region appropriate for the first observation in the bulletin.

o For upper-air alphanumeric encoded data (i.e. with T_1T_2 = **UA** or **UD**, used for AIREP and FM42[4] respectively), A_1A_2 indicates the geographical region appropriate for the observations. Details are published in the Manual on the GTS, WMO-No. 386, Vol. I, Part II, Attachment II.5, Table C1, "Geographical designators A_1A_2" (with preference for Part II – Area designators, prevailing over Part I, National designators), see figure 3 below:

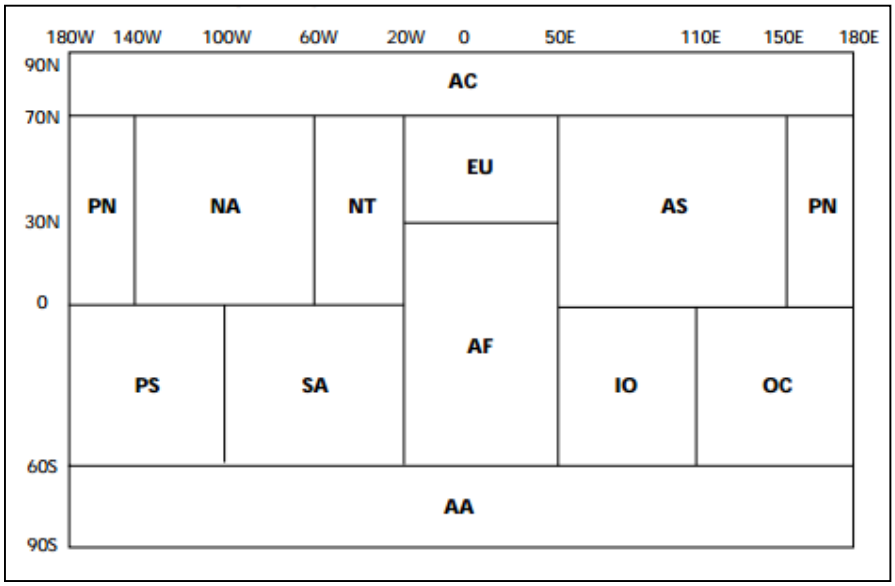


Figure 3

For further details on the old geographical and/or data type designators used for TAC encoded bulletins, see [REF AMDAR Reference Manual (WMO-No. 958, 2003)].

ii Shall be a number with two digits (starting with '01'). When an originator or compiler of bulletins issues two or more bulletins with the same $T_1T_2A_1A_2$ and CCCC the ii shall be used to differentiate the bulletins and will be unique to each bulletin.

Note: ii has no significance for BUFR encoded AMDAR bulletins (i.e. with T_1T_2 = **IU**). For AIREP bulletins, encoded in TAC (*i.e.* with T_1T_2 = **UA**), the following rule should be followed (see details in [REF Manual on the GTS, WMO-No. 386, Vol. I, Part II, Attachment II.5, Table D3, "Level designator ii (when T1T2 = FA or UA)"]):

[4] TAC code formats, FM41 and FM42 are considered obsolete from 11 November 2014 and thus, when this transition is complete, it should be expected that all ABO bulletins would use only the BUFR code format with T_1T_2 = **IU**.

T_1T_2	Designator ii	Data type	Code form (name)
UA	01–59	Routine aircraft reports	ICAO AIREP
UA	60–69	Special aircraft reports, except for volcanic ash	ICAO AIREP
UA	70–79	Special aircraft reports, related to volcanic ash	ICAO AIREP
UA	80–99	Routine aircraft reports	ICAO AIREP

Note: Noting that there is no known use of the series 80–99, these series were allocated to routine aircraft reports up to 1 September 2008. After 1 September 2008, the series are reserved for future use.

Figure 4: Extract from [REF Manual on the GTS, WMO-No. 386, Vol. I, Part II, Attachment II.5, Table D3, "Level designator ii (when T1T2 = FA or UA)"]

CCCC: International four-letter location indicator of the station or centre originating or compiling the bulletin, as agreed internationally, and published in [REF Weather Reporting (WMO-No. 9), Volume C1 – Catalogue of Meteorological Bulletins, Annex I].

Notes:

1. Once a bulletin has been originated or compiled, the CCCC may not be changed. However, if the contents of a bulletin is changed or recompiled afterwards by another centre for any reason, the CCCC should be changed to indicate the centre or station making the change.
2. Originating/generating centres are also reported within each BUFR bulletin (in [REF Section 1, descriptor 0-01-035; see Manual on Codes (WMO-No. 306), Volume I.2, Common Code Table C-11])

YYGGgg: International date-time group, where:

YY: Day of the month,

GGgg: The time of compilation in UTC (hour and minute)

Note: Only day (of month), hour and minute are given. Year, month, or seconds are not provided.

BBB (without brackets if reported): Because an abbreviated heading defined by $T_1T_2A_1A_2$ ii CCCC YYGGgg shall be used only once, for any addition, a correction or an amendment, it shall be mandatory to add an appropriate BBB indicator. The BBB indicator shall have the following forms: RRx for additional or subsequent issuance of bulletins; CCx for corrections to previously relayed bulletins; AAx for amendments to previously relayed bulletins; where x is an alphabetic character of A through X as described in the [REF Manual on the GTS (WMO-No. 386), Attachment II-12].

Description of the bulletin codes

The relevant contents of a bulletin is within the code block. As explained above this block is an encoded block built up of purely binary information, usually called BUFR. In the past this block was in an ASCII compatible format, called TAC. Some bulletin originating centres, like centres associated with ICAO related ABO observations, still produce these type of TAC based bulletins, but as already stated, this practice is obsolete and expected to be phase out soon.

For a description of the obsolete TAC code blocks, see [REF Manual on Codes (WMO-No. 306) Vol I.1, Part A, Alphanumeric Codes].

Description of the BUFR code (FM 94)

A BUFR message is a continuous binary data stream. It is organised into 6 sections. Section 0 is 64 bits, fixed length and is used to indicate the type and length of the total message. Sections 2-4 are variable in length and contain data descriptors and data. Section 5 is 32 bits, fixed content to indicate the end of the BUFR message. The content of each section is best shown in tabular form. This mimics the BUFR encoding process. The contents of each section are organised into 8 bit bytes, called 'octets'. A constraint placed on all sections is that they must contain an even number of complete octets. Detailed information on these Table-Driven Code Forms (TDCF) can be found in the [REF Manual on Codes (WMO-No. 306)] and the most current versions are available from [REF http://wis.wmo.int/ManCodes].

Table I: Basic Structure of a BUFR bulletin code:

Section Number	Name	BUFR Table (see Manual on Codes (WMO-No. 306)	Remarks
0	Indicator section		Starting with "**BUFR**"; length of message, BUFR edition number
1	Identification section	Table A – Data category	Length of section, **identification of the message**. For AMDAR, use code figure 4, "Single level upper-air data (other than satellite)"
2	Optional section		Length of section and additional items for local use by automatic data processing centres. Not required for AMDAR
3	Data description section	Table B – Classification of elements Table C – Data description operators Table D – List of common sequences	Length of section, number of data subsets, data category flag, data compression flag and **a collection of descriptors** which define the form and content of individual data elements
4	Data section	Table B – Classification of elements Table C – Data description operators Table D – List of common sequences	Length of section and **binary data**
5	End section		Ending with "**7777**"

Within the BUFR bulletin, the most relevant sections are section 1 (Identification section, containing metadata of the bullet itself), and sections 3 and 4 (Data description and Data section, respectively). Typically, section 3 presents the list of descriptors and common sequences for the datasets, reported in section 4.

Descriptors

Variables, code tables and other elements are represented by so-called descriptors. Schematically, a BUFR descriptor can be visualized as follows:

F	X	Y
2 BITS	6 BITS	8 BITS

F denotes the type of descriptor. With 2 bits, there are 4 possible values for F: 0, 1, 2 and 3. The four values have the following meanings:

F = 0 - Element descriptor, and refers to Table B entries

F = 1 - Replication operator

F = 2 - Operator descriptor, and refers to Table C entries

F = 3 - Sequence descriptor, and refers to Table D entries

The meanings of and uses for X and Y depend on the value of F. Evidently, for variables and code tables most relevant are the values for F = 0 or 3. For these values, the descriptor refers to BUFR Tables B or D. X (6 bits) indicates the class or category of descriptor within the Table. In case F=0 reference is made to single variables or predefined table values. For instance, F-X-Y = 0-12-101 stands for “Temperature/air temperature” (Class 12, “Temperature”, is represented with X=12. In case F=3 (Sequence descriptor, used for templates), Category 11 – Single level report sequences (conventional data) – is used to represent AMDAR data, so X=11. For instance, F-X-Y = 3-11-010 for the “BUFR template for AMDAR, version 7”.

Tables

As indicated in this table, references are made to four tables, which are the base of this table driven code format:

Table A – Data category. In fact the data category provides a quick check for the type of data represented in the message

Table B – Classification of elements (F=0). Table B is the heart of the data description language for BUFR. First, each individual parameter, or element, defined for use in BUFR is assigned an element name and a descriptor value (values for the F, X, and Y parts of the descriptor as described above). As noted above, the value of F for all descriptors in Table B is 0 (zero). The X part of the descriptor is determined by organizing all the possible parameters into a set of classes based on their nature (e.g., X=11 for temperature parameters, X=12 for wind parameters, or X=13 for Hydrographic and hydrological elements including moisture parameters). The Y part of the descriptor is the entry within a Class X of the parameter (*e.g.* Y=101 in F-X-Y = 0-12-101 for “Temperature/air temperature”)

Table C – Data description operators (F=2). These are used when there is a need to redefine Table B attributes temporarily, such as the need to change data width, scale or reference value of a Table B entry. Table C is also used to add associated fields such as quality control information, indicate characters as data items, and signify data width of local descriptors.

Table D – List of common sequences (F=3). A group of data items always transmitted can be defined in what is called a common sequence descriptor, so that, the individual element descriptors will not need to be repeated each time in the data description section. It is only the common sequence descriptor, which will be listed in the data description section. For AMDAR

BUFR bulletins, F-X = 3-11 – “Single level report sequences (conventional data)”. A typical example of a common sequences is:

TABLE REFERENCES				TABLE REFERENCES			
F	X	Y		F	X	Y	
3	01	011	Year, month, day	0	04	001	Year
				0	04	002	Month
				0	04	003	Day

Value representation

Descriptors referring to numerical values and defined in Table B are integers based on four such characteristics: unit, scale, reference value, and data width (in bits).

- Units: In most cases, the basic (SI) units for the element. However, numeric, character, code table, or flag table are also possible.
- Scale: The power of 10 by which the element has been multiplied prior to encoding.
- Reference value: A number to be subtracted from the element, after scaling (if any), and prior to encoding.
- Data width (bits): The number of bits the element requires for representation in Section 4.

The table below presents two typical examples, used for encoding AMDAR data.

TABLE REFERENCE	ELEMENT NAME	***BUFR***			
F X Y		UNIT	SCALE	REFERENCE VALUE	DATA WIDTH (Bits)
0 12 101	Temperature/air temperature	K	2	0	16
0 11 101	Aircraft ground speed u-component	m s^{-1}	1	–4096	13

Note: Where a code table or flag table is appropriate, “code table” or “flag table”, respectively is entered in the UNITS column of Table B.

To encode values into BUFR, the data (with units as specified in the UNIT column) must be multiplied by 10 to the power SCALE. Then subtract the REFERENCE VALUE to give the coded value found in Section 4 of the BUFR message. For example, an aircraft ground speed u-component is –200 m s^{-1}. The descriptor is 0 11 101 and the encoded value is -200×10^1 – (-4096) = 2096. Or, if the air temperature is –70.32°C (202.83 K), for descriptor 0 12 101 the encoded value is 203.5×10^2 – (0) = 20383 (a data width of 16 bits implies a maximum value of 2^{16} -1 = 65535)

Note:

- Missing values shall be set to fields of all ones (e.g. each octet shall be set to 11111111 binary). This shall apply to code tables as well as data elements; flag tables shall be augmented to contain a missing indicator bit where this is deemed to be necessary.
- UNIT is the basic unit before scaling.

Lists of Common Sequences (Templates)

Although each data centre may define its own set of variables to be disseminated over the GTS it is recommended to follow a standard approach based on predefined lists of variables. Such a list or table containing a predefined set of variables and other parameters is called a List of Common Sequence, or "template". For all type of observing systems standard templates are developed and endorsed to be implemented. For each type of observing system, like the ABO system, a category is defined. Aircraft based observations belong to "Single level upper-air data (other than satellite)" using the templates in category 11, " Single level report sequences (conventional data)". The overview of all Lists of Common Sequences (templates) is maintained in BUFR Table D of the Manual on Coded (see REF WMO-No. 306, Vol I.2 - International Codes, Part B (for BUFR) and C (for CREX). There are 11 templates for BUFR encoded aircraft based observations and 9 templates for CREX encoded aircraft based observations (note that CREX will become obsolete in the near future when all bulletins will report BUFR only).

Recommended BUFR templates

Although a number of 11 BUFR templates are defined for ABO observations, it is highly recommended to use only one of such template to be regarded as a standard. All others, except those for dedicated observations, must be regarded as obsolete. Such obsolete templates are kept in force during a transitional phase towards the recommended template, or for archive practices.

The following templates are the recommended standard templates to be used for ABO:

1. [3 11 010] "template for AMDAR, version 7"
2. [3 11 011] "IAGOS template for a single observation, version 2"[5]

Template [3 11 010] is the recommended standard template for all types of aircraft-based observations.

Template [3 11 011] is developed in addition to the standard template to provide observations and derived data related to aerosol and chemical components to support the ongoing research of the chemical composition of the atmosphere.

For the further development of the WMO Integrated Global Observing System (WIGOS) framework these standard templates were developed making it suitable to deliver all types of possible observations (or derived data), performed on board aircraft, including ICAO Aircraft Reports.

The standard and general "template for AMDAR, version 7" [3 11 010] described and explained in detail in [REF Attachment 1] to this annex. For completeness, a brief description of the special template "IAGOS template for a single observation, version 2" [3 11 011] is presented in [REF Attachment 2]. The associated code and flag tables are given in [REF Attachment 3] Encoding of Other ABO Data Sources.

Other sources of ABO that are described within [REF section 1.6.3] should be disseminated over the GTS using the same BUFR format as described within [REF Attachment 1]. This Attachment contains a table with columns indicating what descriptors should be used (i.e. are mandatory) or refer to variables, defined by then other data sources.

These data typically sourced from commercially operated observing systems, such as the Panasonic Avionics Corp. TAMDAR system and the FLYHT Aerospace Solutions AFIRS system. These may be available on the GTS, depending on the arrangements between the contracting NMHS and the vendor for the purchase of the data.

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[5] IAGOS stands for "In-service Aircraft for a Global Observing System", an European Research Infrastructure conducting long-term observations of atmospheric composition, aerosol and cloud particles on a global scale from commercial aircraft of internationally operating airlines.

Other (obsolete) BUFR templates

Although the BUFR "template for AMDAR Version 7" is recommended for use with all ABO (also for reporting profiles), other templates are still in practice or were used in the past. For a reference to these older BUFR templates see [REF Attachment 4] to this annex.

Description of the obsolete TAC codes (FM41, FM42, AIREP)

While it is expected that all ABO reports will eventually be disseminated in BUFR only, a number of bulletins are still generated and transmitted on the GTS in the alphanumeric format. Code tables used in the past for reporting ABO are FM-41 ("CODAR") and FM-42 ("AMDAR"). Details on both formats can be found in [REF Manual on Codes (WMO-No. 306) Vol I.1, Part A, Alphanumeric Codes].

Based on a mutual agreement with the International Civil Aviation Organization (ICAO), and in line with [REF Technical Regulations, WMO-No. 49, Vol II), aircraft-based observations or derived meteorological data are provided from ICAO associated centres (WAFCs). Such observations can be generated on board manually (e.g. by pilots) or automatically. Derived data is generated on ground after dedicated processing of specific measurements, reported by aircraft. Although the recommended format is the standard BUFR template, the observations, reported by the aircraft ("aircraft reports", or AIREPs) are provided in an alphanumerical format. This ICAO AIREP format is in fact an enhancement of the obsolete FM41 ("CODAR") format. For a detailed description of the encoding of ICAO AIREPs and ABO Derived from ICAO Aircraft Reports, see [REF Attachment 5].

Attachment 1, BUFR template for AMDAR, version 7 (table reference 3 11 010)

				Mandatory [8], see [REF 1.5.1]	Element Name	Sequence Descriptor (BUFR Table D/B)	Related Descriptor (BUFR Table B)	Resolution and unit/table/ numeric	AOSFRS Version1.1 [REF IOM-115], Appendix A	FM42 symbol [9]	AIREP symbol [10]	Notes
						F X Y	F X Y					
Metadata				M	Aircraft registration number or other identification	0 01 008	0 01 008	*	Table 18, AMDAR Aircraft Identifier	I_A. . . I_A	I_A. . . I_A	[1]; * Max 8 characters, preferable 'AANNNN'; to be implemented for AIREPS
					Observation sequence number	0 01 023	0 01 023	numeric	N/A			[2]
					Aircraft flight number	0 01 006	0 01 006	*	Not documented			[1]; * 8 characters, ICAO code
					Aircraft tail number	0 01 110	0 01 110	*	Not documented			* 6 characters
					Origination airport	0 01 111	0 01 111	*	Table 18, Departure Airport			* 3 characters, ICAO (IATA?) code
					Destination airport	0 01 112	0 01 112	*	Table 18, Arrival Airport			* 3 characters, ICAO (IATA?) code
					Add associated field	2 04 002	2 04 002	Descriptor operator	N/A			[3]; Y=2, so 2 bits extra for indicator of quality (see next field)
					Associated field significance	0 31 021	0 31 021	Code table				[3], [4]; two bits quality information. Possible values: 7 and 8 (see [4]), but 8 is recommended.
				M	Year	3 01 011	0 04 001	numeric	(not provided)			Year (UTC, 4 digits format)
				M	Month		0 04 002	numeric	(not provided)			Month (UTC, 2 digits format)
				M	Day		0 04 003	numeric	Table 6, value = 1 to 31; table 19	YY	YY	Day (UTC, 2 digits format)
				M	Hour	3 01 013	0 04 004	numeric	Table 6, based on HHMMSS format,000000 to 235959 (0 refers to start of day) ; table 19 for ACARS	GG	GG	Hour (UTC, 2 digits format)

				Mandatory [8], see [REF 1.5.1]	Element Name	Sequence Descriptor (BUFR Table D/B) F X Y	Related Descriptor (BUFR Table B) F X Y	Resolution and unit/table/ numeric	AOSFRS Version1.1 [REF IOM-115], Appendix A	FM42 symbol [9]	AIREP symbol [10]	Notes
				M	Minute		0 04 005	numeric	Table 6, based on HHMMSS format,000000 to 235959 (0 refers to start of day) ; table 19 for ACARS	gg	gg	Minute (UTC, 2 digits format)
					Second		0 04 006	numeric	Table 6, based on HHMMSS format,000000 to 235959 (0 refers to start of day) ; table 19 for ACARS			Second (UTC, 2 digits format)
				M	Latitude (high accuracy)	3 01 021	0 05 001	10^{-5} °	Table 6; Table 19 for ACARS; Latitude in seconds	$L_aL_aL_aL_aA$	$L_aL_aL_aL_aA$	Expressed in degrees, WGS84, south is negative
				M	Longitude (high accuracy)		0 06 001	10^{-5} °	Table 6; Table 19 for ACARS; Longitude in seconds	$L_oL_oL_oL_oL_oB$	$L_oL_oL_oL_oL_oB$	Expressed in degrees, WGS84,west is negative
				M	Flight level (Pressure Altitude)	0 07 010	0 07 010	1 m	Table 6; Table 19 for ACARS	$S_hh_lh_lh_l$	$S_hh_lh_lh_l$	[11]; Pressure altitude is with reference to 1013.25 hPa, not MSL (like altitude)
				[M]	Global navigation satellite system altitude	0 10 053	0 10 053	1 m	Table7; Table 20 for ACARS			[12] WGS84 as reference system. Correction for GEOID96 to be considered.
				M	Detailed phase of flight	0 08 009	0 08 009	Code table	Table 6, paragraph 3.3.1; Table 19 for ACARS	$i_pi_pi_p$	$i_pi_pi_p$	
wind				M	Wind Direction	0 11 001	0 11 001	1°	Table 6; Table 19 for ACARS	ddd	ddd	In degree true North (so, not magnetic North)
				M	Wind speed	0 11 002	0 11 002	0.1 m s^{-1}	Table 6; Table 19 for ACARS	fff	fff	In m/s, so not kt
Aircraft speed					Aircraft roll angle quality	0 02 064	0 02 064	Code table	Table 4 and 6, paragraph 3.2.4.4; Table 19 for ACARS			
					Aircraft true airspeed	0 11 100	0 11 100	0.1 m s^{-1}	Table7; Table 20 for ACARS			
					Aircraft ground speed u-component	0 11 101	0 11 101	0.1 m s^{-1}	Table7; Table 20 for ACARS			

				Mandatory [8], see [REF 1.5.1]	Element Name	Sequence Descriptor (BUFR Table D/B) F X Y	Related Descriptor (BUFR Table B) F X Y	Resolution and unit/table/ numeric	AOSFRS Version1.1 [REF IOM-115], Appendix A	FM42 symbol [9]	AIREP symbol [10]	Notes
					Aircraft ground speed v-component	0 11 102	0 11 102	0.1 m s^{-1}	Not documented			May be derived from wind speed and direction.
					Aircraft ground speed w-component	0 11 103	0 11 103	0.1 m s^{-1}	Not documented			May be derived from wind speed and direction.
					Aircraft true heading	0 11 104	0 11 104	1 °	Table7; Table 20 for ACARS			In degree true North (so, not magnetic North)
Temperature					Temperature/air temperature	0 12 101	0 12 101	0.01 K	Table 6; Table 19 for ACARS	SST_ATATA	SST_ATATA	Static air temperature (SAT); high resolution (0.01 K), chosen for correct conversion from kelvintemperature to celsiustemperature.
humidity					Aircraft humidity sensors	0 02 170	0 02 170	Code table	Table 25 and Appendix C.2			See list in code table 0 02 170
					Change data width	2 01 144	2 01 144	Descriptor operator				[3], [7]; Y = 144, so add (144-128) = 16 bits to the default width (14) to become 30.
					Change scale	2 02 133	2 02 133	Descriptor operator				[3], [7]; Y = 133, so add (133-128) = 5 to the default scale (5) to become 10.
				[M]	Mixing ratio	0 13 002	0 13 002	10^{-10} kg/kg	Appendix C.2			Mixing ratio with enhanced resolution, see [7]
					Change scale	2 02 000	2 02 000	Descriptor operator				Reset scale to default (5)
					Change data width	2 01 000	2 01 000	Descriptor operator				Reset data width to default (14 bits)
					Change data width	2 01 135	2 01 135	Descriptor operator				[3], [7]; Y = 135, so add (135-128) = 7 bits to the default width (7) to become 14
					Change scale	2 02 130	2 02 130	Descriptor operator				[3].[7]; Y = 130, so add (130-128) = 2 to the default scale (0) to become 2.

	Mandatory [8], see [REF 1.5.1]	Element Name	Sequence Descriptor (BUFR Table D/B) F X Y	Related Descriptor (BUFR Table B) F X Y	Resolution and unit/table/ numeric	AOSFRS Version1.1 [REF IOM-115], Appendix A	FM42 symbol [9]	AIREP symbol [10]	Notes
		Relative humidity	0 13 003	0 13 003	0.01 %	Appendix C.2	UUU	UUU	Relative humidity with enhanced resolution
		Change scale (to default)	2 02 000	2 02 000	Descriptor operator				Reset scale to default (0)
		Change data width (to default)	2 01 000	2 01 000	Descriptor operator				Reset data width to default (7)
		Delayed replication of 1 descriptor	1 01 000	1 01 000	replication descriptor				[5]; Y=0, so delayed.
		Short delayed descriptor replication factor	0 31 000	0 31 000	*(related to replication descriptor)*				[6] (1 bit)
		Dewpoint temperature	0 12 103	0 12 103	0.1 K	Not documented	$SST_dT_dT_d$		
		Moisture quality	0 33 026	0 33 026	Code table	Table 26 in Appendix C.2			See code table
icing		***Delayed replication of 1 descriptor***	1 01 000	1 01 000	replication descriptor				[5]; Y=0, so delayed.
		Short delayed descriptor replication factor	0 31 000	0 31 000	*(related to replication descriptor)*				[6] (1 bit)
	[M]	Airframe icing present	0 20 042	0 20 042	Code table	Table7; Table 20 for ACARS			Present or not pesent
Liquid water		*Delayed replication of 3 descriptors*	1 03 000	1 03 000	replication descriptor				[5]; Y=0 so delayed.
		Short delayed descriptor replication factor	0 31 000	0 31 000	*(related to replication descriptor)*				[6] (1 bit)
		Peak liquid water content	0 20 043	0 20 043	10^{-4} kg m^{-3}	Not documented			

				Mandatory [8], see [REF 1.5.1]	Element Name	Sequence Descriptor (BUFR Table D/B) F X Y	Related Descriptor (BUFR Table B) F X Y	Resolution and unit/table/ numeric	AOSFRS Version1.1 [REF IOM-115], Appendix A	FM42 symbol [9]	AIREP symbol [10]	Notes
					Average liquid water content	0 20 044	0 20 044	10^{-4} kg m^{-3}	Not documented			
					Supercooled large droplet (SLD) conditions	0 20 045	0 20 045	Code table	Not documented			Present or not present
					Delayed replication of 1 descriptor	1 01 000	1 01 000	replication descriptor				[5]; Y=0 so delayed.
					Short delayed descriptor replication factor	0 31 000	0 31 000	*(related to replication descriptor)*				[6] (1 bit)
					ACARS interpolated values indicator	0 33 025	0 33 025	Code table	Not documented			
turbulence					***Delayed replication of 3 descriptors***	1 03 000	1 03 000	replication descriptor				[5]; Y=0 so delayed.
					Delayed descriptor replication factor	0 31 001	0 31 001	*(related to replication descriptor)*				[6] (8 bit)
					Mean turbulence intensity (eddy dissipation rate)	0 11 075	0 11 075	0.01 $m^{2/3}$ s^{-1}	see paragraph 3.3.5 and appendix C.1.2			
					Peak turbulence intensity (eddy dissipation rate)	0 11 076	0 11 076	0.01 $m^{2/3}$ s^{-1}	see paragraph 3.3.5 and appendix C.1.2			
					Extended time of occurrence of peak eddy dissipation rate	0 11 039	0 11 039	Code table	see paragraph 3.3.5 and appendix C.1.2			
					Delayed replication of 2 descriptors	1 02 000	1 02 000	replication descriptor				[5]; Y=0 so delayed.
					Short delayed descriptor replication factor	0 31 000	0 31 000	*(related to replication descriptor)*				[6] (1 bit)

Mandatory [8], see [REF 1.5.1]	Element Name	Sequence Descriptor (BUFR Table D/B) F X Y	Related Descriptor (BUFR Table B) F X Y	Resolution and unit/table/ numeric	AOSFRS Version1.1 [REF IOM-115], Appendix A	FM42 symbol [9]	AIREP symbol [10]	Notes
[M]	Turbulence index	0 11 037	0 11 037	Code table	Table7; Table 20 for ACARS; see paragraph 3.3.5 and appendix C.1.2	TBB_A		Equivalent to Eddy Decipitation Rate (EDR)
	Reporting interval or averaging time for eddy dissipation rate	0 11 077	0 11 077	1 s	see paragraph 3.3.5 and appendix C.1.2			
	Delayed replication of 3 descriptors	1 03 000	1 03 000	replication descriptor				[5]; Y=0 so delayed.
	Short delayed descriptor replication factor	0 31 000	0 31 000	*(related to replication descriptor)*				[6] (1 bit)
	Vertical gust velocity	0 11 034	0 11 034	0.1 m s^{-1}	Appendix C.1.1	$VGf_gf_gf_g$		
	Vertical gust acceleration	0 11 035	0 11 035	0.01 m s^{-2}	Appendix C.1.1			
	Maximum derived equivalent vertical gust speed	0 11 036	0 11 036	0.1 m s^{-1}	Appendix C.1.1			
	Add associated field (cancel)	2 04 000	2 04 000	Descriptor operator				Cancel *associated field*
	Delayed replication of 19 descriptors	1 19 000	1 19 000	replication descriptor				[5]; Y=0 so delayed.
	Delayed descriptor replication factor	0 31 001	0 31 001	*(related to replication descriptor)*				[6] (1 bit)
	Year	3 01 011	0 04 001	numeric	Table 6; Appendix C.1.1			
	Month		0 04 002	numeric	Table 6; Appendix C.1.1			
	Day		0 04 003	numeric	Table 6; Appendix C.1.1			
	Hour	3 01 013	0 04 004	numeric	Table 6; Appendix C.1.1			

				Mandatory [8], see [REF 1.5.1]	Element Name	Sequence Descriptor (BUFR Table D/B) F X Y	Related Descriptor (BUFR Table B) F X Y	Resolution and unit/table/ numeric	AOSFRS Version1.1 [REF IOM-115], Appendix A	FM42 symbol [9]	AIREP symbol [10]	Notes
					Minute		0 04 005	numeric	Table 6; Appendix C.1.1			
					Second		0 04 006	numeric	Table 6; Appendix C.1.1			
					Latitude (high accuracy)	3 01 021	0 05 001	10^{-5} °	Table 6			
					Longitude (high accuracy)		0 06 001	10^{-5} °	Table 6			
					Height	0 07 007	0 07 007	1 m	(not documented) recommendation: use pressure altitude			Instead of height, pressure altitude (Flight Level should be reported); for height, no reference pane is defined.
					EDR algorithm version	0 11 105	0 11 105	numeric	See paragraph 3.3.5			Data width = 6 bits, so value = 0..63
					Add associated field	2 04 007	2 04 007	Descriptor operator				[3]; Y=7, so 7 bits
					Associated field significance	0 31 021	0 31 021	Code table				[3], [4]; Code figure to be 7, percentage confidence
					Peak turbulence intensity (eddy dissipation rate)	0 11 076	0 11 076	0.01 $m^{2/3}$ s^{-1}	see paragraph 3.3.5 and appendix C.1.2			
					Mean turbulence intensity (eddy dissipation rate)	0 11 075	0 11 075	0.01 $m^{2/3}$ s^{-1}	see paragraph 3.3.5 and appendix C.1.2			
					Add associated field (cancel)	2 04 000	2 04 000	Descriptor operator				Cancel *associated field*
					Running minimum confidence	0 11 106	0 11 106	numeric	(not documented)			Scale = 1, Data width = 4 bits, so value = 0, 10, 20, .. 150
					Maximum number bad inputs	0 11 107	0 11 107	numeric	(not documented)			Scale = 0, Data width = 5 bits, so value = 0 .. 31
					Peak location	0 11 108	0 11 108	numeric	(not documented)			Scale = 1, Data width = 4 bits, so value = 0, 10, 20, .. 150

				Mandatory [8], see [REF 1.5.1]	Element Name	Sequence Descriptor (BUFR Table D/B)	Related Descriptor (BUFR Table B)	Resolution and unit/table/ numeric	AOSFRS Version1.1 [REF IOM-115], Appendix A	FM42 symbol [9]	AIREP symbol [10]	Notes
						F X Y	F X Y					
					Number of good EDR	0 11 109	0 11 109	numeric	(not documented)			Scale = 0, Data width = 4 bits, so value = 0 .. 15
					Temperature/air temperature	0 12 101	0 12 101	0.01 K	Table 6; Table 19 for ACARS			
					Wind direction	0 11 001	0 11 001	1°	Table 6; Table 19 for ACARS			
					Change data width	2 01 130	2 01 130	Descriptor operator				[7] ;Y = 130, so add (130-128) = 2 bits to the default width (8) to become 10
					Wind speed	0 11 084	0 11 084	1 kt	Table 6; Table 19 for ACARS			Data width = 10, scale = 0, so value = 0 .. 1023
					Change data width (to default)	2 01 000	2 01 000	Descriptor operator				Reset Data width to default (8)

Notes on this table:

[1] Care should be taken to use an appropriate identifier. Such an identifier should be a unique identifier related to one single and unique aircraft only (like the aircraft tail number is and which should not be encoded here but is provided, if available, via 0 01 110). The wording 'aircraft identifier' was first used in TAC code FM42, indicated by $I_A...I_A$. For further details see AMDAR Reference Manual (WMO-No. 958, 2003). This identifier should not be confused with 'Aircraft flight number', which is represented by descriptor 0-01-006 and should only ever be used to encode an aviation or airline assigned flight number, if it is available. The recommended and preferred format to be used for AMDAR is XXnnnn, where XX is a fixed character string representing the country in which the aircraft is registered or representing the national or regional AMDAR programme and nnnn is a unique number assigned to the aircraft within the fleet of the programme. For example, for aircraft identity EU0001, EU represents the EUMETNET AMDAR programme and 0001 is a number that uniquely identifies a particular aircraft within the EU AMDAR fleet. Members shall ensure that the XX identity is unique to the programme by obtaining approval for use of the designator from WMO.

[2] The sequence number is a simple observation count to be included in the down linked message. It should be reset at 0000 UTC each day and is especially useful for quality control, data management and archiving purposes.

[3] Data description operators (with F=2) are used when there is a need to redefine Table B attributes temporarily, such as the need to change data width, scale or reference value of a Table B entry. The following three data description operators are used in sequence number 3 11 010:

TABLE REFERENCE F X	OPERAND	OPERATOR NAME	OPERATION DEFINITION
2 01	YYY	Change data width	Add (YYY–128) bits to the data width given for each data element in Table B, other than CCITT IA5 (character) data, code or flag tables.
2 02	YYY	Change scale	Add YYY–128 to the scale for each data element in Table B, other than CCITT IA5 (character) data, code or flag tables.
2 04	YYY	Add associated field	Precede each data element with YYY bits of information. This operation associates a data field (e.g. quality control information) of YYY bits with each data element.

Notes:

(1) The operations specified by operator descriptors 2 01, 2 02, 2 03, 2 04, 2 07 and 2 08 remain defined until cancelled or until the end of the data subset.

(2) If change scale is used, then it may be necessary for the originator of the message to supply an appropriately rescaled reference value and data width.

(3) Cancellation of the use of the redefined value shall be effected by the inclusion of the appropriate operand with YYY set to 000. The value shall then revert to the original Table B value.

(4) Nesting of operator descriptors must guarantee unambiguous interpretation. In particular, operators defined within a set of replicated descriptors must be cancelled or completed within that set, and the 2 07 operator may neither be nested within any of the 2 01, 2 02, and 2 03 operators, nor vice-versa.

(5) Nesting of the operator descriptor 2 04 is defined such that:

(a) Each new definition adds to the currently defined associated field. The order of the included associated information shall correspond with the order in which the associated fields have been defined.

(b) Each cancellation (2 04 000) cancels only the most recently defined addition to the associated field.

(6) When the descriptor 2 04 YYY is to be used, it shall precede the first of the data descriptors to which it applies.

(7) The data description operator 2 04 YYY, other than 2 04 000, shall be followed immediately by the descriptor 0 31 021 to indicate the meaning of the associated field.

(8) In the data stream, the 6 bits described by 0 31 021 (code table) shall precede the YYY bits.

[4] The result of the Associated Field Significance (0 32 021) follows the preceding Add Associated Filed (2 04 002) value for YYY. In case of code figure values 7 and 8 we have:

Code figure		
7	Percentage confidence	(value)
8	2-bit indicator of quality	0 = Not suspected
		1 = Suspected
		2 = Reserved
		3 = Information not required

[5] The replication operation. If F = 1, the descriptor shall be called a “replication descriptor”. For this case, X shall indicate the number of descriptors to be repeated, and Y the total number of occurrences (replications) of the repeated subsequence. A value of Y = 0 associated with the replication descriptor shall indicate delayed replication. In this case, the replication data description operator shall be completed by the next element descriptor, which shall define a data item indicating the number of replications. This descriptor may also indicate (by its value of Y) that the following datum is to be replicated together with the following descriptor.

[6] The “delayed descriptor and data repetition factor” is intended for run-length encoding (e.g. scanning an image). It specifies a count N which applies to both descriptor and data, i.e. the value of the single element defined by the following descriptor is repeated N times (at intervals already specified). A special application of replication consists in specifying a replication factor of either 0 or 1 for a subsequence.

Important feature: For a value of zero, the sub-sequence is replicated “zero” time - that is, not at all. This makes it possible, when appropriate, to shutdown whole sections of a template, thereby shortening the data section! So if e.g. 0-31-00 = 0 a sub-sequence may

be replicated zero times, with the result that, although the sub-sequence exists in the template, it is skipped when the sequence is encoded into the Data Section. This is in particular of relevance for the two sections on turbulence at the end of the template.

[7] Change Data Width and change Scale (see note [3]). In Table B Scale and Data Width are defined. For example, mixing ratio and relative humidity are defined as follows:

TABLE REFERENCE F X Y	ELEMENT NAME	UNIT	SCALE	REFERENCE VALUE	DATA WIDTH (Bits)
0 13 002	Mixing ratio	kg kg^{-1}	5	0	14
0 13 003	Relative Humidity	%	0	0	7

For mixing ratio, a scale = 5 together with a data with of 14 bits and a reference value of 0 implies a range from 0 to $(2^{14} – 1) \times 10^{-5}$, *i.e.* {0, 0.00001, .. 0.16383} kg kg^{-1} and with a resolution of $1x10^{-5}$ kg kg^{-1}. Because the descriptors are presented as integers, a variable like mixing ratio covering a large number of decades cannot be reporting for its full range and required resolution. As a result the scale and the data width should be enhanced. Using a scale of 10 and a data width of 30 the range becomes 0 to 2^{30} x 10^{-10}, or {0, 10^{-10}, .. 0.10737} kg kg^{-1} with a resolution of $1x10^{-10}$ kg kg^{-1}.

[8] M if mandatory; [M] mandatory if available. Note that a large number of descriptors are preceded by FXY = 0 31 000 (Short delayed descriptor replication factor), which implies that reporting is optional (Y = 0 means no report, if the preceding FXY = 1 X 000 (Delayed replication of X descriptors) is set to 0. See note [6].

[9] Selected descriptor for transition from FM42.

[10] Selected descriptor for transition from AIREP; see explanation of symbols used under "ICAO aircraft report AIREP" (Other data formats).

[11] Flight Level is equal to Pressure Altitude by definition. Its value is derived from the measured static pressure using the unique relationship as defined by the International Standard Atmosphere (ISA) in ISO-2533 based on a standard reference pane of 1013.25 hPa (see footnote, this Attachment under ABO requirements). As a result the observed static pressure can be derived directly from the reported pressure altitude (see [REF IOM-115] for details).

[12] Correct use of datum reference system is recommended. If WGS84 is used with its primary earth ellipsoid only, to obtain the altitude with a local reference pane according to GEOID96 further correction is required (GEOID96 confirms to MSL, see [REF WMO-No. 8]).

Attachment 2, IAGOS template for a single observation, version 2 (table reference 3 11 011)

		Element Name	Mandatory (M if mandatory; [M] mandatory if available)	Descriptor (BUFR Table B)	Related Sequence Descriptor (BUFR Table D)	Notes
				F X Y	F X Y	
		Observation sequence number (IAGOS template for a single observation), version 2		0 01 023		
		Observation sequence number		0 01 023		
		Phase of aircraft flight		0 08 004		
		Year, month, day		3 01 011		
		Hour, minute, second		3 01 013		
		Latitude (coarse accuracy)		0 05 002		
		Longitude (coarse accuracy)		0 06 002		
		Pressure		0 07 004		
		Wind direction		0 11 001		
		Wind speed		0 11 002		
		Temperature/air temperature		0 12 101		
		Delayed replication of 6 descriptors		1 06 000		
		Delayed descriptor replication factor		0 31 001		
		Atmospheric chemical or physical constituent type		0 08 046		
		Change data width		2 01 139		20 bits long
		Change scale		2 02 126		Scale: 7
		Concentration of pollutant (mol mol^{-1})		0 15 026		
		Change scale		2 02 000		Cancel
		Change data width		2 01 000		Cancel
		Delayed replication of 6 descriptors		1 06 000		
		Delayed descriptor replication factor		0 31 001		
		Atmospheric chemical or physical constituent type		0 08 046		
		Change data width		2 01 138		19 bits long
		Change scale		2 02 130		Scale: 11
		Concentration of pollutant (mol mol^{-1})		0 15 026		
		Change scale		2 02 000		Cancel
		Change data width		2 01 000		Cancel
		Log_{10} of number density of aerosol particles with diameter greater than 5 nm		0 15 052		
		Log_{10} of number density of aerosol particles with diameter greater than 14 nm		0 15 053		
		Log_{10} of number density of aerosol particles with diameter between 0.25 and 2.5 µm		0 15 054		

		Non volatile aerosol ratio		0 15 055		
		Pressure		0 07 004		
		Pressure		0 07 004		
		Log_{10} of integrated cloud particle density		0 13 099		
		Log_{10} of integrated cloud particle area		0 13 100		
		Log_{10} of integrated cloud particle volume		0 13 101		

Attachment 3, Referred Code Tables

0 02 064

Aircraft roll angle quality

Code figure	Meaning
0	Good
1	Bad
2	Reserved
3	Missing value

Note: Bad is currently defined as a roll angle > 5 degrees from vertical.

0 02 170

Aircraft humidity sensors

Code figure	Sensor type
0	SpectraSensors WVSS-II, Version 1
1	SpectraSensors WVSS-II, Version 2
2	SpectraSensors WVSS-II, Version 3
3–61	Reserved
62	Other
63	Missing value

0 08 009

Detailed phase of flight

Code figure	
0	Level flight, routine observation, unsteady
1	Level flight, highest wind encountered, unsteady
2	Unsteady (UNS)
3	Level flight, routine observation (LVR)
4	Level flight, highest wind encountered (LVW)
5	Ascending (ASC)
6	Descending (DES)
7	Ascending, observation intervals selected by time increments
8	Ascending, observation intervals selected by time increments, unsteady
9	Ascending, observation intervals selected by pressure increments
10	Ascending, observation intervals selected by pressure increments, unsteady
11	Descending, observation intervals selected by time increments
12	Descending, observation intervals selected by time increments, unsteady
13	Descending, observation intervals selected by pressure increments
14	Descending, observation intervals selected by pressure increments, unsteady
15	Missing value

Note: Unsteady in case Roll Angle > 5° and will takes precedence over all other codes

0 11 037

Turbulence index

Code figure	Average value of eddy dissipation rate (ave) ($m^{2/3}$ s^{-1})	Peak value of eddy dissipation rate (peak) ($m^{2/3}$ s^{-1})
0	ave < 0.1	peak < 0.1
1	ave < 0.1	0.1 <= peak < 0.2
2	0.1 <= ave < 0.2	0.1 <= peak < 0.2
3	ave < 0.1	0.2 <= peak < 0.3
4	0.1 <= ave < 0.2	0.2 <= peak < 0.3
5	0.2 <= ave < 0.3	0.2 <= peak < 0.3
6	ave < 0.1	0.3 <= peak < 0.4
7	0.1 <= ave < 0.2	0.3 <= peak < 0.4
8	0.2 <= ave < 0.3	0.3 <= peak < 0.4
9	0.3 <= ave < 0.4	0.3 <= peak < 0.4
10	ave < 0.1	0.4 <= peak < 0.5
11	0.1 <= ave < 0.2	0.4 <= peak < 0.5
12	0.2 <= ave < 0.3	0.4 <= peak < 0.5
13	0.3 <= ave < 0.4	0.4 <= peak < 0.5
14	0.4 <= ave < 0.5	0.4 <= peak < 0.5
15	ave < 0.1	0.5 <= peak < 0.8
16	0.1 <= ave < 0.2	0.5 <= peak < 0.8
17	0.2 <= ave < 0.3	0.5 <= peak < 0.8
18	0.3 <= ave < 0.4	0.5 <= peak < 0.8
19	0.4 <= ave < 0.5	0.5 <= peak < 0.8
20	0.5 <= ave < 0.8	0.5 <= peak < 0.8
21	ave < 0.1	0.8 <= peak
22	0.1 <= ave < 0.2	0.8 <= peak
23	0.2 <= ave < 0.3	0.8 <= peak
24	0.3 <= ave < 0.4	0.8 <= peak
25	0.4 <= ave < 0.5	0.8 <= peak
26	0.5 <= ave < 0.8	0.8 <= peak
27	0.8 <= ave	0.8 <= peak
28	Nil	Nil
29–62	Reserved	Reserved
63	Missing value	Missing value

0 11 039

Extended time of occurrence of peak eddy dissipation rate

Code figure	Minutes prior to observation time (min)
0	min < 1
1	1 <= min < 2
2	2 <= min < 3
3	3 <= min < 4
4	4 <= min < 5
5	5 <= min < 6
6	6 <= min < 7
7	7 <= min < 8
8	8 <= min < 9
9	9 <= min < 10
10	10 <= min < 11
11	11 <= min < 12
12	12 <= min < 13
13	13 <= min < 14
14	14 <= min < 15
15–59	As above to 59 <=min < 60
60	No timing information available
61–62	Reserved
63	Missing value

0 20 042

Airframe icing present

Code figure	
0	No icing
1	Icing present
2	Reserved
3	Missing value

0 20 045

Supercooled large droplet (SLD) conditions

Code figure	
0	No SLD conditions present
1	SLD conditions present
2	Reserved
3	Missing value

0 33 025

ACARS interpolated values indicator

Code figure	
0	Time interpolated, latitude and longitude reported
1	Time reported, latitude and longitude interpolated
2	Time, latitude, and longitude interpolated
3	Time, latitude, and longitude reported
4–6	Reserved
7	Missing value

0 33 026

Moisture quality

Code figure	
0	Normal operations – measurement mode
1	Normal operations – non-measurement mode
2	Small RH
3	Humidity element is wet
4	Humidity element contaminated
5	Heater fail
6	Heater fail and wet/contaminated humidity element
7	At least one of the input parameters used in the calculation of mixing ratio is invalid
8	Numeric error
9	Sensor not installed
10	Calculated RH > 100%
11	Input laser power too low
12	Probe WV temperature out of range
13	Probe WV pressure out of range
14	Spectral line out of range
15	No laser output
16–62	Reserved
63	Missing value

Attachment 4 - Other BUFR templates still in use or used in the past

All these templates follow the common sequences, as published in Table D ([REF Manual on Codes, FM94 BUFR]), with F XX = 3 11:

Category 11 – Single level report sequences (conventional data)

3 11 001: Aircraft reports for ASDA, using common sequence (template) 3 01 051 (Flight number, navigational system, date/time, location, phase of flight) and standard descriptors

3 11 002: ACARS reports, using four common sequences (templates) only: 3 01 065 (ACARS identification), 3 01 066 (ACARS location), 3 11 003 (ACARS standard reported variables) and 3 11 004 (ACARS supplementary reported variables)

3 11 003 ACARS standard reported variables (used by 3 11 002), with standard descriptors only

3 11 004 ACARS supplementary reported variables (used by 3 11 002) with standard descriptors only

3 11 005 Standard AMDAR reports, using common sequences (template) 3 01 021 (Latitude/longitude -high accuracy), 3 01 011 (Year, month, day), 3 01 013 (Hour, minute, second) and standard descriptors

3 11 006 AMDAR data or aircraft data for one level without latitude/longitude, with standard descriptors only

3 11 007 Aircraft data for one level with latitude/longitude indicated, using common sequence (template) 3 01 021 (Latitude/longitude -high accuracy and standard descriptors

3 11 008 Aircraft ascent/descent profile without latitude/longitude indicated at each level, using common sequences (template) 3 01 021 (Latitude/longitude -high accuracy), 3 01 011 (Year, month, day), 3 01 013 (Hour, minute, second), 3 11 006 (AMDAR data or aircraft data for one level without latitude/longitude) and standard descriptors. This template is designed for reporting profiles based on 3 11 006, AMDAR data or aircraft data for one level without latitude/longitude

3 11 009 Aircraft ascent/descent profile with latitude/longitude given for each level, using common sequences (template) 3 01 021 (Latitude/longitude -high accuracy), 3 01 011 (Year, month, day), 3 01 013 (Hour, minute, second), 3 11 006 (AMDAR data or aircraft data for one level without latitude/longitude) and standard descriptors. This template is designed for reporting profiles based on 3 11 007, Aircraft data for one level with latitude/longitude indicated

Attachment 5 - Encoding of aircraft based observations and derived data from ICAO Aircraft Reports

Automatic Dependent Surveillance (ADS) reports

Automatic Dependent Surveillance (ADS) reports are generated automatically. ADS is a component of CNS/ATM systems of ICAO (for details see ICAO Doc. 9377, Manual on the Coordination between Air Traffic Control Services, Aeronautical Information Services and Aeronautical Meteorological Services, paragraph 2.2). ADS is a service for use by Air Traffic Services (ATS) in which aircraft automatically provide, via a data link, data derived from on-board navigation and position-fixing systems. As a minimum, the data include aircraft identification, time and position and additional data may be provided as appropriate. The 'additional data' may include a meteorological information data block. Data transmitted by digital data link are required to be forwarded to the WAFCs and RAFCs (as appropriate) without delay in the form that they are received. Only the ADS-C (“contract”) subtype contains meteorological data containing the following elements:

	ADS element	
	Message type designator	
	aircraft-address	
Data Block 1	Position	Latitude
		Longitude
		Level

	DateTime Group	Year,Month,Day
		TimeHours, TimeMinutes, Timeseconds
Data block 2	Wind-speed	
	Wind-direction	
	Wind-quality-flag	
	Air Temperature	
	Turbulence (if available)	Time-of-occurrence, index
	Humidity (if available)	

Note: Aircraft Icing is not reported if ADS or SSR Mode-S is being applied.

ABS-B itself does not provide observational data. ADS reports are currently and generally formatted as AIREP for dissemination over the GTS. Details on the quality of these reports can be found in Haan, S. de, and L.J. Bailey, and J.E. Konnen, 2013: "Quality assessment of Automatic Dependent Surveillance Contract (ADS-C) wind and temperature observation from commercial aircraft", Atmospheric Measurement Techniques, 6, 199–206.

- Aircraft Derived Data (ADD) such as data derived from Secondary Surveillance Radar (SSR) Mode-S EHS (Mode-Select Enhanced Surveillance). Data formats of single level observations as publically received by SSR receivers are explained in Haan, S. de, M. de Haij and J. Sondij, "The use of a commercial ADS-B receiver to derive upper air wind and temperature observations from Mode-S EHS information in The Netherlands" KNMI publication TR-336, 2013.
- Observational data (air reports) received by manual communications with pilots and encoded manually as e.g. AIREP (aircraft report) or PILOT (pilot report), as defined by ICAO.

ICAO Aircraft Report - AIREP

AIREP is an alphanumerical code designed originally for encoding manual (pilot) aircraft observations according to ICAO aviation meteorological requirements. In fact this code is quite comparable to the WMO code format of FM41, CODAR and to a certain extent to WMO code format FM42, AMDAR, both being obsolete (phased out). In practice there is no well-defined format of the AIREP code format and national rules are implemented resulting in dissemination of AIREP bulletins not being encoded according to any standard (like BUFR or other WMO code formats). The AIREP code format is not regulated by WMO and not published in the *Manual on Codes* (WMO-No. 306). However, some documentation on AIREP encoding is available ICAO Doc. 8896, Manual of Aeronautical Meteorological Practice, Chapter 7, Aircraft Observations and Reports. Reference to this document can be found in ICAO Doc. 4444, Air Traffic Management (PANS-ATM), paragraph 4.12. Although the detailed instructions on how to encode AIREP in ICAO Doc. 8896, paragraph 7.9 refers to "Detailed Instructions Concerning the Content of Special Air-Reports Received by Voice Communications by MWOs", i.e. SPECIAL AIREP (ARS), it can also be used for ROUTINE AIREP reports (ARP). Note that this instruction also refers to ICAO Doc. 4444, Appendix 1, Instructions for Air-reporting by Voice Communications (on acronyms to be used to report special phenomena).

AIREP Code format

CCCC	ICAO of transmitting unit
AIREP	Type ARP (Routine AIREP) or ARS (Special AIREP). Will precede all AIREP text. See Table below for ARS conditions
Aircraft Number	Reported as a seven-character group. The identifier will be a combination of numbers and letters.
Latitude	Four figures indicating the latitude of the aircraft to the nearest minute followed by the letter N (North) or S (South).
Longitude	Five figures indicating the longitude of the aircraft to the nearest minute followed by the letter E (East) or W (West).
UTC Time	Four figures depicting time to the nearest minute. For AIREP corrections, add one minute to the actual time.
Flight Level	A four-character group (the letter F followed by three figures), representing the aircraft altitude in hundreds of feet (e.g., F370).
Air Temperature	Two figures indicating the temperature in whole degrees Celsius preceded by “PS” (plus) or “MS” (minus).
Spot Wind	A wind group. The first three figures indicate true wind direction in Degrees. The last two figures indicate wind speed to the nearest knot. In the following code: DDD = True wind direction at current position; SS = Wind speed at current position. If the wind is above 99 knots use three figures.
Turbulence	Severe turbulence is reported as TURB SEV and moderate turbulence as TURB MOD - when turbulence in cloud is experienced INC is added. TURB SEV is reported immediately on occurrence and this requires an AIREP SPECIAL (ARS), otherwise TURB MOD is reported only if it occurs within the last 10 minutes prior to reaching the position.
Icing	Severe aircraft icing is reported as ICE SEV. Moderate aircraft icing is reported as ICE MOD. ICE SEV is reported immediately on occurrence and this requires an AIREP SPECIAL (ARS), otherwise ICE MOD is reported only if it occurs within the last 10 minutes prior to reaching the position.
Supplementary Information	Cloud bases and /or tops are reported as BASE and/or TOP followed by the respective height indication F(number) or (number)M or (number)FT. Thunderstorm tops may be reported by TS TOP followed by the flight level. Other abbreviations include: Present weather – RA (rain), SN (snow), FZRA (freezing rain), FC (funnel cloud), TS (thunderstorm), FRONT (front). Clouds – SCT (scattered), BKN (broken), CNS (continuous), CB (cumulonimbus). To correct an AIREP, add 1 minute to the initial time and add a remark (e.g., COR 1814) when the correction is transmitted as the last entry.

Meteorological Conditions Requiring Special AIREP (ARS).

Thunderstorms (see note)	Severe Icing
Tropical Storm	Severe or Extreme Turbulence
Squall Line	Mountain Wave Turbulence
Hail	Widespread Sandstorm
Widespread Duststorm/Sandstorm	Volcanic Eruption or Ash Cloud

Note: The requirement for thunderstorms refers to the occurrence of an area of widespread activity, thunderstorms along a line with little or no space between individual storms, or thunderstorms

embedded in cloud layers or concealed by haze. It does not refer to isolated or scattered thunderstorms not embedded in clouds or concealed in haze.

Supplementary information that can be reported includes: turbulence, towering thunderstorms etc.

AIREPs are compiled automatically or manually and can be transmitted as a Routine (ARP) or as a Special (ARS) air-report.

Below is an example of a Special AIREP message as recorded on the ground by the MWO concerned from [REF ICAO Doc 8896]

ARS VA812 2020N07005W 1215 F180 MTW SEV

Meaning:

Special air-report from VIASA* flight number 812. Report refers to position 20 degrees 20 minutes north and 70 degrees 5 minutes west at 1215 UTC, at flight level 180. Severe mountain wave has been encountered.

* Fictitious operator

To stimulate uniform use of the AIREP format and to reduce ambiguity due to misinterpreting these reports it is recommended to follow the following standard format:

SECTION 1	**AIREP** YYGG
SECTION 2	RRR I_A...I_A $L_aL_aL_aL_aA$ $L_oL_oL_oL_oL_oB$ GGgg $S_hh_lh_lh_l$ $i_pi_pi_p$ $SST_AT_AT_A$ ddd/fff SYMBOLS=

Explanation:

YYGG	Day YY and Hour GG in UTC related to the bulletin.
RRR:	**ARP** for routine air-reports, **ARS** for special air-reports. Use of ARS is mandatory, use of ARP is recommended.
I_A ... I_A	Aircraft identification. Aircraft identification consists of either the operator's designator and aircraft registration, or flight number, reported as one unit without any spaces or hyphens. However it is recommended to provide an identifier, unique for the aircraft (like the aircraft registration number).
$L_aL_aL_aL_aA$	Position (Latitude, in degrees and minutes). Latitude position is given in in degrees and minutes (four figures for latitude L_a, followed without a space by A = **N** or **S**, i.e. direction of latitude, N = North, S = South).
$L_oL_oL_oL_oL_oB$	Position (Longitude, in degrees and minutes). Longitude position is given in degrees and minutes (five figures for longitude L_o, followed without a space by B= **E** or **W**; i.e. direction of longitude, E = East, W = West). Note: ICAO Doc. 8896 (7.9.3, Position) suggests not to use a space between $L_aL_aL_aL_aA$ and $L_oL_oL_oL_oL_oB$. However it is recommended spaces to avoid misinterpretations.
GGgg	Time of observation. The time of aircraft, at the position indicated, is shown in hours (GG) and minutes (gg) UTC.
$S_hh_lh_lh_l$	Flight level or altitude. The flight level is shown by sign S_h (**F** for positive flight levels, **A** for negative flight levels) followed by the actual level $h_lh_lh_l$; the altitude is shown by an S_h followed by $h_lh_lh_l$ and **M** or **FT**, as appropriate.
$i_pi_pi_p$	Phase of flight. Flight level $S_hh_lh_lh_l$ is followed by "ASC" (level) or "DES" (level) when ascending or descending to a new level; else omitted.

SST_AT_A Sign of the temperature and air temperature in whole °C. If air temperature is zero or positive, SS shall be encoded as the letters **PS**, if air temperature is negative, SS shall be encoded as the letters **MS**. Air temperature T_AT_A, in whole degrees Celsius, at the level given by $S_hh_lh_lh_l$.

Note: it is encouraged to use a three digit $T_AT_AT_A$, providing air temperature, in tenths of degrees Celsius.

ddd/fff Wind direction and wind speed separated by a slash. Wind direction ddd to be the true direction, in whole degrees, from which wind is blowing. Wind speed fff, in knots, at the level given by $S_hh_lh_lh_l$. Unit, separated with a space from fff may be added (**KT** for knots, **MPS** for m/s).

SYMBOLS Phenomenon prompting a special air-report:

- severe turbulence as “TURB SEV”
- moderate turbulence as “TURB MOD”
- severe icing as “ICE SEV”
- moderate icing as “ICE MOD”
- severe mountain wave as “MTW SEV”
- thunderstorm without hail1 as “TS”
- thunderstorm with hail1 as “TSGR”
- heavy dust storm or sandstorm as “HVY SS”
- volcanic ash cloud as “VA CLD”
- pre-eruption volcanic activity or a volcanic eruption as “VA”

General

- In a bulletin of AIREP reports, the contents of Section 1 (the code name AIREP and the group YYGG) shall be included only as the first line of the bulletin.
- An AIREP report shall include Section 2 containing at least the aircraft identifier, its geographical location and the day and time of observation, as well as the observed temperature and wind.
- Use of solidi data shall be encoded as solidi when not available, when the data collection platform cannot acquire correct data, or in the event of parity errors.
- Section 1 and section 2 data shall be reported on single lines without line breaks. Section 2 data to be ended with a “=”.

Example

AIREP 1521

ARP UAL137 1712N 14249E 2153 F380 MS470 100/024=

AIREP 1521 Air report for day 15, at 21 H UTC

ARP Routine air report

UAL137 Flight Number

1712N Latitude 17 deg 12 min North

14249E	Longitude 142 deg 49 min East
2153	Time 21:53 UTC
F380	Flight Level +380
MS47	Air temperature -47.0°C
100/024	Wind direction 100° true, wind speed 12 m/s (24 knots).

Annex IV - Guidance on Aircraft-Based Observations Metadata Maintenance and Provision

Note: This Annex is still under development and review. Parts of it will be considerably revised prior to publication.

Background

The obtaining, maintenance and international provision of Aircraft-Based Observations (ABO) metadata supports the following primary functions in the operation of ABO observing systems:

- Ongoing and historical documentation by Members of the platforms (aircraft), systems (e.g. AMDAR, ADS-C, etc.) and sensors (e.g. Total Air Temperature probe) that contribute to observing system observations;
- Definition of the capabilities of the observing system in terms of various fundamental aspects, which include uncertainty, spatial and temporal resolution or coverage, latency and reporting frequency;
- Provision of additional information about the observing system including:
    - Variables observed;
    - Purpose of the observation and the networks and applications for which they are intended to contribute;
    - The environment in which the observations are made and their representativeness;
    - The methods of observation employed;
    - The way in which the measurements are sampled and processed;
    - Data ownership and policy; and
    - Contact details of operators, authorities, data owners, etc.

ABO metadata consists of three basic types:

1. Metadata about aircraft platforms and associated observational practices to be obtained, maintained and retained by members;
2. Metadata about aircraft platforms and observational practices to be provided to and maintained by WMO; and
3. Metadata about aircraft-based observations that should be maintained and provided with observational data.

Metadata type 1 would consist of all data within type 2 plus the additional national metadata that is not required to be exchanged.

Metadata type 2 consists of those metadata required to be exchanged by WMO Members to fulfil the requirements and provisions relating to WIGOS.

Metadata type 3 can be described as the additional data that provides further information about required observational variables. For example, the roll angle flag can be considered metadata for the AMDAR wind direction and speed variables, as it provides information about the quality of the wind measurement.

This Annex is chiefly concerned with the first two types of metadata.

Requirements for Metadata

The regulations for maintenance and provision of metadata for WIGOS observing systems are defined within the [REF Manual on WIGOS, Sections 2.4.4].

The requirements for ABO metadata are based upon the WIGOS Metadata Standard, which is defined in the [REF Manual on WIGOS, Appendix 2.4].

WIGOS Metadata Profile

The WMDS provides a framework to define and ensure the availability of all required metadata so as to ensure maximum usefulness of WIGOS observations in support of all WIGOS observing system data users and WMO Application Areas.

Although the WIGOS Metadata Standard (WMDS) is still under development by the Inter-Commission Group on WIGOS (ICG-WIGOS) Task Team on WIGOS Metadata (TT-WMD), the primary categories that have been approved provide a framework for the specification of a metadata profile for ABO.

The WMDS makes provision for the following primary categories of metadata:

1. Observed variable
2. Purpose of observation
3. Station/platform
4. Environment
5. Instruments and methods of observation
6. Sampling
7. Data processing and reporting
8. Data quality
9. Ownership and data policy
10. Contact

Eventually, the WMDS will provide a full set of metadata elements that will map to all ABO metadata elements. The current mapping from the ABOM Metadata Elements to the WMDS elements is provided in the first column of the table within Attachment 1.

Requirements for ABO Metadata

The initially envisaged requirements for and applications of Aircraft Based Observation (ABO) metadata were first identified under the WIGOS Pilot Project for AMDAR (WIGOS-PP-AMDAR) and subsequently updated by the Expert Team on Aircraft Based Observing Systems (ET-ABO) based on the outcomes of the WMO AMDAR Panel Aircraft Observing System Data Management Workshop (June 2012). The ABO metadata set, as provided in Attachment 1 has been further refined and approved by ET-ABO in consultation with the WMO OSCAR Project Team.

Members operating ABO Observing Systems that report observational data to the WIS will be expected to provide metadata within several categories and/or levels:

1. Metadata in support of ABO Data Discovery – this will generally be in support of the operation of the WMO Information System and is not relevant to this guide.

2. Metadata in support of ABO data:

    a. Metadata to be maintained at the national level – this is the superset of all ABO metadata, encompassing national, regional and global metadata. Note that not all national ABO metadata required is specifically identified in this guide. Members must identify all national metadata that is required to meet the provisions for ABO observing system operation as described within [REF Guide to the GOS, This Guidance, Section 2].

    b. Metadata to be provided at the regional level – to be provided to a regional operator such as the EUMETNET E-AMDAR programme. The requirements for Regional ABO metadata are not specified within this guide.

    c. Metadata to be provided at the global level – to be provided as described below via the interface to the Surface component of the Observing Systems Capability Analysis and Review Tool (OSCAR/Surface). More information on this aspect of metadata is provided below.

The ABO metadata elements required to be maintained by ABO observing system operators are specified within the table in [REF Attachment 1] below. The notes below the table provide a description of the columns and their content. These metadata support the requirements for ABO metadata under category 2c. above.

[REF Attachment 2] provides an alternative structural depiction of the ABO metadata elements.

Metadata Requirements for ABO Systems Capabilities in OSCAR

OSCAR (Observing Systems Capability Analysis and Review Tool) is a web based resource being developed through consultancy under coordination by WMO and its Technical Commissions. The system is being developed to store all internationally required metadata for WIGOS observing systems and also to define and allow analysis of the capabilities of the WIGOS component observing systems that support the various WMO Application Areas.

Within OSCAR, the capabilities of observing systems that provide ABO are defined in terms of two observing types;

- Atmospheric vertical profilers – observations made during ascent (ASC) and descent (DES) phases of flight to/from airports; and

- High speed mobile platforms – observations are made during the en-route or cruise (ENR) phase of flight.

Atmospheric Vertical Profilers will be modelled in OSCAR as observations of vertical profiles of a given variable or set of variables, made with a “virtual instrument”. For ABO, the virtual instrument will be provided by a fleet of aircraft that, by virtue of their operational and reporting schedule, make a program of vertical profiles at one or more airports.

High speed mobile platforms will be modelled as “virtual stations” in 3D space, located at the center of regular grid cells (1°x1°, for example) and at one of the 13 flight levels. Such stations can also provide observations using virtual instruments, each with its own schedule of observation. For ABO, the programme of observations made be virtual instruments will be, at least initially, based on the aggregated data output derived from the ABO programme, on a system-by-system basis.

OSCAR requires metadata relating to each ABO observing system that will provide a means for determining the capabilities of each ABO observing system in terms of the various user requirements for WMO Application Areas that have been defined and specified within the OSCAR User Requirements database. These requirements include spatial and temporal coverage and resolution, data latency and uncertainty. This means that, in addition to the metadata describing the aircraft platforms and the sensors that provide measurements of atmospheric variables, there will also be a requirement for the provision of programmatic metadata that describes where and when aircraft make observations. It is expected that OSCAR will eventually differentiate between the “programmatic capability” and the “actual coverage” provided by the observations. However, in the first stage of OSCAR development, the capability of horizontal coverage (ENR) will be provided based on a statistical compilation or “snapshot” of observational ABO data, while the capabilities of vertical profiles (ASC and DES phases of flight) will be depicted based on the programmatic information for airport locations serviced by “Aircraft Fleets”, as defined and provided by national programme managers.

Therefore, in addition to the metadata fields defined within the ABO Metadata template and the WIGOS Metadata Standard (WMDS), OSCAR will provide “key link fields” which will associate aircraft with one or more Aircraft Fleets, and which will provide a programme of vertical profiles for an associated set of “Fleet Airports”.

An Aircraft Fleet will be a set of aircraft of the same system type (e.g. AMDAR or ADS-C) with common programmatic and OSCAR capability attributes. The Aircraft Fleet metadata will hold common Observing Systems Capabilities (OSC), e.g. vertical resolution (lower and upper troposphere, observations/km), the uncertainty of the observed variables and latency of observations.

Metadata relating to Fleet Airports will also define a set of airports serviced by the Aircraft Fleet which will provide a specific cycle of vertical profiles at each airport e.g. number of profiles per hour/day/week with any diurnal resolution variance.

This structure along with the associated and require metadata is depicted within the ABO Metadata Profile Map in [REF Attachment 2].

Responsibilities for Maintenance and Provision of Metadata

In order for ABO metadata for operational aircraft-based observing systems to be obtained and maintained and the required internationally-exchanged metadata and information provided to the OSCAR system, Members will be required to ensure that roles and procedures are developed and assigned to appropriate staff in order to fulfil the functions outlined below.

- Member Permanent Representative to WMO:
    - Nominate and provide contact details of WMO National Focal Point on Aircraft-Based Observations.
    - Designate role of ABO Programme Manager
- WMO National Focal Point on Aircraft-Based Observations:
    - Receive and act upon information and advice relating to ABO metadata management and provision.

  - Liaise with the ABO Programme Manager to ensure requirements for ABO metadata are understood and met.
  - Oversee the development of the procedures of their organization for timely provision of internationally-exchanged ABO metadata to WMO via OSCAR.

- Member ABO Programme Manager (PM):
  - Establish roles and procedures for the collection, maintenance and provision to WMO of required ABO metadata – see Attachment 1.
  - Liaise with partner system operators, airlines, data service providers, avionics vendors and other relevant 3rd parties to ensure that required ABO metadata are able to be made available to the ABO Programme and establish the procedures for enabling this exchange.

Responsibility and Procedures for Maintenance of Metadata Within OSCAR

As with all OSCAR metadata, Members will be responsible for the routine and timely maintenance of the internationally-exchanged component of ABO metadata through manual and/or machine interface to the OSCAR system.

Detailed instructions for and guidance on OSCAR metadata maintenance procedures will be provided in the developing [REF Guide to WIGOS].

Manual input will be carried out based on the instructions that will be contained within the OSCAR User Manual, which will be contained within the Guide to WIGOS.

Automated input will involve a “machine to machine” exchange, most likely using XML data format.

To allow for the transfer of ABO metadata (not in XML) to OSCAR/Surface, a metadata conversion tool will need to be developed i.e. MSExcel→XML, csv→XML etc. This conversion tool will be the responsibility of the Programme Focal Point.

Members and ABO Focal Points of operational ABO Programmes should ensure that they make and implement plans for adherence to the above requirements and responsibilities immediately and should ensure compliance with the requirements for the operation of OSCAR and maintenance of OSCAR metadata upon WMO provision of the relevant regulations and guidance and notification of completion of the operational implementation of the OSCAR system.

Attachment 1, Aircraft-Based Observations Metadata Profile

WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
9.01	WMO Member country		N	WMO Member country having jurisdiction over the ABO observing system and the observations. For a regional collaboration, the ABO Programme Operator or the ABO System Operator field can be used to provide the regional collaborative body – e.g. E-AMDAR or E-AMDAR AMDAR	Canada	M,I	M,I	M,I	This should generally be the country in which the aircraft fleets are registered. However, in the case of some ICAO Aircraft Observations (Air-reports), it may be the country of the Aviation Navigation Service Provider (ANSP) that receives the observations and makes them available for provision to the WIS. If the data provider is the WAFC, this field may indicate the country of the WAFC or delegated authority for putting the data to the WIS but usually only if the WAFC is unable to trace the aircraft to a particular country.
10.01	WMO ABO Focal Point Contact	WMO Member country	N	WMO ABO Focal Point contact details: Name, E-mail, Address, Phone Number		M,I	M,I	M,I	
2	ABO Programme Operator	WMO Member country	N	The name of the observations programme operator – usually this will be the name of the member country NMHS	Australian Bureau of Meteorology	M,I	M,I	M,I	This field is expected to convey the programme owner and will usually be the entity responsible for putting the data to the WIS.
10	ABO Programme Contact	ABO Programme	N	Set of ABO Programme Manager contact details: Name, Email, Address, Phone Number		M,I	M,I	M,I	
9.01	ABO Programme	WMO Member country	N	Name of the ABO Programme. Will generally be the same as the WMO Member country.	Canada ABO Programme, France ABO Programme	M,I	M,I	M,I	Used to collect the ABO systems together under the WMO Member country.

WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
3-04	ABO System	ABO Programme	N	Provides the ABO system category.	AMDAR AIREP ADS-C TAMDAR	M,I	M,I	M,I	ABO Programmes will have 1 or more ABO Systems. ABO Systems will have 1 or more fleets of aircraft.
9	ABO System Operator	ABO System	N	The name of the ABO observing system operator – usually this will be the name of the member country NMHS but it may also be a regional or commercial entity.	E-AMDAR, Bureau of Meteorology	M,I	M,I	M,I	
9	ABO System Operator Contact	ABO System	N	Contact details for ABO System Operator contact: Name, E-mail, Address, Phone Number		M,I	M,I	M,I	
3.04	ABO System Fleet	ABO System	Y	Will identify a fleet based on a set of aircraft within a particular ABO System Type. An ABO System Aircraft Identifier can be in more than one ABO System Type – for example, an aircraft can report under both the AMDAR programme and also provide AIREPs. However a particular aircraft should be associated with only one ABO System Fleet within a particular ABO System.		M,I	M,I	M,I	Key field identifier – this allows OSCAR to group aircraft platforms with common programmatic attributes to provide information on “observing system capabilities (OSC)”.

WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
9	Data Origination Centre	ABO System Fleet	Y	Identity of Centre issuing the ABO report to the WIS.		M,I	M,I	M,I	Selectable standard WIS centres only.
9	Data Origination Centre Contact	ABO System Fleet	Y	Set of Data Origination Centre contact details: Name, E-mail, Address, Phone Number		M,I	M,I	M,I	
9	Operating Authority	ABO System Fleet	Y	Name of organization or country responsible for ownership of the majority of the component sensors deployed.	United Airways, Panasonic Avionics Corporation	M,I	M,I	M,I	
9	Operating Authority Contact	ABO System Fleet	Y	Set of Data Origination Centre contact details: Name, E-mail, Address, Phone Number		M,I	M,I	M,I	
1	Measured Variable	ABO System Fleet	Y	Provides a Key Link to the set of measured variable metadata for the System Fleet.		M,I	M,I	M,I	
1.01	Variable Name	Measured Variable	Y	Name of the measured variable.	Air Temperature	M,I	M,I	M,I	Selectable set of OSCAR standard fields.
7	Reporting Status	Measured Variable	Y	Provides the current status of reporting of the measurand. “Suppressed” could be used to provide a blacklisting status (usually would require all measurands to be suppressed).	Reported	M,I	M,I	M,I	Selectable set of OSCAR standard fields: Downlink only, Reported, Future Reported, Downlink Suppressed, Reporting Suppressed

WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
8	Quality Status	Measured Variable	Y	Provides the current quality status of the measurand.	Good	M,I	M,I	M,I	Selectable set of OSCAR standard fields. Should be consistent with Reporting Status.
1.02	Measured Units	Measured Variable	Y	The units in which the measurand is measured onboard the aircraft	g/kg	M,I	M,I	M,I	Selectable set of OSCAR standard fields.
7	Reported Units	Measured Variable	Y	The units in which the measurand is reported to the WIS.	% humidity	M,I	M,I	M,I	Selectable set of OSCAR standard fields.
7.12	Reported Resolution	Measured Variable	Y	The resolution to which the measurand is reported to the WIS.	5 g/kg	M,I	M,I	M,I	Selectable set of OSCAR standard fields.
6.05	Measurement Resolution	Measured Variable	Y	The resolution to which the measurand is measured onboard the aircraft	1 %	M,I	M,I	M,I	Selectable set of OSCAR standard fields.
6.02	Smoothing	Measured Variable	Y	Has the measurand been smoothed as part of the onboard measurement process.	Y	M,I	M,I	M,I	Y/N/U. (U=Unknown).
6.02	Algorithm	Measured Variable	Y	The name, version and/or description of the algorithm used to process the measurand onboard the aircraft		M,I	M,I	M,I	Free text offering existing field entries as pseudo-standard.

WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
6.03	Sampling Method Upper	Measured Variable	Y	Indication of method used to sample the measurand in the upper troposphere. Should indicate whether the sampling regime is based on pressure or time.	Pressure	M,I	M,I	M,I	Selectable set of OSCAR standard fields with “Add New” option: Pressure, Time, Event-based, Other.
6.03	Sampling Method Lower	Measured Variable	Y	Indication of method used to sample the measurand in the lower troposphere. Should indicate whether the sampling regime is based on pressure or time.	Time	M,I	M,I	M,I	Selectable set of OSCAR standard fields with “Add New” option: Pressure, Time, Event-based, Other.
6.03	Sampling Method Enroute	Measured Variable	Y	Indication of method used to sample the measurand while enroute. Should indicate whether the sampling regime is based on pressure or time.	Event-based	M,I	M,I	M,I	Selectable set of OSCAR standard fields with “Add New” option: Pressure, Time, Event-based, Other.
6.08	Sampling Frequency Ascent Upper	Measured Variable	Y	Frequency or reporting conditional upon Reporting Method Upper. Used to determine the vertical resolution of the measurand.	10 hPa	M,I	M,I	M,I	Controlled data entry.
6.08	Sampling Frequency Ascent Lower	Measured Variable	Y	Frequency or reporting conditional upon Sampling Method Lower. Used to determine the vertical resolution of the measurand.	1 min.	M,I	M,I	M,I	Controlled data entry.

WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
6.08	Sampling Frequency Descent Upper	Measured Variable	Y	Frequency or reporting conditional upon Sampling Method Upper. Used to determine the vertical resolution of the measurand.	50 hPa	M,I	M,I	M,I	Controlled data entry.
6.08	Sampling Frequency Descent Lower	Measured Variable	Y	Frequency or reporting conditional upon Sampling Method Lower. Used to determine the vertical resolution of the measurand.	1 min.	M,I	M,I	M,I	Controlled data entry.
6.08	Sampling Frequency Enroute	Measured Variable	Y	Frequency or reporting conditional upon Sampling Method Enroute. Used to determine the hortizontal resolution of the measurand.	7 min.	M,I	M,I	M,I	Controlled data entry.
1.04	Ascent Second Phase Level	Measured Variable	Y	Estimation of the Second Phase Level for transition between ascent flight phases.	1000 m	M,I	M,I	M,I	Controlled data entry of metres of altitude.
1.04	Enroute Level	Measured Variable	Y	Estimation of the enroute or cruise level of the fleet.	10500 m	M,I	M,I	M,I	Controlled data entry of metres of altitude.
1.04	Top of Descent	Measured Variable	Y	Estimation of the Top of Descent altitude.	6000 m	M,I	M,I	M,I	Controlled data entry of metres of altitude.
8.01	Uncertainty	Measured Variable	Y	Uncertainty of the measurand in Reported Units.	1.0 C	M,I	M,I	M,I	Controlled data entry.

WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
8.01	Uncertainty Determination Method	Measured Variable	Y	Method used to determine the Uncertainty.	Comparison with national standard.	M,I	M,I	M,I	Free text entry.
7.13	Data Latency	Measured Variable	Y	Estimate of the data latency of the measured variable, which will generally be consistent across the observations set. Should be estimated based on average availability of 90% of the set of vertical profile data (ascent and descent).	15 min.	M,I	M,I	O,I	Controlled data entry.
7.05	ABO System Software	ABO System Fleet	Y	Provides a Key Link to the set of system software metadata for the System Fleet.		M,I	NA	O,I	The ABO System Software metadata should be historised.
7.05	System Software Specification	ABO System Software	Y	The name of the software specification upon which the software is based.	AOSFRS 1.1	M,I	NA	O,I	Selectable set of OSCAR standard fields with “Add New” option.
7.05	System Software Version	ABO System Software	Y	The ABO software version as provided by the developer/manufacturer.	Honeywell AOSFRS 1.0	M,I	NA	O,I	Selectable set of OSCAR standard fields with “Add New” option:
7.05	Avionics Manufacturer	ABO System Software	Y	The Avionics Manufacturer and name of the avionics system on which the ABO System Software is deployed.	Honeywell ACMS	M,I	NA	O,I	Selectable set of OSCAR standard fields with “Add New” option:

WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
7.05	Avionics Serial Number	ABO System Software	Y	The Avionics Serial Number of the avionics system on which the ABO System Software is deployed.		M,I	NA	O,I	Selectable set of OSCAR standard fields with “Add New” option:
7.05	Avionics Software Number	ABO System Software	Y	The Avionics Software Number of the avionics system on which the ABO System Software is deployed.		M,I	NA	O,I	Selectable set of OSCAR standard fields with “Add New” option:
3.08	Communications System	ABO System Software	Y	The avionics Communications System unit utilized by the ABO System Software for downlink messaging.	Honeywell ATSU	M,I	NA	O,I	Selectable set of OSCAR standard fields with “Add New” option:
3.08	Communications Serial Number	ABO System Software	Y	The serial number of the avionics Communications System unit utilized by the ABO System Software for downlink messaging.		M,I	NA	O,I	Selectable set of OSCAR standard fields with “Add New” option:
3.08	Communications Software Number	ABO System Software	Y	The software number of the avionics Communications System unit utilised by the ABO System Software for downlink messaging.		M,I	NA	O,I	Selectable set of OSCAR standard fields with “Add New” option:
7.05	Uplink Configurable	ABO System Software	Y	Binary flag to indicate whether or not the ABO System Software supports uplink configurability.	Y	M,I	NA	O,I	Y/N
6.03	Number Airport Configurable	ABO System Software	Y	Number of airport locations configurable in the ABO System Software.	10	M,I	NA	O,I	Controlled data entry: number from 0 to 99

WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
6.03	Number Boxes Configurable	ABO System Software	Y	Number of geographical boxes configurable in the ABO System Software.	5	M,I	NA	O,I	Controlled data entry: number from 0 to 99
3.06	ABO System Aircraft Identifier	ABO System Fleet	N	The combination [ABO Programme.ABO System Type.ABO System Aircraft Identifier] must be unique. While it would be preferable to use the Aircraft Tail Number within the unique aircraft identity, this may not be divulged or authorised by the Aircraft Owner.	EU1234	M,I	M,I	M,I	Aircraft identity mapping list should be held by the ABO System Operator
9	Airline Name	ABO System Aircraft Identifier	N	Name of the airline to which the aircraft belong.	Jetstar	M,I	O,I	M,I	Selectable set of OSCAR standard fields with “Add New” option:
9	Parent Airline	ABO System Aircraft Identifier	N	Name of the parent airline	Qantas	O,I	O,I	O,I	Selectable set of OSCAR standard fields with “Add New” option:
10	Airline Contact	ABO System Aircraft Identifier	N			O,I	O,I	O,I	
9	Aircraft Owner	ABO System Aircraft Identifier	N	Name of the organization or entity that has ownership of the aircraft platform. May be different from the Airline Name.	United Airways, British Airways	O,I	O,I	O,I	Selectable set of OSCAR standard fields with “Add New” option:

WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
5	Operating QMS	ABO System Aircraft Identifier	N	Binary flag to indicate whether or not the airline is compliant with an QMS ISO standard.	Y	O,I	O,I	O,I	Y/N
5	QMS Details	ABO System Aircraft Identifier	N	Identity of the QMS standard to which the airline complies.	ISO9001	O,I	O,I	O,I	Free test field.
5.09	Sensor Type	ABO System Aircraft Identifier	Y	Provides a Key Link to the sets of measured variable metadata for the aircraft.	Total Air Temperature Probe	O,I	O,I	O,I	Selectable set of OSCAR standard fields.
1.01	MeasurementVariable	ABO System Aircraft Identifier	Y	The variable measured by the sensor.	Air Temperature	O,I	O,I	O,I	Selectable set of OSCAR standard fields.
1.02	Measurement Units	ABO System Aircraft Identifier	Y	The unit of measurement of the sensor.	Degrees C	O,I	O,I	O,I	Selectable set of OSCAR standard fields.
5.09	Part Number	ABO System Aircraft Identifier	Y	The part number of the sensor.		O,I	O,I	O,I	Free text field.
5.09	Serial Number	ABO System Aircraft Identifier	Y	The serial number of the sensor.		O,I	O,I	O,I	Free text field
5.09	Manufacturer	ABO System Aircraft Identifier	Y	The name of the manufacturer of the sensor.	Rosemount	O,I	O,I	O,I	Selectable set of OSCAR standard fields with “Add New” option:

WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
3.05	Aircraft Call Sign	ABO System Aircraft Identifier	N	The aircraft registration call sign.	VH-ABC	O,I	O,I	O,I	While this is the unique aircraft identity used by the airline, it may be a stipulation that this identity is not to be used by the WMO AMDAR program.
3.05	Aircraft Manufacturer	ABO System Aircraft Identifier	N	The name of the manufacturer of the aircraft.	Boeing	M,I	O,I	O,I	Selectable set of OSCAR standard fields with “Add New” option:
3.05	Model Serial Number	ABO System Aircraft Identifier	N	Unique airframe Model Serial Number provided by the manufacturer.	nnnn	O,I	O,I	O,I	Free text field.
3.04	Type	ABO System Aircraft Identifier	N	Aircraft Type	747	M,I	O,I	O,I	Selectable set of OSCAR standard fields with “Add New” option:
3.04	Series	ABO System Aircraft Identifier	N	Aircraft Type Series	400	M,I	O,I	O,I	Selectable set of OSCAR standard fields with “Add New” option:
3.04	Model	ABO System Aircraft Identifier	N	Aircraft Type Model	436	O,I	O,I	O,I	Selectable set of OSCAR standard fields with “Add New” option:
3.05	Engine	ABO System Aircraft Identifier	N	Aircraft Engine serial number.	4 x RR RB211-524G2-19	O,I	O,I	O,I	Free text field.
5.02	Navigation System	ABO System Aircraft Identifier	N	Navigation System type.	GPS	O,I	O,I	O,I	Selectable set of OSCAR standard fields with “Add New” option: GPS, Inertia
3.05	Structure	ABO System Aircraft Identifier	N	Aircraft structure type.	Fixed-wing Landplane	O,I	O,I	O,I	Selectable set of OSCAR standard fields with “Add New” option:

WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
3.05	EASA Category	ABO System Aircraft Identifier	N	Aircraft EASA category.	CS-25 Large Aeroplane	O,I	O,I	O,I	Selectable set of OSCAR standard fields with “Add New” option:
3.01	Airports	ABO System Fleet	Y	Provides a Key Link to the set of airport metadata for the Fleet.		M,I	O,I	O,I	Provides OSCAR with a list of airport locations at which vertical profiles are produced by the Fleet.
6.08	Profile Time Unit	Airports	Y	Unit of time to which the Number of Profiles pertains.	Daily	M,I	O,I	O,I	Selectable set of OSCAR standard fields: Hourly, Daily, Weekly
6.08	Hour of Day	Airports	Y	If Profile Time Unit is Hourly, then optionally provide stratification of profiles over each UTC hour of the day.		M,I	O,I	O,I	0,1,2,…23 If used, a Number Profiles for each hour might be optionally specified. If a particular hour is not specified, this should indicate that the Number Profiles for that particular hour is 0.
6.08	Number Profiles	Airports	Y	Number of profiles per Profile Time Unit (or at Hour of Day).	2	M,I	O,I	O,I	Integer from 1 to 99.
3.01	Enroute Airport Pairs	ABO System Fleet	Y	Provides a Key Link to the set of Enroute Airport Pairs metadata for the Fleet.		O,I	O,I	O,I	Provides OSCAR with a list of airport pairs between which enroute legs are produced by the Fleet.
6.08	Number Enroute Legs	Enroute Airport Pairs	Y	Number of flights or legs between the Enroute Airport Pairs.	10	O,I	O,I	O,I	Note that the ordering of the pairs dictates the path or the route: departing from the first airport and going to the second. Integer from 1 to 99.

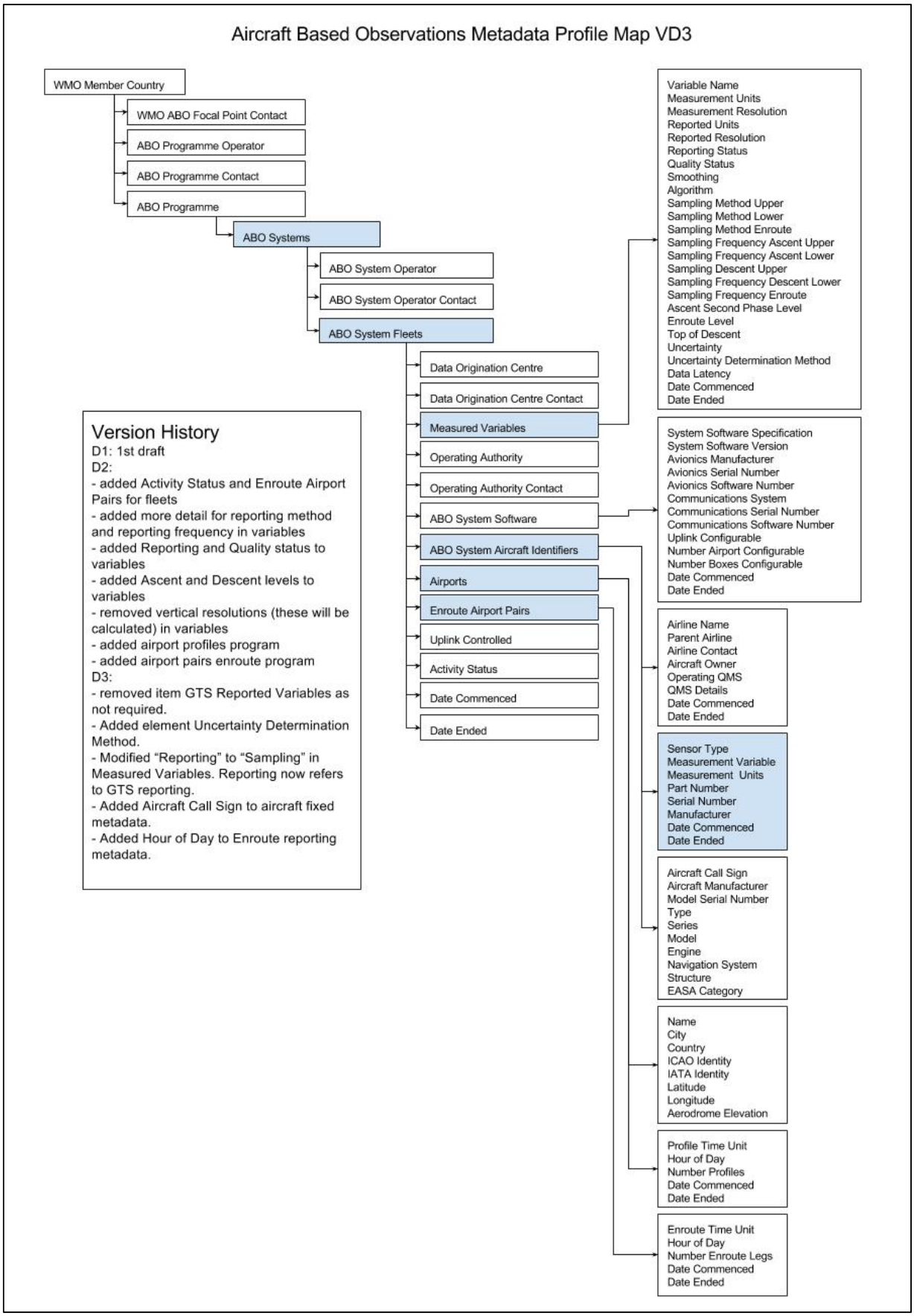
WIGOS MDS Category. Element	ABO Metadata Element	Parent Metadata Element	Historical Record Required	Description	Examples	AMDAR (M/O, N/I)	ICAO ABO (M/O, N/I)	Other ABO (M/O, N/I)	Additional Comments
6.08	Enroute Time Unit	Enroute Airport Pairs	Y	Unit of time to which the Number Enroute Legs pertains.	Daily	O,I	O,I	O,I	Selectable set of OSCAR standard fields: Daily, Weekly
6.08	Hour of Day	Enroute Airport Pairs	Y	If Enroute Time Unit is Hourly, then optionally provide stratification of profiles over each UTC hour of the day.		M,I	O,I	O,I	0,1,2,…23 If used, a Number Enroute Legs for each hour might be optionally specified. The hour indicated should specify and estimate the beginning time of the Enroute leg between the Enroute Airport Pairs. If a particular hour is not specified, this should indicate that the Number Enroute Legs for that particular hour is 0.
6.01	Uplink Controlled	ABO System Fleet	Y	Binary flag to indicate whether or not the fleet is uplink controlled by a ground based optimization system.	Y	O,I	O,I	O,I	Y/N
6.08	Activity Status	ABO System Fleet	Y	Provides an indication of the Fleet's reporting status	Reporting	O,I	O,I	O,I	Selectable set of OSCAR standard fields with "Add New" option: Reporting, Temporarily Not Reporting, Future Planned, Ceased Reporting

Notes:

1. Column "WIGOS MDS Category.Element" provides the mapping to the WIGOS Metadata Standard.
2. Column "ABO Metadata Element" provides the metadata element which the "Description" column describes.
3. Column "Parent Metadata Element" provides the ABO Metadata Element that is the parent element of the ABO Metadata Element.
4. Column "Historical Record Required" provides an indication as to whether the Member and/or OSCAR system should maintain and provide a historical record of changes in the ABO Metadata Element.
5. Column "Description" provides a description of the ABO Metadata Element.
6. Column "Examples" provides an example of the content of the ABO Metadata Element.

7. Columns “AMDAR (M/O,N/I)”, “ICAO ABO” (M/O,N/I)” and “Other ABO (M/O,N/I)” provide an indication as to whether the ABO Metadata Element is a Mandatory (M) or Optional (O) element and if the element is to be maintained at the National (N) or National and International (I) levels for each of the respective ABO System types. “I” indicates that the ABO Metadata Element will be maintained within the OSCAR system. O indicates that the element may not be provided. “NA” indicates that the ABO Metadata Element is not relevant to the ABO Observing System.
8. Column “Additional Comments” provides information describing how the element might be submitted within OSCAR.
9. If an element is not maintained Internationally (I), then every effort should be made to ensure that the element is maintained Nationally (N) if it is available to the National Programme.

Attachment 2, Aircraft-Based Observations Metadata Profile Map



Annex V – Guidance on AMDAR Observing System Data Optimization

Background

The AMDAR Observing System

Aircraft Meteorological DAta Relay[6] predominantly uses the on-board aircraft sensors to measure meteorological information. The resulting data are then transmitted to the ground via VHF or satellite link using the aircraft's own communications system (ACARS - Aircraft Communications Addressing and Reporting System). When the airline receives the data, it sends it on to the National Meteorological and Hydrological Services (NMHS) where it is processed, checked for quality and incorporated into meteorological applications, including Numerical Weather Prediction (NWP) models and forecasts for aviation.[7]

The WMO global AMDAR system now produces over 600,000 high-quality observations per day of air temperature, wind speed and direction, together with the required positional and temporal information and with an increasing number of humidity and turbulence measurements being made.

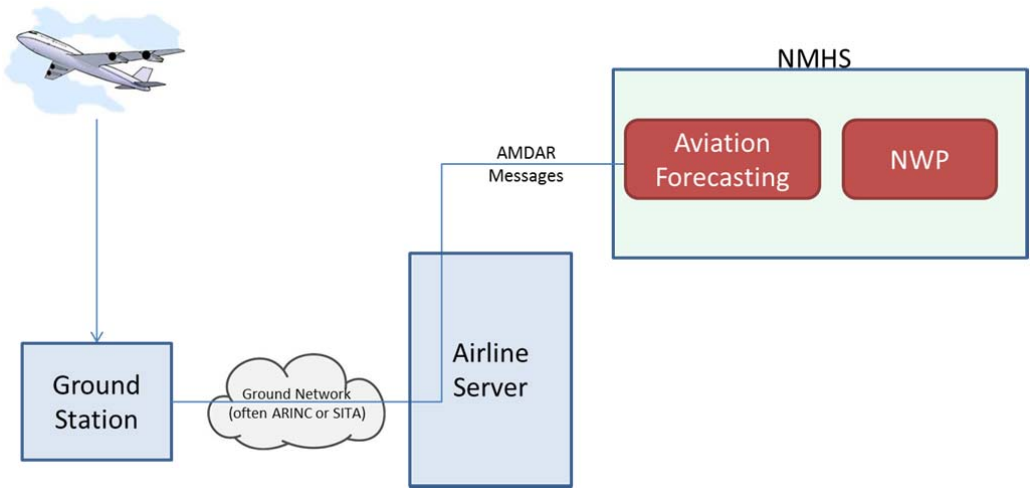


Figure 1: Block diagram of a typical non-optimized AMDAR Observation System

While the cost per observation is generally lower than for other upper-air measurement systems, for example, the balloon borne radiosonde measurement system, most AMDAR programs involve a cost for each observation received by the NMHS. A large component of this cost is associated with the air to ground communications which, particularly over remote land and ocean areas, can be significant in a larger programme with a fleet of many aircraft. It becomes a more significant issue still when satellite communications are required to be used (in preference to VHF communications).

Requirements for Data

Redundant Data

Redundant data are any observations that are surplus to requirements of data users and their applications. Meteorological requirements for upper-air observational data are defined by WMO

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6 See http://www.wmo.int/amdar for more information

7 The WMO AMDAR Observing System: Benefits to airlines and aviation. http://www.wmo.int/pages/prog/www/GOS/ABO/AMDAR/documents/JN14991_amdar_foldout_080914_en.pdf

under its Rolling Review of Requirements[8] process. WMO Members should ensure that they are aware of both national and international requirements of data users for the provision of upper-air data before determining the best methods and configurations for optimization of aircraft-based observations and AMDAR observing systems.

Importantly, some data users may actually specify a requirement for what might initially be considered "redundant" data. For example, numerical weather prediction systems may be advantaged by the provision of one or more additional observations of particular variables at the same point in space and time so as to obtain or allocate a higher degree of certainty to such observations. Consideration of such requirements should also be made.

Data Coverage

Data coverage refers to the spatial and temporal distribution of aircraft observations.

For an AMDAR Program with redundant data, there are two key aspects of data coverage that are required to be specified and controlled:

1. The temporal and spatial separation of vertical profiles (of meteorological parameters) made on aircraft ascent and descent; and,
2. The temporal and spatial separation of isolated reports made during level flight.

The principal aim of an effective AMDAR data optimization system is to enable delivery of output data at sufficient spatial resolution and temporal frequency to satisfy user requirements, without delivering greater volumes than required (redundant data).

One of the challenges is that such requirements may vary with location, local weather situation and season.

Whereas data supply will depend on:

- Passenger demand: this affects the number of aircraft that fly to a destination, and the types of aircraft used;
- Airline priorities and agreements made with NMHS for provision of data; and
- Airport capacity and regulations (for example curfews).

Figure 2 shows modelling based on data from the Australian Bureau of Meteorology. While actual figures for each AMDAR program will vary, the relationship between AMDAR fleet size and the trends in vertical profile production and redundancy are likely to be similar:

- The % of redundant profiles increases linearly with the number of non-optimized aircraft. In this data, with 50 aircraft ~1/3 of the profile are redundant.
- The number of redundant profiles (and hence their cost) increases non-linearly with the number of non-optimized aircraft. That is, a greater percentage of a greater number of profiles are redundant. In this particular example, the number of redundant profiles increases as the square of the number of aircraft.
  Based on this programme and the requirements specified, 50 aircraft produce ~66,000 redundant profiles a year. Assuming US$ 2/profile, this amounts would amount to $132,000/year in redundant data and a potential saving of 33 per cent of communications costs if eliminated.

[8] See: http://www.wmo.int/pages/prog/www/OSY/GOS-RRR.html

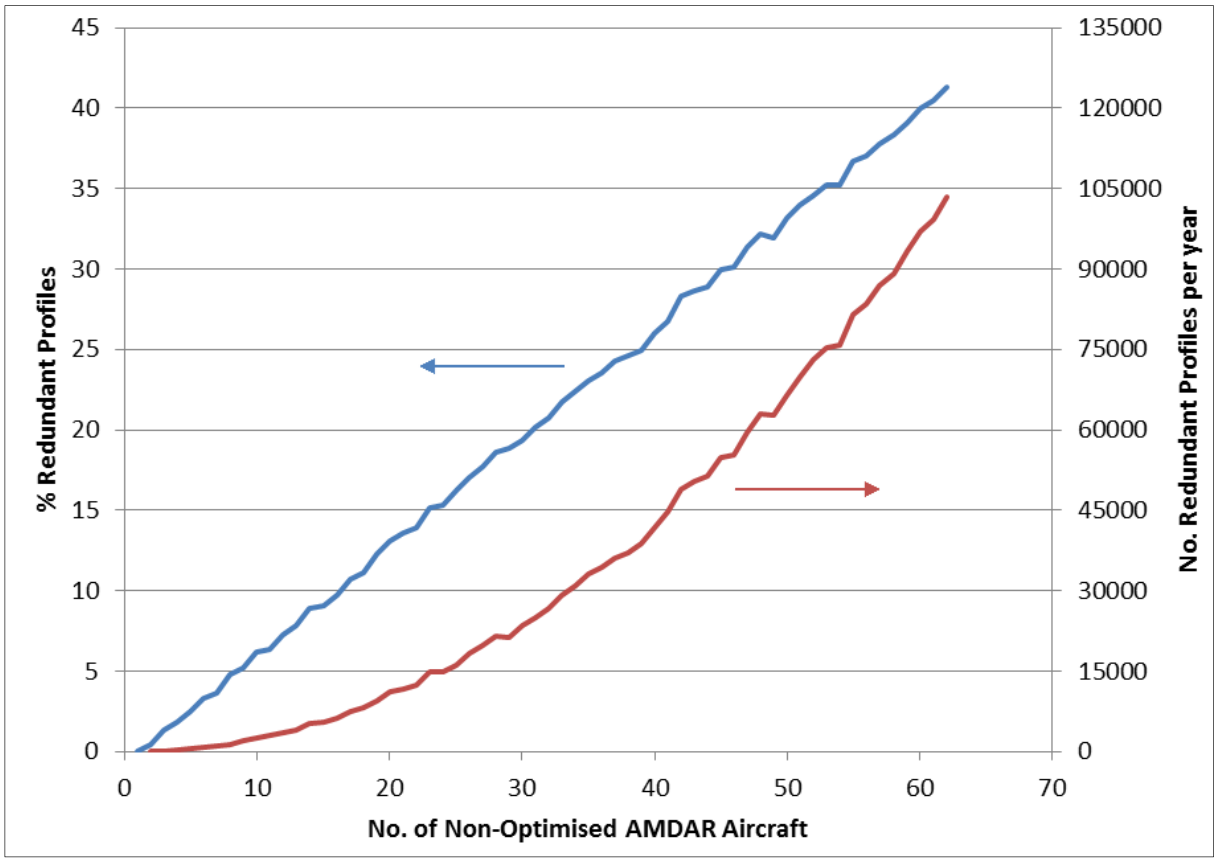

Figure 2: Increase in Redundant Data with number of aircraft

Optimization Methods/Strategies

AMDAR Software Capabilities

The AMDAR On-board Software Functional Requirements Specification (AOSFRS) specifies possible functionality of the AMDAR onboard software which would allow for varying degrees of data optimization, depending on the level of compliance implemented. This includes:

1. Initiation of AMDAR onboard software configurations to manage:
   - Production of vertical profile data at a list of airports:
     - with airport specific profile frequencies.
     - with airport specific sampling frequencies.
   - Production of AMDAR data during the enroute phases with aircraft specific sampling frequencies.
   - Production of AMDAR data within geographical boxes.
   - Production of AMDAR data within time windows.
2. Ability to adjust stored configurations both manually and remotely.
3. Ability to receive and process requests to remotely make changes to the AMDAR reporting configuration, to be effective either permanently or for the current or next flight only.

While use of the stored/default configurations for each aircraft can provide a degree of control over data output and programme optimization, in isolation, it is (by definition) unable to respond dynamically to the reporting of observations by other aircraft, which will be variable and changing, being subject to airline operational schedules. For this reason, the ability to make changes to an aircraft configuration, both remotely and automatically, in response to a command request, is required.

Remote changes typically require a formatted command message to be sent to the aircraft using the standard ACARS (data) link. This command is often referred to as an *uplink*.

AMDAR Optimization Systems

While it is feasible for some degree of data optimization to be achieved by a person issuing uplink commands in response to changing conditions, the best solution comes from using a ground-based and automated (optimization) system. This allows 24/7 response to changing meteorological requirements for data and aircraft operations and data availability.

The section below outlines the steps such optimization software ideally should implement. The perfect system would be one that had the flexibility to manage all the AMDAR equipped aircraft available to a NMHS. This allows the best response to changes in weather conditions and demand.

However, it is recognized that in practice, perhaps due to issues of compatibility between the systems used by different airlines or due to their preferences, an AMDAR optimization system may well have to rely on individual airline-by-airline optimization.

Optimization System Processes

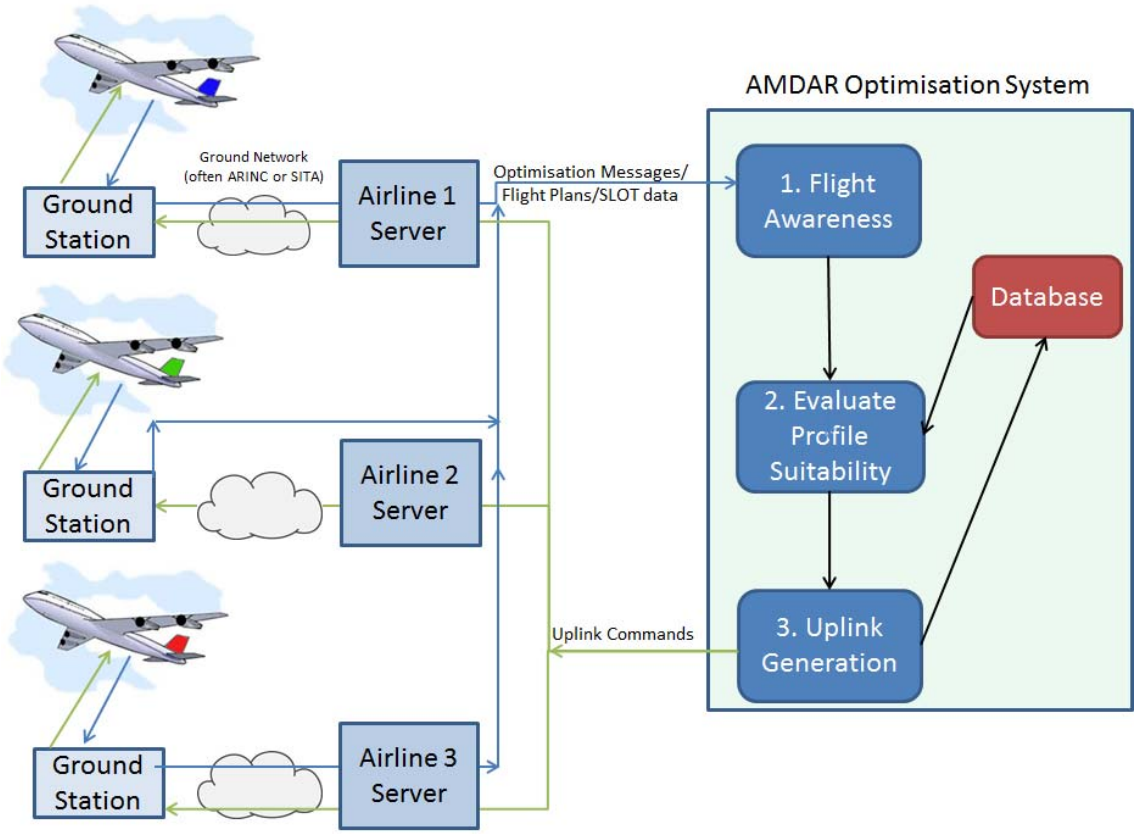

Figure 3: Block diagram of a full AMDAR optimization system.

A full AMDAR optimization system is depicted in Figure 4 and consists of three main steps. These are outlined in greater detail below, but consist of:

1. Flight Awareness: Before take-off (generally when the aircraft leaves the gate) it sends an Optimization Message to the AMDAR Optimization system. This contains sufficient information for the System to identify the aircraft and the route (origin/destination) involved. Alternatively, the aircraft can be identified from flight plans.

2. Evaluate Profile Suitability: Before the aircraft takes off, the Optimization system decides what data, if any, is required from this flight.
3. Uplink Generation: sends the appropriate uplink command to switch on/off data collection during the different flight phases. Even if no data is required from this flight, an uplink command may still be required to override the settings from the previous flight by this aircraft.

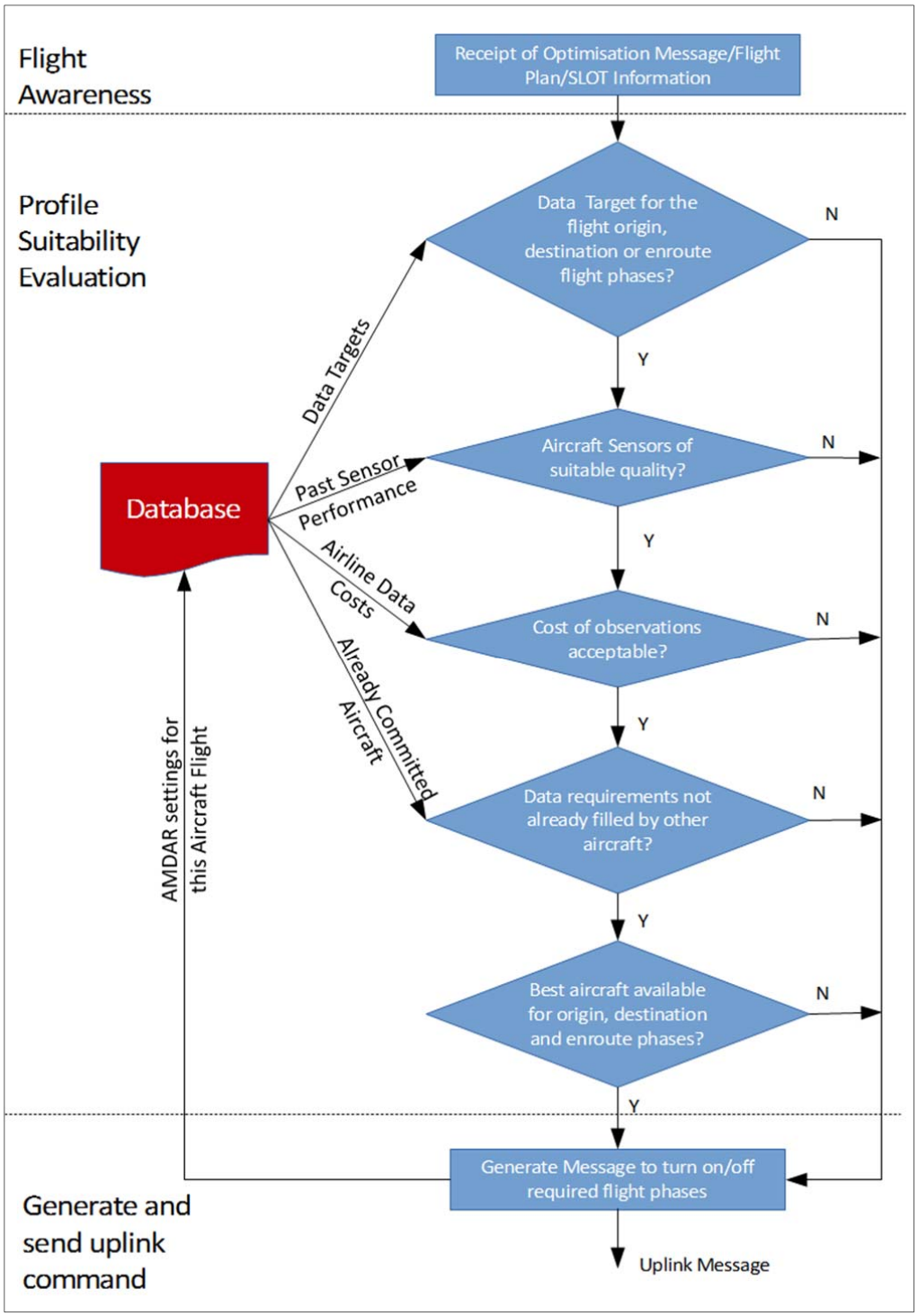

Figure 4: Decision Steps for AMDAR Optimization processing.

Step 1: Flight Awareness

The first stage of any optimization is the system "becoming aware" of an AMDAR aircraft flight. This can be the result of the receipt of an Optimization Message. Alternatively, flight plans can be reviewed to extract the required information.

Whatever the format, the message contains (at a minimum):

- Aircraft identity – either providing or able to be linked to the aircraft call sign (or tail number)
- Flight origin
- Flight destination
- Time of departure
- Time of arrival at destination

Step 2: Profile Suitability Evaluation

Once the optimization system is aware of a flight, it must decide if that aircraft meets the requirements or if there is a better flight available. In any case the optimization system must decide which flight phases (if any) shall be configured to report AMDAR data.

The decision to activate or deactivate the AMDAR onboard software for data collection will depend on one or more of the following factors:

- Data Requirements:
    - From the "Flight Awareness" phase, the flight origin and destination are known. Thus it can be determined where and (an estimate of) when profiles (on aircraft ascent and descent) and the series of enroute reports (made between the departure and destination airports) will be generated.
    - This potential data availability is then compared to a maintained set or database of rules or targets for AMDAR data collection for a list of airports, areas and routes, which are based on the requirements for upper-air data. Rules may also be dependent on:
        - time of day
        - season
        - local weather conditions
        - a preference for ascent profile data over descent
        - a special area or airport configuration
        - a preference for short or long-haul flights
        - a preference for en-route reporting

- Aircraft reporting and configuration status:
    - From the "Flight Awareness" phase the identity of the aircraft is known. This can be used to interrogate an internal NMHS database to determine the status of the aircraft-based on available metadata. Factors to be considered include:
        - Data quality of reported parameters: Has the aircraft been "black-listed" for reporting based on previous data quality checks, e.g. comparison to computer model or radiosonde.
        - The preference of one aircraft over another for the provision of critical parameters, e.g. the reporting of humidity or turbulence.

- Aircraft/Airline observation cost:
    - From the "Flight Awareness" phase the identity of the aircraft is known which can then be used to obtain from the database the aircraft or airline-based cost of the data.
    - This can be compared with the costs of any alternative flights for the same time and departure or destination airport and the enroute segment.

- Flights already committed by aircraft not configurable by uplink:
    - There may already be aircraft committed to provide some or all of the data requirements for the particular time and flight phases offered by the uplink-capable aircraft. While these may not be changed by the optimization system, they might be taken into consideration if the system is “aware” of their operations.
    - An optimization system can be made aware of these flights and their output data from their OOOI/Optimization messages, or deduced from received observations, if these messages and data are provided to and processed by the optimization system.

- Uplink capable AMDAR aircraft already committed:
    - Many airlines charge a cost for uplink messages. The comparative cost of uplink vs downlink/observation messages determines whether changing an aircraft configuration in flight provides any benefit.

No data may be required from this flight because the AMDAR quota for the origin and destination airports, and the route are already filled by flights nearby in time and/or space.

An optimization system may wait to see if “better” aircraft becomes available (for example one with a humidity sensor). While changing an aircraft’s configuration during flight is usually possible, the decision on, at least, whether an Ascent Profile is collected needs to be made before the aircraft takes off.

Step 3: Generate and Send Uplink Command

Once the optimization system has decided which flight phases (if any) to activate, the system should generate the necessary message(s) and send it (them) automatically.

An uplink message may still be required to turn off flight phases that are activated from previous flights or by default.

Uplink Message Security

Airlines understandably have security concerns about allowing third parties to directly uplink to their aircraft. Instead, the optimization system may send uplink commands to an airline server, where they undergo further checks before being sent to the aircraft. These checks are ideally automated (to save time and allow continuous, unattended operation), but may require additional interfaces to be developed on the airline server.

Airline server checks include:

- Message formatting is correct – parameters are within allowed ranges and there has been no corruption during transmission.
- Message type/content is allowed – only certain types/formats of uplink messages are authorised to be sent by the optimization system. This stops a hacked optimization system having unlimited access to the aircraft.
- Message volumes are within acceptable limits. This stops a malfunctioning (or hacked) optimization system overloading the aircraft uplink.

Optimization System Formats

Flight Awareness Messages

Several formats are currently in use including:

- OUT[9] message
- G-ADOS[10] OPS or SLOT format
- AOSFRS[11] Optimization Message.

Uplink Messages

Currently a number of different formats for this message are in use. The key difference between the formats is whether the message is:

- Passed unchanged through the airline servers to aircraft [BOM ADOS, AOFSRS].
- In a format that an airline's server translates into the appropriate (airline specific) format [G-ADOS].

AMDAR Optimization System Functionality Requirements

Component	Functionality	Section	Importance
System User Interface	Allow modification of targets for data coverage		Essential
System User Interface	Allow NMHS direct access via a graphical user interface.		Recommended
System User Interface	Allow temporary adjustment of coverage targets for a set period, followed by reversion to a default.		Optional
System User Interface	Allow maintenance of fleet metadata		Essential
System User Interface	Allow configuration for:- - airports - aircraft - geographic areas		Essential
System User Interface	Allow configuration for routes/airport pairs		Recommended
Database	Store target number of profiles for an airport (e.g. profiles per hour).	1.2.3.2	Essential
Database	Store target data coverage for routes (i.e. airport pair), e.g. route legs per hour.	1.2.3.2	Recommended
Optimizer	Awareness of future flights with enough lead time to make decisions as to best aircraft configurations to meet targets	1.2.3.3	Essential
Optimizer	Algorithm to decide which phases of flight (if any) to enable	1.2.3.3	Essential
Optimizer	Optimization incorporates preferential selection of aircraft-based on		Recommended

[9] [OUT of the gate, OFF the ground, ON the ground, INTO the gate, collectively known as] OOOI messages are transmitted automatically by aircraft systems to the ground station. These are used by the airline industry to track the status of aircraft.

[10] G-ADOS General Task Description, v1.8 29th October 2014, Deutscher WetterDienst

[11] AMDAR Onboard Software Requirements Specification (AOSFRS). Latest version is available at the WMO AMDAR/Resources site: http://www.wmo.int/pages/prog/www/GOS/ABO/AMDAR/resources/index_en.html#amdar_stds

Component	Functionality	Section	Importance
	measurement capabilities		
Optimizer	Optimization incorporates preferential selection of aircraft-based on observations cost		Optional
Optimizer	Optimization incorporates preferential selection of aircraft-based on measurement quality status		Recommended
Optimizer	Optimization incorporates preferential selection of aircraft-based on estimated time of flight phase		Optional
Optimizer	Reception and analysis of response and non-response to uplink commands		Optional
Optimizer	Reception and analysis of AMDAR data to assess response and non-response to configuration		Optional
Optimizer	Optimization incorporates awareness of AMDAR equipped aircraft which cannot have their configurations changed by uplink		Optional
Database	Ability to store current aircraft configurations for reference when assessing future flights	1.2.3.3	Essential
Communications	Ability to send (re)configuration messages to aircraft (possibly via airline server)	1.2.3.4	Essential
Database	Store data quality status information for aircraft to assist configuration decisions	1.2.3.2	Recommended
Database	Store aircraft additional sensor (e.g. Water Vapour, icing) to assist configuration decisions	1.2.3.2	Recommended
Database	Store airline/aircraft data cost to assist configuration decisions	1.2.3.2	Optional

Appendix A: AMDAR Optimization Implementations

A.1 Australian Bureau of Meteorology

The Australian Bureau of Meteorology runs a fully automated AMDAR Optimization System (ADOS). The screenshot (Figure 4) shows the available options for each aircraft, including:

- Sensor quality information for Temperature, Wind, DEVG (Turbulence) and Water Vapour
- Aircraft specific rules for establishing a reporting schedule of observations
- Airports reporting schedules
- Latitude/Longitude Reporting boxes
- Reporting times

This system uses the OOOI messages as its Flight Awareness message and generates an uplink command that is passed unchanged to the aircraft after checking by the airline's servers.

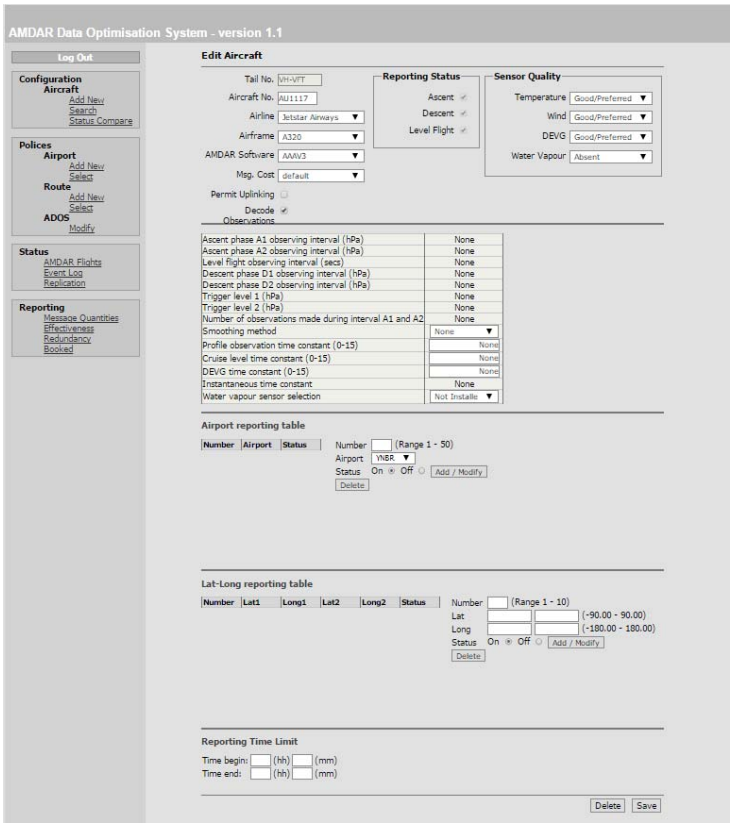

Figure 4: Australian Bureau of Meteorology ADOS system screen shot.

A.2 E-AMDAR

Currently (January 2016), the E-AMDAR programme has a range of optimization options. These include:

- E-AMDAR Data Optimization System (E-ADOS):
  - Full automated and flexible AMDAR optimization.
  - Graphical interface allows real configuration.
  - Optimization configurations for airports, aircraft, routes and geographic regions in general or for time periods.
  - For Flight Awareness E-ADOS accepts several message formats including IATA (ASM and OOOI) messages.
  - Standard format Flight Awareness and Uplink Command messages are generated by the system, which each airline then translates/adapts to their own system. Alternatively an uplink command is generated that is passed unchanged to the aircraft after checking by the airline's servers.
  - Supports uplink message formats according ARINC-620 and AAA V3 specification.
  - Airlines:
    - Lufthansa (DLH)
    - Lufthansa Cityline (CLH)
    - Lufthansa Cargo (GEC)
    - Germanwings (GWI)
    - Thomas Cook Scandinavia (VKG)
    - Finnair (FIN)
    - Austrian Airlines (AUA)
    - KLM (B737NG Fleet) (KLM)

        - Air France B777 Fleet (AFR)
- AFR Flight Selection System (FSS):
    - Optimization on profiles in a time period (e.g.1 profile in 120 minutes) at an airport
    - Aircraft:
        - Air France A320 Fleets (AFR)

    NOTE: AFR A320 fleets may also migrate to E-ADOS.

- SAS Flight Selection System:
    - Optimization on city pairs (that is, can select ascent, cruise or descent profiles for a route e.g. LGKF to ENGM
    - Airlines:
        - Scandinavian Airlines (SAS)
        - Blue1 (BLF)
- NOTE: SAS and any remaining BLF operations will migrate to E-ADOS April 2016.

- British Airways Flight Selection System:
    - Optimization rules for each participating airport
    - Aircraft:
        - British Airways (BAW) B737, B747, B767 fleets

- EZY ARINC OpCenter:
    - Optimization on airport/route pairs
    - Airline:
        - easyJet (EZY)
        - Novair (NVR)

Annex VI – Guidance on AMDAR Onboard Software Development

1. Introduction

This document provides brief and general guidance to WMO Members and their partner airlines on the requirements and process to develop and implement AMDAR onboard software on commercial aircraft fleets. Such development enables onboard atmospheric measurements to be accessible in near real-time for use by National Meteorological and Hydrological Services (NMHSs) in numerical weather prediction and other meteorological forecasting applications for both aviation and the general public. The document consists of:

- An overview of the various aircraft and avionics (aviation electronics) platforms and AMDAR applications solutions; and

- A simple road map for the process of AMDAR onboard software development and implementation.

General descriptions and information about the AMDAR observing system and its functionality can be found on the website of WMO (see http://www.wmo.int/pages/prog/www/GOS/ABO/AMDAR/).

Specific and detailed requirements for AMDAR onboard functionality are provided in the WMO AMDAR Onboard Software Functional Requirements Specification (AOSFRS), available from the AMDAR/Resources site.

Guidance on the wider requirements for implementation and operation of an AMDAR program are available in WMO WIGOS Technical Report 2014-2, *Requirements for the Implementation and Operation of an AMDAR Programme*.

2. Background

Until the middle of the 20th century, information and data relating to various aspects of aircraft flight operation, performance and navigation were available within the cockpit only as visual analogue or coarsely digitized displays and gauges. Then, gradually, the avionics evolved into digitized systems, either receiving digital input or converting the analogue input after reception.

In modern aircraft, atmospheric data, including static and total pressure and air temperature are sampled as close as possible to the sensor elements by the air data computer (ADC) and sent, or made available to other avionics units within the aircraft, for example, the flight management system (FMS), via digital connections.

All the flight mechanical and navigation signals as well as all other system data (for example, engine status) are processed digitally. The real-time flight data are of interest to the cockpit crew for a range of purposes associated with flight operation and aircraft performance and some elements also to air traffic management. Whereas the communication of this information in-flight was once done via voice radio, nowadays, large volumes of data can be automatically transmitted to ground via ground-based or satellite-borne networks of transceiver stations or else downloaded on arrival for use by the airline for post-flight analysis.

3. Automatic Aircraft Data Processing and Communications Systems

The first international deployment of an automatic aircraft communications system is the ARINC system solution called Aircraft Communications Addressing and Reporting System (ACARS). The corresponding equipment aboard an aircraft may be called the Management Unit (MU) or, in the case of newer versions with more functionality, the Communications Management Unit (CMU). Since the late 1990s Airbus aircraft are equipped with a system called Air Traffic Services Unit (ATSU). In addition to the conventional ACARS data and message processing, this system also handles the routing of Air Traffic Control (ATC) information.

These avionics units function both as data acquisition systems and as routers for the processed data.

On some aircraft types (e.g., UPS aircraft Boeing B757) the data sampling and processing is carried out by a system called the Digital Flight Data Acquisition Unit (DFDAU), which sends these data to a separate ACARS unit. Another kind of data acquisition unit is called the Aircraft Condition Monitoring System (ACMS). These units are modular in design and transfer their output data to the system component that provides the ACARS downlink communications function.

There are a range of vendors of these avionics systems that include the most common and widespread in deployment, including Teledyne, Rockwell-Collins, Honeywell, etc.

In most cases, the unit's sampling behavior is programmable in compliance with special ARINC standards. Key standards include:

- ARINC 618 - Air/Ground Character-Oriented Protocol Specification: which governs the format of user defined ACARS messages (that is air to ground)
- ARINC 620 - Data Link Ground System Standard and Interface Specification (DGSS/IS): which describes the sampling activity and frequency being configurable depending on the user's interest.
- ARINC 429 - Digital Information Transfer System (DITS): which describes the data bus used on most commercial aircraft.

Using such functionality, purpose-built applications can be developed for the avionics systems to enable the controlled recording and sending of data in real-time or based on various triggers, such as time, or the value of particular parameters and variables. External and ground-based control of

these applications is also possible, through the use of uplink commands sent via the communication provider to the onboard ACARS unit or the corresponding data acquisition unit. In this way, the applications can be reconfigured before or in-flight for specified sampling and reporting behavior during different flight phases.

In the case of the AMDAR onboard application - the AMDAR Onboard Software - it is the aircraft's sampled data of the ambient atmosphere that is of interest for meteorological purposes.

4. Special Amendment of ACARS for Meteorological Use

4.1 AMDAR Onboard Software

In the following description, the AMDAR Onboard Software (AOS) is referred to as the "AOS module". It consists of the following components and functionality:

- Accept input data from a variety of the aircraft innate avionics equipment.
- Perform high level quality checks on the input data.
- Perform calculations upon the input data to derive required meteorological parameters (flags and optionally turbulence statistics).
- At set intervals, process collected data into standard output messages for transmission to ground stations.
- Accept inputs, allowing users to alter the AMDAR Onboard Software behavior.

WMO and its expert teams have historically developed and maintained several standards for AOS functionality and corresponding uplink and downlink formats:

1. AOSFRS issued by WMO, an approach for overarching the standards for the aircraft communications systems:
   [see: http://www.wmo.int/pages/prog/www/GOS/ABO/AMDAR/resources/index_en.html]
   This specification provides the primary WMO meteorological-based specification for AMDAR onboard software.
   The AOSFRS defines the recommended formats for AMDAR data uplink and downlink for ACARS applications of AMDAR onboard software. This specification will be consistent with and provide the functional requirements for the ARINC 620-8 Meteorological Report Version 6.
   The AOSFRS is published and will be maintained as a CIMO, Instruments and Observing Methods (IOM) technical report.
2. ARINC 620 issued by Airlines Electronic Engineering Committee (AEEC), i.e. for applications on ACARS units like MU or CMU (programmed i.e. by Honeywell):
3. This document contains the specifications of the AMDAR onboard software, Meteorological Report (from version 1 - 6). Data link formats and flags are defined here.
4. A copy of the latest specification can be purchased from the ARINC Store.
5. AAA (ACARS AMDAR ACMS) once written for applications on Teledyne units. These software applications have been developed by AirDatec and implemented for Qantas and Jetstar Airbus and Boeing fleets, South African Airways Airbus fleets and British Airways fleets. The AAA specification series is now superseded by the AOSFRS (see above).

The standards provide the specification of requirements for functionality and message formats for the AOS module's implementation by an avionics applications developer. It is recommended that only the most recent versions of these standards are used as a basis for new and future AOS application solutions using ACARS and alternative or succeeding systems. In particular, the AOSFRS provides the full and detailed specification of required functionality for AOS, with version 1.1 compatible and consistent with version 6 of the Meteorological Report formats as specified within the ARINC 620 Supplement 8 and later.

The feasibility of AMDAR implementation, the level of functionality and also the options (humidity, turbulence, event controlled transmissions, optional parameters for quality control) able to be implemented will heavily depend on the performance and architecture of the avionics.

Figure 1 provides a schematic and simplified overview of those parts of the avionics infrastructure playing a role in the AOS operation.

On the left hand side are the existing avionics system components that continuously generate the input for the AOS, such as:

1. The air data computer for the aerodynamic parameters;
2. The navigation system delivering flight mechanic data and the position.

These data are transmitted to a system normally called the “flight management system” (FMS). Many of the real-time flight operational processes are run in the FMS, for example, the wind calculation.

The parameters listed in the output column of the FMS box in figure 1 are transmitted to the data acquisition unit running the AMDAR on-board software (AOS). On some aircraft types this is the same unit that hosts the data link functions for ACARS (e.g. MU, CMU, ATSU, etc.). On other aircraft the AOS may be run on separate data acquisition units, e.g. DFDAU or ACMS.

The parameters FMS 1. to 7. are the conventional set of AMDAR data to be processed by the AOS.

The humidity values get directly into the AOS unit via an extra ARINC 429 interface driven by the humidity sensor system.

The parameters FMS 8. and 9. are requested by the latest ARINC 620 or AOSFRS versions. These parameters are useful input to the nowcasting and the numerical weather prediction respectively.

The parameters FMS 10. to 16. are parameters being required if the AOS also consists of the turbulence statistics process.

The parameters FMS 17. to 19. are temporarily of interest for quality control purposes. The activation depends on corresponding uplink commands sent on demand to the aircraft.

Depending on the avionics architecture or the firmware’s dimensioning the AOS unit can process uplink commands from ACARS.

By all means, this unit sends the AMDAR data to ACARS for downlink transmission.

It may happen that the downlink does not only have to send the regular reports but also additional reports having been triggered in between by turbulence events.

4.2 Development and Implementation of AMDAR Onboard Software

4.2.1 Availability of Existing AOS Modules

In some cases, it may be that an AOS application is already available as an ARINC 620 compliant module (enabling provision of AMDAR reporting via the ARINC 620 Meteorological Report) within the existing avionics system and the applications suite delivered by the avionics vendor of the prospective airline AMDAR fleet.

Alternatively, it may also be possible that such an application is available but not yet installed within the particular avionics system in question. This has been true of several AMDAR programs taking advantage of Honeywell systems. However, unfortunately, at the current time, this seems to be rare and, in most cases, a special AOS application development will be necessary, especially in the case that compliance with the latest AOS standards is required.

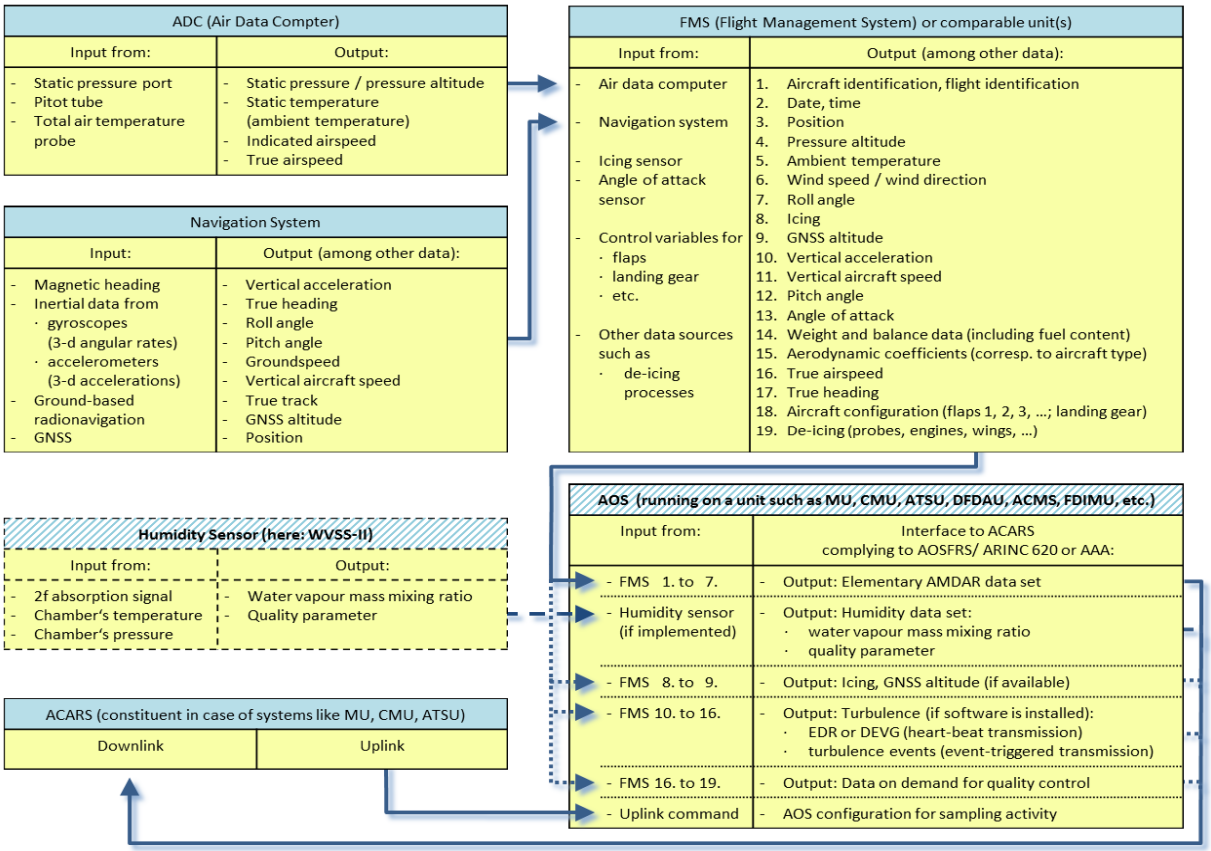

Figure 1:

Schematic overview of the information flow on an aircraft from the relevant sensors to the system component where the AMDAR On-Board Software (AOS) is running and where the transfer to the downlink process of ACARS is done. The table blocks with the hatched title bar describe the parts which do not belong to the standard aircraft equipment. The dashed and dotted arrows mark the handling of parameters beyond the basic AMDAR dataset. Provision of humidity data depends on the existence of humidity instrumentation and on the implementation of an AOS complying with the latest AOSFRS or ARINC 620 standard.

In addition, an AOS module for the prospective AMDAR airline fleet and its particular avionics configuration may have already been developed and implemented in another AMDAR program. In which case, it may also be possible to arrange for that AOS to be provided or purchased through negotiation with either the relevant airline or avionics vendor. A list of current airframes supporting AMDAR is in Appendix 1.

However, care should be taken to ascertain if the existing AOS module provides the required functionality for the new or prospective AMDAR program. Additionally it is often the case that an

AOS module that functions correctly on one airline fleet, may not do the same on that of another, even if the avionics systems are the same, due to differences in configuration and other factors. Therefore, ground-based and in-flight testing of all AOS modules, whether new or ported from another development, should be undertaken and it should be understood that there may be a requirement for some reprogramming and/or reconfiguration of the AOS module by a developer.

4.2.2 Development of AOS Modules

The development of AOS applications for the relevant avionics equipment of an airline can be done in one of several possible ways:

- The corresponding avionics vendor;
- By a suitably qualified and certified Third Party contractor; or possibly
- By a specialized department of the airline itself.

In most cases, the airline will make the decision about which of these possible solutions for AOS development is appropriate and/or permissible. The cost of AOS implementation is outlined in the WMO Technical Report No. 2014-02 (Requirements for the Implementation and Operation of an AMDAR Program). Depending on the circumstances ranging from readily installable routines to the necessity of a completely new software development the costs might be anywhere in the range of US$10K and US$100K.

4.2.3 Process to Achieve AMDAR Onboard Software Implementation

In the Section 4.1 of the document, Requirements for the Implementation and Operation of an AMDAR Program (WIGOS Technical Report No. 2014-02) the organizational project frame for the software implementation is given.

However, the required meteorological functionalities are to be programmed in compliance with or at least following the latest releases of AOSFRS and / or ARINC 620.

4.2.4 Decision about the commercial structure of the AMDAR project

The question about the topology and herewith the contract partners has to be solved. The NMHS or the regional AMDAR program has to decide if they take either the individual airlines or the network provider as contract partner. As a consequence, the path of the downlinked meteorological data to the principal either goes through the airline's communication centre or directly via the network provider.

Both cases need the cooperation of the partner airlines.

Two things have to be cleared with the airline either directly or by the contracted network provider:

1. The possibility of an AOS implementation (possibly including humidity and turbulence);
2. The legal frame of the AMDAR data use because the owner of the data is the airline.

4.2.5 The AOS design or preparation

The entity finally to be addressed for any modification of the ACARS functionality is the corresponding airline. They will decide if the communication system may be modified. Some airlines are able to do the software modification or configuration by themselves, but in most cases there is the avionics vendor or another system integration partner having the administration rights and capabilities for the avionics units hosting data acquisition and ACARS. The final success depends on several things, such as:

1. Performance of the AOS host unit;
2. Portability of possibly available software to the host unit;
3. Certification efforts to be financed, if an AOS could interact with system parts being relevant for aircraft security or air traffic services communication.

Depending on the feasibility and finally on the price of the implementation compared to the number of accessible aircraft with compatible AOS hosting units the NMHS or regional AMDAR program can decide about ordering.

On the side of the physical functionalities, apart from the turbulence, all design parts of the AOS are independent of the aircraft type. The extent of handled parameters just depends on their availability via interfaces to the AOS host unit.

The software's part for turbulence needs some coefficients depending on the aircraft type. This means some extra software configuration for each different aircraft type.

4.2.6 Testing of the AOS

The elementary precondition for this test is the correct operation of the ground systems doing both:

- The separation of the meteorological data from the downlinked ACARS reports; and
- The meteorological data transmission to the NMHS or regional programme.

The AOS prototype implementation has to be tested during the normal flight operation over some months. The data analysis has to take into consideration data plausibility, outliers, deviations of the meteorological parameters from the first guess background of models.

The turbulence measurement part of the AOS needs test flights for each different type of aircraft. The sampled data need to be analysed offline by specialists who derive the correct coefficients to be applied for the aerodynamically different aircraft.

4.2.7 Final Implementation of the AOS

In the case of AOS without turbulence, the implementation consists of identical software installations on the appropriate family of hosting units of the fleet. In case of covering also the turbulence part, the installations need different modules depending on the aircraft type.

However, the realization of AMDAR software implementations always depends on the cooperation of the partner airline. They need to see the advantages of the outcomes for improved weather forecasts as well as the improved quality control possible for the onboard instruments.

4.3 Ground Component of AMDAR Software

While not strictly part of the AMDAR Onboard Software, any development needs to consider the ground software systems that have the job of converting AMDAR data and controlling the AOS activity. Currently there is no international standard for this, with many different implementations in use around the world.

Two main considerations are:

- Conversion/decoding of downlinked data.
- Optimization of AMDAR data collection.

4.3.1 Converter for Downlinked Data

The meteorological data sent to the ground have to be picked out of the ACARS downlink data stream and sent to the corresponding NMHS or the data management centre of the regional AMDAR program. This diverting job can either been done by:

- The contracted airline as being the proper receiver of the data; or
- (By agreement with the airline directly) the broadcasting network service provider such as ARINC or SITA; or
- By the receiving NMHS

In any of these scenarios it is necessary to implement or at least configure software systems for that data diverting job.

4.3.2 Ground-based Optimization & AOS Control

Ideally, the AOS should be controllable via ACARS uplinks as this can provide a significant operating cost reduction by limiting redundant data. For example, within a region like central Europe there are a large number of AMDAR configured aircraft. Over the frequented air traffic hubs the problem of costly redundancies from too many ascent and descent profiles has to be considered. Via an optimizing tool controlled by a ground based system, reporting can be activated or deactivated so as to optimally meet meteorological requirements for the production of profiles and possibly en route data in both time and space.

The AOS features to be uplink configurable should be:

- Data production and reporting during selected flight phases;
- Modification of configurable software settings and parameters affecting the reporting regime; and
- Addition or removal of optionally-reported flight operations parameters for quality control purposes.

The detailed requirements for the uplinks are given by ARINC 620 and AOSFRS. An overview about the already existing systems for optimization and AOS control is provided in [REF Annex V].

Annex VII – General Terms & Conditions for Hosting a WMO Regional Workshop on AMDAR

1. The workshop will generally be held in the location and country of a WMO Member that has a strong interest and commitment to the development of an AMDAR program and where such development will advance the global AMDAR program. The workshop will usually be of 1-2 days duration.
2. One or more national airlines from the host country must be represented at the workshop.
3. In order to emphasize the regional importance of AMDAR, there should be at least several other regional Members represented at the workshop and, for most of those, national airline representatives should also be in attendance.
4. The host will be responsible for:
    a. Providing a suitable conference venue with audio-visual equipment for the workshop;
    b. Organization of all associated local logistical requirements, including information for participants on local arrangements, identification of suitable hotels and any requirements for interpretation and language translation;
    c. Invitation of other regional stakeholders, except those under 5.c.; and
    d. Unless otherwise agreed with WMO, the costs associated with the above items.

5. WMO will be responsible for:
   a. The workshop programme and agenda, in consultation with the host and regional Members;
   b. The provision of lecturers, teaching experts and material;
   c. Invitation of Members of the Region/sub-region; and
   d. Unless otherwise agreed, the costs associated with the above items, including travel of experts.
6. Regional participating members will be responsible for:
   a. The costs associated with the attendance of their respective experts at the workshop; and
   b. Invitation and any required costs of national airline representatives to the workshop.

7. WMO must be advised of the request to host a workshop by official correspondence from the host PR to WMO, preferably six months before the expected date of the workshop.
8. A Memorandum of Understanding between WMO and the workshop host with the agreed terms and conditions for hosting of the workshop will be provided by WMO and required to be signed by the candidate host.

Note that, in the case of some regions and areas, particularly in the case of developing and Least Developed Countries, the costs associated with the hosting of the workshop (i.e. the costs associated with item 4) might also be borne by WMO.

Annex VIII – List of Aircraft-Based Observations & AMDAR Technical and Scientific Publications and References

WMO Manuals

1. *Manual on WMO Integrated Global Observing System* (WMO-No. 1160)
2. *Manual on the WMO Information System* (WMO-No. 1060)
3. *Manual on the Global Observing System* (WMO- No. 544)
4. *AMDAR Reference Manual* (WMO-No. 958)
5. *Manual on the Global Telecommunication System* (WMO-No. 386)
6. *Manual on the Global Data-Processing and Forecasting System* (WMO-No. 485)

WMO Guidance Material

7. *Guide to WIGOS* (Draft)
8. *Guide to the Global Observing System* (WMO-No. 488)
9. *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8)

Standards

1. AMDAR Onboard Software Functional Requirements Specification (AOSFRS) (CIMO IOM Report No. 115)
2. ARINC Specification 620-8 Data Link Ground System Standard and Interface Specification (DGSS/IS) (Meteorological Report)

Technical Reports

1. The Benefits of AMDAR Data to Meteorology and Aviation (WIGOS Technical Report No. 2014-01)
2. Requirements for the Implementation and Operation of an AMDAR Program (WIGOS Technical Report No. 2014-02)
3. Validations of the Water Vapor Sensing System WVSS-II (CIMO IOM Report No. XXX)
4. Frédéric Falise: AMDAR Benefits to the Air Transport Industry (WIGOS Technical Report No. 2015-XX)
5. Graham D. Bruce and Darryl E. Jacobs: AMDAR Coverage and Targeting for Future Airline Recruitment (In AMDAR Data Sparse Regions) (2013, WMO AMDAR Website, Resources)

Publications

A. AMDAR Data Impact Studies

1. Eyre, J. and R. Reid, July 2014: Cost-benefit studies of observing systems. Forecasting (Research Technical Report No: 593. Met Office, Exeter, United Kingdom)
2. William R. Moninger, Richard D. Mamrosh, Patricia Pauley: Automated Meteorological Reports from Commercial Aircraft (BAMS-2-2003)
3. Petersen, R.A.: On the Current Impact and Future Benefits of AMDAR Observations in Operational Forecasts – Part 1 – A Review of the Impact of Automated Aircraft Wind and Temperature Reports (BAMS-x-2014)
4. Ralph Alvin Petersen, Lee Cronce, Richard Memrosh and Randy Baker: On the Current Impact and Future Benefits of AMDAR Observations in Operational Forecasting – Part 2 – Water Vapor Observation (BAMS-x-2015)
5. Petersen, R.A.: Impact of AMDAR Data on Numerical Prediction Models (WMO/TD-No. 1228, 2004)
6. Carla Cardinali. Lars Isaksen, and Erik Andersson: Use and Impact of Automated Aircraft Data in a Global 4DVAR Data Assimilation System (BAMS Volume 131, 2003)
7. Randy Baker, R. Curtis, D. Helms, A. Homans and B. Ford: Studies of the effectiveness of the water vapor sensing system, WVSS-II, in supporting airline operations and improved air traffic capacity (BAMS, 2011)
8. Erik Andersson, Carla Cardinali, Bruce Truscott and Ture Hovberg: High-Frequency AMDAR Data-a European aircraft data collection trial and impact assessment ((ECMWF Technical Memorandum 457, 2005)

B. Scientific Publications on AMDAR[12]

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Annex IX – Acronyms

AAA	ACARS ACMS AMDAR (AMDAR Onboard Software)
ABO	Aircraft-Based Observations
ABOP	Aircraft-Based Observations Programme (WMO)
ACARS	Aircraft Communications Addressing and Reporting System
ACMS	Aircraft Condition Monitoring System
ADOS	AMDAR Data Optimization System
ADS-B	Automatic Dependent Surveillance-Broadcast (ICAO)
ADS-C	Automatic Dependent Surveillance-Contract (ICAO)
AEEC	Airlines Electronic Engineering Committee (ARINC)
AFIRS	Automated Flight Information Reporting System (FLYHT Aerospace Solutions Ltd.)
AIREP	Aircraft Report (ICAO)
ATI	Air Transport Industry
AMDAR	Aircraft Meteorological DAta Relay
ANSP	Air Navigation Service Provider
AOS	AMDAR Onboard Software
AOSFRS	AMDAR Onboard Software Functional Requirements Specifications
ARINC	Aeronautical Radio, Inc. (Rockwell Collins)
ARINC 620-8	Datalink Ground System Standard and Interface Specification (DGSS/IS), Supplement 8
A-RIP	ABOP Regional Implementation Plan
ASDAR	Aircraft-to-Satellite DAta Relay
ASECNA	L'Agence pour la Sécurité de la Navigation aérienne en Afrique et à Madagascar (Agency for Aerial Navigation Safety in Africa and Madagascar)
ATM	Air Traffic Management
BAMS	Bulletin of the American Meteorological Society
BOM	Bureau of Meteorology (Australia)
BUFR	Binary Universal Form for the Representation of meteorological data
CAD	Consortium for ASDAR Development
CBS	Commission for Basic Systems (WMO)
CEO	Chief Executive Officer
CIMO	Commission for Instruments and Methods of Observation (WMO)
CMU	Communications Management Unit
COMET®	Program under UCAR ‘s Community Programs (United States)
DEVG	Derived Equivalent vertical Gust (turbulence measurement representation)
DGSS/IS	Data Link Ground System Standard and Interface Specification (ARINC 620)
DMC	Data Management Center
DPC	Data Processing Center
DSP	Data (communication) Service Provider
E-AMDAR	EUMETNET AMDAR
EDR	Eddy dissipation Rate (turbulence measurement representation)
EGOS-IP	Implementation Plan for the Evolution of the GOS (CBS)
ET-ABO	Expert Team on Aircraft-based Observing Systems (CBS)
ET-AO	Expert Team on Aircraft-based Observations (CIMO)
EUMETNET	Network of European National Meteorological Services
FAAM	Facility for Airborne Atmospheric Measurements (United Kingdom)
FGGE	First Global GARP Experiment
FM	Meteorological (Data) Format (WMO)
FTP	File Transfer Protocol
GARP	Global Atmospheric Research Program
GDPFS	Global Data-Processing and Forecasting System (WMO)
GOS	Global Observing System (WMO)
GTS	Global Telecommunication System (WMO)
hPa	HectoPascal
ICAO	International Civil Aviation Organization
IT	Information Technology
MDCRS	Meteorological Data Collection and Reporting System (United States)
Mode-S	Mode-Select (ICAO)
MU	Management Unit

MWO	Meteorological Watch Office (ICAO)
NCEP	National Centers for Environmental Prediction (NOAA)
NMHS	National Meteorological and Hydrological Service
NOAA	National Oceanic and Atmospheric Administration (United States)
NWP	Numerical Weather Prediction
OCAP	Operational Consortium for ASDAR Participants
PIREP	Pilot Report
PR	Permanent Representative (WMO)
QEC	Quality Evaluation Centre
QMS	Quality Management System (WMO)
RAN	Regional Air Navigation (ICAO)
RAs	Regional Associations (WMO)
RH	Relative Humidity
RRR	Rolling Review Requirements (WMO)
SASAS	South African Society for Atmospheric Sciences
SITA	Societé Internationale de Télécommunications Aéronautiques
SoG	Statement of Guidance
SSR	Secondary Surveillance Radar
TAC	Traditional Alphanumeric Code
TAMDAR	Tropospheric Airborne Meteorological DAta Reporting (Panasonic Weather Solutions)
TCP/IP	Transmission Control Protocol/Internet Protocol
UCAR	University Corporation for Atmospheric Research (United States)
URL	Uniform Resource Locator
UTC	Coordinated Universal Time
VHF	Very High Frequency
VPN	Virtual Private Network
WAFC	World Aria Forecast Center
WIGOS	WMI Integrated Global Observing System
WMO	World Meteorological Organization
WVM	Water Vapour Measurement
WVSS	Water Vapor Sensing System (SpectraSensors®,Inc., United States)
WWW	World Weather Watch Programme (WMO)

Draft History

Draft Version	Author	Changes Made	Date
1	ET-ABO Sub-group on Regulatory Material	Draft 1 of Version 1 – Version produced at the conclusion of meeting of SG-RM.	19 Dec 2014
1	Edits by Stig Carlberg	Revisions and edits.	12 Jan 2015
2	F. Grooters	Revision and edits.	10 Feb 2015
3	D. Lockett	Major revision, restructure and edits. Inclusion of proposed Annexes.	24 Feb 2015
4	D. Body & F. Grooters	Minor edits of body and Annex V	
5	D. Lockett, F. Grooters	Major update: • Updates to Annexes I and II. • Re-write of sections 6.1.2 and 6.3.2 by FG • Superfluous comments removed	12 Nov 2015
6	J. van der Muelen	Addition of Annex III	26 Nov 2015
7	S. Taylor	Addition of Annex IV	11 Jan 2016
8	D. Lockett	Major review and revision by the Secretariat. Address corrections and comments by ABOP reviewers.	2 Feb 2016
9	D. Lockett	Review and input by B.Ford Minor corrections from various reviewers.	2 Mar 2016
10	D. Lockett	Rename document to Guide to Aircraft-Based Observations Review with various corrections by D.Lockett. Revised for better consistency with the new sections of the Manual on the GOS and the Guide to the GOS.	8 Aug 2016

		Edits made based on review by R. Merrouchi and A. Mouhtadi Insertion of revised Annex III by J.v.d. Meulen Edits and corrections to Annexes II and IV	
10	D. Lockett	Removed attachment I to Annex VI.	27 Sept 2016

Recommendation 7 (CBS-16)

AMENDMENTS TO CODE TABLES SUPPORTING WMO INTEGRATED GLOBAL OBSERVING SYSTEM METADATA

THE COMMISSION FOR BASIC SYSTEMS,

Noting Resolution 26 (Cg-17) – *Technical Regulations* (WMO-No. 49) – Manual on the WMO Integrated Global Observing System, that defines the requirements for the WMO Integrated Global Observing System (WIGOS) metadata,

Noting further:

(1) That subsequent work by the Inter-commission Coordination Group on WIGOS Task Team on the WIGOS Metadata had further developed and improved the code tables supporting the WIGOS metadata standard,

(2) That the code tables supporting the WIGOS metadata standard were critical to the representation of WIGOS metadata,

(3) That recording the same information in two locations within the Technical Regulations is unnecessary,

Recommends to the Executive Council that:

(1) Code tables supporting the WIGOS metadata standard should be removed from the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160);

(2) The revised code tables supporting the WIGOS metadata standard listed in the annex to the present recommendation should be published using the web-based registry http://codes.wmo.int and become effective immediately on approval;

(3) Amendments, including addition of code tables, to http://codes.wmo.int may be implemented using the "simple (fast-track) procedure" described in Resolution 12 (EC-68);

Authorizes the Secretary-General to make editorial corrections to the contents of the tables in the annex to the present recommendation and to complete the missing entries (marked "NA") in the "WMO306_CD" columns;

Requests the Secretary-General to make the editorial adjustments to the *Manual on the WMO Integrated Global Observing System* to ensure that references within that Manual refer to the new locations for the code tables supporting the WIGOS metadata standard.

Annex to Recommendation 7 (CBS-16)

AMENDMENTS TO CODE TABLES SUPPORTING WMO INTEGRATED GLOBAL OBSERVING SYSTEM METADATA

Remove the code tables Annex from APPENDIX 2.4. ANNEX: Code Tables of the Manual on WIGOS (WMO-No. 1160)

Add the following to the Manual on Codes (WMO-No. 306) Volume I.3

241.18 Code tables used by the WIGOS metadata standard

241.17.1 Table 241-8 lists the code tables that shall be used in WIGOS metadata records.

Table 241-18. Code tables used by the WIGOS metadata standard and WMDRS-XML

WIGOS table reference	*Description*	*Location of code table*
1-01	Observed variable – measurand	http://codes.wmo.int/common/wmdsObservedVariable
1-02	Measurement unit	http://codes.wmo.int/common/unit
1-05	Representativeness	http://codes.wmo.int/common/wmdsRepresentativeness
2-01	Application areas	http://codes.wmo.int/common/wmdsApplicationArea
2-02	Programme/Network affiliation	http://codes.wmo.int/common/wmdsProgramAffiliation
3-01	Region of origin of data	http://codes.wmo.int/common/wmdsWMORegion
3-02	Territory of origin of data	http://codes.wmo.int/common/wmdsTerritoryName
3-04	Station/platform type	http://codes.wmo.int/common/wmdsFacilityType
3-08	Data communication method	http://codes.wmo.int/common/wmdsDataCommunicationMethod
3-09	Station/Platform operating status	http://codes.wmo.int/common/wmdsReportingStatus
4-01-01	Surface cover types (IGBP)	http://codes.wmo.int/common/wmdsSurfaceCoverIGBP
4-01-02	Surface cover types (UMD)	http://codes.wmo.int/common/wmdsSurfaceCoverUMD
4-01-03	Surface cover types (LAI/fPAR)	http://codes.wmo.int/common/wmdsSurfaceCoverLAI
4-01-04	Surface cover types (NPP)	http://codes.wmo.int/common/wmdsSurfaceCoverNPP
4-01-05	Surface cover types (PFT)	http://codes.wmo.int/common/wmdsSurfaceCoverPFT
4-01-06	Surface cover types (LCCS)	http://codes.wmo.int/common/wmdsSurfaceCoverLCCS
4-02	Surface cover classification scheme	http://codes.wmo.int/common/wmdsSurfaceCoverClassification
4-03-01	Local topography	http://codes.wmo.int/common/wmdsLocalTopography
4-03-02	Relative elevation	http://codes.wmo.int/common/wmdsRelativeElevation
4-03-03	Topographic context	http://codes.wmo.int/common/wmdsTopographicContext
4-03-04	Altitude/depth	http://codes.wmo.int/common/wmdsAltitudeOrDepth
4-04	Events at station/platform	http://codes.wmo.int/common/wmdsEventAtFacility

4-06	Surface Roughness (Davenport roughness classification)	http://codes.wmo.int/common/wmdsSurfaceRoughnessDavenport
4-07	Climate Zone	http://codes.wmo.int/common/wmdsClimateZone
5-01	Source of observation	http://codes.wmo.int/common/wmdsSourceOfObservation
5-02	Measurement/observing method	http://codes.wmo.int/common/wmdsObservingMethod
5-04	Instrument operating status	http://codes.wmo.int/common/wmdsInstrumentOperatingStatus
5-08-01	Control standard type	http://codes.wmo.int/common/wmdsControlStandardType
5-08-02	Control location	http://codes.wmo.int/common/wmdsControlLocation
5-08-03	Instrument control result	http://codes.wmo.int/common/wmdsInstrumentControlResult
5-14	Status of observation	http://codes.wmo.int/common/wmdsInstrumentOperatingStatus
5-15	Exposure of instrument	http://codes.wmo.int/common/wmdsExposure
6-03	Sampling strategy	http://codes.wmo.int/common/wmdsSamplingStrategy
7-06	Level of data	http://codes.wmo.int/common/wmdsLevelOfData
7-07	Data format	http://codes.wmo.int/common/wmdsDataFormat
7-10	Reference time	http://codes.wmo.int/common/wmdsReferenceTime
8-03-01	Quality Flag (BUFR derived from CIMO guide)	http://codes.wmo.int/common/wmdsQualityFlagCIMO
8-03-02	Quality Flag (From WaterML2)	http://codes.wmo.int/common/wmdsQualityFlagOGC
8-03-04	Quality Flag System	http://codes.wmo.int/common/wmdsQualityFlagSystem
8-05	Traceability	http://codes.wmo.int/common/wmdsTraceability
9-02	Data policy/use constraints	http://codes.wmo.int/common/wmdsDataPolicy
11-01	Coordinates source/service	http://codes.wmo.int/common/wmdsGeopositioningMethod
11-02	Coordinates reference	http://codes.wmo.int/common/wmdsCoordinateReferenceSystem
11-03	Meaning of time stamp	http://codes.wmo.int/common/wmdsTimeStampMeaning

Add the following code tables to http://codes.wmo.int

Code table 1-01: : Observed variable – measurand. http://codes.wmo.int/common/wmdsObservedVariable
Observed variable – measurand

#	Path	Name	Definition	WMO306_CD
6	>Earth>Crustal motion (horizontal and vertical)	Crustal motion (horizontal and vertical)	Changes in time of the position and height of the Earth plates. Indicative of the lithosphere dynamics, thus useful for earthquake prediction.	NA
7	>Earth>Crustal plates positioning	Crustal plates positioning	Basis for monitoring the evolution of the lithosphere dynamics.	NA
8	>Earth>Earth Rotation	Earth Rotation	Rotation velocity of the Earth, determining the length of the day.	NA

#	Path	Name	Definition	WMO306_CD
9	>Earth>Geoid	Geoid	Equipotential surface which would coincide exactly with the mean ocean surface of the Earth, if the oceans were in equilibrium, at rest, and extended through the continents (such as with very narrow channels).	NA
10	>Earth>Geomagnetic field	Geomagnetic field	Magnitude and direction of the 3D magnetic field on the surface of Earth and within the magnetosphere.	NA
11	>Earth>Gravity field	Gravity field	Indicative of the statics and dynamics of the lithosphere and the mantle.	NA
12	>Earth>Gravity gradients	Gravity gradients	Gradient of the Earth's gravity field measured at the satellite orbital height.	NA
13	>Ocean>Topography>Bathymetry	Bathymetry	NA	oceanBathymetry
18	>Ocean>Basic Physical Properties>Pressure	Pressure	Pressure(depth) measured by CTD.	oceanPressure
37	>Atmosphere>Aerological soundings	Aerological soundings	NA	NA
39	>Atmosphere>Atmospheric density	Atmospheric density	3D field of density of the atmosphere.	NA
44	>Atmosphere>Integrated air samples	Integrated air samples	NA	NA
56	>Atmosphere>Special phenomena	Special phenomena	NA	NA
57	>Atmosphere>State of ground	State of ground	NA	NA
62	>Ocean>Currents>Ocean Current - Direction	Ocean Current - Direction	NA	oceanCurrentDirection
63	>Ocean>Currents>Ocean Current - Speed	Ocean Current - Speed	Ocean motion measured at various depth levels.	oceanCurrentSpeed
64	>Ocean>Topography>Ocean dynamic topography (ODT)	Ocean dynamic topography (ODT)	Deviation of sea level from the geoid caused by ocean currents (after corrections for tides and atmospheric pressure effects).	oceanDynamicTopography
65	>Ocean>Currents>Ocean surface currents (vector)	Ocean surface currents (vector)	Water flow on ocean surface.	oceanSurfaceCurrent
67	>Ocean>Miscellaneous>Carbon species>Dissolved inorganic carbon (DIC)	Dissolved inorganic carbon (DIC)	The cumulated concentration of inorganic carbon species (dissolved carbon dioxide, carbonic acid, bicarbonate and carbonate) in solution.	oceanDissolvedInorganicCarbon
68	>Ocean>Miscellaneous>Carbon species>Dissolved organic carbon	Dissolved organic carbon	NA	oceanDissolvedOrganicCarbon

#	Path	Name	Definition	WMO306_CD
69	>Ocean>Miscellaneous>Nitrogen species>Dissolved organic nitrogen	Dissolved organic nitrogen	NA	oceanDissolvedOrganicNitrogen
70	>Ocean>Miscellaneous>Diffuse attenuation coefficient (DAC), turbidity	Diffuse attenuation coefficient (DAC), turbidity	Indicator of water turbidity and vertical processes in the ocean, extracted from ocean colour observation.	oceanTurbidity
71	>Ocean>Biology>Chlorophyll concentration	Chlorophyll concentration	Indicator of living phytoplankton biomass, extracted from ocean colour observation.	oceanChlorophyllConcentration
72	>Ocean>Miscellaneous>Ocean suspended sediments concentration	Ocean suspended sediments concentration	Variable extracted from ocean colour observation. Indicative of river outflow, re-suspension or pollution of other-than-biological origin.	oceanSuspendedSedimentConcentration
73	>Ocean>Miscellaneous>Oil spill cover	Oil spill cover	Fraction of an ocean area polluted by hydrocarbons released from ships or off-shore platforms, accidentally or deliberately.	oceanOilSpillCover
74	>Ocean>Biology>Primary production	Primary production	NA	oceanPrimaryProduction
75	>Ocean>Miscellaneous>Sea surface Mass Flux	Sea surface Mass Flux	Sea Surface Mass Flux.	oceanSeaSurfaceMassFlux
76	>Ocean>Miscellaneous>Sea surface heat flux	Sea surface heat flux	Sea Surface Heat Flux.	oceanSeaSurfaceHeatFlux
77	>Ocean>Topography>Sea surface height anomaly (SSHA)	Sea surface height anomaly (SSHA)	Sea surface height anomaly.	oceanSeaSurfaceHeightAnomaly
78	>Ocean>Miscellaneous>Total alkalinity (AT)	Total alkalinity (AT)	The amount of acid necessary to titrate all weak bases in seawater.	oceanTotalAlkalinity
79	>Ocean>Miscellaneous>pH	pH	The hydrogen ion concentration in seawater, which is a measure of acidity and alkalinity.	oceanPH
82	>Ocean>Biology>SiO3= (metasilicate)	SiO3= (metasilicate)	NA	oceanMetaSilicate
84	>Ocean>Other Gas>N2, Ar, O2	N2, Ar, O2	NA	oceanN2ArO2
85	>Ocean>Other Gas>O2/Ar ratio	O2/Ar ratio	NA	oceanO2ArRatio
86	>Ocean>Other Gas>Ocean subsurface dissolved oxygen concentration	Ocean subsurface dissolved oxygen concentration	Concentration of dissolved oxygen.	oceanSubsurfaceDissolvedOxygenConcentration
87	>Ocean>Other Gas>Oxygen, dissolved	Oxygen, dissolved	NA	oceanDissolvedOxygen

#	Path	Name	Definition	WMO306_CD
89	>Ocean>Radiation>Water-leaving spectral radiance	Water-leaving spectral radiance	Upward spectral radiance from the ocean surface, i.e. amount of light leaving the ocean per unit area, per wavelength and per solid angle.	oceanOutgoingspectralRadiance
90	>Ocean>Reactive Gas>C2H6S (dimethylsulfide, DMS)	C2H6S (dimethylsulfide, DMS)	NA	oceanDMS
91	>Ocean>Basic Physical Properties>Ocean salinity	Ocean salinity	3D field of salinity of the ocean Requested in upper and deep ocean.	oceanSalinity
92	>Ocean>Basic Physical Properties>Sea surface salinity	Sea surface salinity	Salinity of sea water in the surface layer. In the open ocean the correct term should be "halinity" with reference of the diversity of salts involved.	oceanSurfaceSalinity
94	>Ocean>Basic Physical Properties>Ocean temperature	Ocean temperature	3D field of temperature of the ocean Requested in upper and deep ocean.	oceanTemperature
95	>Ocean>Basic Physical Properties>Sea surface temperature	Sea surface temperature	Temperature of the sea water at surface. This includes both or either of the "bulk" temperature refers to the depth of typically 2 m, and the "skin" temperature refers to within the upper 1 mm.	oceanSurfaceTemperature
96	>Ocean>Topography>Coastal sea level (tide)	Coastal sea level (tide)	Deviation of sea level from local references in coastal zones, caused by local currents and tides (astronomical and wind-induced).	oceanCoastalSeaLevel
98	>Ocean>Waves>Dominant wave direction	Dominant wave direction	The direction of the most energetic wave in the spectrum.	oceanDominantWaveDirection
99	>Ocean>Waves>Dominant wave period	Dominant wave period	The period of the most energetic wave in the ocean wave spectrum.	oceanDominantWavePeriod
100	>Ocean>Waves>Significant wave height	Significant wave height	Average amplitude of the highest 30 out of of 100 waves.	oceanDominantWaveHeight
101	>Ocean>Waves>Wave 1D energy frequency spectrum	Wave 1D energy frequency spectrum	The total wave energy in each frequency band (e.g. 25 frequency bands) regardless of the direction of propagation. Colloquially referred to as the "1D wave spectrum".	oceanWave1DEnergySpectrum
102	>Ocean>Waves>Wave directional energy frequency spectrum	Wave directional energy frequency spectrum	Describes The wave energy travelling in each direction and frequency band (e.g. 24 distinct azimuth sectors each 15° wide, and 25 frequency bands). Colloquially referred to as the "2D wave spectrum".	oceanWaveDirectionalEnergySpectrum
103	>Ocean>Wind>Wind stress	Wind stress	The shear force per unit area exerted by wind blowing over the sea surface.	oceanWaveStress

#	Path	Name	Definition	WMO306_CD
104	>Outer Space>Energetic particles / solar wind >Electron flux energy spectrum	Electron flux energy spectrum	Flux density energy spectrum of low-, medium-, and high-energy electrons from the magnetosphere, the radiation belts or the interplanetary medium.	NA
105	>Outer Space>Energetic particles / solar wind >Electrostatic charge	Electrostatic charge	Measurement of the electrostatic charge of a satellite accumulated because of the environmental situation.	NA
106	>Outer Space>Energetic particles / solar wind >Heavy ion angular flux energy and mass spectrum	Heavy ion angular flux energy and mass spectrum	Flux density energy and mass spectrum of heavy ions ranging from Helium to Iron, per unit solid angle.	NA
107	>Outer Space>Energetic particles / solar wind >Heavy ion flux energy and mass spectrum	Heavy ion flux energy and mass spectrum	Flux density energy and mass spectrum of heavy ions ranging from Helium to Iron.	NA
108	>Outer Space>Energetic particles / solar wind >Interplanetary magnetic field	Interplanetary magnetic field	Vector magnetic field (3D) in the solar wind.	NA
111	>Outer Space>Energetic particles / solar wind >Radiation Dose Rate	Radiation Dose Rate	Dose rate of energetic particles. Often reported as a 3D field.	NA
112	>Outer Space>Energetic particles / solar wind >Solar wind temperature	Solar wind temperature	Temperature of solar wind protons.	NA
113	>Outer Space>Energetic particles / solar wind >Solar wind velocity	Solar wind velocity	Vector velocity of solar wind plasma.	NA
114	>Outer Space>Ionospheric disturbances>Aurora	Aurora	Fluorescence of the upper atmosphere through ionization by energetic charged particles accelerated by the Earth's magnetic field.	NA
115	>Outer Space>Ionospheric disturbances>Electric Field	Electric Field	Magnitude and direction of the Earth's electric field.	NA
116	>Outer Space>Ionospheric disturbances>Electron Density	Electron Density	Electron density in the ionosphere. Often reported as a 3-D field.	NA
117	>Outer Space>Ionospheric disturbances>Ionospheric Radio Absorption	Ionospheric Radio Absorption	Attenuation of a radio wave passing through the lower ionosphere.	NA

#	Path	Name	Definition	WMO306_CD
118	>Outer Space>Ionospheric disturbances>Ionospheric Scintillation	Ionospheric Scintillation	Random fluctuations of radio waves resulting of small scale variations of the ionospheric electron density in space and time.	NA
119	>Outer Space>Ionospheric disturbances>Ionospheric Vertical Total Electron Content (VTEC)	Ionospheric Vertical Total Electron Content (VTEC)	Number of electrons between two points.	NA
120	>Outer Space>Ionospheric disturbances>Ionospheric plasma density	Ionospheric plasma density	Total number of ionized particles in a volume unit of ionospheric plasma.	NA
121	>Outer Space>Ionospheric disturbances>Ionospheric plasma velocity	Ionospheric plasma velocity	Velocity of bulk plasma or electrons (depending on measurement technique) as a function of altitude in the ionosphere.	NA
122	>Outer Space>Ionospheric disturbances>Spread F	Spread F	Vertical thickness of highly structured ion density in the F-region of the ionosphere.	NA
123	>Outer Space>Ionospheric disturbances>foEs	foEs	The highest ordinary-wave frequency reflected back from a sporadic E layer and observed by an ionosonde.	NA
124	>Outer Space>Ionospheric disturbances>foF2	foF2	Critical frequency of the F2 layer of the ionosphere. This critical frequency (f, in MHz) is associated with the electron density.	NA
125	>Outer Space>Ionospheric disturbances>h'F	h'F	Virtual height of the bottom of the ionospheric F-layer.	NA
126	>Outer Space>Ionospheric disturbances>hmF2	hmF2	Altitude of the peak density in the ionospheric F2 layer.	NA
127	>Outer Space>Solar monitoring>EUV flux	EUV flux	Radiative flux integrated over the EUV band.	NA
128	>Outer Space>Solar monitoring>EUV flux spectrum	EUV flux spectrum	Energy spectrum of the radiative flux measured in the EUV band.	NA
129	>Outer Space>Solar monitoring>EUV sky image	EUV sky image	Extreme Ultra-Violet (EUV) image of the sky.	NA
130	>Outer Space>Solar monitoring>Gamma-ray flux	Gamma-ray flux	Radiative flux integrated over the gamma-ray domain.	NA
131	>Outer Space>Solar monitoring>Gamma-ray flux spectrum	Gamma-ray flux spectrum	Energy spectrum of the radiative flux measured in the gamma-ray domain.	NA
132	>Outer Space>Solar monitoring>Heliospheric image	Heliospheric image	Image of the interplanetary space between the Sun and Earth	NA

#	Path	Name	Definition	WMO306_CD
133	>Outer Space>Solar monitoring>Radio-waves	Radio-waves	Travelling radio-waves of solar, galactic and extragalactic origin, entering the Earth's environment.	NA
134	>Outer Space>Solar monitoring>Solar Ca II-K image	Solar Ca II-K image	Image of the Sun in the K-line of Ca-II(393.4 nm).	NA
135	>Outer Space>Solar monitoring>Solar EUV flux	Solar EUV flux	Integrated Extreme Ultra-Violet (EUV) flux over the solar disk.	NA
136	>Outer Space>Solar monitoring>Solar EUV flux spectrum	Solar EUV flux spectrum	Energy spectrum of the Extreme Ultra-Violet (EUV) flux integrated over the solar disk.	NA
137	>Outer Space>Solar monitoring>Solar EUV image	Solar EUV image	Images of the Sun in the Extreme Ultra-Violet (EUV) wavelengths.	NA
138	>Outer Space>Solar monitoring>Solar H-alpha image	Solar H-alpha image	Image of the Sun in the Hydrogen-alpha transition wavelength (656.3 nm).	NA
139	>Outer Space>Solar monitoring>Solar Lyman-alpha flux	Solar Lyman-alpha flux	Solar flux in the Hydrogen Lyman-alpha transition wavelength (121.6 nm).	NA
140	>Outer Space>Solar monitoring>Solar Lyman-alpha image	Solar Lyman-alpha image	Image of the Sun in the Hydrogen Lyman-alpha transition wavelength (121.6 nm).	NA
141	>Outer Space>Solar monitoring>Solar UV flux	Solar UV flux	Integrated Ultra-Violet (UV) flux over the solar disk.	NA
142	>Outer Space>Solar monitoring>Solar UV flux spectrum	Solar UV flux spectrum	Energy spectrum of the Ultra-Violet (UV) flux integrated over the solar disk.	NA
143	>Outer Space>Solar monitoring>Solar UV image	Solar UV image	Images of the Sun in the Ultra-Violet (UV) wavelengths.	NA
144	>Outer Space>Solar monitoring>Solar VIS flux	Solar VIS flux	Integrated VIS (energy at visible wavelengths) flux over the solar disk	NA
145	>Outer Space>Solar monitoring>Solar VIS flux spectrum	Solar VIS flux spectrum	Energy spectrum of the integrated VIS (energy at visible wavelengths) flux over the solar disk.	NA
146	>Outer Space>Solar monitoring>Solar VIS image	Solar VIS image	Images of the Sun in the VIS (visible) wavelengths.	NA
147	>Outer Space>Solar monitoring>Solar X-ray flux	Solar X-ray flux	Integrated X-ray flux over the solar disk.	NA
148	>Outer Space>Solar monitoring>Solar X-ray flux spectrum	Solar X-ray flux spectrum	Energy spectrum of the X-ray flux integrated over the solar disk.	NA

#	Path	Name	Definition	WMO306_CD
149	>Outer Space>Solar monitoring>Solar X-ray image	Solar X-ray image	Image of the Sun in X-ray wavelengths.	NA
150	>Outer Space>Solar monitoring>Solar coronagraphic image	Solar coronagraphic image	Image of the solar corona surrounding the Sun.	NA
151	>Outer Space>Solar monitoring>Solar electric field	Solar electric field	Map of magnitude and direction of the electric field at the solar surface (photosphere).	NA
152	>Outer Space>Solar monitoring>Solar gamma-ray flux	Solar gamma-ray flux	Integrated gamma-ray flux over the solar disk.	NA
153	>Outer Space>Solar monitoring>Solar gamma-ray flux spectrum	Solar gamma-ray flux spectrum	Energy spectrum of the gamma-ray flux integrated over the solar disk.	NA
154	>Outer Space>Solar monitoring>Solar magnetic field	Solar magnetic field	Vector magnetic field (1D or 3D) at the solar surface (photosphere/chromosphere).	NA
155	>Outer Space>Solar monitoring>Solar radio flux	Solar radio flux	Integrated radio flux over the solar disk.	NA
156	>Outer Space>Solar monitoring>Solar radio flux spectrum	Solar radio flux spectrum	Solar radio flux energy spectrum integrated over the solar disk.	NA
157	>Outer Space>Solar monitoring>Solar radio image	Solar radio image	2D image of the solar radio flux.	NA
158	>Outer Space>Solar monitoring>Solar velocity fields	Solar velocity fields	Map of 3D velocity of particles of the Solar atmosphere, significant of the Sun interior.	NA
159	>Outer Space>Solar monitoring>Solar white light image	Solar white light image	Image of the Sun in white light.	NA
160	>Outer Space>Solar monitoring>UV flux	UV flux	Integrated Ultra-Violet (UV) flux.	NA
161	>Outer Space>Solar monitoring>UV sky image	UV sky image	Ultra-Violet (UV) image of the sky.	NA
162	>Outer Space>Solar monitoring>X-ray flux	X-ray flux	Integrated X-ray flux.	NA
163	>Outer Space>Solar monitoring>X-ray flux spectrum	X-ray flux spectrum	Energy spectrum of the integrated X-ray flux.	NA

#	Path	Name	Definition	WMO306_CD
164	>Outer Space>Solar monitoring>X-ray sky image	X-ray sky image	X-ray image of the sky.	NA
165	>Terrestrial>Ground water>Ground water (amount per unit area)	Ground water (amount per unit area)	Amount of water present beneath the ground surface per unit area.	NA
166	>Terrestrial>Ground water>Ground water (level)	Ground water (level)	NA	NA
167	>Terrestrial>Lake>Lake area	Lake area	Area extent of the surface of a lake.	NA
168	>Terrestrial>Lake>Lake level	Lake level	Map of the height of the lake surface.	NA
171	>Terrestrial>River>River discharge	River discharge	Volume of water flowing through a river per unit of time.	NA
172	>Terrestrial>River>River stage (level above reference)	River stage (level above reference)	NA	NA
174	>Terrestrial>Well>Well discharge	Well discharge	NA	NA
179	>Atmosphere>Clouds>Cloud amount	Cloud amount	NA	NA
180	>Atmosphere>Clouds>Cloud cover	Cloud cover	NA	NA
181	>Atmosphere>Clouds>Cloud drop effective radius	Cloud drop effective radius	Size distribution of liquid water drops, assimilated to spheres of the same volume. Considered as both a 3D field throughout the troposphere and a 2D field at the top of cloud surface.	NA
182	>Atmosphere>Clouds>Cloud hydrometeor concentration	Cloud hydrometeor concentration	NA	NA
183	>Atmosphere>Clouds>Effective radius of cloud hydrometeors	Effective radius of cloud hydrometeors	NA	NA
186	>Atmosphere>Clouds>Melting layer depth in clouds	Melting layer depth in clouds	Depth of the atmospheric layer in cloud where liquid-solid states transform into each other.	NA
188	>Atmosphere>Clouds>PSC occurrence	PSC occurrence	3D field of Polar Stratospheric Clouds occurrence.	NA
192	>Atmosphere>Greenhouse Gas>CH4	CH4	CH4	NA
193	>Atmosphere>Greenhouse Gas>CH4 [C-13]	CH4 [C-13]	CH4 with C-13 isotope	NA
194	>Atmosphere>Greenhouse Gas>CO2	CO2	CO2	NA
195	>Atmosphere>Greenhouse Gas>CO2 [C-13]	CO2 [C-13]	CO2 with C-13 isotope	NA

#	Path	Name	Definition	WMO306_CD
196	>Atmosphere>Greenhouse Gas>CO2 [O-18]	CO2 [O-18]	CO2 with O-18 isotope	NA
201	>Atmosphere>Greenhouse Gas>N2O	N2O	N2O	NA
203	>Atmosphere>Greenhouse Gas>SF6	SF6	SF6	NA
204	>Atmosphere>Greenhouse Gas>SO2F2 (sulphuryl fluoride)	SO2F2 (sulphuryl fluoride)	SO2F2 (sulphuryl fluoride)	NA
205	>Atmosphere>Other Gas>H2	H2	H2	NA
206	>Atmosphere>Other Gas>H2O (as a chemical species)	H2O (as a chemical species)	H20 as a chemical species relevant for atmospheric chemistry.	NA
207	>Atmosphere>Other Gas>HDO (as a chemical species)	HDO (as a chemical species)	HDO (water vapour with one hydrogen nucleus replaced by its deuterium isotope).	NA
210	>Atmosphere>Precipitation> Amount of precipitation	Amount of precipitation	NA	NA
211	>Atmosphere>Precipitation> Duration	Duration	NA	NA
212	>Atmosphere>Precipitation> Intensity of precipitation	Intensity of precipitation	NA	NA
213	>Atmosphere>Precipitation> Occurrence during last period (yes/no)	Occurrence during last period (yes/no)	NA	NA
214	>Atmosphere>Precipitation> Rate of ice accretion	Rate of ice accretion	NA	NA
215	>Atmosphere>Precipitation> Type of precipitation	Type of precipitation	NA	NA
216	>Atmosphere>Pressure>Atmospheric pressure	Atmospheric pressure	NA	NA
217	>Atmosphere>Pressure>Characteristic of pressure tendency	Characteristic of pressure tendency	NA	NA
218	>Atmosphere>Pressure>Pressure tendency	Pressure tendency	NA	NA
219	>Atmosphere>Radionuclide> Beryllium [Be-7]	Beryllium [Be-7]	NA	NA
220	>Atmosphere>Radionuclide> CO2 [C-14]	CO2 [C-14]	CO2 with C-14 isotope	NA
221	>Atmosphere>Radionuclide> Krypton [Kr-85]	Krypton [Kr-85]	Krypton (Kr-85 isotope)	NA

#	Path	Name	Definition	WMO306_CD
222	>Atmosphere>Radionuclide> Lead [Pb-210]	Lead [Pb-210]	Lead (Pb-210 isotope)	NA
223	>Atmosphere>Radionuclide> Radon [Rn-222]	Radon [Rn-222]	Radon (Rn-222 isotope)	NA
224	>Atmosphere>Temperature> Air temperature (at specified distance from reference surface)	Air temperature (at specified distance from reference surface)	NA	NA
225	>Atmosphere>Temperature> Dew-point temperature (at specified distance from reference surface)	Dew-point temperature (at specified distance from reference surface)	NA	NA
226	>Atmosphere>Temperature> Extreme temperature (min, max) (at specified distance from reference surface)	Extreme temperature (min, max) (at specified distance from reference surface)	NA	NA
227	>Atmosphere>Temperature> Temperature profile	Temperature profile	NA	NA
229	>Atmosphere>Visibility>Run way visual range	Runway visual range	NA	NA
230	>Atmosphere>Visibility>Visib ility	Visibility	NA	NA
231	>Terrestrial>Land surface>Braking action/friction coefficient	Braking action/friction coefficient	NA	NA
232	>Terrestrial>Land surface>Coastlines	Coastlines	Location of coastline.	NA
236	>Terrestrial>Land surface>Land cover	Land cover	Fraction of an area that is land.	NA
237	>Terrestrial>Land surface>Land surface topography	Land surface topography	Height of land surface.	NA
239	>Terrestrial>Land surface>Runway conditions	Runway conditions	NA	NA
243	>Terrestrial>Land surface>Wetland extent	Wetland extent	Fraction of an area flood by water.	NA
245	>Terrestrial>Soil>Soil heat Flux	Soil heat Flux	NA	NA
246	>Terrestrial>Soil>Soil type	Soil type	Classification of the type of soil.	NA
248	>Atmosphere>Dynamics>Tra nsport calculations (e.g., trajectories)	Transport calculations (e.g., trajectories)	NA	NA

#	Path	Name	Definition	WMO306_CD
249	>Atmosphere>Dynamics>Turbulence	Turbulence	Kinetic energy density of turbulent motion of the air.	NA
250	>Atmosphere>Dynamics>Turbulence type (low levels and wake vortex)	Turbulence type (low levels and wake vortex)	NA	NA
251	>Atmosphere>Humidity>Humidity (at specified distance from reference surface)	Humidity (at specified distance from reference surface)	NA	NA
252	>Atmosphere>Humidity>Integrated water vapour	Integrated water vapour	NA	NA
253	>Atmosphere>Humidity>Mass mixing ratio	Mass mixing ratio	NA	NA
254	>Atmosphere>Humidity>Object wetness duration	Object wetness duration	NA	NA
255	>Atmosphere>Humidity>Water vapour pressure	Water vapour pressure	NA	NA
256	>Atmosphere>Humidity>Watervapor profile	Watervapor profile	NA	NA
257	>Atmosphere>Lightning>Lightning discharge energy	Lightning discharge energy	NA	NA
258	>Atmosphere>Lightning>Lightning discharge polarity	Lightning discharge polarity	NA	NA
259	>Atmosphere>Lightning>Lightning discharge rates	Lightning discharge rates	NA	NA
260	>Atmosphere>Lightning>Lightning discharge type (cloud to cloud, cloud to surface)	Lightning discharge type (cloud to cloud, cloud to surface)	NA	NA
262	>Atmosphere>Ozone>Surface ozone	Surface ozone	NA	NA
263	>Atmosphere>Ozone>Total column ozone	Total column ozone	NA	NA
264	>Atmosphere>Ozone>Vertical ozone profile	Vertical ozone profile	NA	NA
265	>Atmosphere>Past weather>Past weather	Past weather	NA	NA
266	>Atmosphere>Present weather>Present weather	Present weather	NA	NA
267	>Atmosphere>Radiation>Background luminance	Background luminance	NA	NA
270	>Atmosphere>Radiation>Sunshine duration	Sunshine duration	NA	NA

#	Path	Name	Definition	WMO306_CD
271	>Atmosphere>Radiation>Surface albedo	Surface albedo	NA	NA
273	>Atmosphere>Radiation>UV-B radiation	UV-B radiation	NA	NA
274	>Atmosphere>Reactive Gas>BrO (bromine monoxide)	BrO (bromine monoxide)	NA	NA
275	>Atmosphere>Reactive Gas>C2Cl4 (tetrachloroethene)	C2Cl4 (tetrachloroethene)	NA	NA
276	>Atmosphere>Reactive Gas>C2HCl3 (trichloroethene)	C2HCl3 (trichloroethene)	NA	NA
277	>Atmosphere>Reactive Gas>CH2Br2 (dibrimomethane)	CH2Br2 (dibrimomethane)	NA	NA
278	>Atmosphere>Reactive Gas>CH2Cl2 (dichloromethane)	CH2Cl2 (dichloromethane)	NA	NA
279	>Atmosphere>Reactive Gas>CH3Br (methylbromide)	CH3Br (methylbromide)	NA	NA
280	>Atmosphere>Reactive Gas>CH3Cl (methylchloride)	CH3Cl (methylchloride)	NA	NA
281	>Atmosphere>Reactive Gas>CH3I (methyliodide)	CH3I (methyliodide)	NA	NA
282	>Atmosphere>Reactive Gas>CHBr3 (bromoform)	CHBr3 (bromoform)	NA	NA
283	>Atmosphere>Reactive Gas>CHCl3 (chloroform)	CHCl3 (chloroform)	NA	NA
284	>Atmosphere>Reactive Gas>CO	CO	NA	NA
285	>Atmosphere>Reactive Gas>COF2 (difluoromethanal, carbonyl fluoride)	COF2 (difluoromethanal, carbonyl fluoride)	NA	NA
286	>Atmosphere>Reactive Gas>ClO (chlorine monoxide)	ClO (chlorine monoxide)	NA	NA
287	>Atmosphere>Reactive Gas>H2O2 (hydrogen peroxide)	H2O2 (hydrogen peroxide)	NA	NA
288	>Atmosphere>Reactive Gas>HCl (hydrochloric acid)	HCl (hydrochloric acid)	NA	NA

#	Path	Name	Definition	WMO306_CD
289	>Atmosphere>Reactive Gas>HF (hydrofluoric acid)	HF (hydrofluoric acid)	NA	NA
291	>Atmosphere>Reactive Gas>ROOH	ROOH	NA	NA
294	>Atmosphere>Total Atmospheric Deposition>Acidity/Alkalinity	Acidity/Alkalinity	NA	NA
295	>Atmosphere>Total Atmospheric Deposition>Electric conductivity	Electric conductivity	NA	NA
296	>Atmosphere>Total Atmospheric Deposition>Hydrogen ion (H+) or pH	Hydrogen ion (H+) or pH	NA	NA
302	>Atmosphere>Total Atmospheric Deposition>Sulphur (S)	Sulphur (S)	NA	NA
304	>Atmosphere>Wind>Direction of cloud movement	Direction of cloud movement	NA	NA
305	>Atmosphere>Wind>Gust Speed	Gust Speed	NA	NA
307	>Atmosphere>Wind>Wind (Z component, vertical)	Wind (Z component, vertical)	Z component of wind vector.	NA
309	>Atmosphere>Wind>Wind (surface wind direction and speed, horizontal)	Wind (surface wind direction and speed, horizontal)	Horizontal component of wind as speed and direction.	NA
310	>Atmosphere>Wind>Wind (X, Y components, horizontal)	Wind (X, Y components, horizontal)	Horizontal component of wind as a vector in an orthogonal coordinate system.	NA
311	>Ocean>Biology>Nitrogen species>NO2- (nitrite)	NO2- (nitrite)	Nitrite concentration in sea water.	oceanNitrite
312	>Ocean>Biology>Nitrogen species>NO3- (nitrate)	NO3- (nitrate)	Nitrate concentration in sea water.	oceanNitrate
314	>Atmosphere>Aerosol>Optical properties>Aerosol Absorption Optical Depth	Aerosol Absorption Optical Depth	Vertical column integral of spectral aerosol absorption coefficient (AAOD).	NA
315	>Atmosphere>Aerosol>Optical properties>Aerosol Extinction Coefficient	Aerosol Extinction Coefficient	Spectral volumetric extinction cross-section of aerosol particles.	NA
316	>Atmosphere>Aerosol>Optical properties>Light absorption coefficient, PM1	Light absorption coefficient, PM1	NA	NA

#	Path	Name	Definition	WMO306_CD
317	>Atmosphere>Aerosol>Optical properties>Light absorption coefficient, PM10	Light absorption coefficient, PM10	NA	NA
318	>Atmosphere>Aerosol>Optical properties>Light absorption coefficient, total aerosol	Light absorption coefficient, total aerosol	NA	NA
319	>Atmosphere>Aerosol>Optical properties>Light backscattering coefficient, PM1	Light backscattering coefficient, PM1	NA	NA
320	>Atmosphere>Aerosol>Optical properties>Light backscattering coefficient, PM10	Light backscattering coefficient, PM10	NA	NA
321	>Atmosphere>Aerosol>Optical properties>Light backscattering coefficient, total aerosol	Light backscattering coefficient, total aerosol	NA	NA
322	>Atmosphere>Aerosol>Optical properties>Light scattering coefficient, PM1	Light scattering coefficient, PM1	NA	NA
323	>Atmosphere>Aerosol>Optical properties>Light scattering coefficient, PM10	Light scattering coefficient, PM10	NA	NA
324	>Atmosphere>Aerosol>Optical properties>Light scattering coefficient, total aerosol	Light scattering coefficient, total aerosol	NA	NA
325	>Atmosphere>Aerosol>Optical properties>Multiwavelength optical depth, total aerosol	Multiwavelength optical depth, total aerosol	NA	NA
326	>Atmosphere>Aerosol>Optical properties>Vertical distribution of properties	Vertical distribution of properties	NA	NA
327	>Atmosphere>Clouds>Ice>Cloud ice	Cloud ice	Atmospheric water in the solid phase (precipitating or not).	NA
328	>Atmosphere>Clouds>Ice>Cloud ice (total column)	Cloud ice (total column)	Atmospheric water in the solid phase (precipitating or not) as total column.	NA
329	>Atmosphere>Clouds>Ice>Cloud ice effective radius	Cloud ice effective radius	Size distribution of ice particles, assimilated to spheres of the same volume.	NA

#	Path	Name	Definition	WMO306_CD
330	>Atmosphere>Clouds>Ice>Freezing level height in clouds	Freezing level height in clouds	Height of the atmospheric layer in cloud where liquid-solid states transform into each other.	NA
331	>Atmosphere>Clouds>Ice>Icing potential	Icing potential	Super-cooled liquid water, enabling the formation of ice coating on an object.	NA
332	>Atmosphere>Greenhouse Gas>Halon>CBrClF2 (Halon 1211)	CBrClF2 (Halon 1211)	NA	NA
333	>Atmosphere>Greenhouse Gas>Halon>CBrF3 (bromotrifluoromethane, Halon 1301)	CBrF3 (bromotrifluoromethane, Halon 1301)	NA	NA
334	>Atmosphere>POPs>PAH>C13H10 (9H-fluorene, fluorene), in air	C13H10 (9H-fluorene, fluorene), in air	NA	NA
335	>Atmosphere>POPs>PAH>C14H10 (anthracene), PM10	C14H10 (anthracene), PM10	NA	NA
336	>Atmosphere>POPs>PAH>C14H10 (anthracene), in aerosol	C14H10 (anthracene), in aerosol	NA	NA
337	>Atmosphere>POPs>PAH>C14H10 (anthracene), in aerosol and air	C14H10 (anthracene), in aerosol and air	NA	NA
338	>Atmosphere>POPs>PAH>C14H10 (anthracene), in air	C14H10 (anthracene), in air	NA	NA
339	>Atmosphere>POPs>PAH>C14H10 (phenanthrene), PM10	C14H10 (phenanthrene), PM10	NA	NA
340	>Atmosphere>POPs>PAH>C14H10 (phenanthrene), in aerosol	C14H10 (phenanthrene), in aerosol	NA	NA
341	>Atmosphere>POPs>PAH>C14H10 (phenanthrene), in air	C14H10 (phenanthrene), in air	NA	NA
342	>Atmosphere>POPs>PAH>C14H10 (phenanthrene), in air and aerosol	C14H10 (phenanthrene), in air and aerosol	NA	NA
343	>Atmosphere>POPs>PAH>C14H10 (phenanthrene), in precipitation	C14H10 (phenanthrene), in precipitation	NA	NA
344	>Atmosphere>POPs>PAH>C14H10 (phenanthrene), in total precipitation	C14H10 (phenanthrene), in total precipitation	NA	NA

#	Path	Name	Definition	WMO306_CD
345	>Atmosphere>POPs>PAH>C 16H10 (pyrene), in air and aerosol	C16H10 (pyrene), in air and aerosol	NA	NA
346	>Atmosphere>POPs>PAH>C 18H12 (Benz(a)anthracene), PM10	C18H12 (Benz(a)anthracene), PM10	NA	NA
347	>Atmosphere>POPs>PAH>C 18H12 (Benz(a)anthracene), in aerosol	C18H12 (Benz(a)anthracene), in aerosol	NA	NA
348	>Atmosphere>POPs>PAH>C 18H12 (Benz(a)anthracene), in air	C18H12 (Benz(a)anthracene), in air	NA	NA
349	>Atmosphere>POPs>PAH>C 18H12 (Benz(a)anthracene), in air and aerosol	C18H12 (Benz(a)anthracene), in air and aerosol	NA	NA
350	>Atmosphere>POPs>PAH>C 18H12 (Benz(a)anthracene), in precipitation	C18H12 (Benz(a)anthracene), in precipitation	NA	NA
351	>Atmosphere>POPs>PAH>C 18H12 (Benz(a)anthracene), in total precipitation	C18H12 (Benz(a)anthracene), in total precipitation	NA	NA
354	>Terrestrial>Land surface>Snow / Ice / Glacier>Permafrost	Permafrost	NA	NA
356	>Atmosphere>Radiation>UV >UV Broadband	UV Broadband	NA	NA
357	>Atmosphere>Radiation>UV >UV Erythemally weighted	UV Erythemally weighted	NA	NA
358	>Atmosphere>Radiation>UV >UV Multiband	UV Multiband	NA	NA
359	>Atmosphere>Radiation>UV >UV Spectral	UV Spectral	NA	NA
361	>Atmosphere>Aerosol>Physical properties - primary>Aerosol column burden (mass density)	Aerosol column burden (mass density)	Column burden of condensed particles in the atmosphere.	NA
362	>Atmosphere>Aerosol>Physical properties - primary>Aerosol effective radius	Aerosol effective radius	Mean aerosol particle size, defined as the ratio of the third and second moments of the number size distribution of aerosol particles.	NA

#	Path	Name	Definition	WMO306_CD
364	>Atmosphere>Aerosol>Physical properties - primary>Mass concentration (coarse) or Mass PM10	Mass concentration (coarse) or Mass PM10	NA	NA
365	>Atmosphere>Aerosol>Physical properties - primary>Mass concentration (fine) or Mass PM1	Mass concentration (fine) or Mass PM1	NA	NA
366	>Atmosphere>Aerosol>Physical properties - primary>Mass concentration (medium), PM2.5	Mass concentration (medium), PM2.5	NA	NA
367	>Atmosphere>Aerosol>Physical properties - primary>Mass concentration (size fractionated)	Mass concentration (size fractionated)	NA	NA
368	>Atmosphere>Aerosol>Physical properties - primary>Mass concentration (total aerosol) or Mass TSP	Mass concentration (total aerosol) or Mass TSP	NA	NA
369	>Atmosphere>Aerosol>Physical properties - primary>Number concentration	Number concentration	NA	NA
370	>Atmosphere>Aerosol>Physical properties - primary>Number size distribution, PM10	Number size distribution, PM10	NA	NA
371	>Atmosphere>Aerosol>Physical properties - primary>Number size distribution, total aerosol	Number size distribution, total aerosol	NA	NA
373	>Atmosphere>Clouds>Liquid water>Cloud liquid water (CLW)	Cloud liquid water (CLW)	Atmospheric water in the liquid phase (precipitating or not).	NA
374	>Atmosphere>Clouds>Liquid water>Cloud liquid water (CLW, total column)	Cloud liquid water (CLW, total column)	Atmospheric water in the liquid phase (precipitating or not).	NA
375	>Atmosphere>POPs>POP>C12H8Cl6 (aldrin), in aerosol	C12H8Cl6 (aldrin), in aerosol	NA	NA
376	>Atmosphere>POPs>POP>C12H8Cl6 (aldrin), in air	C12H8Cl6 (aldrin), in air	NA	NA

#	Path	Name	Definition	WMO306_CD
377	>Atmosphere>POPs>POP>C 12H8Cl6 (aldrin), in air and aerosol	C12H8Cl6 (aldrin), in air and aerosol	NA	NA
378	>Atmosphere>POPs>POP>C 12H8Cl6 (aldrin), in total precipitation	C12H8Cl6 (aldrin), in total precipitation	NA	NA
379	>Atmosphere>POPs>POP>C 12H8Cl6 (aldrin), in wet precipitation	C12H8Cl6 (aldrin), in wet precipitation	NA	NA
380	>Atmosphere>POPs>POP>C 6Cl6 (hexachlorobenzene, HCB), in air	C6Cl6 (hexachlorobenzene, HCB), in air	NA	NA
381	>Atmosphere>POPs>POP>C 6H6Cl6 (1,2,3,4,5,6-hexachlorocyclohexane, alpha-lindane, alpha-HCH), in aerosol	C6H6Cl6 (1,2,3,4,5,6-hexachlorocyclohexane, alpha-lindane, alpha-HCH), in aerosol	NA	NA
382	>Atmosphere>POPs>POP>C 6H6Cl6 (1,2,3,4,5,6-hexachlorocyclohexane, alpha-lindane, alpha-HCH), in air	C6H6Cl6 (1,2,3,4,5,6-hexachlorocyclohexane, alpha-lindane, alpha-HCH), in air	NA	NA
383	>Atmosphere>POPs>POP>C 6H6Cl6 (1,2,3,4,5,6-hexachlorocyclohexane, alpha-lindane, alpha-HCH), in wet precipitation	C6H6Cl6 (1,2,3,4,5,6-hexachlorocyclohexane, alpha-lindane, alpha-HCH), in wet precipitation	NA	NA
384	>Atmosphere>POPs>POP>C 6H6Cl6 (1,2,3,4,5,6-hexachlorocyclohexane, gamma-lindane, gamma-HCH), in air	C6H6Cl6 (1,2,3,4,5,6-hexachlorocyclohexane, gamma-lindane, gamma-HCH), in air	NA	NA
385	>Atmosphere>POPs>POP>C 6H6Cl6 (1,2,3,4,5,6-hexachlorocyclohexane, gamma-lindane, gamma-HCH), in wet precipitation	C6H6Cl6 (1,2,3,4,5,6-hexachlorocyclohexane, gamma-lindane, gamma-HCH), in wet precipitation	NA	NA
386	>Terrestrial>Land surface>Fire>Fire fractional cover	Fire fractional cover	Fraction of a land area where fire is occurring.	NA

#	Path	Name	Definition	WMO306_CD
387	>Terrestrial>Land surface>Fire>Fire radiative power	Fire radiative power	Power radiated by the fire occurring within an area.	NA
388	>Terrestrial>Land surface>Fire>Fire temperature	Fire temperature	Temperature of the fire occurring within an area.	NA
389	>Terrestrial>Land surface>Temperature>Land surface temperature	Land surface temperature	Temperature of the apparent surface of land (bare soil or vegetation).	NA
390	>Atmosphere>Reactive Gas>Nitrogen containing compounds>Ammonia (NH3)	Ammonia (NH3)	NA	NA
391	>Atmosphere>Reactive Gas>Nitrogen containing compounds>C2H3O5N (peroxyacetylnitrate, PAN)	C2H3O5N (peroxyacetylnitrate, PAN)	NA	NA
392	>Atmosphere>Reactive Gas>Nitrogen containing compounds>ClONO2 (chlorine nitrate)	ClONO2 (chlorine nitrate)	NA	NA
393	>Atmosphere>Reactive Gas>Nitrogen containing compounds>HCN (formonitrile, hydrogen cyanide)	HCN (formonitrile, hydrogen cyanide)	NA	NA
394	>Atmosphere>Reactive Gas>Nitrogen containing compounds>HNO3 (nitric acid)	HNO3 (nitric acid)	NA	NA
395	>Atmosphere>Reactive Gas>Nitrogen containing compounds>NO	NO	NA	NA
396	>Atmosphere>Reactive Gas>Nitrogen containing compounds>NO2	NO2	NA	NA
397	>Atmosphere>Reactive Gas>Nitrogen containing compounds>NOx	NOx	NA	NA
398	>Atmosphere>Reactive Gas>Nitrogen containing compounds>NOy	NOy	NA	NA

#	Path	Name	Definition	WMO306_CD
399	>Ocean>Biology>Phosporus species>PO4= (phosphate)	PO4= (phosphate)	Phosphate concentration in sea water.	oceanPhosphate
400	>Ocean>Biology>Phosporus species>Total organic phosphorus	Total organic phosphorus	NA	oceanTotalOrganicPhosphorous
401	>Ocean>Snow / Ice / Glacier>Ice>Sea-ice cover	Sea-ice cover	Fraction of an ocean area where ice is present.	seaIceCover
402	>Ocean>Snow / Ice / Glacier>Ice>Sea-ice elevation	Sea-ice elevation	Elevation of the surface of the sea-ice sheet above sea level.	seaIceElevation
403	>Ocean>Snow / Ice / Glacier>Ice>Sea-ice motion	Sea-ice motion	Sea-ice motion.	seaIceMotion
404	>Ocean>Snow / Ice / Glacier>Ice>Sea-ice surface characteristics	Sea-ice surface characteristics	Sea-ice surface characteristics (albedo, meltpond, dust, snow properties, temperature).	seaIceSurfaceCharacteristics
405	>Ocean>Snow / Ice / Glacier>Ice>Sea-ice surface temperature	Sea-ice surface temperature	Temperature of the surface of sea-ice.	seaIceSurfaceTemperature
406	>Ocean>Snow / Ice / Glacier>Ice>Sea-ice thickness	Sea-ice thickness	Thickness of the ice sheet.	seaIceThickness
407	>Ocean>Snow / Ice / Glacier>Ice>Sea-ice type	Sea-ice type	Categorization of the type of sea ice.	seaIceType
408	>Ocean>Transmissivity>CTD >Transmissivity	Transmissivity	NA	oceanTransmissivity
409	>Outer Space>Energetic particles / solar wind >Particle density>Solar wind density	Solar wind density	Density of solar wind plasma.	NA
410	>Terrestrial>Lake>Temperature>Lake Surface Temperature	Lake Surface Temperature	Temperature of the lake surface.	NA
411	>Atmosphere>Aerosol>Physical properties - secondary>CCN concentration at single supersaturation	CCN concentration at single supersaturation	NA	NA
412	>Atmosphere>Aerosol>Physical properties - secondary>CCN concentration spectra	CCN concentration spectra	NA	NA

#	Path	Name	Definition	WMO306_CD
413	>Atmosphere>Aerosol>Physical properties - secondary>Hygroscopic growth factor, 110 µm equivalent	Hygroscopic growth factor, 110 µm equivalent	NA	NA
414	>Atmosphere>Aerosol>Physical properties - secondary>Hygroscopic growth factor, 165 µm equivalent	Hygroscopic growth factor, 165 µm equivalent	NA	NA
415	>Atmosphere>Aerosol>Physical properties - secondary>Hygroscopic growth factor, 35 µm equivalent	Hygroscopic growth factor, 35 µm equivalent	NA	NA
416	>Atmosphere>Aerosol>Physical properties - secondary>Hygroscopic growth factor, 50 µm equivalent	Hygroscopic growth factor, 50 µm equivalent	NA	NA
417	>Atmosphere>Aerosol>Physical properties - secondary>Hygroscopic growth factor, 75 µm equivalent	Hygroscopic growth factor, 75 µm equivalent	NA	NA
418	>Atmosphere>Aerosol>Physical properties - secondary>Hygroscopic growth factor, total aerosol	Hygroscopic growth factor, total aerosol	NA	NA
419	>Atmosphere>Greenhouse Gas>PFCs>C2F6 (hexafluoroethane, PFC-116)	C2F6 (hexafluoroethane, PFC-116)	NA	NA
420	>Atmosphere>Greenhouse Gas>PFCs>C3F8 (octafluoropropane, PFC-218)	C3F8 (octafluoropropane, PFC-218)	NA	NA
421	>Atmosphere>Greenhouse Gas>PFCs>CF4 (tetrafluoromethane, carbon tetrafluoride, perfluoromethane, PFC-14)	CF4 (tetrafluoromethane, carbon tetrafluoride, perfluoromethane, PFC-14)	NA	NA
422	>Terrestrial>Land surface>Greenhouse Gas>CO2 flux	CO2 flux	Flux of carbon dioxide from the surface to the atmosphere	NA

#	Path	Name	Definition	WMO306_CD
423	>Terrestrial>Land surface>Vegetation>Biomass	Biomass	Total amount of vegetation in a reference area.	NA
424	>Terrestrial>Land surface>Vegetation>Fraction of vegetated land	Fraction of vegetated land	Fraction of a land area where vegetation is present.	NA
425	>Terrestrial>Land surface>Vegetation>Leaf Area Index (LAI)	Leaf Area Index (LAI)	Total one-sided area of photosynthetic tissue per unit ground surface area (Leaf Area Index, LAI).	NA
426	>Terrestrial>Land surface>Vegetation>Normalised Difference Vegetation Index (NDVI)	Normalised Difference Vegetation Index (NDVI)	Difference between maximum (in the near infra-red frequencies) and minimum (around the red frequencies) vegetation reflectance, normalised to the summation.	NA
427	>Terrestrial>Land surface>Vegetation>Vegetation type	Vegetation type	Category of vegetation type within a vegetated area.	NA
428	>Atmosphere>Reactive Gas>Sulfur containing compounds>COS (OCS, carbon oxide sulfide, carbonyl sulfide)	COS (OCS, carbon oxide sulfide, carbonyl sulfide)	NA	NA
429	>Atmosphere>Reactive Gas>Sulfur containing compounds>CS2 (Carbon disulfide)	CS2 (Carbon disulfide)	NA	NA
430	>Atmosphere>Reactive Gas>Sulfur containing compounds>SO2	SO2	NA	NA
431	>Atmosphere>Lightning>Position>Lightning detection (time and location)	Lightning detection (time and location)	Time and location (latitude, longitude) of lightning events.	NA
432	>Atmosphere>Lightning>Position>Lightning direction from station	Lightning direction from station	NA	NA
433	>Atmosphere>Lightning>Position>Lightning distance from station	Lightning distance from station	NA	NA
434	>Atmosphere>Reactive Gas>VOC>C2H2 (ethyne, acetylene)	C2H2 (ethyne, acetylene)	NA	NA
435	>Atmosphere>Reactive Gas>VOC>C2H2O2 (oxaldehyde, ethanedial)	C2H2O2 (oxaldehyde, ethanedial)	NA	NA

#	Path	Name	Definition	WMO306_CD
436	>Atmosphere>Reactive Gas>VOC>C2H4 (ethene)	C2H4 (ethene)	NA	NA
437	>Atmosphere>Reactive Gas>VOC>C2H6 (ethane)	C2H6 (ethane)	NA	NA
438	>Atmosphere>Reactive Gas>VOC>C2H6S (dimethylsulfide, DMS)	C2H6S (dimethylsulfide, DMS)	NA	NA
439	>Atmosphere>Reactive Gas>VOC>C3H4 (propyne)	C3H4 (propyne)	NA	NA
440	>Atmosphere>Reactive Gas>VOC>C3H4O (prop-2-enal, acrolein)	C3H4O (prop-2-enal, acrolein)	NA	NA
441	>Atmosphere>Reactive Gas>VOC>C3H4O2 (2-oxopropanal, methylglyoxal)	C3H4O2 (2-oxopropanal, methylglyoxal)	NA	NA
442	>Atmosphere>Reactive Gas>VOC>C3H6 (propene)	C3H6 (propene)	NA	NA
443	>Atmosphere>Reactive Gas>VOC>C3H6O (acetone, propanone)	C3H6O (acetone, propanone)	NA	NA
444	>Atmosphere>Reactive Gas>VOC>C3H6O (propanal)	C3H6O (propanal)	NA	NA
445	>Atmosphere>Reactive Gas>VOC>C3H8 (propane)	C3H8 (propane)	NA	NA
446	>Atmosphere>Reactive Gas>VOC>C4H6 (1,3-butadiene, butadiene)	C4H6 (1,3-butadiene, butadiene)	NA	NA
447	>Atmosphere>Reactive Gas>VOC>C4H6O (2-methylprop-2-enal, methacrolein)	C4H6O (2-methylprop-2-enal, methacrolein)	NA	NA
448	>Atmosphere>Reactive Gas>VOC>C4H6O (but-3-en-2-one, methylvinylketone)	C4H6O (but-3-en-2-one, methylvinylketone)	NA	NA
449	>Atmosphere>Reactive Gas>VOC>C4H8 (1-butene)	C4H8 (1-butene)	NA	NA
450	>Atmosphere>Reactive Gas>VOC>C4H8 (sum of butenes)	C4H8 (sum of butenes)	NA	NA
451	>Atmosphere>Reactive Gas>VOC>C4H8O (butan-2-one, methylethylketone)	C4H8O (butan-2-one, methylethylketone)	NA	NA

#	Path	Name	Definition	WMO306_CD
452	>Atmosphere>Reactive Gas>VOC>C4H8O (butanal isomers)	C4H8O (butanal isomers)	NA	NA
453	>Atmosphere>Reactive Gas>VOC>C5H10 (1-pentene)	C5H10 (1-pentene)	NA	NA
454	>Atmosphere>Reactive Gas>VOC>C5H10 (2-methyl-1-butene)	C5H10 (2-methyl-1-butene)	NA	NA
455	>Atmosphere>Reactive Gas>VOC>C5H10 (2-methyl-2-butene)	C5H10 (2-methyl-2-butene)	NA	NA
456	>Atmosphere>Reactive Gas>VOC>C5H10 (3-methyl-1-butene)	C5H10 (3-methyl-1-butene)	NA	NA
457	>Atmosphere>Reactive Gas>VOC>C5H10 (cyclopentane)	C5H10 (cyclopentane)	NA	NA
458	>Atmosphere>Reactive Gas>VOC>C5H10 (sum of 1-pentene & 2-methyl-2-butene)	C5H10 (sum of 1-pentene & 2-methyl-2-butene)	NA	NA
459	>Atmosphere>Reactive Gas>VOC>C5H10 (sum of pentenes)	C5H10 (sum of pentenes)	NA	NA
460	>Atmosphere>Reactive Gas>VOC>C5H10O (pentanal, valeraldehyde)	C5H10O (pentanal, valeraldehyde)	NA	NA
461	>Atmosphere>Reactive Gas>VOC>C5H12 & C4H8 (sum of 2,2-dimethylpropane & c-2-butene)	C5H12 & C4H8 (sum of 2,2-dimethylpropane & c-2-butene)	NA	NA
462	>Atmosphere>Reactive Gas>VOC>C5H12 (2,2-dimethylpropane)	C5H12 (2,2-dimethylpropane)	NA	NA
463	>Atmosphere>Reactive Gas>VOC>C5H14 (2,3-dimethylbutane)	C5H14 (2,3-dimethylbutane)	NA	NA
464	>Atmosphere>Reactive Gas>VOC>C5H8 (2-methyl-1,3-butadiene, isoprene)	C5H8 (2-methyl-1,3-butadiene, isoprene)	NA	NA

#	Path	Name	Definition	WMO306_CD
465	>Atmosphere>Reactive Gas>VOC>C5H8 (cyclopentene)	C5H8 (cyclopentene)	NA	NA
466	>Atmosphere>Reactive Gas>VOC>C5Hn (n={10, 8}; sum of 3-methyl-1-butene & cyclopentene)	C5Hn (n={10, 8}; sum of 3-methyl-1-butene & cyclopentene)	NA	NA
467	>Atmosphere>Reactive Gas>VOC>C5Hn (n={12, 10}; sum of n-pentane & cyclopentane)	C5Hn (n={12, 10}; sum of n-pentane & cyclopentane)	NA	NA
468	>Atmosphere>Reactive Gas>VOC>C6H12 (cyclohexane)	C6H12 (cyclohexane)	NA	NA
469	>Atmosphere>Reactive Gas>VOC>C6H12 (methylcyclopentane)	C6H12 (methylcyclopentane)	NA	NA
470	>Atmosphere>Reactive Gas>VOC>C6H12O (hexanal isomers)	C6H12O (hexanal isomers)	NA	NA
471	>Atmosphere>Reactive Gas>VOC>C6H14 (2,2-dimethylbutane)	C6H14 (2,2-dimethylbutane)	NA	NA
472	>Atmosphere>Reactive Gas>VOC>C6H14 (2-methylpentane)	C6H14 (2-methylpentane)	NA	NA
473	>Atmosphere>Reactive Gas>VOC>C6H14 (3-methylpentane)	C6H14 (3-methylpentane)	NA	NA
474	>Atmosphere>Reactive Gas>VOC>C6H14 (n-hexane)	C6H14 (n-hexane)	NA	NA
475	>Atmosphere>Reactive Gas>VOC>C6H14 (sum of methylpentanes)	C6H14 (sum of methylpentanes)	NA	NA
476	>Atmosphere>Reactive Gas>VOC>C6H6 (benzene)	C6H6 (benzene)	NA	NA
477	>Atmosphere>Reactive Gas>VOC>C6Hn (n={14, 12}; sum of 3-methylpentane & cyclohexane)	C6Hn (n={14, 12}; sum of 3-methylpentane & cyclohexane)	NA	NA

#	Path	Name	Definition	WMO306_CD
478	>Atmosphere>Reactive Gas>VOC>C6Hn (n={14, 12}; sum of 2,2-dimethylbutane & methylcyclopentane	C6Hn (n={14, 12}; sum of 2,2-dimethylbutane & methylcyclopentane	NA	NA
479	>Atmosphere>Reactive Gas>VOC>C6Hn (n={14, 12}; sum of 2,3-dimethylbutane & methylcyclopentane	C6Hn (n={14, 12}; sum of 2,3-dimethylbutane & methylcyclopentane	NA	NA
480	>Atmosphere>Reactive Gas>VOC>C7H16 (sum of methylhexanes)	C7H16 (sum of methylhexanes)	NA	NA
481	>Atmosphere>Reactive Gas>VOC>C7H6O (benzene carbaldehyde)	C7H6O (benzene carbaldehyde)	NA	NA
482	>Atmosphere>Reactive Gas>VOC>C7H8 (toluene)	C7H8 (toluene)	NA	NA
483	>Atmosphere>Reactive Gas>VOC>C8H10 (ethylbenzene)	C8H10 (ethylbenzene)	NA	NA
484	>Atmosphere>Reactive Gas>VOC>C8H10 (m-xylene)	C8H10 (m-xylene)	NA	NA
485	>Atmosphere>Reactive Gas>VOC>C8H10 (o-xylene)	C8H10 (o-xylene)	NA	NA
486	>Atmosphere>Reactive Gas>VOC>C8H10 (p,m-xylene)	C8H10 (p,m-xylene)	NA	NA
487	>Atmosphere>Reactive Gas>VOC>C9H12 (1,2,4-trimethylbenzene)	C9H12 (1,2,4-trimethylbenzene)	NA	NA
488	>Atmosphere>Reactive Gas>VOC>C9H12 (1,3,5-trimethylbenzene)	C9H12 (1,3,5-trimethylbenzene)	NA	NA
489	>Atmosphere>Reactive Gas>VOC>CH2O (formaldehyde)	CH2O (formaldehyde)	NA	NA
490	>Atmosphere>Reactive Gas>VOC>CH3CH2OH (ethanol)	CH3CH2OH (ethanol)	NA	NA

#	Path	Name	Definition	WMO306_CD
491	>Atmosphere>Reactive Gas>VOC>CH3CHO (acetaldehyde, ethanal)	CH3CHO (acetaldehyde, ethanal)	NA	NA
492	>Atmosphere>Reactive Gas>VOC>CH3CN (acetonitrile)	CH3CN (acetonitrile)	NA	NA
493	>Atmosphere>Reactive Gas>VOC>CH3OH (methanol)	CH3OH (methanol)	NA	NA
494	>Atmosphere>Reactive Gas>VOC>NMHC	NMHC	NA	NA
495	>Atmosphere>Reactive Gas>VOC>c-C4H8 (cis-2-butene)	c-C4H8 (cis-2-butene)	NA	NA
496	>Atmosphere>Reactive Gas>VOC>c-C5H10 (cis-2-pentene)	c-C5H10 (cis-2-pentene)	NA	NA
497	>Atmosphere>Reactive Gas>VOC>i-C4H10 (2-methylpropane, iso-butane)	i-C4H10 (2-methylpropane, iso-butane)	NA	NA
498	>Atmosphere>Reactive Gas>VOC>i-C4H8 (2-methylpropene, iso-butene)	i-C4H8 (2-methylpropene, iso-butene)	NA	NA
499	>Atmosphere>Reactive Gas>VOC>i-C5H12 (2-methylbutane, iso-pentane)	i-C5H12 (2-methylbutane, iso-pentane)	NA	NA
500	>Atmosphere>Reactive Gas>VOC>i-C7H16 (2-methylhexane, isoheptane)	i-C7H16 (2-methylhexane, isoheptane)	NA	NA
501	>Atmosphere>Reactive Gas>VOC>n-C4H10 (n-butane)	n-C4H10 (n-butane)	NA	NA
502	>Atmosphere>Reactive Gas>VOC>n-C5H12 (n-pentane)	n-C5H12 (n-pentane)	NA	NA
503	>Atmosphere>Reactive Gas>VOC>n-C7H16 (n-heptane)	n-C7H16 (n-heptane)	NA	NA
504	>Atmosphere>Reactive Gas>VOC>t-C4H8 (trans-2-butene)	t-C4H8 (trans-2-butene)	NA	NA

#	Path	Name	Definition	WMO306_CD
505	>Atmosphere>Reactive Gas>VOC>t-C5H10 (trans-2-pentene)	t-C5H10 (trans-2-pentene)	NA	NA
506	>Atmosphere>Clouds>Optical properties>Cloud optical depth	Cloud optical depth	Effective depth of a cloud from the viewpoint of radiation propagation.	NA
507	>Atmosphere>Clouds>Optical properties>Optical depth of fog	Optical depth of fog	NA	NA
508	>Atmosphere>Clouds>Optical properties>Optical depth within each layer	Optical depth within each layer	NA	NA
509	>Atmosphere>Clouds>Optical properties>Short-wave cloud reflectance	Short-wave cloud reflectance	Reflectance of the solar radiation from clouds.	NA
510	>Terrestrial>Land surface>Humidity>Evaporation	Evaporation	Quantity of water evaporated from the soil and plants when the ground is at its natural moisture content.	NA
511	>Outer Space>Energetic particles / solar wind >Particle flux>Alpha particles differential directional flux	Alpha particles differential directional flux	NA	NA
512	>Outer Space>Energetic particles / solar wind >Particle flux>Alpha particles integral directional flux	Alpha particles integral directional flux	The flux of alpha particles through a reference surface limited to a specified solid angle as a function of the direction. An alpha particle has positive charge and consists of two protons and two neutrons (the nucleus of a helium atom). Flux is the rate of flow through a reference surface. The directional flux is the flux limited to a certain solid angle as a function of the direction (pitch angle).	NA
513	>Outer Space>Energetic particles / solar wind >Particle flux>Cosmic ray neutron flux spectrum	Cosmic ray neutron flux spectrum	Flux density energy spectrum of neutrons from the Sun or as component of the cosmic radiation.	NA
514	>Outer Space>Energetic particles / solar wind >Particle flux>Electron differential directional flux	Electron differential directional flux	Flux density energy spectrum of low-, medium-, and high-energy electrons from the magnetosphere, the radiation belts or the interplanetary medium, per unit solid angle	NA

#	Path	Name	Definition	WMO306_CD
515	>Outer Space>Energetic particles / solar wind >Particle flux>Electron flux density	Electron flux density	Flux density of low-, medium-, and high-energy electrons from the magnetosphere, the radiation belts or the interplanetary medium.	NA
516	>Outer Space>Energetic particles / solar wind >Particle flux>Electron integral directional flux	Electron integral directional flux	Flux density of low-, medium-, and high-energy electrons from the magnetosphere, the radiation belts or the interplanetary medium, per unit solid angle.	NA
517	>Outer Space>Energetic particles / solar wind >Particle flux>Heavy ion differential directional flux	Heavy ion differential directional flux	Flux density of heavy ions (heavier than Helium) per unit solid angle.	NA
518	>Outer Space>Energetic particles / solar wind >Particle flux>Heavy ion integral directional flux	Heavy ion integral directional flux	Flux density of heavy ions ranging from Helium to Iron.	NA
519	>Outer Space>Energetic particles / solar wind >Particle flux>Proton differential directional flux	Proton differential directional flux	Flux density energy spectrum of low-, medium-, and high-energy protons from the magnetosphere, the radiation belts or the interplanetary medium, per unit solid angle.	NA
520	>Outer Space>Energetic particles / solar wind >Particle flux>Proton integral directional flux	Proton integral directional flux	Flux density of low-, medium-, and high-energy protons from the magnetosphere, the radiation belts or the interplanetary medium.	NA
521	>Atmosphere>Visibility>Obscurations>Extinction coefficient	Extinction coefficient	NA	NA
522	>Atmosphere>Visibility>Obscurations>Hydrometeor radius	Hydrometeor radius	NA	NA
523	>Atmosphere>Visibility>Obscurations>Hydrometeor type	Hydrometeor type	NA	NA
524	>Atmosphere>Visibility>Obscurations>Lithometeor type	Lithometeor type	NA	NA
525	>Atmosphere>Visibility>Obscurations>Meteorological Optical Range	Meteorological Optical Range	NA	NA
526	>Atmosphere>Visibility>Obscurations>Obscuration type	Obscuration type	NA	NA
527	>Terrestrial>Soil>Humidity> Soil moisture (in the roots region)	Soil moisture (in the roots region)	Fractional content of water in a volume of wet soil. Typically in a layer from the surface down to approximately 3m.	NA

#	Path	Name	Definition	WMO306_CD
528	>Terrestrial>Soil>Humidity> Soil moisture at surface	Soil moisture at surface	Fractional content of water in a volume of wet soil. Surface layer (upper few centimetres).	NA
529	>Atmosphere>Total Atmospheric Deposition>Inorganic acid>Strong acids	Strong acids	NA	NA
531	>Atmosphere>Clouds>Position>Height of cloud base	Height of cloud base	NA	NA
532	>Atmosphere>Clouds>Position>Height of cloud top	Height of cloud top	NA	NA
533	>Atmosphere>Clouds>Position>Height of inversion	Height of inversion	NA	NA
534	>Atmosphere>Greenhouse Gas>HCFCs>C2H3Cl2F (1,1-dichloro-1-fluoroethane, HCFC-141b)	C2H3Cl2F (1,1-dichloro-1-fluoroethane, HCFC-141b)	NA	NA
535	>Atmosphere>Greenhouse Gas>HCFCs>C2H3ClF2 (1-chloro-1,1-difluoroethane, HCFC-142b)	C2H3ClF2 (1-chloro-1,1-difluoroethane, HCFC-142b)	NA	NA
536	>Atmosphere>Greenhouse Gas>HCFCs>C2H3F3 (1,1,1-trifluoroethane, HCFC-143a)	C2H3F3 (1,1,1-trifluoroethane, HCFC-143a)	NA	NA
537	>Atmosphere>Greenhouse Gas>HCFCs>CHClF2 (chlorodifluoromethane, HCFC-22)	CHClF2 (chlorodifluoromethane, HCFC-22)	NA	NA
538	>Atmosphere>Total Atmospheric Deposition>Inorganic anions>Bromide (Br-)	Bromide (Br-)	NA	NA
539	>Atmosphere>Total Atmospheric Deposition>Inorganic anions>Chloride (Cl-)	Chloride (Cl-)	NA	NA
540	>Atmosphere>Total Atmospheric Deposition>Inorganic anions>Fluoride (F-)	Fluoride (F-)	NA	NA

#	Path	Name	Definition	WMO306_CD
541	>Atmosphere>Total Atmospheric Deposition>Inorganic anions>Iodide (I-)	Iodide (I-)	NA	NA
542	>Atmosphere>Total Atmospheric Deposition>Inorganic anions>Phosphate (PO4---)	Phosphate (PO4---)	NA	NA
543	>Atmosphere>Total Atmospheric Deposition>Inorganic anions>Sulphate (SO4=), corrected	Sulphate (SO4=), corrected	NA	NA
544	>Atmosphere>Total Atmospheric Deposition>Inorganic anions>Sulphate (SO4=), total	Sulphate (SO4=), total	NA	NA
545	>Atmosphere>Total Atmospheric Deposition>Inorganic cations>Calcium (Ca++)	Calcium (Ca++)	NA	NA
546	>Atmosphere>Total Atmospheric Deposition>Inorganic cations>Magnesium (Mg++)	Magnesium (Mg++)	NA	NA
547	>Atmosphere>Total Atmospheric Deposition>Inorganic cations>Potassium (K+)	Potassium (K+)	NA	NA
548	>Atmosphere>Total Atmospheric Deposition>Inorganic cations>Sodium (Na+)	Sodium (Na+)	NA	NA
549	>Ocean>Other Gas>CTD>pO2	pO2	NA	oceanPO2
550	>Atmosphere>Clouds>Type> Type of cloud	Type of cloud	Cloud type classification.	NA
551	>Atmosphere>Clouds>Type> Type of high clouds	Type of high clouds	NA	NA
552	>Atmosphere>Clouds>Type> Type of low clouds	Type of low clouds	NA	NA

#	Path	Name	Definition	WMO306_CD
553	>Atmosphere>Clouds>Type> Type of middle clouds	Type of middle clouds	NA	NA
554	>Atmosphere>Greenhouse Gas>HFCs>C2H2F4 (1,1,1,2-tetrafluoroethane, HFC-134a)	C2H2F4 (1,1,1,2-tetrafluoroethane, HFC-134a)	NA	NA
555	>Atmosphere>Greenhouse Gas>HFCs>C2H4F2 (1,1-difluoroethane, HFC-152a)	C2H4F2 (1,1-difluoroethane, HFC-152a)	NA	NA
556	>Atmosphere>Greenhouse Gas>HFCs>C2HF5 (pentafluoroethane, HFC-125)	C2HF5 (pentafluoroethane, HFC-125)	NA	NA
557	>Atmosphere>Greenhouse Gas>HFCs>C3H2F6 (1,1,1,2,3,3-hexafluoropropane, HFC-236fa)	C3H2F6 (1,1,1,2,3,3-hexafluoropropane, HFC-236fa)	NA	NA
558	>Atmosphere>Greenhouse Gas>HFCs>C3H3F5 (1,1,1,3,3-Pentafluoropropane, HFC-245fa)	C3H3F5 (1,1,1,3,3-Pentafluoropropane, HFC-245fa)	NA	NA
559	>Atmosphere>Greenhouse Gas>HFCs>C3HF7 (1,1,1,2,3,3,3-Heptafluoropropane, HFC-227ea)	C3HF7 (1,1,1,2,3,3,3-Heptafluoropropane, HFC-227ea)	NA	NA
560	>Atmosphere>Greenhouse Gas>HFCs>C4H5F5 (1,1,1,3,3-pentafluorobutane, HFC-365mfc)	C4H5F5 (1,1,1,3,3-pentafluorobutane, HFC-365mfc)	NA	NA
561	>Atmosphere>Greenhouse Gas>HFCs>CH2F2 (difluoromethane, HFC-32)	CH2F2 (difluoromethane, HFC-32)	NA	NA
562	>Atmosphere>Greenhouse Gas>HFCs>CHF3 (trifluoromethane, HFC-23)	CHF3 (trifluoromethane, HFC-23)	NA	NA
563	>Terrestrial>Land surface>Radiation>Fraction of Absorbed PAR (FAPAR)	Fraction of Absorbed PAR (FAPAR)	Fraction of PAR absorbed by vegetation (land or marine) for photosynthesis processes (generally around the 'red' frequencies).	NA

#	Path	Name	Definition	WMO306_CD
564	>Terrestrial>Land surface>Radiation>Photosynthetically Active Radiation (PAR)	Photosynthetically Active Radiation (PAR)	Flux of downwelling photons of wavelength 400-700 nm.	NA
565	>Atmosphere>Radiation>IR >Long-wave radiation (direction unspecified)	Long-wave radiation (direction unspecified)	NA	NA
566	>Atmosphere>Radiation>IR >Long-wave radiation (downwelling)	Long-wave radiation (downwelling)	NA	NA
567	>Atmosphere>Radiation>IR >Long-wave radiation (upwelling)	Long-wave radiation (upwelling)	NA	NA
568	>Atmosphere>Total Atmospheric Deposition>Inorganic nitrogen species>Ammonium (NH4+)	Ammonium (NH4+)	NA	NA
569	>Atmosphere>Total Atmospheric Deposition>Inorganic nitrogen species>Nitrate (NO3-)	Nitrate (NO3-)	NA	NA
570	>Atmosphere>Total Atmospheric Deposition>Inorganic nitrogen species>Nitrite (NO2-)	Nitrite (NO2-)	NA	NA
571	>Atmosphere>Radiation>Solar>Diffuse solar radiation	Diffuse solar radiation	NA	NA
572	>Atmosphere>Radiation>Solar>Direct solar radiation	Direct solar radiation	NA	NA
573	>Atmosphere>Radiation>Solar>Global solar radiation (downwelling)	Global solar radiation (downwelling)	NA	NA
574	>Atmosphere>Radiation>Solar>Global solar radiation (upwelling)	Global solar radiation (upwelling)	NA	NA
575	>Atmosphere>Radiation>Solar>Reflected solar radiation	Reflected solar radiation	NA	NA

#	Path	Name	Definition	WMO306_CD
576	>Atmosphere>Total Atmospheric Deposition>Organic acid>Acetate (CH3COO-)	Acetate (CH3COO-)	NA	NA
577	>Atmosphere>Total Atmospheric Deposition>Organic acid>Formate (HCOO-)	Formate (HCOO-)	NA	NA
578	>Atmosphere>Total Atmospheric Deposition>Organic acid>Propionate (C2H5COO-)	Propionate (C2H5COO-)	NA	NA
579	>Atmosphere>Aerosol>Composition>Acidity/Alkalinity, total aerosol	Acidity/Alkalinity, total aerosol	NA	NA
589	>Atmosphere>Greenhouse Gas>CFCs>C2Cl2F4 (1,2-dichlorotetrafluoroethane, CFC-114)	C2Cl2F4 (1,2-dichlorotetrafluoroethane, CFC-114)	NA	NA
590	>Atmosphere>Greenhouse Gas>CFCs>C2Cl3F3 (1,1,2-trichloro-1,2,2-trifluoroethane, CFC-113)	C2Cl3F3 (1,1,2-trichloro-1,2,2-trifluoroethane, CFC-113)	NA	NA
591	>Atmosphere>Greenhouse Gas>CFCs>C2ClF5 (1-chloro-1,1,2,2,2-pentafluoroethane, CFC-115)	C2ClF5 (1-chloro-1,1,2,2,2-pentafluoroethane, CFC-115)	NA	NA
592	>Atmosphere>Greenhouse Gas>CFCs>CCl2F2 (dichlorodifluoromethane, CFC-12)	CCl2F2 (dichlorodifluoromethane, CFC-12)	NA	NA
593	>Atmosphere>Greenhouse Gas>CFCs>CCl3F (trichlorofluoromethane, CFC-11)	CCl3F (trichlorofluoromethane, CFC-11)	NA	NA
594	>Atmosphere>Greenhouse Gas>Halocarbons>CCl4 (carbon tetrachloride)	CCl4 (carbon tetrachloride)	NA	NA
595	>Atmosphere>Greenhouse Gas>Halocarbons>CH3CCl3 (1,1,1-trichloroethane)	CH3CCl3 (1,1,1-trichloroethane)	NA	NA

#	Path	Name	Definition	WMO306_CD
596	>Terrestrial>Soil>Temperature>Soil temperature	Soil temperature	Temperature at a specified depth.	NA
597	>Atmosphere>Total Atmospheric Deposition>Trace elements>Aluminum (Al)	Aluminum (Al)	NA	NA
598	>Atmosphere>Total Atmospheric Deposition>Trace elements>Arsenic (As)	Arsenic (As)	NA	NA
599	>Atmosphere>Total Atmospheric Deposition>Trace elements>Cadmium (Cd)	Cadmium (Cd)	NA	NA
600	>Atmosphere>Total Atmospheric Deposition>Trace elements>Chromium (Cr)	Chromium (Cr)	NA	NA
601	>Atmosphere>Total Atmospheric Deposition>Trace elements>Cobalt (Co)	Cobalt (Co)	NA	NA
602	>Atmosphere>Total Atmospheric Deposition>Trace elements>Copper (Cu)	Copper (Cu)	NA	NA
603	>Atmosphere>Total Atmospheric Deposition>Trace elements>Iron (Fe)	Iron (Fe)	NA	NA
604	>Atmosphere>Total Atmospheric Deposition>Trace elements>Lead (Pb)	Lead (Pb)	NA	NA
605	>Atmosphere>Total Atmospheric Deposition>Trace elements>Manganese (Mn)	Manganese (Mn)	NA	NA
606	>Atmosphere>Total Atmospheric Deposition>Trace elements>Mercury (Hg)	Mercury (Hg)	NA	NA

#	Path	Name	Definition	WMO306_CD
607	>Atmosphere>Total Atmospheric Deposition>Trace elements>Nickel (Ni)	Nickel (Ni)	NA	NA
608	>Atmosphere>Total Atmospheric Deposition>Trace elements>Vanadium (V)	Vanadium (V)	NA	NA
609	>Atmosphere>Total Atmospheric Deposition>Trace elements>Zinc (Zn)	Zinc (Zn)	NA	NA
610	>Terrestrial>Land surface>Snow / Ice / Glacier>Glacier>Glacier cover	Glacier cover	Fraction of a land area covered by permanent ice.	NA
611	>Terrestrial>Land surface>Snow / Ice / Glacier>Glacier>Glacier motion	Glacier motion	Velocity of the ice measured at the surface of a glacier.	NA
612	>Terrestrial>Land surface>Snow / Ice / Glacier>Glacier>Glacier topography	Glacier topography	Map of the height of the glacier surface.	NA
613	>Terrestrial>Land surface>Snow / Ice / Glacier>Ice>Ice sheet topography	Ice sheet topography	Map of ice sheet height over land .	NA
614	>Atmosphere>Aerosol>Composition>Inorganic anions>Chloride (Cl-), PM1	Chloride (Cl-), PM1	NA	NA
615	>Atmosphere>Aerosol>Composition>Inorganic anions>Chloride (Cl-), PM10	Chloride (Cl-), PM10	NA	NA
616	>Atmosphere>Aerosol>Composition>Inorganic anions>Chloride (Cl-), PM2.5	Chloride (Cl-), PM2.5	NA	NA
617	>Atmosphere>Aerosol>Composition>Inorganic anions>Chloride (Cl-), total aerosol	Chloride (Cl-), total aerosol	NA	NA

#	Path	Name	Definition	WMO306_CD
618	>Atmosphere>Aerosol>Composition>Inorganic anions>Fluoride (F-), total aerosol	Fluoride (F-), total aerosol	NA	NA
619	>Atmosphere>Aerosol>Composition>Inorganic anions>Sulphate (SO4=), corrected	Sulphate (SO4=), corrected	NA	NA
620	>Atmosphere>Aerosol>Composition>Inorganic anions>Sulphate (SO4=), total	Sulphate (SO4=), total	NA	NA
621	>Atmosphere>Aerosol>Composition>Inorganic anions>Sulphate (SO4=), total, PM10	Sulphate (SO4=), total, PM10	NA	NA
622	>Atmosphere>Aerosol>Composition>Inorganic anions>Sulphate (SO4=), total, PM2.5	Sulphate (SO4=), total, PM2.5	NA	NA
623	>Atmosphere>Aerosol>Composition>Inorganic carbonaceous>Elemental carbon (coarse), PM10	Elemental carbon (coarse), PM10	NA	NA
624	>Atmosphere>Aerosol>Composition>Inorganic carbonaceous>Elemental carbon, PM1	Elemental carbon, PM1	NA	NA
625	>Atmosphere>Aerosol>Composition>Inorganic carbonaceous>Elemental carbon, PM2.5	Elemental carbon, PM2.5	NA	NA
626	>Atmosphere>Aerosol>Composition>Inorganic carbonaceous>Total carbon (coarse), PM10	Total carbon (coarse), PM10	NA	NA
627	>Terrestrial>Land surface>Snow / Ice / Glacier>Snow>Depth of fresh snowfall	Depth of fresh snowfall	NA	NA

#	Path	Name	Definition	WMO306_CD
628	>Terrestrial>Land surface>Snow / Ice / Glacier>Snow>Snow cover (fraction of area)	Snow cover (fraction of area)	Fraction of a given area which is covered by snow.	NA
629	>Terrestrial>Land surface>Snow / Ice / Glacier>Snow>Snow depth	Snow depth	Vertical distance from the snow surface to the underlying surface (ground, glacier ice or sea ice).	NA
630	>Terrestrial>Land surface>Snow / Ice / Glacier>Snow>Snow status (wet/dry)	Snow status (wet/dry)	Binary product (dry or melting/thawing) expressing the presence of liquid water in a snow layer.	NA
631	>Terrestrial>Land surface>Snow / Ice / Glacier>Snow>Snow water equivalent	Snow water equivalent	Vertical depth of the water that would be obtained by melting a snow layer. Linked to snow depth through the density of the snow layer.	NA
632	>Atmosphere>Aerosol>Composition>Inorganic cations>Calcium (Ca++), PM10	Calcium (Ca++), PM10	NA	NA
633	>Atmosphere>Aerosol>Composition>Inorganic cations>Calcium (Ca++), PM2.5	Calcium (Ca++), PM2.5	NA	NA
634	>Atmosphere>Aerosol>Composition>Inorganic cations>Calcium (Ca++), total aerosol	Calcium (Ca++), total aerosol	NA	NA
635	>Atmosphere>Aerosol>Composition>Inorganic cations>Magnesium (Mg++), PM10	Magnesium (Mg++), PM10	NA	NA
636	>Atmosphere>Aerosol>Composition>Inorganic cations>Magnesium (Mg++), PM2.5	Magnesium (Mg++), PM2.5	NA	NA
637	>Atmosphere>Aerosol>Composition>Inorganic cations>Magnesium (Mg++), total aerosol	Magnesium (Mg++), total aerosol	NA	NA

#	Path	Name	Definition	WMO306_CD
638	>Atmosphere>Aerosol>Composition>Inorganic cations>Potassium (K+), PM10	Potassium (K+), PM10	NA	NA
639	>Atmosphere>Aerosol>Composition>Inorganic cations>Potassium (K+), PM2.5	Potassium (K+), PM2.5	NA	NA
640	>Atmosphere>Aerosol>Composition>Inorganic cations>Potassium (K+), total aerosol	Potassium (K+), total aerosol	NA	NA
641	>Atmosphere>Aerosol>Composition>Inorganic cations>Sodium (Na+), PM10	Sodium (Na+), PM10	NA	NA
642	>Atmosphere>Aerosol>Composition>Inorganic cations>Sodium (Na+), PM2.5	Sodium (Na+), PM2.5	NA	NA
643	>Atmosphere>Aerosol>Composition>Inorganic cations>Sodium (Na+), total aerosol	Sodium (Na+), total aerosol	NA	NA
644	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species>Ammonia (NH3), PM2.5	Ammonia (NH3), PM2.5	NA	NA
645	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species>Ammonium (NH4+), PM10	Ammonium (NH4+), PM10	NA	NA
646	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species>Ammonium (NH4+), PM2.5	Ammonium (NH4+), PM2.5	NA	NA
647	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species>Ammonium (NH4+), total aerosol	Ammonium (NH4+), total aerosol	NA	NA

#	Path	Name	Definition	WMO306_CD
648	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species>Ammonium nitrate (NH4NO3), total aerosol	Ammonium nitrate (NH4NO3), total aerosol	NA	NA
649	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species>Ammonium nitrate (NH4NO3, PM1	Ammonium nitrate (NH4NO3, PM1	NA	NA
650	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species>Nitrate (NO3-), PM10	Nitrate (NO3-), PM10	NA	NA
651	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species>Nitrate (NO3-), PM2.5	Nitrate (NO3-), PM2.5	NA	NA
652	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species>Nitrate (NO3-), total aerosol	Nitrate (NO3-), total aerosol	NA	NA
653	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species>Nitrite (NO2-), total aerosol	Nitrite (NO2-), total aerosol	NA	NA
654	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species>Sum of ammonia (NH3) and ammonium (NH4+), in air and aerosol	Sum of ammonia (NH3) and ammonium (NH4+), in air and aerosol	NA	NA
655	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species>Sum of nitric acid (HNO3) and nitrate (NO3-), in air and aerosol	Sum of nitric acid (HNO3) and nitrate (NO3-), in air and aerosol	NA	NA
656	>Atmosphere>Aerosol>Composition>Major inorganic components>Major chemical components (size fractionated)	Major chemical components (size fractionated)	NA	NA
657	>Atmosphere>Aerosol>Composition>Major inorganic components>Major inorganic components (TSP)	Major inorganic components (TSP)	NA	NA

#	Path	Name	Definition	WMO306_CD
658	>Atmosphere>Aerosol>Composition>Major inorganic components>Major inorganic components (coarse)	Major inorganic components (coarse)	NA	NA
659	>Atmosphere>Aerosol>Composition>Major inorganic components>Major inorganic components (fine)	Major inorganic components (fine)	NA	NA
660	>Atmosphere>Aerosol>Composition>Major inorganic components>Other chemical components (coarse)	Other chemical components (coarse)	NA	NA
661	>Atmosphere>Aerosol>Composition>Major inorganic components>Other chemical components (fine)	Other chemical components (fine)	NA	NA
662	>Atmosphere>Aerosol>Composition>Organic anions>C2H3O2- (CH3COO-, acetate), PM1	C2H3O2- (CH3COO-, acetate), PM1	NA	NA
663	>Atmosphere>Aerosol>Composition>Organic anions>C2H3O2- (CH3COO-, acetate), in aerosol	C2H3O2- (CH3COO-, acetate), in aerosol	NA	NA
664	>Atmosphere>Aerosol>Composition>Organic anions>C2O4= (oxalate, ethanedioate), PM1.0	C2O4= (oxalate, ethanedioate), PM1.0	NA	NA
665	>Atmosphere>Aerosol>Composition>Organic anions>C2O4= (oxalate, ethanedioate), PM10	C2O4= (oxalate, ethanedioate), PM10	NA	NA
666	>Atmosphere>Aerosol>Composition>Organic anions>C2O4= (oxalate, ethanedioate), total aerosol	C2O4= (oxalate, ethanedioate), total aerosol	NA	NA
667	>Atmosphere>Aerosol>Composition>Organic anions>CH3O3S- (methanesulphonate), PM1.0	CH3O3S- (methanesulphonate), PM1.0	NA	NA

#	Path	Name	Definition	WMO306_CD
668	>Atmosphere>Aerosol>Composition>Organic anions>CH3O3S- (methanesulphonate), total aerosol	CH3O3S- (methanesulphonate), total aerosol	NA	NA
669	>Atmosphere>Aerosol>Composition>Organic anions>CHO2- (HCOO-, formate), in aerosol	CHO2- (HCOO-, formate), in aerosol	NA	NA
670	>Atmosphere>Aerosol>Composition>Organic carbonaceous>Carbonaceous/organic material (coarse), PM10	Carbonaceous/organic material (coarse), PM10	NA	NA
671	>Atmosphere>Aerosol>Composition>Organic carbonaceous>Carbonaceous/organic material (fine)	Carbonaceous/organic material (fine)	NA	NA
672	>Atmosphere>Aerosol>Composition>Trace elements>Titanium (Ti), total aerosol	Titanium (Ti), total aerosol	NA	NA
673	>Atmosphere>Aerosol>Composition>Trace elements>Aluminium (Al), PM2.5	Aluminium (Al), PM2.5	NA	NA
674	>Atmosphere>Aerosol>Composition>Trace elements>Aluminium (Al), total aerosol	Aluminium (Al), total aerosol	NA	NA
675	>Atmosphere>Aerosol>Composition>Trace elements>Antimony (Sb), PM2.5	Antimony (Sb), PM2.5	NA	NA
676	>Atmosphere>Aerosol>Composition>Trace elements>Antimony (Sb), total aerosol	Antimony (Sb), total aerosol	NA	NA
677	>Atmosphere>Aerosol>Composition>Trace elements>Arsenic (As), PM10	Arsenic (As), PM10	NA	NA

#	Path	Name	Definition	WMO306_CD
678	>Atmosphere>Aerosol>Composition>Trace elements>Arsenic (As), total aerosol	Arsenic (As), total aerosol	NA	NA
679	>Atmosphere>Aerosol>Composition>Trace elements>Barium (Ba), PM2.5	Barium (Ba), PM2.5	NA	NA
680	>Atmosphere>Aerosol>Composition>Trace elements>Barium (Ba), total aerosol	Barium (Ba), total aerosol	NA	NA
681	>Atmosphere>Aerosol>Composition>Trace elements>Bismuth (Bi), PM2.5	Bismuth (Bi), PM2.5	NA	NA
682	>Atmosphere>Aerosol>Composition>Trace elements>Bismuth (Bi), total aerosol	Bismuth (Bi), total aerosol	NA	NA
683	>Atmosphere>Aerosol>Composition>Trace elements>Cadmium (Cd), PM1	Cadmium (Cd), PM1	NA	NA
684	>Atmosphere>Aerosol>Composition>Trace elements>Cadmium (Cd), PM10	Cadmium (Cd), PM10	NA	NA
685	>Atmosphere>Aerosol>Composition>Trace elements>Cadmium (Cd), PM2.5	Cadmium (Cd), PM2.5	NA	NA
686	>Atmosphere>Aerosol>Composition>Trace elements>Cadmium (Cd), PM2.5 thru PM10	Cadmium (Cd), PM2.5 thru PM10	NA	NA
687	>Atmosphere>Aerosol>Composition>Trace elements>Cadmium (Cd), total aerosol	Cadmium (Cd), total aerosol	NA	NA

#	Path	Name	Definition	WMO306_CD
688	>Atmosphere>Aerosol>Composition>Trace elements>Cerium (Ce), PM2.5	Cerium (Ce), PM2.5	NA	NA
689	>Atmosphere>Aerosol>Composition>Trace elements>Cerium (Ce), total aerosol	Cerium (Ce), total aerosol	NA	NA
690	>Atmosphere>Aerosol>Composition>Trace elements>Chromium (Cr), total aerosol	Chromium (Cr), total aerosol	NA	NA
691	>Atmosphere>Aerosol>Composition>Trace elements>Cobalt (Co), total aerosol	Cobalt (Co), total aerosol	NA	NA
692	>Atmosphere>Aerosol>Composition>Trace elements>Copper (Cu), PM10	Copper (Cu), PM10	NA	NA
693	>Atmosphere>Aerosol>Composition>Trace elements>Copper (Cu), total aerosol	Copper (Cu), total aerosol	NA	NA
694	>Atmosphere>Aerosol>Composition>Trace elements>Iron (Fe), total aerosol	Iron (Fe), total aerosol	NA	NA
695	>Atmosphere>Aerosol>Composition>Trace elements>Lanthanum (La), PM2.5	Lanthanum (La), PM2.5	NA	NA
696	>Atmosphere>Aerosol>Composition>Trace elements>Lanthanum (La), total aerosol	Lanthanum (La), total aerosol	NA	NA
697	>Atmosphere>Aerosol>Composition>Trace elements>Lead (Pb), PM10	Lead (Pb), PM10	NA	NA
698	>Atmosphere>Aerosol>Composition>Trace elements>Lead (Pb), total aerosol	Lead (Pb), total aerosol	NA	NA

#	Path	Name	Definition	WMO306_CD
699	>Atmosphere>Aerosol>Composition>Trace elements>Lithium (Li), PM2.5	Lithium (Li), PM2.5	NA	NA
700	>Atmosphere>Aerosol>Composition>Trace elements>Lithium (Li), total aerosol	Lithium (Li), total aerosol	NA	NA
701	>Atmosphere>Aerosol>Composition>Trace elements>Manganese (Mn), PM10	Manganese (Mn), PM10	NA	NA
702	>Atmosphere>Aerosol>Composition>Trace elements>Manganese (Mn), total aerosol	Manganese (Mn), total aerosol	NA	NA
703	>Atmosphere>Aerosol>Composition>Trace elements>Mercury (Hg), total aerosol	Mercury (Hg), total aerosol	NA	NA
704	>Atmosphere>Aerosol>Composition>Trace elements>Nickel (Ni), PM10	Nickel (Ni), PM10	NA	NA
705	>Atmosphere>Aerosol>Composition>Trace elements>Nickel (Ni), total aerosol	Nickel (Ni), total aerosol	NA	NA
706	>Atmosphere>Aerosol>Composition>Trace elements>Phosphorous (P), PM2.5	Phosphorous (P), PM2.5	NA	NA
707	>Atmosphere>Aerosol>Composition>Trace elements>Phosphorous (P), total aerosol	Phosphorous (P), total aerosol	NA	NA
708	>Atmosphere>Aerosol>Composition>Trace elements>Rubidium (Rb), PM2.5	Rubidium (Rb), PM2.5	NA	NA
709	>Atmosphere>Aerosol>Composition>Trace elements>Rubidium (Rb), total aerosol	Rubidium (Rb), total aerosol	NA	NA

#	Path	Name	Definition	WMO306_CD
710	>Atmosphere>Aerosol>Composition>Trace elements>Selenium (Se), total aerosol	Selenium (Se), total aerosol	NA	NA
711	>Atmosphere>Aerosol>Composition>Trace elements>Strontium (Sr), PM2.5	Strontium (Sr), PM2.5	NA	NA
712	>Atmosphere>Aerosol>Composition>Trace elements>Strontium (Sr), total aerosol	Strontium (Sr), total aerosol	NA	NA
713	>Atmosphere>Aerosol>Composition>Trace elements>Thallium (Tl), PM2.5	Thallium (Tl), PM2.5	NA	NA
714	>Atmosphere>Aerosol>Composition>Trace elements>Thallium (Tl), total aerosol	Thallium (Tl), total aerosol	NA	NA
715	>Atmosphere>Aerosol>Composition>Trace elements>Thorium (Th), PM2.5	Thorium (Th), PM2.5	NA	NA
716	>Atmosphere>Aerosol>Composition>Trace elements>Thorium (Th), total aerosol	Thorium (Th), total aerosol	NA	NA
717	>Atmosphere>Aerosol>Composition>Trace elements>Tin (Sn), PM2.5	Tin (Sn), PM2.5	NA	NA
718	>Atmosphere>Aerosol>Composition>Trace elements>Tin (Sn), total aerosol	Tin (Sn), total aerosol	NA	NA
719	>Atmosphere>Aerosol>Composition>Trace elements>Uranium (U), PM2.5	Uranium (U), PM2.5	NA	NA
720	>Atmosphere>Aerosol>Composition>Trace elements>Uranium (U), total aerosol	Uranium (U), total aerosol	NA	NA

#	Path	Name	Definition	WMO306_CD
721	>Atmosphere>Aerosol>Composition>Trace elements>Vanadium (V), PM2.5	Vanadium (V), PM2.5	NA	NA
722	>Atmosphere>Aerosol>Composition>Trace elements>Vanadium (V), total aerosol	Vanadium (V), total aerosol	NA	NA
723	>Atmosphere>Aerosol>Composition>Trace elements>Zinc (Zn), PM2.5	Zinc (Zn), PM2.5	NA	NA
724	>Atmosphere>Aerosol>Composition>Trace elements>Zinc (Zn), total aerosol	Zinc (Zn), total aerosol	NA	NA
725	>Terrestrial>Lake>Snow / Ice / Glacier>Ice>Ice thickness	Ice thickness	NA	NA
726	>Terrestrial>River>Snow / Ice / Glacier>Ice>Ice thickness	Ice thickness	NA	NA
727	>Atmosphere>Aerosol>Physical properties - primary>Dust>Aerosol dust concentration (mass)	Aerosol dust concentration (mass)	Concentration of dust or sand in the atmosphere.	NA
728	>Atmosphere>Aerosol>Physical properties - primary>Volcanic ash>Aerosol volcanic ash (mass concentration)	Aerosol volcanic ash (mass concentration)	Mass mixing ratio of volcanic ash.	NA
729	>Atmosphere>Aerosol>Physical properties - primary>Volcanic ash>Aerosol volcanic ash (Total column)	Aerosol volcanic ash (Total column)	Total column mass of volcanic ash.	NA
731	>Ocean>Basic Physical Properties>Conductivity	Conductivity	Conductivity measured by CTD or MicroCAT.	oceanConductivity
732	>Ocean>Basic Physical Properties>Density	Density	Density measured by CTD.	oceanDensity
733	>Ocean>Biology>Zooplankton (size and/or development stage)	Zooplankton (size and/or development stage)	Aggregate of animal or animal-like organisms in plankton, as protozoans.	oceanZooplanktonSizeDev

#	Path	Name	Definition	WMO306_CD
735	>Ocean>Greenhouse Gas>pCO2	pCO2	Partial pressure of CO2.	oceanPCO2
736	>Ocean>Greenhouse Gas>pCO2 air-sea flux	pCO2 air-sea flux	Flux of CO2 from the ocean into the atmosphere.	oceanPCO2AirSeaFlux
739	>Ocean>Miscellaneous>Fluorescence (DOM)	Fluorescence (DOM)	Flurometric coloured dissolved Organic matter concentration.	oceanFluorescence
740	>Ocean>Topography>Mean dynamic topography (MDT)	Mean dynamic topography (MDT)	NA	oceanMeanDynamicTopography
741	>Ocean>Topography>Mean sea surface (MSS)	Mean sea surface (MSS)	NA	oceanMeanSeaSurface
742	>Ocean>Topography>Sea surface height (SSH, OST)	Sea surface height (SSH, OST)	NA	oceanSeaSurfaceHeight
743	>Ocean>Waves>Wave height	Wave height	Average of height (trough to crest) of the waves sampled over a specified time period.	oceanWaveHeight
744	>Ocean>Waves>Wave period	Wave period	Time required for two successive wave crests to pass a fixed point, or the time for a single wave crest to travel a distance equal to the length of the wave. This is averaged over a specified period of time.	oceanWavePeriod
745	>Ocean>Waves>Directional waves	Directional waves	Waves measured in X,Y,Z directions.	oceanDirectionalWaves
10000	>Atmosphere	Atmosphere	NA	NA
10001	>Atmosphere>Aerosol	Aerosol	NA	NA
10002	>Atmosphere>Aerosol>Composition	Composition	NA	NA
10003	>Atmosphere>Aerosol>Composition>Inorganic anions	Inorganic anions	NA	NA
10004	>Atmosphere>Aerosol>Composition>Inorganic carbonaceous	Inorganic carbonaceous	NA	NA
10005	>Atmosphere>Aerosol>Composition>Inorganic cations	Inorganic cations	NA	NA
10006	>Atmosphere>Aerosol>Composition>Inorganic nitrogen species	Inorganic nitrogen species	NA	NA
10007	>Atmosphere>Aerosol>Composition>Major inorganic components	Major inorganic components	NA	NA
10008	>Atmosphere>Aerosol>Composition>Organic anions	Organic anions	NA	NA

#	Path	Name	Definition	WMO306_CD
10009	>Atmosphere>Aerosol>Composition>Organic carbonaceous	Organic carbonaceous	NA	NA
10010	>Atmosphere>Aerosol>Composition>Trace elements	Trace elements	NA	NA
10011	>Atmosphere>Aerosol>Optical properties	Optical properties	NA	NA
10012	>Atmosphere>Aerosol>Physical properties - primary	Physical properties - primary	NA	NA
10013	>Atmosphere>Aerosol>Physical properties - primary>Dust	Dust	NA	NA
10014	>Atmosphere>Aerosol>Physical properties - primary>Volcanic ash	Volcanic ash	NA	NA
10015	>Atmosphere>Aerosol>Physical properties - secondary	Physical properties - secondary	NA	NA
10016	>Atmosphere>Clouds	Clouds	NA	NA
10017	>Atmosphere>Clouds>Ice	Ice	NA	NA
10018	>Atmosphere>Clouds>Liquid water	Liquid water	NA	NA
10019	>Atmosphere>Clouds>Optical properties	Optical properties	NA	NA
10020	>Atmosphere>Clouds>Position	Position	NA	NA
10021	>Atmosphere>Clouds>Type	Type	NA	NA
10022	>Atmosphere>Dynamics	Dynamics	NA	NA
10023	>Atmosphere>Greenhouse Gas	Greenhouse Gas	NA	NA
10024	>Atmosphere>Greenhouse Gas>CFCs	CFCs	NA	NA
10025	>Atmosphere>Greenhouse Gas>Halocarbons	Halocarbons	NA	NA
10026	>Atmosphere>Greenhouse Gas>Halon	Halon	NA	NA
10027	>Atmosphere>Greenhouse Gas>HCFCs	HCFCs	NA	NA
10028	>Atmosphere>Greenhouse Gas>HFCs	HFCs	NA	NA

#	Path	Name	Definition	WMO306_CD
10029	>Atmosphere>Greenhouse Gas>PFCs	PFCs	NA	NA
10030	>Atmosphere>Humidity	Humidity	NA	NA
10031	>Atmosphere>Lightning	Lightning	NA	NA
10032	>Atmosphere>Lightning>Position	Position	NA	NA
10033	>Atmosphere>Other Gas	Other Gas	NA	NA
10034	>Atmosphere>Ozone	Ozone	NA	NA
10035	>Atmosphere>Past weather	Past weather	NA	NA
10036	>Atmosphere>POPs	POPs	NA	NA
10037	>Atmosphere>POPs>PAH	PAH	NA	NA
10038	>Atmosphere>POPs>POP	POP	NA	NA
10039	>Atmosphere>Precipitation	Precipitation	NA	NA
10040	>Atmosphere>Present weather	Present weather	NA	NA
10041	>Atmosphere>Pressure	Pressure	NA	NA
10042	>Atmosphere>Radiation	Radiation	NA	NA
10043	>Atmosphere>Radiation>IR	IR	NA	NA
10044	>Atmosphere>Radiation>Solar	Solar	NA	NA
10045	>Atmosphere>Radiation>UV	UV	NA	NA
10046	>Atmosphere>Radionuclide	Radionuclide	NA	NA
10047	>Atmosphere>Reactive Gas	Reactive Gas	NA	NA
10048	>Atmosphere>Reactive Gas>Nitrogen containing compounds	Nitrogen containing compounds	NA	NA

#	Path	Name	Definition	WMO306_CD
10049	>Atmosphere>Reactive Gas>Sulfur containing compounds	Sulfur containing compounds	NA	NA
10050	>Atmosphere>Reactive Gas>VOC	VOC	NA	NA
10051	>Atmosphere>Temperature	Temperature	NA	NA
10052	>Atmosphere>Total Atmospheric Deposition	Total Atmospheric Deposition	NA	NA
10053	>Atmosphere>Total Atmospheric Deposition>Inorganic acid	Inorganic acid	NA	NA
10054	>Atmosphere>Total Atmospheric Deposition>Inorganic anions	Inorganic anions	NA	NA
10055	>Atmosphere>Total Atmospheric Deposition>Inorganic cations	Inorganic cations	NA	NA
10056	>Atmosphere>Total Atmospheric Deposition>Inorganic nitrogen species	Inorganic nitrogen species	NA	NA
10057	>Atmosphere>Total Atmospheric Deposition>Organic acid	Organic acid	NA	NA
10058	>Atmosphere>Total Atmospheric Deposition>Trace elements	Trace elements	NA	NA
10059	>Atmosphere>Visibility	Visibility	NA	NA
10060	>Atmosphere>Visibility>Obscurations	Obscurations	NA	NA
10061	>Atmosphere>Wind	Wind	NA	NA
10062	>Earth	Earth	NA	NA
10063	>Ocean	Ocean	NA	NA
10064	>Ocean>Topography	Topography	NA	NA
10065	>Ocean>Currents	Currents	NA	NA

#	Path	Name	Definition	WMO306_CD
10066	>Ocean>Miscellaneous	Miscellaneous	NA	NA
10067	>Ocean>Biology	Biology	NA	NA
10068	>Ocean>Biology>Nitrogen species	Nitrogen species	NA	NA
10069	>Ocean>Biology>Phosporus species	Phosporus species	NA	NA
10070	>Ocean>Other Gas	Other Gas	NA	NA
10071	>Ocean>Other Gas>CTD	CTD	NA	NA
10072	>Ocean>Pressure	Pressure	NA	NA
10073	>Ocean>Pressure>CTD	CTD	NA	oceanCTD
10074	>Ocean>Radiation	Radiation	NA	NA
10075	>Ocean>Reactive Gas	Reactive Gas	NA	NA
10076	>Ocean>Basic Physical Properties	Basic Physical Properties	NA	NA
10077	>Ocean>Snow / Ice / Glacier	Snow / Ice / Glacier	NA	NA
10078	>Ocean>Snow / Ice / Glacier>Ice	Ice	NA	NA
10079	>Ocean>Temperature	Temperature	NA	oceanTemperature
10080	>Ocean>Tides	Tides	NA	oceanTides
10081	>Ocean>Transmissivity	Transmissivity	NA	NA
10082	>Ocean>Transmissivity>CTD	CTD	NA	NA
10083	>Ocean>Waves	Waves	NA	NA
10084	>Ocean>Wind	Wind	NA	NA
10085	>Outer Space	Outer Space	NA	NA
10086	>Outer Space>Energetic particles / solar wind	Energetic particles / solar wind	NA	NA

#	Path	Name	Definition	WMO306_CD
10087	>Outer Space>Energetic particles / solar wind >Particle density	Particle density	NA	NA
10088	>Outer Space>Energetic particles / solar wind >Particle flux	Particle flux	NA	NA
10089	>Outer Space>Ionospheric disturbances	Ionospheric disturbances	NA	NA
10090	>Outer Space>Solar monitoring	Solar monitoring	NA	NA
10091	>Terrestrial	Terrestrial	NA	NA
10092	>Terrestrial>Ground water	Ground water	NA	NA
10093	>Terrestrial>Lake	Lake	NA	NA
10094	>Terrestrial>Lake>Snow / Ice / Glacier	Snow / Ice / Glacier	NA	NA
10095	>Terrestrial>Lake>Snow / Ice / Glacier>Ice	Ice	NA	NA
10096	>Terrestrial>Lake>Temperature	Temperature	NA	NA
10097	>Terrestrial>Land surface	Land surface	NA	NA
10098	>Terrestrial>Land surface>Fire	Fire	NA	NA
10099	>Terrestrial>Land surface>Greenhouse Gas	Greenhouse Gas	NA	NA
10100	>Terrestrial>Land surface>Humidity	Humidity	NA	NA
10101	>Terrestrial>Land surface>Radiation	Radiation	NA	NA
10102	>Terrestrial>Land surface>Snow / Ice / Glacier	Snow / Ice / Glacier	NA	NA
10103	>Terrestrial>Land surface>Snow / Ice / Glacier>Glacier	Glacier	NA	NA
10104	>Terrestrial>Land surface>Snow / Ice / Glacier>Ice	Ice	NA	NA

#	Path	Name	Definition	WMO306_CD
10105	>Terrestrial>Land surface>Snow / Ice / Glacier>Snow	Snow	NA	NA
10106	>Terrestrial>Land surface>Temperature	Temperature	NA	NA
10107	>Terrestrial>Land surface>Vegetation	Vegetation	NA	NA
10108	>Terrestrial>River	River	NA	NA
10109	>Terrestrial>River>Snow / Ice / Glacier	Snow / Ice / Glacier	NA	NA
10110	>Terrestrial>River>Snow / Ice / Glacier>Ice	Ice	NA	NA
10111	>Terrestrial>Soil	Soil	NA	NA
10112	>Terrestrial>Soil>Humidity	Humidity	NA	NA
10113	>Terrestrial>Soil>Temperature	Temperature	NA	NA
10114	>Terrestrial>Well	Well	NA	NA
10115	>Ocean>Greenhouse Gas	Greenhouse Gas	NA	NA
10116	>Ocean>Miscellaneous>Carbon species	Carbon species	NA	NA
10117	>Ocean>Miscellaneous>Nitrogen species	Nitrogen species	NA	NA

Code table 1-05 (representativeness) http://codes.wmo.int/common/wmdsRepresentativeness

#	Name	Definition	WMO306_CD
1-05-01	(unspecified)	Not applicable in the context of the observed quantity; or: unknown; or: not available.	unspecified
1-05-02	microscale	An area or volume less than 100 m horizontal extent (for example, evaporation).	microscale
1-05-03	toposcale, local scale	An area or volume of 100 m to 3 km horizontal extent (for example, air pollution, tornadoes).	toposcale
1-05-04	mesoscale	An area or volume of 3 km to 100 km horizontal extent (for example, thunderstorms, sea and mountain breezes).	mesoscale

#	Name	Definition	WMO306_CD
1-05-05	large scale	An area or volume of 100 km to 3000 km horizontal extent (for example, fronts, various cyclones, cloud clusters).	largeScale
1-05-06	planetary scale	An area or volume of more than 3000 km horizontal extent (for example, long upper tropospheric waves).	planetaryScale
1-05-07	drainage area	An area (also known as 'catchment') having a common outlet for its surface runoff.	drainageArea

Code table 2-01 (application areas) http://codes.wmo.int/common/wmdsApplicationArea

#	Name	Definition	WMO306_CD
1	Global numerical weather prediction (GNWP)	Global numerical weather prediction (GNWP) covers numerical weather prediction on a global scale, required for weather forecasting for more than a few days ahead. NWP uses mathematical models of the atmosphere and oceans to predict the weather based on current conditions of the atmosphere and oceans. http://www.wmo.int/pages/prog/www/OSY/SOG/SoG-Global-NWP.pdf	globalNumericalWeatherPrediction
2	High-resolution numerical weather prediction (HRNWP)	High-resolution numerical weather prediction (HRNWP) covers forecasting of meteorological events over a limited area with a 1-5 km horizontal resolution, for 1 or 2 days ahead. Its high spatial resolutions allows: (i) to get more realistic descriptions of the surface and of atmospheric phenomena such as clouds and precipitation or boundary layer processes; and (ii) to use denser and more frequent observations than global NWP over the area of interest. http://www.wmo.int/pages/prog/www/OSY/SOG/SoG-HighRes-NWP.pdf	highResolutionNumericalWeatherPrediction
3	Nowcasting and very short-range forecasting (NVSRF)	Nowcasting and very short-range forecasting (NVSRF) covers the 0-12 hours forecasting range with high time and space resolution, focusing on rapid evolving phenomena like convection and using dedicated algorithms with combined relevant observed and model data, to produce forecasts usually near the surface, in a seamless way for the forecast range. http://www.wmo.int/pages/prog/www/OSY/SOG/SoG-Nowcasting-VSRF.pdf	nowcasting
4	Sub-seasonal to longer predictions	Sub-seasonal to longer predictions covers predictions in sub-seasonal to decadal time-ranges (roughly two weeks to 10 years), using numerical prediction models based on current and past observations and analyses. http://www.wmo.int/pages/prog/www/OSY/SOG/SoG-SSLP.pdf	seasonalForecasting
5	Aeronautical meteorology	Aeronautical meteorology covers worldwide, reliable provision of high quality, timely and cost-effective meteorological services to aviation users.	aeronauticalMeteorology
7	Ocean applications	http://www.wmo.int/pages/prog/www/OSY/SOG/SoG-Ocean.pdf	oceanApplications

#	Name	Definition	WMO306_CD
8	Agricultural meteorology	Agricultural Meteorology relates to specific weather and climate services addressed to the agricultural community to help develop sustainable agricultural production systems. http://www.wmo.int/pages/prog/www/OSY/SOG/SoG-Agriculture.pdf	agriculturalMeteorology
9	Hydrology	Hydrology covers the assessment of the quantity and quality of water resources, both surface and groundwater (in support of the National Authorities responsible for water management in a wide range of activities), in order to meet the needs of society, to permit mitigation of water-related hazards, and to maintain or enhance the condition of the global environment. http://www.wmo.int/pages/prog/www/OSY/SOG/SOG-Hydrology.pdf	hydrology
10	Climate monitoring (as supported through the Global Climate Observing System, GCOS)	GCOS, an internationally coordinated network of global observing systems for climate, is designed to meet the requirements for climate observations, which are essential to climate monitoring. Climate observations are fundamental to detect, model and assess climate change, support adaptation to climate change, monitor the effectiveness of policies for mitigating climate change, develop climate information services, promote sustainable national economic development and meet other requirements of the UNFCCC and other convention and agreements.	climateMonitoring
11	Climate applications	Fosters the effective application of climate knowledge and information for the benefit of society and the provision of climate services, including the prediction of significant climate variations both natural and as a result of human activity. http://www.wmo.int/pages/prog/www/OSY/SOG/SoG-Climate- CCl.pdf	climateApplications
12	Space weather	Space weather is a discipline which aims at observing, understanding and predicting the state of the Sun, of the interplanetary and planetary environments, their disturbances, and the potential impacts of these disturbances on biological and technological systems. http://www.wmo.int/pages/prog/www/OSY/SOG/SoG-SW.pdf	spaceWeather
13	Cryosphere	EGOS-IP	cryosphere
14	Energy sector	Economic activities that produce or distribute energy, such as renewable energies, e.g. solar, thermal, wind	energy
15	Transportation sector	Economic activities related to transportation of people and goods, on land, air and water	transport
16	Health sector	Health-related services, often provided to the public, particularly those related to prevention, e.g. pollen allergies, UV radiation, heat wave alerts	health
17	Terrestrial ecology	Activities and services related to the terrestrial environment, e.g., relating to bio-diversity	terrestrialEcology
21	Atmospheric composition forecasting	Applications from global to regional scales (with horizontal resolutions similar to global NWP (~10 km and coarser) with stringent timeliness requirements (NRT) to support operations such as sand and dust storm and chemical weather forecasts [source: http://www.wmo.int/pages/prog/arep/gaw/documents/FINAL_GAW_221.pdf]	atmosphericCompositionForecasting

#	Name	Definition	WMO306_CD
22	Atmospheric composition monitoring and analysis	Applications related to evaluating and analysing changes (temporally and spatially) in atmospheric composition regionally and globally to support treaty monitoring, climatologies and re-analyses, assessing trends in composition and emissions/ fluxes, and to better understand processes, using data of controlled quality (and with less stringent time requirements (not needed in NRT)), and used in products such as Ozone and Greenhouse Gas Bulletins, and State/Health of the Atmosphere reports [source: http://www.wmo.int/pages/prog/arep/gaw/documents/FINAL_GAW_221.pdf]	atmosphericCompositionMonitoring
23	Integrated urban services	Applications that target limited areas (with horizontal resolution of a few km or smaller and stringent timeliness requirements to support services related to weather/climate/pollution, such as air quality forecasting [source: http://www.wmo.int/pages/prog/arep/gaw/documents/FINAL_GAW_221.pdf]	integratedUrbanServices

Code table 2-02 (Programme/Network affiliation) http://codes.wmo.int/common/wmdsProgramAffiliation

#	Path	Name	Definition	WMO306_CD
17	>Co-sponsored	Co-sponsored	WMO contributions to co-sponsored observing systems	NA
2	>Co-sponsored>GCOS	GCOS	Global Climate Observing System	gcos
9	>Co-sponsored>GCOS>GRUAN	GRUAN	GCOS Reference Upper-Air Network	gruan
10	>Co-sponsored>GCOS>GSN	GSN	GCOS Surface Network	gsn
11	>Co-sponsored>GCOS>GUAN	GUAN	GCOS Upper-Air Network	guan
62	>Co-sponsored>GOOS	GOOS	Global Ocean Observing System	goos
13	>Co-sponsored>GOOS>Argo	Argo	IOC/WMO Argo program of drifting sub-surface floats	argo
73	>Co-sponsored>GOOS>Argo>ARGO ARGENTINA	ARGO ARGENTINA	NA	argoArgentina
74	>Co-sponsored>GOOS>Argo>ARGO AUSTRALIA	ARGO AUSTRALIA	NA	argoAustralia
75	>Co-sponsored>GOOS>Argo>ARGO AUSTRALIA EQ.	ARGO AUSTRALIA EQ.	NA	aroEqAustralia
76	>Co-sponsored>GOOS>Argo>ARGO AWI	ARGO AWI	NA	argoAWI
77	>Co-sponsored>GOOS>Argo>ARGO BRAZIL	ARGO BRAZIL	NA	argoBrazil

#	Path	Name	Definition	WMO306_CD
318	>Co-sponsored>GOOS>Argo>ARGO BRAZIL NAVY	ARGO BRAZIL NAVY	NA	NA
78	>Co-sponsored>GOOS>Argo>ARGO BSH	ARGO BSH	NA	argoBSH
79	>Co-sponsored>GOOS>Argo>ARGO CANADA	ARGO CANADA	NA	argoCanada
80	>Co-sponsored>GOOS>Argo>ARGO CHILE	ARGO CHILE	NA	argoChile
81	>Co-sponsored>GOOS>Argo>ARGO CHINA	ARGO CHINA	NA	argoChina
82	>Co-sponsored>GOOS>Argo>ARGO CHINA SOA	ARGO CHINA SOA	NA	argoChinaSOA
83	>Co-sponsored>GOOS>Argo>ARGO COSTA RICA	ARGO COSTA RICA	NA	argoCostaRica
84	>Co-sponsored>GOOS>Argo>ARGO DENMARK	ARGO DENMARK	NA	argoDenmark
85	>Co-sponsored>GOOS>Argo>ARGO ECUADOR	ARGO ECUADOR	NA	argoEcuador
86	>Co-sponsored>GOOS>Argo>ARGO EQ. AOML	ARGO EQ. AOML	NA	argoEqAOML
87	>Co-sponsored>GOOS>Argo>ARGO EQ. AWI	ARGO EQ. AWI	NA	argoEqAWI
88	>Co-sponsored>GOOS>Argo>ARGO EQ. BSH	ARGO EQ. BSH	NA	argoEqBSH
89	>Co-sponsored>GOOS>Argo>ARGO EQ. CHINA	ARGO EQ. CHINA	NA	argoEqChina
90	>Co-sponsored>GOOS>Argo>ARGO EQ. ESP-OMZ	ARGO EQ. ESP-OMZ	NA	argoEqESPOMZ
91	>Co-sponsored>GOOS>Argo>ARGO EQ. FERHRI	ARGO EQ. FERHRI	NA	argoEqFERHRI
92	>Co-sponsored>GOOS>Argo>ARGO EQ. FSU	ARGO EQ. FSU	NA	argoEqFSU
93	>Co-sponsored>GOOS>Argo>ARGO EQ. HNFRI	ARGO EQ. HNFRI	NA	argoEqHNFRI
94	>Co-sponsored>GOOS>Argo>ARGO EQ. IFM	ARGO EQ. IFM	NA	argoEqIFM
95	>Co-sponsored>GOOS>Argo>ARGO EQ. IFM2	ARGO EQ. IFM2	NA	argoEqIFM2
96	>Co-sponsored>GOOS>Argo>ARGO EQ. IRELAND	ARGO EQ. IRELAND	NA	argoEqIreland
97	>Co-sponsored>GOOS>Argo>ARGO EQ. JAMSTEC	ARGO EQ. JAMSTEC	NA	argoEqJamstec

#	Path	Name	Definition	WMO306_CD
98	>Co-sponsored>GOOS>Argo>ARGO EQ. JMA	ARGO EQ. JMA	NA	argoEqJMA
99	>Co-sponsored>GOOS>Argo>ARGO EQ. NAVOCEANO	ARGO EQ. NAVOCEANO	NA	argoEqNavoceano
100	>Co-sponsored>GOOS>Argo>ARGO EQ. NDBC	ARGO EQ. NDBC	NA	argoEqNDBC
101	>Co-sponsored>GOOS>Argo>ARGO EQ. NIPR	ARGO EQ. NIPR	NA	argoEqNIPR
102	>Co-sponsored>GOOS>Argo>ARGO EQ. NRIFS	ARGO EQ. NRIFS	NA	argoEqNRIFS
103	>Co-sponsored>GOOS>Argo>ARGO EQ. OIST	ARGO EQ. OIST	NA	argoEqOIST
104	>Co-sponsored>GOOS>Argo>ARGO EQ. ORI	ARGO EQ. ORI	NA	argoEqORI
105	>Co-sponsored>GOOS>Argo>ARGO EQ. PMEL	ARGO EQ. PMEL	NA	argoEqPMEL
106	>Co-sponsored>GOOS>Argo>ARGO EQ. POMME	ARGO EQ. POMME	NA	argoEqPomme
107	>Co-sponsored>GOOS>Argo>ARGO EQ. SAGE	ARGO EQ. SAGE	NA	argoEqSage
108	>Co-sponsored>GOOS>Argo>ARGO EQ. TNFRI	ARGO EQ. TNFRI	NA	argoEqTNFRI
109	>Co-sponsored>GOOS>Argo>ARGO EQ. TSK	ARGO EQ. TSK	NA	argoEqTSK
110	>Co-sponsored>GOOS>Argo>ARGO EQ. TU	ARGO EQ. TU	NA	argoEqTU
111	>Co-sponsored>GOOS>Argo>ARGO EQ. UH	ARGO EQ. UH	NA	argoEqUH
112	>Co-sponsored>GOOS>Argo>ARGO EQ. UHH	ARGO EQ. UHH	NA	argoEqUHH
113	>Co-sponsored>GOOS>Argo>ARGO EQ. UM-OSU	ARGO EQ. UM-OSU	NA	argoEqUMOSU
114	>Co-sponsored>GOOS>Argo>ARGO EQ. VOCALS	ARGO EQ. VOCALS	NA	argoEqVocals
115	>Co-sponsored>GOOS>Argo>ARGO EQ. WHOI	ARGO EQ. WHOI	NA	argoEqWHOI
116	>Co-sponsored>GOOS>Argo>ARGO FINLAND	ARGO FINLAND	NA	argoFinland
117	>Co-sponsored>GOOS>Argo>ARGO GABON	ARGO GABON	NA	argoGabon
118	>Co-sponsored>GOOS>Argo>ARGO GERMANY	ARGO GERMANY	NA	argoGermany

#	Path	Name	Definition	WMO306_CD
119	>Co-sponsored>GOOS>Argo>ARGO GREECE	ARGO GREECE	NA	argoGreece
120	>Co-sponsored>GOOS>Argo>ARGO IFM-GEOMAR	ARGO IFM-GEOMAR	NA	argoIFMGeomar
121	>Co-sponsored>GOOS>Argo>ARGO INDIA	ARGO INDIA	NA	argoIndia
122	>Co-sponsored>GOOS>Argo>ARGO IRELAND	ARGO IRELAND	NA	argoIreland
123	>Co-sponsored>GOOS>Argo>ARGO ITALY	ARGO ITALY	NA	argoItaly
124	>Co-sponsored>GOOS>Argo>ARGO JAMSTEC	ARGO JAMSTEC	NA	argoJamstec
125	>Co-sponsored>GOOS>Argo>ARGO JMA	ARGO JMA	NA	argoJMA
126	>Co-sponsored>GOOS>Argo>ARGO KENYA	ARGO KENYA	NA	argoKenya
127	>Co-sponsored>GOOS>Argo>ARGO KIOST	ARGO KIOST	NA	argoKiost
128	>Co-sponsored>GOOS>Argo>ARGO LEBANON	ARGO LEBANON	NA	argoLebanon
129	>Co-sponsored>GOOS>Argo>ARGO MAURITIUS	ARGO MAURITIUS	NA	argoMauritius
130	>Co-sponsored>GOOS>Argo>ARGO MEX-CO-US	ARGO MEX-CO-US	NA	argoMexCoUS
131	>Co-sponsored>GOOS>Argo>ARGO MEXICO	ARGO MEXICO	NA	argoMexico
132	>Co-sponsored>GOOS>Argo>ARGO NETHERLANDS	ARGO NETHERLANDS	NA	argoNetherlands
133	>Co-sponsored>GOOS>Argo>ARGO NEW ZEALAND	ARGO NEW ZEALAND	NA	argoNewZealand
134	>Co-sponsored>GOOS>Argo>ARGO NIMR/KMA	ARGO NIMR/KMA	NA	argoMIMRKMA
135	>Co-sponsored>GOOS>Argo>ARGO NORWAY	ARGO NORWAY	NA	argoNorway
136	>Co-sponsored>GOOS>Argo>ARGO PMEL	ARGO PMEL	NA	argoPMEL
137	>Co-sponsored>GOOS>Argo>ARGO POLAND	ARGO POLAND	NA	argoPoland
138	>Co-sponsored>GOOS>Argo>ARGO RUSSIA	ARGO RUSSIA	NA	argoRussia
139	>Co-sponsored>GOOS>Argo>ARGO SAUDI ARABIA	ARGO SAUDI ARABIA	NA	argoSaudiArabia

#	Path	Name	Definition	WMO306_CD
140	>Co-sponsored>GOOS>Argo>ARGO SIO	ARGO SIO	NA	argoSIO
141	>Co-sponsored>GOOS>Argo>ARGO SIO EQ (ASIRI)	ARGO SIO EQ (ASIRI)	NA	argoSIOEqASIRI
142	>Co-sponsored>GOOS>Argo>ARGO SIO EQ. (OKMC)	ARGO SIO EQ. (OKMC)	NA	argoSIOEqOKMC
143	>Co-sponsored>GOOS>Argo>ARGO SOUTH AFRICA	ARGO SOUTH AFRICA	NA	argoSouthAfrica
144	>Co-sponsored>GOOS>Argo>ARGO SPAIN	ARGO SPAIN	NA	argoSpain
145	>Co-sponsored>GOOS>Argo>ARGO SRI LANKA	ARGO SRI LANKA	NA	argoSriLanka
146	>Co-sponsored>GOOS>Argo>ARGO TWR ENGINEERING	ARGO TWR ENGINEERING	NA	argoTWREng
147	>Co-sponsored>GOOS>Argo>ARGO UK	ARGO UK	NA	argoUK
148	>Co-sponsored>GOOS>Argo>ARGO UK BIO	ARGO UK BIO	NA	argoUKBIO
149	>Co-sponsored>GOOS>Argo>ARGO UK EQ.	ARGO UK EQ.	NA	argoUKEq
150	>Co-sponsored>GOOS>Argo>ARGO UW	ARGO UW	NA	argoUW
151	>Co-sponsored>GOOS>Argo>ARGO UW EQ.	ARGO UW EQ.	NA	argoUWEq
152	>Co-sponsored>GOOS>Argo>ARGO UW-APL EQ.	ARGO UW-APL EQ.	NA	argoUWAplEq
153	>Co-sponsored>GOOS>Argo>ARGO UW-MBARI EQ.	ARGO UW-MBARI EQ.	NA	argoUWMbariEq
154	>Co-sponsored>GOOS>Argo>ARGO UW-SOCCOM EQ.	ARGO UW-SOCCOM EQ.	NA	argoUWSoccomEq
155	>Co-sponsored>GOOS>Argo>ARGO UW-SPURS EQ.	ARGO UW-SPURS EQ.	NA	argoUWSpursEq
156	>Co-sponsored>GOOS>Argo>ARGO UW-UA EQ.	ARGO UW-UA EQ.	NA	argoUWUAEq
157	>Co-sponsored>GOOS>Argo>ARGO WHOI	ARGO WHOI	NA	argoWHOI
158	>Co-sponsored>GOOS>Argo>ARGO WHOI EQ. IR	ARGO WHOI EQ. IR	NA	argoWHOIEqIR
159	>Co-sponsored>GOOS>Argo>ARGO WHOI-MRV EQ.	ARGO WHOI-MRV EQ.	NA	argoWHOIMRVEq
169	>Co-sponsored>GOOS>Argo>BULARGO	BULARGO	NA	argoBulargo
175	>Co-sponsored>GOOS>Argo>CORIOLIS	CORIOLIS	NA	argoCoriolis

#	Path	Name	Definition	WMO306_CD
176	>Co-sponsored>GOOS>Argo>CORIOLIS-BIOARGO	CORIOLIS-BIOARGO	NA	argoCoriolisBioargo
177	>Co-sponsored>GOOS>Argo>CORIOLIS-CANOA	CORIOLIS-CANOA	NA	argoCoriolisCanoa
178	>Co-sponsored>GOOS>Argo>CORIOLIS-CONGAS	CORIOLIS-CONGAS	NA	argoCoriolisCongas
179	>Co-sponsored>GOOS>Argo>CORIOLIS-DRAKE	CORIOLIS-DRAKE	NA	argoCoriolisDrake
180	>Co-sponsored>GOOS>Argo>CORIOLIS-EGEE	CORIOLIS-EGEE	NA	argoCoriolisEGEE
181	>Co-sponsored>GOOS>Argo>CORIOLIS-EGYPT	CORIOLIS-EGYPT	NA	argoCoriolisEqypt
182	>Co-sponsored>GOOS>Argo>CORIOLIS-FLOPS	CORIOLIS-FLOPS	NA	argoCoriolisFlops
183	>Co-sponsored>GOOS>Argo>CORIOLIS-FLOSTRAL	CORIOLIS-FLOSTRAL	NA	argoCoriolisFlostral
184	>Co-sponsored>GOOS>Argo>CORIOLIS-FNOB-JCOMMOPS	CORIOLIS-FNOB-JCOMMOPS	NA	argoCoriolisFNOBJCOMMOPS
185	>Co-sponsored>GOOS>Argo>CORIOLIS-FRONTALIS	CORIOLIS-FRONTALIS	NA	argoCoriolisFrontalis
186	>Co-sponsored>GOOS>Argo>CORIOLIS-GOOD HOPE	CORIOLIS-GOOD HOPE	NA	argoCoriolisGoodHope
187	>Co-sponsored>GOOS>Argo>CORIOLIS-OVIDE	CORIOLIS-OVIDE	NA	argoCoriolisOvide
188	>Co-sponsored>GOOS>Argo>CORIOLIS-PIRATA	CORIOLIS-PIRATA	NA	argoCoriolisPirata
189	>Co-sponsored>GOOS>Argo>CORIOLIS-PREVIMER	CORIOLIS-PREVIMER	NA	argoCoriolisPrevimer

#	Path	Name	Definition	WMO306_CD
190	>Co-sponsored>GOOS>Argo>CORIOLIS-PROSAT	CORIOLIS-PROSAT	NA	argoCoriolisProsat
191	>Co-sponsored>GOOS>Argo>CORIOLIS-REMOCEAN	CORIOLIS-REMOCEAN	NA	argoCoriolisRemocean
320	>Co-sponsored>GOOS>Argo>CORIOLIS-REMOCEAN EQ.	CORIOLIS-REMOCEAN EQ.	NA	NA
192	>Co-sponsored>GOOS>Argo>CORIOLIS-SPICE	CORIOLIS-SPICE	NA	argoCoriolisSpice
193	>Co-sponsored>GOOS>Argo>CORIOLIS-TRACK	CORIOLIS-TRACK	NA	argoCoriolisTrack
196	>Co-sponsored>GOOS>Argo>DEKOSIM	DEKOSIM	NA	argoDekosim
198	>Co-sponsored>GOOS>Argo>E-AIMS	E-AIMS	NA	argoEAims
207	>Co-sponsored>GOOS>Argo>EUROARGO	EUROARGO	NA	argoEurargo
213	>Co-sponsored>GOOS>Argo>GYROSCOPE	GYROSCOPE	NA	argoGyroscope
228	>Co-sponsored>GOOS>Argo>ITP-DAMOCLES	ITP-DAMOCLES	NA	argoDamocles
229	>Co-sponsored>GOOS>Argo>ITP-WHOI	ITP-WHOI	NA	argoWHOI
234	>Co-sponsored>GOOS>Argo>MEDARGO	MEDARGO	NA	argoMedargo
235	>Co-sponsored>GOOS>Argo>MERIDIAN GOODHOPE	MERIDIAN GOODHOPE	NA	argoMeridianGoodHope
236	>Co-sponsored>GOOS>Argo>MERSEA	MERSEA	NA	argoMersea
240	>Co-sponsored>GOOS>Argo>NAOS-FRANCE	NAOS-FRANCE	NA	argoNaosFrance
68	>Co-sponsored>GOOS>DBCP	DBCP	NA	NA
70	>Co-sponsored>GOOS>DBCP>AOML	AOML	NA	dbcpAOML
71	>Co-sponsored>GOOS>DBCP>AOML-E-SURFMAR	AOML-E-SURFMAR	NA	dbcpAOMLeSurfmar
330	>Co-sponsored>GOOS>DBCP>AOML-MF DB	AOML-MF DB	NA	NA
72	>Co-sponsored>GOOS>DBCP>APL-UW	APL-UW	NA	dbcpAPLUW
161	>Co-sponsored>GOOS>DBCP>AWI-DB	AWI-DB	NA	dbcpAWIDB

#	Path	Name	Definition	WMO306_CD
162	>Co-sponsored>GOOS>DBCP>BOM DB	BOM DB	NA	dbcpBomDB
163	>Co-sponsored>GOOS>DBCP>BOM-TSU	BOM-TSU	NA	dbcpBomTSU
164	>Co-sponsored>GOOS>DBCP>BP INC	BP INC	NA	dbcpBPInc
165	>Co-sponsored>GOOS>DBCP>BRAZIL PNBOIA-INPE	BRAZIL PNBOIA-INPE	NA	dbcpBrazilPNBOIAINPE
166	>Co-sponsored>GOOS>DBCP>BSH-DWD-FIXED	BSH-DWD-FIXED	NA	dbcpBshDWDFixed
167	>Co-sponsored>GOOS>DBCP>BSH-DWD-MB	BSH-DWD-MB	NA	dbcpBshDWDMD
168	>Co-sponsored>GOOS>DBCP>BSH-MB	BSH-MB	NA	dbcpBshMB
170	>Co-sponsored>GOOS>DBCP>CANDHIS	CANDHIS	NA	dbcpCandhis
171	>Co-sponsored>GOOS>DBCP>CARICOOS	CARICOOS	NA	dbcpCaricoos
172	>Co-sponsored>GOOS>DBCP>CARIOCA	CARIOCA	NA	dbcpCarioca
173	>Co-sponsored>GOOS>DBCP>CDIP	CDIP	NA	dbcpCDIP
174	>Co-sponsored>GOOS>DBCP>COLOMBIA-TSU	COLOMBIA-TSU	NA	dbcpColombiaTSU
194	>Co-sponsored>GOOS>DBCP>CORMP-NC	CORMP-NC	NA	dbcpCormpNC
195	>Co-sponsored>GOOS>DBCP>DBCP	DBCP	NA	dbcp
197	>Co-sponsored>GOOS>DBCP>DFO DB	DFO DB	NA	cbcpDFODB
205	>Co-sponsored>GOOS>DBCP>EC DB	EC DB	NA	dbcpECDB
206	>Co-sponsored>GOOS>DBCP>EC MB	EC MB	NA	dbcpECMB
321	>Co-sponsored>GOOS>DBCP>EC-IABP	EC-IABP	NA	NA
200	>Co-sponsored>GOOS>DBCP>E-SURFMAR	E-SURFMAR	NA	eSurfmar
201	>Co-sponsored>GOOS>DBCP>E-SURFMAR-IRISH IMI	E-SURFMAR-IRISH IMI	NA	eSurfmarIrishIMI
202	>Co-sponsored>GOOS>DBCP>E-SURFMAR-NOAA	E-SURFMAR-NOAA	NA	eSurfmarNOAA
203	>Co-sponsored>GOOS>DBCP>E-SURFMAR-UK MB	E-SURFMAR-UK MB	NA	eSurfmarUKMB
204	>Co-sponsored>GOOS>DBCP>E-SURFMAR-UK/FR MB	E-SURFMAR-UK/FR MB	NA	eSurfmarUKFRMB

#	Path	Name	Definition	WMO306_CD
208	>Co-sponsored>GOOS>DBCP>EUROSITES PLANIER	EUROSITES PLANIER	NA	dbcpEurositesPlanier
209	>Co-sponsored>GOOS>DBCP>FERHRI-TSU	FERHRI-TSU	NA	dbcpFerhriTSU
210	>Co-sponsored>GOOS>DBCP>GERMANY MB	GERMANY MB	NA	dbcpGermanyMB
211	>Co-sponsored>GOOS>DBCP>GLOSCAL	GLOSCAL	NA	dbcpGloscal
212	>Co-sponsored>GOOS>DBCP>GREECE MB	GREECE MB	NA	dbcpGreeceMB
322	>Co-sponsored>GOOS>DBCP>HK-OBS-DB	HK-OBS-DB	NA	NA
214	>Co-sponsored>GOOS>DBCP>IABP	IABP	NA	dbcpIABP
215	>Co-sponsored>GOOS>DBCP>IABP CANADA	IABP CANADA	NA	dbcpIABPCanada
216	>Co-sponsored>GOOS>DBCP>IABP NIC	IABP NIC	NA	dbcpIABPNIC
217	>Co-sponsored>GOOS>DBCP>IABP US	IABP US	NA	dbcpIABPUS
218	>Co-sponsored>GOOS>DBCP>IABP-EC	IABP-EC	NA	dbcpIABPEC
219	>Co-sponsored>GOOS>DBCP>IABP-UW	IABP-UW	NA	dbcpIABPUW
220	>Co-sponsored>GOOS>DBCP>IBPIO	IBPIO	NA	dbcpIBPIO
221	>Co-sponsored>GOOS>DBCP>INCOIS-TSU	INCOIS-TSU	NA	dbcpINCOISTSU
222	>Co-sponsored>GOOS>DBCP>INDIA NIO	INDIA NIO	NA	dbcpIndiaNIO
223	>Co-sponsored>GOOS>DBCP>INDIA NIO-TSU	INDIA NIO-TSU	NA	dbcpIndiaNIOTSU
224	>Co-sponsored>GOOS>DBCP>INDIA-NIOT	INDIA-NIOT	NA	dbcpIndiaNIOT
225	>Co-sponsored>GOOS>DBCP>INOCAR-TSU	INOCAR-TSU	NA	dbcpINOCARTSU
226	>Co-sponsored>GOOS>DBCP>ITALY DB	ITALY DB	NA	dbcpItalyDB
227	>Co-sponsored>GOOS>DBCP>ITALY-OGS	ITALY-OGS	NA	dbcpItalyOGS
230	>Co-sponsored>GOOS>DBCP>JMA DB	JMA DB	NA	dbcpJMADB
231	>Co-sponsored>GOOS>DBCP>JMA-TSU	JMA-TSU	NA	dbcpJMATSU
232	>Co-sponsored>GOOS>DBCP>KMA MB	KMA MB	NA	dbcpKMAMB

#	Path	Name	Definition	WMO306_CD
233	>Co-sponsored>GOOS>DBCP>LOCEAN	LOCEAN	NA	dbcpLocean
323	>Co-sponsored>GOOS>DBCP>MARLIN-DB	MARLIN-DB	NA	NA
237	>Co-sponsored>GOOS>DBCP>METEO FRANCE DB	METEO FRANCE DB	NA	dbcpMeteoFranceDB
238	>Co-sponsored>GOOS>DBCP>METEO FRANCE MB	METEO FRANCE MB	NA	dbcpMeteoFranceMB
239	>Co-sponsored>GOOS>DBCP>METEO FRANCE WB	METEO FRANCE WB	NA	dbcpMeteoFranceWB
241	>Co-sponsored>GOOS>DBCP>NCCOOS	NCCOOS	NA	dbcpNCCOOS
242	>Co-sponsored>GOOS>DBCP>NDBC-BP	NDBC-BP	NA	dbcpNDBCBP
243	>Co-sponsored>GOOS>DBCP>NDBC-COE	NDBC-COE	NA	dbcpNDBCCOE
244	>Co-sponsored>GOOS>DBCP>NDBC-CSI	NDBC-CSI	NA	dbcpNDBCCSI
245	>Co-sponsored>GOOS>DBCP>NDBC-MB	NDBC-MB	NA	dbcpNDBCMB
246	>Co-sponsored>GOOS>DBCP>NDBC-MBARI	NDBC-MBARI	NA	dbcpNDBCMBARI
247	>Co-sponsored>GOOS>DBCP>NDBC-NASA	NDBC-NASA	NA	dbcpNDBCNASA
248	>Co-sponsored>GOOS>DBCP>NDBC-NOAA-NWS	NDBC-NOAA-NWS	NA	dbcpcNOAANWS
249	>Co-sponsored>GOOS>DBCP>NDBC-TABS	NDBC-TABS	NA	dbcpNDBCTABS
250	>Co-sponsored>GOOS>DBCP>NDBC-TSU	NDBC-TSU	NA	dbcpNDBCTSU
251	>Co-sponsored>GOOS>DBCP>NDBC-USCG	NDBC-USCG	NA	dbcpNDBCUSCG
252	>Co-sponsored>GOOS>DBCP>NDWC-TSU	NDWC-TSU	NA	dbcpNDWCTSU
253	>Co-sponsored>GOOS>DBCP>NEW ZEALAND DB	NEW ZEALAND DB	NA	dbcpNewZealandDB
324	>Co-sponsored>GOOS>DBCP>NIC-IABP	NIC-IABP	NA	NA
254	>Co-sponsored>GOOS>DBCP>NOAA-CBIBS	NOAA-CBIBS	NA	dbcpNOAACBIBS
255	>Co-sponsored>GOOS>DBCP>NORWAY-IMR	NORWAY-IMR	NA	dbcpNorwayIMR
256	>Co-sponsored>GOOS>DBCP>NWS-NDBC-MB	NWS-NDBC-MB	NA	dbcpNWSNDBCMB

#	Path	Name	Definition	WMO306_CD
257	>Co-sponsored>GOOS>DBCP>NWS-NDBC-WB	NWS-NDBC-WB	NA	dbcpNDBCWB
258	>Co-sponsored>GOOS>DBCP>PACIOOS	PACIOOS	NA	dbcpPacioos
259	>Co-sponsored>GOOS>DBCP>PETROBRAS	PETROBRAS	NA	dbcpPetrobras
325	>Co-sponsored>GOOS>DBCP>PMEL MB	PMEL MB	NA	NA
260	>Co-sponsored>GOOS>DBCP>SCRIPS	SCRIPS	NA	dbcpScrips
261	>Co-sponsored>GOOS>DBCP>SHELL	SHELL	NA	dbcpShell
262	>Co-sponsored>GOOS>DBCP>SHOA-TSU	SHOA-TSU	NA	dbcpShoaTSU
263	>Co-sponsored>GOOS>DBCP>SIO-DB	SIO-DB	NA	dbcpSIODB
264	>Co-sponsored>GOOS>DBCP>SPAIN-PDE MB	SPAIN-PDE MB	NA	dbcpSpainPDEMB
265	>Co-sponsored>GOOS>DBCP>STRATUS	STRATUS	NA	dbcpStratus
266	>Co-sponsored>GOOS>DBCP>TAO ATLAS	TAO ATLAS	NA	dbcpTaoAtlas
267	>Co-sponsored>GOOS>DBCP>TAO PIRATA	TAO PIRATA	NA	dbcpTaoPirata
268	>Co-sponsored>GOOS>DBCP>TAO PIRATA US	TAO PIRATA US	NA	dbcpTaoPirataUS
269	>Co-sponsored>GOOS>DBCP>TAO RAMA US-INDIA	TAO RAMA US-INDIA	NA	dbcpTaoRamaUSIndia
270	>Co-sponsored>GOOS>DBCP>TAO TRITON	TAO TRITON	NA	dbcpTaoTriton
271	>Co-sponsored>GOOS>DBCP>UCSD-SCRIPPS	UCSD-SCRIPPS	NA	dbcpUCSDScripps
272	>Co-sponsored>GOOS>DBCP>UK-JERSEY MB	UK-JERSEY MB	NA	dbcpUKJerseyMB
273	>Co-sponsored>GOOS>DBCP>UK-MO DB	UK-MO DB	NA	dbcpUKMODB
274	>Co-sponsored>GOOS>DBCP>UK-MO FIXED	UK-MO FIXED	NA	dbcpUKMOFixed
327	>Co-sponsored>GOOS>DBCP>UK-MO LV	UK-MO LV	NA	NA
275	>Co-sponsored>GOOS>DBCP>UK-MO MB	UK-MO MB	NA	dbcpUKMOMB
276	>Co-sponsored>GOOS>DBCP>US-CG DB	US-CG DB	NA	dbcpUSCGDB
69	>Co-sponsored>GOOS>SOT	SOT	NA	sot

#	Path	Name	Definition	WMO306_CD
14	>Co-sponsored>GOOS>SOT>ASAP	ASAP	GOS Automated Shipboard Upper-Air Sounding Program	asap
160	>Co-sponsored>GOOS>SOT>ASAP>ASAP-AWI	ASAP-AWI	NA	asapAWI
199	>Co-sponsored>GOOS>SOT>ASAP>E-ASAP	E-ASAP	NA	eAsap
319	>Co-sponsored>GOOS>SOT>ASAP-ZA	ASAP-ZA	NA	NA
304	>Co-sponsored>GOOS>SOT>GO-SHIP	GO-SHIP	Global Ocean Ship-Based Hydrographic Investigations Programme	goShip
326	>Co-sponsored>GOOS>SOT>SOOP-BOM	SOOP-BOM	NA	NA
305	>Co-sponsored>GOOS>SOT>SOOT	SOOT	Ship Of Opportunity Programme	soot
19	>Co-sponsored>GOOS>SOT>VOS	VOS	GOS Voluntary Observing Ship Program	vos
277	>Co-sponsored>GOOS>SOT>VOS>VOS-3P	VOS-3P	NA	vos3P
278	>Co-sponsored>GOOS>SOT>VOS>VOS-AU	VOS-AU	NA	vosAU
279	>Co-sponsored>GOOS>SOT>VOS>VOS-CA	VOS-CA	NA	vosCA
280	>Co-sponsored>GOOS>SOT>VOS>VOS-CL	VOS-CL	NA	vosCL
281	>Co-sponsored>GOOS>SOT>VOS>VOS-DE	VOS-DE	NA	vosDE
282	>Co-sponsored>GOOS>SOT>VOS>VOS-ES	VOS-ES	NA	vosES
283	>Co-sponsored>GOOS>SOT>VOS>VOS-EU	VOS-EU	NA	vosEU
284	>Co-sponsored>GOOS>SOT>VOS>VOS-FR	VOS-FR	NA	vosFR
285	>Co-sponsored>GOOS>SOT>VOS>VOS-GB	VOS-GB	NA	vosGB
286	>Co-sponsored>GOOS>SOT>VOS>VOS-GR	VOS-GR	NA	vosGR
287	>Co-sponsored>GOOS>SOT>VOS>VOS-HK	VOS-HK	NA	vosHK
288	>Co-sponsored>GOOS>SOT>VOS>VOS-IE	VOS-IE	NA	vosIE
289	>Co-sponsored>GOOS>SOT>VOS>VOS-IL	VOS-IL	NA	vosIL

#	Path	Name	Definition	WMO306_CD
290	>Co-sponsored>GOOS>SOT>VOS>VOS-IN	VOS-IN	NA	vosIN
291	>Co-sponsored>GOOS>SOT>VOS>VOS-IS	VOS-IS	NA	vosIS
292	>Co-sponsored>GOOS>SOT>VOS>VOS-JP	VOS-JP	NA	vosJP
293	>Co-sponsored>GOOS>SOT>VOS>VOS-KR	VOS-KR	NA	vosKR
294	>Co-sponsored>GOOS>SOT>VOS>VOS-MY	VOS-MY	NA	vosMY
295	>Co-sponsored>GOOS>SOT>VOS>VOS-NL	VOS-NL	NA	vosNL
296	>Co-sponsored>GOOS>SOT>VOS>VOS-NO	VOS-NO	NA	vosNO
297	>Co-sponsored>GOOS>SOT>VOS>VOS-NZ	VOS-NZ	NA	vosNZ
298	>Co-sponsored>GOOS>SOT>VOS>VOS-RU	VOS-RU	NA	vosRU
299	>Co-sponsored>GOOS>SOT>VOS>VOS-SE	VOS-SE	NA	vosSE
300	>Co-sponsored>GOOS>SOT>VOS>VOS-SHIP-MASK	VOS-SHIP-MASK	NA	vosShipMask
301	>Co-sponsored>GOOS>SOT>VOS>VOS-US	VOS-US	NA	vosUS
302	>Co-sponsored>GOOS>SOT>VOS>VOS-ZA	VOS-ZA	NA	vosZA
328	>Co-sponsored>GOOS>SOT>VOS-PL	VOS-PL	NA	NA
63	>Co-sponsored>GTOS	GTOS	Global Terrestrial Observing System	gtos
303	>Non-affiliated	Non-affiliated	Observing elements that are not affiliated with WIGOS or any of the co-sponsored programmes	nonAffiliated
15	>WIGOS	WIGOS	WMO Integrated Observing System components	NA
1	>WIGOS>GAW	GAW	Global Atmosphere Watch	gaw
5	>WIGOS>GAW>GAW Contributing networks	GAW Contributing networks	Networks contributing to GAW that have signed an agreement with GAW	gawContributing
38	>WIGOS>GAW>GAW Contributing networks>ALINE	ALINE	ALINE Latin America Lidar Network	aline
34	>WIGOS>GAW>GAW Contributing networks>CASTNET	CASTNET	Clean Air Status and Trends Network	castnet
36	>WIGOS>GAW>GAW Contributing networks>GALION	GALION	GAW Aerosol Lidar Observation Network	NA

#	Path	Name	Definition	WMO306_CD
37	>WIGOS>GAW>GAW Contributing networks>GALION>ADNet	ADNet	AD-Net Asian Dust and Lidar Observation Network	galionAdnet
35	>WIGOS>GAW>GAW Contributing networks>GALION>EARLINET	EARLINET	EARLINET European Lidar	galionEarlinet
41	>WIGOS>GAW>GAW Contributing networks>GALION>MPLNET	MPLNET	Micro-Pulse Lidar Network	galionMplnet
40	>WIGOS>GAW>GAW Contributing networks>GALION>NDACC	NDACC	Network for the Detection of Atmospheric Composition Change	galionNdacc
8	>WIGOS>GAW>GAW Contributing networks>GAW-PFR	GAW-PFR	GAW Precision Filter Radiometer Network	gawPFR
316	>WIGOS>GAW>GAW Contributing networks>IDAF	IDAF	IGAC/DEBITS Africa	idaf
28	>WIGOS>GAW>GAW Contributing networks>IMPROVE	IMPROVE	IMPROVE Optical Aerosol	improve
22	>WIGOS>GAW>GAW Contributing networks>NADP	NADP	National Atmospheric Deposition Program	nadp
31	>WIGOS>GAW>GAW Contributing networks>TCCON	TCCON	Total Carbon Column Observing Network	tccon
306	>WIGOS>GAW>GAW Global	GAW Global	Global GAW station	gawGlobal
308	>WIGOS>GAW>GAW Local	GAW Local	Local GAW station	gawLocal
315	>WIGOS>GAW>GAW Other elements	GAW Other elements	Other international/national networks that provide atmospheric composition observations but are not (yet) affiliated with GAW	gawOther
23	>WIGOS>GAW>GAW Other elements>AGAGE	AGAGE	AGAGE/SOGE/NIES	agage
7	>WIGOS>GAW>GAW Other elements>AOD	AOD	Aerosol Optical Depth	globalAOD
43	>WIGOS>GAW>GAW Other elements>AOD>AEROCAN	AEROCAN	AEROCAN, federated to AERONET	aerocan
44	>WIGOS>GAW>GAW Other elements>AOD>AERONET	AERONET	AERONET	aeronet
47	>WIGOS>GAW>GAW Other elements>AOD>German AOD network	German AOD network	German AOD network	germanAOD
45	>WIGOS>GAW>GAW Other elements>AOD>PHOTONS	PHOTONS	PHOTONS, federated to AERONET	photons
46	>WIGOS>GAW>GAW Other elements>AOD>PolarAOD	PolarAOD	PolarAOD	polarAOD
48	>WIGOS>GAW>GAW Other elements>AOD>SibRad	SibRad	SibRad	sibrad
49	>WIGOS>GAW>GAW Other elements>AOD>SKYNET	SKYNET	SKYNET	skynet

#	Path	Name	Definition	WMO306_CD
24	>WIGOS>GAW>GAW Other elements>CAPMoN	CAPMoN	Canadian Air and Precipitation Monitoring Network	capmon
39	>WIGOS>GAW>GAW Contributing networks>GALION>CIS-LiNet	CIS-LiNet	Atmosphere aerosol and ozone monitoring in CIS regions through lidar stations network	cislinet
42	>WIGOS>GAW>GAW Other elements>CLN	CLN	The NOAA Cooperative Remote Sensing Science and Technology (CREST) Lidar network	cln
25	>WIGOS>GAW>GAW Other elements>EANET	EANET	EANET	eanet
21	>WIGOS>GAW>GAW Other elements>EMEP	EMEP	European Monitoring and Evaluation Programme	emep
26	>WIGOS>GAW>GAW Other elements>ESRLCCG	ESRLCCG	NOAA-ESRL (CCG)	esrlccg
27	>WIGOS>GAW>GAW Other elements>IAGOS	IAGOS	MOZAIC-IAGOS	iagos
33	>WIGOS>GAW>GAW Other elements>NDACC	NDACC	Network for the Detection of Atmospheric Composition Change	ndacc
317	>WIGOS>GAW>GAW Other elements>Non-affiliated	Non-affiliated	Observing elements that are not affiliated with GAW or any of the co-sponsored programs	NA
30	>WIGOS>GAW>GAW Other elements>SHADOZ	SHADOZ	Southern Hemisphere ADditional Ozonesondes	shadoz
307	>WIGOS>GAW>GAW Regional	GAW Regional	Regional GAW station	gawRegional
3	>WIGOS>GCW	GCW	Global Cryosphere Watch	gcw
66	>WIGOS>GCW>CryoNet	CryoNet	NA	cryonet
4	>WIGOS>GOS	GOS	Global Observing System	gos
310	>WIGOS>GOS>GOS Contributing networks	GOS Contributing networks	Networks contributing to the Global Observing System (GOS)	gosContributing
55	>WIGOS>GOS>GOS Contributing networks>CTBTO	CTBTO	Comprehensive Nuclear-Test Ban Treaty Organization International Monitoring System Network monitoring station	ctbto
311	>WIGOS>GOS>GOS Other elements	GOS Other elements	Other elements of the Global Observing System (GOS)	gosOther
392	>WIGOS>GOS>GOS Other elements>ADD	ADD	Aircraft Derived Data (Mode-S/ADS-B)	add
391	>WIGOS>GOS>GOS Other elements>ADS-C	ADS-C	Automatic Data Surveillance (ICAO). These are transmitted at selected points of the flightpath.	adsc
394	>WIGOS>GOS>GOS Other elements>AFIRS	AFIRS	Automated Flight Information & Reporting System (Commercial/FLYHT). Not currently open to GTS, contract with Panasonic and airline and/or NMHS	afirs
390	>WIGOS>GOS>GOS Other elements>AIREP	AIREP	Aircraft Report (Manual). These are transmitted by the aircraft when a weather event encountered e.g. severe turbulence or icing.	airep

#	Path	Name	Definition	WMO306_CD
12	>WIGOS>GOS>GOS Other elements>AMDAR	AMDAR	Aircraft Meteorological Data Relay	amdar
64	>WIGOS>GOS>GOS Other elements>Ceilometers	Ceilometers	Elastic lidar (ceilometer) networks	ceilometer
314	>WIGOS>GOS>GOS Other elements>GNSS radio-occultation system	GNSS radio-occultation system	NA	gnssRadioOccultation
313	>WIGOS>GOS>GOS Other elements>Lightning detection system	Lightning detection system	Surface-based lightning detection system	lightningDetection
393	>WIGOS>GOS>GOS Other elements>TAMDAR	TAMDAR	Tropospheric Aircraft Meteorological Data Relay (Commercial/Panasonic). Not currently open to GTS, contract with Panasonic and airline and/or NMHS	tamdar
312	>WIGOS>GOS>GOS Other elements>Wind Profilers	Wind Profilers	Wind profilers for upper-air wind observations	windProfiler
20	>WIGOS>GOS>GOS Other elements>WRO	WRO	GOS Weather Radar	wro
309	>WIGOS>GOS>GOS Surface networks	GOS Surface networks	Surface-based observing networks of the Global Observing System (GOS)	gosSurface
50	>WIGOS>GOS>GOS Surface networks>ANTON	ANTON	Antarctic Observing Network surface synoptic station (SYNOP/CLIMAT)	anton
51	>WIGOS>GOS>GOS Surface networks>ANTON>ANTON(T)	ANTON(T)	Antarctic Observing Network upper-air station (TEMP)	antonT
32	>WIGOS>GOS>GOS Surface networks>BSRN	BSRN	Baseline Surface Radiation Network	bsrn
56	>WIGOS>GOS>GOS Surface networks>RBCN	RBCN	Regional Basic Climatological Networks	rbcn
52	>WIGOS>GOS>GOS Surface networks>RBCN>CLIMAT(C)	CLIMAT(C)	Station for which monthly climatological means of surface elements are transmitted	rbcnClimatC
54	>WIGOS>GOS>GOS Surface networks>RBCN>CLIMAT(CT)	CLIMAT(CT)	Station for which monthly climatological means of both surface and upper- air elements are transmitted	rbcnClimatCT
53	>WIGOS>GOS>GOS Surface networks>RBCN>CLIMAT(T)	CLIMAT(T)	Station for which monthly climatological means of upper-air elements are transmitted	rbcnClimatT
16	>WIGOS>GOS>GOS Surface networks>RBSN	RBSN	GOS Regional Basic Synoptic Networks	rbsn
59	>WIGOS>GOS>GOS Surface networks>RBSN>RBSN(P)	RBSN(P)	Regional Basic Synoptic Network upper-air station (PILOT)	rbsnP
57	>WIGOS>GOS>GOS Surface networks>RBSN>RBSN(S)	RBSN(S)	Regional Basic Synoptic Network surface station (SYNOP)	rbsnS
61	>WIGOS>GOS>GOS Surface networks>RBSN>RBSN(SP)	RBSN(SP)	NA	rbsnSP

#	Path	Name	Definition	WMO306_CD
60	>WIGOS>GOS>GOS Surface networks>RBSN>RBSN(ST)	RBSN(ST)	Regional Basic Synoptic Network surface and upper-air station (SYNOP/TEMP)	rbsnST
58	>WIGOS>GOS>GOS Surface networks>RBSN>RBSN(T)	RBSN(T)	Regional Basic Synoptic Network upper-air station (TEMP)	rbsnT
329	>WIGOS>GOS>OceanSITES	OceanSITES	NA	NA
331	>WIGOS>GOS>OceanSITES>OS-AWI	OS-AWI	NA	NA
332	>WIGOS>GOS>OceanSITES>OS-BAS	OS-BAS	NA	NA
333	>WIGOS>GOS>OceanSITES>OS-BCCR	OS-BCCR	NA	NA
334	>WIGOS>GOS>OceanSITES>OS-BIOS	OS-BIOS	NA	NA
335	>WIGOS>GOS>OceanSITES>OS-CENTRE D'OCEANOLOGIE DE MARSEILLE	OS-CENTRE D'OCEANOLOGIE DE MARSEILLE	NA	NA
336	>WIGOS>GOS>OceanSITES>OS-CNR	OS-CNR	NA	NA
337	>WIGOS>GOS>OceanSITES>OS-CNRS	OS-CNRS	NA	NA
338	>WIGOS>GOS>OceanSITES>OS-CSIRO	OS-CSIRO	NA	NA
339	>WIGOS>GOS>OceanSITES>OS-DFO	OS-DFO	NA	NA
340	>WIGOS>GOS>OceanSITES>OS-DML	OS-DML	NA	NA
341	>WIGOS>GOS>OceanSITES>OS-EU-THOR	OS-EU-THOR	NA	NA
342	>WIGOS>GOS>OceanSITES>OS-GEOMAR	OS-GEOMAR	NA	NA
343	>WIGOS>GOS>OceanSITES>OS-HAMBURG UNIVERSITY	OS-HAMBURG UNIVERSITY	NA	NA
344	>WIGOS>GOS>OceanSITES>OS-HAV	OS-HAV	NA	NA
345	>WIGOS>GOS>OceanSITES>OS-HELLENIC CENTRE FOR MARINE RESEARCH	OS-HELLENIC CENTRE FOR MARINE RESEARCH	NA	NA
346	>WIGOS>GOS>OceanSITES>OS-ICCM - ACIISI - GOBIERNO DE CANARIAS	OS-ICCM - ACIISI - GOBIERNO DE CANARIAS	NA	NA
347	>WIGOS>GOS>OceanSITES>OS-IFREMER	OS-IFREMER	NA	NA
348	>WIGOS>GOS>OceanSITES>OS-IMARPE	OS-IMARPE	NA	NA
349	>WIGOS>GOS>OceanSITES>OS-INSTITUTE OF MARINE RESEARCH	OS-INSTITUTE OF MARINE RESEARCH	NA	NA
350	>WIGOS>GOS>OceanSITES>OS-IO-NTU	OS-IO-NTU	NA	NA
351	>WIGOS>GOS>OceanSITES>OS-IO-WARNEMUENDE	OS-IO-WARNEMUENDE	NA	NA

#	Path	Name	Definition	WMO306_CD
352	>WIGOS>GOS>OceanSITES>OS-IRD	OS-IRD	NA	NA
353	>WIGOS>GOS>OceanSITES>OS-JAMSTEC	OS-JAMSTEC	NA	NA
354	>WIGOS>GOS>OceanSITES>OS-KIOST	OS-KIOST	NA	NA
355	>WIGOS>GOS>OceanSITES>OS-LDEO	OS-LDEO	NA	NA
356	>WIGOS>GOS>OceanSITES>OS-MARUM	OS-MARUM	NA	NA
357	>WIGOS>GOS>OceanSITES>OS-MBARI	OS-MBARI	NA	NA
358	>WIGOS>GOS>OceanSITES>OS-NIO	OS-NIO	NA	NA
359	>WIGOS>GOS>OceanSITES>OS-NIOT	OS-NIOT	NA	NA
360	>WIGOS>GOS>OceanSITES>OS-NIWA	OS-NIWA	NA	NA
361	>WIGOS>GOS>OceanSITES>OS-NOAA/AOML	OS-NOAA/AOML	NA	NA
362	>WIGOS>GOS>OceanSITES>OS-NOAA/PMEL	OS-NOAA/PMEL	NA	NA
363	>WIGOS>GOS>OceanSITES>OS-NOC	OS-NOC	NA	NA
364	>WIGOS>GOS>OceanSITES>OS-OGS	OS-OGS	NA	NA
365	>WIGOS>GOS>OceanSITES>OS-ROYAL NETHERLANDS INSTITUTE FOR SEA RESEARCH (NIOZ)	OS-ROYAL NETHERLANDS INSTITUTE FOR SEA RESEARCH (NIOZ)	NA	NA
366	>WIGOS>GOS>OceanSITES>OS-SIO	OS-SIO	NA	NA
367	>WIGOS>GOS>OceanSITES>OS-SNU	OS-SNU	NA	NA
368	>WIGOS>GOS>OceanSITES>OS-SOA	OS-SOA	NA	NA
369	>WIGOS>GOS>OceanSITES>OS-UN_HAWAII_MANOA	OS-UN_HAWAII_MANOA	NA	NA
370	>WIGOS>GOS>OceanSITES>OS-UN_MIAMI	OS-UN_MIAMI	NA	NA
371	>WIGOS>GOS>OceanSITES>OS-USP	OS-USP	NA	NA
372	>WIGOS>GOS>OceanSITES>OS-UW	OS-UW	NA	NA
373	>WIGOS>GOS>OceanSITES>OS-WHOI	OS-WHOI	NA	NA
374	>WIGOS>GOS>OceanSITES>OS-WHOI/SIO/OSU	OS-WHOI/SIO/OSU	NA	NA
65	>WIGOS>WHOS	WHOS	NA	whos
67	>WIGOS>WHOS>WHYCOS	WHYCOS	NA	whycos

Code table: 3-01 (Region of origin of data) http://codes.wmo.int/common/wmdsWMORegion

#	WMO_RA_CD	Name	Name_FR	WMO306_CD
1	I	Africa	Afrique	africa
2	II	Asia	Asie	asia
3	III	South America	Amérique du Sud	southAmerica
4	IV	North America, Central America and the Caribbean	Amérique du Nord, Amérique Centrale et Caraïbes	northCentralAmericaCaribbean
5	V	South-West Pacific	Pacifique Sud-Ouest	southWestPacific
6	VI	Europe	Europe	europe
7	NA	Antarctica	Antarctique	antarctica
8	NA	(unknown)	(unknown)	unknown

Code table: 3-02 (Territory of origin of data) http://codes.wmo.int/common/wmdsTerritoryName

#	Name	ISO2_COUNTRY_CD	ISO3_COUNTRY_CD	ISO_COUNTRY_NU	WMO306_CD
1	Afghanistan	AF	AFG	4	AFG
2	Albania	AL	ALB	8	ALB
3	Algeria	DZ	DZA	12	DZA
4	Angola	AO	AGO	24	AGO
5	Anguilla	AI	AIA	660	AIA
6	Antarctica	AQ	ATA	10	ATA
7	Antigua and Barbuda	AG	ATG	28	ATG
8	Argentina	AR	ARG	32	ARG
9	Armenia	AM	ARM	51	ARM
10	Australia	AU	AUS	36	AUS
11	Austria	AT	AUT	40	AUT
12	Azerbaijan	AZ	AZE	31	AZE
13	Bahamas	BS	BHS	44	BHS
14	Bahrain	BH	BHR	48	BHR
15	Bangladesh	BD	BGD	50	BGD
16	Barbados	BB	BRB	52	BRB

#	Name	ISO2_COUNTRY_CD	ISO3_COUNTRY_CD	ISO_COUNTRY_NU	WMO306_CD
17	Belarus	BY	BLR	112	BLR
18	Belgium	BE	BEL	56	BEL
19	Belize	BZ	BLZ	84	BLZ
20	Benin	BJ	BEN	204	BEN
21	Bermuda	BM	BMU	60	BMU
22	Bhutan	BT	BTN	64	BTN
23	Bolivia, Plurinational State of	BO	BOL	68	BOL
24	Bosnia and Herzegovina	BA	BIH	70	BIH
25	Botswana	BW	BWA	72	BWA
26	Brazil	BR	BRA	76	BRA
27	British Caribbean Territories	BC	BCT	NA	BCT
28	British Virgin Islands	VG	VGB	92	VGB
29	Brunei Darussalam	BN	BRN	96	BRN
30	Bulgaria	BG	BGR	100	BGR
31	Burkina Faso	BF	BFA	854	BFA
32	Burundi	BI	BDI	108	BDI
33	Cabo Verde	CV	CPV	132	CPV
34	Cambodia	KH	KHM	116	KHM
35	Cameroon	CM	CMR	120	CMR
36	Canada	CA	CAN	124	CAN
37	Cayman Islands	KY	CYM	136	CYM
38	Central African Republic	CF	CAF	140	CAF
39	Chad	TD	TCD	148	TCD
40	Chile	CL	CHL	152	CHL
41	China	CN	CHN	156	CHN
42	Christmas Island	CX	CXR	162	CXR
43	Cocos (Keeling) Islands	CC	CCK	166	CCK
44	Colombia	CO	COL	170	COL
45	Comoros	KM	COM	174	COM
46	Congo	CG	COG	178	COG
47	Congo, Democratic Republic of the	CD	COD	180	COD

#	Name	ISO2_COUNTRY_CD	ISO3_COUNTRY_CD	ISO_COUNTRY_NU	WMO306_CD
48	Cook Islands	CK	COK	184	COK
49	Costa Rica	CR	CRI	188	CRI
50	Côte d'Ivoire	CI	CIV	384	CIV
51	Croatia	HR	HRV	191	HRV
52	Cuba	CU	CUB	192	CUB
53	Curaçao and Sint Maarten	CW	CUW	531	CUW
54	Cyprus	CY	CYP	196	CYP
55	Czechia	CZ	CZE	203	CZE
56	Denmark	DK	DNK	208	DNK
57	Djibouti	DJ	DJI	262	DJI
58	Dominica	DM	DMA	212	DMA
59	Dominican Republic	DO	DOM	214	DOM
60	Ecuador	EC	ECU	218	ECU
61	Egypt	EG	EGY	818	EGY
62	El Salvador	SV	SLV	222	SLV
63	Equatorial Guinea	GQ	GNQ	226	GNQ
64	Eritrea	ER	ERI	232	ERI
65	Estonia	EE	EST	233	EST
66	Ethiopia	ET	ETH	231	ETH
67	Falkland Islands (Malvinas)	FK	FLK	238	FLK
68	Fiji	FJ	FJI	242	FJI
69	Finland	FI	FIN	246	FIN
70	France	FR	FRA	250	FRA
71	French Polynesia	PF	PYF	258	PYF
72	Gabon	GA	GAB	266	GAB
73	Gambia	GM	GMB	270	GMB
74	Georgia	GE	GEO	268	GEO
75	Germany	DE	DEU	276	DEU
76	Ghana	GH	GHA	288	GHA
77	Gibraltar	GI	GIB	292	GIB
78	Greece	GR	GRC	300	GRC
79	Greenland	GL	GRL	304	GRL
80	Grenada	GD	GRD	308	GRD
81	Guatemala	GT	GTM	320	GTM
82	Guinea	GN	GIN	324	GIN

#	Name	ISO2_COUNTRY_CD	ISO3_COUNTRY_CD	ISO_COUNTRY_NU	WMO306_CD
83	Guinea-Bissau	GW	GNB	624	GNB
84	Guyana	GY	GUY	328	GUY
85	Haiti	HT	HTI	332	HTI
86	Honduras	HN	HND	340	HND
87	Hong Kong, China	HK	HKG	344	HKG
88	Hungary	HU	HUN	348	HUN
89	Iceland	IS	ISL	352	ISL
90	India	IN	IND	356	IND
91	Indonesia	ID	IDN	360	IDN
92	Iran, Islamic Republic of	IR	IRN	364	IRN
93	Iraq	IQ	IRQ	368	IRQ
94	Ireland	IE	IRL	372	IRL
95	Israel	IL	ISR	376	ISR
96	Italy	IT	ITA	380	ITA
97	Jamaica	JM	JAM	388	JAM
98	Japan	JP	JPN	392	JPN
99	Jordan	JO	JOR	400	JOR
100	Kazakhstan	KZ	KAZ	398	KAZ
101	Kenya	KE	KEN	404	KEN
102	Kiribati	KI	KIR	296	KIR
103	Korea, Democratic People's Republic of	KP	PRK	408	PRK
104	Korea, Republic of	KR	KOR	410	KOR
105	Kuwait	KW	KWT	414	KWT
106	Kyrgyzstan	KG	KGZ	417	KGZ
107	Lao People's Democratic Republic	LA	LAO	418	LAO
108	Latvia	LV	LVA	428	LVA
109	Lebanon	LB	LBN	422	LBN
110	Lesotho	LS	LSO	426	LSO
111	Liberia	LR	LBR	430	LBR
112	Libya	LY	LBY	434	LBY
113	Liechtenstein	LI	LIE	438	LIE
114	Lithuania	LT	LTU	440	LTU
115	Luxembourg	LU	LUX	442	LUX
116	Macao, China	MO	MAC	446	MAC
117	Macedonia, the former Yugoslav Republic of	MK	MKD	807	MKD

#	Name	ISO2_COUNTRY_CD	ISO3_COUNTRY_CD	ISO_COUNTRY_NU	WMO306_CD
118	Madagascar	MG	MDG	450	MDG
119	Malawi	MW	MWI	454	MWI
120	Malaysia	MY	MYS	458	MYS
121	Maldives	MV	MDV	462	MDV
122	Mali	ML	MLI	466	MLI
123	Malta	MT	MLT	470	MLT
124	Marshall Islands	MH	MHL	584	MHL
125	Mauritania	MR	MRT	478	MRT
126	Mauritius	MU	MUS	480	MUS
127	Mexico	MX	MEX	484	MEX
128	Micronesia, Federated States of	FM	FSM	583	FSM
129	Moldova, Republic of	MD	MDA	498	MDA
130	Monaco	MC	MCO	492	MCO
131	Mongolia	MN	MNG	496	MNG
132	Montenegro	ME	MNE	499	MNE
133	Montserrat	MS	MSR	500	MSR
134	Morocco	MA	MAR	504	MAR
135	Mozambique	MZ	MOZ	508	MOZ
136	Myanmar	MM	MMR	104	MMR
137	Namibia	NA	NAM	516	NAM
138	Nauru	NR	NRU	520	NRU
139	Nepal	NP	NPL	524	NPL
140	Netherlands	NL	NLD	528	NLD
141	New Caledonia	NC	NCL	540	NCL
142	New Zealand	NZ	NZL	554	NZL
143	Nicaragua	NI	NIC	558	NIC
144	Niger	NE	NER	562	NER
145	Nigeria	NG	NGA	566	NGA
146	Niue	NU	NIU	570	NIU
147	Norway	NO	NOR	578	NOR
148	Oman	OM	OMN	512	OMN
149	Pakistan	PK	PAK	586	PAK
150	Palau	PW	PLW	585	PLW
151	Palestine, State of	PS	PSE	275	PSE
152	Panama	PA	PAN	591	PAN

#	Name	ISO2_COUNTRY_CD	ISO3_COUNTRY_CD	ISO_COUNTRY_NU	WMO306_CD
153	Papua New Guinea	PG	PNG	598	PNG
154	Paraguay	PY	PRY	600	PRY
155	Peru	PE	PER	604	PER
156	Philippines	PH	PHL	608	PHL
157	Pitcairn	PN	PCN	612	PCN
158	Poland	PL	POL	616	POL
159	Portugal	PT	PRT	620	PRT
160	Puerto Rico	PR	PRI	630	PRI
161	Qatar	QA	QAT	634	QAT
162	Romania	RO	ROM	642	ROM
163	Russian Federation	RU	RUS	643	RUS
164	Rwanda	RW	RWA	646	RWA
165	Saint Helena	SH	SHN	654	SHN
166	Saint Kitts and Nevis	KN	KNA	659	KNA
167	Saint Lucia	LC	LCA	662	LCA
168	Saint Pierre and Miquelon	PM	SPM	666	SPM
169	Saint Vincent and Grenadines	VC	VCT	670	VCT
170	Samoa	WS	WSM	882	WSM
171	Sao Tome and Principe	ST	STP	678	STP
172	Saudi Arabia	SA	SAU	682	SAU
173	Senegal	SN	SEN	686	SEN
174	Serbia	RS	SRB	688	SRB
175	Seychelles	SC	SYC	690	SYC
176	Sierra Leone	SL	SLE	694	SLE
177	Singapore	SG	SGP	702	SGP
178	Slovakia	SK	SVK	703	SVK
179	Slovenia	SI	SVN	705	SVN
180	Solomon Islands	SB	SLB	90	SLB
181	Somalia	SO	SOM	706	SOM
182	South Africa	ZA	ZAF	710	ZAF
183	South Georgia and the South Sandwich Islands	GS	SGS	239	SGS
184	South Sudan	SS	SSD	728	SSD
185	Spain	ES	ESP	724	ESP
186	Sri Lanka	LK	LKA	144	LKA
187	Sudan	SD	SDN	729	SDN

#	Name	ISO2_COUNTRY_CD	ISO3_COUNTRY_CD	ISO_COUNTRY_NU	WMO306_CD
188	Suriname	SR	SUR	740	SUR
189	Swaziland	SZ	SWZ	748	SWZ
190	Sweden	SE	SWE	752	SWE
191	Switzerland	CH	CHE	756	CHE
192	Syrian Arab Republic	SY	SYR	760	SYR
193	(unknown)	NA	NA	NA	NA
194	Taiwan, Province of China	TW	TWN	NA	TWN
195	Tajikistan	TJ	TJK	762	TJK
196	Tanzania, United Republic of	TZ	TZA	834	TZA
197	Thailand	TH	THA	764	THA
198	Timor-Leste	TL	TLS	626	TLS
199	Togo	TG	TGO	768	TGO
200	Tokelau	TK	TKL	772	TKL
201	Tonga	TO	TON	776	TON
202	Trinidad and Tobago	TT	TTO	780	TTO
203	Tunisia	TN	TUN	788	TUN
204	Turkey	TR	TUR	792	TUR
205	Turkmenistan	TM	TKM	795	TKM
206	Turks and Caicos Islands	TC	TCA	796	TCA
207	Tuvalu	TV	TUV	798	TUV
208	Uganda	UG	UGA	800	UGA
209	Ukraine	UA	UKR	804	UKR
210	United Arab Emirates (the)	AE	ARE	784	ARE
211	United Kingdom (the)	GB	GBR	826	GBR
212	United States (the)	US	USA	840	USA
213	Uruguay	UY	URY	858	URY
214	Uzbekistan	UZ	UZB	860	UZB
215	Vanuatu	VU	VUT	548	VUT
216	Venezuela, Bolivarian Republic of	VE	VEN	862	VEN
217	Viet Nam	VN	VNM	704	VNM
218	Western Sahara	EH	ESH	732	ESH
219	Yemen	YE	YEM	887	YEM
220	Zambia	ZM	ZMB	894	ZMB
221	Zimbabwe	ZW	ZWE	716	ZWE

Code table 3-04 Station/platform type http://codes.wmo.int/common/wmdsFacilityType

#	Name	Definition	WMO306_CD
1	Land (fixed)	Station/platform on solid terrain, at fixed position	landFixed
2	Land (mobile)	Station/platform on solid terrain, moving around	landMobile
3	Sea (fixed)	Station/platform at sea surface, at fixed position	seaFixed
4	Sea (mobile)	Station/platform at sea surface, moving around	seaMobile
5	Air (fixed)	Airborne station/platform, at fixed position	airFixed
6	Air (mobile)	Airborne station/platform, moving around	airMobile
7	Underwater (fixed)	Station/platform under water, at fixed horizontal position	underwaterFixed
8	Underwater (mobile)	Station/platform under water, moving around	underwaterMobile
9	Land (on ice)	Station/platform on ice-covered ground, moving with the ice	landOnIce
10	Sea (on ice)	Station/platform on floating ice, moving with the ice	seaOnIce
11	Lake/River (fixed)	Station/platform at lake/river surface, at fixed position	lakeRiverFixed
12	Lake/River (mobile)	station/platform at lake/river surface, moving around	lakeRiverMobile
13	Space-based	Satellite platform in orbit	spaceBased

Code table 3-08 (Data communication method): http://codes.wmo.int/common/wmdsDataCommunicationMethod

#	Name	Definition	WMO306_CD
1	Voice/landline	Voice communications using a fixed terrestrial telecommunications network	voiceLandline
2	Voice/cellular	Voice communications using a cellular or similar terrestrial telecommunications network	voiceCellular
3	Voice/radio	Voice communications using a direct radio system (such as VHF, HF SSB)	voiceRadio
4	Voice/satellite	Voice communications using a satellite telecommunications network	voiceSatellite
5	Data/landline	Data communications (digital or modem) using a fixed terrestrial telecommunications network (copper or fibre)	dataLandline
6	Data/cellular	Data communications (digital or modem) using a cellular or similar terrestrial telecommunications network	dataCellular
7	Data/radio	Data communications (digital or modem) using a direct radio system (such as VHF, HF SSB, microwave)	dataRadio
8	Data/satellite/geostationary	Data communications (digital or modem) using a geostationary satellite service (such as METEOSAT)	dataSatGeostationary
9	Data/satellite/constellation	Data communications (digital or modem) using a satellite constellation service (such as IRIDIUM)	dataSatConstellation
10	Data/satellite/intermittent	Data communications (digital or modem) using a satellite service with intermittent cover (such as ARGOS)	dataSatIntermittent

#	Name	Definition	WMO306_CD
11	Fax/landline	Facsimile using fixed terrestrial telecommunications network	faxLandline
12	Fax/cellular	Facsimile using a cellular or similar terrestrial telecommunications network	faxCellular
13	Fax/radio	Facsimile using a direct radio system (such as VHF, HF SSB)	faxRadio
14	Post	Physical transfer of information by postal, delivery service, courier service or similar	post

Code table: 3-09 (Station/Platform operating status) http://codes.wmo.int/common/wmdsReportingStatus

#	Name	Definition	WMO306_CD
1	Operational	The station fully complies with the reporting obligations of the observation programme/network concerned	operational
2	Partly operational	The station partially complies with the reporting obligations of the observation programme/network concerned	partlyOperational
3	Non-reporting	The station is considered non-operational/non-reporting temporarily, but is expected to resume its operations/reporting after the temporary suspension	nonReporting
4	Closed	The station has been declared as closed by the responsible supervising organization	closed
5	Planned	The station is planned to be deployed sometime in the future, and all information	planned
6	Pre-operational	The station is deployed and producing data but still not fully ready to start reporting operationally	preOperational
7	Stand-by	NA	standBy

Code table: 4-01-01 Surface cover types (IGBP) http://codes.wmo.int/common/wmdsSurfaceCoverIGBP

#	Name	Definition	WMO306_CD
4-01-01-01	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)	notApplicable
4-01-01-02	Water	NA	water
4-01-01-03	Evergreen Needleleaf forest	NA	evergreenNeedleleafForest
4-01-01-04	Evergreen Broadleaf forest	NA	evergreenBroadleafForest
4-01-01-05	Deciduous Needleleaf forest	NA	deciduousNeedleleafForest
4-01-01-06	Deciduous Broadleaf forest	NA	deciduousBroadleafForest
4-01-01-07	Mixed forest	NA	mixedForest

#	Name	Definition	WMO306_CD
4-01-01-08	Closed shrublands	NA	closedShrublands
4-01-01-09	Open shrublands	NA	openShrublands
4-01-01-10	Woody savannas	NA	woodySavannas
4-01-01-11	Savannas	NA	svannas
4-01-01-12	Grasslands	NA	grasslands
4-01-01-13	Permanent wetlands	NA	permanentWetlands
4-01-01-14	Croplands	NA	croplands
4-01-01-15	Urban and built-up	NA	urbanBuiltup
4-01-01-16	Cropland/Natural vegetation mosaic	NA	mosaic
4-01-01-17	Snow and ice	NA	snowIce
4-01-01-18	Barren or sparsely vegetated	NA	barren
4-01-01-19	Unclassified	NA	unclassified

Code table: 4-01-02 Surface cover types (UMD) http://codes.wmo.int/common/wmdsSurfaceCoverUMD

#	Name	Definition	WMO306_CD
4-01-02-01	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason).	notApplicable
4-01-02-02	Water	NA	water
4-01-02-03	Evergreen Needleleaf forest	NA	evergreenNeedleleafForest
4-01-02-04	Evergreen Broadleaf forest	NA	evergreenBroadleafForest
4-01-02-05	Deciduous Needleleaf forest	NA	deciduousNeedleleafForest
4-01-02-06	Deciduous Broadleaf forest	NA	deciduousBroadleafForest
4-01-02-07	Mixed forest	NA	mixedForest

#	Name	Definition	WMO306_CD
4-01-02-08	Closed shrublands	NA	closedShrublands
4-01-02-09	Open shrublands	NA	openShrublands
4-01-02-10	Woody savannas	NA	woodySavannas
4-01-02-11	Savannas	NA	savannas
4-01-02-12	Grasslands	NA	grasslands
4-01-02-13	Croplands	NA	croplands
4-01-02-14	Urban and built-up	NA	urbanBuiltup
4-01-02-15	Barren or sparsely vegetated	NA	barren
4-01-02-16	Unclassified	NA	unclassified

Code table: 4-01-03 Surface cover types (LAI/fPAR) http://codes.wmo.int/common/wmdsSurfaceCoverLAI
Code table: 4-01-03

Code table title: Land cover types (LAI/fPAR)

#	Name	Definition	WMO306_CD
4-01-03-01	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)	notApplicable
4-01-03-02	Water	NA	water
4-01-03-03	Grasses/Cereal crops	NA	grassesCerealCrops
4-01-03-04	Shrubs	NA	shrubs
4-01-03-05	Broadleaf crops	NA	broadleafCrops
4-01-03-06	Savanna	NA	savannas
4-01-03-07	Evergreen broadleaf forest	NA	evergreenBroadleafForest

#	Name	Definition	WMO306_CD
4-01-03-08	Deciduous broadleaf forest	NA	deciduousBroadleafForest
4-01-03-09	Evergreen needleleaf forest	NA	evergreenNeedleleafForest
4-01-03-10	Deciduous needleleaf forest	NA	deciduousNeedleleafForest
4-01-03-11	Non vegetated	NA	nonVegetated
4-01-03-12	Urban	NA	urban
4-01-03-13	Unclassified	NA	unclassified

Code table: 4-01-04 Surface cover types (NPP) http://codes.wmo.int/common/wmdsSurfaceCoverNPP

#	Name	Definition	WMO306_CD
4-01-04-01	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)	notApplicable
4-01-04-02	Water	NA	water
4-01-04-03	Evergreen needleleaf vegetation	NA	evergreenNeedleleafVegetation
4-01-04-04	Evergreen broadleaf vegetation	NA	evergreenBroadleafVegetation
4-01-04-05	Deciduous needleleaf vegetation	NA	deciduousNeedleleafVegetation
4-01-04-06	Deciduous broadleaf vegetation	NA	deciduousBroadleafVegetation
4-01-04-07	Annual broadleaf vegetation	NA	annualBroadleafVegetation
4-01-04-07	Non-vegetated land	NA	nonVegetated
4-01-04-09	Urban	NA	urban
4-01-04-10	Unclassified	NA	unclassified

Code table: 4-01-05 Surface cover types (PFT) http://codes.wmo.int/common/wmdsSurfaceCoverPFT

#	Name	Definition	WMO306_CD
4-01-05-01	Water	None of the codes in the table are applicable in the context of this particular observation (nilReason)	water
4-01-05-02	Evergreen Needleleaf trees	NA	evergreenNeedleTrees
4-01-05-03	Evergreen Broadleaf trees	NA	evergreenBroadleafTrees
4-01-05-04	Deciduous Needleleaf trees	NA	deciduousNeedleafTrees
4-01-05-05	Deciduous Broadleaf trees	NA	deciduousBroadleafTrees
4-01-05-06	Shrub	NA	shrub
4-01-05-07	Grass	NA	grass
4-01-05-08	Cereal crops	NA	cerealCrops
4-01-05-09	Broad-leaf crops	NA	broadLeafCrops
4-01-05-10	Urban and built-up	NA	urbanBuiltUp
4-01-05-11	Snow and ice	NA	snowIce
4-01-05-12	Barren or sparse vegetation	NA	barren
4-01-05-13	Unclassified	NA	unclassified
4-01-05-14	Fill Value	NA	NA

Code table: 4-01-06 Surface cover types (LCCS) http://codes.wmo.int/common/wmdsSurfaceCoverLCCS

#	Name	Definition	WMO306_CD
4-01-06-01	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)	notApplicable
4-01-06-02	Cultivated and Managed Terrestrial Areas		cultivatedManagedTerrestrial
4-01-06-03	Natural and Semi-Natural Terrestrial Vegetation		naturalSemiNaturalTerrestrial
4-01-06-04	Cultivated Aquatic or Regularly Flooded Areas		cultivatedAquatic

#	Name	Definition	WMO306_CD
4-01-06-05	Natural and Semi-Natural Aquatic or Regularly Flooded Vegetation		naturalSemiNaturalAquatic
4-01-06-06	Artificial Surfaces and Associated Areas		artificialSurfaces
4-01-06-07	Bare Areas		bareAreas
4-01-06-08	Artificial Waterbodies, Snow and Ice		artificialWaterbodiesSnowIce
4-01-06-09	Natural Waterbodies, Snow and Ice		naturalWaterbodiesSnowIce
4-01-06-10	Unclassified		unclassified

Code table: 4-02 Surface cover classification scheme http://codes.wmo.int/common/wmdsSurfaceCoverClassification

#	Name	Definition	WMO306_CD
4-02-01	Surface cover types (IGBP)	International Geosphere-Biosphere Programme https://lpdaac.usgs.gov/products/modis_products_table/mcd12q1	igbp
4-02-02	Surface cover types (UMD)	The University of Maryland Department of Geography generated global land cover classification collection from 1998. http://glcf.umd.edu/data/landcover/	umd
4-02-03	Surface cover types (LAI/fPAR)	Leaf Area Index (LAI) and Fractional Photosynthetically Active Radiation (FPAR). FPAR/LAI is the Fraction of Absorbed Photosynthetically Active radiation that a plant canopy absorbs for photosynthesis and growth in the 0.4 – 0.7nm spectral range.	laifpar
4-02-04	Surface cover types (NPP)	Net Primary Production (NPP) lansurfaced cover scheme	npp
4-02-05	Surface cover types (PFT)	Plant Functional Types (PFT) surface cover scheme	pft
4-02-06	Surface cover types (LCCS)	Land cover classification scheme (LCCS)	lccs

Code table: 4-03-01 Local topography http://codes.wmo.int/common/wmdsLocalTopography

#	Name	Definition	WMO306_CD
4-03-01-1	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)	nilReason
4-03-01-2	Hilltop	Higher than all or nearly all of the surrounding land or subsurface.	hilltop
4-03-01-3	Ridge	Higher than all or nearly all of the surrounding land or subsurface, but elongated and extending beyond a 50 m radius.	ridge

#	Name	Definition	WMO306_CD
4-03-01-4	Slope	Neither crest nor depression or valley bottom, and with a slope more than 3%.	slope
4-03-01-5	Flat	Slope less than 3% and not a top, ridge, valley bottom or depression. Use for plains.	flat
4-03-01-6	Valley bottom	Lower than nearly all of surrounding land or subsurface, but water can flow out.	valleyBottom
4-03-01-7	Depression	Lower than surrounding land or subsurface, with no above-ground outlet for water.	depression

Code table: 4-03-02 Relative elevation http://codes.wmo.int/common/wmdsRelativeElevation

#	Name	Definition	WMO306_CD
4-03-02-1	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)	nilReason
4-03-02-2	Lowest	In the bottom 5% of the elevation range	lowest
4-03-02-3	Low	Between 5% and 25% of the elevation range	low
4-03-02-4	Middle	Between 25% and 75% of the elevation range	middle
4-03-02-5	High	Between 75% and 95% of the elevation range	high
4-03-02-6	Highest	In the highest 5% of the elevation range	highest

Code table: 4-03-03 Topographic context http://codes.wmo.int/common/wmdsTopographicContext

#	Name	Definition	WMO306_CD
4-03-03-1	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)	nilReason
4-03-03-2	Plains	Very low relief	plains
4-03-03-3	Hollows	Low relief, tending to convergent form	hollows
4-03-03-4	Rises	Low relief, tending to divergent form	rises
4-03-03-5	Valleys	Medium relief, tending to convergent form	valleys

#	Name	Definition	WMO306_CD
4-03-03-6	Hills	Medium relief, tending to divergent form	hills
4-03-03-7	Mountains	High relief	mountains

Code table: 4-03-04 Altitude/Depth http://codes.wmo.int/common/wmdsAltitudeOrDepth

#	Name	Definition	WMO306_CD
4-03-04-1	Not applicable	None of the codes in the table are applicable in the context of this particular observation (nilReason)	nilReason
4-03-04-2	Very small	between -100 m and 100 m	verySmall
4-03-04-3	Small	Between -300 and -100 m or between 100 and 300 m	small
4-03-04-4	Middle	Between -1000 and -300 m or between 300 and 1000 m	middle
4-03-04-5	Large	Between -3000 and -1000 m Between 1000 and 3000 m	large
4-03-04-6	Very large	Deeper than -3000 m or above 3000 m	veryLarge

Code table: 4-04 Events at station/platform http://codes.wmo.int/common/wmdsEventAtFacility

#	Path	Name	Definition	WMO306_CD
1	>(not applicable)	(not applicable)	None of the codes in the table is applicable in the context of the observing facility; or: Unknown; or: Information not available	notApplicable
2	>Incident	Incident	An unexpected event that has (or may have) impacted the observations	incident
3	>Intervention	Intervention	Human activity that has (or may have) impacted the observations	intervention
4	>Incident>Environmental	Environmental	NA	environmental
5	>Incident>Fire	Fire	Fire inside building	fire
6	>Incident>Severe weather	Severe weather	A natural severe weather event that has (or may have) impacted the observations	severeWeather
7	>Incident>Space weather	Space weather	An event in outer space that has (or may have) impacted the observations	spaceWeather
8	>Incident>Technical	Technical	NA	technical

#	Path	Name	Definition	WMO306_CD
9	>Intervention>Agricultural activity	Agricultural activity	NA	agriculturalActivity
10	>Intervention>Biomass burning (planned)	Biomass burning (planned)	NA	biomassBurningPlanned
11	>Intervention>Construction	Construction	NA	construction
12	>Intervention>Equipment cleaning/ painting	Equipment cleaning/ painting	NA	equipmentCleaning
13	>Intervention>Equipment maintenance	Equipment maintenance	how is this different from "preventive maintenance"?	equipmentMaintenance
14	>Intervention>Equipment repair/ replacement	Equipment repair/ replacement	NA	repairReplacement
15	>Intervention>Equipment verification/ calibration	Equipment verification/ calibration	NA	equipmentVerificationCalibration
16	>Intervention>Personnel absent	Personnel absent	NA	personnelAbsence
17	>Intervention>Infrastructure works	Infrastructure works	NA	infrastructureWorks
18	>Intervention>Inspection/ auditing	Inspection/ auditing	Corrosion of components, seizing	inspectionAuditing
19	>Intervention>Land use change	Land use change	NA	landUseChange
20	>Intervention>Planned service outage	Planned service outage	NA	plannedServiceOutage
21	>Intervention>Preventative maintenance	Preventative maintenance	NA	preventiveMaintenance
22	>Intervention>Road work	Road work	NA	roadWork
23	>Intervention>Theft of equipment	Theft of equipment	NA	theft
24	>Intervention>Unrest/strike	Unrest/strike	NA	unrestStrike
25	>Intervention>Urban development	Urban development	NA	urbanDevelopment
26	>Intervention>Vandalism	Vandalism	NA	vandalism
27	>Intervention>Vegetation trimming/ cutting	Vegetation trimming/ cutting	NA	vegetationTrimming
28	>Incident>Environmental>Cyclone/tornado	Cyclone/tornado	NA	cycloneTornado
29	>Incident>Environmental>Dust/sand storm	Dust/sand storm	NA	dustSandStorm
30	>Incident>Environmental>Extreme cold	Extreme cold	NA	extremeCold
31	>Incident>Environmental>Extreme heat	Extreme heat	NA	extremeHeat
32	>Incident>Environmental>Hail	Hail	NA	hail

#	Path	Name	Definition	WMO306_CD
33	>Incident>Environmental>Heavy precipitation/flooding	Heavy precipitation/flooding	NA	flooding
34	>Incident>Environmental>High wind/ blowing debris	High wind/ blowing debris	NA	windDebris
35	>Incident>Environmental>Snow/blizzard/icing	Snow/blizzard/icing	NA	snowBlizzardIcing
36	>Incident>Environmental>Thunderstorm/ lightning strike	Thunderstorm/ lightning strike	NA	thunderstormLightning
37	>Incident>Fire>Magnetic storm	Magnetic storm	NA	magneticStorm
38	>Incident>Fire>Solar flares	Solar flares	NA	solarFlares
39	>Incident>Severe weather>Avalanche	Avalanche	NA	avalanche
40	>Incident>Severe weather>Biological fouling	Biological fouling	NA	biologicalFouling
41	>Incident>Severe weather>Biomass burning (unplanned)	Biomass burning (unplanned)	NA	biomassBurningUnplanned
42	>Incident>Severe weather>Corrosion	Corrosion	NA	corrosion
43	>Incident>Severe weather>Earthquake	Earthquake	NA	earthQuake
44	>Incident>Severe weather>Erosion	Erosion	NA	erosion
45	>Incident>Severe weather>Guano fouling	Guano fouling	NA	guanoFouling
46	>Incident>Severe weather>Insect/animal infestation	Insect/animal infestation	NA	infestation
47	>Incident>Severe weather>Land slide/mudslide	Land slide/mudslide	Hazard event	landslide
48	>Incident>Severe weather>Pollution	Pollution	NA	pollution
49	>Incident>Severe weather>Storm surge	Storm surge	NA	stormSurge
50	>Incident>Severe weather>Tsunami	Tsunami	NA	tsunami
51	>Incident>Severe weather>Volcanic eruption/ Ash	Volcanic eruption/ Ash	NA	volcanicEruption
52	>Incident>Space weather>Cyber security penetration/ virus/ worm	Cyber security penetration/ virus/ worm	NA	cyberAttack
53	>Incident>Space weather>Data communications outage	Data communications outage	NA	dataCommOutage
54	>Incident>Space weather>Equipment malfunction	Equipment malfunction	NA	malfunction

#	Path	Name	Definition	WMO306_CD
55	>Incident>Space weather>Ground clutter/ signal blockage/ degradation	Ground clutter/ signal blockage/ degradation	NA	groundClutter
56	>Incident>Space weather>Hardware failure	Hardware failure	NA	hardwareFailure
57	>Incident>Space weather>Power outage	Power outage	NA	powerOutage
58	>Incident>Space weather>Radio frequency interference	Radio frequency interference	NA	radioFrequencyInterference
59	>Incident>Space weather>Software failure	Software failure	NA	softwareFailure

Code table 4-06 - Surface Roughness (Davenport roughness classification) http://codes.wmo.int/common/wmdsSurfaceRoughnessDavenport

#	Name	Definition	WMO306_CD
4-06-1	(unspecified)	None of the codes in the table are applicable in the context of this particular observation (nilReason)	
4-06-2	Sea	Open sea or lake (irrespective of the wave size), tidal flat, snow-covered flat plain, featureless desert, tarmac and concrete, with a free fetch of several kilometers. (z_o 0.0002)	sea
4-06-3	Smooth	Featureless land surface without any noticeable obstacles and with negligible vegetation; e.g. beaches, pack ice without large ridges, morass, and snow-covered or fallow open country. (z_o 0.005)	smooth
4-06-4	Open	Level country with low vegetation (e.g. grass) and isolated obstacles with separations of at least 50 obstacle heights; e.g. grazing land without windbreaks, heather, moor and tundra, runway area of airports. (z_o 0.03)	open
4-06-5	Roughly open	Cultivated area with regular cover of low crops, or moderately open country with occasional obstacles (e.g. low hedges, single rows of trees, isolated farms) at relative horizontal distances of at least 20 obstacle heights. (z_o 0.10)	roughlyOpen
4-06-6	Rough	Recently-developed "young" landscape with high crops or crops of varying height, and scattered obstacles (e.g. dense shelterbelts, vineyards) at relative distances of about 15 obstacle heights. (z_o 0.25)	rough
4-06-7	Very rough	"Old" cultivated landscape with many rather large obstacle groups (large farms, clumps of forest) separated by open spaces of about 10 obstacle heights. Also low large vegetation with small interspaces, such as bushland, orchards, young densely-planted forest. (z_o 0. 5)	veryRough

#	Name	Definition	WMO306_CD
4-06-8	Closed	Landscape totally and quite regularly covered with similar size large obstacles, with open spaces comparable to the obstacle heights; e.g. mature regular forests, homogeneous cities or villages. (z_o 1.0)	closed
4-06-9	Chaotic	Centres of large towns with mixture of low-rise and high-rise buildings. Also irregular large forests with many clearings. ($z_o \geq 2$)	chaotic

Code Table 4-07 – Climate Zone - http://codes.wmo.int/common/wmdsClimateZone

#	Name	Definition	WMO306_CD
4-07-1	(unspecified)	unspecified	unspecified
4-07-2	Af	Equatorial rainforest - fully humid	equatorialRainforestFullyHumid
4-07-3	Am	Equatorial – Monsoon	equatorialMonsoon
4-07-4	Aw	Equatorial – Savannah – dry summer	equatorialSavannahDrySummer
4-07-5	As	Equatorial – Savannah – dry winter	equatorialSavannahDryWinter
4-07-6	BWh	Desert – Hot arid	desertHotArid
4-07-7	BWk	Desert – Cold arid	desertColdArid
4-07-8	BSh	Steppe – Hot arid	steppeHotArid
4-07-9	BSk	Steppe – Cold arid	steppeColdArid
4-07-10	Csa	Warm temperate – Dry, hot summer	warmTemperateDryHotSummer
4-07-11	Csb	Warm temperate – Dry, warm summer	warmTemperateDryWarmSummer
4-07-12	Csc	Warm temperate – Dry, cool summer	warmTemperateDryCoolSummer
4-07-13	Cwa	Warm Temperate – Dry winter – Hot summer	warmTemperateDryWinterHotSummer
4-07-14	Cwb	Warm Temperate – Dry winter – Warm summer	warmTemperateDryWinterWarmSummer

#	Name	Definition	WMO306_CD
4-07-15	Cwc	Warm Temperate – Dry winter – Cool summer	warmTemperateDryWinterCoolSummer
4-07-16	Cfa	Warm Temperate – Fully humid – Hot summer	warmTemperateFullyHumidHotSummer
4-07-17	Cfb	Warm Temperate – Fully humid – Warm summer	warmTemperateFullyHumidWarmSummer
4-07-18	Cfc	Warm Temperate – Fully humid – Cool summer	warmTemperateFullyHumidCoolSummer
4-07-19	Dsa	Snow – Dry and hot summer	snowDryHotSummer
4-07-20	Dsb	Snow – Dry and warm summer	snowDryWarmSummer
4-07-21	Dsc	Snow – Dry and cool summer	snowDryCoolSummer
4-07-22	Dsd	Snow – Dry summer – Very cold winter	snowDrySummerVeryColdWinter
4-07-23	Dwa	Snow – Dry winter – Hot summer	snowDryWinterHotSummer
4-07-24	Dwb	Snow – Dry winter – Warm summer	snowDryWinterWarmSummer
4-07-25	Dwc	Snow – Dry winter – Cold summer	snowDryWinterColdSummer
4-07-26	Dwd	Snow – Dry winter – Very cold winter	snowDryWinterVeryColdWinter
4-07-27	Dfa	Snow – Fully humid – Hot summer	snowFullyHumidHotSummer
4-07-28	Dfb	Snow – Fully humid – Warm summer	snowFullyHumidWarmSummer
4-07-29	Dfc	Snow – Fully humid – Cool summer	snowFullyHumidCoolSummer
4-07-30	Dfd	Snow – Fully humid – Very cold winter	snowFullyHumidVeryColdWinter
4-07-31	ET	Polar - Tundra	polarTundra
4-07-32	EF	Polar – Frost	polarFrost

Code table: 5-01 Source of observation http://codes.wmo.int/common/wmdsSourceOfObservation

#	Name	Definition	WMO306_CD
1	Instrumental automatic reading	Automatically produced measurement result	automaticReading
2	Instrumental manual reading	Manual reading of instrument, both analog and digital outputs	manualReading
3	Human observation	Human, non-instrumented observation	humanObservation
4	(unspecified)	Procedure used to obtain result unspecified	unspecified

Code table: 5-02 Measurement/observing method http://codes.wmo.int/common/wmdsObservingMethod (this table will initially be empty)

Code table: 5-04 Instrument operating status http://codes.wmo.int/common/wmdsInstrumentOperatingStatus

#	Name	Definition	WMO306_CD
1	Operational	The instrument is declared operational and subject to routine maintenance	operational
2	Testing / commissioning	The instrument is deployed for testing purposes and the information provided may not be reliable	testing
3	Not in service / inactive	The instrument is deployed but presently not in service	inactive

Code table: 5-08-01 control standard type http://codes.wmo.int/common/wmdsControlStandardTyp

#	Name	Definition	WMO306_CD
5-08-01-01	International	NA	internationalStandard
5-08-01-02	Primary	NA	primaryStandard
5-08-01-03	Secondary	NA	secondaryStandard
5-08-01-04	Reference	NA	referenceStandard
5-08-01-05	Working	NA	workingStandard
5-08-01-06	Transfer	NA	transferStandard
5-08-01-07	Travelling	NA	travellingStandard
5-08-01-08	Collective	NA	collectiveStandard

Code table: 5-08-02 control location http://codes.wmo.int/common/wmdsControlLocation

#	Name	Definition	WMO306_CD
5-08-02-01	Field calibration	Instrument control activity performed on site	onSite
5-08-02-02	Laboratory calibration	Instrument control activity performed in the laboratory	laboratory
5-08-02-03	Remote (non in-situ)	Instrument control activity performed remotely	remote

Code table 5-08-03 Instrument control result http://codes.wmo.int/common/wmdsInstrumentControlResult

#	Name	Definition	WMO306_CD
5-08-03-01	no changes - in calibration	Instrument verified and found to be in calibration	inCalibration
5-08-03-02	no changes - out of calibration	Instrument checked and found to be out of calibration; no changes to calibration function	outOfCalibration
5-08-03-03	no changes – calibration unknown	Instrument visited but calibration could not be carried out	unknown
5-08-03-04	recalibrated - in calibration	Instrument checked and found to be out of calibration; instrument recalibrated (calibration function changed)	recalibrated

Code table: 5-14 Status of observation http://codes.wmo.int/common/wmdsInstrumentOperatingStatus

#	Name	Definition	WMO306_CD
5-14-01	Primary	The primary or official observation of the observed variable	primary
5-14-02	Additional	Additional or supplemented observation of the observed variable	additional

Code table: 5-15 Exposure of instrument http://codes.wmo.int/common/wmdsExposure

#	Name	Definition	WMO306_CD
1	(unspecified)	Classification not specified	unspecified
2	Class 1	Exposure of instrument allows reference level measurements	class1
3	Class 2	Exposure of instrument has small or infrequence influence on measurement	class2
4	Class 3	Exposure of instrument leads to increased uncertainty or occasional invalid measurements	class3
5	Class 4	Exposure of instrument leads to high uncertainty or regular invalid measurements	class4
6	Class 5	Exposure of instrument leads to invalid measurements	class5

Code table: 6-03 Sampling strategy http://codes.wmo.int/common/wmdsSamplingStrategy

#	Name	Definition	WMO306_CD
6-03-1	Continuous	Sampling is done continuously, but not necessarily at regular time intervals. Sampling is integrating, i.e., none of the medium escapes observations.	continuous
6-03-2	Discrete	Sampling is done at regular time intervals for certain sampling periods that are smaller than the time interval. Sampling is not integrating, i.e., parts of the medium escape observation.	discrete
6-03-3	Event	Sampling is done at irregular time intervals.	event

Code table: 7-06 Level of data http://codes.wmo.int/common/wmdsLevelOfData

#	Name	WMO306_CD	Definition	
			CIMO (WMO-No. 8, 2008, Updated 2010)	**CEOS** (http://www.ceos.org/images/WGISS/Documents/Handbook.pdf)
7-06-1	Unknown	unknown		
7-06-2	Raw	raw		Physical information: Data in their original packets, as received from a satellite
7-06-3	Level 0	level0	Analogue/digital electric signals	Physical information: Reconstructed unprocessed instrument data at full space time resolution with all available supplemental information to be used in subsequent processing (e.g. ephemeris, health and safety) appended.
7-06-4	Level I	level1	Level I data (Primary Data): in general, are instrument readings expressed in appropriate physical units, and referred to Earth geographical coordinates. They require conversion to the normal meteorological variables (identified in Part I, Chapter 1). Level I data themselves are in many cases obtained from the processing of electrical signals such as voltages, referred to as raw data. Examples of these data are satellite radiances and water-vapour pressure, positions of constant-level balloons, etc. but not raw telemetry signals. Level I data still require conversion to the meteorological parameters specified in the data requirements.	Physical information: Unpacked, reformatted level 0 data, with all supplemental information to be used in subsequent processing appended. Optional radiometric and geometric correction applied to produce parameters in physical units. Data generally presented as full time/space resolution. A wide variety of sub level products are possible.
7-06-5	Level II	level2	Level II data (Meteorological parameters). They may be obtained directly from many kinds of simple instruments, or derived from Level I data. For example, a sensor cannot measure visibility, which is a Level II quantity; instead, sensors measure the extinction coefficient, which is a Level I quantity.	Geophysical information. Retrieved environmental variables (e.g., ocean wave height, soil moisture, ice concentration) at the same resolution and location as the level 1 source data.
7-06-6	Level III	level3	Level III (Initial state parameters) are internally consistent data sets, generally in grid-point form obtained from Level II data by applying established initialization procedures. NOTE: Data exchanged internationally are Level II or Level III data.	Geophysical information. Data or retrieved environmental variables which have been spatially and/or temporally re-sampled (i.e., derived from level 1 or 2 products). Such re-sampling may include averaging and compositing.
7-06-7	Level IV	level4		Thematic information. Model output or results from analyses of lower level data (i.e., variables that are not directly measured by the instruments, but are derived from these measurements).

Code table: 7-07 Data format http://codes.wmo.int/common/wmdsDataFormat

#	Name	Definiton	WMO306_CD
1	ASCII	ASCII (American Standard Code for Information Interchange) is a character-encoding scheme used for text files. Plain text files are often called "ASCII" files.	ascii
3	NASA AMES	The NASA AMES format is a set of nine ASCII-based file formats that comply with an overall common structure but make provision of different features adapted to various cases. It consists of a header and a data part.	nasaAmes
4	HDF4	Hierarchical Data Format (HDF) is a set of file formats (HDF4, HDF5) designed to store and organize large amounts of data.	hdf4
5	HDF5	Hierarchical Data Format (HDF) is a set of file formats (HDF4, HDF5) designed to store and organize large amounts of data.	hdf5
6	XML	Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format which is both human-readable and machine-readable.	xml
8	CSV	A comma-separated values (CSV) file stores tabular data (numbers and text) in plain text. Each line of the file is a data record. Each record consists of one or more fields, separated by commas, hence the name for this file format.	csv
10	NetCDF	A set of software libraries and self-describing, machine-independent data formats that support the creation, access, and sharing of array-oriented scientific data. http://www.unidata.ucar.edu/software/netcdf/	netcdf
12	FM 13 - SHIP	Report of surface observation from a fixed sea station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	ship
13	FM14 - SYNOP MOBIL	Report of a surface observation from a mobile land station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	synopMobil
14	FM 15 - METAR	Aerodrome routine meteorological report (with or without trend forecast). Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	metar
15	FM 16 - SPECI	Aerodrome special meteorological report (with or without trend forecast). Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	speci
16	FM 18 - BUOY	Report of a buoy observation. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	buoy
17	FM 20 - RADOB	Report of ground radar weather observation. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	radob
18	FM 22 - RADREP	Radiological data report (monitored on a routine basis and/or in case of accident). Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	radrep
19	FM 32 - PILOT	Upper-wind report from a fixed land station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	pilot
20	FM33 - PILOT SHIP	Upper-wind report from a sea station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	pilotShip
21	FM 34 - PILOT MOBIL	Upper wind report from a mobile land station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	pilotMobil
22	FM 35 - TEMP	Upper-level pressure, temperature, humidity and wind report from a fixed land station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	temp
23	FM 36 - TEMP SHIP	Upper-level pressure, temperature, humidity and wind report from a sea station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	tempShip

#	Name	Definiton	WMO306_CD
24	FM 37 - TEMP DROP	Upper-level pressure, temperature, humidity and wind report from a sonde released by carrier balloons or aircraft. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	tempDrop
25	FM 38 - TEMP MOBIL	Upper-level pressure, temperature, humidity and wind report from a mobile land station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	tempMobil
26	FM 39 - ROCOB	Upper-level temperature, wind and air density report from a land rocketsonde station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	rocob
27	FM 40 - ROCOB SHIP	Upper-level temperature, wind and air density report from a rocketsonde station on a ship. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	rocobShip
28	FM 41 - CODAR	Upper-air report from an aircraft (other than weather reconnaissance aircraft). Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	codar
29	FM 42 - AMDAR	Aircraft report (aircraft meteorological data relay). Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	amdar
30	FM 44 - ICEAN	Ice analysis. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	icean
31	FM 45 - IAC	Analysis in full form. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	IAC
32	FM 46 - IAC FLEET	Analysis in abbreviated form. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	iacFleet
33	FM 47 - GRID	Processed data in the form of grid-point values. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	grid
34	FM 49 - GRAF	Processed data in the form of grid-point vlues (abbreviated code form). Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	graf
35	FM 50 - WINTEM	Forecast upper wind and temperature for aviation. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	wintem
36	FM 51 - TAF	Aerodrome forecast. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	taf
37	FM 53 - ARFOR	Area forecast for aviation. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	arfor
38	FM 54 - ROFOR	Route forecast for aviation. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	rofor
39	FM 57 - RADOF	Radiological trajectory dose forecast (defined time of arrival and location). Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	radof
40	FM 61 - MAFOR	Forecast for shipping. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	mafor
41	FM 62 - TRACKOB	Report of marine surface observation along a ship's track. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	trackob
42	FM 63 - BATHY	Report of bathythermal observation. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	bathy
43	FM 64 - TESAC	Temperature, salinity and current report from a sea station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	tesac
44	FM 65 - WAVEOB	Report of spectral wave information from a sea station or from a remote platform (aircraft or satellite). Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	waveob
45	FM 67 - HYDRA	Report of hydrological observation from a hydrological station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	hydra
46	FM 68 - HYFOR	Hydrological forecast. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	hyfor

#	Name	Definiton	WMO306_CD
47	FM 71 - CLIMAT	Report of monthly values from a land station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	climat
48	FM 72 - CLIMAT SHIP	Report of monthly means and totals from an ocean weather station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	climatShip
49	FM 73 - NACLI, CLINP, SPCLI, CLISA, INCLI	Report of monthly means for an oceanic area. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	nacli
50	FM 75 - CLIMAT TEMP	Report of monthly aerological means form a land station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	climatTemp
51	FM 76 - CLIMAT TEMP SHIP	Report of monthly aerological means form an ocean weather station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	climatTempShip
52	FM 81 - SFAZI	Synoptic report of bearings of sources of atmospherics. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	sfazi
53	FM 82 - SFLOC	Synoptic report of the geographical location of sources of atmospherics. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	sfloc
54	FM 83 - SFAZU	Detailed report of the distribution of sources of atmospherics by bearings for any period up to and including 24 hours. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	sfazu
55	FM 85 - SAREP	Report of synoptic interpretation of cloud data obtained by a meteorological satellite. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	sarep
56	FM 86 - SATEM	Report of satellite remote upper-air soundings of pressure, temperature and humidity. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	satem
57	FM 87 - SARAD	Report of satellite clear radiance observations. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	sarad
58	FM 88 - SATOB	Report of satellite observations of wind, surface temperature, cloud, humidity and radiation. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	satob
59	FM 92 - GRIB	Processed data in the form of grid-point values expressed in binary form. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes2	grib
60	FM 94 - BUFR	Binary Universal Form for the Representation of meteorological data. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes2	bufr
61	FM 95 - CREX	Character form for the representation and exchange of data. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	crex
62	FM 201 - COLLECT	Collection of reports that use the same XML application schemas. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes3	collect
63	FM 202 - METCE	Meteorological information. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes3	metce
64	FM 203 - OPM-XML	Observable property model. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes3	opmXML
65	FM 204 - SAF-XML	Simple aeronautical features. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes3	safXML
66	FM 205 - IWXXM-XML	International Civil Aviation Organization meteorological information exchange model. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes3	iwxxmXML
11	FM 12 - SYNOP	Report of surface observation from a fixed land station. Manual on Codes Volume I.1. http://wis.wmo.int/ManCodes1	synop

Code table: 7-10 ***Reference time http://codes.wmo.int/common/wmdsReferenceTime***

#	Name	Definition	WMO306_CD
1	(unknown)	Source of reference time unknown	unknown
2	Global navigation satellite system (GNSS)	A Global Navigation Satellite System (GNSS) signal controlled clock, which receives a signal that comes from the atomic clock of a GNSS constellation of satellites.	gnss
3	Manual comparison	A regular procedure of manual comparison with a reference clock	manualComparison
4	Radio clock	A radio controlled clock, which receives a radio signal that comes from a reference/atomic clock.	radioClock
5	Time server (internet based)	A server computer that reads the actual time from a reference/atomic clock and distributes this information to its clients using a computer network. The time server may be a local network time server or an internet time server.	timeServer

Code table: 8-03-01 Quality flag http://codes.wmo.int/common/wmdsQualityFlagCIMO

#	Name	Definition	WMO306_CD
8-03-01-1	Good	The data has been examined and represents a reliable measurement.	good
8-03-01-2	Inconsistent	The data has been examined and one or more parameters are inconsistent; the relationship between different elements does not meet defined criteria.	inconsistent
8-03-01-3	Doubtful	The data should be treated as suspect.	suspect
8-03-01-4	Wrong	The data has been examined and determined to contain errors	erroneous
8-03-01-5	Not checked	The data has not been checked by any qualitative or quantitative method.	unchecked
8-03-01-6	Has been changed	The original value has been replaced with another value.	changed
8-03-01-7	Estimated	The value has been estimated rather than measured.	estimate
8-03-01-8	Missing value	The data is missing.	missing

Code table: 8-03-02 Quality flag [From OGC WaterML 2.0]

#	Name	Definition	WMO306_CD
8-03-02-1	Good	The data has been examined and represents a reliable measurement.	good
8-03-02-2	Suspect	The data should be considered as low quality and may have been rejected.	poor
8-03-02-3	Estimate	The data should be treated as suspect.	suspect
8-03-02-4	Poor	The data has not been checked by any qualitative or quantitative method.	unchecked
8-03-02-5	Unchecked	The value has been estimated rather than measured.	estimate
8-03-02-6	Missing	The data is missing.	missing

Code table: 8-04 Code table title: Quality Flag System http://codes.wmo.int/common/wmdsQualityFlagOGC

#	Name	Quality_Flag_Sys_URL	Definition	WMO306_CD
1	(unknown)	NA	Quality flagging system not known	unknown
2	WMO BUFR table 0 33 020	http://codes.wmo.int/bufr4/codeflag/0-33-020	Quality flags are specified according to BUFR table 0 33 020 (http://codes.wmo.int/bufr4/codeflag/0-33-020)	bufr033020
3	Other quality flagging system	NA	Quality flags are specified according to another system	other
4	WaterML2	http://www.opengis.net/def/waterml/2.0/quality/	Quality flags are specified according to WaterML2, http://www.opengis.net/def/waterml/2.0/quality/	waterML2.0

Code table: 8-05 Traceability http://codes.wmo.int/common/wmdsTraceability

#	Name	Definition	WMO306_CD
8-05-1	(unknown)	The traceability of the observations is unknown.	unknown
8-05-2	Traceable to international standard	The observations made are traceable to an internationally agreed standard.	traceableToInternationalStandard
8-05-3	Traceable to non-international standard	The observations made are traceable to some other standard.	traceableToOtherStandard

Code table: 9-02 Data policy/use constraints http://codes.wmo.int/common/wmdsDataPolicy

#	Name	Definition	WMO306_CD
9-02-1	WMOEssential	WMO Essential Data: free and unrestricted international exchange of basic data and products.	WMOEssential
9-02-2	WMOAdditional	WMO Additional Data: free and unrestricted access to data and products exchanged under the auspices of WMO to the research and education communities for non-commercial activities. A more precise definition of the data policy may be additionally supplied within the metadata. In all cases it shall be the responsibility of the data consumer to ensure that they understand the data policy specified by the data provider – which may necessitate dialogue with the data publisher for confirmation of terms and conditions.	WMOAdditional
9-02-3	WMOOther	Data identified for global distribution via WMO infrastructure (GTS / WIS) that is not covered by WMO Resolution 25 neither WMO Resolution 40; e.g. aviation OPMET data. Data marked with "WMOOther" data policy shall be treated like "WMOAdditional" where a more precise definition of the data policy may be additionally supplied within the metadata. In all cases it shall be the responsibility of the data consumer to ensure that they understand the data policy specified by the data provider – which may necessitate dialogue with the data publisher for confirmation of terms and conditions.	WMOOther
9-02-4	(unspecified)	No limitation on distribution or use	noLimitation

Code table: 11-01 Coordinates Source/Service http://codes.wmo.int/common/wmdsGeopositioningMethod

#	Name	Definition	WMO306_CD
1	GPS	Location determined using the Global Positioning System. http://www.gps.gov/	gps
2	ARGOS DOPPLER	Location determined using the frequency shift of transmissions to the ARGOS communications satellite service. http://www.argos-system.org/web/en/333-why-choose-argos.php	argosDoppler
3	IRIDIUM DOPPLER	Location determined using the frequency shift of transmissions to the Iridium communications satellite constellation. https://www.iridium.com/	iridiumDoppler
4	ARGOS Kalman	Location determined using the Kalman filtering technique and the ARGOS communications satellite service. http://www.argos-system.org/web/en/393-faq-kalman.php.	argosKalman
5	GALILEO	Location determined using the European GALILEO global navigation satellite system. http://galileognss.eu/	galileo
6	LORAN	Location determined using the LORAN (LOng RAnge Navigation) hyperbolic radio system.	loran
7	Survey	Location determined using a geographic survey.	survey
8	From map	Location extracted by locating the object on a map.	map

Code table: 11-02 Coordinates reference http://codes.wmo.int/common/wmdsCoordinateReferenceSystem

1	WGS84	An Earth-centered, Earth-fixed terrestrial reference system and geodetic datum. Currently, WGS84 uses the EGM96 (Earth Gravitational Model 1996) geoid, revised in 2004.	wgs84

Code table: 11-03 Meaning of time stamp http://codes.wmo.int/common/wmdsTimeStampMeaning

#	Name	Definition	WMO306_CD
1	(unknown)	The beginning and end of the period described by the timestamp are unknown.	unknown
2	Beginning	Time stamps indicate the end of a period covering the range up to but excluding the preceding time stamp	beginning
3	End	Time stamps indicate the middle of a period beginning at the middle of the range described by this and the preceding time stamp and ending right before the middle of the range described by this and the following time stamp.	end
4	Middle	Time stamps indicate the middle of a period beginning at the middle of the range described by this and the preceding time stamp and ending right before the middle of the range described by this and the following time stamp.	middle

Recommendation 8 (CBS-16)

RECOGNITION OF TIMESERIESML FOR THE REPRESENTATION OF TIME SERIES INFORMATION

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) That joint WMO and Open Geospatial Consortium teams had developed TimeSeriesML to provide a generic mechanism for representing information in time series in XML,

(2) The need of WMO for data representations derived from data models will include the need to represent time series of information,

Recommends to the Executive Council the amendments to the *Manual on Codes* (WMO-No. 306), Volume I.3 in the annex to the present recommendation to facilitate the use of TimeSeriesML;

Authorizes the Secretary-General to make editorial corrections to the contents of the annex to the present recommendation.

Annex to Recommendation 8 (CBS-16)

AMENDMENTS TO THE *MANUAL ON CODES* (WMO-No. 306) TO SUPPORT USE OF TIMESERIESML

Make the following changes to the Manual on Codes (WMO-No. 306) Volume I.3.

Add the following entry to the section "FM system of numbering XML markup language application schemas"

FM 221-16 TSML-XML Representation of information as time series. Resolution XX (EC-XX).

Add the following section in sequence of FM number

FM 221: REPRESENTATION OF INFORMATION AS TIME SERIES

FM 221-16 <u>TSML</u>-XML REPRESENTATION OF INFORMATION AS TIME SERIES

221.1 Scope

221.1 TSML-XML shall be used for the exchange in extensible markup language (XML) of time series information conforming to the "Timeseries Profile of Observations and Measurements" conceptual model. TSML-XML may be used directly to encode timeseries information or incorporated as components within other XML encodings.

221.2 The definition of TSML-XML application schema is in documents published by the Open Geospatial Consortium as "OGC/IS 15-043r3 Timeseries Profile of Observations and Measurements" with the XML encoding described in "OGC/IS 15-042r3 TimeseriesML 1.0 – XML Encoding".

Notes:

(1) Copies of the schema are also available from http://schemas.wmo.int/tsml/1.0.

(2) Copies of the definition documents are available from http://schemas.wmo.int/tsml/1.0/documents/OGC-IS-15-043r3-TimeseriesProfile.pdf and http://schemas.wmo.int/tsml/1.0/documents/OGC-IS-15-043r3-TimeseriesXML.pdf.

Add the following section to Appendix B

6. TSML-XML (REPRESENTATION OF INFORMATION AS TIME SERIES)

6.1 http://schemas.opengis.net/tsml/1.0/timeseriesML.xsd

Recommendation 9 (CBS-16)

AMENDMENT TO THE COLLECT-XML DATA REPRESENTATION

THE COMMISSION FOR BASIC SYSTEMS,

Recalling that the data representation derived from models known as COLLECT-XML, defined in the *Manual on Codes* (WMO-No. 306), Volume I.3 as code number FM 201, is intended to permit exchange of groups of reports in XML format within a single file,

Noting that:

(1) Feedback on the first version of COLLECT-XML (version 1.1) indicated that the same functionality could be implemented in a more compact way,

(2) User applications that correctly implemented COLLECT-XML version 1.1 would be able to process COLLECT-XML version 1.2 without modification,

Recommends to the Executive Council that the definition of COLLECT-XML in the *Manual on Codes* should be amended as in the annex to the present recommendation;

Authorizes the Secretary-General to make editorial adjustments to the text of the annex to the present recommendation and to electronic information supporting the definition of COLLECT-XML prior to submission to the Executive Council;

Requests the Secretary-General to make provision for the definition of version 1.1 of COLLECT-XML to be available permanently so that archived information recorded in that version may be interpreted correctly.

Annex to Recommendation 9 (CBS-16)

SPECIFICATION OF COLLECT 1.2

Make the following changes to the Manual on Codes (WMO-No. 306) Volume I.3.

In the section "FM system of numbering XML markup language application schemas"

~~FM 201-15 Ext.~~ FM 201-16 **COLLECT-XML**	Collection of reports that use the same XML application schemas. Resolution 32 (Cg-17)

Amend Note 2 of section 201.2 XML schema for COLLECT-XML

2. Schematron schemas providing additional constraints are provided as an external file to the XSD defining COLLECT-XML. The canonical location of this file is http://schemas.wmo.int/collect/rule/1.2~~1.1~~/collect.sch.

In Table 2 (XML namespaces defined for COLLECT-XML)

XML namespace	*Default namespace prefix*	*Canonical location of all-components schema document*
http://def.wmo.int/collect/2014	collect	~~http://schemas.wmo.int/collect/1.1/collect.xsd~~ http://schemas.wmo.int/collect/1.2/collect.xsd

Amend the final row of Table 3 "External XML namespaces used in COLLECT-CML

Standard	*XML namespace*	*Default namespace prefix*	*Canonical location of all-components schema document*
ISO ~~19136:2006~~ 19136:2007 GML	http://www.opengis.net/gml/3.2	gml	http://schemas.opengis.net/gml/3.2.1/gml.xsd

Amend note 2 to Table 4 "Requirements class xsd-meteorological-bulletin"

2. Meteorological information reports include METAR, SPECI, TAF, ~~and~~ SIGMET, AIRMET, Tropical Cyclone Advisory and Volcanic Ash Advisory – represented using XML elements iwxxm:METAR, iwxxm:SPECI, iwxxm:TAF, ~~and~~ iwxxm:SIGMET, iwxxm:AIRMET, iwxxm:TropicalCycloneAdvisory and iwxxm:VolcanicAshAdvisory.

Recommendation 10 (CBS-16)

CEASING MAINTENANCE OF TRADITIONAL ALPHANUMERIC CODES

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) Migration plans for table-driven code forms agreed at successive sessions of the Commission for Basic Systems up to and including its extraordinary session in 2014,

(2) That a significant motivation for introducing table-driven code forms was the inflexibility of the traditional alphanumeric codes and the difficulty and cost of implementing changes to them,

Noting the efforts being made by Members to complete the migration to table-driven code forms,

Recommends to the Executive Council:

(1) That no further development of the traditional alphanumeric codes should take place with the exception of those traditional alphanumeric codes prescribed by WMO for the International Civil Aviation Organization (ICAO);

(2) That WMO encourages ICAO to use modern alternatives to traditional alphanumeric codes to meet new requirements to exchange of meteorological information in line with the move to ICAO System Wide Information Management.

Recommendation 11 (CBS-16)

AMENDMENTS TO METCE (*MODÈLE POUR L'ÉCHANGE DES INFORMATIONS SUR LE TEMPS, LE CLIMAT ET L'EAU*) DATA REPRESENTATION

THE COMMISSION FOR BASIC SYSTEMS,

Recalling that the data representation derived from a logical data model called METCE (*Modèle pour l'Echange des Informations sur le Temps, le Climat et l'Eau*), defined in the *Manual on Codes* (WMO-No. 306), Volume I.3 as code number FM 202, is intended to underpin data representations for all forms of weather, water and climate information,

Noting that development of the WMO Integrated Global Observing System (WIGOS) metadata data representation and compatibility with TimeSeriesML required flexibilities that were unavailable within the version of METCE,

Considering that the proposed amendments to METCE (known as METCE 1.2RC1 and specified in the annex to the present recommendation):

(1) Are purely technical redistributions of the location of elements between the data models supporting METCE and other WMO data representations,

(2) Are essential to support IWXXM 2.0 and the WIGOS metadata data representation,

(3) Will have no impact on the content of XML records for the types of information that are already represented using METCE,

(4) Are expected to simplify future developments,

Considering further that Members using IWXXM 2.0 and the WIGOS metadata data representation will also be using METCE 1.2 and will be providing feedback on METCE 1.2 as part of their feedback on the other data representations,

Recommends to the Executive Council version 1.2 of METCE as specified in the annex to the present recommendation and its supporting schemas for inclusion in the *Manual on Codes*, Volume I.3;

Requests the Secretary-General to make provision for all versions of FM 202 METCE to be available permanently so that archived information recorded in that version may be interpreted correctly.

Annex to Recommendation 11 (CBS-16)

AMENDMENTS TO METCE (*MODÈLE POUR L'ÉCHANGE DES INFORMATIONS SUR LE TEMPS, LE CLIMAT ET L'EAU*) DATA REPRESENTATION

The text of this Annex is expressed as changes to the 2015 Edition of the *Manual on Codes* (WMO-No. 306) Volume I.3.

Additions are marked as green dotted-underline text, and deletions are marked as ~~red strikeout~~ text. Text marked with a double underline or that appears to be a URL should be reproduced verbatim in translated versions of this text (without the double underline). Where complete sections of text are to be added or removed the mark-up colours are not used.

Amend the first column of the second row of the Table "FM System of Extensible Markup Language Representations"

~~FM 202-15 Ext.~~ FM 202-16

Amend paragraph 1.2 of section 1. Representation if information in Extensible Markup Language

1.2 XML documents conforming to XML schema that have been allocated an FM identifier within this Manual shall, in addition to conforming to the Regulation for the specified code form, conform to the requirements specified in ~~Clauses 7 to 19~~ Clause 2.4 of ISO 19136:2007 [ISO 19136:2007, Geographic information – Geography Markup Language (GML)].

Amend Table 5. Requirements classes defined in METCE-XML

Requirements classes	
~~Requirements class~~	~~http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement, 202.4~~
~~Requirements class~~	~~http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement, 202.5~~
~~Requirements class~~	~~http://def.wmo.int/metce/2013/req/xsd-sampling-observation, 202.6~~
Requirements class	http://def.wmo.int/metce/2013/req/xsd-volcano, 202.7
Requirements class	http://def.wmo.int/metce/2013/req/xsd-erupting-volcano, 202.8
Requirements class	http://def.wmo.int/metce/2013/req/xsd-tropical-cyclone, 202.9
Requirements class	http://def.wmo.int/metce/2013/req/xsd-process, 202.10
Requirements class	http://def.wmo.int/metce/2013/req/xsd-measurement-context, 202.11
Requirements class	http://def.wmo.int/metce/2013/req/xsd-observation, 202.12
Requirements class	http://def.wmo.int/metce/2013/req/xsd-measurement, 202.13

Requirements classes	
Requirements class	http://def.wmo.int/metce/2013/req/xsd-category-observation, 202.14
Requirements class	http://def.wmo.int/metce/2013/req/xsd-count-observation, 202.15
Requirements class	http://def.wmo.int/metce/2013/req/xsd-truth-observation, 202.16
Requirements class	http://def.wmo.int/metce/2013/req/xsd-geometry-observation, 202.17
Requirements class	http://def.wmo.int/metce/2013/req/xsd-temporal-observation, 202.18
Requirements class	http://def.wmo.int/metce/2013/req/xsd-complex-observation, 202.19
Requirements class	http://def.wmo.int/metce/2013/req/xsd-discrete-coverage-observation, 202.20

Amend the Location column of Table 6 in section 202.2

XML namespace	*Default namespace prefix*	*Canonical location of all-components schema document*
http://def.wmo.int/metce/2013	metce	http://schemas.wmo.int/metce/~~1.1~~1.2/metce.xsd

Delete the second row labelled OGCOMXML from Table 7

Standard	*XML namespace*	*Default namespace prefix*	*Canonical location of all-components schema document*
…	…	…	…
OGC OMXML	http://www.opengis.net/om/2.0	om	http://schemas.opengis.net/om/2.0/observation.xsd
~~OGC OMXML~~	~~http://www.opengis.net/samplingSpatial/2.0~~	~~sams~~	~~http://schemas.opengis.net/samplingSpatial/2.0/spatialSamplingFeature.xsd~~
…	…	…	…

Amend the third note of paragraph 202.3.1

3. The URI for each observation type is composed by appending the *notation* to the *code-space*. As an example, the URI of OM_ComplexObservtion ~~ComplexSamplingMeasurement~~ is ~~http://codes.wmo.int/common/observation-type/METCE/2013/ComplexSamplingMeasurement~~ http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_ComplexObservation.

Replace the contents sections 202.4 and 202.6, including all paragraphs, notes and tables in those sections, and replace the text in the section headers with the following text

The contents of this section were removed in FM 202-16.

Add the following sections 202.12 to 202.20 following section 2.03.11

202.12 Requirements Class: Generic observation data

202.12.1 This requirements class mandates use of the XML element om:OM_Observation for encoding observation data.

Note: The term ""observation" evokes a particular concept to meteorologists: the measurement of physical phenomena using a human observer, instrument or sensor. However, OM_Observation, as defined in ISO 19156:2011, provides a generalised pattern for describing an event that estimates the value(s) of a property for a subject using a specified process. These semantics are equally applicable to describe forecasts and other numerical simulations.

202.12.2 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_Observation or where element om:type is not specified shall conform to all requirements specified in Table 202.12-1.

202.12.3 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_Observation or where element om:type is not specified shall conform to all requirements of all relevant dependencies specified in Table 202.12-1.

Note: XML implementation of OM_Observation is dependent on:

- GML [ISO 19136:2007 Geographic Information – Geography Markup Language];
- OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation].

Table 202.12-1. Requirements class xsd-observation

Requirements class	
http://def.wmo.int/metce/2013/req/xsd-observation	
Target Type	Data instance
Name	Observation
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation, OMXML clause 7.3

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/observation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/observation (OMXML clause A.1).

202.13 Requirements Class: Measurement data

202.13.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the "result" of the observation is a scaled number. This "result" is represented in XML as a measure from the Geography Markup Language (GML).

Notes:

(1) OM_Measurement, as defined in ISO 19156:2011, is intended for use where the observation event is concerned with measurement of a single property at a specified location and time instant or duration. The "result" of this class of observations is a single scaled value with associated unit of measurement.

(2) A description of the XML implementation of measures (gml:MeasureType) is provided in ISO 19136:2007 Clause 16.3.

202.13.2 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_Measurement shall conform to all requirements specified in Table 202.13-1.

202.13.3 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_Measurement shall conform to all Requirements of all relevant dependencies specified in Table 202.13-1.

Note: XML implementation of OM_Measurement is dependent on:

- GML [ISO 19136:2007 Geographic Information – Geography Markup Language];
- OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation].

Table 202.13-1. Requirements class xsd-measurement

Requirements class	
http://def.wmo.int/metce/2013/req/xsd-measurement	
Target Type	Data instance
Name	Measurement
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/measurement, OMXML clause 7.4

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/measurement has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/measurement (OMXML clause A.2).

202.14 Requirements Class: Category observation data

202.14.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the "result" of the observation is a term from a controlled vocabulary or ontology.

Note: a description of the XML implementation of terms from a controlled vocabulary (gml:ReferenceType) is provided in ISO 19136:2007 Clause 7.2.3.

202.14.2 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_CategoryObservation shall conform to all requirements specified in Table 202.14-1.

202.14.3 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_CategoryObservation shall conform to all requirements of all relevant dependencies specified in Table 202.14-1.

Note: XML implementation of OM_CategoryObservation is dependent on:

- GML [ISO 19136:2007 Geographic Information – Geography Markup Language];
- OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation].

Table 202.14-1. Requirements class xsd-category-observation

Requirements class	
http://def.wmo.int/metce/2013/req/xsd-category-observation	
Target Type	Data instance
Name	Category observation
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/categoryObservation, OMXML clause 7.5

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/categoryObservation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/categoryObservation (OMXML clause A.3).

202.15 Requirements Class: Count observation data

202.15.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the "result" of the observation is an integer.

Note: the XML implementation of integer values is provided in XML Schema Part 2: Datatypes, Clause 3.3.13.

202.15.2 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_CountObservation shall conform to all requirements specified in Table 202.15-1.

202.15.3 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_CountObservation shall conform to all requirements of all relevant dependencies specified in Table 202.15-1.

Note: XML implementation of OM_CountObservation is dependent on:

- GML [ISO 19136:2007 Geographic Information – Geography Markup Language];
- OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation].

Table 202.15-1. Requirements class xsd-count-observation

Requirements class	
http://def.wmo.int/metce/2013/req/xsd-count-observation	
Target Type	Data instance
Name	Count observation
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/countObservation, OMXML clause 7.6

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/countObservation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/countObservation (OMXML clause A.4).

202.16 Requirements Class: Truth observation data

202.16.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the "result" of the observation is a Boolean that can be used to express "true" or "false".

Note: the XML implementation of Boolean values is provided in XML Schema Part 2: Datatypes, Clause 3.2.2.

202.16.2 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_TruthObservation shall conform to all requirements specified in Table 202.16-1.

202.16.3 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_TruthObservation shall conform to all requirements of all relevant dependencies specified in Table 202.16-1.

Note: XML implementation of OM_TruthObservation is dependent on:

- GML [ISO 19136:2007 Geographic Information – Geography Markup Language];
- OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation].

Table 202.16-1. Requirements class xsd-truth-observation

Requirements class	
http://def.wmo.int/metce/2013/req/xsd-truth-observation	
Target Type	Data instance
Name	Truth observation
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/truthObservation, OMXML clause 7.7

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/truthObservation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/truthObservation (OMXML clause A.5).

202.17 Requirements Class: Geometry observation data

202.17.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the "result" of the observation is a geometry object.

Note: the XML implementation of geometry objects (geometric primitives) is provided in ISO 19136:2007 Clause 10.

202.17.2 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_GeometryObservation shall conform to all requirements specified in Table 202.17-1.

202.17.3 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_GeometryObservation shall conform to all requirements of all relevant dependencies specified in Table 202.17-1.

Note: XML implementation of OM_GeometryObservation is dependent on:

- GML [ISO 19136:2007 Geographic Information – Geography Markup Language];
- OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation].

Table 202.17-1. Requirements class xsd-geometry-observation

Requirements class	
http://def.wmo.int/metce/2013/req/xsd-geometry-observation	
Target Type	Data instance
Name	Geometry observation
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/geometryObservation, OMXML clause 7.8

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/geometryObservation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/geometryObservation (OMXML clause A.6).

202.18 Requirements Class: Temporal observation data

202.18.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the "result" of the observation is a temporal object.

Note: the XML implementation of temporal objects is provided in ISO 19136:2007 Clause 14.

202.18.2 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_TemporalObservation shall conform to all requirements specified in Table 202.18-1.

202.18.3 Instances of om:OM_Observation with element om:type specifying http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_TemporalObservation shall conform to all requirements of all relevant dependencies specified in Table 202.18-1.

Note: XML implementation of OM_TemporalObservation is dependent on:

- GML [ISO 19136:2007 Geographic Information – Geography Markup Language];
- OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation].

Table 202.18-1. Requirements class xsd-temporal-observation

Requirements class	
http://def.wmo.int/metce/2013/req/xsd-temporal-observation	
Target Type	Data instance
Name	Temporal observation
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/temporalObservation, OMXML clause 7.9

Note: dependency http://www.opengis.net/spec/OMXML/2.0/req/temporalObservation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/temporalObservation (OMXML clause A.7).

Sections 202.4 and 202.5 of the 2015 edition of the Manual on Codes Volume I.3 are to be moved here; changes in this text for sections 202.19 and 202.20 are marked against the original versions of sections 202.4 and 202.5.

202.19 Requirements Class: Complex observation data

202.19.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the "result" of the observation is a set of values relating to a specified location and time instant or duration.~~, the "feature of interest"~~ This "result" is represented in XML as a simple data record or vector from the SWE Common Data Model. ~~is or body of water and so forth based on a predetermined sampling regime and the "procedure" provides the set of information as specified by WMO~~.

Notes:

1. ~~ComplexSamplingMeasurement (a subclass of~~OM_ComplexObservation~~)~~, as defined in ISO 19156:2011, is intended for use where the observation event is concerned with the evaluation of multiple ~~measurands~~properties at a specified location and time instant or duration. The "result" of this class of observations is a group of ~~measures~~values, provided as a Record (as defined in ISO 19103:2005, Geographic information – Conceptual schema language).

2. A description of data records, vectors and their XML implementation is provided in SWE Common 2.0 Clauses 7.3 and 8.2.

202.~~4~~19.2 Instances of om:OM_Observation with element om:type specifying ~~http://codes.wmo.int/common/observation-type/METCE/2013/ComplexSamplingMeasurement~~http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_ComplexObservation shall conform to all requirements specified in ~~Table 8.~~202.19-?.

202.~~4~~19.3 Instances of om:OM_Observation with element om:type specifying ~~http://codes.wmo.int/common/observation-type/METCE/2013/ComplexSamplingMeasurement~~http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_ComplexObservation shall conform to all requirements of all relevant dependencies specified in Table 202.19-?.

Note: XML implementation of ~~metce:ComplexSamplingMeasurement~~OM_ComplexObservation is dependent on:

- GML [ISO 19136:2007 Geographic Information – Geography Markup Language];
- OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation];
- SWE Common 2.0 [OGC/IS 08-094r1 SWE Common Data Model Encoding Standard 2.0].

Table-202.19-?. Requirements class xsd-complex-~~observationsampling-measurement~~

TABLE: Table shaded header with lines

Requirements class	
http://def.wmo.int/metce/2013/req/xsd-complex-observation~~sampling-measurement~~	
Target type	Data instance
Name	Complex observation~~sampling-measurement~~
~~Dependency~~	~~http://www.opengis.net/spec/OMXML/2.0/req/observation, OMXML clause 7.3~~
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/complexObservation, OMXML clause 7.10
~~Dependency~~	~~http://www.opengis.net/spec/OMXML/2.0/req/sampling, OMXML clause 7.14~~
~~Dependency~~	~~http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling, OMXML clause 7.15~~
~~Dependency~~	~~http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components, SWE Common 2.0 clause 8.1~~
~~Dependency~~	~~http://www.opengis.net/spec/SWE/2.0/req/xsd-record-components, SWE Common 2.0 clause 8.2~~
~~Dependency~~	~~http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-encodings, SWE Common 2.0 clause 8.5~~
~~Dependency~~	~~http://www.opengis.net/spec/SWE/2.0/req/general-encoding-rules, SWE Common 2.0 clause 9.1~~
~~Dependency~~	~~http://www.opengis.net/spec/SWE/2.0/req/text-encoding-rules, SWE Common 2.0 clause 9.2~~
~~Dependency~~	~~http://www.opengis.net/spec/SWE/2.0/req/xml-encoding-rules, SWE Common 2.0 clause 9.3~~
Requirement	~~http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement/xmlns-declaration-swe~~ http://def.wmo.int/metce/2013/req/xsd-complex-observation/xmlns-declaration-swe The OGC SWE Common 2.0 namespace http://www.opengis.net/swe/2.0 shall be declared within the XML document.
~~Requirement~~	~~http://def.wmo.int/metce/2013/req/xsd-complex-sampling-measurement/procedure-metce-process~~ ~~The XML element om:procedure shall contain a child element metce:Process or any element of a substitution group of metce:Process.~~
Recommendation	http://def.wmo.int/metce/2013/req/xsd-complex-observation/xmlns-prefix-swe The default namespace prefix used for http://www.opengis.net/swe/2.0 should be "swe".

Notes:

~~1. Dependency http://www.opengis.net/spec/OMXML/2.0/req/observation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/observation (OMXML clause A.1).~~

1.~~2.~~ Dependency http://www.opengis.net/spec/OMXML/2.0/req/complexObservation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/complexObservation (OMXML clause A.8).

~~3. Dependency http://www.opengis.net/spec/OMXML/2.0/req/sampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/sampling (OMXML clause A.12).~~

~~4. Dependency http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/spatialSampling (OMXML clause A.13).~~

~~5. Dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-simple-components (SWE Common 2.0 clause A.8).~~

~~6. Dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-record-components has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-record-components (SWE Common 2.0 clause A.9).~~

2.~~7. Dependency~~The canonical schema location for OGC SWE Common 2.0 (http://www.opengis.net/swe/2.0) is http://schemas.opengis.net/sweCommon/2.0/swe.xsd.

202.~~5~~20 Requirements class: Discrete coverage observation ~~dataSampling coverage measurement~~

202.~~5~~20.1 This requirements class restricts the content model for the XML element om:OM_Observation such that the "result" of the observation is a set of values describing the variation of properties with space and/or time.~~., the "feature of interest" is a representative subset of the atmosphere or body of water and so forth based on a predetermined sampling regime and the "procedure" provides the set of information as specified by WMO.~~

Note~~s~~:

~~1.~~ ~~SamplingCoverageMeasurement (a subclass of~~ OM_DiscreteCoverageObservation~~)~~, as defined in ISO 19156:2011, is intended for use where the observation event is concerned with the evaluation of ~~measurands~~properties that vary with respect to space and/or time. ~~OM_DiscreteCoverageObservation is used because the~~ The "result" of this class of observations is a discrete coverage (as defined in ISO 19123:2005 Geographic information – Schema for coverage and geometry ~~and~~ functions).

~~2. SamplingCoverageMeasurement is based on the informative SamplingCoverageObservation specialization of OM_Observation outlined in ISO 19156:2011, clause D.3.4. Within METCE, additional restrictions are applied to the "procedure". Furthermore, the name is changed from SamplingCoverageObservation to SamplingCoverageMeasurement in an attempt to disambiguate the two classes and to mitigate confusion arising from use of the term observation.~~

202.~~5~~20.2 Instances of om:OM_Observation with element om:type specifying ~~http://codes.wmo.int/common/observation-type/METCE/2013/SamplingCoverageMeasurement~~http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_DiscreteCoverageObservation shall conform to all requirements specified in ~~Table 9.~~Table 202-20.

202.~~5~~20.3 Instances of om:OM_Observation with element om:type specifying ~~http://codes.wmo.int/common/observation-type/METCE/2013/SamplingCoverageMeasurement~~ http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_DiscreteCoverageObservation shall conform to all requirements of all relevant dependencies specified in ~~Table 9.~~Table 202.20-1

Note: XML implementation of ~~metce:ComplexSamplingMeasurement~~OM_DiscreteCoverageObservation is dependent on:

- GML [ISO 19136:2007 Geographic Information – Geography Markup Language];
- OMXML [OGC/IS 10-025r1 Observations and Measurements 2.0 – XML Implementation];
- SWE Common 2.0 [OGC/IS 08-094r1 SWE Common Data Model Encoding Standard 2.0];
- GMLCOV 1.0 [OGC/SAP 09-146r2 GML Application Schema – Coverages 1.0.1].

Table ~~9.~~202.20-1. Requirements class xsd-discrete-coverage-observation~~sampling-coverage-measurement~~

TABLE: Table shaded header with lines

Requirements class	
~~http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement~~ *http://def.wmo.int/metce/2013/req/xsd-discrete-coverage-observation*	
Target type	Data instance
Name	Sampling ~~measuremen~~Discrete coverage observation
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation, OMXML clause 7.3
~~Dependency~~	~~http://www.opengis.net/spec/OMXML/2.0/req/sampling, OMXML clause 7.14~~
~~Dependency~~	~~http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling, OMXML clause 7.15~~
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components, SWE Common 2.0 clause 8.1
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-record-components, SWE Common 2.0 clause 8.2
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-block-components, SWE Common 2.0 clause 8.4
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-encodings, SWE Common 2.0 clause 8.5
~~Dependency~~	~~http://www.opengis.net/spec/SWE/2.0/req/general-encoding-rules, SWE Common 2.0 clause 9.1~~
~~Dependency~~	~~http://www.opengis.net/spec/SWE/2.0/req/text-encoding-rules, SWE Common 2.0 clause 9.2~~
~~Dependency~~	~~http://www.opengis.net/spec/SWE/2.0/req/xml-encoding-rules, SWE Common 2.0 clause 9.3~~
Dependency	http://www.opengis.net/spec/gmlcov/1.0/req/gml-coverage, GMLCOV 1.0 clause 6
Dependency	http://www.opengis.net/spec/gmlcov/1.0/req/gml, GMLCOV 1.0 clause 7
Requirement	http://def.wmo.int/metce/2013/req/xsd-discrete-coverage-observation/xmlns-declaration-swe The OGC SWE Common 2.0 namespace http://www.opengis.net/swe/2.0 shall be declared within the XML document.
Requirement	http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement/xmlns-declaration-gmlcov The OGC GMLCOV 1.0 namespace http://www.opengis.net/gmlcov/1.0 shall be declared within the XML document.
Requirement	http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement/result-discrete-or-grid-coverage The XML element om:result shall contain a child element gml:DiscreteCoverage (or any element of a substitution group of

	gml:DiscreteCoverage), gml:GridCoverage, gml:RectifiedGridCoverage or gml:ReferenceableGridCoverage.
Requirement	http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement/result-coverage-gml-encoding The child element of om:result shall be represented in GML as defined in GMLCOV 1.0 clause 7. MultiPart representation and special format representation shall not be used.
~~Requirement~~	~~http://def.wmo.int/metce/2013/req/xsd-sampling-coverage-measurement/procedure-metce-process~~ ~~The XML element om:procedure shall contain a child element metce:Process or any element of a substitution group of metce:Process.~~
Recommendation	http://def.wmo.int/metce/2013/req/xsd-discrete-coverage-observation/xmlns-prefix-swe The default namespace prefix used for http://www.opengis.net/swe/2.0 should be "swe".
Recommendation	http://def.wmo.int/metce/2013/req/xsd-discrete-coverage-observation/xmlns-prefix-gmlcov The default namespace prefix used for http://www.opengis.net/gmlcov/1.0 should be "gmlcov".

Notes:

1. Dependency http://www.opengis.net/spec/OMXML/2.0/req/observation has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/observation (OMXML clause A.1).

~~2. Dependency http://www.opengis.net/spec/OMXML/2.0/req/sampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/sampling (OMXML clause A.12).~~

~~3. Dependency http://www.opengis.net/spec/OMXML/2.0/req/spatialSampling has associated conformance class http://www.opengis.net/spec/OMXML/2.0/conf/spatialSampling (OMXML clause A.13).~~

2.~~4.~~ Dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-simple-components (SWE Common 2.0 clause A.8).

3.~~5.~~ Dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-record-components has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-record-components (SWE Common 2.0 clause A.9).

4.~~6.~~ Dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-block-components has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-block-components (SWE Common 2.0 clause A.11).

5.~~7.~~ Dependency http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-encodings has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xsd-simple-encodings (SWE Common 2.0 clause A.12).

~~8. Dependency http://www.opengis.net/spec/SWE/2.0/req/general-encoding-rules has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/general-encoding-rules (SWE Common 2.0 clause A.14).~~

~~9. Dependency http://www.opengis.net/spec/SWE/2.0/req/text-encoding-rules has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/text-encoding-rules (SWE Common 2.0 clause A.15).~~

~~10. Dependency http://www.opengis.net/spec/SWE/2.0/req/xml-encoding-rules has associated conformance class http://www.opengis.net/spec/SWE/2.0/conf/xml-encoding-rules (SWE Common 2.0 clause A.16).~~

6.~~11.~~ The canonical schema location for OGC SWE Common 2.0 (http://www.opengis.net/swe/2.0) is http://schemas.opengis.net/sweCommon/2.0/swe.xsd.

7.~~12.~~ Dependency http://www.opengis.net/spec/gmlcov/1.0/req/gml-coverage has associated conformance class (GMLCOV 1.0 clause A.1)

8.~~12.~~ Dependency http://www.opengis.net/spec/gmlcov/1.0/req/gml has associated conformance class (GMLCOV 1.0 clause A.2)

9.~~14.~~ The canonical schema location for OGC GMLCOV 1.0 (http://www.opengis.net/gmlcov/1.0) is http://schemas.opengis.net/gmlcov/1.0/gmlcovAll.xsd.

Update reference to the location of the schemas for METCE

Replace every occurrence of http://schemas.wmo.int/metce/1.1/metce.xsd with http://schemas/wmo.int/metce/1.2rc1/metce.xsd

Amend the first column(Label) of the existing three rows from Code Table D-3 to show the row as Deprecated

Complex Sampling Measurement (Deprecated)

Sampling Coverage Measurement (Deprecated)

Sampling Observation (Deprecated)

Add the following rows to Table D-3

Label	*Notation*	*Code-space*	*Description*
Category observation	OM_CategoryObservation	http://www.opengis.net/def/observationType/OGC-OM/2.0/	Observation whose result is a Scoped Name (as defined in ISO 19156:2011 Clause 7.2.2). For example: A category observation of the "taxon" (property-type) of "specimen 123" (feature-of-interest) by "Amy Bachrach" (procedure) had the result "Eucalyptus caesia" (from the Flora of Australia).
Complex observation	OM_ComplexObservation	http://www.opengis.net/def/observationType/OGC-OM/2.0/	Observation whose result is a Record (as defined in ISO 19156:2011 Clause 7.2.2). For example: A complex observation of "major element composition" (property-type) for "specimen h8j" (feature-of-interest) using the "ICPMS" (procedure) had the result "(… array of element proportions …)". OM_ComplexObservation is intended for use where the observation event is concerned with the evaluation of multiple properties at a specified location and time instant or duration. The 'result' of this class of observations is a group of values, provided as a Record (as defined in ISO 19103:2005 Geographic information – Conceptual schema language).

Label	*Notation*	*Code-space*	*Description*
Count observation	OM_CountObservation	http://www.opengis.net/def/observationType/OGC-OM/2.0/	Observation whose result is an Integer (as defined in ISO 19156:2011 Clause 7.2.2). For example: A count observation of "the number of votes cast" (property-type) at "the municipal election" (feature-of-interest) using the "electronic voting machine tally" (procedure) had the result "3542".
Discrete coverage observation	OM_DiscreteCoverageObservation	http://www.opengis.net/def/observationType/OGC-OM/2.0/	Observation whose result is a Discrete Coverage (as defined in ISO 19156:2011 Clause 7.3.2). Examples include: (i) The colour of a scene varies with position. The result of an observation of the property "colour" of the scene is a coverage. Each domain element is a pixel whose index allows the spatial location within the scene to be obtained. (ii) Temperature may be sampled using an array of weather stations. The temperature field of the region covered by the array may be represented as a discrete point coverage, whose domain-elements correspond to the station locations. OM_DiscreteCoverageObservation is intended for use where the observation event is concerned with the evaluation of properties that vary with respect to space and/or time. The 'result' of this class of observations is a discrete coverage (as defined in ISO 19123:2005 Geographic information – Schema for coverage and geometry functions).
Geometry observation	OM_GeometryObservation	http://www.opengis.net/def/observationType/OGC-OM/2.0/	Observation whose result is a geometry (as defined in ISO 19156:2011 Clause 7.2.2). For example: A geometry observation of "perimeter" (property-type) for "plot 987" (feature-of-interest) using the "field survey GHJ" (procedure) had the result "(… description of polygon …)".

Label	*Notation*	*Code-space*	*Description*
Measurement	OM_Measurement	http://www.opengis.net/def/observationType/OGC-OM/2.0/	Observation whose result is a scaled number or Measure (as defined in ISO 19156:2011 Clause 7.2.2). For example: A measurement of "mass" (property-type) of "the seventh banana" (feature-of-interest) using the "kitchen scales" (procedure) had the result "150g".
Observation	OM_Observation	http://www.opengis.net/def/observationType/OGC-OM/2.0/	Observation whose result type is unconstrained (as defined in ISO 19156:2011 Clause 7). An observation is an act that results in the estimation of the value of a feature property, and involves application of a specified procedure, such as a sensor, instrument, algorithm or process chain. The procedure may be applied in-situ, remotely, or ex-situ with respect to the sampling location. Use of a common model allows observation data using different procedures to be combined unambiguously. Observation details are also important for data discovery and for data quality estimation. Observation feature types are defined by the properties that support these applications.
Temporal observation	OM_TemporalObservation	http://www.opengis.net/def/observationType/OGC-OM/2.0/	Observation whose result is a TM_Object (as defined in ISO 19156:2011 Clause 7.2.2). For example: A temporal observation of "duration" (property-type) for "Usain Bolt 100m dash" (feature-of-interest) using the "stop watch" (procedure) had the result "9.6s".
Truth observation	OM_TruthObservation	http://www.opengis.net/def/observationType/OGC-OM/2.0/	Observation whose result is a Boolean (as defined in ISO 19156:2011 Clause 7.2.2). For example: A truth observation of "presence" (property-type) of "intruder" (feature-of-interest) using the "CCTV" (procedure) had the result "false".

Make the following editorial amendments to Note 3 of section 2.2.3 for consistency

202.3 Virtual typing

3. The URI for each observation type is composed by appending the *notation* to the *code-space*. As an example, the URI of ~~ComplexSamplingMeasurement~~ DiscreteTimeSeriesObservation is ~~http://codes.wmo.int/common/observation-type/METCE/2013/ComplexSamplingMeasurement~~ http://codes.wmo.int/common/observation-type/METCE/2013/DiscreteTimeSeriesObservation

Recommendation 12 (CBS-16)

DATA REPRESENTATIONS FOR HYDROLOGICAL INFORMATION

THE COMMISSION FOR BASIC SYSTEMS,

Noting that the Commission for Hydrology had initiated development of the WMO Hydrological Observing System that would require the exchange of hydrological information between Members,

Noting further:

(1) That standardizing on a limited number of data representations offered potential savings of time and money for Members,

(2) That the Commission for Hydrology had worked closely with the Open Geospatial Consortium in developing a standard representation of time series of hydrological information known as WaterML2 Part 1 and a standard representation of streamflow information known as WaterML2 Part 2,

(3) That the *Manual on the WMO Information System* (WMO-No. 1060) requires Members to create WMO Information System discovery metadata records to describe the information they wish to make available to other Members,

Recommends to the Executive Council, subject to the concurrence of the Commission for Hydrology at its fifteenth session, the draft resolution — Data representations for hydrological information, contained in the annex to the present recommendation and Annex 1 to that draft resolution;

Authorizes its Management Group to reconcile that draft resolution with any modifications proposed by the Commission of Hydrology at its fifteenth session and prepare it for submission to the Executive Council.

Annex to Recommendation 12 (CBS-16)

DRAFT RESOLUTION FOR CONSIDERATION BY THE EXECUTIVE COUNCIL AT ITS SIXTY-NINTH SESSION ON WATERML 2.0

DATA REPRESENTATIONS FOR HYDROLOGICAL INFORMATION

THE EXECUTIVE COUNCIL,

Noting that the Commission for Hydrology had initiated the WMO Hydrological Observing System that would require the exchange of hydrological information between Members,

Noting further:

(1) That standardizing on a limited number of data representations offered potential savings of time and money for Members,

(2) That the Commission for Hydrology had worked closely with the Open Geospatial Consortium in developing a standard representation of time series of hydrological information known as WaterML2 Part 1 and a standard representation of streamflow information known as WaterML2 Part 2,

(3) That the *Manual on Codes* (WMO-No. 306) Volume I.3 records data representations derived from data models,

(4) That the *Manual on WIS* (WMO-No. 1060) requires Members to create WIS Discovery Metadata records to describe the information they wish to make available to other Members,

(5) That the published edition of the *Guide to Hydrological Practices,* Volume I (WMO-No. 168) pre-dates the WMO Information System and the work of the Open Geospatial Consortium on data representations for hydrology,

Decides:

(1) To amend the *Manual on Codes* (WMO-No. 306) Volume I.3 to introduce WaterML2 Part 1 and WaterML2 Part 2 as data representations that are suitable for the exchange of hydrological information as specified in Annex 1 - *Introduction of WaterML2 Part 1 and WaterML2 Part 2*;

[Note: Decides (2) and Annex 2 are provided for information to show the complete context of the resolution. CHy-15 will consider their contents and recommend any changes that are needed.]

(2) To amend the *Guide to Hydrological Practices* (WMO-No. 168) Volume I as specified in Annex 2;

Requests the Secretary-General to amend the text of the *Manual on Codes* (WMO-No. 306) Volume I.3 and WMO-No. 168 as specified in Annexes 1 and 2 respectively and to make editorial changes as needed.

Annexes: 2

Annex 1 to the draft Resolution for consideration by EC-69 on WaterML 2.0

Introduction of WaterML2 Part 1 and WaterML2 Part 2 into Volume I.3 of WMO-No. 306 *Manual on Codes*

Amend WMO-No. 306 Manual on Codes Volume I.3 as follows.

In the section "FM system of extensible markup language representations" add the following entry.

FM 231 Ext. WMLTS-XML	Hydrological Timeseries. Allows a monotonic series of observations over time to be described to the level of detail required for accurate representation as timeseries, with specific consideration for Hydrological data. Res. X (EC-69)
FM 232 Ext. WMLRGS-XML	Ratings, Gaugings and Sections. Allows the description of the process and conversions used to determine hydrological observations such as river discharge. Res. X (EC-69)

Add new section FM231: WMLTS-XML and FM232 WMLRGS-XML following section FM 221: TMSL-XML.

FM 231: WaterML2 – Time series

FM 231-16 WMLTS-XML WATERML2 TIME SERIES OBSERVATIONS

231.1 Scope

WMLTS-XML shall be used for the exchange in extensible markup language (XML) of time series of hydrological information conforming to the "WaterML2.0 Part 1 Timeseries" conceptual model. WMLTS-XML may be used directly to represent time series information or incorporated as components within other XML encodings.

Note; WaterML2.0 Part 1 Timeseries was developed jointly by the World Meteorological Organization and the Open Geospatial Consortium.

Note: the WMLTS-XML application schema and XML encoding are both described in the document OGC/IS 10-126r4 WaterML 2.0: Part 1 - Timeseries. A copy of that document is available at http://wis.wmo.int/WMLTS and the reference version of the associated schema is available from http://schemas.opengis.net/waterml/2.0 (WMO retains a copy of the schema at http://schemas.wmo.int/waterml/2.0).

Note: further information on handling application schema and data modelling can be found in the informal document Guidelines on Data Modelling for WMO Codes (available in English only from http://wis.wmo.int/metce-uml).

Note: representation of non-hydrological information in time series should use FM-221 TSML.

FM 232: WaterML2 – Ratings, Gaugings and Sections

FM 232-16 WMLRGS -XML WATERML Ratings, gaugings and sections

232.1 Scope

WMLRGS-XML shall be used for the exchange in extensible markup language (XML) of hydrological information conforming to the "WaterML2.0 Part 2 Ratings, Gaugings and Sections" conceptual model. WMLRGS-XML may be used directly to encode Ratings, Gaugings and Sections information or incorporated as components within other XML encodings.

Note; WaterML2.0 Part 2 Ratings, Gaugings and Sections was developed jointly by the World Meteorological Organization and the Open Geospatial Consortium.

Note: the WMLRGS-XML application schema and XML encoding are both described in the document 15-018r2_OGC_WaterML2.0_part_2_-_Ratings_Gaugings_and_Sections (Version 1.0). A copy of that document is available at http://wis.wmo.int/WMLRGS and the reference version of the associated schema is available from http://schemas.opengis.net/waterml/part2/1.0 (WMO retains a copy of the schema at http://schemas.wmo.int/waterml/part2/1.0).

Note: further information on handling application schema and data modelling can be found in the informal document Guidelines on Data Modelling for WMO Codes (available in English only from http://wis.wmo.int/metce-uml).

Annex 2 to the draft Resolution for consideration by EC-69

[Note: this draft of Annex 2 is provided for information. CHy-15 will consider its contents and recommend any changes that are needed].

Add the following new paragraph before the first paragraph of section "10.4.2Catalogues of data availability" to read

The first step in using data is to discover what is available and where to find more information about it. For data that are exchanged between Members, the Manual on the *WMO Information System* (WMO-No. 1060) defines "WIS Discovery Metadata Records" that are published in the

WIS Discovery Metadata Catalogue that is available from all the Global Information System Centres (http://wis.wmo.int/giscs). These records describe the datasets of information that are available; a record could describe as little as a single report or as much as a complete archive of all observations from a country at the discretion of the owner of the data. They should include enough information to allow a potential user to decide whether the data are likely of use and are focussed on describing the datasets. The *Manual on WIGOS* (WMO-No. 1160) defines the complementary station metadata that describe the conditions under which observations were made, and these records, compatible with the advice in section 10.2.3.2, are available from http://oscar.wmo.int/surface).

Amend the first paragraph in section 10.4.6 to read as follows

~~There are currently no standards~~ Standards for data exchange formats for hydrological data have been developed but not widely adopted. ~~The only standards that exist are~~ The most common exchange formats are the de facto standard formats produced by the most common data loggers and database software systems. Current data exchange formats generally fall into two categories, as follows.

Amend the final two paragraphs in section paragraph 10.4.6 to read as follows.

One major advantage of XML is that it can be specialized in particular subjects. For example, libraries have defined an international format for describing the tags and rules for storing information about books in XML. These standards indicate that all libraries can provide data that can be read and understood by all other libraries. The same is gradually occurring in the more complex area of environmental science. Already there are emerging XML formats for a wide range of applications, including the description of molecules and the Climate Science Modelling Language. GIS data now have a comprehensive XML-based standard called the Geography Markup Language (GML) that will allow the interaction of digital maps from all sources, and could be used for the dissemination of spatial data. GML is the XML grammar ~~defined by the Open Geospatial Consortium (OGC)~~ to express geographical features defined by the Open Geospatial Consortium (OGC) and adopted by the International Organization for Standardization as ISO 19136-2 (Cox and others, 2004). GML serves as a modelling language for geographic systems as well as an open interchange format for geographic transactions on the Internet.

~~Many of the definitions of these XML specialisms (areas in which XML specializes) are still evolving and thus should be used with care. However, some successfully defined languages have achieved ISO standard recognition. An XML specialization in the field of hydrology has not yet been developed, although the United States National Weather Service has established a Hydrology XML consor- tium and produced a draft hydrology XML schema.~~ The World Meteorological Organization and the Open Geospatial Consortium have jointly developed representations for time series of hydrological data (WaterML2.0 Part 1) and for ratings, gaugings and sections (WaterML2.0 Part 2). Standard references for these representations are available from WMO-No. 306 *Manual on Codes* Volume I.3 as FM-231 and FM-232.

Recommendation 13 (CBS-16)

PROVISIONAL OPERATIONAL IMPLEMENTATION OF DATA REPRESENTATION FOR INFORMATION IN SUPPORT OF INTERNATIONAL AIR NAVIGATION

THE COMMISSION FOR BASIC SYSTEMS,

Recalling that version 1.1 of the International Civil Aviation Organization (ICAO) meteorological information exchange model (IWXXM 1.1) was approved by the Seventeenth World Meteorological Congress in 2015,

Noting that Amendment 77 to Annex 3 of the Convention on International Civil Aviation (also published as *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation) introduced exchange in XML of information that cannot be represented by IWXXM 1.1 and permits bilateral exchange of such information from November 2016,

Recognizing that the Task Team on Aviation XML (TT-AvXML) prepared and made available for use the version 2.0RC2 of IWXXM in August 2016 to meet the new requirements in exchanging information in XML/GML as specified in Amendment 77 to Annex 3 of the Convention on International Civil Aviation,

Understanding that ICAO is expected to propose to upgrade the requirements for exchanging information in XML/GML from a recommended practice to a standard as part of Amendment 78 to Annex 3 of the Convention on International Civil Aviation, with an expected effective date in July 2018 and applicability date in November 2020,

Recognizing further that training workshops on the implementation of IWXXM 2.0RC2 had been conducted in 2016 and Hong Kong, China is planning to hold another training workshop in 2017,

Understanding further that TT-AvXML has reviewed user feedbacks on IWXXM 2.0RC2 since it was made available and has concluded that IWXXM 2.0RC2 is stable and mature for operational use,

Noting further that the president of the Commission for Aeronautical Meteorology (CAeM) is of the view that IWXXM 2.0RC2 should be approved as early as possible and called "IWXXM 2.0" to enable the exchange of meteorological information in support of international air navigation, and that it would be highly desirable if the Commission for Basic Systems fast track procedure could be considered for approving future amendments to IWXXM,

Recommends to the Executive Council:

(1) To endorse use of version IWXXM 2.0 and its supporting schemas as described in the annex to the present recommendation;

(2) To use the code identifier FM 205-16 IWXXM-XML to identify the constituent components of the version described in the annex to the present recommendation so that it can be distinguished from later versions;

(3) To adopt IWXXM 2.0 for inclusion in the *Manual on Codes* (WMO-No. 306), Volume I.3;

(4) To designate *Manual on Codes*, Volume I.3, Part D – Representations derived from data models, as Technical Specifications to which the fast track (simple) procedure for amendments may be applied;

Authorizes the Secretary-General to make editorial changes to the documentation defining and supporting the IWXXM 2.0 as provided in the annex to the present recommendation;

Requests the Secretary-General to make provision for IWXXM 2.0 as approved by the Executive Council together with supporting reference material required for its operation to be available permanently so that archived information recorded in that version may be interpreted correctly;

Urges Members to start using version IWXXM 2.0 and its supporting schemas and provide feedback to the Open Programme Area Group on Information Systems and Services (OPAG-ISS) through their focal point for codes and data representation;

Requests OPAG-ISS:

(1) To collect further feedback from Members and review the effectiveness of version IWXXM 2.0 and its supporting schemas following a period of use by Members;

(2) To modify IWXXM 2.0 in response to user comments;

(3) To gather feedback on the effectiveness of IWXXM 2.0 and to provide a revised version to also cover other aeronautical meteorological information exchange for recommendation to the Executive Council in time for implementation before the applicability date when the requirements for exchanging information in XML/GML become a standard;

Requests the Secretary-General to communicate to ICAO WMO Members' concern over timelines associated with implementation and further development of ICAO IWXXM;

Requests its Management Group to set up a mechanism for improved communication with CAeM on implementation and further development of IWXXM.

Annex to Recommendation 13 (CBS-16)

SPECIFICATION OF THE INTERNATIONAL CIVIL AVIATION ORGANIZATION METEOROLOGICAL INFORMATION EXCHANGE MODEL VERSION 2.0RC2

The text of this Annex is expressed as changes to the 2015 Edition of the *Manual on Codes* (WMO-No. 306) Volume I.3.

Additions are marked as green dotted-underline text, and deletions are marked as ~~red strikeout~~ text. Text marked with a double underline or that appears to be a URL should be reproduced verbatim in translated versions of this text (without the double underline). Where complete sections of text are to be added or removed the mark-up colours are not used.

In the section "FM System of numbering XML markup language application schemas" amend Notes on nomenclature (a)

(a) ... For example, ~~FM 202-15 Ext.~~ FM 202-16 METCE-XML has the namespace http://def.wmo.int/metce/2013 (initial year of work 2013) whilst ~~FM 205-15 Ext.~~ FM 205-16 IWXXM- XML has the namespace ~~http://icao.int/iwxxm/1.1~~ http://icao.int/iwxxm/2.0 (version number ~~1.1~~2.0).

In the section "FM System of extensible markup language representations" remove the entry FM- 204-15 Ext. SAF-XML and amend the entry FM 205-15 Ext. IWXXM-XML

FM 205-16 **~~FM 205-15 Ext.~~** **IWXXM-XML**	ICAO Meteorological Information Exchange Model. Defines the reports required by the International Civil Aviation Organization (ICAO) – with information content equivalent to that in the alphanumeric METAR/SPECI, TAF, ~~and~~ SIGMET, AIRMET, Tropical Cyclone Advisory and Volcanic Ash Advisory code forms – that are built from the components of the packages managed by WMO. Resolution ~~32 (Cg-17)~~ ?? (EC-??)

Remove section FM 204:SAF and all its text and tables.

Amend paragraph 205.1.2 and its notes

205.1.2 IWXXM-XML includes provision for aerodrome routine meteorological reports (METAR), aerodrome special meteorological reports (SPECI), aerodrome forecast (TAF) reports, ~~and~~ SIGMET information, AIRMET information, Tropical Cyclone Advisory and Volcanic Ash Advisory.

Notes:

1. SIGMET information is information issued by a meteorological watch office concerning the occurrence or expected occurrence of specified en-route weather phenomena that may affect the safety of aircraft operations.

2. AIRMET Information is information issued by a meteorological watch office concerning the occurrence or expected occurrence of specified en-route weather phenomena that may affect the safety of low-level aircraft operations and which was not already included in the forecast issued for low-level flights in the flight information region concerned or sub-area thereof.

3. Tropical Cyclone Advisory Information is information issued by a Tropical Cyclone Advisory Centre (TCAC) regarding the position, forecast direction and speed of movement, central pressure and maximum surface wind of tropical cyclones.

4. Volcanic Ash Advisory Information is information issued by a Volcanic Ash Advisory Centre (VAAC) regarding the lateral and vertical extent and forecast movement of volcanic ash in the atmosphere following volcanic eruptions.

Amend table 37 "Requirements classes defined in IWXXM-XML"

Requirements classes	
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-cloud-layer, 205.4~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast, 205.5~~
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report, 205.4
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-speci, 205.5
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-metar, 205.6
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record, 205.7
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record, 205.8
Requirements class	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state, 205.6~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state, 205.9
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-visual-range, 205.10
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-aerodrome-sea-state, 205.11
Requirements class	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-wind-shear, 205.7~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-wind-shear, 205.12
Requirements class	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds, 205.8~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-observed-clouds, 205.13
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range, 205.9~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state, 205.10~~

Requirements class	http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind, 205.14
Requirements class	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility, 205.11~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-horizontal-visibility, 205.15
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind, 205.12~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record, 205.13~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation, 205.14~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast, 205.15~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record, 205.16~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast, 205.17~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report, 205.18~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-metar, 205.19~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-speci, 205.20~~
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-taf, 205.16
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record, 205.17
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-aerodrome-air-temperature-forecast, 205.18
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-forecast, 205.21~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast, 205.22~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record, 205.23~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast, 205.24~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-taf, 205.25~~
Requirements class	~~http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition, 205.26~~ http://icao.int/iwxxm/2.0/req/xsd-evolving-meteorological-condition, 205.22
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet-evolving-condition-analysis, 205.27~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-position, 205.28~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-position-collection, 205.29~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet-position-analysis, 205.30~~
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet, 205.31~~
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-sigmet, 205.23

Requirements class	~~http://icao.int/iwxxm/1.1/req/xsd-volcanic-ash-sigmet, 205.32~~ http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-sigmet, 205.24
~~Requirements class~~	~~http://icao.int/iwxxm/1.1/req/xsd-tropical-cyclone-sigmet, 205.33~~
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-airmet, 205.25
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-airmet-evolving-meteorological-condition, 205.26
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-advisory, 205.27
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-observed-conditions, 205.28
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-forecast-conditions, 205.29
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-advisory, 205.30
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-conditions, 205.31
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-cloud, 205.32
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-report, 205.33
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-aerodrome-cloud-forecast, 205.34
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind-forecast, 205.35
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind-trend-forecast, 205.36
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-cloud-layer, 205.37
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-angle-with-nil-reason, 205.38
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-distance-with-nil-reason, 205.39
Requirements class	http://icao.int/iwxxm/2.0/req/xsd-length-with-nil-reason, 205.40

Amend the notes to section 205.2 "XML schema for IWXXM-XML"

2. The XML schema is packaged in five XML schema documents (XSD) describing one XML namespace: ~~http://icao.int/f/1.1~~ http://icao.int/iwxx/2.0.

3. Schematron schemas providing additional constraints are ~~embedded within~~ provided as an external file to the XSD defining IWXXM-XML. The canonical location of this file is http://schemas.wmo.int/iwxxm/2.0/rule/iwxxm.sch.

Amend Table 38 "XML namespaces defined for IWXXM-XML"

XML namespace	*Default namespace prefix*	*Canonical location of all-components schema document*
~~http://icao.int/iwxxm/1.1~~ http://icao.int/iwxxm/2.0	iwxxm	~~http://schemas.wmo.int/iwxxm/1.1/iwxxm.xsd~~ http://schemas.wmo.int/iwxxm/2.0/iwxxm.xsd

Amend Table 39 "External XML namespaces used in IWXXM-XML" Amend the 5th row after the heading and replace the last row in the table

Standard	*XML namespace*	*Default namespace prefix*	*Canonical location of all-components schema document*
…	…	…	…
ISO 19136:~~2006~~2007 GML	http://www.opengis.net/gml/3.2	gml	http://schemas.opengis.net/gml/3.2.1/gml.xsd
…	…	…	…
~~FM 204-15 Ext SAF XML~~	~~http://icao.int/saf/1.1~~	~~saf~~	~~http://schemas.wmo.int/saf/1.1/saf.xsd~~
AIXM 5.1.1	http://www.aixm.aero/schema/5.1.1	aixm	http://www.aixm.aero/schema/5.1.1_profiles/AIXM_WX/5.1.1a/AIXM_Features.xsd

Amend notes in section 205.3 "virtual typing"

2. Code table D-4 is published online at ~~http://codes.wmo.int/49-2/observation-type/IWXXM/1.0~~ http://codes.wmo.int/49-2/observation-type/IWXXM/2.0.

3. The URI for each observation type is composed by appending the *notation* to the *code-space*. ~~As an~~For example, the URI of MeteorologicalAerodromeForecast is ~~http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeForecast~~http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/MeteorologicalAerodromeForecast.

Move section 205.18 "Requirements class: Meteorological aerodrome observation report". Update paragraph numbers to reflect the new section number. Amend old table 56 to table 205-1, update its contents as follows, and change the table reference in old paragraphs 205.18.2 and 205.18.3 to refer to Table 205-1.

Table ~~56~~205-1. Requirements class xsd-meteorological-aerodrome-observation-report

TABLE: Table shaded header with lines

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report	
Target type	Data instance
Name	Meteorological aerodrome observation report
~~Dependency~~	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation, 205.14~~
~~Dependency~~	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast, 205.17~~
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/valid~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report/valid The content model of this element shall have a value that matches the content model of iwxxm:MeteorologicalAerodromeObservationReport.

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/status~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report/status The status of the report shall be indicated using the XML attribute @status with the value being one of the enumeration: "NORMAL", "MISSING" or "CORRECTION".
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/automated-station~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report/automated-station If the meteorological aerodrome observation included within the report has been generated by an automated system, the value of XML attribute @automatedStation shall be set to "true".
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/observation~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report/observation The XML element //iwxxm:observation shall contain a valid child element om:OM_Observation of type MeteorologicalAerodromeObservation. The value of XML attribute //iwxxm:observation/om:OM_Observation/om:type/@xlink:href shall be the URI ~~"http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeObservation"~~ "http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/MeteorologicalAerodromeObservation".
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/trend-forecast~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report/trend-forecast If trend forecasts are reported, the value of XML element //iwxxm:trendForecast shall be a valid child element om:OM_Observation of type MeteorologicalAerodromeTrendForecast. For each trend forecast, the value of XML attribute //iwxxm:trendForecast/om:OM_Observation/om:type/@xlink:href shall be the URI ~~"http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeTrendForecast"~~ "http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/MeteorologicalAerodromeTrendForecast".
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/number-of-trend-forecasts~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report/number-of-trend-forecasts No more than three trend forecasts shall be reported.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/unique-subject-aerodrome~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-

Requirements class	
	report/unique-subject-aerodrome The observation and, if reported, trend forecasts shall refer to the same aerodrome. All values of XML element ~~//om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/saf:Aerodrome/gml:identifier~~ //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/aixm:AirportHeliport/gml:identifier within the meteorological aerodrome observation report shall be identical.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/nil-report~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report/nil-report If XML attribute @status has value "MISSING", then a NIL report shall be provided: (i) XML element //iwxxm:observation/om:OM_Observation/om:result shall have no child elements and XML attribute //iwxxm:observation/om:OM_Observation/om:result/@nilReason shall provide an appropriate nil-reason; (ii) XML attribute @automatedStation shall be absent; and (iii) XML element //iwxxm:trendForecast shall be absent.
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/nosig~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report/nosig If no change of operational significance is forecast, then a single XML element //iwxxm:trendForecast should be included with no child elements therein and the value of XML attribute //iwxxm:trendForecast/@nilReason should indicate "inapplicable".

Notes:

…

5. Within an XML encoded meteorological aerodrome report, it is likely that only one instance of ~~saf:Aerodrome~~ aixm:AirportHeliport will physically be present; subsequent assertions about the aerodrome may use xlinks to refer to the previously defined ~~saf:Aerodrome~~ aixm:AirportHeliport element in order to keep the XML document size small. As such, validation of requirement ~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report/unique-subject-aerodrome~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report/unique-subject-aerodrome is applied once any xlinks, if used, have been resolved.

Move old section 205.20 "Requirements class: SPECI" to form new section 205.5 and renumber paragraphs accordingly. Re-label Table 58 and its reference to Table 205.5-1 and amend the contents as shown.

Table ~~58~~205.5-1. Requirements class xsd-speci

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-speci~~http://icao.int/iwxxm/2.0/req/xsd-speci	
Target type	Data instance
Name	SPECI

Requirements class	
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report, 205.18~~http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report, 205.4
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-speci/valid~~ http://icao.int/iwxxm/2.0/req/xsd-speci/valid The content model of this element shall have a value that matches the content model of iwxxm:SPECI.

Move old section 205.19 "Requirements class: METAR" to form new section 205.6 and renumber paragraphs accordingly. Re-label Table 57 and its reference to Table 205.6-1 and amend the contents as shown.

Table ~~57~~205.6-1. Requirements class xsd-metar

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-metar~~http://icao.int/iwxxm/2.0/req/xsd-metar	
Target type	Data instance
Name	METAR
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-report, 205.18~~http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-report, 205.4
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-metar/valid~~ http://icao.int/iwxxm/2.0/req/xsd-metar/valid The content model of this element shall have a value that matches the content model of iwxxm:METAR.

Move old section 205.16 "Requirements class: Meteorological aerodrome trend forecast record " to form new section 205.7 and renumber paragraphs accordingly. Re-label Table 53 and its reference to Table 205.7-1 and amend the contents as shown.

Table ~~53~~205.7-1. Requirements class xsd-meteorological-aerodrome-trend-forecast-record

Requirements class	
http://icao.int/iwxxm/~~1.1~~2.0/req/xsd-meteorological-aerodrome-trend-forecast-record	
Target type	Data instance
Name	Meteorological aerodrome trend forecast record
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast, 205.5~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-cloud-forecast, 205.34
Dependency	http://icao.int/iwxxm/~~1.1~~2.0/req/xsd-aerodrome-surface-wind-trend-forecast, 205.~~15~~36

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/valid~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record/valid The content model of this element shall have a value that matches the content model of iwxxm:MeteorologicalAerodromeTrendForecastRecord.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/change-indicator-nosig~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record/change-indicator-nosig If no operationally significant changes …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/change-indicator-becmg~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record/change-indicator-becmg If the meteorological …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/change-indicator-tempo~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record/change-indicator-tempo If temporary fluctuations …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/cavok~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record/cavok If the conditions associated with CAVOK …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/prevailing-visiblity~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record/prevailing-visiblity If reported, the prevailing visibility…
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/prevailing-visibility-exceeds-10000m~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record/prevailing-visibility-exceeds-10000m If the prevailing visibility exceeds 10 000 metres,…
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/prevailing-visibility-comparison-operator~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record/prevailing-visibility-comparison-operator If present, the value of XML element …

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/forecast-weather~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record/forecast-weather If forecast weather is reported, …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/number-of-forecast-weather-codes~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record/number-of-forecast-weather-codes No more than three forecast weather codes shall be reported.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/surface-wind~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record/surface-wind Surface wind conditions forecast …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-trend-forecast-record/cloud~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-trend-forecast-record/cloud If reported, the cloud conditions …

Move old section 205.13 "Requirements class: Meteorological aerodrome observation record " to form new section 205.8 and renumber paragraphs accordingly. Re-label Table 49 and its reference to Table 205.8-1 and amend the contents as shown.

Table ~~49~~205.8-1. Requirements class xsd-meteorological-aerodrome-observation-record

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record~~http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record	
Target type	Data instance
Name	Meteorological aerodrome observation record
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state, 205.6~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state, 205.9
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-wind-shear, 205.7~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-wind-shear, 205.12
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds, 205.8~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-observed-clouds, 205.13
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range, 205.9~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-visual-range, 205.10

Requirements class	
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state, 205.10~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-sea-state, 205.11
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility, 205.11~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-horizontal-visibility, 205.15
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind, 205.12~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind, 205.14
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/valid~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/valid The content model of this element shall have a value that matches the content model of iwxxm:MeteorologicalAerodromeObservationRecord.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/cavok~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/cavok If the conditions associated with CAVOK are observed, …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/air-temperature~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/air-temperature The air temperature observed at the aerodrome …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/dew-point-temperature~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/dew-point-temperature The dewpoint temperature observed at the aerodrome …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/qnh~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/qnh The atmospheric pressure, known as QNH, …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/present-weather~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/present-weather If present weather is reported, …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/number-of-present-weather-codes~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/number-of-present-weather-codes No more than three present weather codes shall be reported.

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/recent-weather~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/recent-weather If recent weather is reported, …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/number-of-recent-weather-codes~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/number-of-recent-weather-codes No more than three recent weather codes shall be reported.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/surface-wind~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/surface-wind Surface wind conditions …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/runway-state~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/runway-state If reported, the surface conditions for a given runway direction …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/wind-shear~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/wind-shear If reported, the wind shear …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/cloud~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/cloud If reported, the cloud conditions …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/runway-visual-range~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/runway-visual-range If reported, the visual range conditions …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/number-of-rvr-groups~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/number-of-rvr-groups Visual range conditions shall be reported for no more than four runway directions.

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/sea-state~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/sea-state If reported, the sea-state conditions …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/visibility~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/visibility If reported, the horizontal visibility conditions …
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-observation-record/present-weather-not-observable~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-observation-record/present-weather-not-observable If present weather is not observable …

Move old section 205.6 "Requirements class: Aerodrome runway state" to form new section 205.9 and renumber paragraphs accordingly. Re-label Table 42 and its reference to Table 205.9-1 and amend the contents as shown.

Table ~~42~~205.9-1. Requirements class xsd-aerodrome-runway-state

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state	
Target type	Data instance
Name	Aerodrome runway state
~~Dependency~~	~~http://icao.int/saf/1.1/req/xsd-runway-direction, 204.6~~
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/valid~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state/valid The content model of this element…
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/applicable-runway~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state/applicable-runway If XML attribute //iwxxm:AerodromeRunwayState/@allRunways is absent or has value “false”, then XML element //iwxxm:AerodromeRunwayState/iwxxm:runway, with valid child element ~~//iwxxm:AerodromeRunwayState/iwxxm:runway/saf:RunwayDirection~~ //iwxxm:AerodromeRunwayState/iwxxm:runway/aixm:RunwayDirection, shall be used to indicate the runway direction to which these conditions apply.

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/all-runways~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state/all-runways If XML attribute //iwxxm:AerodromeRunwayState/@allRunways has value "true", then XML element //iwxxm:AerodromeRunwayState/iwxxm:runway shall be absent.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/snow-closure~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state/snow-closure If the aerodrome is closed due to an extreme deposit of snow…
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/cleared~~ http://icao.int/iwxxm/2.0 /req/xsd-aerodrome-runway-state/cleared If the runway has been cleared of meteorological deposits, …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/surface-friction-estimate~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state/surface-friction-estimate If reported, the estimated surface friction …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/surface-friction-estimate-unit-of-measure~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state/surface-friction-estimate-unit-of-measure If reported, the estimated surface friction …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/unreliable-surface-friction-estimate~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state/unreliable-surface-friction-estimate If the surface friction estimate …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/unreliable-surface-friction-estimate-true~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state/unreliable-surface-friction-estimate-true If XML attribute //iwxxm:AerodromeRunwayState/ @estimatedSurfaceFrictionUnreliable has value "true", then XML element //iwxxm:AerodromeRunwayState/iwxxm:estimatedSurfaceFriction shall be absent.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/deposit-type-code~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state/deposit-type-code If deposit type is reported, …

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/contamination-code~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state/contamination-code If runway contamination is reported, …
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/snow-closure-affects-all-runways~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state/snow-closure-affects-all-runways If XML attribute //iwxxm:AerodromeRunwayState/@snowClosure has value "true", then XML //iwxxm:AerodromeRunwayState/@allRunways should also have value "true"; snow closure affects all runways at an aerodrome.
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-state/deposit-depth-unit-of-measure~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-state/deposit-depth-unit-of-measure If reported, the depth of deposit …

Move old section 205.9 "Requirements class: Aerodrome runway visual range " to form new section 205.10 and renumber paragraphs accordingly. Re-label Table 45 and its reference to Table 205.10-1 and amend the contents as shown.

Table ~~45~~205.10-1. Requirements class xsd-aerodrome-runway-visual-range

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-visual-range	
Target type	Data instance
Name	Aerodrome runway visual range
~~Dependency~~	~~http://icao.int/saf/1.1/req/xsd-runway-direction, 204.6~~
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/valid~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-visual-range/valid The content model of this element …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/applicable-runway~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-visual-range/applicable-runway The XML element //iwxxm:AerodromeRunwayVisualRange/iwxxm:runway, with valid child element ~~//iwxxm:AerodromeRunwayState/iwxxm:runway/saf:RunwayDirection~~ //iwxxm:AerodromeRunwayState/iwxxm:runway/aixm:RunwayDirection, shall be used to indicate the runway direction to which these visual range conditions apply.

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/mean-rvr~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-visual-range/mean-rvr The XML element //iwxxm:AerodromeRunwayVisualRange/iwxxm:meanRVR ….
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/mean-rvr-unit-of-measure~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-visual-range/mean-rvr-unit-of-measure The mean runway visual …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/mean-rvr-exceeds-2000m~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-visual-range/mean-rvr-exceeds-2000m If the mean runway visual range …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/mean-rvr-comparison-operator~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-visual-range/mean-rvr-comparison-operator If present, the value of XML element //iwxxm:AerodromeRunwayVisualRange/iwxxm:meanRVROperator shall be one of the enumeration: "ABOVE" or "BELOW".
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/upward-or-downward-visual-range-tendency~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-visual-range/upward-or-downward-visual-range-tendency If the runway visual range values observed in the 10-minute period have shown a distinct tendency, …
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-runway-visual-range/no-change-in-visual-range-tendency~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-runway-visual-range/no-change-in-visual-range-tendency If the runway visual range values observed in the 10-minute period have not shown a distinct tendency, …

Move old section 205.10 "Requirements class: Aerodrome sea state" to form new section 205.11 and renumber paragraphs accordingly. Re-label Table 46 and its reference to Table 205.11-1 and amend the contents as shown.

Table ~~46~~205.11-1. Requirements class xsd-aerodrome-sea-state

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-sea-state	
Target type	Data instance

Requirements class	
Name	Aerodrome sea state
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state/valid~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-sea-state/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeSeaState.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state/sea-surface-temperature~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-sea-state/sea-surface-temperature The sea-surface temperature …
Requirement	http://icao.int/iwxxm/~~1.1~~2.0/req/xsd-aerodrome-sea-state/either-significant-wave-height-or-sea-state When significant wave height is reported, …
Requirement	http://icao.int/iwxxm/~~1.1~~2.0/req/xsd-aerodrome-sea-state/significant-wave-height If reported, the observed significant wave height …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state/sea-state-code~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-sea-state/sea-state-code If sea state is reported, …
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-sea-state/significant-wave-height-unit-of-measure~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-sea-state/significant-wave-height-unit-of-measure The significant wave height …

Move old section 205.7 "Requirements class: Aerodrome wind shear" to form new section 205.12 and renumber paragraphs accordingly. Re-label Table 43 and its reference to Table 205.12-1 and amend the contents as shown.

Table ~~43~~205.12-1. Requirements class xsd-aerodrome-wind-shear

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-wind-shear~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-wind-shear	
Target type	Data instance
Name	Aerodrome wind shear
~~Dependency~~	~~http://icao.int/saf/1.1/req/xsd-runway-direction, 204.6~~
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-wind-shear/valid~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-wind-shear/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeWindShear.

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-wind-shear/applicable-runways~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-wind-shear/applicable-runways If XML attribute //iwxxm:AerodromeWindShear/@allRunways is absent or has value "false", then one or more XML elements //iwxxm:AerodromeWindShear/iwxxm:runway, each with valid child element ~~//iwxxm:AerodromeWindShear/iwxxm:runway/saf:RunwayDirection~~ //iwxxm:AerodromeWindShear/iwxxm:runway/iwxxm:RunwayDirection, shall be used to indicate the set of runway directions to which wind shear conditions apply.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-wind-shear/all-runways~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-wind-shear/all-runways If XML attribute //iwxxm:AerodromeWindShear/@allRunways …

Move old section 205.8 "Requirements class: Aerodrome observed clouds" to form new section 205.13 and renumber paragraphs accordingly. Re-label Table 44 and its reference to Table 205.13-1 and amend the contents as shown.

Table ~~44~~205.13-1. Requirements class xsd-aerodrome-observed-clouds

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-observed-clouds	
Target type	Data instance
Name	Aerodrome observed clouds
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-cloud-layer, 205.4~~ http://icao.int/iwxxm/2.0/req/xsd-cloud-layer, 205.37
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/valid~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-observed-clouds/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeObservedClouds.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/amount-and-height-not-detectable-by-auto-system~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-observed-clouds/amount-and-height-not-detectable-by-auto-system When an automatic observing system observes cumulonimbus clouds …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/either-vertical-visibility-or-cloud-layers~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-observed-clouds/either-vertical-visibility-or-cloud-layers When vertical visibility is reported, …

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/vertical-visibility~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-observed-clouds/vertical-visibility When cloud of operational significance is …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/vertical-visibility-unit-of-measure~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-observed-clouds/vertical-visibility-unit-of-measure If the vertical visibility is reported …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/cloud-layers~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-observed-clouds/cloud-layers When the amount and height of cloud of operational significance are observed, …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-observed-clouds/number-of-cloud-layers~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-observed-clouds/number-of-cloud-layers No more than four cloud layers shall be reported. …

Move old section 205.12 "Requirements class: Aerodrome surface wind " to form new section 205.14 and renumber paragraphs accordingly. Re-label Table 48 and its reference to Table 205.14-1 and amend the contents as shown.

~~Table 48~~Table 205.14-1. Requirements class xsd-aerodrome-surface-wind

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind	
Target type	Data instance
Name	Aerodrome surface wind
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind/valid~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeSurfaceWind.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind/mean-wind-speed~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind/mean-wind-speed The mean wind speed shall be stated using the XML element //iwxxm:AerodromeSurfaceWind/iwxxm:meanWindSpeed, …

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind/variable-wind-direction~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind/variable-wind-direction If the wind direction is variable, then the XML attribute //iwxxm:AerodromeSurfaceWind/@variableDirection …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind/steady-wind-direction~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind/steady-wind-direction If the wind direction is not variable…
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind/extreme-wind-direction~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind/extreme-wind-direction If the extremes of wind direction variability are reported …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind/gust-speed~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind/gust-speed If reported, the observed gust speed …

Move old section 205.11 "Requirements class: Aerodrome horizontal visibility" to form new section 205.15 and renumber paragraphs accordingly. Re-label Table 47 and its reference to Table 205.15-1 and amend the contents as shown.

Table ~~47~~105.15-1. Requirements class xsd-aerodrome-horizontal-visibility

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-horizontal-visibility	
Target type	Data instance
Name	Aerodrome horizontal visibility
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility/valid~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-horizontal-visibility/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeHorizontalVisibility.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility/prevailing-visibility~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-horizontal-visibility/prevailing-visibility The prevailing visibility …

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility/prevailing-visibility-exceeds-10000m~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-horizontal-visibility/prevailing-visibility-exceeds-10000m If the prevailing visibility …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility/prevailing-visibility-comparison-operator~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-horizontal-visibility/prevailing-visibility-comparison-operator If present, the value of XML element //iwxxm:AerodromeHorizontalVisibility/iwxxm:prevailingVisibilityOperator shall be one of the enumeration: “ABOVE” or “BELOW”.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility/minimum-visibility~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-horizontal-visibility/minimum-visibility If reported, the minimum visibility …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-horizontal-visibility/minimum-visibility-direction~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-horizontal-visibility/minimum-visibility-direction If reported, the observed angle between true north and the direction of minimum visibility …

Move old section 205.25 "Requirements class: TAF" to form new section 205.16 and renumber paragraphs accordingly. Re-label Table 64 and its reference to Table 205.16-1 and amend the contents as shown.

Table ~~64~~205.16-1. Requirements class xsd-taf

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-taf~~http://icao.int/iwxxm/2.0/req/xsd-taf	
Target type	Data instance
Name	TAF
~~Dependency~~	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast, 205.24~~
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-taf/valid~~ http://icao.int/iwxxm/2.0/req/xsd-taf/valid The content model of this element shall have a value that matches the content model of iwxxm:TAF.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-taf/status~~ http://icao.int/iwxxm/2.0/req/xsd-taf/status The status of the TAF …

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-taf/issue-time~~ http://icao.int/iwxxm/2.0/req/xsd-taf/issue-time The XML element //iwxxm:TAF/iwxxm:issueTime …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-taf/base-forecast~~ http://icao.int/iwxxm/2.0/req/xsd-taf/base-forecast If the prevailing forecast conditions …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-taf/change-forecast~~ http://icao.int/iwxxm/2.0/req/xsd-taf/change-forecast If change forecasts or forecasts …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-taf/unique-subject-aerodrome~~ http://icao.int/iwxxm/2.0/req/xsd-taf/unique-subject-aerodrome The base forecast and, if reported, change forecasts shall refer to the same aerodrome. All values of XML element ~~//iwxxm:TAF/*/om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/saf:Aerodrome/gml:identifier~~ //iwxxm:TAF/*/om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/aixm:AirportHeliport/gml:identifier within the TAF shall be identical.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-taf/status-normal~~ http://icao.int/iwxxm/2.0/req/xsd-taf/status-normal If the status of the TAF is …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-taf/status-amendment-or-correction~~ http://icao.int/iwxxm/2.0/req/xsd-taf/status-amendment-or-correction If the status of the TAF is "AMENDMENT" …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-taf/status-cancellation~~ http://icao.int/iwxxm/2.0/req/xsd-taf/status-cancellation If the status of the TAF is "CANCELLATION" … (iv) The aerodrome for which TAF reports are cancelled shall be reported using the XML element ~~//iwxxm:TAF/iwxxm:previousReportAerodrome/saf:Aerodrome~~ //iwxxm:TAF/iwxxm:previousReportAerodrome/aixm:AirportHeliport; and (v) …
Requirement	http://icao.int/iwxxm/~~1.1~~2.0/req/xsd-taf/nil-report-status-missing If the status of the TAF is "MISSING" … (ii) The value of XML element ~~//iwxxm:TAF/iwxxm:baseForecast/om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/saf:Aerodrome~~ //iwxxm:TAF/iwxxm:baseForecast/om:OM_Observation/om:featureOfIn

Requirements class	
	terest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/aixm:AirportHeliport shall indicate the aerodrome for which the TAF is missing; (iii) …
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-taf/number-of-change-forecasts~~ http://icao.int/iwxxm/2.0/req/xsd-taf/number-of-change-forecasts The number of …
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-taf/issue-time-matches-result-time~~ http://icao.int/iwxxm/2.0/req/xsd-taf/issue-time-matches-result-time The TAF issue time …
Recommendation	http://icao.int/iwxxm/~~1.1~~2.0/req/xsd-taf/valid-time-includes-all-phenomenon-times The valid times of all forecasts …
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-taf/status-amendment-or-correction-previous-aerodrome~~ http://icao.int/iwxxm/2.0/req/xsd-taf/status-amendment-or-correction-previous-aerodrome If the status of the TAF is "AMENDMENT" or "CORRECTION" … ~~//iwxxm:TAF/iwxxm:previousReportAerodrome/saf:Aerodrome~~ //iwxxm:TAF/iwxxm:previousReportAerodrome/aixm:AirportHeliport.

Amend note 4 to section new 205.16

4. Within an XML encoded TAF, it is likely that only one instance of ~~saf:Aerodrome~~ aixm:AirportHeliport will physically be present; subsequent assertions about the aerodrome may use xlinks to refer to the previously defined ~~saf:Aerodrome~~ aixm:AirportHeliport element in order to keep the XML document size small. As such, validation of requirement http://icao.int/iwxxm/1.1/req/xsd-taf/unique-subject-aerodrome is applied once any xlinks, if used, have been resolved.

Move old section 205.23 "Requirements class: Meteorological aerodrome forecast record" to form new section 205.17 and renumber paragraphs accordingly. Re-label Table 61 and its reference to Table 205.17-1 and amend the contents as shown.

Table ~~61~~Table 205.17-1. Requirements class xsd-meterological-aerodrome-forecast-record

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record~~http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record	
Target type	Data instance
Name	Meteorological aerodrome forecast record
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast, 205.5~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-cloud-forecast, 205.34
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-forecast, 205.21~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind-forecast, 205.35

Requirements class	
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast, 205.22~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-air-temperature-forecast, 205.18
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/valid~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/valid The content model of this element shall have a value that matches the content model of iwxxm:MeteorologicalAerodromeForecastRecord.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/prevailing-forecast-conditions~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/prevailing-forecast-conditions The XML attribute ...
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-fm~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-fm If the meteorological conditions …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-becmg~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-becmg If the meteorological conditions …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-tempo~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-tempo If temporary fluctuations …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-prob30~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-prob30 If meteorological conditions …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-prob30-tempo~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-prob30-tempo If the temporary fluctuations …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-prob40~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-prob40 If meteorological conditions forecast …

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-prob40-tempo~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/change-indicator-prob40-tempo If the temporary fluctuations …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/cavok~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/cavok If the conditions associated …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/prevailing-visiblity~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/prevailing-visiblity If reported, the prevailing visibility …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/prevailing-visibility-exceeds-10000m~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/prevailing-visibility-exceeds-10000m If the prevailing visibility exceeds 10 000 metres…
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/prevailing-visibility-comparison-operator~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/prevailing-visibility-comparison-operator If present, the value of XML element …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/temperature~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/temperature If reported, the temperature conditions …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/number-of-temperature-groups~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/number-of-temperature-groups No more than two sets of temperature conditions shall be reported.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/cloud~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/cloud If reported, the cloud conditions …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/forecast-weather~~

Requirements class	
	http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/forecast-weather If forecast weather is reported, …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/number-of-forecast-weather-codes~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/number-of-forecast-weather-codes No more than three forecast weather codes shall be reported.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-aerodrome-forecast-record/surface-wind~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-aerodrome-forecast-record/surface-wind Surface wind conditions forecast …

Move old section 205.22 "Requirements class: Aerodrome air temperature forecast " to form new section 205.18 and renumber paragraphs accordingly. Re-label Table 60 and its reference to Table 205.18-1 and amend the contents as shown.

Table ~~60~~Table 205.18-1. Requirements class xsd-aerodrome-air-temperature-forecast

TABLE: Table shaded header with lines

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-air-temperature-forecast	
Target type	Data instance
Name	Aerodrome air temperature forecast
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast/valid~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-air-temperature-forecast/valid The content model of this …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast/maximum-temperature~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-air-temperature-forecast/maximum-temperature The maximum air temperature …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast/maximum-temperature-time~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-air-temperature-forecast/maximum-temperature-time The XML element …

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast/minimum-temperature~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-air-temperature-forecast/minimum-temperature The minimum air temperature …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-air-temperature-forecast/minimum-temperature-time~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-air-temperature-forecast/minimum-temperature-time The XML element …

Move old section 205.28 "Requirements class: Meteorological position" to form new section 205.19 and renumber paragraphs accordingly. Re-label Table 67 and its reference to Table 205.19-1 and amend the contents as shown.

Table ~~67~~Table 205.19-1. Requirements class xsd-meteorological-position

TABLE: Table shaded header with lines

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-position~~http://icao.int/iwxxm/2.0/req/xsd-meteorological-position	
Target type	Data instance
Name	Meteorological position
~~Dependency~~	~~http://icao.int/saf/1.1/req/xsd-airspace-volume, 204.8~~
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-position/valid~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-position/valid The content model …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-position/geometry~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-position/geometry The geometric extent of the SIGMET phenomenon shall be reported using the XML element //iwxxm:MeteorologicalPosition/iwxxm:geometry with valid child element ~~saf:AirspaceVolume~~ aixm:AirspaceVolume.

Move old section 205.29 "Requirements class: Meteorological position collection" to form new section 205.20 and renumber paragraphs accordingly. Re-label Table 49 and its reference to Table 205.20-1 and amend the contents as shown.

Table ~~68~~Table 205.20-1. Requirements class xsd-meteorological-position-collection

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-position-collection~~http://icao.int/iwxxm/2.0/req/xsd-meteorological-position-collection	
Target type	Data instance
Name	Meteorological position collection
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-position, 205.28~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-position, 205.19
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-position-collection/valid~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-position-collection/valid The content model ..
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-meteorological-position-collection/members~~ http://icao.int/iwxxm/2.0/req/xsd-meteorological-position-collection/members If reported, the geometries ..

Move old section 205.31 "Requirements class: SIGMET" to form new section 205.21 and renumber paragraphs accordingly. Re-label Table 70 and its reference to Table 205.21-1 and amend the contents as shown.

Table ~~70~~Table 205.21-1. Requirements class xsd-sigmet

TABLE: Table shaded header with lines

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-sigmet~~http://icao.int/iwxxm/2.0/req/xsd-sigmet	
Target type	Data instance
Name	SIGMET
~~Dependency~~	~~http://icao.int/saf/1.1/req/xsd-aeronautical-service-provision-units, 204.7~~
~~Dependency~~	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet-evolving-condition-analysis, 205.27~~
~~Dependency~~	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet-position-analysis, 205.30~~
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/valid~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/valid The content model …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/status~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/status The status of the SIGMET …

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/issuing-air-traffic-services-unit~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/issuing-air-traffic-services-unit The air traffic services unit responsible for the subject airspace shall be indicated using the XML element //iwxxm:issuingAirTrafficServicesUnit with a valid child element ~~saf:Unit~~ aixm:Unit.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/originating-meteorological-watch-office~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/originating-meteorological-watch-office The meteorological watch office that originated the SIGMET report shall be indicated using the XML element //iwxxm:originatingMeteorologicalWatchOffice with a valid child element ~~saf:Unit~~ aixm:Unit. The value of XML element //iwxxm:issuingAirTrafficServicesUnit/saf:aixm:Unit/saf:aixm:type shall be "MWO" (Meteorological Watch Office).
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/sequence-number~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/sequence-number The sequence number …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/valid-period~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/valid-period The period of validity …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/phenomenon~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/phenomenon The XML attribute …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/unique-subject-airspace~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/unique-subject-airspace All SIGMET analyses included in the report shall refer to the same airspace. All values of XML element ~~//om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/saf:Airspace/gml:identifier~~ //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/aixm:Airspace/gml:identifier within the SIGMET shall be identical.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/analysis~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/analysis If reported, XML element //iwxxm:analysis shall contain a valid child element //om:OM_Observation of type SIGMETEvolvingConditionAnalysis. The value of XML attribute //iwxxm:analysis/om:OM_Observation/om:type/@xlink:href shall be the URI ~~"http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/SIGMETEvolvingConditionAnalysis"~~ "http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/SIGMETEvolvingConditionAnalysis" .
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/forecast-position-analysis~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/forecast-position-analysis If reported, the forecast position of the phenomenon shall be reported using the XML element //iwxxm:forecastPositionAnalysis with valid child element

Requirements class	
	//om:OM_Observation of type SIGMETPositionAnalysis. The value of XML attribute //iwxxm:forecastPositionAnalysis/om:OM_Observation/om:type/@xlink:href shall be the URI ~~"http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/SIGMETPositionAnalysis"~~ "http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/SIGMETPositionAnalysis".
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/status-normal~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/status-normal If the status of the SIGMET …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/status-cancellation~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/status-cancellation If the status of the SIGMET is "CANCELLATION" …
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/issuing-air-traffic-services-unit-type~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/issuing-air-traffic-services-unit-type The value of XML element ~~//iwxxm:SIGMET/iwxxm:issuingAirTrafficServicesUnit/saf:Unit/saf:type~~ //iwxxm:SIGMET/iwxxm:issuingAirTrafficServicesUnit/aixm:Unit/aixm:type should be one of the enumeration: "ATSU" (Air Traffic Services Unit) or "FIC" (Flight Information Centre).
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/valid-period-start-matches-result-time~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/valid-period-start-matches-result-time The start time …
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/valid-time-includes-all-phenomenon-times~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/valid-time-includes-all-phenomenon-times The observation …
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/7-point-definition-of-airspace-volume~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/7-point-definition-of-airspace-volume The horizontal extent of any airspace volumes enclosing a SIGMET phenomenon (reported using XML element ~~//om:OM_Observation/om:result/*/iwxxm:geometry/saf:AirspaceVolume/saf:horizontalProjection~~ //om:OM_Observation/om:result/*/iwxxm:geometry/aixm:AirspaceVolume/aixm:horizontalProjection) should use no more than seven points to define the bounding polygon.

Amend note 4 of new section 205.21:

4. Within an XML encoded SIGMET, it is likely that only one instance of ~~saf:Airspace~~ aixm:Airspace will physically be present; subsequent assertions about the airspace may use xlinks to refer to the previously defined ~~saf:Airspace~~ aixm:Airspace element in order to keep the XML document size small. As such, validation of requirement ~~http://icao.int/iwxxm/1.1/req/xsd-sigmet/unique-subject-airspace~~ http://icao.int/iwxxm/2.0/req/xsd-sigmet/unique-subject-airspace is applied once any xlinks, if used, have been resolved.

Move old section 205.26 "Requirements class: Evolving meteorological condition " to form new section 205.22 and renumber paragraphs accordingly. Re-label Table 65 and its reference to Table 205.22-1 and amend the contents as shown.

Table ~~65~~205.22-1. Requirements class xsd-evolving-meteorological-condition

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition~~http://icao.int/iwxxm/2.0/req/xsd-evolving-meteorological-condition	
Target type	Data instance
Name	Evolving meteorological condition
~~Dependency~~	~~http://icao.int/saf/1.1/req/xsd-airspace-volume, 204.8~~
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition/valid~~ http://icao.int/iwxxm/2.0/req/xsd-evolving-meteorological-condition/valid The content model …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition/intensity-change~~ http://icao.int/iwxxm/2.0/req/xsd-evolving-meteorological-condition/intensity-change The anticipated change …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition/geometry~~ http://icao.int/iwxxm/2.0/req/xsd-evolving-meteorological-condition/geometry The geometric extent of the SIGMET phenomenon shall be reported using the XML element //iwxxm:EvolvingMeteorologicalCondition/iwxxm:geometry with valid child element ~~saf:AirspaceVolume~~ aixm:AirspaceVolume.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition/speed-of-motion~~ http://icao.int/iwxxm/2.0/req/xsd-evolving-meteorological-condition/speed-of-motion The speed of motion …
Requirement	http://icao.int/iwxxm/~~1.1~~/req/xsd-evolving-meteorological-condition/direction-of-motion http://icao.int/iwxxm/2.0/req/xsd-evolving-meteorological-condition/direction-of-motion If reported, the angle …

Requirements class	
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-evolving-meteorological-condition/stationary-phenomenon~~ http://icao.int/iwxxm/2.0/req/xsd-evolving-meteorological-condition/stationary-phenomenon If the SIGMET phenomenon …

Move old section 205.33 "Requirements class: Tropical cyclone SIGMET " to form new section 205.23 and renumber paragraphs accordingly. Re-label Table 72 and its reference to Table 205.23-1 and amend the contents as shown.

Table ~~72~~205.23-1. Requirements class xsd-tropical-cyclone-sigmet

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-tropical-cyclone-sigmet~~http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-sigmet	
Target type	Data instance
Name	Tropical cyclone SIGMET
Dependency	http://def.wmo.int/metce/2013/req/xsd-tropical-cyclone, 202.9
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet, 205.31~~http://icao.int/iwxxm/2.0/req/xsd-sigmet, 205.21
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-tropical-cyclone-sigmet/valid~~ http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-sigmet/valid The content model of this element shall have a value that matches the content model of iwxxm:TropicalCycloneSIGMET.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-tropical-cyclone-sigmet/cyclone~~ http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-sigmet/cyclone Details of the tropical cyclone …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-tropical-cyclone-sigmet/phenomenon~~ http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-sigmet/phenomenon The XML attribute //iwxxm:phenomenon/@xlink:href …

Move old section 205.32 "Requirements class: Volcanic Ash SIGMET" to form new section 205.24 and renumber paragraphs accordingly. Re-label Table 71 and its reference to Table 205.24-1 and amend the contents as shown.

Table ~~71~~205.24-1. Requirements class xsd-volcanic-ash-sigmet

TABLE: Table shaded header with lines	
Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-volcanic-ash-sigmet~~http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-sigmet	
Target type	Data instance
Name	Volcanic ash SIGMET
Dependency	http://def.wmo.int/metce/2013/req/xsd-erupting-volcano, 202.8
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-sigmet, 205.31~~http://icao.int/iwxxm/2.0/req/xsd-sigmet, 205.21
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-volcanic-ash-sigmet/valid~~ http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-sigmet/valid The content model of this element shall have a value that matches the content model of iwxxm:VolcanicAshSIGMET.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-volcanic-ash-sigmet/source-volcano~~ http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-sigmet/source-volcano Details of the volcano …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-volcanic-ash-sigmet/phenomenon~~ http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-sigmet/phenomenon The XML attribute //iwxxm:phenomenon/@xlink:href …

Add new sections 205.25 to 205.33

205.25 Requirements class: AIRMET

205.25.1 This requirements class is used to describe the AIRMET report within which the characteristics of a specific AIRMET phenomenon are described.

Note: The reporting requirements for AIRMETs are specified in the *Technical Regulations* (WMO-No. 49), Volume II, Part II, Appendix 6, section 2.

205.25.2 XML elements describing AIRMET reports shall conform to all requirements specified in Table 205.25-1.

205.21.3 XML elements describing AIRMET reports shall conform to all requirements of all relevant dependencies specified in Table 205.17-1.

Table 205.25-1. Requirements class xsd-airmet

TABLE: Table shaded header with lines	
Requirements class	
http://icao.int/iwxxm/2.0/req/xsd-airmet	
Target type	Data instance
Name	AIRMET
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet/valid The content model of this element shall have a value that matches the content model of iwxxm:AIRMET.

Requirements class	
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet/status The status of the AIRMET shall be indicated using the XML attribute @status with the value being one of the enumeration: "NORMAL" or "CANCELLATION".
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet/issuing-air-traffic-services-unit The air traffic services unit responsible for the subject airspace shall be indicated using the XML element //iwxxm:issuingAirTrafficServicesUnit with a valid child element aixm:Unit.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet/originating-meteorological-watch-office The meteorological watch office that originated the AIRMET report shall be indicated using the XML element //iwxxm:originatingMeteorologicalWatchOffice with a valid child element aixm:Unit. The value of XML element //iwxxm:issuingAirTrafficServicesUnit/aixm:Unit/aixm:type shall be "MWO" (Meteorological Watch Office).
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet/sequence-number The sequence number of this AIRMET report shall be indicated using XML element //iwxxm:sequenceNumber.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet/valid-period The period of validity of this AIRMET report shall be indicated using XML element //iwxxm:validPeriod with valid child element gml:TimePeriod.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet/phenomenon The XML attribute //iwxxm:phenomenon/@xlink:href shall have a value that is the URI of a valid term from Code table D-10: Significant weather phenomena.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet/unique-subject-airspace All AIRMET analyses included in the report shall refer to the same airspace. All values of XML element //om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sam:sampledFeature/aixm:Airspace/gml:identifier within the AIRMET shall be identical.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet/analysis If reported, XML element //iwxxm:analysis shall contain a valid child element //om:OM_Observation of type AIRMETEvolvingConditionAnalysis. The value of XML attribute //iwxxm:analysis/om:OM_Observation/om:type/@xlink:href shall be the URI "http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/AIRMETEvolvingConditionAnalysis".
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet/status-normal If the status of the AIRMET is "NORMAL" (as specified by XML attribute @status), then: (i) The characteristics of the AIRMET phenomenon shall be reported using one or more of the XML element //iwxxm:analysis; (ii) Each XML element //iwxxm:analysis shall contain a valid element //iwxxm:analysis/om:OM_Observation/om:result/iwxxm:EvolvingMeteorologicalCondition within which the characteristics of the AIRMET phenomenon are described;

Requirements class	
	(iii) The XML element //iwxxm:cancelledSequenceNumber shall be absent; and (iv) The XML element //iwxxm:cancelledValidPeriod shall be absent.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet/status-cancellation If the status of the AIRMET is "CANCELLATION" (as specified by XML attribute @status), then: (i) The details of the airspace for which the AIRMET has been cancelled shall be provided by a single instance of XML element //iwxxm:analysis; (ii) The XML element //iwxxm:analysis/om:OM_Observation/om:result shall have no child elements and XML attribute //iwxxm:analysis/om:OM_Observation/om:result/@nilReason shall provide an appropriate nil-reason; (iii) The value of XML element //iwxxm:cancelledSequenceNumber shall indicate the sequence number of the AIRMET that has been cancelled; and (iv) The XML element //iwxxm:cancelledValidPeriod shall contain a valid child element gml:TimePeriod that indicates the validity period of the AIRMET that has been cancelled.
Recommendation	http://icao.int/iwxxm/2.0/req/xsd-airmet/issuing-air-traffic-services-unit-type The value of XML element //iwxxm:AIRMET/iwxxm:issuingAirTrafficServicesUnit/aixm:Unit/aixm:type should be one of the enumeration: "ATSU" (Air Traffic Services Unit) or "FIC" (Flight Information Centre).
Recommendation	http://icao.int/iwxxm/2.0/req/xsd-airmet/valid-period-start-matches-result-time The start time of the validity period of the AIRMET report (expressed using XML element //iwxxm:validPeriod/gml:TimePeriod/gml:beginPosition) should match the result time of each AIRMET analysis included within the report (expressed using XML element //om:OM_Observation/om:resultTime/gml:TimeInstant/gml:timePosition).
Recommendation	http://icao.int/iwxxm/2.0/req/xsd-airmet/valid-time-includes-all-phenomenon-times The observation and/or forecast times of all AIRMET analyses and, if reported, forecast position analyses included in the report (specified by XML element //om:OM_Observation/om:phenomenonTime/*) should occur within the valid time period of the AIRMET (specified by XML element //iwxxm:validPeriod/gml:TimePeriod).
Recommendation	http://icao.int/iwxxm/2.0/req/xsd-airmet/7-point-definition-of-airspace-volume The horizontal extent of any airspace volumes enclosing a AIRMET phenomenon (reported using XML element //om:OM_Observation/om:result/*/iwxxm:geometry/aixm:AirspaceVolume/aixm:horizontalProjection) should use no more than seven points to define the bounding polygon.

Notes:

1. Requirements relating to sequence numbers within AIRMET reports are specified in the *Technical Regulations* (WMO-No. 49), Volume II, Part II, Appendix 6, 2.1.2.

2. Requirements for reporting the AIRMET phenomenon are specified in the *Technical Regulations* (WMO-No. 49), Volume II, Part II, Appendix 6, 2.1.4.

3. Within an XML encoded AIRMET, it is likely that only one instance of aixm:Airspace will physically be present; subsequent assertions about the airspace may use xlinks to refer to the previously defined aixm:Airspace element

in order to keep the XML document size small. As such, validation of requirement http://icao.int/iwxxm/1.1/req/xsd-airmet/unique-subject-airspace is applied once any xlinks, if used, have been resolved.

4. Code table D-1 provides a set of nil reason codes and is published at http://codes.wmo.int/common/nil.

5. Code table D-10 is published online at http://codes.wmo.int/49-2/AirWxPhenomena.

205.26 Requirements class: AIRMET Evolving Meteorological Condition

205.26.1 This requirements class is used to describe the presence of a specific AIRMET phenomenon such as thunderstorms or mountain obscuration, along with expected changes to the intensity of the phenomenon, its speed and direction of motion. The geometric extent of the *AIRMET* phenomenon is specified as a two-dimensional horizontal region with bounded vertical extent.

205.26.2 XML elements describing the characteristics of a AIRMET phenomenon shall conform to all requirements specified in Table 205.26-1.

205.26.3 XML elements describing the characteristics of a AIRMET phenomenon shall conform to all requirements of all relevant dependencies specified in Table 205.26-1.

Table 205.26-1. Requirements class xsd-airmet-evolving-meteorological-condition

TABLE: Table shaded header with lines

Requirements class	
http://icao.int/iwxxm/2.0/req/xsd-airmet-evolving-meteorological-condition	
Target type	Data instance
Name	AIRMET Evolving meteorological condition
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet-evolving-meteorological-condition/valid The content model of this element shall have a value that matches the content model of iwxxm:AIRMETEvolvingMeteorologicalCondition.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-evolving-meteorological-condition/intensity-change The anticipated change in intensity of the AIRMET observed phenomenon shall be indicated using the XML attribute //iwxxm:AIRMETEvolvingMeteorologicalCondition/@intensityChange with the value being one of the enumeration: "NO_CHANGE", "WEAKEN" or "INTENSIFY".
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet-evolving-meteorological-condition/geometry The geometric extent of the AIRMET phenomenon shall be reported using the XML element //iwxxm:AIRMETEvolvingMeteorologicalCondition/iwxxm:geometry with valid child element aixm:AirspaceVolume.

Requirements class	
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet-evolving-meteorological-condition/speed-of-motion The speed of motion of the AIRMET phenomenon shall be reported using the XML element //iwxxm:AIRMETEvolvingMeteorologicalCondition/iwxxm:speedOfMotion, with the unit of measure metres per second, knots or kilometres per hour. The unit of measure shall be indicated using the XML attribute //iwxxm:AIRMETEvolvingMeteorologicalCondition/iwxxm:speedOfMotion/@uom with value "m/s" (metres per second), "[kn_i]" (knots) or "km/h" (kilometres per hour).
Requirement	http://icao.int/iwxxm/2.0/req/xsd-airmet-evolving-meteorological-condition/direction-of-motion If reported, the angle between true north and the direction of motion of the AIRMET phenomenon shall be given in degrees using the XML element //iwxxm:AIRMETEvolvingMeteorologicalCondition/iwxxm:directionOfMotion. The unit of measure shall be indicated using the XML attribute //iwxxm:AIRMETEvolvingMeteorologicalCondition/iwxxm:directionOfMotion/@uom with value "deg".
Recommendation	http://icao.int/iwxxm/2.0/req/xsd-airmet-evolving-meteorological-condition/stationary-phenomenon If the AIRMET phenomenon is not moving (indicated by the XML element //iwxxm:AIRMETEvolvingMeteorologicalCondition/iwxxm:speedOfMotion having numeric value zero), XML element //iwxxm:AIRMET EvolvingMeteorologicalCondition/iwxxm:directionOfMotion should be absent.

Notes:

1. Units of measurement are specified in accordance with 1.9 above.

2. The true north is the north point at which the meridian lines meet.

205.27 Requirements class: Tropical Cyclone Advisory

205.27.1 This requirements class is used to describe the Tropical Cyclone Advisory report within which the characteristics of a specific Tropical Cyclone advisory phenomenon are described.

Note: The reporting requirements for Tropical Cyclone Advisories are specified in the *Technical Regulations* (WMO-No. 49), Volume II, Part II, Appendix 2, section 5.

205.27.2 XML elements describing Tropical Cyclone Advisory reports shall conform to all requirements of all relevant dependencies specified in Table 205.27-1.

Table 205.27-1. Requirements class xsd-tropical-cyclone-advisory

TABLE: Table shaded header with lines	
Requirements class	
http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-advisory	
Target type	Data instance
Name	Tropical Cyclone Advisory
Requirement	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-advisory/valid The content model of this element shall have a value that matches the content model of iwxxm:TropicalCycloneAdvisory.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-advisory/issuing-tropical-cyclone-advisory-centre The air traffic services unit responsible for the subject airspace shall be indicated using the XML element //iwxxm:issuingTropicalCycloneAdvisoryCentre with a valid child element aixm:Unit.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-advisory/advisory-number The advisory number of this Tropical Cyclone Advisory report shall be indicated using XML element //iwxxm:advisoryNumber.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-advisory/issue-time The issuance time of this Tropical Cyclone Advisory report shall be indicated using XML element //iwxxm:issueTime with valid child element gml:TimeInstant.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-advisory/observation If reported, XML element //iwxxm:observation shall contain a valid child element //om:OM_Observation of type TropicalCycloneObservedConditions. The value of XML attribute //iwxxm:observation/om:OM_Observation/om:type/@xlink:href shall be the URI "http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/TropicalCycloneObservedConditions".
Requirement	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-advisory/forecast If reported, XML element //iwxxm:forecast shall contain a valid child element //om:OM_Observation of type TropicalCycloneForecastConditions. The value of XML attribute //iwxxm:forecast/om:OM_Observation/om:type/@xlink:href shall be the URI "http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/TropicalCycloneForecastConditions".

Notes:

1. Requirements for reporting the Tropical Cyclone Advisory phenomenon are specified in the *Technical Regulations* (WMO-No. 49), Volume II, Part II, Appendix 2, section 5.1.1.

2. Code table D-1 provides a set of nil reason codes and is published at http://codes.wmo.int/common/nil.

205.28 Requirements class: Tropical Cyclone Observed Conditions

205.28.1 This requirements class is used to describe the presence of specific Tropical Cyclone observed phenomenon, along with expected changes. The geometric extent of the phenomenon is specified as a two-dimensional horizontal region with bounded vertical extent.

205.28.3 XML elements describing the characteristics of a Tropical Cyclone observed phenomenon shall conform to all requirements of all relevant dependencies specified in Table 205.28-1.

Table 205.28-1. Requirements class xsd-tropical-cyclone-obs-condition

TABLE: Table shaded header with lines	
Requirements class	
http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-obs-condition	
Target type	Data instance
Name	Tropical Cyclone Observed Condition
Requirement	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-obs-condition/valid The content model of this element shall have a value that matches the content model of iwxxm:TropicalCycloneObservedCondition.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-obs-condition/geometry The geometric extent of the Tropical Cyclone observed phenomenon shall be reported using the XML element //iwxxm:forecast/om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sams:shape with valid child element gml:Point.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-obs-condition/speed-of-motion The speed of motion of the Tropical Cyclone observed phenomenon shall be reported using the XML element //iwxxm:TropicalCycloneObservedCondition/iwxxm:movementSpeed, with the unit of measure metres per second, knots or kilometres per hour. The unit of measure shall be indicated using the XML attribute //iwxxm:TropicalCycloneObservedCondition/iwxxm:movementSpeed/@uom with value "m/s" (metres per second), "[kn_i]" (knots) or "km/h" (kilometres per hour).
Requirement	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-obs-condition/direction-of-motion If reported, the angle between true north and the direction of motion of the Tropical Cyclone observed phenomenon shall be given in degrees using the XML element //iwxxm:TropicalCycloneObservedCondition/iwxxm:movementDirection. The unit of measure shall be indicated using the XML attribute //iwxxm:TropicalCycloneObservedCondition/iwxxm:directionOfMotion/@uom with value "deg".

Notes:

1. Units of measurement are specified in accordance with 1.9 above.

205.29 Requirements class: Tropical Cyclone Forecast Conditions

205.29.1 This requirements class is used to describe the presence of specific Tropical Cyclone forecast phenomenon, along with expected changes. The geometric extent of the phenomenon is specified as a two-dimensional horizontal region with bounded vertical extent.

205.29.3 XML elements describing the characteristics of a Tropical Cyclone forecast phenomenon shall conform to all requirements of all relevant dependencies specified in Table 205-29-1.

Table 205.29-1. Requirements class xsd-tropical-cyclone-fcst-condition

TABLE: Table shaded header with lines	
Requirements class	
http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-fcst-condition	
Target type	Data instance
Name	Tropical Cyclone Forecast Condition
Requirement	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-fcst-condition/valid The content model of this element shall have a value that matches the content model of iwxxm:TropicalCycloneForecastCondition.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-tropical-cyclone-fcst-condition/geometry The geometric extent of the Tropical Cyclone forecast phenomenon shall be reported using the XML element //iwxxm:observation/om:OM_Observation/om:featureOfInterest/sams:SF_SpatialSamplingFeature/sams:shape with valid child element gml:Point.

Notes:

1. Units of measurement are specified in accordance with 1.9 above.

205.30 Requirements class: Volcanic Ash Advisory

205.27.1 This requirements class is used to describe the Volcanic Ash Advisory report within which the characteristics of a specific Volcanic Ash advisory phenomenon are described.

Note: The reporting requirements for Volcanic Ash Advisories are specified in the *Technical Regulations* (WMO-No. 49), Volume II, Part II, Appendix 2, section 3.

205.27.2 XML elements describing Volcanic Ash Advisory reports shall conform to all requirements of all relevant dependencies specified in Table 205.30-1.

Table 205.30-1. Requirements class xsd-volcanic-ash-advisory

TABLE: Table shaded header with lines	
Requirements class	
http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-advisory	
Target type	Data instance
Name	Volcanic Ash Advisory
Requirement	http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-advisory/valid The content model of this element shall have a value that matches the content model of iwxxm:VolcanicAshAdvisory.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-advisory/issuing-volcanic-ash-advisory-centre The air traffic services unit responsible for the subject airspace shall be indicated using the XML element //iwxxm:issuingVolcanicAshAdvisoryCentre with a valid child element aixm:Unit.

Requirements class	
Requirement	http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-advisory/advisory-number The advisory number of this Volcanic Ash Advisory report shall be indicated using XML element //iwxxm:advisoryNumber.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-advisory/issue-time The issuance time of this Volcanic Ash Advisory report shall be indicated using XML element //iwxxm:issueTime with valid child element gml:TimeInstant.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-advisory/analysis If reported, XML element //iwxxm:analysis shall contain a valid child element //om:OM_Observation of type VolcanicAshConditions. The value of XML attribute //iwxxm:analysis/om:OM_Observation/om:type/@xlink:href shall be the URI "http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/VolcanicAshConditions".

Notes:

1. Requirements for reporting the Volcanic Ash Advisory phenomenon are specified in the *Technical Regulations* (WMO-No. 49), Volume II, Part II, Appendix 2, section 3.1.1.

2. Code table D-1 provides a set of nil reason codes and is published at http://codes.wmo.int/common/nil.

205.31 Requirements class: Volcanic Ash Conditions

205.31.1 This requirements class is used to describe the presence of specific Volcanic Ash phenomenon.

205.31.3 XML elements describing the characteristics of a Volcanic Ash phenomenon shall conform to all requirements of all relevant dependencies specified in Table 205.31-1.

Table 205.31-1. Requirements class xsd-volcanic-ash-condition

TABLE: Table shaded header with lines

Requirements class	
http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-condition	
Target type	Data instance
Name	Volcanic Ash Condition
Requirement	http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-condition/valid The content model of this element shall have a value that matches the content model of iwxxm:VolcanicAshCondition.

205.32 Requirements class: Volcanic Ash Cloud

205.32.1 This requirements class is used to describe the presence of specific Volcanic Ash Clouds.

205.32.3 XML elements describing the characteristics of a Volcanic Ash Cloud shall conform to all requirements of all relevant dependencies specified in Table 205.32-1.

Table 205.32-1. Requirements class xsd-volcanic-ash-cloud

TABLE: Table shaded header with lines	
Requirements class	
http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-cloud	
Target type	Data instance
Name	Volcanic Ash Cloud
Requirement	http://icao.int/iwxxm/2.0/req/xsd-volcanic-ash-cloud/valid The content model of this element shall have a value that matches the content model of iwxxm:VolcanicAshCloud.
Requirement	http://icao.int/iwxxm/2.0/req/xsd- volcanic-ash-cloud/geometry The geometric extent of the Volcanic Ash Cloud shall be reported using the XML element //iwxxm:VolcanicAshCloud/iwxxm:ashCloudExtent with valid child element aixm:AirspaceVolume.
Requirement	http://icao.int/iwxxm/2.0/req/xsd- volcanic-ash-cloud/speed-of-motion The speed of motion of the Volcanic Ash Cloud observed phenomenon shall be reported using the XML element //iwxxm:VolcanicAshCloud/iwxxm:speedOfMotion, with the unit of measure metres per second, knots or kilometres per hour. The unit of measure shall be indicated using the XML attribute //iwxxm:VolcanicAshCloud/iwxxm:movementSpeed/@uom with value "m/s" (metres per second), "[kn_i]" (knots) or "km/h" (kilometres per hour).
Requirement	http://icao.int/iwxxm/2.0/req/xsd- volcanic-ash-cloud/direction-of-motion If reported, the angle between true north and the direction of motion of the Volcanic Ash Cloud shall be given in degrees using the XML element //iwxxm:VolcanicAshCloud/iwxxm:directionOfMotion. The unit of measure shall be indicated using the XML attribute //iwxxm: VolcanicAshCloud/iwxxm:directionOfMotion/@uom with value "deg".

Notes:

1. Units of measurement are specified in accordance with 1.9 above.

205.33 Requirements class: Report

205.33.1 This requirements class is used to describe the Report within which the characteristics common to all IWXXM reports (such as METAR and SIGMET) are described. The Report type cannot be instantiated directly, but Report members are included on all sub-types.

205.33.2 XML elements describing Report shall conform to all requirements of all relevant dependencies specified in Table 205.33-1.

Table 205.33-1. Requirements class xsd-report

TABLE: Table shaded header with lines	
Requirements class	
http://icao.int/iwxxm/2.0/req/xsd-report	
Target type	Abstract Data instance
Name	Report
Requirement	http://icao.int/iwxxm/2.0/req/xsd-report/permissible-usage The permissible usage (operational or non-operational) for the report shall be indicated using the XML attribute //iwxxm:Report/@permissibleUsage.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-report/permissible-usage-reason When the permissible usage is non-operational, the reason for this usage (test or exercise) shall be indicated using XML attribute //iwxxm:Report/@permissibleUsageReason.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-report/permissible-usage-supplementary When the permissible usage is non-operational, the human-readable descriptive supplementary information shall be indicated using XML attribute //iwxxm:Report/@permissibleUsageSupplementary
Requirement	http://icao.int/iwxxm/2.0/req/xsd-report/translatedBulletinId If reported on a report that was translated from TAC, XML attribute //iwxxm:Report/@translatedBulletinId shall contain the bulletin id of the form 'TTAAiiCCCYYGGgg'.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-report/translatedBulletinReceptionTime If reported on a report that was translated from TAC, XML attribute //iwxxm:Report/@translatedBulletinReceptionTime shall contain the time at which the bulletin was received by the translation centre.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-report/translatedCentreDesignator If reported on a report that was translated from TAC, XML attribute //iwxxm:Report/@translatedCentreDesignator shall contain the ICAO designator of the translation centre.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-report/translatedCentreName If reported on a report that was translated from TAC, XML attribute //iwxxm:Report/@translatedCentreName shall contain the name of the translation centre.
Requirement	http://icao.int/iwxxm/2.0/req/xsd-report/translationTime If reported on a report that was translated from TAC, XML attribute //iwxxm:Report/@translationTime shall contain the time at which the bulletin was translated.

Requirements class	
Requirement	http://icao.int/iwxxm/2.0/req/xsd-report/translatedFailedTAC If reported on a report that was translated from TAC which could not be completely translated, XML attribute //iwxxm:Report/@translationFailedTAC shall contain the original Traditional Alphanumeric Code report (TAC) that was not translated. When translation fails only the report type (i.e, SIGMET or METAR), translation information and other basic report metadata should be provided. In this case no translated content will be included other than the original TAC. Permissible usage may be set as normal and TAC that failed translation may still be used for operational purposes, but under no circumstances should partially translated content be distributed or marked as operational.

This is the end of the contents of added sections 205.25 to 205.33

Move old section 205.5 "Requirements class: Aerodrome cloud forecast " to form new section 205.34 and renumber paragraphs accordingly. Re-label Table 41 and its reference to Table 205.34-1 and amend the contents as shown.

Table ~~41~~Table 205.34-1. Requirements class xsd-aerodrome-cloud-forecast

TABLE: Table shaded header with lines

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-cloud-forecast	
Target type	Data instance
Name	Aerodrome cloud forecast
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-cloud-layer, 205.4~~http://icao.int/iwxxm/2.0/req/xsd-cloud-layer, 205.37
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast/valid~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-cloud-forecast/valid The content model of this element shall have a value that matches the content model of iwxxm:AerodromeCloudForecast.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast/vertical-visibility~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-cloud-forecast/vertical-visibility When cloud of operational significance is forecast, then the XML element //iwxxm:AerodromeCloudForecast/iwxxm:verticalVisibility shall be used to report the vertical visual range.
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast/vertical-visibility-unit-of-measure~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-cloud-forecast/vertical-visibility-unit-of-measure If the vertical visibility …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast/cloud-layers~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-cloud-forecast/cloud-layers When cloud …

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-cloud-forecast/number-of-cloud-layers~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-cloud-forecast/number-of-cloud-layers No more than four …

Move old section 205.21 "Requirements class: Aerodrome surface wind forecast" to form new section 205.35 and renumber paragraphs accordingly. Re-label Table 59 and its reference to Table 205.35-1 and amend the contents as shown.

Table ~~59~~205.35-1. Requirements class xsd-aerodrome-surface-wind-forecast

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-forecast~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind-forecast	
Target type	Data instance
Name	Aerodrome surface wind forecast
Dependency	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast, 205.15~~http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind-trend-forecast, 205.36
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-forecast/valid~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind-forecast/valid The content model …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-forecast/variable-wind-direction~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind-forecast/variable-wind-direction If the wind direction is variable, …

Move old section 205.15 "Requirements class: Aerodrome surface wind trend forecast " to form new section 205.36 and renumber paragraphs accordingly. Re-label Table 52 and its reference to Table 205.36-1 and amend the contents as shown.

Table ~~52~~205.36-1. Requirements class xsd-aerodrome-surface-wind-trend-forecast

TABLE: Table shaded header with lines

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind-trend-forecast	
Target type	Data instance
Name	Aerodrome surface wind trend forecast

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast/valid~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind-trend-forecast/valid The content model …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast/mean-wind-speed~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind-trend-forecast/mean-wind-speed The forecast …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast/wind-direction~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind-trend-forecast/wind-direction If the forecast …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-aerodrome-surface-wind-trend-forecast/gust-speed~~ http://icao.int/iwxxm/2.0/req/xsd-aerodrome-surface-wind-trend-forecast/gust-speed If reported, …

Move old section 205.4 "Requirements class: Cloud layer " to form new section 205.37 and renumber paragraphs accordingly. Re-label Table 40 and its reference to Table 205.37-1 and amend the contents as shown.

Table ~~40~~205.37-1. Requirements class: xsd-cloud-layer

TABLE: Table shaded header with lines

Requirements class	
~~http://icao.int/iwxxm/1.1/req/xsd-cloud-layer~~ http://icao.int/iwxxm/2.0/req/xsd-cloud-layer	
Target type	Data instance
Name	Cloud layer
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/valid~~ http://icao.int/iwxxm/2.0/req/xsd-cloud-layer/valid The content model …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/cloud-amount~~ http://icao.int/iwxxm/2.0/req/xsd-cloud-layer/cloud-amount The XML element …

Requirements class	
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/cloud-amount-code~~ http://icao.int/iwxxm/2.0/req/xsd-cloud-layer/cloud-amount-code If cloud amount is reported…
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/cloud-base~~ http://icao.int/iwxxm/2.0/req/xsd-cloud-layer/cloud-base The XML element …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/cloud-base-unit-of-measure~~ http://icao.int/iwxxm/2.0/req/xsd-cloud-layer/cloud-base-unit-of-measure If the cloud base is reported, …
Requirement	~~http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/cloud-type-code~~ http://icao.int/iwxxm/2.0/req/xsd-cloud-layer/cloud-type-code If cloud type is reported, …
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/cloud-type~~ http://icao.int/iwxxm/2.0/req/xsd-cloud-layer/cloud-type If reporting observed cloud, …
Recommendation	~~http://icao.int/iwxxm/1.1/req/xsd-cloud-layer/nil-significant-cloud~~ http://icao.int/iwxxm/2.0/req/xsd-cloud-layer/nil-significant-cloud If no cloud of operational significance is reported, …

Remove old sections 205.6, 205.13, 205.14, 205.16, 205.17, 205.24, 205.27 and 205.30

Amend code table D-4 and supporting text.

CODE TABLE D-4: IWXXM OBSERVATION TYPES

The items within this code table … As an example, the URI of MeteorologicalAerodromeForecast is ~~http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/MeteorologicalAerodromeForecast~~ http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/MeteorologicalAerodromeForecast. The URI is also a URL providing additional information about the associated observation type. This code table is published at ~~http://codes.wmo.int/49-2/observation-type/IWXXM/1.0~~ http://codes.wmo.int/49-2/observation-type/IWXXM/2.0.

TABLE: Table shaded header with lines

Label	*Notation*	*Code-space*	*Description*
Meteorological aerodrome forecast	MeteorologicalAerodromeForecast	~~http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/~~ http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/	MeteorologicalAerodromeForecast (a subclass of …

Label	*Notation*	*Code-space*	*Description*
Meteorological aerodrome observation	MeteorologicalAerodromeObservation	~~http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/~~ http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/	MeteorologicalAerodromeObservation (a subclass of …
Meteorological aerodrome trend forecast	MeteorologicalAerodromeTrendForecast	~~http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/~~ http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/	MeteorologicalAerodromeTrendForecast (a subclass of …
SIGMET evolving condition analysis	SIGMETEvolvingConditionAnalysis	~~http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/~~ http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/	SIGMETEvolvingConditionAnalysis (a subclass …
SIMGET position analysis	SIGMETPositionAnalysis	~~http://codes.wmo.int/49-2/observation-type/IWXXM/1.0/~~ http://codes.wmo.int/49-2/observation-type/IWXXM/2.0/	SIGMETPositionAnalysis (a subclass of …

Recommendation 14 (CBS-16)

UPDATES TO THE *MANUAL ON THE WMO INFORMATION SYSTEM* (WMO-No. 1060)

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) That the *Manual on the WMO Information System* (WMO-No. 1060), Appendix B, records those centres that are approved WMO Information System (WIS) centres,

(2) Resolution 31 (Cg-17) – Report of the extraordinary session (2014) of the Commission for Basic Systems relevant to centres and networks of the WMO Information System, that extended conditional designation of specified WIS centres until the sixteenth session of the Commission for Basic Systems (CBS),

(3) That the Open Programme Area Group on Information Systems and Services Task Team on Centre Audits and Certification endorsed the centres listed in Table 1 and Table 2 of the annex to the present recommendation as compliant with the Technical Specifications laid out in the *Manual on the WMO Information System*,

Requests its Management Group:

(1) To review the procedure for designation of WIS centres with a view to simplification and make recommendations to the Executive Council as appropriate;

(2) To consider whether it is appropriate to ask the Executive Council to extend conditional designation of centres;

Recommends that the Executive Council:

(1) Approve the CBS endorsement of WIS Data Collection or Production Centres (DCPCs) as listed in Table 1 of the annex to the present recommendation;

(2) Designate as WIS DCPCs those centres listed in Table 2 of the annex to the present recommendation;

(3) Amend Table 3 of Appendix B to the *Manual on the WMO Information System* so that the "WMO Member or contributing organization" name for the entry "NMC (Aruba)" under the Netherlands becomes "Aruba (Netherlands)", the centre name bcomes "National Meteorological Centre (Aruba)", and the GTS function becomes "NMC";

(4) Amend the *Manual on the WMO Information System* so that the principal Global Information System Centre for centres in Algeria in the tables of Appendix B is "Toulouse".

Annex to Recommendation 14 (CBS-16)

UPDATES TO THE *MANUAL ON THE WMO INFORMATION SYSTEM* (WMO-No. 1060)

AMMENDMENTS TO APPENDIX B OF THE *MANUAL ON WIS* (WMO-No. 1060)

Table 1 – CBS Endorsement of WIS Data Collection or Production Centres conditionally designated under Resolution 51 (Cg-XVI)

WMO Member or Contributing Organization	Name	Centre location region/city		Principal GISC	Const. Body
India	RSMC-Activity-TC	II	New Delhi	New Delhi	CBS
Netherlands	RCC–De Bilt	RA VI	De Bilt	Exeter	CCl
Norway	Norwegian Institute for Air Research (NILU)	RA VI	Kjeller	Offenbach	CAS

Table 2 – Proposed additions to Appendix B, Manual on WIS list of WIS Data Collection or Production Centre

WMO Member or Contributing Organization	Name / Function	Centre location region/city		Principal GISC	Const. Body
Argentina	VAAC	III	Buenos Aires	Brasilia	CAeM
	RTH	III	Buenos Aires	Brasilia	CBS
	RSMC-Geographical	III	Buenos Aires	Brasilia	CBS

Recommendation 15 (CBS-16)

ADVICE ON METADATA IN THE *GUIDE TO THE WMO INFORMATION SYSTEM* (WMO-No. 1061)

THE COMMISSION FOR BASIC SYSTEMS,

Recalling that at its extraordinary session in 2014 the Commission had asked that:

(1) Guidance for authors of WMO Information System (WIS) discovery metadata should be prepared for inclusion in the *Guide to the WMO Information System* (WMO-No. 1061) (*Abridged Final Report with Resolutions and Recommendations of the Extraordinary Session of the Commission for Basic Systems* (WMO-No. 1140), general summary 3.2.19),

(2) Only guidance that was expected to remain valid for a long time should be published in WMO Guides and that other guidance should be made available on the web,

Noting that in respect of recording data policy applicable to information:

(1) Resolution 40 (Cg-XII) urges Members to “make known to all Members, through the WMO Secretariat, those meteorological data and products which have conditions related to their re-export for commercial purposes outside of the receiving country or group of countries forming a single economic group”; that Resolution 25 (Cg-XIII) contains a similar provision for hydrological information; and that Resolution 60 (Cg-17) similarly urges that third parties are informed of “any terms and conditions associated with the additional GFCS [Global Framework for Climate Services] relevant data and products”,

(2) The method of notification used to meet the requirements of Resolutions 40 (Cg-XII) and 25 (Cg-XIII) has been a letter from the permanent representative to the Secretary-General and that the WMO Secretariat responded by including the designation in *Weather Reporting* (WMO-No. 9), Volume C1 – Catalogue of Meteorological Bulletins,

(3) That the WMO core profile of the ISO 19115 geographic metadata standard provides a mechanism to declare the WMO data policy constraint applicable to information described by a WIS discovery metadata record,

(4) That a permanent representative has to authorize individuals to create or modify WIS discovery metadata records,

Noting further that in respect of the WMO core profile the Open Programme Area Group on Information Systems and Services (OPAG-ISS) had concluded that:

(1) Although the International Organization for Standardization had published a revision of its standard on geographic metadata, the needs of WIS were met adequately by the standard underpinning version 1.3 of the WMO core profile of the ISO 19115 geographic metadata standard,

(2) Priority should be given to assisting Members create metadata records that were relevant to users,

Decides:

(1) To postpone adoption of an update to the WMO core profile of the ISO 19115 geographic metadata standard until more examples of best practice are available from other user communities to guide a WMO standard;

(2) To make available detailed guidance on the WMO core profile on the WMO website, particularly in support of those developing applications;

Requests OPAG-ISS to publish on the WMO website emerging best practice on the use of the WMO core profile;

Recommends to the Executive Council:

(1) That updating the value assigned to “WMO_DataLicenseCode” in the WIS discovery metadata record describing shared information should be the mechanism used by permanent representatives to notify the Secretary-General, Members and third parties of the data policy to be applied to that information, and that a letter from the permanent representative should no longer be required;

(2) The text in the annex to the present recommendation for inclusion in the *Guide to the WMO Information System* and the reference to it from the *Manual on the WMO Information System* (WMO-No. 1060);

Authorizes the Secretary-General to make editorial amendments to the contents of the annex to the present recommendation.

Annex to Recommendation 15 (CBS-16)

TEXT FOR INCLUSION IN THE *GUIDE TO THE WMO INFORMATION SYSTEM* (WMO-No. 1061)

Add the text of the Annex to Resolution 12 (EC-68) to the Manual on WIS (WMO-No. 1060).

Amend paragraph 5.4 of Part V "WIS Discovery metadata" of the Manual on WIS (WMO-No. 1060)

5.4 **CBS shall maintain and develop the WMO Core Metadata Profile. ~~Changes to the WMO Core Metadata Profile shall be governed using the procedures defined in Appendix C to this Manual.~~**

Note: Resolution 12 (EC-68) designated Appendix C Part 2 section 3 (Data Dictionary) as technical specifications for the purposes of managing amendments.

Note: Guidance on application of the WIS Core Metadata Profile is available in Part V of the *Guide to the WMO Information System* (WMO-No. 1061).

Amend the first paragraph in section 9.3 pf Appendix C Part 1 of the Manual on WIS (WMO-No. 1060)

WMO data policy pertaining to Resolution 40 (Cg-XII), ~~and~~ Resolution 25 (Cg-XIII), Resolution 60 (Cg-17) or ~~and~~ other regulations (e.g. ICAO Annex 3 – Meteorological Services for International Air Navigation) shall be expressed using the following controlled vocabulary: "WMOEssential", "WMOAdditional" and "WMOOther".

Note: Inclusion of the data policy in a metadata record describing information satisfies the requirements in the above resolutions to notify the Secretary-General or third parties of limitations on the use of the information described in the metadata record (Resolution XX, EC-69). Additional information on the type of restriction on use should be included in the metadata record if the text in the Resolution does not describe the restriction adequately. Further information on describing data policy is provided in the *Guide to the WMO Information System* (WMO-No. 1061).

Add the text of the Annex to Resolution 12 (EC-68) to the Guide to the WIS WMO-No. 1061 .

Add the following as the first paragraph in Part V "Metadata Guidance" of the Guide to the WIS (WMO-No. 1061)

Note: Resolution 12 (EC-68) designated Part V section 3 (Metadata Guidance) as technical specifications for the purposes of managing amendments.

Replace the original text in Part V "Metadata Guidance" of the Guide to the WIS (WMO-No. 1061) with the following text.

Guidance for creating WMO Core Profile Metadata in version 1.3

Introduction

Metadata records, by providing the product information that will allow WIS users to discover access and retrieve products, have a very important role in the WMO Information System (WIS). Metadata has to adhere to standards (such as standard vocabularies, and standard schemas) to ensure product definition homogeneity, and to contribute to making systems interoperable. There are a number of metadata standards that address the needs of meteorological and hydrological communities. The WIS "discovery" metadata standard (for

dataset discovery catalogues), is called the "WMO Core Profile 1.3". It is a profile of the ISO 19115:2003 metadata standard, with its associated ISO 19139 XML mapping. ISO19115 is a complex standard, and the creation of high quality ISO19115 metadata records can require both organizational expertise and subject expertise, in order to describe an object, and its context for use.

This guidance documentation is intended for metadata authors or product/infrastructure specialist who would like to create WMO Core Profile 1.3 (WMCP) metadata records for making their datasets discoverable within the WMO Information System (WIS) catalogue(s). It will also assist those who wish to create high quality WIS metadata records for data that will be ingested and distributed by a WMO GISC.

This Guidance documentation suite is composed of the present document, and associated WMO Core Profile Templates (see Section 0 References) which can be used to create individual metadata records, or to automate the creation of several records. It also provides a set of recommendations to be followed, in order to provide the right level / granularity of product information in the WMO Core Profile metadata records.

References

WMOCore Profile 1.3 Template XML records:

Template records containing PLACEHOLDERS (to be replaced with content) are available from

http://wis.wmo.int/MD-Templates

A valid example XML record, containing example field content (to be replaced) is also available there.

WMO WIS Wiki Page:

http://wis.wmo.int/MD_Index

WMO Core Profile documentation:

Part 1: http://wis.wmo.int/WCMPpart1
Part 2: http://wis.wmo.int/WCMPPart2

This GUIDANCE WMO Core Profile documentation suite:

http://wis.wmo.int/MD_Index or http://wis.wmo.int/WIS-Manual (for a summary of changes)

Additional WMCP Metadata Examples (for particular product types):

http://wis.wmo.int/MD-Examples

WIS Discovery Metadata

WMO Core Profile Presentation

The WMO Core Profile (WMCP) v1.3, while sometimes referred to as "discovery" metadata, is also aimed at providing catalogue users with sufficient information for them to decide on the suitability of the data, and to provide access to, or details on how to access the data. Some of the information contained in a WMCP metadata record is vital for optimizing the searching functionality offered by the WIS Product catalogues. In the WIS, users typically need to search one of the WIS catalogues, for discovering and accessing products.

A "discovery" metadata record has to contain the following components of information, to help users understand that product: What, When, Where, Who, How. A summary overview is provided below, and details are provided in Section 9.1.

(a) Product Information:

- **What**: This is the product content, and it is mainly defined by the Product Title and the Product Abstract fields, though additional fields can also be used. The information in the title and abstract is very important because the Product Title and Abstract are indexed by any Product catalogue, and thus searchable. In addition, the title and part of the abstract are presented to users, in the search results of each WIS Catalogue, and so good content here can assist users' efficiency in their "search, view search results, and decide" activity.

- **When**: This is the temporal coverage of the dataset or product, and is captured in the "temporal extent" section of the metadata record. It is possible to describe on-going, finite, or 'rolling window' datasets.

- **Where**: This is the geospatial extent of the dataset, describing which geographical area(s) the product covers, over the Earth or atmosphere. It can be the full Earth, a region or a specific place. In the WMCP, if the data is geographical, the metadata record must define as at least one bounding box with latitude-longitude coordinates, but that information can also be enhanced by using geographical identifiers for geographical regions, features (such as coastlines) and the like.

- **Who**: This is the contact details of the organization that is responsible for the product; the contact details of the organization responsible for the metadata, and (optionally) the name of the party that should be "cited", when referencing the data. It's possible, but not necessary for the same party to be responsible for both the metadata and data.

- **How - Data access and use**: This information is composed of the distribution information, but also includes the data policy, or terms and conditions for accessing the product. Most of the time, the distribution section offers a URL linking to a data access service. The data access service might require registration, and /or might offer sub-select/sub-sampling of the product. Currently, users wishing to access information that has the Data Policy (shown in "ResourceConstraints") of “WMOAdditional” must be registered with their regional GISC. Data with a Data Policy of "WMOEssential" can be accessed wihout restriction. Users wishing to set up a “subscription” service, however, must register, regardless of the type of information they require.

(b) **WIS necessary technical information**: Section 9.2 of this document defines the set of information required, to have a functioning, distributed WIS infrastructure. This includes, for instance, the WIS unique identifier for each metadata records.

WMO Core Profile and ISO standard

The WMO Core Profile 1.3 is a customization, also called a profile, of the more generic ISO 19115 discovery metadata standard. It allows the meteorological community to better define meteorological products (terrestrial, Earth observations, numerical weather predictions model outputs). The ISO 19115 structure is detailed and complex, because it was designed to

accommodate a wide range of information resource types. The WMO Core Profile, as well as providing more targeted searching, aimed to remove the need to understand some of those intricacies of ISO19115. This Guide aims to simplify the knowledge needed by users who are starting to create WMO Core Profile v.1.3 metadata records.

WMO Core Profile Metadata Granularity and Scope

One difficulty, when creating a metadata record, is to understand what level of detail of a dataset should be described, in the record for a particular product/dataset. Some products of the same type are continuously produced, during the life time of a satellite, or as model forecast outputs. Creating a new metadata record for each individual satellite instrument measurement granule (produced every three minutes), or for each forecast run (produced three times a day) would make the WIS catalogues' content grow at a huge rate, and the thousands of new metadata records would contain the same information, apart from the measurement time. This would dramatically damage the catalogue search experience, and would make it difficult to find products.

To solve that problem, the creation of one metadata record for an entire "collection" of "like" products is generally recommended, provided that effective searching, and other WIS infrastructure needs are not compromised. An example of "like" products is where each observation product only varies within one or two dimensions (time, geographical position, etc.), while still coming from the same measurement instrument or station.
An example of this approach is the EUMETSAT Meteosat Second Generation (MSG) Seviri Level 1.5 dataset which includes all the level 1.5 radiances over the entire MSG mission with a global coverage, and is described by one unique metadata record. The user discovering this product collection, via the WIS portals, is re-directed to a EUMETSAT service offering sub-sampling capacities for selecting the interesting time period and geographic region.

That said, it is up to the data provider to decide what is a valid collection. To assist, IPET-MDRD has defined, in the Annex Section 12 (**Collection Definition Criteria**), a set of "granularity" criteria to consider when defining a collection metadata record.

WIS product Categories

Two forms of information (and corresponding transport protocols) are used in WIS catalogues:

(a) **GTS-delivered data**. This is mainly, but not exclusively, traditional WMO 'bulletins';

(b) **Non-GTS-delivered data**. This can include both data stored as files, and data as services.

(a) The first category is governed by the set of regulations described in the *Manual on the GTS* (WMO-No. 386), including the bulletin header (abbreviated header line) which identifies a bulletin like ISMS01 AMMC.

Metadata records for GTS bulletin datasets need to follow a set of additional rules, and require an understanding of the GTS regulations. Non-bulletin files can also be distributed via the GTS.
The most notable feature is the store-and-forward delivery mechanism for bulletins and other data on the GTS. This is the reason that there used to be no URL for a bulletin - once a bulletin is delivered, it is not retained for later reference.

Today, GISCs serve bulletins issued in the past 24 hours, but the common practice is still that a metadata record for bulletins does not include the access URL(s).

(b) The second category includes datasets described and searchable from the WIS catalogues, but which are served from the different responsible organizations, via their own infrastructure and data access services. WMO Core Profile (WMCP) 1.3 metadata records for this second category have to follow a minimum set of rules, to stay compliant with the standard. This is a subset of the rules which apply to GTS-served data.

Typically, these metadata records include a URL for access to the data.

This guide provides extensive support for creating the different information parts of a metadata record, for both non-GTS and GTS delivered datasets. When necessary, an additional section for creating metadata records for GTS bulletins has been added, in each information category (e.g. Product information abstract).

COMPLIANCE to additional metadata standards

This guide provides information to help create metadata records that comply with WMO Core Metadata Profile (**WMCP**) v.1.3. The WMCP Profile is based on ISO-19115 (Geographic information — Metadata standard). ISO 19115 provides two profiling mechanisms:

(i) Recommending a more constrained use of ISO19115 (either by recommending use of less fields, making an optional element mandatory, or constraining the expected content of a field) - to suit the needs of a particular community; and

(ii) In addition to (i), defining additional non-ISO19115 fields (and field content) to be added to any record.

Examples of type (i) ISO19115 profiles, in addition to the WMCP, include the INSPIRE Metadata Profile (Infrastructure for Spatial Information in the European Community), the North American Profile, the Australian and New Zealand Metadata Profile (ANZLIC) and UK GEMINI. An example of (ii) is the Marine Community Profile. For more information see also http://www.dcc.ac.uk/resources/metadata-standards/iso-19115.

Each ISO19115 profile defines specific rules that should be met. For example, to comply with the INSPIRE metadata profile, the additional requirements to be met include the provision of one keyword from the general environmental multilingual thesaurus (GEMET), a lineage statement and a conformance statement to Regulation (EC) No. 1205/2008.

The content of a WMO Core Profile 1.3 metadata record, defined following this current guide, can be extended, so that the record also supports additional profiles (such as, for instance, INSPIRE or ANZLIC). In such a case, the metadata author is required to implement any additional requirements specified in the corresponding profile's documentation. The extended WMO Core Profile 1.3 metadata record can still be published on the WIS.

WMO Core Profile - Validation Tools

Metadata publishers are required to ensure that created metadata records conform to relevant technical specifications. For example, XML documents need to be well-formed, schema-valid, and conformant with other requirements imposed by the specifications.

A set of ISO and WMCP validation tools can be used, to ensure that a created WMO Core Profile record is correctly formatted (syntactically and semantically), and can be ingested by a GISC.

In most cases, to validate metadata, the metadata author will need a local copy of the metadata record, or the URL of the metadata file, and offer the local location or URL in an online service, or with a locally installed validation software.
Online validation services can automatically evaluate the content of the metadata in terms of the completeness, accuracy and conformance. Some validation tools, such as the one developed by NOAA (http://www.ngdc.noaa.gov/docucomp/recordServices) may give a score based on different aspects including content and quality of metadata.

It is recommended to test the metadata with one of the available tools. It is also always possible to seek assistance from your Principal GISC.

Below is a list of web services and tools used to validate WMO Core Profile 1.3 and ISO 19115/19139 metadata records.

WMO Core Profile 1.3 validation services / tools:

- **NOAA's WMO validation service**:
  http://www.ngdc.noaa.gov/docucomp/validationServicesWmo

- **GeoNetwork-ANZMEST, with WMO Core Profile Validation**

- https://sourceforge.net/projects/anzmest/files/bom-releases/
  This directory has the Bureau of Meteorology releases of ANZMEST 2.10.x (based on GeoNetwork), which includes WMO Core Profile 1.3 editing and validation tool.
  For instructions on running the software and validation, see the WIS Wiki page on validation tools [below]

WIS Wiki page on validation tools : http://wis.wmo.int/MD-Validate

ISO 19115 / 19139 validation services / tools:

- NOAA ISO validation page:
  http://www.ngdc.noaa.gov/docucomp/recordServices

- GeoNetwork-ANZMEST – BOM branch

- https://sourceforge.net/projects/anzmest/files/bom-releases/ (includes 19115:2006, 19115:INSPIRE)

Principles of metadata management on the WIS

The Global Information System Centres (GISCs) are responsible for the management of metadata. According to the WMO technical regulations, each GISC shall:

- Provide a comprehensive metadata catalogue with discovery services for all National Centres (NC) and Data Collection and Production Centres (DCPC) data content across the WIS,

- Support the Search and Retrieve via URL protocol (SRU),

- Ensure the synchronization of metadata among GISCs, using the OAI-PMH protocol,
- Support user's identification and authorization, including in terms of metadata maintenance,
- Provide metadata publishing facilities: Using Uploading/Harvesting metadata publishing or on-line Metadata editing to allow Metadata author creating metadata records.

How to publish metadata?

- Metadata could be published at DCPC or GISC level,
- Find which GISC you belong to (i.e. which is your principal GISC). The official reference of WIS centres (GISCs and affiliated DCPCs and NCs, areas of responsibility) is the Annex VII to the WMO Technical Regulations, *Manual on WIS* (WMO-No. 1060), ***Annex B Approved WIS Centres***. The list of GISCs, and related links, is also available online on WMO portal: https://www.wmo.int/pages/prog/www/WIS/centres/index_en.php. The procedure to be used for metadata management (account creation, editing facilities, ...) may vary between centres, but will usually be via the GISC portal (at least, as a first point of contact),
- Proceed to registering on your principal GISC (this could be done online, depending on GISC's capabilities or policies), after which you will be assigned a username and a role,
- Publish your metadata via your principal GISC: In order to publish your metadata records, use the appropriate method among those allowed by the GISC (import/insert metadata, or harvest metadata using OAI-PMH).
  Note: For a limited number of records, it is typically also possible to use a GISC's online editing services.

For more comprehensive information regarding the WIS and publishing metadata on the WIS, please consult the WIS Manual (http://wis.wmo.int/WIS-Manual).

Generating WMO Core Profile METADATA

This guide is intended to help product specialists create WIS metadata records which are compliant with the WMO Core Profile 1.3. It provides practical guidance on key information needed in WMCP metadata creation (such as describing how, and where, to insert the necessary product information into a template record, and the WIS specific information required in the XML metadata record), while abstracting (as much as possible) the WMO Core Profile standard, the ISO 19115 standard and its XML mapping (ISO 19139).

The current guide defines [in Section 9: "Necessary Information to create a WMO Core Profile "] a set of recommendations for adding each individual piece of information regarding a product (title, abstract, data responsible party, data access, etc.).

This guide uses an **XML template** based approach. A metadata author consulting this guide should use a copy of the **Template xml record**(s) [the url to access these is indicated in the

"References" section of this document) in conjunction with this Guide, especially Section 9. "Necessary Information to create a WMO Core Profile ".

The template-based approach allows a person without any knowledge of ISO 19115 to create an XML WMO Core Profile metadata record populated with the key information needed to make the record easily searchable and accessible within a WIS portal.

The template files can also be used as the foundation for building a web-based editing tool where the user completes a web form, and the content is used to overwrite the placeholders, and create the final WMO Core Profile 1.3 compliant metadata record.

Template-based principle

The Template xml files are metadata records encoded as xml. These contain PLACEHOLDERS, that is: GENERIC-TEXT that should be replaced with information related to the specific product that the WIS discovery metadata record describes.

Placeholders in the 2 template files are all in capital letters, in the form of, for instance:

```
ADD-CREATION-DATE*M or PRODUCT-TITLE*M.        i.e.    <xml field name>ADD-
                    ORGANISATION-NAME*M</xml field name>
```

The 2 **Template** WMCP xml metadata records are "WMCPv1.3 _MAND-**Template**.xml" and "WMCPv1.3 _OPTandMAND-**Template**.xml" (see Section 0: References, for its access url).

There is also a "WMPv1.3 _OPTandMAND-**Content**.xml" file, which has example content, rather than the placeholders. This latter is a valid WMCP record, which can be added into any editor, and then modified, or can be manually edited.

As well as PLACEHOLDERS, the two Template files contain hints and comments, formatted as follows:

```
<!--  this is a comment : use this XML block, if ….., otherwise, remove it    -->
```

Metadata content discussed in this Guidance document (and for which there are placeholders) includes all mandatory WMCP content, and some key content that is optional. The optional elements can be one of the following:

(i) Highly recommended [*HR]

(ii) Conditionally mandatory [*C]

(iii) Likely to be needed [*O]
*(As noted elsewhere, other ISO19115 elements, while not mentioned in the WMCP v1.3 documentation, may also be deemed useful, and **can** be used within a WMCP record. An example might be the DataQuality section, or the SupplementalInformation field. For reasons of brevity, however, these have been omitted from this document.)*

An example of (iii) is Section 9.1.7 Geographic Identifier.

An example of (ii) is Section 9.1.6 Geographic Bounding Box (which is only mandatory if the dataset is geospatial) or Section 9.1.10 Data Policy, which, while OPTIONAL, is mandatory if the product is GTS data.

An example of (i) is Section 9.1.5 Product Temporal Information, which, while OPTIONAL, is highly recommended.

Note that many optional <<subsections>> of a WMCP record contain elements which are mandatory **only if** that subsection is used. These are marked with "-MW", meaning "mandatory within subsection".

An example of that is the .. 'identifier'/'authority'/'title', as shown on lines 53-57, in the ANNEX's hierarchical list of fields (and in excerpt below), where 'identifier' is optional ([0..n]), and even if it is used, 'authority' is optional ([0..n]); however, if 'authority' **is** used, then 'title' is mandatory ([1..1]).

```
53 _ ._ ._ ._ ._ .identifier_ ._ .ISO[0..n]
54_ ._ ._ ._ ._ ._ .MD_Identifier
55_ ._ ._ ._ ._ ._ ._ .authority_ ._ .ISO[0..1]
56_ ._ ._ ._ ._ ._ ._ ._ .CI_Citation
57_ ._ ._ ._ ._ ._ ._ ._ ._ .title_ .char_ ._ .ISO[1..1]
```

(Excerpt from ANNEX, Section 13)

The cardinality notation of [x..y] indicates the minimum and maximum allowable times that the element may be used, within that part of the hierarchy/tree. For instance: [0..n] means that the element is optional, but can also be used any number of times; the notation of [1..2] means that it is mandatory, and may be used a maximum of two times. Refer to the ANNEX for a hierarchical list of the main elements mentioned in this document, and their cardinality. ***Placeholders for WMCP mandatory content end with *M.***

The "WMOCoreProfile1.3 _OPTandMAND-**Template**.xml" file contains placeholders for all mandatory and optional elements that have been mentioned in this Guidance document. The "WMOCoreProfile1.3 _MAND-**Template**.xml" file contains placeholders for all mandatory elements mentioned in this Guidance document.

Where the metadata author chooses not to populate an **optional** field, then ***the related xml block (as indicated in the comments in the 2 template files) should be removed.***

A metadata author can, by following placeholders in the Template file, and the guidance recommendations in Section 9: [" Necessary Information to create a WMO Core Profile "], replace the different `PLACEHOLDERS`, and follow the `<!-- comments -->` in the template file, to create a WMO Core Profile 1.3 compliant record.

The 2 template WMCP xml metadata records, with only the placeholders, can be used as a starting template record for automating the generation of metadata records.

Necessary Information to create a WMO Core Profile COMPLIANT METADATA Record

Section 9 describes the information components needed, to build a meaningful metadata record. For each individual component, it includes:

- ***TEMPLATE Value:*** the template XML record's placeholder value(s), which are to be replaced;

- A summary of the type of information (from the metadata creator) that should replace the placeholder;
- ***Necessity:*** whether the component is always mandatory, conditionally mandatory, highly recommended or is optional, within WMO Core Profile 1.3;
- ***XPath:*** its location within the WMCP XML metadata record; and
- Example XML for that component, containing example content, instead of the Placeholder(s).

The metadata creator should, while reading the documentation, open the relevant metadata template record, and find the corresponding placeholder(s), which are to be replaced by the relevant product information.

For each component, this Guidance document offers a description of what is generally required for a Product, followed, where relevant, by details of what is required in a WMCP record for GTS Bulletin-specific metadata.

Product Information

Product Title

9.1.1 Product Title	
TEMPLATE Value:	ADD-PRODUCT-TITLE*M, ADD-ALTERNATE-TITLE*O
Information:	Product Name
Necessity:	Mandatory for WMO Core Profile 1.3
Category:	Product information
XPath:	/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:citation/*/gmd:title/*/text() (Line 45 in ANNEX, Section 13)

The Product Title and the Product Abstract are the two most relevant elements in the WCMP metadata record, in the context of the WIS Product catalogues, as those two elements are presented to the users in the search results and product description page. They therefore need to focus on highlighting the product's key characteristics, to assist users searching for relevant products.

The title should be as specific about the product as is possible. If the product only contains one parameter, for instance, this can be stated in the title; however, if the product contains many parameters, then a more general term should be used in the title, and the parameters stated elsewhere in the metadata record (the abstract and/or the keywords). For a satellite product offering one main data parameter, the title will typically define which parameter is contained in the product, and from which instrument or instrument type it originates. For instance “AMSR-2 Sea Surface Temperature” or “SLSTR L1B radiances and brightness temperatures”.
Below is an example:

```
<gmd:identificationInfo>

   <gmd:MD_DataIdentification>

      <gmd:citation>

         <gmd:CI_Citation>

            <gmd:title>

               <gco:CharacterString>AMSR-2 Sea Surface Temperature</gco:CharacterString>

            </gmd:title>
```

```
            <gmd:alternateTitle>

               <gco:CharacterString>

               AMSR-2 Sea Surface Temperature SST

               </gco:CharacterString>

            </gmd:alternateTitle>
           . . . . . .

       </gmd:CI_Citation>

     </gmd:citation>
         . . .. .

   </gmd:MD_DataIdentification>

</gmd:identificationInfo>
```

- **Title for GTS bulletins**

The title for a GTS bulletin should also aim to be specific about the product, describing, as much as possible, the type of observation, and including the bulletin code or identifier, and original distributor (e.g. "from XXX").

For instance:

```
<gmd:identificationInfo>

    <gmd:MD_DataIdentification>

      <gmd:citation>

        <gmd:CI_Citation>

          <gmd:title>

            <gco:CharacterString>Sea level observations data [ SZPS01 ] for the South Pacific area.
CREX encoded. Every 3 minutes or as required (available from AMMC).</gco:CharacterString>

          </gmd:title> …
```

Product Abstract

9.1.2 Product Abstract	
TEMPLATE Value:	ADD-PRODUCT-ABSTRACT*M
Information:	Abstract describing the product
Necessity:	Mandatory for WMO Core Profile 1.3
Category:	Product information
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:abstract/*/text()*

The product abstract is important in the context of the WIS catalogues, as it is part of the product information that is presented in the search results page. It should describe aspects which the data producer judges as important, and which will enable potential users to understand the key characteristics of, and nature of the product, so that they more quickly judge the suitability of that product for their needs.

The following structure of the abstract is recommended, in order to create a more coherent and homogenous set of data product descriptions, on the WIS. Having product abstracts structured similarly will help users who are comparing related and different data products.

The product abstract should complement the title by more accurately explaining the title's content, and should provide further detail, where appropriate, describing the product and in

particular the source of the data (such as the instrument type or model when applicable), the coverage, production frequency (hourly, every 3 minutes, etc.), the data processing level (near real-time, derived, quality controlled), the available formats, and the data access services when relevant.

Below are typical abstracts for

(a) A NWP product:

Title: Copernicus Atmosphere Service MACC-IFS near real-time 5-day forecast of global black carbon aerosol concentration

Abstract: This service provides pre-operational daily forecasts up to 5 days of global black carbon aerosol using the IFS-LMD aerosol model. The product black carbon aerosol mixing ratios at 60 model levels. There are two forecasts per day, with base times of 00:00UTC (5-day forecast) and 12:00UTC (1-day forecast). Forecast steps are available at 3-hourly intervals and the spatial resolution is 0.75x0.75 degree. The forecast fields are generated in GRIB.

(b) A Satellite Observation Product

Title: IASI Atmospheric Temperature Water Vapour and Surface Skin Temperature - Metop

Abstract: The Atmospheric Temperature, Water Vapour and Surface Skin Temperature (TWT) product contains the vertical profiles of atmospheric temperature and humidity, with a vertical sampling at 101 pressure levels, and surface skin temperature. The vertical profiles are retrieved from the IASI sounder measurements (of IASI L1C product) together with collocated microwave measurements (AMSU & MHS 1B) when available. The main objective of the Infrared Atmospheric Sounding Interferometer (IASI) is to provide high-resolution atmospheric emission spectra to derive temperature and humidity profiles with high spectral and vertical resolution and accuracy. Additionally it is used for the determination of trace gases, as well as land and sea surface temperature, emissivity and cloud properties. The products are provided at the single IASI footprint resolution (which is about 12 km with a spatial sampling of about 25 km at Nadir). The quality and yield of the vertical profiles retrieved in cloudy IFOVs is strongly related to the cloud properties available in the IASI CLP product and the availability of collocated microwave measurements.

More examples for Metadata Titles and Abstracts can be found in the WIS Wiki http://wis.wmo.int/WIS-MD-Examples

Abstract for GTS bulletins

For the SMPS02 bulletin:

Title: SMPS02 SYNOP reports (pressure, wind and temperature) –South Pacific area; Available from NZKL (WELLINGTON/KELBURN) at 00, 06, 12 and 18 UTC

Abstract:

This bulletin dispatches synoptic data (pressure, temperature and wind) every 6 hours, starting at 0 UTC. The bulletin includes reports from the following stations: 91823 (NIUE AERO AWS) and 91962 (PITCAIRN ISLAND AWS).

Data Type: Surface data - Main synoptic hour - South Pacific area.

Actual data parameters sent include: Pressure, Pressure reduced to mean sea level, 3 hour pressure-change, characteristic of pressure change (increasing/decreasing), temperature (dry-bulb and dewpoint), wind direction, and wind speed.

Format: FM 12 (SYNOP, Report of surface observation from a fixed land station).
(Refer to WMO No.306 - Manual on Codes for the definition of WMO international codes)

---- The SMPS02 TTAAii Data Designators decode (2) as:
T1 (S): Surface data.
T2 (M): Main synoptic hour.
A1A2 (PS): South Pacific area.
(2: Refer to WMO No.386 - Manual on the GTS - Attachment II.5)

Metadata Responsible Party

9.1.3 Metadata Responsible Party	
TEMPLATE Value:	ADD-METADATA-CONTACT-ORGANISATION-NAME*M; ADD-ADDRESS-STREET*O; ADD-CITY*O; ADD-REGION*O; ADD-POSTCODE*O; ADD-COUNTRY*O; ADD-EMAIL-ADDRESS*HR ; ADD-ORGANISATION-WEBSITE*O.
Information:	Responsible party for the created metadata record
Necessity:	Mandatory for WMO Core Profile 1.3
Category:	Administrative information
XPath:	*/gmd:MD_Metadata/gmd:contact/gmd:CI_ResponsibleParty*

This element describes the contact details (address, telephone, email) of the party responsible for the metadata. For example:

```
<gmd:MD_Metadata>
   …… .. .. .

   <gmd:contact>

        <gmd:CI_ResponsibleParty>

            <gmd:organisationName>

                <gco:CharacterString>EUMETSAT</gco:CharacterString>

            </gmd:organisationName>

            <gmd:contactInfo>

                <gmd:CI_Contact>

                    <gmd:address>

                        <gmd:CI_Address>

                            <gmd:deliveryPoint>

                                <gco:CharacterString>EUMETSAT Allee 1</gco:CharacterString>

                            </gmd:deliveryPoint>

                            <gmd:city>

                                <gco:CharacterString>Darmstadt</gco:CharacterString>
```

```
                            </gmd:city>
                            <gmd:administrativeArea>
                                <gco:CharacterString>Hessen</gco:CharacterString>
                            </gmd:administrativeArea>
                            <gmd:postalCode>
                                <gco:CharacterString>64295</gco:CharacterString>
                            </gmd:postalCode>
                            <gmd:country>
                                <gco:CharacterString>Germany</gco:CharacterString>
                            </gmd:country>
                            <gmd:electronicMailAddress>
                                <gco:CharacterString>ops@eumetsat.int</gco:CharacterString>
                            </gmd:electronicMailAddress>
                        </gmd:CI_Address>
                    </gmd:address>
                    <gmd:onlineResource>
                        <gmd:CI_OnlineResource>
                            <gmd:linkage>
                                <gmd:URL>http://www.eumetsat.int</gmd:URL>
                            </gmd:linkage>
                        </gmd:CI_OnlineResource>
                    </gmd:onlineResource>
                </gmd:CI_Contact>
            </gmd:contactInfo>
            <gmd:role>
                <gmd:CI_RoleCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#MD_ScopeCode" codeListValue="pointOfContact">pointOfContact</gmd:CI_RoleCode>
            </gmd:role>
        </gmd:CI_ResponsibleParty>
    </gmd:contact>
```

Product Responsible Party

9.1.4 Product Responsible Party	
TEMPLATE Value:	ADD-PRODUCT-RESPONSIBLE-PARTY-ORGANISATION-SHORTNAME*M, ADD-PRODUCT-RESPONSIBLE-PARTY-EMAIL*HR
Information:	Organization responsible for the product described in the metadata record
Necessity:	Mandatory for WMO Core Profile 1.3
Category:	Product Information
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:pointOfContact/gmd:CI_ResponsibleParty*

This element contains the contact details of the organization responsible for the product. A minimum of a name and an e-mail address are required, and the role should be "pointOfContact".

```
<gmd:MD_Metadata>
  …… .. .. .

 <gmd:identificationInfo>

   <gmd:MD_DataIdentification>

      <gmd:citation>

       .. .. .. .. .

      </gmd:citation>

      .. . . . . . .

      <gmd:pointOfContact>

         <gmd:CI_ResponsibleParty>

            <gmd:organisationName>

                <gco:CharacterString>EUMETSAT</gco:CharacterString>

            </gmd:organisationName>

            <gmd:contactInfo>

                <gmd:CI_Contact>

                    <gmd:address>

                        <gmd:CI_Address>

                            <gmd:country>

                                <gco:CharacterString>Germany</gco:CharacterString>

                            </gmd:country>

                            <gmd:electronicMailAddress>

                                <gco:CharacterString>ops@eumetsat.int</gco:CharacterString>

                            </gmd:electronicMailAddress>

                        </gmd:CI_Address>

                    </gmd:address>

                    <gmd:onlineResource>

                        <gmd:CI_OnlineResource>

                            <gmd:linkage>
```

```
                                <gmd:URL>http://www.eumetsat.int</gmd:URL>

                            </gmd:linkage>

                        </gmd:CI_OnlineResource>

                    </gmd:onlineResource>

                </gmd:CI_Contact>

            </gmd:contactInfo>

            <gmd:role>

                <gmd:CI_RoleCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#MD_ScopeCode" codeListValue="pointOfContact">pointOfContact</gmd:CI_RoleCode>

            </gmd:role>

        </gmd:CI_ResponsibleParty>

    </gmd:pointOfContact>
```

Temporal Extent

9.1.5 Product Temporal Information	
TEMPLATE Value:	ADD-TEMPORAL-INFORMATION *HR ADD-TEMPORAL-INFORMATION-startDate*HR, ADD-TEMPORAL-INFORMATION-endDate*HR
Information:	Time period to which the product applies
Necessity:	Optional for WMO Core Profile 1.3
Category:	Product information
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/*/ gmd:extent/*/gmd:temporalElement/*/gmd:extent/*

This element describes the period of time that the available product covers. Where the product has a clear start and end date, and where the entire set of data is available, the specific start Date and end Date should both contain a date or dateTime. The date information is constructed as YYYY-MM-DD; while the date and time information is constructed as YYYY-MM-DDTHH:MM:SSZ (for UTC time). For example: 2016-04-17T13:42:54Z.

The following temporal Extents examples are described:

(a) **[DateX]** to **[DateY]** e.g. start Date:2005-10-01 end Date:2014-10-20

(b) **[DateX]** to **[Now]** e.g. start Date:2005-10-01 end Date:Now

(c) **[Now]** plus **[period]** e.g. start Date:now end Date:after duration: P1M (+1 month)

Where it is not possible to accurately capture (using start Date, end Date and duration) in the temporalExtent, then record details that are as close as possible, and then explain it in words, using the "description" field.

(a) [DateX] to [DateY] e.g. start Date:2005-10-01 end Date:2014-10-20

The following example shows a dataset with a known start date and a known end date

```
<gmd:temporalElement>
  <gmd:EX_TemporalExtent id="boundingTemporalExtent">
    <gmd:extent>
      <gml:TimePeriod gml:id="boundingTemporalExtentPeriod">
        <gml:beginPosition>2005-10-01</gml:beginPosition>
        <gml:endPosition>2014-10-20</gml:endPosition>
      </gml:TimePeriod>
    </gmd:extent>
  </gmd:EX_TemporalExtent>
</gmd:temporalElement>
```

(b) [DateX] to [now] e.g. start Date:2005-10-01 end Date:now

It is also possible to describe an on-going dataset with a known start date, but no known end Date. In that case, then end Date should contain the attribute of indeterminatePosition="now". For instance, where a dataset is from 2005-10-01 onwards, it would be encoded as follows :

```
<gmd:temporalElement>
  <gmd:EX_TemporalExtent id="temporalExtent">
    <gmd:extent>
      <gml:TimePeriod gml:id="boundingTemporalExtentPeriod">
        <gml:beginPosition>2005-10-01</gml:beginPosition>
        <gml:endPosition indeterminatePosition="now"/>
      </gml:TimePeriod>
    </gmd:extent>
  </gmd:EX_TemporalExtent>
</gmd:temporalElement>
```

The temporalExtent **options**, for a timePeriod, include beginPosition, endPosition and duration, e.g.:

```
<gml:beginPosition> ..   …  …</gml:beginPosition>
<gml:endPosition> ..   …  …</gml:endPosition>
<gml:duration> ..   …  …</gml:duration>
```

For a timePeriod, the **begin** and **end** Positions must always be included, and **duration** is optional.

The encoding of duration [(- or +) PnYnMnDTnhnmns] allows the expression of time intervals such as:

> A number of years (nY), and/or months (nM), and/or (nD) days, or hours (nh), or minutes (nm), or seconds (ns), where "n" represents a number.

For example: a duration of 4 hours is expressed as **P0Y0M0DT4h0m0s** or **PT4h**
Note that duration can be expressed as either the long form (eg P0Y5M0DT0h0m0s) or short form, but the short form must include "T" for intervals of hours, minutes or seconds (e.g. P5M is 5 months, PT5m is 5 minutes).

For more information on encoding a 'duration', see the "Durations" segment, at https://en.wikipedia.org/wiki/ISO_8601.

(b) [Now] plus [period] e.g. start Date:now end Date:after duration: P0Y0M7DT0h0m0s (+7 days)

For a dataset which is ongoing (that is, new data is continuously produced), but for which only the latest file is available (e.g. data is only ever available for a "rolling" window of time), the temporaExtent should reflect the period covered by the available data, in this case, the period that the latest file covers.

For instance, where only the latest file is ever available, and the latest file is a forecast for the next 7 days, it would be encoded as follows:

```
<gmd:temporalElement>
   <gmd:EX_TemporalExtent>
      <gmd:extent>
         <gml:TimePeriod>
            <gml:description>Next 7 days only</gml:description>
            <gml:beginPosition indeterminatePosition="now"/>
            <gml:endPosition indeterminatePosition="after"/>
            <gml:duration>P7D</gml:duration>
         </gml:TimePeriod>
      </gmd:extent>
   </gmd:EX_TemporalExtent>
</gmd:temporalElement>
```

Geographic Information

9.1.6 Geographical Information	
TEMPLATE Value:	(ADD-GEOSPATIAL-INFORMATION*C) ADD-BBOX-VALUE-WEST*M--MW, ADD-BBOX-VALUE-EAST*M-MW, ADD-BBOX-VALUE-SOUTH*M-MW, ADD-BBOX-VALUE-NORTH*M-MW
Information:	Geographic coverage of the product, as a bounding box in Latitude/Longitude
Necessity:	Conditional - Is Mandatory for WMO Core Profile 1.3, if the data is geographical
Category:	Product Information
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:extent/*/gmd:geographicElement/ gmd:EX_GeographicBoundingBox/*/*/text() [having 4 elements]*

Geographical area covered by the data product. The geographical area is described as a bounding box with latitude and longitude in decimal degrees.

The following example shows the XML for a dataset's bounding box information :

```
<gmd:geographicElement>
   <gmd:EX_GeographicBoundingBox id="boundingGeographicBoundingBox">
      <gmd:westBoundLongitude>
         <gco:Decimal>-180</gco:Decimal>
      </gmd:westBoundLongitude>
      <gmd:eastBoundLongitude>
         <gco:Decimal>180</gco:Decimal>
      </gmd:eastBoundLongitude>
      <gmd:southBoundLatitude>
         <gco:Decimal>-90</gco:Decimal>
      </gmd:southBoundLatitude>
      <gmd:northBoundLatitude>
         <gco:Decimal>90</gco:Decimal>
      </gmd:northBoundLatitude>
   </gmd:EX_GeographicBoundingBox>
</gmd:geographicElement>
```

Bounding boxes that cross the 180 degree meridian can be differentiated from bounding boxes that do not, by the following rule:

- In a dataset that does not cross the 180 degree meridian, the western-most longitude shall always be less than the eastern-most longitude;
- Conversely, if a bounding box crosses the 180 degree meridian, then the western-most longitude shall be greater than the eastern-most longitude.

Other constraints on geographic bounding boxes:

- Geographic points shall be designated with the northern-most and southern-most longitudes equal, and the western-most and eastern-most longitudes equal;
- Except for a geographic point, the total longitudinal span shall be greater than zero, and less than or equal to 360 degrees;
- The northern-most latitude shall always be greater than or equal to than the southern-most latitude;
- Longitude and latitude shall be recorded in a coordinate reference system that has the same axes, units and prime meridian as WGS84.

Geographic Identifier

9.1.7 Geographic Identifier	
TEMPLATE Value:	(ADD-GEOGRAPHIC-IDENTIFIER INFORMATION *O) ADD-GEOGRAPHIC-IDENTIFIER-THESAURUS-NAME*O, ADD-GEOGRAPHIC-IDENTIFIER-CODE*C-MW
Information:	Geographic Identifier indicating the zone covered on earth by the product
Necessity:	Optional
Category:	Product Information
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:extent/*/gmd:geographicElement/*/gmd:geographicIdentifier/gmd:MD_Identifier/code/*/text()*

Optional geographic identifier, indicating the area covered by the product. This can be used when the identifier is a well-known (within a targeted user community) or codified acronym for an area (such as a region), or feature (such as a water storage, coastline section, etc.). If the GeographicIdentifier block is used, then a code must be provided.

The GeographicIdentifier can be expressed in 2 ways:

(a) With just the Geographic Identifier Code, and a link to the related Codelist [Authority])

```
<gmd:extent>

   <gmd:EX_Extent id="geographicExtent">

      <gmd:geographicElement>

         <gmd:EX_GeographicDescription id="SouthAustralia__allGensRegister">

            <gmd:geographicIdentifier>

               <gmd:MD_Identifier>

                  <gmd:code>

                     <gco:CharacterString>
                           South Australia (SA)
                            (http://find.ga.gov.au/FIND/profileinfo/anzlic-allgens.xml#SA )

                     </gco:CharacterString>

                  </gmd:code>

               </gmd:MD_Identifier>

            </gmd:geographicIdentifier>

         </gmd:EX_GeographicDescription>

      </gmd:geographicElement>

   </gmd:EX_Extent>

</gmd:extent>
```

(b) With the Geographic Identifier Code, as well as a link to the related Codelist (via "Citation").


```
<gmd:extent>

   <gmd:EX_Extent id="geographicExtent">

      <gmd:geographicElement>

         <gmd:EX_GeographicDescription id="SouthAustralia__allGensRegister">

            <gmd:geographicIdentifier>

               <gmd:MD_Identifier>



                  <gmd:authority>

                     <gmd:CI_Citation>

                        <gmd:title>

                           <gco:CharacterString>
                           ANZLIC Geographic Extent Name Register

                            (http://find.ga.gov.au/FIND/profileinfo/anzlic-allgens.xml )

                           </gco:CharacterString>

                        </gmd:title>

                        <gmd:alternateTitle>

                           <gco:CharacterString>
                           ANZLIC AllGens / subcategory: anzlic-sla_2001edition
                           </gco:CharacterString>

                        </gmd:alternateTitle>

                        <gmd:date>

                           <gmd:CI_Date>

                              <gmd:date>

                                 <gco:Date>2011-10-25</gco:Date>

                              </gmd:date>

                              <gmd:dateType>

                                 <gmd:CI_DateTypeCode
codeList="http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode"
codeListValue="revision">revision</gmd:CI_DateTypeCode>

                              </gmd:dateType>

                           </gmd:CI_Date>

                        </gmd:date>

                     </gmd:CI_Citation>

                  </gmd:authority>



                  <gmd:code>
```

```
                    <gco:CharacterString>South Australia (SA)
                          (http://find.ga.gov.au/FIND/profileinfo/anzlic-allgens.xml#SA )

                    </gco:CharacterString>

                 </gmd:code>



               </gmd:MD_Identifier>

            </gmd:geographicIdentifier>

         </gmd:EX_GeographicDescription>

      </gmd:geographicElement>

   </gmd:EX_Extent>

</gmd:extent>
```

Station Identifiers for GTS bulletins

References in WIS metadata records, to Stations for a GTS bulletin, should point to WIGOS station identifiers (available through OSCAR/surface), and should be provided as keywords. See: **Section 9.1.8 (ii)**.

Descriptive keywords

9.1.8 Descriptive Keywords

Descriptive keywords are additional "controlled" terms which further classify (and so increase searching accuracy for) the products. The following general rules apply, for keywords in a WMCP record:

- Terms from the same keyword thesaurus/codelist, and of the same KeywordTypeCode, shall be grouped into a single instance of the <gmd:descriptiveKeywords> class;
- All WMO Core Profile metadata records shall have a least one WMO CategoryCode keyword, and the related KeywordTypeCode will be 'theme';
- All WMCP records for GTS data must contain a keyword from the WMO_DistributionScopeCode codelist, and it must be accompanied by the KeywordTypeCode of "dataCentre";
- A WMP metadata record describing data for global exchange via the WIS* shall indicate the scope of distribution using the keyword “GlobalExchange” of type “dataCentre”;
- Where data is related to WMO stations, the related WIGOS Station Identifiers should be recorded as keywords, see 9.1.8 (iii);
- Any 'Data parameter' term added as a keyword should be accompanied by the KeywordTypeCode of "dataParam".

WMO Category Code Keyword

9.1.8 (i) WMO CategoryCode Keyword	
TEMPLATE Value:	WCMP-WMO-CATEGORY-CODE*M
Information:	One or more WMO Category keywords, for classifying the product.
Necessity:	Mandatory for WMO Core Profile 1.3
Category:	Product Information
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/ */gmd:descriptiveKeywords/*/gmd:keyword/*/ text() /gmd:MD_Metadata/gmd:identificationInfo/ */gmd:descriptiveKeywords/*/ gmd:type/*/@codeListValue="theme" /gmd:MD_Metadata/gmd:identificationInfo/ */gmd:descriptiveKeywords/*/gmd:thesaurusName/ */ gmd:title/*/ text() ="WMO_CategoryCode*

Any WMO Core Profile metadata record shall have a least one WMO CategoryCode keyword, and the related KeywordTypeCode will be 'theme'.

The WMO CategoryCode list of terms is occasionally revised. For the latest list of terms, see:

http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#WMO_CategoryCode

At the time of writing, the WMO_CategoryCode list of terms includes:

WMO_CategoryCode	**Term**
WMO_CategoryCode_weatherObservations	weatherObservations
WMO_CategoryCode_weatherForecasts	weatherForecasts
WMO_CategoryCode_meteorology	Meteorology
WMO_CategoryCode_hydrology	Hydrology
WMO_CategoryCode_climatology	climatology
WMO_CategoryCode_landMeteorologyClimate	landMeteorologyClimate
WMO_CategoryCode_synopticMeteorology	synopticMeteorology
WMO_CategoryCode_marineMeteorology	marineMeteorology
WMO_CategoryCode_agriculturalMeteorology	agriculturalMeteorology
WMO_CategoryCode_aerology	aerology
WMO_CategoryCode_marineAerology	marineAerology
WMO_CategoryCode_oceanography	oceanography
WMO_CategoryCode_landHydrology	landHydrology
WMO_CategoryCode_rocketSounding	rocketSounding
WMO_CategoryCode_pollution	pollution
WMO_CategoryCode_waterPollution	waterPollution
WMO_CategoryCode_landWaterPollution	landWaterPollution

WMO_CategoryCode	**Term**
WMO_CategoryCode_seaPollution	seaPollution
WMO_CategoryCode_landPollution	landPollution
WMO_CategoryCode_airPollution	airPollution
WMO_CategoryCode_glaciology	glaciology
WMO_CategoryCode_actinometry	actinometry
WMO_CategoryCode_satelliteObservation	satelliteObservation
WMO_CategoryCode_airplaneObservation	airplaneObservation
WMO_CategoryCode_observationPlatform	observationPlatform
WMO_CategoryCode_spaceWeather	spaceWeather
WMO_CategoryCode_atmosphericComposition	atmosphericComposition
WMO_CategoryCode_radiation	Radiation

The example encoding below, for a satellite product, uses the terms "satelliteObservation" and "meteorology" as keywords from the WMO_CategoryCode thesaurus/codelist:

```
<gmd:descriptiveKeywords>
  <gmd:MD_Keywords>
    <gmd:keyword>

      <gco:CharacterString>satelliteObservation</gco:CharacterString>
    </gmd:keyword>

    <gmd:keyword>

      <gco:CharacterString>meteorology</gco:CharacterString>
    </gmd:keyword>
    <gmd:type>
    <MD_KeywordTypeCode xmlns="http://www.isotc211.org/2005/gmd" codeListValue="theme"
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#MD_KeywordTypeCode">Theme</MD_KeywordTypeCode>
    </gmd:type>
    <gmd:thesaurusName>
    <gmd:CI_Citation>
          <gmd:title>
             <gco:CharacterString>WMO_CategoryCode</gco:CharacterString>

      </gmd:title>
      <gmd:date>
        <gmd:CI_Date>
        <gmd:date>
           <gco:Date>2016-04-01</gco:Date>
        </gmd:date>
            <gmd:dateType>
           <gmd:CI_DateTypeCode codeListValue="publication"
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#CI_DateTypeCode"/>
        </gmd:dateType>
       </gmd:CI_Date>
          </gmd:date>
        </gmd:CI_Citation>
    </gmd:thesaurusName>
  </gmd:MD_Keywords>
</gmd:descriptiveKeywords>
```

WMO Distribution Scope Keyword

9.1.8 (ii) WMO Distribution Scope Code Keyword	
TEMPLATE Value:	ADD-DISTRIBUTION-SCOPE*C
Information:	Scope of distribution of data within the WMO Information System.
Necessity:	Conditional. Mandatory for WMO Core Profile 1.3, for GTS data.
Category:	Product Information
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:descriptiveKeywords/*/gmd:keyword/*/text()* */gmd:MD_Metadata/gmd:identificationInfo/*/gmd:descriptiveKeywords/*/gmd:type/*/@codeList Value="dataCentre"* */gmd:MD_Metadata/gmd:identificationInfo/*/gmd:descriptiveKeywords/*/gmd:thesaurusName/*/ gmd:title/*/text() ="WMO_DistributionScopeCode"*

Any WMCP record for GTS data must contain a DistributionScopeCode keyword. The scope of distribution, for data within WIS, shall be expressed as a keyword, using a term from the "WMO_DistributionScopeCode", and that keyword shall have a **KeywordTypeCode** of "datacentre". The keyword will be one of the following terms (from the controlled vocabulary called "WMO_DistributionScopeCode"):

- GlobalExchange,
- RegionalExchange,
- OriginatingCentre.

A WIS Discovery Metadata record describing data for global exchange via the WIS shall have a keyword "GlobalExchange", of KeywordTypeCode "dataCentre", from the thesaurus of "WMO_DistributionScopeCode"; it must also include a term from both the WMO_DataLicenseCode and WMO_GTSProductCategoryCode within the resourceConstraints section of the record (see Section 9.1.10, for details).

The GTS (Global Telecommunication System) is the part of the WIS that is concerned with rapid, near-real time information exchange. GISCs are required to retain at least 24h of information exchanged globally using the GTS.

The keyword term from the codelist called WMO_DistributionScopeCode is used to indicate whether the product described by a metadata record is or isn't delivered via the GTS and GISCS, and, within the GTS, whether it is exchanged globally or regionally.

- Metadata marked **GlobalExchange** or **RegionalExchange** describes data delivered via the GTS. Data is transmitted from an originating NC/DCPC to the principal GISC, distributed to all (or some) GISCs, then placed on the GISC caches;
- Metadata marked **RegionalExchange**, is for data that, while transmitted on the GTS, might be simply exchanged between two WMO Members (by bilateral agreement). Some example data are regional warnings, or voluminous NWP products;
- The metadata marked **OriginatingCentre** indicates "non-GTS data", and includes, for instance, data delivered to users from a DCPC.

Below is an example for "globally exchanged" GTS data:

```
<gmd:descriptiveKeywords>

    <gmd:MD_Keywords>

        <gmd:keyword>

            <gco:CharacterString>GlobalExchange</gco:CharacterString>

        </gmd:keyword>
```

```
        <gmd:type>

            <gmd:MD_KeywordTypeCode
codeList="http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#MD_KeywordTypeCode"
codeListValue="dataCentre">dataCentre</gmd:MD_KeywordTypeCode>

        </gmd:type>

        <gmd:thesaurusName>

            <gmd:CI_Citation>

                <gmd:title>

                    <gco:CharacterString>WMO_DistributionScopeCode
[http://wis.wmo.int/2012/codelists/WMOCodeLists.xml]</gco:CharacterString>

                </gmd:title>

                <gmd:date>

                    <gmd:CI_Date>

                        <gmd:date>

                            <gco:Date>2012-06-27</gco:Date>

                        </gmd:date>

                        <gmd:dateType>

                            <gmd:CI_DateTypeCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/codel
ist/gmxCodelists.xml#CI_DateTypeCode" codeListValue="revision">revision</gmd:CI_DateTypeCode>

                        </gmd:dateType>

                    </gmd:CI_Date>

                </gmd:date>

            </gmd:CI_Citation>

        </gmd:thesaurusName>

    </gmd:MD_Keywords>

</gmd:descriptiveKeywords>
```

WIGOS Station Identifier Keyword

9.1.8 (iii) WIGOS Station Identifiers Keywords	
TEMPLATE Value:	ADD-WIGOS-STATION-IDENTIFIER-CODE*O; ADD-WIGOS-STN-ID-CODE-AUTHORITY*O;
Information:	Where a product includes data from Stations which have been assigned a WIGOS Station Identifier, include these as keywords
Necessity:	Optional for WMO Core Profile 1.3
Category:	Product Information
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:descriptiveKeywords/*/gmd:keyword/*/text()* */gmd:MD_Metadata/gmd:identificationInfo/*/gmd:descriptiveKeywords/*/gmd:type/*/@codeListValue="place"* */gmd:MD_Metadata/gmd:identificationInfo/*/gmd:descriptiveKeywords/*/gmd:thesaurusName/*/ gmd:title/*/text()="WMO WIGOS Station Identifiers"*

Where products include data from Stations which have been assigned a WIGOS Station Identifier, include these as keywords. Where metadata records previously included WMO

Station numbers as keywords, the WIGOS Station Identifier should now be used. The related **KeywordTypeCode** should be "place".

Below is example encoding of WIGOS Station Identifiers, as keywords

```
<gmd:descriptiveKeywords>
   <gmd:MD_Keywords>
       <gmd:keyword>

         <gco:CharacterString>
          0-20000-0-94287; CAIRNS AERO [ http://data.wmo.int/wigosid=0-20000-0-94287 ]
         </gco:CharacterString>
      </gmd:keyword>
       <gmd:keyword>

         <gco:CharacterString>
          0-20000-0-94374; ROCKHAMPTON  AERO [ http://data.wmo.int/wigosid=0-20000-0-94374 ]
         </gco:CharacterString>
      </gmd:keyword>
       <gmd:keyword>

         <gco:CharacterString>
          0-20000-0-94294; TOWNSVILLE AERO [ http://data.wmo.int/wigosid=0-20000-0-94294 ]
         </gco:CharacterString>
      </gmd:keyword>


       <gmd:type>
          <gmd:MD_KeywordTypeCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/codel
ist/gmxCodelists.xml#MD_KeywordTypeCode"  codeListValue="place"</gmd:MD_KeywordTypeCode>
       </gmd:type>

       <gmd:thesaurus>
          <gmd:CI_Citation>
             <gmd:title>
                  <gco:CharacterString>WMO WIGOS Station Identifiers</gco:CharacterString>

             </gmd:title>


              <gmd:date>

                 <gmd:CI_Date>

                    <gmd:date>

                       <gco:Date>2016-06-25</gco:Date>

                    </gmd:date>

                 <gmd:dateType>

                     <gmd:CI_DateTypeCode
codeList="http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode"
codeListValue="revision">revision</gmd:CI_DateTypeCode>

                 </gmd:dateType>

              </gmd:CI_Date>

           </gmd:date>


       </gmd:CI_Citation>
    </gmd:thesaurus>
  </gmd:MD_Keywords>
</gmd:descriptiveKeywords>
```

Data Parameters

9.1.8 (iv) Data Parameter Keyword	
TEMPLATE Value:	ADD-DATA-PARAMETER*O
Information:	Data parameter keywords, for classifying the product.
Necessity:	Optional for WMO Core Profile 1.3
Category:	Product Information
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:descriptiveKeywords/*/gmd:keyword/*/text()* */gmd:MD_Metadata/gmd:identificationInfo/*/gmd:descriptiveKeywords/*/gmd:type/*/@codeListValue="dataParam"*

Where feasible, a list of the data parameters may be added as keywords. These should be added under a separate 'descriptiveKeywords' block, and should use the **KeywordTypeCode** of "dataParam".

Below is example encoding of a Data Parameter as a keyword.

```
<gmd:descriptiveKeywords>
   <gmd:MD_Keywords>
      <gmd:keyword>

         <gco:CharacterString>Dewpoint temperature</gco:CharacterString>

      </gmd:keyword>

       <gmd:type>
          <gmd:MD_KeywordTypeCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/codel
ist/gmxCodelists.xml#MD_KeywordTypeCode"  codeListValue="dataParam">dataParam</
gmd:MD_KeywordTypeCode>
       </gmd:type>


       <gmd:thesaurus>
          <gmd:CI_Citation>
             <gmd:title>
                <gco:CharacterString>WMO Grib2 parameter list
http://codes.wmo.int/grib2/codeflag/4.2/ </gco:CharacterString>
             </gmd:title>

              <gmd:date>

                 <gmd:CI_Date>

                    <gmd:date>

                       <gco:Date>2016-06-25</gco:Date>

                    </gmd:date>

                 <gmd:dateType>

                    <gmd:CI_DateTypeCode
codeList="http://www.isotc211.org/2005/resources/Codelist/gmxCodelists.xml#CI_DateTypeCode"
codeListValue="revision">revision</gmd:CI_DateTypeCode>

                 </gmd:dateType>

              </gmd:CI_Date>

           </gmd:date>


       </gmd:CI_Citation>
    </gmd:thesaurus>
  </gmd:MD_Keywords>
</gmd:descriptiveKeywords>
```

Product Sample Visualization URL

9.1.9 Product Sample Visualization URL	
TEMPLATE Value:	ADD-PRODUCT-IMAGERY-URL*O
Information:	URL to a sample data visualization
Necessity:	Optional for WMO Core Profile 1.3, but used by WIS Portal to display products
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:graphicOverview/*/gmd:fileName/*/text()*

The addition of a link to the product visualization is suggested, when possible. The display of related linked images can make the products more attractive for end users.

Below is an example, based on EUMETSAT Seviri Level 1.5.

```
<gmd:graphicOverview>
   <gmd:MD_BrowseGraphic>
      <gmd:fileName>

         <gco:CharacterString>http://navigator.eumetsat.int:80/smartEditor/preview/msg-level-1-
5.jpg</gco:CharacterString>
      </gmd:fileName>
      <gmd:fileDescription>
         <gco:CharacterString>preview</gco:CharacterString>
      </gmd:fileDescription>
      <gmd:fileType>
         <gco:CharacterString>jpg</gco:CharacterString>
      </gmd:fileType>
   </gmd:MD_BrowseGraphic>
</gmd:graphicOverview>
```

Data Policy Information

Data Policy Information	
TEMPLATE Value:	ADD-DATA-POLICY-CODE*C
Information:	Data usage and limitations to access the resource
Necessity:	Mandatory for WMO Core Profile 1.3, for data intended for Global Exchange on the GTS. Otherwise, highly recommended, since the absence of a policy can result in users assuming that there are no limitations on Data use. To avoid uncertainty, where there ARE no limitations, use the Data Policy of "NoLimitation".
Category:	Product Information
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:resourceConstraints/gmd:MD_LegalConstraints/*↘ {complex content}, including ↘ */gmd:otherConstraints/*/text()=WMO_DataLicenseCode* and ↘ */gmd:otherConstraints/*/text()=WMO_GTSProductCategoryCode*

The Data Policy category is used to specify the conditions under which the data products can be accessed and used. Completing the data policy section of a WMO Core Profile metadata record is very dependent on the type of data, data policy and the different ways that the data is being distributed. For those reasons, and to minimize the complexity of this section, three representative examples, covering some typical data policies - are presented below.

- Example 1: Non GTS Product, with a policy of no constraints on use or distribution;
- Example 2: Non GTS Product, with a policy applicable in the WMO context;
- Example 3: GTS Data, Intended for Global Exchange.

For a more comprehensive documentation, please refer to the documentation of the WMO Core Profile contained in the Manual on WIS.

When adding the data policy information, two different parts of the metadata record have be filled:

- The **resourceConstraints** part, which contains the data policy information; and
- The **scope of distribution** part: using one of the terms: "GlobalExchange", "RegionalExchange" or "OriginatingCentre" (to be inserted as a keyword, as explained in Section 9.1.8 (ii)).

Each of the 3 examples below present the first part of the above information (**resourceConstraints**), that is to be added.

Within the the **resourceConstraints** section, the DataLicenseCode term is added into an "otherConstraints" field; and an explanation of the Data Policy is typically added to an additional "otherConstraints" field.

```
/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:resourceConstraints/gmd:MD_LegalConstraints/gmd:otherConstraints/*/text()
```

Allowable terms from the DataLicenseCode include: "WMOAdditional", "WMOEssential", "WMOOther" or "NoLimitation". All of these terms are defined at http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#WMO_DataLicenseCode

Example 1 details: Non GTS Product, with a policy of no constraints on use or distribution

Publicly available datasets are datasets where no conditions and restrictions apply, on data access and data usage.

The 'useLimitation' field in the 'resourceConstraints' block should contain "No conditions apply", and an 'otherConstraints' field should contain the phrase "NoLimitation".

```
<!-- Example of publicly available, unrestricted data -->

<gmd:resourceConstraints>

  <gmd:MD_LegalConstraints>

    <!--  add useLimitation with ..No conditions apply..  -->

    <gmd:useLimitation>

      <gco:CharacterString>No conditions apply</gco:CharacterString>

    </gmd:useLimitation>

    <gmd:useConstraints>

      <!--  Restriction code have to point to WMOCodeLists.xml -->

<gmd:MD_RestrictionCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codelist/gmxCodelists.xml#MD_RestrictionCode"

         codeListValue="otherRestrictions">otherRestrictions</gmd:MD_RestrictionCode>

    </gmd:useConstraints>

    <!--  otherConstraints with ..NoLimitation..  -->
```

```
    <gmd:otherConstraints>

      <gco:CharacterString>NoLimitation</gco:CharacterString>

    </gmd:otherConstraints>

  </gmd:MD_LegalConstraints>

</gmd:resourceConstraints>
```

In addition, the **scope of distribution** would also ideally be stated (as a keyword), and for non GTS products it should be 'OriginatingCentre'

```
<!-- Scope of distribution for non GTS products: OriginatingCentre -->

<gmd:descriptiveKeywords>

  <gmd:MD_Keywords>

    <gmd:keyword>

      <!--  keyword OriginatingCentre applies for DCPC Data -->

      <gco:CharacterString>OriginatingCentre</gco:CharacterString>

    </gmd:keyword>

    <gmd:type>

      <gmd:MD_KeywordTypeCode
           codeList="http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#MD_DistributionScopeCode"

           codeListValue="dataCentre">dataCentre</gmd:MD_KeywordTypeCode>

    </gmd:type>

    <gmd:thesaurusName>

      <gmd:CI_Citation>

        <gmd:title>

          <gco:CharacterString>WMO_DistributionScopeCode, WMOCodelists dictionary Version 1.3
[http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#WMO_DistributionScopeCode]</gco:CharacterString>

        </gmd:title>

    .. .. .. etc    (see Section 9.1.8 (ii) for full details
```

Example 2 details: Non GTS Product, with a policy applicable in the WMO context

This example describes a data product that is not distributed on the GTS, and which has a single data policy applicable in the WMO context. Note that policies that are applicable in the WMO context (and therefore flagged, in an 'otherConstraints' field, with the term "WMOOther") will be presented by the GISCs to the users when they discover the data. GISCs have no obligations to show the other data policies.

A term from the **WMO_DataLicenseCode** codelist, http://wis.wmo.int/2012/metadata/version_1-3/WMOCodelists.xml#WMO_DataLicenseCode, should be added to an "otherConstraints" field.

Note: The Data Policy term of "WMOOther" can also be used for data that is delivered via the GTS.

```
<gmd:resourceConstraints>

  <gmd:MD_LegalConstraints>

    <!--   Add useLimitation to indicate the limitations of usage for the data  -->

      <gmd:useLimitation>

        <gco:CharacterString>Disclaimer - While every effort has been made to ensure that these data
are accurate and reliable within the limits of the current state of the art, OrganisationX cannot
assume liability for any damages caused by any errors or omissions in the data, nor as a result of
the failure of the data to function on a particular system. OrganisationX makes no warranty,
expressed or implied, nor does the fact of distribution constitute such a warranty.

        </gco:CharacterString>

      </gmd:useLimitation>

      <gmd:accessConstraints>

<gmd:MD_RestrictionCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#MD_RestrictionCode"
codeListValue="copyright">copyright</gmd:MD_RestrictionCode>

      </gmd:accessConstraints>

      <gmd:accessConstraints>

         <gmd:MD_RestrictionCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#MD_RestrictionCode"
codeListValue="otherRestrictions">otherRestrictions</gmd:MD_RestrictionCode>

      </gmd:accessConstraints>

      <gmd:useConstraints>

        <gmd:MD_RestrictionCode

codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#MD_RestrictionCode"
codeListValue="copyright">copyright</gmd:MD_RestrictionCode>

      </gmd:useConstraints>

      <gmd:useConstraints>

         <gmd:MD_RestrictionCode

codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#MD_RestrictionCode"
codeListValue="otherRestrictions">otherRestrictions</gmd:MD_RestrictionCode>

      </gmd:useConstraints>

      <!--  Add WMOOther, to signal that the policy is applicable in the WMO Context -->

      <gmd:otherConstraints>

         <gco:CharacterString>WMOOther

Ordnance Survey Open Data License [https://www.ordnancesurvey.co.uk/docs/licences/os-opendata-
licence.pdf]
         </gco:CharacterString>

      </gmd:otherConstraints>

   </gmd:MD_LegalConstraints>

</gmd:resourceConstraints>
```

The scope of distribution, using the term "OriginatingCentre" would also, ideally, be added (as a keyword).

Please refer to the example encoding of "scope of distribution", provided (above) under Example 1 above, or in Section 9.1.8 (ii).

Example 3 details: GTS Data, Intended for Global Exchange

This example describes data distributed via the GTS and available from the cache at a GISC. For data that are delivered via the GTS, the data policy term to be added to the "otherConstraints" field can only be "WMOAdditional" or "WMOEssential" – both of these terms are defined at http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#WMO_DataLicenseCode.

In the example below, the code is "WMOEssential".

WMO data policies (licence conditions) are defined by Resolution 40 (Cg-XII), Resolution 25 (Cg-XIII) and Resolution 60 (Cg-17) for data and products. Free and unrestricted basis data are "WMOEssential"; data classed as having a data policy of "WMOAdditional" have restrictions on commercial activities. Operational meteorological information for aviation is not included in these resolutions, but is controlled by ICAO; these data are an example of "WMOOther" data.

Only one term from the **WMO_DataLicenseCode** may be used, within a metadata record. As well as assigning one of these terms, it is expected, where the term used is "WMOOther" or "WMOAdditional", that further clarification of thelLicence constraints will also be provided (either directly in the metadata record, or else via a URL).

For data circulating on the GTS, "WMOAdditional" is used to qualify products under the "WMO Additional" data policy, "WMOEssential" is used for products made available under the "WMO Essential" data policy, and "WMOOther" can be applied (where applicable) for other products , regardless of whether the data is being delivered via the GTS/GISC or otherwise.

Where data is for GlobalExchange on the GTS (which is signified by the WMO_DistributionScopeCode Keyword), both a **WMO_DataLicenseCode** and a **WMO_GTSProductCategoryCode** term must be provided, under ResourceConstraints.
The choice of terms, from the **WMO_GTSProductCategoryCode** codelist, are: "GTSPriority1", "GTSPriority2", "GTSPriority3", "GTSPriority4".

Below is the resourceConstraints element for a "WMOEssential" GTS product, intended for global exchange:

```
<!--   Data intended for WMOEssential data intended for Global exchange -->

<gmd:resourceConstraints>

   <gmd:MD_LegalConstraints>

      <gmd:useLimitation>

        <gco:CharacterString>Data is near realtime, and is not quality controlled. License
conditions apply, as indicated below</gco:CharacterString>

      </gmd:useLimitation>

      <!--   MD_RestrictionCode to be 'otherRestrictions' -->

      <gmd:accessConstraints>
```

```
<gmd:MD_RestrictionCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#MD_RestrictionCode"  codeListValue="copyright">copyright</gmd:MD_RestrictionCode>

      </gmd:accessConstraints>

      <gmd:accessConstraints>

         <gmd:MD_RestrictionCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#MD_RestrictionCode"
codeListValue="otherRestrictions">otherRestrictions</gmd:MD_RestrictionCode>

      </gmd:accessConstraints>

      <gmd:useConstraints>

        <gmd:MD_RestrictionCode

codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#MD_RestrictionCode"
codeListValue="copyright">copyright</gmd:MD_RestrictionCode>

      </gmd:useConstraints>

      <gmd:useConstraints>

         <gmd:MD_RestrictionCode

codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#MD_RestrictionCode"
codeListValue="otherRestrictions">otherRestrictions</gmd:MD_RestrictionCode>

      </gmd:useConstraints>



      <!-- Add WMO Data policy and GTSPriority -->

      <gmd:otherConstraints>

         <gco:CharacterString>WMOEssential  A definition of "WMOEssential" is available at:
http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#wMO_ DataLicenseCode </gco:CharacterString>

      </gmd:otherConstraints>

      <gmd:otherConstraints>

         <gco:CharacterString>GTSPriority2</gco:CharacterString>

      </gmd:otherConstraints>

   </gmd:MD_LegalConstraints>

</gmd:resourceConstraints>
```

In addition, the scope of distribution of "GlobalExchange" has to be added, as a keyword (with KeywordTypeCode of "dataCentre").

```
<!-- keyword for stating the scope of distribution: Global Exchange   -->

<gmd:descriptiveKeywords>

  <gmd:MD_Keywords>

    <gmd:keyword>

      <gco:CharacterString>GlobalExchange</gco:CharacterString>

    </gmd:keyword>
```

```
    <gmd:type>

      <gmd:MD_KeywordTypeCode
           codeList="http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#MD_DistributionScopeCode"

           codeListValue="dataCentre">dataCentre</gmd:MD_KeywordTypeCode>

    </gmd:type>

  .. .. .. etc   (see Section 9.1.8 (ii), for full example
```

Distribution Information

9.1.11 Distribution Information	
TEMPLATE Value:	ADD-URL-TO-DATA-ACCESS-SERVICE*HR-MW, ADD-DISTRIBUTOR-SHORTNAME*HR (e.g.:EUM), ADD-DISTRIBUTOR-EMAIL-ADDRESS*HR, ADD-FORMAT-NAME*O-MW, ADD-FORMAT-VERSION*O-MW
Information:	Resource format, distributor information, and resource transfer options (urls)
Necessity:	Highly Recommended for WMO Core Profile 1.3
Category:	Product Information
XPath:	*/gmd:MD_Metadata/gmd:distributionInfo/*/gmd:distributionFormat/*/gmd:formatDistributor/*/* {complex content}, including ↘*distributorContact/gmd:CI_ResponsibleParty/* and ↘*distributorTransferOptions/*/gmd:online/*

Below is an example for a GRIB product made available via FTP server (distributor details are not included in this snippet, for readability, but are included in the TEMPLATE record)

```
<gmd:distributionInfo>

    <gmd:MD_Distribution>

        <gmd:distributionFormat>

            <gmd:MD_Format>

                <gmd:name>

                    <gco:CharacterString>GRIB</gco:CharacterString>

                </gmd:name>

                <gmd:version>

                    <gco:CharacterString>FM 92 GRIB Edition 2</gco:CharacterString>

                </gmd:version>

                <gmd:specification>

<gco:CharacterString>http://www.wmo.int/pages/prog/www/WMOCodes.html</gco:CharacterString>

                </gmd:specification>

            </gmd:MD_Format>

        </gmd:distributionFormat>

        <gmd:transferOptions>

            <gmd:MD_DigitalTransferOptions>

                <gmd:onLine>

                    <gmd:CI_OnlineResource>

                        <gmd:linkage>
```

```
                            <gmd:URL>ftp://data-portal.ecmwf.int/</gmd:URL>

                        </gmd:linkage>

                        <gmd:protocol>

                            <gco:CharacterString>WWW:DOWNLOAD-1.0-ftp--download</gco:CharacterString>

                        </gmd:protocol>

                        <gmd:name>

                            <gco:CharacterString>ECMWF DCPC FTP Server</gco:CharacterString>

                        </gmd:name>

                        <gmd:description>

                            <gco:CharacterString>WMO Information System download service through
ECMWF DCPC</gco:CharacterString>

                        </gmd:description>

                        <gmd:function>

                            <gmd:CI_OnLineFunctionCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#CI_OnLineFunctionCode"
codeListValue="download">download</gmd:CI_OnLineFunctionCode>

                        </gmd:function>

                    </gmd:CI_OnlineResource>

                </gmd:onLine>

            </gmd:MD_DigitalTransferOptions>

        </gmd:transferOptions>

    </gmd:MD_Distribution>

</gmd:distributionInfo>
```

Party to be cited

9.1.12 Cited Party Information	
TEMPLATE Value:	ADD-CITED-RESPONSIBLE-PARTY-ORGANISATION*O-MW
Information:	Party that should be cited as the 'originator' [that is, data-author], for the resource
Necessity:	Optional for WMO Core Profile 1.3
Category:	Product Information
XPath:	*/gmd:MD_Metadata/gmd:distributionInfo/*/gmd:citation/*/gmd:citedResponsibleParty/gmd:CI_ResponsibleParty/* {complex content}

Where the data owner wishes to be cited, in references made to their data, they can stipulate this in the citedResponsibleParty block, using a role of 'originator'

Below is an example:

```
<gmd:identificationInfo>

<gmd:MD_DataIdentification>

   <gmd:citation>

      <gmd:CI_Citation>

         …. .. .. ..

         <gmd:citedResponsibleParty>
```

```
            <gmd:CI_ResponsibleParty>

                <gmd:organisationName>

                    <gco:CharacterString>EUMETSAT</gco:CharacterString>

                </gmd:organisationName>

                <gmd:role>

                    <gmd:CI_RoleCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#MD_ScopeCode" codeListValue="pointOfContact">originator</gmd:CI_RoleCode>

                </gmd:role>

            </gmd:CI_ResponsibleParty>

         </gmd:citedResponsibleParty>

         <gmd:otherCitationDetails>

             <gco:CharacterString>Add other citing instructions here</gco:CharacterString>

         </gmd:otherCitationDetails>
           .. .. .. ..

       </gmd:CI_Citation>

    </gmd:citation>
     .. .. .. ..

  </gmd:MD_DataIdentification>

</gmd:identificationInfo>
```

Additional details on how the item should be cited can be added to the "otherCitationDetails" block.

Resource Update frequency

9.1.13 Resource Update Frequency Information	
TEMPLATE Value:	ADD-PRODUCT-UPDATE-FREQ-PERIOD*O, ADD-PRODUCT-UPDATE-FREQ-CODE*O-MW
Information:	Frequency of resource update
Necessity:	Optional for WMO Core Profile 1.3
Category:	Product Information
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:resourceMaintenance/*/gmd:maintenanceAndUpdateFrequency/*

If the Resource Update frequency block is used, then the *MD_MaintenanceFrequencyCode* is mandatory.

The example below is for a product which is available every 6 hours, starting at 3 UTC

```
<gmd:resourceMaintenance>

   <gmd:MD_MaintenanceInformation>

      <gmd:maintenanceAndUpdateFrequency>

         <gmd:MD_MaintenanceFrequencyCode codeListValue="irregular"
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/codel
ist/gmxCodelists.xml#MD_MaintenanceFrequencyCode"/>

      </gmd:maintenanceAndUpdateFrequency>
```

```
      <gmd:userDefinedMaintenanceFrequency>

         <gts:TM_PeriodDuration>PT6H</gts:TM_PeriodDuration>

      </gmd:userDefinedMaintenanceFrequency>

      <gmd:maintenanceNote>

         <gco:CharacterString>ADD-PRODUCT-UPDATE-FREQ-NOTE    (e.g.  Instances of bulletin
SIKB20NGTT are available every 6 hours starting at 03 UTC)</gco:CharacterString>

      </gmd:maintenanceNote>

   </gmd:MD_MaintenanceInformation>

</gmd:resourceMaintenance>
```

Mandatory WIS Technical Information

In addition to those mandatory elements included on section 9.1 above, the following information is required:

Metadata Record Unique Identifier

9.1.14 Metadata Record Unique Identifier	
TEMPLATE Value:	ADD-WMCP-IDENTIFIER*M
Information:	Unique Identifier for individual WIS Discovery Metadata Records
Necessity:	Mandatory for WMO Core Profile 1.3
Category:	WIS Technical Information
XPath:	*/gmd:MD_Metadata/gmd:fileIdentifier/*/text()*

The WCMP UID (fileIdentifier) should be structured as

`urn:x-wmo:md:DataProviderInternetDomainName::`ProductUID

where:

"**:**" is used as a separator;

urn:x-wmo:md: is mandatory;

DataProviderInternetDomainName:: designates the citation authority based on the reversed Internet domain name of the data-provider organization (e.g. int.eumetsat, gov.noaa) – note the recommended use of two colons "**::**";

ProductUID is a unique identifier with a structure defined by the organization responsible for the metadata record.

Examples:

UID for Roshydromet MTVZA-GY Level 1C data Meteor-M N2:

`urn:x-wmo:md:planet.iitp.ru:EO:ROSHDAT:METEOR-M:MTVZA-GY`

EUMETSAT Meteosat Seviri Level 1.5:

`urn:x-wmo:md:int.eumetsat:EO:EUM:DAT:MSG:HRSEVIRI`

Unique Identifier for GTS products

Additional rules apply, for metadata records describing products distributed in the GTS. The file identifier for bulletin metadata has the following structure:

```
urn:x-wmo:md:int.wmo.wis::{uid}
```

where {uid} is a unique identifier derived from the GTS bulletin or file name.

Further background, on constructing a fileIdentifier for products distributed on the GTS, is available in the WMCP v.1.3, Part 1, Section 9.2 ("Identifiers for metadata describing data published for global exchange").

An example File Identifier for a Deutscher Wetterdienst Numerical Weather Prediction Model, GTS Bulletin is:

```
urn:x-wmo:md:int.wmo.wis::HTXC85EDZW
```

An example File Identifier Meteo France Numerical Weather Prediction Model is:

```
urn:x-wmo:md:int.wmo.wis::FR-meteofrance-toulouse,GRIB,ARPEGE-75N10N-
60W65E_C_LFPW
```

Metadata modification DateStamp

9.1.15 Metadata Modification DateStamp	
TEMPLATE Value:	ADD-METADATA-LAST-MODIFICATION-DATE*M
Information:	Last modification date of the metadata record
Necessity:	Mandatory for WMO Core Profile 1.3
Category:	WIS Technical Information
XPath:	*/gmd:MD_Metadata/gmd:dateStamp*

This is the metadata record's latest modification date, and is a DATETIME.
It has the following date pattern: **YYYY-MM-DDThh:mm:ss**, for example 2015-12-29T11:45:55.

Product Creation Date

9.1.16 Creation Date	
TEMPLATE Value:	ADD-PRODUCT-CREATION-DATE*M
Information:	Creation date of the product
Necessity:	Mandatory for WMO Core Profile 1.3
Category:	WIS Technical Information
XPath:	*/gmd:MD_Metadata/gmd:identificationInfo/*/gmd:citation/*/gmd:date/*/* ↘ */gmd:date/*/text()* *and* ↘ */gmd:dateType/*/@codeListValue="creation"*

This is the product Creation date, and has the following date pattern: **YYYY-MM-DD** or **YYYY-MM-DDThh:mm:ss.**

For instance:

```
<gmd:date>
   <gmd:CI_Date>
      <gmd:date>
         <gco:Date>2015-03-23</gco:Date>
      </gmd:date>
      <gmd:dateType>
```

```
        <gmd:CI_DateTypeCode
codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codel
ist/gmxCodelists.xml#CI_DateTypeCode" codeListValue="creation"/>
      </gmd:dateType>
   </gmd:CI_Date>
<gmd:date>
```

Technical Document

More details on the WMO Core Profile Metadata can be found at http://wis.wmo.int/MD_Index

Annex

Glossary

- CGMS: Coordination Group for Meteorological Satellites
- CGMS-WMO TFMI: CGMS-WMO Task Force on Metadata Implementation
- GTS: Global Telecommunication Network
- WMO IPET-SUP: WMO Inter-Programme Expert Team on Satellite Utilization and Products
- WIS: WMO Information System
- GISC: Global Intercommunication System Centre
- DCPC: Data Collection and Production Centre
- NC: National Centre
- WMCP: WMO Core Profile
- ISO 19115: http://www.iso.org/iso/catalogue_detail?csnumber=26020

Collection Definition Criteria

This part of the document defines criteria and elements to consider, when creating a metadata record representing a collection of products.

To understand the notion of collection, it is important to distinguish between a dataset and a temporal subset of a dataset. As well, the availability of meteorological data is often transient (e.g. observations, forecasts, NWP products), and continuously updated. A dataset is typically seen as an aggregate of temporal “instances”/subsets of the same dataset (the collection) and, as explained below, metadata for a dataset is not typically set at “instance” level. This is so, even when a new instance/subset of a dataset is produced daily, and when only the latest day of data is ever available (in that case, the temporalExtent of the dataset is “latest 24 hours only”).

Additional criteria can be considered, when creating the collection metadata record include :

(a) Size of dataset instances.

An important thing to consider, in terms of Dataset granularity, is how the dataset instances will be made available to end users. For instance, push or pull services, with filter capabilities or not.

Numerical model X output could be seen as a 4 and even 5-D dataset (latitude, longitude, Z, time, reference time). It is possible to set granularity at this level, but the amount of data will be huge, and it will not be possible to exchange the whole dataset, using 'push' mode: Such large scale granularity of data is ideally provided via download (or publish-subscribe) services with sub setting capabilities (e.g. WCS, or "Direct" download INSPIRE services).

When the data provider is not able to implement such services, and when only pre-defined datasets or time-windows are made available (i.e., the use case of datasets for global exchange on the WIS) the granularity may have to be finer.

For example, the French high resolution model, AROME, is split into two daily subsets:

Dataset 1 : AROME 0°01 FRANCE - 00h-23h

Dataset 2 : AROME 0°01 FRANCE - 24h-45h

Where Dataset 1 covers hourly steps H to H+23h and Dataset 2 covers hourly steps H+24 to H+45.

The granularity of the subsets is chosen according to the size of the instances to be exchanged, and the size of the granules (500 Mb, 1Gb, ...) should be compatible with the bandwidth available for data exchange. Note that it is also possible to define an aggregate of the two subsets, for instance:

Dataset 0 : AROME 0°01 FRANCE, where Dataset 0 is an aggregation of Dataset 1 and Dataset 2.

(b) Content consistency

It is recommended, if possible, to not blend multiple data categories or topics in the same dataset, resulting in an heterogeneous aggregate.

For example an aggregate of satellite observations, and weather forecasts would not typically make sense (unless they had been combined for a particular purpose); whereas an aggregate of pollution and water pollution data makes sense, especially if the data processing has been similar and the data license is the same.

More generally, dataset heterogeneity in terms of content can result in very generalized descriptions in the metadata, which will, in turn, affect data discoverability on the WIS.

(c) Update frequency, other temporal characteristics

The refresh-rate of data also has to be taken into account, in terms of dataset granularity, because this will have an impact on catalogues.

Setting the dataset/metadata granularity at the "temporal instance" level, instead of "time series" level, would require the generation (automatically) of a lot of metadata records, and the update of catalogues in near real-time. It would also present difficulties in synchronizing metadata records among the GISCs, especially through harvesting processes. Such a large number of metadata records would also make it difficult for users to find the information they were seeking.

For instance, a "French WMO Resolution 40 Essential SYNOP" dataset could be seen as a temporal "series", and, provided that the entire dataset continues to be available, the discovery metadata should be provided at this level, and not at "temporal instance" level (e.g. "French WMO Resolution 40 Essential SYNOP 2016-04-07T12:00:00Z").

It is also recommended to not blend data of different refresh-rates in the same dataset, because it will not be possible to specify the update frequency in discovery metadata records.

(d) Data policy and distribution scope

A dataset shall be homogeneous in terms of data policy, including WMO distribution policy, which is described through WMO_DistributionScopeCode, WMO_DataLicenseCode, WMO_GTSProductCategoryCode and MD_RestrictionCode code lists.

The definition of the WCMP 1.3 mentions, in section 9.3 of Appendix C Part 1 of the Manual on WIS, that:

> "The presence of more than one WMO Data Policy in a single metadata record yields an ambiguous state, a WIS Discovery Metadata record describing data for global exchange shall declare only a single Data Policy".

Beyond WCMP 1.3 compliance, it is not easy to describe multiple data policies in a same metadata record, and if a dataset is heterogeneous in terms of data policy, the implementation of these policies by the services may be difficult.

(e) Spatial extent

Except for global datasets, a coarse granularity is likely to affect the discoverability of data on the basis of spatial criterion, especially if the effective areas where data is available are disjoint. For example synoptic observations for the French Overseas Departments of Guyana, Martinique, Reunion, Guadeloupe are dispatched in different datasets.

Field hierarchy and cardinality

Below is a nested list of fields likely to be used in an WMCP record, together with their cardinality.

Cardinality is denoted by [x..y]. Where the cardinality is preceded by "ISO" then the cardinality in the WMCP is the same. Where it is different, the cardinality for both ISO and WMCP is appended to the element name.

As noted in Section 8.1, many optional <<subsections>> of a WMCP record contain elements which are mandatory **only if** that subsection is used. An example of that is the .. 'identifier'/'authority'/'title', as shown on lines 53-57, in the following hierarchical list of fields (and see excerpt below), where 'identifier' is optional [0..n], and even if it is used, 'authority' is optional [0..n]; however, if 'authority' **is** used, then 'title' is mandatory [1..1].

```
53 _ ._ ._ ._ ._ .identifier_ ._ .ISO[0..n]
54_ ._ ._ ._ ._ ._ .MD_Identifier_ ._ .
55_ ._ ._ ._ ._ ._ ._ .authority_ ._ .ISO[0..1]
56_ ._ ._ ._ ._ ._ ._ ._ .CI_Citation_ ._ .
57_ ._ ._ ._ ._ ._ ._ ._ ._ .title_ .char_ ._ .ISO[1..1]
```

(Excerpt from ANNEX, Section 13)

The cardinality notation of [x..y] indicates the minimum and maximum allowable times that the element may be used, within that part of the hierarchy/tree.

For instance the notation:

[0..n] means that the element is optional, but can also be used any number of times;

[1..2] means that it is mandatory (there must be at least one), and may be used a maximum of two times.

```
1    MD_Metadata_ ._ .ISO[1..1]
2    _ .fileIdentifier_ .char_ ._ . WMO[1..1] , ISO[0..1]
3    _ .language_ .char_ ._ .ISO[0..1]
4    _ .characterSet_ .CODE:MD_CharacterSetCode_ ._ .ISO[0..1]
5    _ .parentIdentifier_ .char_ ._ .ISO[0..1]
6    _ .hierarchyLevel_ .char_ ._ .ISO[0..n]
7    _ .hierarchyLevelName_ .char_ ._ .ISO[0..n]
8
9    _ .contact_ ._ .ISO[1..n]
10   _ ._ .CI_ResponsibleParty
   see lines 66-99, for all fields available for CI_ResponsibleParty
11   _ ._ ._ .individualName_ .char_ ._ .ISO[0..1]
12   _ ._ ._ .organisationName_ .char_ ._ .ISO[0..1]
13   _ ._ ._ .contactInfo_ ._ .ISO[0..1]
14   _ ._ ._ ._ . CI_Contact_ ._ .
15   _ ._ ._ ._ . _ .address_ ._ .ISO[0..1]
16   _ ._ ._ ._ ._ . _ .CI_Address_ ._ .
17   _ ._ ._ ._ ._ ._ . _ .electronicMailAddress_ .char_ ._ .ISO[0..n]
18   _ ._ ._ .role_ .CODE:CI_RoleCode_ ._ .ISO[1..1]
19
20   _ .dateStamp_ .DATETIME_ ._ .ISO[1..1]
21     _ .metadataStandardName_ .char_ ._ .ISO[0..1]
22   _ .metadataStandardVersion_ .char_ ._ .ISO[0..1]
23     _ .dataSetURI_ .char_ ._ .ISO[0..1]
24
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
25   _ .spatialRepresentationInfo_ ._ .ISO[0..n]
26   _ ._ .MD_GridSpatialRepresentation
27   _ ._ ._ .numberOfDimensions_ .integer_ ._ .ISO[1..1]
28   _ ._ ._ .axisDimensionProperties_ ._ .ISO[1..1]
29   _ ._ ._ ._ .MD_Dimension_ ._ .
30   _ ._ ._ ._ ._ .dimensionName_ .CODE:MD_DimensionNameTypeCode_ ._ .ISO[1..1]
31   _ ._ ._ ._ ._ .dimensionSize_ .integer_ ._ .ISO[1..1]
32   _ ._ ._ ._ ._ .resolution_ .SCALE_ ._ .ISO[0..1]
33   _ ._ ._ ._ ._ .dimensionName_ .CODE:MD_DimensionNameTypeCode_ ._ .ISO[1..1]
34   _ ._ ._ ._ ._ .dimensionSize_ .integer_ ._ .ISO[1..1]
35   _ ._ ._ ._ ._ .resolution_ .SCALE_ ._ .ISO[0..1]
36   _ ._ ._ .cellGeometry_ .CODE:MD_CellGeometryCode_ ._ .ISO[1..1]
37   _ ._ ._ .transformationParameterAvailability_ .Boolean_ ._ .ISO[1..1]
38
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
39
40   _ .identificationInfo_ ._ .ISO[1..n]
41   _ ._ .MD_DataIdentification_ .
42
43   _ ._ ._ .citation_ ._ .ISO[1..1]
44   _ ._ ._ ._ .CI_Citation_ ._ .
45   _ ._ ._ ._ ._ .title_ .char_ ._ .ISO[1..1]
```

```
46      _ ._ ._ ._ ._ .alternateTitle_ .char_ ._ .ISO[0..n]
47      _ ._ ._ ._ ._ .DATE_ ._ .ISO[1..n]
48      _ ._ ._ ._ ._ ._ .CI_Date_ .
49      _ ._ ._ ._ ._ ._ ._ .DATE_ .DATETIME_ ._ .ISO[1..1]
50      _ ._ ._ ._ ._ ._ ._ .dateType_ .CODE:CI_DateTypeCode_ ._ .ISO[1..1]
51      _ ._ ._ ._ ._ .edition_ .char_ ._ .ISO[0..1]
52
53      _ ._ ._ ._ ._ .identifier_ ._ .ISO[0..n]
54      _ ._ ._ ._ ._ ._ .MD_Identifier_ ._ .
55      _ ._ ._ ._ ._ ._ ._ .authority_ ._ .ISO[0..1]
56      _ ._ ._ ._ ._ ._ ._ ._ .CI_Citation_ ._ .
see lines 43-111, for all fields available for CI_Citation
57      _ ._ ._ ._ ._ ._ ._ ._ ._ .title_ .char_ ._ .ISO[1..1]
58      _ ._ ._ ._ ._ ._ ._ ._ ._ .alternateTitle_ .char_ ._ .ISO[0..n]
59      _ ._ ._ ._ ._ ._ ._ ._ ._ .DATE_ ._ .ISO[1..n]
60      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ .CI_Date_ .
61      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .DATE_ .DATE_ ._ .ISO[1..1]
62
        _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .dateType_ .CODE:CI_DateTypeCode_ ._ .ISO[1..
1]
63      _ ._ ._ ._ ._ ._ ._ .code_ .char_ ._ .ISO[1..1]
64
65      _ ._ ._ ._ ._ .citedResponsibleParty_ ._ .ISO[0..n]
66      _ ._ ._ ._ ._ ._ .CI_ResponsibleParty_ ._ .
67      _ ._ ._ ._ ._ ._ ._ .individualName_ .char_ ._ .ISO[0..1] *C
68      _ ._ ._ ._ ._ ._ ._ .organisationName_ .char_ ._ .ISO[0..1] *C
69      _ ._ ._ ._ ._ ._ ._ .positionName_ .char_ ._ .ISO[0..1] *C
70
71      _ ._ ._ ._ ._ ._ ._ .contactInfo_ ._ .ISO[0..1]
72      _ ._ ._ ._ ._ ._ ._ ._ .CI_Contact_ ._ .
73
74      _ ._ ._ ._ ._ ._ ._ ._ ._ .phone_ ._ .ISO[0..1]
75      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ .CI_Telephone_ ._ .
76      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .voice_ .char_ ._ .ISO[0..n]
77      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .facsimile_ .char_ ._ .ISO[0..n]
78
79      _ ._ ._ ._ ._ ._ ._ ._ ._ .address_ ._ .ISO[0..1]
80      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ .CI_Address_ ._ .
81      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .deliveryPoint_ .char_ ._ .ISO[0..n]
82      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .city_ .char_ ._ .ISO[0..1]
83      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .administrativeArea_ .char_ ._ .ISO[0..1]
84      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .postalCode_ .char_ ._ .ISO[0..1]
85      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .country_ .char_ ._ .ISO[0..1]
86      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .electronicMailAddress_ .char_ ._ .ISO[0..n]
87
88      _ ._ ._ ._ ._ ._ ._ ._ ._ .onlineResource_ ._ .ISO[0..1]
89      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ .CI_OnlineResource_ ._ .
90      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .linkage_ .URL_ ._ .ISO[1..1]
91      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .protocol_ .char_ ._ .ISO[0..1]
```

```
92      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .applicationProfile_ .char_ ._ .ISO[0..1]
93      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .name_ .char_ ._ .ISO[0..1]
94      _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .description_ .char_ ._ .ISO[0..1]
95
        _ ._ ._ ._ ._ ._ ._ ._ ._ ._ ._ .function_ .CODE:CI_OnLineFunctionCode_ ._ .I
SO[0..1]
96
97      _ ._ ._ ._ ._ ._ ._ ._ ._ .hoursOfService_ .char_ ._ .ISO[0..1]
98      _ ._ ._ ._ ._ ._ ._ ._ ._ .contactInstructions_ .char_ ._ .ISO[0..1]
99      _ ._ ._ ._ ._ ._ ._ .role_ .CODE:CI_RoleCode_ [1..1].
100
101     _ ._ ._ ._ ._ .presentationForm_ .CODE:CI_PresentationFormCode_ ._ .ISO[0..n]
102
103     _ ._ ._ ._ ._ .series_ ._ .ISO[0..1]
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Recommendation 16 (CBS-16)

INFORMATION MANAGEMENT PRACTICES

THE COMMISSION FOR BASIC SYSTEMS,

Noting that:

(1) The Seventeenth World Meteorological Congress had requested the Commission for Basic Systems to develop Part C of the WMO Information System that would address issues of information management,

(2) The Commission for Climatology had developed guidance on best practice for managing information about observations and stations related to climate,

(3) The meteorological satellite community had developed guidance on the use of satellite-based telecommunications systems,

Recommends to the Executive Council that:

(1) A new Part VI "Information Management" is added to the *Manual on the WMO Information System* (WMO-No. 1060) and Part VII with the same title is added to the *Guide to the WMO Information System* (WMO-No. 1061);

(2) Pending development of provisions relating to information management, the text of Part VI of the *Manual on the WMO Information System* should be: "Note: guidance on information management best practices is provided in Part VII of the *Guide to the WMO Information System* (WMO-No. 1061)";

(3) The contents of the annex to the present recommendation should be published as Part VII of the *Guide to the WMO Information System*;

Authorizes the Secretary-General to make editorial amendments to the text in the annex to the present recommendation, including changes needed to maintain consistency with regulations.

Annex to Recommendation 16 (CBS-16)

PART VII OF THE *GUIDE TO THE WMO INFORMATION SYSTEM* (WMO-No. 1061)

Add the following text in Part I of the Guide to the WMO Information System (WMO-No. 1061)

1.7.5 Guidance on the use of the direct broadcast network (DBNet) for near real-time relay of low Earth orbit satellite data is provided in the document *Guidelines to the Direct Broadcast Network (DBNet)* (WMO-No. xxxx) (http://wis.wmo.int/DBNet-Guide) that is an Attachment to this Guide.

Add the following text as Part VII of the Guide to the WMO Information System (WMO-No. 1061)

PART VII. INFORMATION MANAGEMENT

7.1 Guidance on management of information about climate reports and climate observing stations is available in the *Climate Data Management System Specifications* (WMO-No. 1131). (http://wis.wmo.int/CDMS-Specification) that is an Attachment to this Guide.

Recommendation 17 (CBS-16)

GUIDE TO THE DIRECT BROADCAST NETWORK

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) That the meteorological satellite community had developed guidance on the use of satellite-based telecommunications systems,

(2) That Resolution 12 (EC-68) – Fast-track procedure for amendments to Manuals and Guides managed by the Commission for Basic Systems, permits sections of Manuals or Guides to be designated as technical specifications and to be amended using the fast-track (simple) procedure,

Recommends to the Executive Council that:

(1) The text in the annex to the present recommendation be published in a publication with a WMO number as "Guidance on DBNet";

(2) The "Guidance on DBNet" should be designated as an attachment to *Guide to the WMO Information System* (WMO-No. 1061);

(3) The "Guidance on DBNet" in its entirety is to be designated as a technical specification and that it may be amended using the fast-track procedure;

Authorizes the Secretary-General to make editorial amendments to the text, provided in the annex to the present recommendation, including changes needed to maintain consistency with regulations.

Annex to Recommendation 17 (CBS-16)

GUIDANCE ON THE DIRECT BROADCAST NETWORK

WMO Information System

WMO Space Programme

GUIDE TO THE DIRECT BROADCAST NETWORK (DBNet)

For Near Real-Time Relay of Low Earth Orbit Satellite Data

Final Draft (22 September 2016)

WMO No. XXXX

2016

World Meteorological Organization

Weather • Climate • Water

WMO-No. xxxx

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1. INTRODUCTION

1.1. PURPOSE AND SCOPE

The purpose of this Guide is to define the minimum standards applicable to the Direct Broadcast Network for Near Real-Time Relay of Low Earth Orbit Satellite Data (DBNet) and to provide guidance for implementing these standards.

In the present Guide, the verb “shall” is used when referring to the standards necessary for DBNet to work properly, and “should” when referring to recommended practices. The DBNet standards are applicable to all voluntary contributions of WMO Members to DBNet.

The aims of these standards are twofold:

- To help ensure that the data provided by each particular DBNet regional network can be used operationally to meet user requirements as recorded in the WIGOS Information Resource [RD.2];
- To facilitate inter-regional data exchange and interoperability around the globe, with a particular focus on ensuring the global consistency of the DBNet datasets.

This Guide is primarily directed to the DBNet station operators and coordinating entities. It also contains provisions for consideration by providers of processing software and by satellite operators. Furthermore, it can be a useful reference for the users of DBNet products.

1.2. STRUCTURE OF THE DOCUMENT

This Guide consists of the following sections:

Section 1: Introduction;

Section 2: Defines DBNet and describes its components;

Section 3: Addresses the overall DBNet coordination processes;

Section 4: Contains common standards and practices applicable to the production of DBNet data across all DBNet regional networks;

Section 5: Contains specific standards and practices applicable to the production of each DBNet service;

Section 6: Conclusions;

Annexes: Contain ancillary information which is provided separately for easier reference and to facilitate updating.

1.3. APPLICABLE DOCUMENTS

[AD.1]: WMO Manual on Codes, Volume 1.2, Parts B and C, WMO-No. 306

[AD.2]: WMO Manual on the GTS (WMO-No. 386)

[AD.3]: WMO Manual on the WIS (WMO-No. 1060)

1.4. REFERENCE DOCUMENTS

[RD.1]: Statements of Guidance for Global Numerical Weather Prediction and High-Resolution Numerical Weather Prediction

[RD.2]: WIGOS Information Resource, Observing System Capabilities Analysis and Review (OSCAR): www.wmo.int/oscar

[RD.3]: DBNet Network Status and Plan http://www.wmo.int/pages/prog/sat/documents/DBNet_Network-status-and-plans.pdf

[RD.4]: DBNet Coding Summary http://www.wmo.int/pages/prog/sat/documents/DBNet_Coding-summary.xls

2. OVERVIEW OF DBNet

2.1. AIM AND FUNCTIONS OF DBNet

The aim of DBNet is to provide near real-time access to near-global data from Low Earth Orbit (LEO) satellites, in order to meet in a cost-efficient manner the timeliness requirements of regional and global Numerical Weather Prediction (NWP) and other applications.

As a system, DBNet performs the following functions:

- Reception and acquisition of satellite Direct Broadcast signals at local DBNet stations;
- Processing of the acquired data into products;
- Near real-time delivery of products;
- Performance monitoring and quality control;
- User information;
- Coordination and planning.

2.2. JUSTIFICATION OF DBNet

Access to LEO data is normally relying on data dumps at one Command and Data Acquisition (CDA) station, which allows retrieving complete orbit data, however with a data latency resulting from on-board data storage between the time of acquisition and the time when the data is dumped to the CDA. This on-board storage can be reduced roughly by a factor of two when two high-latitude CDAs are used, one in the North and the other in the South. Further reduction requires a whole network of mid- or low latitude stations distributed around the globe, which involves higher ground infrastructure costs and a highly complex scheduling of data storage and dumps.

When satellites have a Direct Broadcast capability, which is the case of most LEO meteorological satellites, an alternative data access route is the acquisition of the Direct Broadcast data stream at

a local ground station, which allows real-time acquisition, albeit with coverage limited to the portion of orbit within the area of visibility of the local station.

The Direct Broadcast Network for Near Real-Time Relay of LEO satellite data (DBNet) overcomes this limitation in offering a cost-efficient trade-off between coverage and timeliness. It coordinates data acquisition through a globally distributed network of local Direct Broadcast receiving stations, their processing in accordance with agreed standards, and their rapid delivery to the global user community through appropriate telecommunication systems.

The substantial improvement in timeliness is crucial for NWP models with short cut-off, which otherwise cannot take advantage of the most recent satellite passes. This concept was initially promoted by the HIRLAM community and EUMETSAT for the collection of ATOVS data to support regional NWP over Europe. It was then extended by WMO to the global scale under the name Regional ATOVS Retransmission Services (RARS) and quickly adopted by the global NWP as the timeliness requirements of global models became more stringent. Impact studies have given evidence of the benefit of RARS for regional and global NWP. Several papers and posters on RARS are available on the WMO RARS web page (http://www.wmo.int/pages/prog/sat/rars-implementation_en.php#RARSdocs).

DBNet is expanding the RARS concept to other data types in support of a wider range of applications. The present Guide thus replaces the former RARS Operators Standards with a wider scope to accommodate new sensor data, to ensure interoperability with the NOAA Direct Broadcast Real Time Network and to take into account the WMO Information System.

2.3. DBNet COMPONENTS

DBNet is composed of several regional or sub-regional networks of receiving stations. The list of stations contributing to these networks is provided in [RD. 3].

A DBNet Network Coordinator is designated for each DBNet regional or sub-regional network.

The role of the regional/sub-regional Network Coordinators is to:

- Ensure coordination of the regional or sub-regional network, report to the DBNet Coordination Group, and contribute to the overall DBNet planning and coordination described in Section 3;
- Provide guidance to Station Operators for implementing new services, and oversee the validation procedures defined in Annex B;
- Ensure performance monitoring as defined in Section 3.2;
- Maintain a website providing information as listed in Section 3.3.

Table 1 contains the list of DBNet regional or sub-regional networks and coordinating centers.

Regional network	Regional Network Coordinator	Sub-regional network	Sub-regional Network Coordinator
DBNet-EUMETSAT (EARS European stations and other regional partners)	EUMETSAT		
DBNet-Asia-Pacific	BOM	Asia-Pacific North	JMA
		Asia-Pacific South	BoM
DBNet-South America		South America/North	INPE
		South America/South	SMN /CONAE
DBNet-NOAA (DBRTN US stations and other regional partners)(1)	NOAA/CIMSS		

(1) DBNet-NOAA is implemented by NOAA/CIMSS in partnership with EUMETSAT and shares some functions with EARS.

Table 1: DBNet regional or sub-regional network components

Global Monitoring Centres should perform a systematic control of product consistency. This function is assumed by the EUMETSAT NWP SAF, led by the Met Office (United Kingdom) for the IR/MW sounding service. For other services global monitoring centres have not yet been identified.

The list of Network Coordinators is maintained by the WMO Secretariat and is available online as Operational Information. (Currently: http://www.wmo.int/pages/prog/sat/dbnet-implementation_en.php#DBNetcontacts).

Each DBNet regional or sub-regional network contributes to one or several DBNet "Services". A DBNet Service is performing the acquisition and relay of a certain category of satellite data. Table 2 lists the DBNet services (current and potential).

Categories of Services	Services (Instruments)
IR/MW sounding	RARS (AMSU-A, MHS, HIRS), ATMS, VASS (MWTS/2, MWHS/2, IRAS)
IR/VIS imaging	VIIRS, AVHRR, MERSI
Hyperspectral IR sounding	CrIS, IASI, HIRAS, AIRS
Scatterometry	ASCAT, Wind RAD
MW imagery	MWRI

Table 2: Current and potential DBNet services (as of August 2016)

Significant NWP user interest has been expressed for data from the Russian MW imaging/sounding radiometer MTVZA-GY, manifested on the METEOR series of satellites. The feasibility of including this instrument in the DBNet services will be further analysed.

A service based on GNSS Radio-occultation data could be considered for DBNet, as the Metop satellites and the FY-3 satellites fly GNSS-RO instruments. Due the limb-sounding nature of the GNSS-RO such a service would not produce regional atmospheric profiles, but for space weather application there is an interest in fast delivery of global data from the ionosphere. The feasibility of such a service requires further analysis, which will be undertaken together with CGMS.

2.4. HIGH-LEVEL SERVICE SPECIFICATIONS

The DBNet Service Specifications are determined with the aim to respond to user requirements of WMO Application Areas, as recorded in OSCAR [RD.2]. For example, the requirements of Global NWP (http://www.wmo-sat.info/oscar/applicationareas/view/1) and High-Resolution NWP (http://www.wmo-sat.info/oscar/applicationareas/view/2) require for atmospheric temperature, humidity profiles and wind vector at sea surface, a timeliness of less than 6 to 15 min as a goal and 30 min as breakthrough. The DBNet specifications represent the agreed commitment by DBNet Regional Networks to contribute to meeting these requirements, taking into account the technical capabilities and resource constraints. The table below summarizes the operational service specification for each DBNet Service category.

These specs will be validated in consultation with relevant user groups, for example the GODEX-NWP as representing the global NWP data exchange community and the ITWG representing the satellite atmospheric sounding community.

The DBNet high-level specifications are summarized in Table 3.

Category of Service	Driving Application	Products	Data latency goal/threshold	Availability	Coverage
IR/MW sounding	Global and High-Resolution NWP	Level 1 brightness temperatures	20 min/ 30 min	95%	90%
IR/VIS imaging	Nowcasting	Level 1 radiance /reflectivity	10 min/ 20 min	95%	30%
HiRes IR sounding	Global and High-Resolution NWP	Level 1 radiances and PC scores	20 min/ 30 min	95%	90% (60% initially)
Scatterometry	NWP, Nowcasting and Ocean Applications	backscatter cross-sections	20 min/ 30 min	95%	50% (of oceanic areas)
MW imagery	NWP, Nowcasting,	Level 1 brightness temperatures	20 min/ 30 min	95%	30%

Table 3: DBNet High-Level Service Specifications

Data latency is defined here as the maximum time elapsed between observation time (sensor time) and the availability on the WMO Information System (WIS) core network to be satisfied by at least 90% of the data.

The availability rate is an indicator of the target uptime for a DBNet station when there is no special operational constraint (i.e. not considering particularly remote sites such as Antarctic stations). It is defined here as the percentage of days where the station is operating normally. The number of passes acquired depends on local factors (including the station latitude and the scheduling priorities) and cannot be fixed as a high-level specification, but is monitored (e.g. on a monthly basis) as a performance indicator. The availability is defined for an individual station. Adjacent stations with significantly overlapping acquisition areas can back-up each other, which is important primarily to solve possible reception scheduling conflicts.

The coverage is defined here as the percentage of the Earth's surface that can be viewed by the relevant satellite instrument and the data transmitted to DBNet stations via direct broadcast. This is calculated in merging the areas of visibility of the local stations contributing to the service. As an order of magnitude, an isolated station (not overlapping with the area of visibility of another station) without mask contributes to the global coverage by about 4%. (Note: this index takes only into account the latitudes between 82°S and 82°N which are flown over by sun-synchronous satellites.)

3. DBNet COORDINATION

3.1. DBNet NETWORK IMPLEMENTATION

The WMO Secretariat and all DBNet Network Coordinators strive to ensure smooth operation of the DBNet Services across all regional networks, to plan expansion of DBNet, to review the priorities and to take any appropriate measure to meet evolving user requirements. The regional/sub-regional Network Coordinators identify candidate stations and negotiate agreements with Station Operators with a view to expand the network and fill gaps when necessary.

This coordination is achieved through the DBNet Coordination Group, the Terms of Reference of which are provided in Annex A.

The WMO Secretariat maintains a list of DBNet contributing stations associated to each regional network with the status and plans of the different services [AD.4], based on the reports from DBNet Network Coordinators. This allows monitoring the coverage of the respective DBNet services.

The procedure contained in Annex B describes the steps to be followed for adding a station to DBNet, modifying its status, or removing it from DBNet.

3.2. QUALITY OF SERVICE

3.2.1. Quality assurance

In order to help ensure that the service provided is of an appropriate quality, the DBNet Station Operator shall:

- Uutilize an appropriate system for the tracking and resolution of operational anomalies;
- Ensure that all operations and maintenance staff are appropriately trained;
- Ensure that appropriate provisions are in place to protect against unauthorized access to the DBNet equipment (from both physical, and network security points of view);

- Ensure that the maintenance approach (e.g. levels of redundancy, spares holdings, maintenance contracts and maintenance team size) is consistent with the service availability targets (see section 2.4);
- Ensure that adequate arrangements are in place to monitor the satisfactory performance of the service (supported by the availability of validated operational and maintenance procedures.

3.2.2. Quality control

Each DBNet Regional Network shall implement appropriate quality control measures to monitor the integrity of DBNet data that are disseminated, in particular with respect to timeliness and correct formatting.

The regional/subregional Network Coordinators:

- Organize the near real-time monitoring function;
- Maintain the list of operational points of contacts of individual station operators;
- Perform overall performance monitoring (including implementation of the standards);
- Manage software updates to ensure that proper software versions are used on each station;
- Ensure an operational point of contact for resolving anomalies.

For the IR/MW sounding and Hyperspectral IR sounding services, global monitoring is performed by the EUMETSAT NWP SAF to assess the consistency of DBNet data with the global data and their timeliness. The results of this monitoring are sent to the operators and statistics are published online, see NWP SAF website http://nwpsaf.eu.

3.2.3. Issue management

Each DBNet Station operator and each DBNet Network Coordinator shall designate an Operational Point of Contact to be contacted in case of operational problems.

The contact details of Operational Points of Contact of each regional/sub-regional network will be posted on the DBNet Regional Network website to allow the users to report operational problems. Depending on the nature of the problem, the DBNet coordinating entity will contact the relevant DBNet station operator, the relevant WIS DCPC/GISC as defined in Appendix B of [AD.3], and/or the global monitoring unit (EUMETSAT NWP SAF Help Desk).

Each DBNet Network Coordinator should implement appropriate issue management processes in order to properly track and manage the resolution of problems, including notification of the providers of pre-processing software packages.

Each DBNet Processing Software Provider of a pre-processing software package should implement software anomaly management processes, for fast resolution of software problems that affect the end-users.

3.3. PUBLICATION OF SERVICE INFORMATION

The WMO Space Programme provides and maintain a DBNet e-mail list-server, which allows DBNet Network Coordinators and Processing Software Providers to support all Station Operators and operational Users by keeping them up-to-date with system changes (e.g. announcement of AAPP and CSPP S/W releases and their impact on DBNet operations).

Each DBNet regional or sub-regional Network Coordinator should also maintain a website containing an up-to-date description of the service, including:

- For each Service, the instruments and satellites from which data are collected;
- The geographic coordinates of the collection stations that form part of the DBNet data collection network, together with the associated geographical coverage maps;
- The processing software versions that are used to generate the products for the stations in the regional network;
- The target timeliness and target availability of the service;
- Details of the data distribution mechanism and any associated user reception equipment requirements (e.g., for receiving data from a satellite direct broadcast system);
- File naming and structure;
- The administrative procedures to be followed by a user to gain access to the data;
- A link to the scheduling priorities (including any instrument/satellite priorities);
- Operational points of contact of the Network Coordinator allowing users to report problems with the service (including generic e-mail addresses).

When this information is available for individual stations:

- Planned acquisition schedule;
- Acquired passes in the last 24 hour period compared to the planned acquisition schedule (referenced to the planned acquisition schedule);
- Long-term planning information that may affect the service in the future (e.g., planned outages, upgrade of software version, etc.);
- Quality monitoring results.

Each DBNet Processing Software Provider maintains on its website a record of the current recommended software versions and configurations.

For operational issues strictly related to the distribution of DBNet products through the WIS core networks (including e.g. RMDCN), WIS communication procedures must be followed.

4. COMMON DBNet STANDARDS AND RECOMMENDED PRACTICES

4.1. INTRODUCTION

The common standards and recommended practices cover aspects of DBNet operations that are not specific to a particular service and should apply for any regional network contributing to the overall DBNet network. The standards are mandatory and are only defined in areas that affect the

interoperability of DBNet regional networks, the access to and the utilization of DBNet products, and the interface to the WIS. On the other aspects, some practices are recommended or indicated as guidance, but the actual implementation can be defined in an optimal manner by each DBNet regional network.

A DBNet Network Coordinator is defined as the managing entity responsible for ensuring an end-to-end service within a particular region (i.e., with responsibility for data collection from the HRPT stations, processing, dissemination of the products to users and inter-regional data exchange). If responsibility for the implementation of these functions is shared between several parties, then it is the responsibility of the lead entity to ensure that all the involved parties comply with the relevant parts of this standard.

Overall DBNet standards and recommended practices are defined in the following areas:

- Product processing and product format;
- Product registration and distribution;
- Quality of service;
- Operations and maintenance including anomaly processing;
- Publication of service Information;
- DBNet network coordination.

4.2. ACQUISITION

4.2.1. Satellite acquisition scheduling priorities

Guidelines for satellite acquisition scheduling priorities are established by the DBNet Coordination Group considering:

- Availability and timeliness of global data;
- Equatorial Crossing Time diversity;
- Instrument health;
- DB signal quality;
- Ability of NWP to assimilate instruments.

The scheduling priorities are reviewed annually or when needed. The current priorities are recorded in an Operational Information maintained on the WMO Space Programme website (www.wmo.int/pages/prog/sat). As an example, the 2015 priorities are listed in Annex C.

4.3. PRODUCT PROCESSING (COMMON ASPECTS)

4.3.1. Processing Level

Any products exchanged inter-regionally shall be at level 1, unless otherwise specified for the specific service.

Level 1 is understood to be radiances, reflectances or brightness temperatures for sounders and imagers and sigma-0 or kp for scatterometers, all on original instrument grid with geolocation data.

The AAPP Software Description (http://nwpsaf.eu/site/software/aapp/documentation/) includes the following definition of processing levels:

“Level 0: HRPT data (NOAA) or PFS L0 (METOP): Raw telemetry data including housekeeping and others raw data. Data of the different instruments are merged into a HRPT stream for NOAA. One file per instrument for METOP.

AAPP level 1a: separated data for each instrument AAPP level 1b: Earth located and calibration coefficients (reversible: calibration coefficients are separated from raw data).

AAPP level 1c: Earth located and converted to brightness temperature data (non-reversible: calibration coefficients are applied to data) AAPP level 1d: Mapped and filtered data (with optional cloud mask in the case of HIRS).

PFS level 1B (for AVHRR): Earth located and calibration coefficients, flags.

PFS level 1C (for IASI): Gaussian-apodised, resampled radiance spectra, corrected for all geometrical and instrumental effects, with mapped AVHRR. Earth located.

For SNPP, JPSS and some other programmes (e.g. DMSP), NOAA have adopted the following naming convention, and these names are used in the AAPP documentation where applicable:

- Raw data records (RDR): Raw data from the instrument.
- Temperature data records (TDR): Calibrated, geolocated antenna temperatures from microwave sounder (i.e. no correction for antenna pattern). Original instrument grid.
- Sensor data records (SDR): Calibrated, geolocated brightness temperatures, radiances or reflectivities. In the case of microwave instruments, antenna correction has been applied. Either original instrument grid or re-mapped.
- Environmental data records (EDR): Geophysical quantities.”

Processing to level 1, and BUFR encoding, can be done at the regional centre, or locally at the receiving station location.

The DBNet Network Coordinator is responsible for ensuring that appropriate local centre and sub-centre codes are defined and are included in the BUFR messages as described in Section 4.4.

4.3.2. Product Processing Packages

DBNet Network Coordinators and Stations Operators shall use agreed processing packages and agreed auxiliary input data such as orbit information and instrument calibration files in order to ensure that the processed products are fully consistent with the corresponding global data sets pre-processed by the respective satellite operators.

The suite of processing packages to be used by DBNet is described below and is detailed in the sections of this document addressing specific services. The list of software processing packages and organizations responsible for maintaining them is provided in the following tables. For the scatterometry and MW imagery services, information about processing packages will be included when they become generally available.

Level-0 Processing Packages			
Package	Satellites	Provider	Comment
RT-STPS	SNPP, Metop, FY-3, Aqua	NASA DRL	CADU to CCSDS Source Packets
FY3L0PP	FY-3	CMA	CADU to CCSDS Source Packets
Metopizer	Metop	EUMETSAT	CCSDS Source Packets to EPS Level-0

Table 4: Level-0 Processing Packages

Level-1 Processing Packages			
Package	DBNet Service	Provider	Comment
AAPP	RARS, AVHRR	EUMETSAT (via NWP SAF)	
OPS-LRS	IASI	EUMETSAT (via NWP SAF)	Released as an optional part of AAPP.
CSPP	ATMS, CrIS, VIIRS	NOAA (via SSEC, UW-Madison)	
FY3L1PP	VASS, MERSI	CMA	
IMAPP	AIRS, Aqua AMSU	SSEC, UW-Madison	

Table 5: Level-1 Processing Packages

Encoding Packages			
Package	DBNet Service	Provider	Comment
AAPP	RARS, IASI, ATMS, CrIS, VASS	EUMETSAT (via NWP SAF)	Requires BUFR library
IMAPP	AIRS, Aqua AMSU	SSEC, UW-Madison	
CVIIRS	VIIRS	EUMETSAT	Converts between VIIRS SDR and Compact VIIRS SDR

Table 6: Encoding Packages

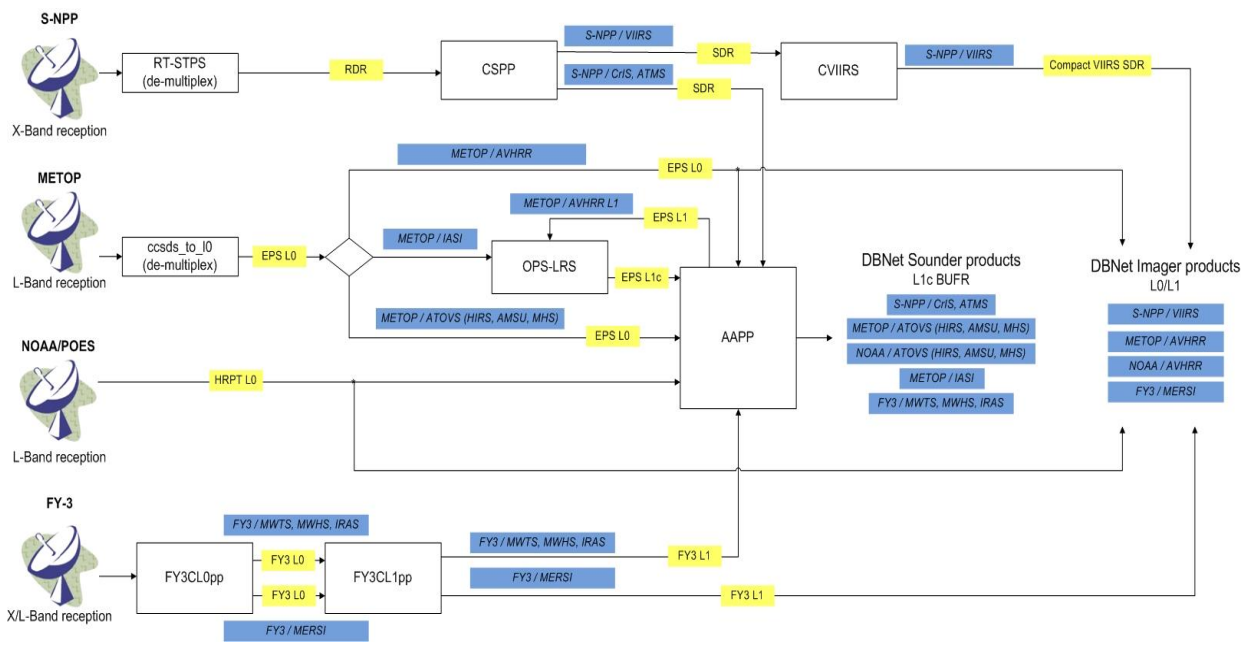

Figure 1: Schematic diagram of processing packages to be used for DBNet

4.3.3. Auxiliary Data

A Direct Broadcast station requires satellite orbit information in the form of Two Line Elements (TLE) for the prediction of future satellite passes, for antenna pointing during the acquisition of satellite data and for processing and geolocation of the sensor data. Orbital elements shall be updated at least once per day.

Additional instrument processing related auxiliary data are also required.

- For AAPP, auxiliary data files are provided by the NWP SAF (www.nwpsaf.eu).
- For CSPP, auxiliary data files for processing of VIIRS, CrIS, and ATMS are obtained periodically from NOAA operations and are made available for Internet download by the CSPP team. This includes TLEs and PolarWander files, as well as Calibration Tables. DBNet operators are encouraged to run the automated lookup table update scripts supplied with the CSPP SDR software regularly to ensure the most up to date auxiliary data are available.

Currently (August 2016) orbital data are made available directly by satellite operators at:

- Metop: http://oiswww.eumetsat.org/metopTLEs/html/index.htm (“long TLEs”) or the Multi-Mission Administration Messages contained in the Metop HKTM L0 files.
- NOAA: https://www.space-track.org (login needed) or http://celestrak.com/NORAD/elements/.
- FY3: http://www.shinetek.com.cn/eos_data/ or http://satellite.cma.gov.cn/portalsite/default.aspx.

For the future it is planned that each satellite operator will make TLE data publicly available in a standardized manner, along the lines of the service provided by NOAA for the SNPP satellite under https://msds.npoess.noaa.gov/MSDS/AUXILIARY/tle/. This will enable station operators, in an automated manner, to select the most recent reference TLE date and time in order to propagate the orbit into the future in the most accurate way, taking into account in particular spacecraft manoeuvres. Such procedure will be further detailed and submitted to CGMS satellite operators for endorsement as a technical standard. The following description is a preliminary overview only.

- TLE files are made publicly available on the Internet based on the HTTPS protocol. The files are standard ASCII text files each containing a single set of TLE data in the well-established two-line format, see for example https://www.space-track.org/documentation#/tle.
- As indicated in Table 7, the file name starts with the satellite name and the reference date and time (starting with “r”) of the TLE. The reference date and time are defined by the satellite operator and indicate the time of the orbit determination campaign which the TLE is based on.
- The newer generations of polar orbiting satellites typically perform manoeuvres as part of routine orbit maintenance. To account for this the TLE filename should systematically include the TLE interval of validity. The interval is defined by the dates and times of the start (starting with ”s”) and end (starting with ”e”) of the validity, where the start and end are defined by the satellite manoeuvre execution times.
- If the start of validity is left undefined (all zeros), the TLE is valid until a manoeuvre as shown in the first example in Table 7. If both start and end are defined, the TLE is valid between two manoeuvres as shown in the second example in Table 7. If the end is left undefined, the TLE is valid after a manoeuvre a shown in the third example in Table 7. This

scheme supports both the issuing of predicted post-manoeuvre TLEs and the issuing of determined post-manoeuvre TLEs.

- Finally, both the start and end of the validity interval can be left undefined as shown in the fourth example in Table 7. This indicates that the satellite is either not performing manoeuvres (example NOAA POES) or that there are no recent or planned manoeuvres for the satellite.

TLE Filename	Explanation
Metop-B_r20150820120000Z_s00000000000000Z_e20150823123000Z.txt	Issued on 20 August 2015. Validity ending on 23 August 2015 at 12:30 UTC (first manoeuvre).
Metop-B_r20150820120000Z_s20150823123000Z_e20150823141100Z.txt	Issued on 20 August 2015. Validity starting on 23 August 2015 at 12:30 UTC (first manoeuvre) and ending on 23 August 2015 at 14:11 UTC (second manoeuvre).
Metop-B_r20150824020000Z_s20150823141100Z_e00000000000000Z.txt	Issued on 24 August 2015. Validity starting on 23 August 2015 at 14:11 UTC (second manoeuvre).
Metop-B_r20151005120000Z_s00000000000000Z_e00000000000000Z.txt	Issued on 5 October 2015. No validity limitations.

Table 7: Example of TLE filenames for semi-open, closed and open intervals of validity.

4.3.4. Segmentation

Classically the raw satellite data acquired by a Direct Broadcast reception station is transferred to the product processing system after completion of the full satellite pass.

To achieve the challenging DBNet timeliness requirements, it can however be necessary for certain services (e.g. IR/VIS imagery) to transfer the data in segments, shorter than the full satellite pass, during the pass. Each segment is transferred to the product processing system as soon as its acquisition is completed. The duration of a segment is a configurable parameter, typically set to 2 minutes. The last segment of a pass may be shorter to match the overall duration of the pass.

It is recommended to transfer the data as CCSDS CADU, CCSDS VCDU or CCSDS Source Packets without adding any additional structure to the data and with each segment containing a sequence of complete CCSDS packets. These formats are well defined and enable easy segmentation and concatenation. CCSDS CADU is recommended as the most generic. CCSDS VCDU or CCSDS Source Packets can be chosen if data from a subset of instruments is required and the overall bandwidth of the transfer is of concern.

A typical implementation is based on the FTP protocol with the reception station acting as the FTP client and the product processing system as the FTP server. To improve the reliability of the transfer in the presence of equipment resets on either side or short interruptions of the network, the FTP client shall implement a retry mechanism. An appropriate mechanism could be for example to retry up to 10 times with a time interval between retries of 30 seconds.

The segment file name should indicate the name of the satellite, start of pass date, start of pass time, segment start time, segment end time, orbit number and station acronym. To simplify the handling of the segments by the product processing system, it is recommended that the last segment of a pass additionally has an indication that it is the last segment, that segments are transferred in order of acquisition and that during an ongoing FTP transfer the filename has an indication that the file is temporary and incomplete, e.g. by adding a suffix of .temp and atomically renaming the file once its transfer is complete.

Further details can be found in the service-specific paragraphs below.

The data acquisition and processing architecture can further be optimized in order to eliminate duplication of data. A possible approach is the one used by the EARS pilot AVHRR service, employing line-by-line acquisition planning to ensure no overlaps between neighbouring stations. The issue of overlap will be addressed in future revisions of the guide.

4.3.5. Global and local product consistency

Global (full orbit central processing) and local (usually direct broadcast) product consistency specifications are set based on considerations of NWP requirements.

Global and local product processing shall be harmonized in that brightness temperature products derived from both paths agree within tolerances that are not greater than few tenths (goal is 10%) of the respective performance requirements for bias error at a reference brightness temperature.

As a concrete example, this implies that for the MWS instrument to be flown on Metop-SG, the relevant performance requirement is the bias variation over an orbit (0.2K) – because DBNet products will be used regionally to complement global data. So the goal for local-global consistency should be 10% × 0.2K = 0.02K.

The instrument navigation shall be harmonized in that geographical coordinates derived from both paths agree within 10% of nadir Instantaneous Field of View (IFOV) for sounder instruments and 50% of nadir IFOV for imagers. Current recommended values are displayed in the NWP SAF monitoring plots for DBNet products.

4.4. PRODUCT CODING AND FORMAT (COMMON ASPECTS)

4.4.1. Format harmonization: general principles

In order to ensure that all DBNet products are fully interoperable, it is important that all DBNet operators use WMO standard formats, with the same implementation of these formats, and follow the agreed DBNet conventions in the implementation of these formats. For instance, for BUFR the same globally defined BUFR Table D sequence descriptors (also known as templates see [AD.1]) shall be used. These templates are embedded within the BUFR tables, which along with the conversion software will be released together with the recommended service specific processing software. All DBNet Operators shall make use of this recommended, or equivalent, BUFR conversion software for format conversion.

A “DBNet product” is the result of the processing of the data acquired by one station, from one satellite pass, from one instrument. A DBNet product shall be comprised of a series of BUFR encoded messages, which shall each be included in a bulletin, which should all preferably be

embedded in one file. DBNet formatting standards are thus defined at three different levels: BUFR message; Meteorological Bulletin; Filenames.

- The first level of standardization of DBNet product format is the BUFR Message encoding. For each satellite pass and each instrument (with the exception of imagery products), DBNet products are encoded in BUFR messages. Because of GTS message size limitations, a DBNet product exchanged on the GTS must be segmented into several BUFR messages. The number of BUFR messages needed for one product depends on the instrument and the duration of the satellite pass. The BUFR Message encoding should be in accordance with the Manual on Codes [AD.1] with DBNet specific provisions for Section 1 (Identification) and Section 3 (Data Description) of the BUFR message as described in Section 4.4.2.
- The second level of standardization of DBNet product format is the Abbreviated Bulletin Heading. An Abbreviated Heading is assigned to each BUFR message to form a "Meteorological Bulletin". The bulletin heading information is used by Regional Telecommunication Hubs (RTHs) to organize the routing of the messages over the GTS. The bulletin heading is not generally used by users of the BUFR messages to interpret the information; as all the necessary information to decode the BUFR message is contained within the actual BUFR message (in combination with the associated Code Tables - see the WMO Manual on Codes). Hence there is some duplication of information between Section 1 of the BUFR message and the bulletin headings (albeit with different representations). The structure of the heading is described in "Explanation of Data Designators $T_1T_2A_1A_2$ii CCCC YYGGgg BBB ([AD.2], Vol I, Part II, 2.3.2.2/Attachment II-5)". The different Bulletins composing a product have all the same headings, with the exception of the number "ii" which differentiates the individual Bulletins of the same product. Specific provisions are defined in Section 4.4.3 for the determination of $T_1T_2A_1A_2$ in the case of DBNet products.
- As the WIS continues to evolve, and the focus progressively shifts from bulletins to files, it is anticipated that this issue will assume less relevance. However, for the time being, bulletins remain a much-used communication mechanism within the WIS, and harmonization of bulletin headings is required within the DBNet network;
- The third level of standardization of DBNet products is the file. DBNet production centres can submit products to the GTS either directly as Meteorological Bulletins, or embedded in files. These files shall follow the WIS file naming convention: pflag_productidentifier_oflag_originator_yyyyMMddhhmmss[_freeformat].type[.compression]. Guidance for DBNet product filenames are provided in Section 4.4.4.

  [Note: More explanations on "Accumulating messages into files can be found in the Manual on the GTS [AD.2] Vol.1, Part II, Attachment II-15, as of page 158].

The DBNet conventions applicable to the BUFR identification section, the BUFR data description, the abbreviated heading and the file name are summarized in the DBNet Coding Summary [RD.4], which is posted on the DBNet website:
http://www.wmo.int/pages/prog/sat/documents/RARS_Coding-summary.xls .

[Note: the template will be reviewed in order to accommodate the additional DBNet Services]

4.4.2. Encoding of the DBNet BUFR Message

The structure of the BUFR Message is defined in the Manual on Codes [AD.1]. In order to facilitate identification and use of BUFR messages containing DBNet products, a specific convention shall be followed to determine certain fields of the identification section (Section 1) and for the data description section (Section 3).

The BUFR tables and Common Code Tables (CCT) referred to in this section are extracted from the Manual on Codes, Vol. I.2 [AD.1] and can be found at:
https://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/LatestVERSION/LatestVERSION.html

Section 1, Octets 5-6: Identification of Originating/Generating Centre

The Originating/Generating Centre shall indicate the centre responsible for the processing to level 1 and BUFR encoding.

If processing to level 1 and BUFR encoding are done locally at the station site, then the Originating/Generating Centre is the organization responsible for the station. If the processing to level 1 and/or the BUFR format conversion are performed, or managed by the DBNet regional centre, then the Originating/Generating Centre is the DBNet Regional Centre.

The corresponding ID is defined in Common Code Table (CCT) C-11 and recalled in [RD.4]

Section 1, Octets 7-8: Identification of Originating/Generating Sub-centre

The Originating/Generating Sub-centre shall indicate the Direct Broadcast station that receives the data. Each sub-centre is defined with reference to the Originating/Generating Centre it is functionally related to for the considered application.

The corresponding ID is defined in CCT C-12 and recalled in [RD.4].

The sub-centres ID are allocated by the relevant centres and shall be shared with the WMO Secretariat for inclusion in CCT C-12 and [RD.4]

Section 1, Octet 11: International Data Category

The data category indicated in Octet 11 is defined by BUFR Code Table A which gives e.g. “3” for satellite vertical sounding data, “12” for satellite surface data, “21” for satellite radiance data, “24” for scatterometry, and “101” for satellite image data. (See Annex D)

Section 1, Octet 12: International Data Sub-category

Subcategories of the above categories are defined by CCT C-13 for specific instruments (AMSU-A, AMSU-B, HIRS, MHS, IASI, SSMI, ASCAT, CrIS, ATMS, VIIRS) or for generic types of instruments (IR sounding, Hyperspectral sounding, MW sounding, radio-occultation).

Octet 12 of section 1 (BUFR Edition 4) must be populated using an appropriate International sub-category. When an instrument specific entry exists in CCT C-13, this should be used. If there is no specific entry in CCT C-13 for the instrument, the most appropriate generic instrument category entry should be used. If no generic entry in CCT C-13 is applicable, a request should be made to have such an appropriate entry added to the table.

Additional details can be provided in Octet 13, which is available to indicate a local sub-category (e.g. to differentiate instruments of the same sub-category, or different operating modes of an instrument, see Annexes D and E).

Section 3: The Data Description section (Section 3) includes a definition of the elements that are used to build the message. This definition usually takes the form of a single Table D sequence descriptor. It is recommended that WMO-approved sequences are used, as given in the following table.

Instrument	Sequence (F-X-Y)	Comment
HIRS	3-10-008	20 channels
AMSU-A	3-10-009	15 channels
MHS	3-10-010	5 channels
IASI	3-40-008	Channels + PCs (variable)
CrIS	3-10-060	Channels (variable)
ATMS	3-10-061	22 channels
MWTS-2	TBD	
MWHS-2	TBD	
IRAS	TBD	

Table 8: Section 3 data descriptor sequences

If an agreed Table D sequence is not available (the case for FY-3 instruments as of August 2016), then a list of Table B descriptors may be used.

Consistency with the equivalent global data should be maintained. Usually the agency responsible for dissemination of the global data is responsible for defining the BUFR sequence.

4.4.3. Bulletin Headings

The structure of the abbreviated bulletin heading is: **$T_1T_2A_1A_2$iiCCCCYYGGgg(BBB)** as described in [AD.2] "Explanation of Data Designators $T_1T_2A_1A_2$ii CCCC YYGGgg BBB (Manual on the GTS, Vol I, Part II, 2.3.2.2/Attachment II-5)".

For DBNet products, the following implementation shall be applied:

- **T_1T_2** should be set to "IN";
- **A_1** identifies the instrument (i.e. A=AMSU-A, B=AMSU-B, H=HIRS, M=MHS…..). Harmonization of instrument identifiers in the bulletin heading and the filename is desirable (i.e. the value of A_1 in the bulletin heading and the <data designator> value in the filename should be harmonised). (See Annex E)
- **A_2** is the geographic area designator - as per Table C3 of the Manual on the GTS (see https://www.wmo.int/pages/prog/www/ois/Operational_Information/Publications/WMO_386/AHLsymbols/TableC3.html). Concerning the value of A_2, a Regional Indicator or a Global Indicator ("X") can be used, depending on the most appropriate characterisation of the coverage. Where meaningful, the use of regional indicators is encouraged (e.g. "N" for Arctic and "S" for Antarctic stations).

Examples:

Bulletin headings from Casey:

INAS01 AMMC YYGGgg (for AMSU-A data)

INBS01 AMMC YYGGgg (for AMSU-B data)

INHS01 AMMC YYGGgg (for HIRS data)

4.4.4. Filenames

i) DBNet data files shall follow the GTS file-naming convention (with pflag=W) (see [AD.2]);

ii) A metadata file (which would generally be static) shall be associated with each DBNet data file.

The filename structure should be of the form:

W_productidentifier_oflag_originator_yyyyMMddhhmmss[_freeformat].type[.compression]

Where:

productidentifier is a variable length field that describes the nature of the data in the file. It consists of 2 parts; a “static part” and an “optional part” – which is not used in the context of DBNet.

The **“static part”** is the product description and consists of**:**

<**location indicator**>, <**data designator**>, <**free description**>

Where <**location indicator**> defines the producer: Country, Organization and the Production Centre. For example: for Brazil <**location indicator**> could be “br-INPE-cp”

Where <**data designator**> specifies the type of data with reference to the categories and sub-categories defined in the Common Table C-13 of the Manual on Codes, with “+” used to indicate composite data.

In the context of DBNet the following convention is used:

<**data designator**> should be the instrument name without a separator, for example: amsua, amsub, hirs, mhs, iasi or ascat (See Annex F).

<**free description**> should be used to indicate satellite and originating HRPT station, and should be preceded by “DBNet”. For example: for data from NOAA-17 from Cachoeira Paulista the <free description> should read “DBNet+noaa17+cpt”. Note: For backward compatibility “rars” can be used instead of “DBNet”.

(See details in Annex F.)

oflag – at this time the only admissible value of **oflag** is “C” – indicating that the <originator> field will be decoded as a standard CCCC country code (and the use of the CCCC value in filenames and bulletins should be consistent).

originator is a variable length field indicating where the file originated from (and is decoded according to the value of <oflag>). For example: “SBBR” for Brasilia Airport.

yyyyMMddhhmmss is a fixed length date and time stamp field, containing the **time of BUFR file creation.**

[_freeformat] in the context of DBNet should be “_(AAPP filename)_bufr”. This usage needs to be shared with users of DBNet data.

type in the context of DBNet this value would typically be set to “bin” to indicate file containing data encoded in a WMO binary code form such as BUFR.

So a typical filename for AMSU-A data from NOAA17 provided by CPTEC/INPE in Brazil, from the HRPT station in Cachoeira Paulista, could be:

W_br-INPE-CP,amsua,DBNet+noaa17+cpt_C_SBBR_20110701090858_(AAPP filename)_bufr.bin

4.5. DBNet PRODUCTS REGISTRATION AND DISCOVERY

4.5.1. WIS discovery metadata

In order to make the DBNet products discoverable in the WMO Information System they shall be registered in the WIS discovery metadata catalogue with a metadata entry (Manual on WIS [AD.3] Appendix C). This enables any WMO Member to be aware of the availability of these products through the WIS catalogue and, if interested, to request them from the relevant WIS centre, i.e. Global Information System Centres (GISC) or Data Collection and Production Centres (DCPC).

4.5.2. Recording in Vol.C1

In addition, the Abbreviated Headings of Meteorological Bulletins are recorded in the Catalogue of Meteorological Bulletins (WMO Publication No. 9, Vol.C1). This enables any WMO Member to be aware of the availability of these bulletins and, if interested, to request them from the relevant Regional Telecommunication Hub (RTH). However, when DBNet products are embedded in “files” they are not systematically recorded in Vol. C1. In order to make the DBNet products more easily discoverable, it is recommended to record the DBNet bulletins in Vol.C1 even if embedded in a file.

The procedure for recording Meteorological Bulletins is described in: http://www.wmo.int/pages/prog/www/ois/Operational_Information/VolC1_en.html under “UPDATING PROCEDURES AND METHODS OF NOTIFYING THE WMO SECRETARIAT OF AMENDMENTS / ADVANCED NOTIFICATIONS”. The WMCs and RTHs on the Main Telecommunication Network (MTN) shall maintain Vol. C1 as regards bulletins issued from the zone for which they are responsible. The format to record a bulletin is described in: http://www.wmo.int/pages/prog/www/ois/Operational_Information/VolumeC1/AN_RecordFormat_en.html.

Table 9 provides guidance to complete the fields 9-15 of this record.

Field N°	Field	Value
9	Category	“E” (Essential data/products)
10	TTAAii	(Indicate TTAAii as defined by the DBNet coding
11	CCCC	(Indicate CCCC as defined by the DBNet coding convention)
12	CodeForm	“FM 94-XIV”
13	TimeGroup	"AS AVAILABLE"
14	Content	“DBNet”
15	Remarks	“TRANSMITTED AS A FILE”

Table 9: Guidance to record in Vol.C1 a DBNet bulletin sent as a file

4.6. PRODUCT DISTRIBUTION

The DBNet regional networks shall strive to make DBNet products available to the global user community and in particular to the NWP centres worldwide, through the WMO Information System.

The recommended route for DBNet data access within a region is to be defined at the regional level in consultation between the GISC/DCPC and the DBNet regional nodes taking into account the level of connectivity of the main regional users.

Inter-regional data exchange shall be implemented between regional nodes and GISCs, taking into account the recommendations of the GODEX-NWP group, which keep under review the requirements of NWP centres for inter-regional exchange of satellite data.

It will be the matter of a trade-off between the benefit provided by additional data and the resulting load on the telecommunications. While the primary distribution means will be the GTS/RMDCN networks), the use of a satellite broadcast service such as EUMETCast or CMACast or Internet is an advantage for users with limited WIS/GTS connectivity. A schematic illustration of the telecommunication scheme is provided in Figure 2.

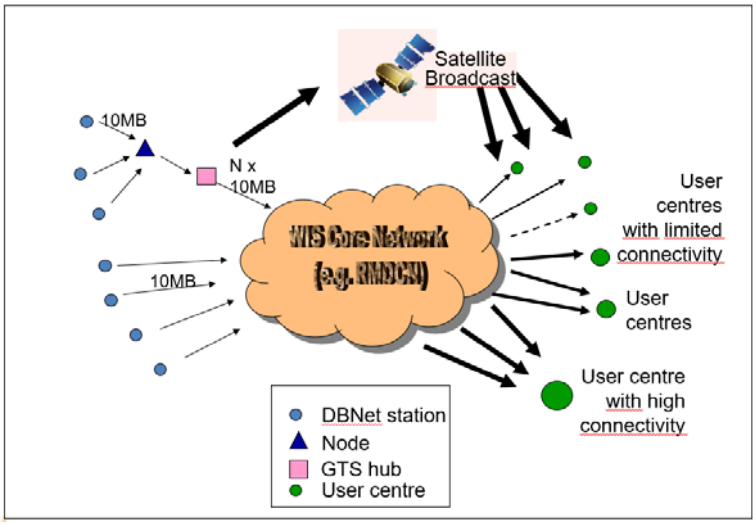

Figure 1: DBNet connectivity to GTS/RMDCN

Specific aspects of DBNet-WIS connectivity:

- DBNet stations with direct access to a core WIS node (GISC or DCPC) should directly inject into the WIS (e.g. Kyose/Tokyo, Crib Point/Melbourne);
- DBNet station with GTS access should directly inject into the GTS (e.g. New Delhi);
- DBNet station with no WIS/GTS access should send their products either to a GTS or WIS core node via FTP (e.g. Maupuia to Melbourne, Cordoba to Buenos Aires, Cachoeira Paulista to Brasilia, Jincheon to Seoul);
- As an alternative, DBNet stations which are part of a coordinated regional/sub-regional network should send their products to the regional/sub-regional node that will send the whole DBNet product package to a GTS hub/GISC/DCPC (e.g. EARS stations concentrated by EUMETSAT via VPN, before being sent to GISC/RTH Offenbach; Natal, Cuiaba via Cachoeira Paulista, before being sent to GISC/RTH Brasilia).

5. STANDARDS FOR SPECIFIC DBNet SERVICES

These standards and best practices are applicable to the provision of individual DBNet services. The DBNet services are defined in terms of groups of equivalent or similar instruments, potentially flying on different satellites. A particular DBNet operator may only provide a subset of the defined services. The scope of the overall DBNet includes the services listed in Table 2.

The areas covered by these standards are service-specific aspects of product processing, formats, quality control and monitoring.

5.1. IR/MW SOUNDING SERVICE

This service is provided for the ATOVS suite of instruments flying on NOAA/POES and EUMETSAT/Metop satellites as well as from equivalent instruments flying on CMA/FY-3 and NOAA/SNPP and JPSS satellites.

5.1.1. Product Processing Software

To ensure global consistency of the DBNet dataset, the DBNet operator shall make use of the AAPP (ATOVS and AVHRR Pre-processing Package) software for product processing for the ATOVS suite of instruments, of CSPP for ATMS and of the FY-3 L0/L1 pre-processing software package for MWTS, MWHS and IRAS.

The AAPP package is supplied and maintained by EUMETSAT's Numerical Weather Prediction Satellite Application Facility (NWP SAF). The package is freely available (subject to the signing of a license agreement) and the process for obtaining the package is fully described on the NWP SAF AAPP web pages (http://www.nwpsaf.eu). General background information on the AAPP software is also available on this web-page. The version of the AAPP software to be used shall be the latest release as defined on the AAPP web-page.

For changes affecting the data output, this latest release shall be implemented operationally within 1 month of release by the NWP SAF, otherwise the latest release shall be implemented operationally within 3 months.

For SNPP ATMS, The product processing shall be performed by AAPP and CSPP software. CSPP performs Level 1 processing which delivers Sensor Data Records (SDR) in HDF5 format for ATMS. AAPP ingests these SDRs, and carries out BUFR encoding. CSPP can be downloaded from: http://cimss.ssec.wisc.edu/cspp/

FY-3 pre-processing software: FY-3 data are pre-processed by the FY3L0/L1pp software packages distributed by CMA, see http://satellite.cma.gov.cn/portalsite/ "Tools".

AAPP can ingest the SDRs of MWTS, MWHS and IRAS, and can BUFR encode them.

5.1.2. Processing Level

Any products exchanged inter-regionally shall be at the level of brightness temperatures with geolocation on the original instrument grid.

5.1.3. Quality Checking and Quality Flags

The pre-processing software includes quality checking, and any products distributed shall include quality flags. For AMSU-A, MHS, HIRS and ATMS quality flags are available in the BUFR product. It must however be noted that currently (August 2016) quality flags are not available in the BUFR products for VASS (MWTS-2, MWHS-2 and IRAS), instead suspect measurements values are set to “missing”.

5.1.4. Product Quality Monitoring

Routine monitoring of DBNet IR/MW sounding data quality is performed by the NWP SAF. Monitoring results are available on the “Monitoring reports” section of the NWP SAF website http://www.nwpsaf.eu.

5.2. IR/VIS IMAGING SERVICE

5.2.1. Product Processing Software

For SNPP VIIRS, the product processing shall be performed by the CSPP software, followed by CVIIRS. For MERSI, the product processing shall be performed by the FY3L0/L1pp software packages.

For NOAA AVHRR, raw data are currently disseminated, therefore no product processing or encoding is required at this point in time (August 2016).

For Metop AVHRR, Metopizer or similar software is needed to first create EPS level 0.

5.2.2. Processing Level

The processing level shall be either raw HRPT (NOAA POES / Metop) or at the level of radiances/reflectivities (VIIRS / MERSI).

It is preferable for the orbit pass to be segmented to enable on-the-fly transmission of product segments in order to ensure low latency and to facilitate handling of large data sets.

As it is important to provide seamless imagery (without missing lines or overlaps) the acquisition schedules of the local stations shall be coordinated and where feasible the acquisition source shall be switched from one station to the next one at a defined imagery line.

Data compression is critical, efficient compression procedures shall be used. For VIIRS a compact SDR format has been developed and implemented in DBNet-EUMETSAT. This format provides a compact representation of VIIIRS Geolocation, Angular Information and Measurement Data. For further info see:

http://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&dDocName=PDF_VIIRS_SDR_PF_UG&RevisionSelectionMethod=LatestReleased&Rendition=Web.

5.2.3. Quality Checking and Quality Flags

Not applicable to raw data.

5.2.4. Product Quality Monitoring

Not applicable to raw data.

5.3. HYPERSPECTRAL IR SOUNDING SERVICE

5.3.1. Product Processing Software

For IASI EUMETSAT has implemented a computer at each station running AAPP together with the IASI Level 1 processor (OPS-LRS). Both AAPP and OPS-LRS are distributed by the NWP SAF (http://www.nwpsaf.eu/) and are freely available to any interested user. AAPP requires Metop Level 0 as input (Note: If not already delivered by the receiving station, the Level 0 can be generated by the "Metopizer" freeware available from EUMETSAT: http://www.eumetsat.int/website/home/Data/DataDelivery/SupportSoftwareandTools/index.html.

For OPS-LRS the IASI instrument auxiliary files are made available by the NWP SAF (www.nwpsaf.eu) to registered users of the package and announced via the NWP SAF AAPP Announcements Forum. Due to the interdependency between on-board instrument configuration and the on-ground processing software, it is essential that DBNet Station Operators install the updated auxiliary files into AAPP before corresponding on-board configuration changes are uploaded to Metop by EUMETSAT operations. Details on the installation process are found in the OPS-LRS User Manual.

For SNPP CrIS, the product processing shall be performed by AAPP and CSPP software. CSPP performs Level 1 processing which delivers Sensor Data Records (SDR) in HDF5 format for ATMS, CrIS and VIIRS instruments. AAPP ingests these SDRs, performs CrIS channel selection, and BUFR encodes. CSPP can be downloaded from: http://cimss.ssec.wisc.edu/cspp/

For HIRAS the availability of a product processing package has not yet been confirmed.

5.3.2. Processing Level

Any products exchanged inter-regionally shall be at channel subset of level 1 radiances, optionally supplemented with Principal Component (PC) Scores that allow a reconstruction of the full spectra with minimal loss of information. The definition of the set of selected channels for each of the hyperspectral sounders as well as the selection of the appropriate PC score representation is performed by the agencies, in consultation with users, according to the following table.

Service	Channel selection responsible	PC score selection responsible	Apodization applied
IASI	EUMETSAT	EUMETSAT	Yes
CrIS	NOAA	TBD	Yes
HIRAS	CMA	TBD	Yes
AIRS	NOAA	N.A.	No

Table 10: Data selection for hyperspectral sounders

In brief, at the PC encoding step each spectrum is projected onto a set of orthogonal basis functions (eigenvectors) and the resulting amplitudes are the PC scores. In a reverse process, the DBNet user can reconstruct radiances when he has the PC scores and the eigenvectors. The number of PCs is defined by the agency, with the aim to preserve as much as possible of the real atmospheric signal, while discarding PCs that contain only instrument noise.

For information on the implementation of PC scores in AAPP, please see the document NWPSAF-MO-UD-022 “IASI Principal Components in AAPP: User Manual”, available from http://www.nwpsaf.eu/deliverables/aapp/index.html.

Regarding channel selection for CrIS, NOAA has documented a recommended channel selection of 399 channels, in "Methodology and Information Content of the NOAA NESDIS Operational Channel Selection for the Cross-Track Infrared Sounder (CrIS)” by Antonia Gambacorta and Christopher D. Barnet. IEEE Transactions on Geoscience and Remote Sensing, Vol. 51, No. 6, June 2013.

Regarding channel selection for IASI, EUMETSAT has documented a recommended channel selection of 500 channels in the IASI Level 1 Product Guide http://www.eumetsat.int/website/wcm/idc/idcplg?IdcService=GET_FILE&dDocName=pdf_iasi_level_1_prod_guide&RevisionSelectionMethod=LatestReleased&Rendition=Web.

The channel selections for the hyper-spectral IR sounders will be revisited in the future based on increasing capabilities of the users, improved WIS capacity for global product distribution and changes in instrument capability (for example upon transition from SNPP to NOAA-20).

5.3.3. Quality Checking and Quality Flags

The processing software includes quality checking, and any products distributed shall include quality flags. For IASI and CrIS all quality flags in the native sounder products formats are transferred to the BUFR formatted product.

5.3.4. Product Quality Monitoring

Routine monitoring of DBNet hyperspectral sounding data quality is performed by the NWP SAF. Monitoring results are available on the “Monitoring reports” section of the NWP SAF web site http://www.nwpsaf.eu. Consistency between global and local data products is monitored, and also the consistency between raw and reconstructed radiances.

5.4. SCATTEROMETRY SERVICE

This service is currently provided by the EUMETSAT EARS network for the ASCAT instrument flying on Metop-A/B.

5.4.1. Product Processing Software

For ASCAT, the processing software used is the ASCAT Level 1 Product Processing Facility (PPF) software, ported from the EUMETSAT EPS Central Ground Segment.

Availability of a Wind RAD (FY-3) processing package has not yet been confirmed

5.4.2. Processing Level

Any products exchanged inter-regionally shall be at level 1 (backscatter cross-sections) or at level 2 (winds and soil moisture).

5.4.3. Quality Checking and Quality Flags

The pre-processing software includes quality checking, and any products distributed shall include quality flags.

5.4.4. Product Quality Monitoring

TBD

5.5. MW IMAGERY SERVICE

This service is currently not provided, but is under consideration for the MWRI instrument on FY-3.

5.5.1. Product Processing Software

Availability of a MWRI processing package has not yet been confirmed

5.5.2. Processing Level

TBD

5.5.3. Quality Checking and Quality Flags

The pre-processing software includes quality checking, and any products distributed shall include quality flags.

5.5.4. Product Quality Monitoring

TBD

6. CONCLUSION

The provisions contained in this document contain the standards to be followed by DBNet Operators to:

- Ensure that an appropriate level of service is provided regionally;
- Facilitate the inter-regional exchange of DBNet data;
- Ensure the global consistency of the DBNet datasets.

ANNEXES

A. TERMS OF REFERENCE OF THE DBNet COORDINATION GROUP

1. A DBNet Coordination Group is established by the WMO Space Programme in order to support the development and implementation of the Direct Broadcast Network for Acquisition and Near Real-Time Relay of Low Earth Orbit Satellite data (DBNet).
2. The aim of the DBNet Coordination Group is:
    - To keep under review the High-Level Specifications of DBNet Services, in consultation with the users;
    - To coordinate the implementation and expansion of DBNet Services responding to the user needs;
    - To define and maintain the standards ensuring interoperability and Inter-regional exchange of DBNet products, and the consistency with the WMO Information System;
    - To monitor the performance of DBNet components and define actions to improve this performance as appropriate;
    - To keep under review the priorities for filling coverage gaps and for scheduling the acquisition of satellite data;
    - Identifying issues to be submitted for consideration by CGMS satellite operators.
3. The DBNet Coordination Group is composed of DBNet regional or subregional network coordinators, organizations providing software for L0/L1 processing, technical experts designated by organizations contributing to the global DBNet network, planning or considering to contribute to it, and the WMO Secretariat.
4. A focal point is designated within the DBNet CG to ensure liaison with IPET-DRMM.
5. The DBNet Coordination group meets nominally once a year, or more frequently if necessary.
6. The DBNet Coordination Group reports on its activities to CGMS and to the WMO Commission for Basic Systems through the Inter-Programme Expert Team on Satellite Utilization and Products (IPET-SUP). It receives guidance from CGMS, from CBS through IPET-SUP, and from representative user groups such as the International TOVS Working Group (ITWG).

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B. PROCEDURE FOR ADDING/MODIFYING A STATION IN THE DBNet NETWORK

The purpose of this procedure is to guide the station operator on the steps to be followed when including a new station in the DBNet network, or modifying the operation mode of a station, ensuring appropriate coordination and information of all parties involved.

The following steps shall be followed for adding a new station:

Step 1: The Station Operator (or the regional/subregional coordinator) informs the WMO Space Programme Office (WMOSP) of the WMO Secretariat of the characteristics of the new DBNet station:

- Latitude and Longitude of the station (in degrees, with decimals);
- Name of the station;
- Three-letter abbreviated name;
- Centre administratively responsible for this station;
- Identifier of the centre in Common Code Table (CCT) C-1/C-11 (if available);
- Identifier of the station as sub-centre of this centre in CCT C-12 (if available);
- RTH/GISC which will transmit the data over the GTS/WIS Core Network;
- CCCC identifier of this RTH/GISC;
- DBNet Services which will be supported by the station.

Step 2: If the Centre is not yet identified in CCT C-11, or if the station is not yet identified in CCT C-12 as a sub-centre of this centre, the operator requests the addition of a code for the centre and/or the sub-centre in the relevant Common Code Tables. The procedure for amending the tables is to send a request from the Permanent Representative (PR) to the Secretary-General, or from the focal point for codes and data representation matters of the country/territory to the WMO Secretariat (OBS/WIS/DRMM with copy to OBS/SAT). The procedures for amending the tables are initiated after each update implementation in May and November.

Step 3: The Operator implements the operational processes for acquisition, pre-processing, processing, coding and routing of DBNet products in accordance with the applicable DBNet standards defined in Sections 3 and 4.

Step 4: The Station operator sends file samples by FTP for validation during a minimum test period of one week:

- To the RTH in charge of transmitting the data into the GTS (if different from the Operator);
- To the relevant DBNet regional coordinating center;
- To the DBNet monitoring centre.

Step 5: The RTH, the Regional Coordinator check the consistency with DBNet conventions and regularity and timeliness of the products. The Global DBNet Monitoring centre checks the consistency of the products with global data and their timeliness. They interact as appropriate with the Station Operator until full compliance is demonstrated.

Step 6: Once the test is successful, the Operator:

- Informs the WMO Space Programme Office of the planned start of the routine dissemination, and of any change to the bulletin headings and file naming (if relevant);
- Requests the responsible RTH Focal Point in an appropriate manner so that the Focal Point can update relevant parts of the Vol. C1 with respect to the new bulletins at least two months in advance. A/N (advanced notification) of Vol. C1 will be released to WMO Members;
- Updates the discovery metadata record to share with the responsible DCPCs or GISCs.

Step 7: The PR of the Operator's country/territory or the regional/subregional coordinator informs the WMO Secretariat of changes to the DBNet operation and provides input for inclusion of an announcement in the World Weather Watch Operational Newsletter (http://www.wmo.int/pages/prog/www/ois/Operational_Information/index_en.html); the Secretariat, updates the DBNet documentation accordingly and takes any other appropriate action to inform the satellite community.

In case of modification or termination of a DBNet station operation, the Operator informs the Space Programme Office of any change of status of the station, for instance if an additional DBNet Service is ready to be implemented at the station. The production associated with the new Service is implemented following Steps 3 to 7 above.

If a Service is cancelled, or the overall operation of a station is terminated, the Operator:

- Informs the WMO Space Programme Office of the planned termination;
- Records the end of the bulletins in Vol. C1;
- Deletes the discovery metadata record.

The WMO Space Programme Office updates the DBNet documentation accordingly.

C. DBNet RECEPTION SCHEDULING PRIORITIES

Last update: May 2015

Satellite	**Orbit and satellite status** (D=descending, A=ascending)	**Instrument health**	**Global data** (DBNet impact is largest when global data are late)	**Direct broadcast transmission**	**DBNet priority** (H/M/L)
SNPP	NOAA Prime Polar Orbiter PM 1330A	Good	1 dump per orbit	Good (X-band). Occasional short gaps due to solar array obscuration.	H
Metop-B	Primary AM service. 0930D	Good	Very good: Arctic and Antarctic	Good (L-band)	H

			dumps		
NOAA-19	Prime NOAA Services Mission PM. Close to SNPP 1400A/0200D	Good	1 dump per orbit	Good (L-band)	H
NOAA-18	Has drifted to an early morning orbit 1700A/0500D	Good. HIRS degraded	Some blind orbits	Good (L-band)	H
Metop-A	Same orbital plane as Metop-B 0930D	Good	1 dump per orbit	Limited geographically	M
NOAA-15	Close to NOAA-18 0530D	Poor. AMSU-B and HIRS not working. AMSU-A is still useful.	Some blind orbits. Low priority in NESDIS L1 processing.	Poor signal strength (L-band), can only be received by large dishes	L
FY-3C	1030D	MWTS-2 not working, MWHS-2 OK.	Significant delays	Good (L-band for sounders, X-band for MERSI)	L

D. EXTRACT OF THE MANUAL ON CODES: EXTRACT OF COMMON CODE TABLE C-13

The present extract contains the satellite-related entries as of August 2015.

Link to Current version:
http://www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/LatestVERSION/WMO306_vI2_CommonTable_en.docx

Data categories		**International data sub-categories**	
BUFR Edition 4 Octet 11 in Section 1		BUFR Edition 4 Octet 12 in Section 1	
Code figure	**Name**	**Code figure**	**Name (corresponding traditional alphanumeric codes are in brackets)**
3	Vertical soundings (satellite)	0	Temperature (SATEM)
		1	TIROS (TOVS)
		2	ATOVS
		3	AMSU-A
		4	AMSU-B
		5	HIRS
		6	MHS
		7	IASI
		20	IR temperature/humidity sounding
		30	Hyperspectral temperature/humidity sounding
		40	MW temperature/humidity sounding
		50	Radio occultation sounding
12	Surface data (satellite)	0	ERS-uwa
		1	ERS uwi

		2	ERS-ura
		3	ERS-uat
		4	SSM/I radiometer
		5	Surface temp./radiation (SATOB)
		6	Quikscat
		7	ASCAT data
		8	Soil moisture
		9	Normalized differential vegetation index (NDVI)
		10	Normalized radar backscatter
		11	Surface emissivity
		12	Sea surface temperature
21	Radiances (satellite measured)	0	Earth radiation budget
		5	Cross-track infrared sounder (CrIS)
		6	Advanced technology microwave sounder (ATMS)
		7	Visible/infrared imager radiometer suite (VIIRS)
22	Radar (satellite) but not altimeter and scatterometer	0	Cloud and precipitation radar
		1	Synthetic aperture radar
23	Lidar	0	Lidar based missions (for wind, for cloud/aerosol, for water vapour, for altimetry)
24	Scatterometry (satellite)	0	Wind scatterometry
25	Altimetry (satellite)	0	Radar altimetry
26	Spectrometry (satellite)	0	Cross nadir shortwave spectrometry (for chemistry)
		1	Cross nadir IR spectrometry (for chemistry)
		2	Limb sounding shortwave spectrometry
		3	Limb sounding IR spectrometry
		4	Limb sounding sub-millimetre wave spectrometry
30	Calibration dataset	0	Sub-setted data
		1	Collocated data
		2	On-board calibration data
		3	Bias monitoring
		4	Near real-time correction
		5	Re-analysis correction
101	Image data (satellite)	0	Multi-purpose VIS/IR imagery
		1	Conical scanning MW imagery (intermediate frequencies)
		2	Low frequency MW imagery
		3	Ocean colour imagery
		4	Imagery with special viewing geometry
		5	Lightning imagery
		6	High-resolution shortwave imagery for land observation
		7	SMOS data

E. EXISTING/PROPOSED CODE VALUES FOR INSTRUMENTS USED IN DBNet

"A_1" Data type designator in GTS Headings "T_1 T_2 A_1 A_2ii" **defined in the Manual on the GTS, WMO-No. 386 Vol. 1 [AD.2]** See current values in Table C6 in the Explanation of Data Designators: http://www.wmo.int/pages/prog/www/ois/Operational_Information/Publications/WMO_386/AHLsymbols/TableDefinitions.html		
Definition	Comment	Corresponding category/sub-category in CCT C-13 (WMO-No. 306) [AD.1]
With T_1 T_2 =IN :	Level 1 sounding products	
A AMSU-A		003 / 03
B AMSU-B	(Code values extracted from Table C6 as of 1/01/2016)	003 / 04
C CrIS (selected channels)		021 / 05
H HIRS		003 / 05
I IRAS		003 / 20
J HIRAS		003 / 30
K MWHS/MWHS-2		003 / 40
M MHS		003 /0 6
Q IASI (PC scores)		003 / 07
S ATMS		021 / 06
T MWTS/MWTS-2		003 / 40
Additional codes (for information only)		
With T_1 T_2 =IE:		
A AMSU-A/METOP	Used by EUMETSAT with T_1T_2 =IE for products from EUMETSAT satellites.	003 / 03
D IASI L2 products		003 / 07
H HIRS/METOP		003 / 05
M MHS/METOP		003 / 06
Q IASI (PC scores)		003 / 07

F. PRODUCT IDENTIFIER FOR DBNet PRODUCT FILENAMES

Product identifier = <location indicator>, <data designator>, <free description> **In the filename structure defined in the Manual on the GTS [AD.2]**		
DBNet convention for the location indicator	**DBNet convention for the data designator**	**DBNet convention for the free description**
<Country ID - Organization-Production Centre>	<instrument> Where: IASI = iasi CrIS = cris ATMS = atms MWTS = mwts MWHS = mwhs IRAS = iras HIRAS = hiras AMSU-A = amsua AMSU-B = amsub MHS = mhs	"DBNet+<satellite>+<station>" Where <satellite> is: NOAA-xx = noaaxx METOP-A = metopa METOP-B = metopb Suomi-NPP = snpp FY-3A = fy3a FY-3B = fy3b FY-3C = fy3c FY-3D = fy3d JPSS-1 = noaa20 JPSS-2 = noaa21 Where <station> is the Direct Broadcast receiving station (same as "Originating sub-centre" in the BUFR Section 1)
For example: "br-inpe-cpt" for a product generated by INPE in Cachoeira Paulista (Brazil)		Example: "DBNet+metopb+ath" for a DBNet product generated with METOP-B data received in Athens.

[Note: More explanations on "Accumulating messages into files can be found in the Manual on the GTS (WMO-No. 386) Vol.1, Part II, Attachment II-15, as of page 158]

[Note: the identifiers "rars" and "npp" are accepted as alternatives to "DBNet" and "snpp" for backward compatibility]

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G. GLOSSARY

ATOVS	Advanced TIROS Operational Vertical Sounder (instrument package including HIRS, AMSU-A and AMSU-B)
CCSDS	Consultative Committee for Space Data Systems (http://public.ccsds.org/default.aspx); "CCSDS" also designates the data format standard defined by this committee.
CCSDS to L0	The conversion from CCSDS to EPS level 0 is generally included in the receiving station software. It is also available from EUMETSAT as part of the « Metopizer » software.
CDA	Command and Data Acquisition station, major ground facility of a Low Earth Orbit satellite programme
CSPP	Community Satellite Processing Package provided by NOAA through the University of Wisconsin for Direct Broadcast users.
DBNet Coordinator	Regional coordinator in charge of providing technical guidance to operators, monitoring the timeliness, and maintaining on line information for users, for a regional component of the global DBNet network
DBNet Monitoring centre	Organization in charge of DBNet product quality monitoring at the global scale (NWP SAF, Met Office/United Kingdom)
DBNet Operator	Organization responsible for data acquisition and pre-processing
DBNet Station	Facility including a Direct Readout station that acquires the data
DBNet:	Direct Readout Acquisition and Relay System for LEO Satellite Data. It is a system based on the concept of RARS, but expanded to address a broader range of data and products, and a variety of formats and protocols while complying with a set of standards and best practices which are described in the present guide.
EPS	EUMETSAT Polar System
GISC	Global Information System Centre
GODEX-NWP	Group for establishing and maintaining requirements for Global Data Exchange for NWP centers
HIRLAM	High Resolution Limited Area Model, developed and maintained through a cooperation of European meteorological institutes for operational short-range weather forecasting.
ITWG	International TOVS Working Group
JPSS	Joint Polar System Satellite programme. The JPSS-1 and JPSS-2 satellites of the JPSS programme will be renamed NOAA-20 and NOAA-21 after successful launch.
LEO	Low Earth Orbit
NWP	Numerical Weather Prediction
OPS-LRS	IASI "Operation Software for Local Reception Station", which processes IASI instrument data from Level 0 (raw instrument data) through to level 1c (calibrated, geolocated, Gaussian-apodised radiances). OPS-LRS is provided by EUMETSAT through the NWP SAF as part of the AAPP deliverable.
PFS	Product Format Specification (EUMETSAT)

RARS	Regional ATOVS Retransmission Service. It is an arrangement among HRPT station operators to acquire, pre-process, and share satellite sounding data from ATOVS instrument package aboard NOAA and METOP satellites, in near real-time, in accordance with agreed standards, in support of NWP.
RDR	Raw Data Record
RMDCN	Regional Meteorological Data Communication Network
RTH	Regional Telecommunication Hub of the Global Telecommunication System (GTS)
RT-STPS	Real-time Software Telemetry Processing System, a generalized CCSDS data processing package that ingests telemetry data from a spacecraft transmission in real-time, performs multi-mission protocol processing, and produces output to a file or TCP/IP socket. RT-STPS is provided by the NASA Direct Readout Laboratory.
SDR	Sensor Data Record
SNPP	Suomi National Polar-orbiting Partnership
WIS	WMO Information System
WMOSP	WMO Space Programme Office, within the WMO Observing and Information Systems Department (OBS/SAT)

Recommendation 18 (CBS-16)

AMENDMENTS TO THE *MANUAL ON THE GLOBAL TELECOMMUNICATION SYSTEM* (WMO-No. 386) AND ITS ATTACHMENTS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The *Manual on the Global Telecommunication System* (WMO-No. 386), Volume I, Attachment I-5 that defines the World Weather Watch quantitative monitoring procedures,

(2) The need to update the *Manual on the Global Telecommunication System* to define the areas of responsibility and preferred routing for the Regional Telecommunication Hubs in line with Resolution 32 (Cg-17) following discontinuation of the *Manual on the Global Telecommunication System*, Volume II,

(3) The *Manual on the Global Telecommunication System*, Attachment II-15 defining recommended practices and procedures for the implementation, use and application of Transmission Control Protocol/Internet Protocol on the GTS,

(4) The *Guide to Information Technology Security* (WMO-No. 1115),

(5) The *Guide to Virtual Private Networks (VPN) via the Internet between GTS Centres* (WMO-No. 1116),

Noting further:

(1) The importance of maintaining the currency of operational guidance in ensuring the secure and effective operation of the Global Telecommunication System,

(2) That the simple (fast-track) procedure had been used to introduce data designators in support of international civil air navigation into Attachment II-5 of the *Manual on the Global Telecommunication System*,

Recommends to the Executive Council to amend the *Manual on the Global Telecommunication System* and its attachments as defined in the annexes to the present recommendation:

(1) Amend the *Manual on the Global Telecommunication System*, Attachment I-5 as per Annex 1 to the present recommendation;

(2) Amend the *Manual on the Global Telecommunication System*, Part I and Attachments I-2 and I-3 as per Annex 2 to the present recommendation;

(3) Amend the *Manual on the Global Telecommunication System*, Attachment II-I5 as per Annex 3 to the present recommendation;

(4) Amend the *Guide to Information Technology Security* as per Annex 4 to the present recommendation;

(5) Amend the *Guide to Virtual Private Networks (VPN) via the Internet between GTS Centres* as per Annex 5 to the present recommendation.

Annex 1 to Recommendation 18 (CBS-16)

AMEND THE *MANUAL ON THE GLOBAL TELECOMMUNICATIONS SYSTEM* (WMO-No. 386), ATTACHMENT I-5 AS FOLLOWS

1 In Attachment I-5 Section 4 (Priorities)

Add a note after the list of information types in paragraph 4.1:

Note: Reference to report types includes any World Weather Watch code form representation of that information.

Amend paragraph 4.2 to read:

4.2 Monitoring of satellite data presents a special case. There are only a few operators and their standards for monitoring, including quality control of satellite data, are already high. Monitoring of satellite data bulletins and ~~GRID~~ GRIB code bulletins shall be a special event for a limited time as designated by the WMO Secretariat.

2 In Attachment I-5 Section 5 (Responsibilities)

Amend paragraph 5.5 to read:

5.5 In order to keep under review the efficient operation of the WWW, internationally coordinated monitoring on a non-real-time basis should be carried out periodically ~~once~~ four times a year in October, January, April and July, on the full range of global on the full range of global observational data and with the participation of a limited number of major WWW centres. During other periods, particular problem areas should be monitored, in respect of either selected information only or limited parts of the world. The Secretary-General will arrange, in consultation with the appropriate centres, details of the special monitoring exercises and the periods during which they should be carried out, and will provide adequate notice well in advance.

3 In Attachment I-5 Section 6 (Procedures)

Amend paragraph 6.1 and 6.2 to read:

6.1 As far as real-time monitoring is concerned, each centre should develop the necessary detailed procedures for this purpose. These procedures will vary from centre to

centre, but should be designed to facilitate the real-time checking of the receipt of bulletins and observations as appropriate. At fully automated centres, these procedures may include the use of telecommunication system records~~, visual display units, special programmes in telecommunication and data processing computers, and so on~~. At manual centres, check lists or sheets may be developed for the same purposes using ticks, crosses or the entry of times to indicate when selected bulletins and/or reports have been received. ~~To avoid excessive use of paper forms, it may be convenient to place transparent sheets of plastic over the check sheets and make entries using soft wax pencils.~~ The entries can be removed very easily when a suitable period has elapsed and the sheets made ready for the checks to be repeated for a later period. Some further guidance on the operation of real-time monitoring, together with examples of the kind of forms which might be developed, are given in Table C.

6.2 As far as non-real-time monitoring is concerned, when special exercises are requested by the Secretariat, an indication of the form in which contributions should be made will be provided at the time the request is made. It is important that, as far as possible, centres should follow closely the procedures indicated in order that results from various centres be directly comparable with each other. It is particularly important that this should be the case when the annual global monitoring exercise is carried out. The procedures, together with the standard ~~forms~~ formats to be used for the provision of results, are given in Table D.

4 In Attachment I-5 Table C (Guidance for real-time monitoring)

Add a note immediately following the title of Table C:

Note: In this Table, reference to a report type (such as SYNOP) refers to that information in any WWW code form.

5 In Attachment I-5 Table D (Procedures for internationally coordinated non-real-time monitoring)

Amend paragraph 1 Monitoring Periods to read:

The internationally coordinated monitoring of data for global exchange will be carried out ~~once~~ four times a year in October, January, April and July with a view to check periodically the efficiency of the operation of the WWW. Statistics should be compiled ~~by manually operated and automated centres~~ for the periods ~~1–5 October and~~ 1–15 October, 1-15 January, 1-15 April and 1-15 July. ~~In order to facilitate the comparison of results between manually operated and automated centres, automated centres should also provide results for the two periods of 1–5 October and 1–15 October.~~

~~Note: As regards CLIMAT, the monitoring period should be extended to 15 days, even if (for other observations) a return for a period of only five days is made.~~

Amend paragraph 2 (Types of data to be monitored) to read:

The types of data listed in the following table should be monitored:

Types of data	*Abbreviated headings of bulletins* $T_1T_2A_1A_2$	*Reference format for presentation of results (See http://wis.wmo.int/iwm)*
SYNOP reports	SMA_1A_2/$ISMA_2$/$ISNA_2$	A
Parts A and B of TEMP reports	USA_1A_2/UKA_1A_2/$IUKA_2$	B1/B2
Parts A and B of PILOT reports	UPA_1A_2/UGA_1A_2/$IUJA_2$	B1/B2
SHIP reports	SMA_1A_2/$ISSA_2$	C1/C2
Parts A and B of TEMP SHIP reports	USA_1A_2/UKA_1A_2/$IUKA_2$	D1/D2/D3/D4
Parts A and B of PILOT SHIP reports	UPA_1A_2/UGA_1A_2/$IUJA_2$	D5/D6/D7/D8
BUOY reports	SSA_1A_2/$IOBA_2$	E
AIREP reports	UAA_1A_2/$IUAA_2$	F
AMDAR reports	UDA_1A_2/$IUAA_2$/$IUOA_2$	G
BATHY/TESAC/TRACKOB reports	SOA_1A_2/$IOSA_2$	H
CLIMAT reports	CSA_1A_2/$ISCA_2$	I1

(a) Monitoring of SYNOP reports

For each monitored station identified by the WIGOS station identifier and, if it exists, the World Weather Watch station index number (IIiii), the number of SYNOP reports made at ~~the main standard synoptic hour hours (0000, 0600, 1200 and 1800 UTC)~~ and available during the monitoring period within one hour, 2 hours and 6 hours of the standard bulletins times should be ~~inserted in the appropriate columns of Format A~~ recorded in the relevant file defined in http://wis.wmo.int/iwm;

(b) Monitoring of Parts A and B of TEMP and PILOT reports (or ascent to 100mb for reports in Table Driven Code Forms)

For each monitored station identified by the WIGOS station identifier and, if it exists, the World Weather Watch station index number (IIiii), the number of parts A and B of TEMP and PILOT reports (made by tracking a free balloon by electronic or optical means ~~at the main standard synoptic hours (0000, 0600, 1200 and 1800 UTC~~) and available during the monitoring period within 2 hours and 12 hours of the standard bulletin times should be inserted in the ~~appropriate columns of the forms, formats B1 and B2~~ recorded in the relevant file defined in http://wis.wmo.int/iwm;

(c) Monitoring of SHIP reports

The number of bulletins identified by their abbreviated headings (T1T2A1A2ii CCCC) including SHIP reports ~~made at the main synoptic hours (0000, 0600, 1200 and 1800 UTC)~~ and available during the monitoring period within 2 hours and 12 hours of the standard bulletin times with the number of reports included in these bulletins should be recorded in the relevant file defined in http://wis.wmo.int/iwm;

(d) Monitoring of parts A and B of TEMP SHIP and PILOT SHIP reports (or ascent to 100mb for reports in Table Driven Code Forms)

The number of bulletins identified by their abbreviated headings (T1T2A1A2ii CCCC) including parts A and B of TEMP SHIP and PILOT SHIP reports (or ascent to 100mb for reports in Table Driven Code Forms) ~~made at the main synoptic hours (0000, 0600, 1200 and 1800 UTC)~~ and available during the monitoring period within 12 hours and 24 hours of the standard bulletin times with the number of reports included in these bulletins, should be ~~inserted in the appropriate columns of the forms, formats D1 to D8~~ recorded in the relevant file defined in http://wis.wmo.int/iwm;

(e) Monitoring of BUOY, AIREP and AMDAR reports

The number of bulletins identified by their abbreviated headings (T1T2A1A2ii CCCC) including BUOY, AIREP and AMDAR reports compiled between 2100 to 0259 UTC, 0300 to 0859 UTC, 0900 to 1459 UTC and 1500 to 2059 UTC and available during the monitoring period before 0500, 1100, 1700 and 2300 UTC, respectively, as well as the number of reports included in these bulletins, should be ~~inserted in the appropriate columns of the forms, formats E, F and G~~ recorded in the relevant file defined in http://wis.wmo.int/iwm;

(f) Monitoring of BATHY/TESAC/TRACKOB

The time of receipt of bulletins identified by their complete abbreviated headings (T1T2A1A2ii CCCC YYGGgg (BBB)) containing BATHY/TESAC/TRACKOB reports as well as the number of reports included in these bulletins should recorded in the relevant file defined in http://wis.wmo.int/iwm;

(g) Monitoring of CLIMAT reports

For each station monitored and identified by the WIGOS station identifier and, if it exists, the World Weather Watch station index number (IIiii), "I" should be recorded in the relevant file defined in http://wis.wmo.int/iwm.

Amend paragraph 5 (Implementation of monitoring procedures and questionnaires) to read:

5.1 A questionnaire ~~Questionnaires~~ related to the procedures implemented at the centres, ~~suspension of observing programmes at observing stations and suspension of transmission on circuits are~~ is provided in the section "Questionnaire on the implementation of the monitoring procedures" at http://wis.wmo.int/iwm. ~~given in formats J, K and L, respectively.~~

5.2 Monitoring procedures should be implemented at centres in such a way that all replies to the questions included in the questionnaire ~~format J~~ should be positive (reply: 1 ~~Yes~~). ~~Questions 7, 8 and 10 are only applicable to SYNOP, TEMP, PILOT and CLIMAT reports.~~

Amend paragraph 6.1 (Standard format for the statistics) to read:

6.1 With a view to enabling the easy comparison of results of internationally coordinated monitoring carried out by the different centres, the standard formats ~~attached at~~ specified in http://wis.wmo.int/iwm should be used. All centres carrying out monitoring should state clearly the period covered. In each format, centres should present the results region by region as well as for the Antarctic and give totals of the number of bulletins or reports received within the specified time region by region and for the Antarctic.

Delete paragraph current paragraph 6.2 and re-number paragraph 6.3 to 6.2.

Delete the format tables A to L inclusive (pages 34 to 55 of the English edition)

Annex 2 to Recommendation 18 (CBS-16)

AMEND THE *MANUAL ON THE GLOBAL TELECOMMUNICATIONS SYSTEM* (WMO-No. 386), PART I AND ATTACHMENTS I-2 AND I-3

1. Amend Part 1, Section 1, paragraph 1.1 as follows

1.1 Functions

The functions of the Global Telecommunication System (GTS) as a key component within the WMO Information System (WIS) shall be to facilitate the flow of data and processed products to meet the WWW requirements in a timely, reliable and cost-effective way, ensuring that all Members have access to data and products in accordance with approved procedures and within the limits of the agreed WWW system.

Note: It also gives telecommunication support to other programmes as a part of WIS and as decided by the WMO Congress or the Executive Council, within the limits of its primary objectives.

2. Amend Part 1, Section 1, paragraph 1.2.1 as follows

1.2.1 The Global Telecommunication System shall be so organized as to accommodate the volume of meteorological information and its transmission within the required time limits

as the core network of WIS and to meet the needs of World, Regional Specialized and National Meteorological Centres, resulting from the implementation of the WWW.

Insert note after paragraph 1.2.2(c) to read

1.2.2 The GTS shall be organized on a three-level basis, namely:

… (c) The national telecommunication networks.

Note: The components of the MTN connecting the WIS Global Information System Centres is also referred to as the WIS Core Network (See the *Manual on the WMO Information System* WMO-No. 1060)

3. Amend Part 1, Section 3 as follows

3. FUNCTIONS AND CHARACTERISTICS OF THE NETWORKS OF THE GLOBAL TELECOMMUNICATION SYSTEM

3.1 The Main Telecommunication Network (MTN)

3.1.1 The MTN shall be an integrated system of circuits linking together the GISCs on the WIS Core Network ~~WMCs~~ and designated RTHs. ~~The circuits which directly link WMCs and/or RTHs situated on the MTN may, at the request of Members concerned, be designated as circuits of the MTN.~~

Note: The names of these centres, together with a diagram indicating the configuration of the MTN, are given in Attachment I-2.

3.1.2 The MTN shall be designed in such a way that the traffic originating from each centre (WMC, designated RTH) will be routed selectively towards the addressee centre(s). Each centre on the MTN shall ensure selective relay of the traffic which it receives towards the circuit(s) which it serves.

3.1.3 The MTN shall have the function of providing an efficient, reliable communication service between the designated centres, in order to ensure:

(a) Rapid and reliable exchange of observational data required to meet the GDPFS requirements;

(b) Exchange of processed information between the WMCs, including data received from meteorological satellites;

(c) Transmission of processed information produced by the WMCs, to meet the requirements of RSMCs and NMCs;

(d) Transmission of other observational data and processed information required for interregional exchange.

Note: Responsibilities of RTHs, including those ~~centres~~ located on the MTN, for the transmission of observational data and processed information are given in Attachment I-3.

4. Amend Part 1, Attachment I-2 by replacing the existing diagram with the following diagram (Figure 1 WIS RTH routeing) as follows

Attachment I-2. CONFIGURATION OF THE MAIN TELECOMMUNICATION NETWORK

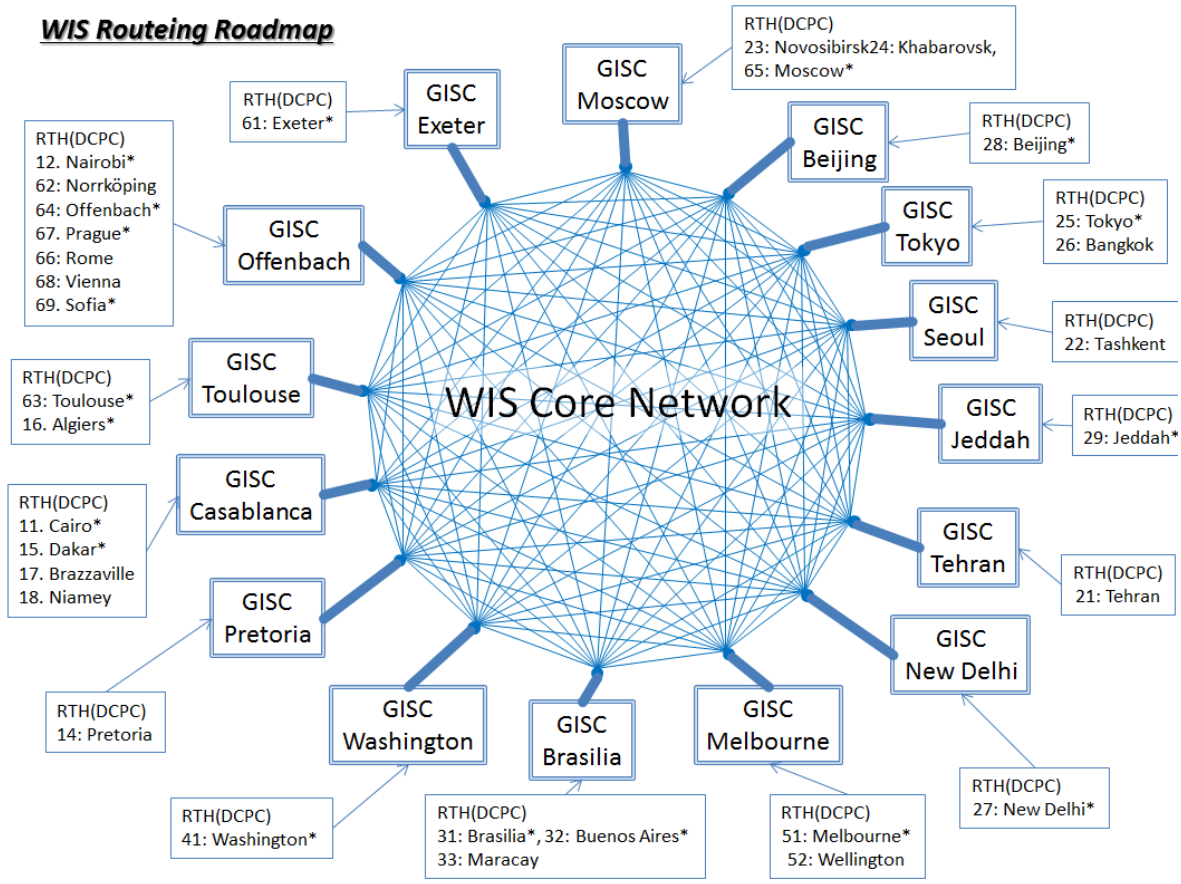


Figure 1 WIS RTH routeing plan

5. Amend Part 1, Attachment I-3 as follows

ATTACHMENT I-3. RESPONSIBILITIES OF REGIONAL TELECOMMUNICATION HUBS ~~CENTRES ON THE MAIN TELECOMMUNICATION NETWORK~~ FOR THE TRANSMISSION OF OBSERVATIONAL DATA AND PROCESSED INFORMATION

1. RESPONSIBILITIES FOR THE COLLECTION, EXCHANGE AND DISTRIBUTION OF OBSERVATIONAL DATA OF ~~WMCs AND~~ RTHs ~~LOCATED ON THE MAIN TELECOMMUNICATION NETWORK~~

~~The responsibilities are~~

[Replace the table under 1. with the following table shown in Figure 2 (RTH - Areas of Responsibility)]

RTH Region	RTH Reference No.	RTH _____ City (Country) (*=RTH/MTN)	RTH's Principal GISC	RTH's Backup GISC	RTH's Area of Responsibility
1	11	Cairo* (Egypt)	Casablanca	Toulouse	Egypt, Sudan, Libya, adjacent sea areas
1	12	Nairobi* (Kenya)	Offenbach	Moscow ___/ Tokyo	Kenya, Ethiopia, Burundi, Djibouti, Uganda, Rwanda, Somalia, La Réunion, United Republic of Tanzania, adjacent ocean areas
1	13	Lusaka (Zambia)	Pretoria	Exeter	Zambia, Zimbabwe, Malawi
1	14	Pretoria __(South Africa)	Pretoria	Exeter	South Africa, Angola, Botswana, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Swaziland, La Réunion, Zimbabwe, and the following centres via La Réunion: Antananarivo, Comoros, Mauritius, Seychelles, Amsterdam island, Kerguelen, adjacent ocean areas
1	15	Dakar* (Senegal)	Casablanca	Toulouse	Senegal, Ascension Island, Cabo Verde, Canary Islands, Cote d'Ivoire, Guinea, Guinea-Bissau, Liberia, Madeira, Mali, Mauritania, Morocco, Nigeria, Sierra Leone, St. Helena, Gambia, adjacent ocean areas
1	16	Algiers* (Algeria)	Toulouse	Exeter	Algeria, Morocco, Lebanon, Tunisia, adjacent sea areas
1	17	Brazzaville (Congo)	Casablanca	Toulouse	Congo, Cameroon, Central African Republic, Gabon, Equatorial Guinea, São Tomé and Príncipe, Democratic Republic of the Congo, adjacent ocean areas
1	18	Niamey (Niger)	Casablanca	Toulouse	Benin, Burkina Faso, Chad, Ghana, Niger, Nigeria, Togo
2	21	Tehran (Islamic Republic of Iran)	Tehran	TBD	Iran (Islamic Republic of), Iraq, Pakistan, Yemen, other territories in the Arabian Peninsula, adjacent sea and ocean areas
2	22	Tashkent (Uzbekistan)	Seoul	Moscow	Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan
2	23	Novosibirsk (Russian Federation)	Moscow	Offenbach / Toulouse	Mongolia, Russian Federation (in Region II)

RTH Region	RTH Reference No.	RTH City (Country) (*=RTH/MTN)	RTH's Principal GISC	RTH's Backup GISC	RTH's Area of Responsibility
2	24	Khabarovsk (Russian Federation)	Moscow	Offenbach / Toulouse	Democratic People's Republic of Korea, Russian Federation (in Region II), adjacent sea and ocean areas
2	25	Tokyo* (Japan)	Tokyo	Beijing / Offenbach / Melbourne	Hong Kong(China), Japan, Macao(China), Republic of Korea, adjacent sea and the Pacific Ocean areas
2	26	Bangkok (Thailand)	Tokyo	Beijing / Offenbach / Melbourne	Cambodia, Lao People's Democratic Republic, Myanmar, Thailand, Viet Nam, adjacent sea and ocean areas
2	27	New Dehli* (india)	New Delhi	TBD	Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, Pakistan, Sri Lanka, adjacent sea and ocean areas
2	28	Beijing* (China)	Beijing	Tokyo	China, Democratic People's Republic of Korea, Viet Nam, adjacent sea and ocean areas
2	29	Jeddah* (Saudi Arabia)	Jeddah	TBD	Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Yemen, other territories in the Arabian Peninsula, adjacent sea and ocean areas
3	31	Brasilia* (Brazil)	Brasilia	Washington / Pretoria	Brazil, Colombia, Ecuador, French Guyana, Guyana, Suriname, Venezuela, ships' and aircraft reports
3	32	Buenos Aires* (Argentina)	Brasilia	Washington / Pretoria	Argentina, Plurinational State of Bolivia, Chile, Paraguay, Peru, Uruguay, ships' and aircraft reports
3	33	Maracay (Venezuela)	Brasilia	Washington / Pretoria	Colombia, Ecuador, French Guyana, Guyana, Suriname, Venezuela, ships' and aircraft reports
4	41	Washington* (United States of America)	Washington	Brasilia	Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, British Caribbean Territories, Canada, Cayman Islands, Colombia, Costa Rica, Cuba, Curaçao and Sint Maarten, Dominica, Dominican Republic, El Salvador, Grenada, Guatemala, Haiti, Honduras, Jamaica, Mexico, Monserrat, Nevis, Nicaragua, Panama, Saint Kitts, Saint Lucia, Trinidad and Tobago, United States of America

RTH Region	RTH Reference No.	RTH City (Country) (*=RTH/MTN)	RTH's Principal GISC	RTH's Backup GISC	RTH's Area of Responsibility
5	51	Melbourne* (Australia)	Melbourne	Tokyo / Seoul	Australia and outlying islands, Brunei Darussalam, Democratic Republic of Timor-Leste, Federated States of Micronesia, Fiji, French Polynesia, Indonesia, Kiribati, Malaysia, New Caledonia, Papua New Guinea, Philippines, Samoa, Singapore, Solomon Islands, Tonga, Tuvalu, Vanuatu, Wallis and Futuna
5	52	Wellington (New Zealand)	Melbourne	Tokyo / Seoul	New Zealand and outlying islands, Cook Islands, Niue, Pitcairn, Tokelau
6	61	Exeter* (United Kingdom of Great Britain and Northern Ireland)	Exeter	Toulouse	Gibraltar, Greenland, Iceland, Ireland, Netherlands, United Kingdom, ocean weather stations (OWS)
6	62	Norrköping (Sweden)	Offenbach	Moscow / Tokyo	Denmark, Estonia, Finland, Latvia, Lithuania, Norway, Sweden
6	63	Toulouse* (France)	Toulouse	Exeter	Belgium, France, Luxembourg, Monaco, Portugal, Spain
6	64	Offenbach* (Germany)	Offenbach	Moscow / Tokyo	Germany, Jordan, Israel, Switzerland
6	65	Moscow* (Russian Federation)	Moscow	Offenbach / Toulouse	Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova, Russian Federation (in Region VI), Ukraine
6	66	Rome (Italy)	Offenbach	Moscow / Tokyo	Greece, Italy, Lebanon, Malta, Turkey
6	67	Prague* (Czechia)	Offenbach	Moscow / Tokyo	Czechia, Poland
6	68	Vienna (Austria)	Offenbach	Moscow / Tokyo	Austria, Croatia, Hungary, Slovakia, Slovenia
6	69	Sofia* (Bulgaria)	Offenbach	Moscow / Tokyo	Albania, Bosnia and Herzegovina, Bulgaria, Cyprus, Montenegro, Romania, Serbia, Syrian Arab Republic, the former Yugoslav Republic of Macedonia

Figure 2 RTH - Areas of Responsibility (* denotes RTH on the MTN)

Annex 3 to Recommendation 18 (CBS-16)

AMEND THE *MANUAL ON THE GLOBAL TELECOMMUNICATIONS SYSTEM* (WMO-No. 386), ATTACHMENT II-15

A) Proposed amendments to Attachment II-15

The following amendments are proposed for the Att.II-15 of the Manual on the GTS :

1. In "Foreword" (p.144):

"Various protocols were used including X.25 in ~~recent years~~ the 80s and the 90s."

"Considerable efforts have been applied in defining the framework for applying TCP/IP to the GTS ~~and for the orderly transition from the Open Systems Interconnection (OSI) X.25-based origin of the GTS~~. Furthermore, ~~it is understood that~~ TCP/IP ~~will be~~ is now the basis for all new telecommunication functions implemented in support of the WMO Information System (WIS)."

2. In "Introduction / Historical perspectives" (p. 144):

"The GTS at present is predominantly used to support the message switching application using message exchange in WMO format. This exchange is done using~~:~~

~~(a)~~ TCP/IP protocols~~;~~

~~(b) Limited OSI transport service based on point-to-point X.25;~~

and is supplemented by broadcasts."

3. In "Introduction / Purpose of this attachment" (p. 145):

"The aim of this attachment is to describe those aspects of the application of TCP/IP that apply specifically to the GTS to meet new requirements and also the long-established routine data exchange undertaken by MSSs. This attachment ~~takes into account the technical evolution of the GTS from an X.25-based network, and~~ maintains the philosophy that Centres continue to be autonomous as far as possible. It is recognized that the timing for implementation of new systems is determined by individual Members in the light of their available resources and relative priorities, but it is also understood that new WIS functionality is expected to be achieved mostly via TCP/IP protocols."

4. In "Evolution of the GTS" (p. 146):

~~"The use of the ISO/ITU standard X.25 was adopted by WMO in the early 1980s to facilitate the exchange of data and products encoded in WMO binary code forms (GRIB, BUFR, etc.) and to act as a base for higher level OSI applications. Although OSI was regarded at the time as the strategic direction for the evolution of data communications, this has changed. Today, there is no doubt that TCP/IP protocols are the most accepted and widespread protocols for the exchange of data"~~

5. In "GTS DATA EXCHANGE METHODS – Introduction" (p. 156):

"~~There are three data exchange methods defined for used on the GTS. The first two are for the exchange of traditional GTS messages. The third is for the exchange of other data.~~

FTP and SFTP are the two data exchange methods that can be used on the GTS.

~~For traditional GTS messages (those with TTAAii CCCC) the two standards are based on:~~

~~(a) TCP/IP sockets~~

~~(b) FTP.~~

Centres are ~~able to choose between these standards~~ encouraged to choose FTP or SFTP by bilateral agreement. SFTP is to be preferred on the Internet

~~Other data may also be exchanged on the GTS using a separate standard based on FTP~~."

6. In "GTS DATA EXCHANGE METHODS" (p. 156-157):

~~TCP sockets based data exchange~~

~~The TCP socket standard involves establishing a connection from the sender to the receiver and for GTS messages to be sent preceded by two control fields. The first field contains the message length and the second is a 2-character field indicating message type (binary, alphanumeric or fax). The third field is the actual GTS message contained within a standard GTS SOH/ETX envelope. The receiving centre uses the message length to determine where each incoming message begins and ends.~~

~~The GTS TCP socket protocol does not guarantee end-to-end delivery and data may be lost if the link or one of the message switching systems fails.~~

~~The complete data structure is illustrated in Figure 6. Note that the message length does not include the length of the first two fields (message length and type). The message length must always be eight characters long and include leading zeroes as required. The message type field should be encoded using ASCII characters BI for binary, AN for alphanumeric and FX for facsimile.~~

~~<FIGURE 6>~~

~~The rules for use of TCP/IP socket exchange can be summarized as follows:~~

~~1. All new connections must start from a new message.~~

~~2. Each message is preceded by a message length field of eight ASCII characters and a message type field of two ASCII characters.~~

~~3. Message length is counted from SOH to ETX inclusive and must contain leading zeroes as necessary.~~

~~4. Message type must be encoded as BI for binary, AN for alphanumeric or FX for facsimile.~~

~~5. Receiving centres will check synchronization as follows:~~
~~• Check that the first 8 characters are ASCII numeric;~~
~~• Check that the 9th and 10th characters are BI, AN or FX;~~
~~• Check that the 11th character is SOH;~~
~~• Check that the last character is ETX.~~

~~6. If synchronization is lost the receiver shall break the connection using the following sequence of TCP user primitives:~~
~~• shutdown (to make sure that all data in the TCP send buffer has been transferred);~~
~~• close.~~

~~7. It is recommended to use separate sockets for ASCII and binary messages, and separate connections for sending and receiving. The sender should always be responsible for establishing the connection.~~

~~8. Once a connection is established, it should be maintained.~~

~~9. If there should be a need to close a socket, the procedure should be as follows:~~
~~• shutdown (to make sure that all data in the TCP send buffer has been transferred);~~
~~• close.~~

~~10. This procedure should also be used when an MSS is being shut down.~~

~~11. If the receiving side receives a new unexpected connection request on a port for which it has an established socket, the old socket should be closed and the new socket accepted.~~

~~12. TCP/IP service/port numbers for these connections will be decided by bilateral agreement. The use of reserved ports (1 to 1023) should be avoided. The use of ports above 10000 is recommended.~~

~~13. To reduce the amount of data lost if an established connection fails, the TCP send and receive buffer sizes can be adjusted. The recommended value for the buffer size is 4KByte, however this value may be agreed on a bilateral basis.~~

~~14. To enable detection of message loss, the use of the channel sequence number (CSN) is mandatory. When using the CSN to check for missing messages, the WMO request/repeat procedures should be used to recover these. It may be useful to automate this mechanism to avoid delays caused by manual interaction. In order to minimize data loss, it is strongly recommended that Centres implement a 5 character long CSN in the future.~~

~~15. The channel sequence number 000 (or 00000 respectively) should indicate an initialization, and should not cause retransmission requests.~~

7. In "GTS DATA EXCHANGE METHODS" (p. 157):

"SFTP/FTP procedures and file naming convention

Introduction

SSH File Transfer Protocol (SFTP) is a secure file transfer protocol based on SSH. There is no official standard RFC. Despite this, SSH (and therefore SFTP) is now widely available and used over the Internet.

File Transfer Protocol (FTP) is a convenient and reliable method for exchanging files, especially large files. The protocol is defined in RFC 959.

The main issues to be considered are:

1. Procedures for accumulating messages into files so as to minimize SFTP/FTP overheads with short messages (applies only to existing message types);

2. File naming conventions for existing message types (existing AHL);

3. General file naming conventions;

4. File renaming;

5 Use of directories;

6. Account names and passwords;

7. SFTP/FTP sessions;

8. Local SFTP/FTP requirements;

9. File compression.

Accumulating messages into files

~~One of the problems with using FTP to send traditional GTS messages is the overhead if each message is sent in a separate file. To overcome this problem, multiple~~ Multiple messages in the standard GTS message envelope ~~should~~ could be placed in the same file according to the rules set out below. This method of accumulating multiple messages applies only to messages for which AHLs have been assigned. ”

8. In “GTS DATA EXCHANGE METHODS” (p. 164-165):

Use of directories

Some receiving centres may wish the files to be placed in specific subdirectories. This should be limited to require only that all files of the same type be delivered to the same directory. It is recommended that a separate directory be used for each host system that is initiating SFTP/FTP sessions to avoid the possibility of filename duplication.

Account names and passwords

Using SFTP/FTP, the sender “logs in” to a remote machine using a specific account name and password. The receiving centre defines the account name and the password. There are potential security implications for centres so care needs to be taken.

The following general rules, however, should apply:

(a) The receiving centre defines the user account and password for the sending centre; (b) Anonymous FTP may be used or a specific account may be created. (If anonymous FTP is used, each sending Centre must have its own subdirectory on the FTP server.)

SFTP sessions can also be authenticated using asymmetric keys. NMHS can choose between user/password or asymmetric keys.

SFTP/FTP sessions

To limit the load on both the sending and receiving systems, no more than one SFTP/FTP session per file type should exist at the same time. If, for example, Centre A wishes to send two files to Centre B of the same type (for example, .ua), the second file must not be sent until the first is finished. Centres should limit the number of concurrent sessions with a particular Centre to five maximum.

The idle timer for closing the SFTP/FTP session should be set to a value between the cut-off time for accumulating messages (maximum 60 seconds) and a maximum of 3 minutes.

To minimize overheads the sending centre should keep the SFTP/FTP session connected for at least 10 minutes or until the idle timeout has been reached (subject to bilateral agreement).

Local SFTP/FTP requirements

All sending centres will need to allow for additional “static” FTP commands to be included in the FTP commands that they issue. For example, some Multiple Virtual Storage centres may require the inclusion of “SITE” commands to define record and block lengths. Centres should support FTP commands as specified in RFC 959 unless some are excluded by bilateral agreement. There may also need to be bilaterally agreed procedures and commands.

It is the responsibility of receiving Centres to delete files after they have been processed.

In order to meet the 2-minute maximum delivery requirement for warning messages, centres receiving files via SFTP/FTP should aim to pick up and process incoming files no later than 15 seconds after they are received.

B) Update of Compression Values table 6, Attachment II-15. Manual on GTS

ET-CTS noted that IPET-DRMM had agreed with the proposed changes and agreed to include the following update in the Manual on GTS Attachment II-15 as follows:

ATTACHMENT II-15 should be amend to accepted new compression values in "Table 6. Accepted compression values" of ATTACHMENT II-15 (p. 162), and "Z" compression shall be tagged to 'deprecated'.

Compression	*Meaning*
Z	DEPRECATED The file has been compressed using the Unix COMPRESS technique
zip	The file has been compressed using the PKWare zip technique
gz	The file has been compressed using the Unix gzip technique
bz2	The file has been compressed using the Unix bzip2 technique
xz	The file has been compressed using the xz technique

C) Update of Table 3. Accepted pflag values

ATTACHMENT II-15 should be updated to include the ability of packing files before transfer (p. 160) include the example and notes as shown below.

Table 3. Accepted pflag values

pflag	*Meaning*
T	The productidentifier field will be decoded as a standard $T_1T_2A_1A_2$ii data designator (The WMO standard data designators are given in Attachment II-5)
A	The productidentifier field will be decoded as a standard Abbreviated Heading, including BBB as appropriate, space characters being discarded,e.g. $T_1T_2A_1A_2$iiCCCCYYGGgg[BBB]
W	WMO Product Identifier
Z	Originating centre's local product identifier
X	Multiple valid GTS files archive, shall be extracted according to the type of the archive.
TM	The productidentifier field will be decoded as a standard T1T2A1A2ii data designator (the WMOstandard data designators are given in Attachment II-5). The file will contain the metadatacorresponding to the related "T" file.
AM	The productidentifier field will be decoded as a standard Abbreviated Heading, including BBB as appropriate, space characters being discarded, e.g. T1T2A1A2iiCCCCYYGGgg[BBB]. The file will contain the metadata corresponding to the related "A" file.
WM	WMO Product Identifier. The file will contain the metadata corresponding to the related "W" file.
ZM	Originating centre's local product identifier. The file will contain the metadata corresponding to the related "Z" file.

Example of file:

X_fr-meteofrance-Toulouse_C_LFPW_20060913030000.tar.xz

This could contain after extraction the following files:

- T_PGBE07_C_KWBC_20020610180000_D241_SIG_WEATHER_250-600_VT_06Z.tif
- W_fr-meteofrance-Toulouse,SYNOP,MAIN+HOURS,,RRA_C_LFPW_20060913030000.txt
- LFPW00000123.b
- LFPW00000124.f
- LFPW00000125.b

[And adding notes:]

a) Use of files archives for FTP exchange is through bilateral agreement of Centres. Any new GISCs should have this functionality from the start of 2018 and any existing GISC's before the end of 2020.

b) For pflag X only compressed archive file format extension is allowed (tar, tar.gz, tar.xz and .zip)

Annex 4 to Recommendation 18 (CBS-16)

AMEND THE *GUIDE TO INFORMATION TECHNOLOGY SECURITY* (WMO-No. 1115)

Make the following amendments be made to the *Guide to Information Technology Security* (WMO-No. 1115)

(See http://wis.wmo.int/file=2479 for authors' full text track changes)

1. Under Revision History include:

2016-April – ET-CTS, document review

2. Under 1. Executive Summary

(Paragraph 1)

The quality of ~~our~~ work, ~~our~~ research and ~~our~~ services ~~for~~ supporting ~~the~~ health and safety of humans depends on the exchange of meteorological and environmental data, and on discussions that occur within the WMO ~~our~~ scientific community.

(Paragraph 3)

However, in parallel to these positive changes in the way our community works, an increasing number of threats are prevalent throughout the ~~whole~~ Internet, and …

(Paragraph 5)

For example, it would potentially only take minutes for a newly purchased computer system to become infected with some form of electronic virus if it was ~~installed on~~ connected to the Internet without …

(Paragraph 8)

… It should ~~help to~~ act as an aid to understanding the basic concepts and principles of ITS, …

(Paragraph 9)

– … approach to all ITS matters

– Building a zoned network architecture that will provide resilience against attempts to ~~illegally penetrate~~ compromise systems, networks and hosts. In this context, a zone is a logical area within a networking environment with a defined level of network security

– Monitoring external connections in order to detect any abnormal access or activity

– Regularly applying security patches to critical systems as they become available

– Ensuring that access control mechanisms are in place, commensurate with the system being protected, and ~~M~~managing them with diligence. ~~care the user access codes and passwords~~

– reinforcing best security and cultural practices across Organisations through continual security education

The complete list as defined in the International Standards Organization (ISO) / International Electrotechnical Commission (IEC) information security standard can be found at http://en.wikipedia.org/wiki/ISO/IEC_27002. ~~Another helpful reference is http://www.itgovernance.co.uk/bs7799.aspx.~~

3. Under 2. Definition of Information Technology Security

The purpose of Information Technology Security (ITS) is to help an organization fulfil its mission by protecting its IT resources, which also include observation systems, and through that, its assets. ~~These assets must be properly identified so that adequate security requirements can be defined.~~

Adequate security requirements can be defined using the following steps:

1. Identifying the assets

2. Identifying the proper security criteria with, for each criterion, a proper scale (cf. §2.3)

3. Identifying the assets' security needs, according to the defined criteria

4. conducting a risk analysis (some risks described in § 2.2)

5. Identifying the security techniques and procedures to consider (cf. §2.4)

Additional information regarding the information security standard can be found at http://en.wikipedia.org/wiki/ISO/IEC_27002, and http://en.wikipedia.org/wiki/ISO/IEC_27001 and in section five of this document.

The next four sections briefly mention some of the tasks necessary ~~tasks~~ to implement ITS…

4. Under 2.1 Protecting systems against potential failures

All Information Technology (IT) resources play a part, which must be correctly understood, in permitting an organization to deliver services according to its mission. Any failure in these IT resources can then affect the capability to deliver these services.

Moreover, ~~most~~ some organizations have dedicated links with partners. By default, these partner links should be considered similarly to ~~as unsecure as~~ any other public link (such as a ~~the~~ connection to the Internet). They could be used to propagate security threats ~~incidents between organizations. In the best case scenario, these could damage reputation, and, in the worst-case scenario, generate legal proceedings~~.

Thus, ITS is concerned …

5. Under 2.2 Malicious versus non-malicious

… For example, malicious activities can include fraud and theft, internal or external hackers, malicious codes such as viruses or spyware, espionage, etc. …

6. Under 2.4 Security techniques and procedures to consider

Once an organization has properly identified its ITS requirements, ~~prevention measures are set up to prevent or restrict an error, omission or unauthorized intrusion~~ measures are implemented to technically and procedurally deliver against them.

Monitoring and reporting should give the organization some ~~proper~~ visibility of its information system. ~~They~~ It must be defined so that a security incident can be ~~quickly~~ detected, ~~and~~ its origin ~~properly~~ identified, and for this to act as an enabler to a complementary process that would limit the threat boundary (such that it is prevented from doing further damage to connected systems/data).

Predefined ~~I~~incident handling and disaster recovery procedures are helpful in minimizing ~~essential to minimize~~ the impact of an ITS-linked ~~incident~~ event within an organization, by reacting quickly and in a proper manner to the incident, and by being able to recover the essential elements impacted ~~by the incident~~.

Once the incident is over, it ~~must~~ should be analysed so ~~that prevention measures can be reviewed~~ potential lessons can be learned ~~if necessary~~.

7. Under 3.1 Reasons for threats

~~The motivations~~ Motives can be deliberate or accidental.

8. Under 3.1.3 Playful or exploration to 3.2.3 Malicious hacking

Another kind of motivation is curiosity, boredom, game or challenge. Many famous governmental institutions have been impacted ~~hit~~ by such ~~motivated~~ attacks, degrading their reputation.

3.1.4 Accident

The last category is human or physical accident or oversight. It can take many forms and touch any part of the information system (network, hardware, ~~and~~ software, procedural), and can be ~~prevented~~ mitigated by adequate ~~disaster recovery~~ procedures and training, such as implementing system redundancy and automatic failover procedures, being aware of public visibility, or delivering regular training.

9. Under 3.2 Common threats

3.2 Common threats

A very resourceful link for this topic is https://www.sans.org/critical-security-controls ~~http://www.sans.org/top-cyber-security-risks/~~.

3.2.1 Malicious codes: viruses, ransomware, worms and Trojans ~~horses~~

A virus is a destructive computer program that spreads from computer to computer using a range of methods, including infecting portable storage (e.g. USB), infected web pages ~~floppy disks~~ and other programs. Viruses ~~typically~~ often attach themselves to a program and modify it so that the virus code runs when the program is first started. The infected program typically appears to run~~s~~ normally, but the virus code then infects other programs whenever it can.

A worm is a special type of virus that does not attach itself to programs, but rather spreads via other methods such as e-mail.

A Trojan~~horse~~ (or backdoor) is a program that performs the desired task, but also includes unexpected functions, such as allowing remote connection to the infected computer or sending information.

All these codes have the potential to disrupt services, destroy information, use resources for their own good, or any other function that the originator of the code may wish to implement.

3.2.2 Denial of service

A denial-of-service attack is characterized by an attempt to prevent legitimate users of a service from using that service. These attacks can be deliberate or accidental, such as abusive use of storage, network and supercomputing resources. They can also be from distributed (and therefore difficult to block) sources, using networks of compromised hosts called a "botnet".

10. Under 3.3.1 Hacking systems …

All these components, if not kept up to date regarding security holes, or if not properly configured, can easily be used by a threat agent (human, such as malicious hackers, or non-human, such as viruses) to compromise the system. If the security hole is not known to the vendor it is known as a zero-day vulnerability. Patches should be applied when they become available.

Specific tools exist, used by security staff as well as malicious hackers, to identify both security holes and configuration weaknesses of a system.

11. Under 3.3.4 Spying …

One of the most dangerous forms of spying is a class of software called keyloggers. Once installed on a computer, these systems can collect every keystroke, mouse movement and screen update on a computer, thus allowing a hacker to obtain all privileged information before it is encrypted or after it is decoded. Keyloggers can also be of the hardware variety, often placed in-line on USB ports, and can use their own wireless connectivity to report what they gather back to an off-site system.

3.3.5 Root or Domain Controller access

Hackers try to get access to the most privileged user or account in order to gain control of the entire network. Avoid keeping the passwords hard coded in the software or saved in flat files or in spreadsheets.

3.3.6 Wireless LAN Networks

Wifi has become an accepted method of connection of mobile devices. Mobile devices connect to a wifi access point to access IP services. These services can be replicated by "imposter" systems to look like official wifi services, but can act very differently. For example, when they are used to access the Internet they can locally show a Web page to be secure when accessed, but the secure access is only to the "imposter" device, not the end website. Users information

including their passwords and keys can then be captured in the open, and used to steal personal information and access services.

Users are less likely to be vulnerable if they are accessing internet services through a VPN tunnel to their home organization. The use of split tunnelling (where Internet services are accessed locally) increases the risk and is not recommended for Corporate use.

It is possible for official organizations wifi to detect and suppress these "imposter" access points, but this is unlikely where you do not control the environment. In a public space be vigilant for wifi services which have multiple similar names, or if in doubt, ask someone in charge which service to use.

12. Under 4 Impacts of Threats and Security Events

Although it can be difficult to predict exactly what the impacts can be, the following are key potential impacts, which can be used to prepare security plans and contingency plans. Understanding the potential impacts is also important in justifying the funding for security measures, as the cost of repair, loss of business, loss of reputation and even loss of life often far exceed the cost of ~~defence~~ mitigation measures.

It should also be noted that although some events may seem to be low impact at first, they could be of major importance to an organization at a later date, since many events are just part of a set-up process for later events. In addition, because all organizations will be interconnected, these types of events can be set-ups for attacks in other organizations. In this respect, it is important to note our responsibility to the community of interconnected ~~machines~~ systems.

… 4.1 System and service impacts …

(c) *System or component of system or data destroyed:* The events cause not only the systems and services not to be available for a period of time, but cause the destruction of resources. Typically, this can be the destruction of data on ~~hard disk drives~~ storage media, or stored in the database. Some viruses have been demonstrated to harm hardware by putting it in states that it was not designed to be in ~~used for~~. These problems waste much time, but also require system components to be either replaced or reinitialized. There is often an important cost associated with these repairs.

(e) *System used to compromise others:* The events would compromise an organization's systems in a way that is not detected, and may be left unused for a long time. However, these components can be used to compromise other systems. Although the impact on a given organization may seem negligible, harm to other organizations is possible. Furthermore, hackers often use such techniques to hide themselves behind several layers of obscurity as a ~~of apparently unnecessary hops~~ disguise. These layers render troubleshooting very difficult and provide much hiding space for illicit components. An organization could be falsely accused of being the source of trouble because of this technique.

4.2 Administrative, legal and reputation impacts

In addition to the obvious system and service impacts, all security events can also cause administrative, legal and reputation impacts. By being connected to the Internet, all organizations need to act as good corporate citizens. They must mitigate the problems of security and ensure they are not the cause of problems to others. Failure to do so may eventually lead to legal action. It is also obvious that bad information and poor service will certainly have administrative impacts, as well as the loss of reputation ~~impacts~~. This is particularly important in the weather business, where state agencies have an important responsibility for the health and safety of their citizens.

The perception that a member in the GTS community may be compromised can lead to a series of restrictions or concerns that this may be a threat to connected agencies. Members

may isolate one another until further information on the issue is sought. This can take some time as this may involve the national intelligence counterparts. During this period the exchange of critical meteorological information across the world may be disrupted reducing the quality of the services offered.

13. Under 5 Information technology security processes

5 INFORMATION TECHNOLOGY SECURITY PROCESS~~ES~~

The ISO 27000 family of standards helps organizations to keep their information assets secure. ISO/IEC 27001 is the best known standard in the family providing requirements for an information security management system.

These request are described below in more detail.

5.1 …

Security criteria that are important for the organization must then be defined, so that each asset's security needs can be expressed regarding these criteria. The most common ones are availability, integrity and confidentiality.

14. Under 6 Information Technology Security Best Practices

6.1 IT ~~Network and~~ system security

IT system security in this context includes application, operating system, data, and network security. The following paragraphs refer to network and operating system security only. Application and data security will be addressed by an update of this document.

…

Integrity

System integrity is assured through network and system protection, host-based or network-based intrusion detection/prevention systems and an appropriate backup/restore strategy. Data integrity can be assured through cryptographic measures such as hash and signing algorithms.

Confidentiality

Confidentiality is achieved through organization, ~~network, and~~ system~~, protection~~ and cryptographic protection measures.

Accountability

Accountability is achieved through logging of system access and authorization wherever possible.

A key measure for all three security criteria is network and system protection. A key technology for network protection is using firewall systems. The most common use ~~application~~ for firewall systems is a central firewall between the internal network and the Internet based on a proper zoned design. However, depending on the complexity of the internal network, distributed firewall systems should be put in place to protect sensitive internal network zones and systems, for example, databases and servers running critical services, from more dangerous parts, for example, network zones connecting user personal computers (PCs) and workstations (see section 6.2). Network protection can also be improved by introducing an intrusion detection/prevention system (IDS/IPS) to monitor the network traffic at certain points and to detect unwanted or suspicious traffic according to the security policy (section 6.5).

System protection is more complex. The following measures have to be taken:

(a) *Access control:* Make sure that only authorized personnel have both physical and electronic access to a system. In addition, authentication has to be ~~as strong as possible~~ of appropriate strength (appropriate password policy, certificate- or token-based authentication). Finally, logging is important to trace user activity, especially on mission critical systems. Hence, group-based accounts should be avoided wherever possible (where a single account is used and the password shared between users).

(b) *Minimize services:* Disable all services and processes that are not necessary for system operation and service offerings. ~~Run only one single service on critical systems such as Domain Name System (DNS) servers, web servers, etc. Do not combine multiple services whenever possible.~~

...

(e) *Diversification and redundancy:* Make mission critical services, such as DNS servers, customer-related web and File Transfer Protocol (ftp) servers, database servers, e-mail relays, etc., redundant. Make sure that these redundant servers and gateways are physically separated to protect the overall system from fire, flooding, etc.

6.2 …

Virtual networks can be set up on top of physical networks or other virtual networks. There are numerous types of virtual networks. The most popular are:

– VLANs: Virtual LANs are used to segment a LAN-based Intranet into different network zones; a VLAN is built on top of a LAN and is based upon Ethernet packet tagging according to the Institute of Electrical and Electronics Engineers (IEEE) standard 802.1q.

– VPLS: Virtual Private LAN Service is a way to provide Ethernet-based multipoint to multipoint communication over IP or MPLS networks.

…

~~Be careful~~ Care should be taken with encrypted virtual networks such as IPSec-based VPNs that are set up in tunnel mode versus VPNs in transport mode, which make use of data signing only. Because data are encrypted, virus scanners, intrusion detection/prevention systems and other centralized security measures may ~~do~~ not work. …

6.2.1 …

… while a PC is always at risk of Internet worms, Trojan horses and other malicious software.

The host (or PC) in the internal network must strictly follow the security policy of the corresponding network zone, and invalid external connection detection software should be installed in the host which could access the critical IT resource. The LAN segments that connected most critical IT resource or the sensitive data should be physically isolated by the local law.

To protect the disjunctive network segments from each other, they should be interconnected through appropriate ~~firewall~~ separation systems.

The security of an Ethernet LAN or LAN segment can be increased by using ISO/OSI (Open Systems Interconnection) layer 2 switching technology instead of broadcast media, so that traffic from a host A to another host B cannot be sniffed by a third-party host C. However, layer 2 switching cannot avert the so-called Address Resolution Protocol (ARP) spoofing. Additional security measures, such as Port Based Network Access Control in conjunction with the use of host certificates, either based on registered hardware addresses or as defined in

IEEE standard 802.1x have to be taken into consideration to protect LANs from such attacks. Port-based access control makes sure that hosts which have not been registered cannot be connected to the network.

~~6.2.2 Wide Area Networks~~

~~A WAN interconnects a number of local networks that can be LANs or other WANs, for example, Metropolitan Area Networks. In this context, a VPN can also be seen as a WAN.~~

~~Typically, WANs are public or semi private networks that are used by different companies, public offices or even private people. Furthermore, a WAN has to carry multiple protocols mostly making it impossible to apply certain filters that comply with the demands of all users.~~

~~Therefore, WAN security can mostly be considered low. Measures have to be taken to protect a private Intranet against public WANs. These measures are referred to as firewalls or firewall systems.~~

6.2.~~3~~2 Wireless Local Area Networks

Securing Wireless LANs (WLANs) ~~are very critical with~~ is critical in regards to availability, integrity and confidentiality:

– *Availability:* …

– *Integrity and confidentiality:* Cryptographic measures have to be taken to guarantee data integrity and data confidentiality, if required. In particular, authentication data such as user names, passwords and token codes have to be encrypted to avert scanning and spoofing. One such method could be using IEEE 802.1x.

The following measures have to be taken to protect WLANs and other network zones that are connected to WLANs:

– *WLAN footprint:* Make the reception area of a WLAN (footprint) ~~as small as possible~~ match only the area of intended coverage. Make sure that WLAN radio cannot be received outside desired borders. Use a WLAN radio scanner to verify.

– *Radio shielding:* ...

– *Encryption:* Use encryption on WLANs. Choose the best available encryption algorithm and change the default settings before activating WLANs. ~~Do not rely on standard encryption (Wireless Application Protocol (WAP), IEEE 802.11i) for mission critical WLANs.~~ For user authentication and data encryption, …

– …

– *Intrusion detection:* If necessary, install an IDS/IPS for additional security. Note that an IDS/IPS does not work well for encrypted network zones. However, the IDS/IPS can monitor communication relations and can generate alarms in case of illegal activity up to ISO/OSI layer 4, for example, port scans.

– *Protecting access:* Mechanism to protect the Wireless Network to unauthorized access must be used. This includes, for example, 802.1x or WPA2.

6.2.~~4~~3 Firewall systems

Firewalls can be divided into two major groups:

– Packet filters

– Application Layer and rule based (also known Next Generation firewalls) Gateways

Packet filters control network traffic …

…

While a firewall always reassembles incoming IP packets to prevent attacks caused by fragmentation, access lists on routers do not reassemble fragmented packets. Therefore, access lists cannot always be considered as a substitute for a firewall.~~.~~

6.3 Remote access

Remote access to network resources is one of the most critical applications with regards to network security. Remote-access systems can be:

– Plain Old Telephone Systems, Public Switched Telephone Networks or Integrated Service Data Networks dial-in servers

– Secured Internet access (IPSec- or SSL-based VPN gateways)

~~– Wireless access servers (for example, Bluetooth)~~

There are four items that have to be taken into consideration when designing and operating remote access:

(a) *Network architecture:* …

(b) *User authentication:* In particular, for remote-access systems, proper user authentication is essential for overall network security. Strong authentication mechanisms such as certificate- or token-based or multi-factor methods are preferred over weak, password-based methods.

(c) *User authorization:* Make sure that even authenticated users will not obtain access to all systems. Authorization rules have to be in place to limit access to systems that the user is authorized for. For easy maintenance, authorization should be based on groups rather than on per-user rights. A user may be a member of several groups, granting the individual all the rights of each group. The host, that is being by an authorized user to get access to an internal system, should meet the security requirement.

(d) *Logging and accounting:* …

6.4 Server access and security

…

– The servers are well patched against all known security holes. Make sure that the latest patches have been applied. ~~Verify the p~~ Patches should be ~~before~~ verified in accordance with change and configuration management processes prior to being installed~~ing~~ ~~them~~ (especially on mission critical systems).~~.~~

In addition to authorization mechanisms, …

… Systems that serve anonymous users should be separated from pre-authorized systems that store confidential data. They should be located in separate firewall zones. Never operate both anonymous and pre-authorized services on one single machine.~~.~~

…

6.4.1 File system authorization rules

Both anonymous and pre-authorized systems require strict authorization rules. By default, only read access should be allowed. Write access should only be allowed when required. Systems with write access should have dedicated directories to store the data and to scan for viruses and malicious code before making them available to internal resources or users.

~~Finally, make sure that directory and file visibility rules are in place. Hide as much information as possible and only make information visible to the remote user required to successfully use the service offered. This also comprises directory and file access rules. Make sure that private files and directories cannot be accessed through fraudulent user behaviour such as directory traversal attacks.~~

Sometimes, it might be required to only accept signed data to verify data integrity. Unsigned data …

6.5.2 Developing a policy

…

Finally, policies should be approved and signed by an appropriate ~~a high~~ authority in the organization. Again, since security is the matter of several (if not all) components of an organization, only ~~a high~~ such an authority will ensure consistency in approach and in implementation.

…

6.8.2 New system installation and change management

All new systems or new system components should be introduced in the production environment through a predefined installation procedure. This procedure should include at least the following steps:

– Suppress all the accounts that do not have passwords

– Back up all configuration files

– Ensure software is up to date according to the organizations configuration and version control processes, and keep a list of components and version numbers

– Suppress network services that are not necessary

– Configure and install a logging system for all important system activities

~~– Use shadow passwords and limit validity of passwords~~

All changes should be tracked to control the system components and be capable of tracing unwanted changes.

6.8.3 Installation of security patches

Follow the security advisories from the Computer Emergency Response Team (CERT) (for example, http://www.us-cert.gov, http://www.dfn-cert.de, https://www.cert.be or http://www.cert.ssi.gouv.fr) and install patches as soon as they are available.

6.8.4 User account management

– All accounts must belong to a specific user.

– Each user should read and understand the organization’s security policy.

– End-users' ~~User~~ accounts that are unused for a period of time (3 months) should be deactivated.

~~– Password crackers should be run on a regular basis to identify easily cracked passwords and notify the users to change these passwords to more difficult ones. However, be aware to pay attention to possible legal issues! Best practise is to inform the users about regular password checks and let them individually sign a declaration of agreement, for example, in terms of a common IT user policy before running any password cracking tools.~~

– A password policy should be defined, which outlines the requirements for password complexity, strength, and duration; this policy should be known by all users.~~Passwords must be changed on a regular basis (at least every 3 months).~~

– Remote-access users should use one-time password systems to eliminate the possibility of password capture by illicit users.

~~– Users should be informed of what constitutes a good password.~~

6.8.5 Backup/restore procedures and regular testing …

6.8.6 Detection procedures

Several detection procedures can be put in place to monitor system activity and possible illicit or unwanted activity. These procedures should be 24/7 and can include intrusion detection and prevention, abnormal system activity detection, vulnerability scanning, loss of system or loss of data procedures.

6.8.6.1 Protection from ~~viruses~~ malicious code

Real-time anti-virus systems should be installed and applied ~~on all operational computer equipment~~ where appropriate. Whole-of-server scans should be run on a daily basis. Anti-virus software should be configured in real-time mode to ensure any infections are identified and cleaned immediately upon detection.

A separate server or computer should be configured to sit inside the organization's firewall in real-time mode. This server should be configured with appropriate software to check for ~~viruses~~ malicious code. If ~~a virus~~ such code is detected and all incoming and outgoing e-mail attachments can be cleaned, then the message can be distributed. If attachments cannot be cleaned, then the message should be blocked.

~~Anti-virus software should be regularly updated with new definition files. Anti-virus software should be regularly reviewed. It may be necessary to use more than one type of scanning software to ensure that maximum protection is provided for all information platforms and environments. Organizations should ensure that virus protection and recovery strategies are included in risk management and business continuity plans.~~

Typical controls to protect against malicious use technology, policies and procedures, and training, applied in a layered manner from perimeters inwards to hosts and data. They should be applied at the host, network, and user level.

6.8.6.2 User education

…

6.8.8 Security information and event management

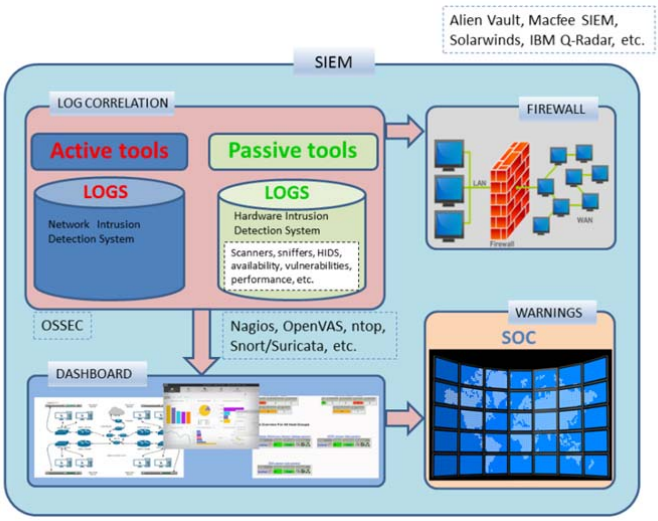
It is recommended to implement a solution capable to monitor, evaluate and correlate events related to security issues. This type of solution, known as SIEM - Security Information and Event Management, is a software-based solution, which combines events and alerts, provides

by network agents in real-time mode. It behaves as a "land mine" in front of your system and helps you visualize or pay attention on what is going on and take actions in advance.

A SIEM solution allows events generated by various security applications (such as firewalls, proxies, intrusion prevention systems and antivirus) to be collected, normalized, stored and correlated in order to enable a rapid identification and response to incidents. A standard SIEM tool would include the following topics:

- Combine the features offered in both technologies SIM (Security Information Management) and SEM (Security Event Management). Real-time access, centralized and consistent to all logs and security events, regardless of the technology and manufacturer;
- Correlation of heterogeneous technologies logs, connecting common or significant attributes between sources, in order to transform the data into useful information;
- Identification of behaviours, incidents, fraud, anomalies and baseline breaks;
- Alerts and notifications triggered automatically in the event of non-compliance with security policies, regulatory standards or according to pre-established business rules;
- Sophisticated reporting on environmental safety conditions for SOC (Security Operations Centre) teams auditing and incident response;
- Retention and indexing long-term data allowing subsequent forensic analysis;
- Auditing event log related information.

The concept of a SIEM system can represented as indicated in the picture:



6.9 Public server configuration

…

It is very important to minimize risks by securing such servers. Here are a few good practices:

(a) Architecture: Install the server in a ~~DMZ~~ dedicated zone, for example, a semi-private network that is visible through the network's firewalls, but that is not part of the private networks of an organization;

(b) Filtering:

(i) Protect the server from network access by a firewall filtering all network ~~fluxes~~ flows, but the port used by the service to access the server;

(ii) …

(c) Bandwidth: A bandwidth management tool should be used to avoid excessive use of bandwidth by a single user (or group of users);

(d) System/application:

(i) The server should process as few types of data as possible (for example, do not combine multiple server applications on the same virtual or physical system);

(ii) The server should be stripped of all unnecessary services and applications, see also section 6.1 for system security;

(iii) …

Annex 5 to Recommendation 18 (CBS-16)

AMEND THE *GUIDE TO VIRTUAL PRIVATE NETWORKS (VPN) VIA THE INTERNET BETWEEN GTS CENTRES* (WMO-No. 1116) (AVAILABLE IN ENGLISH ONLY)

Make the following amendments to the *Guide to Information Technology Security* (WMO-No. 1115) and the *Guide to Virtual Private Networks (VPN) via the Internet between GTS centres* (WMO-No. 1116)

(See http://wis.wmo.int/file=2481 for authors' full text track changes)

1. Under 2.2 Types of virtual private networks

(i) Asynchronous Transfer Mode (ATM) and Frame Relay connection;

(ii) Multiprotocol Label Switching;

(iii) Virtual Private LAN Service;

(iv) Link-Layer Encryption (Layer 2 Tunnelling Protocol (L2TP) or Point-to-Point Tunnelling Protocol (PPTP));

2. Under 2.2.1.1 Asynchronous Transfer Mode and Frame Relay

Following the definition of VPN given in chapter 1, early data network, such as ATM and Frame Relay solutions, must be considered as VPNs. ~~By construction, a Frame Relay (and ATM) network, such as the Regional Meteorological Data Communications Network (RMDCN), is a VPN. The provider Orange Business Services (OBS) has a network that is securely divided among all customers. Therefore, on a global telecommunication system, multiple isolated sub-networks coexist.~~ In this case, the VPNs rely on the operator.

3. Under 2.2.1.2 Multiprotocol Label Switching

This solution is now widely offered by operators.

Virtual Private LAN Service

VPLS is a way to provide Ethernet-based multipoint-to-multipoint communication over IP or MPLS networks. It allows geographically dispersed sites to share an Ethernet broadcast domain by connecting sites through pseudo-wires, and VPLS allows any-to-any (multipoint) connectivity.

4. Netscape created the protocol SSL. In the TCP/IP layering model it is on top of the TCP layer. Therefore, it could be used for adding security (strong authentication and encryption) for all TCP-based application (telnet, File Transfer Protocol (FTP), etc.). SSL is no longer recommended for use, all SSL versions are deprecated by now. The recommended protocol is now TLS. Companies use this technology to provide secure remote access to their internal infrastructure by using SSL/TLS VPNs with additional strong authentication, Under 2.2.2.1 Secure Socket Layer and Transport Layer Security

4. Under 3.1 Internet Protocol Security architecture

From RFC 2401 (~~now~~ replaced by RFC 4301; Kent and Seo, 2005; RFC 4301 partly replaced by RFC 6040, Briscoe, 2010 and RFC 7619, Smyslov and Wouters, 2015):

5. Under 4.2.1 Physical layers

– Frame Relay lines: The leased line is replaced by a connection to a Frame Relay network, but only two peers share the same Frame Relay network

– An MPLS network such as the RMDCN (as WIS core network) ~~in Region VI~~ is such a network

– Connections using the Internet

– Satellite communication channels

…

With the growth of products and data, and with the ~~upcoming Weather~~ WMO Information System (WIS) network, National Centres (NCs), Data Collection or Production Centres (DCPCs) and Global Information System Centres (GISCs) will want to exchange much more information. …

Recommendation 19 (CBS-16)

REVISED *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485)

THE COMMISSION FOR BASIC SYSTEMS,

Considering the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

Recalling:

(1) Resolution 6 (Cg-XVI) – Revised *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

(2) Resolution 12 (Cg-17) – Report of the extraordinary session (2014) of the Commission for Basic Systems concerning the introduction of the new *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

Recalling further that the Seventeenth World Meteorological Congress affirmed the authority of the Executive Council to adopt the revised *Manual on the Global Data-processing and Forecasting System* as it would be completed before the Eighteenth Congress and would not compromise the operation and development of the Global Data-processing and Forecasting System (GDPFS),

Acknowledging the progress and productive work of the Commission for Basic Systems (CBS) experts, as well as the collaboration and coordination with relevant WMO technical commissions and programmes, and other international organizations, in relation to the revision of the *Manual on the Global Data-processing and Forecasting System*,

Acknowledging further that many WMO Members provided comments to the draft version of the revised Manual during the review process, and that these comments have been incorporated into the current version,

Decides to follow:

(1) The procedure for the incorporation of new types of GDPFS centres, including the list of mandatory products to be made available in the context of the GDPFS, as described in the Introduction to the revised Manual;

(2) The designation process of GDPFS centres, as described in Part I, section 1.2.6, of the revised Manual;

Urges Members hosting World Meteorological Centres (WMCs) and Regional Specialized Meteorological Centres (RSMCs) to create web pages describing the characteristics of the systems as identified in the revised *Manual on the Global Data-processing and Forecasting System*, so that they can be incorporated in Part III of the Manual;

Recommends to the Executive Council the adoption of the revised *Manual on the Global Data-processing and Forecasting System*, as provided in the annex to the present recommendation, to take effect as per Resolution 12 (Cg-17) and Regulation 127 of the General Regulations (2015 edition);

Authorizes the president of CBS, in consultation with the Secretariat, to make any consequential purely editorial amendments with respect to the *Manual on the Global Data-processing and Forecasting System*.

Annex to Recommendation 19 (CBS-16)

REVISED *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485)

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PART III. GDPFS IMPLEMENTATION

INTRODUCTION

General

1. The *Manual on the Global Data-processing and Forecasting System* (GDPFS) is the single source of technical regulations for all operational data-processing and forecasting systems of WMO Members designated meteorological centres.

2. The advances in Numerical Weather Prediction (NWP) since the previous full edition of this *Manual* in 1992 have been tremendous: higher accuracy, higher resolution, longer lead-time, and a wider range of relevant applications. Consequently the emphasis in operational meteorology, hydrology and climatology has shifted towards the implementation of increasingly sophisticated and diverse numerical models and applications, for an ever-increasing variety of users.

3. The Global Data-processing and Forecasting System (GDPFS) enables Members to make use of these advances by providing a framework for the sharing of data related to operational meteorology, hydrology, and climatology.

4. The main support for the exchange and delivery of these data – that is, GDPFS products – is the WMO Information System (WIS). One of the key features of the WIS compared to the previous GTS is the expansion of the range of centres that can connect to the system; this in turn supports growth in the range of GDPFS applications.

5. A large number of amendments to the *Manual on the GDPFS* have been adopted by Members over the past 20 years since the previous edition, and the pace at which new changes will be required in the coming years is not likely to slow down. Therefore, the World Meteorological Congress requested that this edition should be flexible enough to allow an easy incorporation of technical and organizational aspects that may arise from the development of new application areas, e.g. in relation to the GFCS.

6. In addition, noting that there are fundamental changes underway in the Basic Systems, Congress requested that this edition of the *Manual* should take account of the existing structure of the GDPFS and of its likely future evolution, such as the inclusion of all WMO operated meteorological centres that provide operational data-processing and forecasting services (including those coordinated by CBS and joint CBS-other technical commissions and/or WMO Programmes, as well as joint WMO-other international organizations centres).

7. It should be noted that this edition has been developed in accordance with quality management principles, which will ensure its sustainability as part of the WMO Quality Management Framework.

How to read this *Manual*

8. The *Manual* consists of three Parts, as follows:

(a) Part I. Outline of the WMO GDPFS – it presents the overall purpose of the GDPFS, its organization and the general characteristics of the various activities to be performed;

(b) Part II. Specification of GDPFS activities – it gives detailed information on the various activities: mandatory functions including production, verification and documentation, and additional recommended functions and products. It also specifies overall requirements applicable to all types of activities, regarding dissemination, verification, training, etc.;

(c) Part III. GDPFS implementation – it presents the status of implementation of the GDPFS from the user's point of view: table of performed activities with indication of the participating centres, as well as from the producer's point of view: table of GDPFS centres with indication of the performed activities.

9. The reader seeking general information on the GDPFS and its applications should refer to Part I, whereas Parts II and III provide detailed information on the various components of the system, available products and information, status of implementation, as well as compliance criteria.

10. The *Manual* is designed so that it can be modified as frequently as necessary to keep it up-to-date. While Part I should be rather stable and seldom require updating, it is expected that the evolution of science, technique, and user requirements, will continue to induce developments requiring frequent changes to Parts II and III.

11. In line with quality management requirements, the bodies in charge of managing the information contained in the *Manual* are explicitly specified for every type of GDPFS activity. This is done in Part II, item 2.2, through Tables under "Note" labelled "Responsibility" (cf. example hereafter), where:

(a) The three lines under "Changes to activity specification" indicate the team(s) and bodies in charge of preparing specification updates, approving them, and deciding to update the *Manual* accordingly;

(b) The two lines under "Centres designation" indicate the bodies responsible for approving the designation of a GDPFS centre for the activity under consideration and for deciding accordingly;

(c) The two lines under "Compliance" indicate the team(s) and bodies in charge of ensuring that the designated GDPFS centres remain compliant with the activity specification.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OWFPS		
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	CBS		
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-OWFPS		
To be reported to:	CBS/ICT-DPFS	CBS	

12. The following procedure is applied for the incorporation of new types of GDPFS centres into this *Manual*:

(1) Relevant technical commission or programme expert team to develop the criteria/functions for new type of centres, including the list of mandatory products to be made available in the context of the GDPFS;

(2) The criteria/functions for new type of centres to be endorsed by the relevant technical commission management group or programme steering committee, and submitted to CBS through its president;

(3) The president of the commission responsible for maintaining this Manual decides on an expert team of that commission to be responsible for reviewing the proposal and applies the standard procedure for amendments as defined in the General Provisions.

PART I. OUTLINE OF THE WMO GLOBAL DATA PROCESSING AND FORECASTING SYSTEM (GDPFS)

1.1 PURPOSE AND SUPPORTED ACTIVITIES

1.1.1 General description

1.1.1.1 The GDPFS shall be the world-wide network of operational centres operated by WMO Members. Its purpose shall be to make operationally available among WMO Members and relevant operational organizations, defined products and services for applications related to weather, climate, water and environment.

1.1.1.2 The GDPFS shall enable scientific and technological advances made in meteorology and related fields to be accessible and exploitable by WMO Members.

1.1.1.3 The activities, organizational structure and operations of the GDPFS shall be systematically designed in accordance with Members' needs and their ability to

contribute to, and benefit from, the system in an efficient manner and minimizing duplication.

1.1.1.4 A key objective of the GDPFS should be to facilitate cooperation and the exchange of information, thereby also contributing to capacity development amongst developing countries.

1.1.1.5 Defined products and services for applications related to weather, climate, water and environment shall include:

(a) Numerical weather, oceanographic and climate prediction products (analysis and forecast, including probabilistic information);

(b) Specialized products tailored for specific applications.

1.1.1.6 Additional information necessary for an appropriate use of the identified products and services shall be available. This includes non-real-time information as follows:

(a) Systems description and characteristics;

(b) Product metadata;

(c) Verification and monitoring results.

1.1.2 Activities supported by the GDPFS

1.1.2.1 Through the GDPFS, Members shall provide and have access to meteorological, hydrological, oceanographic and climatological information supporting a range of operational activities.

1.1.2.2 The GDPFS shall be organized as a three-tier system of activities as follows:

Note: A distinction is made between general purpose activities and specialized activities: general purpose activities are those which encompass essential data processing required for a wide range of end-usage, while specialized activities are those which make forecasting products, which may include guidance based on human interpretation, tailored for a specific type of application or user community. In addition to these activities conducted in real-time, non-real-time operational coordination activities are also part of the GDPFS. The list of GDPFS activities is given in this paragraph; however associated commitments and other appropriate details are specified in Part II.

(a) General purpose activities:

- **Global deterministic numerical weather prediction**
- **Limited area deterministic numerical weather prediction**
- **Global ensemble numerical weather prediction**
- **Limited area ensemble numerical weather prediction**
- **Global numerical long-range prediction**
- **Numerical ocean wave prediction** *[see Annex 1, Recommendation 20 (CBS-16)]*
- **Storm surge prediction** *[see Note below]*

- **Global numerical ocean prediction** *[see Annex 2, Recommendation 20 (CBS-16)]*
- **Nowcasting** *[see Annex 3, Recommendation 20 (CBS-16)]*

(b) Specialized activities:

- **Regional severe weather forecasting** *[see Annex 4, Recommendation 20 (CBS-16)]*
- **Regional climate prediction and monitoring**
- **Coordination of multi-model ensemble prediction for long-range forecasts**
- **Coordination of near-term climate prediction** *[see Annex 7, Recommendation 20 (CBS-16)]*
- **Tropical cyclone forecasting, including marine-related hazards**
- **Volcanic contaminants** *[see Annex 5, Recommendation 20 (CBS-16)]*
- **Marine meteorological services** *[see Annex 8, Recommendation 20 (CBS-16)]*
- **Marine environmental emergency response** *[see Annex 9, Recommendation 20 (CBS-16)]*
- **Nuclear environmental emergency response**
- **Non-nuclear environmental emergency response** *[see Annex 6, Recommendation 20 (CBS-16)]*
- **Atmospheric sand and dust storm forecasts**

(c) Non real-time coordination activities:

- **Coordination of deterministic numerical weather prediction (NWP) verification**
- **Coordination of ensemble prediction system (EPS) verification**
- **Coordination of long-range forecast (LRF) verification**
- **Coordination of wave forecast verification** *[see Annex 10, Recommendation 20 (CBS-16)]*
- **Coordination of tropical cyclone forecast verification** *[see Annex 11, Recommendation 20 (CBS-16)]*
- **Coordination of observation monitoring**

Note: Other activities, including those related to hydrology, agriculture, Polar Regions, storm surge prediction, and space weather would be developed in future.

1.2 GDPFS CENTRES

1.2.1 Definitions

1.2.1.1 The meteorological forecasting ranges shall be those defined in Appendix 1.1.

1.2.1.2 The GDPFS shall be organized as a three-level system of World Meteorological Centres (WMCs), Regional Specialized Meteorological Centres (RSMCs) and National Meteorological Centres (NMCs), which carry out GDPFS functions at the global, regional and national levels, respectively. These Centres are referred as GDPFS Centres.

1.2.2 National Meteorological Centre (NMC)

1.2.2.1 A National Meteorological Centre (NMC) shall carry out functions to meet the national and international requirements of the Member concerned.

Note: In order to fulfill their national and international obligations, National Meteorological Centres need to be adequately staffed and equipped to enable it to play its part in the World Weather Watch (WWW) system.

1.2.2.2 The functions of a NMC shall include the preparation of forecasts and warnings at all forecasting ranges necessary to meet the requirements of the Member.

1.2.2.3 Depending on the context, other activities of a NMC should include the production of:

(a) Special application-user products, including climate and environmental quality monitoring and prediction products;

(b) Non-real-time climate-related products.

1.2.3 Regional Specialized Meteorological Centre (RSMC)

1.2.3.1 A Member, having accepted the responsibility for providing a Regional Specialized Meteorological Centre (RSMC), shall arrange for this centre to carry out operationally at least one of the General Purpose or Specialized activities listed in paragraph 1.1.2.2, which specified standards are described in Part II.

1.2.3.2 An RSMC for General Purpose activities should provide products which an RSMC for at least one of the Specialized activities consider necessary and make request to produce.

Notes:

1. The designation as RSMC does not preclude the use of other names as defined in other contexts, e.g. Global Producing Centre for Long-Range Forecasts (GPCLRFs).

2. An RSMC that leads a coordination activity is also referred as Lead Centre.

1.2.4 World Meteorological Centre (WMC)

1.2.4.1 A Member, having accepted the responsibility for providing a World Meteorological Centre (WMC), shall arrange for this centre to carry out operationally at least the following activities, which specified standards are described in Part II.:

(a) Global deterministic numerical weather prediction;

(b) Global ensemble numerical weather prediction; and,

(c) Global numerical long-range prediction.

1.2.5 RSMC Network

1.2.5.1 An RSMC Network (that is an association of RSMCs participating in an identified activity of the GDPFS) shall follow the same specifications and adhere to the same criteria and commitments as individual RSMCs carrying out the same activity.

1.2.5.2 Appropriate documentation shall be produced and made available by Members having accepted the responsibility to contribute to the RSMC Network, to distribute the tasks and responsibilities among the participating RSMCs. A unique focal point shall be designated to answer requests from users of the RSMC Network's products.

1.2.6 Designation process

1.2.6.1 Each Member shall designate a National Meteorological Centre.

1.2.6.2 Word Meteorological Centres, Regional Specialized Meteorological Centres and RSMC Networks shall be designated by a decision of the World Meteorological Congress or the WMO Executive Council. The designation of such centres shall include the specification of the activity/function (or activities/functions) to be carried out.

1.2.6.3 Requests for designation as a World Meteorological Centre or Regional Specialized Meteorological Centre shall be put forward by the Permanent Representative of the country of the candidate centre, or in the case of international organizations by the Permanent Representative of the country where the candidate centre is located or the president of the relevant regional association(s).

1.2.6.4 Requests for designation as an RSMC Network shall be put forward by the president of the relevant regional association, or in the case of Networks established across two or more RAs, jointly by their presidents.

Note: centres constituting in a Network will organize themselves as appropriate, depending on their own context and specifities, so as to ensure that the documentation requested as per para. 1.2.5.2 is available.

1.2.6.5 Requests for designation shall be addressed to the WMO Secretariat, who will forward them to the relevant constituent bodies as indicated in the tables labeled "Responsibility" given for each activity in Part II, item 2 of the Manual. Supporting information demonstrating compliance with designation criteria shall be included with the request.

1.2.6.6 Depending on the type of activity, endorsement by the regional association(s) and technical commission(s) may be required before designation by Congress or EC, as specified in Part II, section 2, of the Manual.

1.3 COORDINATION WITH OTHER SYSTEMS OR PROGRAMMES

1.3.1 The GDPFS shall support all WMO Programmes and related programmes of other international organizations in accordance with decisions of the Organization.

Notes:

1. In many cases the activities undertaken by GDPFS Centres constitute the operational component of a system developed under another structure or programme, either by WMO on its own or jointly with other international organizations. In such cases, the regulations pertaining to these activities cover both

(1) The specific requirements defined by the relevant structure; and

(2) The general GDPFS criteria regarding operational quality and reliability, verification, documentation and compliance (described in Part II of this Manual).

2. Coordination mechanisms appropriate for the context and characteristics of the various categories of activity are specified in Part II.

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APPENDIX 1.1. DEFINITIONS OF METEOROLOGICAL FORECASTING RANGES

[Insert the current APPENDIX I-4,]

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PART II. SPECIFICATIONS OF GDPFS ACTIVITIES

2.1 OVERALL REQUIREMENTS AND STANDARDS

2.1.1 Quality control of incoming observations

2.1.1.1 WMCs and RSMCs shall identify the observational requirements to conduct all functions of their own activities and express them through the corresponding application areas of the Rolling Review of Requirements.

Note: Details of the Rolling Review of Requirements are described in the *Manual on the WMO Integrated Global Observing System (WIGOS)* (WMO-No. 1160), Appendix 2.3.

2.1.1.2 WMCs and RSMCs shall apply quality control to the incoming observations they use for GDPFS purposes. The objectives of the GDPFS quality control shall be:

(a) To ensure the best possible quality of the observations which are used in the real-time operations of the GDPFS;

(b) In non-real-time, to protect and improve the quality and integrity of observations destined for storage and retrieval within the GDPFS;

(c) To provide the basis for feedback of information on errors and questionable observations to the source of the data.

Note: The minimum standards for quality control of observations include quality control at various stages of processing. They apply to both real-time and non-real-time processing and lead to various records of quality control actions and relevant metadata.

2.1.1.3 Quality control processes implemented in the GDPFS should adhere to the WIGOS quality assurance and quality control standards.

Note: Details of the WIGOS quality assurance and quality control standards are described in the *Manual on the WMO Integrated Global Observing System (WIGOS)* (WMO-No. 1160), item 2.4.3.

2.1.1.4 GDPFS Centres with global, hemispheric or near-hemispheric models should monitor the quality of one or more of the main types of observations using techniques such as those listed in Appendix 2.1.1. Statistics should be compiled separately for each land station by

station index number, for each ship or aircraft by call sign, for each buoy by identifier, and for each satellite by identifier, and for various geographic areas and levels in the atmosphere.

2.1.1.5 GDPFS centres should analyse the results and produce in an agreed format lists of observations believed to be consistently of low quality, together with information on which element of the observation (pressure, temperature, etc.) is thought to be of low quality and the evidence for considering it as such. These lists should be based on data received over one month and should be exchanged monthly between participating centres. Standard procedures and formats for the exchange of monitoring results are given in Appendix 2.1.2.

Note: Lead Centres, described in 2.2.3, play an essential role in resolving and minimizing recurrence of deficiencies reported by GDPFS Centres.

2.1.2 Data collection and product dissemination

2.1.2.1 GDPFS Centres shall be connected to the WIS to ensure suitable exchange of information with other Centres.

2.1.2.2 WMCs and RSMCs shall describe their required products and services according to WMO metadata standards and make them available to other GDPFS Centres through the WMO Information System in a timely manner for operational use.

Note: Details on the metadata standards are described in the *Manual on the WMO Information System* (WMO-No. 1060)

2.1.3 Long-term storage of data and products

Note: The non-real-time functions of the GDPFS include long-term (i.e. around 10 years) storage of observations, products and verification results for operational and research use.

2.1.3.1 WMCs and RSMCs shall operate an archiving and retrieval system to serve the needs of their continual improvement process; this process should include the non-real-time assessment of their products and the ability to perform re-runs of their operational production.

2.1.3.2 Members should ensure that their NMCs archive and retrieve appropriate data originating from their national observing networks and facilities.

2.1.4 Product verification / performance of GDPFS Centres

2.1.4.1 The accuracy of forecast products provided by WMCs and RSMCs shall be monitored by objective verification procedures.

Notes:

1. The goal of the objective verification procedures is to provide consistent standardized verification of the forecast products of WMCs and RSMCs so that users can make best use of products and so that opportunities for improvement are identified.

2. Detailed procedures for the production and display of a standard set of verification scores are provided in Appendix 2.2.21. A mandatory set shall be provided by participating Centres. Centres should also provide, if possible, additional statistics as recommended in Appendix 2.2.21.

2.1.4.2 Lead Centres for verification shall play an essential role in the coordination of verification and have responsibility for maintaining websites containing verification results and relevant guidance (cf. in Part II, section 2.2.3), ensuring that users benefit from a consistent presentation of the results.

2.1.4.3 GDPFS Centres receiving RSMC products via the WIS should carry out verification over appropriate areas using the standardized measures listed in Appendixes 2.2.21, 2.2.22 and 2.2.23 and make these results available to the producing RSMCs.

2.1.5 Documentation on system and products

2.1.5.1 WMCs and RSMCs shall make available, on a publically available website, documentation on the technical characteristics of their operational system and on the products it delivers. RSMCs shall ensure that the information provided is kept current by updating it as required after every significant change to their operational system. The mandatory (minimum) information to be provided is specified for every activity separately in the following section 2.2.

2.1.5.2 Documentation shall use the International System of Units (SI units). If other units are used, conversion equations should be included.

Note: Addresses of WMCs and RSMC websites containing such system documentation are in Part III section 2 of this Manual. *[In development]*

2.1.6 Training

2.1.6.1 WMCs and RSMCs shall provide guidance, including training materials, on the interpretation, performance characteristics, strengths and limitations of their products. They shall ensure that this information is kept current by updating it after every significant change to their operational system.

2.1.6.2 WMCs and RSMCs may be requested to contribute to specific training activities in support of capacity development and related activities. Products used in such training activities should subsequently be available to users in their own operational working environments.

2.1.7 Reporting on compliance

2.1.7.1 WMCs and RSMCs shall provide information about the current implementation of their system. This information should be available on the same website as that used for providing system and products documentation and described in section 2.1.5.

2.1.7.2 WMCs and RSMCs shall report non-compliance between the mandatory minimum specifications and their actual implementation to the WMO Secretariat and make corresponding information available on a website. When this non-compliance is reported to Congress or the Executive Council, it shall reconsider the designation.

2.1.8 Graphical representation of observations, analyses and forecasts

2.1.8.1 WMCs and RSMCs that have a mandate of chart-based analysis shall maintain standardized weather forecasting process, including graphical representation of observations, analyses and forecasts.

2.1.8.2 Standard sets of graphical representation

2.1.8.2.1 The standard set of symbols and styles should be used in graphical representations of observations and analyses. This may also be used for presentation of forecasts.

Note: The set of symbols and styles is given in XXX of the *Manual on Codes* (WMO-No. 306). *[Appendix II-4 of the current Manual on the GDPFS to be incorporated into the Manual on Codes]*

2.1.8.2.2 All colour scales for colour maps should be properly defined to avoid misinterpretation by any category of users, and they should be standardized whenever possible.

2.1.8.3 Analysis and forecasting practices

2.1.8.3.1 Reference surfaces for upper-air analysis

[Insert Part II, paragraphs 3.1.1 to 3.1.3 of the current Manual on the GDPFS]

2.1.8.3.2 Preparation of upper-air charts

[Insert Part II, paragraph 3.2.1 of the current Manual on the GDPFS, and replace "Members" by "GDPFS Centres"]

2.1.8.3.3 Weather forecasting

Note: The weather forecasting process includes analysis, prognoses and interpretation of state and forecasts of weather parameters at the surface and/or in the free atmosphere for short-, medium-, extended- and long-ranges for purposes according to the obligations of GDPFS Centres and its network and as agreed by the regional associations.

2.1.8.4 Practices for pictorial representation of information on meteorological charts and diagrams

2.1.8.4.1 Scales and projections of meteorological charts

[Insert Part II, paragraphs 4.1.1 to 4.1.3 of the current Manual on the GDPFS]

2.1.8.4.2 Symbols used on meteorological charts

[Insert Part II, paragraphs 4.2.1 to 4.2.2 of the current Manual on the GDPFS, and replace Appendix II-4 of the current Manual on the GDPFS by XXX of the Manual on Codes]

2.1.8.4.3 Construction of aerological diagrams

[Insert Part II, paragraphs 4.3.1 to 4.3.2 of the current Manual on the GDPFS]

2.1.8.4.4 Preparation of charts and diagrams for facsimile transmission

[Insert Part II, paragraphs 4.4.1 to 4.4.6 of the current Manual on the GDPFS, and replace Appendix II-4 of the current Manual on the GDPFS by XXX of the Manual on Codes]

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APPENDIX 2.1.1. TECHNIQUES FOR MONITORING THE QUALITY OF OBSERVATIONS

1. Compilation of statistics on the difference between observed values and the analysis and first-guess field;

2. Compilation of statistics on observations which fail the routine quality-control checks;

3. Examination of time series of observations from a particular station (particularly useful in data-sparse areas);

4. Compilation of statistics on the differences between reported values of geopotential height and geopotential height recalculated from significant level data for radiosonde stations, using common formulae for all stations;

5. For surface stations which report both mean sea-level pressure and station-level pressure, compilation of statistics on differences between reported mean sea-level pressure and mean sea-level pressure recomputed from reported station-level pressure and temperature and published values of station elevation;

6. Compilation of co-location statistics.

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APPENDIX 2.1.2. PROCEDURES AND FORMATS FOR THE EXCHANGE OF MONITORING RESULTS

[Insert ATTACHMENT II.9 of the current Manual on the GDPFS]

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2.2 Specification of activities and procedures for introducing modifications

2.2.1 General purpose activities

2.2.1.1 Global deterministic numerical weather prediction

2.2.1.1.1 Centres conducting global deterministic numerical weather prediction (NWP) shall:

(a) Produce global analyses of the three-dimensional structure of the atmosphere;

(b) Produce global forecast fields of basic and derived atmospheric parameters;

(c) Make available on the WIS a range of these products. The list of mandatory and highly recommended global deterministic NWP products to be made available is given in Appendix 2.2.1;

(d) Produce verification statistics according to the standard defined in Appendix 2.2.21, and make them available to the Lead Centre(s) for Deterministic NWP Verification;

(e) Make available on a website up-to-date information on the characteristics of its global numerical weather prediction system. The minimum information to be provided is given in Appendix 2.2.2.

Note: The bodies in charge of managing the information contained in the *Manual* related to global deterministic NWP are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OWFPS		
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	RA	CBS	
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-OWFPS		
To be reported to:	CBS/ICT-DPFS	CBS	

2.2.1.2 Limited area deterministic numerical weather prediction

2.2.1.2.1 Centres conducting limited area deterministic numerical weather prediction (NWP) shall:

(a) Produce limited area analyses of the three-dimensional structure of the atmosphere;

(b) Produce limited area forecast fields of basic and derived atmospheric parameters;

(c) Make available on the WIS a range of these products. The list of mandatory and highly recommended limited area deterministic NWP products to be made available, including metadata, is given in Appendix 2.2.3;

(d) Produce verification statistics according to the standard defined in Appendix 2.2.21, adapted for the region covered by the model, at an appropriate resolution, and make available consistent up-to-date graphical displays of the verification results on a website;

(e) Make available on a website up-to-date information on the characteristics of its limited area numerical weather prediction system. The minimum information to be provided is given in Appendix 2.2.4.

Note: The bodies in charge of managing the information contained in the *Manual* related to limited area deterministic NWP are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OWFPS		
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			

To be recommended by:	RA	CBS	
To be decided by:	EC / Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-OWFPS		
To be reported to:	CBS/ICT-DPFS	CBS	

2.2.1.3 Global ensemble numerical weather prediction

2.2.1.3.1 Centres conducting global ensemble numerical weather prediction (NWP) shall:

(a) Produce global ensemble forecast fields of basic and derived atmospheric parameters;

(b) Make available on the WIS a range of these products. The list of mandatory and highly recommended global ensemble NWP products to be made available is given in Appendix 2.2.5;

(c) Make verification statistics available to the Lead Centre(s) for EPS Verification according to the standard defined in Appendix 2.2.22;

(d) Make available on a website up-to-date information on the characteristics of its global ensemble numerical weather prediction system. The minimum information to be provided is given in Appendix 2.2.6.

Note: The bodies in charge of managing the information contained in the *Manual* related to global ensemble NWP are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OWFPS		
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	RA	CBS	
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-OWFPS		
To be reported to:	CBS/ICT-DPFS	CBS	

2.2.1.4 Limited area ensemble numerical weather prediction

2.2.1.4.1 Centres conducting limited area ensemble numerical weather prediction (NWP) shall:

(a) Produce limited area ensemble forecast fields of basic and derived atmospheric parameters;

(b) Make available on the WIS a range of these products. The list of mandatory and highly recommended limited area ensemble NWP products to be made available is given in Appendix 2.2.7;

(c) Produce verification statistics according to the standard defined in Appendix 2.2.22, adapted for the region covered by the model, and make available consistent up-to-date graphical displays of the verification results on a website;

(d) Make available on a website up-to-date information on the characteristics of its limited area ensemble numerical weather prediction system. The minimum information to be provided is given in Appendix 2.2.8.

Note: The bodies in charge of managing the information contained in the *Manual* related to limited area ensemble NWP are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OWFPS		
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	RA	CBS	
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-OWFPS		
To be reported to:	CBS/ICT-DPFS	CBS	

2.2.1.5 Global numerical long-range prediction

2.2.1.5.1 Centres conducting global numerical long-range prediction (known as Global Producing Centres for Long-Range Forecasts (GPCLRFs)) shall:

Note: Functions are defined for the seasonal (1-6 month) prediction activity.

(a) Generate seasonal forecast products with global coverage;

(b) Make available on the WIS a range of these products. Mandatory products to be made available are listed in Appendix 2.2.9;

(c) Produce verification statistics according to the standard defined in Appendix 2.2.23, and make them available to the Lead Centre(s) for Standardized Verification System for Long-Range Forecast and on a website;

(d) Make available on a website up-to-date information on the characteristics of its global seasonal numerical prediction system. The minimum information to be provided is given in Appendix 2.2.10.

2.2.1.5.2 In addition to the mandatory activities above, the following activities are highly recommended:

(a) Provide forecast output to the LC-LRFMME, as detailed in Appendix 2.2.12 (section 1);

(b) Make available on the WIS the highly recommended products listed in Appendix 2.2.9;

(c) Make available, on request by RCCs or NMCs, the additional data, products and services listed in Attachment 2.2.1, noting that these services may be subject to conditions attached by GPCs.

Note: The bodies in charge of managing the information contained in the *Manual* related to global numerical long-range prediction are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS-CCI/IPET-OPSLS		
To be recommended by:	CBS	CCI	
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	RA	CBS	
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS-CCI/IPET-OPSLS		
To be reported to:	CBS/ICT-DPFS	CBS	

2.2.2 Specialized activities

2.2.2.1 Regional climate prediction and monitoring

2.2.2.1.1 Centres conducting regional climate prediction and monitoring (known as Regional Climate Centres (RCCs)) shall:

(a) Operational activities for Long Range Forecasting (LRF), both dynamical and statistical, within the range of a 1-month to 2-year timescale, based on regional needs:

– **Interpret and assess relevant LRF products from Global Producing Centres for Long-Range Forecasts (GPCs), make use of the products**

from the Lead Centre for Standard Verification for LRF (refer to 2.2.3.3), distribute relevant information to users, and provide feedback to GPCs (guidelines are given in Attachment 2.2.3);

- **Generate regional and subregional tailored products relevant to user needs, including seasonal outlooks;**
- **Generate "consensus" statement on forecasts;**
- **Generate and display forecast verification;**
- **Provide online access to products and services;**
- **Assess use of products and services through feedback from users;**

(b) Operational activities for climate monitoring:

- **Perform climate diagnostics including analysis of climate variability and extremes, at the regional and subregional scales;**
- **Establish a historical reference climatology for the Region and/or subregions;**
- **Implement a regional climate watch;**

(c) Operational data services, to support operational LRF and climate monitoring;

- **Develop quality controlled regional climate datasets, gridded where applicable;**
- **Provide climate database and archiving services;**

(d) Training in the use of operational RCC products and services:

- **Provide information on methodologies and product specifications for mandatory RCC products, and provide guidance on their use;**
- **Coordinate training for RCC users in interpretation and use of mandatory RCC products.**

Notes:

1. Recipients of RCC products and services will be NMHSs, other RCCs and international institutes recognized by the Regional Association, and will be referred to as RCC users.

2. Details on functions are provided in Appendix 2.2.11. Additional requirements for RCC functions may vary in detail from Region to Region. A list of highly recommended, but not mandatory, functions is given in Attachment 2.2.2.

3. The bodies in charge of managing the information contained in the *Manual* related to regional climate prediction and monitoring are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CCl-CBS/ET-RCC	CBS-CCl/IPET-OPSLS	
To be recommended by:	CBS	CCl	
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	RA	CBS	CCl
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CCl-CBS/ET-RCC		
To be reported to:	CBS/ICT-DPFS	CBS	

2.2.2.2 Coordination of Multi-Model Ensemble Prediction for Long-Range Forecasts

2.2.2.2.1 Centres conducting coordination of multi-model ensemble prediction for long-range forecasts (known as Lead Centre for Long-Range Forecast of Multi-Model Ensemble prediction (LC-LRFMME)) shall:

(a) Collect an agreed set of forecast data from RSMCs participating in seasonal numerical prediction under activity 2.2.1.5 (GPCs);

(b) Make available on a website appropriate minimum (Appendix 2.2.12) and additional (Attachment 2.2.4) products and GPC's forecasts in standard format;

(c) Redistribute digital forecast data as described in Appendix 2.2.13 for those GPCs that allow it;

(d) Maintain an archive of the real-time GPC and MME forecasts;

(e) Maintain a repository of documentation for the system configuration of all GPC systems;

(f) Verify their products using the SVSLRF (Appendix 2.2.23);

(g) Based on comparison among different models, provide feedback to GPCs about model performance and make available on a website the verification results;

(h) Promote research and experience in MME techniques and provide guidance and support on MME techniques to GPCs, RCCs and NMHSs.

Note: The bodies in charge of managing the information contained in the *Manual* related to coordination of multi-model ensemble prediction for long-range forecasts are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS-CCl/IPET-OPSLS		
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	CBS		
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS-CCl/IPET-OPSLS		
To be reported to:	CBS/ICT-DPFS	CBS	

2.2.2.3 Tropical Cyclone Forecasting, including marine-related hazards

Note: This activity includes a single network of a Regional Centre and associated National Meteorological Centres (NMCs) within every Tropical Cyclone Regional Body.

2.2.2.3.1 Centres conducting tropical cyclone forecasting shall:

(a) **Monitor continuously meteorological phenomena such as convective activities to predict or detect tropical cyclone formation;**

(b) **Analyse and forecast tropical cyclones based on all available observational data and forecasting guidance, including NWP/EPS and satellite-based products;**

(c) **Issue tropical cyclone advisories to associated NMCs;**

(d) **As appropriate, add information in tropical cyclone advisories on hazardous phenomena associated with tropical cyclones such as heavy rains, strong winds and storm surges;**

(e) **Name tropical cyclones when they have been analysed with maximum wind speeds of 34 knots or more;**

(f) **Conduct post-event analysis of tropical cyclones based on quality-assured observational data and issue best-track data within an appropriate period of time (preferably on annual basis). Issue such data to the tropical cyclone community including the International Best Track Archive for Climate Stewardship;**

(g) **Promote research and development (R&D) and training in tropical cyclone analysis, forecasting and warning techniques.**

2.2.2.3.2 National Meteorological Centres (NMCs) associated with this activity shall:

(a) Issue forecasts and warnings of tropical cyclones to threatened communities;

(b) Coordinate with national agencies responsible for disaster risk reduction;

(c) Provide relevant regional centres with observational data of tropical cyclones on a real-time basis.

2.2.2.3.3 All TC RSMCs and TCWC Darwin, which are designated as a Tropical Cyclone Advisory Centre (TCAC) by regional air navigation agreement within the framework of the tropical cyclone watch of ICAO, shall issue Tropical Cyclone Advisories for aviation in accordance with the provisions made in ICAO Annex 3- Meteorological Service for International Air Navigation / WMO Technical Regulations [C3.1]. SIGMET information concerning tropical cyclones shall be issued by Meteorological Watch Offices (MWO) for the concerned flight information region and should be based on the tropical cyclone advisory information issued by the TCACs.

2.2.2.3.4 Members holding Metareas of their responsibility under the Global Maritime Distress and Safety System (GMDSS) protocols established by the International Convention of Safety Of Life At Sea (SOLAS) shall include information on tropical cyclones as needed in their GMDSS maritime weather information for shipping.

Note: The bodies in charge of managing the information contained in the *Manual* related to tropical cyclone forecasting are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	Technical Coordination Meeting		
To be recommended by:	CBS	Regional TC Committee	
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	CBS	Regional TC Committee	
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	Technical Coordination Meeting		
To be reported to:	CBS		

2.2.2.4 Nuclear Environmental Emergency Response

2.2.2.4.1 Centres conducting nuclear environmental emergency response shall:

(a) Contribute to support for WMO Members and International Atomic Energy Agency (IAEA):

(1) Prepare on request from a Delegated Authority[1] and/or IAEA, basic information relating to events in which nuclear contaminants have been released into the atmosphere. The activation of support for nuclear emergency response is described in Appendix 2.2.14;

(2) Within two to three hours of reception of a request, make a range of products available to the NMHS operational contact point[2] and/or the IAEA on the WIS[3]. The minimum list, including parameters, forecast range, time steps and frequency, is given in Appendix 2.2.15;

(3) Use agreed standard emission source parameters for atmospheric transport modelling when source information is not available. Default source parameters are given in Appendix 2.2.16;

(4) Make available up-to-date information on the characteristics of their atmospheric transport modelling (ATM) systems (minimum information to be provided is given in Appendix 2.2.17) and a user interpretation guide for ATM products.

Note: The forms to request WMO support by a Delegated Authority and by the IAEA are in Appendix 2.2.18.

(b) Contribute to support for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO)

(1) Prepare, on request from CTBTO, relevant atmospheric backtracking products

(2) Make the requested products available to CTBTO.

Note: Arrangements for activation and product specifications are in Appendix 2.2.19.

Note: The bodies in charge of managing the information contained in the *Manual* related to nuclear environmental emergency response are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-ERA		
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	CBS		
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-ERA		
To be reported to:	CBS/ICT-DPFS	CBS	

[1] The person authorized by the Permanent Representative of the WMO member to request support.
[2] Designated by the Permanent Representative
[3] Password protected dedicated website

2.2.2.5 Atmospheric sand and dust storm forecasting

2.2.2.5.1 Centres conducting atmospheric sand and dust storm forecasts shall:

(a) Operate a numerical weather prediction model incorporating parameterizations of all the major phases of the atmospheric dust cycle;

(b) Prepare limited area analyses of variables relevant to atmospheric sand and dust storms;

(c) Prepare limited area forecast fields of variables relevant to atmospheric sand and dust storms;

(d) Make available on the WIS and on a web portal a range of these products. The list of mandatory products to be made available is given in Appendix 2.2.20.

Note: The bodies in charge of managing the information contained in the *Manual* related to atmospheric sand and dust storm forecasts are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CAS/SDS-WAS Steering Committee	CBS/ET-ERA	
To be recommended by:	CAS (WWRP/SSC)	CBS	
To be decided by:	EC/Congress		
CENTRES DESIGNATION(*)			
To be recommended by:	CAS (WWRP/SSC, SDS-WAS Steering Group)	CBS	RA
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-ERA		
To be reported to:	CBS/ICT-DPFS	CBS	

(*) The detailed designation procedure of RSMC ASDF is referred to Chapter 7 of the SDS-WAS Science Implementation Plan.

2.2.3 Non-real-time coordination activities

2.2.3.1 Coordination of deterministic NWP verification

2.2.3.1.1 Centres conducting coordination of deterministic NWP verification (known as Lead Centre for deterministic NWP verification) shall:

(a) Provide the facility for GDPFS Centres producing global NWP to automatically deposit their standardized verification statistics as defined in Appendix 2.2.21, and access to these verification statistics;

(b) Maintain an archive of the verification statistics to allow the generation and display of trends in performance;

(c) Monitor the received verification statistics and consult with the relevant participating centre if data is missing or suspect;

(d) Collect annually from the participating centres information on their implementation of the standardized verification system, confirm any changes to their implementation (including the annual change of station list, changes in additional statistics) and changes in their NWP models;

(e) Provide access to standard data sets needed to perform the standard verification, including climatology and lists of observations and keep this up to date according to CBS recommendation;

(f) Provide on its (their) website(s):

- **Consistent up-to-date graphical displays of the verification results from participating Centres through processing of the received statistics;**
- **Relevant documentation including access to the standard procedures required to perform the verification, and links to the websites of GDPFS participating Centres;**
- **Contact details to encourage feedback from NMHSs and other GDPFS Centres on the usefulness of the verification information.**

2.2.3.1.2 The Lead Centre(s) for deterministic NWP verification may also provide access to standardized software for calculating scoring information.

Note: The bodies in charge of managing the information contained in the *Manual* related to coordination of deterministic NWP verification are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OWFPS		
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	CBS		
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-OWFPS		
To be reported to:	CBS/ICT-DPFS	CBS	

2.2.3.2 Coordination of EPS verification

2.2.3.2.1 Centres conducting coordination of EPS verification (known as Lead Centre for EPS verification) shall:

(a) Provide the facility for the GDPFS Centres producing global EPS to automatically deposit their standardized verification statistics as defined in Appendix 2.2.22, and access to these verification statistics;

(b) Maintain an archive of the verification statistics to allow the generation and display of trends in performance;

(c) Monitor the received verification statistics and consult with the relevant participating centre if data is missing or suspect;

(d) Provide access to standard data sets needed to perform the standard verification, including climatology and lists of specified observation sites and keep this up to date according to CBS recommendation;

(e) Provide on its (their) website(s):

- **Consistent up-to-date graphical displays of the verification results from participating Centres through processing of the received statistics;**
- **Relevant documentation including access to the standard procedures required to perform the verification, and links to the websites of GDPFS participating Centres;**
- **Contact details to encourage feedback from NMHSs and other GDPFS Centres on the usefulness of the verification information.**

2.2.3.2.2 The Lead Centre(s) for EPS verification may also provide access to standardized software for calculating scoring information.

Note: The bodies in charge of managing the information contained in the *Manual* related to coordination of EPS verification are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OWFPS		
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	CBS		
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-OWFPS		
To be reported to:	CBS/ICT-DPFS	CBS	

2.2.3.3 Coordination of LRF verification

2.2.3.3.1 Centres conducting coordination of LRF verification (known as Lead Centre for Standardized Verification System for Long-Range Forecast (SVSLRF)) shall:

(a) Provide the facility for RSMCs participating in global numerical long-range prediction under activity 2.2.1.5 to automatically deposit their standardized verification statistics as defined in Appendix 2.2.23, and to access to these verification statistics;

(b) Maintain an archive of verification statistics to allow the generation and display of trends in performance;

(c) Monitor the received verification statistics and consult with the relevant participating centre if data is missing or suspect;

(d) Provide on its (their) website(s):

- **Consistent up-to-date graphical displays of verification results from participating Centres through processing of the received statistics;**
- **Relevant documentation including access to the standard procedures required to perform the verification, and links to the websites of GDPFS participating Centres;**
- **Contact details to encourage feedback from NMHSs and other GDPFS Centres on the usefulness of the verification information;**

(e) Provide access to verification data sets at an appropriate horizontal resolution.

2.2.3.3.2 Additionally, these Lead Centre(s) should:

(a) Liaise with other groups involved in verification (e.g. WGSIP, CCl, etc.) on the effectiveness of the current standardized verification system (SVS) and identify areas for future development and improvement;

(b) Provide periodic reports to CBS and other relevant Commissions assessing the effectiveness of the SVS.

Note: Detailed tasks for the Lead Centres for the SVSLRF, and verification scores, are listed in Appendix 2.2.23.

Note: The bodies in charge of managing the information contained in the *Manual* related to coordination of LRF verification are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET- OPSLS		
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	CBS		
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	ET-OPSLS		
To be reported to:	CBS/ICT-DPFS	CBS	

2.2.3.4 Coordination of observation monitoring

2.2.3.4.1 For each type of observation, a Lead Centre for coordination of observation monitoring shall be nominated from time to time by the president of CBS.

2.2.3.4.2 The Lead Centre should liaise with the participating centres to coordinate all the monitoring results of that observation type and to define common methods and criteria to be used for compiling the monthly statistics.

2.2.3.4.3 The Lead Centre should draw the attention of appropriate focal points where they have been identified and of the WMO Secretariat to obvious problems as they are detected.

2.2.3.4.4 The Lead Centre should also produce every six months a consolidated list of observations of the relevant observation type believed to be of consistently low quality. Information on problems with observing systems, as well as individual observations, should also be included. When compiling the consolidated lists of suspect stations the Lead Centre should be rigorous so as to identify only those stations where they are confident that the observations are of consistently low quality. It should state which elements of the observation are considered to be of low quality and provide as much information as possible identifying the problem. The list should be passed on to the participating centres and to the WMO Secretariat.

2.2.3.4.5 Where focal points have not been identified, the Secretariat should notify Members of agencies responsible for the observations which appear to be of low quality, and request them to make an investigation with a view to identifying and correcting any possible cause of error. Members should be asked to reply within a fixed period of time, reporting on any remedial action and stating if any assistance is required.

2.2.3.4.6 Monitoring results including follow-up action should be made available to CBS, the Executive Council and Congress. In the case of enquiries made by WMO, feedback to the lead centres is requested.

Notes:

1. Lead centres for data-quality monitoring are given in the *Guide to the Global Observing System* (WMO-No. 488), Part VII, paragraph 7.2.2.1.

2. WIGOS Quality Management System is being developed to incorporate observational quality monitoring process described above. The coordination will be defined in this section in due course.

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APPENDIX 2.2.1. MANDATORY AND HIGHLY RECOMMENDED GLOBAL DETERMINISTIC NWP PRODUCTS TO BE MADE AVAILABLE ON THE WIS

Parameter	Level	Resolution	Forecast range	Time steps	Frequency
Geopotential height	850/500/250	1.5º x 1.5º	Up to 3d / Beyond 3d up to 6d	Every 6h / Every 12h	Twice a day (00 and 12 UTC) / Once a day
Temperature	850/500/250				
u,v	925/850/700/500/250				
Relative humidity	850/700				
Divergence, vorticity	925/700/250				
MSL pressure	Surface				
2m Temp 10m u, 10m v Total precipitation	Surface				

Additional recommended products:

- Tropical storm tracks (lat/lon locations, maximum sustained wind speed, MSLP)

_____

APPENDIX 2.2.2. CHARACTERISTICS OF GLOBAL DETERMINISTIC NWP SYSTEMS

1. System

System name (version)

Date of implementation

2. Configuration

Horizontal resolution of the model, with indication of grid spacing in km

Number of model levels

Top of model

Forecast length and forecast step interval

Runs per day (Times in UTC)

Is model coupled to an ocean, waves, sea ice models? Specify which models

Integration time step

Additional comments

3. Initial conditions

Data assimilation method

Additional comments

4. Surface Boundary Conditions

Sea-surface temperature? If yes, briefly describe method(s)

Land surface analysis? If yes, briefly describe method(s)

Additional comments

5. Other details of model

What kind of soil scheme is in use?

How are radiations parametrized?

What kind of Large scale dynamics is in use (e.g. gridpoint semi-Lagrangian)?
Hydrostatic or Nonhydrostatic?
What kind of boundary layer parametrization is in use?

What kind of convection parametrization is in use?

What cloud scheme is in use?

Other relevant details?

6. Further Information

Operational contact point

URLs for system documentation

URL for list of products

APPENDIX 2.2.3. MANDATORY AND HIGHLY RECOMMENDED LIMITED AREA DETERMINISTIC NWP PRODUCTS TO BE MADE AVAILABLE ON THE WIS

Parameter	Level	Resolution	Forecast range	Time steps	Frequency
Geopotential height	925/850/700/500/250	0.5° x 0.5°	1d	Every 6h	Twice a day
Temperature	925/850/700/500/250				
u,v	925/850/700/500/250				
Relative humidity	925/850/700/500				
Divergence, vorticity	925/850/700/500/250				
MSL pressure	Surface				
2m Temp 10m u, 10m v Total precipitation	Surface				

Additional recommended products:

- Vertical velocity
- Cloud cover
- Tropical storm tracks (lat/lon locations, maximum sustained wind speed, MSLP)

_____

APPENDIX 2.2.4. CHARACTERISTICS OF LIMITED AREA DETERMINISTIC NWP SYSTEMS

1. System

System name

Date of implementation

2. Configuration

Domain

Horizontal resolution of the model, with indication of grid spacing in km

Number of model levels

Top of model

Forecast length and forecast step interval

Runs per day (Times in UTC)

Is model coupled to an ocean, waves, sea ice models? Specify which models

Integration time step

Additional comments

3. Initial conditions

Data assimilation method

Additional comments

4. Surface Boundary Conditions

Sea-surface temperature? If yes, briefly describe method(s)

Land surface analysis? If yes, briefly describe method(s)

Additional comments

5. Lateral Boundary Conditions

Model providing lateral boundary conditions

Lateral boundary conditions update frequency

6. Other details of model

What kind of soil scheme is in use?

How are radiations parametrized?

What kind of Large scale dynamics is in use (e.g. gridpoint semi-Lagrangian)? Hydrostatic or Nonhydrostatic?

What kind of boundary layer parametrization is in use?

What kind of convection parametrization is in use?

What Cloud/Microphysics scheme is in use?

Other relevant details?

7. Further Information

Operational contact point

URLs for system documentation

URL for list of products

_____

APPENDIX 2.2.5. MANDATORY AND HIGHLY RECOMMENDED GLOBAL EPS PRODUCTS TO BE MADE AVAILABLE ON THE WIS

Parameter	Level	Thresholds	Resolution (lat/lon grid)	Forecast range	Time steps	Frequency
Probability of Precipitation	Surface	1, 5, 10, 25, 50 mm and 100 mm/24 hours	1.5º x 1.5º	10d (or the maximum range if less)	Every 12h	Once a day
Probability of 10 m sustained wind and gusts	Surface	10, 15 and 25 m s^{-1}				
Probability of Temperature anomalies	850	± 1, ± 1.5, ± 2 standard deviations with respect to a reanalysis climatology specified by the producing Centre				
Ensemble mean + spread (standard	500					

deviation) of Geopotential height						
Ensemble mean + spread (standard deviation) of MSL pressure	Surface					
Ensemble mean + spread (standard deviation) of wind speed	850/250					

Additional recommended products

- Location-specific time series of temperature, precipitation, wind speed, depicting the most likely solution and an estimation of uncertainty ("EPSgrams"). The definition, method of calculation and the locations should be documented
- Tropical storm tracks (lat/long locations, maximum sustained wind speed, MSLP from EPS members)

_____

APPENDIX 2.2.6. CHARACTERISTICS OF GLOBAL EPS

1. Ensemble System

Ensemble name (version)

Date of implementation

2. Configuration of the EPS

Horizontal resolution of the model, with indication of grid spacing in km

Number of model levels

Top of model

Forecast length and forecast step interval

Runs per day (Times in UTC)

Is there an unperturbed control forecast included? (Y/N)

Number of perturbed ensemble members (excluding control)

Is model coupled to an ocean, waves, sea ice models? Specify which models

Integration time step

Additional comments

3. Initial conditions and Perturbations

Initial perturbation strategy

Optimization time in forecast (if applicable)

Horizontal resolution of perturbations (if different from model resolution)

Initial perturbed area

Data assimilation method for control analysis

Are perturbations to observations employed? (Y/N)

(If Yes, which observation types are perturbed?)

Perturbations added to control analysis or derived directly from ensemble analysis

Perturbations in +/- pairs? (Y/N)

Additional comments

4. Model Uncertainty Perturbations

Is model physics perturbed? If yes, briefly describe method(s)

Do all ensemble members use exactly the same model version, or are, for example, different parameterization schemes used? Please describe any differences

Is model dynamics perturbed? If yes, briefly describe method(s)

Are the above model uncertainty perturbations applied to the control forecast?

Additional comments

5. Surface Boundary Perturbations

Perturbations to sea-surface temperature? If yes, briefly describe method(s)

Perturbations to soil moisture? If yes, briefly describe method(s)

Perturbations to surface wind stress or roughness? If yes, briefly describe method(s)

Any other surface perturbations? If yes, briefly describe method(s)

Are the above surface perturbations applied to the control forecast?

Additional comments

6. Other details of model

What kind of soil scheme is in use?

How are radiations parametrized?

What kind of Large scale dynamics is in use (e.g. gridpoint semi-Lagrangian)? Hydrostatic or nonhydrostatic?

What kind of boundary layer parametrization is in use?

What kind of convection parametrization is in use?

What cloud scheme is in use?

Other relevant details?

7. Products

Method of the calculation, if the method is not unique.

Other detailed specifications, if necessary

8. Further Information

Operational contact point

URLs for system documentation

URL for list of products

APPENDIX 2.2.7. MANDATORY AND HIGHLY RECOMMENDED LIMITED AREA EPS PRODUCTS TO BE MADE AVAILABLE ON THE WIS

Parameter	Level	Thresholds	Resolution (lat/lon grid)	Forecast range	Time steps	Frequency
Probability of Precipitation	Surface	1, 5, 10, 25, 50 mm and 100 mm/24 hours	0.5º x 0.5º	2d (or the maximum range if less)	Every 6h	Once a day
Probability of 10 m sustained wind and gusts	Surface	10, 15 and 25 m s^{-1}				
Probability of Temperature anomalies	850	± 1, ± 1.5, ± 2 standard deviations with respect to a reanalysis climatology specified by the producing Centre				

Ensemble mean + spread (standard deviation) of Geopotential height	500					
Ensemble mean + spread (standard deviation) of MSL pressure	Surface					
Ensemble mean + spread (standard deviation) of wind speed	850/250					

Additional recommended products

- Location-specific time series of temperature, precipitation, wind speed, depicting the most likely solution and an estimation of uncertainty ("EPSgrams"). The definition, method of calculation and the locations should be documented
- Tropical storm tracks (lat/long locations, maximum sustained wind speed, MSLP from EPS members)

_____

APPENDIX 2.2.8. CHARACTERISTICS OF LIMITED AREA EPS

1. Ensemble System

Ensemble name (version

Date of implementation

2. Configuration of the EPS

Horizontal resolution of the model, with indication of grid spacing in km

Number of model levels

Top of model

Forecast length and forecast step interval

Runs per day (times in UTC)

Is there an unperturbed control forecast included? (Y/N)

Number of perturbed ensemble members (excluding control)

Is model coupled to an ocean, waves, sea ice models? Specify which models

Integration time step

Additional comments

3. Initial conditions and Perturbations

Initial perturbation strategy

Optimization time in forecast (if applicable)

Horizontal resolution of perturbations (if different from model resolution)

Initial perturbed area

Data assimilation method for control analysis

Are perturbations to observations employed? (Y/N)

(If Yes, which observation types are perturbed?)

Perturbations added to control analysis or derived directly from ensemble analysis

Perturbations in +/- pairs? (Y/N)

Additional comments

4. Model Uncertainty Perturbations

Is model physics perturbed? If yes, briefly describe method(s)

Do all ensemble members use exactly the same model version, or are, for example, different parameterization schemes used? Please describe any differences

Is model dynamics perturbed? If yes, briefly describe method(s)

Are the above model uncertainty perturbations applied to the control forecast?

Additional comments

5. Surface Boundary Perturbations

Perturbations to sea-surface temperature? If yes, briefly describe method(s).

Perturbations to soil moisture? If yes, briefly describe method(s)

Perturbations to surface wind stress or roughness? If yes, briefly describe method(s)

Any other surface perturbations? If yes, briefly describe method(s)

Are the above surface perturbations applied to the control forecast?

Additional comments

6. Other details of model

What kind of soil scheme is in use?

How are radiations parametrized?

What kind of Large scale dynamics is in use (e.g. gridpoint semi-Lagrangian)? Hydrostatic or nonhydrostatic?

What kind of boundary layer parametrization is in use?

What kind of convection parametrization is in use?

What cloud/microphysics scheme is in use?

Other relevant details

7. Regional Ensemble specifics

Regional domain descriptor (lat/long of boundaries)

Normal source of lateral boundary conditions

Are lateral boundary conditions perturbed?

Specification of lateral boundary conditions required

Are lateral boundary condition requirements compatible with any other global models or standards? If so, please describe

Additional comments

8. Products

Method of the calculation, if the method is not unique

Other detailed specifications, if necessary

9. Further Information

Operational contact point

URLs for system documentation

URL for list of products

_____

APPENDIX 2.2.9. MANDATORY AND HIGHLY RECOMMENDED GLOBAL NUMERICAL LONG-RANGE PREDICTION PRODUCTS TO BE MADE AVAILABLE ON THE WIS

GPC mandatory products (maps)

Parameter	Coverage	Forecast range or Lead Time	Temporal Resolution	Output Type	Issuance Frequency
2-meter Temperature	Global	Any forecast range (lead time)	Averages over 1-month or longer	(1) Ensemble mean	Monthly

Sea Surface Temperature	Global oceans	between 0 and 4 months	periods (seasons)	anomaly (2) Probabilities for tercile forecast categories (where applicable) (3) Probabilities for extremes (*Note: highly recommended, not mandatory*)	
Total Precipitation	Global				

GPC highly recommended products (maps)

Parameter	Coverage	Forecast range or Lead Time	Temporal Resolution	Output Type	Issuance Frequency
500 hPa Height	Global	Any forecast range (lead time) between 0 and 4 months	Averages over 1-month or longer periods (seasons)	(1) Ensemble mean anomaly (2) Probabilities for tercile forecast categories	Monthly
Mean Sea Level Pressure					
850 hPa Temperature					

GPC highly recommended products (SST indices)

Index	Description	Coordinates
Pacific Ocean		
Niño 1+2	Region off coasts of Peru and Chile	90°W - 80°W, 10°S - 0°
Niño 3	Eastern/Central Tropical Pacific	150°W - 90°W, 5°S - 5°N
Niño 3.4	Central Tropical Pacific	170°W - 120°W, 5°S - 5°N
Niño 4	Western/Central Tropical Pacific	160°E - 150°W, 5°S - 5°N
Atlantic Ocean		

TNA	Tropical North Atlantic	55°W - 15°W, 5°N - 25°N
TSA	Tropical South Atlantic	30°W - 10°E, 20°S - 0°
TAD	Tropical Atlantic Dipole	TNA-TSA
Indian Ocean		
WTIO	Western Tropical Indian Ocean	50°E - 70°E, 10°S - 10°N
SETIO	Southeastern Tropical Indian Ocean	90°E - 110°E, 10°S - 0°
IOD (DMI)	Indian Ocean Dipole (Dipole Mode Index)	WTIO-SETIO

Notes:

1. Extremes products are highly recommended (not mandatory). The recommended definitions to be used for extremes are; below 20th percentile and above 80th percentile.

2. Output types: Rendered images (e.g. forecast maps and diagrams). Note: GPCs are encouraged to make available the retrospective forecast (hindcast) and forecast fields underlying the products. GRIB-2 format should be used for fields posted on FTP sites or disseminated through the WIS. GPC are also encouraged to provide hindcast and forecast fields, as listed in Attachment 2.2.4 (section 1), to the LC-LRFMME.

3. Definition of lead time: for example, a three-monthly forecast issued on 31 December has a lead time of 0 months for a January to March seasonal mean forecast, and a lead time of 1 month for a February to April seasonal mean forecast.

4. For all products, forecasts are to be expressed relative to a climatology using at least 15 years of retrospective forecasts.

5. Information on how category boundaries are defined should be made available.

6. Indices are to be displayed using "plumes" of individual ensemble members and/or the "climagram" approach.

7. Indications of skill shall be provided in accordance with Appendix 2.2.23.

———————————————————

APPENDIX 2.2.10. CHARACTERISTICS OF GLOBAL NUMERICAL LONG-RANGE PREDICTION SYSTEMS

Date of implementation of the current seasonal forecast system

Whether the system is a coupled ocean-atmosphere forecast system (Y/N)

Whether the system is a Tier-2 forecast system (Y/N)

Atmospheric model resolution

Ocean model and its resolution (if applicable)

Source of atmospheric initial conditions

Source of ocean initial conditions

If Tier-2, the source of SST predictions

Hindcast period

Ensemble size for the hindcasts

Method of configuring the hindcast ensemble

Ensemble size for the forecast

Method of configuring the forecast ensemble

Length of forecasts

Data format

The latest date that predicted anomalies for the next month/season become available

Method of construction of the forecast anomalies

URL where forecast are displayed

Point of Contact

_____

APPENDIX 2.2.11. RCC mandatory functions

[Insert APPENDIX II-11 of the current Manual on the GDPFS, and replace reference to Attachment II.13 by Attachment 2.2.2]

_____

APPENDIX 2.2.12. Minimum information to be available from LCs-LRFMME

[Insert section 3. of the ATTACHMENT II.12 of the current Manual on the GDPFS, and replace reference to paragraph 3.1 by Appendix 2.2.12]

_____

APPENDIX 2.2.13. Access to GPC data and visualization products held by the Lead Centres for LRFMME

[Insert section 6. of the ATTACHMENT II.12 of the current Manual on the GDPFS]

_____

APPENDIX 2.2.14. Activation of support for nuclear emergency response and standards in the provision of international services by RSMCs

[Insert APPENDIX I-3 of the current Manual on the GDPFS, followed by the: (a) first three paragraphs of APPENDIX II-7 with the following amendments and addition; and (b) last paragraph of APPENDIX II-7, item 5.]

STANDARDS IN THE PROVISION OF INTERNATIONAL SERVICES BY RSMCs FOR NUCLEAR ERA

The Delegated Authority requests support from WMO RSMC for atmospheric transport modelling products by using the form entitled "Environmental Emergency Response — Request for WMO RSMC Support by Delegated Authority" (Appendix 2.2.18). […].

The IAEA requests support from WMO RSMCs for atmospheric transport modelling products by using the form agreed between the WMO and the IAEA (Appendix 2.2.18). […].

The designated RSMCs shall […]:

(a) […];

(b) […];

(c)[…] (~~Appendix I-3, Regional arrangements,~~ paragraphs 9 and 10 of the REGIONAL ARRANGEMENTS);

(d) […].

The RSMCs will distribute their standard products to the NMS Operational Contact Points by […]. The RSMC may also make use of other appropriate technologies.

_____

APPENDIX 2.2.15. Mandatory products and rules for displaying products

[Insert APPENDIX II-7, items 2, 3 and 5.]

_____

APPENDIX 2.2.16. Default emission source parameters

[Insert APPENDIX II-7, item 1.]

_____

APPENDIX 2.2.17. Characteristics of atmospheric transport modelling system

The designated Centres shall document and maintain in WMO/TD-No. 778 and on the WMO Emergency Response Activities website up-to-date information on the characteristics of their atmospheric transport modelling (ATM) system. The information will contain at a minimum:

For ATM:

- Name of model(s) and type (Lagrangian, Eulerian)
- Horizontal grid(s) spacing and extent
- Number of vertical levels and type of vertical coordinates
- Model calculation time step(s) and model output time step(s)
- Information on dry and wet scavenging schemes
- How the emission (source term) is represented / modelled
- Isotopes that can be taken into account

For Numerical Weather Prediction data used for ATM:

- Name of system
- Horizontal grid(s) spacing and extent
- Number of vertical levels and type of vertical coordinates
- Forecast length (hours)
- Update frequency

_____

APPENDIX 2.2.18. Request form to activate RSMC support

[Insert APPENDIX II-7, the form to request WMO support by a Delegated Authority, and the form to request WMO support by IAEA.]

_____

APPENDIX 2.2.19. Specifications for support to CTBTO

[Insert APPENDIX I-6, with the following amendments, followed by APPENDIX II-9]

GLOBAL ARRANGEMENTS FOR ALL RSMCs TO DISTRIBUTE THE PRODUCTS TO CTBTO

~~**NOTIFICATION**~~

In the framework of the cooperation agreement between the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) and WMO that […].

1. All notified RSMCs shall […].
2. […].
3. […].
4. […].

~~**REGIONAL ARRANGEMENTS FOR ONE OR MORE RSMCs TO DISTRIBUTE PRODUCTS TO AN NMHS**~~

~~If support is required for response to an incident requiring backtracking using atmospheric transport models, then the Permanent Representative with WMO, or the person authorized of the requesting country may direct the request for support to the operational contact point of the designated RSMC(s) for its regional association.~~

~~1. The RSMC shall consider each request with regard to its capabilities and the suitability of its products to address the requirements and will then respond accordingly.~~

~~2. The RSMC shall inform the WMO Secretariat of the request and the agreed actions, and may inform all other designated RSMCs of the request.~~

~~3. The RSMC products will be provided to the NMS Operational Contact Point designated by the Permanent Representative.~~

PRODUCTS PROVIDED BY RSMCs WITH ACTIVITY SPECIALIZATION IN ATMOSPHERIC TRANSPORT MODELLING (BACKTRACKING FOR CTBT VERIFICATION SUPPORT)

The CTBTO Provisional Technical Secretariat (PTS) requests support from WMO […].

[…]

_____

APPENDIX 2.2.20. Mandatory atmospheric sand and dust storm products to be made available on the WIS

Forecasts, with an appropriate uncertainty information statement, of the following set of variables:

- Dust load (kg•m^{-2})
- Dust concentration at the surface (µg•m^{-3})
- Dust optical depth at 550 nm (–)
- 3-hour accumulated dry and wet deposition (kg•m^{-2})

Forecasts shall cover the period from the starting forecast time (00 and/or 12 UTC) up to a forecast time of at least 72 hours, with an output frequency of at least 3 hours. They shall cover the whole designated area. The horizontal resolution shall be finer than 0.5x0.5 degrees.

Forecasts shall be disseminated through the WIS and provided on a Web portal in pictorial form not later than 12 hours after the starting forecast time.

An explanatory note should be published on the Web portal when operations are stopped due to technical problems.

_____

APPENDIX 2.2.21. Standardized verification of deterministic NWP products

[Insert ATTACHMENT II.7, Table F, section I of the current Manual on the GDPFS and amend as follows]

1. Introduction

[…]The Lead Centre functions, as described in ~~II.~~2.2.3.1, […]

[…]

[…] implementation across participating centres.

The mathematical formulation of the scores is documented on the LC-DNV website(s), together with supplementary information on score calculation, the observational and climate datasets to be used for verification and procedures for submitting scores.

2. Verification statistics

The following ~~subsections~~sections define two sets of verification statistics. A mandatory set shall be provided by all participating centres. A set of additional recommended statistics is also defined which all centres should provide if possible. ~~The current specifications are for the verification of upper-air fields. The specifications will be expanded as recommended procedures for surface parameters (including 2m temperature, wind, total precipitation) are developed and in response to changing user requirements.~~The procedures for upper-air fields and for surface fields are different and are presented separately. The detailed procedures are required to

ensure it is possible to compare results from the different participating centres in a scientifically valid manner.

~~3~~3. Exchange of scores

Each centre shall provide scores monthly to the LC-DNV. Details of the procedure and the required format for the data are provided on the website of the LC-DNV. All scores for all forecasts verifying within a month shall be provided as soon as possible after the end of that month.

4. Documentation

Participating centres shall provide to the LC-DNV information on their implementation of the standardized verification system annually, shall confirm to the LC-DNV any changes to its implementation (including the annual change of station list for upper-air verification, changes in additional statistics) and changes in their NWP model.

I – STANDARDIZED VERIFICATION OF UPPER-AIR FIELDS

1. Parameters

[…]

~~4~~2. Forecast times

[…]

~~5~~3. Forecast steps

[…]

~~6~~4. Areas

[…]

~~7~~5. Verification against analyses

~~7~~5.1 Grid and interpolation

[…]

6. Verification against observations

~~8~~6.1 Observations

[…]

[…] to compute verification statistics. Whenever possible, these correction procedures should be documented (e.g. by reference to a technical report or journal paper).

~~8~~6.2 Interpolation

[…]

~~8~~6.3 Areas

[…] Section ~~6~~4.

[…] (see subsection ~~8~~6.1)

~~9.~~ **6.4 Scores ~~[move~~for individual stations**

It is recommended that, in addition to ~~*Part II, 1.4]*~~the areas listed in Section 4, scores against observations should be computed for each station individually. The exchange of scores over areas is to be phased out over time.

7. Scores

[…]

~~9.1 Score definitions~~

The ~~following definitions should be used~~

~~Mean error~~ $$M = \left(\sum_{i=1}^{n} w_i (x_f - x_v)_i \right) / \sum_{i=1}^{n} w_i$$

~~Root mean square (rms) error~~ $$rms = \sqrt{\sum_{i=1}^{n} w_i (x_f - x_v)_i^2} \Big/ \sqrt{\sum_{i=1}^{n} w_i}$$

~~Correlation coefficient between forecast and analysis anomalies~~

$$r = \frac{\sum_{i=1}^{n} w_i (x_f - x_c - M_{f,c})_i (x_v - x_c - M_{v,c})_i}{\left(\sum_{i=1}^{n} w_i (x_f - x_c - M_{f,c})_i^2 \right)^{1/2} \left(\sum_{i=1}^{n} w_i (x_v - x_c - M_{v,c})_i^2 \right)^{1/2}}$$

~~rms vector wind error~~ $$rms = \sqrt{\sum_{i=1}^{n} w_i (\vec{V}_f - \vec{V}_v)_i^2} \Big/ \sqrt{\sum_{i=1}^{n} w_i}$$

~~Mean absolute error~~ $$MAE = \sum_{i=1}^{n} w_i \left| x_f - x_v \right|_i / \sum_{i=1}^{n} w_i$$

~~rms anomaly~~ $$rmsa = \sqrt{\sum_{i=1}^{n} w_i (x - x_c)_i^2} \Big/ \sqrt{\sum_{i=1}^{n} w_i}$$

~~standard deviation~~mathematical formulation of ~~field~~ $$sd = \sqrt{\sum_{i=1}^{n} w_i (x - M_x)_i^2} \Big/ \sqrt{\sum_{i=1}^{n} w_i}$$ ~~where~~

$$M_x = \sum_{i=1}^{n} w_i x_i / \sum_{i=1}^{n} w_i$$

~~S1 score~~ $S_1 = 100 \frac{\sum_{i=1}^{n} w_i (e_g)_i}{\sum_{i=1}^{n} w_i (G_L)_i}$

~~Where:~~

x_f ~~=~~ the ~~forecast value of the parameter in question~~

x_v ~~= the corresponding verifying value~~

x_c ~~= the climatological value of the parameter~~

n ~~= the number of grid points or observations in the verification area~~

$M_{f,c}$ ~~= the mean value over the verification area of the forecast anomalies from climate~~

$M_{v,c}$ ~~= the mean value over the verification area of the analysed anomalies from climate~~

$\vec{V}_f$ ~~= the forecast wind vector~~

e_g ~~=~~ $\left\{ \left| \frac{\partial}{\partial x}(x_f - x_v) \right| + \left| \frac{\partial}{\partial y}(x_f - x_v) \right| \right\}$

G_L ~~=~~ $\max\left(\left| \frac{\partial x_f}{\partial x} \right|, \left| \frac{\partial x_v}{\partial x} \right| \right) + \max\left(\left| \frac{\partial x_f}{\partial y} \right|, \left| \frac{\partial x_v}{\partial y} \right| \right)$

~~where the differentiation~~ scores is ~~approximated by differences computed~~documented on the ~~verification grid~~LC-DNV website, together with supplementary information on score calculation.

~~The weights~~ w_i ~~applied at each grid point or observation location are defined as~~

~~Verification against analyses:~~ $w_i = \cos\phi_i$ ~~, cosine of latitude at grid point i~~

~~Verification against observations:~~ $w_i = 1/n$ ~~, all observations have equal weight~~

~~10. **Exchange of scores**~~

~~Each centre shall provide scores monthly to the LC-DNV. Details of the procedure and the required format for the data are provided on the website of the LC-DNV. All scores (12-hourly)~~

~~for all forecasts verifying within a month shall be provided as soon as possible after the end of that month.~~

~~11~~8. Climatology

[…]

~~12~~9. Monthly and annual averaged scores

[…]

~~13~~10. Confidence Intervals

[…]

II – STANDARDIZED VERIFICATION OF SURFACE FIELDS

1. Parameters and units

Mandatory

- 2-m temperature K
- 10-m wind speed m s^{-1}
- 10-m wind direction deg
- 24-h precipitation mm

Additional recommended

- Total cloud cover 0-1 (convert to okta for contingency tables)
- 6-h precipitation mm
- 2-m relative humidity %
- 2-m dewpoint K

For 2-m temperature, a simple height-correction between model altitude and station elevation shall be applied using a constant lapse rate of 0.0065 K m^{-1}. For 2-m dewpoint an analogous height-correction shall be applied using a constant lapse rate of 0.0012 K m^{-1}. This approximates the dewpoint lapse rate in an atmosphere with a temperature lapse rate of 0.0065 K m^{-1} and constant specific humidity.

2. Forecast times

Scores shall be computed daily for forecasts initialized at 00 UTC and 12 UTC separately. For those~~. **Documentation**~~

~~Participating~~ centres not running forecasts from either 00 UTC or 12 UTC, scores may be provided for forecasts initiated at other times and must be labelled as such.

3. Forecast steps

Mandatory:

6-hourly up to T+72, 12-hourly up to T+240 or end of the forecast

For 24-h precipitation: 24-hourly up to T+240 or end of the forecast

Additional recommended:

3-hourly up to T+72, 6-hourly up to T+240 or end of the forecast (for improved representation of diurnal cycle)

For 6-h precipitation: 6-hourly up to T+240 or end of the forecast

4. Grid and interpolation

Verification shall be based on the native model grid using the grid point nearest to the observation location.

5. Observations

Verification ~~shall provide to~~ shall be carried out for SYNOP surface stations distributed via the GTS. Each participating centre should aim to include as many stations as possible to ensure good global coverage. The list of stations used in the verification is allowed to differ between centres. This is made possible by the fact that scores for individual stations will be exchanged.

Centres are encouraged to make use of the quality control procedures available to them to reduce the effect of observation errors on scores. This includes removal of occasional unphysical values as well as data at individual stations which has been systematically rejected over a certain time period. Whenever possible, the quality control procedures should be documented (e.g. by reference to a technical report or journal paper).

6. Scores

Scores are computed for each station individually. A station for which scores are computed should have at least 90% data availability during the verification period.

For 2-m temperature, 2-m relative humidity, 2-m dewpoint, 10-m wind speed, 10-m wind direction, and total cloud cover the following error scores are computed:

- Mean error (ME)
- Mean absolute error (MAE)
- Root mean square error (RMSE)

10-m wind direction is verified only when the observed wind speed is ≥ 3 m s^{-1}. For 10-m wind direction the equivalence of 360 and 0 degrees needs to be taken into account (cyclic continuation).

For 10-m wind speed, precipitation, and total cloud cover, contingency-tables for the following thresholds shall be provided:

- 10-m wind speed: 5, 10, and 15 m s^{-1}
- 24-h precipitation: 1, 10, and 50 mm
- 6-h precipitation: 1, 5, and 25 mm
- Total cloud cover: 2 okta, 7 okta

For total cloud cover, the model output should be rounded to the nearest okta prior to verification (for the contingency tables only).

Error scores shall be reported with a precision of at least 4 significant digits, e.g. 3.142 for an error of π. In the contingency tables, absolute number of counts shall be given rather than relative frequencies so that the sample size can be derived.

The contingency tables for each parameter shall contain all thresholds given above. The mathematical formulation of the scores is documented on the LC-DNV website, together with supplementary information on ~~their implementation of the standardized verification system annually, shall confirm~~score calculation.

7. Temporal and spatial aggregation

For any given 1 month period, error scores and contingency tables are computed for each station individually. It forms the basis for aggregation by users of the exchanged verification data, both in time and space. For a defined period, the average shall be computed over all forecasts verifying during the period.

Spatial aggregation is not part of the exchange, and is left to user discretion. Exchanging scores in this way allows forecast users to get detailed information on model performance for individual stations. It also ensures a high level of transparency and flexibility for model intercomparison studies. Furthermore, it removes the requirement of coordinating, circulating, and updating whitelists of surface stations for verification. For model intercomparison studies the intersection of the different sets of stations used by global modelling centres would be used for comparison ('smallest common denominator').

If users would like to aggregate the exchanged scores, they can refer to the LC-DNV ~~any changes to its implementation (including the annual change of station list, changes in additional statistics) and changes in their NWP model.~~website which provides guidelines for the choice of aggregation areas. Compared to upper-air verification, more emphasis needs to be put on aggregating over climatologically relatively homogeneous areas (since absolute thresholds are used for the contingency tables).

_____

APPENDIX 2.2.22. Standard verification measures of global EPS

1. Introduction

This Appendix presents detailed procedures for the production and exchange of a standard set of verification scores for EPS forecasts produced by GDPFS centres. The goal is to provide consistent verification information on the EPS products of GDPFS participating centres for forecasters in the NMHSs and to help the GDPFS Centres compare and improve their forecasts. Scores will be exchanged between the participating producing centres via the Lead Centre for EPS Verification. The Lead Centre functions, as described in 2.2.3.2, include creating and maintaining a website for EPS verification information, so that potential users will benefit from a consistent presentation of the results.

EPS provides a complete estimation of the forecast probability distribution, including a best-estimate deterministic forecast from the ensemble mean as well as measures of forecast uncertainty and probabilities. Verification of the EPS therefore includes verification of the ensemble mean as a deterministic NWP forecast following the guidance set out in Appendix 2.2.21 as well as specific measures of the probabilistic performance.

The standardized verification should provide key relevant information appropriate to the state-of-the-art in EPS, while being as simple and as easy to implement as possible, and ensuring a

consistent implementation across participating centres, in particular in the interpolation to verification grid, and use of a common climatology and set of observations.

2. Verification statistics

The following subsections define four sets of verification statistics. A mandatory set shall be provided by all participating centres. A set of additional recommended statistics is also defined which all centres should provide if possible. The detailed procedures are required to ensure it is possible to compare results from the different participating centres in a scientifically valid manner.

The four sets of statistics are summarized as:

Mandatory

- Ensemble Mean
- Spread - standard deviation of the ensemble averaged over the same regions and variables as used for the ensemble mean
- Continuous Ranked Probability Score (CRPS)

Additional recommended

- Probability Scores – scores for probabilities of specific thresholds are exchanged in the form of reliability tables. Several different scores are computed by the Lead Centre(s) based on the reliability tables provided by participating centres

Specifications of forecast verification set out in the paragraphs below apply to calculation of the CRPS and Probability Scores. Verification of the Ensemble Mean and Spread should follow the specifications set out in Appendix 2.2.21 as stated above.

3. Parameters

Root mean square error and correlation coefficient between forecast and analysis anomalies of ensemble mean shall be calculated for the following set of parameters:

- Mean Sea Level Pressure (PMSL)
- 500 hPa geopotential height
- u and v wind components at 850 and 250 hPa
- 850 hPa temperature

Spread shall be calculated for the same set of parameters for ensemble mean.

Reliability tables for the calculation of probability scores shall be calculated for the following set of parameters and thresholds:

- PMSL anomalies ± 1, ± 1.5, ± 2 standard deviation with respect to the defined climatology
- 500 hPa geopotential height anomalies with thresholds ± 1, ± 1.5, ± 2 standard deviation with respect to the defined climatology
- 850 hPa wind speed with thresholds of 10, 15, 25 m s^{-1}

- 850 hPa u and v wind components with thresholds of 10th, 25th, 75th and 90th percentile points with respect to the defined climatology.
- 250 hPa u and v wind components with thresholds of 10th, 25th, 75th and 90th percentile points with respect to the defined climatology.
- 850 hPa temperature anomalies with thresholds ± 1, ± 1.5, ± 2 standard deviation with respect to the defined climatology.
- Precipitation with thresholds 1, 5, 10, and 25 mm/24 hours
- 10m wind speed with thresholds 10 and 15 m s^{-1}
- 2m temperature anomalies with thresholds ± 1, ± 1.5, ± 2 standard deviation with respect to the defined climatology

NOTE: Where thresholds are defined with respect to climatology, the defined climatology is set out in paragraph 11 below.

CRPS shall be calculated for the same set of parameters for probability score.

4. Forecast times

Scores shall be computed daily for forecasts initialized at times to be specified by the centre, but should include all forecast cycles made available on the WIS.

5. Forecast steps

Every 24h to the end of the forecast range.

6. Areas

Northern hemisphere extra-tropics 90°N - 20°N, inclusive, all longitudes

Southern hemisphere extra-tropics 90°S - 20°S, inclusive, all longitudes

Tropics 20°N - 20°S, inclusive, all longitudes

Verification against analyses for grid points within each area, including points on the boundary.

7. Verification against analyses

7.1 Grid and interpolation

All parameters except precipitation shall be verified against the centre's own analysis on a regular 1.5° x 1.5° grid.

In selecting the verification grid, consideration has been given to the variety of resolutions of current global NWP models, the resolved scales of models (several grid-lengths), the resolution of the available climatologies, the potential to monitor long-term trends in performance (including earlier, lower resolution forecasts) and computational efficiency.

Interpolation of higher resolution model fields to the verification grid shall be performed to retain features at the scale of the verification grid but not to introduce any additional smoothing. The following procedures shall be used:

- Spectral fields: truncate to equivalent spectral resolution (T120) for verification grid;
- Grid point fields: use area-weighting to interpolate to verification grid.

For scores requiring a climatology the climatology is specified in paragraph 11 below.

Verification of precipitation is recommended to be performed against observations (paragraph 8), but may alternatively be against a proxy analysis (i.e. a short-range forecast from the control or high-resolution deterministic forecast, e.g. 12-36h forecast to avoid spin-up problems).

8. Verification against observations

8.1 Observations

Observations for EPS verification of precipitation should be based on the GCOS list of surface networks (GSN). Producing centres shall have the right to omit certain observation sites should they fail a quality control.

8.2 Interpolation

Verification shall be made using the nearest native model grid point to the observation location.

8.3 Areas

The networks used in verification against observations consist of observation stations located in the areas listed in Section 6.

9. Scores

Root mean square error and correlation coefficient between forecast and analysis anomalies are to be calculated for all parameters by the participating centres and provided to the Lead Centre in the form specified on the Lead Centre website.

The following scores are to be calculated for all parameters *(computed by Lead Centre(s) based on reliability tables provided by participating centres)*:

- Brier Skill Score (with respect to climatology);
- Relative Operating Characteristic (ROC);
- Relative economic value (C/L) diagrams;
- Reliability diagrams with frequency distribution.

The CRPS is to be calculated for all parameters by the participating centres and provided to the Lead Centre in the format specified on the Lead Centre website. Centres are encouraged to submit CRPS scores for both EPS and the deterministic (control and high-resolution) forecast - CRPS for deterministic forecast is equal to the mean absolute error.

10. Exchange of scores

Each centre shall provide scores monthly to the Lead Centre. Details of the procedure and the required format for the data are provided on the Lead Centre website. All scores for all forecasts verifying within a month shall be provided as soon as possible after the end of that month.

11. Climatology

To ensure consistency between results from different centres a common climatology shall be used for those scores requiring a climatology. All centres shall use the climatology provided via the Lead Centre website, which is the same climatology specified in Appendix 2.2.21 and available from the LC-DNV website.

A daily climatology of upper-air parameters are available for both 00 UTC and 12 UTC. This provides an up-to-date estimate of climate characteristics for each day of the year, including climate mean, standard deviation and selected quantiles of the climate distribution. These latter statistics are required for the CBS standardized verification of EPS forecasts.

The data is made available in GRIB format. Information on access to the data and further documentation are provided on the LC-DNV website.

12. Documentation

Participating centres shall provide to the Lead Centre information on their implementation of the standardized verification system annually, shall confirm to the Lead Centre any changes to its implementation (including the annual change of station list, changes in additional statistics) and changes in their NWP model.

_____

APPENDIX 2.2.23. Standardized verification System for long-range forecasts (SVSLRF)

1. Introduction

This Appendix describes procedures for the production and exchange of a standard set of verification scores for long-range forecasts (LRF) produced by GDPFS centres. Provision of the verification products described is mandatory for Global Producing Centres of Long-Range Forecasts (GPCs). The goal is to provide consistent verification information on the LRF products of GPCs that will assist forecasters in RCCs, NMHSs and at RCOFs to prepare regional and national seasonal outlooks, and also to help the GPCs compare and improve their forecast systems. The verification scores described are to be calculated on retrospective forecasts (hindcasts). GPCs will exchange scores via the Lead Centre for Standardized Verification System for Long-Range Forecasts (LC-SVSLRF). The Lead Centre functions, as described in 2.2.3.3, include creating and maintaining a website for displaying standardized verification products from GPCs, so that potential users will benefit from a consistent presentation of the results. Skill measures recommended for use by RCCs in verification of regional forecasts include those described here.

This Appendix describes the verification scores and the variables, regions, seasons and lead-times for which the scores shall be applied. The mathematical formulation of the scores is documented on the LC-SVSLRF website(s), together with supplementary information on score calculation, the observational datasets to be used for verification and procedures for submitting scores.

2. Verification statistics

The following sections describe the scores that are mandatory for GPCs. Information on additional recommended scores is provided on the LC-SVSLRF website.

Two types (levels) of verification are required:

Level 1: scores aggregated over all grid-points within specified regions (which, collectively, include global coverage) and scores for climate indices;

Level 2: scores evaluated at individual grid points (with global coverage).

For level 1 and level 2, verification of both deterministic (ensemble mean) forecasts and probabilistic forecasts (for tercile categories) is required.

3. Parameters

The variables and categorical stratifications to be verified for level 1 are:

a. 3-month-mean T2m (screen temperature): ensemble mean and probabilities for 3 tercile categories;

b. 3-month precipitation accumulation: ensemble mean and probabilities for 3 tercile categories;

c. Monthly Niño3.4 Sea Surface Temperature (SST) indices (for GPCs operating coupled (1-tier) prediction systems): ensemble mean and probabilities for 3 tercile categories.

The variables and categorical stratifications to be verified for level 2 are:

a. As (a);

b. As (b);

c. 3-month-mean SST: ensemble mean and probabilities for 3 tercile categories.

Where the terciles of the climatology are defined over the hindcast period used (see section 11) and the 3-month-mean periods are described in section 5.

4. Forecast times/frequency

In general scores shall be computed for hindcasts initialized at monthly intervals. Some Level 1 scores are required only at quarterly intervals (see next section).

5. Forecast target periods and lead-times

Level 1: T2m and precipitation

Target periods: The 3-month target periods for level 1 are:

March-April-May (MAM), June-July-August (JJA), September-October-November (SON) and December-January-February (DJF).

Lead times: nominal 1-month lead time. For example, forecasts issued e.g. on 15 May for the JJA season are considered to have a nominal lead time of 1 month.

Level 1: Niño3.4 indices (for GPCs operating coupled systems)

Target periods: each calendar month of the forecast;

Lead times: 1, 2, 3, 4 and 5 months.

Level 2: T2m and precipitation

Target periods: Twelve rolling 3-month periods (e.g. MAM, AMJ, MJJ…).

6. Areas

Northern hemisphere extra-tropics: 90°N - 20°N, inclusive, all longitudes

Southern hemisphere extra-tropics: 90°S - 20°S, inclusive, all longitudes

Tropics: 20°N - 20°S, inclusive, all longitudes

Verification to be aggregated over all grid points within each area, including points on the boundary.

For verification of the Niño3.4 region index, SST averaged over the Nino3.4 region (5°N - 5°N; 170°W - 120°W) shall be used.

7. Verification against analyses

7.1 Grid and interpolation

All parameters (excepting indices) shall be interpolated to a regular 2.5° x 2.5° grid prior to verification.

The historical SST, T2m and precipitation analyses to be used for verification may be subject to change and are specified on the LC-SVSLRF website. The LC-SVSLRF will inform GPCs when a change is made.

Skill scores require verification of climatology-based forecasts as baseline reference against 'true' forecasts. The same analysis shall be used to verify the reference and the forecast.

8. Verification against observations

Verification against station observations is not mandatory for GPCs. GPCs should use the scores described here and verify against observation sets of their choice that are suitable for purpose.

9. Scores

The following scores are to be calculated for all parameters:

Level 1: T2m and precipitation

Probability forecasts:

- Reliability diagrams with frequency histograms;
- Relative Operating Characteristic (ROC) diagram with standardized area under the ROC curve.

Deterministic forecasts:

- Mean Square Skill Score (MSSS) with respect to climatology.

Level 1: Niño3.4 indices (for GPCs operating coupled systems)

Probability forecasts:

- Relative Operating Characteristic (ROC) diagram with standardized area under the ROC curve.

Deterministic forecasts:

- Mean Square Skill Score (MSSS) with respect to climatology and its 3-term decomposition.

Level 2: T2m and precipitation

Probability forecasts:

- Relative Operating Characteristic (ROC) diagram with standardised area under the ROC curve.

Deterministic forecasts:

- Mean Square Skill Score (MSSS) with respect to climatology and its 3-term decomposition.

Provision of the statistical significance of scores and/or error bars is not currently mandatory but is strongly recommended. GPCs are free to choose the method of calculation (guidance is available on the LC-SVSLRF website).

10. Exchange of scores

Each centre should provide scores to the LC-SVSLRF and update the scores on any change of the real-time prediction system. Details of the procedure and the required format for the data exchange are provided on the Lead Centre website.

11. Hindcast datasets

Hindcast datasets shall be generated with the same prediction system that is used to generate the real-time forecasts, though it is recognized that the hindcast ensemble may necessarily be smaller than used in real-time. It is also recognized that the source of initial conditions used for hindcasts may, for some centres, be different from that used for real-time forecasts.

The hindcast period used should be as long as possible, but at least 15 years. The recommended period is provided on the LC-SVSLRF website.

12. Documentation

Participating centres shall provide to the Lead Centre information on the specification of their prediction system, and promptly update the specification when there are system changes.

———————————————————

ATTACHMENT 2.2.1. ADDITIONAL GLOBAL NUMERICAL LONG-RANGE PREDICTION PRODUCTS TO BE MADE AVAILABLE ON THE WIS

Other long-range seasonal forecast data, products or other information, in addition to the minimum list in Appendix 2.2.9, which could also be provided by GPCs on request by RCCs or NMCs (the RCCs and NMCs would adhere to conditions, if any, attached by the GPCs to these data and products):

1. Grid point data values:

- Hindcast and forecast data for downscaling algorithms;
- Data for RCM boundary and initial conditions;

- Predicted global weekly values of SST.

2. Information to assist in building capacity in areas such as:

- Interpretation and use of seasonal forecast products;
- Downscaling techniques (both statistical and dynamical);
- Verification techniques (to be used for local verification of RCC generated products);
- Development of local user applications for RCC downscaled products;
- Use and implementation of regional climate models.

_____

ATTACHMENT 2.2.2. ADDITIONAL HIGHLY RECOMMENDED RCC FUNCTIONS

[Insert ATTACHMENT II.10 of the current Manual on the GDPFS]

_____

ATTACHMENT 2.2.3. GUIDELINES FOR FEEDBACK FROM RCCS/NHMSS TO GPCS

[Insert ATTACHMENT II.13 of the current Manual on the GDPFS, and replace reference to Appendix II-6, section 4.2 by Appendix 2.2.9 and insert a new item 6. as follows]

[…]

6. Report on the comparative performance of GPCs for the region of RCC/NMHSs responsibility; both for real-time forecasts and, if available, from retrospective forecasts.

[…]

_____

ATTACHMENT 2.2.4. ADDITIONAL INFORMATION TO BE AVAILABLE FROM LCs-LRFMME

[Insert section 4. of the ATTACHMENT II.12 of the current Manual on the GDPFS, and replace reference to paragraph 3.1 by Appendix 2.2.12 and to Appendix II-6, section 4.2 by Appendix 2.2.9]

_____

PART III. GDPFS IMPLEMENTATION

[Insert Appendix I 1 of the current Manual]

Recommendation 20 (CBS-16)

INTRODUCTION OF NEW TYPES OF CENTRE INTO THE REVISED *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485)

THE COMMISSION FOR BASIC SYSTEMS,

Considering the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

Recalling:

(1) Resolution 6 (Cg-XVI) – Revised *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

(2) Resolution 12 (Cg-17) – Report of the extraordinary session (2014) of the Commission for Basic Systems concerning the introduction of the new *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

Noting Recommendation 19 (CBS-16) – Revised *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

Acknowledging the important collaboration and coordination between the Commission for Basic Systems (CBS) Open Programme Area Group on Data-processing and Forecasting Systems (OPAG-DPFS) and other technical commissions and international organizations, in relation to the introduction of new types of centre into the revised *Manual on the Global Data-processing and Forecasting System*,

Urges OPAG-DPFS, in collaboration and coordination with relevant WMO technical commissions and programmes, and other international organizations, to develop text for the missing elements in the new Manual, including those related to hydrology, agriculture, polar regions, storm surge prediction, and space weather;

Recommends to the Executive Council the introduction of new types of centre into the revised *Manual on the Global Data-processing and Forecasting System*, in line with the Resolution 12 (Cg-17) as follows:

(1) Under "General purpose activities" (section 2.2.1):

(a) Numerical ocean wave prediction, as provided in Annex 1 to the present recommendation;

(b) Global numerical ocean prediction, as provided in Annex 2 to the present recommendation;

(c) Nowcasting, as provided in Annex 3 to the present recommendation;

(2) Under "Specialized activities" (section 2.2.2):

(a) Regional severe weather forecasting, as provided in Annex 4 to the present recommendation;

(b) Volcanic contaminants, as provided in Annex 5 to the present recommendation;

(c) Non-nuclear environmental emergency response, as provided in Annex 6 to the present recommendation;

(d) Coordination of near-term climate prediction, as provided in Annex 7 to the present recommendation,

(e) Marine meteorological services, as provided in Annex 8 to the present recommendation,

(f) Marine environmental emergencies, as provided in Annex 9 to the present recommendation,

(3) Under "Non-real-time coordination activities" (section 2.2.3):

(a) Coordination of wave forecast verification, as provided in Annex 10 to the present recommendation;

(b) Coordination of tropical cyclone forecast verification, as provided in Annex 11 to the present recommendation;

Authorizes the president of CBS, in consultation with the Secretariat, to make any consequential purely editorial amendments with respect to the *Manual on the Global Data-processing and Forecasting System*.

Annex 1 to Recommendation 20 (CBS-16)

NUMERICAL OCEAN WAVE PREDICTION

2.2.1.X. Numerical ocean wave prediction

2.2.1.X.1 Centres conducting numerical ocean wave prediction shall:

(a) Prepare global analyses of ocean wave parameters;

(b) Prepare global forecast fields of basic and derived ocean wave parameters;

(c) Make available on the WIS a range of these products. The list of mandatory and highly recommended products to be made available is given in Appendix 1;

(d) Prepare verification data and make them available to the Lead Centre(s) for Wave Forecast Verification;

(e) Make available on a website up-to-date information on the characteristics of its global numerical ocean wave prediction system. The minimum information to be provided is given in Appendix 2;

Note: The bodies in charge of managing the information contained in the *Manual* related to numerical ocean wave prediction are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	JCOMM/ETWCH		
To be recommended by:	CBS	JCOMM	
To be decided by:	EC/Congress		

CENTRES DESIGNATION			
To be recommended by:	RA	CBS	JCOMM
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	JCOMM/ETWCH		
To be reported to:	CBS	JCOMM	

APPENDIX 1. MANDATORY AND HIGHLY RECOMMENDED NUMERICAL OCEAN WAVE PREDICTION PRODUCTS TO BE MADE AVAILABLE ON THE WIS

Parameter	Level	Minimum Resolution	Forecast range	Time steps	Frequency
Significant Wave Height	surface	0.5º x 0.5º	Up to 3d / Beyond 3d up to 7d	Every 3h / Every 6h	Twice a day
Peak Wave Period and Mean Zero-upcrossing Period	surface				
Prevailing Direction - Mean Wave Direction and/or - Principle Wave Direction	surface				

Additional recommended products:

- U and V component of 10 wind
- Full 2-D wave spectra at subset of grid points
- Wind sea and swell split at all grid points
- Derived parameters including wave steepness, directional spreading, rogue wave potential

APPENDIX 2. CHARACTERISTICS OF THE NUMERICAL OCEAN WAVE PREDICTION SYSTEMS

1. System
System name (version)
Date of implementation
2. Configuration
Horizontal resolution of the model, with indication of grid spacing in km
Number of model frequency bands
Number of model directional bands
Forecast length and forecast step interval
Runs per day (Times in UTC)
Is model coupled to an ocean, atmosphere, sea ice models? Specify which models
Integration time step
Additional comments
3. Initial conditions
Data assimilation method
Additional comments
4. Surface Boundary Conditions
Surface forcing, briefly describe method(s).
Lateral boundary conditions e.g., sea ice cover? If yes, briefly describe method(s).
Additional comments
5. Other details of model
What kind, if any, of sea/swell splitting scheme is in use?
Are wave observations, or spectra, assimilated? If so, describe method briefly.
Does the model contain shallow water physics? What bathymetry data base is used for shallow water areas?
Verification approach?
Other relevant details?
6. Further Information
Operational contact point
URLs for system documentation
URL for list of products

Annex 2 to Recommendation 20 (CBS-16)

GLOBAL NUMERICAL OCEAN PREDICTION

2.2.1.X. Global Numerical Ocean Prediction

2.2.1.X.1 Centres conducting global numerical ocean prediction shall:

(a) Prepare global analyses of oceanographic parameters;

(b) Prepare global forecast fields of basic and derived oceanographic parameters;

(c) Make available on the WIS a range of these products. The list of mandatory and highly recommended products to be made available is given in Appendix 3;

(d) Prepare verification statistics and make them available on a website;

(e) Make available on a website up-to-date information on the characteristics of its global numerical ocean prediction system. The minimum information to be provided is given in Appendix 4.

Note: The bodies in charge of managing the information contained in the *Manual* related to global numerical ocean prediction are specified in the Table below.

RESPONSIBILITY *CHANGES TO ACTIVITY SPECIFICATION*			
To be proposed by:	JCOMM/ETOOFS		
To be recommended by:	CBS	JCOMM	
To be decided by:	EC/Congress		
DESIGNATION			
To be recommended by:	RA	CBS	JCOMM
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	JCOMM/ETOOFS		
To be reported to:	CBS	JCOMM	

APPENDIX 3. MANDATORY AND HIGHLY RECOMMENDED GLOBAL NUMERICAL OCEAN PREDICTION PRODUCTS TO BE MADE AVAILABLE ON THE WIS

Parameter	Level	Minimum Resolution	Forecast range	Minimum Time steps	Frequency
Sea surface elevation	Surface	0.5 º x 0.5 º	Up to 6d	Every 24h	Once a day
Sea surface Temperature	Surface (mixed layer)				
Surface u, v	Surface				
Sea surface salinity	Surface				
U, V	Depth TBD				
Temperature	10/50/100/250/500 (m)				
Mixed layer depth					

Additional recommended products:

- None

APPENDIX 4. CHARACTERISTICS OF THE GLOBAL NUMERICAL OCEAN PREDICTION SYSTEMS

1. System
System name (version)
Date of implementation
2. Configuration
Horizontal resolution of the model, with indication of grid spacing in km
Number of model levels
Bottom of model
Forecast length and forecast step interval
Runs per day (Times in UTC)
Is model coupled to an atmosphere, waves, sea ice models? Specify which models
Integration time step
Additional comments
3. Initial conditions
Data assimilation method
Additional comments
4. Surface Boundary Conditions
Surface forcing, briefly describe method(s).
Lateral boundary conditions e.g., river discharge ? If yes, briefly describe method(s).
Additional comments
5. Other details of model
What kind of mixing scheme is in use?
How are radiations parametrized?
What kind of Large scale dynamics is in use (e.g. gridpoint semi-Lagrangian)? Hydrostatic?
Data assimilation scheme?
QC scheme?
Verification approach?
Other relevant details?
6. Further Information
Operational contact point
URLs for system documentation
URL for list of products

Annex 3 to Recommendation 20 (CBS-16)

NOWCASTING

2.2.1.X. Nowcasting

2.2.1.X.1 Centres conducting nowcasting shall:

(a) Operate a system, including a web-based or generic graphical service, describing in real-time or near real-time the current state of the weather in detail and the prediction of its changes in several hours ahead (0-6 hours) over their area of interest or parts of that area;

(b) Provide access to this service to NMHSs whose operational warning services may benefit from it;

(c) Prepare verification statistics and evaluations of the system;

(d) Make available on a website up-to-date information on the characteristics of the system. The minimum information to be provided is given in Appendix 5.

Note: The bodies in charge of managing the information contained in the *Manual* related to nowcasting are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OWFPS		
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	RA	CBS	
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-OWFPS		
To be reported to:	CBS/ICT-DPFS	CBS	

APPENDIX 5. CHARACTERISTICS OF NOWCASTING SYSTEMS

1. System

Application areas

Name(s) of system(s) involved

Date(s) of implementation

2. Configuration

Domain and resolution

Parameters

Production cycle *(frequency of updates, time range, time interval)*

Production methods *(extrapolation, blending, NWP (Deterministic or Ensemble), expert system, human-machine interfaced system...)*

Additional comments

3. Input data

(observations, analyses, numerical forecasts, …)

Additional comments

4. NWP

Refer to Appendices related to the characteristics of Global Deterministic and Limited Area NWP systems, and characteristics of Global and Limited Area EPS (no need to repeat system description if available under those sections).

5. Output data (Product)

6. Data visualization system

7. Verification system

(Verified parameters, performance matrix, …)

8. Further Information

Operational contact point

URLs for system documentation

URL for list of products

Annex 4 to Recommendation 20 (CBS-16)

REGIONAL SEVERE WEATHER FORECASTING

2.2.2.X. Regional severe weather forecasting

Note: This activity includes a network of Regional Centre(s) and associated National Meteorological Centres (NMCs).

2.2.2.X.1 Centres conducting regional severe weather forecasting shall:

(a) Agree on the targeted severe events, phenomena, criteria for guidance and extent of regional domain with associated NMCs;

(b) Prepare, at least once per day, severe weather forecasting guidance products for associated NMCs containing an interpretation of deterministic NWP, EPS and remote sensing-based guidance products;

(c) Make available, on a dedicated website (with password protection as appropriate), relevant deterministic NWP, EPS and remote sensing-based guidance products;

(d) Where severe weather is associated with Tropical Cyclones, the centre will take guidance from the appropriate RSMC for Tropical Cyclone Forecasting and interpret it in terms of severe weather guidance.

2.2.2.X.2 National Meteorological Centres (NMCs) associated in this activity shall:

(a) Provide criteria for severe weather warnings to the relevant Regional Centre(s) participating in this activity;

(b) Evaluate products, including the daily severe weather forecasting guidance, and provide feedback to the Regional Centre(s);

(c) Ensure that appropriate warnings of severe weather are issued.

Note: The bodies in charge of managing the information contained in the *Manual* related to regional severe weather forecasting are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OFPS	SG SWFDP	
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	RA	CBS	
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	SG SWFDP		
To be reported to:	CBS/ICT-DPFS	CBS	

Annex 5 to Recommendation 20 (CBS-16)

VOLCANIC CONTAMINANTS

2.2.2.X. Volcanic contaminants

Notes:

(1) For services in support of international air navigation, WMO *Technical Regulation* (WMO-No. 49), Volume II, sections 3.5 and 3.6 refer.

(2) For all other services, non-nuclear environmental emergency response refers.

Annex 6 to Recommendation 20 (CBS-16)

NON-NUCLEAR ENVIRONMENTAL EMERGENCY RESPONSE

2.2.2.X. Non-nuclear environmental emergency response

2.2.2.X.1 Centres conducting non-nuclear emergency response shall:

(a) Prepare on request, from an authorized person[1], atmospheric transport and dispersion forecast or hindcast products relating to events in which hazardous non-nuclear contaminants have been released into the atmosphere. The criteria for activation of the regional support procedures and the Request Form are given in Appendices 6 and 10;

(b) As soon as possible, but usually within 2 hours of a request from an authorized person[1], make available a range of products to the NMHS operational contact point [2] by e-mail or retrieval from the RSMC password protected designated website. The list of mandatory and highly recommended products to be made available, including parameters, forecast range, time steps and frequency, is given in Appendix 7;

(c) Use agreed default emission source parameters for essential parameters when actual source information is not available. Default source parameters for a range of release scenarios are given in Appendix 8;

(d) Make available on a website up-to-date information on the characteristics of its atmospheric transport and dispersion modelling (ATDM) system (minimum information to be provided is given in Appendix 9) and a users interpretation guide for ATDM products (Appendix 11).

Note: The bodies in charge of managing the information contained in the *Manual* related to non-nuclear emergency response are specified in the Table below.

RESPONSIBILITY *CHANGES TO ACTIVITY SPECIFICATION*			
To be proposed by:	CBS/ET-ERA		
To be recommended by:	CBS		
To be decided by:	EC/Congress		
DESIGNATION			
To be recommended by:	CBS		

[1] The person authorized by the Permanent Representative of the WMO Member to request RSMC support; normally the NMHS operational contact point.
[2] Designated by the Permanent Representative.

To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-ERA		
To be reported to:	CBS/ICT-DPFS	CBS	

APPENDIX 6. ACTIVATION OF SUPPORT FOR NON-NUCLEAR ENVIRONMENTAL EMERGENCY RESPONSE

Environmental emergencies can be caused by a broad range of events with various temporal and spatial scales involving the release of hazardous substances into the environment. The scope of non-nuclear ERA includes: smoke from large fires, emissions from volcanic eruptions, and large chemical releases. Volcanic ash activities are not covered here, but are instead covered under activity 2.2.2.X. Atmospheric sand and dust storm forecasts are covered under activity 2.2.2.5.

NMHSs may request RSMC support for releases that have the potential for large-scale (i.e. mesoscale) and/or long-duration (hours to days) impacts, according to the capability of the RSMC. RSMC products are typically not applicable for shorter range incidents. RSMCs will advise NMHSs if requests are not within their capabilities.

NMHSs requesting RSMC support shall:

- Request via the authorized person[3] that an RSMC provides, in accordance to its designation, products relating to events in which hazardous non-nuclear contaminants have been released into the atmosphere.
- Requests should be made by e-mailing (preferred) or faxing the completed form in Appendix 10 to the appropriate RSMC. If the RSMC has not confirmed reception within 20 minutes, the requester should contact the RSMC by phone or e-mail.
- Provide the RSMCs with the essential information specified on the request form.
- NMHSs will distribute the products within their State based on their national arrangements.

APPENDIX 7. MANDATORY AND HIGHLY RECOMMENDED LIST OF NON-NUCLEAR ENVIRONMENTAL EMERGENCY RESPONSE

Smoke from forest, grass or peat fires (default values in Appendix 8 will be used for source parameters not provided)

- Forecast duration 36 hours
- Relative concentrations[4] from the surface to 200 m^2
- Images at intervals of 1, 3 or 6 hours[5]

[3] The person authorized by the Permanent Representative of the WMO Member to request RSMC support; normally the NMHS operational contact point.
[4] Absolute concentrations may be provided if an estimate of the total mass released or actual mass rate are provided.

- Contouring to be determined based on specifics of the event or the request

Smoke from industrial fire (default values for parameters not provided)

- Forecast duration 12 hours
- Relative concentrations[4] from the surface to 200 m[2]
- Images at intervals of 1 or 3 hours[2]
- Contouring to be determined based on specifics of the event or the request

Chemical releases not involving fire (default values for parameters not provided)

- Forecast duration 12 hours
- Relative concentrations[4] from the surface to 100 m[2]
- Images at intervals of 1 or 3 hours[2]
- Contouring to be determined based on specifics of the event or the request

All products shall include a list of parameters that were used for the dispersion modelling as listed in Appendix 11.

The RSMC will perform a quick assessment of the products before they are issued, and may provide a short explanatory message if any issues of concern are noted.

APPENDIX 8. DEFAULT EMISSION SOURCE PARAMETERS

Scenario*	Type of Event	Material released	Rate of Emission	Vertical Distribution
Forest, grass or peat fires	Smoke	Tracer	One unit per hour over 36 hours	Constant from the surface to 500 m
Major industrial fire	Smoke	Tracer	One unit per hour over 6 hours	Constant from the surface to 500 m
Chemical release not involving fire	Chemical	Tracer	One unit per hour over 6 hours	Constant from the surface to 20 m
Other events	RSMC defined	Tracer	RSMC defined	RSMC defined

* Default date and start time of release are those given in the request form (mandatory information). If not provided, date and time of the reception of the request will be used.

APPENDIX 9. CHARACTERISTICS OF ATMOSPHERIC TRANSPORT AND DISPERSION MODELLING SYSTEM

The designated Centres will document and maintain in WMO/TD-No. 778 and on the WMO Emergency Response Activities website up-to-date information on the characteristics of their

[5] Additional products (e.g. GIS-format files) may be provided to requesting NMHSs if possible.

atmospheric transport and dispersion modelling (ATDM) system. The information will contain at a minimum:

For ATDM:

- Name of model(s) and type (Lagrangian, Eulerian)
- Horizontal grid(s) spacing and extent
- Vertical spacing and type of vertical coordinates used to calculate layer concentrations
- Model calculation time step(s) and model output time step(s)
- Information on horizontal and vertical diffusion schemes for the tracers
- Information on dry and wet scavenging schemes
- Information on how chemicals are treated (if available)
- How the emission (source term) is represented/modelled

For Numerical Weather Prediction data used for ATDM:

- Name of system
- Horizontal grid(s) spacing and extent
- Number of vertical levels and type of vertical coordinates
- Forecast length (hours)
- Update frequency

APPENDIX 10. REQUEST FORM TO ACTIVATE RSMC SUPPORT

ENVIRONMENTAL EMERGENCY RESPONSE REQUEST FOR WMO RSMC SUPPORT BY AUTHORIZED PERSON[6]

1. This form should be sent by e-mail to one the RSMCs operational contact in the regional association when support is needed for releases that have the potential for large-scale (i.e. mesoscale) and/or long-duration (hours to days) impacts. The RSMC operational contact information is available on:

   http://www.wmo.int/pages/prog/www/DPFSERA/transport_model_products.htm.

2. If the RSMC does not confirm the reception of the request within 20 minutes, requester will phone the RSMC.

3. The RSMC shall make available its products as soon as possible but usually within 2 hours. An e-mail will be sent by the RSMC with information on where to access the products. The requester will confirm reception by e-mail.

[6] The person authorized by the Permanent Representative of the WMO Member to request RSMC support; normally the NMHS operational contact point.

DATE AND TIME OF REQUEST:

1) MANDATORY INFORMATION:

- Status: (Exercise/Event)
- Name, title, Organization/Agency, Country, phone number and e-mail of the requester:
- Select type of event and provide brief description or details:

☐ Forest, grass or peat fire:

☐ Chemical incident:

☐ Industrial Fire/Smoke:

☐ Other:

- Date and Start time of release (DD/MM/YYYY and UTC):
-
- Location of release (as accurately as possible) in order of preference:
  1) Geographic coordinates (**decimal degrees** or degrees, minutes and seconds):

Latitude	
Longitude	

  2) (*if appropriate*) Address, City, Country:

2) OTHER INFORMATION: If known, the following would be useful for the modelling and should be provided as well *(if not provided, modeller will use default parameters or make a reasonable assumption)*:

- Name of location (name of chemical plant, factory, etc.):
- Meteorological conditions at location at the start of the release (wind speed and direction, weather, cloudiness, presence of inversion, etc.):
- Name or type of pollutant(s) to be modelled if known (smoke, natural gas, sulphur dioxide, etc.). *If unknown, a tracer will be used.*
- Quantity (mass) or release rate (mass per unit time) of pollutant. *If unknown, one unit mass or one unit mass per hour will be used.*
- Expected or estimated release duration.

- Duration of simulation for the dispersion model run.
- Size of area of interest (for example, within 300 km of source).
- Base of release (surface or meters above surface), dimension of release area and estimated maximum height in meters reached by the release (top of smoke plume for example).
- If quantity (mass) and name of pollutant(s) are provided, what concentrations should be displayed on modelling outputs? Please specify.
- Any other information that may be useful:

APPENDIX 11. USERS INTERPRETATION GUIDE FOR NON-NUCLEAR ATMOSPHERIC TRANSPORT AND DISPERSION MODELLING PRODUCTS PROVIDED BY RSMCs

The designated Centres will make available in WMO/TD-No. 778 on the WMO Emergency Response Activities website an interpretation guide for users.

General rules for displaying results:

In order to make the interpretation of the maps easier, the producing centres should adopt the following guidelines:

General guidelines for all maps:

(a) Provide labelled latitude and longitude lines at regular intervals and sufficient geographic map background (shore lines, country borders, rivers, etc. and possibly roads and town names for localized events) to be able to locate precisely the trajectories and contours;

(b) Indicate the source location with a highly visible symbol (▲, ●, ■, etc.);

(c) Indicate the source location in decimal degrees (latitude – N or S specified, longitude – E or W specified, plotting symbol used), date/time of release (UTC), and the meteorological model initialization date/time (UTC);

(d) Each set of maps should be uniquely identified by at least product issue date and time (UTC) and issuing centre;

(e) Previously transmitted products from the dispersion model need not be retransmitted;

(f) Indicate with a legend if this is an exercise or requested services.

Specific guidelines for concentration maps:

(a) Adopt a maximum of five concentration contours;

(b) A legend should indicate contours used on the chart;

(c) Contours may be colour-filled but should be clearly distinguishable from map background lines;

(d) Indicate the following input characteristics: (i) source assumption (height, duration, pollutant type, amount released); and (ii) the units of concentration. In addition, charts should specify: (i) “surface to xxx-m layer concentrations”, where xxx depends on the

pollutant type, and if the default source is used; and (ii) "Results based on default initial values";

(e) Indicate, if possible, the location of the maximum concentration with a symbol on the map and include a legend indicating the symbol used and the maximum numerical value;

(f) Indicate the starting and ending date/time (UTC).

Specific guidelines for backtrajectory maps:

(a) Distinguish each trajectory (levels chosen will depend on specifics of the event or the request) with a symbol (▲, ●, ■, etc.) at synoptic hours (UTC);

(b) Use solid lines (darker than map background lines) for each trajectory.

Provide a time-height (m or hPa) diagram, preferably directly below the trajectory map, to indicate vertical movement of trajectory parcels.

The RSMCs will distribute their standard products to the NMHS Operational Contact Points by e-mail or enabling retrieval by the NMHS from RSMCs password protected designated website. Standard products in the ITU-T T4 format suitable for group 3 facsimile machines will be maintained by exception and only if requested by the NMHS Operational Contact Point. The RSMC may also make use of other appropriate technologies.

Annex 7 to Recommendation 20 (CBS-16)

COORDINATION OF NEAR-TERM CLIMATE PREDICTION

2.2.2.X. Coordination of near-term climate prediction

2.2.2.X.1 Centres conducting coordination of near-term climate prediction (known as Lead Centres for near-term climate prediction (LC-NTCP)) shall:

(a) Select a group of modelling centres to contribute to the LC-NTCP (the "contributing centres") with systems and outputs that meet published criteria set by the LC-NTCP and coordinate regular contributions of real-time predictions and related data. Manage changes in the membership of the group, as and when they occur, to maintain sufficient contributions;

(b) Maintain a list of the active contributing centres and the specification of their prediction systems;

(c) Collect an agreed set of hindcast, forecast and verification data (Appendix 13) from the contributing centres;

(d) Make available (on a password protected website) agreed forecast products in standard format, including multi-model ensemble (MME) products (Appendix 13);

(e) Make available on the website agreed hindcast verification products in standard format, including verification of the MME (Appendix 14);

(f) Redistribute digital hindcast and forecast data for those contributing centres that allow it;

(g) Maintain an archive of the real-time forecasts from individual contributing centres and from the MME;

(h) Promote research and experience in NTCP techniques and provide guidance and support on NTCP to RCCs and NMHSs;

(i) Based on comparison among different models, provide feedback to the contributing centres on model performance;

(j) Coordinate, in liaison with relevant WCRP activities, an annual consensus prediction product giving global prospects for the next 1–5 years.

2.2.2.X.2 Access to data and visualization products held by the LC-NTCP should follow the rules as detailed in Appendix 12 .

Note: The bodies in charge of managing the information contained in the *Manual* related to coordination of near-term climate prediction are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS-CCl/IPET-OPSLS		
To be recommended by:	CBS	CCl	
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	CBS	CCl	
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS-CCl/IPET-OPSLS		
To be reported to:	CBS/ICT-DPFS	CBS	

APPENDIX 12: ACCESS TO DATA AND VISUALIZATION PRODUCTS HELD BY THE LEAD CENTRE(S) FOR NEAR-TERM CLIMATE PREDICTION (LC-NTCP)

(a) Access to data and graphical products from LC-NTCP Website(s) will be password-protected;

(b) Digital data will be redistributed only in cases where the contributing centre data policy allows it. In other cases, requests for contributing centre output should be referred to the relevant contributing centre;

(c) Contributing centres, RCCs, NMHSs and institutions coordinating RCOFs are eligible for password-protected access to information held and produced by the LC-NTCP;

(d) Institutions other than those identified in (c) above, may also request access to LC-NTCP products. These institutions, including research centres may not use LC-NTCP products to generate and display/disseminate independent products for operational forecasting. These institutions must agree with these restrictions to be eligible for access. Prior to access being granted to an applicant institution, the LC-NTCP will refer the application to the CBS-CCl Inter-Programme Expert Team on Operational Prediction from Subseasonal to Longer-time Scales (IPET-OPSLS) through the WMO Secretariat, for final consultation and review. Decisions to allow access must be unanimous. The Lead Centre will be informed by the WMO Secretariat of such new users accepted for access;

(e) A list of users provided with password access will be maintained by LC-NTCP and reviewed periodically by the CBS-CCl IPET-OPSLS, to measure the degree of effective use and also to identify any changes in status of eligible users, and determine further necessary follow-up.

APPENDIX 13. HINDCAST AND FORECAST DATA TO BE COLLECTED BY THE LEAD CENTRE(s) AND PRODUCTS TO BE GENERATED AND DISPLAYED

Contributing centres shall provide necessary hindcast and forecast data to the LC to allow generation of the following minimum products for each contributing centre and for the MME.

Stage 1:

a. Global maps of ensemble mean anomalies with indications of ensemble spread for the following variables averaged over at least year 1 and years 1-5 of the forecast:
   - near-surface air temperature;
   - precipitation;
   - sea level pressure.

b. Ensemble mean annual global mean near-surface temperature and indications of ensemble spread, for every year of the forecast.

Stage 2 (with 2 years of designation of the LC-NTCP):

c. Global maps of probability for tercile categories (or other events) for the following variables averaged over at least year 1 and years 1-5 of the forecast:
   - near-surface air temperature;
   - precipitation;
   - sea level pressure

APPENDIX 14. VERIFICATION INFORMATION TO BE COLLECTED BY THE LEAD CENTRE(s) AND PRODUCTS TO BE DISPLAYED

Hindcast verification:

The LC shall collect hindcasts and/or verification results from each contributing centre to allow generation and display of the following for each predicted variable (near-surface air temperature, precipitation and sea level pressure):

Stage 1: individual contributing centres

- global maps of grid-point temporal correlation of the ensemble mean with observations.

Stage 2: individual contributing centres and the MME

- global maps of Relative Operating Characteristic (ROC) scores for specified categories;
- reliability and sharpness diagrams for specified categories for the agreed geographical regions.

Contributing centres must adhere to a specified configuration for hindcasts that will form part of criteria set by the LC-NTCP. In accord with the DCPP protocol, hindcasts will ideally be initialized in each year from 1960 to present, with initialization every other year (specified as 1960, 1962 etc.) a minimum requirement. Hindcasts shall be of sufficient range to verify performance out to at least 5 years ahead.

Real-time verification (valid only for Stage 1):

- Side-by-side global maps of ensemble mean predicted and observed anomalies for temperature, precipitation and sea level pressure for at least year 1 and years 1-5. Regions where the observations lie outside the 5-95% model predicted range will be highlighted;
- Spatial pattern correlation coefficients between observations and ensemble mean forecasts for global fields of temperature, precipitation and sea level pressure
- A time series of observed annual mean global temperature will be updated each year and a graphic generated to compare the past-predicted and observed timeseries.

Annex 8 to Recommendation 20 (CBS-16)

MARINE METEOROLOGICAL SERVICES

Regulations specific to marine meteorological services are contained in the *Manual on Marine Meteorological Services* (WMO-No. 558)

Annex 9 to Recommendation 20 (CBS-16)

MARINE ENVIRONMENTAL EMERGENCIES

Regulations specific to marine environmental emergencies are contained in the *Manual on Marine Meteorological Services* (WMO-No. 558)

Annex 10 to Recommendation 20 (CBS-16)

COORDINATION OF WAVE FORECAST VERIFICATION

2.2.3.X. Coordination of wave forecast verification

2.2.3.X.1 Centres conducting coordination of wave forecast verification (known as Lead Centres for wave forecast verification (LC-WFV)) shall:

(a) Provide the facility for JCOMM participating Centres producing global or ocean basin scale wave forecasts to automatically deposit their gridded forecast fields as defined in Appendix 14, and have access to the verification statistics computed for these fields;

(b) Maintain an archive of the verification statistics to allow the generation and display of trends in performance;

(c) Monitor the received forecast fields and consult with the relevant JCOMM participating Centre if data are missing or suspect;

(d) Collect annually from the participating centres information on any changes to their wave forecast systems;

(e) Provide access to the data sets used to perform the standard verification, including lists of observations and keep this up to date according to JCOMM recommendation;

(f) Provide on its (their) website(s):

- **Consistent up-to-date graphical displays of the verification results from JCOMM participating Centres based on verification of the received forecast fields;**
- **Relevant documentation including access to the standard procedures required to perform the verification, and links to the websites of JCOMM participating Centres;**
- **Contact details to encourage feedback from JCOMM participating Centres on the usefulness of the verification information.**

2.2.2.X.2 The Lead Centre(s) may also provide access to standardized software for calculating scoring information.

Note: The bodies in charge of managing the information contained in the *Manual* related to wave forecast verification are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OWFPS	JCOMM-ETWCH	
To be recommended by:	CBS		

To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	CBS		
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-OWFPS		
To be reported to:	CBS/ICT-DPFS	CBS	

APPENDIX 15. STANDARDIZED VERIFICATION OF WAVE FORECASTS

1. Introduction

This Appendix presents detailed procedures for the generation of a standard set of verification scores for wave forecasts produced by the Lead Centre for Wave Forecast Verification (LC-WFV), based on gridded wave forecast fields provided by JCOMM participating Centres. The goal is to provide consistent verification information on the wave forecast products from different centres for forecasters in the ocean forecast services and to help JCOMM participating Centres compare and improve their forecasts. The Lead Centre functions, as described in 2.2.3.X, include creating and maintaining a website for wave verification information, so that potential users will benefit from a consistent presentation of the results.

The standardized verification should provide key relevant information appropriate to the state-of-the-art in wave forecasting, ensuring a consistent verification methodology applied to forecasts from different JCOMM participating Centres, and the use of a common set of observations.

2. Parameters

a) Atmospheric forcing

- 10m wind speed U and V components (10u, 10v)

b) Wave fields

- Significant wave height (Hs)
- Peak period (Tp)
- Mean wave period based on the second moment of the frequency spectrum (Tz)
- Mean wave direction (mdir)

3. Forecast times

If available, forecasts from 00, 06, 12, and 18 UTC should be provided.

4. Forecast steps

In as fine temporal granularity as available but at least every 6 h to the end of the forecast range.

5. Verifying observations

Forecasts of the above parameters will be evaluated against in-situ observations from buoys and platforms available at the LC-WFV. If additional in-situ observations become available over time they will be added following a careful selection and quality control. JCOMM participating Centres are encouraged to promote the exchange of in-situ wind and wave observations.

6. Interpolation

Verification shall be made using the nearest native model ocean grid point to the observation location.

7. Scores

The following scores are to be calculated for all parameters against observations.

- Mean error (ME)
- Root mean square error (RMSE)
- Error standard deviation (SDEV)
- Scatter index (SDEV normalized by observed mean)
- Symmetric slope (variance ratio)
- Quantile-quantile (Q-Q) plots

8. Exchange of forecast fields

Each JCOMM participating Centre shall provide fields to the LC-WFV on a regular latitude-longitude grid at the resolution that is best matching the native resolution of the direct model output. Details of the procedure and the required format for the data are provided on the website of the LC-WFV.

9. Documentation

JCOMM participating Centres shall provide to the LC-WFV information on any changes to its production of the exchanged forecast fields and changes in their wave forecast system.

Annex 11 to Recommendation 20 (CBS-16)

COORDINATION OF TROPICAL CYCLONE FORECAST VERIFICATION

2.2.3.X. Coordination of tropical cyclone forecast verification

2.2.3.X.1 Centres conducting coordination of tropical cyclone forecast verification (known as Lead Centres for tropical cyclone forecast verification (LC-TCFV)) shall:

(a) Provide the facility for GDPFS Centres, including RSMCs participating in global deterministic numerical weather prediction defined in 2.2.1.1, who produce tropical cyclone forecasts, to deposit their gridded forecast fields as defined in Appendix 15, and have access to the verification statistics computed for these fields;

(b) Maintain an archive of the verification statistics to allow the generation and display of trends in performance;

(c) Monitor the received forecast fields and consult with the relevant participating GDPFS Centre if data are missing or suspect;

(d) Provide access to the data sets used to perform the standard verification, including best track data produced by RSMCs participating in tropical cyclone forecasting defined in 2.2.2.3;

(e) Provide on its (their) website(s):

- **Consistent up-to-date graphical displays of the verification results from participating Centres through processing of the received statistics;**
- **Relevant documentation including access to the standard procedures required to perform the verification, and links to the websites of participating GDPFS Centres;**
- **Contact details to encourage feedback from NMHSs and other GDPFS Centres on the usefulness of the verification information.**

2.2.3.X.2 The Lead Centre(s) may also provide access to standardized software for calculating scoring information.

Note: The bodies in charge of managing the information contained in the *Manual* related to tropical cyclone forecast verification are specified in the Table below.

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OWFPS	CAS/JWGFVR	WGNE
To be recommended by:	CBS		
To be decided by:	EC/Congress		
CENTRES DESIGNATION			
To be recommended by:	CBS		
To be decided by:	EC/Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-OWFPS		
To be reported to:	CBS/ICT-DPFS	CBS	

APPENDIX 16. STANDARDIZED VERIFICATION OF TROPICAL CYCLONE FORECAST PRODUCTS

1. Introduction

This Appendix presents detailed procedures for the production and exchange of a standard set of verification scores for tropical cyclone (TC) forecasts produced by the Lead Centre for Tropical Cyclone Forecast Verification (LC-TCFV) based on gridded forecast fields provided by participating GDPFS centres. The goal is to provide consistent verification information on the

TC forecast products of participating GDPFS centres for forecasters in the NMHSs and to help the participating GDPFS centres compare and improve their forecasts. The Lead Centre functions, as described in 2.2.3.X, include creating and maintaining a website for TC forecast verification information, so that potential users can benefit from a consistent presentation of the results.

The standardized verification should provide key relevant information appropriate to the state-of-the-art in tropical cyclone forecasting, while being as simple and as easy to implement as possible, and ensuring a consistent implementation across participating GDPFS centres.

2. Tropical cyclones to be verified

TCs which intensity reached tropical storm (TS) with the maximum sustained wind of 34 knots or stronger are set as targets for this verification. The tropical depression (TD) stage of the targeted TCs is also included in this verification. However, the TCs which never evolve from TD to TS stage during their life time are excluded.

TCs which are not recorded in the best track dataset (ref. section 7) are also excluded.

3. Parameters

Mandatory

- Mean sea-level pressure

Recommended

- u and v wind components at 850hPa

4. Forecast times

Scores shall be computed for forecasts initialised at 12 UTC. Annual scores shall be computed for a year from 1 January to 31 December in the northern hemisphere and for a year from 1 September to 31 August in the southern hemisphere, respectively.

5. Forecast steps

Every 6h to 192h of the forecast range.

6. Verification areas

Scores are to be calculated separately for each verification area shown below.

Verification Area	Specification of Area
Western North Pacific:	EQ - 90°N, 100°E –180°
Eastern North Pacific including Central North Pacific	EQ - 90°N, 180° – West coast of North and South American Continent (*) TCs that generate in this area are categorized as those in this area through its life-time.

North Atlantic Ocean	Caribbean Sea, The Gulf of Mexico, and EQ - 90°N, East coast of North and South American Continent – 35°W (*) TCs that generate in this area are categorized as those in this area through its life-time.
North Indian Ocean	EQ – Eurasian Continent, 30°E - 100°E
South Indian Ocean	EQ - 90°S, 30°E - 90°E
South Pacific and around Australia	EQ - 90°S, 90°E – 120°W

7. Verifying datasets

Verification shall be carried out for best track dataset available at the Lead Centre. Best track dataset are originally provided by RSMCs participating in tropical cyclone forecasting defined in 2.2.2.3.

8. Grid and interpolation

Verification shall be made using forecast data on a regular latitude-longitude grid. The Lead Centre shall calculate position and pressure of TC centres by linear interpolation using five data of the nearest grid point and its four neighboring grid points in the north, south, east and west.

9. Scores

Scores are to be calculated for each tropical cyclone individually.

The following scores are to be calculated against the best track dataset:

(a) Detection rate;

(b) Storm track verification:

- Position error: Distance between predicted and analysed TC centres;
- ATCT-bias (shown in the pictorial form of scatter diagram):
  - AT(along-track)-bias: The bias in the direction of cyclone movement;
  - CT(cross-track)-bias: The bias in the rectangular direction of cyclone;

(c) Bias of central pressure.

The mathematical formulation of the scores is documented on the LC-TCFV website, together with supplementary information on score calculation.

10. Exchange of forecast fields

Each participating GDPFS centre shall provide global fields annually to the LC-TCFV on a regular latitude-longitude grid at the resolution of 1.5° longitude by 1.5° latitude or finer resolution. Details of the procedure and the required format for the data are provided on the website of the LC-TCFV.

11. Exchange of scores

All calculated scores in the text or binary form shall be made available on the LC-TCFV website.

The LC-TCVF shall also make available the scores in the pictorial form on the LC-TCFV website as follows:

(a) Detection rate of tropical storm: the score is drawn every 12h till 120h;

(b) Storm track verification: position error and ATCT-bias are shown every 24 till 192h. Position error is shown as map. ATCT-bias is shown in scatter diagram form;

(c) Bias of central pressure: scatter diagram of analysed and predicted central pressure is shown every 24h till 192h.

12. Documentation

Participating GDPFS centres shall provide to the LC-TCFV information on any changes to its production of the exchanged forecast fields.

Recommendation 21 (CBS-16)

MAPPING OF EXISTING GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM CENTRES ONTO THE CORRESPONDING DESIGNATIONS DESCRIBED IN THE REVISED *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485)

THE COMMISSION FOR BASIC SYSTEMS,

Considering:

(1) The *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

(2) The proposed revised *Manual on the Global Data-processing and Forecasting System*, as given in the annexes to Recommendations 19 (CBS-16) and 20 (CBS-16),

(3) The *Abridged Final Report with Resolutions and Recommendations of the Extraordinary Session of the Commission for Basic Systems* (WMO-No. 1140),

Realizing that the new Manual introduces a new definition for a World Meteorological Centre (WMC), which shall be appointed if fulfilling the following functions:

(1) Global deterministic numerical weather prediction,

(2) Global ensemble numerical weather prediction,

(3) Global numerical long-range prediction,

Realizing further that, as per the summary of changes of functions and procedures agreed at the extraordinary session (2014) of the Commission for Basic Systems, Regional Specialized Meteorological Centres (RSMCs) with geographical specialization would become RSMCs with specialization in one (or more) of the following activities:

(1) Regional severe weather forecasting,

(2) Global deterministic numerical weather prediction,

(3) Limited-area deterministic weather prediction,

(4) Global ensemble numerical weather prediction,

(5) Limited-area ensemble numerical weather prediction,

Acknowledging that RSMCs with other activity specialization are redefined in the revised *Manual on the Global Data-processing and Forecasting System* for clarity in the description of functions, not altering the designation criteria,

Having considered that a number of WMO Members hosting a WMC and/or an RSMC confirmed the mapping of their centres onto the corresponding designations described in the revised *Manual on the Global Data-processing and Forecasting System*, and are seeking designation,

Noting that many WMO Members currently hosting RSMCs with geographical specialization have not as yet confirmed the mapping of their centres onto the corresponding designations for RSMCs with specialization in one (or more) of the activities described above,

Urges WMO Members currently hosting a WMC and/or an RSMC that have not as yet confirmed the mapping of their centres onto the corresponding designations described in the revised *Manual on the Global Data-processing and Forecasting System*, to do so for inclusion in the Manual, to be submitted to the Executive Council at its sixty-ninth session;

Recommends to the Executive Council that:

(1) WMO Members currently hosting a WMC and/or an RSMC that have confirmed the mapping of their centres onto the corresponding types of centre described in the revised *Manual on the Global Data-processing and Forecasting System*, be confirmed in that new designation;

(2) The denomination of RSMCs with geographical specialization be maintained until the Eighteenth World Meteorological Congress in 2019, and that the RSMCs with geographical specialization that have not confirmed the mapping of their centres retain that status until then.

Recommendation 22 (CBS-16)

DESIGNATION OF NEW GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM CENTRES AGAINST THE EXISTING CRITERIA/FUNCTIONS AND THEIR INCLUSION IN THE REVISED *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485)

THE COMMISSION FOR BASIC SYSTEMS,

Considering the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

Noting the proposed Parts I and III of the new *Manual on the Global Data-processing and Forecasting System*, as given in the annex to Recommendation 19 (CBS-16),

Acknowledging the completion of demonstration phases of operational capabilities of the following candidates for designation:

(1) For Regional Specialized Meteorological Centre (RSMC) for Atmospheric Sand and Dust Storm Forecasts (ASDF):

(a) RSMC-ASDF Beijing (Regional Association (RA) II),

(2) For Regional Climate Centre (RCC):

(a) RCC Intergovernmental Authority on Development (IGAD) hosted by the IGAD Climate Prediction and Applications Centre (ICPAC) (RA I),

(b) RCC-Network for Northern Africa (RA I),

(c) RCC Pune (RA II),

(d) RCC-Network for Southern South America (RA III),

(e) RCC Caribbean hosted by the Caribbean Institute for Meteorology and Hydrology (CIMH) (RA IV),

(3) For global numerical long-range prediction (known as Global Producing Centre for Long-range Forecasts (GPCLRF)):

(a) GPCLRF Offenbach,

Acknowledging further that the presentation of their demonstration of capabilities has provided evidence that these candidates have complied with all mandatory functions, as described in the revised *Manual on the Global Data-processing and Forecasting System*,

Recommends:

(1) The formal designation of the RCC IGAD hosted by ICPAC (RA I), RCC-Network for Northern Africa (RA I), RCC Pune (RA II), RCC-Network for Southern South America (RA III), RCC Caribbean hosted by CIMH (RA IV), of RSMC-ASDF Beijing (RA II), and of GPCLRF Offenbach;

(2) Their inclusion in Part III of the revised *Manual on the Global Data-processing and Forecasting System*, as provided in the annex to the present recommendation.

Annex to Recommendation 22 (CBS-16)

INCLUSION OF DESIGNATED GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM CENTRES IN THE REVISED *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485)

The proposed inclusion in the revised *Manual on the GDPFS*, Part III, relates to the designation of a Global Producing Centre for Long-range Forecasts (GPCLRF), a Regional Specialized Meteorological Centre for Atmospheric Sand and Dust Storm Forecasts (RSMC-ASDF), and Regional Climate Centres (RCCs):

PART III

[…]

Global numerical long-range prediction (known as Global Producing Centre for Long-range Forecasts (GPCLRF))

[…]

GPCLRF Offenbach

[…]

Provision of atmospheric sand and dust storm forecasts (ASDF)

[…]

RSMC-ASDF Beijing (RA II)

[…]

Regional Climate Centres (RCCs) providing regional climate prediction and monitoring

[…]

RCC Intergovernmental Authority on Development (IGAD) hosted by the IGAD Climate Prediction and Applications Centre (ICPAC) (RA I)

RCC-Network Northern Africa (RA I)

[…]

RCC Pune (RA II)

[…]

RCC-Network Southern South America (RA III)

RCC Caribbean hosted by the Caribbean Institute for Meteorology and Hydrology (CIMH) (RA IV)

[…]

Recommendation 23 (CBS-16)

PROPOSED AMENDMENT TO THE WMO *TECHNICAL REGULATIONS* (WMO-No. 49), VOLUME I ON DATA-PROCESSING AND FORECASTING ASPECTS

THE COMMISSION FOR BASIC SYSTEMS,

Considering the WMO *Technical Regulations* (WMO-No. 49), Volume I – General Meteorological Standards and Recommended Practices,

Recalling:

(1) Resolution 45 (Cg-XVI) – Technical Regulations of the World Meteorological Organization,

(2) Resolution 6 (Cg-XVI) – Revised *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

(3) Resolution 12 (Cg-17) – Report of the extraordinary session (2014) of the Commission for Basic Systems concerning the introduction of the new *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

Noting that the *Manual on the Global Data-processing and Forecasting System* is the single source of technical regulations for all operational data-processing and forecasting systems of WMO Members, including their designated centres,

Noting further the proposed new *Manual on the Global Data-processing and Forecasting System*, as given in the annex to Recommendation 19 (CBS-16),

Considering that:

(1) The new *Manual on the Global Data-processing and Forecasting System* and the WMO *Technical Regulations*, Volume I, shall be aligned,

(2) These publications shall conform to the principles and procedures contained in the *Guidelines on the Preparation and Promulgation of the WMO Technical Regulations* (WMO-No. 1127),

Recommends to the Executive Council to adopt the proposed amendment to the WMO *Technical Regulations*, Volume I, as provided in the annex to the present recommendation, which ensures the necessary alignment with the new *Manual on the Global Data-processing and Forecasting System*.

Annex to Recommendation 23 (CBS-16)

PROPOSED AMENDMENT TO THE WMO *TECHNICAL REGULATIONS* (WMO-No. 49), VOLUME I, ON DATA-PROCESSING AND FORECASTING ASPECTS

GENERAL PROVISIONS

Status of annexes and appendices

9. […]

IV *Manual on the Global Data-processing and Forecasting System* (WMO-No.485)~~, Volume I~~;

DEFINITIONS

Global Data-processing and Forecasting System (GDPFS). The coordinated global system of ~~meteorological~~ centres ~~and~~ operating under established arrangements for ~~meteorological~~ the ~~analyses~~ analysing, ~~and~~ forecasting, ~~and for the~~ processing, storage and retrieval of meteorological, climatological, hydrological, oceanographic and environmental-related information ~~within the framework of the World Weather Watch~~.

National Meteorological Centre (NMC). A centre responsible for carrying out required ~~national~~ functions ~~including those under the World Weather Watch~~to meet the national and international requirements and commitments of the Member under the GDPFS.

Regional Specialized Meteorological Centre (RSMC). A centre that specializes ~~either~~ in an activity ~~or in a geographical area~~ of the Global Data-processing and Forecasting System ~~:~~

~~(a) The Regional Specialized Meteorological Centre with activity specialization has~~ with the primary purpose of providing tailored-made information and products to serve~~ice~~ users in a particular area of activity.~~;~~

~~(b) The Regional Specialized Meteorological Centre with geographic specialization has the primary purpose of issuing meteorological analyses and prognoses on a regional scale for a specified geographical area.~~

RSMC Network. An association of RSMCs participating in an identified activity of the Global Data-processing and Forecasting System (GDPFS).

World Meteorological Centre (WMC). A centre of the Global Data-processing and Forecasting System which has the primary purpose of issuing meteorological analyses and prognoses, including probabilistic information, and long-range forecasts on a global scale.

World Weather Watch (WWW). The worldwide, coordinated, ~~developing~~ dynamic system of meteorological facilities and services provided by Members to ensure that all Members obtain the meteorological information they require both for operational work and for research. The essential elements of the World Weather Watch are: the Global Observing System (GOS), part of the Global Data-processing and Forecasting System (GDPFS) dealing with meteorological analyses and prognoses, and the Global Telecommunication System (GTS).

PART I. THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM

2.4.2.2 […]

Note: Technical specifications and details are given mainly in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), *Guide to Climatological Practices* (WMO-No. 100), *Guide to Hydrological Practices* (WMO-No. 168), Volume I, ~~*Guide on the Global Data-processing System* (WMO-No. 305)~~ and *Guide to the Global Observing System* (WMO-No. 488).

2.4.4.1 […]

Note: Minimum standards of quality control for meteorological data are specified in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485))~~, Volume I~~.

PART III. DATA PROCESSING AND FORECASTING

1. GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM

1.1 ~~Organization and functions of the Global Data-processing and Forecasting System~~Purpose and scope

~~1.1.1 *General*~~

1.1.1~~.1~~ The Global Data-processing and Forecasting System~~ shall include World Meteorological Centres, Regional Specialized Meteorological Centres and National Meteorological Centres.~~

~~1.1.1.2 Members that have accepted the responsibility of establishing and operating World Meteorological Centres and Regional Specialized Meteorological Centres specified in the World Weather Watch plan~~ **shall:**

(a) Be a world-wide network of operational centres operated by WMO Members;

(b) ~~Prepare and m~~Make operationally available ~~to other~~among WMO Members and relevant international organizations,~~processed meteorological information~~ agreed products and services for applications related to weather, climate, water and environment;

(~~b~~c) ~~Archive and process data for research and applications~~Enable scientific and technological advances made in meteorology and related fields to be accessible and exploitable by WMO Members;

(~~c~~d) ~~Provide opportunities for training, conducting of both basic and applied research and publishing of selected data~~Support all WMO Programmes and related programmes of other international organizations in accordance with decisions of the Organization.

1.1.2 **The Global Data-processing and Forecasting System shall be systematically designed in accordance with Member's needs and their ability to contribute to, and benefit from, the system in an efficient manner and minimizing duplication.**

1.1.~~1.~~3 **The Global Data-processing and Forecasting System shall be established and operated in accordance with procedures and practices set out in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No.485))~~, Volume I~~.**

1.2 **Organization**

1.2.1 **The Global Data-processing and Forecasting System shall be organized in such a way as to ensure the discharge of the required operational data-processing and forecasting functions. It shall also incorporate real-time and non-real-time functions.**

1.2.2 **The Global Data-processing and Forecasting System shall be organized as a three-tier system of activities as follows:**

(a) General purpose activities;

(b) Specialized activities;

(c) Non-real-time activities.

1.2.3 **The Global Data-processing and Forecasting System shall be structured as a three-level system of:**

(a) National Meteorological Centres (NMC);

(b) Regional Specialized Meteorological Centres (RSMC);

(c) World Meteorological Centres (WMC).

1.2.4 **Each Member shall designate a National Meteorological Centre.**

1.2.5 **Word Meteorological Centres, Regional Specialized Meteorological Centres and GDPFS Networks shall be designated by a decision of the World Meteorological Congress or the WMO Executive Council. The designation of such centres shall include the specification of the activity/function (or activities/functions) to be carried out.**

1.2.6 **An association of centres constituted to undertake an identified RSMC activity shall be designated as an RSMC Network.**

Note: Details of the designation process and procedure are specified in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)).

1.2.7 The performance of the World Meteorological Centres, Regional Specialized Meteorological Centres and GDPFS Networks should be regularly reviewed by relevant WMO bodies.

1.2.8 Any deficiencies or non-conformities with requirements identified during the performance review should be resolved immediately by the responsible Member. The designation of a centre

should be reconsidered in case of systematic deficiencies or non-compliance with the requirements.

Note: Details of the performance assessment procedure for World Meteorological Centres, Regional Specialized Meteorological Centres and GDPFS Networks are given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)).

1.2.9 The Global Data-processing and Forecasting System functions and operation shall be based on catalogues provided by Members operating Word Meteorological Centres, Regional Specialized Meteorological Centres and RSMC Networks on their websites. The catalogues shall contain the technical characteristics of the operational systems and products these centres deliver across WMO, and the metadata describing dissemination and access options as part of the WMO Information System (WIS). GDPFS centres shall be linked to the WIS.

Note: Standard procedures and recommended practices with respect to metadata description are specified in Annex VII (*Manual on the WMO Information System* (WMO-No. 1060)).

1.3~~1.2~~ Functions and responsibilities of centres

1.3.1 National Meteorological Centre

1.3.1.1 A National Meteorological Centre shall carry out functions to meet the national and international requirements of the Member concerned.

Note: In order to fulfil their national and international obligations, National Meteorological Centres need to be adequately staffed and equipped to enable it to play its part in the World Weather Watch (WWW) system.

1.3.1.2 The functions of a National Meteorological Centre shall include preparation of forecasts and warnings at all ranges necessary to meet the requirements of the Member.

1.3.1.3 Depending on the context, other activities of a National Meteorological Centre should include the production of:

(a) Special application-user products, including climate and environmental quality monitoring and prediction products;

(b) Non-real-time climate-related products.

1.3.2 Regional Specialized Meteorological Centre

1.3.2.1 A Member, having accepted the responsibility for providing a Regional Specialized Meteorological Centre, shall arrange for this centre to carry out operationally at least one of the General Purpose activities or Specialized activities.

Note: A list of General Purpose activities and Specialized activities is given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)).

1.3.3 World Meteorological Centre

1.3.3.1 A Member, having accepted the responsibility for providing a World Meteorological Centre, shall arrange for this centre to carry out at least the following activities:

(a) Global deterministic numerical weather prediction;

(b) Global ensemble numerical weather prediction;

(c) Global numerical long-range prediction.

1.3.4 RSMC Network

1.3.4.1 An RSMC Network shall follow the same specifications and adhere to the same criteria and commitments as individual RSMC centres carrying out the same activity.

1.3.4.2 **Appropriate documentation shall be produced and made available by Members having accepted the responsibility to contribute to the RSMC Network, to distribute the tasks and responsibilities among the participating RSMC centres. A unique focal point shall be designated to answer requests from users of the RSMC Network's products.**

Note: Details on the ~~R~~real-time and non-real-time functions of World Meteorological Centres, Regional Specialized Meteorological Centres~~, and~~ National Meteorological Centres and RSMC Networks ~~should be as~~are given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485))~~, Volume I~~.

1.3.5 **Members operating National Meteorological Centres, Regional Specialized Meteorological Centres and World Meteorological Centres shall:**

(a) Monitor their performance and provide information about the current implementation of their systems;

(b) Report non-compliance between the mandatory minimum specifications and their actual implementation to the WMO Secretariat; if this non-compliance is expected to persist for more than two months, a schedule for returning to compliance shall be provided.

1.3.6 **Members operating National Meteorological Centres, Regional Specialized Meteorological Centres, World Meteorological Centres and GDPFS Networks shall provide guidance information, including training materials, on the interpretation, performance characteristics, strengths and limitations of their products.**

1.4~~2~~ ~~**Analysis and forecasting p**~~**Practices, procedures and specifications**

1.~~2~~4.1 **Members operating National Meteorological Centres, Regional Specialized Meteorological Centres, World Meteorological Centres and RSMC Networks shall maintain the standardized weather forecasting process, including the use of units, graphical representation of observations, analyses and forecasts.**~~***General – Constants, definitions and specifications***~~

Note: Standardized weather forecasting process (including units, graphical representation of observations, analyses and forecasts) description is specified in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)).

~~1.2.1.1 **If the formula for a function or the value of a constant is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No.8), Members shall use that formula or value, when required, for meteorological purposes.***~~

~~1.2.1.2 **Each Member shall use the definitions and specifications of water vapour in the atmosphere given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No.8).***~~

~~1.2.2 ***Units***~~

~~1.2.2.1 Members should use the International System of Units (SI), as defined by the International Organization for Standardization (ISO), in scientific publications and documents, except where otherwise indicated by WMO or ICAO.~~

~~Note: Guidance on the use of these units is given by ISO.~~

~~1.2.2.2 **The hectopascal shall be used as the unit of atmospheric pressure for both the operational and research work of WMO.***~~

~~1.2.3 ***Standard atmosphere***~~

~~Members should use as the standard atmosphere that which has been defined by ISO and specified in ISO 2533.~~

~~1.2.4 ***Weather charts – Projections, scales and symbols***~~

~~1.2.4.1 Appropriate projections and scales along the standard parallels used for weather charts should be as given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.~~

~~1.2.4.2 The symbols used on weather charts for the pictorial representation of observed data and for analysis and prognosis should be those set out in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I, Appendix II.4.~~

~~1.2.5 ***Properties of aerological diagrams – General requirements***~~

~~1.2.5.1 Diagrams used for representation and analysis of upper-air observations of pressure, temperature and humidity should be as given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.~~

~~1.2.5.2 Diagrams used for the accurate computation of geopotential from upper-air observations of pressure, temperature and humidity should possess the features given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.~~

~~1.2.6 ***Upper-air analyses – Reference surfaces***~~

~~1.2.6.1 **Rules and procedures for representing and analysing the conditions in the free atmosphere, including standard isobaric surfaces to be used (except above 100 hPa), shall be as given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No.485)), Volume I.~~

~~1.2.6.2 The standard isobaric surfaces for representing and analysing the conditions in the atmosphere above 100 hPa should be as given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.~~

~~1.2.7 ***General – Publication of synoptic observations***~~

~~Each Member should publish, with as little delay as possible, a daily or monthly bulletin consisting, if so desired, of reports in the international code form, including:~~

~~(a) Reports made at main standard times by its surface land stations included in the RBSN, or a selection of them if the network is dense;~~

~~(b) Reports from all its upper-air stations;~~

~~(c) Reports from sea stations, or a selection of them if the network is dense.~~

Recommendation 24 (CBS-16)

IMPACT OF THE REVISED *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485) ON OTHER WMO MANUALS AND GUIDES

THE COMMISSION FOR BASIC SYSTEMS,

Considering:

(1) The *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

(2) The proposed revised *Manual on the Global Data-processing and Forecasting System*, as given in the annexes to Recommendations 19–21 (CBS-16),

(3) The *Manual on the Global Observing System* (WMO-No. 544), Volume I – Global Aspects,

(4) The *Manual on Codes* (WMO-No. 306), International Codes, Volume I.2,

(5) The *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160),

(6) The *Manual on the WMO Information System* (WMO-No. 1060),

Considering further that the new *Manual on the Global Data-processing and Forecasting System* and other WMO Manuals and Guides shall be aligned,

Recalling Resolution 6 (Cg-XVI) – Revised *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

Recalling further that the Sixteenth World Meteorological Congress decided that the *Manual on the Global Data-processing and Forecasting System*, Volume II – Regional Aspects, which has no regulatory status for Members, should be reviewed and the relevant parts should be incorporated into the revised Manual,

Recommends the adoption of the proposed amendments to the:

(1) *Manual on the Global Observing System*, as provided in Annex 1 to the present recommendation;

(2) *Manual on Codes*, as provided in Annex 2 to the present recommendation;

(3) *Manual on the WMO Integrated Global Observing System*, as provided in Annex 3 to the present recommendation;

(4) *Manual on the WMO Information System*, as provided in Annex 4 to the present recommendation.

Annex 1 to Recommendation 24 (CBS-16)

PROPOSED AMENDMENTS TO THE *MANUAL ON THE GLOBAL OBSERVING SYSTEM* (WMO-No. 544)

[…]

GENERAL PROVISIONS

[…]

IV *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)~~, Volume I~~;

[…]

ATTACHMENT II.1. SPECIAL OBSERVATIONAL REQUIREMENTS FOR ENVIRONMENTAL EMERGENCY RESPONSE ACTIVITIES

A. **METEOROLOGICAL DATA REQUIREMENTS**

1. […], and are given in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)~~, Volume I – Global Aspects~~, […].

ATTACHMENT II.2. OBSERVATIONAL REQUIREMENTS IN THE EVENT OF VOLCANIC ACTIVITY

[…]

A. **METEOROLOGICAL DATA REQUIREMENTS**

[…], and are given in the *Manual on the Global Data-Processing and Forecasting System* (WMO-No. 485)~~, Volume I – Global Aspects, Appendix II.2~~ and […].

APPENDIX. DEFINITIONS

[…]

Global Data-processing and Forecasting System (GDPFS). The coordinated global system of ~~meteorological~~ centres ~~and~~ operating under established arrangements for ~~meteorological~~ the ~~analyses~~ analysing, ~~and~~ forecasting, ~~and for the~~ processing, storage and retrieval of meteorological, climatological, hydrological, oceanographic and environmental-related information ~~within the framework of the World Weather Watch~~.

[…]

Annex 2 to Recommendation 24 (CBS-16)

PROPOSED AMENDMENTS TO THE *MANUAL ON CODES* (WMO-No. 306)

[…]

GENERAL PROVISIONS

[…]

IV *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)~~, Volume I~~;

[…]

The text in section 4.2 "Symbols used on meteorological charts" and in Appendix II-4 "Graphical representation of data, analyses and forecasts" of the 2010 edition (updated in 2015) of the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), Volume I, be transferred to form a new section F of the *Manual on Codes* (WMO-No. 306), Volume I.1.

Annex 3 to Recommendation 24 (CBS-16)

PROPOSED AMENDMENTS TO THE *MANUAL ON THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM* (WMO-No. 1160)

[…]

GENERAL PROVISIONS

[…]

IV *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)~~, Volume I~~;

[…]

DEFINITIONS

Notes:

2. […], the Manual on the Global Data-processing and Forecasting System (WMO-No. 485)~~, Volume I~~, […].

[…]

2.4.3.2 **Members shall implement real-time quality control prior to exchange of observations via the WMO Information System.**

Notes:

[…]

3. […] *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)~~, Volume I: Global Aspects, Appendix II-1, Table I~~. The *Guide on the Global Data-processing System* (WMO-No. 305) […].

Annex 4 to Recommendation 24 (CBS-16)

PROPOSED AMENDMENTS TO THE *MANUAL ON THE WMO INFORMATION SYSTEM* (WMO-No. 1060)

[…]

GENERAL PROVISIONS

[…]

IV *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)~~, Volume I~~;

[…]

APPENDIX A. SELECTED WMO DOCUMENTS RELEVANT TO WIS

[…]

WMO-No. 485 Manual on the Global Data-processing and Forecasting Systems~~, Volume I, Parts 1, 2 and 3~~

[…]

Recommendation 25 (CBS-16)

REVIEW OF TECHNICAL REGULATIONS MANAGED BY THE COMMISSION FOR BASIC SYSTEMS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The resolutions of the Seventeenth World Meteorological Congress, the resolutions of the sixty-seventh session of the Executive Council and the resolutions and decisions of the sixty-eighth session of the Executive Council,

(2) Decision 93 (EC-68) – Roadmap to an enhanced framework for WMO Technical Regulations,

Recommends that:

(1) The *Manual on Codes* (WMO-No. 306), Volumes I.2 and I.3 be designated as technical specifications;

(2) Provisions in technical regulations other than the *Manual on Codes* that specify obligations to exchange information be amended to state explicitly which information representations in the *Manual on Codes* are to be used to represent that information, and to specify what information has to be exchanged;

(3) The *Manual on Codes*, Volumes I.2 and I.3 be amended to remove provisions in those volumes that place obligations on Members to exchange information, so that the term "shall" in these volumes designates conformance to technical specifications that is required in order that systems using data representations can perform correctly;

(4) The status of the *Manual on Codes*, Volume I.1 should remain unchanged until such time as the traditional alphanumeric codes are no longer supported for operational exchange by the World Weather Watch, but that if any provision for information exchange that is expressed as an obligation in that Volume should change, that provision should be transferred to the technical regulations from which the obligation is derived;

Requests its Open Programme Area Groups (OPAGs) on Integrated Observing Systems and on Information Systems and Services to coordinate changes to the *Manual on Codes*, Volumes I.2 and I.3 with changes to the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160) and to the *Manual on the Global Observing System* (WMO-No. 544) in order to remove provisions that place obligations on Members to exchange information from these volumes of the *Manual on Codes*;

Requests further all its OPAGs to take note of the *Guidelines on the Preparation and Promulgation of the WMO Technical Regulations* (WMO-No. 1127) when creating or amending Technical Regulations, Manuals or Guides;

Decides that the Commission for Basic Systems will withdraw the *Guide on World Weather Watch Data Management* (WMO-No. 788) after the *Manual on the WMO Information System* (WMO-No. 1060) and the *Guide to the WMO Information System* (WMO-No. 1061) have been amended to include provisions and guidance on information management.

Recommendation 26 (CBS-16)

TERMS OF REFERENCE FOR THE COMMISSION FOR BASIC SYSTEMS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 43 (Cg-XVI) – Terms of reference of the technical commissions,

(2) That the Executive Council Working Group on WMO Strategic and Operational Planning (WG-SOP) is reviewing the governance of WMO and is expected to report in time for the Eighteenth World Meteorological Congress to implement its recommendations,

Considering the wording of the terms of reference for the Commission for Basic Systems (CBS) General Regulations, *Basic Documents No. 1* (WMO-No. 15), 2015 edition,

Recommends to the Executive Council that the terms of reference for CBS should be amended as shown in the annex to the present recommendation;

Authorizes its president, after consultation with its Management Group, to propose to the Eighteenth World Meteorological Congress amended terms of reference for CBS that address issues arising from reports of WG-SOP.

Annex to Recommendation 26 (CBS-16)

TERMS OF REFERENCE FOR THE COMMISSION FOR BASIC SYSTEMS

[Changes from the text of Resolution 43 (Cg-XVI) are shown as additions or ~~deletions~~].

The Commission shall be responsible for matters relating to:

(a) Cooperation with Members, other technical commissions, regional associations and relevant bodies in the development and operation of integrated systems for observing, data processing, forecasting, telecommunications, and data management. These activities shall be in response to requirements and in support of all WMO Programmes, particularly contributing to disaster risk reduction, and taking advantage of opportunities provided by technological developments;

(b) The assessment of opportunities for, and the provision of, a common infrastructure to meet the requirements defined by technical commissions and regional associations, as well as by organizations with whom WMO has relations, taking into account new applications of meteorology, hydrology, oceanography, and related environmental sciences;

(c) Continued development and modernization of the World Weather Watch (WWW);

(d) Further development and implementation of the Public Weather Services Programme, with particular attention to the implementation of the WMO strategy for service delivery, including impact-based forecasting and risk-based warnings, to ensure end-to-end service delivery;

(e) Further development and implementation of the WMO Space Programme;

(f) Contribution to the development and implementation of the Global Framework for Climate Services;

(g) ~~The~~ Further development and implementation of processing, storage and retrieval of basic data for meteorological and related purposes including, in particular, the organization of the seamless Global Data-processing and Forecasting System of the WWW;

(h) ~~The~~ Further development and application of systems and techniques to meet user requirements including those of operational weather analysis and forecasting and of services for environmental emergency authorities;

(i) Provision of operational technical support to Disaster Risk Reduction and humanitarian activities, in particular the multi-hazard early warning system and service delivery;

~~(i)~~(j) Observational systems, facilities and networks (land, sea, air, and space) as decided by Members including, in particular, all technical aspects of the WMO Integrated Global Observing System, particularly the global observing systems;

~~(j)~~(k) Telecommunication networks, radio-frequency allocation and facilities for operational, research and applications purposes including, in particular, the organization of the WMO Information System, including the Global Telecommunication System of the World Weather Watch;

~~(k)~~(l) The development and application of operational procedures, schedules, and arrangements for the exchange of and access to weather, climate and water information (data and, products), including warnings, required by all WMO Programmes, in particular~~,~~ through the WMO Information System;

~~(l)~~(m) The development and application of data management principles and procedures including monitoring and evaluation of the common infrastructure, in particular, of the World Weather Watch;

(n) Promote assessment of social and economic benefits of meteorological and hydrological services, including a more systematic basis for prioritizing the use of available resources for infrastructure.

Recommendation 27 (CBS-16)

WORLD WEATHER WATCH PROGRAMME, PUBLIC WEATHER SERVICES PROGRAMME AND WMO SPACE PROGRAMME

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 20 (Cg-17) – World Weather Watch Programme,

(2) Resolution 5 (Cg-17) – Public Weather Services Programme,

(3) Resolution 5 (Cg-XIV) – WMO Space Programme,

(4) Resolution 11 (Cg-17) – Towards a future enhanced integrated and seamless Data-processing and Forecasting System,

Noting further that the Executive Council Working Group on the Strategic and Operational Plan is reviewing the governance of WMO and is expected to report in time for the Eighteenth World Meteorological Congress to implement its recommendations,

Considering that responding to the challenges and opportunities of changing technologies and practices relating to the availability and processing of information are within the scope of the recommended World Weather Watch Programme and the WMO Space Programme,

Realizing that addressing the challenges and opportunities of enhancing the quality and the delivery of services by Members through the WMO Strategy for Service Delivery and through the seamless Global Data-processing and Forecasting System may impact on the definitions of WMO programmes,

Recommends to the Executive Council:

(1) For review and submission to the Eighteenth World Meteorological Congress:

(a) Draft resolution World Weather Watch Programme (Cg-18) in Annex 1 to the present recommendation;

(b) Draft resolution Public Weather Services Programme (Cg-18) in Annex 2 to the present recommendation;

(c) Draft resolution WMO Space Programme (Cg-18) in Annex 3 to the present recommendation;

(2) That it consider whether these draft resolutions need to be amended as a consequence of further planning of the implementation of the WMO Strategy for Service Delivery.

Annex 1 to Recommendation 27 (CBS-16)

DRAFT RESOLUTION WORLD WEATHER WATCH PROGRAMME (CG-18)

WORLD WEATHER WATCH PROGRAMME

THE WORLD METEOROLOGICAL CONGRESS,

Noting:

(1) Article 2 of the Convention of the World Meteorological Organization,

(2) Resolution 20 (Cg-17) — World Weather Watch Programme,

(3) Resolution *[XX]* (Cg-18) – WMO Strategic Plan 2020–2023,

Noting further:

(1) The *Abridged Final Report with Resolutions of the Seventeenth World Meteorological Congress* (WMO-No. 1157), general summary, agenda item 4.2.1,

(2) The *Abridged Final Report of the Sixteenth Session of the Commission for Basic Systems* (WMO-No. *[XX]*),

(3) The *Abridged Final Report with Resolutions and Recommendations of the Seventeenth Session of the Commission for Instruments and Methods of Observation* (WMO-No. *[XX]*),

Expresses:

(1) Its satisfaction that progress has been made in the further improvement of the operation of the World Weather Watch (WWW) Programme during the period 2016-2019;

(2) Its concern that deficiencies remain in the implementation of the Programme in some areas;

(3) Its concern that climate variability and change are likely to result in higher frequency and greater intensity high-impact weather and climate extremes;

(4) The need for intensified and coordinated activities for the operation and maintenance of the Programme in meeting needs for improved weather services and in support of other WMO Programmes and high-priority areas to meet the objectives of the WMO Strategic Plan and maximize the benefits available to all Members;

Confirms:

(1) That the WWW Programme has the highest priority as the backbone WMO Programme on which all other Programmes of the Organization depend and provides the basis for the operations of National Meteorological and Hydrological Services;

(2) That the Programme continues to provide an effective mechanism for the application of science and technology in operations;

(3) That the Programme contributes to the WMO Strategy for Service Delivery;

(4) That the Programme should be used only for peaceful purposes, due account being taken of the national sovereignty and security of Member States and Territories, in accordance with the provisions of the Charter of the United Nations and the spirit and tradition of the Convention of the World Meteorological Organization;

Considering:

(1) The absolute importance of weather, climate and hydrological observations for determining the current state of the atmosphere, for weather forecasting, including severe weather forecasting and warning services, for monitoring climate variability and climate change, for climate prediction and as a fundamental underpinning of the Global Framework for Climate Services,

(2) That advanced technology for improving the technical systems of the WWW Programme calls for special efforts in the provision of technical guidance, specialized training and capacity-building,

Decides that the WWW Programme shall be aligned with the WMO Strategic Plan 2019-2023 and high priorities of WMO;

Stresses the role to be played by regional associations in coordinating WWW Programme implementation, identifying deficiencies, specifying requirements, and planning system support projects, on a regional scale;

Invites the regional associations to promote the coordinated implementation of the WWW Programme and to keep under continuous review related regional requirements;

Requests the Executive Council:

(1) To ensure that the further development of the WWW Programme is carried out in accordance with the WMO Strategic Plan;

(2) To adjust the Programme as necessary, particularly in the light of the recommendations made by the Commission for Basic Systems, the Commission for Instruments and Methods of Observation, the regional associations and requirements expressed by other technical commissions;

(3) To assist Members in all possible ways in meeting their respective responsibilities within the Programme;

(4) To promote the establishment of cooperative arrangements for the implementation, operation and maintenance of Programme system components, as appropriate;

Requests the Commission for Basic Systems:

(1) To pursue the technical planning and further development of the WWW Programme in accordance with the WMO Strategic Plan, taking into account any adjustments and directives from the Executive Council;

(2) To take a leading role, together with the Commission for Instruments and Methods of Observation, in the technical development and implementation of the Global Observing System (GOS), as the key component of the WMO Integrated Global Observing System (WIGOS), to meet, in an optimal way, the requirements of all WMO and co-sponsored Programmes;

(3) To pursue its leading role in the technical implementation and operation of the WMO Information System (WIS), including the Global Telecommunication System as its core network, for the collection and sharing of information for all WMO and related international programmes;

(4) To pursue its leading role in the technical implementation and operation of the future Global Data-processing and Forecasting System (GDPFS) and environmental Emergency Response Activities through increased lead time and reliability of forecasts and warnings, and its critical support to the delivery of services, including support of impact-based forecasting, to the general public as well as to all relevant socioeconomic sectors;

(5) To maintain close liaison with the other technical commissions, the regional associations, other relevant international organizations and international programmes, in particular the Global Climate Observing System, with a view to ensuring that their relevant requirements and recommendations are taken in due consideration;

Urges all Members, especially donor countries, individually and through appropriate multinational arrangements, to cooperate actively in the further development and operation of the World Weather Watch, and in particular:

(1) To continue, to the best of their ability, to further develop, implement, operate and maintain the WWW Programme component systems (observation, information, data-processing and forecasting components) , to provide early access to data and to ensure the requirements of Members for the provision of products and services are fully met;

(2) To contribute to the implementation and operation of WIGOS, WIS, the future seamless and integrated GDPFS and environmental Emergency Response Activities;

(3) To coordinate and pool their national efforts and resources, in order to establish realistic goals, minimize the implementation and operational costs, and avoid duplication of Programme activities as far as possible;

(4) To participate in the deployment and use of new systems and techniques, including appropriate capacity development activities, and, individually or collectively, to evaluate their effectiveness and their integration in the Programme;

(5) To keep the Secretary-General informed about their plans and activities regarding the implementation of the Programme, in collaboration with other relevant technical commissions;

Requests the Secretary-General:

(1) To keep Members informed of progress and developments in the planning and implementation of the WWW Programme;

(2) To further improve the monitoring of the operation of the Programme and the publication of results;

(3) To assist Members, as necessary, in overcoming difficulties that may arise in the implementation of the Programme during the seventeenth financial period;

(4) To propose projects and priorities for the consolidation and further development of key Programme facilities;

(5) To assist the Executive Council, the regional associations, the Commission for Basic Systems and the Commission for Instruments and Methods of Observation in the implementation of the present resolution;

(6) To bring the present resolution to the attention of all concerned;

(7) To submit a report to the Eighteenth World Meteorological Congress on the implementation of the WWW component systems during the eighteenth financial period together with proposals for further development of the World Weather Watch.

Note: This resolution replaces Resolution 20 (Cg-17), which remains in force only until 31 December 2019.

Annex 2 to Recommendation 27 (CBS-16)

DRAFT RESOLUTION PUBLIC WEATHER SERVICES PROGRAMME (CG-18)

PUBLIC WEATHER SERVICES PROGRAMME

THE WORLD METEOROLOGICAL CONGRESS,

Noting:

(1) Resolution 5 (Cg-17) – Public Weather Services Programme,

(2) Resolution 2 (Cg-17) – Implementation of the WMO Strategy for Service Delivery,

(3) Resolution 40 (Cg-XII) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities,

(4) Resolution 25 (Cg-XIII) – Exchange of hydrological data and products,

(5) Resolution 60 (Cg-17) – WMO policy for the international exchange of climate data and products to support the implementation of the Global Framework for Climate Services,

Considering:

(1) That the Public Weather Services (PWS) Programme constitutes the main conduit connecting National Meteorological and Hydrological Services (NMHSs) to the public, media, disaster management authorities, communities affected by weather-related disasters, and social and economic user sectors,

(2) The continuing need to strengthen the capability of Members to deliver high-quality services for the safety of life and livelihood, the protection of property, and for contributing to sustainable development,

(3) That it is critical for decision-makers to understand and translate meteorological information and especially warnings into effective actions,

(4) That addressing the challenges and opportunities of enhancing the quality and the delivery of services by Members through the WMO Strategy for Service Delivery and the seamless and integrated Global Data-processing and Forecasting System may impact on the definitions of WMO Programmes,

(5) The progress and accomplishments made by the World Weather Information Service (WWIS) and the Severe Weather Information Centre (SWIC) in strengthening the recognition of NMHSs by providing a centralized and authoritative source of official weather forecasts, climatological information and weather warnings to the public and the media,

Decides:

(1) That the substance of the PWS Programme shall be as indicated in the WMO Strategic and Operating Plans (2019-2023) adopted under Resolution *[XX]* (Cg-18);

(2) That the WMO Strategy for Service Delivery should guide the implementation of the WMO Programmes, and in particular the PWS Programme;

(3) That the information content of WWIS, including the official weather forecasts and climatological information for worldwide cities, should be made available on a free and unrestricted basis;

Requests the Commission for Basic Systems:

(1) To continue to provide assistance to the technical planning and further development of the PWS Programme, in particular in the implementation of emerging technologies in the provision of public weather services to the user communities, in accordance with the WMO Strategic and Operating Plans;

(2) To enhance its crucial support to the Programme in the delivery of services to the public and to socioeconomic sectors;

(3) To enhance its support to the initiatives of the PWS Programme in addressing emerging user needs and in assisting Members to benefit from the implementation of impact-based forecast and warning services;

(4) To support definition of clear roles, responsibilities and "rules of engagement" for retaining the authoritative voice of NMHSs, especially with respect to warning services, and preparation of strategies to allow mutual benefits between public and private sectors through private support to PWS activities;

(5) To provide further guidance to Members in enhancing their city forecasts with longer lead time, higher spatial and temporal resolutions, and additional weather elements, and in converting weather warnings into Common Alerting Protocol (CAP) format;

(6) To provide technical guidance to Members, as needed, for the use of CAP format in the dissemination of information contained on the WWIS and SWIC websites;

Invites the regional associations:

(1) To continue to be actively engaged with the PWS Programme;

(2) To promote the implementation of the Competency Framework for PWS Forecasters and Advisors in their respective Regions;

(3) To establish requirements in the light of the evolving needs of Members and technical developments in the delivery of services;

(4) To encourage the positive exploitation of Public Private Partnerships in the provision of public weather services;

Requests the Executive Council to take all necessary actions to guide the PWS Programme and to enable it to meet the needs of Members in service delivery and thus to achieve its objectives under the WMO Strategic and Operating Plans (2019-2023);

Urges Members:

(1) To take all possible measures to continue to support the implementation of the PWS Programme;

(2) To take all possible steps to strengthen their national PWS through ensuring effective service delivery to user communities and stakeholders, and raising the level of public awareness of and response to these services through effective communication and public education efforts;

(3) To participate in PWS capacity development activities;

(4) To evaluate the effectiveness of PWS in the delivery of services to users;

(5) To assess the contribution of PWS to the social and economic benefits provided to users through the work of NMHSs, and demonstrate such benefits to governments with the aim of securing due support for NMHSs, and further strengthening their capacity to deliver quality service;

(6) To participate in initiatives aimed at provision of impact-based forecast and warning services;

(7) To contribute more city forecasts with longer lead time, higher spatial and temporal resolutions, current weather observations and additional weather elements to WWIS;

Requests the Secretary-General:

(1) To support Members, as necessary, in their efforts to implement PWS activities at the national level in accordance with the WMO Strategy for Service Delivery with the aim of achieving the highest possible levels of user satisfaction;

(2) To collaborate closely with Members to ensure the further development and implementation of the PWS Programme and to establish clear performance metrics so that the Programme is enabled to contribute fully to the realization of Expected Result 1 – Improved service quality and service delivery;

(3) To support Member' efforts in the positive exploitation of public-private partnerships in the provision of public weather services;

(4) To propose projects for the further development of key PWS components;

(5) To promote collaboration between the PWS Programme and other relevant WMO Programmes;

(6) To liaise with the Member that hosts the SWIC website to carry out the enhancement necessary to enable the website to disseminate weather warnings that would be provided in CAP format by Members;

(7) To promote collaboration with relevant national and international organizations.

Note: This resolution replaces Resolution 5 (Cg-17) that remains in force only until 31 December 2019.

Annex 3 to Recommendation 27 (CBS-16)

DRAFT RESOLUTION WMO SPACE PROGRAMME (CG-18)

WMO SPACE PROGRAMME

THE WORLD METEOROLOGICAL CONGRESS,

Noting Resolution 5 (Cg-XIV) of the *Fourteenth World Meteorological Congress Abridged Final Report with Resolutions* (WMO-No. 960),

Recognizing the critical importance for data, product and services provided by the World Weather Watch's expanded space-based component of the GOS to WMO Programmes and supported Programmes and that such importance would continue to expand rapidly,

Decides:

(1) To continue the WMO Space Programme as a cross-cutting programme to increase the effectiveness and contributions from satellite systems to WMO Programmes and provide the space-based contribution to the WMO Integrated Global Observing System;

(2) That the substance of the WMO Space Programme shall be as indicated in the WMO Strategic and Operating Plans (2019-2023) adopted under Resolution [XX] (Cg-18);

Urges Members to collaborate actively in, and give all possible support to, the implementation and operation of the WMO Space Programme, and to provide early access to data;

Invites participating international and intergovernmental organizations also to collaborate actively in, and give all possible support to, the implementation of the WMO Space Programme;

Requests the Executive Council and the Consultative Meetings on High-level Policy on Satellite Matters, with the assistance from all technical commissions and with the Commission for Basic Systems providing lead responsibility, to promote the implementation of the WMO Space Programme;

Requests the Secretary-General, within the available budgetary resources:

(1) To assist in the implementation of the Programme;

(2) To collaborate in the implementation of the Programme with other interested international and intergovernmental organizations and programmes.

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Note: This resolution replaces Resolution 5 (Cg-XIV) that only remains in force until 31 December 2019.

Recommendation 28 (CBS-16)

SUBMISSION AND MAINTENANCE OF WMO INTEGRATED GLOBAL OBSERVING SYSTEM METADATA IN THE OBSERVING SYSTEMS CAPABILITY ANALYSIS AND REVIEW TOOL BY MEMBERS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 25 (Cg-17) – *Technical Regulations* (WMO-No. 49), Volume I, Part I – WMO Integrated Global Observing System,

(2) Resolution 26 (Cg-17) – *Technical Regulations* (WMO-No. 49) – Manual on the WMO Integrated Global Observing System,

(3) The *Final Report of the Ninth Session of the Implementation Coordination Team on Integrated Observing Systems (ICT-IOS-9)* (18–21 April 2016), general summary 6.3,

Recalling the obligation of Members, according to the WMO Integrated Global Observing System (WIGOS) Technical Regulations and the Manual on the WMO Integrated Global Observing System (WMO-No. 1160), to submit WIGOS metadata about the WIGOS observing systems they operate,

Acknowledging:

(1) The contribution of Switzerland for the operation and long-term maintenance of the Observing Systems Capability Analysis and Review tool (OSCAR) and the Global Atmosphere Watch Station Information System (GAWSIS); and the specific mechanism in place for collecting GAW observing stations metadata supported by several Members hosting data archives relevant for GAW,

(2) The contribution of Turkey with regard to the establishment and operation of the WMO Weather Radar Database (WRD) and the process established by the Secretariat in which National Focal Points for weather radar metadata are requested to maintain the WRD,

(3) The contribution of the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) with the JCOMM in situ Observations Programme Support Centre (JCOMMOPS) with regard to the collection of WIGOS metadata concerning marine meteorological and oceanographic observing systems,

(4) That some Members are maintaining their own databases of WIGOS metadata for the observing systems they operate,

(5) That WIGOS metadata need to be kept up to date in order to be of full value to the Members,

Noting further that the development of machine-to-machine interfaces for the exchange of metadata between existing databases (including national databases) and OSCAR is essential for the upload and management of WIGOS metadata, for avoiding duplication of work, and for increasing reliability and quality of WIGOS metadata in OSCAR,

Recommends that Members submit to OSCAR required WIGOS metadata for all observing stations for which observations are internationally exchanged through the following mechanisms:

(1) Directly to OSCAR, preferably through machine-to-machine interfaces as they become available, for all relevant WIGOS observing systems operated by them, in addition to the ones explicitly listed below;

(2) GAWSIS (https://gawsis.meteoswiss.ch/) for any GAW observing stations they operate;

(3) WRD (http://wrd.mgm.gov.tr/) for any weather radars they operate;

(4) JCOMMOPS (http://www.jcommops.org) for any marine meteorological and oceanographic observing systems they operate;

Urges JCOMM to ensure that JCOMMOPS will be fully compliant with the WIGOS metadata standard and to facilitate ingestion of relevant WIGOS metadata in its database while providing fully compliant machine-to-machine interfaces with the surface-based observation system component of OSCAR (OSCAR/Surface);

Urges Members operating their own databases of WIGOS metadata to develop and implement procedures for the use of the machine-to-machine interfaces with OSCAR;

Strongly urges Members who have not already done so to nominate OSCAR/Surface National Focal Points as soon as possible in order to ensure that WIGOS metadata in OSCAR/Surface are maintained to the agreed standard.

Recommendation 29 (CBS-16)

TRAINING ON THE SURFACE-BASED OBSERVING SYSTEMS COMPONENT OF THE OBSERVING SYSTEMS CAPABILITY ANALYSIS AND REVIEW TOOL

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 23 (Cg-17) – Pre-operational phase of the WMO Integrated Global Observing System,

(2) Resolution 2 (EC-68) – Plan for the WMO Integrated Global Observing System pre-operational phase 2016–2019,

Recalling:

(1) The obligation of Members, according to the WMO Integrated Global Observing System (WIGOS) Technical Regulations and the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), to submit WIGOS metadata about the observing systems they operate,

(2) The transition period of *Weather Reporting* (WMO-No. 9), Volume A – Observing Stations to the surface-based observation system component of the Observing Systems Capability Analysis and Review tool (OSCAR/Surface) from May 2016 to the end of 2017,

Considering:

(1) That OSCAR/Surface is a completely new tool, recently made available to Members,

(2) The two ways of possible interaction with OSCAR/Surface:

(a) Manually, via the web interface,

(b) Automatically, via a machine-to-machine interface,

(3) That very few Members have received any kind of training on the use of OSCAR/Surface (web interface),

Recommends adoption of the training plan for OSCAR/Surface, as described in the annex to the present recommendation, for the period 2017–2018, as an important component of the WMO Education and Training Programme;

Recommends the Secretary-General:

(1) To develop training materials, especially e-learning modules, on OSCAR/Surface and make them available on the WIGOS web page;

(2) To develop and deliver OSCAR/Surface training events to Members;

Recommends regional associations to contribute to the effort of developing and delivering OSCAR/Surface training events;

Recommends the WMO Education and Training Department to work closely with the Regional Training Centres and the WIGOS Project Office to organize and deliver training events according to the OSCAR/Surface training plan;

Recommends to the WIGOS Project Office that the OSCAR/Surface training plan be expanded to include training mechanisms to sustain the capabilities;

Urges Members to contribute to this effort by offering expertise and resources, especially towards development of e-learning materials for OSCAR/Surface.

Annex to Recommendation 29 (CBS-16)

DRAFT TRAINING PLAN FOR THE SURFACE-BASED OBSERVATION SYSTEMS COMPONENT OF THE OBSERVING SYSTEMS CAPABILITY ANALYSIS AND REVIEW TOOL 2017–2018

Type of training	Content	Audience	Region / Subregion	Language	Date
Classroom	Web interface	NFPs O/S	RA I	French	4th Q 2016
Classroom	Web interface	NFPs O/S	RA I	English	1st Q 2017
Classroom	Web interface	NFPs O/S	RA III/IV	Spanish	1st Q 2017
Classroom	Web interface	NFPs O/S	RA VI	English	2nd Q 2017
Classroom	Web interface	NFPs O/S	RA II	English	2nd Q 2017
Classroom	Web interface	NFPs O/S	RA II /RA-VI	Russian	2nd Q 2017
Classroom	Web interface	NFPs O/S	RA V	English	3rd Q 2017
Classroom	Web interface	NFPs O/S	RA III/IV	English	3rd Q 2017
Webinar	M-2-M interface	Members IT staff	RA IV/VI	English	3rd Q 2017
Webinar	M-2-M interface	Members IT staff	RA III/VI	Spanish	3rd Q 2017

Webinar	M-2-M interface	Members IT staff	RA II/V	English	4th Q 2017
Webinar	M-2-M interface	Members IT staff	RA II/VI	Russian	4th Q 2017
Webinar	M-2-M interface	Members IT staff	RA I	English	4th Q 2017
Webinar	M-2-M interface	Members IT staff	RA I	French	4th Q 2017

Assumptions:

- Not all NFPs for OSCAR/Surface will be able to participate in the regional training events (classroom);
- Some of the NFPs for OSCAR/Surface participating in the regional training events (classroom), could play an important role, in subsequent years, in assisting other Members of their Region(s), e.g. via Regional/Sub-regional WIGOS Centre(s);
- The M-2-M interface is expected to be fully operational from mid-2017;
- Subsequent to the training events in 2017, the e-learning materials should become available for additional non-synchronous training, as self-directed learning.

Recommendation 30 (CBS-16)

STANDARDIZATION OF OBSERVING SYSTEMS INSTALLED ON SHIPS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The *Final Report of the Ninth Session of the Implementation Coordination Team on Integrated Observing Systems (ICT-IOS-9)* (18–21 April 2016), general summary 4.3,

(2) That the Surface Marine Operational Service (E-SURFMAR) of the Economic Interest Group of European Meteorological Services (EUMETNET) has worked extensively to develop the new E-SURFMAR Shipboard Automatic Weather Station (AWS) system named EUCAWS (European Common AWS) with detailed design specifications and recommendations,

(3) That tendering documents for the EUCAWS system were issued in mid-2012 and following detailed evaluation of the tenders, EUMETNET has decided to establish a framework agreement with the chosen manufacturer,

Having considered the importance of standardizing marine meteorological observations installed on ships with the view to providing homogeneous observational data of known quality, and to facilitate the maintenance of instruments and data acquisition equipment by port meteorological officers (PMOs),

Recommends the Executive Council to invite Members to collaborate in the European effort, to facilitate standardization of AWS systems and their observations installed on ships as well as the maintenance of such systems by PMOs.

Recommendation 31 (CBS-16)

IMPACT ASSESSMENT FOR OBSERVING SYSTEM DESIGN AND EVOLUTION

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The *Final Report of the Ninth Session of the Implementation Coordination Team on Integrated Observing Systems (ICT-IOS-9)* (18–21 April 2016), general summary 6.8,

(2) The outcome and recommendations of the sixth WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction (Shanghai, China, 10–13 May 2016),

Recalling the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), paragraph 2.2.5, whereby: (1) Members, or groups of Members within regions, should conduct and/or participate in observation impact studies and related scientific evaluations to address WMO Integrated Global Observing System network design questions; and (2) Members should provide expertise for synthesizing the results of impact studies and making recommendations on the best mix of observing systems to address the gaps identified by the Rolling Review of Requirements process,

Recalling further the *Abridged Final Report with Resolutions and Recommendations of the Extraordinary Session of the Commission for Basic Systems* (WMO-No.1140), general summary paragraph 3.1.28, recommending enhanced contributions of Members to continue with the development and research of adjoint-based observation impact assessment tools as a complement to traditional Observing System Experiments (OSEs), to undertake OSEs for the optimization of regional composite networks, and to conduct OSEs and Observing System Simulation Experiments (OSSEs) to address specific science questions,

Having considered the need to assess the impact of various observing systems on numerical weather prediction (NWP),

Having considered further that observation impact studies provide a wealth of information of relevance to the evolution of the Global Observing System, and that the traditional OSE and OSSE techniques are complemented by new adjoint- and ensemble-based approaches that help inform network design activities and investment,

Endorses a need to undertake such studies;

Agrees that priority should be given to studies that address the identified science questions that are anticipated to include observation impact assessment for longer-range forecasting and non-NWP application areas;

Further agrees that the series of WMO Workshops on the Impact of Various Observing Systems on NWP should continue;

Decides to task the Implementation–Coordination Team on Integrated Observing Systems with undertaking the necessary technical and scientific preparations for organizing a seventh WMO Workshop on the Impact of Various Observing Systems on NWP in the 2020 time frame;

Recommends that the Executive Council request Members:

(1) To continue the development and research of adjoint- and ensemble-based observation impact assessment tools, as a complement to traditional OSEs;

(2) To develop OSEs for the optimization of regional composite networks;

(3) To address the science questions listed in the annex to the present recommendation, and to undertake the required impact studies (for example, OSEs and OSSEs) during the period 2017 to 2020 at their NWP Centres;

(4) To volunteer to host the seventh WMO Workshop on the Impact of Various Observing Systems on NWP in 2020.

Annex to Recommendation 31 (CBS-16)

SCIENCE QUESTIONS TO BE ADRESSED FOR OBSERVING SYSTEM DESIGN AND EVOLUTION

Short name: Full name	***Science question***
Surface-based	
S1Marine: Surface pressure and winds over ocean	What density of surface pressure observations over the ocean is needed to complement high-density surface wind observations from satellites? What is the required coverage of SCAT winds?
S2AMDAR: Coverage of AMDAR	What are the priorities for expansion of the AMDAR network? Assess the impact regionally, specifically also in the in the tropics where profiling coverage is sparse. Provide guidance for AMDAR optimization. Evaluate the impact of MODE-S data in high-resolution NWP.
S3Radar: Radar observations	What are the impacts of current radar observations, including wind profiles, radial winds and reflectivities?
S4Strat: In situ observations of the stratosphere	What network of in situ profiling observations is needed in the stratosphere to complement current satellite observations (including radio occultation)? Assessments addressing the Tropics are encouraged.
S5PBL: Observations of the PBL for regional and high-resolution NWP	What should be the focus of improvements for observations of the planetary boundary layer (PBL) in support of regional and high-resolution NWP? Which variables and what space-time resolution?
S6GCW: High elevation surface observing stations	Estimate the actual and potential impacts of high elevation meteorological data from the high mountain regions, specifically 4000m or more above sea level.
S7Sat: Impact of satellite observing capabilities on the design of the surface-based observing systems	Impact study on the design and evolution of surface-based observing systems of the increasing capabilities of space-based observing systems, with special emphasis on the impact on network design in areas with very sparse surface-based networks.
Space-based	
S7SatLand: Satellite sounding over land and ice	What is the impact of new developments in the assimilation of radiance data over land, snow and sea ice?

S8Sounders: Impact of multiple satellite sounders	What benefits are found when data from more than one passive sounder are available from satellites in complementary orbits, e.g. the current unprecedented availability of hyper-spectral sounders?
S9AMVs: Atmospheric Motion Vectors	Based on evidence from current AMV impacts, which AMV characteristics should be enhanced for the next generation of GEO satellites? What are the impacts of recent new types of AMVs such as MISR-AMV?
General	
S10UA: Regional upper-air network design studies	Upper-air network design studies such as those that have been performed for the European composite observing system (EUCOS) are required also in other Regions, especially in Region I where the basic networks are under pressure. Assessments of recent changes in the networks, including the impact of launching radiosondes once per day or at non-synoptic times.
S11AdjEns: Application of adjoint and ensemble methods	What insights can be gained from adjoint and ensemble-based impact measures tailored for applications such as severe weather, aviation and energy? Specific impact metrics may be required.
S12Ocean: Impact in ocean-coupled assimilation	Which ocean observations are particularly important for NWP? Investigate the role of ocean observations in coupled atmosphere-ocean data assimilation with a focus on the 7-14 day range.
S13Land: Impact in land-coupled assimilation	Which land-surface observations are particularly important for NWP at all forecast time ranges? Investigate the role of surface observations in coupled atmosphere-land data assimilation with a focus on the 7-14 day range.
S14 Time frequency	What is the required time frequency of observations? Consider AMDAR, GEO satellites and ground-based remote sensing observations (such as Doppler radar, wind profiler, ground based GNSS receivers) for regional and global NWP.
S15 Atmospheric composition	Study observation impact in atmospheric composition and air quality application and the impact of atmospheric composition observations (e.g. aerosol) on NWP.
S16 OSSEs	Observing system simulation experiments are encouraged in support of satellite system design criteria such as orbit optimization for GPS-RO satellites, or configurations for hypersperspectral IR sounders on geostationary orbit.

Recommendation 32 (CBS-16)

STUDY TO BE UNDERTAKEN TO ANALYSE OPTIONS FOR OPTIMIZATION OF THE UPPER-AIR OBSERVATIONS PROGRAMME OF THE GLOBAL OBSERVING SYSTEM

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The *Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP)* (WIGOS Technical Report No. 2013-4),

(2) The *Final Report of the Ninth Session of the Implementation Coordination Team on Integrated Observing Systems (ICT-IOS-9)* (18–21 April 2016), general summary 4.3,

(3) The report of the Sixth WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction (Shanghai, China, 10–13 May 2016),

Recognizing Action G10 of the EGOS-IP, which calls for Members to "Investigate possibility to optimize the radiosonde network in order to make the upper-air conventional observation coverage more uniform taking into account all the user requirements in terms of space and time distribution; and make relevant recommendations to the CBS for updating Technical Regulations accordingly",

Acknowledging the growth over the past several decades and the expected continued growth in the future of the Aircraft Meteorological Data Relay (AMDAR) observing system and the volume of aircraft-based observations on the Global Telecommunications System,

Having considered the recommendations of the Implementation–Coordination Team on Integrated Observing Systems and of the Sixth WMO Workshop on the Impact of Various Observing Systems on NWP,

Having examined the plan submitted by the Open Programme Area Group on the Integrated Observing System (OPAG-IOS) Expert Team on Surface-Based Observations (ET-SBO) for the project aimed at assessing evidence of the impact of a potential change to the radiosonde network configuration based on complementary optimization with the AMDAR observing system (hereafter referred to as "Radiosonde Optimization Study Plan"),

Endorses the Radiosonde Optimization Study Plan as provided in the annex to the present recommendation;

Requests OPAG-IOS and its ET-SBO to finalize the Radiosonde Optimization Study Plan by the end of 2016 and undertake coordination and implementation of that Plan and report to the Commission for Basic Systems on its outcomes;

Recommends the Executive Council to request:

(1) The Secretary-General to provide appropriate resources to support the Radiosonde Optimization Study Plan;

(2) Members to support the execution of the Radiosonde Optimization Study Plan.

Annex to Recommendation 32 (CBS-16)

OPEN PROGRAMME AREA GROUP ON THE INTEGRATED OBSERVING SYSTEM OUTLINE PLAN FOR THE PROJECT AIMED AT ASSESSING EVIDENCE OF THE IMPACT OF A POTENTIAL CHANGE TO THE RADIOSONDE NETWORK CONFIGURATION BASED ON COMPLEMENTARY OPTIMIZATION WITH THE AIRCRAFT METEOROLOGICAL DATA RELAY OBSERVING SYSTEM (IMPLEMENTATION PLAN FOR THE EVOLUTION OF GLOBAL OBSERVING SYSTEMS ACTION G10)

(Version reviewed by ICT-IOS-9, April 2016)

INTRODUCTION

The Implementation Plan for the Evolution of the Global Observing System (EGOS-IP) was approved by CBS in 2012. The Actions within the Implementation Plan are varied and in some cases complex and solutions will be developed by a range of bodies. In some cases the OPAG-IOS Expert Team on Surface-Based Observing Systems (ET-SBO) will be the lead body or catalyst for progressing an EGOS-IP Action. Action G10 is one such action where ET-SBO will take the lead in developing the concept but it will be the Members of WMO, as the owners of the national radiosonde programmes, who will ultimately be responsible for the delivery of the changes. What follows is an outline of the task required to progress action G10.

Whilst ET-SBO will act as the lead ET in progressing the work it is expected that many other WMO teams, such as IPET-OSDE, will also contribute to progressing the various stages of the action.

DETAILS OF ACTION G10

The context of action G10 is described in the text preceding the action in the EGOS-IP. All the text from the Radiosonde section is included here in italics for context:

5.3.1.1.1. Radiosonde network and data coverage: optimization

[Numerical Weather Prediction] NWP impact studies have consistently shown the importance of vertical profile data, particularly radiosonde data from isolated locations (see Section 4 of the proceedings of the fourth WMO Workshop on the Impact of Observations on NWP), and a network of upper-air measurements of sufficient coverage is required for climate monitoring. Inadequacies include some large continental regions that are not monitored by any radiosonde site. It is essential to reduce these big gaps in the radiosonde data coverage, or at least, to prevent these gaps from expanding. It is essential to maintain operational radiosonde and pilot balloon stations in the least observed areas of Regions I, II and III, keeping in mind that the optimization of the radiosonde coverage cannot be done independently of aircraft and other observing systems.

One of the highest priorities in terms of observation requirements is to add more profile observations in many data sparse areas. Thus all the AMDAR opportunities (see section 5.3.1.3) should be used to improve the wind and temperature data coverage, especially in data sparse areas like the inter-tropical regions or central and southern Africa. This implies collecting new wind and temperature profiles at certain airports by equipping some aircrafts flying regularly to these airports, and also acquiring data from cruise levels in these regions.

Several studies and campaigns (see reference to AMMA in the proceedings of the fourth WMO workshop on the impact of various observing systems on NWP) have shown that

in some cases NWP forecasts can be significantly improved by using additional targeted measurements in pre-computed sensitive areas (from operational NWP runs). Although the radiosonde network is operated from fixed points, it has also been shown that increased effectiveness may be reached by varying the observation time or the launch frequency at some radiosonde sites, as confirmed by tests done by the Network of European Meteorological Services (EUMETNET) Composite Observing System (EUCOS28). Benefits can be drawn in the coming years by making the existing radiosonde network more adaptive or at least more optimal in time-space coverage. The radiosonde network could be tuned in the following features: (i) the radiosonde observation time (e.g.: could it be switched from 00 and 12 UTC to other times in response to the local meteorology); (ii) the distance from the radiosonde sites to the airports (where AMDAR data can be easily obtained); (iii) the radiosonde time-series required by climate applications at fixed sites and regular times.

The EGOS-IP action G10 is listed below:

Action G10

Action*: Investigate possibility to optimize the radiosonde network in order to make the upper-air conventional observation coverage more uniform taking into account all the user requirements in terms of space and time distribution; and make relevant recommendations to the CBS for updating Technical Regulations accordingly.*

Who*: NMSs/NMHSs, in coordination with WMO's own and co-sponsored programmes, TCs, RAs and other relevant organizations. CBS and RAs to lead the action.*

Time frame*: 2015, then continuous.*

Performance indicators*: Standard monitoring indicators.*

To progress this action it is suggested that first ET-SBO carried out a general examination, followed by CBS commissioning an NWP and Nowcasting and Very Short-Range Forecasting (NVSRF – to suit local forecasting issues) impact assessment. Once these results are available a proposal can be further developed to be discussed by Members at RA sessions.

NEXT STEPS

Whilst ET-SBO cannot undertake all the tasks, it has have a responsibility to lay out the plan of action and then work with other groups to progress the various tasks identified. To help put the activity into context the following points are considered relevant:

(a) Existing national Radiosonde programmes result in radiosonde ascents being predominately flown at 00Z and 12Z (with a few flown at 06Z and 18Z);

(b) A significant increase in the volume of AMDAR data in the last 10 years has allowed this observational data source to move from a supplementary observing network to a complimentary observing network;

(c) The spatial and temporal distribution of AMDAR observations has a general minima between 2200 local and 0400 local when air traffic is generally at a minimum;

(d) In some global time zones of the world this night-time minimum is aligned with the 06Z or 18Z centred NWP assimilation windows;

(e) In some global time zones of the world there is an overlapping between the maxima in AMDAR data and the flights of 00Z and/or 12Z national radiosonde programmes;

(f) By moving some radiosonde flights from 00Z or 12Z to 06Z or 18Z there will be an improved temporal distribution of upper-air data, as called for by the Action;

(g) The adjustment in the timing of radiosonde programmes to improve the temporal distribution of upper-air observations should not negatively impact climate-related application areas, should have a neutral or positive impact on NWP (improved skill), a positive impact on nowcasting, and provide a positive cost-benefit to Members.

Not all users of radiosonde data will be happy with the move from 00Z or 12Z to 06Z or 18Z but some will be. Careful selection of sites at the national level will be necessary.

All of the points above will need to be examined and tested to demonstrate if the premise is correct. Confirming the above is the task that ET-SBO should lead on or coordinate depending upon the key players in each of the actions.

Addressing A

To address the first point a simple plot of the number of radiosonde observations at the four main synoptic hours is required. We probably know about the distribution with 00Z and 12Z being dominant but it is always good to reinforce this point with our colleagues who are not so familiar with radiosonde operational practices. This task should be led by ET-SBO and be completed in early 2016.

Addressing B

We should have a number of plots of the increase in the volume of AMDAR data in recent years and again, whilst we may be familiar with this, it would be good to show the increases, both globally and on a continental/RA/programme scale. Some graphics should be available on this at the Secretariat. The data can be sources from the AMDAR data centres and so this task should be led by ET-SBO with support from the Secretariat.

Addressing C and D

The plotting of three dimensional products in a two dimensional form is always challenging but we could select four periods for the AMDAR data to align with the 4 main launch times for AMDAR data. The plotting of three dimensional products in a two dimensional form is always challenging but we could select four periods for the AMDAR data to align with the four main launch times for AMDAR data so as to be able to demonstrate when AMDAR data density has a minima during the local night time. By selecting the time periods both points C and D can be addressed. These time periods could be: 22Z to 03Z; 04Z to 09Z; 10Z to 15Z and 16Z to 21Z. This task should be led by ET-SBO.

Addressing E

A simple comparison of the output from A and the output from D will show the overlaps of data maxima and data minima. This task should be led by ET-SBO.

Addressing F

A series of options could be articulated to help improve the distribution of upper-air observational data. These would need to respect the national needs and the needs of all key application areas for radiosonde data. This task should be led by ET-SBO in close consultation with regional association leaders with regard to observations.

Addressing G

This is a key element to the proposal and the design of an observing system experiment would need to carefully thought out. My simple view on this is as follows:

If in a geographical region of the world where 100 radiosonde stations exist and 40 radiosonde stations have been identified as candidates to move from a 00Z and 12Z programme to a 00Z and 06Z (or 00Z & 18Z) programme, or a 12Z and 18Z (or 12Z & 06Z) programme then an impact study could be designed where additional flights could be arranged at the 'minima' period.

It was originally assumed that 2 additional flights would be needed, but it may appear that only one may be sufficient, at the time of the AMDAR minima. We'll probably need to carry out the programme at non GUAN or national climatological observing sites as it is assumed a 00Z and 12Z programme or any change is a function of the needs of the climate community rather than the WWW community (for GCOS to consider).

Therefore the existing and revised programme may look like:

Existing:
All AMDAR + 100 radiosonde stations at 00Z and 12Z

Test period:
All AMDAR and 60 radiosonde stations at 00Z and 12Z and 40 radiosonde stations at 00Z & 12Z and one of 06Z or 18Z (depending upon geographical location and AMDAR minima).

The NWP test would then operate a control of all AMDAR + 100 radiosonde stations at 00Z and 12Z (blocking the 40 flights at 06Z or 18Z).

The NWP test would run an impact run of all AMDAR + 60 radiosonde stations at 00Z and 12Z and 40 stations at one of the revised configurations with the other main radiosonde observation being removed. So if 00Z and 06Z is the revised programme the 12Z flight would be blocked by NWP.

This test would run for approximately 30 days (NWP to advise on optimum period of test) and the business as usual operation of the stations running at 00Z and 12Z would not be affected.

The total cost of addition R/S consumables would be 30 days x 40 sites x $200 (WMO rule of thumb) per flight. Additional staff costs would also need to be accounted for but the consumables cost would be approximately $240k.

Of course no addition cost of consumables would be incurred if the 40 sites were simply reconfigured to operate at 00Z & 06Z or 18Z or 12Z & 06Z or 18Z but this would impact on the BaU 00Z and 12Z operations for the 30 day period and make it difficult to operate a real control run.

Nearly $0.25M is a considerable investment in a re-configuration test but without just making a change it is difficult to see how the NWP skill can be assessed without flying additional radiosondes. However given the general estimate of ~$90M of radiosonde consumables for the annual global 00Z and 12Z programme, a cost of only ~0.27% of the total consumables budget would seem to be a great investment in order to assess a mechanism to improve the performance of the network.

We would need clear support from the WMO community and some willing volunteer countries and NWP centres to carry out this test.

The issue was considered at the Sixth WMO Workshop on the Impact of Various Observing Systems on NWP (Shanghai, China, 10-13 May 2016). While no studies pertaining to this topic were presented to the Workshop, it agreed on two recommendations for future work: (i) WMO to develop specific alternative scenarios for radiosonde launch schedules; NWP centres were encouraged to perform data impact experiments for such scenarios; and (ii) recent CMA field experiments with augmented launches have provided a useful dataset that could be used by other NWP centres for impact experiments; CMA to consider whether the extra soundings could be made available to the international NWP community. These recommendations should be coordinated by ET-SBO with significant support from IPET-OSDE and the NWP Impacts Workshop community.

Other notes

An understanding of the national and other needs for 00Z and 12Z operations is needed and so a questionnaire of the potentially impacted countries is needed. Potentially impacted as the list of countries will be where an active AMDAR programme exists and the 00Z and 12Z radiosonde programme exists during a local AMDAR maxima. As stated at ET-SBO-2 the first order consideration of these zones are between 60 & 120 deg W and 60 & 120 deg E. The number of countries that fall into these categories is probably between 12 and 14, and so the questionnaire could be very focussed on this reduced set, if that is allowed in the WMO questionnaire context. Equally any proposal for change should be focussed on those countries operating the radiosonde programmes. This will need careful consideration when it comes to writing regulatory material. This task should be coordinated by ET-SBO with support from other interested parties and RAs in the coordination of the responses.

At all points the other communities with interest in the scheduling of radiosonde programmes need to be informed of the proposal and if applicable consulted in any changes. However the design of the proposed changes should be seen as a benefit rather than a threat to the ongoing operation of an effective global programme of radiosonde ascents.

Recommendation 33 (CBS-16)

ESTABLISHMENT AND DESIGNATION OF THE WMO GLOBAL DATA CENTRE FOR AIRCRAFT-BASED OBSERVATIONS

THE COMMISSION FOR BASIC SYSTEMS,

Noting the growth over the past several decades and the expected continued growth in the future of the Aircraft Meteorological Data Relay observing system and the volume of aircraft-based observations on the Global Telecommunications System,

Noting further:

(1) That these observations contribute to significant positive impact on meteorological, forecasting and other applications as a critical component of the Global Observing System, the WMO Integrated Global Observing System and the World Weather Watch Programme,

(2) The high quality of the data and their value to the climate record as a reliable and growing source of global upper-air temperature, wind and, increasingly, humidity meteorological information,

(3) The current lack of a formally recognized international repository for aircraft-based observations and the expected benefits to WMO Members, data users and contributing airline partners of having access to such a resource,

Recognizing:

(1) That the Commission for Basic Systems (CBS) has defined and endorsed the functional requirements and the formal terms of reference of a WMO Global Data Centre for Aircraft-based Observations (GDC-ABO),

(2) That CBS has sought expressions of interest from and made assessment of potential candidates to undertake the role of the WMO GDC-ABO,

Considering:

(1) That the United States of America has formally offered in principle to the WMO Secretary-General to undertake the role of operation of the WMO GDC-ABO under its terms of reference, as a contribution to WMO activities, through establishment of the centre within the National Oceanic and Atmospheric Administration National Centers for Environmental Prediction Meteorological Assimilation Data Ingest System (MADIS),

(2) That CBS has determined that the MADIS will meet the functional requirements of the GDC-ABO and has recommended to the Executive Council to accept the offer of the United States to host the GDC-ABO under the management of the National Weather Service Aircraft-based Observations Programme Manager,

Recommends the Executive Council:

(1) To designate the MADIS as the WMO GDC-ABO;

(2) To request the Secretary-General, in collaboration with CBS, to establish an agreement with the Unites States, to be designated and authorized to operate the WMO GDC-ABO under the terms of reference defined by CBS and to come into effect as soon as possible.

Recommendation 34 (CBS-16)

DEFINITION OF "SPACE"

THE COMMISSION FOR BASIC SYSTEMS,

Noting that the definition and delineation of "space" has been a matter of discussions within the United Nations Committee on the Peaceful Uses of Outer Space for many years, due to its legal implications,

Recognizing that the *International Meteorological Vocabulary* (WMO-No. 182) does not include a definition of "space",

Noting also that the common understanding of "space" as the part of the universe "above the atmosphere" is not practical since there is no precise top of the atmosphere, and since this is not technically consistent with the understanding of space activities and space weather; for example there are orbiting spacecraft with circular orbits as low as 130 km, which is not above the atmosphere but in the thermosphere, that is, the atmospheric layer above the mesopause,

Noting further that the upper atmosphere is defined in the *International Meteorological Vocabulary* as the part of the atmosphere above the mesopause (at around 80–90 km),

Recalling that the Implementation–Coordination Team on Integrated Observing Systems, based on a proposal by the Expert Team on Satellite Systems, has agreed to the definition of "space" as "The unlimited part of the universe including the upper atmosphere and extending above the atmosphere",

Recommends that the Executive Council accept this definition.

Recommendation 35 (CBS-16)

WMO INFORMATION SYSTEM 2.0 STRATEGY

THE COMMISSION FOR BASIC SYSTEMS,

Noting Decision 38 (EC-68) – Development of a strategy for the WMO Information System,

Recognizing the importance of creating and delivering a long-term vision for the evolution of the WMO Information System (WIS),

Having considered the draft WIS 2.0 Strategy as given in the annex to the present recommendation,

Emphasizes that the support to Members and capacity development activities should continue to be provided through the WIS 2.0 governance structure as described in the Strategy;

Recommends the Executive Council to endorse the WIS 2.0 Strategy as per the annex to the present recommendation;

Authorizes its president to incorporate modifications to the draft WIS 2.0 Strategy resulting from advice from regional associations and technical commissions prior to the sixty-ninth session of the Executive Council.

Annex to Recommendation 35 (CBS-16)

WMO INFORMATION SYSTEM 2.0 STRATEGY

1. Introduction

1.1 The WMO Information System (WIS) was established to provide high performance and reliable information sharing and management services for all WMO Programmes and related activities. After a decade of implementation, WIS became operational in 2012 and must evolve to meet the ever growing requirements of its users. The status of WIS in August 2016 is described in Annex I, current Status of WIS.

1.2 The CBS extraordinary 2014 session in Asuncion, Paraguay requested ICT-ISS to develop and maintain a strategic plan for developing WIS over a ten year forward looking period. The sixty-eighth session of the WMO Executive Council requested that CBS present a proposal for governance structure and strategy for the evolution of WIS to EC-69. This document outlines the strategic activities for the evolution of WIS toward its next generation, "WIS 2.0", with an enhanced focus on supporting global agendas, such as GFCS, DRR, UN SDG and the UNFCCC, as well as reducing costs, facilitating NMHS activities and improving efficiency and processes. Further effort will be required to define how services will be delivered and supported to help WMO Members achieve maximum advantage from WIS.

1.3 Note that the terms "cloud computing" and "open ecosystem" are terms of limited meaning in this document as defined in Annex II.

2. Vision

2.1 WIS 2.0 will provide users with seamless access to diverse information from a wide range of sources and will enable weather, water and climate information to be related to

socioeconomic and other application contexts. Through an open eco-system of tools, applications and services, WIS 2.0 will allow all information providers to manage, publish and share their data, products and services and will allow all users to develop value added services and new products.

3. Drivers and Challenges for WIS 2.0

3.1 User Expectation

3.1.1 Effective use of information, including combining data from multiple societal benefit areas, is a factor of economic growth. It is increasingly important that information becomes available in a way that maximizes uptake and business opportunities.

3.1.2 Users expect to access weather, water and climate information and services through the same mechanisms that they use for other types of information, using familiar interfaces and applications. Users will expect more social interaction and mobile delivery. They will also expect services that are built on more creative use of information, such as those that derive insight from analysis of "Big Data".

3.1.3 Key changes in the world of IT are taking place which require the traditional approach of pushing the information to be amended. It is anticipated that WIS 2.0 users will combine mobile, cloud computing and social technologies to access a much wider range of information sources and to collaborate in new and different ways. In the current design, NMHS are, in general, pushing pre-defined static set of information to the end user communities. In WIS 2.0, this will evolve to a model where end users are pulling selected information into environments and collaboration areas of their choice.

3.1.4 WMO Members find it increasingly challenging to deliver the services necessary to meet such needs in a rapidly evolving environment. These challenges will be a result of increasing volumes and variety of information required. WIS has to evolve to provide the foundation to support these services.

3.1.5 User expectations are driven by the services provided by global companies with the financial resources to invest in innovative solutions. Public sector organizations typically cannot access funding on the same scale. As a consequence, they may need to work in close partnership to develop common components and deliver services.

3.2 Data Volumes and Complexity

3.2.1 Satellites, radars and numerical models are producing information in greater volumes than ever before. For example, the current generation of satellites produces about 50 times more data than its predecessor. Furthermore, improvements in weather science will drive demand for the exchange of weather radar data at much higher frequency and on a global scale.

3.2.2 In addition to information traditionally used by NMHSs, increasing use will be made of information from sources not previously considered, both private and public.

3.2.3 Other sources of information are becoming available that may have data volumes that exceed those of traditional data sources, such as indirect information from social networks and crowd sourcing. Some of these sources of information may contain quantitative information but will not be formatted in traditional ways using WMO code forms, and will require processing before they can be utilized.

3.2.4 Data volumes created by Earth observing and numerical prediction systems continue to grow considerably faster than the performance of telecommunications networks.

This ever increasing flow of information poses significant challenges for processing, distribution and storage.

3.2.5 It will therefore be ever-more challenging to manage and share the increasing volume of data by sending it all to end users. Instead, users may want to select the subsets that meet their needs, or execute their queries and algorithms in close proximity with the data in order to reduce the volume of information to be transferred. This is described as "bringing the user to the data". For some services, however, timely provision of the underpinning data to the user will still remain critical, "taking the data to the user".

3.3 Costs

3.3.1 NMHSs face continuing pressure on budgets. It is important to remove duplication of effort, to facilitate the use of existing solutions (such as commercial, open source or off the shelf systems), and to make the infrastructure more cost-effective through simplification.

3.3.2 Collaboration needs to be enhanced to reduce the number and variety of local solutions across WIS, with NMHSs working in close partnership to develop common components and deliver services, rather than being solely responsible for those services.

3.3.3 WIS 2.0 will offer mechanisms to increase collaborative development, maintenance and support of services, promote the exchange of best practices and enable the uptake of new technologies.

3.4 Policy Environment

3.4.1 Many policymakers and funders place requirements on public sector organizations to provide their information as "open data". This has led to a number of global and regional initiatives that place obligations on Members.

3.4.2 Publishers of information are being increasingly required to describe, explain and justify the workflows and methods they have used to create that information. As a consequence, WIS 2.0 will need to define an information assurance framework. This will, in particular, include a data lifecycle management that demonstrates compliance with these policy requirements.

3.5 Technology Trends

3.5.1 Technology in recent years, in responding to user needs and expectations, has moved toward a service-centric approach. WIS 2.0 needs to take these changes into account when developing services and infrastructure. Cloud computing, Web services, data analytics and other technologies are expected to offer opportunities through new paradigms and concepts that will enable users to exploit data with much lower barriers.

3.5.2 Among technical and policy changes, those in Annex III are considered as being the most relevant for WIS 2.0.

4. WIS 2.0 Strategy

4.1 Strategy

4.1.1 Changes in data supply patterns and user expectations over the past decade present new challenges that the current WIS struggles to meet. At the same time, changes in technology (e.g. cloud computing infrastructure, messaging, search engines, web services etc.) present new opportunities.

4.1.2 WIS 2.0 will facilitate exchange of the right information at the right time with the right people. It will be built on redundant, resilient, efficient and scalable infrastructure. It will use applications and services based on standard interfaces for data exchange ready for SMAC (Social, Mobile, Analytics (Big Data), Cloud) and Internet of Things.

4.1.3 WIS 2.0 will be operated by the WMO community, built on industry standards, incorporating existing services and solutions provided by the public and private sectors. It aims to establish a 'global information management, processing and sharing platform' that will provide the following benefits:

(a) Accessibility: a platform enhancing the collection of data and allowing applications and services to be developed, capable of working with high-volume and archived data, and operated and managed without the complexity of building and maintaining infrastructure or managing local repositories of data;

(b) Interoperability: software components interact with the platform using industry common approaches and open standards;

(c) Visibility: authoritative data from NMHSs are visible to government, commerce and citizens;

(d) Utility: a focus on meeting the needs of users to exploit meteorological data in context with data from other domains, enabled through services offered by the WMO community;

(e) Reliability: data and services are safe and accessible with guaranteed performance at any time;

(f) Cost-effectiveness: avoid duplication through use of shared components built on infrastructure of organizations that can leverage economies of scale; use of standard technology, avoiding the need for WIS-specific skills;

(g) Capacity-building: training to enable all NMHSs, particularly from least developed countries and small island developing States, to use infrastructure and services of the WIS 2.0 platform to build services that meet the needs of their domestic stakeholders.

4.1.4 A core principle of the WIS 2.0 strategy is the recognition that advances in technology make it feasible for organizations to provide services and components that serve a global audience. The WIS 2.0 platform will support the provision of such shared components, reducing the need for duplication of components and the overhead of associated data synchronization.

4.1.5 WIS 2.0 encourages Members to coordinate delivery and operation of the shared components that comprise the WIS 2.0 platform. Fundamentally, the WIS 2.0 platform is intended to support the needs of the WMO community, providing the foundation that makes it simple for the WMO community to provide information and services and simple for users to find them.

4.1.6 The WIS 2.0 platform will support a change in user behaviour from downloading a copy of information for local processing to using services that process the information at its source. The WIS 2.0 platform will be complemented by a set of principles to encourage best-practice information assurance (data life cycle management) by the WMO community. This will support emergence of common approaches designed to provide users with a confidence about the quality of information utilizing user feedback mechanisms, to support continuous improvement, and to present a seamless user experience across Members' services.

4.1.7 WIS 2.0 will continue to provide data collection and distribution at national, regional and global scales.

4.1.8 Technical aspects of WIS 2.0 are anticipated to include:

(a) Use of cloud computing infrastructure to host shared components (such as data repositories and applications) to provide low-latency global data sharing to enable the WMO community to 'plug' their components into shared infrastructure and easily deliver value-added services to their users and to provide facilities that enable users to work with high-volume data in-situ rather than require download for local usage;

(b) Use of Web standards, Web services and well-defined APIs to enable WIS 2.0 to become 'machine interoperable' - i.e. enabling software systems to find and use the meteorological data and services hosted on the WIS 2.0 platform without requiring routine human intervention;

(c) Use of common open data formats (e.g. JSON, CSV, XML, netCDF, HDF) complementing Table-driven Code Forms (GRIB, BUFR), to simplify data provision and use by a broader community;

(d) Use of analytics and user feedback to drive continued improvement of user experience;

(e) Integration with global search engines (such as Google, Bing or Yahoo) to improve visibility of the authoritative information provided by NMHSs while retaining data sovereignty;

(f) Integration with third-party identity management services (such as eduGAIN) to simplify authentication of users;

(g) Retirement of traditional GTS message switching as the basis for operational, real-time data exchange in favour of industry standard data distribution methods and protocols such as secure file transfer and publish-subscribe messaging;

(h) Fault tolerant design of WIS 2.0 components and applications to deliver high quality of service even where underlying infrastructure cannot guarantee a level of service.

4.1.9 Implementation of this strategy must be based on the most cost-effective way for shared components to be provided, comparing the benefits of managed cloud computing services that are operated on behalf of the WMO community with a federated solution that takes advantage of the competencies and strengths of organizations within the community.

4.2 Governance

4.2.1 A governance regime supporting a financially sustainable WIS 2.0 platform will be developed alongside the technical aspects. National Centres and Data Collection or Production Centres remain the primary centres within WIS 2.0 as these are the centres that collect data, generate content and deliver services. WIS 2.0 will continue relying on the contribution of GISCs, including their associated collaboration and capacity development activities. Their role will evolve from infrastructure provision to focus on providing more-effective support to centres in their area of responsibility.

4.2.2 WIS 2.0 governance will need to address issues such as:

(a) Data life cycle management,

(b) Data licensing and access,

(c) Information security,

(e) Cost sharing and contract management with commercial infrastructure suppliers,

(f) Resource allocation (e.g. compute, storage) within shared components,

(g) Private sector participation.

4.3 Incremental change

4.3.1 Considering operational aspects of the WIS and the risks involved with a "big-bang" approach, WIS 2.0 will be implemented step-by-step with defined and manageable incremental phases.

4.3.2 Activities within OPAG ISS are providing insight into the first incremental steps to transition to WIS 2.0. For example, evaluation of the "cache in and through the cloud" is a step in this direction.

4.3.3 OPAG ISS, in collaboration with other technical commissions and programmes, will prepare an implementation plan describing the transition to WIS 2.0 that takes into account priorities based on management of risks and benefits.

5. Risk Identification

5.1 The overall strategy is ambitious, involving many contributors, new technologies and standards. Hardware, systems, development and ongoing support have to be integrated into strategic planning and system replacement processes.

5.2 Each contributor's solution has to interface with other contributors' solutions, whilst meeting local, national and regional requirements. WIS 2.0 will also invoke extensive alterations to current business processes. There is also a critical requirement for the evolution from existing information systems to WIS 2.0 not be disruptive to the present systems which have established very high availability, robustness and performance. These qualities are also required in WIS 2.0.

5.3 The successful implementation of the WIS 2.0 strategy will require the participation of experts from around the world. Many of them are not allocated full-time to the task and already face pressing operational issues as they also support critical operational systems and procedures. The WIS 2.0 implementation team will have to work as a virtual team.

5.4 WMO systems support many high profile or critical activities in Member countries such as the preparation and distribution of warnings. Failures in the new system could lead to critical information not reaching the right place at the right time, a risk that must be addressed in the implementation plan.

5.5 WIS 2.0 will provide new capabilities that could create opportunities for Members to run their operations more efficiently. Some components of WIS 2.0 such as data policy and data access via the Internet have raised concerns that will need to be addressed.

5.6 To reduce the exposure to the above risks and to ensure prompt delivery of WIS 2.0, it is recommended that a full time project manager is appointed to guide implementation of the strategy, to maintain a comprehensive risk assessment and to act as the focal point for all significant issues.

Annex I - WIS Status

1. WIS and WMO Programmes

1.1 WIS is the single coordinated global infrastructure responsible for telecommunications and data management functions. It is the pillar of the WMO strategy for managing and moving weather, climate and water information in the 21st century. WIS provides an integrated approach suitable for all WMO Programmes to meet the requirements

for routine collection and automated dissemination of observed data and products, as well as data discovery, access and retrieval services for all weather, climate, water and related data produced by centres and Member countries in the framework of any WMO Programme.

1.2 In its current form, the WIS (and GTS) is a niche infrastructure that supports the expert meteorological community. WIS intended to support all WMO Programmes; however the reality in 2016 is that only the World Weather Watch Programme is well represented.

2. WIS Architecture

2.1 The infrastructure used for operational exchange between WIS centres is a combination of Private MPLS Networks (such as the RMDCN), Public Network (Internet) and satellite broadcast (such as Eumetcast). Services rely largely on well-known applications (FTP and SFTP). Although operational and workable, dedicated MPLS networking is complex, has increasing IT security challenges and contractual complexities. Further, MPLS networks can offer a SLA, but at a very high cost for limited bandwidth, so the resulting operational costs can constrain bandwidth, limiting the amount and types of data exchanged through traditional GTS processes.

2.2 WIS Part A, the continued evolution of the GTS, though providing an efficient operational service, hinders the WIS by imposing "old" technologies. The mapping of the TTAAii bulletin header to metadata creates problems and imposes two rather different solutions: TTAAii on the one hand, DAR on the other hand. Both components should be merged while preserving the operational quality of the GTS and ensuring information arrives when and where it is needed.

2.3 The Functional Architecture document (http://wis.wmo.int/WIS-FuncArch) has been the baseline to design the WIS as we know it today. A large majority of the requirements have not changed and the obligations that the WIS has to fulfil are still the same. However, the topology of the WIS in 2016 is largely inherited from the pre-existing GTS[1], and the technical solutions available twenty years ago.

2.4 Due to their collaboration and networking GISCs played a central role in building the WIS. In addition to hosting of the discovery metadata services and new functionality of WIS, they have significantly contributed to capacity development and within their area of responsibility. GISCs and other WIS centres will evaluate and test new technologies in the evolution process to the future WIS 2.0.

3. Strengths and Weaknesses of WIS

3.1 WIS provides access to diverse information for a broad range of users in both public and private sectors. Those data, information and knowledge enable stakeholders to improve decision-making processes.

3.2 WIS is very reliable. it has been established as the common communication infrastructure to support all WMO Programmes and related organizations. World Weather Watch data/products have been circulated through the GTS only for WMO Members. Today, the information intended for global exchange is also available to WMO Members and the meteorological communities through the WIS DAR (Discovery Access and Retrieval) service over the Internet.

3.3 WIS facilitates the sharing of weather and climate data and information collected and processed by WIS centres. It ensures that those data are discoverable and accessible to support the development of products and the delivery of information services.

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[1] The GTS is a merge of technical and procedural elements involving NMHSs and RTH. The term GTS covers many different technical, functional, administrative and operational aspects. In most cases, the decommissioning of the GTS will only address the technical part of the "Manual on the GTS".

3.4 WIS provides reliable service through redundant systems, e.g. Disaster Recovery Centres and backup arrangement with partner GISC(s). Area Meteorological Data Communication Networks (AMDCN) with their Area of Responsibilities (AoR) are being used not only for network infrastructure but also as a framework for capacity development with the WIS competency and training guidance.

4. Metadata

4.1 The WIS DAR Catalogue comprises around 150,000 metadata records, which is significantly larger than many catalogues.

4.2 Metadata records conform to ISO 19115:2003, encoded in XML format complying with WMO Core Metadata profile. The quality of metadata is mixed and impacts the discovery service offered to WIS users. For example when a user is searching for temperature products, they are deluged with search results of bulletins as the catalogue contains very 'fine-grained' metadata, dominated by GTS bulletins. Represented "one metadata record per TTAAii+timestep" is damaging the search experience.

4.3 With the retirement of WMO-No. 9 Vol C1, the primary function of WIS appears to have become management of operational bulletins; e.g. notification of changes between operational centres.

Annex II – Definition of terms of limited meaning

Cloud computing: Network- or Internet-based services, computing, storage or processing that provides shared resources to WIS centres to support flexible levels of demand.

Open eco-system: Interoperable virtualized digital services focusing on maximizing re-use, agility of operations and scalability built on open standards.

Annex III - Information and Technology Trends

1. Big Data

1.1 "Big Data" is a term widely used and usually refers to new technical solutions to deal with massive amounts of data (volume), that might in addition also cover velocity (the data are being created frequently), variety (the nature of data can be very different) and veracity (can the data be trusted?). It is often referred to these elements together as the 4 V' of Big Data. In the context of WIS, we have to address these 4 V's, and this can have operational consequences. For example, transferring to users huge amount of data might no longer be possible. In the current system, the data is usually sent to the process. In the future the opposite should be possible, where the process is sent to the data.

2. Cloud

2.1 The big players on the Internet (e.g. Google, Amazon) and other providers are making available to users applications, computing and storage resources to host data and process it in a shared environment called "The Cloud". Instead of using internal resources, in certain situations, it may be much more cost-effective for an organization to use a Cloud service for processing, storing and exchanging data.

2.2 Considering Big Data as described above, the Cloud and the associated services (applications, processing and storage) are likely to be a very cost-effective way for the WIS to deliver services and data to the users.

2.3 ICT ISS is investigating the applicability and potential of cloud computing services and cloud computing based data exchange in support of the WMO Information System.

3. Search Engines

3.1 The current WIS is based on a catalogue of metadata. In order to find a particular dataset, users have to connect to a GISC portal and use their search tools. It means that the "gates" to enter into the WIS are the GISCs. However, nowadays, the "gates" for all content on the Internet are the search engines such as Google and Bing. Therefore, making data available to users will require the WIS to use the de facto standards and common practice of the Internet. The catalogue should therefore be searchable and accessible via the common "gates" of the Internet, the search engines.

4. Messaging and Social Networking

4.1 Sharing notifications, messages and alerts has become common place through the medium of social media. Services such as Twitter are built using industry standard messaging protocols and quickly scale to support many millions of concurrent users sharing information in real-time. Social media messages often include images, the size of which easily exceeds that of a typical GTS message. These technologies offer new opportunities for sharing meteorological data in real-time based on common industry practices.

5. Internet of Things

5.1 Along with available network connectivity almost everywhere (Wi-Fi, 3G, Bluetooth, very low speed networks…) and very cheap sensors of all kinds, the Internet of Things is developing rapidly. Whether it takes the form of windscreen wipers connected on cars, or weather stations for homes, the Internet of Things is creating and will continue to create a vast ecosystem of companies, which are not WIS users, but who will be nevertheless interested in exchanging data with WIS users to develop their business and in return provide an incredibly large amount of observation data. The WIS should facilitate these interactions with weather-related Internet of Things.

6. API and Web services

6.1 Application Programming Interfaces (APIs) and Web Services are now very common solutions for machine to machine interaction. By offering standard interfaces and by allowing exchange of data using official or de facto standards (JSON, XML, CSV,...), the WIS should offer, in addition of the human interface it currently has, solutions to facilitate machine to machine communication. The Open Geospatial Consortium (OGC) is developing several standards to facilitate such interactions. Along with these solutions, the WIS should provide lightweight interfaces to allow users to interact with the WIS. As such interactions often require users to be authenticated, WIS Members should be encouraged to accept validated third party authentication services, such as those provided by research network GEANT (eduGAIN) or by commercial entities like Google or Facebook.

7. Open data

7.1 Open data is data that anyone can access, use or share and whose licence allows users to do what they need to do with the data without additional constraints. Many governments have decided to release data in this way, aiming to foster the development of applications and services that will benefit citizens. In addition, it is sometimes required to propose this data using standard protocols and format.

Recommendation 36 (CBS-16)

INTER-COMMISSION TASK TEAM ON THE WMO INFORMATION SYSTEM

THE COMMISSION FOR BASIC SYSTEMS,

Noting that Decision 38 (EC-68) – Development of a strategy for the WMO Information System, endorsed the establishment of an Inter-commission Task Team on the WMO Information System (ICTT-WIS) to develop a governance structure for the operation management of WIS and to facilitate stakeholder input into the WIS strategy and the development of Part C of WIS,

Noting further:

(1) That ICTT-WIS had provided a report (http://wis.wmo.int/file=3082) addressing the issues under the terms of reference defined in the annex to Decision 38 (EC-68),

(2) The importance of involvement of WMO programmes, technical commissions and regional associations in the governance and development of WIS,

(3) That Decision 38 (EC-68) requested the Commission for Basic Systems (CBS) to present a proposal for governance structure and strategy for the evolution of WIS to the Executive Council at its sixty-ninth session,

Endorses the recommendations of ICTT-WIS as listed in Annexes 1, 2, 3 and 4 to the present recommendation;

Recommends that the Executive Council endorse the continuation of the ICTT-WIS as a CBS team with the draft terms of reference as listed in Annex 5 to the present recommendation, as a conduit for programme, technical commission and regional association involvement in the governance and operation of WIS and the development of WIS 2.0.

Annex 1 to Recommendation 36 (CBS-16)

RECOMMENDATIONS OF THE INTER-COMMISSION TASK TEAM ON THE WMO INFORMATION SYSTEM

1. The Inter-commission Task Team on the WMO Information System (ICTT-WIS) recommended the escalation procedure described in Annex 2 for decisions concerning WIS that could not be resolved at an operational level.

2. ICTT-WIS supported the proposed security incident management process, but commented that care was needed to make sure that the process itself did not raise threat levels. It suggested that the text in Annex 3 should be included in the process.

3. ICTT-WIS endorsed, the WIS 2.0 strategy including the proposed changes listed in Annex 4 for consideration by CBS-16.

4. ICTT-WIS recommended that participation by all Commissions in TT-IM would be important for the success of the information lifecycle management component of the WIS.

5. ICTT-WIS supported the concept of an information management workshop to be held mid-2017, but noted that conflicts with other activities might limit attendance.

6. ICTT-WIS recommended that it should continue with the revised terms of reference in Annex 5.

7. ICTT-WIS agreed that it should work remotely as required.

8. ICTT-WIS recommended that membership of ICTT-WIS should include:

(a) Two co-chairpersons, one from CBS and the other a representative of a technical commission other than CBS;

(b) A representative for all technical commissions (one of these will be a co-chairperson);

(c) Chairperson of CBS OPAG ISS;

(d) A representative implementing the WMO Strategy for Service Delivery; and

(e) A representative of those regional associations that do not have representation through one of the other roles.

Annex 2 to Recommendation 36 (CBS-16)

RECOMMENDED ESCALATION PROCEDURE FOR WMO INFORMATION SYSTEM INFRASTRUCTURE DECISIONS

Background:

1. The scope of distribution for data within WIS shall be expressed using the following controlled vocabulary: "GlobalExchange", "RegionalExchange" and "OriginatingCentre".

2. Data with WIS discovery metadata entry "GlobalExchange" shall be held in the 24 hour global cache of all GISCs.

3. Data with WIS discovery metadata entry "RegionalExchange" shall be held in the 24 hour local cache of those GISCs serving the target distribution area.

4. Data with WIS discovery metadata entry "OriginatingCentre" would not be held in the global or local cache of any GISC.

Precondition:

1. A provider or user requests data be added to or removed from the global or regional cache and associated distribution.

Procedure:

1. Global Information System Centres' representatives (i.e. TT-GISC) should, based on discussion with the providers (Data Collection or Production Centres and National Centres) and users, be the group to decide whether a data stream should go in or out of the 24 hour cache and be routinely distributed:

   (a) That all GISCs have to maintain (e.g. GlobalExchange flag);

   (b) That a number of GISCs have to maintain (e.g. RegionalExchange flag).

2. Normally, the decision to add a new or to remove an existing data stream will be by consensus of GISCs representatives in line with normal operational collaboration:

   (a) An implementation time line will be a part of the decision;

   (b) Decisions should be made in a short timescale (e.g. less than 2 weeks).

3. If unable to reach consensus or if the requester is not satisfied with the decision, the problem should be escalated to ICTT-WIS:

   (a) ICTT-WIS should then make its recommendations based on information from requesters and GISCs;

   (b) The president of CBS will make a decision based on the ICTT-WIS recommendation, utilizing fast track procedures as appropriate.

Note that issues may be escalated by a GISC either in response to events, occurred or planned, where it is anticipated it might impact on the functioning of WIS.

Annex 3 to Recommendation 36 (CBS-16)
(available in English only)

SECURITY INCIDENT MANAGEMENT FOR THE WMO INFORMATION SYSTEM

ICT-ISS recommends that the following should be included in incident management process:

[See document "Draft Security Incidents" (http://wis.wmo.int/file=3007) paragraph 8 for full version with track changes.]

X. Confidentiality – Detailed information on security alerting process, incidents and communications between WMO/Reporting Member States/GISCs.

X.1 Detailed information about the security alerting process shall not be made publicly available and shall remain confidential.

X.2 Detailed information on the security incidents as well as the corresponding communications between the WMO Contact Point, the reporting Member State/s and the GISCs on them, shall not be made publicly available and shall remain confidential, unless otherwise agreed by the involved party/ies. Notwithstanding, such information might be used in the development of IT Security best practices whilst safeguarding the identity of those affected.

Annex 4 to Recommendation 36 (CBS-16)
(available in English only)

WMO INFORMATION SYSTEM STRATEGY

[See Document WIS 2.0 Strategy (http://wis.wmo.int/file=3003) for full text and track changes.]

1. Change title from WIS Strategy 2030 to WIS 2.0 Strategy

2. Update paragraph 1.2 and insert new paragraph 1.3 as follows:

   1.2 This document outlines the strategic activities for the evolution of WIS toward its next generation, "WIS 2.0", with ~~the~~ an enhanced focus on supporting global agendas, such as GFCS, DRR, UN SDG and the UNFCCC, as well as reducing costs, facilitating NMHS ~~activities as well as~~ and improving efficiency

and processes. Further effort will be required to define how services will be delivered and supported to help ~~NMHS~~ WMO Members achieve maximum advantage from WIS

1.3 Note that the terms "cloud computing" and "open ecosystem" are terms of limited meaning in this document as defined in Annex II.

3. Update the WIS 2.0 vision (para 2.1) as follows:

2.1 WIS 2.0 will provide users with seamless access to diverse information from a wide range of sources and will enable weather, water and climate information to be related to socioeconomic and other applications context. Through an open eco-system of tools, applications and services , WIS 2.0 will allow all information providers to manage, publish and share their data, products and services and will allow all users to develop value added services and new products.

4. Update paragraph 3.1.1 as follows:

3.1.1 … multiple societal benefit areas, is ~~considered to be~~ a factor of economic growth. …

5. Replace the word "cloud" (lower case "c") with cloud computing in the following cases:

3.1.3 ... It is anticipated that WIS 2.0 users will combine mobile, cloud computing and social technologies …

3.5.1… Cloud computing, Web services, data analytics and other technologies …

4.1.1 … (e.g. cloud computing infrastructure, messaging, search engines, web services etc.) …

4.1.8 … (a) Use of cloud computing infrastructure to host shared …

4.1.9 … comparing the benefits of managed cloud computing services that are operated …

Annex II paragraphs 2.1 and 2.3

2.1 … "it may be much more cost-effective for an organisation to use a ~~Cloud~~ cloud computing service for processing"

2.3 ICT ISS is investigating the applicability and potential of cloud computing services and cloud based data exchange in support of the WMO Information System

6. Update paragraphs 3.2.1, 3.2.2, 3.2.5 and 3.4.1 as follows:

3.2.1 … For example, the current generation of satellites produces about 50 times more data ~~that~~ than its predecessor. …

3.2.2 In addition to ~~traditional~~ information traditionally used by NMHSs, increasing use will be made of ~~private sector~~ information ~~and data~~ from sources not previously considered, both private and public.

3.2.5 It will therefore be ever-more challenging to manage and share the increasing volume …

3.4.1 Many policy makers and funders ~~now~~ place requirements on public sector …

7. Update paragraphs 4.1.3, 4.1.3 (a), 4.1.6, 4.1.7, 4.1.8 (c) and 4.3.3

4.1.3 ... It aims to establish a 'global ~~data~~ information management, processing and sharing platform' that will provide the following benefits:

(a) Accessibility: a platform enhancing the collection of data and allowing applications and services to be developed, capable of working with high-volume and archived data …

4.1.6 … This will support emergence of common approaches designed to provide users with a confidence about the quality of information utilising user feedback mechanisms for continuous improvement and to present a seamless user experience across Members' services.

4.1.7 WIS 2.0 will continue to provide data collection and distribution at national, regional and global scales

4.1.8 (c) … Table-driven Code Forms (GRIB, BUFR), to simplify data provision and use by a broader …

4.3.3 OPAG ISS will, in collaboration with other technical commissions and programmes, prepare an implementation plan describing the transition to WIS 2.0 that takes into account priorities based on management of risks and benefits.

8. Update paragraphs 5.2 and 5.6 as follows:

5.2 Each contributor's solution has to interface with other contributors' solutions, whilst meeting local, national and regional requirements …

5.6 … it is recommended that a full time project manager is appointed to guide implementation of the strategy, to ~~complete~~ maintain a comprehensive risk assessment and to act as the focal point for all significant issues.

9. Add a new Annex II and relabel old Annex II to Annex III and fix internal references accordingly in contents and in paragraph 3.5.2. New Annex II is :

Annex II – Definition of terms of limited meaning

Cloud computing: Network- or Internet-based services, computing, storage or processing that provides shared resources to WIS centres to support flexible levels of demand.

Open eco-system: Interoperable virtualized digital services focusing on maximizing re-use, agility of operations and scalability built on open standards.

Annex III – Information and Technology Trends

1. Big Data …

Annex 5 to Recommendation 36 (CBS-16)

DRAFT TERMS OF REFERENCE FOR THE INTER-COMMISSION TASK TEAM ON THE WMO INFORMATION SYSTEM

The Inter-commission Task Team on the WMO Information System (ICTT-WIS) recommended that the ICTT-WIS will play an important role as a conduit to CBS from WMO Programmes, technical commissions and regional associations. It proposed the following draft terms of reference for the team.

Provide a channel for technical commission input into the operation and development of the WIS, in particular:

(a) Advise the president of CBS on the use of GlobalExchange and RegionalExchange flags in WIS in those cases that could not be resolved using normal operational coordination activities;

(b) Recommend to ICT-ISS solutions on issues unable to be resolved through the collaborative mechanisms established between WIS centres;

(c) Assist ICT-ISS in gathering the requirements of programmes, technical commissions and regional associations for what WIS would provide for them in the 2020s and beyond;

(d) Advise ICT-ISS on whether the guidance developed for WMO information management practices meets the requirements of all programmes, technical commissions and regional associations;

(e) Communicate to WMO Programmes and technical commissions on topics relating to WIS to support ICT-ISS outreach activities;

(f) Assist ICT-ISS in monitoring implementation of the WIS 2.0 strategy.

Recommendation 37 (CBS-16)

RESOURCES FOR THE IMPLEMENTATION OF THE SEAMLESS DATA-PROCESSING AND FORECASTING SYSTEM

THE COMMISSION FOR BASIC SYSTEMS,

Recalling Resolution 11 (Cg-17) – Towards a future enhanced integrated and seamless Data-processing and Forecasting System,

Noting that addressing Resolution 11 (Cg-17) is a major undertaking for the Global Data-processing and Forecasting System (GDPFS), similar to defining and implementing the WMO Integrated Global Observing System and WMO Information System, which are the expansion of the Global Observing System and Global Telecommunications System components of the World Weather Watch,

Noting further:

(1) That the GDPFS is one of the important operational pillar systems in providing services to a number of socioeconomic sectors,

(2) That users' demands are evolving at a fast pace as a result of technological and climate changes,

(3) That the requirement for impact-based forecasting and risk-based warning services will necessitate an integration of non-conventional information such as exposure and vulnerability into the operational system,

Recalling Decision 27 (CBS-16) – Implementation plan of the future seamless Data-processing and Forecasting System,

Mindful of the urgency to move forward with the implementation of the seamless DPFS to rise to the challenges of meeting users' needs,

Recommends the Executive Council:

(1) To call on Members to make a special effort to mobilize resources needed for the implementation of the seamless DPFS;

(2) To identify seamless DPFS as one of the strategic pillars/priorities for the WMO 2019–2023 Strategic Plan, to highlight its importance to future WMO services.

Recommendation 38 (CBS-16)

STEERING GROUP ON THE SEAMLESS DATA-PROCESSING AND FORECASTING SYSTEM – AREAS FOR CONSIDERATION

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

(1) Resolution 11 (Cg-17) – Towards a future enhanced integrated and seamless Data-processing and Forecasting System,

(2) Decision 55 (EC-68) – Implementation of the seamless Data-processing and Forecasting System,

Noting that following the request by the Seventeenth World Meteorological Congress, the Executive Council at its sixty-eighth session established a Steering Group on the Seamless Data-processing and Forecasting System (Decision 55 (EC-68)), chaired by the president of the Commission for Basic Systems (CBS) and comprising representatives of technical commissions and regional associations, and the Chairperson and Co-chairperson of the CBS Open Programme Area Group on Data-processing and Forecasting Systems (OPAG-DPFS),

Considering the discussion on seamless DPFS during the meeting of the Implementation–Coordination Team of OPAG-DPFS held in Exeter, United Kingdom of Great Britain and Northern Ireland, from 23 to 27 May 2016,

Considering further the paradigm shift of the service delivery move to impact-based forecasting and risk-based warning,

Recommends the Executive Council:

(1) To consider defining the role of the Global DPFS (GDPFS), including research on how to define impacts and what information needs to be stored and how it is to be verified, how to calculate impact, how to store the information on impacts if it is retained, and how non-conventional information (such as exposure and vulnerability data) should be brought into the GDPFS;

(2) To ensure that work related to impact-based forecasting is reflected in the seamless DPFS solution;

(3) To consider the inclusion of designation criteria of partner systems related to the GDPFS in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), or the inclusion of references and links to the relevant partner manuals.

Recommendation 39 (CBS-16)

IMPLEMENTATION OF THE COMPETENCY FRAMEWORK FOR PUBLIC WEATHER SERVICES AND DEVELOPMENT OF PUBLIC WEATHER SERVICES PROVISIONS FOR *TECHNICAL REGULATIONS* (WMO-No. 49), VOLUME I

THE COMMISSION FOR BASIC SYSTEMS

Recalling:

(1) Resolution 4 (Cg-17) – Report of the extraordinary session (2014) of the Commission for Basic Services relevant to Technical Regulations concerning public weather services competencies, through which the Seventeenth World Meteorological Congress approved the public weather services (PWS) forecasters and advisors top-level competency requirements to take effect from 1 December 2017,

(2) Decision 45 (EC-68) – Implementation of the Competency Framework for Public Weather Services, through which the Council decided that the Competency Framework for Public Weather Services as approved by the Seventeenth Congress should be included as recommended practices in the 2017 update of the *Technical Regulations* (WMO-No. 49), Volume I, along with the inclusion of provisions for PWS, defining the scope and areas of PWS delivery,

(3) The request of the Executive Council at its sixty-eighth session to the Commission for Basic Systems at its sixteenth session to approve the draft PWS provisions for the *Technical Regulations*, Volume I as a prerequisite for implementing the Competency Framework for Public Weather Services following approval by the Executive Council at its sixty-ninth session,

Decides to endorse the PWS provisions for inclusion in the *Technical Regulations*, Volume I as contained in the annex to the present recommendation;

Requests the Open Programme Area Group on Public Weather Services Delivery in collaboration with the WMO Education and Training Programme to prepare, as requested by the Executive Council at its sixty-eighth session, related guidance (as part of the WMO Guide on Competency, to be developed) and appropriate training materials for Members on the implementation of competency requirements based on the Competency Framework for Public Weather Services to enable timely implementation of the recommended practices appropriate to PWS forecasters and advisors;

Recommends to the Executive Council at its sixty-ninth session that the PWS provisions as given in the annex to the present recommendation be included in the *Technical Regulations*, Volume I;

Requests the Secretary-General to facilitate training events for Members to assist them in the implementation of the PWS competencies in line with their implementation of the WMO Strategy for Service Delivery and WMO Quality Management Framework, thus enhancing the satisfaction of their users through improvement of services and products of their National Meteorological and Hydrological Services.

Annex to Recommendation 39 (CBS-16)

PUBLIC WEATHER SERVICES PROVISION FOR INCLUSION IN *TECHNICAL REGULATIONS* (WMO-No. 49), VOLUME I

IV Meteorological, Hydrological and Climatological Services

5. PUBLIC WEATHER SERVICES

5.1 General

5.1.1 Members should provide Public Weather Services to cover:

(a) Forecasts and related services in the areas of weather, climate and water to aid citizens in their day-to-day activities;

(b) Warnings of high impact weather and extremes of climate, and information to other government authorities as appropriate in pursuance of their mission to protect the lives, livelihoods and property of the citizens.

5.1.2 The purpose of Public Weather Services provided by Members should be to support decision-making related to:

(a) Protection of life, livelihood and property;

(b) Welfare and well-being of the population;

(c) Social and economic development in response to the wide spectrum of requirements of the public and weather-sensitive user groups.

5.2 Public Weather Services Delivery

5.2.1 User Focus

Members should identify users and understand their needs for weather, climate, water and environmental-related information in their decision-making practices. Close coordination should be maintained with users and effective feedback mechanisms should be established.

5.2.2 Quality

Members should establish a properly organized quality assurance system comprising procedures, processes and resources necessary to provide for sustainable quality levels of public weathers services to be supplied to users.

Note: Quality assurance system in conformity with ISO 9000 standards could be considered as a good practice.

5.2.3 Dissemination and communication of products

Members should ensure preparation and timely dissemination to relevant users, of public weather information including warning information concerning occurrence and evolution of severe weather phenomena. Such information should be fit for purpose for integration into decision-making processes and procedures related to protection of life and property and general welfare of the public.

5.2.4 Preparation of warnings

Warning information intended for decision-making related to protection of life, livelihood and property should be provided by bodies designated and mandated by government.

Members should provide warning information through the implementation of an early warning system.

Warning information should incorporate, to the extent possible, information about impacts of weather hazards on individuals and communities.

5.2.5 Socioeconomic benefits of meteorological and hydrological services

Members should perform socioeconomic benefit assessments to both measure and demonstrate the value of their services to the public and other users.

5.2.6 Public education and outreach

Members should engage in education, awareness and preparedness activities aimed at helping citizens make the best use of forecasts and warnings information, understand the potential threats of high impact weather and extremes of climate, and be aware of the appropriate mitigating actions.

5.3 Organization

Members should ensure that their NMHSs are properly equipped to provide essential Public Weather Services and especially warnings of severe weather.

5.4 Competency

Members should ensure that the competency requirement of personnel engaged in the provision of Public Weather Services is in accordance with the requirements indicated in Part V of the *WMO Technical Regulations, Volume I* (WMO-No. 49)(to be developed*).*

Recommendation 40 (CBS-16)

DEVELOPMENT OF THE GLOBAL CRYOSPHERE WATCH

THE COMMISSION FOR BASIC SYSTEMS,

Noting that the observing component of the Global Cryosphere Watch (GCW) is one of the four component observing systems of the WMO Integrated Global Observing System (WIGOS),

Recalling:

(1) Resolution 40 (Cg-17) – WMO polar and high-mountain activities, which also decided that concerted efforts continue to improve services in high-altitude regions by promoting observations,

(2) Resolution 43 (Cg-17) – Global Cryosphere Watch, and Resolution 3 (EC-67) – Executive Council Panel of Experts on Polar and High-mountain Observations, Research and Services, that decided to implement GCW during the seventeenth financial period with the goal that GCW should become operational and urged Members to develop their observing systems to support the observing component of the GCW,

(3) Decision 50 (EC-68) – Development of the Global Cryosphere Watch, endorsing the updated CryoNet concept,

(4) Decision 51 (EC-68) – High-mountain activities, to facilitate development of high-elevation cryosphere observational sites for inclusion into CryoNet, with attention to sites over 4 000 metres,

Having considered that national WIGOS implementation is one of the five priority areas in its pre-operational phase (2016–2019),

Having considered further that the future Regional Basic Observing Network (RBON) will be based on WIGOS component observing systems,

Recommends the Executive Council to request:

(1) Members, through a partnership among national research institutes, universities and academia, to contribute their respective stations to CryoNet, according to a concept endorsed by Decision 50 (EC-68);

(2) Regional associations to consider relevant CryoNet stations for inclusion in RBON;

(3) Members that did not nominate focal point(s) to do so, with a view of taking part in the development of the GCW surface observing network; several focal points may represent national GCW partners.

Recommendation 41 (CBS-16)

INTERNATIONAL EXCHANGE OF SNOW DATA

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 60 (Cg-17) – WMO policy for the international exchange of climate data and products to support the implementation of the Global Framework for Climate Services, that includes climate relevant cryospheric data, in particular snow cover and snow depth,

(2) Decision 50 (EC-68) – Development of the Global Cryosphere Watch, urging Members to exchange in situ snow measurements in real-time,

Having considered the positive impact of snow depth data collected in Europe on numerical weather prediction, using the binary universal form for the representation of meteorological data (BUFR) template 3 07 101 (Snow observation), adopted by the Commission for Basic Systems at its extraordinary session in 2014,

Having considered further a need for real-time access to in situ snow measurements to support future Polar and High Mountain Regional Climate Centres, a tool of the Global Framework for Climate Services services provision,

Recommends the Executive Council:

(1) To approve amendment to the *Manual on the Global Observing System* (WMO-No. 544), Volume I – Global Aspects, by adding new provisions as follows:

    (a) Members should report snow cover and snow depth from all stations where snow is experienced, four times a day, namely 00, 06, 12 and 18 UTC;

(b) Members should report values of zero snow depth (0 cm) from the above stations when snow is not present, for the entire period during which snow can be expected. This period shall be defined for each location by the relevant WMO regional association;

(2) To request Members to exchange in situ snow measurements in real-time in BUFR through the Global Telecommunications System/WMO Information System in accordance with the *Manual on the Global Observing System*;

Requests the Commission for Basic Systems Open Programme Area Group on Information Systems and Services to review and harmonize practices for reporting snow cover and snow depth in the *Manual on Codes* (WMO-No. 306).

Recommendation 42 (CBS-16)

WORKING WITH REGIONAL ASSOCIATIONS

THE COMMISSION FOR BASIC SYSTEMS,

Noting that implementation of standards and working practices that had been developed by the Commission for Basic Systems (CBS) had been most successful where there had been active involvement of regional associations,

Noting further that creation of the WMO Operating Plan provides an opportunity for further coordination between technical commissions and regional associations,

Decides to set up a coordination mechanism to facilitate improved coordination and complementary roles between CBS and regional associations;

Requests its Management Group to consider how best to coordinate the work of CBS with the work of regional association management groups.

Recommendation 43 (CBS-16)

CONTINUANCE OF THE WORK OF THE EXECUTIVE COUNCIL STEERING GROUP ON THE SEAMLESS DATA-PROCESSING AND FORECASTING SYSTEM

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 11 (Cg-17) – Towards a future enhanced integrated and seamless Data-processing and Forecasting System,

(2) Decision 55 (EC-68) – Implementation of the seamless Data-processing and Forecasting System,

Considering that work beyond the terms of reference of the Steering Group established by Decision 55 (EC-68) will be needed to meet the requirements of Resolution 11 (Cg-17),

Recommends that the Executive Council authorize the Commission for Basic Systems (CBS):

(1) To coordinate collaboration between constituent bodies to create the documentation requested in Resolution 11 (Cg-17), namely:

(a) Description of the set of products to be generated by the integrated and seamless Data-processing and Forecasting System;

(b) Report on the integrated and seamless Data-processing and Forecasting System for consideration at the Eighteenth World Meteorological Congress;

(2) To establish a CBS steering group to act as successor to the Executive Council Steering Group established by Decision 55 (EC-68) with terms of reference and membership as defined in the annex to the present recommendation;

Authorizes its president to establish the working structures requested by the Executive Council in response to this recommendation.

Annex to Recommendation 43 (CBS-16)

TERMS OF REFERENCE FOR THE COMMISSION FOR BASIC SYSTEMS STEERING GROUP ON IMPLEMENTATION OF THE SEAMLESS DATA-PROCESSING AND FORECASTING SYSTEM

The Steering Group is chaired by the president of the Commission for Basic Systems (CBS) and is composed of representatives of technical commissions and regional associations, and the chairperson and co-chairperson of the CBS Open Programme Area Group on Data-Processing and Forecasting Systems (OPAG DPFS).

The Terms of Reference are:

(1) To provide guidance on and monitor the development of the process for the gradual establishment of a future enhanced integrated and seamless WMO Data-processing and Forecasting System, based on the achievements of the World Weather Watch;

(2) To manage the integration of new components in the Global Data-Processing and Forecasting System, including addressing synergies with and requirements of all WMO Programmes and Regions, through active consultation with technical commissions and regional associations;

(3) To develop a description of the set of products the system should produce, including impact-based forecast products;

(4) To maintain and further develop for consideration by the Eighteenth World Meteorological Congress the road map and Implementation Plan for a future enhanced integrated and seamless WMO Data-processing and Forecasting System;

(5) To provide annual reports to the Executive Council on progress with and the content of the Implementation Plan and description of the set of products.

Recommendation 44 (CBS-16)

RESPONSIBILITY FOR OVERSIGHT OF INFORMATION ABOUT SPACE WEATHER AND WEATHER RADAR OBSERVING CAPABILITIES HELD IN THE OBSERVING SYSTEMS CAPABILITY ANALYSIS AND REVIEW TOOL

Noting Decision 16 (CBS-16) – Responsibilities for the oversight and review of the Observing Systems Capability Analysis and Review tool,

Recalling that the Executive Council determined the terms of reference for the Inter-programme Expert Team on Operational Weather Radars and for the Inter-programme Team on Space Weather Information, Systems and Services,

Recommends to the Executive Council that:

(1) The Inter-programme Expert Team on Operational Weather Radars should have the following added to its terms of reference: "oversee the development and review of the Observing Systems Capability Analysis and Review tool (OSCAR) so that it meets the needs of WIGOS for information operational weather radar observing system capabilities";

(2) The Inter-Programme Team on Space Weather Information, Systems and Services should have the following added to its terms of reference: "oversee the development and review of OSCAR so that it meets the needs of the WMO Integrated Global Observing System (WIGOS) for information concerning user space weather observing system capabilities";

(3) That the short name of the Inter-programme Team on Space Weather Information, Systems and Services should be IPT-SWeISS.

Recommendation 45 (CBS-16)

REVIEW OF PREVIOUS RESOLUTIONS AND DECISIONS OF THE EXECUTIVE COUNCIL AND CONGRESS RELATIVE TO THE COMMISSION FOR BASIC SYSTEMS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 82 (Cg-17) – Review of previous Congress resolutions,

(2) Resolution 13 (EC-68) – Review of previous resolutions of the Executive Council,

(3) Regulation 191 (9) of the General Regulations (*Basic Documents No. 1* (WMO-No. 15), 2015 edition) concerning the review of technical commission resolutions,

(4) Rule 27 of the Rules of Procedure of the Executive Council on the same subject,

Recommends the Executive Council:

(1) To keep in force the following resolutions:

Resolution 13 (EC-XXXIV);

Resolutions 16, 17 and 19 (EC-LIX);

Resolution 14 (EC-64);

Resolutions 11 and 12 (EC-65);

Resolution 10 (EC-66);

Resolutions 2, 3 and 12 (EC-68);

(2) Not to keep in force the following resolutions:

Resolution 10 (EC-64);

Resolutions 4 and 10 (EC-65);

Resolution 5 (EC-66);

Resolution 4 (EC-68);

(3) To keep in force the following decisions:

Decisions 5, 6, 9, 30, 33, 36, 42, 51, 55, 56 and 58 (EC-68);

(4) Not to keep in force the following decisions:

Decisions 31, 32, 35, 37, 38, 45, 50 and 57 (EC-68);

Requests its Management Group to review the resolutions of Congress before the Eighteenth World Meteorological Congress.

APPENDIX 5. LIST OF PARTICIPANTS

1. Officers of the session

Fredrick R. BRANSKI	President of the Commission for Basic Systems (CBS)
Sue BARRELL (Ms)	Vice-President of CBS

2. Members of CBS

Argentina

Pablo LOYBER	Principal Delegate

Australia

Sue BARRELL (Ms)	Principal Delegate
Anthony REA	Alternate
Adam MORGAN	Delegate
Bienifer VINLUAN (Ms)	Delegate

Belgium

Liliane FRAPPEZ (Ms)	Principal Delegate

Benin

Pierre Adjakobinon DAKO	Principal Delegate

Botswana

Radithupa RADITHUPA	Principal Delegate

Brazil

José Mauro DE REZENDE	Principal Delegate
Carlos Alberto Pires CASTRO FILHO	Delegate
Eliseu DIAS DA SILVA	Delegate
João FRANSWILLIAM BARBOSA	Delegate
Carlos Cesar GOMES SAO BRAZ	Delegate

British Caribbean Territories

Tyrone SUTHERLAND	Principal Delegate
David FARRELL	Delegate
Adrian TROTMAN	Delegate

Burundi

Simon SINDAYIHEBURA	Principal Delegate
Godefroy NSHIMIRIMANA	Delegate

Canada

David GRIMES	Principal Delegate
Michel JEAN	Alternate
Veronique BOUCHET (Ms)	Delegate
Michael MANORE	Delegate

China

Guoguang ZHENG	Principal Delegate
Meiyan JIAO (Ms)	Alternate
Baogui BI	Delegate
Hongguang CUI	Delegate
Jianfeng GU	Delegate
Huifeng HOU	Delegate
Liangxu LI	Delegate
Mingmei LI (Ms)	Delegate

Long SUN	Delegate
Jinsong WANG	Delegate
Hui YI (Ms)	Delegate
Licheng ZHAO	Delegate
Heng ZHOU	Delegate
Xudong ZHUANG	Delegate

Costa Rica

Martha PEREIRA MOLINA (Ms)	Principal Delegate

Croatia

Ivan CACIC	Principal Delegate
Kreso PANDZIC	Delegate

Curaçao and Sint Maarten

Albert MARTIS	Principal Delegate

Czechia

Pavla SKRIVANKOVA (Ms)	Principal Delegate

Democratic Republic of the Congo

Nestor NIANGA NKUFI	Principal Delegate

Denmark

Claus Kern-Hansen ERNSTSEN	Principal Delegate

Egypt

Mohamed SAAD MOHAMED ISMAEIL	Principal Delegate

Finland

Juhana HYRKKÄNEN	Principal Delegate

France

Bernard STRAUSS	Principal Delegate
Matteo DELL'ACQUA	Delegate

Germany

Jochen DIBBERN	Principal Delegate
Dieter SCHROEDER	Alternate
Dirk ENGELBART	Delegate

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Guinea

Soumah FACINET	Principal Delegate

Hong Kong, China

Chi Ming SHUN	Principal Delegate
Sai Tick CHAN	Alternate
Cho Ming CHENG	Delegate

India

K. J. RAMESH	Principal Delegate
Kuldeep SRIVASTAVA	Delegate

Indonesia

Edward TRIHADI	Principal Delegate
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Abdul KAMID	Delegate

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Takayuki MATSUMURA	Delegate
Kenji TSUNODA	Delegate

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Peter AMBENJE	Principal Delegate
Nicholas MAINGI	Alternate

Kuwait

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Nasser Talal AL FADHLI	Delegate
Emad A. ALSANOUSI	Delegate

Macao, China

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Morocco

Hassan HADDOUCH	Alternate
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Namibia

Willem GOEIEMANN	Principal Delegate
Franz UIRAB	Alternate

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New Zealand

Peter KREFT	Principal Delegate
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Norway

Bard FJUKSTAD	Principal Delegate
Oystein HOV	Delegate
Cecilie STENERSEN (Ms)	Delegate

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Abdul Sattar KHOKHAR	Principal Delegate

Paraguay

Eduardo Jose MINGO VEGA	Principal Delegate

Peru

Olimpio SOLIS CACERES	Principal Delegate

Philippines

Landrico DALIDA	Principal Delegate

Qatar

Abdulla Mohamed A. AL-MANNAI	Principal Delegate
Mohammad ALKUBAISI	Delegate
Omar FAKHRO	Delegate

Republic of Korea

Yunhwa KO	Principal Delegate
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Namsan CHO	Delegate
Chulwoon CHOI	Delegate
Sungsoo DO	Delegate
Hyunsik JANG	Delegate
Jengeun LEE (Ms)	Delegate
Seungwoo LEE	Delegate
Seungkyun PARK	Delegate
Jaegwang WON	Delegate
Minjeong YOUN (Ms)	Delegate

Russian Federation

Igor SHUMAKOV	Principal Delegate
Tatiana DMITRIEVA (Ms)	Delegate
Alexander GUSEV	Delegate
Dmitry KIKTEV	Delegate
Sergey LUBOV	Delegate
Dmitry ZAYTSEV	Delegate

Senegal

Samba DIENG LAKH	Principal Delegate

Singapore

Lesley CHOO (Ms)	Alternate
Shwei Lin WONG	Delegate

Slovakia

Branislav CHVILA	Principal Delegate

South Africa

Tshepho NGOBENI	Principal Delegate

Spain

Maria LOPEZ BARTOLOME (Ms)	Principal Delegate
Jose Pablo ORTIZ-DE-GALISTEO MARÍN	Alternate

Sudan

Ahmed M. A. ABDELRAHMAN	Principal Delegate

Sweden

Stefan NILSSON	Principal Delegate

Switzerland

Estelle GRUETER (Ms)	Principal Delegate
Heike KUNZ (Ms)	Alternate

Thailand

Somwhang LODCHANAANGSU	Principal Delegate
Wanchalearm PETSUWAN	Delegate
Wattana SINGTUY (Ms)	Delegate

The former Yugoslav Republic of Macedonia

Aleksandar KARANFILOVSKI	Principal Delegate

Trinidad and Tobago

Marlon NOEL	Principal Delegate

Turkey

Mustafa SERT	Principal Delegate
Askin BILGI	Delegate

Uganda

Anita KIGONYA (Ms)	Principal Delegate
Bob Alex OGWANG	Delegate

Ukraine

Viacheslav MANUKALO	Principal Delegate

United Arab Emirates

Mohamed AL HARMOODI	Principal Delegate
Majed ALSHEIKILI	Alternate
Mohamed AL EBRI	Delegate
Mohamed SHAMSAN	Delegate

United Kingdom of Great Britain and Northern Ireland

Jeremy TANDY	Principal Delegate
Jane WARDLE (Ms)	Alternate
Charles EWEN	Delegate
Stuart GOLDSTRAW	Delegate
Ken MYLNE	Delegate

United Republic of Tanzania

Agnes KIJAZI (Ms)	Principal Delegate
Hamza KABELWA	Alternate
Wilbert Timiza MURUKE	Delegate
Abilah Hassan NAMWAMBE	Delegate

United States of America

John MURPHY	Principal Delegate
William BOLHOFER	Alternate
Robert BUNGE	Delegate
Jeff CUPO	Delegate
Neal DIPASQUALE	Delegate

Uzbekistan

Kamola MAKHMUDOVA (Ms)	Principal Delegate

Zimbabwe

Amos MAKARAU	Principal Delegate
Dennis KAPASO	Alternate

3. WMO Members not represented in the Commission for Basic Systems

Algeria

Mohamed DJABALLAH	Principal Delegate

Tajikistan

Iftikhor KARIMOV	Principal Delegate

4. Presidents of constituent bodies and chairpersons of other bodies

Øystein HOV	President of the Commission for Atmospheric Sciences (CAS)
Byong Lyol LEE	President of the Commission for Agricultural Meteorology (CAgM)
Zhiyu LIU	Vice-President of the Commission for Hydrology (CHy)

5. Invited experts

Remy GIRAUD
Yasutaka HOKASE
Hiroyuki ICHIJO

6. Representatives of international organizations and other bodies

Association of the Hydro-meteorological Equipment Industry (HMEI)

Martino FANTATO	Observer

Coordination Group for Meteorological Satellites (CGMS)

Simon ELLIOTT	Observer

East African Community (EAC)

Guleid ARTAN	Observer
Zachary ATHERU	Observer

Economic and Social Commission for Asia and the Pacific (ESCAP)

Jixin YU	Observer

European Centre for Medium-range Weather Forecasts (ECMWF)

Erik ANDERSSON	Observer

European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)

Simon ELLIOTT	Observer
Lothar WOLF	Observer

International Telecommunication Union (ITU)

Vadim NOZDRIN	Observer

International Union of Geodesy and Geophysics (IUGG)

Dongqi ZHANG	Observer

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