Commission for Basic System

Fifteenth session

Jakarta
10–15 September 2012

Abridged final report with resolutions and recommendations

World Meteorological Organization
Weather • Climate • Water

WMO-No. 1101

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Chair, Publications Board
World Meteorological Organization (WMO)
7 bis, avenue de la Paix
P.O. Box 2300
CH-1211 Geneva 2, Switzerland

Tel.: +41 (0) 22 730 84 03
Fax: +41 (0) 22 730 80 40
E-mail: publications@wmo.int

ISBN 978-92-63-11101-2

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GENERAL SUMMARY OF THE WORK OF THE SESSION

1. OPENING OF THE SESSION (agenda item 1)

1.1 At the kind invitation of the Government of the Republic of Indonesia, the fifteenth session of the Commission for Basic Systems (CBS-15) was held in Jakarta, Indonesia from 10 to 15 September, 2012. The session was declared open by Mr Fredrick Branski, president of the Commission, at 10.30 a.m. on Monday, 10 September, at the Mercure Ancol Hotel.

1.2 Dr Sri Woro B. Harijono, Director-General of the Indonesian Agency for Meteorology, Climatology and Geophysics, and Permanent Representative of Indonesia with WMO welcomed the delegates to Indonesia and wished them a productive session.

1.3 Dr Harijono noted the ever present, and increasing, threat of natural disasters and the role of WMO through CBS, and through new mechanisms such as the GFCS in assisting vulnerable communities to deal with them. Taking a regional perspective she considered that the implementation of WIS and WIGOS to be important but challenging tasks and encouraged improved working arrangements between the technical commissions and regional associations.

1.4 Mr Fred Branksi, president of the CBS welcomed the distinguished guests and delegates to the Fifteenth Session of CBS. He noted the high vulnerability of Indonesia to natural hazards of both a meteorological and geophysical character and how each of the OPAGs of CBS contributed to reducing that vulnerability.

1.5 Mr Branski noted that this agenda covered many significant items including implementation of WIGOS, making a significant contribution to GFCS, and improving interactions with regional associations. He encouraged the delegates to work as efficiently as possible given the short time available for dealing with the large agenda.

1.6 Mr Branski concluded by thanking the Government of the Republic of Indonesia for agreeing to host the Session and for making such excellent facilities available.

1.7 The WMO Deputy Secretary-General, Mr Jeremiah Lengoasa, opened by thanking the Republic of Indonesia for hosting the meeting. He went on to note the increasing engagement of Indonesia in the work of the WMO and acknowledging that Indonesia was regarded as one of the Organization's senior Members.

1.8 Mr Lengoasa noted the important role that CBS had played throughout the lifetime of WMO, with keystone activities such as the World Weather Watch that was initiated at the request of the United Nations General Assembly in 1963, and support for ground breaking research programmes such as the Global Atmosphere Research Programme (GARP), the GARP Atlantic Tropical Experiment (GATE) and the MONsoon EXperiment (MONEX).

1.9 Mr Lengoasa recalled recent achievements of CBS and anticipated a range of new challenges including:

- Implementation of WIGOS;
- Achieving the full potential of WIS;
- Safeguarding the radio frequencies used by the meteorological community;
- Extending SWFDP to all those who could benefit from it.

1.10 His Excellency, Mr Agung Laksono, Coordinating Minister for People's Welfare of the Republic of Indonesia, expressed a warm welcome to the delegates from all over the World. He noted that the range of users dependent upon weather and climate services had grown rapidly in recent times with agriculture, in particular, now a major user community.

1.11 Minister Agung Laksono noted that the impacts of climate change are of concern to governments and looked to the WMO, through both CBS and GFCS to address these impacts. In relation to this he encouraged CBS to build stronger cooperation with related communities, particularly those working towards the achievement of the Millennium Development Goals. He also encouraged further efforts by CBS in capacity development. Finally he wished the session every success.

1.12 A complete list of participants is given in the appendix to the present report.

2. ORGANIZATION OF THE SESSION (agenda item 2)

2.1 Consideration of the report on credentials (agenda item 2.1)

In accordance with General Regulations 21 to 24, the Commission noted and approved the report of the representative of the Secretary-General as the first report on credentials.

2.2 Adoption of the agenda (agenda item 2.2)

The agenda for the session was unanimously adopted, as contained in document CBS-15/Doc. 2.2.

2.3 Establishment of committees (agenda item 2.3)

In accordance with Regulations 23 to 32, the session decided to establish a Nomination Committee, a Coordination Committee and a WIS Centres Committee. The Nomination Committee comprised J. Mukabana (Kenya) as the Chair and A. Ebrahim (Qatar). The Coordination Committee comprised the president of the Commission, the vice-president of the Commission, the representative of the Secretary-General and a representative of the host country, the Chairs and Co-Chairs of the OPAGs and the Secretariat staff at the meeting who were responsible for managing the documents. The Committee on WIS Centres was chaired by M. dell'Acqua (Chair, France) with representatives from Australia, Brazil, Canada, China, Croatia, Finland, Germany, Japan, the Republic of Korea, the United Kingdom of Great Britain and Northern Ireland and the United States of America. The Commission agreed that the work of the session would be carried out in plenary. The president of the Commission would chair agenda items 1, 2, 3, 4.1, 4.3, 4.5, 5, 6, 7, 9, 10 and 11, and the vice-president would chair agenda items 4.2, 4.4, 8.

2.4 Other organizational issues (agenda item 2.4)

2.4.1 The Commission agreed on the working hours of the session. It was agreed that minutes of the meeting were not required in view of the technical nature of discussions. In accordance with Regulation 3, the Commission agreed to suspend Regulation 110 for the duration of the whole session.

Procedural documents

2.4.2 The Commission recognized that some of the decisions it has to make are determined solely by administrative procedures. The Commission agreed that errors in these documents could be corrected through editorial action and would not normally need to be debated in session.

2.4.3 The Commission also recognized that some of its decisions are of a highly technical nature and have been reviewed carefully by OPAG experts in the subject area. Such decisions would unlikely benefit from further debate by the Commission concerning the technical details. It noted as an example that the "fast track" and "approval between sessions" procedures for changes to the Table Driven Code Forms had been successful, but that similar procedures may not have been put in place for all technical decisions of a similar nature, such as those where changes are infrequent or being made for the first time.

2.4.4 The Commission noted that documents containing only decisions determined solely by administrative procedures, or of a highly technical nature and that had already been reviewed by experts in the subject, had been marked as "Procedural." The Commission agreed that it would only debate these documents if a Member asked to do so during the relevant agenda item.

2.4.5 The Commission requested the Secretariat to consider how documents might be structured in future meetings to separate out issues that needed substantial debate from those of a more procedural nature that could be approved by the session without requiring discussion unless so requested by a Member.

2.4.6 The Commission requested the Management Group to define the conditions and procedures under which session documents can be considered and processed as "procedural" taking due consideration of the Executive Council discussions and decisions about "non-controversial documentation" and to report to the next session of CBS.

3. REPORT BY THE PRESIDENT OF THE COMMISSION (agenda item 3)

3.1 The Commission noted with appreciation the report by Mr F. Branski, president of the Commission for Basic Systems (CBS). Noting the significance of CBS activities for all WMO Programmes, including the leading role for many activities, the Commission recognized the substantial work carried out since the extraordinary session of CBS (2010), and in particular:

(a) A "Competency Framework for PWS/ Weather Forecasters and Advisors" was developed which the Commission would review;

(b) Guidance material on impact-based information and warning services for hydrometeorological hazards in support of disaster reduction and mitigation was prepared;

(c) Further work on the "WMO Register of Alerting Authorities" and adoption of the Common Alerting Protocol (CAP). The Register is an important to achieving "single official voice" status for NMHSs;

(d) Much was learned from the World Expo Nowcasting Service (WENS) project (2008–2011) regarding how nowcasting systems can improve the range of forecast and warnings services. Focus was now on how to make this knowledge available;

(e) Cg-XVI said priority should be given to forecasting severe and high-impact weather and related-phenomena over a wide-range of forecast scales, including through the implementation of the Severe Weather Forecasting Demonstration Project (SWFDP) in all WMO Regions. Significant benefits have resulted from the SWFDP in five areas (Southern Africa, South Pacific, Eastern Africa, Southeast Asia, Bay of Bengal) but some countries have experienced difficulties in participating effectively in the SWFDP. The Commission will consider how to address country-specific implementation plans within the SWFDP;

(f) Significant progress was made on the revision of the *Manual on the GDPFS* (WMO-No. 485). The Global Framework for Climate Services (GFCS), the increased scope of the Emergency Response Activities (ERA) Programme, and the Global Integrated Polar Prediction System (GIPPS) have implications for the GDPFS. The Commission is working towards approval of the revised Manual in 2015 and will likely need a transition plan for its implementation;

(g) Considerable work was done in the area of forecast verification. The Commission thanked the ECMWF as the Lead Centre for Deterministic NWP Verification (http://apps.ecmwf.int/wmolcdnv/) and JMA as the Lead Centre for EPS Verification (http://epsv.kishou.go.jp/EPSv/). To support GIPPS, the Commission recommended

inclusion of two new geographical areas (polewards of 60º) in the CBS standard verification procedures;

(h) Significant progress has been made in the integration of EPS into core operational forecasting at GDPFS centres. There is now a set of “Guidelines on EPS and Forecasting” to aid forecasters;

(i) Integration of satellite-based products, high-resolution LAM and post-processing systems can be powerful tools for very short to short-range forecasting especially where national radar coverage is sparse. CBS and CAS will collaborate on the uptake of these products and develop regional/national guidelines on their use using the SWFDP–Eastern Africa as a pilot;

(j) GPC Exeter (United Kingdom) reported promising first results regarding informal exchange of multi-annual to decadal predictions. The Commission encouraged this activity by GPC Exeter (United Kingdom) and other interested GPCs and also needed to consider how such multi-annual/decadal predictions might be incorporated into the CSIS of GFCS;

(k) Several major ERA events have occurred since CBS-Ext.(10), including volcanic eruptions in Chile, Iceland and Indonesia, and the Fukushima Daiichi NPP accident in Japan. The Commission thanked the RSMCs involved for their excellent work and response, especially RSMC Tokyo and the Japan Meteorological Agency (JMA) who responded diligently throughout the Fukushima Daiichi NPP event in the face of tragedy and adversity;

(l) The Commission thanked ZAMG (Austria) and MeteoSwiss (Switzerland) for providing expert assistance to International Atomic Energy Agency (IAEA) and the WHO, respectively for the Fukushima Daiichi NPP event;

(m) The Commission needed continued close collaboration with the IAEA to further improve meteorological support. There is an initiative to develop meteorological analyses suitable for atmospheric transport, dispersion, and deposition modelling for the post-accident study undertaken by the United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR) on the levels and effects of radiation released from the accident;

(n) RSMCs are looking at improving ERA products including for forecast time-range up to 10 days and geo-referenced information. Some RSMCs provided such products to the IAEA on an experimental basis during the Fukushima event. The Commission needs further work in this area including procedures regarding ‘‘Plume Time of Arrival’’ products;

(o) WMO Technical Note 170, Meteorological and Hydrological Aspects of Siting and Operations of Nuclear Power Plants, was thoroughly reviewed. Several WMO Programmes and other Commissions will need to be involved in updating it;

(p) Recognizing the expanding role of the ERA Programme, a revision of its description was developed;

(q) DRR will shortly deliver a report on capabilities within WMO networks, initial meteorological, hydrological and climate information and service needs for humanitarian agencies and high-level concept of operations;

(r) WIS became operational early in 2012, with the publishing of the first edition of the Manual on WIS and designation of its first centres. Five GISCs (Beijing, Offenbach, Tokyo, Exeter and Toulouse) are designated and operational. TWO GISCs (Melbourne

and Seoul) had been audited by CBS and formally designated by EC-64, and Brasilia and Tehran will be audited by CBS soon. Additionally, 18 DCPCs are also designated;

(s) IPET-DRC has actively maintained, developed and refined the Table Driven Code Forms and their associated tables, making effective use of the Fast Track and Between Sessions approval procedures to meet the needs of WMO Programmes;

(t) IPET-DRC developed a “universal station identifier” methodology. The Commission will now develop procedures for assigning these;

(u) The WMO Core Metadata Profile Version 1.2 was approved and will be published in the Manual on WIS including Fast Track change procedures;

(v) An initial version of a WMO Logical Data Model to support an XML standard that can support aviation has been developed;

(w) The Commission has updates for the “Guide on IT Security” and the “Guide for Virtual Private Networks (VPN) via the Internet between GTS centres”;

(x) Migration of the GTS to IP has been completed;

(y) EC-64 approved the WIGOS Framework Implementation Plan (WIP). There is risk that resource limitations will extend some implementation activities beyond the fifteenth financial period;

(z) Significant effort was put into the Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP). Its adoption will be an important contribution to WIGOS and improved observing capabilities to support Members;

(aa) The Commission is working to strengthen regional working groups dealing with observing systems to address shortcomings in regional networks and increase observation availability;

(bb) The nine CBS Lead Centres for GCOS working with the GCOS Implementation Manager made remarkable improvement in CLIMAT reports received at the GCOS Archive Centre. GCOS Surface Network reports received increased to over 80 per cent globally. GCOS Upper-air Network stations meeting minimum performance have also increased;

(cc) Implementation of the GCOS Reference Upper-Air Network (GRUAN) has progressed and GRUAN data has been flowing through NOAA’s National Climatic Data Centre (NCDC) to users since summer 2011;

(dd) Transition of the AMDAR programme into the WMO WWW Programme is progressing;

(ee) The Turkish State Meteorological Service (TSMS) led, and other Members collaborated in establishing and operating the WMO Weather Radar Database. The Commission appreciated TSMS’s commitment to maintain this vital operational tool noting 49 Members have registered their weather radars and respective metadata;

(ff) A questionnaire on wind profiling radar was launched. The Commission needs Members currently operating or planning to operate wind profiling radars to complete the questionnaire;

(gg) The WMO Workshop on the Impact of Various Observing Systems on NWP identified a large impact on NWP from surface pressure observations from drifters. CBS encourages Members to make additional commitments towards the buoy programme;

(hh) There was substantial progress by the Coordination Group for Meteorological Satellites (CGMS) agencies toward adopting a new baseline contribution to the GOS. This is important to fully implement the space-based component of the Vision for the GOS in 2025. CBS wants to reflect this new baseline in the Manual on the GOS;

(ii) The Commission is working to define Region-oriented requirements for satellite data access and exchange and recently developed a “Procedure for Documenting Regional Requirements for Satellite Data Access and Exchange”;

(jj) To prepare satellite data users for the planned introduction of several next generation geostationary satellite systems a “CBS Guidelines for Ensuring User Readiness for New Generation Satellites” was developed;

(kk) There were positive outcomes from the ITU World Radiocommunication Conference for all thirteen agenda items identified by the Steering Group on Radio-Frequency Coordination;

(ll) The Commission now has a “Strategy towards an Architecture for Climate Monitoring from Space” jointly completed by the Committee on Earth Observation Satellites (CEOS), the Coordination Group for Meteorological Satellites (CGMS), and the WMO Secretariat in consultation with OPAG IOS. CBS expects the architecture will become the space-based component of the Observation and Monitoring pillar of the GFCS;

(mm) The Inter-Programme Coordination Team on Space Weather defined space weather observation requirements, set up an observing capabilities and operational product portal, and collaborated with the ICAO International Airways Volcano Watch Operations Group on information services for aviation.

3.2 The following priorities for the work of CBS in the next intersessional period were approved by EC-64:

(a) Further implementation of the World Weather Watch Programme in accordance with Resolution 1 (Cg-XVI) – “World Weather Watch Programme for 2012–2015” as the basic WMO Programme on which all other Programmes of the Organization depend and which provides the basis for the operations of National Meteorological and Hydrological Services;

(b) Implementation of the WMO Integrated Global Observing System (WIGOS). Make recommendations to EC-65 regarding the WIGOS Implementation Plan paying attention to available resources to match the implementation period;

(c) Further implementation of the WMO Information System (WIS) and strengthening of the GTS/WIS operational coordination;

(d) Development of the Severe Weather Forecasting Demonstration Project (SWFDP), forecast verification activities, and Extended- and Long-Range Forecasting;

(e) Support to capacity development for Public Weather Services;

(f) Support to the Disaster Risk Reduction Programme;

(g) Support to the implementation of the Global Framework for Climate Services (GFSC);

(h) Support to the development of the Quality Management Framework.

3.3 CBS is actively engaged with the EC effort to continuously improve WMO practices and procedures and will continue to do so. The Commission will consider a more flexible working structure with fewer standing groups and the ability for creating and disbanding targeted teams for

specific issues. There is a proposed increase in Inter-Programme Teams. The Commission is strengthening engagement with regional associations. Lastly, the Commission hopes to increase the use of ICT tools to save costs and to improve information sharing.

4. DECISIONS RELATED TO THE WORK PROGRAMME OF THE COMMISSION, INCLUDING THE REPORTS BY THE CHAIRS OF THE OPEN PROGRAMME AREA GROUPS (agenda item 4)

4.1 Review of decisions of Sixteenth Congress and the Executive Council related to the Commission and the requirements of the regional associations, including those related to the WMO Strategic Plan (2012–2015) and WMO Operating Plan, the Global Framework for Climate Services and other priorities (agenda item 4.1)

4.1.1 The Commission reviewed the relevant decisions taken by Sixteenth Congress and the sixty-third and sixty-fourth sessions of the Executive Council. It discussed the impact of those decisions on the future work programme of the Commission and included its conclusions in the general summary under their respective agenda items.

4.1.2 The Commission noted items of relevance to CBS in the reports of the fifteenth sessions Regional Associations I and III that had been published since CBS-Ext (10).

Global Framework for Climate Services

4.1.3 The Commission reviewed the second order draft Implementation Plan for the GFCS (http://www.wmo.int/pages/gfcs/office/2ndOrderDraft.php) and noted that CBS will have important contributions to make to aspects of the User Interface Platform, Climate Service Information System and Observations and Monitoring pillars of GFCS as well as to its capacity development initiatives.

CBS Contribution to the User Interface Platform

4.1.4 The Commission noted that the User Interface Platform (UIP) is the pillar of the Framework that provides a structured means for users, climate researchers and climate service providers to interact at the global, regional, and national levels. It recognized that the objective of the UIP is to ensure that the Framework meets user needs for climate services and that the interactions between users and providers facilitated by the UIP would be aimed at identifying what credible climate information is available and what information the user needs to inform their decision making. This mutual understanding would then frame an end-to-end climate service that may involve the development of useable products or merely training in using existing products.

4.1.5 The Commission noted that currently through the OPAGs on PWS and DPFS, it already has in place task teams that bring users and providers together to match user needs with available operational products in areas where a “seamless” service, requiring both climate and weather timescale products, is called for (e.g. seasonal forecasts that may involve extremes such as droughts, unusual foods or high numbers of tropical cyclones). As GFCS becomes operational there will be an increasing requirement for these and other task teams to work closely with CCl in providing what are essentially UIP functions. The Commission encouraged the experts involved in the OPAGs on PWS and DPFS to monitor development of the GFCS UIP and support it where possible.

CBS Contribution to the Climate Services Information System

4.1.6 The GFCS Climate Services Information System lists requirements that can be served by two important functional capabilities that are coordinated by CBS: (1) an information exchange system, whose requirements can be met in many aspects by WIS; and, (2) a data processing and product generation capability, whose requirements can at least partially be met by the GDPFS.

Communications

4.1.7 With respect to the mechanisms for exchange, communication and dissemination of climate data and products, the required technologies available for exchanging climate data and information (including the Internet and mobile telecommunications) are improving at a rapid pace and are being exploited by, among others, the WIS. The Commission noted that Congress expected that the WMO Information System (WIS) could serve as a key dissemination mechanism under GFCS to avoid duplicating existing institutions and efforts as much as possible. However there are considerable weaknesses in the implementation and exploitation of the data communications systems in several parts of the world, particularly in developing countries, that need to be addressed under the GFCS. Furthermore, the Commission recognized that enhancement of WIS might be required, as appropriate, to accommodate the potential greater scope of GFCS data and products and/or to utilize them in agreement with specific data policies.

Data Processing

4.1.8 Many elements of the data processing and product generation capability exist, however this capability is not consistent from country-to-country. It has been assessed that a significant number of countries can, at present, provide only very minimal climate services or even no services because they either do not have the necessary national databases, expertise to analyse the data, facilities to analyse the data or facilities to build a service capability upon their climate capabilities. This said, global elements of the Climate Services Information System are relatively well-developed and regional elements are just being launched, while at the national levels there is great disparity in the capabilities ranging from the non-existent or minimal to highly advanced.

4.1.9 CBS, working closely with CCl, will need to assist NMSs up-dating their methods and tools, hardware and software, so that they can achieve sustainable, operational preparation of climate products. Furthermore, to meet specific needs within countries and sectors, these methods and tools need to be adapted to users' priorities at national and local scales, and supported by strong provider-user cooperation.

4.1.10 Also influencing the usefulness of climate service provision is the lack of standardized methods and tools, and of outputs and formats that are more uniform and are targeted to user needs. For example, there are multiple sources of climate information about the same phenomenon with products packaged in different ways, making it difficult for users to compare and contrast them and make their own assessment of the key messages to be incorporated in their decision making. There have also been varied or even lack of expression of the aspects of uncertainty associated with climate products, which is crucial for climate risk management. CBS has a long experience in the development of standardized products, and should be closely engaged in efforts to standardize the expressions of uncertainty used in operational, meteorological products. The Commission recognized that the WMO Lead Centre for Long-range Forecasts Multi-model Ensemble (LC-LRFMME) has been serving as a coordinator and leader in the development and production of the Global Seasonal Climate Update (GSCU), which is a mechanism to generate regular global consensus statements on the seasonal climate (through expert assessments of global climate monitoring products of the current season and the outlooks for the ensuing season in terms of the broad patterns of precipitation and temperature, along with the indication of the situation and expected evolution of the major general circulation features of both atmosphere and ocean), and requested the Secretary-General to continue to support this work.

4.1.11 The Commission encouraged the experts involved in the OPAGs on DPFS and ISS to monitor development of the GFCS Climate Services Information System and to support its work, where possible.

Contributions to the Observations and Monitoring Pillar

4.1.12 The Commission noted that climate observations consist of in-situ measurements taken on land, on oceans and in the atmosphere, with increasing use of automated observation systems,

and, in recent decades, satellite data which contribute very significantly to climate datasets and are the only way to provide a global coverage of some parameters. The Commission further noted that the vast majority of all climate data currently available for the generation of climate services were collected according to standards, and under arrangements put in place, by CBS. Often these arrangements and standards were designed with the needs of the weather services in mind; the challenge for CBS is have WIGOS address climate and weather requirements in an optimum way.

4.1.13 The Commission agreed that one fundamental activity it is undertaking that will give support to the GFCS is the ongoing work to address the significant shortcomings in the quality, frequency, reliability and accuracy of reporting from many stations to national and international centres, and in particular reducing the network gaps and number of “silent” stations. While the Commission, through the OPAG on IOS is constantly working to improve the meteorological data coverage of the globe, it encouraged the IOS to pay particular attention to the requirements of the GFCS as they are developed.

4.1.14 The Commission noted that climate services require the observational data to be assembled in standardized formats, subjected to quality control and accompanied by metadata describing the history of the observing site, details of the instrumentation used there over its lifetime, the calibration history and the environmental changes in the site’s surroundings. The Commission considered that while not all data collected through arrangements coordinated by CBS will be to the precision ideally required for climate change detection, the key for CBS is to know, and record in a standard form, the precision to which the different types of observation have been taken, and to support the collection, storage and exchange of these observation-related metadata.

4.1.15 The Commission noted that in addition to the use of meteorological data, the provision of a full set of climate services requires access to social and economic data so that climate impacts and vulnerabilities can be understood, and so that predictions concerning anthropogenic climate change can be improved. For example, those concerned with the climate aspects of disaster risk reduction require climatologies of extreme weather events that cause disasters and also substantial socio-economic data so that they can combine them with climate data to understand and cope with the impacts of extreme events. The Commission agreed that it could greatly assist GFCS by bringing a standardized approach of NMSs to the analysis and recording of extreme hydrometeorological events in national databases, and by supporting the international exchange and validation of these data.

4.1.16 The Commission encouraged the experts involved in the OPAG on IOS to monitor development of the GFCS Observations and Monitoring pillar and to support its work where possible.

CBS Support for Capacity Development undertaken through GFCS

4.1.17 The Commission noted that the draft Implementation Plan for GFCS proposes a range of capacity development projects, funded through donor mechanisms to support the further development of the four pillars. These projects would be focused on the developing countries and offer the prospect for an increase in the capacity of members to collect, store, utilize and exchange meteorological data for the benefit of national, as well as regional and global service users. The Commission encouraged experts in each of its OPAGs to support these initiatives to the extent possible.

4.2 Decisions for the Open Programme Area Group on Integrated Observing Systems, including the WMO Integrated Global Observing System and the WMO Space Programme (agenda item 4.2)

Integrated Observing Systems

4.2.1 The Commission expressed its appreciation to the chair of the OPAG-IOS, Dr Lars Peter Riishojgaard and his co-chair Dr Jochen Dibbern for their comprehensive report on the

performance and further development of the Global Observing System. It reiterated that a sustainable provision of indispensable global observational data on the state of the Earth and its atmosphere continued to be ensured thanks to coordinated efforts of Members operating the surface-based and space-based subsystems of the GOS that resulted in further improvements in meeting evolving user needs.

4.2.2 The Commission appreciated the progress toward the implementation of an integrated observing system within GOS including merging the Space Weather into the activities of OPAG-IOS, reflecting the guidance provided by EC-LXII, Cg-XVI, and the Eleventh Consultative Meeting on High Level Policy on Satellite Matters.

4.2.3 The Commission appreciated the good cooperation between OPAG-IOS and CIMO working bodies. It emphasized the many positive outcomes resulting from collaboration with CIMO experts on the deliberations of the OPAG-IOS expert teams.

Implementation of the WMO Integrated Global Observing System (WIGOS)

4.2.4 The Commission noted with satisfaction the actions taken by OPAG-IOS toward the implementation of WIGOS, in particular its engagement in the development of the WIGOS Framework Implementation Plan (WIP) that was approved by EC-64, through the participation of OPAG-IOS experts in the ICG-WIGOS and its Task Teams.

4.2.5 The Commission noted a number of challenging tasks in the WIP (see Resolution 10 (EC-64)) related to the CBS – OPAG-IOS activities. It felt, however, that the limited resources available would imply a risk that the WIGOS Framework Implementation may be extended beyond the fifteenth financial period if required resources are not available for implementation. In supporting the WIP, the Commission endorsed harmonization of Terms of Reference of the future OPAG-IOS working structure with the WIP (Annex VII to the present report).

4.2.6 The Commission also emphasized that the Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP) will be an important contribution to the WIGOS implementation (see also paragraph 4.2.40).

4.2.7 The Commission noted with appreciation the involvement of OPAG-IOS in initiating the development of Architecture for Climate Monitoring from Space. This development is now a major international effort and the Commission noted that this Architecture will, when completed, be an important element of WIGOS and of the space-based component of observation and monitoring pillar of GFCS.

4.2.8 The Commission considered and endorsed specific actions to be undertaken by CBS as its contribution to the WIGOS Framework Implementation Plan (WIP), taking into account a decision of Cg-XVI of the leading role of CBS in the WIGOS implementation.

4.2.9 The Commission noted with appreciation that the Council adopted Resolution 10 (EC-64) – WIGOS Framework Implementation Plan (WIP) developed by ICG-WIGOS. In this regard, the Commission expressed its concern at the large number of tasks assigned to CBS, specifically the OPAG-IOS, as well as to other TCs and the Secretariat, given the limited resources available. It noted that this implies a risk that the WIGOS Implementation may extend beyond the sixteenth financial period. The Commission requested that ICG-WIGOS takes into account the level of available resources and update the WIP. It also recalled that EC-64 requested the Secretary-General to propose possible adjustments to the budget for the second biennium.

4.2.10 The Commission expressed its concerned that the recently established WIGOS Project Office is under-staffed, and that some of the key activities critical to the success of WIGOS Implementation as presented in the WIP have not been fully resourced. Therefore, the Commission encouraged its Members to continue to provide resources, through the WIGOS Trust Fund and seconded experts or Junior Professional Officers, to help support the implementation of WIGOS. The Commission underlined the role of the WIGOS Project Manager for a successful

implementation and recommended that the ICG-WIGOS work with the Secretariat Project Oversight Board on WIGOS to resolve and implement effective arrangements.

4.2.11 The Commission further recognized that there is a need for a holistic approach to unite the various databases (e.g. standards, observational user requirements, observing systems capabilities, and platform metadata) required for WIGOS implementation and operations into a WIGOS Operational Information Resource. It requested the ICG-WIGOS to make sure that this requirement is included in the WIGOS Functional Architecture, and recommended the Secretariat to lead its development.

4.2.12 The Commission acknowledged the value of the database of space- and surface-based capabilities as a key building block of the WIGOS Rolling Requirements Review (RRR) process, and the pivotal role of this database and associated analysis tool in support of global coordination of observing systems planning. The Commission stressed the need to secure resources with high priority within the Secretariat to ensure technical maintenance, sustainability and reliability of such a resource. In this connection, the Commission adopted Recommendation 1 (CBS-15) – Implementation and sustainability of the database of observation requirements and observing capabilities.

4.2.13 Following the request of EC-64 to support CIMO standardization activities, the Commission requested its president to nominate a focal point to represent CBS in the further development of the Siting classification for surface observing stations on land as a WMO-ISO common standard.

4.2.14 In support of the WIGOS Framework Implementation, including requirements for the update of the WMO Regulatory Material, the Commission agreed that the current function of a Rapporteur on GOS Regulatory Material would not be sufficient. Therefore, the Commission agreed to delegate activities on the regulatory matters to the proposed new OPAG-IOS Inter-Programme Expert Team on WIGOS Framework Implementation Matters (IPET-WIFI) with the Terms of Reference as proposed in Annex VII to the present report.

Implementation and operation of the surface-based subsystem of the GOS

Regional Basic Synoptic Network (RBSN) and Regional Basic Climatological Network (RBCN)

4.2.15 The Commission noted the monitoring results of RBSN and RBCN performance and welcomed an increased sustainability in the implementation of the surface-based subsystem of the GOS. It also noted that all Regions reported a significant growth in automatic weather stations (AWS) operated in Member countries both by the NMHS and by other parties external to the NMHS. The Commission underlined that insertion of these AWS reports into the GTS would greatly improve the representation of surface synoptic observations. In this connection it requested the Secretariat to better enable and support the PRs of Member countries to issue station identifiers so as to register these stations in the current Publication No. 9, Volume A, or its successor to be developed under WIP, and ensure the exchange of those data through the GTS as the matter of urgency.

4.2.16 The Commission noted with concern that the regional working groups dealing with observing systems and respective implementation aspects are not active in some Regions. It recognized the need for improved collaboration with and provision of technical advice for regional associations in the implementation and operation of observing systems, and requested its Management Group and the teams and experts within the OPAG-IOS to find ways to address this need.

GCOS Surface and Upper-air Networks (GSN/GUAN/GRUAN)

4.2.17 The Commission noted that the combined efforts of the GCOS Implementation Manager and the nine CBS Lead Centres for GCOS resulted in a remarkable improvement in the

number of CLIMAT reports received at the GCOS Archive Centre. It noted in particular, that the rate of CLIMAT receipt from GCOS Surface Network (GSN) stations increased to over 80 per cent globally. The number of GCOS Upper-air Network (GUAN) stations meeting the minimum performance requirements has also been increasing and steadily during the last few years.

4.2.18 The Commission also noted that implementation of GCOS Reference Upper-Air Network (GRUAN) has progressed steadily over the past years and that GRUAN data have been flowing since summer 2011 through NOAA's National Climatic Data Centre (NCDC) to data users. It noted that specific details of, and information on, GRUAN from the forthcoming GRUAN Reference Manual and Guide are planned to be included in WMO regulatory material related to GOS, CIMO, and ultimately for WIGOS. The Commission requested OPAG-IOS to nominate its representative in the GCOS AOPC Working Group on GRUAN to contribute to its activities as required.

Aircraft-based observations

4.2.19 The Commission appreciated the progress made in the transition of the AMDAR programme into the WMO WWW Programme under a new governance structure within CBS supported by the Secretariat. It agreed with the transition plan proposed by the OPAG-IOS Implementation Coordination Team at its Seventh session (Geneva, 18–22 June 2012) at the end of which all AMDAR activities are transferred to the appropriate CBS and CIMO working structure. At this time the AMDAR Panel at its final session (Boulder, Colorado, 5–9 November 2012) will cease to operate; however the AMDAR Trust Fund will continue to support activities related to aircraft-based observations under the new governance, recalling the request of Cg-XVI urging Members to continue providing contributions to the AMDAR Trust Fund.

4.2.20 The Commission noted recent developments in water vapour measurement for AMDAR and the promising results in the validation of a water vapour sensor through intercomparison with standard instrumentation on research aircraft. It acknowledged that this sensor meets the requirements for wider operational implementation.

4.2.21 The Commission recognized the efforts made by Members operating AMDAR programmes to increase the coverage of AMDAR observations over data sparse areas, such as the African continent, through AMDAR programme expansion and enhancement and encouraged its continuation in line with the associated actions in the Implementation Plan for the Evolution of the Global Observing Systems (EGOS-IP).

Requirements and implementation of AWS platforms

4.2.22 The Commission expressed its appreciation to OPAG-ISS and OPAG-IOS, for their development, through collaboration between IPET-DRC and ET-AWS, of BUFR descriptors for variables listed in the table of "Functional Specifications for Automatic Weather Stations" (see the *Guide to the Global Observing System* (WMO-No. 488), Appendix III.1), as requested by CBS-XIV. It agreed that new revision was needed and adopted Recommendation 2 (CBS-15) – Revised functional specifications for automatic weather stations.

4.2.23 For the next revision of the Functional Specifications for Automatic Weather Stations, the Commission requested that consideration be given to specifying a minimum sampling rates for AWS sensors.

4.2.24 The Commission, noting the limitations of humidity sensors needed for high quality data at both extremes of the humidity range (fire weather, aviation and agricultural applications), requested CIMO to consider evaluating by intercomparison the performance of different humidity measurement systems at the extreme ends of humidity (<5%, >95%) ranges. It also requested CIMO to consider recommending the use of standardized AWS algorithms to ensure interoperability of different AWS systems.

Surface-based remote sensing observations

4.2.25 The Commission welcomed the valuable work by the Turkish State Meteorological Service (TSMS) as the Lead, and other Members in establishing and operating the WMO Weather Radar Database (WRD), and appreciated TSMS's commitment to maintain this vital operational tool for the benefit of all Members. Noting that so far 49 Members had registered their Weather Radars and respective metadata in WRD, the Commission requested other Members with operational weather radars to provide their input to the WRD. The Commission also requested OPAG-IOS to continue liaising with the EUMETNET OPERA programme in harmonizing their Weather Radars databases.

4.2.26 The Commission agreed on the necessity to organize the Workshop on the Regional and Global Exchange of Weather Radar Data with the goal to provide clear guidance to Members on the requirements for exchange of Doppler radial winds and reflectivity data in accordance with recommendations from the Fourth WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction.

4.2.27 The Commission recognized the need for training on weather radar operation, maintenance and data interpretation, given the rapid expansion in use of weather radars in many developing countries, for example, Africa.

4.2.28 The Commission welcomed the progress made with the development and launch of the wind profiling radar Questionnaire, with engagement of national points of contact, and noted that it will be available on the WMO Website by the end of 2012. The Commission encouraged Members currently operating or planning to operate wind profiling radars to complete the questionnaire as required. The results of this survey would help the Commission and Members to realize more fully the potential of this important observing technology, especially concerning its contribution to WIGOS.

4.2.29 The Commission stressed that the development of the observing capabilities database, development of which is planned under WIP, and its subsequent population, would be the key activity in assessing the contribution of surface-based remote sensing systems to the Vision for the GOS in 2025.

Marine meteorological and oceanographic observations

4.2.30 The Commission noted with concern that the percentage of completion of the initial composite ocean observing system has not increased substantially in the last few years, and remained at the level of about 62 per cent. It requested its Members to contribute to the ocean observation platforms that address the requirements in support of WMO Programmes.

4.2.31 The Commission noted that the Fifth WMO Workshop on the Impact of Various Observing Systems on NWP (see also paragraph 4.2.44) has shown a larger impact of surface pressure observations from drifters on the NWP that extends from the surface throughout the troposphere in mid-latitudes. It therefore encouraged its members to consider making additional commitments towards the buoy programme.

Cryospheric Observations

4.2.32 Observations of cryospheric parameters were recognized by the Commission as a new component of the WIGOS as result of the advancement of the Global Cryosphere Watch (GCW). The Commission also recognized the leadership of CIMO in addressing the challenges of measuring solid precipitation through the Solid Precipitation Intercomparison Experiment (SPICE) initiated in 2011.

Implementation and operation of the space-based subsystem of the GOS

Satellite systems

4.2.33 The Commission welcomed the substantial progress accomplished by Members' agencies participating in the Coordination Group for Meteorological Satellites (CGMS) in adopting a new baseline for their contribution to the GOS. It agreed that this was an important step toward fully implementing the space-based component of the Vision for the GOS in 2025. Commission decided to reflect this new baseline in the WMO regulatory material and adopted Recommendation 3 (CBS-15) – Amendments to the *Manual on the Global Observing System* (WMO-No. 544), Volume I.

4.2.34 The Commission recognized, that the gap analysis performed by ET-SAT had specifically highlighted gaps in early morning orbit sounding coverage, geostationary hyperspectral infrared sounding, the transition to operations of global precipitation measurements, Earth radiation budget, and limb sounding. The Commission subsequently adopted Recommendation 4 (CBS-15) – Actions towards avoiding gaps in essential space-based observation.

Satellite Utilization

4.2.35 The Commission welcomed the progress by Members in defining Region-oriented requirements for satellite data access and exchange, particularly in RA I, III, and IV, and encouraged Members in other RAs to initiate similar efforts in their respective Regions. It recalled the recommendation by Cg-XVI to "organize the formulation of data requirements and the dialogue between data users and providers" and emphasized that a common approach to defining such requirements would facilitate this dialogue. The Commission subsequently adopted Recommendation 5 (CBS-15) – Procedure for documenting regional requirements for satellite data access and exchange.

4.2.36 The Commission recognized the need for appropriate and timely preparation of satellite data users to the planned introduction of several next generation geostationary satellite systems by the operators in the 2014–2018 timeframe. This affects all WMO Regions, and the preparation should involve user training, guidance to upgrade processing software and hardware, information and tools. Emphasizing that optimal utilization of the new operational satellite systems should be assured and the risk of disruption for operational users be mitigated, the Commission endorsed the *CBS Guidelines for Ensuring User Readiness for New Generation Satellites*, as given in Annex I to the present report.

4.2.37 The Commission endorsed the candidature by the Directorate for Météorologie Nationale (DMN) Morocco to host a WMO-CGMS VLab Centre of Excellence for Training and Education in Satellite Meteorology with EUMETSAT as sponsoring satellite operator. The Commission recognized that many VLab Centres of Excellence require assistance and requested Members to consider appropriate arrangements.

4.2.38 The Commission confirmed the need to monitor the progress of satellite data access and use by WMO Members and requested that CBS Members respond to the 2012 survey on this matter.

4.2.39 The Commission acknowledged the importance of updating the satellite observation part of the *Guide to Instruments and Methods of Observation* as a reference document for satellite users and a record of best practices for satellite designers. It encouraged the CIMO to work with the OPAG-IOS and Space Programme for completing such update.

Evolution of global observing systems

4.2.40 The Commission reviewed the new version of the "Implementation Plan for the Evolution of Global Observing Systems" (EGOS-IP), which had been prepared in response to the "Vision for the GOS in 2025" *[approved by EC-LI in 2009]* and to the needs of WIGOS, through valuable contributions from various expert teams and other collaborators. Accordingly, the

Commission adopted Recommendation 6 (CBS-15) – Implementation Plan for the Evolution of Global Observing Systems.

4.2.41 The Commission noted with appreciation the contributions received from the National Focal Points (NFPs) of many Members, reporting on progress and plans in their countries related to actions in the original EGOS-IP. It requested those Members who have not yet nominated a NFP for this activity to do so.

4.2.42 The Commission requested OPAG-IOS to monitor progress made by Members and other implementing agents on the many actions contained in the new EGOS-IP, and to find ways of improving the engagement of Members and Regions with EGOS-IP actions. It encouraged Members, together with the Secretariat, to mobilize additional resources to drive these activities forward.

4.2.43 The Commission noted the important role played by the Rolling Review of Requirements (RRR) process in support of the development of the "Vision for the GOS in 2025" and of EGOS-IP, and its pivotal future role in support of WIGOS activities. It also noted the key role of the databases – of user requirements for observations and of observing system capabilities – within the RRR process. It supported plans for the further development and maintenance of these databases and noted the significant commitment of resources that will be needed to sustain these activities.

Observing System Experiments (OSEs) and Observing System Simulation Experiments (OSSEs)

4.2.44 The Commission welcomed the report on the Fifth WMO Workshop on the Impact of Various Observing Systems on NWP (Sedona, United States, 22–25 May 2012) and noted with interest that certain studies and experiments may provide a valuable input to design studies for WIGOS.

4.2.45 The Commission noted with appreciation that good progress was made during the last intersessional period regarding impact studies, and particularly OSEs and OSSEs with emphasis on the future evolution of the global observing systems.

4.2.46 The Commission concurred with the list of specific studies and science questions to be addressed by CBS during the next intersessional period. The list is provided in Annex II to the present report.

4.2.47 The Commission encouraged the NWP centers to continue the development of and research in the use of observation impact assessment tools (e.g. Forecast Sensitivity to Observations (FSO), Degrees of Freedom for Signal (DFS)), as a complement to traditional OSEs. It also encouraged NMHSs to conduct OSEs and OSSEs to address the specific science questions listed in Annex II to the present report.

4.2.48 The Commission recognized that there are now various tools which are available to perform impact studies on a relatively cost-effective basis, and encouraged the operators of the observational programmes to propose specific questions on the impact of observations on NWP through the Inter-Programme Expert Team on Observing System Design and Evolution (IPET-OSDE). The use of impact tools in network design studies is a potentially very important contribution to the WIGOS implementation.

4.2.49 The Commission requested OPAG-IOS to organize the Sixth WMO Impact Workshop in 2016.

GCOS matters in relationship to CBS

4.2.50 The Commission noted that further progress was made in CBS collaboration with GCOS. The Commission endorsed the proposed new TOR and the new Areas of Responsibilities of CBS Lead Centres for GCOS as reproduced in Annex III to the present report.

Radio Frequencies

4.2.51 The Commission welcomed the positive outcome of the ITU World Radiocommunication Conference 2012 (WRC-12) for the meteorological and Earth observation community. It noted that all thirteen agenda items that had been identified by the CBS Steering Group on Radio-Frequency Coordination (SG-RFC) had been successfully represented at WRC-12 and that the final decisions of WRC-12 had been in line with the WMO position. It further noted that this was an excellent outcome for WMO, reflecting the significant preparation in the years leading up to WRC-12 by CBS and Members.

4.2.52 The Commission noted that the result of WRC-12 deliberations for WMO is that radio frequency spectrum, which is vital for weather forecasts, disaster warnings and climate monitoring, will remain available to the meteorological community and protected from interference from other applications. The WRC-12 reinforced the commitment of previous World Radiocommunication Conferences to the special needs of meteorological and hydrological services, despite competing pressure for scarce radio frequencies from wireless technology and other uses.

4.2.53 The Commission recognized that despite the very positive outcome of WRC-12 the threat to the frequencies used by meteorological and related systems and applications will continue due to the powerful lobby and requirements of the Information and Communication Technology industry. The Commission urged all Members to ensure continuous coordination with their national radio communication authorities, and to participate actively in national, regional, and international activities involving radio communication regulatory issues for the defence of radio frequency bands for meteorological and environmental activities. It noted the short time in preparing for WRC-15 and urged Members to ensure relevant experts to address issues fully. The Commission adopted Recommendation 7 (CBS-15) – Radio frequencies for meteorological and related environmental activities.

4.2.54 The Commission noted that radio frequency issues regarding the Direct Readout from future polar-orbiting satellite systems were considered within the WMO Space Programme as reported in 4.2.61.

Monitoring and Reporting

4.2.55 The Commission noted the request of EC-64 for consideration of a single progress report on WMO observing systems under the identity of WIGOS, and the request for a clearer indication of the extent of compliance with the WMO regulatory material, and for a clearer indication of progress achieved against the various implementation plans of WMO's component observing systems. The Commission agreed to develop options for responding to these requests, in consultation with the Secretariat.

Collaboration with GEO

4.2.56 The Commission noted that the EC-64 reviewed the Cg-XVI discussion regarding the Group on Earth Observations (GEO) and its Global Earth Observation System of Systems (GEOSS), reaffirming that WMO engagement is to be based on mutual benefit that maximizes synergies and avoids duplication. CBS noted that strong linkages exists between GEOSS and the WMO Integrated Global Observing System (WIGOS). In addition, it noted that very good linkages exist between WIS and the GEOSS Common Infrastructure (GCI).

4.2.57 CBS noted some benefits to the WMO from participating in GEOSS and agreed that, to date, the specific benefits of cooperation with GEO for WMO Members have not been fully realized. In this regard, WMO's future participation in GEO should increase benefits to WMO Members. The CBS supported continued GEO focus on improving observations and encouraged that GEO continue to enhance efforts to fulfil this mandate.

WMO Space Programme

4.2.58 The Commission recalled that Congress (Cg-XVI) had endorsed the extension of the scope of the WMO Space Programme to include space weather coordination. It noted that WMO Space Programme activities were structured around five pillars: space-based observing systems, satellite data products, accessibility of satellite data and products, capacity-building and cross-cutting activities. Many of the issues, outcomes and deliverables of the WMO Space Programme were reported under the OPAG IOS agenda item as part of the outcome of the Expert Team on Satellite Systems (ET-SAT) and Expert Team on Satellite Utilization and Products (ET-SUP). In addition, the Commission discussed specific issues related to the Architecture for Climate Monitoring from Space, satellite inter-calibration activities, impact of new direct satellite readout frequencies, geostationary coverage, and space weather.

Architecture for Climate Monitoring from Space

4.2.59 The Commission welcomed the Strategy towards an Architecture for Climate Monitoring from Space (http://www.wmo.int/pages/prog/sat/documents/ARCH_strategy-climate-architecture-space.pdf) jointly completed by the Committee on Earth Observation Satellites (CEOS), the Coordination Group for Meteorological Satellites (CGMS), and the WMO Secretariat in consultation with OPAG IOS. It recalled Resolution 19 (Cg-XVI) requesting the technical commissions, including CBS, to guide the technical aspects of the development activities and to provide the technical lead for the architecture. The Commission therefore invited the parties involved to pursue this effort and to complete the logical and physical descriptions of the architecture and report at the next extraordinary session of CBS. The Commission expected that the architecture would become the space-based component of the Observation and Monitoring pillar of the GFCS. Furthermore, it anticipated that the CGMS contribution to the WMO global observing systems, which is referred to as the CGMS baseline, would be an essential building block of the architecture.

Satellite instrument calibration and inter-calibration (GSICS)

4.2.60 The Commission emphasized the importance of satellite instrument calibration and inter-calibration to ensure interoperability of space-based measurements throughout the space-based component of WIGOS. In this regard, it welcomed the progress made within the Global Space-based Inter-calibration System GSICS (http://gsics.wmo.int) in establishing globally agreed best practices and procedures for improved on-orbit calibration, and making calibration corrections routinely available through the online GSICS product portal. It invited GSICS members to bring these products to an operational stage and to incorporate GSICS calibration information into their near-real time Level 1 data dissemination streams.

Direct readout frequencies

4.2.61 The Commission noted that several satellite operators are now considering to use the X-Band (specifically the 7750–7900 MHz frequency range) for direct readout from future generations of polar-orbiting systems, rather than the L-Band (specifically the 1675–1710 MHz frequency range) because future high-resolution instruments will generate high data rates that cannot be accommodated in lower frequency transmissions. Furthermore, progress in radio-communication techniques renders X-Band receiving equipment more affordable than it used to be. The Commission acknowledged that for users the consequence of direct readout services being available in X–Band, in comparison to the L-Band, can be summarized as follows:

(a) Access to higher data rate services (order of magnitude 100 Mb/s instead of 10 Mb/s), which is necessary for full data access at full resolution;

(b) Need to use a higher-class antenna and receiving chain;

(c) Higher sensitivity to rain, requiring appropriate margins in the link budget, especially for inter-tropical latitudes;

(d) Higher risk of interfering sources: the X-Band is shared with fixed terrestrial communication services, and the possibility of interference has to be evaluated on a case by case basis for each site. It is essential to register the receiving site and frequency with the national radio frequency regulator for the intended operation, in order to claim a protection area.

4.2.62 The Commission recalled the current WMO requirement for maintaining two parallel direct broadcast services: a high data rate stream, containing full resolution data, and a low data rate stream, containing a subset of data (e.g. selected channels, lossy compressed data). In this regard, while the high data rate stream is likely to be in X-Band in the future, the low data rate stream is expected to be in L-Band. The Commission was informed on the outcome of the survey sent to all Members in July 2012 (http://www.surveymonkey.com/s/wmolbandxbandsurvey2012) with a view to re-assess this requirement, upon request from the Coordination Group for Meteorological Satellites (CGMS).

4.2.63 The Commission recommended to WMO Members to plan for receiving high data rate Direct Readout services from future polar-orbiting satellites in X-Band. It stressed the need to register receiving stations with their national authorities. It also recommended to satellite operators to implement Direct Readout in both X-Band and L-Band, since L-Band should provide weather resilient back-up and enable an affordable access to low data rate streams. It further recommended that satellite operators supplement the Direct Readout with near-real time retransmission of key datasets on regional broadcast services (such as EUMETCast or CMACast), where appropriate.

Geostationary coverage

4.2.64 The Commission expressed its appreciation to the satellite operators for maintaining the constellation of meteorological satellites and underscored the role of EUMETSAT providing geostationary coverage over the Indian Ocean since the late 1990's. Noting that Indian Ocean coverage was currently planned by EUMETSAT until the end of 2013 only, it requested EUMETSAT to consider a further extension of this mission.

Space Weather

4.2.65 The Commission appreciated the achievements of the Inter-Programme Coordination Team on Space Weather (ICTSW) regarding space weather observation requirements, observing capabilities and operational product portal, and welcomed the ongoing collaboration with the ICAO International Airways Volcano Watch Operations Group (IAVWOPSG). The Commission encouraged the ICTSW to continue to work with the IAVWOPSG on the definition of space weather requirements for international air navigation, the contents of space weather information to be delivered, and the recommended organization to produce and deliver such information on an operational basis, with a view to providing the basis for an amendment to Annex 3 of the ICAO Convention for consideration by a planned conjoint ICAO Meteorology (MET) Divisional Meeting and CAeM-15 in July 2014. It requested the ICTSW co-chairs to keep the President of CBS and of CAeM informed of the progress made on this matter.

4.3 Decisions for the Open Programme Area Group on Information Systems and Services, including the WMO Information System (agenda item 4.3)

Amendments to the *Manual on the WMO Information System* (WMO-No. 1060)

4.3.1 The Commission thanked the Chair of OPAG-ISS, Mr H. Ichijo (Japan) for his report, and the experts who contributed to the activities of OPAG-ISS. The Commission noted with satisfaction that the new functionality of WIS became operational from the end of January 2012 supported by GISCs Beijing, Offenbach and Tokyo. It noted that GISCs Exeter and Toulouse went operational in mid-June 2012 and that GISCs Melbourne and Seoul had been successfully audited prior to EC-64. The commission noted that GISC Moscow would be ready for audit before the end of 2012. It expressed its appreciation to all centres and expert teams that had contributed to the

successful launch of an operational WIS. The Commission noted that the Manual on the WIS as approved by Resolution 4 (Cg-XVI) was published in January 2012 and recognized that the Manual would benefit from the updates and clarifications based on experience of making WIS operational as proposed by OPAG-ISS.

4.3.2 The Commission noted that Resolution 51 (Cg-XVI) designated the initial GISCs and DCPCs in WIS as reflected in Appendices B1 and B2 of the Manual on WIS and that Appendix B3, listing designated National Centres (NCs) in WIS remained empty. It noted that the authorization of National Centres lies with the Permanent Representatives of Members and thanked OPAG-ISS for working with Members and regional associations to identify the initial list of NCs for consideration by EC-65 for inclusion in the Manual on WIS Appendix B3. It noted that some Regions were still addressing WIS centre and GISC associations. In particular, it noted the request from Congress to RA II that "each National Centre should be linked to a principal GISC and to a secondary GISC, taking into account the efficiency of options, the cost effectiveness for both NCs and GISCs, data distribution capacity of the GISCs, and the current structure of the GTS". As RA II is not scheduled to meet until late in 2012, the Commission noted that decisions from RA II on WIS centre/GISC associations need to be incorporated into the Manual on WIS before it is presented to EC-65.

4.3.3 The Commission reviewed the information provided by OPAG-ISS and adopted Recommendation 8 (CBS-15) – Amendments to the *Manual on the WMO Information System* (WMO-No. 1060).

4.3.4 The Commission noted Resolution 12 (EC-64) – Designation of Centres of the WMO Information System had extended the timeline for designated centres to demonstrate their WIS compliance until EC-65. It expressed its appreciation to the Expert Team on GISC and DCPC Demonstration Process (ET-GDDP) for their efforts in supporting Members that had designated WIS Centres under Resolution 51 (Cg-XVI) in demonstrating their WIS compliance to CBS. It encouraged Centres that had yet to implement and demonstrate their WIS functionality to do so as soon as possible. The Commission emphasized that as more WIS centres are designated and become operational, it is necessary to perform periodical assessment of the performance of those centres, especially the GISCs, to ensure the level of service provided by a WIS Centre. It requested OPAG-ISS to develop proposals for performance indicators and procedures to implement the periodical assessment. It requested the OPAG-ISS to take into consideration the new requirements of WIGOS, GFCS and other WMO initiatives on WIS when further developing the capability of WIS.

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

4.3.5 The Commission recalled the need stated by Cg-XVI for additional components of the Guide to WIS including a "best practices for metadata management" and appropriate training material. The Commission also noted the recommendation of OPAG-ISS to publish the guide and that the components still under development relating to the management of metadata, be made available in draft form on the WMO Web. In this way, WIS centres will have earlier access to available guidance, while providing feedback on the guidance material for eventual publication in the Guide to WIS. It recalled the request from Congress that the Guide to WIS should also be made available in all official WMO languages. The Commission adopted Resolution 1 (CBS-15) – *Guide to the WMO Information System* (WMO-No. 1061).

Amendments to Manual on the GTS annexed Guides

Guides on Information and Communication Technologies Security

4.3.6 The Commission noted the repeated emphasis from the Executive Council and Congress on ensuring WMO information systems, especially with the use of the Internet, are secure. It expressed its appreciation to the OPAG-ISS for monitoring security issues and practices related to Information and Communication Technologies and endorsed the recommended changes proposed by OPAG-ISS on IT Security and the use of Virtual Private Networking. The Commission adopted Resolution 2 (CBS-15) – Amendments to the *Guide on Information Technology Security*

and adopted Resolution 3 (CBS-15) – Amendments to the *Guide for Virtual Private Networks (VPN) via the Internet between GTS centres*. It further highlighted the need for identifying annexes to the Manual on the GTS as official WMO publications and emphasized that such annexes should be provided with a formal WMO publication number.

4.3.7 The Commission noted that the migration of the GTS to IP is now effectively complete and that guidance material related to the use of IPv4 and associated addresses are now fully incorporated into the Manual on the GTS Attachment II-15. It agreed that maintaining separate guides on use of IP in the GTS and on provisional arrangements are no longer necessary. The Commission adopted Resolution 4 (CBS-15) – Removal of the guides to *The Use of TCP/IP on the GTS* and *Provisional Arrangement for the Use of IP Addresses over the GTS*.

4.3.8 The Commission further highlighted that many Members are now being required to prepare for implementation of IPv6 and noting that OPAG-ISS has already committed to providing guidance for the use of IPv6 in the WIS, it encouraged Members with experience in implementing IPv6 to support the OPAG-ISS in this activity.

Review of the Manual on the GTS Volume II

4.3.9 The Commission noted the progress of reviews of the Manual on the GTS Volume II in RA I and RA II. It agreed that it was inappropriate to maintain the Manual on the GTS Volume II in its present form and requested the OPAG-ISS to monitor the reviews by RA I and RA II of the Manual on the GTS Volume II, and to make recommendations to the CBS Management Group on how to proceed for all Regions. It also requested the OPAG-ISS to investigate ways of monitoring and displaying the status of WIS circuits including those registered as GTS circuits in a timely and authoritative manner.

WIS Information Management

Management of Table Driven Code Forms (TDCF)

4.3.10 The Commission noted that amendments to the *Manual on Codes* (WMO-No. 306) were implemented five times during the intersessional period of the CBS (December 2010–August 2012) using the new procedures; the new fast-track procedure (three times) and the procedure for adoption between CBS sessions (twice). It encouraged this approach to be used for non-controversial decisions in other areas of the business of the Commission.

4.3.11 The Commission recognized that the successful procedures for managing to the Table Driven Code Forms could be further improved, and so agreed to adopt Recommendation 9 (CBS-15) – Amendments to the *Manual on Codes* (WMO-No. 306), Introduction chapter of Volumes I.1 and I.2.

4.3.12 The Commission reviewed the decision by the CBS-XIII to withdraw BUFR edition 3 and CREX edition 1 on the first Tuesday of November 2012. It agreed that BUFR 3 and CREX 1 should be removed from the *Manual on Codes* (WMO-No. 306), and requested that the Secretary-General ensure that the definitions were retained on the WMO Website so that archived data could still be referenced.

4.3.13 The Commission noted that the exchange of information in BUFR Edition 3 (for specific purposes such as aviation) and CREX Edition 1 would continue beyond November 2012, but also encouraged Members to convert to software that can handle the later Editions. To clarify which centre originates data in bulletins that are converted to Table Driven Code Forms by another centre, the Commission adopted Recommendation 10 (CBS-15) – Amendments to the *Manual on the Global Telecommunication System* (WMO-No. 386), Volume I, Part II.

4.3.14 The Commission reminded Members that they should use the latest versions of tables; these are available through links provided on the 2011 CD-ROM and from the WMO Website.

Role of Focal Points for codes and data representation matters

4.3.15 The Commission noted that the fast track procedure for changes to the TDCF has placed greater responsibility on the national focal points for codes and data representation matters. It agreed on the terms of reference for these focal points given in Annex IV to the present report, and authorized the CBS Management Group to maintain these and to produce formal Terms of Reference for other national focal points to clarify their roles. The Commission requested Members to draw the attention of their focal points to these terms of reference.

Changes to OPMET Traditional Alphanumeric Code Forms

4.3.16 The Commission noted amendments to the aeronautical codes (METAR, SPECI and TAF) in the *Manual on Codes* consequential to the Amendment 76 to ICAO Annex 3 and the Amendment 37 to Annex 15. The Amendments to ICAO Annexes 3 and 15 will be reviewed by ICAO Air Navigation Commission (ANC) in November 2012 and finally approved by ICAO Council in February or March 2013. ICAO's timetable for implementation on 14 November 2013 could not be met if CBS were to wait for the ICAO Council decision before consulting Members. The Commission agreed to the principle that Members could be consulted once the changes had been recommended by the ICAO Air Navigation Commission (ANC); this would allow time for the procedure for adoption between sessions to be completed.

Station Identifiers

4.3.17 The Commission noted that many Members and WMO Programmes were experiencing difficulties in obtaining station identifiers and that this was leading to observations not being exchanged. It recognized that this was the consequence of limitations of the Traditional Alphanumeric Codes (TAC), and recalled that a reason for implementing the TDCF was the cost and risk of making changes to the TAC. It agreed that it was not possible to solve the problem using the TAC. The Commission also noted that IPET-DRC had proposed a "universal station identifier" within the TDCF. It requested the CBS Management Group to prepare a procedure for assigning "universal station identifiers" and to make a recommendation to EC between sessions using the consultation method for changes to codes between sessions.

Migration to Table Driven Code Forms

4.3.18 Noting the intention to exchange all information in TDCF (other than OPMET) from November 2012 (CBS-Ext.(10), paragraph 4.3.14), and to cease parallel exchange in both TDCF and TAC formats by November 2014, the Commission thanked those Members that were assisting other Members in the migration, and reminded Members of the WMO Software Registry that contains software than can help with migration. It emphasized that Members need to consider their observing and forecasting procedures when planning for migration.

4.3.19 The Commission strongly encouraged all Members to complete migration. There are many demands for exchanging information that cannot be met by the TAC. Members unable to handle TDCF would not have access to these additional sources of information.

WMO Core Metadata Profile

4.3.20 The Commission noted that EC-64 had approved version 1.2 of the WMO Core Metadata Profile, but that further changes were required so that the WIS Discovery Metadata could meet the operational requirements from WIS. It adopted Recommendation 8 (CBS-15) – Amendments to the *Manual on the WMO Information System* (WMO-No. 1060).

4.3.21 The Commission asked Members operating GISCs to note the expected timetable for major changes to the WMO Core Profile. Versions that would need software changes were anticipated in 2014 and 2020, but the actual timing will depend on when the base ISO 19115 standard is updated.

Future data representation methods, including aviation XML

4.3.22 The Commission noted the initial development of an initial WMO Logical Data Model to support creation of an XML standard that ICAO will be able to use for exchanging meteorological information. It agreed that the "namespace" used to describe the components of the WMO Logical Data Model should be "*metce*" (Modéle pour l'Échange des informations sue le Temps, le Climate et l'Eau). It also noted Resolution 13 (EC-64) that defined how responsibilities for defining components of XML would be shared between WMO and organizations with which it cooperates. The Commission requested the OPAG-ISS to work with ICAO to complete the initial version of the WMO Logical Data Model and the XML representation of meteorological information with the ICAO community, and to participate in ICAO's trial use of XML. The Commission also requested that the OPAG-ISS further develop the WMO Logical Data Model to support emerging requirements for data exchange such as WIGOS and GFCS. The Commission emphasized the importance of consistency between the TDCF and the WMO Logical Data Model, and requested the OPAG-ISS to investigate automating the derivation of TDCF Templates from the WMO Logical Data Model reflecting the existing practice whereby XML Schema are derived from a Logical Data Model.

4.3.23 The Commission noted the requirement to publish terminology and definitions developed for TDCF as web-accessible resources in order to provide keyword thesauri for WIS DAR Metadata records and to support ICAO's trial use of XML for exchanging meteorological information. The Commission requested that OPAG-ISS proceed with implementation of a response to this requirement on a timescale commensurate with ICAO's needs.

Quantitative Monitoring of the WWW

4.3.24 The Commission thanked the eleven RTHs on the MTN that had participated in the Integrated WWW Monitoring in 2011, and the centres that had provided additional information as part of the Special MTN Monitoring. It encouraged all Members consider the analyses of the monitoring information that is produced by the RTHs and the Secretariat.

4.3.25 Noting that exchange of information in TAC is scheduled to finish in November 2014, the Commission noted that the monitoring showed that the volume of data available in TDCF is increasing, but it was also concerned at the slow progress in some areas. It stressed the importance of up to date and representative monitoring statistics to the success of migration. It was also concerned about the low availability of observations in some areas, even in Traditional Alphanumeric Codes, particularly within Region I.

4.3.26 With a greater variety of data being exchanged through the WIS, the Commission agreed that the current WWW monitoring has to evolve. The Commission agreed Recommendation 11 (CBS-15) – Quantitative monitoring of the WMO Information System that updates the Manual on WIS (WMO-No. 1060) to clarify the requirements for monitoring.

4.3.27 To support these changes to the Manual on WIS, the Commission requested OPAG-ISS to prepare an effective plan for monitoring the WIS by October 2013, and to invite designated GISCs and DCPCs to participate in pre-operational implementation to test its effectiveness, and to report progress to CBS-Ext.(14).

Data Management Applications in support of the GFCS

Collection and dissemination of the World Weather Records/role of CBS Lead Centres for GCOS

4.3.28 The Commission was informed about the EC-64 decision relevant to the dissemination of the World Weather Records as requested by CCl for improving the collection and the submission of WWRs on an annual basis starting from the records pertaining to 2011.

4.3.29 The Commission recognized the critical role of CBS lead centres for GCOS in providing their support for the collection and dissemination of climate data and products. It invited these

centres to actively participate in the collection, compilation and the dissemination of these records as described in Resolution14 (EC-64). The WMO Guidelines, WCDMP No. 77, provides the technical guidance on the content, format, and the dissemination mechanism including the area of responsibility for CBS lead centres for GCOS in collecting the WWRs.

New National Climate Monitoring Products

4.3.30 The Commission was informed on the steps being taken by CCl to define six (6) new National Climate Monitoring Products (NCMPs) aimed at improving WMO Climate System Monitoring (CSM). It noted the emerging potential need for disseminating these products on a regular basis with the required format, representation and coding.

4.3.31 The Commission recognized its growing role in furthering its assistance to the World Climate Programme in using WMO standards and infrastructure for achieving optimal, cost effective and timely dissemination of climate data and products in support of the GFCS.

4.3.32 It invited CCl to define the specific requirements for data representation, coding and metadata that would be used for the dissemination and exchange of the new NCMPs and make proposal to the OPAG-ISS.

4.4 Decisions for the Open Programme Area Group on Data-Processing and Forecasting System (agenda item 4.4)

4.4.1 The Commission thanked the active participation of many experts which resulted in considerable progress achieved by the OPAG on DPFS. The Commission thanked Mr Bernard Strauss (France) for his long and dedicated service, and leadership and guidance as both chairman of the OPAG on DPFS and chairman of the Steering Group of the SWFDP, leading to the development of a new vision for the GDPFS.

4.4.2 The Commission agreed that the GDPFS, including ERA, is a critical component of the end-to-end Basic Systems (from observation to service delivery) across multi-scale (space and time), which consists of a global forecasting operational infrastructure operated by Members that greatly contributes to their national warning programmes. In this context, the Commission affirmed that the GDPFS contributes to many of the WMO's high priorities: (i) through the Severe Weather Forecasting Demonstration Project (SWFDP) and the use of Ensemble Prediction Systems (EPS) for predicting severe and high-impact weather that contribute to Disaster Risk Reduction and Capacity Development; (ii) through a network of centres that carry out global monthly and seasonal forecasts that are essential for the Climate Services Information System (CSIS) of the Global Framework for Climate Services (GFCS); (iii) through the use of applications of NWP/EPS such as atmospheric transport and dispersion modelling for environmental emergency response activities (ERA), thereby contributing to Disaster Risk Reduction; and (iv) through the provision of benefits to other socio-economic sectors, including aviation, agriculture, and marine safety.

Severe Weather Forecasting Demonstration Project (SWFDP)

4.4.3 While the scope of the GDPFS spans the production of day-to-day weather forecasts, the Commission recalled that Cg-XVI agreed that priority should be given to forecasting severe and high-impact weather and related-phenomena over a wide-range of forecast scales, including through the implementation of the Severe Weather Forecasting Demonstration Project (SWFDP) in all WMO Regions. Recognizing the great impact of this Project in assisting WMO Members to deliver effective warning services through improved forecasting capabilities, using the "Cascading Forecasting Process", the Commission reinforced its strong support to the SWFDP.

4.4.4 While significant benefits have already accrued from the SWFDP, either in implementation or in development in five regions (Southern Africa, South Pacific, Eastern Africa, Southeast Asia and Bay of Bengal – Regional Subproject Implementation Plans available on the WMO web site at http://www.wmo.int/pages/prog/www/CBS-Reports/DPFS-index.html), the Commission noted that some participating countries have experienced difficulties to effectively

participate in the SWFDP, and therefore recommended the development of country-specific implementation plans within the SWFDP, addressing their gaps and weaknesses, to facilitate the participation of least-capacity NMHSs, including those from least developed countries and small island developing States. These plans should include a review of current levels of services, training requirements and outputs, and stakeholders' engagement, with a view to ensuring on-going sustainability of projects.

4.4.5 While noting that the SWFDP is targeted to all WMO Regions, the Commission noted that RA III had not as yet engaged in the Project. The Commission noted that RA III had decided for the development of its severe weather warning system involving initially four countries (Brazil, Argentina, Uruguay and Paraguay), using its regional resources and tools. Noting that there were plans to expand this system to the remaining countries in RA III, the Commission stressed that the SWFDP could have an important role to play in that Region in complementing its regional efforts, and recommended that new opportunities for partnership be explored.

4.4.6 The Commission recalled that Cg-XVI approved a vision for the SWFDP as an end-to-end cross-programme collaborative activity led by the GDPFS. While recognizing that the SWFDP should engage all WMO Programmes that concern the real-time prediction of hydrometeorological hazards (from observations, to information exchange, to delivery of services, education and training, and to the transfer of relevant promising research outputs into operations), the Commission stressed the importance to move SWFDP forward with a phased approach; starting with manageable elements, first focusing on most important severe weather identified by the participating countries for protection of life and property, and expand the scope, including cross-programme activities (e.g. flood forecasting), in phases 3 and 4 of the project. However, recalling that EC-64 urged that as a part of SWFDP regional projects, consideration be given to collecting and conveying the requirements for the Basic Systems, including WIGOS and WIS, in the participating countries, the Commission agreed that these elements should be addressed together with aspects related to severe weather forecasting and warning services in the initial phases of the project.

4.4.7 The Commission acknowledged the importance of the continued project-critical support from advanced global centres that provided NWP and satellite-based products, and the equally project-critical roles played by the regional centres. The Commission recognized the substantial amount of human resources devoted to the project by the leading regional centres and acknowledged that resource constraints in regional centres must be taken into consideration when planning the project especially in latter phases, in order to ensure a transition to sustainable operations. The Commission commended all these centres for their enthusiastic participation in SWFDP regional projects thus far, and strongly encouraged them to continue these efforts. The Commission also encouraged the Steering Group of the SWFDP to assist the efficient conduct of training activities, e.g. by sharing training materials on the fundamental subjects, in order to make effective and maximum use of limited resources.

4.4.8 The Commission noted the inadequate resources available for supporting existing and setting up of new regional projects. Noting the main results of the study on resource requirements for ensuring effective implementation and long-term sustainability of the benefits gained with the SWFDP (see Annex V to the present report), which was carried out following the request by EC-64, the Commission recommended the establishment of a Severe Weather Forecasting Development Project (SWFDP) Office and of a Trust Fund for the SWFDP, and adopted Recommendation 12 (CBS-15) – Establishment of the Severe Weather Forecasting Development Project Office.

Operational Weather Forecasting Process and Support

Further Development and Evolution of the Global Data-processing and Forecasting System (GDPFS)

4.4.9 The Commission agreed that, similarly to the WIGOS and WIS, the Global Data-processing and Forecasting System (GDPFS) is an all-encompassing system focusing on the

improvement of all WMO data-processing and forecasting systems, including those coordinated by CBS, jointly with other technical commissions and/or WMO Programmes, as well as other international organizations. It further agreed that the GDPFS fosters the orderly evolution of the present WMO data-processing and forecasting systems into an integrated, comprehensive and coordinated system. The GDPFS is the basis for the operational provision of accurate, reliable and timely weather, climate, water and related environmental forecasts and products by all WMO operated meteorological centres, and would therefore satisfy, in a cost-effective and sustainable manner, the evolving data-processing and forecasting requirements of WMO Members.

4.4.10 The Commission encouraged centres running global models to consider providing boundary conditions to NMCs running Limited Area Models (LAMs). Recalling the request by Cg-XVI to the Secretary-General and CBS to develop a strategy to assist Members in the implementation of improved high-resolution regional NWP (including data assimilation and boundary condition aspects), and the subsequent recommendations by EC-64, the Commission requested the OPAG on DPFS to establish a task team for a limited time period to develop such a strategy for consideration by the next CBS session.

4.4.11 The Commission encouraged RSMCs and RCCs running models to ensure dissemination of the products to NMHSs of countries covered by their models' footprint.

4.4.12 Notwithstanding the great improvements in NWP, the Commission noted that there was still improvement needed in NWP accuracy and usefulness in the tropical areas, particularly in the handling of convection in the tropics. In this context, the Commission encouraged those Members running ocean reanalysis to consider making them available to NMCs running coupled atmosphere-ocean models.

***Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)**

4.4.13 The Commission was pleased to note the significant progress that has been made with the comprehensive revision of the Manual on the GDPFS (WMO-No. 485), following the adoption by Cg-XVI of the revised Manual's outline. It also noted with appreciation the active cooperation and enhanced coordination among the relevant technical commissions and partner organizations in incorporating aspects related to all WMO data-processing and forecasting systems in the revised Manual on the GDPFS. Noting that the SWFDP, the Global Framework for Climate Services (GFCS), and the Global Integrated Polar Prediction System (GIPPS) may have implications for the GDPFS by way of new requirements for products, the Commission recommended that the revised Manual continue to be organized in such a way that it should allow the future incorporation of, and accommodate, technical aspects that may arise from such new initiatives.

4.4.14 The Commission noted that the new Manual introduces a number of changes to the current procedures, and therefore acknowledged that some GDPFS centres may report temporary non-compliance with regard to some of the requirements, mainly because of resource constraints during system development or adaptation. In this context, and noting that the new Manual would most likely be in force by 2015, the Commission requested the Secretariat to clearly indicate the comprehensive summary of changes of functions and procedures well in advance to ensure the smooth transition, and also recommended that a transition plan for the implementation of the new Manual (which will replace the current version) be developed to manage the technical changes and the initial designation of the GDPFS centres as defined in the new Manual, including WMCs and RSMCs, for consideration by the next session of CBS.

4.4.15 The Commission noted that the new Manual was being developed in accordance to quality management principles and agreed that it would facilitate the review of compliance of GDPFS Centres against the designation criteria, which include, amongst others, forecast verification activities. Therefore, acknowledging that some Centres produce activity reports regularly, the Commission recommended that the review process should be established, taking into account such existing reports to avoid duplication. The Commission stressed this is critical to quality assurance and management of the outputs of the GDPFS, and therefore concluded that the

verification of numerical and other forecasts is an activity that supports continuous improvement of the forecasting and warning systems.

4.4.16 Noting the results of the work of the ad hoc joint CAS-CBS Task Team on Sand and Dust Storm Warning Assessment Systems (SDS-WAS), the Commission agreed that there is a need to incorporate the mandatory functions and criteria for the designation of RSMC with activity specialization in Atmospheric Sand and Dust storm Forecasts (RSMC-ASDF) in the current version of the Manual on the GDPFS, and therefore proposed an amendment to the Manual on the GDPFS, as found in Annex 1 to Recommendation 13 (CBS-15). The Commission was presented with the nomination of the centre in Barcelona (Spain) to act as an RSMC-ADSF for the Northern Africa (north of Equator), Middle East and Europe. Noting that this centre complies with the mandatory functions, the Commission recommended its formal designation, and therefore proposed an amendment to the Manual on the GDPFS, as found in Annex 1 to Recommendation 13 (CBS-15). The Commission adopted Recommendation 13 (CBS-15) – Amendments to the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485).

4.4.17 The Commission noted that atmospheric sand and dust storm forecasts are of particular importance as dust storms strongly affect socio-economic sectors, including maritime and air transportation. However, the Commission expressed its concern regarding the uncertainty of the sand and dust storm model outputs and the consistency between these products and the observations. It therefore requested the OPAG on DPFS to work with the CAS Steering Groups on SDS-WAS in the assessment of the reliability/maturity of such products for operational purposes, as well as in further developing and utilizing widespread dust forecasting models. Until these matters are resolved, the Commission decided to include a statement concerning their reliability with these products.

4.4.18 Many Members have informed of their capabilities to produce and delivery atmospheric sand and dust storm forecasts, and expressed interest in cooperating with the centre in Barcelona on these issues, including on verification.

Forecast Verification

4.4.19 The Commission expressed its appreciation to the ECMWF for the development and maintenance of the Lead Centre for Deterministic NWP Verification (LC-DNV) Website (http://apps.ecmwf.int/wmolcdnv/, username/password protected). The Commission recommended that access to the LC-DNV Website should be provided to all WMO Members through their WMO accounts, and urged them to visit it to access and make best use of results of verification of upper-air and surface fields for both operational forecasting and management purposes. The Commission urged those WMO Members that have not as yet requested to the ECMWF a WMO account, to do so following the procedures stated on the ECMWF Website at http://www.ecmwf.int/about/wmo_nmhs_access/index.html. In addition, the Commission requested that unrestricted access be given to the web pages including the basic verification plots. In addition, the Commission encouraged WMO Members to visit the Lead Centre for EPS Verification Website (http://epsv.kishou.go.jp/EPSv/), maintained by JMA (no longer password protected), which has recently added the new CRPS score as per the procedures stated in the Manual on the GDPFS.

4.4.20 Noting the results of the studies on the potential application of CBS standard verification procedures for Polar Regions, the Commission recommended the inclusion of two new geographical areas (polewards of 60º) in the CBS standard verification procedures, and therefore proposed an amendment to the Manual on the GDPFS, as found in Annex 2 to Recommendation 13 (CBS-15). The Commission noted that this is a contribution to the development of GIPPS.

4.4.21 While recognizing that more preparatory studies are required, the Commission stressed the importance of, and the need for developing, standard procedures for surface weather verification. It noted that the LC-DNV Website includes a selection of plots of the scores computed for precipitation (SEEPS and a few others for comparison) and requested that this be expanded to include plots of the scores computed for other surface fields. While global NWP centres generally

compute CBS scores globally and provide the results in a graphical format, the Commission encouraged WMO Members to use global NWP products to perform verification of fields from global models at a regional level and/or for specific locations. It further encouraged WMO Members to perform qualitative evaluation by forecasters from a synoptic point of view (chart verification) and provide their feedback to global NWP centres. In this context, and within the framework of the SWFDP, the Commission urged global NWP centres, RSMCs, and individual NMHSs to work together in order to benefit from the use of additional observational data which are not routinely available on the WIS/GTS, as well as to benefit from knowledge of regional weather.

Integration of EPS into Core Operational Forecasting

4.4.22 The Commission noted that most NMHSs' operational forecast production on all timescales continues to be predominantly based on deterministic model outputs, with the ensembles being used to provide peripheral and supplementary information. However, it noted that at a number of GDPFS centres significant progress has been made in integrating EPS into core operational forecasting for guiding in all timescales, including short- and very short-range forecasting. The Commission stressed that EPS products, used in conjunction with high-resolution deterministic NWP outputs, represent an enhanced forecasting strategy for predicting severe weather events, especially with longer forecast lead-times. In this context, the Commission was pleased to note that the OPAG on DPFS has completed a set of Guidelines on EPS and Forecasting to aid forecasters in effective application of EPS. The Commission requested the OPAG on DPFS to continue to provide guidance on the use of the best combination of both EPS and deterministic NWP, especially for severe weather forecasting.

4.4.23 The Commission noted that a number of NMHSs are now issuing risk-based severe weather warnings, where risk may be defined using a combination of probability (estimated from EPS) and impact. While noting that assessment of impact is still largely subjective, based on weather thresholds (which may vary according to local climatology and societal vulnerability), the Commission agreed that there is a growing amount of research on how to quantify the impact. In this context, the Commission recommended that suitable training be provided to trigger a fundamental change in thinking by both weather forecasters and users (e.g. disaster management organizations) whereby alerts and warnings of severe weather would become more probabilistic in nature to represent the risks associated with severe and high-impact weather. In addition, effective communication of uncertainty and/or probabilistic information to the public and other users is essential to ensure valuable use in the decision-making processes. In this context, the Commission requested the OPAG on DPFS, in collaboration with the OPAG on PWS, to collaboratively address these issues, including within the SWFDP framework (see 4.5.13).

Integration of Satellite-based Products, high-resolution LAM and Post-processing Systems into Very Short- to Short-range Forecasting

4.4.24 While noting that many NMHSs in developing countries do not have operating weather radars and/or national-wide radar coverage to support timely and accurately forecasts and warnings of severe convective in the very short-range forecasting period, the Commission agreed that satellite data processing systems and products represent powerful tools for very short- to short-range forecasting. In addition, recognizing that there are difficulties in the uptake of these products into weather forecasting daily routines of the forecasters, the Commission requested the OPAG on DPFS, in collaboration with the WMO Space Programme and the WWRP/CAS Working Group on Nowcasting Research (WGNR), to develop guidelines on how to use and interpret these products at the regional level, taking into account regional and national requirements, using the SWFDP–Eastern Africa as a pilot. In the same context, the Commission was informed that EUMETSAT plans to make a number of products (e.g. precipitation, soil moisture, cloud, etc.) from the Satellite Application Facility (SAF) on Support to Operational Hydrology and Water Management (H-SAF) and SAF Nowcasting and Very Sort-range Forecasting available via EUMETCast, which could be of relevance to NMHSs in developing countries in RA I.

4.4.25 The Commission noted that there is a diversity of high-resolution LAM and post-processing systems developed and implemented by WMO Members, and agreed that there is a

need to exchange such systems and share knowledge. In this context, the Commission requested the Secretary-General to work with those WMO Members that have developed and implemented such systems to facilitate the transfer of technology and knowledge among NMHSs.

Operational Predictions from Sub-seasonal to Longer-time scales, including Contributions to the GFCS/CSIS

4.4.26 Noting the operational nature of the Global Producing Centres (GPCs) for Long-Range Forecasts and recalling that Cg-XVI envisioned that some GPCs could play an important role in providing global climate predictions from sub-seasonal to longer-time scales, within the context of the Global Framework for Climate Services (GFCS), the Commission endorsed the continued close collaboration between CBS and CCl, and recommended a joint CBS/CCl workshop between GPCs/LCs and RCCs to facilitate consolidation and prioritization of requirements.

4.4.27 The Commission noted the completion of demonstration phases of the RA VI RCC-Network and the RA II North Eurasian Climate Centre (NEACC) operations, which have provided evidence that both have complied with all the mandatory functions, as described in the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485). In this context, the Commission recommended their formal designation, and therefore proposed an amendment to the Manual on the GDPFS, as found in Annex 3 to Recommendation 13 (CBS-15).

4.4.28 Noting the increased demands on GPCs and LCs coming from their envisaged roles in the Climate Services Information System (CSIS) component of the GFCS, the Commission recognized that further development of the seasonal-range exchange and verification is needed. In this context, the Commission requested the OPAG on DPFS to further address: (a) the hindcast exchange; (b) the exchange of forecasts with longer lead-time than 1 month; (c) the provision of forecasts for higher order categories (e.g. outer quintiles), and exchange of additional variables in indices; and (d) the verification of the LC-LRFMME multi-model products, GPC compliance with verification requirements of the SVSLRF, and real-time verification of LRF.

4.4.29 Recalling the request by Cg-XVI to the LC-LRFMME to extend its role to include the exchange of extended-range predictions and inviting GPCs to provide data from their monthly forecast systems for display and generation of multi-model extended range products along the same lines as for seasonal range products, the Commission recommended a phased approach, starting by a pilot exchange with GPCs supplying forecasts on a voluntary basis and the LC-LRFMME generating and displaying a range of products. While this pilot exchange is developing, and to accelerate the availability of extended-range products to WMO Members, GPCs running extended-range forecasts are encouraged to display their products on their individual websites. Noting that standard procedures for verification of extended-range forecasts would be required to support the exchange of forecasts, the Commission recommended that this pilot exchange be made in coordination with the WWRP/THORPEX/WCRP research activities on sub-seasonal to seasonal prediction.

4.4.30 The Commission recalled the request by EC-LXI to CBS in collaboration with CCl to consider how multi-annual to decadal prediction systems being developed by some GPCs might be brought into the CSIS of the GFCS, and the agreement by GPC Exeter (United Kingdom) to coordinate an informal exchange of real-time decadal predictions. Noting that first results of this exchange are promising, the Commission encouraged GPC Exeter (United Kingdom) to continue with the informal exchange and to prepare a written submission to CBS and CCl on results and recommendations on how such multi-annual/decadal predictions might be incorporated into the CSIS of GFCS.

Emergency Response Activities (ERA)

4.4.31 The Commission recalled that a number of major ERA events with significant impacts have occurred since CBS-Ext.(10), including volcanic eruptions in Iceland, Chile and Indonesia, and the Fukushima Daiichi Nuclear Power Plan (NPP) accident in Japan. The Commission noted the significant operational impact of these events to the RSMCs with activity specialization for the

provision of atmospheric transport modelling for environmental emergency response (EER) and/or backtracking, and therefore expressed its sincere thanks to all for the excellent work and response provided throughout these events. A special note of appreciation was expressed to the staff at the Japan Meteorological Agency (JMA) and RSMC Tokyo, who in the face of tragedy and adversity arisen from the Fukushima Daiichi NPP accident, continued to respond with diligence throughout the event.

4.4.32 The Commission noted that according to the request by Cg-XVI, the Coordination Group for the nuclear ERA (CG-NERA) met in Vienna, Austria (October–November 2011) to review lessons learned from the Fukushima Daiichi NPP accident and to devise necessary actions. A number of important lessons were reported not only by RSMCs, RTH, and related international organizations but also by NMHSs in the influenced region. The Commission noted that participants of the meeting agreed to keep the reference material (WMO-No. 485 and WMO-TD 778) consistent to ensure the secure provision of this important information service.

4.4.33 The Commission noted the increasing need to provide meteorological information for general public interest as well as special user applications. The Commission may need to strengthen activities to address the issue of dissemination of ERA-related information to the public, including the representation of the output from the dispersion models. It therefore requested the OPAG on DPFS to further address these aspects in WMO-TD 778, as appropriate, in order to assist users in the interpretation and application of ERA-related products for their own purposes.

4.4.34 In addition, the Commission thanked ZAMG (Austria) and MeteoSwiss (Switzerland) for having provided expert assistance to IAEA/IEC and WHO/emergency centre, respectively, in their response functions to the Fukushima Daiichi NPP accident. In addition, the Commission noted the active participation of WMO within the United Nations system to review and assess the emergency preparedness and response system. It therefore recommended further discussions between WMO and other international organizations on identifying the nature and the scope of the cooperation between the two agencies in the event of an emergency, in order to develop or update joint bilateral Concept-of-Operations or Memorandum of Understanding.

4.4.35 In the context of nuclear accidents, in following up to the Fukushima Daiichi NPP accident of 2011, the Commission encouraged the continued close collaboration with the International Atomic Energy Agency (IAEA) to examine the lessons learned for enhancing meteorological support to emergency response, and supported the early initiative of WMO to organize a technical team to develop meteorological analyses suitable for atmospheric transport, dispersion, and deposition modelling, to contribute to the post-accident study undertaken by the United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR) on the levels and effects of radiation released from the accident.

4.4.36 The Commission noted that RSMCs continue to experiment with different parameters and formats for charts, including for the forecast time-range of the standard products, and for longer time ranges up to 10 days as well as geo-referenced information. Some RSMCs provide such products to the IAEA on an experimental, non-official basis during the Fukushima event. Uncertainty in dispersion calculations and inclusion of precipitation data in deposition calculations continue to be of interest. The Commission requested the OPAG on DPFS to continue the experiment and develop procedures in the EER arrangements regarding the ‘‘Plume Time of Arrival’’ products.

4.4.37 Recognizing the increasing sophistication of the atmospheric transport models used in the RSMCs, and the importance of full and correct interpretation of this information by forecasters in NMHSs, the Commission requested Members who host RSMCs to consider the provision of appropriate training courses in the use and interpretation of their guidance and products.

4.4.38 The Commission noted that following the request by Cg-XV with regards to the outdated WMO Technical Note 170, entitled: “Meteorological and Hydrological Aspects of Siting and Operations of Nuclear Power Plants”, the OPAG on DPFS reviewed this publication and noted that only a few sections concern CBS, and several WMO Programmes and Technical

Commissions should be involved in updating the Technical Note. Following a throughout review of the CBS-relevant sections, a proposed expanded outline for updating these sections was developed. The Commission urged the OPAG on DPFS, in collaboration with the relevant WMO Programmes and Technical Commissions to complete the revision of this publication as required.

4.4.39 The Commission stressed the need for the development of operational procedures for significant non-nuclear incidents, where a NMHS could request and receive ATM support from an RSMC, and therefore tasked the OPAG on DPFS to prepare such operational procedures for consideration by the next session of CBS.

4.4.40 The Commission stressed the need for designation criteria and functions for Centres that could specialize in the development and provision of products and services to assist humanitarian agencies in mitigating the impacts of meteorological-related hazards, which could be based on the lessons learnt from the ERA. It therefore requested the OPAG on DPFS to include these aspects in its work programme (see 4.5.15).

4.5 Decisions for the Open Programme Area Group on Public Weather Services (agenda item 4.5)

The WMO Strategy for Service Delivery

4.5.1 The Commission recalled that the sixteenth session of the World Meteorological Congress (Cg-XVI, Geneva, May 2011), had adopted “The WMO Strategy for Service Delivery” http://www.wmo.int/pages/prog/amp/pwsp/documents/WMO_Strategy_for_Service_Delivery.pdf as a WMO-wide Strategy, applicable to all activities and programmes having a role in service delivery. The Public Weather Services (PWS) Programme had been tasked by the Executive Council Working Group on Service Delivery (ECWG-SD) to lead the coordination of the development of the Strategy. It noted that Congress had requested the Secretary-General to have an Implementation Plan for the Strategy developed.

4.5.2 The Commission noted with great appreciation the development of the Implementation Plan (see Part II of the abridged final report of the fifteenth session of the Commission), which involved consultations with presidents of regional associations, technical commissions, WMO Programmes and experts from NMHSs, prior to submission to EC-65 for approval. The Implementation Plan clearly reflects the fundamental role of Service Delivery in all WMO Programmes and important initiatives, in particular the Global Framework for Climate Services (GFCS), Quality Management System (QMS), disaster risk reduction, and capacity development. The Commission, while recognizing that the draft may be further modified as a result of inputs from other WMO bodies and programmes prior to its consideration and approval by EC-65, endorsed the draft Implementation Plan. The Commission requested its president to ensure the inclusion of comments by CBS members in the draft Implementation Plan and to take the necessary measures for mainstreaming "The WMO Strategy for Services Delivery" and it’s IP into the work of the Commission.

Decisions of the Commission with respect to the OPAG/PWS

4.5.3 The Commission considered the major issues which had emerged from the work of the OPAG/PWS, and decided as follows:

(a) That while the work of the OPAG would be guided by the WMO Strategy for Service Delivery and its implementation plan, the name of the OPAG should continue as the OPAG on PWS;

(b) To endorse the new Terms of Reference (ToRs) (see Annex VII to the present report) and Deliverables for the ICT as proposed by the Chair of the OPAG;

(c) To endorse the restructuring and re-naming of the PWS ETs, and their ToRs (see Annex VII to the present report) as follows:

(i) The "Expert Team on PWS in Support of Disaster Prevention and Mitigation (ET/DPM)" was re-named as the "PWS Expert Team on Meeting User Needs in Reducing the Impacts of Hydrometeorological Hazards";

(ii) The "Expert Team on Communication, Outreach and Public Education Aspects of PWS (ET/COPE)" was re-named as the "Expert Team on Communication, Outreach and Public Education Aspects of Public Weather Services Delivery";

(iii) The "Expert Team on Services and Products Improvement (ET/SPI)" was re-named as the "Expert Team on Services and Products Innovation and Improvement";

(d) That the Expert Teams will focus on addressing a number of specific issues related to their ToRs for a fixed duration of time and the Chair of each Team will determine, in consultation with the Secretariat the participation of the experts relevant to those issues accordingly;

(e) To emphasize that multi-hazard, multi-scale early warning systems need to be embedded within an operational end-to-end service delivery framework, to be applied for preparing and delivering warnings through PWS programmes and channels of NMHSs. The Commission recognized that many Members were already pursuing a multi-hazard approach, and encouraged Members to consider such an integrated approach in the future. In this context, the Commission requested WMO to consider assisting NMHSs to build their capacity on preparing and delivering multi-hazard warnings;

(f) To establish a "Competency Framework for Public Weather Services (PWS)/Weather Forecasters and Advisors" and approve Resolution 5 (CBS-15) – Competency Framework for Public Weather Services Forecasters and Advisors, that contributes to the high priority area of capacity development;

(g) To review the guidance material for NMHSs on developing multi-hazard impact-based information and warning services (see Annex VI to the present report), contributing to disaster reduction and mitigation. The Commission further decided, in collaboration with relevant CBS OPAGs, to elaborate this material, recognizing the challenges of impact-based forecast services as well as national circumstances as regards the responsibilities of NMHSs and existing task sharing in national risk management, and enrich it with examples and best practices of impact-based forecast and warning services, before it would be widely available to all NMHSs;

(h) To strongly encourage the engagement of Members in: (i) the "WMO Register of Alerting Authorities" initiative, using the PWS guide "Administrative Procedure for Registering WMO Alerting Identifiers (PWS-20, WMO/TD-No. 1556)"; and (ii) adopting the Common Alerting Protocol (CAP) technology for communicating alerts. The Register is an important tool towards achieving a "single official voice" status for NMHSs in issuing weather warnings;

(i) To strengthen the involvement of NMHSs' PWS National Focal Points with the work of the OPAG and of the PWS Programme;

(j) To further strengthen the PWS component of the SWFDP to enhance the delivery of high quality warning and forecast services to users and thus ensure the full realization of the benefits of all current and future SWFDP projects. The Commission also supported the application of CAP in the SWFDP to improve the delivery of warning services;

(k) That considering the increased population in disaster-prone areas, the link between NMHSs and media should be strengthened so that the warnings of hazardous phenomena could be disseminated to the general public;

(l) That considering the importance of proper understanding, and appropriate use, of meteorological and hydrological information and services, weather forecasts, and warnings by the public, attention should be given to popularising meteorology through outreach activities and societal education, using books, television and radio programmes, magazine articles, internet sites and other popular channels of communication, from school age upwards;

(m) That the OPAG/PWS contribute to the implementation of the follow up actions and application of the results of the World EXPO 2010 Nowcasting Services (WENS) Demonstration Project, whose objective had included the demonstration of enhanced Multi-Hazard Early Warning Systems (MHEWS) through nowcasting applications;

(n) That the OPAG/PWS closely collaborate with the OPAG on DPFS within the framework of the CBS Task Team on the Provision of Operational Meteorological Assistance to Humanitarian Agencies, incorporating the legacy of the Task Team on Meteorological Services for Improved Humanitarian Planning and Response, which had been established by CBS-XIV under the responsibility of the OPAG/PWS (see 4.5.16).

Overview of the OPAG/PWS activities

ET/SPI

4.5.4 The ET/SPI met in Bohemia, New York, United States, 13–17 August 2012. Two major deliverables of the Team since its last meeting in 2010 were the compilation of an inventory of training material for forecasters aimed at the delivery and communication of uncertainty and probabilistic weather products to the public and other users; and the preparation of guidance for NMHSs on developing user surveys accompanied by a collection of existing surveys. The ET/SPI established a new set of deliverables for the next two years.

ET/COPE

4.5.5 The ET/COPE held its intersessional meeting in Mombasa, Kenya, 5–9 December 2011. Two major deliverables of the Team since its last meeting in 2009 were the "Guidelines on Strategies for the Use of Social Media by National Meteorological and Hydrological Services" and five Summary Guides: (i) Communicating Forecast Uncertainty; (ii) Communication, Public Education and Outreach; (iii) Communicating with the Public; (iv) Using Surveys to Evaluate Services; and (v) Working with the Media. The ET/COPE had also drafted a set of competencies for the personnel of NMHSs involved in communication and media work. The ET/COPE established a new set of deliverables for the next two years.

ET/DPM

4.5.6 The ET/DPM met in Beijing, China, 17–21 October 2011. Among the finalized deliverables of the ET/DPM since its last meeting in 2009 were completion of work on the enhancement of the World Weather Information Service (WWIS); preparation of the Register of WMO Alerting Authorities; organization of a workshop on early warning systems in connection with the opening of Meteoworld Pavilion at the World Expo in Shanghai; publication of the "Guidelines on Early Warning Systems and Application of Nowcasting and Warning Operations" (PWS-21, WMO/TD-No. 1559); publication of the "Guidelines on International and Cross-border Collaboration in the Warning Process" (PWS-22, WMO/TD-No. 1560); and the drafting of a set of competencies for the PWS personnel working in the capacity of DPM advisors.

4.5.7 The ET/DPM established a new set of deliverables, including guidance material for NMHSs on developing impact-based information and warning services (see 4.5.3 (f)). It also

undertook to prepare, in collaboration with ET/COPE, a template for Memoranda of Understanding (MoUs) aimed at assisting NMHSs govern their relationships with other agencies such as those in the media and emergency management.

ICT/PWS

4.5.8 The ICT/PWS met in Montreal, Canada, 23–27 April 2012. It reviewed the work of the PWS ETs, prepared its new set of ToRs for submission to CBS, and set its deliverables accordingly. The ICT/PWS considered how it might best promote the concept of Service Delivery throughout WMO, and decided on a set of actions to advance this. The ICT agreed on drafting a "Competency Framework" relevant to PWS forecasters and advisors, with a view to presenting the draft for approval to CBS-15 (see 4.5.3 (e)).

WWIS and Severe Weather Information Service (SWIC)

4.5.9 The Commission noted that WWIS was now available in ten language versions as follows, with host Members in brackets: Arabic (Oman), Chinese (China), English (Hong Kong, China), French (France), German (Germany), Italian (Italy), Polish (Poland), Russian (Russian Federation), Portuguese (Portugal), and Spanish (Spain), and that the number of cities for which forecasts were provided had increased to 1,611. It recalled the decisions of the WMO Cg-XVI as regards the need to further enhance the quality and quantity of the information on this Website. The Commission therefore welcomed the outcomes of the "Third Meeting of the WWIS Hosts" (Offenbach, Germany, 18–20 October 2011), in which important decisions were reached to enhance the WWIS Website by increasing the participation of Members in terms of provision of more city forecasts, longer-term forecasts and more frequent updating of the forecasts, as well as preparation of a set of guidelines for NMHSs on how to improve their participation in WWIS. The Commission encouraged the organization of similar self-funded workshops every two years to ensure the further development of all language versions in a harmonized manner and to provide an opportunity to address new innovations in WWIS. It also welcomed the launching of the "MyWorldWeather" iPhone application (http://itunes.apple.com/hk/app/myworldweather/id453654229?mt=8), noting that the development of similar applications for other mobile platforms is underway. Regarding the SWIC, the Commission welcomed the addition of "observed fog" information that had been added, as a new feature, to the Website.

Social and Economic Applications of PWS

4.5.10 The Commission strongly supported the work of the OPAG and the PWS Programme in assisting Members with the assessment and demonstration of the socio-economic benefits of the services provided by NMHSs and re-iterated the urgent need for developing methodologies for this purpose. It supported the collaboration of WMO with the World Bank to compile and publish an authoritative joint WMO-World Bank document on methodologies for assessment of such socio-economic benefits. It noted that EC-64 (Geneva, 25 June–3 July 2012) had similarly requested the production of such a document and the implementation of pilot projects on socio-economic benefits of meteorological and hydrological services, as well as the collection and analysis of the outcomes and lessons learnt. On this basis, the Commission encouraged the development of an authoritative assessment report on meteorological service benefits, at an appropriate stage.

4.5.11 The Commission expressed satisfaction that the PWS Socio-economic Benefits Website (www.wmo.int/socioec), which had recently been revamped, continued to be a valuable resource for decision-support tools and case studies.

Capacity Development Activities and Technical Cooperation

4.5.12 The Commission welcomed the capacity development activities of the PWS Programme, which included 15 training events since the CBS-Ext.(10), and the preparation of a number of guidance materials. The full list of the events can be viewed at: http://www.wmo.int/pages/prog/amp/pwsp/eventsworkshops_en.htm.

Quality Management System (QMS)

4.5.13 The Commission fully supported the mainstreaming of QMS in NMHSs through the implementation of the WMO Strategy for Service Delivery. It requested the OPAG and the PWS Programme to assist NMHSs in the application of this Strategy, and emphasized that implementing an effective QMS with a strong user focus will go a long way to promoting good service delivery.

Decisions related to Disaster Risk Reduction (DRR)

4.5.14 The Commission recalled that its fourteenth session (CBS-XIV, Dubrovnik, Croatia, 2009) established a Task Team on Meteorological Services for Improved Humanitarian Planning and Response under the OPAG on PWS, which worked in coordination with other CBS OPAGs, as well as with representatives of the Commissions for Climatology (CCl) and Hydrology (CHy). The Commission endorsed the actions identified by the Task Team, including the pilot projects within the framework of the WMO Global Data-processing and Forecasting System (GDPFS) for the development of prototype products and services to support humanitarian agencies' emergency contingency planning, preparedness and response. In this regard, the Commission stressed the need for designation criteria, and functions, of Centres that could specialize in the development and provision of such products and services.

4.5.15 The Commission noted that in the preparations for the implementation of the GFCS there has been close consultation with a wide spectrum of users of hydro-meteorological services in support of DRR. These users had, inter alia, highlighted the success of DRR services delivered under the umbrellas of the WMO's Tropical Cyclone Programme (TCP) and GDPFS-ERA and had requested that the WMO explore opportunities for putting in place similar procedures to cover disasters more generically, therefore the lessons learnt from these successes could be built upon as we move forward.

4.5.16 In this context, the Commission decided to establish a CBS Task Team on the Provision of Operational Meteorological Assistance to Humanitarian Agencies, incorporating the legacy of the Task Team on Meteorological Services for Improved Humanitarian Planning and Response, as given in the annex to Resolution 6 (CBS-15). The Commission therefore adopted Resolution 6 (CBS-15) – Provision of operational meteorological assistance to humanitarian agencies.

5. WORKING STRUCTURE AND WORK PROGRAMME OF THE COMMISSION (agenda item 5)

5.1 Future work programme of the Commission (agenda item 5.1)

5.1.1 The Commission thanked all the chairs and members of the expert teams and the rapporteurs for their contribution to the CBS Open Programme Area Groups (OPAGs), and in particular those who will no longer serve within the CBS OPAGs. The Commission expressed its sincere gratitude to those chairs and co-chairs of the OPAGs who were no longer able to continue serving in these positions for their important contribution to the work of the Commission over many years.

5.1.2 With a view to making the necessary arrangements for efficiently carrying out the various tasks under the agreed work programme and the corresponding activities, the Commission agreed to establish teams as well as rapporteurs within each of the OPAGs and to allocate them tasks as given in Annex VII to the present report.

5.1.3 The list of chairs, co-chairs, rapporteurs and CBS representatives, who were designated by the Commission, is given in Annex VIII to the present report.

5.1.4 The Commission requested the CBS Management Group to establish the membership of the ICTs and the ETs of each OPAG. It invited the chairs of the OPAGs and respective teams, in

cooperation with the Secretariat, to develop targets for deliverables, and adequate working mechanisms to ensure that all experts could actively participate and contribute to the work programme and assist the respective teams.

5.2 Working structure of the Commission (agenda item 5.2)

5.2.1 The Commission decided to re-establish the four Open Programme Area Groups (OPAGs) on Integrated Observing Systems, on Information Systems and Services, on Data Processing and Forecasting Systems, and on Public Weather Services. It also decided to appoint a Coordinator on Disaster Risk Reduction, a Coordinator on Capacity Development and a Coordinator on GEO/GEOSS activities related to WMO. It further decided to re-establish the Inter-programme Coordination Team on Space Weather. The Commission adopted Resolution 7 (CBS-15) – Open Programme Area Groups of the Commission for Basic Systems.

5.2.2 The Commission decided to re-establish the CBS Management Group by adopting Resolution 8 (CBS-15) – Commission for Basic Systems Management Group.

5.2.3 The Commission also agreed that task teams may be established, as required, within each of the OPAGs to address specific tasks included in its work plan. These task teams could include experts in any of the CBS expert teams. Between sessions, OPAG chairs can propose the formation and terms of reference of these teams for the president to endorse.

5.2.4 The Commission noted the use of information technology by many of the teams to avoid the need for travel and encouraged all OPAGs to exploit the technology whenever possible.

5.2.5 The Commission noted the discussion on the possibility of changing the name of CBS to include the word “Services” and recalled that the EC WG SOP Task Group on Continuous Improvement of Processes and Practices was charged with identifying mechanisms for improving the effectiveness and efficiency of WMO, including the constituent bodies. The Commission requested the EC WG SOP to consider the implications of changing the name of CBS and provide guidance to the Commission at its next session.

6. REVIEW OF PREVIOUS RESOLUTIONS AND RECOMMENDATIONS OF THE COMMISSION AND RELEVANT EXECUTIVE COUNCIL RESOLUTIONS (agenda item 6)

6.1 The Commission considered its previous resolutions and recommendations that remain in force, and decided on the actions shown in the Table in Annex IX to the present report.

6.2 The Commission also considered the Resolutions of Executive Council that concern CBS. It decided on the actions shown in the Table in the Annex X to the present report.

7. ELECTION OF OFFICERS (agenda item 7)

The Commission elected Mr Fredrick R. Branski (United States of America) as president and Ms Susan L. Barrell (Australia) as vice-president of the Commission for Basic Systems.

8. REPORT ON THE TECHNICAL CONFERENCE (agenda item 8)

8.1 The Commission welcomed the report, contained in Annex XI to the present report, on the Technical Conference (TECO) on WIGOS and Valuing Systems and Services, held on 12–13 September 2012 in Jakarta, embedded within CBS-15. The Commission thanked the presenters for their informative presentations and welcomed the active participation that they stimulated amongst those in attendance on the issues of significant relevance to its work.

8.2 The TECO was chaired by the Vice President of CBS and was structured in two main parts, with the President of CIMO co-chairing for Part 1 and the CBS DRR Coordinator co-chairing for Part 2.

8.3 The TECO Part 1, titled "Understanding and using the WIGOS Implementation Plan" provided practical examples on how WIGOS is progressively moving from a concept towards reality. The Commission recognized that there is still much work to do before WIGOS can be implemented, but the sharing of examples of regional and national WIGOS implementation plans and some early achievements, strengthened understanding of the steps required and the challenges to be addressed at global, regional and national levels.

8.4 The Commission appreciated the opportunities that WIGOS presents for improved efficiency and effectiveness of NMHS systems and services. The Commission also noted that WIGOS provides a real opportunity for NMHSs to strengthen their national leadership and build national partnerships, both through communication and engagement with users around making use of more standardized and quality-assured observations, and as a framework for encouraging greater contribution of observations from partner agencies.

8.5 The TECO provided an opportunity also to demonstrate the effective application of the EC-64 approved WIGOS framework Implementation Plan as a basis for structuring and developing the regional and national WIGOS implementation plans. The Commission requested its Vice-President to consider this information in further progressing WIGOS implementation activities through the Inter-commission Coordination Group on WIGOS.

8.6 The TECO Part 2, titled "Understanding and Communicating the Return on Investment through Basic Systems and Services", was focused on informing CBS Members on benefits, methodologies and case studies associated with understanding the 'return on investment' in basic systems and services and communicating that information to others, especially governments and donors.

8.7 The Commission recognized the importance of economic studies in conveying the contributions made by NMHSs and especially by the CBS components in delivering the associated benefits, but underlined the necessity of ensuring such information is directed to the attention of the appropriate and most influential stakeholders. The concept of brand was acknowledged as key to ensuring the value delivered by NMHS systems and services is attributed to the NMHS.

8.8 The Commission emphasized that value was delivered by all parts of the CBS value chain and that the value returned to both users and investors could be optimized by improvements to all 'links'. The CBS basic systems 'links' serve multiple application areas and services outcomes, extending well beyond public weather services, extending the delivered value well beyond the range of CBS directly. The value extracted by the user from the services they receive can also be maximised through improved focus on the services message itself, how it is delivered and how the user is empowered to interpret it.

8.9 The Commission agreed that it should put a greater focus in its work on social and economic value, building on efforts already underway in other technical commissions, such as the CAS WWRP WG-SERA (Working Group on Societal Economic Research Applications), and requested its Management Group to consider how such a work programme should be structured and how it might proceed, including through collaboration with other technical commissions. The Commission encouraged greater formal linkages to be made between experts from WMO and bodies such as the World Bank to advance this work. An important output of this work would be formal documentation on methodologies and assessments to assist NMHSs in conducting relevant dialogue with governments.

8.10 The Commission noted that a strong message to emerge from the TECO sessions (both on WIGOS and on the value of systems and services) was that communications and engagement are critical to ensuring that users, partners and investors are presented with the information that best helps NMHSs to achieve their goals and strengthen their national role.

8.11 In addition to the main TECO session, a series of one-hour focus sessions on matters of topical relevance to each of the OPAGs, were conducted. These ‘extended’ TECO sessions allowed a useful exchange of information and views and improved the background knowledge and guidance for technical implementation of programmes, and the Commission agreed to consider such an arrangement at future sessions. The Commission requested that the Management Group consider how to involve experts from more regions in the TECO.

9. ANY OTHER BUSINESS (agenda item 9)

There was no other business.

10. DATE AND LOCATION OF THE NEXT MEETING (agenda item 10)

10.1 The Commission considered that it would be necessary to hold an extraordinary session to address the technical and regulatory issues associated with implementing WIS and WIGOS in the context of GFCS, but acknowledged the costs of holding an intergovernmental session.

10.2 The Commission did not receive any declaration of intent to host the next meeting of CBS that is proposed to be held in the fourth quarter of 2014. It was noted that the form, date and place of that meeting shall be determined by the president of the Commission after consultation with the Secretary-General according to General Regulation 188.

11. CLOSURE OF THE SESSION (agenda item 11)

The fifteenth meeting of the Commission for Basic Systems was closed at 11.35 a.m. on 15 September 2012.

RESOLUTIONS ADOPTED BY THE SESSION

Resolution 1 (CBS-15)

GUIDE TO THE WMO INFORMATION SYSTEM (WMO-No. 1061)

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The *Abridged Final Report with Resolutions of the Sixteenth World Meteorological Congress* (WMO-No. 1077*)*,

(2) Resolution 1 (Cg-XVI) – World Weather Watch Programme for 2012–2015,

(3) Resolution 4 (Cg-XVI) – Report of the extraordinary session (2010) of the Commission for Basic Systems relevant to Technical Regulations concerning the Global Telecommunication System, data management and the WMO Information System,

(4) Resolution 51 (Cg-XVI) – Designation of Centres of the WMO Information System,

Noting further that the Sixteenth World Meteorological Congress reviewed the progress on the *Guide to the WMO Information System* (WMO-No. 1061) and requested the Commission for Basic Systems to continue and complete this effort,

Considering:

(1) The need of Members for guidance relating to the *Manual on the WMO Information System* (WMO-No. 1060), particularly for the management of discovery metadata,

(2) The proposal of the Open Programme Area Group on Information Systems and Services to make discovery metadata guidance available via the WMO Wiki as a draft content of the Guide to accelerate the availability of guidance material,

Approves the content of the Guide as given in the annex to the present resolution, with effect from 1 January 2013;

Requests the Secretary-General:

(1) To publish the Guide, as given in the annex to the present resolution;

(2) To facilitate the establishment of a Wiki-based Discovery Metadata Management Guide;

Authorizes the Secretary-General to make any consequent purely editorial amendments to the *Guide to the WMO Information System.*

Annex to Resolution 1 (CBS-15)

GUIDE TO THE WMO INFORMATION SYSTEM (WMO-No. 1061)

Note that tracked changes relate to the draft presented at the extraordinary session of the Commission for Basic Systems in 2010.

Editorial note: Meanings of marks below are as follows.

Text — No changes
Text — Addition or modification
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~~1.~~ INTRODUCTION

~~1.1~~ Purpose of this Guide

1.~~1.1~~ In conjunction with the Manual on WIS, the Guide to WIS is designed to ensure adequate uniformity and standardization in the data, information, and communications practices, procedures and specifications employed among WMO Members in the operation of WIS as it supports the mission of WMO. The Manual on WIS (WMO No. 1060), Annex VII to the WMO Technical Regulations, contains standard and recommended practices, procedures and specifications. The Guide to WIS contains additional information concerning practices, procedures and specifications which Members are invited to follow or implement in establishing and conducting their arrangements in compliance with WMO Technical Regulations and in developing meteorological and hydrological services.

~~1.1.~~2. Because WIS cross cuts all WMO related discipline areas, many other WMO practices, procedures and specifications intersect WIS. Recommended as well as standard practices, procedures and specifications are primarily defined in their specific publications, for example the Guide on the Global Data Processing and Forecast System (WMO-No. 305) and the Guide to the Global Observing Systems (WMO-No. 488), among others.

~~1.2~~ Benefits of WIS

~~1.2.1~~ 3. WIS provides an overarching approach to data and information management for all WMO and related international programmes, leveraging the long-standing collaborative culture of WMO as well as new technologies.

~~1.2.2~~ 4. WMO Members expect to realize specific benefits from WIS:

- WIS should enhance the collection of critical data needed to monitor and predict aspects of the environment, including hazards;
- WIS should catalogue the full range of data and products, simplifying search and assuring equitable access per WMO policies;
- WIS should enhance the availability of time-critical data and products at centres in all nations, ensuring the effective provision of services to their populations and economies;
- WIS should open up the WMO private network (the WMO Global Telecommunication System) to other types of environmental data so that all programmes have stronger infrastructure support; and
- WIS should exploit opportunities as they become available with technology innovation.

PART I

1. ORGANIZATION AND RESPONSIBILITIES

~~2~~1.1 Organization of WIS

WMO Members implement and operate WIS, using existing centres with some additional or modified capabilities. Centres participating in WIS are categorized by three types:

- Global Information System Centres (GISCs),
- Data Collection or Production Centres (DCPCs),
- National Centres (NCs).

Refer to Manual on WIS Part III for a description of the functions of the three types of WIS Centres.

~~2~~1.2 Compliance with Required WIS Functions

As required per WMO-No. 49, Vol I, A.3 and Manual on WIS Part I and Part III, WIS Centres shall maintain compliance with required WIS functions. The Guide to WIS contains additional guidance on practices, procedures and

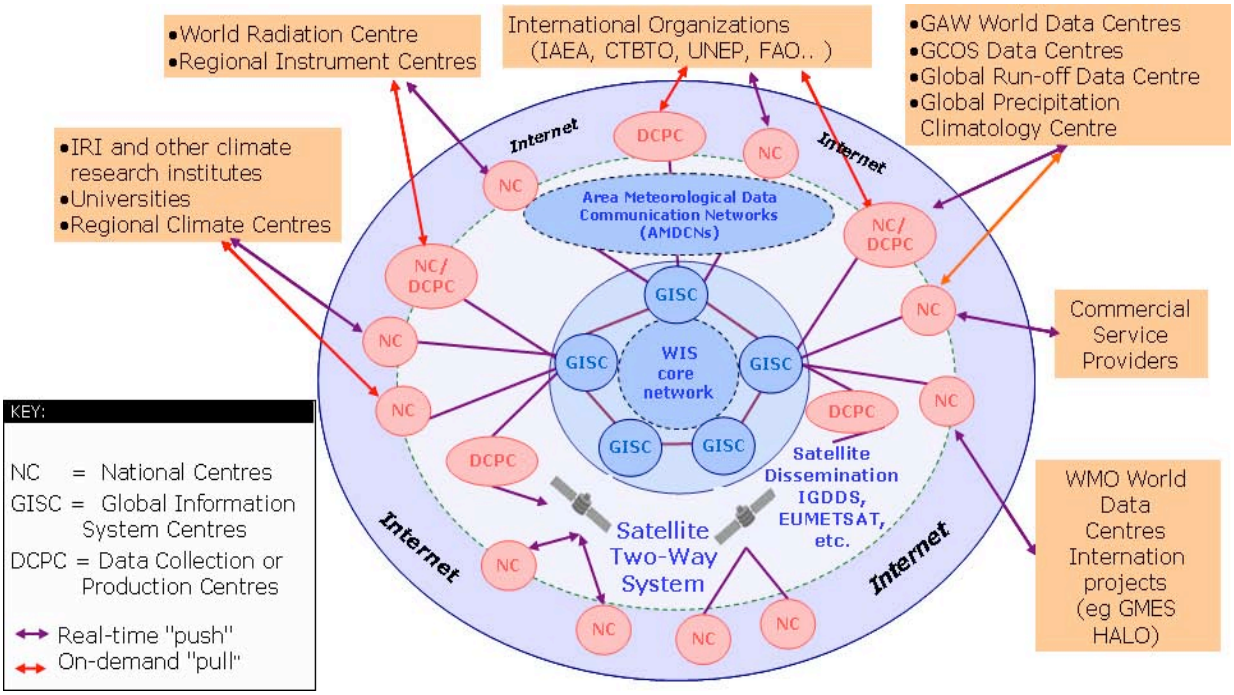

Figure 1. Types of WIS Centres and Typical Interactions

specifications for WIS functions, supplementing the standard and recommended practices, procedures and specifications for WIS functions set out in the Manual on WIS (WMO-No. 1060).

~~2~~1.3 Interaction among WIS Centres

As required per Manual on WIS 1.3, GISCs shall connect to each other by the WIS Core Network. Data, products and metadata shall flow to a GISC from DCPCs and from NCs within its area of responsibility. An illustration of likely interaction among WIS Centres is provided in Figure 1 (next page). Note: Named centres are illustrative examples and do not comprise a complete list of likely WIS Centres.

~~2~~1.4 Implementation of WIS

As required per Manual on WIS 1.4, WIS is implemented in two parallel parts: continued evolution of the WMO Global Telecommunication System (GTS), and extension of WMO services through Discovery, Access and Retrieval (DAR) facilities, as well as flexible timely delivery.

~~2~~1.5 Discovery, Access and Retrieval Function

~~2~~1.5.1 As required per WMO-No. 49, Vol I, A.3, and Manual on WIS 1.5, WIS is based on metadata catalogues describing data and products available across WMO, plus metadata describing dissemination and access options. The Discovery, Access and Retrieval (DAR) function of WIS is the primary realization of the WIS comprehensive catalogue, maintained collaboratively by all WIS Centres.

~~2~~1.5.2 A typical user of WIS DAR should find available data and products using a Web browser or other Internet tool. The searcher should be able to discover available data and products by browsing the catalogue or by searching the catalogue using discovery concepts such as subject keywords, geographic extent, or temporal range.

~~2~~1.5.3 A typical user of WIS DAR should first receive a list of relevant items with associated metadata such as originator, data type, generation date, use constraints, and the like.

Once desired data or products have been identified, a user may request immediate retrieval ("pull") or subscription for recurring delivery ("push") if locally available, or be referred to another centre holding the item. The WIS Centre having the item should then facilitate delivery through any of a broad range of online and offline transmission options. In the case of a subscription, the WIS Centre should maintain further information to support recurring delivery.

~~2~~1.6 Robustness and Reliability of Components

As required per Manual on WIS 1.6, high robustness and reliability of WIS components are essential to the operation of WIS. Indicators of performance are evaluated in the designation procedure for WIS Centres, to include assurance that data content flowing via WIS network technologies fully satisfies requirements for security, authenticity, and reliability. Some specifications of service levels are identified within the Manual on WIS and this Guide to WIS, but further specifications can be anticipated.

~~2~~1.7 Collection and Dissemination Services

~~2~~1.7.1 Refer to Manual on WIS 1.7 for standard and recommended practices, procedures and specifications on this topic.

~~2~~1.7.2 With regard to satellite-based data and products, the WMO Integrated Global Data Dissemination Service (IGDDS) addresses: user requirements review; data concentration: inter-regional data exchange; data dissemination; data discovery; data access on request; data delivery to authorized users; and, data management, including interoperable catalogue, quality of service monitoring and user support.

~~2~~1.7.3 In addition to satellite-based data and products, IGDDS should distribute a basic subset of the information intended for global exchange.

~~2~~1.7.4 IGDDS calls for regional dissemination components linked in a global network for inter-regional data exchange. Each regional component should include a DCPC and should ensure routine dissemination by various means including a satellite-based Digital Video Broadcast (DVB-S) service covering its region.

PART II DESIGNATION PROCEDURES FOR WIS CENTRES

~~2. DESIGNATION PROCEDURES FOR WIS CENTRES~~

~~3~~2.1 General

~~In addition to the provisions of~~ Designation procedures for WIS centres are defined in the Manual on WIS Part II.~~, t~~The ~~Inter-~~Commission ~~Coordination Group on WIS (ICG-WIS)~~ for Basic Systems (CBS) reviews relevant aspects of the Manual on WIS ~~documents, including the~~ to ensure alignment of WIS User Requirements, the WIS Functional Architecture, and the WIS Compliance Specifications. CBS is also developing monitoring procedures to complement the designation procedures of WIS and to ensure on-going compliance of WIS centres with the agreed standards and practices.

~~3~~2.2 Procedure for a Global Information System Centre (GISC)

Procedures for designation as a GISC are given in Manual on WIS 2.2, in keeping with WMO-No. 49, Vol I, A.3. During the initial phase of WIS Centre designations, CBS analyzes GISC service offers and formulates a recommendation for designation.

~~3~~2.3 Procedure for a Data Collection or Production Centre (DCPC)

Procedures for designation as a DCPC are given in Manual on WIS 2.3, in keeping with WMO-No. 49, Vol I, A.3. During the initial phase of WIS Centre designations, ~~ICG-WIS~~ CBS determines which centres should be integrated

in WIS, analyzes DCPC service offers and formulates a recommendation for designation.

~~3~~2.4 Procedure for a National Centre (NC)

~~3~~2.4.1 Procedures for designation as an NC are given in Manual on WIS 2.4, in keeping with WMO No. 49, Vol I, A.3.

~~3~~2.4.2 National Meteorological Centres are expected to be NCs. A WMO Member may also elect to designate other centres as NCs.

~~3~~2.4.3 In addition to the data and metadata requirements of an NC set out in Manual on WIS, a typical NC should: collect, generate or disseminate observational data and products; and, provide to other WIS Centres certain observations and products intended for global dissemination or for regional or specialized distribution.

~~3~~2.4.4 The "Study on policy-level implications of the future WMO information system" (described in Cg XIV 3.1.2.1) asserts that introduction of WIS will not result in new responsibilities or additional resource requirements for most Members. The stated expectation is that WIS would result in lower costs, especially for the least developed Members, through expanded use of commercial off-the-shelf technology and increased use of the Internet.

PART III FUNCTIONS OF WIS
~~3. FUNCTIONS OF WIS~~

3.1 Roles in and Review of WIS Functions

3.1.1 Roles in and review of WIS functions are given in Manual on WIS 3.1.

3.1.2 Each of the relevant user requirements processes across WMO should link into the WIS user requirements process. For instance, observing program needs should be incorporated into WIS requirements through linkage with the Rolling Review of Requirements (RRR) process in the Manual of the Global Observing System (WMO-No. 544).

3.1.3 Current WIS User Requirements are described in a technical document available at http://www.wmo.int/pages/prog/www/WIS/documents/WIS-RRR.doc .

3.2 List of WIS Functions

WIS Centres collectively support the major WIS functions as described in Manual on WIS 3.2. The required standard interfaces to these functions are described in Manual on WIS Part IV, WIS Technical Specifications.

3.3 Functional Architecture of WIS

The Functional Architecture of WIS is provided as supplementary guidance for WIS Centres in a technical document available at http://www.wmo.int/pages/prog/www/WIS/documents/WIS-FuncArch.doc. As shown in that document, the following list provides one possible method for decomposing the required major WIS functions into more detailed functions.

A1 Collect Observations, Generate Products, Create Metadata and Archive Information
A11 Collect, Generate and Archive National Information & Create Metadata
A111 Collect National Observations
A112 Check Meteorological Content of Products and Observations
A113 Archive
A114 Generate National Products
A115 Generate Metadata
A116 Unpack Information
A117 Verify Correct Telecommunication Attributes of Information
A12 Collect, Generate and Archive Regional, Programme-related and Specialised Information & Create Metadata
A121 Collect Regional, Specialised and Programme-related Observations
A122 Check Meteorological Content of Observations
A123 Archive

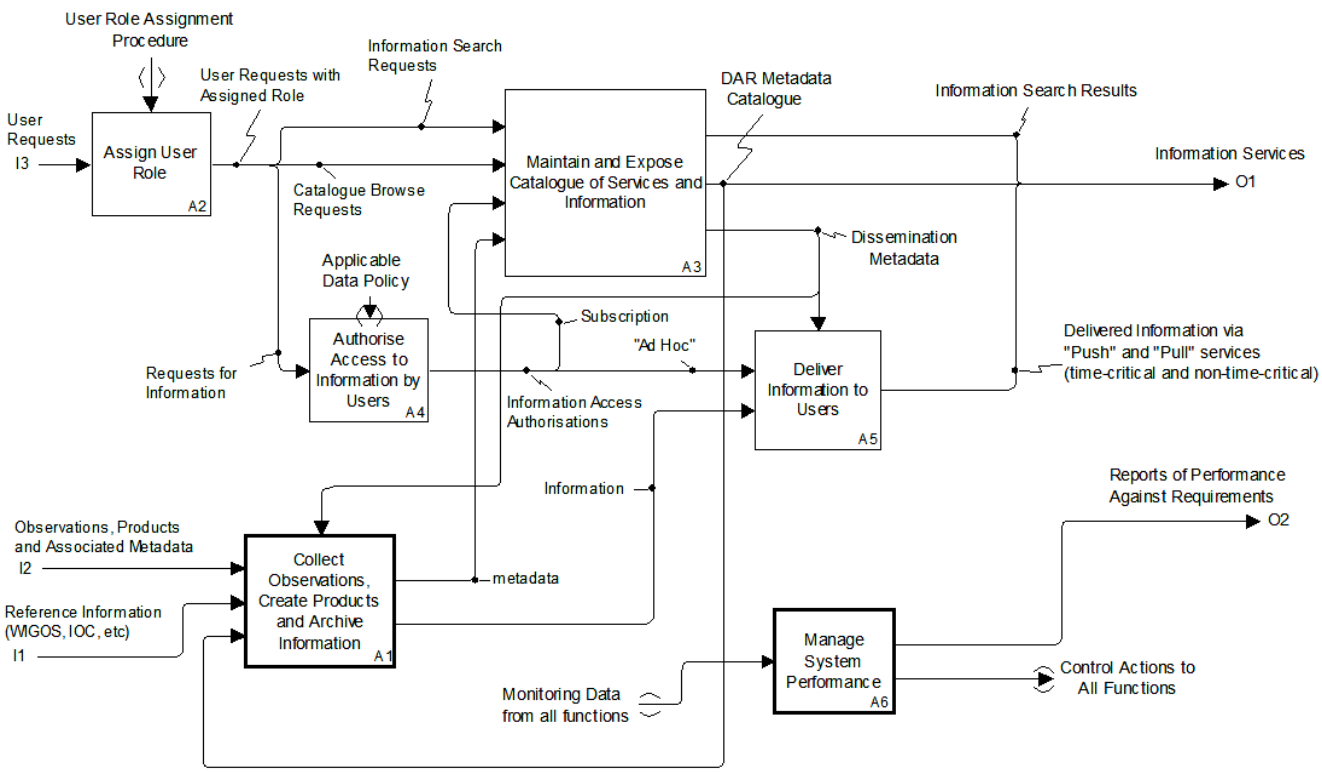

Figure 2. Data Flow Model of the WIS Functional Architecture

A124 Generate Regional, Specialised and Programme-related Products
A125 Generate Metadata
A126 Unpack Information
A127 Verify Correct Telecommunication Attributes of Information
A13 Collect and Cache Global Information
A131 Unpack Information
A132 Associate Information with DAR Metadata
A133 Verify Correct Communication Attributes of Information
A134 Maintain and make available Cache of Global Information for 24 Hours
A2 Assign User Role
A3 Maintain and Expose Catalogue of Services and Information
A31 Search DAR Metadata Catalogue
A32 Maintain and Expose Consolidated DAR Metadata Catalogue
A33 Maintain Dissemination Metadata Catalogue in Accordance with Authorised Subscriptions
A4 Authorise Access to Information by Users
A5 Deliver Information to Users (Internal and External)
A51 Schedule and Control Activities
A511 Derive Time-driven (synchronous) activity schedule and list of event-driven (asynchronous) activities
A512 Monitor for Events
A513 Resolve any activity scheduling conflicts, reflecting relative service priorities
A52 Package Information for Delivery
A53 Deliver Information
A6 Manage System Performance
A61 Non Real-time Performance Monitoring
A611 Analyse Traffic Trends
A612 Analyse Performance Against Requirements and SLAs
A62 Real-time Performance Monitoring
A621 Real-time Monitoring of Telecommunication Network
A622 Real-time Monitoring of the Application Content

3.4 Data Flow among WIS Functions

3.4.1 The Functional Architecture of WIS (noted in 4.3 above) models data flow among required WIS functions and illustrative subordinate functions. The model uses Integration Definition for Function Modelling (IDEF0), a data flow diagramming technique that illustrates interrelationships between system components, at levels ranging from very general processes to specific technology interfaces.

3.4.2 Figure 2 (above) presents an IDEF0 functional decomposition of the major WIS functions, labelled A1 through A6. Data flows inherit between levels of the diagrams and are labelled as I1, I2, I3 for inputs and O1, O2 for outputs.

3.5 Functional Requirements of a GISC

There are no general recommendations in addition to the statements in Manual on WIS 3.5.

3.6 Functional Requirements of a DCPC

There are no general recommendations in addition to the statements in Manual on WIS 3.6.

3.7 Functional Requirements of an NC

There are no general recommendations in addition to the statements in Manual on WIS 3.7.

PART IV. WIS TECHNICAL SPECIFICATIONS

~~4. WIS TECHNICAL SPECIFICATIONS~~

~~5~~4.1 General

As required in Manual on WIS 3.1, there are fifteen WIS Technical Specifications (WIS-TechSpecs) that should be regarded as "mandatory if applicable", that is, the Technical Specification is required wherever the interface applies. A summary of the applicability of each WIS-TechSpec by type of WIS Centre is given in Table 1 (next page). Supplementary details of WIS Technical Specifications are provided in "WIS Compliance Specifications for GISCs, DCPCs, and NCs", available at http://www.wmo.int/pages/prog/www/WIS/documents/TechnicalSpecification.doc

~~5~~4.2 WIS-TechSpec-1: Uploading of Metadata for Data and Products

~~5~~4.2.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.2.

~~5~~4.2.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, this interface should make use of a mix of dedicated network and public network services, including public or private Internet with TCP/IP which may include encryption.

~~5~~4.2.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to two functions: (1) "Compile observations into bulletins/files, generate metadata and archive", and (2) "Convert products and data into bulletins/files and generate associated metadata".

~~5~~4.2.4 Additional Notes

This interface builds on existing GTS practice, adding the particular standard format for WIS metadata about data, products, and services. Centres should be aware that metadata uploaded to a GISC could take up to 24 hours to be synchronized across all GISCs. Thus, where a data or product is required to be distributed sooner than 24 hours after publication of its metadata, the centre must transmit the metadata directly to the centre's principle GISC via the GTS or by a method already agreed with the GISC.

~~5~~4.3 WIS-TechSpec-2: Uploading of Data and Products

~~5~~4.3.1 Applicable Standards

The following information for this requirement is in addition to the standard and

recommended practices, procedures and specifications in Manual on WIS 4.3.

~~5~~4.3.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, this interface is associated with dedicated bandwidth and high reliability and should make use of the GTS. This can incorporate private Internet with TCP/IP and may include encryption. In some cases IGDDS satellite uplinks may be employed.

~~5~~4.3.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to two functions: (1) "Package bulletins, files, and metadata according to distribution requirements", (2) "Convert products and data into bulletins/files and generate associated metadata".

~~5~~4.3.4 Additional Notes

This interface builds on existing GTS practice, supplemented with other file transfer mechanisms such as the Internet. Although it is required that data arrives only after its associated metadata, a grace period of two minutes is allowed before the data file is regarded as erroneous.

~~5~~4.4 WIS-TechSpec-3: Centralization of Globally Distributed Data

5.4.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.4.

~~5~~4.4.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, this interface is associated with dedicated bandwidth and high reliability and should make use of the GTS. This can incorporate private Internet with TCP/IP and may include encryption.

~~5~~4.4.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to the function: "Maintain Cache of Global Information for 24 Hours".

~~5~~4.4.4 Additional Notes

~~5~~4.4.4.1 The set of WMO data and products required to be cached for 24 hours at the GISCs is that information "intended for global exchange". This does not encompass all of the material handled by IGDDS.

Interface Technical Specification Identifier	Interface Technical Specification Name	Required for:		
		NC	DCPC	GISC
WIS-TechSpec-1	Uploading of Metadata for Data and Products	✓	✓	✓
WIS-TechSpec-2	Uploading of Data and Products	✓	✓	✓
WIS-TechSpec-3	Centralization of Globally Distributed Data			✓
WIS-TechSpec-4	Maintenance of User Identification and Role Information	✓	✓	✓
WIS-TechSpec-5	Consolidated View of Distributed Identification and Role Information			✓
WIS-TechSpec-6	Authentication of a User		✓	✓
WIS-TechSpec-7	Authorization of a User Role		✓	✓
WIS-TechSpec-8	DAR Catalogue Search and Retrieval		✓	✓
WIS-TechSpec-9	Consolidated View of Distributed DAR Metadata Catalogues			✓
WIS-TechSpec-10	Downloading Files via Dedicated Networks	✓	✓	✓
WIS-TechSpec-11	Downloading Files via Non-dedicated Networks	✓	✓	✓
WIS-TechSpec-12	Downloading Files via Other Methods	✓	✓	✓
WIS-TechSpec-13	Maintenance of Dissemination Metadata	✓	✓	✓
WIS-TechSpec-14	Consolidated View of Distributed Dissemination Metadata Catalogues			✓
WIS-TechSpec-15	Reporting of Quality of Service	✓	✓	✓

Table 1. WIS Interface Technical Specifications

~~5~~4.4.4.2 Although the cache of data and products intended for global exchange is required to be current across all GISCs to within 15 minutes, warnings must be current to within two minutes.

~~5~~4.4.4.3 The cache size is expected to grow from one gigabyte per day. The cache needs to be highly accurate and the system for logical centralization needs to be affordable and robust; single points of failure and complex procedures are not acceptable.

~~5~~4.5 WIS-TechSpec-4: Maintenance of User Identification and Role Information

~~5~~4.5.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.5.

~~5~~4.5.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, this interface should make use of public network services, including Internet with TCP/IP which may include encryption and other privacy protection for identified individuals as required by national laws.

~~5~~4.5.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to two functions: (1) "Assign User Role", (2) "Authorise Access to Information by Users".

~~5~~4.5.4 Additional Notes

For updating the identification and role information concerning candidate or current users of WIS, WIS Centres should support two kinds of maintenance facilities: a file upload facility for batch updating (add, replace, or delete identification and role records treated as separate files); and an online form for changing individual identification and role entries (add, change, or delete of elements in a record as well as whole records).

~~5~~4.6 WIS-TechSpec-5: Consolidated View of Distributed Identification and Role Information

~~5~~4.6.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.6.

~~5~~4.6.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, this interface should make use of a mix of dedicated network and public network services, including public or private Internet with TCP/IP which may include encryption and other privacy protection for identified individuals as required by national laws.

~~5~~4.6.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to two functions: (1) "Assign User Role", (2) "Authorise Access to Information by Users".

~~5~~4.7 WIS-TechSpec-6: Authentication of a User

~~5~~4.7.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.7.

~~5~~4.7.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, this interface should make use of a mix of dedicated network and public network services, including public or private Internet with TCP/IP which may include encryption and other privacy protection for identified individuals as required by national laws.

~~5~~4.7.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to the function: "Assign User Role".

~~5~~4.7.4 Additional Notes

In a typical design for this interface, the client sends to the authentication server an authentication request for a particular user whose identification and credentials are included in the request. The authentication server references the consolidated identification and role information resource for WIS and returns an authentication response. That response either confirms or denies that the identified user has provided sufficient credentials.

~~5~~4.8 WIS-TechSpec-7: Authorization of a User Role

~~5~~4.8.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.2.

~~5~~4.8.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, within the constraints of dedicated bandwidth and reliability service levels, this interface should make use of public network services, including Internet with TCP/IP which may include encryption.

~~5~~4.8.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to the function: "Authorise Access to Information by Users".

~~5~~4.8.4 Additional Notes

In a typical design for this interface, the client sends to the authorization server an authorization request for a particular user whose identification is included in the request. The authorization server references the consolidated identification and role information resource for WIS and returns an authorization response. That response either contains a list of the authorised roles for the user or denies that the identified user has any authorised roles.

~~5~~4.9 WIS-TechSpec-8: DAR Catalogue Search and Retrieval

~~5~~.9.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.9.

~~5~~4.9.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, within the constraints of bandwidth and reliability service levels, this interface should make use of public network services, including Internet with TCP/IP which may include encryption.

~~5~~4.9.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to the function: "Maintain and Expose Catalogue of Services and Information".

~~5~~4.9.4 Additional Notes

The procedures for designation of a GISC or DCPC require that both type of WIS centre maintain data, product and service catalogues in the WMO-agreed standard format and facilitate access to these catalogues. Therefore, network services should be treated as a type of WIS product that can be discovered through the DAR catalogue.

Note: The WIS SRU Implementors Note is available at

http://www.wmo.int/pages/prog/www/WIS/Publications/SRU_Implementors_Note.doc

~~5~~4.10 WIS-TechSpec-9: Consolidated View of Distributed DAR Metadata Catalogues

~~5~~4.10.1 Applicable Standards

The following information for this requirement is in addition to the standard and

recommended practices, procedures and specifications in Manual on WIS 4.10.

~~5~~4.10.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, this interface should make use of a mix of dedicated network and public network services, including public or private Internet with TCP/IP which may include encryption.

~~5~~4.10.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to the function: "Maintain and Expose Catalogue of Services and Information".

~~5~~4.11 WIS-TechSpec-10: Downloading Files via Dedicated Networks

~~5~~4.11.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.11.

~~5~~4.11.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, this interface is associated with dedicated bandwidth and high reliability and should make use of the GTS and IGDDS satellite broadcast. This can incorporate private Internet with TCP/IP and may include encryption.

~~5~~4.11.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to the function: "Deliver Information to Users".

~~5~~4.12 WIS-TechSpec-11: Downloading Files via Non-dedicated Networks

~~5~~4.12.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.12.

~~5~~4.12.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, this interface should not use a non-dedicated network for operation-critical data. Otherwise, within the constraints of bandwidth and reliability service levels, this interface should make use of public network services, including Internet with TCP/IP which may include encryption. This interface should also make use of IGDDS satellite broadcast (at radio or television frequencies).

~~5~~4.12.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to the function: "Deliver Information to Users".

~~5~~4.13 WIS-TechSpec-12: Downloading Files via Other Methods

~~5~~4.13.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.13.

~~5~~4.13.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, this interface should not use a non-dedicated method for operation-critical data. Otherwise, this interface is associated with requirements for delivery using methods other than data telecommunication networks. Delivery via voice lines and postal services in paper or digital media are included, among others.

~~5~~4.13.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to the function: "Deliver Information to Users".

~~5~~4.14 WIS-TechSpec-13: Maintenance of Dissemination Metadata

~~5~~4.14.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.14.

~~5~~4.14.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, this interface should make use of a mix of dedicated network and public network services, including public or private Internet with TCP/IP which may include encryption.

~~5~~4.14.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to the function: "Maintain and Expose Catalogue of Services and Information".

~~5~~4.14.4 Additional Notes

~~5~~4.14.4.1 For updating the Dissemination Metadata, WIS Centres should support two kinds of maintenance facilities: a file upload facility for batch updating (add, replace, or delete metadata records treated as separate files); and an online form for changing individual entries (add, change, or delete of elements in a record as well as whole records).

~~5~~4.14.4.2 Initially, population of the DAR Metadata is accomplished centrally, based on Volume C1 of WMO Publication No. 9 and other sources. Because full transition of WMO centres to the new metadata will occur over some time, procedures are required to assure that changes to either set of metadata are reflected in both.

~~5~~4.15 WIS-TechSpec-14: Consolidated View of Distributed Dissemination Metadata Catalogues

~~5~~4.15.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.15.

~~5~~4.15.2 Types of Collection and Dissemination Service

To provide a quality of service that meets user requirements, this interface should make use of a mix of dedicated network and public network services, including public or private Internet with TCP/IP which may include encryption.

~~5~~4.15.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to the function: "Maintain and Expose Catalogue of Services and Information".

~~5~~4.16 WIS-TechSpec-15: Reporting of Quality of Service

~~5~~4.16.1 Applicable Standards

The following information for this requirement is in addition to the standard and recommended practices, procedures and specifications in Manual on WIS 4.16.

~~5~~4.16.2 Types of Collection and Dissemination Service

This interface should make use of public network services, including Internet with TCP/IP which may include encryption.

~~5~~4.16.3 Function Interfaces

In the WIS Functional Architecture, this WIS Technical Specification acts as an interface to the function: "Manage System Performance".

~~5~~4.16.4 Additional Notes

~~5~~4.16.~~5~~4.1 Agreements on service levels can be anticipated eventually for WIS operations. These should include data and network security as well as performance and reliability.

~~5~~4.16~~5~~.~~5~~4.2 Performance reports could be generated efficiently by having each WIS Centre upload its reports to a single analysis site within a fixed time window.

PART V. METADATA GUIDANCE

~~5. METADATA GUIDANCE~~

5.1 WIS Discovery Metadata

Note: Part V of this Guide is being developed and will contain information on the creation and management of Discovery Metadata in relation to WIS in addition to the standard and recommended practices, procedures and specifications in Manual on WIS Part V. The latest guidance is available on the WIS WIKI page

http://www.wmo.int/pages/prog/www/WIS/wiswiki/tiki-index.php?page=WmoCoreMetadata. For more details on the WMO Metadata profile visit http://wis.wmo.int]

APPENDIX A – SELECTED WMO MANUALS AND GUIDES RELEVANT TO WIS

Refer to the Manual on WIS, Appendix A, for the list of selected WMO Manuals and Guides relevant to WIS.

APPENDIX B – APPROVED WIS CENTRES

Refer to the Manual on WIS, Appendix B, for the list of approved GISCs, DCPCs, and NCs.

APPENDIX C – WIS DISCOVERY METADATA

Refer to the Manual on WIS, Appendix C for details on WIS Discovery Metadata and WIS WIKI page http://www.wmo.int/pages/prog/www/WIS/wiswiki/tiki-index.php?page=WmoCoreMetadata for the latest guidance material on creating and managing WIS Discovery Metadata.

APPENDIX ~~A~~ D – LIST OF ABBREVIATIONS

Cg	World Meteorological Congress
CBS	Commission for Basic Systems
DAR	Discovery, Access and Retrieval
DCPC	Data Collection or Production Centre
GDPFS	Global Data Processing and Forecast System
GISC	Global Information System Centre
GTS	Global Telecommunication System
~~ICG-WIS~~	~~Inter-Commission Coordination Group on WIS~~
IGDDS	Integrated Global Data Distribution Service
MTN	Main Telecommunication Network
NC	National Centre
NMC	National Meteorological Centre
TCP/IP	Transmission Control Protocol / Internet Protocol
WIS	WMO Information System
WMO	World Meteorological Organization

Resolution 2 (CBS-15)

AMENDMENTS TO THE *GUIDE ON INFORMATION TECHNOLOGY SECURITY*

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 1 (Cg-XVI) – World Weather Watch Programme for 2012–2015,

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

Noting further:

(1) The importance for organizations to protect their information systems in order to maintain operational data processing and communication as well as ensuring the integrity of the data and processes within those systems,

(2) That WMO information systems are increasingly interconnected and that each centre has a responsibility to secure itself to ensure that it will not be the cause of further security problems with other centres,

Considering:

(1) The need to keep guidance on information technology security up to date with information technology systems and practices, including those managing threats associated with the use of the Internet,

(2) That the *Guide on Information Technology Security* is an important annex to the *Manual on the Global Telecommunication System* and needs an appropriate WMO publication number,

Approves the amendments to the Guide provided in the annex to the present resolution;

Requests the Secretary-General to arrange for the update and publishing of this Guide, including the allocation of a WMO publication number;

Authorizes the Secretary-General to make any consequent editorial amendments.

Annex to Resolution 2 (CBS-15)

AMENDMENTS TO THE *GUIDE TO INFORMATION TECHNOLOGY SECURITY*

Changes to the *Guide to Information Technology Security*

Editorial note: Meanings of marks below are as follows.

Text — No changes
Text — Addition or modification
~~Text~~ — Deletion or modification
Text — Move from other article
~~Text~~ — Move to other article

Summary of changes follows:

Change 1
Update Revision History as follows:

2005-02-02 – ET-EUDCS, Draft version.
2006-07-19 – ET-CTS, First complete version.
2012-04-18 – ET-CTS, Second version with review of all text and addition of external references.

Change 2
Update second and third paragraphs of Executive Summary as follows:

Communication is essential for us to achieve our business goals and the Internet is ~~fast becoming~~ one of the essential tools to exchange information. Electronic means to transfer files, such as electronic mail ~~and~~, the World Wide Web and social networks, have allowed the development of cooperation between scientists and improvements in the forecast and distribution of elaborated meteorological products.

But in parallel to these positive changes in the way our community is working, more and more threats and risks ~~have now appeared~~ are present everywhere throughout the whole Internet and it is necessary for our organizations to ~~face~~ manage the ~~dangers~~ risks and protect our Information Systems in order to maintain operational data processing and communication.

Change 3
Insert new paragraph in the Executive Summary after sixth paragraph as follows:

Furthermore, because we are interconnected, we all have a responsibility to secure ourselves to ensure we will not be the cause of further security problems with our partners. All centres are only as secure as the least secure centre in the network. Therefore the risks must be managed.

For information about the top security risks and methods to prevent or to mitigate them please refer to appropriate links, such as http://www.sans.org/top-cyber-security-risks/

The purpose of this document is to provide …

Change 4
Insert paragraph in Executive Summary following bulleted list of paragraph 8 as follows:

- regularly applying security patches to critical systems as they become available
- managing with care the user access codes and passwords

The complete list as defined in the ISO/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

Change 5
Insert new paragraph after paragraph one in "Definition of Information Technology Security (ITS)" as follows:

The purpose of Information Technology Security (ITS) is to help an organization to fulfil its mission by protecting its IT resources, and through that, its assets. Those assets must be properly identified so that adequate security requirements can be defined.

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.

The next 4 sections briefly mention 4 of the necessary tasks in order to implement information technology security. Again, this is not a complete list, and should always be complemented by tasks from the above mentioned standards.

Change 6
Insert new paragraph between section 3.2 header and subsection 3.2.1 as follows:

3.2 Common threats
A very resourceful link for this topic is http://www.sans.org/top-cyber-security-risks/.

3.2.1 Malicious codes: viruses, worms, Trojan horses

Change 7
Update text under section 6.1, subsection on Confidentiality, second and third paragraphs as follows:

Confidentiality is achieved through network and systems protection and cryptographic measures.

A key measure for all three security criteria is network and systems protection. A key technology for network protection ~~is~~are ~~a~~ firewall systems. The most common application for firewall systems is a central firewall between the internal network and the Internet. However, depending on the complexity of the internal network distributed firewall systems shall be put in place to protect sensitive internal network zones and systems, e.g. databases and servers running critical services, from more dangerous parts, e.g. network zones connecting user PCs and workstations (see sec 6.2).

Network protection can also be improved by introducing intrusion detection/prevention systems (IDS/IPS) to monitor the network traffic at certain points and to detect unwanted or suspicious traffic.

Change 8
Update text under section 6.2.4, paragraph 10 as follows:

Modern firewall appliances have both an internal and an external packet filter, respectively packet filter and stateful firewall with protocol analysers in one single box. The former DMZ has become the so-called “service network” (SN).

Change 9
Update section 6.8.3 and 6.8.4 as follows:

6.8.3 Installation of security patches

Follow the security advisories from the CERT (e.g. http:// www.us-cert.gov, http://www.dfn-cert.de, https://www.cert.be) 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
- 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. But be aware to pay attention to possible legal issues! Best practice is to inform the users about regular password checks and let them individually sign a declaration of agreement, e.g. in terms of a common IT user policy before running any password cracking tools.
- Passwords must be changed on a regular basis (at least every 3 months)

Change 10
Add sub-paragraph numbers under section 6.8.6 on “Detection procedures” and make minor correction to the third paragraph as follows:

6.8.6.1 Protection from Viruses

Anti-virus software should be regularly updated with new definition files. Anti-virus software should be regularly reviewed. It ~~my~~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.

6.8.6.2 User Education

6.8.6.3 Unauthorised software

Change 11
Update bulleted list in section 7 on "Information Technology Security Useful Resources"

…
- National Security Agency (NSA) documents on "securing systems" (http://www.nsa.gov/)
- Internet Security alliance guidance (http://www.isalliance.org)
- ISO guidance on ITS such as ISO/IEC 27000-series ~~17799~~ (must be purchased from ISO)
- http://en.wikipedia.org/wiki/Standard_of_Good_Practice
- http://en.wikipedia.org/wiki/Cloud_computing_security
- https://cloudsecurityalliance.org/guidance/csaguide.v3.0.pdf
- http://en.wikipedia.org/wiki/Information_security

Change 12
Update references in section 8 "Bibliography" as follows:

1. Ryan Russell, Rain Forest Puppy and Muidge ~~Ryan Russell, Stace Cunningham~~, Hack Proofing your Network, Copyright June 1, 2002 by Syngress Publishing Inc.
2. George Kurtz, Stuart McClure Joel Scambray, Hacking exposed, Copyright Feb 1, 2009 by Osborne/McGraw-Hill
3. William R. Cheswick, Steven M. Bellovin, Aviel D. Rubin, Firewalls and Internet Security, Copyright 2003 by Addison-Wesley
4. Jeffrey Carr, Inside Cyber Warfare, 2nd Edition Copyright December 2011 by O'Reilly Media
5. Gary A. Donahue, Network Warrior, 2nd Edition Copyright May 2011 by O'Reilly Media

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Resolution 3 (CBS-15)

AMENDMENTS TO THE *GUIDE FOR VIRTUAL PRIVATE NETWORKS (VPN) VIA THE INTERNET BETWEEN GTS CENTRES*

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 1 (Cg-XVI) – World Weather Watch Programme for 2012–2015,

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

Noting further:

(1) The increasing use of the public Internet by Members as primary or backup Global Telecommunication System or WMO Information System circuits,

(2) The importance for organizations to protect their information systems in order to maintain operational data processing and communication as well as ensuring the integrity of the data and processes within those systems and in transit between systems in other centres,

(3) That WMO information systems are increasingly interconnected and that each centre has a responsibility to secure itself to ensure that it will not be the cause of further security problems with other centres,

Considering:

(1) The need to keep guidance on information technology up to date with information technology systems and practices, including those managing threats associated with the use of the Internet,

(2) That the *Guide for Virtual Private Networks (VPN) via the Internet between GTS centres* is an important annex to the *Manual on the Global Telecommunication System* and needs an appropriate WMO publication number,

Approves the amendments to the Guide provided in the annex to the present resolution;

Requests the Secretary-General to arrange for the update and publishing of this Guide, including the addition of a WMO publication number;

Authorizes the Secretary-General to make any consequent editorial amendments.

Annex to Resolution 3 (CBS-15)

AMENDMENTS TO THE *GUIDE FOR VIRTUAL PRIVATE NETWORKS (VPN) VIA THE INTERNET BETWEEN GTS CENTRES*

Editorial note: Meanings of marks below are as follows.

Text — No changes
Text — Addition or modification
~~Text~~ — Deletion or modification
Text — Move from other article
~~Text~~ — Move to other article

Summary of changes follows:

Change 1
Update title of paragraph 2.2.1 "The Link Layer solutions" as follows:

2.2.1 Key management describing The Link Layer solutions

Change 2
Remove sub paragraph number and update text in paragraph 2.2.1.3.2 on "Layer Two Tunnelling Protocol (L2TP)" as follows:

~~2.2.1.3.2~~ Key management describing ~~Layer Two Tunnelling Protocol (L2TP)~~ L2TP is a combination of PPTP and Layer 2 Forwarding (L2F), a technology proposed by Cisco Systems … **…** In Windows operating system versions, starting from Windows 2000, IPSec Encapsulating Security Payload (ESP) is used to encrypt the L2TP packet. This is known as L2TP/IPSec. The result after applying ESP is shown below.

Change 3
Update paragraph 2.2.2.1 on "SSL and TLS" and insert sub-paragraph as follows:

Netscape~~, few years ago,~~ created the protocol SSL (Secure Socket Layer). In the TCP/IP layering model it is on top of the TCP layer.

Therefore, it could be used for adding security (that is strong authentication and encryption) for all TCP-based application (Telnet, FTP…).

Companies use this technology to provide secure remote access to their internal infrastructure by using SSL-VPN's with additional strong authentication, oftentimes using either via one time password generators or X.509 certificates. The advantage is that no VPN client software has to be installed on the client computers in advance. Instead, the VPN client software is downloaded as ActiveX controls or a Java applets just before the VPN connection is established.

Besides commercial SSL VPN solutions there are as well powerful Public Domain VPN solutions like OpenVPN and stunnel which can be used free of charge.

Some other implementations exist for these protocols but the success story of SSL is HTTPS. HTTPS is used in e-commerce application to allow secure information exchanges between client and servers. TSL is the IETF proposed standard and the successor of SSL and an IETF standard as well.

Change 4
Remove section 2.2.2.3 on "SOCKS …" In total

Change 5
Minor editorial in Section 3.1 as follows:

• Key management describing the key management schemes.
– keys are generated with Internet Key Exchange (IKE) in IPSec protocols

Change 6
Add bulleted point to list in section 4.2.1 on "Physical layer"

– MPLS network like the RMDCN in region VI is such a network
– Connections using the Internet.

Change 7
Update section 4.2.2 on "Upper layers" as follows:

The "Guide on the use of TCP/IP on the GTS" describes how to use IP as a replacement of the legacy X25 protocol. The IP protocol is now widely used on the GTS ~~future. of the GTS is IP and technical evolution on the network should be searched in the IP direction~~.

At the application layer, for the GTS data exchange two protocols are usable on top of the IP layer: FTP and sockets. Every new solution must be compatible to these standards.

Change 8
Update section 4.3 on "the Internet" as follows:

Therefore, the Internet is now~~becoming~~ a possible media to complement the current GTS private infrastructure, and it is used as the connection to the GTS in a few countries already (see also 4.2.1).

Change 9
Update section 4.5 on "Solution Suppliers" as follows:

Over the last 7~~5~~ years, ECMWF and its partners in Europe made a lot of tests on IPSEC. The latest one in 2007, showed that interoperability is still an issue.

Change 10
Update first paragraph of section 4.6 on "Network architecture" as follows:

The placement of the VPN gateway in a security solution is of paramount importance. Improper placement of the VPN gateway will impact effectiveness of the solution. In this context, all the VPN gateways are operating in tunnel~~ing~~ mode only. The following…

Change 11
Update third and fourth paragraph of section 4.6 on "Network architecture" as follows:

… Placing both the functions firewall and VPN onto the same box results in an easier management. Note that this setup is typically used for smaller VPN solutions.

The disadvantage of this solution is that the ~~resource~~ CPU utilization of the firewall/VPN gateway will be very high and adequate measures have to be taken to address this issue. In other words …

Change 12
Update list in section 4.7 on "Implementation Scenario"

– Setup appropriate filter rules on the firewall. The following rules
  allow UDP port 500 is used for ISAKMP
  allow UDP port 4500 (NAT traversal)
  allow IP protocol number 50 (ESP protocol)

~~….~~
are the basic rules for an IPSec connection.
– implement the defined configuration
– test

Change 13
Update first paragraph of section 5.4 "Conclusion" as follows:

For the MTN or a regional network, a managed service from a provider (either MPLS VPN ode IPSec VPN) offers a service level agreement (SLA). Depending on the technology used, this SLA will cover guaranteed bandwidth, performance, class of service, Round Trip Time, recovery time in case of problems or failures, etc....
The technical benefits …

Change 14
Insert new subheadings under section header 6.3 "Configuration Example for an OpenVPN-based solution" and additional text as follows:

6.3.1 Server Configuration
By starting up with the Server configuration first thing we have to do is to create a series of certificates and keys. For all …

… Note: former configuration files that remain into the /etc/openvpn directory should have to be removed in order to avoid making futures mistakes.

6.3.2 Generate the Certificate Authority (CA).
This Certificate has to be generated just once in the Server and then will be one of the files to be ~~copy~~ copied and submitted to the clients (Met Centers)…

… Note: don't ~~let~~ leave the Common Name blank!
6.3.3 Generate certificate and key for the Server
#sh build-key-server servidor …

… * servidor.key
6.3.4 Generate certificates and keys for the clients (Met Centers).
Likewise as we did before for the server we shall do for each of the clients, i.e. certificates and encrypt keys are created and unique for any of them…

… In this way we are generating certificates and encrypted keys with the names clienteVE, clienteUY, etc.

6.3.5 Generate Diffie-Hellman parameter

Diffie-Hellman parameter is generated executing this command which will provide us of a safety key exchange...

… The above command shall create the file dh1024.pem inside the directory /etc/openvpn/easy-rsa/ which should be copied at /etc/openvpn directory.

6.3.6 Coping files here and there

Once carried out previously steps we've got several files stored in …

…
clienteBR.key
Server configuration
We need to count on a configuration file either in the client ~~as~~ or in the Server.

This will contain all configuration parameters and should be have the .conf extension and of course shall be stored in the /etc/openvpn directory

servidor.conf

port 1194 …

… push: indicate the Server which IP subnet could be reached by the connected clients

6.3.7 Client configuration

Client …

Resolution 4 (CBS-15)

REMOVAL OF THE GUIDES TO *THE USE OF TCP/IP ON THE GTS* AND *PROVISIONAL ARRANGEMENT FOR THE USE OF IP ADDRESSES OVER THE GTS*

THE COMMISSION FOR BASIC SYSTEMS,

Noting Resolution 4 (Cg-XVI) – Report of the extraordinary session (2010) of the Commission for Basic Systems relevant to Technical Regulations concerning the Global Telecommunication System, data management and the WMO Information System,

Considering:

(1) That relevant components of the guide to *The Use of TCP/IP on the GTS* and the guide to *Provisional Arrangement for the Use of IP Addresses over the GTS* had been migrated to the *Manual on the Global Telecommunication System* (WMO-No. 386), Volume I, Part II, Attachment II-15, following the extraordinary session of the Commission for Basic System in Namibia in 2010,

(2) That the migration to IPv4 is complete and that the Open Programme Area Group on Information Systems and Services is now investigating practices for migration to IPv6,

Considering further the recommendation of the Open Programme Area Group on Information Systems and Services that it is no longer required to maintain these guides as individual guides,

Decides:

(1) To withdraw the guide to *The Use of TCP/IP on the GTS*;

(2) To withdraw the guide to *Provisional Arrangement for the Use of IP Addresses over the GTS*;

Requests the Secretary-General to remove these guides from the WMO Web pages.

Resolution 5 (CBS-15)

COMPETENCY FRAMEWORK FOR PUBLIC WEATHER SERVICES FORECASTERS AND ADVISORS

THE COMMISSION FOR BASIC SYSTEMS,

Noting that the Sixteenth World Meteorological Congress recommended that all technical commissions make the definitions of competence requirements for the core job-tasks in meteorology and hydrology a high-priority activity and incorporate this task into their current work programmes,

Noting further:

(1) That Sixteenth Congress requested that the technical commissions follow the model developed by the Commission for Aeronautical Meteorology in providing top-level competence requirements,

(2) That the Commission for Basic Systems at its extraordinary session in 2010 took an action to investigate developing competency requirements in weather forecasting and in the Public Weather Services area,

(3) That this Competency Framework will inform the education and training of forecasters,

(4) That this Competency Framework will also guide the content of WMO education and training courses, workshops and seminars,

Considering the development by the Open Programme Area Group on Public Weather Services of a Competency Framework which describes the basic forecaster competencies and then adds on those skills and knowledge that are required for effective service delivery and liaison with users (Annexes I to V to the present resolution),

Requests:

(1) That other relevant Commission for Basic Systems Open Programme Area Group expert teams review and comment on the draft Competency Framework;

(2) That the president of the Commission liaise with the chair of the Executive Council Panel of Experts on Education and Training to obtain the Panel's recommendations on the draft Competency Framework;

(3) That the Open Programme Area Group on Public Weather Services bring the consolidated drafts back to the Commission at its extraordinary session in 2014 for consideration and approval.

Annex 1 to Resolution 5 (CBS-15)

COMPETENCY REQUIREMENTS FOR PUBLIC WEATHER SERVICES/WEATHER FORECASTERS

The competency requirements for the work of an operational forecaster can be divided into five top-level competency areas. A Public Weather Service/weather forecaster, taking into consideration the following:

(a) The geographical area of responsibility,

(b) Weather water and climate impacts on society, and,

(c) Weather water and climate user requirements, local procedures and priorities,

should have completed successfully the BIP-M as defined in the *Technical Regulations* (WMO-No. 49) and, in taking into account conditions (a) to (c), should be able to perform the work indicated in the five top-level competencies below:

1. Analyse and continually monitor the evolving weather situation;

2. Interpret observational and model data to forecast meteorological phenomena and parameters;

3. Warn of hazardous phenomena;

4. Ensure the quality of meteorological information, systems and services;

5. Communicate weather, water and climate information to internal and external users.

Each of these top-level competency areas is expanded below into second-level competencies that are expressed and structured in such a manner as to facilitate the clear application of an assessment procedure. Each is also associated with a range of background knowledge and skills which may not be particular to meteorology but are nonetheless essential discharge of the forecaster's duties.

1. Analyse and continually monitor the evolving weather situation

(a) Read and interpret coded/plotted weather observations;

(b) Use atmospheric sounding, surface and upper-air weather charts;

(c) Analyse surface and upper-air weather charts, together with satellite, radar and other available data to correctly identify weather features relevant to (or, likely to be relevant to) the area of forecast responsibility;

(d) Issue, cancel or amend forecasts and warnings according to documented thresholds, criteria and regulations.

1.1 Background knowledge and skills

(a) Has knowledge of the theory, methods and practices of meteorological analysis and diagnosis;

(b) Can visualize/conceptualize meteorological information in multiple dimensions (spatial, temporal);

(c) Demonstrates an understanding of the influence of topography, land cover and, if relevant, bodies of water and/or snow fields on local meteorology;

(d) Demonstrates an understanding of synoptic, dynamical and physical meteorology;

(e) Can correctly interpret satellite imagery, including composite multi-channel imagery;

(f) Can correctly interpret weather radar and other ground-based remotely sensed imagery;

(g) Demonstrates an understanding of meteorological sensors and instruments;

(h) Demonstrates knowledge of the acquisition, processing and assimilation of meteorological data, including quality control.

2. Interpret observational and model data to forecast meteorological phenomena and parameters

(a) Evaluate model predictions with observations and imagery and make adjustments to the model forecast parameters;

(b) Interpret model forecasts at different time ranges;

(c) Utilize Ensemble Prediction Systems (EPS) output to estimate forecast uncertainty, especially for hazardous conditions.

2.1 Background knowledge and skills

(a) Demonstrates an understanding of the methods used in numerical weather prediction (NWP), including EPS;

(b) Understands the strengths and limitations of the NWP models used in the forecast office;

(c) Can critically examine a variety of forecast models and make a reasoned estimation of the most likely evolution of the weather.

3. Warn of hazardous phenomena

(a) Use the forecast production systems to produce and disseminate forecasts and warnings;

(b) Respond to systems failure to ensure continuation of service.

3.1 Background knowledge and skill

(a) Demonstrates an overview knowledge of the communications systems in use in the forecast office;

(b) Shows a thorough knowledge of the visualization and display systems used for weather information, and an ability to recover/view all of the information contained therein.

4. Ensure the quality of meteorological information, systems and services

(a) Follow sound scientific principles in the development and monitoring of all meteorological products;

(b) Assess and interpret meteorological information objectively;

(c) Organize the work required on each shift to ensure that forecasts and other output are issued in good time;

(d) Verify forecasts and warnings;

(e) Mentor junior colleagues and provide support and advice as required;

(f) Contribute to a cooperative and positive work dynamic in the forecast office.

4.1 Background knowledge and skills

(a) Works in a cooperative fashion with colleagues and external stakeholders;

(b) Deals with confrontational situations, demonstrating tact and consideration for differing points of view;

(c) Has the resilience, self-discipline and stamina necessary to work shifts as required to ensure continuation of service to users and the public;

(d) Makes sound decisions under the pressure of deadlines and carrying workloads;

(e) Demonstrates an understanding of the technical knowledge and methodologies necessary to work in a multidisciplinary team.

5. Communicate weather, water and climate information to internal and external users

(a) Prepare forecasts texts;

(b) Prepare warnings texts including information on likely impacts and possible mitigation activities;

(c) Present information on hydrometeorological hazards through the mass media, in particular television, radio, press and the Internet;

(d) Communicate forecast uncertainty to users;

(e) Provide briefings to colleagues/peers;

(f) Contribute to the preparation and maintenance of operational manuals;

(g) Create training resources and deliver training as required;

(h) Create and deliver presentations on meteorological topics to external agencies and the public.

5.1 Background knowledge and skills

(a) Demonstrates an understanding of users' needs for, and use of, meteorological information;

(b) Demonstrates an understanding of the application of meteorology to human activities.

Annex 2 to Resolution 5 (CBS-15)

COMPETENCY REQUIREMENTS FOR WEATHER BROADCASTERS

These competency requirements are for Public Weather Services/weather forecasters who specialize in media work and routinely present weather information on radio or television, or prepare material for weather websites. They build upon, and should be read in conjunction with, the competency requirements for a Public Weather Services/weather forecaster, although it is recognized that some people engaged in weather broadcasting may not come from a forecasting background.

There are three top-level competency areas for the work of weather broadcasters, as follows:

(a) Oral and written communication;

(b) Effective use of tools and systems;

(c) Self-management and team-working.

Each of these areas is expanded below into second-level competencies that are expressed and structured in a manner that facilitates the clear application of an assessment procedure. Not all of these second-level competencies will be relevant to each weather broadcaster; the individual context of each weather broadcaster will need to be considered when establishing relevancy.

1. Oral and written communication

(a) Is aware of the range of users reached through media forecasts;

(b) Understands the likely impact of upcoming weather on users and their activities;

(c) Identifies the key points in the weather story and develops these into a coherent narrative or presentation;

(d) Articulates the weather story in clear and natural language and achieves a well-paced delivery of information during weather broadcasts;

(e) Prepares effective weather graphics that visually communicate the weather story;

(f) Communicates the concept of forecast uncertainty to viewers and listeners;

(g) Presents warnings of hydrometeorological hazards clearly and effectively, including information on possible mitigating actions where appropriate;

(h) Understands the working environment of journalists and other media professionals;

(i) Provides clear, structured briefings to colleagues/peers;

(j) Creates and delivers presentations on meteorological topics to external agencies and to the public;

(k) Prepares and delivers educational material to a wide range of audience, from children to fellow-professionals.

2. Effective use of tools and systems

(a) Has a thorough knowledge and understanding of the function and operation of the different hardware elements (PCs, servers, mixers, amplifiers, cameras, etc.) commonly employed in weather broadcasting;

(b) Has a thorough knowledge of the weather graphics software packages used to prepare weather bulletins, and an ability to exploit this knowledge effectively;

(c) Knows the routine production protocols appropriate to their own service provision environment and understands the requirements of routine production;

(d) Has an ability to design and incorporate new graphic elements into a weather bulletin while maintaining alignment with broader editorial policies.

3. Self-management and team-working

(a) Works in a cooperative fashion with colleagues from a National Meteorological and Hydrological Service (NMHS) and, where appropriate, with the editorial and production staff of a broadcaster;

(b) Knows the editorial policy applied to weather broadcasting and is capable of developing and proposing revisions to such policies in response to changing circumstances, both meteorological and otherwise;

(c) Delivers weather broadcasts reliably and on time in accordance with broadcast schedules;

(d) Implements, where relevant, the "Single Official Voice" policy with respect to warnings of severe weather and other public safety messages;

(e) Is suitably groomed towards an acceptable on-screen presence, taking relevant social and cultural norms into account. Presents an appearance that enhances the brand values of the NMHS and the broadcaster, and does not detract from, or conflict with, the proper tone of the weather message;

(f) Has the confidence to express personality in a manner that facilitates the authoritative delivery of the weather forecast;

(g) Is able to sell and promote weather presentation services to broadcast companies, understands the concept of branding, and has the ability to articulate the benefits of good weather broadcasting practices both within the NMHS and to broadcaster;

(h) While appreciating the role of commercial sponsorship in weather broadcasting, does not allow such sponsorship to obscure, or conflict with, the weather message;

(i) Critiques his or her own and other broadcasters' performances, and communicates these to others in a constructive and positive manner;

(j) Mentors junior colleagues and provides support and advice as required.

Annex 3 to Resolution 5 (CBS-15)

COMPETENCY REQUIREMENTS FOR PUBLIC WEATHER SERVICES ADVISORS ENGAGED IN USER INTERACTION, MEDIA LIAISON AND OTUREACH ACTIVITIES

These competency requirements are for Public Weather Services (PWS) Advisors who specialize in media liaison work and in education/outreach. They build upon, and should be read in conjunction with, the competency requirements for a PWS/weather forecaster, although it is recognized that some people engaged in media liaison and outreach on behalf of a National Meteorological and Hydrological Service (NMHS) may not come from a forecasting background.

There are four top-level competency areas for the work of media liaison and outreach, as follows:

(a) Oral and written communication;

(b) Effective use of tools and systems;

(c) User interaction;

(d) Self-management and team-working.

Each of these areas is expanded below into second-level competencies that are expressed and structured in a manner that facilitates the clear application of an assessment procedure. Not all of these second-level competencies will be relevant to each PWS Advisor; the individual context of each weather broadcaster will need to be considered when establishing relevancy.

1. Oral and written communication

(a) Is aware of the range of users reached through media forecasts;

(b) Understands the likely impact of upcoming weather on users and their activities;

(c) Presents warnings of hydrometeorological hazards clearly and effectively, including information on possible mitigating actions where appropriate;

(d) Understands the working environment of journalists and other media professionals;

(e) Provides clear, structured briefings to colleagues/peers;

(f) Works closely with colleagues responsible for Communication and Public Affairs in the NMHS to assist in preparing press releases or interviews as required;

(g) Creates and delivers presentations on meteorological topics to external agencies and to the public;

(h) Prepares and delivers educational material to a wide range of audience, from children to fellow professionals;

2. Effective use of tools and systems

(a) Has thorough knowledge of the channels used to communicate weather and related information, and an ability to exploit this knowledge effectively;

(b) Knows the routine production protocols appropriate to their own service provision environment.

3. User interaction

(a) Demonstrate knowledge of the methods, operational procedures and organization relating to the investigation of user requirements and assessment of service benefits;

(b) Provide guidance to users to assist their proper understanding of meteorological service information in taking informed decisions;

(c) Provide advice and comments on the potential improvement of meteorological services and products in accordance with user requirements.

4. Self-management and team-working

(a) Works in a cooperative fashion with colleagues from an NMHS and, where appropriate, with journalists and other media staff;

(b) Is suitably groomed towards an acceptable presence, taking relevant social and cultural norms into account. Presents an appearance that enhances the brand value of the NMHS;

(c) Is able to sell and promote weather presentation services to broadcast companies, understands the concept of branding and has the ability to articulate the benefits of good weather broadcasting practices both within NMHSs and to broadcasters;

(d) While appreciating the role of commercial sponsorship in weather broadcasting, does not allow such sponsorship to obscure, or conflict with, the weather message;

(e) Demonstrates appropriate levels of trust, integrity, consideration of broadcast needs, timeliness, confidentiality and discretion in all work activities;

(f) Demonstrates respect for differences in approach and values;

(g) Mentors junior colleagues and provides support and advice as required.

Annex 4 to Resolution 5 (CBS-15)

COMPETENCY REQUIREMENTS FOR DISASTER PREVENTION AND MITIGATION WEATHER ADVISORS

These competency requirements are for weather advisors who work in the area of Disaster Prevention and Mitigation (DPM) and engagement with the Emergency Management (EM) community. They build upon, and should be read in conjunction with, the competency requirements for a Public Weather Services (PWS)/weather forecaster, although it is recognized that some people engaged in liaison and outreach in EM on behalf of a National Meteorological and Hydrological Service (NMHS) may not come from a forecasting background. In such cases, the DPM Advisor needs to work closely with the PWS/weather forecaster to develop the products and services indicated in the following sections. A DPM Advisor, taking into consideration the following conditions (a) to (c):

(a) The geographical area of responsibility,

(b) Weather, water and climate impacts on society,

(c) Weather, water and climate societal requirements, local procedures and priorities,

should be able to perform the work (in close association with the PWS/weather forecaster if needed) indicated in the five top-level competencies below:

1. Communicate warnings and associated information to users;

2. Develop products, procedures and services to meet community and user needs;

3. Develop and manage DPM stakeholder relationships;

4. Promote and implement impact assessments and community outreach;

5. Ensure the quality of information, services and procedures.

Each of these top-level competency areas is expanded below into second-level competencies that are expressed and structured in such a manner as to facilitate the clear application of an assessment procedure. Each is also associated with a range of background knowledge and skills which may not be particular to meteorology but are nonetheless essential for the discharge of the weather advisor's duties.

1. Communicate warnings and associated information to users

(a) Present information at times of severe weather through the mass media, and in particular television, radio and the press, at a frequency specified by pre-determined arrangements;

(b) Tailor weather warning products for disaster management decision support and for other key users;

(c) Communicate forecast and warning uncertainty to users;

(d) Apply new technology and scientific research in Multi-Hazard Early Warning Systems, including meteorological and hydrological observations and telecommunication networks (experience sharing with success stories, and detailed synthesis of these good practices);

(e) Integrate city-specific numerical weather prediction with the warning process.

2. Develop products, procedures and services to meet community and user needs

(a) Identify the weather, climate and water information requirements of the disaster management and civil protection community to ensure the necessary support may be provided;

(b) Ensure formatting and timely dissemination of warnings in order to facilitate the actions of disaster management community to safeguard life and property;

(c) Ensure the use of appropriate language and terminology in NMHSs' warnings;

(d) Tailor weather warning products for disaster management decision support and for other key users;

(e) Develop very short-range forecasting and nowcasting methods and products tailored for the disaster management community;

(f) Develop Ensemble Prediction Systems-based probabilistic forecasts of weather related threats, based on user needs for such products;

(g) Develop impact-based forecast products to assist the emergency management and civil protection agencies with their decision-making processes;

(h) Assist in improving dissemination of warning information through utilization of new communication technologies.

3. Develop and manage DPM stakeholder relationships

(a) Establish working relationships at operational and technical levels with the emergency management and civil protection community, including identification of contact points and their coordinates (address, telephone, facsimile, e-mail, etc.);

(b) Build relationships with the media to enable optimal dissemination of warnings prior to and during weather threats;

(c) Strengthen the coordination between NMHSs and relevant agencies and public service providers in cities and megacities to improve the emergency planning, preparedness and responses of the city as a whole to weather threats;

(d) Assist in the design of effective warning signal systems for coordinated emergency response to natural hazards;

(e) Develop, in close coordination with the disaster management and civil protection authorities, response advice and call-to-action statements based on the potential impact of the hazards in the region of concern.

4. Promote and implement impact assessments and community outreach

(a) Assess the socio-economic impacts of weather related disasters, in collaboration with social science experts;

(b) Foster coordination with socio-economic experts in order to evaluate the benefits of Early Warning Systems of weather, hydrological and climate hazards;

(c) Enable sustainable and institutionalized feedback mechanisms, including user-based service assessment and product verification, for evaluating and improving NMHSs' warnings;

(d) Promote community awareness and preparedness for weather-related disasters through public education and outreach.

5. Ensure the quality of information, services and procedures

(a) Work with the disaster management authorities to strengthen the role of NMHSs in the national disaster management structures as the "Single Official Voice" for warnings of severe weather;

(b) Develop a communication strategy to foster the authority of NMHSs, as the "Single Official Voice" for warnings of severe weather, to ensure credibility of, and effective public response to, these warnings;

(c) Build emergency plans and develop standard operational procedures to facilitate multi-agency and multi-hazard risk management and planning;

(d) Improve documentation and archiving systems for meteorological hazard and impact data, including data rescue, quality assurance and data management;

(e) Engage with international projects including the World Weather Information Service, Severe Weather Information Centre, METEOALARM and the Severe Weather Forecasting Demonstration Project and other WMO initiatives.

Annex 5 to Resolution 5 (CBS-15)

COMPETENCY REQUIREMENTS FOR PERSONS ENGAGED IN THE IMPROVEMENT, INNOVATION AND DELIVERY OF METEOROLOGICAL SERVICES AND PRODUCTS

These competency requirements are primarily aimed at National Meteorological and Hydrological Service (NMHS) personnel who are engaged in the area of improvement, innovation and delivery of meteorological services and products. They should be read in conjunction with the competency requirements for a Public Weather Services/weather forecaster, although it is recognized that many people engaged in these aspects of NMHSs work may not come from a forecasting background.

(a) Knowledge of synoptic meteorology, including observing systems;

(b) Knowledge of numerical weather prediction (NWP) systems;

(c) User focus, knowledge of sectoral applications of meteorological and hydrological information, oral and written communication;

(d) Effective use of tools and systems;

(e) Team-working and effective self-management.

Each of these areas needs to be expanded into second-level competencies that must be expressed and structured in a manner that facilitates the clear application of an assessment procedure.

1. Knowledge of synoptic meteorology, including observing systems

(a) Demonstrates knowledge of the acquisition, processing and assimilation of meteorological data;

(b) Demonstrates an understanding of synoptic, dynamical, and physical meteorology;

(c) Demonstrates an understanding of the influence of topography and (if relevant) bodies of water and/or snow fields on local meteorology;

(d) Demonstrates knowledge of the methods and practices of meteorological analysis and diagnosis.

2. Knowledge of numerical weather prediction (NWP) systems

(a) Demonstrates an understanding of the methods used in NWP;

(b) Understands the strengths and limitations of the NWP models used in the forecast process.

3. User focus, knowledge of sectoral applications of meteorological and hydrological information, oral and written communication

(a) Demonstrates an understanding of the application of meteorology, and in particular meteorological services, to human activities;

(b) Demonstrates an ability to work with the users to understand the nature of their business and their needs for improved or new products and services, and is capable of using this information to work effectively on his or her own or with other colleagues who are responsible for product and service improvement and innovation, to meet these requirements;

(c) Can provide clear, structured briefings to users and colleagues;

(d) Can create and deliver presentations on meteorological topics to users, external agencies and the public;

(e) Can create training resources and deliver training as required;

(f) Can contribute to the preparation and maintenance of operational manuals.

4. Effective use of tools and systems

(a) Shows a thorough knowledge of user visualization and display systems utilized for weather information;

(b) Demonstrates knowledge of the production systems in use in the forecast office, and the proper employment of these systems in producing and disseminating forecasts and warnings;

(c) Keeps abreast of the science of meteorology and related technological advance and can specify and lead the development of meteorological products and services relevant to his/her own NMHS to meet user needs;

(d) Demonstrates an ability to respond appropriately to systems' failure and to use all available/necessary means to ensure continuation of service.

5. Team-working and effective self-management

(a) Works in a cooperative fashion with colleagues and with external stakeholders;

(b) Makes sound decisions under the pressure of deadlines and carrying workloads;

(c) Deals effectively with confrontational situations, demonstrating tact and consideration for differing points of view;

(d) Demonstrates an understanding of the technical knowledge and methodologies necessary to work in a multidisciplinary team;

(e) Demonstrates appropriate levels of trust, integrity, consideration of client needs, timelines, confidentiality and discretion in all work activities;

(f) Follows sound scientific principles in the development and monitoring of all meteorological products;

(g) Demonstrates respect for differences in approach and values;

(h) Mentors junior colleagues and provides support and advice as required;

(i) Serves as a role model through consistent demonstration of integrity and professional values;

(j) Holds others accountable to their professional obligations.

Resolution 6 (CBS-15)

PROVISION OF OPERATIONAL METEOROLOGICAL ASSISTANCE TO HUMANITARIAN AGENCIES

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The *Abridged Final Report with Resolutions and Recommendations of the Fourteen Session of the Commission for Basic Systems* (WMO-No. 1040), Annex X, which contains the terms of reference of the Task Team on Meteorological Services for Improved Humanitarian Planning and Response under the Open Programme Area Group on Public Weather Services that was established by the Commission,

(2) The final report of the first meeting of the Task Team on Meteorological Services for Improved Humanitarian Planning and Response (Geneva, 31 August–2 September 2010),

Noting further:

(1) That the Emergency Response Activities programme has been highly successful in assisting National Meteorological and Hydrological Services and other relevant agencies of Members, as well as relevant international organizations, to respond to environmental emergencies,

(2) That the Global Data-processing and Forecasting System programme is carried out through the provision of specialized products by designated Regional Specialized Meteorological Centres, and through the development and implementation of efficient procedures for the provision and exchange of specific data, information and products, and training,

(3) That the Public Weather Services Programme is responsible for the coordination and support for the use, interpretation and delivery of products and services to the users,

Recalling:

(1) That the Global Data-processing and Forecasting System is the basis for the operational provision of accurate, reliable and timely weather, climate, water, and related environmental forecasts and products by all WMO operated meteorological centres,

(2) That Public Weather Services Programme provides the interface between providers and users of meteorological products and services,

(3) That the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485), Part I, Appendix I-5 – Arrangements for the provision of meteorological assistance to United Nations humanitarian missions is out of date,

Considering:

(1) The expressed needs of humanitarian agencies for weather, climate, water and environmental information to mitigate the impacts of meteorological-related hazards,

(2) The importance of collaborating with relevant international organizations in aspects of mitigating the impacts of meteorological-related hazards,

Decides to establish a Commission for Basic Systems Task Team on the Provision of Operational Meteorological Assistance to Humanitarian Agencies, incorporating the legacy of the Task Team on Meteorological Services for Improved Humanitarian Planning and Response with terms of reference as given in the annex to the present resolution;

Requests the presidents of technical commissions to continue to guide the cross-programmatic aspects related to the provision of effective support to humanitarian agencies.

Annex to Resolution 6 (CBS-15)

TERMS OF REFERENCE OF THE COMMISSION FOR BASIC SYSTEMS TASK TEAM ON THE PROVISION OF OPERATIONAL METEOROLOGICAL ASSISTANCE TO HUMANITARIAN AGENCIES

The Commission for Basic Systems (CBS) Task Team on the Provision of Operational Meteorological Assistance to Humanitarian Agencies is established under the joint leadership/responsibility of the Open Programme Area Groups on Data-processing and Forecasting System and on Public Weather Services, and in liaison with other relevant technical commissions and Programmes. The CBS Task Team is chaired by the CBS Coordinator on Disaster Risk Reduction.

(a) Based on the identified needs and requirements of humanitarian agencies, develop designation criteria and functions for existing Global Data-processing and Forecasting System 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 National Meteorological and Hydrological Services (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 Emergency Response Activities, 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 the regional and national levels;

(d) Coordinate with relevant United Nations and international organizations on collecting and responding to their requirements;

(e) 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.

Resolution 7 (CBS-15)

OPEN PROGRAMME AREA GROUPS OF THE COMMISSION FOR BASIC SYSTEMS

THE COMMISSION FOR BASIC SYSTEMS,

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

(1) Surface- and space-based components of the global observing systems,

(2) Information systems and 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 the WMO Integrated Global Observing System (WIGOS), in particular the work of the expert, implementation/coordination and inter-programme expert teams and/or rapporteurs established by the Commission 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 scientific and technical developments on observing technology and techniques of the surface-based and space-based components of the 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 the 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 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 the Commission;

(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 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;

(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, in particular the work of the expert and implementation/coordination teams and/or rapporteurs established by the Commission 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 the International Telecommunication Union and the International Organization for Standardization;

(c) To monitor the operation of the WMO Information System (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 subregional 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 monitoring 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 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 the Commission;

(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 and the Global Framework for Climate Services;

(3) To re-establish the OPAG on 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 the Commission 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 production of sub-seasonal to longer-time scales, on the basis of the emerging requirements from Regional Climate Centres, Regional Climate Outlook Forums and National Meteorological and Hydrological Services, and in the context of 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, 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 Data-processing and Forecasting System and recommend training events as appropriate;

(j) To monitor progress on implementation of the current WMO Strategic and Operating Plans on matters related to the GDPFS and ERA programmes, and to contribute to the development of the next Strategic and Operating Plans and the related strategic aims of the Commission;

(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;

(4) To re-establish the OPAG on Public Weather Services 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 the Commission under the responsibility of the OPAG, and to liaise and cooperate with the other OPAGs, and regional associations technical teams;

(b) To integrate “The WMO Strategy for Service Delivery” and its Implementation Plan by using them to guide development of its work;

(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 National Meteorological and Hydrological Services 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, multi-scale early warning systems within an operational end-to-end service delivery framework;

(f) To coordinate with the OPAG on Data-Processing and Forecasting System on matters related to assistance to National Meteorological and Hydrological Services in the

delivery of products and services, and to promote and support the education and training of the public and other users of such 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, as well as the inclusion of information on the impacts of weather phenomena and the corresponding advice, and coordinate the related recommendations for application by Members;

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

(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 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 the Commission;

Decides further:

(1) To designate a Coordinator on Disaster Risk Reduction (DRR) with the following terms of reference:

(a) To coordinate Commission activities, across its relevant OPAGs, related to DRR and advise Commission members on activities that will contribute fully to the DRR Programme, including relevant enhanced operation of the World Weather Watch;

(b) To provide the Commission for Basic Systems Management Group with appropriate information and recommendations concerning the DRR-related activities of the Commission;

(2) To designate a Coordinator on Capacity Development with the following terms of reference:

(a) To review and consolidate the contribution of the Commission to the Capacity Development Strategy and the WMO Programme for the Least Developed Countries;

(b) To identify the technical support required for project implementation plans, including guidance materials, technical specifications and project documentation for resource mobilization activities;

(3) To designate a Coordinator on Group on Earth Observations (GEO) and Global Earth Observation System of Systems (GEOSS) activities related to WMO with the following terms of reference:

(a) To coordinate Commission activities, across its relevant OPAGs, related to implementation aspects of the GEOSS 10-Year Implementation Plan and advise OPAGs on activities that will contribute fully to the development and implementation of GEOSS, including enhanced operation of the World Weather Watch relevant to GEOSS;

(b) Through the GEO Secretariat, and with the support of the WMO Secretariat, to keep GEO informed of the relevant activities of the Commission;

(c) To liaise with other regional and technical commission GOESS rapporteurs, with the support of the WMO Secretariat, on relevant GEOSS activities;

(d) To provide the Commission for Basic Systems Management Group with appropriate information and recommendations on GEOSS-related activities of the Commission;

(4) To establish an Inter-Programme Coordination Team on Space Weather with the following terms of reference:

(a) To standardize and enhance space weather data exchange and delivery through WIS;

(b) To harmonize the definition of end products and services, including, for example, quality assurance guidelines and emergency warning procedures, in interaction with aviation and other major application sectors;

(c) To integrate space weather observations, through the review of space- and surface-based observation requirements, harmonize sensor specifications and monitor plans for space weather observation;

(d) To encourage the dialogue between the research and operational space weather communities;

(5) To select, in accordance with Regulation 33 of the WMO General Regulations (2011 edition):

L.P. Riishojgaard (United States) as chair and J. Dibbern (Germany) as co-chair of the OPAG on Integrated Observing Systems;

M. Dell'Acqua (France) as chair and K. Tsunoda (Japan) as co-chair of the OPAG on Information Systems and Services;

K. Mylne (United Kingdom) as chair and Y. Honda (Japan) as co-chair of the OPAG on Data-Processing and Forecasting System;

G. Fleming (Ireland) as chair and M. Jiao (China) as co-chair of the OPAG on Public Weather Services;

T. Onsager (United States) as co-chair and a representative chosen by the Commission for Aeronautical Meteorology as co-chair of the Inter-programme Coordination Team on Space Weather;

M. Jean (Canada) as Coordinator on Disaster Risk Reduction;

J. Kongoti (Kenya) as Coordinator on Capacity Development;

A. Gusev (Russian Federation) as Coordinator on GEO and GEOSS activities related to WMO;

Requests:

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

(2) The chairs of the OPAGs, the Coordinator on Disaster Risk Reduction, the Coordinator on Capacity Development and the Coordinator on GEO/GEOSS activities related to WMO to submit a report to the Commission not later than three months prior to its session.

Note: This resolution replaces Resolution 2 (CBS-XIV), which is no longer in force.

Resolution 8 (CBS-15)

COMMISSION FOR BASIC SYSTEMS MANAGEMENT GROUP

THE COMMISSION FOR BASIC SYSTEMS,

Recalling:

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

(2) The *Abridged Final Report with Resolutions of the Sixtieth Session of the Executive Council* (WMO-No. 1032), general summary, paragraph 3.4.43,

(3) Resolution 1 (CBS-XIV) – CBS Management Group,

(4) Resolution 2 (CBS-XIV) – Open Programme Area Groups,

Recognizing:

(1) That the effectiveness of the Commission 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 Commission for Basic Systems (CBS) Management Group with the following terms of reference:

(a) To advise the president on all matters related to the work of the Commission;

(b) To provide inputs to the president as regards priorities and the planning, coordination, monitoring and evaluation of the work of the Commission, its Open Programme Area Groups (OPAGs), expert teams and rapporteurs;

(c) To advise the president as regards the provision of the Commission's input to the WMO Strategic Plan and the Operating Plan, and the monitoring and evaluation of activities relevant to the CBS-related expected results;

(d) To manage and evaluate OPAG activities, with special attention to the five WMO strategic high-priority areas: the Global Framework for Climate Services, aviation meteorological services, capacity development for developing and least developed countries, implementation of the WMO Integrated Global Observing System (WIGOS) and the WMO Information System (WIS), and disaster risk reduction with specific attention to providing the lead for WIS and relevant technical aspects of WIGOS;

(e) To keep under review the internal structure and working methods of the Commission and make necessary adjustments;

(f) To advise the president on matters related to collaboration with, and provision of technical advice for, regional associations in support of WMO basic systems;

(g) To advise the president on matters related to cooperation and collaboration with other technical commissions in support of other WMO and related international programmes;

(h) To coordinate the activities of the Commission with respect to the Global Earth Observation System of Systems;

(i) To advise the president on all team leader designations necessary between sessions of the Commission;

(j) To review and endorse the work plans of CBS expert teams and approve their membership;

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

(a) President of CBS (chair);

(b) Vice-president of CBS;

(c) Chairs and co-chairs of the four OPAGs;

(d) CBS Coordinator for Disaster Risk Reduction;

(e) CBS Coordinator on Capacity Development;

(f) CBS Coordinator on the Group on Earth Observations (GEO) and Global Earth Observation System of Systems (GEOSS) activities related to WMO.

Note: This resolution replaces Resolution 1 (CBS-XIV) and Resolution 2 (CBS-Ext.(98)), which are no longer in force.

RECOMMENDATIONS ADOPTED BY THE SESSION

Recommendation 1 (CBS-15)

IMPLEMENTATION AND SUSTAINABILITY OF THE DATABASE OF OBSERVATION REQUIREMENTS AND OBSERVING CAPABILITIES

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The pivotal role of the Rolling Review of Requirements database in the Rolling Requirements Review process within the WMO Integrated Global Observing System,

(2) The need to maintain quantitative observational user requirements for the WMO application areas,

(3) The benefit of maintaining a unique reference source of information on evolving satellite plans in support of global coordination of the space-based observing system and in support of user studies and projects,

(4) The benefit of recording the capabilities of space- and surface-based observing systems, in order to perform critical review by comparing those capabilities with the user requirements and identify gaps,

(5) The scope of this database, which includes potentially all WMO Programmes and co-sponsored programmes, including new fields of activities such as space weather,

Considering:

(1) That it is critical to ensure sustainability and reliability of such types of complex information,

(2) That this must rely on collaborative efforts of satellite operators, expert groups and the Secretariat, under the guidance of the Commission for Basic Systems,

Recommends:

(1) That resources be assigned with high priority within the Secretariat to complete the software development and, on a sustained basis, for technical maintenance, first-level contents updating and, through consultancy, for technical-level updating and quality control, as a key activity of the WMO Integrated Global Observing System;

(2) That Members, expert teams of the Open Programme Area Group on Integrated Observing Systems, satellite operators including the Expert Team on Satellite Systems and members of the Coordination Group for Meteorological Satellites, support the database updating process through submitting inputs and providing reviews and feedback.

Recommendation 2 (CBS-15)

REVISED FUNCTIONAL SPECIFICATIONS FOR AUTOMATIC WEATHER STATIONS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The request of its extraordinary session in 2006 to revise automatic weather station (AWS) functional specifications,

(2) The Expert Team on Requirements and Implementation of AWS Platforms (ET-AWS) Work Plan 2009–2012 to revise AWS functional specifications,

Considering that the AWS functional specifications have been reviewed and updated based on the inputs and proposals of other WMO technical commissions,

Recommends that the revised functional specifications for automatic weather stations in the annex to the present recommendation be approved;

Requests the Secretary-General to make arrangements for publication of the revised functional specifications in the *Guide to the Global Observing System* (WMO-No. 488).

_____

Note: This recommendation replaces Recommendation 2 (CBS-XIV), which is no longer in force.

Annex to Recommendation 2 (CBS-15)

FUNCTIONAL SPECIFICATIONS FOR AUTOMATIC WEATHER STATIONS

(Note: Updated table entries and notes are shown in bold text.)

VARIABLE [1)]	Maximum effective range [2)]	Minimum reported resolution [3)]	Mode of observation [4)]	BUFR / CREX [5)]	Status [5)]
ATMOSPHERIC PRESSURE					
Atmospheric pressure	500 – 1080 hPa	10 Pa	I, V	0 10 004	**OP**
TEMPERATURE [9)]					
Ambient air temperature (over specified surface) [14)]	–80 °C – +60 °C	0.1 K	I, V	0 12 101	**OP**
Dew-point temperature [14)]	–80 °C – +60 °C	0.1 K	I, V	0 12 103	**OP**
Ground (surface) temperature (over specified surface) [14)]	–80 °C – +80 °C	0.1 K	I, V	**0 12 120**	**VAL**
Soil temperature [14)]	–50 °C – +50 °C	0.1 K	I, V	0 12 130	**OP**
Snow temperature [14)]	–80 °C – 0 °C	0.1 K	I, V	**0 12 131**	**VAL**
Water temperature – river, lake, sea, well	–2 °C – +100 °C	0.1 K	I, V	0 13 082 or **0 22 043**	**OP** **OP**
HUMIDITY [9)]					
Relative humidity	0 – 100%	1%	I, V	0 13 003	**OP**
Mass mixing ratio	0 – 100%	1%	I, V	**0 13 110**	**VAL**
Soil moisture	0 – 10^3 g kg^{-1}	1 g kg^{-1}	I, V	**0 13 111**	**VAL**
Water vapour pressure	0 – 100 hPa	10 Pa	I, V	0 13 004	**OP**

VARIABLE [1)]	Maximum effective range [2)]	Minimum reported resolution [3)]	Mode of observation [4)]	BUFR / CREX [5)]	Status [5)]
Evaporation/evapotranspiration	0 – **0.25** m	0.1 kg m^{-2} 0.0001 m	T	**2 01 130** 0 13 033 **2 01 000**	**OP**
Object wetness duration	0 – 86 400 s	1 s	T	**0 13 112**	**VAL**
WIND					
Direction	0 [11,13)]; 1° – 360°	1°	I, V	0 11 001	**OP**
Speed	0 – 75 m s^{-1}	0.1 m s^{-1}	I, V	0 11 002	**OP**
Gust speed	0 – 150 m s^{-1}	0.1 m s^{-1}	I, V	0 11 041	**OP**
X,Y component of wind vector **Z component of wind vector** (horizontal and vertical profile)	**–150** – 150 m s^{-1} **–40 – 40 m s^{-1}**	0.1 m s^{-1}	I, V	**0 11 003** **0 11 004** **0 11 006**	**OP** **OP** **OP**
Turbulence type (Low levels and wake vortex) [16)]	up to 15 types	BUFR Table **Not specified yet**	I, V	—	**N**
Turbulence intensity [16)]	up to 15 types	BUFR Table **Not specified yet**	I, V	—	**N**
RADIATION [6)]					
Sunshine duration	0 – 86 400 s	60 s	T	0 14 031	**OP**
Background luminance	**0 – 1·10^5** Cd m^{-2}	**1**Cd m^{-2}	I, V	**0 14 056**	**VAL**
Global downward solar radiation	0 – **1·10^8** J m^{-2}	**1. 10^2** J m^{-2}	I, T, V	**0 14 028**	**OP**
Global upward solar radiation	**–1·10^8 – 0** J m^{-2}	**1. 10^2** J m^{-2}	I, T, V	**0 14 052**	**VAL**
Diffuse solar radiation	**0 – 1·10^8** J m^{-2}	**1. 10^2** J m^{-2}	I, T, V	**0 14 029**	**OP**
Direct solar radiation	**0 – 1·10^8** J m^{-2}	**1. 10^2** J m^{-2}	I, T, V	**0 14 030**	**OP**
Downward long-wave radiation	**0 – 6·10^7** J m^{-2}	**1. 10^3** J m^{-2}	I, T, V	0 14 002	**OP**
Upward long-wave radiation	**–6·10^7 – 0** J m^{-2}	**1. 10^3** J m^{-2}	I, T, V	0 14 002	**OP**
Net radiation	**–1·10^8 – 1·10^8** J m^{-2}	**1. 10^2** J m^{-2}	I, T, V	**0 14 053**	**VAL**
UV-B radiation [8)]	**0 – 26·10^4** J m^{-2}	**1** J m^{-2}	I, T, V	**0 14 072**	**VAL**
Photosynthetically active radiation [22)]	0– **6·10^7** J m^{-2}	**1·10^3** J m^{-2}	I, T, V	**0 14 054**	**VAL**
Surface albedo	0 – 100%	1%	I, V	0 14 019	**OP**
Soil heat flux	**–1·10^8 – 1·10^8 J m^{-2}**	**1. 10^2 J m^{-2}**	**I, T, V**	**0 14 057**	**VAL**
CLOUDS					
Cloud base height	0 – 30 km	10 m	I, V	0 20 013	**OP**
Cloud top height	0 – 30 km	10 m	I, V	0 20 014	**OP**
Cloud type, convective vs. other types	up to 30 classes	BUFR Table	I	0 20 012	**OP**
Cloud hydrometeor concentration	1 – 700 hydrometeors dm^{-3}	1 hydrometeor dm^{-3}	I, V	**0 20 130**	**VAL**
Effective radius of cloud hydrometeors	2·10^{-5} – 32·10^{-5} m	2·10^{-5} m	I, V	**0 20 131**	**VAL**
Cloud liquid water content	1·10^{-5} –1.4·10^{-2} kg m^{-3}	1·10^{-5} kg m^{-3}	I, V	**0 20 132**	**VAL**
Optical depth within each layer	Not specified yet	Not specified yet	I, V	**—**	**N**
Optical depth of fog	Not specified yet	Not specified yet	I, V	**—**	**N**
Height of inversion	**0 – 1 000 m**	**10 m**	**I, V**	**0 20 093**	**VAL**
Cloud cover	0 – 100%	1%	I, V	0 20 010	**OP**
Cloud amount	0 – 8/8	1/8	I, V	0 20 011	**OP**
PRECIPITATION					
Accumulation [7)]	0 – **1600 mm**	0.1 kg m^{-2}, 0.0001 m	T	0 13 011	**OP**
Depth of fresh snowfall	0 –1000 cm	0.001 m	T	**0 13 118**	**VAL**
Duration	up to 86 400 s	60 s	T	0 26 020	**OP**
Size of precipitating element [17)]	1·10^{-3} – **0.25** m	1·10-3 m	I, V	**0 13 058** **0 20 066**	**OP**
Intensity – quantitative	0 – 2000 mm h^{-1}	0.1 kg m^{-2} s^{-1}, 0.1 mm h^{-1}	I, V	**0 13 155**	**OP**
Type	up to 30 types	BUFR Table	I, V	0 20 021	**OP**
Rate of ice accretion	0 – 1 kg dm^{-2} h^{-1}	1·10-3 kg dm^{-2} h^{-1}	I, V	**0 13 114**	**VAL**

VARIABLE [1)]	Maximum effective range [2)]	Minimum reported resolution [3)]	Mode of observation [4)]	BUFR / CREX [5)]	Status [5)]
OBSCURATIONS					
Obscuration type	up to 30 types	BUFR Table	I, V	0 20 025	**OP**
Hydrometeor type	up to 30 types	BUFR Table	I, V	0 20 025	**OP**
Lithometeor type	up to 30 types	BUFR Table	I, V	0 20 025	**OP**
Hydrometeor radius	$2\cdot10^{-5}$ – $32\cdot10^{-5}$ m	$2\cdot10^{-5}$ m	I, V	**0 20 133**	**VAL**
Extinction coefficient	0 – 1 m^{-1}	**0.00001 m^{-1}**	I, V	**0 15 029**	**VAL**
Meteorological Optical Range [10)]	1 – 100 000 m	1 m	I, V	**0 15 051**	**VAL**
Runway visual range	1 – 4 000 m	1 m	I, V	0 20 061	**OP**
Other weather type	up to 18 types	BUFR Table	I, V	0 20 023	**OP**
LIGHTNING					
Lightning rates of discharge	0 – **4 500 000** h^{-1}	**1 h^{-1}**	I, V	**0 20 126**	**VAL**
Lightning discharge type (cloud to cloud, cloud to surface)	3 types	BUFR **Code** Table	I, V	**0 20 023**	**OP**
Lightning discharge polarity	2 types	BUFR **Code** Table	I, V	**0 20 119**	**VAL**
Lightning discharge energy	Not specified yet	Not specified yet	I, V	**—**	**N**
Lightning – distance from station	0 – **$2\cdot10^5$** m	10^3 m	I, V	**0 20 127**	**VAL**
Lightning – direction from station	1° – 360°	1 degree	I, V	**0 20 128**	**VAL**
HYDROLOGIC AND MARINE OBSERVATIONS					
Flow discharge – river	0 – $2.5\cdot10^5$ m^3 s^{-1}	0.1 m^3 s^{-1}	I, V	**0 23 040**	**VAL**
Flow discharge – well	0 – 50 m^3 s^{-1}	0.001 m^3 s^{-1}	I, V	**0 23 041**	**VAL**
Ground water level	0 – 1 800 m	0.01 m	I, V	**0 13 074**	**VAL**
Ice surface temperature [14)]	–80 °C – +0 °C	0.5 K	I, V	**0 12 132**	**VAL**
Ice thickness – river, lake [15)]	0 – 50 m	0.01 m	I, V	**0 08 029** **0 13 115**	**VAL**
Ice thickness – glacier, sea [15)]	0 – 4 270 m	1 m	I, V	**0 08 029** **0 13 115**	**VAL**
Ice thickness [18)]	0 – 3 m	0.015 m	T	**2 01 133** **2 02 129** 0 20 031 **2 02 000** **2 01 000**	**OP**
Water level	0 – 100 m	0.01 m	I, V	0 13 071 0 13 072	**OP** **OP**
Wave height	0 – 50 m	0.1 m	V	0 22 021	**OP**
Wave period [18)]	0 – 100 s	1 s	V	**2 01 129** 0 22 011 **2 01 000**	**OP**
Wave direction	0 [13)]; **1** – 360 degrees	1 degree	V	0 22 001	**OP**
1D spectral wave energy density [18)]	0 – $5\text{x}10^5$ $m2Hz^{-1}$	10^{-3} $m2Hz^{-1}$	V, T	**2 01 135** 0 22 069 **2 01 000**	**OP**
2D spectral wave energy density [18)]	0 – $5\text{x}10^5$ $m2Hz^{-1}$	10^{-3} $m2Hz^{-1}$	V, T	**2 01 135** 0 22 069 **2 01 000**	**OP**
Water practical salinity [18)]	0 – 400 psu12	10^{-3} psu	I, V	**2 01 130** 0 22 064 **2 01 000**	**OP**
Water conductivity [18)]	0 – 600 S m^{-1}	10^{-6} S m^{-1}	I, V	**2 01 132** 0 22 066 **2 01 000**	**OP**
Water pressure [18) 19)]	0 – $11\text{x}10^7$ Pa	100 Pa	I, V	**2 07 001** 0 22 065 **2 07 000**	**OP**
Ice mass	0 – 50 kg m^{-1}	0.5 kg m^{-1} (on 32 mm rod)	T	**0 20 135**	**VAL**
Snow density (liquid water content)	100 – 700 kg m^{-3}	1 kg m^{-3}	T	**0 13 117**	**VAL**
Tidal elevation with respect to local chart datum [18)]	–10 – +30 m	0.001 m	I, V	**2 01 129** 0 22 038 **2 01 000**	**OP**

VARIABLE [1)]	Maximum effective range [2)]	Minimum reported resolution [3)]	Mode of observation [4)]	BUFR / CREX [5)]	Status [5)]
Tidal elevation with respect to national land datum [18)]	–10 – +30 m	0.001 m	I, V	**2 01 129** 0 22 037 **2 01 000**	**OP**
Meteorological residual tidal elevation (surge or offset) [18) 20)]	–10 – +16m	0.001 m	I, V	0 22 040	**OP**
Ocean Current – Direction	0 [13)]; 1° – 360°	1°	I, V	0 22 004 or 0 22 005	**OP**
Ocean Current – Speed	0 – 10 m s^{-1}	0.01 m s^{-1}	I, V	0 22 031 or 0 22 032	**OP**
OTHER SURFACE VARIABLES					
Runway conditions	up to 10 types	BUFR Table	I, V	**0 20 085**	**OP**
Braking action/friction coefficient	up to 7 types	BUFR Table	I, V	**0 20 089**	**OP**
State of ground	up to 30 types	BUFR Table	I, V	0 20 062	**OP**
Type of surface specified	up to 15 types	BUFR Table	I, V	0 08 010	**OP**
Snow depth	0 – 25 m	0.01 m	T	0 13 013	**OP**
OTHER					
Gamma radiation dose rate [12)]	1 – 10^3nSv h^{-1}	**0.1** nSv h^{-1}	I, T	**0 24 014**	**VAL**
Categories of stability	9 types	BUFR Table	I, V	0 13 041	**OP**

Notes:

1. Name of variable, in line with WMO vocabulary and Technical Regulations.
2. Maximum Effective Range – Maximum range of measuring capability; units traceable to SI.
3. Minimum Reported Resolution – Lower resolution of reporting is not permitted.
4. Mode of Observation – Type of data being reported:

   I: Instantaneous – 1-minute value (instantaneous as defined in WMO-No. 8, **Appendix VI.2**);

   V: Variability – Average (mean), Standard Deviation, Maximum, Minimum, Range, Median, etc. of samples – those reported depend upon meteorological variable;

   T: Total – Integrated value over defined period; maximum 24 hours for all parameters except radiation which requires a maximum of one hour (exception, see note 6), and precipitation accumulation (6 hours maximum). **The relevant element descriptor shall be preceded by a time period descriptor 0 04 024 (in hours) or 0 04 025 (in minutes)**.

   A: Average (mean) value.
5. **BUFR/CREX descriptors for representation of the listed variables;**

   OP: Operational descriptors of BUFR/CREX Table B, Version Number 14 and subsequent versions.

   VAL: Descriptors which became operational on 2 May 2012 (BUFR/CREX Table B. Version Number 18).

   N: Not yet specified requirements.
6. Radiation energy amounts are given over a 24-hour period.
7. **Liquid water equivalent**. Maximum interval: 6 hours.
8. Definition of UV-B according to WMO-No. 8 (Vol. 1, Chapter on Radiation). **Descriptor 0 14 072 (Global UV irradiation) was recommended for validation in September 2008, revised in July 2010.**
9. Humidity related variables (*i.e.* dew point temperature) expressed as temperature are collected under temperature.
10. MOR uniquely related to "extinction coefficient",σ, by MOR = –ln(5%)/σ.
11. Direction to indicate 0 (zero) if speed = 0.
12. **Absolute Salinity (kg.kg^{-1}) is now being used for ocean applications (IOC Res XXV-7). However, salinity that is reported to national oceanographic data centres remains the Practical Salinity (psu). Ocean water is about 35 psu. Lake Assal (Djibouti) is the most saline body of water on earth with 348 psu salt concentration.**
13. Calm.

14. **Temperature data represented by 0 12 101, 0 12 103, 0 12 113, 0 12 120, 0 12 130, 0 12 131 and 0 12 132 shall be reported with precision in hundredths of a degree even if they are measured with the accuracy in tenths of a degree. This requirement is based on the fact that conversion from the Kelvin to the Celsius scale has often resulted into distortion of the data values. Temperature t (in degrees Celsius) shall be converted into temperature T (in degrees Kelvin) using equation: T = t + 273.15.**
15. **Ice thickness 0 13 115 shall be preceded by 0 08 029 (Surface type) set to 11, 12, 13 or 14 to specify river, lake, sea or glacier, respectively.**
16. **If the UNIT is specified as "BUFR Table", the BUFR descriptor cannot be proposed without the content of the table being available.**
17. **0 13 058 (Size of precipitation element) is capable to express size of any precipitation element, apart from hailstones. Size of hailstones shall be represented by 0 20 066.**
18. **These requirements being confirmed, it has to be noted that the selected descriptors are suitable for the normal operating conditions and shall be combined with appropriate operator descriptors to allow representation of the extreme values or the requested high precision.**
19. **Operator 2 07 Y is recommended to be used with Water pressure 0 22 065 (Pa, –3, 0, 17), if the data are produced in BUFR, Edition 4. The same result, i.e. change to (Pa, –2, 0, 21) would be obtained by the combined use of the less sophisticated operators 201Y and 202Y:**
    2 01 132
    2 02 129
    0 22 065 Reported value of "Water pressure"
    2 02 000
    2 01 000
20. **The following sequence is to be used to change data width and reference value of 0 22 040 (m, 3, –5000, 14) to become (m, 3, –10000, 15):**
    2 01 129
    2 03 015
    0 22 040 New reference value = –10000
    2 03 255
    0 22 040 Reported value of "Meteorological residual tidal elevation"
    2 01 000
    2 03 000
21. **Gamma radiation dose rate 0 24 014 is intended to be used for reporting of this element under normal conditions, nuclear accidents excluded.**
22. **Photosynthetically active radiation (PAR). Various forms of the electromagnetic energy flux in the 400–700 nm wavelength range, either as integrated spectra or using different weighting functions. For example converted to the photosynthetic photon flux (PPF) in quanta per second per square metre, or mole of quanta per second per square metre or microeinsteins per second per square meter. Approximate conversion is 1 J m^{-2} s^{-1} equivalent to 5 μE m^{-2} s^{-1} based on a mean wavelength of 550 nm.**

Recommendation 3 (CBS-15)

AMENDMENTS TO THE *MANUAL ON THE GLOBAL OBSERVING SYSTEM* (WMO-No. 544), VOLUME I

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The final report of the seventh session of the Expert Team on Satellite Systems (Geneva, 17–19 April 2012),

(2) The final report of the seventh session of the Implementation Coordination Team on Integrated Observing Systems (Geneva, 18–22 June 2012),

Considering the requirement that, for maintaining the *Manual on the Global Observing System* (WMO-No. 544), the need for periodic review is necessary to accommodate timely updates,

Recommends that the *Manual on the Global Observing System*, Volume I, Part IV – Space-based Subsystem be replaced with the text in the annex to the present recommendation.

Annex to Recommendation 3 (CBS-15)

AMENDMENTS TO THE *MANUAL ON THE GLOBAL OBSERVING SYSTEM* (WMO-No. 544), VOLUME I, PART IV – SPACE-BASED SUBSYSTEM

1. COMPOSITION OF THE SUBSYSTEM

The main elements of the space-based subsystem are:

(a) An Earth observation space segment:

(i) Operational satellites on Geostationary Earth Orbit (GEO);

(ii) Operational satellites on distributed, sun-synchronous, Low Earth Orbits (LEO);

(iii) Other operational/sustained satellites or instruments on appropriate orbits;

(iv) Research and development (R&D) satellites;

(b) A space-based intercalibration system;

(c) Associated ground segment for data reception, dissemination, and stewardship;

(d) A user segment.

Notes:

1. Information on the detailed characteristics and capabilities of current and planned systems of environmental satellites of the GOS is contained in the Database on Space-based Observation Capabilities, which is available online: http://www.wmo.int/oscar.

2. Information on the principles of remote sensing from space and on the derivation of geophysical variables from space-based measurements can be found in the *Guide to Meteorological Instruments and Methods of Observations* (WMO-No. 8), Part IV.

2. IMPLEMENTATION OF THE SUBSYSTEM

2.1 General

2.1.1 Requirements: Operators of environmental satellites should meet, to the extent possible, the uncertainty, timeliness, temporal resolution, spatial resolution, and coverage requirements of the GOS as defined in the Rolling Requirements Review (RRR) process described in Part II of this Manual, and recorded in the requirements database: http://www.wmo.int/oscar.

2.1.2 Technical coordination: Members operating satellites should ensure the greatest possible compatibility between their different systems, through following recommended Coordination Group for Meteorological Satellites (CGMS) practices, and publish details of the technical characteristics of their instrumentation, data processing and transmissions, as well as the dissemination schedules.

2.1.3 Continuity: A period of overlap of new and old satellite systems should be ensured to determine inter-satellite biases and maintain the homogeneity and consistency of time series observations, unless reliable transfer standards are available.

2.1.4 Contingency arrangements: The satellite operators, working together under the auspices of the CGMS or otherwise, should ensure the continuity of operation, and the data dissemination and distribution services of the operational satellites within the subsystem.

2.1.5 Data collection platforms:

(a) Members operating satellites with a capability to receive data from Data Collection Platforms (DCP) should maintain technical and operational co-ordination under the auspices of CGMS in order to ensure compatibility;

(b) A number of “international” DCP channels should be identical on all geostationary satellites to allow movement of mobile platforms across their individual footprints;

(c) The satellite operators should publish details of the technical characteristics and operational procedures of their data-collection missions, including the admission and certification procedures.

2.2 Operational satellites on Geostationary Earth Orbit

2.2.1 Missions

The following capability should be provided:

(a) Multispectral visible and infrared imagery;

(b) Infrared sounding;

(c) Lightning mapping;

(d) Data collection from in-situ observing systems;

(e) Space environment monitoring;

(f) Other capabilities as appropriate, e.g. broadband and spectral visible and infrared (for Earth radiation budget estimates), high spectral resolution UV sounding (for atmospheric composition), high-spectral resolution visible and infrared imaging (for ocean colour), solar activity monitoring.

2.2.2 The constellation of satellites in geostationary orbit should provide full disc imagery at least every 15 minutes, throughout a field of view between 60°S and 60°N. This implies the availability of at least six operational geostationary satellites located at evenly distributed longitudes, with in-orbit redundancy. On-demand rapid-scan capabilities should be implemented where feasible.

2.2.3 For the imagery mission the availability rate of rectified and calibrated data should be at least 99 per cent as a target. Contingency plans, involving the use of in-orbit stand-by flight models and rapid call up of replacement systems and launches, should be in place in order to achieve continuity.

2.3 Operational spacecraft on distributed sun-synchronous Low Earth Orbits

2.3.1 Missions

The following capability should be provided on several, distributed orbital planes:

(a) Multispectral visible and infrared imagery;

(b) Infrared sounding;

(c) Microwave imagery;

(d) Microwave sounding;

(e) Scatterometry (for ocean surface winds);

(f) Radar altimetry (for ocean surface topography);

(g) Radio-occultation sounding;

(h) Broadband visible and infrared radiometry for Earth radiation budget measurements;

(i) Passive UV sounding (for atmospheric composition monitoring);

(j) Space environment monitoring including particle detection and magnetic field measurement;

(k) Solar activity monitoring;

(l) Data collection from in-situ observing systems;

(m) Direct broadcast;

(n) Other capabilities as appropriate.

2.3.2 The orbital configuration of satellites in sun-synchronous orbits should enable to provide global coverage for Visible, Infrared and microwave imagery and Infrared and microwave sounding, which represents the core meteorological mission, at least six times per day with a regular temporal sampling. This will require sun-synchronous satellites operated along three orbital planes: one ante-meridian (a.m.) orbit with a descending equatorial crossing around 9:30 Local Solar Time (LST), one post-meridian (p.m.) orbit with an ascending equatorial crossing around 13:30 LST, and one early-morning orbit with an ascending equatorial crossing around 17:30 LST. There should be at least one operational satellite on each of these planes, with redundancy on the a.m. and p.m. orbits.

2.3.3 At least two of these satellites, one in a.m. and one in p.m., should perform Infrared sounding with a hyperspectral sensor.

2.3.4 At least two satellites, one in am and one in pm, should be equipped with radio-occultation receivers.

2.3.5 At least two satellites, on well separated orbits, should be equipped with wind scatterometers.

2.3.6 At least two satellites, one in a.m. and one in p.m., should perform broadband Visible/Infrared Earth radiation monitoring.

2.3.7 At least two sun-synchronous satellites, on well separated orbits, should be equipped with altimeter packages for global ocean surface topography monitoring.

2.3.8 Data from these satellites should be acquired on a global basis, without temporal gaps for blind orbits, and delivered to users to meet timeliness requirements.

2.3.9 The constellation should be designed to achieve a high level of robustness allowing the delivery of imagery and sounding data from at least three polar orbiting planes, in a.m., p.m. and early morning orbit, on not less than 99 per cent of occasions. This implies provisions for ground

segment, instrument and satellite redundancy, and rapid call up of replacement launches or a.m. and p.m. spares.

2.4 Other operational/sustained spacecraft on appropriate Low Earth Orbits

2.4.1 Missions

The following capability should be provided:

(a) High-precision radar altimetry (for ocean surface topography);

(b) Radio-occultation sounding from non sun-synchronous orbits;

(c) Total solar irradiance;

(d) Dual-angle view infrared imagery (for high-accuracy sea surface temperature measurement);

(e) Narrow-band Visible and Near Infrared imagers for ocean colour, vegetation and aerosol monitoring;

(f) High-spatial resolution multispectral Visible and Infrared imagery.

2.4.2 An altimetry mission on high-precision, inclined orbit should complement the two altimetry missions in sun-synchronous orbits to build a robust ocean surface topography constellation.

2.4.3 A constellation of dedicated spacecraft with radio-occultation sensors on appropriate orbits should complement the radio-occultation missions on sun-synchronous orbits.

2.4.4 At least one satellite should perform downward solar irradiance monitoring, with provisions for overlap between consecutive missions in order to maintain measurement continuity.

2.4.5 A sun-synchronous spacecraft should be maintained on an a.m. orbit with high-accuracy Infrared imagery to provide reference measurements of sea surface temperature.

2.4.6 Continuity should be provided for at least one narrow-band Visible and Near Infrared imager on a sun-synchronous a.m. orbit to monitor ocean colour, vegetation and aerosols.

2.4.7 Several sun-synchronous satellites in a.m. orbit should be equipped with high-resolution (10-m class) multispectral Visible/Infrared imagers to build a constellation providing sufficient coverage of the land surface.

2.5 Research and Development satellites

2.5.1 Purposes: The main purposes of research and development satellites are:

(a) To support scientific investigations on atmospheric, oceanic, and other environment related processes;

(b) To test or demonstrate new or improved sensors and satellite systems in preparation for new generations of operational capabilities to meet WMO observational requirements.

2.5.2 Missions: Observing capabilities should be provided to enable for instance the following:

(a) 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 should include for instance: precipitation radars, Doppler lidars, low-frequency microwave radiometers, geostationary microwave imagers and sounders, geostationary narrow-band Visible and Near Infrared imagers, gravimetric sensors, and imagery missions in high-inclination highly elliptical orbits.

2.5.3 Although neither long term continuity of service nor a reliable replacement policy are assured, research and development satellites also provide, in many cases, information of great value for operational use. To this purpose, and in order to promote the early use of new types of data in an operational environment, provisions shall be made when relevant to enable near-real time data availability.

2.6 Inter-calibration system

2.6.1 Operators of environmental satellites should perform rigorous prelaunch instrument characterization and calibration, including radiance confirmation against an international radiance scale provided by a National Metrology Institute.

2.6.2 After launch, all passive instruments should be inter-calibrated on a routine basis against reference instruments or calibration targets, using established and documented methodologies.

2.6.3 Spacecraft with at least one high-quality Hyperspectral Infrared instrument should be maintained in a LEO orbit to provide reference measurements for intercalibration of operational Infrared instruments respectively in geostationary or LEO orbit. Advantage should be taken of satellite collocation to perform instrument intercalibration.

2.6.4 A range of ground-based calibration targets should be maintained, with precise characterization, in order to support routine Visible channel calibration operations.

2.7 Associated ground segments

2.7.1 Members operating environmental observation satellites should make satellite data available to other Members over the WMO Information System (WIS) in accordance with WIS data management practices, and shall inform the Members of the means of obtaining these data through catalogue entries and metadata enabling their meaningful use.

2.7.2 Receiving and processing facilities should provide for the reception of remote-sensing and DCP data from operational satellites and for the processing of quality-controlled environmental observation information, with a view of further near-real time distribution.

2.7.3 Satellite data archives should include Level 1B, together with all relevant metadata pertaining to the location, orbit and calibration procedures used. The archiving system should be capable of providing on-line access to the archive catalogue with a browse facility, and description of data formats, and allowing users to download data.

2.7.4 Data dissemination

All operational environmental observation satellite systems should ensure near-real-time data dissemination of the appropriate datasets, per the requirement of Members, either by direct broadcast or re-broadcast via telecommunication satellites.

2.7.5 In particular, the operational sun-synchronous satellites providing the core meteorological imagery and sounding mission should have Direct Broadcast capability as follows:

(a) Direct broadcast frequencies, modulations, and formats should allow a particular user to acquire data from either satellite by a single antenna and signal processing hardware. To the extent possible, the frequency bands allocated to Meteorological Satellites should be used;

(b) Direct broadcast should be provided through a high data rate stream, such as the High Resolution Picture Transmission (HRPT) or its 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.

2.7.6 Re-broadcast via telecommunication satellites[1] should complement and supplement direct broadcast services, to facilitate access to integrated data streams including data from different satellites, non-satellite data and geophysical products.

2.7.7 Data stewardship

It is essential to preserve long term, raw data records and ancillary data required for their calibration, reprocessing them as appropriate, with the necessary traceability information to achieve consistent Fundamental Climate Data Records. Operators of environmental satellites should provide full description of all steps taken in the generation of satellite products, including algorithms used, specific satellite datasets used, and characteristics and outcomes of validation activities.

2.8 User Segment

2.8.1 Users' stations

2.8.1.1 All Members should 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 re-broadcast service providing the required information in an integrated way, or a combination of dedicated direct readout stations.

2.8.1.2 Members requiring access to data from research and development satellites will need to download these data from the appropriate servers, or install a relevant re-broadcast service providing the required information, or install an appropriate direct broadcast user station, if the R&D satellite has such direct broadcast capability.

2.8.1.3 Data-collection platforms: In order to extend the GOS by the use of the data-collection and relay capability of the environmental observation satellites, Members should establish fixed or moving DCP systems, in particular to cover data-sparse areas.

2.8.2 Education and Training

2.8.2.1 Centres of Excellence

Support should be provided to education and training of instructors in the use of satellite data and capabilities e.g. at specialized Regional Meteorological Training Centres (RMTCs) or other training institutes designated as Centres of Excellence (CoE) in satellite meteorology, in order to build up expertise and facilities at a number of regional growth points.

2.8.2.2 Training strategy

Individual environmental satellite operators should focus their assistance, to the extent possible, on one or more of these CoEs within their service areas and contribute to the Virtual Laboratory (VLab) for Training and Education in Satellite Meteorology. The aim of the Education and Training strategy implemented through the VLab is to systematically improve the use of satellite data for

[1] Formerly referred to as "Advanced dissemination methods" (ADM), this technique generally uses Digital Video Broadcast (DVB) standard or its evolution.

meteorology, operational hydrology, and climate applications, with a focus on meeting the needs of developing countries.

2.8.2.3 User preparation to new systems

For smooth transition to new satellite capabilities, provisions should be made for appropriate preparation of the users through training, guidance to upgrade receiving equipment and processing software, and information and tools to facilitate the development and testing of applications. In addition to working through the VLab, Members should, as appropriate, exploit partnerships with organizations providing education and training in environmental satellite applications, depending on their specific needs.

2.8.3 Engagement between Users and Providers

To achieve the most effective utilization of satellite data, the close engagement between users and providers should be pursued particularly at a regional level. To this end, each regional association is encouraged to follow systematic steps to document the regional requirements for satellite data access and exchange.

3. OBSERVATIONS FROM SPACE

3.1 Observed variables

Satellite systems should provide quantitative data and qualitative information enabling, independently, as a constellation, or in conjunction with surface-based observations, the determination of:

(a) Three-dimension fields of atmospheric temperature and humidity;

(b) Temperature of sea and land surfaces;

(c) Wind fields at the ocean surface and aloft;

(d) Cloud properties (amount, type, top height, top temperature, and water content);

(e) Radiation balance;

(f) Precipitation;

(g) Lightning detection;

(h) Ozone concentration (Total column and vertical profile);

(i) Greenhouse gases;

(j) Aerosol concentration and properties;

(k) Volcanic ash cloud monitoring;

(l) Vegetation characterization;

(m) Flood and forest fire monitoring;

(n) Snow and ice cover;

(o) Ocean colour;

(p) Wave height, direction and spectra;

(q) Sea level and surface currents;

(r) Sea ice monitoring;

(s) Solar activity;

(t) Space environment (Electric and magnetic fields, particle flows, electron content).

Notes:

1. Information on the principles of Earth Observation from space and on the different types of space-based instruments can be found in the *Guide to Instruments and Methods of Observations*, Part IV.

2. The WMO Database on Space-based Observing Capabilities provides an indication of the main instruments that are relevant for each specific variable observable from space, as well as the potential performance of each instrument technique for the relevant variables.

Recommendation 4 (CBS-15)

ACTIONS TOWARDS AVOIDING GAPS IN ESSENTIAL SPACE-BASED OBSERVATION

THE COMMISSION FOR BASIC SYSTEMS,

Noting the crucial importance of space-based observations, which provide the far major part of input data to numerical weather prediction and play a unique role for global climate monitoring,

Considering:

(1) That with the lack of plan for a follow-on to the current Defense Meteorological Satellite Programme, a gap is anticipated by 2020 for imagery and sounding missions on the early morning orbit,

(2) That the requirement for hyperspectral infrared sounding from geostationary orbit will not be accommodated on all geostationary positions in the coming decade according to current plans, but that the possibility to implement such capability through alternative ways, including through free flyers, can be explored,

(3) That there is no path towards an operational follow-on of the planned Global Precipitation Measurement precipitation radar mission, which is expected to play an important role for global climate monitoring, operational hydrology and tropical cyclone monitoring, building on the Tropical Rainfall Measuring Mission successfully operated over 14 years,

(4) That the long-term continuity of upward radiation measurements at the top of atmosphere is not planned on the afternoon orbit after the first Joint Polar Satellite System mission,

(5) That there is no long-term plan for limb sounders to monitor stratospheric ozone and greenhouse gases,

Urges Members to take initiatives and develop plans to fill such gaps;

Recommends that the Coordination Group for Meteorological Satellites continue to monitor the plans with the support of the Commission for Basic Systems Expert Team on Satellite Systems and coordinate efforts towards a comprehensive, robust and optimized space-based observing system.

Recommendation 5 (CBS-15)

PROCEDURE FOR DOCUMENTING REGIONAL REQUIREMENTS FOR SATELLITE DATA ACCESS AND EXCHANGE

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The challenges of access to satellite data in the light of the dramatic expected increase in the volume of satellite data and products available over the next 5–10 years, while user surveys show that actual access often remains well below expectations,

(2) The regional diversity of needs and capabilities of the various types of users, requiring different data access solutions, for example, high-speed versus low-rate,

(3) The recommendation by the Sixteenth World Meteorological Congress that the Commission consider, among its priorities, "to organize the formulation of data requirements and the dialogue between data users and providers" (*Abridged Final Report with Resolutions of the Sixteenth World Meteorological Congress* (WMO-No. 1077), general summary, paragraph 3.7.6),

(4) The conclusions of the Commission at its extraordinary session in 2010, which stated that "*Considering the positive outcome of the RAs III/IV Satellite Data Requirements workshop, the Commission encouraged a similar approach in other Regions where satellite data access is a limiting factor.*" (*Abridged Final Report with Resolutions and Recommendations of the Extraordinary Session (2010) of the Commission for Basic Systems* (WMO-No. 1070), general summary, paragraph 4.2.25),

(5) The value of maintaining a documented set of requirements for access to and exchange of data from existing satellites on the basis of WMO Regions,

Considering:

(1) That the Satellite Data Requirements Task Team established in Regions III (South America) and IV (North America, Central America and the Caribbean) with key support by NOAA and INPE to define and document satellite data requirements, has been successful in strengthening the partnership between data user and providers in these Regions,

(2) That the Regional Association I (Africa) Dissemination Expert Group established by WMO and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), building on the EUMETSAT User Forum in Africa, has proven to be an efficient mechanism to advise EUMETSAT on how to adjust the dissemination contents of EUMETCast to best meet the needs of the users in the Region,

(3) That the Regional Association II (Asia) pilot project on the development of support for National Meteorological and Hydrological Services in the areas of satellite data, products and training has identified the need to review the priority requirements for data and products best responding to regional user needs,

(4) That existing forums to define requirements for access and exchange of satellite data, such as the Asia-Pacific Satellite Data Exchange and Utilization and the North America-Europe Data Exchange meetings, are specifically addressing numerical weather prediction data requirements,

(5) That a common approach to defining such requirements would facilitate their consideration in the context of the Integrated Global Data Dissemination Service, as part of the WMO Information System,

(6) That a procedure derived from the above practices could serve as a model for establishing regional requirements for other types of data within the WMO Integrated Global Observing System,

Recommends that the Procedure for Documenting Regional Requirements for Satellite Data Access and Exchange in the annex to the present recommendation be adopted as a guidance in all Regions;

Requests the Secretary-General:

(1) To inform all presidents of regional associations of the Procedure, with an encouragement to implement it through regional task teams, in coordination with the WMO Space Programme, and including an indication for the possibility for potential support;

(2) To inform all members of the Coordination Group for Meteorological Satellites of the Procedure, encouraging its use at the regional level, including the solicitation for support to regional task teams.

Annex to Recommendation 5 (CBS-15)

PROCEDURE FOR DOCUMENTING REGIONAL REQUIREMENTS FOR SATELLITE DATA ACCESS AND EXCHANGE

Preamble

The development of a set of requirements for satellite data access and exchange in each of the WMO Regions requires interactions between data providers, product producers, the data users in interaction with the stakeholders and end-users. This can best be accomplished if the process is coordinated within the WMO framework and clear guidelines are defined, based on experiences and lessons learned from pilot initiatives.

The present Procedure is proposed to be followed to develop a set of satellite data requirements that reflects the needs of a Region in the areas of interest of WMO Programmes and co-sponsored Programmes.[1]

The needs depend on the climatological context and the regional socio-economic priorities. The feasibility of the requirements also depends on the available data and information sources, the telecommunication infrastructure and the capabilities of the National Meteorological and Hydrological Service itself, which include subject matter expertise, tools and software. Therefore, the requirements should best be formulated at the regional level. The requirements should also be regularly reviewed to adapt to evolving needs and capabilities.

Scope

1. The primary scope of this Procedure is to identify and document the needs of a Region in the areas of interest of WMO Programmes and co-sponsored Programmes for access and exchange of satellite observation data and derived products. The needs of a Region represent the

[1] For example, the Global Climate Observing System, the World Climate Research Programme, the Global Ocean Observing System and the Intergovernmental Panel on Climate Change

collective needs of WMO Members in order to fulfil their national or international role in support of protection of life and property and other socio-economic benefits.

2. Depending on the other mechanisms existing in each specific Region, a later update of the data requirements could encompass the expression of non-satellite data requirements, for example, surface-based observations or model outputs. The additional complexities of non-satellite data requirements and applications, providers and dissemination pathways are not considered in this first version of the Procedure. However, in the long run, such a comprehensive approach should be encouraged.

3. This process should consider both operational and non-operational satellite data, taking advantage of research and demonstration satellite missions.

Establishment of a Regional Task Team for Satellite Data Access and Exchange Requirements

4. A Regional Task Team for Satellite Data Access and Exchange Requirements is initiated by the relevant Regional Association president and established within the relevant regional WMO Integrated Global Observing System (WIGOS) working structure under the technical guidance of the Commission for Basic Systems and supported by the WMO Secretariat.

5. Members of the Task Team are drawn from those experts nominated as being available for the role by Permanent Representatives. The Task Team lead shall be a space-based applications specialist in the Region (for example, member of ET-SUP,[2] VLab CoE[3] representative). As far as practical, the Task Team membership should reflect the subregional diversity and the different fields of expertise involved in WMO Programmes and co-sponsored Programmes. The Task Team members should – collectively – strive to represent the interest of the whole Region including WMO Members who have no direct representative in the Task Team.

6. Representatives of the main satellite data providers for the Region shall be invited to participate in Task Team activities.

7. The Task Team shall be supported by the WMO Secretariat (through the WMO Space Programme, the Regional Programme and other Programmes as appropriate).

8. Terms of reference of the Task Team are decided by the regional association, based on a common template maintained by the WMO Secretariat. The common template sets the scope, purpose, duration, methodology and reporting scheme of the Task Team.

Task Team activities

9. The Task Team identifies the data already available through the existing services (Global Telecommunication System, Internet, bilateral File Transfer Protocol transmission, Direct Readout, multi-mission broadcast services such as GEONETCast). Data and products shall be classified by categories of variables and derived products.

10. The Task Team, with help of the WMO Secretariat and data providers, gathers information on existing products and related inventories, as for example the WMO Product Access Guide and space agencies' product catalogues.

11. The Task team reviews the potential sources of regional needs for satellite data access including: the regional WIGOS Implementation Plan; the outcome of WMO surveys on availability and use of satellite data; input from regional Centres of Excellence; personal experience, expertise

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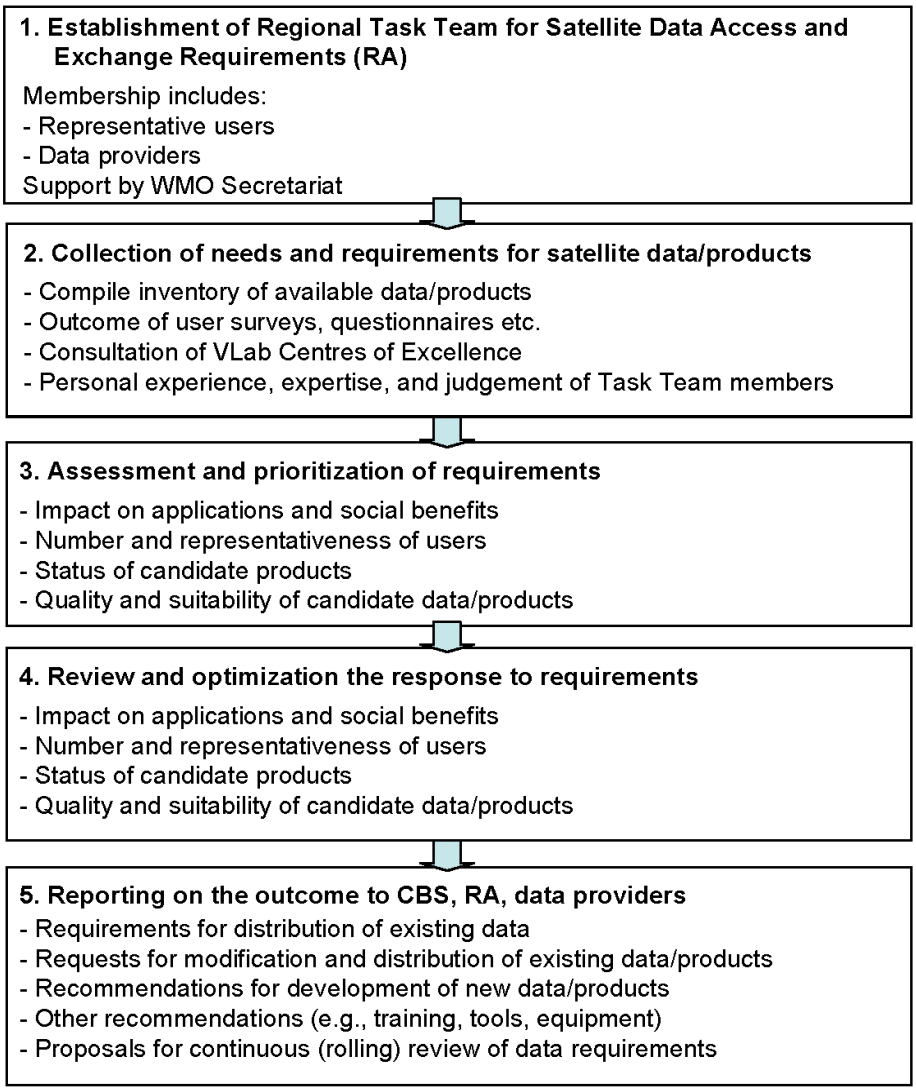
[2] Expert Team on Satellite Utilization and Products, governed by the WMO Commission for Basic Systems Implementation Coordination Team on Integrated Observing Systems

[3] Centre of Excellence for Education and Training in the WMO-CGMS Virtual Laboratory for Education and Training in Satellite Meteorology (VLab)

Workflow: Tasks to be performed to develop and document an initial set of regional requirements for satellite data access and exchange



and judgment of the Task Team members and other available documents such as the Earth observation priorities identified by the Group on Earth Observations for the various Societal Benefit Areas and community-based requirements documented in Global Climate Observing System and Integrated Global Observing Strategy theme reports.

12. The Task Team undertakes further information gathering, such as surveys, as required to ensure that views of WMO Members in the Region are adequately represented.

13. The Task Team analyses the requirements for each relevant category of product, and identifies which requirements are not adequately met by existing services. The unmet requirements are prioritized, taking into account the following:

– The applications supported and their impact;

– The number and representativeness of the users;

– The status of the required data or products;

– The quality and suitability of the required data or products.

14. The WMO Secretariat convenes a workshop, in the Region, with the Task Team and, as required, other data providers, and specialists in the use of satellite data. In this workshop with users and providers, the prioritized list of unmet requirements is reviewed in order to define the optimal response, taking into account the technical options and capabilities available for data distribution, and the capacity of users.

15. In conclusion, the Task Team formulates recommendations pertaining to the following:

– Existing data/products (with detailed references) to be included in existing distribution services (for example, new product on Digital Video Broadcasting by Satellite service) or moving a product from one service to another (for example, Internet product to be put in Low Rate Information Transmission) or assigning lower priority to an existing product (or removing it if obsolete);

– Amendments of existing products or development of new products;

– Evolution (upgrade, or consolidating) of data dissemination means, or other (for example, training, tools, user equipment);

– Short-term action plan to implement these recommendations.

16. Based on this agreed set of requirements, data providers will strive to accommodate these in their operational dissemination procedure. This phase requires active collaboration between the users and data providers in order to test the operational procedures to deliver and use the data/products.

17. The short-term implementation actions are undertaken by the Task Team, calling on additional experts if necessary. The requirements list is updated accordingly.

18. In addition to these tasks, the Task Team is invited to provide feedback to WMO on the global observational requirements registered in the WMO Rolling Review of Requirements database.

19. The Task Team prepares a final report including the latest status of requirements, the status of implementation actions, and a proposal for the regular review of the requirements in the longer term. The final report is provided to the relevant regional association bodies and to the Commission for Basic Systems.

20. The Task Team is then disbanded by the regional association.

Practical guidelines

21. The WMO Secretariat provides one template for two purposes: identifying existing satellite data and products available from satellite operators, and identifying user requirements for such data and products. The template can include for instance: Product Name, Provider, Data characteristics (for example, spatial resolution, accuracy, spectral range, length of record), Format, Geographical area, Frequency, Format expected in the Future, Final Size (compressed), Basic Application, Priority, Timeliness (min) and Required data rate (kb/s).

22. The Task Team leader supports the communication within the Team and organizes its work. The Task Team shall use appropriate tools to support collaborative work (Web page, Google doc, teleconferences or Web meetings) and maintain version control of the data requirements document to facilitate consultation and feedback from the regional user community.

23. In terms of its schedule, the Task Team aims to:

– Within 6 months after its establishment, complete a first draft version of the regional satellite data requirements;

– Within 2 months thereafter, hold the review workshop;

– Within 3 months thereafter, finalize the first version of the Regional Satellite Data Requirements based on consensus among all the Task Team members (both users and providers);

– Complete its Task within 12 months in total.

Maintain the Regional Requirements for Satellite Data Access and Exchange

24. Once the Regional Requirements for Satellite Data Access and Exchange have been established, they need to be maintained on a routine, regular and long-term basis by an appropriate regional mechanism. This could be, for example, a standing Regional Requirements Coordination Group linked to the relevant regional WIGOS working structure. It is up to the WMO regional association to decide upon such a mechanism.

Recommendation 6 (CBS-15)

IMPLEMENTATION PLAN FOR THE EVOLUTION OF GLOBAL OBSERVING SYSTEMS

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The Vision for the Global Observing System (GOS) in 2025 approved by the Executive Council at its sixty-first session in Resolution 6 (EC-LXI) – Report of the fourteenth session of the Commission for Basic Systems relevant to integrated observing systems,

(2) Resolution 3 (Cg-XVI) – Global Observing System,

(3) Resolution 10 (Cg-XVI) – Global Atmosphere Watch Programme,

(4) Resolution 14 (Cg-XVI) – World Hydrological Cycle Observing System,

(5) Resolution 29 (Cg-XVI) – Global Climate Observing System,

(6) Resolution 48 (Cg-XVI) – Implementation of the Global Framework for Climate Services,

(7) Resolution 50 (Cg-XVI) – Implementation of the WMO Integrated Global Observing System,

(8) Resolution 55 (Cg-XVI) – Antarctic Observing Network,

(9) Resolution 60 (Cg-XVI) – Global Cryosphere Watch,

(10) The final report of the seventh session of the Implementation Coordination Team on Integrated Observing Systems (based on recommendations of the Commission for Basic Systems Expert Team on the Evolution of Global Observing Systems),

(11) Resolution 10 (EC-64) – WMO Integrated Global Observing System Framework Implementation Plan,

Considering:

(1) The need for surface and space-based observations to address the requirements of WMO application areas,

(2) The need to consider WMO Integrated Global Observing System and Global Framework for Climate Services requirements and implementation aspects regarding the evolution of global observing systems, WMO priorities and cost-effectiveness of observing systems,

(3) The need to provide Members with clear and focused guidelines and recommended actions in order to stimulate cost-effective evolution of the observing systems to address in an integrated way the requirements of WMO programmes and co-sponsored programmes,

Recognizing:

(1) The importance of global observing systems to address all the requirements of WMO application areas,

(2) The quantitative observational user requirements documented in the WMO Rolling Review of Requirements database,

(3) The critical review performed by experts in each WMO application area, and the identified observational gaps as documented in statements of guidance of those application areas,

(4) The wide lead consultation process of the Commission with the other technical commissions, regional associations, Programmes and co-sponsored Programmes, and relevant experts leading to the drafting and review of the draft Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP) based on the statements of guidance, WMO priorities and cost-effectiveness,

Recommends:

(1) That the Implementation Plan for the Evolution of Global Observing Systems in the annex to the present recommendation be adopted;

(2) That Members, in collaboration with partner organizations, and identified agents in EGOS-IP, address the actions listed in the Plan;

(3) That Members continue to nominate National Focal Points tasked to monitor the implementation of EGOS-IP nationally, report on implementation issues, and provide feedback to the Commission through the Secretariat;

(4) That the technical commissions and regional associations take EGOS-IP into account in their work programmes and promote its effective implementation;

Requests the Secretary-General to bring the Implementation Plan for the Evolution of Global Observing Systems to the attention of Members and identified agents.

Annex to Recommendation 6 (CBS-15)

IMPLEMENTATION PLAN FOR THE EVOLUTION OF GLOBAL OBSERVING SYSTEMS

WORLD METEOROLOGICAL ORGANIZATION

IMPLEMENTATION PLAN FOR THE EVOLUTION OF GLOBAL OBSERVING SYSTEMS (EGOS-IP)

Draft version 13.07

The development of this plan was led by the CBS Open Programme Area Group on the Integrated Observing System (OPAG-IOS), and is a contribution to the WMO Integrated Global Observing System (WIGOS)

WMO OMM

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Chair, Publications Board
World Meteorological Organization (WMO)
7 bis, avenue de la Paix
P.O. Box No. 2300
CH-1211 Geneva 2, Switzerland

Tel.: +41 (0)22 730 84 03
Fax: +41 (0)22 730 80 40
E-mail: Publications@wmo.int

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EXECUTIVE SUMMARY

Introduction

The purpose of this implementation plan is to outline the key activities to be implemented during the period 2012 to 2025 aiming at maintaining and developing all WMO component observing systems. These systems have a collective identity as the WMO Integrated Global Observing System (WIGOS), and the WIGOS vision is taken into account in this plan. The objective of the EGOS-IP is to address the observational requirements of WMO weather, climate and water applications in the most cost-effective way. The component observing systems will also make major contributions to the Global Earth Observation System of Systems (GEOSS) and to the Global Framework for Climate Services (GFCS). Some activities relate to co-sponsored observing systems and will have to be undertaken in close cooperation with partner organizations.

Observations support an increasingly wide range of applications in monitoring and forecasting of the atmosphere, and of the oceans and land surfaces, at different time scales. These activities support an increasing range of services with high socio-economic benefits. User requirements have become more stringent and new requirements have appeared with respect to these applications. More observation systems serve needs for real-time, near-real-time and non-real-time availability. Requirements for observations related to the WMO-IOC-UNEP-ICSU Global Climate Observing System (GCOS) and to the GFCS are expected to increase as well. In many cases, important improvements could be obtained by simply distributing, in a timely manner, observations that are already made for other purposes.

The actions developed in the present EGOS-IP are the results of several ongoing WMO activities, conducted in close cooperation with world experts in relevant disciplines:

- The “Vision for the Global Observing System (GOS) in 2025”, approved by EC-LXI (Geneva, 2009), which provides high-level goals to guide the evolution of global observing systems;
- The “Rolling Review of Requirements” (RRR), which has been carried out for several years. It compares observing systems capabilities with the user requirements in (currently) 12 different WMO application areas, and provides a “Statement of Guidance” (SoG) to identify key gaps;
- The results of impact studies, including observing system experiments and observing system simulation experiments, in some application areas.

Agents for implementation

For the surface-based observing systems the implementation actions rely mainly on national agencies such as National Meteorological Services (NMS) or National Meteorological and Hydrological Services (NMHS), although in several cases, *in-situ* observing networks are implemented by non-meteorological institutes or agencies in the context of an international programme or within a strong international cooperation. In some cases the networks are funded for research purposes and their sustainability is therefore a concern.

For the space-based observing systems, the agents are sometimes national agencies operating satellites for research and/or operational purposes, and sometimes multi-national agencies specialized in space observations.

For both surface and space-based systems, the level of international cooperation needed is high, justifying the existence of several international programmes sponsored or co-sponsored by WMO in partnership with other international organizations.

For land-based in-situ observing networks, the design and development is often carried out through Regional Associations (RAs) which have a key coordination role in their respective regions, using the guidelines of WMO Technical Commissions (TCs), primarily (but not only) CBS. A number of requirements are met through co-sponsored observing systems (GCOS, GOOS, GTOS). Concerning ocean in-situ observing networks, the Joint WMO-IOC Technical Commission

for Oceanography and Marine Meteorology (JCOMM) is involved for all the observing systems making marine meteorological measurements at the surface, as well as oceanographic measurements at the ocean surface or at depth. Atmospheric chemistry observations are implemented through the Global Atmospheric Watch (GAW) Programme and its strategic plan and addendum. For space-based observing systems, there is a general tendency for the satellite observation to be global and less regional than in-situ observing networks. But the role of WMO is equally important, and WMO works in close cooperation with the Coordinating Group for Meteorological Satellites (CGMS), and with national and international agencies.

Some land-based observing networks have a crucial role in climate monitoring and have to be expanded. They are the surface radiation measurements which are complementary to the total solar irradiance obtained from satellite instruments, and all the variables which are necessary to monitor the carbon cycle of the Earth system, especially the soil carbon, and the fluxes of carbon dioxide and methane between the atmosphere, the ocean and the land surface. The GEO Carbon Strategy explains also which institutions are the agents for the implementation of these observations.

Over-arching and cross-cutting actions

In order to meet user needs, actions have to be taken to transfer some research-based observing systems, where they are mature and cost-effective, to an operational status. The changes to existing systems and the development of new systems have to be assessed continuously with the observation users. This is particularly important for several ocean observing systems which are currently maintained by research funding with limited durations. For some observing systems, improved cost-effectiveness is likely to be achieved through an adaptive mode which seeks to vary the observation set according to the meteorological situation.

The integrating role of WIGOS is important for the development of the “Vision for the GOS in 2025”. It is necessary to encourage all operators producing observations to adhere to the WIS and WIGOS standards. The continuity and consistency of data records for the key components of the observing system are also essential for many users.

Data policy actions must be taken to guarantee the continued availability of all essential observational data to all WMO Members, and to ensure a continued adherence to WMO data sharing principles irrespective of the data origin, including data produced by commercial entities. Data policies of Members and WMO need to evolve as user requirements and observing systems evolve to collect and exchange greater quantities and different types of data from a broader range of sources.

By 2025, technical developments will result in more automated procedures, much larger data volumes, and much higher data flow to be transmitted in real-time. Actions are needed to make sure the WIS capacities will be able to handle the observation volume and flow, and also to make sure the radio frequencies needed for WIGOS are protected.

Many developing countries and countries with economies in transition do not have the capabilities or the resources to provide the essential in-situ observations. It is important to tackle this by pursuing capacity building strategies for observing systems through projects funded by international organizations, bilateral partnerships and facilitation of regional cooperation. This may include the provision of guidelines and the organization of training and capacity-building events.

Surface-based observing system

In order to meet the different user requirements, many surface-based observing systems could be made more efficient without necessarily having to produce more observations. This can be realized by processing and exchanging more data, for example in the following ways:

- A global exchange of all hourly data which can be used in global applications, and a promotion of global exchange of sub-hourly data in support of relevant application areas;

- An exchange between different user communities (according to WIGOS standards) of observations coming from the atmosphere, ocean and terrestrial observing systems, with different pre-processing levels when needed.

The upper-air observing systems can be improved through various actions for radiosondes, aircraft data and profilers, such as:

- Making the upper-air global data coverage more uniform when considering all the observation systems together;
- Making a special effort to maintain isolated radiosonde sites or platforms (including Automated Shipboard Aerological Stations – ASAPs);
- Making a special effort to reactivate existing radiosonde sites which have stopped operations or which produce observations which are not transmitted;
- Developing an adaptive component for radiosondes and Aircraft Meteorological Data Relays (AMDARs), in order to produce some observations where and when they are most needed;
- Making a special effort to maintain the GCOS Upper-Air Network (GUAN) radiosonde sites and develop the GCOS Reference Upper-Air Network (GRUAN);
- Improving radiosonde processing and dissemination in order to make available data at a higher vertical resolution, together with position and time for each datum;
- Developing a consistent network of remote-sensing profiling stations on a regional scale;
- Developing and implementing humidity sensors as an integrated component of the AMDAR system.

Most of the surface observing systems over land would greatly benefit from the general actions on WIS/WIGOS standards (concerning the processing and the exchange of observations). Benefits are also expected from more frequent observations data becoming exchanged globally, including those from GAW stations, lightning detection systems and hydrological stations. A very cost-effective way to obtain more surface observations for the different users is to increase and broaden the exchange of observations serving specific applications such as road transport, aviation, agricultural meteorology, urban meteorology and energy production.

Specific actions are needed with respect to weather radar stations in order to:

- Improve the quality of quantitative precipitation estimates;
- Develop a weather radar data processing / exchange framework to serve all the users, achieving homogeneous data formats for international exchange.

Actions have to be taken concerning sea stations, Voluntary Observing Ships (VOS), moored buoys, drifting buoys and ice buoys, in order to improve the geographical coverage of ocean observations, particularly for measuring sea surface temperature, height, salinity, visibility, wave and surface wind.

For the ocean sub-surface, efforts are required in partnership with the Intergovernmental Oceanographic Commission (IOC) of UNESCO to produce more observations (temperature, salinity, etc.) with a high vertical resolution through profiling floats and Expendable Bathy-thermograph (XBT) instruments, and to disseminate all the data in real-time. In the deep ocean, it is challenging to obtain observations, and it is important to push the development of some emerging techniques.

Space-based observing system

The “Vision for the GOS in 2025” foresees an expanded space-based observing capability, an expanded community of space agencies contributing to WMO programmes, and an increased

collaboration between them. More satellites should serve several applications rather than being dedicated to a single scientific activity.

One important issue for most of the space-based components is the continuity and the overlap of key satellite sensors which have to be guaranteed, together with both the real-time and delayed mode data processing and distribution, and also appropriate inter-comparison and inter-calibration procedures.

Continuous actions have to be taken to complement or maintain at least 6 operational geostationary (GEO) satellites separated ideally by no more than 70° of longitude, with at least:

- A visible / infra-red imager;
- A hyperspectral infra-red sounder;
- A lightning imager.

The Low Earth Orbit (LEO) satellite missions should include at least 3 operational sun-synchronous polar orbiting satellites (with equatorial crossing times around 13:30, 17:30 and 21:30 local time, to achieve an optimal global coverage). These orbiting platforms should be equipped with at least:

- A hyperspectral infra-red sounder;
- A microwave sounder;
- A high resolution multi-spectral visible / infra-red imager;
- A microwave imager.

Specific actions are needed for real-time transmission, pre-processing and dissemination to users of the high data volumes which are expected from LEO satellites.

In addition to the core meteorological satellite missions, several other satellite instruments need to be maintained or developed for weather, ocean, climate and other applications. Many of the following instruments serve more than one application area:

- Scatterometer: at least 2 satellites flying on well-separated orbits with a scatterometer onboard are needed;
- Global Navigation Satellite System (GNSS) receivers on LEO satellites: a radio-occultation constellation producing at least 10,000 occultations per day is needed;
- Altimeter: the user requirements call for a reference altimeter mission on a high-precision, non-sun-synchronous, inclined orbit, and 2 other instruments on well separated sun-synchronous orbits;
- Infra-red dual-angle view imager: such an imager onboard a polar orbiting satellite is needed in order to provide sea surface temperature measurements of climate monitoring quality;
- Narrow-band visible / near infra-red imagers: at least one imager of this type is needed for observing ocean colour, vegetation, surface albedo, aerosols and clouds;
- High-resolution multi-spectral visible / infra-red imagers: this type of instrument is important for agricultural meteorology, hydrology, land-use and the monitoring of floods and fires;
- Precipitation radars: associated with passive microwave imagers, these instruments are needed to support the Global Precipitation Measurement (GPM) mission;
- Broad-band visible / infra-red radiometers: this type of radiometer is necessary to monitor the Earth radiation budget (on at least one polar orbiting satellite);
- Various sounders (in the UV, visible and near-infra-red bands) on several GEO and LEO orbits, including a limb-sounding capability. This is mainly for atmospheric chemistry, monitoring of greenhouse gases and air pollution;

– Synthetic Aperture Radar (SAR): it is important to have at least one SAR on a polar orbiting satellite to monitor land surfaces, sea level, water level in flooded areas, etc., in order to contribute effectively to disaster management.

In addition to the instruments on the above list, there are several new or emerging instruments and technologies which should be tested and possibly implemented operationally before 2025. Examples of these on LEO satellites are lidars (for wind, clouds and aerosols) and low-frequency microwave radiometers (for soil moisture and ocean salinity). On GEO satellites, microwave and narrow-band visible / near-infra-red instruments should be demonstrated. Gravimetric sensors have the potential for monitoring the ground water. So far, no meteorological or oceanographic instrument has been flown on a Highly Elliptical Orbit (HEO), and a demonstration of this technology would be valuable.

Space weather

Space weather observations are required: to forecast the occurrence probability of space weather disturbances; to drive hazard alerts when disturbance thresholds are crossed; to maintain awareness of current environmental conditions; to determine climatological conditions for the design of both space-based systems (i.e., satellites and astronaut safety procedures) and ground based systems (i.e., electric power grid protection and airline traffic management); to develop and validate numerical models; and to conduct research that will enhance our understanding. A comprehensive space weather observation network must include ground based and space-borne observatories, with a combination of remote sensing and in-situ measurements.

Actions are needed in particular:

- To coordinate plans ensuring continuity of solar measurements, solar wind and interplanetary magnetic field measurements, and heliospheric imaging from space; to coordinate, standardize and expand the existing ground-based solar observation data; to improve ionospheric monitoring through expanded ground-based GNSS, improved timeliness of space-based GNSS radio-occultation measurements, and sharing of ground-based or space-based GNSS data among the meteorological and space weather communities in near-real-time through the WIS; to coordinate the use of dual-frequency radar altimeter observations by Space Weather community; to increase the availability of ground-based magnetometer data with high timeliness;
- To develop a plan for maintaining and improving space weather observations of the plasma and energetic particle environment.

Implementation strategy

Most of the actions of the document are expected to be feasible by 2025. The main exception is related to research and development actions on emerging observing systems: a lot of uncertainty is attached to some of them regarding their possible operational use by 2025.

The cross-cutting actions (which are not related to one particular observing system) are documented in sections 3 and 4 of this plan. The actions documenting the evolution of the ground-based observing systems are described in section 5, system by system. Those documenting the evolution of the space-based observing systems appear in section 6, also system by system, and those for space weather in section 7.

The implementation of the plan will be reviewed and assessed regularly under CBS guidance during the period 2012–2025, together with other documents, especially the “Vision for the GOS in 2025”. This will require regular reporting of progress against the set of actions within the EGOS-IP.

A summary table of the actions proposed in this implementation plan is provided in Annex II.

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Implementation Plan for the Evolution of Global Observing Systems (EGOS-IP)

1. INTRODUCTION

1.1. Preamble

By 2025, global observing systems will have developed considerably, building upon existing surface- and space-based sub-systems and capitalizing on existing and emerging technologies. They will be the central components of the WMO Integrated Global Observing System (WIGOS), which will provide an integrated and comprehensive system of observing systems in support of the WMO Member States' needs for information on weather, climate, water and related environmental matters. Existing components of the current WMO Global Observing System (GOS) will be interfaced with WMO co-sponsored and other, non-WMO observing systems. They will make major contributions to the Global Earth Observation System of Systems (GEOSS[1]) and to the newly created Global Framework for Climate Services (GFCS[2]). The space-based component will rely on enhanced collaboration through partnerships such as the Coordination Group for Meteorological Satellites (CGMS[3]) and the Committee on Earth Observation Satellites (CEOS[4]). Some observing sub-systems will rely on WMO partner organization systems: the Global Terrestrial Observing System (GTOS[5]), the Global Ocean Observing System (GOOS[6]) and others. Their climate components will be major contributors to the Global Climate Observing System (GCOS[7]).

These observing systems will address the observational requirements of a wide range of application areas across all WMO and WMO-sponsored Programmes, contributing to improved data, products and services from the National Meteorological Services (NMSs) and the National Meteorological and Hydrological Services (NMHSs). Although the observing systems will develop mainly by small incremental additions and technological changes, the scope of the evolution is expected to be major and to involve new approaches in science, data handling, product development and utilization, and training.

1.2. Context

There have been very significant improvements in the WMO Global Observing System (GOS) during the recent decades. They have led to a huge improvement in the range and quality of observations available for operational meteorological activities and hence to the quality of the services that they provide.

The evolution has been particularly significant for the space-based component of the GOS, which is now a composite of many different satellite instruments and systems contributing extensively to a wide range of applications.

In addition to playing their long-standing roles in operational meteorology and supporting rapid advances in numerical weather prediction (NWP), observations have started to support an increasingly wide range of applications, not only in real-time monitoring and forecasting of the atmosphere, but also of the oceans and the land surfaces, including in long-range forecasting at monthly and seasonal scales. User requirements have become more stringent, new requirements and new tools have appeared for these activities, models have progressed rapidly and so have

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1 http://www.earthobservations.org/
2 In 2009, the World Climate Conference-3 (WCC-3) decided to establish a Global Framework for Climate Services (GFCS), to strengthen production, availability, delivery and application of science-based climate prediction and services. More details on: – http://www.wmo.int/pages/gfcs/
3 http://www.cgms-info.org
4 http://www.ceos.org/
5 GTOS is co-sponsored by the FAO, ICSU, UNEP, UNESCO, and WMO – http://www.fao.org/gtos/
6 GOOS is co-sponsored by the ICSU, IOC of UNESCO, UNEP, and WMO – http://www.ioc-goos.org/
7 GCOS is co-sponsored by the ICSU, IOC of UNESCO, UNEP, and WMO – http://www.wmo.int/gcos

their observational requirements. Altogether the observation requirements are becoming increasingly stringent and their evolution increasingly rapid.

The observing requirements take into account all relevant applications within WMO sponsored and co-sponsored programmes. Some are real-time applications, including weather and ocean forecasting. For those the observations are normally exchanged and processed on time-scales from a few minutes to a few hours (depending on the observing technique, on the user requirements and on the type of dissemination). Other applications are operational but can afford longer delays for collecting and using the observations. Others are research activities which are connected to real-time applications, but are not constrained by dissemination delays. Many observation systems serve both real-time and non-real-time needs. The GCOS activities and those of the GFCS have several requirements not affected by real-time constraints, although some aspects can be considerably helped by a real-time or near-real-time exchange of data. Requirements for observations (in terms of variables measured, spatial resolution, frequency of observation, etc.) related to provision of operational climate services under the GFCS are expected to increase as the users of these services become increasingly engaged[8]. In some cases, important improvements could be obtained by simply distributing in real-time observations which are already made for other purposes.

1.3. Background and purpose of the new plan

Under the auspices of the WMO Commission for Basic Systems (CBS), the Open Programme Area Group (OPAG) on the Integrated Observing System (IOS) and its Expert Team on the Evolution of Global Observing Systems (ET-EGOS) guide and monitor the evolution of global observing systems. The OPAG-IOS and the ET-EGOS have overseen the “Rolling Review of Requirements” (RRR) process. Under this process, requirements for observations are classified according to different application areas, and they are quantified in terms of data density (horizontal and vertical resolution), uncertainty (accuracy), observing cycle (frequency), and timeliness, for a comprehensive list of meteorological and environmental variables (wind, temperature, etc.). The RRR process regulates the management of a database[9] containing this information, which is reviewed and updated regularly. The RRR is currently conducted for 12 application areas: global NWP, high-resolution NWP, nowcasting and very short-range forecasting, seasonal to inter-annual forecasting, aeronautical meteorology, ocean applications (including marine meteorology), atmospheric chemistry, agricultural meteorology, hydrology, climate monitoring, climate applications and space weather. Other application areas are added as necessary. For each application area, observation requirements are compared with the capabilities of current and planned observing systems through a “critical review” by experts in the application area. The critical review is also taking into account the results from impact studies. The main deficiencies in present/planned capabilities, in relation to user requirements, are summarized in a gap analysis or “Statement of Guidance” (SoG). The user requirements, the assessment of current and planned capabilities and the SoGs are the primary inputs which have contributed firstly to the “Vision for the GOS in 2025” and now to the analysis and Actions in this Implementation Plan.

The first version of EGOS-IP was developed during the period 2001–2003 and adopted by CBS in 2005. It contained a set of recommendations aimed at improving both the surface and space-based sub-systems of the GOS. This new plan is the result of a complete rewriting of the old plan. The rewriting has been necessary for the following reasons:

- From 2003, many comments and updates have been added on the top of the original recommendations, as part of the process of reporting progress on the EGOS-IP. These comments and updates are now mainly of historical interest and make the document difficult to read;

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8 Users of climate services in the context of the GFCS are a broad and highly diverse group including policymakers, managers, engineers, researchers, students and the public at large, in all sectors and socio-economic systems (including agriculture, water, health, construction, disaster risk reduction, environment, tourism, transportation, etc.), and the full extent of their requirements is not yet known.

9 http://www.wmo.int/pages/prog/www/OSY/RRR-DB.html

- Some recommendations are out-of-date;
- Some new recommendations have been added in the progress report, and many of these are still relevant to the new EGOS-IP;
- The "Vision for the GOS in 2025"[10], which was initiated by ET-EGOS in 2007 and adopted in 2009 by the sixty-first WMO Executive Council (EC-LXI), provides high-level goals for the evolution of observing systems. The new EGOS-IP is a comprehensive response to the new Vision and mirrors it in structure. WIGOS provides a new organizational framework for WMO observing systems, and it is necessary to place EGOS-IP within this framework and to include elements that are important within WIGOS, such as integration and interoperability;
- The new EGOS-IP is more specific concerning who has to take the different implementation Actions;
- The new EGOS-IP responds to the new version of the Implementation Plan for the Global Climate Observing System (GCOS-IP)[11], emerging requirements of the GFCS, and the Global Cryosphere Watch (GCW). In this Plan, Actions are included to emphasize and propagate GCOS requirements for high-quality observations of Essential Climate Variables (ECVs) and the observation practices set out in the GCOS Climate Monitoring Principles (GCMPs).

The purpose of the present EGOS-IP is to document a set of implementation Actions which are important for incremental improvement of global observing systems and for a convergence towards the 2025 Vision. Many of the Actions from the old version of the plan are reiterated and updated. In addition, the new Plan identifies the actors (organizations, bodies) who are responsible of each Action, the expected time-frame, the overall management and monitoring, as well as performance indicators. The performance indicators often refer to "number of observations" or "number of observing systems". Although not specified for each individual Action, these figures should be read as, e.g., number of observations of acceptable quality, and it is envisaged that the WMO Quality Management Framework (QMF), as applied to instruments and observation methods[12], will play an important role here (see section 2.1).

The new EGOS-IP describes the implementation Actions as they are envisaged in the early part of the decade 2010–2020, and it covers the period up to 2025. To monitor the Actions in this Implementation Plan, a progress report will be made regularly; it will describe the progress using this baseline EGOS-IP as reference.

When the existing planned activities appear sufficient to meet the requirements by 2025, no new Action is included in the corresponding sub-section. However, this does not preclude the addition of further Actions at a later date, if monitoring of progress on this Plan shows that the plans of implementing agents have changed and a "gap" has emerged.

Section 3 in this Plan deals with cross cutting Actions, and section 4 addresses special considerations in relation to developing countries. Actions are then documented separately for each observing system – for the surface-based observing systems in section 5, and the space-based observing systems in section 6. Finally section 7 documents the space weather.

2. THE STRATEGIC APPROACH TO IMPLEMENTATION

2.1. Overall approach and relationship to WIGOS

The present plan contains implementation Actions aimed at observing many variables describing the atmosphere and the environment in contact with the atmosphere (ocean, ice and land). It is intended that these Actions are challenging but feasible in the time-frame 2012–2025, although

10 See http://www.wmo.ch/pages/prog/www/OSY/WorkingStructure/documents/CBS-2009_Vision-GOS-2025.pdf
11 See http://www.wmo.int/pages/prog/gcos/Publications/gcos-138.pdf
12 See CIMO Guide (http://www.wmo.int/pages/prog/www/IMOP/CIMO-Guide.html) Part III, Chapter 1 "Quality management"

they may not be completed by 2025. These Actions are derived to a large extent from the gap analyses provided by the RRR process. The priority of the different actions is guided by the RRR in different application areas and by the corresponding SoGs.

The development of these Actions has been informed by a range of information, not only on the gaps between existing/planned observing capabilities and currently-stated user requirements, but also on the most cost-effective ways to fill these gaps. Where possible, guidance has been taken from experiments on the impact of real or hypothetical changes to observing systems. In particular, the results of Observing System Experiments (OSEs), Observing System Simulation Experiments (OSSEs) and other types of impact study performed by NWP centres have been taken into account.

The EGOS-IP Actions specified by this plan take into account the WIGOS vision, requirements, objectives and scope, specified by the WIGOS Development and Implementation Strategy (WDIS), adopted by Cg-XVI (2011), and also the WIGOS Implementation Plan (WIP) to be approved by EC-64 (2012) (see Website[13]):

WIGOS Vision and requirements

The WIGOS Vision calls for an integrated, coordinated and comprehensive observing system to satisfy, in a cost-effective and sustained manner, the evolving observing requirements of WMO Members in delivering their weather, climate, water and related environmental services. WIGOS will provide a framework for enabling the integration and optimized evolution of WMO component observing systems, including WMO's contribution to co-sponsored systems.

To enable improved service delivery, there is a need to improve the existing observing capabilities, make them more cost-effective and sustain their operation. To ensure a coordinated, comprehensive, and sustainable system that meets the requirements of WMO and partners, improved governance, management and integration of observing systems is needed.

Integration must be pursued to ensure interoperability and facilitate optimization across observing components. A principal requirement for integration is the standardization in three key areas: Instruments and Methods of Observation; WMO Information System (WIS) information exchange and discovery; and data management consistent with the QMF.

Quality Management Framework (QMF)

WIGOS is expected to provide timely, quality-assured, quality-controlled and well-documented long-term observations. Implementing Quality Management procedures is required to enable better utilization of existing and emerging observing capabilities.

WIGOS will embrace QMF[14] procedures to ensure that observations, records and reports on weather, water, climate and other environmental resources, operational forecasts, warnings, related information and services are of identified quality, and in compliance with relevant joint standards agreed upon with other international organizations.

This should be based on agreed-upon quality assurance and quality control standards, with the goals of developing and implementing an integrated Quality Management System (QMS); in doing this, and only after effective national implementation, it will deliver reliable and timely data streams with adequate quality control and relevant metadata.

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13 See http://www.wmo.int/wigos
14 http://www.bom.gov.au/wmo/quality_management.shtml

Coordinated Planning and Optimizing of Observing Systems

Within the WIGOS framework, the coordinated planning and optimization of observing systems will be performed through the RRR process, as described in section 1.3.

The development of WIGOS will draw benefits from various pilot projects which are expected to help the long-term development of global observing systems.

The EGOS-IP describes the implementation Actions proposed for each observing system. Other aspects of WIGOS – the management of networks, the relationships with partner organizations, coordination with WIS, etc. – whilst important, are outside the scope of EGOS-IP.

Several elements of the EGOS-IP strategic approach are also shared by the strategic approach of the GCOS-IP. These elements of the strategy are the following:

- Global coverage of surface-based in-situ and remote sensing observing networks. This largely involves improvements in existing networks to achieve the recommended technical, operational and maintenance standards, especially in developing countries;
- Expansion of existing networks and especially improvement of the density and frequency of observations for data-sparse regions, such as the oceans, the tropics and the high latitudes and altitudes, and expansion to meet the emerging requirements of GFCS user communities;
- Improved data acquisition systems and data management procedures, with a goal of minimizing missing data, keeping consistency with the WIS and WIGOS concepts; this includes an adherence to internationally accepted standards for weather, climate, water and related environmental observations, and associated data exchange;
- Effective utilization of satellite data through continuous and improved calibration and/or validation, effective data management, and continuity of current high-priority satellite observations;
- Enhanced monitoring of data availability and quality (at all stages of processing, exchange and use) based on existing data systems;
- Continued generation of new capabilities through research, technical development and pilot-project demonstration.

2.2. Agents for implementation

For the surface-based observing systems the implementation Actions rely mainly on national agencies such as NMSs and NMHSs, although in several cases, in-situ observing networks are implemented by non-meteorological institutes or agencies in the context of an international programme or within a strong international cooperation. In some cases the networks are funded for research purposes and their sustainability is therefore a concern.

For the space-based observing systems, the agents are sometimes satellite operators and national agencies operating satellites for research and/or operational purposes, and sometimes multi-national agencies specialized in space observations.

For both surface and space-based systems, the level of international cooperation needed is high, justifying the existence of several international programmes sponsored or co-sponsored by WMO in partnership with other international organizations. For observing systems evolving from research to operational status, three WMO TCs have a leading role: the Commission for Basic Systems (CBS), the Commission for Atmospheric Sciences (CAS) and the Commission for Instruments and Methods of Observation (CIMO).

For land-based in-situ observing networks, the design and development is often carried out through RAs, which have a key coordination role in their respective regions, using the guidelines of TCs, primarily (but not only) CBS. A number of requirements are met through co-sponsored observing systems (GCOS, GOOS, GTOS). Concerning ocean in-situ observing networks, the

Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) is involved for all the observing systems making marine meteorological measurements at the surface, as well as oceanographic measurements at the ocean surface or at depth. Atmospheric chemistry observations are implemented through the Global Atmospheric Watch (GAW) Programme and its strategic plan and addendum (see web references given in section 5.3.1.4). For space-based observing systems, there is a general tendency for the observations to be global and less regional than in-situ observing networks. But the role of WMO is equally important, and WMO works in close cooperation with the Coordinating Group for Meteorological Satellites (CGMS), and with national and international agencies.

Some land-based observing networks have a crucial role in climate monitoring and have to be expanded. They are the surface radiation measurements which are complementary to the total solar irradiance obtained from satellite instruments, and all the variables which are necessary to monitor the carbon cycle of the Earth system, especially the soil carbon, the fluxes of carbon dioxide and methane between the atmosphere, the ocean and the land surface. The GEO Carbon Strategy[15] explains which institutions are the agents for the implementation of these observations.

3. OVER-ARCHING AND CROSS-CUTTING ACTIONS

This sections of the Implementation Plan follows closely the description of the general trends and issues, as they are documented in the “Vision for the GOS in 2025”, and develops the general Actions which are necessarily associated with these trends and issues.

3.1. Response to user needs

Global observing systems will provide comprehensive observations in response to the needs of all WMO Members and Programmes for improved data, products and services, for weather, water, climate and related environmental matters. Through WIGOS, WMO will continue to provide effective global collaboration in the making and dissemination of observations, through a composite and increasingly complementary system of observing systems.

The sustainability of these observing systems may require partnerships between research and operational agencies. Observations of several variables are made in the context of research programmes or by space agencies whose primary mission is research and development. Once methods are sufficiently mature to guarantee a sustained set of observations to an acceptable level of accuracy, they need to be sustained into the future as an operational observing system if they fulfil the requirements of some user groups.

The operational system includes the observation process, the transmission to a pre-processing centre, and archiving and dissemination to users with procedures compatible with the WIS. These activities may or may not imply a transfer of responsibility from one organization to another. Whenever new or upgraded observing technologies or data processing systems are developed it is essential that there be interaction between the developers and the intermediate and end users to assess requirements and the impact of the new or evolving system before implementation. This will help ensure that all essential requirements are captured, including requirements for homogeneity of observations in time. Provisions should be made to enable users to prepare for new observing systems well in advance of system deployment in terms of data reception, processing and analysis infrastructure, and associated education and training.

At the same time, ongoing attention must continue for existing systems. Long-standing methods of observation remain valuable and should be employed for continuity and expansion of networks to meet user needs.

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15 http://www.earthobservations.org/documents/sbas/cl/201006_geo_carbon_strategy_report.pdf

Action C1

Action: Meet growing user requirements for climate information by encouraging and assisting in expansion of traditional observing platforms for weather and climate observations.
Who: GCOS and CBS to lead the action, together with regional centres representing users and organizations operating component observing systems.
Time-frame: Continuous.
Performance Indicator: Extent to which user needs are met.

Action C2

Action: Once relevant research-based observing systems are shown to be sufficiently mature and cost-effective, follow an appropriate migration methodology to become a sustained operational system.
Who: CBS, in collaboration with CIMO and CAS, to initiate and lead the evolution, with all organizations operating component observing systems.
Time-frame: Continuous. Timetable to be decided on a case by case basis.
Performance indicator: Number of sustained systems compared to the targets.

Action C3

Action: Ensure all operators producing observations adhere to the WIS standards.[16]
Who: Organizations and agencies operating observing programmes. Action monitored by CBS.
Time-frame: Continuous.
Performance: Extent to which WIS standards are applied.

Action C4

Action: Careful preparation is required before introducing new (or changing existing) observing systems. The impact needs to be assessed through prior and ongoing consultation with data users and the wider user community. Also, data users need to be provided with guidance on data reception/acquisition, processing and analysis infrastructure, the provision of proxy data, and the provision of education and training programmes.
Who: All organizations operating component observing systems, following the best practices provided by CBS, CAS or other TCs and co-sponsored programmes.
Time-frame: Continuous.
Performance Indicator: Extent to which user community concerns are captured.

Large parts of marine and ocean observing systems are currently maintained by research funding with limited duration. Considering the importance of continuous, long-term observations for key marine/ocean variables for many applications, including medium-range weather and seasonal climate forecasting, WMO Members should note potential gaps that may occur at the end of these research programmes unless ongoing funding for sustained observing networks is guaranteed. Such observing networks include: (i) the tropical moored arrays; (ii) Argo; (iii) a fraction of barometer upgrades on surface drifters (for weather forecasting); and (iv) altimeter, scatterometer, microwave sea surface temperature (SST) and sea ice measurements from research satellite missions.

Action C5

Action: Ensure sustained funding for the key marine/ocean observing systems (e.g. tropical moorings, Argo, surface drifters with barometers, as well as altimeter, scatterometer, SST from microwave radiometry, sea ice measurements from research satellite missions).
Who: NMSs, NMHSs and partner national institutions, in collaboration with international organizations, TCs responsible for observing system coordination (e.g. JCOMM, CBS, and CIMO) and space agencies.
Time-frame: Continuous.
Performance Indicator: Percentage of observing networks funded through sustained mechanism.

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16 See http://www.wmo.int/pages/prog/wis/

Users require global observing systems to provide observations when and where they are needed in a reliable, stable, sustained and cost-effective manner. They require observations of specified spatial and temporal resolution, accuracy and timeliness. The user requirements will evolve in response to a rapidly changing user and technological environment, based on improved scientific understanding and advances in observational and data-processing technologies. Our ability to measure some key environmental variables is often limited by the lack of suitable techniques. These limitations can vary from the fundamental underlying observing technique to those associated with instrumentation, data processing, suitable calibration/validation techniques, spatial and/or temporal resolution, ease of operation and cost. As new remotely-sensed observations of environmental variables are made, it is critically important that the validation of both the measurements themselves and the retrieval methods used are carried out under a sufficient broad range of geophysical conditions. It is also important to derive observational products in a physically consistent way across ocean, land and atmosphere domains. The development of integrated products requires blending of different datasets or data sources, which needs to be consistent over time and space.

Some level of targeted observations will be achieved, whereby some observations are made or not made, in response to the local meteorological situation and the particular user needs. Their operation should be guided by and in collaboration with NMHSs to ensure interoperability and potential exchange of the data (see also section 5.3.1.1.1).

Action C6

Action: For each observing system proposed for operation in adaptive mode (i.e. a process which would vary the observation set according to the meteorological situation), investigate the feasibility, cost-effectiveness and side effects on the continuity of climate data records.
Who: Organizations operating observing networks on a routine basis. Process to be initiated and coordinated by CBS based on recommendations from CAS, other TCs, the RAs, and GCOS.
Time-frame: Continuous reviewing process of the feasibility and cost-effectiveness assessments.
Performance indicator: Number of networks operated with some level of targeting.

3.2. Integration

WIGOS will provide a framework for enabling the integration and optimized evolution of WMO observing systems (GOS, GAW, GCW, and WHYCOS), including WMO's contribution to co-sponsored systems (GCOS, GOOS, GTOS). Integration will be developed through the analysis of requirements and, where appropriate, through sharing observational infrastructure, platforms and sensors, across systems and with WMO Members and other partners. Surface and space-based observing systems will be planned in a coordinated manner to serve a variety of user needs with appropriate spatial and temporal resolutions in a cost-effective manner.

Data assimilation techniques have an important role to play with respect to a cost-effective integration of the different observing systems serving different applications across different disciplines. Data assimilation techniques are indeed able to add considerable value to observing systems by combining heterogeneous sets of information to provide complete and self-consistent sets of geophysical fields. Taken on its own, each observing system provides only a small sample of information with respect to the ensemble of global requirements as they are documented by the RRR process. However, combined in a global assimilation, the integration of their measurements is able to provide reliable global analyses for many variables, which are essential for many global applications.

For the achievement of this Implementation Plan, an important challenge is to find means for maintaining the long-term operation and the continuity of these observing systems. This does not mean that the continuity of each system should be guaranteed indefinitely; the strategy consists in making sure that the quality of the important variables is not degraded when an instrument or an observing system is replaced by another instrument or another observing system. Several applications use observations which are labelled "research" or "demonstration" for operational

purposes. The border between “research” and “operations” is not well-defined and is moving all the time, mainly because it follows the scientific progress in applications and in data utilization methods. In this context, ensuring that observations of important variables are not degraded may mean ensuring the transition of research/demonstration systems into operational systems (which is recognized to be very challenging).

The integrating role of WIGOS is also supported by the strong complementarity between surface-based and space-based observations. Some examples:

- For observing the atmosphere, surface-based systems are more efficient in the boundary layer whereas satellite instruments are more efficient in the stratosphere and above the clouds;
- High horizontal resolution can be obtained with space-based imagers and sounders with global data coverage; this is impossible to achieve with in-situ observing networks which remain the best systems for high vertical resolution, especially in the lower atmosphere;
- The most accurate SST fields are obtained from a combination of satellite retrievals mixed with in-situ reference measurements.

Observations should be made available to the different users with a timeliness respecting their requirements. They should also be made available using standard practices for data processing, coding formats and dissemination, in order to facilitate the utilization.

Action C7

Action: Ensure time continuity and overlap of key components of the observing system and their data records, in accordance with user requirements, through appropriate change-management procedures.
Who: CBS to lead, in collaboration with other TCs, JCOMM, RAs, satellite agencies, NMSs and NMHSs, and organizations operating observing systems.
Time-frame: Continuous. Timetable to be decided on a case by case basis.
Performance indicator: Continuity and consistency of data records.

3.3. Data policy

The operating paradigm for the GOS has been built on WMO data sharing principles under which all essential data are shared openly among the WMO Members. This has been facilitated by the fact that, in the past, observational data have been provided primarily by national governments and international agencies. User requirements and observing systems have and will continue to evolve. Greater quantities and different types of data are being collected and exchanged, from a broader range of sources. Data policies of Members and WMO need to evolve accordingly.

The potential for an increased role in the future for commercial entities – e.g. hosting of instrument payloads or “data buys” and similar mechanisms – raises important issues regarding the continued availability to all WMO Members of data obtained under such arrangements.

Action C8

Action: For WMO and co-sponsored observing systems, ensure continued adherence to WMO data sharing principles irrespective of origin of data, including data provided by commercial entities.
Who: NMSs and NMHSs, and space agencies. Process monitored by CBS.
Time-frame: Continuous.
Performance indicator: Continued availability of all essential observational data to all WMO Members.

There is also great benefit from open sharing of data by other agencies and every opportunity should be taken to encourage such sharing.

3.4. Expansion

There will be an expansion in both the user applications served and the variables observed. This will include observations to support the production of datasets related to the GCOS essential climate variables (ECVs), adhering to the GCOS climate monitoring principles, and any additional observations required to implement operational climate services at global, regional and national scales under the GFCS. Atmospheric chemistry and hydrology are also two application types requiring an increasing number of variables to be observed from a greater number of stations.

The range and volume of observations exchanged globally will be increased. Several existing local observing systems are currently used only for local or regional applications; they will be used also in global applications as soon as they have proved they are able to bring additional value. The total volume of global data exchange will expand considerably because of new observed variables, because of existing local observations becoming exchanged globally, and because of increased resolutions (time and space) of global observing systems. The role of satellite and radar data sets will expand into applications requiring higher and higher horizontal resolution. This implies that the specialized data centres will have to serve a wider range of applications at all horizontal scales, from global to hectometre scale. This data volume expansion will put pressure on the data processing and dissemination processes which will be operated according to the WIS standards (especially important for real-time applications).

Action C9

Action: Evaluate the future evolution of data volumes to be exchanged and handled, based on the projected data volumes generated by the future space-based and surface-based sources.
Who: WMO/WIS to lead, in collaboration with TCs, JCOMM, RAs, satellite agencies, NMSs and NMHSs, and organizations operating observing systems.
Time-frame: Continuous.
Performance indicator: Evolution of the data volumes handled and exchanged.

Some observations of the land-based cryosphere are part of operational networks; others are part of research programmes and are not acquired in a consistent manner. There is a large and acknowledged gap internationally in the ability to measure reliably solid precipitation (snowfall, snow depth, ice, and rain water equivalent). Solutions should leverage new technologies and techniques for making in situ and remotely-sensed observations, and research is needed to integrate the two types of observations. For example, while snow depth is regularly measured at many land stations, lake ice cover and glacier mass balance are not. Improvements in snowfall observing practices and consistent and regular reporting are needed along with other variables. Some critical snow and ice properties, such as snowfall, snow water equivalent (SWE) and permafrost properties, are difficult to measure from space as well as in situ, though new technologies and satellite sensors are promising. The GCW will evaluate the surface and space-based cryosphere observing systems and will provide recommendations for reducing the gap between current capabilities and user needs.

3.5. Automation

The trend to develop fully automatic observing systems, using new observing and information technologies will continue, where it can be shown to be cost-effective and does not lead to degradation in respect of important requirements of some applications, e.g. climate monitoring. The access to real-time and raw data will be improved. More and more observing systems will have to produce different levels of data, from large volumes of raw data to highly processed data sets. A variety of users will be interested in one or more post-processing levels. It is important to have the different processing packages respecting a general set of WIS standards. Observational data will be collected and transmitted in digital forms, highly compressed where necessary. Data processing will be highly computerized.

A high degree of automation is especially required for observational networks covering areas highly exposed to severe weather phenomena. For nowcasting and risk mitigation in these areas, it is important to have a telecommunication infrastructure that is robust enough against these phenomena. See related **Action G31** on data compatibility.

3.6. Interoperability, data compatibility, consistency and homogeneity

There will be an increased standardization of instruments and observing methods. There will be improvements in calibration of observations and the provision of metadata, to ensure data consistency and traceability to absolute standards. There will be an improved homogeneity of data formats and dissemination via the WIS, and also increased interoperability, between existing observing systems and with newly implemented systems. Metadata are essential for ensuring the quality, traceability and homogeneity of observations, therefore it is essential that an archive of rigorous metadata is maintained to support standardization, enable homogeneity assessments, and ensure data provenance and fitness for purpose.

To ensure consistency and homogeneity of the data sets, the monitoring principles for satellite data which are documented in the GCOS-IP for climatological purposes are all valid to some extent for other WMO applications, including the real-time applications. This is true for the recommendations which concern the time continuity, homogeneity and overlap of the observation, the orbit stability and sensor calibration, the data interpretation, processing and archiving. Global analyses for weather forecasting and other applications are dependent on several key observing systems. The long-term time continuity of these sensors is obviously very important for climate purposes, but it is almost as important for the other applications, including the real-time ones. All these sensors are used in a “synergetic” way, e.g. where one sensor helps in the evaluation of biases and drifts in other sensors. In this process the role of accurate in-situ observations is also important, supporting the GCOS requirements for the GCOS Reference Upper-Air Network (GRUAN).

By 2025 there will be improved methods of quality control and characterization of errors of all observations. Operational systems are needed that can track, identify and notify network managers and operators of observation irregularities, including time-dependent biases, as close to real-time as possible. Such feedback systems are already routine practices for several NWP centres, for the data which are assimilated in operational NWP models, and also for climate monitoring centres to ensure overall data quality. However there is a need to extend these monitoring activities to other applications and also to set up feed-back procedures for observed quantities which cannot be compared to any operational model. Also, even in the existing routine monitoring activities, there is a need to make more rapid and more efficient both the feedbacks to the operators and the correcting actions.

Action C10

Action: Monitor the flow of all essential data to processing centres and to users and ensure timely flow of feedback information to observing network management from monitoring centres.
Who: Data processing centres coordinated by appropriate TCs and international programmes (CBS to lead the process and initiate it when required).
Time-frame: Continuous.
Performance indicator: Usual monitoring criteria[17.]

Action C11

Action: Achieve improved homogeneity of data formats for international exchange, by reducing to a smaller number of internationally coordinated standards.
Who: CBS to lead, in collaboration with other TCs.
Time-frame: Continuous.
Performance indicator: Number of data formats per data type.

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17 http://www.wmo.int/pages/prog/www/ois/monitor/introduction.html

3.7. Radio frequency requirements

WIGOS components make use of a number of different radio applications.

Space-based passive sensing is performed in bands allocated to the Earth exploration satellite (passive) and meteorological satellite service. Passive sensing requires the measurement of naturally occurring radiation, usually of very low power levels and containing essential information on the physical process under investigation.

The relevant frequency bands are determined by fixed physical properties (molecular resonances) that cannot be changed or ignored. These frequency bands are, therefore, an important natural resource. Even low levels of interference received by a passive sensor may degrade its data. In addition, in most cases these sensors are not able to discriminate between natural and man-made radiation. In this respect, the International Telecommunication Union (ITU) Radio Regulations enable the passive services to deploy and operate their systems in the most critical frequency bands.

Several geophysical variables contribute, at varying levels, to natural emissions, which can be observed at a given frequency with unique properties. Therefore, measurements at several frequencies in the microwave spectrum must be made simultaneously in order to extract estimates of the variables of interest from the given set of measurements. Passive frequency bands should hence be considered as a complete system. Current scientific and meteorological satellite payloads are not dedicated to one given band but include many different instruments performing measurements in the entire set of passive bands. Also, full global data coverage is of particular importance for most weather, water and climate applications and services.

Also of great importance is the availability of sufficient and well-protected Earth exploration and meteorological satellite frequency spectrum for telemetry / telecommand, as well as for satellite downlink of the collected data.

The meteorological aids (MetAids) radiocommunication service is used for meteorological and hydrological observations and exploration, and provides the link between an in-situ sensing system (e.g. a radiosonde) for meteorological variables and a remote base station. The base station may be in a fixed or mobile location. Additionally, meteorological radars and wind profiling radars provide important observations. There are currently about 100 wind profiler radars and several hundred meteorological radars world-wide, which provide precipitation and wind information and play a crucial role in meteorological and hydrological alert processes.

The issues related to the above radio spectrum requirements and operation are addressed within WMO by the Steering Group on Radio-Frequency Coordination (WMO SG-RFC). Within Europe, more than 20 National Meteorological Services and other relevant organizations have established the EUMETFREQ programme in order to coordinate their frequency protection activities. Frequency management and protection are particularly important for the WMO Space Programme and Space Agencies have established the Space Frequency Coordination Group (SFCG[18]) to coordinate their activities in this respect.

Action C12

Action: Ensure a continuous monitoring of the radio frequencies that are needed for the different components of WIGOS, in order to make sure they are available and have the required level of protection.
Who: WMO/SG-RFC to lead, in coordination with NMSs, NMHSs and national, regional and international organizations in charge of radio frequency management.
Time-frame: Continuous.
Performance indicator: Observation frequency bands available / not available with required level of protection.

18 See http://www.sfcgonline.org/home.aspx

4. CONSIDERATIONS FOR THE EVOLUTION OF OBSERVING SYSTEMS IN DEVELOPING COUNTRIES

Many developing countries and countries with economies in transition do not have the capabilities or the resources to provide the essential in-situ observations. This is a challenge for the consistency and the homogeneity of observations, especially at the global scale. The support needed by these countries and the mechanisms able to provide this support are the same as those described in the GCOS-IP (see its section on developing countries) for climate purposes, plus some support is often needed to disseminate in real-time observations which are already made, in the proper format, to the WIS.

More effort is needed to support these countries, especially Least Developed Countries (LDCs) and Small Island Developing States (SIDSs), by providing guidelines and organizing training and capacity-building events in the respective Regions. In many areas, including large parts of Africa, Asia and Latin America (Regions I, II, and III and some tropical areas between 25N and 25S), the current surface-based GOS provides insufficient observations. The evolution of observing systems in developing countries must address issues that fall in three categories: (a) lack of public infrastructure such as electricity, telecommunication, transport facilities, etc.; (b) lack of expertise from people to do the job, training, etc.; and (c) lack of funding for equipment, consumables, spare parts, manpower, etc. The lack of infrastructure and expertise may be the result of a lack of funding.

Evolution of observing systems must take into account upgrading, restoring, substitution and capacity building (especially in the use of new technologies). Two aspects need to be considered: the data production and the data use. It is possible that some countries do not and will not be able to produce data and will therefore only be users of data. To help developing countries produce data for international exchange, due consideration must be given to the three issues previously identified, i.e. public infrastructure, expertise and funding.

Possible approaches to observing system evolution in these conditions are the following. A first step should be to identify observing systems that are less dependent on local infrastructure. Where local infrastructure is sufficient, suitable expertise is available, and maintenance can be sustained, it may be possible to augment in-situ observations with other technologies such as satellite data, AMDAR, dropsondes and Automatic Weather Stations (AWS). Automated systems generally require a high level of technical competency and resources to maintain, repair and replace equipment when necessary. The ability to submit manual observations through a globally available web-based system could provide a further alternative for some LDCs and SIDSs.

A minimum set of reliable radiosondes is required as a backbone to the GCOS Upper-Air Network (GUAN). Members should do everything possible to fulfil the operational commitments of stations accepted within the GUAN. NWP impact studies[19] have shown the prominent importance of isolated radiosonde observations for both global and high resolution NWP.

Obtaining vertical profiles (of wind, temperature and, in the near future, humidity) by AMDAR in many data sparse areas appears as a natural way to obtain observations of some basic atmospheric variables in some countries with important airports and very few conventional atmospheric observations.

Capacity building in some countries continues to need attention. International responsibilities for data exchange may be supported by the migration toward the table-driven codes (BUFR[20] or CREX[21]) as a reliable representation of the data. More importantly, it will be necessary to develop and deploy systems for automatically generating messages (such as CLIMAT reports) and to

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19 See http://www.wmo.int/pages/prog/www/OSY/Reports/NWP-4_Geneva2008_index.html
20 FM 94 BUFR Global Telecommunication System (GTS) format – Binary universal form for the representation of meteorological data
21 FM 95 CREX GTS format – Character form for the representation and exchange of data

ensure timely, efficient and quality-controlled flow of essential data, in keeping with the WIS implementation strategy.

Some countries have satellite receiving stations or receive satellite data through the Global Telecommunication System (GTS), but lack the expertise to utilize the information to their benefit. Some countries are acquiring Doppler radar but need training on how to process and interpret the information. For example, Region I has benefited with expanded access to conventional data and satellite imagery through the *Préparation à l'Utilisation de MSG en Afrique* (PUMA) project. This type of project should be expanded to include other data types for routine application (synoptic meteorology, aviation meteorology and nowcasting).

The following guidelines are proposed for the allocation of priorities for technical cooperation activities for the meteorological observing systems (by order of priority):

(a) Set up projects to improve/restore existing and to build new upper-air observational capabilities of the RBSN[22]/RBCN, with emphasis on the activation of silent upper-air stations and the improvement of coverage over data-sparse areas (in particular as regards the purchase of equipment and consumables, telecommunications and the training of staff);

(b) Extend AMDAR coverage to developing countries, LDCs and SIDS to supplement scarce upper-air observations or to provide a cost-effective alternative to countries that cannot afford costly upper-air sounding systems;

(c) Set up projects related to the improvement of data quality, regularity and coverage of surface observations of the RBSN/RBCN with emphasis to the activation of silent stations and the improvement of coverage over data-sparse areas;

(d) Set up projects related to the introduction and/or use of new observing equipment and systems including, where cost-effective, surface-based AWSs, AMDAR, ASAP and drifting buoys.

Technical cooperation for achieving reliable communications would make a valuable contribution to ensure that observations data, once collected, can be widely exchanged.

Finally, the following recommendations should be taken into account when addressing the evolution of observing systems in developing countries:

- Define geographical areas to which priority for additional observations should be given, if additional funding were available;
- Prioritize where the needs are most pressing for WMO Voluntary Cooperation Programme (VCP) or other funding;
- Give high priority, in the Regions to maintaining a minimum radiosonde network with acceptable performance;
- Employ data rescue activities to preserve the historical observation record in developing countries, and make long-term datasets available for activities including reanalysis, research, adaptation, monitoring and other climate services;
- Encourage RAs in concert with CBS to define field experiments over data sparse areas, for a limited time, to evaluate how additional data would contribute to improve performance at the regional and global scale, following the example of the African Multidisciplinary Monsoon Analysis (AMMA[23]) field experiment;
- Examine the extent to which automated stations could become a viable, cost-effective alternative to manned stations for the surface network in the future, and investigate improved configurations of automated and manual stations;

22 GCOS Surface Network (GSN) and GUAN stations are part of the RBSN (Regional Basic Synoptic Network)
23 See http://amma-international.org/

- Follow the GCOS Climate Monitoring Principles (GCMP) and proper change-management practices when changes are made to the climate observing systems through close collaboration between observations managers and climate scientists;[24]
- For nowcasting and risk mitigation in vulnerable areas, the availability of a robust telecommunication infrastructure is an issue (robust against extreme weather conditions). Utilise robust telecommunication networks;
- Use the regional climate centre concept to provide access to specialists who could conduct training and maintenance of more complex systems including AWS.

Action C13

Action: Establish capacity building strategies for observing systems in developing countries through projects funded by International organizations, bilateral partnerships and facilitation of regional cooperation.
Who: NMSs/NMHSs with RAs, CBS, other TCs, in collaboration with international programmes.
Time-frame: Continuous.
Performance indicator: Substantial improvement in observational data return from developing countries.

5. SURFACE-BASED OBSERVING SYSTEM

5.1. Introduction

The surface-based component of the GOS was developed originally to meet the requirements of operational meteorology without consideration of the new and emerging applications now covered by WMO Programmes. The surface-based systems generally provide traceable and temporally consistent observations which are an important historically consistent baseline for many observation systems. The issue of complementarity with the space-based component of the GOS started to be taken into account in the decade 1970-80.

For observing the upper atmosphere, the upper-air synoptic stations (consisting of rawinsondes, radiosondes, radio-wind and PILOT[25] balloon stations) were originally the unique surface-based observing system, until they were complemented by aircraft meteorological measurements and later by remotely-sensed observing systems (profilers and weather radars). The radiosonde station density has always been inadequate with respect to the meteorological requirements over remote areas including the oceans and deserts, and full implementation of the WWW has been a perpetual challenge for WMO even over land areas.

For observing the atmosphere near the surface, the surface observing station network is denser than for the upper-air. Over land it consists mainly of the manned and automatic surface stations. Over sea, it consists mainly of ships of the Voluntary Observing Ships scheme (VOS), fixed and mobile buoys. Many stations which originally served a single purpose (e.g., serving only synoptic or climatological, agricultural meteorology or aviation purposes) have evolved into multi-purpose stations serving multiple programmes and users.

Global synoptic and climatological networks are composed of the Regional Basic Synoptic and Regional Basic Climatological Networks (RBSN/RBCN). RBSN/RBCN should satisfy minimum regional requirements in order to permit WMO Members to fulfil their responsibilities within the World Weather Watch and for monitoring of climate.

Standard observing practices are included in the *Manual on the Global Observing System* (WMO-No. 544) and other Manuals. Recommended practices are included in several Guides, the *Guide to the Global Observing System* (WMO-No. 488) and the *Guide to Meteorological*

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24 See WMO-TD No 1378 on: http://www.wmo.int/pages/prog/wcp/wcdmp/documents/WCDMPNo62.pdf
25 Upper-wind report from a fixed land station

Instruments and Methods of Observation (WMO-No. 8) and other Guides. Individual Actions in this Implementation Plan may result in changes of best practices and in a need to update the above WMO regulatory material. Evolving needs in areas of integration, automation, interoperability, data compatibility, consistency and homogeneity will have to be recognized in the WMO regulatory material. This will be addressed within the implementation of WIGOS and a development of the WIGOS Manual and Guide.

Observing the deep ocean remains a challenge: it cannot be done from space, and very few in-situ systems are available (expendable bathy-thermograph, XBT, instruments from ships, profiling floats). The observation of the ocean surface is less challenging as the satellites can contribute to a large extent, and the observation systems used for meteorology (ships, buoys) can also carry instruments for measuring surface variables like SST.

For observing the land surface, some measurements may be made by surface synoptic stations (such as soil temperature at different levels, state of the ground snow depth and soil moisture). There is also a large variety of stations and networks developed independently for various applications, such as hydrology, urban meteorology, agriculture, monitoring of air pollution, electrical power production. They provide a large variety of variables which are potentially useful for several disciplines and which should be integrated.

Instruments need to be sufficiently robust to sample extremes in keeping with the climatology of the region in which they are deployed. For supporting improved forecasts and climate science, it is essential to withstand high winds, lightning strikes, and to adequately measure extremes in temperature and precipitation.

By 2025, there will be an increased tendency towards the integration of the surface-based observing systems of the three climate components: atmosphere, ocean and terrestrial system. This tendency to integration is natural in the context of the climate monitoring and prediction which require observations from the three components. “Integration” also means that there will be more multi-purpose instruments, stations and networks, and more progress on data interoperability, data exchange and data processing.

Data volumes for some observing systems, such as radiosondes or the surface stations, will stay relatively small. By contrast, for remote-sensing observing systems such as radar, the observed data volume is expected to grow fast (with similarities to satellite data), and the exchanged data volumes are expected to grow even faster.

In the following section (5.2), the generic issues concerning the surface-based global observing systems are put together, with the corresponding recommendations which are appropriate for its implementation in the period 2012–2025. Section 5.3 describes the recommended Actions for the different observing systems which should be used operationally by 2025, including some possible research / development activities which should be carried out, aiming at improving the observing systems.

5.2. Generic issues: representativeness, traceability, instrument calibration, data exchange

To guarantee data quality, especially for climate applications, instrument measurements should be traceable to the International System of Units (SI); that should be done through an unbroken chain of comparisons, quality assessments (including site representativeness) and calibrations of instruments and respective working international standards. Considering the rapid expansion in the number of different agencies operating observing networks (especially AWSs) and their potential contribution to WMO observing systems, evidence of traceability or quality management must be maintained over time. Where traceability to SI is not possible for some manual observations (e.g. cloud type), reference to published WMO standards should be required.

Action G1

Action: Ensure traceability of all meteorological observations and measurements to SI or WMO standards.
Who: NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs, and other relevant organizations. CBS and RAs to lead and supervise.
Time-frame: Continuous.
Performance indicator: Number of stations that make measurements traceable to SI or WMO standards.

The increase of data volumes for some specific observing systems, such as radars and wind profilers, has to be accompanied by actions ensuring capability of WIS to cope with the corresponding increase of data exchange. This increase will be partly due to more frequent observations, e.g., through the automation, or to exchange of existing observations that were not exchanged internationally.

OSEs performed with NWP models have shown that global forecasts can be improved significantly by assimilating hourly data, even if the data are available only on a small portion of the globe, such as hourly atmospheric pressure observations from synoptic stations, radar data, and data from Global Navigation Satellite Systems (GNSS) receiving stations. Similarly, other applications, including climate and aviation, rely increasingly on sub-hourly data. Open and unrestricted access to all available data and their exchange would be needed to improve scope and quality of services provided by NMSs / NMHSs to their users.

Action G2

Action: Ensure, as far as possible, a global exchange of hourly data which are used in global applications, optimized to balance user requirements against technical and financial limitations.
Who: NMSs/NMHSs, RAs, in coordination with CBS and international programmes and agencies. CBS to lead the action.
Time-frame: Continuous. Timetable to be decided for each observing system.
Performance indicators: The standard monitoring indicators used in global NWP (see footnote no. 17 in section 3.6).

Action G3

Action: Promote a global exchange of sub-hourly data in support of relevant application areas.
Who: NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs, and other relevant organizations. CBS to lead the action.
Time-frame: Continuous. Timetable to be decided for each observing system.
Performance indicator: A number of sub-hourly data types exchanged through WIS.

Climate modelling and seasonal forecasts also require an exchange of data between the different centres monitoring the atmosphere, the ocean and the terrestrial sub-system. Although the real-time constraints are less severe than for NWP, it is important to integrate these different observation systems, with common pre-processing and exchange rules, following the WIS and WIGOS standards. Such an action would improve considerably the benefits to the users without creating new observing systems. As the different users have different operational constraints and different requirements in data resolutions, this may imply, for some observing systems producing high data volumes, to organize the processing with different data levels (as done already for many satellite missions). The requirement for the validation of satellite products using surface-based observations can also be addressed by facilitating access to the data.

Action G4

Action: Ensure exchange of observations from atmosphere, ocean, terrestrial observing system, according to the WIGOS/WIS standards. If needed, organize different levels of pre-processed observations in order to satisfy different user requirements.
Who: NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs, and other relevant organizations. CBS to lead the action.
Time-frame: Continuous. Timetable to be decided for each observing system.
Performance indicator: Statistics on the data made available to each application.

Action G5

Action: Surface-based observing network operators should facilitate access to observations suitable to support validation of space-based derivation of surface parameters.
Who: CBS to lead, in collaboration with NMSs and NMHSs.
Time-frame: Continuous.
Performance indicator: Quantity of surface-data made available for the validation of satellite products.

Mainly for the climate monitoring, but also for other applications, it is important:

- To maintain stations with long historically-uninterrupted observation records;
- To perform a regular calibration of instruments;
- To greatest extent possible, adhere to CIMO classification guidelines for siting and maintenance of the station environment;
- To test and intercompare different observing instrument/systems (e.g., radiosonde systems and remote-sensing systems providing different types of vertical profiles with a view of establishing the interoperability of their data);
- To collect and archive sufficient metadata to enable homogeneity assessments to be made and data provenance and fitness for purpose to be assessed;
- For all countries to maintain their GCOS (GSN, GUAN, and RBCN) stations and for these to provide observations on a continuing basis as long as possible.

For more details, see the Quality Management Framework (section 2.1 above).

Action G6

Action: Surface-based observing network operators should consider using space-based observations/products to monitor quality of data from surface-based networks.
Who: CBS to lead, with NMSs and NMHSs.
Time-frame: Continuous.
Performance indicator: Number of surface-based observing systems using satellite data for quality monitoring.

5.3. Issues specific to each observing system component

5.3.1. Upper-air observing systems over land

Upper-air profiles have long been collected using balloon-based methods. These methods are now complemented by a range of other sources over land, over the oceans and from space. WMO now adopts a composite approach, seeking to optimize the use of different methods to satisfy the requirements for upper-air observations. The following section addresses the contributions made by balloon-based upper-air stations, remote sensing profiling stations, aircraft observations, GAW stations and GNSS receiver stations. The contributions made over the oceans are addressed in section 5.3.5 and the contributions made from space are addressed in chapter 6.

5.3.1.1. Upper-air stations[26]

5.3.1.1.1. Radiosonde network and data coverage: optimization

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

26 Including radiosondes, pilot balloon, and dropsondes

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.

Action G7

Action: Expand radiosonde stations, or re-activate silent radiosonde stations, in the data sparse areas of Regions I, II and III which have the poorest data coverage. Make all possible effort to avoid closing of existing stations in these data sparse areas, where even a very small number of radiosonde stations can provide an essential benefit to all the users.
Who: NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs, and other relevant organizations. CBS to lead the action together with the RAs.
Time-frame: Continuous.
Performance indicators: The standard monitoring indicators used in NWP (see footnote no. 17 in section 3.6).

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.

Action G8

Action: Reconsider radiosonde network designs (e.g. by using isolated stations), taking into account other available sources of data, such as AMDAR and wind profilers.
WHO: CBS through NWP impact studies and network design studies, in coordination with NMSs/NMHSs, WMO own and co-sponsored programmes, other TCs, RAs and other relevant organizations. CBS and RAs to lead the action.
Time-frame: 2015 (or earlier) for a first redesign.
Performance indicator: Design developed and implemented.

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[27]) 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 (EUCOS[28]). 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.

27 http://www.wmo.int/pages/prog/www/OSY/Meetings/NWP-4-Geneva2008/Abridged_Version.pdf
28 See http://www.eucos.net/

Action G9

Action: Continue the studies and tests on the usefulness of observations obtained by increasing the frequency of radiosonde launches at some observation sites, in relation with the meteorological situation in the area.
Who: NMSs/NMHSs, research institutions and other organizations operating radiosonde networks or organizing field-experiments, with the NWP centres. CBS and CAS to lead the action.
Time-frame: Continuous, with a time-table depending on regional campaigns.
Performance indicators: A number of radiosonde sites able to become “adaptive” together with the number of observations made (standard monitoring).

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.

5.3.1.1.2. GUAN and GRUAN stations

A selection of upper-air stations from RBSN/RBCN which are significant for both synoptic and climatological purposes form a baseline network called GCOS Upper-Air Network (GUAN). GUAN stations (currently 173) are also used to validate satellite data. GCOS is in the process of coordinating the implementation of an upper-air reference network for upper-air climate observations (GRUAN) that is expected to provide long-term, highly accurate measurements of atmospheric profiles, complemented by ground-based state-of-the-art instrumentation in order to fully characterize the properties of the atmospheric column and their changes. GRUAN is envisaged as a network of 30-40 high-quality, long-term, upper-air observing stations, building on existing observational networks, such as GUAN, the Global Atmospheric Watch (GAW), RBSN and GSN, and providing complete metadata for traceability of measurements. Because there is no other upper-air observing system able to provide a reference at fixed points (satellite and aircraft data are obtained at different positions from one day to another), it is very important to maintain the GUAN and develop the GRUAN (see also section 5.3.8.3).

Action G11

Action: Improve quality, availability and sustainability of GUAN, ensuring maintenance of the existing network, and data quality.
Who: CBS to lead, in coordination with GCOS and with NMSs/NMHSs, TCs, RAs, and other relevant organizations.
Time-frame: Continuous.
Performance indicators: The standard monitoring indicators used in NWP.

Action G12

Action: Continue implementation of GRUAN through support and development of the initial 15 stations and eventual completion of the full 30-40 station network.
Who: CBS to lead in coordination with GCOS and with NMSs/NMHSs, TCs, RAs, and other relevant organizations.
Time-frame: Continuous.
Performance indicators: The standard monitoring indicators used in NWP and the indicators defined in the GRUAN Observation Requirements.

5.3.1.1.3. Improved dissemination

Data from some radiosonde stations are never internationally exchanged in real-time over the GTS, although they may be exchanged and archived locally and made available for climatological purposes. In some cases data exchange over the GTS has several hours delay, which reduces considerably their use for operational purposes. In many cases telecommunication hardware problems or software coding problems are responsible for unavailability of data.

Action G13

Action: Identify radiosonde stations that make regular measurements (including radiosondes operated during campaigns only), but for which data are not transmitted in real-time. Take actions to make data available.
Who: NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs, and other relevant organizations. CBS and RAs to lead the action.
Time-frame: Continuous.
Performance indicator: A number of the above radiosonde stations providing data to GTS, plus standard monitoring indicators on radiosonde data availability and timeliness.

5.3.1.1.4. Reporting of high resolution observations

Many radiosonde observations are thinned (reduction of vertical resolution of the measured profiles) before they are internationally exchanged and assimilated in real-time. As a consequence, NWP and other applications do not have access to radiosonde data at high-vertical resolution, from which they could now derive significant benefits. Also, the user has no access to the exact position and time of each datum. The development of BUFR code for radiosonde data has been driven primarily by the need to address these problems and should help to solve most of the dissemination problems.

Action G14

Action: Ensure a timely distribution of radiosonde measurements at high vertical resolution, together with position and time information for each datum, and other associated metadata.
Who: NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs, and other relevant organizations. CBS and RAs to lead the action.
Time-frame: Continuous.
Performance indicator: Number of radiosonde sites providing the high resolution profiles.

This Action consists of two sub-actions: (i) to code the radiosonde observation in high resolution BUFR (rather than low-resolution BUFR or TEMP[29]); and (ii) to transmit the position and time of each datum.

5.3.1.1.5. Observation of the stratosphere

Only 10 to 20% of the operational radiosonde profiles generally reach 10hPa (about 30km height). Except for some stations from the GRUAN network, whose role is also to serve as reference observations in the lower stratosphere, it may not be cost-effective to deploy radiosondes for measurements in the stratosphere due to the cost of reaching high altitude.

NWP impact studies have shown that the radiosonde data above 100hPa do have a positive impact on forecasts through NWP data assimilation, including on the forecast of tropospheric fields. However, these studies were conducted in a context where neither current satellite sounders nor the GNSS radio-occultation data were assimilated. The question of the usefulness of radiosonde data above 100 hPa should then be reassessed, while recognizing the requirement for continuity of data above 100hPa for climate monitoring.

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29 FM-35 TEMP GTS format : Upper-level pressure, temperature, humidity and wind report from a fixed land station

Action G15

Action: Perform NWP impact studies to evaluate the impact of radiosonde data above 100hPa on global NWP, in the context of current observing systems (2012).
Who: NWP centres, coordinated by CBS/ET-EGOS in collaboration with CAS.
Time-frame: Before end of 2013.
Performance indicator: A number of independent studies carried out.

Observing System Simulation Experiments (OSSEs) are needed to evaluate the impact of a "perfect" atmosphere above 100hPa on the tropospheric forecasts. The idea is to give a quantitative estimate of the maximum benefit which could be obtained in NWP through improved observation of the stratosphere. OSSEs made with a variable number of radiosonde sites (providing data above 100hPa) could be compared to this upper limit.

Action G16

Action: Perform OSSEs to evaluate the impact of improved information above 100hPa on the tropospheric forecasts.
Who: NWP centres, coordinated by CBS/ET-EGOS in collaboration with CAS.
Time-frame: Before end of 2013.
Performance indicator: A number of independent experiments of this kind carried out.

5.3.1.2. Remote-sensing upper-air profiling stations

A variety of remote sensing techniques are emerging for measuring some parts of the atmospheric profile of wind, temperature and humidity. Radar wind profilers are used operationally in many regions. Vertical profiles of wind are also derived from Doppler weather radars in many regions, while Doppler lidar and microwave radiometers are being introduced in some regions. Some devices can be used to measure aerosol, cloud properties and trace species in the atmosphere. Ceilometer data are used to monitor the height of the planetary boundary layer and volcanic ash. GALION (GAW Aeorosol Lidar Observing Network) is a network of regional lidar networks for the observation of atmospheric aerosols. See: http://alg.umbc.edu/galion/.

Compared to the radiosonde measurements, the remotely sensed observations are providing data with much higher frequency. However they currently have a strong limitation in terms of data coverage. Only very few systems are technically able to measure atmospheric profiles from the boundary layer to the stratosphere. Most profilers measure only one variable in one part of the atmosphere, for example, the wind in the boundary layer. In future, the large variety of profiler instruments should be developed and used by an increasing number of applications. This is important from the point of view of complementing the radiosonde and aircraft profiles in the lower and upper troposphere. It would be an advantage to develop regionally a homogeneous network of remote-sensing profiling stations with a few sites integrating a large range of instruments and observing simultaneously (e.g.) wind, temperature and humidity.
In view of the future integrated observation system, in terms of temporal and spatial factors, Observing System Simulation Experiments (OSSEs) could be initiated to evaluate the impact of different remote-sensing profiling stations, in order to optimize upper-air observation profile observation, and in particular provide the guidance for integrated network design.

Action G17

Action: Develop networks of remote-sensing profiling stations on the regional scale in order to complement the radiosonde and aircraft observing systems, mainly on the basis of regional, national and local user requirements (although part of the measured data will be used globally).
Who: Organizations operating profiling stations in routine or research mode, in coordination with NMSs/NMHSs, RAs, TCs (mainly CAS, CBS and CIMO) and other regional institutions (e.g. EUMETNET in Europe). CBS to lead the action, in collaboration with CIMO, CAS and RAs.
Time-frame: Continuous. Detailed timetables to be set up by RAs at the regional level.
Performance indicator: A number of profiling stations providing quality-assessed data in real-time to WIS/GTS.

Global data assimilation schemes are able to assimilate observations which are produced every hour, or even more frequently, and they are able to draw benefits from such frequent observations even if they are produced by few limited profiling stations round the globe. It is useful to exchange globally data profiles produced on an hourly basis (or at least a subset). Appropriate data representation in BUFR should be available for this purpose.

Action G18

Action: Ensure, as far as possible, the required processing and the exchange of profiler data for local, regional and global use. When profiler data can be produced more frequently than 1 hour, a dataset containing only hourly observations can be exchanged globally following the WIS principles.
Who: Organizations operating profiling stations in routine or research mode, in coordination with NMSs/NMHSs, RAs, TCs (mainly CAS, CBS and CIMO) and other regional institutions (e.g. EUMETNET in Europe). CBS to lead the action together with the RAs.
Time-frame: Continuous. Detailed timetables to be set up by RAs at the regional level.
Performance indicator: A number of profiling stations exchanged globally.

5.3.1.3. Aircraft meteorological stations

In the northern hemisphere, meteorological data derived from aircraft stations, especially the automatic data produced by the AMDAR system, are an excellent complement to the data derived from the radiosonde network. This system produces vertical profile data in the vicinity of airports and single-level data when aircraft are flying at cruise levels. It has been shown through NWP impact studies that their impact on numerical forecasts has a magnitude similar to the impact of the radiosonde network. In the southern hemisphere and in the tropics the aircraft data coverage is very poor although there is some potential for developing it, preferably in a way that is complementary to existing AMDAR and radiosonde networks.

Extending aircraft observations data coverage is important and can be achieved through the extension of the programme to new airlines and aircraft operating in data-sparse areas. The programme coverage can also be improved greatly through an optimization process. This can be achieved through two general activities. Firstly, existing programmes can be extended so that internationally-operating aircraft are activated for reporting outside the national areas or regions that tend to be restricted by national programme constraints. Secondly, one can enhance the capabilities of programmes to control data output through the wider development and implementation of automated data optimization systems. Such systems, whilst allowing the efficient growth of the programme outside and across international boundaries with appropriate agreements in place, will also offer the potential to utilize the AMDAR system as an adaptive observing network (capability to change the reporting regime to serve the changing purposes of programme areas).

Action G19

Action: Improve AMDAR coverage over areas that currently have poor coverage, especially within Regions I and III, focussing on the provision of data at airports in the tropics and southern hemisphere where vertical profiles are most needed to complement current radiosonde data coverage and its likely evolution.
Who: NMSs, NMHSs in collaboration with commercial and other airlines, RAs. AMDAR Programme Management to lead the action.
Time-frame: Continuous.
Performance indicators: Number of airports where AMDAR measurements are taken. Amount of vertical profiles and AMDAR data in general, measured by the usual indicators of current AMDAR programmes.

Action G20

Action: Extend the AMDAR programme so as to equip and activate more internationally-operating fleets and aircraft (i.e. fleets and aircraft flying to and between international airports outside the country of origin) and extend the use of data optimization systems in

support of improved upper-air observations coverage and efficiency, and also the adaptive functionality of the system.
Who: NMSs, NMHSs in collaboration with commercial and other airlines, RAs, CBS and AMDAR Programme Management. AMDAR Programme Management to lead the action.
Time-frame: Continuous.
Performance indicators: The number of airports where AMDAR measurements are taken and number of vertical profiles per day at each airport. The number of international airlines and aircraft equipped to provide AMDAR observations. The adaptability of the AMDAR programme.

Action G21

Action: Given the nature of the aircraft observing system as an increasingly critical and basic component of the Global Observing System, seek to establish agreements with airlines and the aviation industry to ensure that the system, infrastructure, data and communications protocols are supported and standardized within relevant aviation industry frameworks so as to ensure continuity and reliability of the system.
Who: NMSs, NMHSs in collaboration with national and other airlines and aviation industry, RAs, CBS and AMDAR Programme Management. AMDAR Programme Management to lead the action.
Time-frame: Continuous.
Performance indicators: Agreements made with aviation industry partners and organizations.

Data produced by humidity sensors are now used operationally from an increasing number of aircraft both in the USA and Europe, and it is critical and strategic to continue this development in order to converge to systems which measure humidity as well as air pressure (pressure altitude), temperature and wind as do radiosondes. Such an extension will provide an increased opportunity to restructure the upper-air observing systems for efficiency and improvement in coverage.

Action G22

Action: Continue the development and operational implementation of humidity sensors as an integrated component of the AMDAR system to ensure that humidity data is, processed and transmitted in the same way as wind and temperature.
Who: NMSs, NMHSs in collaboration with commercial and other airlines and TCs (CBS, CIMO) and AMDAR Programme Management. AMDAR Programme Management to lead the action.
Time-frame: Continuous.
Performance indicator: A number of aircraft providing humidity data in real-time.

The lower cost of aircraft observations in comparison to the radiosonde information as well as the reduced reliance on ground-based systems and infrastructure make it an ideal candidate system for rapid and reliable expansion of upper-air observations for developing countries in support of local, regional and global data users. Such an expansion should be undertaken in parallel with the necessary development action to facilitate the provision and utilization of data.

Observations of turbulence and icing are also made on some aircraft and it is desirable to expand this capability of the AMDAR system with these parameters in support of aviation operations and safety as well as other meteorological applications.

Action G23

Action: Enhance and extend the capability to report observations of atmospheric turbulence and icing variables as an integrated component of the AMDAR system and in line with the requirements of the relevant programme areas and data users.
Who: NMSs, NMHSs in collaboration with airlines and TC (CBS, CIMO) and AMDAR Programme Management I, RAs. AMDAR Programme Management to lead the action.
Time-frame: Continuous.
Performance indicator: A number of aircraft providing atmospheric turbulence and icing data in real-time.

Another source of important potential progress is the research and development actions associated with AMDAR systems for small aircraft, usually referred to as General Aviation (GA) aircraft. These aircraft tend to fly and generate level data in the middle troposphere whilst operating over shorter regional flight legs. This type of observation would be very useful for regional and local purposes and could also contribute to global data coverage. Priority should be placed on equipping aircraft operating on, to and out of isolated islands and remote sites where radiosonde observations are not available, e.g. deserts, islands and the Arctic. The impact of existing data sets (derived from deployment of the commercial communications and sensor system) on high resolution NWP models has been evaluated and compared to other observing systems such as profilers and radars. The results are encouraging: see for example Moninger et al. (2010) and Benjamin et al. (2010). In spite of several technical snags, AMDAR systems for GA aircraft do have potential for contributing to the improvement of data coverage of vertical profiles of AMDAR measurements (wind, temperature, humidity, turbulence and icing) in the lower troposphere and this development should be pursued whilst taking into account the potential associated with new and developing technologies such as ADS-B and Mode S.

Action G24

Action: Develop and implement operational AMDAR systems which are adapted to small aircrafts operating at the regional scale and flying at low altitude in the troposphere.
Who: Airlines operating small aircraft, NMSs, NMHSs in collaboration with RAs, CBS and AMDAR Programme Management. AMDAR Programme Management to lead the action.
Time-frame: Continuous.
Performance indicator: Number of small aircrafts providing AMDAR observations operationally in real-time.

Atmospheric composition measurements for several species, aerosols and volcanic ash are measured on some aircraft, but more in research than in operational mode. The actions related to atmospheric chemistry are documented in section 5.3.8.4.

5.3.1.4. Global Atmosphere Watch stations

Surface-based observations of atmospheric composition, complemented by aircraft measurements (see 5.3.8.4), will contribute to an integrated three-dimensional atmospheric chemistry observation network, together with a space-based component. Networks exist which are making regular measurements of ozone (profile and total) and many other gas species and aerosols (see GAW Strategic Plan[30] and addendum[31] for the complete list of variables). The tasks suggested for maintaining and enhancing the networks and for increasing the coverage in the tropics and southern hemisphere should be supported also for other applications. In addition, where appropriate the atmospheric composition observations are recommended to be processed and disseminated in near-real-time, in order to be used in several applications.

Action G25

Action: Encourage managers of national programmes of meteorological observations to extend the scope of these stations to include atmospheric chemistry observations.
Who: NMSs/NMHSs and respective organizations and research agencies conducting atmospheric composition observations, in coordination with TCs (especially with CAS and CBS) and RAs. CAS and CBS to lead the action with RAs.
Time-frame: Continuous. Timetable to be defined for each RA.
Performance indicator: Number of atmospheric composition stations.

5.3.1.5. GNSS receiver stations

In a similar way to the atmospheric profilers, networks of GNSS ground-based receiver stations have been operational in few regions around the world. The main application of these networks is

30 ftp://ftp.wmo.int/Documents/PublicWeb/arep/gaw/gaw172-26sept07.pdf
31 http://www.wmo.int/pages/prog/arep/gaw/documents/FINAL_GAW_197.pdf

generally not meteorological. Although they are very heterogeneous in quality and observing practices, the meteorological information has been extracted and collected in real-time from some stations. Starting in 2006, the meteorological information has been assimilated in operational NWP (both global and regional) either in the form of an Integrated Water Vapour (IWV = total water vapour integrated on the vertical), or in the form of a Zenith Total Delay (ZTD). The ZTD contains both the "wet delay" (due to the water vapour) and the "dry delay" directly related to the air density (air density directly related to surface pressure). The positive impact of GNSS ground-based meteorological observations on numerical forecasts has been shown (on the water vapour, precipitation and atmospheric pressure fields). See footnote referencing the workshop (on impact studies) in section 4 to access to a synthesis of OSEs.

The ground receiver stations in most countries are owned and operated by agencies other than the NMHSs. Hence the access to data, the processing to produce meteorological data, and permission to use and redistribute the data are all dependent on collaboration by the NMHS (individually or in multilateral groupings) with the owners/operators. In many cases it is not permitted for the NMHS (individually or in multilateral groupings) to exchange the data with other Members of WMO.

Concerning this observing system which is relatively new in meteorology, one important action is to exploit more the meteorological content of the existing GNSS receiver stations (in the form of IWV or ZTD). This action does not require deployment of new infrastructure. In addition, it would be very beneficial to improve the observation of upper-air humidity with denser receiver networks, taking into account all the other instruments that observe the upper-air humidity, and looking especially at areas for which the climatology is subject to rapid variations (in space and time) of the atmospheric water vapour content.

Total electron content (TEC) along a given propagation path can also be measured by tracking the time delay and phase shift of GNSS radio signals acquired by a ground receiver, for ionospheric monitoring. For example, high-rate ground GPS and GLONASS observations from the International GNSS Service (IGS) are made every 15 minutes with a typical delay of 2-3 minutes. This is useful information for monitoring the space weather (see section 7).

Action G26

Action: Derive greater benefit from the existing GNSS receiver stations by establishing collaborative arrangements with station owners and operators for access, processing, and sharing of real-time data to derive meteorological or ionospheric information (ZTD or IWV, TEC).
Who: NMSs/NMHSs (individually or in multilateral groupings) will lead the Action and will need to collaborate with station owners/operators, with RAs (to determine exchange requirements), and with TCs (for relevant guidance).
Time-frame: Continuous.
Performance indicators: Number of GNSS receiver stations making available their data in real-time; number of stations which can be used in NWP according to the usual monitoring criteria (see footnote no. 17 in section 3.6).

Action G27

Action: Organize the global exchange of data from a subset of GNSS receiver stations, aiming at satisfying a frequency requirement of about one hour (for meeting requirements in global applications).
Who: Organizations and research agencies operating GNSS receiver stations, in coordination with NMSs/NMHSs, with RAs, TCs (especially CAS and CBS) and other international organizations (e.g. EUMETNET). CBS to lead the action with RAs.
Time-frame: Continuous.
Performance indicator: A number of GNSS receiver stations whose data are exchanged globally in real-time.

Action G28

Action: Optimize the upper-air water vapour observation over land, considering the collaborative establishment of additional GNSS receiver stations, and also the other humidity observing systems.
Who: Organizations and research agencies operating GNSS receiver stations, in coordination with NMSs/NMHSs, with RAs, TCs (especially CAS and CBS) and other international organizations (e.g. EUMETNET). NMSs/NMHSs to lead the action with RAs.
Time-frame: Continuous.
Performance indicators: Number of GNSS receiver stations making available their data in real-time; number of stations which can be used in NWP according to the usual monitoring criteria (see footnote no. 17 in section 3.6).

5.3.2. Surface observing systems over land

5.3.2.1. Surface synoptic and climate stations

"Synoptic" stations are observing stations originally developed to address the needs for synoptic meteorology and other applications (e.g. aeronautical meteorology, climate monitoring, severe weather and disaster risk reduction), "synoptic" meaning that they belong to an ensemble of stations providing observations at the same time, allowing a weather analysis on a large geographical area at a given time.

Land-surface observations come from a wide variety of in-situ networks, and they serve the requirements of many application areas. Surface synoptic and climatological stations provide measurements at the interface between the atmosphere and the land surface, and also other qualitative or quantitative observations related to atmospheric or environmental phenomena, such as visibility, present weather, cloud height, cloud type, thunderstorms, lightning and type of precipitation, which are increasingly important for emerging environmental societal applications. For initializing NWP models the important variables are surface pressure, surface wind, air temperature and humidity, precipitation and the state of the ground, including snow depth and soil moisture. Most of these variables can be assimilated in NWP models with an hourly frequency, therefore, the global exchange of these data should be adapted accordingly. There are also many variables that serve the full needs of the climate services community, and there is a growing requirement for high frequency measurements and near-real-time transmission and data collection. These include, but are not limited to, ECVs listed in the GCOS-IP. In addition climate reference stations are being established to provide the highest quality observations for climate monitoring while also supporting forecasting through hourly data transmission. The monitoring of the surface radiation budget is very dependent on the surface stations of the BSRN (Baseline Surface Radiative Network)[32].The BSRN should be expanded and secured. Radiation and energy flux measurements (e.g. from Fluxnet) have to be considered as well.

Action G29

Action: Extend the BSRN to achieve global coverage.
Who: NMSs/NMHSs, and research organizations, RAs and TCs, coordinated by CBS.
Time-frame: Continuous.
Performance indicator: Number of BSRN stations.

Action G30

Action: Ensure, as far as possible, global exchange of variables measured by surface observing stations (including climatological stations) with at least one hour frequency and in real-time.
Who: NMSs/NMHSs, RAs and TCs, coordinated by CBS.
Time-frame: Continuous.
Performance indicator: A percentage of observations exchanged globally with a one hour frequency (with respect to the number of stations observing hourly).

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32 http://www.bsrn.awi.de/

An increasing number of variables are measured automatically with required quality. The trend to automation is encouraged, as it could improve the data compatibility and the data coverage, especially from remote locations, and the frequency and availability of data in real-time. Currently, many observations made routinely are not distributed in real-time, although requirements are documented in the RRR, and automation does provide new opportunities for disseminating variables that were in the past collected but not shared in real-time.

In addressing the increasing trend in automation of observations, CBS and CIMO have developed guidelines and procedures for the transition from manual to Automatic Weather Stations (land and marine). Once published, they will be available on the WMO Website[33].

Action G31

Action: Improve data compatibility, availability (also with higher frequency) and data coverage of surface observations (including climatological) through quality management, automation and exchange of data in real-time, as far as possible from all operational stations.
Who: NMSs/NMHSs, RAs and TCs, coordinated by CBS.
Time-frame: Continuous.
Performance indicator: A percentage of stations distributing quality-assessed observations in real-time over WIS/GTS (with respect to the number of stations producing observations).

Several observations are made and transmitted routinely, but they are exchanged in formats that are not adequate to contain metadata needed for appropriate use in data assimilation and in other tools. This is particularly true for the atmospheric pressure which is usually measured with a very good accuracy, but cannot be used without accurate information of the barometer altitude. Another example of needed metadata information is the height (above the surface) where the wind measurement is taken. Other variables including temperature and precipitation and other elements for climate services are sometimes also transmitted without adequate metadata.

Actions aiming at improving the quality, the consistency and the availability of the surface observations (including climatological) are particularly important for climate applications and will contribute to building long-term series of observations and re-analyses. All the actions of the GCOS-IP (section dealing with the surface observations of the atmospheric domain) must also be supported for non climate applications.

ction G32

Action: Ensure variables measured by surface stations (including climatological) are exchanged together with access to relevant metadata according to WIGOS and WIS standards. Special attention should be given to the barometer altitude uncertainty.
Who: NMSs/NMHS, RAs and TCs, coordinated by CBS.
Time-frame: Continuous.
Performance indicators: Usual monitoring indicators (see footnote no. 17 in section 3.6).

Action G33

Action: Improve design of the Regional Basic Synoptic Network (RBSN) and the Regional Basic Climatological Network (RBCN), making every effort to retain climatically significant stations.
Who: CBS leading the action through the appropriate NWP impact studies and network design studies, in coordination with NMSs/NMHSs, WMO-owned and co-sponsored programmes, other TCs, RAs and other relevant organizations.
Time-frame: 2015.
Performance indicator: Design developed and implemented.

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33 http://www.wmo.int/pages/prog/www/IMOP/publications-IOM-series.html

5.3.2.2. Global Atmosphere Watch stations

Surface observations of atmospheric composition contribute to an integrated three-dimensional atmospheric chemistry observation network, together with upper-air measurement stations (ground-based, aircraft, balloons, see 5.3.1.4 and 5.3.8.4) and with a space-based component. Surface observations of CO_2 and CH_4 for example are very important for identifying sources and sinks of these components and for understanding the radiative influences on climate (see references to the GAW documents in section 5.3.1.4, and also the GCOS-IP). Surface observing network for atmospheric chemistry variables is clearly insufficient for global observing requirements. Priorities for different tasks for surface-based trace gases and aerosol observations are laid out in the GAW Strategic Plan and its addendum (see also references of section 5.3.1.4).

By 2025, models used for NWP and climate and atmospheric composition modelling will become increasingly important for climate projection and chemical weather forecast. In support of this, it will be important to progressively integrate the corresponding observing networks, so that atmospheric composition observations are made available in near-real-time.

Action G34

Action: Implement as soon as possible a near-real-time exchange of the atmospheric composition observations which are made at surface stations. Follow the GAW recommendations and WIGOS and WIS practices for implementing this dissemination, and the standard quality assessment practices.
Who: Organizations and research agencies operating atmospheric composition observations, in coordination with NMSs/NMHSs, the RAs and TCs. CAS and CBS to lead the action with RAs.
Time-frame: Continuous. Timetable to be established for each RA.
Performance indicator: A number of surface atmospheric composition stations making quality-assessed data available in real-time.

5.3.2.3. Global Cryosphere Watch stations

The recently established Global Cryosphere Watch (GCW) programme will set up a comprehensive cryosphere observing network called “CryoNet”, a network of reference sites or “super-sites” in cold climate regions, operating a sustained, standardized programme for observing and monitoring as many cryospheric variables as possible at each site. Initially, it will build on existing cryosphere observing programmes or add standardized cryospheric observations to existing facilities as part of super-site environmental observatories. As encouraged by GCOS, GCW will facilitate the establishment of high-latitude super-sites with co-located measurements of key variables, especially permafrost and snow cover, thus enhancing GCOS/GTOS Networks for Permafrost (GTN-P), Glaciers (-G) and Hydrology (-H). GAW stations in cold climates are logical candidates. CryoNet reference sites will provide long-term data sets for monitoring climate variability and change, improved model parameterization of cryospheric processes, and support for development and validation of satellite products and forecast, climate, hydrologic and cryospheric models. The CryoNet Team of the GCW Observing Systems Working Group will develop formal procedures for establishing the GCW network, evaluate potential supersites, and determine data availability.

Action G35

Action: Implement as soon as possible a comprehensive cryosphere observing network of reference sites “CryoNet”.
Who: Organizations, institutes and research agencies conducting cryosphere observation and monitoring, in coordination with NMSs/NMHSs, the RAs and TCs, as required. CryoNet Team will lead the action. GCW Advisory Board and Management Board will oversee the action.
Time-frame: 2014.
Performance indicator: Number of reference sites taking part in CryoNet.

Action G36

Action: Provide, as far as possible, a real-time or near-real-time exchange of the cryospheric data from CryoNet. Follow the GCW, WIGOS and WIS practices for implementing this dissemination, and the standard quality assessment practices and archiving.

Who: Organizations, institutes and research agencies conducting cryosphere observations and monitoring, in coordination with NMSs/NMHSs, the RAs and TCs, as required. CryoNet Team will lead the action. GCW Advisory Board and Management Board will oversee the action.

Time-frame: 2014.

Performance indicator: Number of CryoNet stations making quality-assessed data available.

5.3.2.4. Lightning detection systems

Ground-based (total or only “cloud to ground”) real-time lightning detection and tracking systems have demonstrated their value as an early indicator of the location and intensity of developing convection, and also of the motion of thunderstorms. Especially for nowcasting, severe weather warning and aviation applications, these observing systems may increase the warning lead time associated with severe thunderstorms. For aviation the data coverage requirement is almost global. Advanced lightning systems also provide the 3D structure of the electricity activity for aviation.

In 2025 one can foresee long-range lightning detection systems providing cost-effective, homogenized global data, with high location accuracy, significantly improving the data coverage in data-sparse areas. High resolution lightning detection systems should be also deployed in some specific areas, for special applications, with higher location accuracy, and with cloud-to-cloud and cloud-to-ground discrimination.

Action G37

Action: Improve global lightning detection efficiency by extending the deployment of long-range lightning detection systems and introducing more of these systems. Priorities should be given to filling gaps in populated areas and along commercial airline routes.

Who: NMSs/NMHSs and agencies operating long-range lightning detection systems RAs and TCs, coordinated by CBS and CIMO, leading the action jointly.

Time-frame: Continuous.

Performance indicator: Data coverage for this type of observations.

Action G38

Action: Develop and implement techniques for the integration of lightning detection data from different systems, including from surface- and space-based systems, to enable composite products to be made available.

Who: NMSs/NMHSs and agencies operating lightning detection systems, RAs and TCs, coordinated by CBS and CIMO, leading the action jointly.

Time-frame: Continuous.

Performance indicator: Level of integration of the lightning systems.

Action G39

Action: Improve the exchange of lightning detection data in real-time by establishing and implementing agreed protocols for the exchange of data.

Who: NMSs/NMHSs and agencies operating lightning detection systems, NMSs, NMHS, RAs and TCs, coordinated by CBS and CIMO.

Time-frame: Continuous.

Performance indicator: A percentage of observations exchanged regionally and globally.

5.3.2.5. Surface-based stations serving specific applications

Many specific observing networks have been developed (and are still being developed) to monitor local applications such as the weather variables alongside the roads, motorways or railway tracks, within and around cities and airports, for agricultural or horticultural crops or those needed for electrical power generation. This ensemble of networks is very heterogeneous in terms of observed variables, observing practices, standards, as well as frequency of observations. However these data are essential elements for meeting climate service requirements and are very useful not only for their main application but also for many other larger-scale applications documented in the RRR, including for global and high resolution models.

In the coming years, specific attention needs to be paid to the measurements in the urban environment, for at least two reasons: (i) the monitoring of the climate variability and change is important in such areas where specific issues of adaptation arise; and (ii) the verification and validation of local NWP and air quality models which are likely to be run operationally over limited areas centred over big cities; these models are likely to become an important instrument of the climate variability and change monitoring in addition to their role in meteorological and air-pollution short-range forecasting.

Such specific observations and models are likely to be needed not only in the vicinity of big urban agglomerations, but also in the vicinity of important airports, where the aviation requirements may imply the development of specific high resolution networks for monitoring and nowcasting severe phenomena.

Most of these specific observing systems are fully automatic; they use up-to-date technologies and often produce observations with high frequency. In order to have these systems serving a wider range of users, there should be a coordinated planning on appropriate data representation and codes and reporting practices, approved QM/QA[34] standards for data and metadata. In addition, standards should be developed for the data processing in order to produce derived sets of observations required by different users (local, national, regional, global).

Mutual benefits can be derived from cooperation with the renewable energy installations, which require monitoring of their environment. For the clean energy sources (wind, solar, hydroelectric, geothermal energy), weather and climate information is an essential part of development and operational activities, and they require a continuing assessment of efficiency and environmental impacts.

Action G40

Action: Ensure, as far as possible in real-time, exchange of observations, relevant metadata, including a measure of representativeness made by surface-based stations serving specific applications (road transport, aviation, agricultural meteorology, urban meteorology, etc.).
Who: Agencies operating stations serving specific applications, NMSs/NMHSs, RAs and TCs, coordinated by CBS.
Time-frame: Continuous.
Performance indicator: A percentage of observations from the above stations exchanged regionally and globally in real-time.

Action G41

Action: Enhance observations in candidate areas to support studies associated with the development and operations of renewable energy installations, and also to understand the influence of these installations on local weather and climate phenomena related to the operation of the renewable technologies.
Who: Agencies operating stations serving renewable energies, NMSs/NMHSs, RAs and TCs, coordinated by CBS.
Time-frame: Continuous.
Performance indicator: Number of observations supporting of renewable energies.

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5.3.3. Hydrological observing systems over land

5.3.3.1. Hydrological reference stations

Concerning the global exchange of hydrological variables, GCOS, through its co-sponsored Terrestrial Observation Panel for Climate (TOPC), has established the Global Terrestrial Network for Hydrology (GTN-H), with the objective of designing and implementing the baseline networks, and in order to demonstrate the value of integrated global hydrological products. The activities of the GTN-H and of the WMO/CHy include the global monitoring of rivers, lakes, ground water and water use. The monitoring programme requirements led to the establishment of GCOS/GTOS baseline networks for river runoff and lake level.

The Global Runoff Data Centre (GRDC) has a mandate to collect river discharge data, but long delays can occur before the data are actually collected and distributed. In addition there is a tendency to reduce the number of stations in the existing observing networks, and there is a strong concern over this continuous decline of hydrological networks, especially the closure of climate-relevant stations.[35]

Action G42

Action: For climate purposes, maintain the existing hydrological stations of the GCOS/GTOS baseline network, and facilitate their global exchange.
Who: All hydrological services operating these reference stations, WMO TCs (CHy and CBS), GCOS. CBS and GCOS to lead the action.
Time-frame: Continuous.
Performance indicator: Percentage of hydrological reference stations exchanging globally quality-assessed data.

More details about specific actions on hydrological reference stations can be found in relevant sections of the GCOS-IP. A general description of all the elements contributing to hydrology, water resources and water cycle can also be found in the WHYCOS document[36.]

5.3.3.2. National hydrological network stations

For monitoring the Earth water cycle, many variables are measured by national hydrological networks and other stations from heterogeneous networks: liquid and solid precipitation, snow depth, snow water content, lake and river ice thickness, dates of freezing and break-up, water level, water flow, water quality, soil moisture, soil temperature, sediment loads. Some of them are not relevant to any real-time applications, but some others require a rapid data exchange (e.g. precipitation and river discharges in case of flood event). A small subset requires global exchange whereas most of them need to be exchanged only at the national and local level.

The TOPC has identified hydrometeorological variables with a high observation priority.[37] Several of these variables have an in-situ observation component which is complemented by a satellite component; still, there are important identified gaps in the different hydrology networks which have to be filled. In general there is an insufficient access to hydrological variables.

The observation of hydrological variables on global and regional scales, performed in a continuous and consistent way will require integrated observing systems (both in-situ and satellite-based) and used in support of several application areas. Observations include those of hydrological variables such as evaporation, soil moisture, snow, and surface and groundwater, as defined in GCOS-IP terrestrial actions.

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35 See the paragraph on the exchange of hydrological data in the GCOS-IP.
36 http://www.whycos.org/IMG/pdf/WHYCOSGuidelines_E.pdf
37 See SoG on Hydrology

Action G43

Action: Include observations of key hydrological variables (liquid and solid precipitation, evaporation, snow depth, snow water content, lake and river ice thickness, water level, water flow, soil moisture) into an integrated system for a consistent observation, processing and exchange, following the WIGOS standards.
Who: Hydrological services, GCOS, WMO TCs (CHy and CBS) leading the action.
Time-frame: Continuous.
Performance indicator: percentage of hydrological data integrated in this system.

5.3.3.3. Ground water stations

Ground water has an important role in the environment and its management, although it is less important for many applications covered by the RRR (especially the forecasting applications). It is used as a primary source of drinking water and also in agricultural and industrial activities. Ground water resources need to be protected as, in many regions, withdrawal rates exceed recharge rates. Once modified or contaminated, ground water can be very costly and difficult to restore.

Ground water monitoring is a continuous standardized process involving in-situ, satellite and air-borne observations. The groundwater monitoring includes both its quantity and its quality (analysis of selected physical and chemical variables).

According to a world-wide inventory of ground water monitoring compiled by the International Ground water Resources Assessment Centre (IGRAC), in many countries, a systematic monitoring of ground water quantity and quality is minimal or non-existing.

Action G44

Action: To continue and expand existing programmes of ground water observation and monitoring, including expansion of the IGRAC.
Who: Hydrological services in collaboration with WMO/CHy, the Food and Agriculture Organization (FAO) and GTOS (especially its Global Terrestrial Network for Groundwater – GTN-GW – component). WMO/CHy and GTOS to lead the action.
Time-frame: Continuous.
Performance indicator: number of ground water stations operating.

The ground water actions described in the GCOS-IP should be supported, especially those aimed at establishing a prototype global monitoring information system with the GTN-GW.

5.3.4. Weather radar stations

Weather radars are acquiring an increasing importance in weather forecasting and warning, in hydrology and many applications depending on weather forecasting, e.g. aeronautical meteorology (wind shear). This increased importance is partly related to the development of NWP models at kilometre scale (which progressively become able to assimilate weather radar data) and of other ad hoc tools for nowcasting and short-range forecasting. Weather radars have the capacity to observe several variables related to precipitation: precipitation intensity and geographical distribution, hydrometeor size distribution, phase and type of precipitation. They can also locate sand and dust storms, and they can measure wind components through the Doppler technique, and also humidity through the refractivity. The deployment of polarimetric weather radars contributes to the improvement of quantitative precipitation estimates (QPE), to a better detection of large hail, and to an improved identification of rain/snow transition regimes in winter storms. VHF radars have been tested and can provide observations at higher resolution, but only at shorter range. All these weather phenomena are especially important for aviation and severe weather forecasting and warning for public.

Advances in NWP, climate modelling, and severe weather warnings and disaster mitigation have led to new requirements for precipitation products of high quality constructed from data from one or more radar networks. Also, recent advances in radar technology and in signal and data processing have brought the field to the brink of operational readiness for these products and their quantitative

use for various operational applications. In the past, radars were perceived to address only regional and local applications but this view is rapidly changing as telecommunication networks allow vast amounts of data to be transferred and archived.

The weather radar coverage was improved considerably during the last decades in some regions of the world, with some data exchanged across the national borders (on at least some composite products).

There is still a lot of potential progress which should come before 2025 from improved technology, standardization of observing procedures, and increase of data exchange, including at the global level. Currently (in 2012), in the areas that are well covered by weather radars, there is a lot of heterogeneity in technology deployed, the observing practices, the calibration and processing techniques, and the form of the data presentation and exchange. In the developing countries, the radar coverage is poor or non-existent, including in the areas where the storm nowcasting (and very short-range forecasting – VSRF) is extremely important. A special effort has to be organized for these areas, not only in terms of weather radar deployment, but also in terms of nowcasting tools combining a limited number of weather radars with other sources of information (satellite products, propagation of GNSS signals or of other electromagnetic signals).

Action G45

Action: Increase the deployment, calibration and use of dual polarization radars in those regions where it is beneficial.
Who: CBS to lead the action in collaboration with CIMO, RAs and NMSs/NMHSs.
Time-frame: Continuous.
Performance indicator: Data coverage obtained from this type of radar for each Region.

Action G46

Action: Perform comparison of weather radar software with the objective to improve quality of the quantitative precipitation estimates (QPE).
Who: CIMO in collaboration with NMSs/NMHSs and agencies operating weather radars.
Time-frame*:* Continuous.
Performance indicator: Guidance provided to the operators and Members.

Action G47

Action: For areas in developing countries which are sensitive to storms and floods, a special effort has to be made to establish and maintain weather radar stations.
Who: NMSs/NMHSs, agencies operating weather radars, in collaboration with RAs and TCs (CBS, CIMO and CHy). CBS to lead the action.
Time-frame: Continuous.
Performance indicator: The number of operational weather radar stations in the above areas.

Concerning the use and impact of observations in NWP, the Proceedings of the 2008 WMO workshop states (see reference in footnote no. 19 of section 4): “Radar data have demonstrated their positive impacts on regional data assimilation systems, and on some occasions also on global systems”. By 2025, it is expected that most of the operational global data assimilation systems for NWP (and re-analyses) will assimilate some radar data, at least in the form of Doppler winds. Therefore, a global exchange of selected radar data should be introduced.

Radar information is also important for climate applications. It will be used in the future for (e.g.) regional re-analyses and monitoring of the water cycle. See GCOS-IP – executive summary.

Action G48

Action: Define weather radar data to be exchanged at regional and global levels, propose frequency of exchange of those data and develop a weather radar data processing framework, in concert with development of products based on national, regional, global requirements.
Who: CBS (leading the action), CIMO, CHy in coordination with NMSs/NMHSs, agencies operating weather radars, in collaboration with RAs.
Time-frame: Continuous.
Performance indicator: Volume of radar data which are exchanged globally and regionally.

5.3.5. Upper-air observing system over the oceans. Automated Shipboard Aerological Programme (ASAP) ships

All the Actions documented in section 5.3.1.1 related to radiosonde observations over land, except those for GRUAN (5.3.1.1.2), are relevant for ASAP. These Actions refer to:

- The importance of isolated radiosonde data for removing the biggest gaps in data coverage;
- The appropriate coding of the total radiosonde information in the vertical, followed by a rapid real-time dissemination;
- The possibility to optimize the data coverage by adapting the launching time, taking into account the ensemble of the radiosonde network, but also other observation systems providing vertical profile observations (AMDAR for example).

For the North Atlantic area (with very few islands which can provide fixed radiosonde sites), EUMETNET[38] has developed a European component of the Automated Shipboard Aerological Programme (ASAP), called E-ASAP (EUMETNET – ASAP). See information on E-ASAP by going to the home page of EUMETNET. Between 15 and 20 ships regularly operate radiosonde launches in the North Atlantic on commercial line services from Western Europe to North and Central America. These ASAP ships contribute to about 10 to 15 radiosonde observations per day on average (situation of 2012), most of these observations being made at 00 or 12 UTC (possibility to make them at a different time, in order to optimize space-time coverage). In the year 2011, the E-ASAP programme contributed about 4500 radiosonde launches over the Atlantic Ocean. Concerning the impact of ASAP ships on numerical forecasts, the Proceedings of the 2008 WMO workshop states (see reference in footnote of section 4): “Even a very limited number of radiosondes located in data sparse regions in the oceans can have a significant impact on the forecast”. The North Atlantic ASAP network has not only a direct impact on forecasts, but it helps the use of satellite data by providing in-situ reference observations with a lot of vertical details. More than 80% of the total ASAP launches in 2011 were performed in the Atlantic Ocean. Therefore, for other oceanic areas, and especially for the North Pacific and Indian Ocean, there is potential for improving very significantly the overall quality of the composite observing system through the development of a very limited number of observing stations (typically 10 or 20). Dropsondes launched from reconnaissance aircrafts are an equivalent system which is used both in the Pacific and in the Atlantic, but very irregularly, to support severe storms forecasts.

Action G49

Action: Maintain and optimize the existing ASAP network over North Atlantic, and develop similar programmes for the North Pacific and the Indian Ocean.
Who: NMSs, NMHSs, in collaboration with companies operating commercial ships, RAs, JCOMM, CBS and CAS. JCOMM to lead.
Time-frame: Continuous.
Performance indicator: Volume of ASAP data available in real-time (usual NWP monitoring indicators).

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38 http://www.eumetnet.eu/

5.3.6. Surface observing systems over the oceans

Important ocean variables to measure at the ocean-atmosphere interface include the surface pressure, the SST, the Sea Surface Height (SSH), the Sea Surface Salinity (SSS), the surface wind, the wave characteristics, the ocean surface current and the visibility. Additional variables are needed near the coasts and also when the ocean is covered with ice. Variables related to ocean acidity, ocean colour, nutrients and phytoplankton are important ECVs which are documented in the GCOS-IP.

The uneven geographical coverage of the in-situ ocean observing network is an ongoing issue for ocean applications. Considering the regional variability in requirements, varied deployment logistics (including from remote regions, and insecurity-prone regions), and the difficulty to ensure optimized planning for observing networks with limited resources, WMO Members should note the need for studies on geographical variability in spatial/temporal resolution for ocean observations.

Most of the actions documented in the following sub-sections are aimed at improving the geographical coverage of ocean observing systems, particularly for measuring surface pressure, SST, SSH, SSS and visibility, along with higher resolution geometry. This can be done by extending open-ocean and coastal observing networks, or developing existing observing sites into multi-purpose stations, or also using emerging remote-controlled in-situ observation technologies to cover inaccessible regions.

5.3.6.1. High Frequency (HF) coastal radars

HF coastal radars are a very powerful observing technique for monitoring the sea state and the surface ocean current within a few hundred kilometres of the coasts. These radars can measure both waves (significant height) and current within a kilometric horizontal resolution. For many of the HF radar systems now in use, a triangulation technique using two radars is required to remove directional ambiguities in waves and currents.

The purpose of this radar observing system is not to achieve a good global coverage of the ocean coasts, but to improve the horizontal resolution and the quality with respect to other oceanic observations in the coastal areas which are very sensitive to the weather and oceanic phenomena (for environmental or economical reasons): populated areas near the coasts, harbours with a lot of ship traffic and risk of pollution (for both the terrestrial and the marine wildlife). By 2025, it is likely that specific atmospheric and oceanic Limited Area Models (LAM) will be operated on many coastal areas with a horizontal resolution between 100 and 1000m, in order to help the real-time monitoring of these sensitive areas. HF coastal radars should then become an important source of information to be assimilated in these models. They are already an important source of information for the production of real-time maps of ocean surface currents and significant wave height for ship traffic and for search and rescue operations.

5.3.6.2. Sea stations (ocean, island, coastal and fixed platforms)

The sea observing stations provide the same surface variables as land surface stations (see 5.3.2.1): surface pressure, temperature, humidity, wind, visibility, cloud amount, type and base height, precipitation, past and present weather. With respect to surface stations over land, their role is increased for two reasons:

- They also observe a set of marine variables: SST, wave direction, period and height, sea-ice, etc.;
- They are generally situated either in sensitive coastal areas or on isolated sites like islands and oil platforms, and so they are more important in terms of their contribution to global data coverage.

The recommendations of section 5.3.2.1, valid for land surface stations, apply also to sea stations. The isolated islands which have already a long climate record are particularly important to maintain for climate monitoring.

The sea station networks are very insufficient to meet the different marine and oceanic requirements, especially for SSH, SST, SSS, and wave measurements.[39] A general improvement in measurement capabilities and data accessibility is needed, which has to rely not only on sea stations, but also on ships, buoys, tide stations and profiling floats.

Action G50

Action: Ensure state-of-art technologies are employed to improve accuracy for all measurements made at sea stations. Develop visibility measurement capabilities over the ocean.
Who: NMSs, NMHSs and national partner institutions, in collaboration with international organizations and space agencies. JCOMM, CBS, and CIMO to lead the action.
Time-frame: Continuous.
Performance Indicators: Usual monitoring indicators on availability and quality of marine observations.

5.3.6.3. Voluntary Observing Ships Scheme (VOS)

The list of meteorological and marine variables which is normally observed by VOS ships is the same as the one observed by sea stations (5.3.6.2.). The main practical difference is that ships are mobile: this can be an advantage for a better space-time data coverage, but it is a drawback for climate users interested in long time series.

Many recommendations made for land surface synoptic stations are also valid for VOS ships, especially those concerning: global exchange of hourly data (**Action G30**) and coding and transmission of metadata (**Action G32**). For the atmospheric pressure measurement onboard ships, a particular attention should be given to the barometer height, its correct value, correct coding and correct transmission. Indeed atmospheric pressure (often reduced to sea level in this case) is the most important ship observation for NWP, and it is also very important for marine and aviation applications, as well as synoptic meteorology and nowcasting. The global NWP monitoring of ship data shows that some ship observations are affected by important biases in atmospheric pressure measurements, which is obviously linked to incorrect barometer heights (and/or erroneous reduction to sea level). There are also potential improvements on the quality of ship air temperature, SST and wind observations, improvements which could be obtained by more regular interactions of the observation operators with the NWP monitoring centres. See for example the UK Met office Website[40].

Action G51

Action: Improve the quality of ship observations by more regular interactions with the NWP monitoring centres and more regular checks on the instruments onboard.
Who: Port Meteorological Officers (PMOs), NMSs, NMHSs and other NWP monitoring centres in collaboration with companies operating commercial ships. CBS and JCOMM to lead the action.
Time-frame: Continuous.
Performance indicators: Usual NWP monitoring indicators.

5.3.6.4. Moored and drifting buoys

The moored and drifting buoys normally provide observations for a subset of the following variables: surface pressure, temperature, humidity, wind, visibility, SST, ocean current, 3D wave spectrum, wave direction, period and height and precipitation. As they are fully automatic systems,

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39 See SoG on Marine Applications)
40 http://research.metoffice.gov.uk/research/nwp/observations/monitoring/marine/

this observed subset is reduced compared to what can be observed by ships or synoptic sea stations (e.g. clouds and present/past weather are not observed by buoys). There is a large variety of buoys which are deployed operationally, and sometimes the observed subset is reduced to one or two variables on the simplest buoy types. The advantage of the fully automatic systems is that the observation frequency can be quite high for some buoys (observed data every 10 minutes, for example). Drifting buoys move away from their deployment point shortly after being put into the water. They have a limited operational lifetime for reasons such as battery life, sensor failure, transmitter failure, running ashore, etc. The Data Buoy Cooperation Panel (DBCP) of JCOMM strives to maintain a global network of 1250 drifting buoys deployed to meet a grid spacing of 5 degrees by 5 degrees. New buoys have to be redeployed regularly to maintain oceanic data coverage which is complemented by ship data coverage (commercial sailing lines). For the mid-latitude part of the north Atlantic, a good data coverage (and a good complementarity with ships) has been achieved in the years 2000–2010 mainly through the EUMETNET Surface Marine Programme (E-SURFMAR[41]). However, continuous efforts are needed to maintain this coverage as it is still below the requirements in some small areas of the North Atlantic where the deployment is difficult. In addition, in many other areas of the globe, the buoy data coverage is not as good; it presents significant gaps in (e.g.) the southern oceans and the North Pacific. The operational data coverage (for buoys and other observing systems) can be checked on a daily basis on (e.g.) the ECMWF web[42]. The maps showing the monthly buoy coverage (for different types of instruments, different observed variables) can be seen on the DBCP web[43].

For NWP, the most important variable (among those observed by buoys) is surface pressure, and it is important to improve its data coverage. In data assimilation it is used in synergy with space-based surface wind measurements (scatterometers, microwave instruments). A good SST global coverage is important both for NWP and ocean applications. Ocean current information is valuable for oceanographic analysis and forecasting. The wave information is very important for marine services and applications.

Moored buoys provide a richer and more geographically stable data set than drifting buoys for climate time series which are difficult to build with moving platforms. However, even for climate monitoring, the drifting buoys contribute indirectly through their use in meteorological and ocean data assimilation, and in the re-analyses.

The recommendations G30, G31 and G32 made for synoptic sea stations also apply for moored and drifting buoys. The global collection and exchange of buoy observations should be hourly as a minimum. It is recognized that the limitations of satellite telecommunications limit the timeliness of data collection for a significant number of drifting buoys.

Given the importance of a good atmospheric pressure data coverage and of the technological capacities for measuring pressure, the recommendation of GCOS-IP on buoys should be strongly supported. It calls for the implementation of pressure sensors on all the buoys by 2014. Another GCOS recommendation which should be supported calls for all the buoys of the Ocean Reference Mooring Network (a data buoy subset of the Ocean Sustained Interdisciplinary Timeseries Environment observation System – OceanSites[44]) to be equipped with precipitation measurement instruments. Observations of precipitation are particularly important for the interpretation of satellite data over the oceans. The GCOS recommendation for the implementation of a wave measurement component as part of the Surface Reference Mooring Network is important because of the limited number of marine reference sites providing information on the waves and because of the limitations of satellite-based wave measurements.

In summary, ocean buoy data are useful for weather and ocean forecasts and for climate monitoring, and additionally can be used to complement or validate remotely-sensed data and operational models.

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41 http://www.eumetnet.eu/e-surfmar, http://www.eucos.net/nn_133388/EN/Home/networks/esurfmar/esurfmar__node.html
42 http://www.ecmwf.int/products/forecasts/d/charts/monitoring/coverage/dcover/
43 http://www.jcommops.org/dbcp/
44 http://www.oceansites.org/

Action G52

Action: Support the DBCP in its mission to maintain and coordinate all components of the global network of over 1250 drifting buoys and 400 moored buoys, which provides measurements such as SST, surface current velocity, air temperature and wind speed and direction.

Who: NMSs, NMHSs, national oceanographic institutions, in collaboration with JCOMM, international organizations and companies operating oceanic buoys, CBS and CIMO. CBS and JCOMM to lead the action.

Time-frame: Continuous.

Performance indicators: Volume of quality-controlled moored and drifting buoy data available in real-time (usual NWP monitoring indicators).

Action G53

Action: Install barometer on all newly deployed drifting buoys.

Who: NMSs, NMHSs, national oceanographic institutions, in collaboration with JCOMM, international organizations and companies operating oceanic buoys, CBS and CIMO. CBS and JCOMM to lead the action.

Time-frame: Continuous.

Performance indicator: Availability of surface pressure observations from drifting buoys.

Action G54

Action: In the tropical Indian Ocean, extend the existing network of moored buoys to a data coverage similar to those of the Atlantic and Pacific tropics.

Who: NMSs, NMHSs, national oceanography institutions, in collaboration with JCOMM, international organizations and companies operating oceanic buoys, CBS and CIMO. CBS and JCOMM to lead the action.

Time-frame: Continuous.

Performance indicators: Number and data coverage of moored buoys available in the Indian Ocean tropics (usual monitoring indicators).

5.3.6.5. Ice buoys

Ice buoys observe some of the following variables: surface pressure, temperature, wind, ice thickness, and upper ocean temperature and salinity. Sea ice motion is derived from their movement. Some buoys measure only air temperature, surface pressure, and position (therefore motion). More robust measurements are made by ice mass balance (IMB) buoys, which can measure snow depth, ice thickness, the ice temperature profile, ice motion, and some meteorological variables. In 2012, about 50 buoys were in service in the Arctic Ocean at any time, though fewer than ten measure ice and snow thickness. As with buoys deployed in the open ocean, surface pressure is a very important variable for NWP, and this is especially true for the northern polar cap which is otherwise a gap in the data coverage. Ice thickness, snow depth, and temperature are also key variables to monitor in the context of climate change, and also for many marine applications.

Action G55

Action: Increase ice buoy data coverage on the northern polar cap through a regular deployment of new drifters.

Who: NMSs, NMHSs, national oceanographic and polar institutions, in collaboration with JCOMM, international organizations and companies operating ice buoys, CBS and CIMO. CBS and JCOMM to lead the action.

Time-frame: Continuous.

Performance indicators: Volume of ice buoy data available in real-time (usual NWP monitoring indicators).

5.3.6.6. Tide stations

They measure the sea water height. In some cases other variables such as surface pressure, wind, sea water temperature and salinity are measured at the same site. The main role of the Global Sea Level Observing System (GLOSS) is to provide oversight and coordination for global and regional sea level networks in support of oceanographic and climate research related to tide and mean sea level applications (both real-time and not real-time). The main component is the GLOSS Core Network (GCN), an evenly distributed set of about 300 coastal and island tide gauge stations that serves as the backbone of the global network.

There is a need to complete and sustain the GCN network of tide gauges to monitor the coastal sea level changes. The GCN stations should be linked to continuous GNSS stations where possible (either directly at the gauge or levelling to nearby continuous GNSS stations) to enable determination of vertical land motion near GCN stations and thereby absolute sea level change. This is important in the context of the climate change to support the adaptation planning. In this context, the recommendation in the GCOS-IP concerning the GCN should be supported.

The GCN remains a main focus of the GLOSS programme. Stations at roughly 1000 km intervals along the continental margins and at all the major island groups provide sufficient global coverage for a range of oceanographic applications. A denser station network is typically needed for regional/local applications. When instruments are renewed or upgraded multiple use of the sea level stations should be considered where possible (i.e. tsunami, storm surge and wave monitoring).

Action G56

Action: Ensure global availability of in situ sea level data (tide gauges, tsunameters).
Who: NMSs, NMHSs, and national partner institutions, in collaboration with international organizations and space agencies. JCOMM, CBS, and CIMO to lead the action.
Time-frame: Continuous.
Performance Indicator: Amount of tide gauge data available globally.

5.3.7. Sub-surface oceanic observing systems

5.3.7.1. Profiling floats

In the ocean sub-surface, profiling floats measure some of the following variables: temperature, salinity, dissolved oxygen, ocean acidity and pCO_2. The Argo[45] profiling floats provide global coverage of temperature and salinity profiles down to 2000m. “Deep-Argo” floats are under development and will be able to go down to about 3000m. Data are assimilated in ocean models and used for Seasonal to Inter-Annual (SIA) forecasts, for monitoring the ocean sub-surface and for other marine applications. Higher resolution in the observing network would be needed in some active oceanic areas. Some of these profiling float data are also delivered with delays which are inadequate for real-time applications. Although designed to provide long records of data, most of the national programmes contributing to the Argo programme are currently funded for research purposes, and would benefit from transitioning them to operational mode.

The important actions of the GCOS-IP (concerning profiling floats) should be strongly supported: (i) the appropriate number of floats required for enhancing and sustaining an adequate network; and (ii) a pilot project for putting oxygen sensors on some floats. The main reason is the need to monitor carefully the quantity of dissolved oxygen in the oceans, in relation with the climate evolution and the impact on ocean biochemistry and marine life.

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45 http://www.argo.net

Action G57

Action: For ocean and weather forecasting purposes, transition of the Argo profiling float network from research to operational status, and ensure timely delivery and distribution of high vertical resolution data for sub-surface temperature and salinity.
Who: NMSs, NMHSs, national oceanographic institutions, in collaboration with Argo project, JCOMM, international organizations and companies operating profiling floats, CBS and CIMO. JCOMM to lead the action in cooperation with CBS.
Time-frame: Continuous.
Performance indicators: Volume of profiling float data available in real-time (usual monitoring indicators).

5.3.7.2. Ice-tethered platforms

The ice-tethered platforms move at the speed of the ocean ice cover (slowly) while observing the temperature, the salinity and the current underneath. Because of the lack of other techniques for monitoring the deep polar oceans that are frozen at the surface, the ice-tethered platforms have an important role with respect to the global data coverage of oceanic data.

In the context of research projects dedicated to the Arctic Ocean, pCO_2 (ocean acidity) and CH_4 sensors have been also used on ice-tethered platforms.[46]

5.3.7.3. Ships of opportunity

With XBT instruments, ships of opportunity can provide oceanic temperature profile data with a good vertical resolution (about 1m) down to 1000m. They are used by several applications in the same way as profiling floats (see 5.3.7.1), and there is also a lot of potential to improve their real-time delivery.

Action G58

Action: For ocean and weather forecasting purposes, improve timely delivery and distribute high vertical resolution data for sub-surface temperature from Ships/XBT.
Who: NMSs, NMHSs, national oceanographic institutions, in collaboration with JCOMM, international organizations and companies operating ships of opportunity, CBS and CIMO. JCOMM to lead the action in cooperation with CBS.
Time-frame: Continuous.
Performance indicators: Volume of XBT data available in real-time (usual monitoring indicators).

The action of the GCOS-IP, aimed at improving and sustaining the existing network and coverage of the ships of opportunities should be supported.

5.3.8. Research & development and operational pathfinders

Research efforts are ongoing to observe better details of the atmospheric boundary layer, and these efforts are likely to be required for several years. The observation requirement is primarily for wind, temperature and humidity profiles. It is also for aerosols, some chemical species and cloud properties. Indeed, the lack of detailed vertical profiles in the boundary layer (especially wind profiles) is one of the big weaknesses of the current GOS. It is probably the biggest gap which appears by comparing the RRR with the current observing facilities (see for example the SoG for global NWP). For temperature, water vapour and other atmospheric gases, satellite sounders are unable to observe the boundary layer profiles because of inadequate vertical resolutions, and often also (for infra-red sounders) because of the presence of clouds. (See, for example, the user requirements and SoGs for high resolution NWP, nowcasting and aviation). The only routine surface-based observing system which has currently the capacity of measuring the boundary layer profile is the radiosonde network, but with severe limitations on the data coverage and on the

46 http://www.whoi.edu/science/PO/arcticgroup/projects/ipworkshop_report.html

observation frequency (every 12h most of the time). Ground-based wind profilers and profiling stations integrating wind, temperature and humidity are the best hope for high frequency observations of the boundary layer, at least locally, and perhaps also at the regional level, but research efforts are still needed before the implementation of operational networks. Technological progress for profiling techniques is also dependent on the existence of a small number of reference observatory stations, as suggested by GCOS with the GRUAN. Long periods of intercomparison between reference stations and new types of profilers are sometimes necessary to calibrate properly the new instruments (see 5.3.1.2). The CIMO Testbed and Lead Centres sites will contribute to improve the performance of profilers in the atmospheric boundary layer, see: http://www.wmo.int/pages/prog/www/IMOP/Testbeds-and-LC.html.

There are at least two other domains which are poorly observed with respect to the RRR and where technological developments are needed to achieve significant progress:

- In the atmosphere, a better observation of clouds (with their large variety of water and ice particles – especially important for aviation), of aerosols and chemical species. It is important that manual cloud observations should be continued at representative stations. Manual observations need to be retained at least until technological advances are sufficient to ensure automated measurements can satisfactorily replace manual observations;
- In the ocean sub-surface, where it is difficult to obtain observations, ocean gliders and instrumented marine animals are two observing options which are in development (see 5.3.8.5 and 5.3.8.6 below). The GCOS recommendation about promotion of new improved technologies, in support of the GOOS for climate applications is the important one to activate.

Another general tendency affecting meteorological and environmental observations is the move to more automatic and highly computerized systems. It leads to the production of more frequent data and higher volumes of raw data. The pre-processing of the observations tends also to become fully automatic. This requires higher integration between the observation and the data processing. In order to satisfy different types of user, the observation pre-processing will become more complex and more flexible, and it will follow the same tendency as the satellite data: the necessity to produce 2 or 3 different levels of data for different users. The levels will differ by the amount of pre-processing applied to the raw data and by the data volume.

The tendency to more automation is a factor which contributes to a tendency towards “more observing systems of opportunity”. The best example of opportunity in meteorology (which came in the 1990s and the first decade of this century) is the use of GNSS signals propagating through the atmosphere to extract meteorological information. If research actions are carried out towards new opportunities, one can expect the development of other surface-based observing systems based on technologies and capabilities which are designed primarily for non meteorological purposes. Basically, many telecommunication signals propagating in the atmosphere are potentially able to bring indirectly information about the atmospheric state. This has been already successfully tested for estimating the precipitation rate from the attenuation of the Global System for Mobile Communications (GSM) signals of mobile telephones, see Messer (2007). Wind turbines used for electricity power production is another potential opportunity for getting local information on the wind. The electricity power production is obviously dependent on the wind; this dependence can then be inverted in a way that derives the wind information from the power production. In addition, an ensemble of windmills is an opportunity to have a 100m mast which can be instrumented with meteorological sensors at different heights, to provide high vertical resolution profiles from the first 100m in the atmospheric boundary layer. Such an action requires a cooperation between the wind turbine operators and instrument experts from NMSs or NMHSs.

A third tendency for the period 2010–2025, which is true in many disciplines, is to obtain, transmit and use more and more information presented in the form of images. Intense weather phenomena, clouds, amount and type of precipitation on the ground (rain, snow, hail), visibility, sea state, etc.,

are already exchanged on the Internet through digital pictures or videos. Potentially they can provide the same information as the qualitative information which is in the SYNOP[47] code (with more details). However a lot of research and development is needed to exploit objectively this information which is generally not presented in a standard form, and which is difficult to quantify into environmental variables. This requires retaining manual capabilities at a sufficient number of stations both as a basic reference for representative stations, and for calibration purposes.

The technologies summarized below are observing systems that are still at the stage of research and development, and which could become part of global observing systems by 2025. This list is not intended to be comprehensive.

5.3.8.1. Unmanned Aeronautical Vehicles (UAVs)

UAVs have been used in several meteorological campaigns for obtaining detailed information on temperature, humidity and wind, on some limited geographical areas, in the lower troposphere. (See Mayer et al. (2010)). Unlike a normal aircraft, they can fly up and down, and they can provide vertical profiles of meteorological variables. As the atmospheric boundary layer is an important gap in terms of meteorological profiles, UAVs are well adapted to fill this gap locally, but they are difficult to use in routine mode.

UAVs could become an adaptive element of a composite observing system by 2025. Research has to be continued both on technological aspects and on the development of cost-effective means (for operating UAVs regularly). UAVs are also an excellent opportunity for integrating atmospheric chemical measurements and standard meteorological measurements on the same platform. Also aviation regulations need attention before UAVs can be used on a regular basis.

5.3.8.2. Driftsonde balloons (gondolas)

The driftsonde technique consists in launching a constant level balloon, flying in the stratosphere with several dropsondes (stored in a gondola) which can be dropped on demand, providing a vertical profile of temperature, humidity and wind (like normal radiosondes or dropsondes launched from an aircraft). They have been used in several meteorological campaigns, like the AMMA campaign in Africa (see footnote reference to AMMA in section 4) and the THORPEX/Concordiasi[48] experiment in Antarctica (see Rabier et al. (2010)).

These gondolas look very well adapted to meteorological campaigns which are limited in time (a few weeks), but difficult to use in routine as a key element of the composite observing system (also because of the aviation regulations, like UAVs). Currently it is not possible to recommend any development plan for an operational use of this system.

5.3.8.3. GRUAN stations

The GRUAN is neither a new technology nor a new observing system. It is a concept initiated by GCOS (see section 5.3.1.1.2 of this report), consisting in maintaining a small number of observing sites (up to 40) operating high quality radiosondes, reaching the mid stratosphere (about 30 or 40 km as maximum height). In addition to their role in climate monitoring and as a reference for the GUAN stations, these observing sites should act as “small observation laboratories” in which atmospheric vertical profiles are observed through different techniques (surface-based sounders, profilers radars and lidars, etc.) and inter-compared. These atmospheric profiles should be as complete as possible and should integrate a larger number of variables (compared to ordinary radiosondes), including the measurement of clouds, aerosols and concentration of chemical species. Developing GRUAN sites is a simple way and a good opportunity to stimulate research on new observing technologies.

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47 FM-12 SYNOP GTS format – Report of surface observation from a fixed land station

48 Concordiasi is an international project of the THORPEX-IPY cluster within the International Polar Year effort to provide validation data to improve the usage of polar-orbiting satellite data over Antarctica

5.3.8.4. Aircraft atmospheric measurements

Automated aircraft measurements of wind and temperature have been operational in meteorology for more than two decades. Measurement of humidity from aircraft stations commenced operations around 2010 (see 5.3.1.3).

Atmospheric chemistry measurements from aircraft commenced two decades ago but are limited to a small number of aircraft and not integrated with the other meteorological measurements: see for example the documentation on the IAGOS project (IAGOS = Integration of routine Aircraft observations into a Global Observing System). Different ranges of atmospheric chemistry monitoring packages have been developed (e.g. CARIBIC, CONTRAIL). Atmospheric composition measurements for several gas species and aerosols, including volcanic ash, are made on some aircraft, but more in research than in operational mode. For the future it is important to converge to a more integrated operational system which would measure all these variables on some aircraft, process them consistently and make them available in near real-time where possible, including for models in which chemistry is simulated, for aviation meteorology, and for global and high-resolution NWP.

Action G59

Action: Where possible and appropriate, integrate automatic aircraft measurements of atmospheric composition with measurements of wind, temperature and humidity, with processing and dissemination performed, according to GAW and other relevant standards.
Who: Organizations involved in atmospheric measurements from aircraft platforms, NMSs, NMHSs in collaboration with commercial and other airlines, WMO TCs (CBS, CIMO, CAS) and AMDAR panel. CBS, CAS and AMDAR Panel to lead the action.
Time-frame: Continuous.
Performance indicator: A number of aircraft producing both meteorological observations and atmospheric composition measurements in real-time.

5.3.8.5. Instrumented marine animals

Marine animals provide opportunities for oceanographers to make observations, in the sense that the ensemble of sensors attached to an animal moving in the sea can be used for observing both the animal itself and its environment. Boehlert et al. (2001) stated: “Biological autonomous sampling systems have immense potential to contribute oceanographic data in a cost-effective manner”. Ten years later, around 2010, only modest progress has been noted in the use of this technique, which is limited by its lack of time continuity and its poor data coverage (limited to some coastal areas). Efforts should continue, especially to improve the exchange of data with all the users of ocean measurements, to make it more rapid and more standard.

5.3.8.6. Ocean gliders

The observing role played by UAVs in the atmosphere is similar to the one taken by ocean gliders in the ocean. This type of observations has been used in the past for oceanographic campaigns: see Rudnick et al. (2004) and Davis et al. (2002). They have the same capacity and the same flexibility to target a specific area of the ocean and to observe it in its 3 dimensions. Wave gliders and ocean gliders have been used in several field experiments. Wave gliders could be used on a routine basis in some parts of the world by 2015.

Research and developments should be pursued in at least two directions: on new instruments able to observe more ocean variables, and on the standardization of the data exchange.

6. SPACE-BASED OBSERVING SYSTEM

6.1. Introduction

For several decades two types of satellites have been used in meteorology: geostationary satellites (GEO) and Low Earth Orbiting (LEO) satellites. The GEO satellites are deployed along the equator, with their longitudes chosen to optimize the data coverage. The main advantage of a GEO satellite is the high observation frequency of 15 or 30 minutes. The main drawback is that it cannot observe the polar caps (polarward of about 60° of latitude). LEO satellites are generally deployed on a polar sun-synchronous orbit, although other orbits are used for specific applications. The main advantage of sun-synchronous orbits is the global coverage which can be achieved in 12h with many scanning instruments. The data coverage is quite good near the poles where new observations can be produced at each orbit (i.e. about every 100 minutes). The main drawback is the observation frequency in low latitude regions, where observations are produced generally every 12h for a single platform. A rapid and continuous data collection by the ground segments is also more difficult to organize than for geostationary satellites.

Some satellite series have been operational for several decades, like the American Geostationary Operational Environmental Satellite (GOES) or the European METEOSAT (geostationary satellites), or the American NOAA[49] series of polar orbiting satellites. The main instruments operated on these operational satellites are imagers (visible and infra-red) and atmospheric sounders (infra-red or microwave). Research satellites have played a major role in complementing operational satellites, and they will continue to play a major role in the future, although they cannot guarantee the continuity of observation. Some platforms have different instruments serving different applications, and the tendency to develop multi-user platforms is likely to continue. Some user requirements will be met through constellations of satellites (e.g. the COSMIC[50] constellation for radio-occultation measurements). The data volumes and the variety of instruments which are used routinely for many applications have been increased considerably over the last 20 years. Nowadays, many satellite observing systems (including research satellites) bring a very significant contribution to operational weather and climate monitoring. Data continuity, which is essential for climate monitoring as well as for operational applications, is being threatened by the potential end of satellite missions before follow-on platforms are launched. Space agencies are encouraged to prolong the lifetime of currently flying instruments on relevant satellite missions.

A detailed description of the current satellites and instruments contributing to global observing systems (or are likely to contribute in the period 2012–2025) can be found in the WMO Website[51] satellite observing capabilities database. This information set contains a “gap analysis”, i.e. the more critical gaps which lead to recommendations on the development/improvement of satellite observing systems. For the coming 15 years, one can expect an expanded space-based observing capability, an expanded community of space agencies contributing to WMO Programmes and an increased collaboration between them. One can expect also a tendency to have more and more satellites serving several applications.

In the following section (6.2), generic issues concerning the space-based component of global observing systems are described, with corresponding recommendations for implementation in the period 2012–2025. Section 6.3 describes the recommended Actions for the different observing systems classified in the following components (as foreseen in the Vision 2025):

- Operational geostationary satellites (sub-section 6.3.1);
- Operational polar-orbiting satellites on sun-synchronous orbits (6.3.2);
- Miscellaneous operational satellite missions, with various instruments on various orbits (6.3.3), which complement the previous two components, the ensemble being the backbone of the space-based observing systems;

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49 National Oceanic and Atmospheric Administration (USA)
50 Constellation Observing System for Meteorology, Ionosphere and Climate
51 http://www.wmo-sat.info/oscar/spacecapabilities: this WMO web page contains a comprehensive database on past, present and future satellites with their instruments.

– R&D satellite missions, operational pathfinders and technology demonstrations (6.3.4) whose role within composite observing systems in 2025 is uncertain, but which are likely to have an operational contribution by then.

It is noted that observations for space weather are discussed separately in section 7.

6.2. Generic issues: data calibration, data exchange, product generation, data stewardship, education and training

There will be a tendency towards higher spatial, temporal and spectral resolution for all satellite observing systems. It will enhance the information available, particularly to monitor and predict rapidly-evolving small-scale phenomena. It will increase the demand on data exchange and on processing capabilities. The spatial, temporal and spectral resolutions of the satellite data used in operational forecasting are generally coarser than the resolutions of the instruments, because of limitations in computer resources and in data assimilation methodologies. The resolution of the satellite data which are actually assimilated in meteorological and oceanic models is expected to increase faster than the instrument resolutions, by 2025, because of improvements in data assimilation techniques.

6.2.1. Data availability and timeliness

The progress on instrument capabilities and on the use of satellite information will be fully successful only if it is accompanied by actions aiming at improving the availability and the timeliness of the data for the different users and the different applications, from global assimilation in meteorological or oceanic models to the local use in nowcasting. This is more critical for LEO satellites than for GEO. For LEO satellites, direct readout capabilities should be provided wherever possible. In combination with direct readout, the development of the RARS (Regional ATOVS[52] Re-transmission Systems) has improved the timely delivery of data. This type of “quick re-transmission” action on satellite radiances for polar orbiting sounders has considerably helped NWP in recent years, and it will help more and more regional and local forecast systems in the future. Applying such concepts to other data, e.g. imagery, would be beneficial to many other application areas. For GEO satellites, the data delivery is easier within the geographical area corresponding to the Earth disk which is observed directly by each satellite. The main challenge is the rapid processing and the rapid and global exchange of processed data (such as atmospheric motion vectors, AMVs) which are needed for global NWP with an hourly frequency at least. Other applications have identified different requirements for data timeliness.

User-friendly data dissemination techniques (internet, Digital Video Broadcast) should be provided as appropriate. These various techniques all contribute to the WIS and should also be used to disseminate products and training material.

6.2.2. User information, training and data stewardship

Provisions should be made to enable effective use of the capabilities provided by the space-based GOS, and to prepare users for new satellite capabilities well in advance of system deployment. This includes guidance on data reception, processing and analysis infrastructure, including software.

Users relying on satellite-based datasets and products require sufficient information on their quality (e.g., accuracy), the algorithms used, and fitness for purpose. Satellite operators should provide full description of all steps taken in the generation of satellite products, including algorithms used, specific satellite datasets used, and characteristics and outcomes of validation activities. This should be in adherence with the QMF procedure (see section 2.1). Metadata should follow the

52 Advanced TIROS Operational Vertical Sounder

WMO core metadata profile and compliant with internationally-agreed formats recognized by WMO (see WMO Guidelines on the use of metadata for WIS, 2010[53]).

For climate monitoring and studies of other long-term phenomena, extended satellite time-series (e.g., Fundamental Climate Data Records) are needed. Long-term data stewardship under scientific guidance is necessary to achieve homogeneous long-term records, which should include regular reprocessing (roughly every five years). User-friendly arrangements for access to data archives should be put in place.

As part of continuous improvement in Members' capacity, preparation should include the necessary provision of education and training to users, for example through the CGMS Virtual Laboratory for Education and Training in Satellite Meteorology (VLab) and its Centres of Excellence. The user requirements related to satellite data, products, infrastructure and training should be regularly assessed on global and regional level, as appropriate, in order to monitor the effectiveness of the Actions proposed.

Action S1

Action: Enable Members, as appropriate, to fully benefit from evolving satellite capabilities through guidance on data reception and dissemination systems, including the necessary infrastructure upgrades.
Who: CBS leading the action in consultation with CGMS and satellite operators.
Time-frame: Continuous.
Performance Indicator: Level of positive response to survey of Members' user needs.

Action S2

Action: Satellite operators to provide full description of all steps taken in the generation of satellite products, including algorithms used, specific satellite datasets used, and characteristics and outcomes of validation activities.
Who: Satellite operators in CGMS and CEOS.
Time-frame: Continuous.
Performance Indicator: Number of products fully documented, adhering to the QMF procedure.

Action S3

Action: Satellite operators to ensure long-term data preservation and scientific stewardship of data, including regular reprocessing (roughly every five years).
Who: Satellite operators, in coordination with GCOS.
Time-frame: Continuous.
Performance Indicator: Existence of long-term satellite data archives, with regular reprocessing.

Action S4

Action: Members should be enabled to benefit from evolving satellite capabilities through adequate, application-oriented education and training activities (including distance learning).
Who: CGMS through its Virtual Laboratory (VLab), including Centres of Excellence, and partners.
Time-frame: Continuous.
Performance Indicator: Level of positive response to survey of Members' training needs.

53 http://wis.wmo.int/2010/metadata/version_1-2/WMO%20Core%20Metadata%20Profile%20v1-2%20Guidance%20Documentation%20v0.1%20%28DRAFT%29.pdf

Action S5

Action: Regions should determine and maintain requirements for satellite datasets and products.
Who: RAs and satellite operators through their regional task teams and VLab Centres of Excellence.
Time-frame: Continuous.
Performance Indicator: Completeness and currency of set of regional requirements.

6.2.3. Calibration matters

Because almost all satellite instruments need other instruments or other measurements to improve their calibration, the role of the Global Space-based Inter-calibration System (GSICS) becomes increasingly important with the increase in the number of observing systems and in their variety. It is also essential to combine in-situ observations into the process of calibration, tuning and validation. These activities will be carried out by satellite agencies, national laboratories and major NWP centres, helped by WMO, CGMS and CEOS. These activities cover:

- Earth-based reference sites (such as especially-equipped ground sites and ad hoc field campaigns) used to monitor the satellite instrument performance;
- Extra-terrestrial calibration sources (sun, moon, stars) which are stable calibration targets for monitoring the instrument calibration;
- Model simulations which allow the standard monitoring comparison “observed values vs. model values”;
- Benchmark measurements of the highest accuracy by special satellite and ground-based instruments.

There should be common spectral bands on GEO and LEO sensors to facilitate intercomparisons and calibration adjustments. Globally distributed GEO sensors should be routinely inter-calibrated using a given LEO, and a succession of LEO sensors in a given orbit should be routinely inter-calibrated with a given GEO sensor.

Action S6

Action: Maintain and develop the GSICS intercomparisons and inter-calibrations between GEO and LEO sensors on an operational basis.
Who: GSICS.
Time-frame: Continuous.
Performance indicator: Number of instruments calibrated in accordance with GSICS standards.

Instruments should be inter-calibrated on a routine basis against reference instruments or calibration targets, using common methodologies. At least two infra-red and two high-quality visible and, ultimately, ultra-violet and microwave instruments should be maintained in LEO orbits to provide reference measurements for inter-calibration of operational instruments in geostationary or LEO orbit.

For most applications, and especially for climate monitoring, the time continuity of the key satellite sensors has to be planned and organized at the international level. In order to ensure continuity and consistency of data records, there is a need for: (i) continuity of observations; and (ii) overlap of key reference sensors that are needed to provide traceability, as articulated in the GCOS Climate Monitoring Principles (GCMPs)[54].

54 See: http://www.wmo.int/pages/prog/gcos/aopcXVI/8.9_RecognitionDatasets.pdf

Action S7

Action: Ensure continuity and overlap of key satellite sensors, keeping in mind both real-time processing and processing in delayed mode for consistency of climate records, re-analyses, research, recalibration or case studies.
Who: CGMS leading the action, with TCs, satellite agencies and satellite data processing centres.
Time-frame: Continuous.
Performance indicator: Continuity and consistency of data records.

6.3. Issues specific to each observing system component

6.3.1. Operational geostationary satellites

For geostationary meteorological satellites, one key feature is to have them distributed approximately uniformly along the equator, in order to have no gap between their respective observation disks in the tropics and mid-latitudes, so that they can provide a global, frequent (15-30 minutes) continuous data coverage, except for the polar caps (approximately poleward of 60° latitude). To meet the (current and future) different requirements, at least 6 operational geostationary satellites are needed, with an interval of ideally no more than 70° longitude for their positions along the equator. During recent decades the continuity of coverage over the Indian Ocean has been the main concern. Currently, the interval along the equator between GOES-W and MTSAT, 80 to 85°, is also larger than recommended.

Action S8

Action: Ensure and maintain a distribution of at least 6 operational geostationary satellites along the equator, ideally separated by no more than 70° of longitude. Improve the spatial and temporal coverage with GEO satellites over the Pacific.
Who: CGMS leading the action, with TCs, satellite agencies and satellite data processing centres.
Time-frame: Continuous.
Performance indicator: Quality of the global coverage by the different instruments of operational geostationary satellites.

6.3.1.1. High-resolution multi-spectral visible/infra-red imagers.

Visible/infra-red imagers are currently available on all the geostationary satellites. The number of channels and the imagery resolution are variable from one satellite to the other. The GEO imagers are used in several applications, primarily for nowcasting and VSRF. They are very useful for detecting dangerous weather phenomena and for monitoring their rapid development and motion. They observe the clouds (amount, type, temperature of the top). From tracking clouds and water vapour features on image time series, wind observations are derived: atmospheric motion vectors (AMVs). Surface temperature is derived over sea and over land, as well as atmospheric stability indices. The GEO imagery is also used to detect precipitation, aerosols, snow cover, vegetation cover, including Leaf Area Index (LAI) and Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), fires and volcanic ash.

By 2025, an increased space/time resolution is expected for most of the GEO satellite imagers, and it is important to improve the data collection and the data exchange accordingly.

Action S9

Action: On each operational geostationary satellite, implement and maintain at least one visible/infra-red imager with at least 16 channels providing full disk coverage, with a temporal resolution of at least 15 minutes and a horizontal resolution of at least 2km (at sub-satellite point).
Who: CGMS leading the action, with TCs and satellite agencies.
Time-frame: Continuous.
Performance indicator: Number of geostationary satellites equipped with high resolution imagers.

Action S10

Action: For each geostationary satellite, organize the scanning strategy and the processing of the imagery (together with other instruments or other sources of information) in order to produce AMV with at least a 1h frequency.
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: Number of geostationary satellites producing AMVs operationally.

6.3.1.2. Hyper-spectral infra-red sounders

Infra-red sounders have been used for a long time on LEO satellites. Hyper-spectral infra-red sounders are now operational on some LEO satellites (e.g. IASI on the Metop satellite) but not on GEO. The evaluation of the potential of hyper-spectral sounders on GEO was performed with the GIFTS mission, which was considered by the USA.

Several operators of geostationary satellites have firm plans to include hyper-spectral infra-red sounders for the next series of satellites. Detailed plans for the different series of GEO satellites are given in the WMO Database of Observational User Requirements and Observing Systems Capabilities (see footnote reference in section 6.1 of this report).

These planned sounders put the emphasis on high horizontal resolution (better than 10km), and on high vertical resolution (about 1km). Their main objective is to provide frequent information on the 3D structure of atmospheric temperature and humidity, for the whole Earth disk seen by the satellite (except in and below clouds). They will be used, together with the imagers, to produce high resolution winds (AMVs from clouds or water vapour features), to track rapidly evolving phenomena, and to determine surface temperature (sea and land). They are also designed to have an important role in the frequent observation of atmospheric chemical composition.

Action S11

Action: All meteorological geostationary satellites should be equipped with hyper-spectral infra-red sensors for frequent temperature and humidity soundings, as well as tracer wind profiling with adequately high resolution (horizontal, vertical, time).
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous for the mission planning and preparation; 2015–2025 for making the instruments operational.
Performance indicator: Number of geostationary satellites equipped with hyper-spectral sounders.

6.3.1.3. Lightning imagers

A lightning imaging satellite mission has no heritage from any current or past geostationary mission. It is intended to provide a real-time lightning detection and location (with an accuracy of 5 to 10km) capability, primarily in support to nowcasting and VSRF. It is designed to detect cloud-to-cloud and cloud-to-ground strokes with no discrimination between the two types.

As lightning is strongly correlated with storms and heavy precipitation, another objective of a lightning mission is to serve as proxy for intense convection and convective rainfalls. It could serve as proxy for diabatic and latent heating to be assimilated in NWP models. It will also help the generation of a complete lightning climatology, together with the surface-based lightning observing systems (see 5.3.2.4). Finally, lightning plays a significant role in generating nitrogen oxides, and lightning observations could be an important source of information for atmospheric chemistry models.

A lightning imaging mission is planned before 2025 for most of the geostationary satellite programmes: the European MTG (LI: Lightning Imager), the American GOES, from GOES-R onwards (GLM: Geostationary Lightning Mapper), the Russian GOMS[55] and the Chinese FY-4[56].

Action S12

Action: All meteorological geostationary satellites should be equipped with a lightning imager able to detect cloud-to-cloud and cloud-to-ground strokes.
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous for the mission planning and preparation; 2015–2025 for making the instruments operational.
Performance indicator: Number of geostationary satellites equipped with a lightning imager.

6.3.2. Operational polar-orbiting sun-synchronous satellites

For achieving good global data coverage, the Vision-2025 envisages at least 3 operational polar orbiting satellites (with a minimum set of instruments) plus other satellites on various orbits. The Equatorial Crossing Time (ECT) of the 3 satellites is envisaged at 13:30, 17:30 and 21:30 (local solar time). The orbit ECT choice for the 3 operational satellites (and for all the other polar orbiting satellites) must be permanently monitored through an international cooperation.

Action S13

Action: Ensure the orbit coordination for all core meteorological missions in LEO orbit, in order to optimize temporal and spatial coverage, while maintaining some orbit redundancy. The LEO missions should include at least 3 operational sun-synchronous polar orbiting satellites with ECT equal to 13:30, 17:30 and 21:30 (local time).
Who: CGMS leading the action, with TCs and space agencies.
Time-frame: Continuous.
Performance indicators: Number and orbit distribution of contributing LEO satellite missions.

These orbiting platforms (with ECT equal to 13:30, 17:30 and 21:30) should be equipped with at least a hyper-spectral infra-red sounder, a microwave sounder and a high resolution multi-spectral visible/infra-red imager.

Compared with geostationary satellites, it is more difficult with polar platforms to implement a rapid data collection (from the platform to the ground segment), and then for the data delivery to meet the timeliness requirements of the several user applications.

Action S14

Action: Improve timeliness of LEO satellite data, especially of the core meteorological missions on the three orbital planes, by developing communication and processing systems which achieve delivery in less than 30 minutes (as done with the RARS network for some data sets).
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: Timeliness of LEO satellite data, as judged by the usual monitoring scores.

Action S15

Action: Improve local access in real-time to LEO satellite data, especially to the core meteorological missions on the three orbital planes, by maintaining and developing direct read-out communication and processing systems.
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: volumes of LEO satellite data accessible by direct read-out.

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55 Geostationary Operational Meteorological Satellite
56 FengYun 4 Meteorological Satellite

6.3.2.1. Hyper-spectral infra-red sounders

The current (2012) experience on hyper-spectral sounders is based on the use of IASI on the Metop[57] satellite, and of AIRS on AQUA[58]. Compared to the previous infra-red sounders, they provide much more detail in the vertical on the temperature and humidity structure. Their main drawback is that they are limited to sample the clear-sky atmosphere and the portion which is above the clouds. But they are also a significant source of information for sea/land surface temperature, atmospheric composition and cloud variables. Impact studies have shown that they have a strong positive impact on global NWP. They are also expected to have an important role for complementing microwave instruments in the preparation of climate data records (see next section 6.3.2.2 on microwave sounders).

One difficulty for the users of hyper-spectral infra-red sounders is the huge volume of redundant data to process. Each user is interested in the information from a specific subset of this huge volume, and this subset varies from one application to another. For example, global NWP is interested in a representation of the data that gives most information on the temperature and humidity profiles, whilst the atmospheric composition community is interested in information on specific atmospheric constituents. It is a challenge for the centres pre-processing these observations to provide a satisfactory data delivery to all users in an operational context.

Action S16

Action: Design the ground segments for hyper-spectral infra-red sounders in order to define and implement a data reduction strategy which optimizes the information content accessible within the timeliness and cost constraints, whilst addressing the needs of different user communities.
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: Volume and timeliness of the different data sets distributed to the users of hyper-spectral sounders.

6.3.2.2. Microwave sounders

Microwave sounders have been used in meteorology since the decade 1970-1980, mainly from the American NOAA series of satellites, equipped first with the Microwave Sounding Unit (MSU), then with the Advanced Microwave Sounding Unit (AMSU). They provide information on the atmospheric vertical profiles of temperature and humidity, but with a coarser vertical resolution compared to hyper-spectral infra-red sensors. Their main advantage on infra-red sounders is their capacity to observe in and below the clouds. Currently (2012), they are available for meteorological operations on several satellites (5), and they provide a backbone for large-scale global assimilation systems. NWP impact studies have shown that these observations provide a very strong positive contribution.

In addition to their key role for the observation of atmospheric temperature and humidity, microwave sounders provide information on cloud water content and precipitation.

Specific microwave radiance data from satellites, especially from the MSU and AMSU instruments, have become key elements of the historical climate record, and they need to be continued in the future to sustain a long-term record. A GCOS-IP action aims at ensuring the continued derivation of microwave radiance data for climate data records. This climate recommendation is reinforced by the key role taken by the microwave sounders in global re-analyses.

Action S17

Action: Fill the gap in planned coverage of microwave sounders in the early morning orbit.
Who: CGMS leading the action, with TCs and satellite agencies.
Time-frame: Continuous.
Performance indicator: Number of microwave sounders planned for satellites in early morning orbit.

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57 EUMETSAT Polar Orbiting Operational Meteorological Satellite
58 http://aqua.nasa.gov/

6.3.2.3. High resolution multi-spectral visible/infra-red imagers

Visible/infra-red imagers have been used since the beginning of satellite meteorology in the decade 1960–1970. At this time they provided very useful qualitative information for meteorologists, especially on the type and position of clouds and weather systems. Since then, a lot of technological progress has been performed on imagers, particularly on their horizontal resolutions and on the number of channels. Imagers on LEO satellites complement very well those on GEOs, by observing the middle and high latitudes, although their observation frequency is limited by their orbit configurations.

The observational capabilities of imagers onboard LEO satellites are very similar to those on geostationary satellites. They observe the clouds (amount, type, temperature of the top). Surface temperature is derived over sea and over land. The LEO imagery is also used to detect precipitation, aerosols, snow cover, vegetation cover (including LAI and FAPAR), fires and volcanic ash). They are most useful for nowcasting and VSRF in the polar areas. They can also be exploited for producing AMVs (cloud-tracked winds or water-vapour-tracked winds). MODIS[59] winds have been used in operational NWP for several years, and a very significant positive impact has been demonstrated, probably due to the lack of other types of upper-air wind observations over the polar caps.

Action S18

Action: Use the imagers of all operational polar orbiting platforms to produce AMVs from the tracking of clouds (or water vapour features).
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: Volume and timeliness of the different data sets produced operationally on the polar caps.

Action S19

Action: Implement a water vapour channel (e.g. 6.7 µm) on the imager of all core meteorological polar-orbiting satellites to facilitate the derivation of polar winds from water vapour motion.
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: Number of core meteorological polar-orbiting satellites with a water vapour channel in its imager.

6.3.2.4. Microwave imagers

The microwave imagers are similar to the passive microwave sounders discussed in 6.3.2.2, except they have different characteristics in wavelengths and spatial resolution which make them more appropriate for the observation of the land or sea surface. Over the oceans they provide information on sea-ice, surface wind speed and sea surface temperature. Over land they observe surface temperature, soil moisture and snow water equivalent. They also provide information on the precipitation and total column atmospheric water vapour. Polarimetric imagers also provide information on sea surface wind direction.

Since the decade 1990–2000, the total column water vapour and the surface wind speed information provided by the Special Sensor Microwave Imager (SSM-I) instrument onboard the American satellites DMSP[60] have been used widely for weather and climate applications. Initially the use of the data was limited to the ocean, but more recently a lot of progress has been achieved on the use of microwave satellite information over land. The role of these microwave sensors is

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59 MODIS: MODerate-resolution Imaging Spectrometer (onboard AQUA and TERRA satellites).
60 DMSP: Defence Ministry Satellite Programme (from the USA): among the different instruments onboard DMSP satellites, the SSM-I is the Special Sensor Microwave Instrument (used in operational meteorology).

also important for monitoring the sea ice limits around the polar caps. Due to the continuity of the DMSP/SSM-I observations during the last 20 years, these sensors make important contributions both to climate monitoring and to global re-analyses.

To meet the different user requirements, at least 3 satellites with microwave imagers are needed on well separated orbits. According to current plans most requirements are expected to be met, except possibly for all-weather SST.

Action S20

Action: Ensure availability of microwave imagers with all necessary channels to monitor SST.
Who: CGMS with satellite operators.
Time-frame: Continuous.
Performance Indicator: Number of LEO satellites with a microwave SST sensor.

6.3.3. Additional operational missions in appropriate orbits

In addition to the imagers and sounders listed above and operated on GEO and LEO orbits, several other satellite instruments are used for weather, ocean, climate and other applications. Many of them (but not all) are operated on polar orbiting sun-synchronous satellites. Several instruments serve the needs of more than one application.

6.3.3.1. Scatterometers

Unlike microwave imagers which are passive instruments, scatterometers onboard satellites are an active observing system. Scatterometers provide information mainly on the oceanic surfaces (sea surface wind speed, ice cover) and also for the land surface (soil moisture).

The first scatterometer data to be assimilated in operational global NWP models were the oceanic wind observations of the European ERS-1[61] satellite in the decade 1990–2000. Since then, scatterometers have been provided to NWP and other applications, from satellites like ERS-2, QuikScat[62], Metop (and its ASCAT[63] instrument) – see the WMO Database of Observational User Requirements and Observing Systems Capabilities for a list of instruments and missions. They generally provide a very good global data coverage (with some limitations on the maximum wind speed, or over sea ice) which helps considerably to meet the meteorological and oceanic requirements in terms of surface wind. Over land the use of scatterometer data is not as mature, but a lot of progress has recently been achieved on the use of soil moisture information.

At least two satellites flying on well-separated orbits with a scatterometer onboard are needed and should be maintained in the future. According to the present plans the requirements are expected to be met.

6.3.3.2. Radio-occultation constellation

The use of radio-occultation in meteorology is a good example of observing systems based on an opportunity: (i) the continuous availability of GNSS radio signals emitted by about 30 GNSS satellites (probably around 60 in 2015–2025), orbiting at an altitude of about 22000 km; and (ii) the perturbing role of the atmosphere which slows down the signal propagation, and generates atmospheric refraction. Then, by installing GNSS receivers on other satellites (ad hoc constellation or operational meteorological satellites, generally in LEO), it becomes possible to measure the delays of the signals due to their propagation through the atmosphere. These delays are mainly dependent on the air density, and they provide useful information on temperature, especially in the stratosphere and upper troposphere, and on humidity in the lower troposphere.

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61 ERS = Earth Resource Satellite; ESA mission (ERS-1 started in 1991 and was followed by ERS-2)
62 Quick Scatterometer (NASA)
63 Metop's Advanced SCATterometer

Radio-occultation measurements have been assimilated in operational NWP models since about 2005 from several satellites: CHAMP[64], GRACE-A[65], Metop (with its GRAS[66] instrument), the COSMIC constellation[67] (see Poli et al., 2009). Their impact on the analyses and forecasts has been evaluated by several NWP centres, and the main results have been discussed in the 4th WMO workshop on impact studies (see footnote reference in section 4). Taking into account the very indirect character of the observing system through instruments which were not primarily designed for meteorology, this positive impact has been found surprisingly large. In addition, the data coverage obtained from a constellation of receiving satellites is global and quite uniform. The system offers absolute measurements (self-calibrated), not contaminated by clouds, which is a big advantage with respect to: (i) the general inter-calibration of satellite data; and (ii) the creation of climate data records.

Most of the existing satellites currently providing radio-occultation measurements to operational applications are not operational satellites and do not belong to any satellite programme whose future continuity is guaranteed. For the period 2012–2025, it is important to plan the continuity of a sufficient number of receiving satellites, to avoid losing the benefits of the important investments made on the production of radio-occultation measurements and on their use in operational meteorology. It should be noted that the amount of information delivered by a radio-occultation sensor depends on the number of on-board antennas and the number of GNSS systems it is compatible with (e.g. GPS, GLONASS, Galileo).

Action S21

Action: Ensure and maintain a radio-occultation constellation of GNSS receivers onboard platforms on different orbits producing at least 10,000 occultations per day (order of magnitude to be refined by the next Action). Organize the real-time delivery to processing centres.
Who: CGMS to lead the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: Number of GNSS occultations per day that are processed in near-real-time.

Action S22

Action: Perform an Observing System Simulation Experiment (OSSE) to evaluate the impact of different numbers of occultations per day, and to estimate the optimal number of daily occultations required.
Who: NWP centres, in coordination with CBS (to lead the action) and CAS.
Time-frame: Before end 2013.
Performance indicator: A number of OSSEs carried out.

Another application of the GNSS signals and radio-occultation is the measurement of electron density in the ionosphere. Therefore the future radio-occultation constellations will contribute also to the space weather applications (see section 7).

6.3.3.3. Altimeter constellation

SSH is one of the key variables to observe for ocean analysis and forecasting and for coupled ocean-atmosphere modelling. SSH has been observed through a series of satellite altimeters since the beginning of the decade 1990–2000: ERS-1 and 2, JASON-1[68] and 2, ENVISAT[69], GEOSAT[70], etc. – see the WMO Database of Observational User Requirements and Observing Systems Capabilities, for documentation on these satellites and their instrument characteristics. Satellite altimeters provide measurements of the ocean topography and of the significant wave height with

64 CHAllenging Minisatellite Payload
65 GRACE: Gravity Recovery And Climate Experiment
66 GNSS Receiver for Atmospheric Sounding
67 http://www.cosmic.ucar.edu/
68 Ocean Surface Topography mission (USA/France)
69 ESA Environmental Satellite mission
70 GEOdetic SATellite

a global coverage and a good accuracy. The interest of wide-swath altimeters could be highlighted. The surface wind can also be estimated from the wave observation. However the horizontal and temporal resolutions are limited by the instrument producing observations only at the nadir of the satellite (for most instruments). The horizontal resolution can be good along the satellite track, and the main limitation is "across-track" in mid-latitudes: there is generally a 300km gap between measurements from two consecutive orbits.

Several altimeters are also able to provide measurements on ice topography (over sea and land) and on the lake levels (applications to glacier monitoring and hydrology). Unfortunately, there is a gap in laser altimetry between NASA's first and second ICESat satellites. While the radar altimeter on Cryosat-2 is also for sea and land ice measurements, the ideal altimeter constellation would have both laser and radar altimeters. The combination would provide greater accuracy in sea ice thickness estimates, and might provide information on the depth of snow on the ice.

In the future, several altimeter instruments (planned or already flying) will continue to support these applications: ALT on HY-2A[71], AltiKa[72] on SARAL[73] – see WMO Database of Observational User Requirements and Observing Systems Capabilities. In the period 1990–2010, the number of operational altimeters has varied from 1 to 4. It is generally agreed that a minimum of two satellites on sun-synchronous orbits, plus one reference mission, will be necessary to meet the requirements of operational oceanography.

Action S23

Action: Implement an altimeter constellation comprising a reference mission on high-precision, not sun-synchronous, inclined orbit, and two instruments on well separated sun-synchronous orbits.
Who: CGMS leading the action, with TCs, JCOMM, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: Number and orbit geometry of satellites providing altimetry in real-time.

6.3.3.4. Infra-red dual-angle view imager

For climate monitoring purposes it is important to have continuous records of very accurate measurements of SST. In the GCOS-IP an action states: "Continue the provision of best possible SST fields based on a continuous coverage-mix of polar orbiting and geostationary infra-red measurements, combined with passive microwave coverage and appropriate in-situ networks". To achieve the required quality of SST fields it is important to have at least one infra-red instrument with a dual view for accurate atmospheric corrections. Such instruments have already been used: ATSR[74] on ERS, AATSR[75] on ENVISAT – see the WMO Database of Observational User Requirements and Observing Systems Capabilities. Another one is planned for the Sentinel 3 mission: the SLSTR (Sea and Land Surface Temperature Radiometer).

Action S24

Action: Ensure and maintain in operation at least one infra-red dual-angle view imager onboard a polar orbiting satellite in order to provide SST measurements of climate monitoring quality.
Who: CGMS leading the action, with TCs, JCOMM, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: Operational availability of dual-angle view imagers.

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71 HaiYang ocean satellite mission (China)
72 High accurate oceanography altimeter
73 Environment monitoring mission (India/France)
74 Along Track Scanning Radiometer
75 Advanced Along-Track Scanning Radiometer

The high-quality SST fields obtained through these infra-red imagers will also be useful for applications other than climate monitoring, in operational meteorology and oceanography. Also these imagers will contribute to the observation of aerosols, clouds, and fires.

6.3.3.5. Narrow-band high-spectral and hyper-spectral visible/near infra-red imagers

Remote-sensed observations of the ocean colour and related geophysical variables (e.g. phytoplankton, and nutrients) are useful for detecting several types of marine pollution, they can provide images of biological variables of the marine life with a high horizontal resolution (a few hundred metres). Observations of ocean colour are required for several marine applications and for the validation of ocean models.

The observations of ocean colour require passive imagers with narrow bands in the visible and near-infra-red spectrum. Several instruments of this type have already been operated, like the COCTS[76] on the Chinese HY-satellite series, the GOCI[77] on the Korean COMS[78] satellite, the MERIS[79] on the European ENVISAT satellite, or the OCM on the ISRO Oceansat-1 and Oceansat-2 satellites. For the future, other instruments are planned, like the OCS[80], or the OLCI[81] on the Sentinel-3[82].

The narrow-band imagers operated in the visible and near-infra-red are also useful for observing the vegetation (including LAI, FAPAR and the monitoring of burnt areas), the surface albedo, the aerosols and the clouds.

This narrow-band mission is currently well covered by LEO satellites.

6.3.3.6. High-resolution multi-spectral visible/infra-red imagers

For vegetation classification, land use monitoring and flood monitoring, visible/infra-red imagers are needed with characteristics emphasizing high horizontal resolution. These high-resolution instruments are normally applicable only on LEO satellites. The LAI is one of the main variables sought for agricultural meteorology from satellite data for use in crop simulation models. Although the LAI can be retrieved from several imagers, the highest resolution is achieved through the instruments of the LANDSAT[83] and SPOT[84] series. The land surface is observed with a horizontal resolution of dam order of magnitude. With instruments like the CHRIS onboard PROBA-2[85], the resolution can reach 2.5m on some specific targeted areas.

It is essential to continue this type of satellite mission in the future on order to guarantee the continuity of the existing series. This is important for agricultural meteorology, hydrology, land use, careful monitoring of disasters (floods, fires) and the very high-resolution imagers will have several other specific utilizations.

6.3.3.7. Precipitation radars with passive microwave imagers

Estimating the global field of precipitation amount (with precipitation type) at different time-scales is one of the more challenging tasks in weather and climate applications. One reason is related to the high variability in space and time of precipitation: in convective situations, flooding rains may affect one area with no precipitation at all a few kilometres away; the accumulated rainfalls (on 1h, 1 day,

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76 Chinese Ocean Colour and Temperature Scanner
77 Geostationary Ocean Colour Imager
78 Communication, Ocean and Meteorological Satellite
79 MEd Resolution Imaging Spectrometer
80 Ocean Colour Scanner on the Russian Meteor Satellite
81 Ocean Land Colour Imager
82 A multi-instrument ESA satellite mission contributing to the Global Monitoring for Environment and Security (GMES)
83 Earth-observing satellite mission (NASA/USGS)
84 Satellite Pour l'Observation de la Terre
85 CHRIS = Compact High Resolution Imaging Spectrometer, onboard the PROBA-2 (PRoject for OnBoard Autonomy) satellite. PROBA-2 (after PROBA) is a demonstration mission of ESA, which has more and more routine users.

1 month or 1 year) varies by one or two orders of magnitude between the equator and the poles. A second reason is that there is no hope to obtain a global coverage of precipitation observation through surface-based rain gauges and radars: in spite of the efforts made for expanding and improving the surface-based radar networks (see section 5.3.4.), the coverage will always be limited. However a proper estimation of precipitation fields is essential at all time-scales, from those required by the climate monitoring (several years, globally) to the local estimate of rainfall accumulated on 1h or less (flood monitoring). An ad hoc space-based precipitation observing system is very important to achieve this goal.

The concept of Global Precipitation Measurement (GPM) missions combines active precipitation measurements (made from space-based radars) with a constellation of passive microwave imagers (discussed in 6.3.2.4). The GPM constellation is planned to include a core mission with a 65° inclination orbit (with respect to the equator), plus several satellites developed by several national or international agencies. Its objective is to provide a global coverage of precipitation data at 3h intervals, and 8 satellites are needed to achieve this objective. The satellites will be equipped with active precipitation radars, or passive microwave instruments, or generally both. The characteristics of the existing and planned radars can be found on the WMO Database of Observational User Requirements and Observing Systems Capabilities search for example the CPR (Cloud and Precipitation Radar) or the DPR (Dual-frequency Precipitation Radar) in the Database.

This type of measurement has already proven its value, first on the TRMM[86] mission (satellite launched in 1997), and on the CLOUDSAT[87] mission, launched in 2006 by the USA, as part of the "A-Train"[88], to monitor the water cycle of the Earth, and also clouds and aerosols. The MEGHA-Tropiques Mission (MTM[89]), prepared through collaboration between France and India, launched in 2011, also contributes to this project whose emphasis is put on precipitation and water cycle. Several satellites (planned or already flying) will have a low orbital inclination from the equator. For example, the MTM satellite flies between 20S and 20N. In this way, they will provide more frequent data near the equator, compared to the usual polar orbiting satellites whose inclination is close to 90°. This is important for a better understanding and modelling of the diurnal cycle in the tropics. The data availability in real-time is also important for nowcasting and operational hydrology.

Action S25

Action: To implement at least one Precipitation Radar mission on an inclined orbit, and a follow-on operational mission.
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: 2014 (initial) and continuous (follow-on).
Performance indicator: Availability of one mission.

Action S26

Action: In support of GPM, implement at least one passive MW mission on a low-inclination orbit.
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: Availability of one passive MW satellite mission on a low-inclination orbit.

86 Tropical Rainfall Measuring Mission
87 NASA EOS mission to observe clouds
88 The A-Train includes several satellites flying in formation: AQUA, AURA, CLOUDSAT, CALIPSO, PARASOL (The OCO launch failed in February 2009)
89 CNES/ISRO Megha-Tropiques Mission to observe the water cycle and energy budget in the tropics

Action S27

Action: Organize the delivery of GPM data in real-time to support nowcasting and operational hydrology requirements.
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: Extent to which availability requirements for nowcasting and operational hydrology are met.

6.3.3.8. Broad-band visible/infra-red radiometers for Earth radiation budget

The Earth Radiation Budget (ERB) measures the overall balance between the incoming energy from the sun and the outgoing thermal (long-wave) and reflected (short-wave) energy from the Earth. It can only be measured from space, thus the continuity of observations is an essential issue for climate applications (see GCOS-IP, section about ERB).

In addition to imagers and sounders on LEO and GEO satellites, and to aerosols and cloud properties measurements (see sections above from 6.3.2), the ERB requires at least one polar orbiting satellite equipped with a broad-band visible/infra-red radiometer and a sensor for measuring the total solar irradiance.

Broad-band radiometers were available in the past on the ERB Satellite (ERBS) and are available on the TERRA and AQUA satellites. The SCARAB[90] instrument flying on MTM also contributes to the ERB.

Action S28

Action: Ensure the continuity of ERB type global measurements by maintaining operational broad-band radiometers and solar irradiance sensors on at least one LEO polar orbiting satellite.
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: Number of polar orbiting satellites contributing to the ERB.

6.3.3.9. Atmospheric composition instrument constellation

Measurements of variables related to atmospheric composition are important for a diverse range of applications such as monitoring of the stratospheric ozone layer, monitoring and forecasting of air quality including long-range transport of pollution, investigation into the interaction between atmospheric composition and climate change and monitoring of episodic events such as volcanic eruptions and biomass burning. As mentioned above (5.3.1.4), a number of atmospheric constituents have an important role in climate forcings and feedbacks. This is the case for ozone, methane, CO_2 and others. Details can be found in the GAW Strategic Plan (see footnote references to GAW documents in section 5.3.1.4) and the GCOS-IP. Several of these constituents will also become important variables of NWP and atmospheric chemistry models (or already are, like ozone). The observations of these variables should become fully integrated in the WIGOS and then exchanged in real-time to meet the requirements of the full range of atmospheric chemistry applications, including air quality monitoring, and NWP.

There is a long established tradition, dating back to the 1970's when the ozone hole was first discovered, of monitoring stratospheric ozone from space. Since that time many space-based instruments have contributed to the measurements of atmospheric ozone, reactive trace gases, aerosols and more recently green house gases such as CO_2 and CH_4. The Japanese GOSAT, specifically addresses the observation of key Greenhouse Gas (GHG) for climate change.

Other examples of instruments devoted or largely contributing to atmospheric chemistry are: TOMS (flown on board Nimbus 7, Meteor 3, Earthprobe), SAGE I (flown on AEM-B), SAGE II

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90 Scanning radiative budget instrument

(flown on ERBS), SBUV/2 (flown on board 6 NOAA satellites including current NOAA-19), GOME (flown on ERS-2), SMR & OSIRIS (flown on ODIN), SCIAMACHY, MIPAS & MERIS (flown on Envisat), MLS (flown on UARS and EOS-Aura), OMI & TES (flown on EOS-Aura), MODIS (on EOS-Terra and EOS-Aqua), MISR & MOPITT (on EOS-Terra), AIRS (on EOS-Aqua), GOME-2 and IASI (flown on 3 Metop satellites), AIRS (on EOS-Aqua), CrIS, OMPS & VIIRS (on Suomi NPP), CALIOP (on CALIPSO), TANSO-FTS (flown on GOSAT). In addition, multispectral imagers as described in 6.3.1.1 and 6.3.2.3 can be used in support of aerosol monitoring.

Looking towards the next generation of operational missions, OMPS-nadir[91] is present on Suomi-NPP and planned for its follow-on JPSS-1. It will measure ozone, but also NO_2, SO_2 and other trace gases. The OMPS-limb, also present on Suomi-NPP, performs high vertical resolution sounding in the stratosphere. In the European GMES[92] programme, the missions called Sentinel-4 and Sentinel-5 consist of ultra-violet and visible (and in the case of Sentinel-5 near-infra-red) sounders for supporting atmospheric chemistry to be flown on MTG (GEO) and EPS-SG (LEO) respectively. See the WMO Database of Observational User Requirements and Observing Systems Capabilities for more details.

Action S29

Action: For atmospheric chemistry applications including monitoring of ozone, reactive species relevant to air quality and air pollution, and of greenhouse gases, ensure the operational continuity of ultra-violet/visible/near-infra-red sounders, including high spectral resolution ultra-violet/visible sounders on GEO, and at least one ultra-violet/visible sounder on 3 well-separated polar orbits. Ensure also the continuity of limb-sounding capability.
Who: CGMS leading the action, with TCs, satellite agencies and data processing centres.
Time-frame: Continuous.
Performance indicator: Number of GEO and LEO ultra-violet/visible/infra-red sounders contributing to atmospheric chemistry.

For more details about the operational continuity of some atmospheric composition sounders, see GCOS-IP, section dealing with atmospheric chemistry.

6.3.3.10. Synthetic Aperture Radar (SAR)

Compared with a normal radar, the SAR processes the series of images in a special way, in order to increase considerably the spatial resolution locally, which implies some trade-offs on other geometrical variables of the radar measuring technique: scanning angle, swath size, etc. With SAR observing systems onboard LEO satellites, one can obtain locally very high resolution observations of land surface (including above ground biomass), wave heights (directions plus spectra), sea level (especially near the coasts), water level in flooded areas, sea ice caps, ice sheets and icebergs.

The SAR technology has been used on several satellites: ERS-1, ERS-2, ENVISAT (with its Advanced Synthetic Aperture Radar (ASAR) instrument), ALOS[93] (JAXA[94] satellite with its PALSAR[95] instrument). The ESA satellite CRYOSAT-2[96] has been launched in 2010 with its SAR instrument called SIRAL[97]. These SAR instruments have been used for both research and operational applications. For the future, several SAR missions are planned as well; for example the planning and development of the SAR-C instrument (radar in C band) on the GMES Sentinel-1 mission would be a very good step towards integration of the SAR observing system into the operational observing systems. The future Radarsat Constellation Mission (RCM) planned for 2015–2023 will include 3 satellites phased on the same orbit, enabling a 4-day revisit time.

91 OMPS: Ozone Mapping and Profiler Suite
92 GMES: Global Monitoring for Environment and Security
93 Advanced land observing Satellite "Daichi"
94 Japan Aerospace Exploration Agency
95 Phased Array L-band Synthetic Aperture Radar
96 ESA ice mission
97 Synthetic Aperture Interferometric Radar Altimeter

It is not feasible to obtain in real-time a global coverage of SAR data. In addition the SAR processing delays are important, which often prevents a rapid delivery. However it is important to have at least one operational SAR satellite mission whose continuity is guaranteed, and integrated in the WIGOS, with proper mechanisms to ensure a rapid delivery of data at the regional and local scales, in order to cope efficiently with high-risk phenomena and disaster management. Because of the local character of the SAR-targeted areas and of the high volume of data to process, it is actually desirable to have more than one satellite mission complying with these operational characteristics.

6.3.4. Operational pathfinders and technology demonstrators

It is important to pursue investigations on some new satellite instruments and some new space technologies even if the final operational success is not guaranteed, provided these new systems are expected to help significantly for meeting the user requirements. In the past, several research or demonstration missions produced a beneficial operational outcome much more quickly than expected originally by the potential users. Several pathfinders and technology demonstrators are discussed below. They are all challenging but achievable by 2025, with a good chance to be an operational part of global observing systems by 2025 for some of them, and a reduced chance for some other systems.

6.3.4.1. Lidars on LEO satellites

Lidar instruments flying on satellites have been used in meteorology or are planned to be used as demonstration satellite missions. The lidar can be designed to observe some of the following atmospheric components: profiles of wind components (from Doppler shifts), aerosols, cloud-top and cloud-base height, and water vapour profile. Space-borne lidars are also used in altimetry (see 6.3.3.3).

a) Doppler wind lidars

Space-borne Doppler wind lidars are the best hope for filling a big gap in the global data coverage: the lack of wind profile measurements which are currently too dependent on a single observing system, the radiosonde network.

An ESA demonstration mission, ADM-AEOLUS, is planned from 2013 to 2015 to test wind profile measurements made from the ultra-violet lidar, ALADIN[98]. ADM-AEOLUS[99] will be operated from a polar orbiting satellite and will provide global observations of wind profiles. It is very important to have these data delivered in real-time to the main NWP centres to check rapidly (the estimated life-time of ADM-AEOLUS is only 3 years) to what extent they can improve weather forecasts.

Following a successful demonstration mission, it will become a priority to plan and design an operational system based on wind lidars, using the experience accumulated in the demonstration mission, to decide on the appropriate number of satellites and the instrument characteristics.

Action S30

Action: Use the experience of demonstration missions (like the ADM-AEOLUS one) to plan and design an operational observing system based on Doppler wind measurements (providing a global coverage of wind profiles).
Who: CGMS leading the action, with TCs, ESA and other satellite agencies, data processing and NWP centres.
Time-frame: As soon as possible after data have been provided by demonstration missions.
Performance indicator: Number and quality of Doppler wind lidar profiles (made from space) available to the users.

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98 See http://www.esa.int/esaLP/LPadmaeolus.html; see also Stoffelen et al. (2005)
99 Earth Explorer Atmospheric Dynamics Mission

b) Cloud and aerosol lidars

Cloud and aerosol lidar systems can provide accurate measurements of cloud top height and can also observe cloud base height in some cases (e.g.: stratocumulus). They are also able to provide an accurate observation of aerosol layers in the atmosphere.

The CALIOP[100] instrument has been available on CALIPSO since 2006, and the ATLID[101] instrument should fly on the EARTH-CARE[102] mission prepared by ESA and Japan, and planned for 2015[103]. Given the potential of these lidars, the data should be delivered for evaluation in operational centres (mainly forecasting and atmospheric chemistry applications). For the design of a possible operational system based on cloud/aerosol lidar, it is important to note that a Doppler wind lidar like the ADM-AEOLUS has also the capacity to observe clouds and aerosols, which raises the possibility of designing an operational system which would integrate wind, cloud and aerosol measurements.

For an efficient evaluation of the lidar data (as soon as the instrument is operated), it is important to have these data distributed in real-time, so that they can be used (or at least evaluated) in operational numerical models dealing with atmospheric chemistry and weather forecasting.

Action S31

Action: Deliver cloud/aerosol lidar data produced from satellite missions to operational data processing centres and users. Use this experience to decide about a possible cloud/aerosol operational mission (integrated or not with an operational Doppler wind lidar mission).
Who: CGMS leading the action, with TCs, satellite agencies, data processing centres, forecasting and atmospheric chemistry users.
Time-frame: Continuous with a special effort phased with the EARTH-CARE mission.
Performance indicator: Data volume produced by space-based cloud/aerosol lidars and used by operational applications.

c) Water vapour lidars

Feasibility studies have been carried out on the measurement of atmospheric water vapour profiles from lidars onboard LEO satellites. The objective has been found highly challenging, and no demonstration mission is currently planned for a water vapour lidar. It is still worth keeping a research activity on such an observing system, and worth planning a demonstration mission when appropriate.

6.3.4.2. Low-frequency microwave radiometer on LEO satellites

Microwave radiometers on LEO satellites have a capacity to observe ocean salinity and soil moisture, but with a limited horizontal resolution. At large scales, the salinity information will be useful in ocean applications, in seasonal and inter-annual forecasting and in climate monitoring. The soil moisture produced from these microwave instruments should also be useful in NWP, seasonal and inter-annual forecasting, hydrology and climate monitoring. The horizontal resolution provided by these instruments may be marginal for meeting the user requirements in the coastal areas and for high-resolution marine applications.

The SMOS[104] satellite was launched in January 2009 and is expected to provide data until 2014. The Argentinean/NASA mission[105] SAC-D is expected to provide similar data between 2012 and

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100 Cloud-Aerosol Lidar with Orthogonal Polarisation
101 ATmospheric LIDar
102 Earth Clouds, Aerosols and Radiation Explorer – see http://www.esa.int/esaLP/LPearthcare.html
103 For more details on CALIPSO, CALIOP, EARTH-CARE and ATLID, see the WMO database referenced in section 6.1. http://www.wmo-sat.info/oscar/spacecapabilities
104 SMOS: Soil Moisture and Ocean Salinity; satellite demonstration mission led by ESA, see: http://www.esa.int/esaLP/ESAMBA2VMOC_LPsmos_0.html
105 See http://aquarius.nasa.gov/

2016. Such research data sets should be delivered to operational meteorological, hydrological and oceanographic centres for near-real-time evaluation. If the benefits are judged sufficiently significant, an operational mission should be planned.

Action S32

Action: Study the benefits brought by satellite demonstration missions like SMOS (missions based on low-frequency microwave radiometers) on atmospheric, hydrological and oceanic models, in a quasi operational context, and decide if a similar operational mission can be designed.
Who: CGMS leading the action, with TCs, JCOMM, satellite agencies, data processing centres, meteorological, hydrological and oceanic modelling centres.
Time-frame: As soon as possible for impact studies, from 2013 onwards to decide on new missions.
Performance indicator: Improvement brought by using these microwave data on different models.

Ocean salinity and soil moisture are variables whose variations are important to consider at the climate scale. The archiving of data series is important; see recommendations in the ocean part of the GCOS-IP.

6.3.4.3. Microwave imagers/sounders on GEO satellites

Using microwave imagers and sounders from geostationary satellites could provide very frequent precipitation observations, together with cloud properties (liquid water and ice content), and atmospheric temperature/humidity profiles. However such instruments are highly challenging for several technical reasons. One reason is the need for very large antennas to be operated on GEO orbits.

The potential benefit of such satellite instruments would be very high in terms of global estimation of precipitation fields (at all time scales). They would be very good complements to the same type of instruments on LEO satellites (see sections 6.3.2.4 and 6.3.3.7 about microwave imagers, GPM and precipitation fields). Therefore there is a good case to plan a demonstration mission with microwave instruments onboard a geostationary satellite.

Action S33

Action: Plan and design a demonstration mission with microwave instruments onboard a geostationary satellite, aiming at a significant improvement in terms of real-time observation of clouds and precipitation.
Who: CGMS leading the action, with TCs, satellite agencies, data processing centres, meteorological and hydrological modelling centres.
Time-frame: As soon as possible, taking into account the maturity of technology.
Performance indicator: Success of a microwave instrument onboard a GEO satellite, then improvement brought by the data to meteorological and hydrological forecasting.

6.3.4.4. High-resolution, multi-spectral, narrow-band, visible/near-infra-red on GEO satellites

Such instruments on GEO satellites would be the natural complement of the visible/near-infra-red instruments onboard LEO satellites (presented in section 6.3.3.5). They would contribute to the observation of ocean colour, vegetation, clouds and aerosols, and they would help disaster monitoring, with the usual advantage of GEO versus LEO: the frequency of images which makes the observation almost continuous on the Earth disk seen by the satellite. However their implementation is much more challenging than on LEO because of the high altitude of the geostationary orbit.

Action S34

Action: Plan and design a demonstration mission with high-resolution visible/near-infra-red instruments onboard a geostationary satellite, aiming at improving significantly the observation of ocean colour, vegetation, clouds and aerosols with multi-spectral narrow-band sensors.
Who: CGMS leading the action, with TCs, satellite agencies, data processing centres, meteorological, oceanic and environmental centres.
Time-frame: As soon as possible, taking into account the maturity of technology.
Performance indicator: Success of this type of instrument onboard a GEO satellite, then improvement brought by the data to meteorology, oceanography and environmental science.

6.3.4.5. Visible/infra-red imagers on satellites in high inclination and Highly Elliptical Orbit (HEO)

The HEO has never been used in meteorology and oceanography. Its main advantage is that the satellite can stay close to the vertical of one particular region of the Earth (at high altitude) for several hours, and only a reduced time on the opposite side of the Earth. When the orbit inclination on the equator is high, it almost offers the observation continuity similar to that of a geostationary satellite but in a polar region. With visible/infra-red sensors onboard, a HEO satellite would offer an almost continuous observation of the large number of meteorological and oceanic variables normally observed by this type of sensors: clouds (and AMVs) at high latitudes, surface temperature, sea-ice, ash plumes, vegetation, fires and snow cover.

Action S35

Action: Plan and design a demonstration mission with visible/infra-red instruments onboard a HEO satellite with a highly elliptical orbit and a high inclination over the equator, in order to target a polar area. The aim is to obtain the same environmental observations with a quality similar to those obtained from GEO satellites.
Who: CGMS leading the action, with TCs, satellite agencies, data processing centres, meteorological and environmental centres.
Time-frame: As soon as possible, taking into account the maturity of technology.
Performance indicator: Success of a visible/infra-red instrument onboard a HEO satellite, then improvement brought by the data to meteorology and environmental science.

6.3.4.6. Gravimetric sensors

Satellites have been used for gravity field measurements for several decades. Several gravity field sensors are currently flying, like the USA GRACE[106] mission or the ESA GOCE[107] satellite.

Their instruments can measure the Earth gravity field and follow its variations in space and time. From these variations, one can detect information on the ground water mass, or on the mass of water in some lakes and rivers. Thus they contribute to the monitoring of the ground water, together with a set of in-situ observing systems described in 5.3.3.3.

Note that gravity instruments are often flying on multi-user platforms: for example GNSS receivers embarked on any gravity field measurement platform, if properly set up, can be used for radio-occultation of the atmosphere, contributing to forecasting and climate applications, as described in 6.3.3.2.

106 Gravity Recovery and Climate Experiment – http://www.csr.utexas.edu/grace/
107 Gravity field and steady-state Ocean Circulation Explorer – http://www.esa.int/esaLP/LPgoce.html

7. SPACE WEATHER

Space Weather refers to the physical processes occurring in the space environment, driven by the Sun and Earth's upper atmosphere, and ultimately affecting human activities on Earth and in space. In addition to the continuous ultra-violet (UV), visible and infra-red (IR) radiation which provides radiative forcing to our weather and climate at the top of the atmosphere and maintains the ionosphere, the Sun emits a continuous flow of solar wind plasma which carries the Sun's embedded magnetic field, and releases energy in an eruptive mode, as flares of electromagnetic radiation (radio waves, IR, visible, UV, X-rays), energetic particles (electron, protons, and heavy ions), and high speed plasma through coronal mass ejections. The solar wind and the eruptive disturbances (i.e. solar storms) propagate out into interplanetary space and impact interplanetary space and Earth's environment.

The electromagnetic radiation travels at the speed of light and takes about 8 minutes to move from Sun to Earth, whereas the energetic particles travel more slowly, taking from tens of minutes to hours to move from Sun to Earth. At typical speeds, the background solar wind plasma reaches Earth in about four days, while the fastest coronal mass ejections can arrive in less than one day. The solar wind and the solar disturbances interact with the Earth's magnetic field and outer atmosphere in complex ways, causing strongly variable energetic particles and electric currents in the magnetosphere, ionosphere and thermosphere. These can result in a hazardous environment for satellites and humans at high altitudes, ionospheric disturbances, geomagnetic field variations, and the aurora, which can affect a number of services and infrastructure at the Earth's surface, or airborne or space-borne in Earth orbit. The threats of space weather are certain to increase, both in the near term as solar maximum approaches and in the far term as our dependence on technologies impacted by space weather continues to expand.

Space weather observations are required: to forecast the occurrence probability of space weather disturbances; to drive hazard alerts when disturbance thresholds are crossed; to maintain awareness of current environmental conditions; to determine climatological conditions for the design of both space based systems (i.e., satellites and astronaut safety procedures) and ground based systems (i.e., electric power grid protection and airline traffic management); to develop and validate numerical models; and to conduct research that will enhance our understanding. The vastness of space and the wide range of physical scales which control the dynamics of space weather demand that numerical models be employed to characterize the conditions in space and to predict the occurrence and consequence of disturbances. In order to obtain the maximum benefit from sparse measurements, space weather observations have to be used through assimilation into empirical or physics-based models. A comprehensive space weather observation network must include ground-based and space-borne observatories. Both the ground-based and the space-based segments shall contain a combination of remote sensing and in-situ measurements.

Today, services relying on operational and research observing assets can help all WMO Members to monitor disturbances and to warn of oncoming storms. The space environment, however, is vastly undersampled. Significant gaps in our observing capabilities limit our ability to provide a comprehensive characterization of the important physical parameters, and limit the accuracy of our predictive models. Existing ground-based and space-based assets have not all been integrated into a coordinated observing network. These include a number of Global Navigation Satellite System (GNSS) receiver sites, ground measurements of Earth's magnetic field, and satellite measurements of energetic particles and magnetic field in space. Furthermore, continuity of some essential space-based monitoring missions is not planned.

In the framework of the WMO Information System (WIS) and the WMO Integrated Global Observing System (WIGOS), existing observing systems and service centres can be expanded and further integrated, thus improving the capability to deliver a broad range of services. Space weather is a global challenge requiring coordinated global preparedness. All Members have the opportunity to contribute to future capabilities, and are encouraged to improve the collection and open dissemination of ground-based and space-based space weather data. Working together, we can achieve global preparedness for space weather hazards and response.

Action W1

Action: To develop and implement a coordinated plan ensuring continuity of solar measurements, solar wind and interplanetary magnetic field measurements, and heliospheric imaging, including measurements at different locations such as at the L1 Lagrange point, the Sun-Earth line upstream from the L1 point, the L5 Lagrange point, as well as the required global network of ground-based antennas for data reception and processing.
Who: ICTSW[108], CGMS and space agencies.
Time-frame: End 2014.
Performance indicator: Availability of coordinated plans for continuity until 2030.

Action W2

Action: To coordinate and to standardize the existing ground-based solar observation data, and to expand them where required for redundancy, and to develop a common data portal or virtual observatory within the WIS.
Who: ICTSW and all Members performing solar observations from the surface.
Time-frame: Continuous.
Performance indicator: Availability of data template for ground-based solar observation.

Action W3

Action: To increase the spatial resolution of ground-based GNSS ionospheric observations (TEC and scintillation), either by deploying additional receivers in regions with sparse coverage (e.g. Africa), making the data from existing receivers accessible, or by utilizing different means of receiving GNSS data, such as aircraft-mounted receivers, to reduce gaps over the oceans.
Who: ICTSW and all Members operating or planning ground-based GNSS networks.
Time-frame: continuous.
Performance indicator: Number of ground-based GNSS receivers providing near-real-time data.

Action W4

Action: To improve the timeliness of space-based GNSS measurements from LEO satellites to get near-real-time information about the 3D electron density distribution of the ionosphere/plasmasphere system. (e.g. by use of a RARS concept or other network of satellite ground stations for rapid transmission).
Who: ICTSW, CGMS, relevant space agencies, and WMO Members who support ground stations.
Time-frame: Continuous.
Performance indicator: Number of occultations per day available with a timeliness to meet user requirements.

Action W5

Action: To foster sharing of ground-based GNSS data and GNSS Radio-Occultation among the meteorological and space weather communities, and to facilitate the near-real-time access to these data through WIS.
Who: ICTSW, IROWG[109] and WMO/WIGOS project office.
Time-frame: Continuous.
Performance indicator: Agreement on data sharing.

Action W6

Action: To coordinate the use of dual-frequency radar altimeter observations by Space Weather community to improve or validate ionospheric models and for operational TEC monitoring over the oceans.
Who: ICTSW, WMO Space Programme and altimetry satellite operators.
Time-frame: Continuous.
Performance indicator: Number of satellite altimeters providing data for space weather.

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108 Inter-programme Coordination Team on Space Weather (ICTSW)
109 International Radio Occultation Working Group (IROWG)

Action W7

Action: To increase the availability of ground-based magnetometer data with high timeliness. This can be accomplished by: (i) deployment of magnetometers in regions with limited coverage; (ii) dissemination of data from existing magnetometers within WIS; and (iii) agreement with data providers for their data to be used in space weather products.
Who: ICTSW and magnetometer observatories.
Time-frame: Continuous.
Performance indicator: Number of magnetometer data sources available with timeliness to meet user requirements.

Action W8

Action: Develop a plan for maintaining and improving space weather observations of the plasma and energetic particle environment along the following priorities: (1) maintain long-term continuity, and if possible improve the spatial resolution, of measurements at all altitudes from LEO through GEO orbits; (2) improve the sharing of existing and planned plasma and energetic particle measurements; (3) include energetic particle sensors on HEO satellites; and (4) conduct research to incorporate the plasma and energetic particle data into numerical models to give flux estimates at all locations where our satellites are in orbit.
Who: ICTSW, CGMS and space agencies.
Time-frame: End of 2014.
Performance indicator: Availability of a plan for space weather observation of plasma and energetic particle environment.

ANNEX I – REFERENCES

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ANNEX II – SUMMARY TABLE OF ACTIONS

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
C1	Meet growing user requirements for climate information by encouraging and assisting in expansion of traditional observing platforms for weather and climate observations.	GCOS and CBS to lead the action, together with regional centres representing users and organizations operating component observing systems.	Continuous.	Extent to which user needs are met.
C2	Once relevant research-based observing systems are shown to be sufficiently mature and cost-effective, follow an appropriate migration methodology to become a sustained operational system.	CBS, in collaboration with CIMO and CAS, to initiate and lead the evolution, with all organizations operating component observing systems.	Continuous. Timetable to be decided on a case by case basis.	Number of sustained systems compared to the targets.
C3	Ensure all operators producing observations adhere to the WIS standards.	Organizations and agencies operating observing programmes. Action monitored by CBS.	Continuous.	Extent to which WIS standards are applied.
C4	Careful preparation is required before introducing new (or changing existing) observing systems. The impact needs to be assessed through prior and ongoing consultation with data users and the wider user community. Also, data users need to be provided with guidance on data reception/acquisition, processing and analysis infrastructure, the provision of proxy data, and the provision of education and training programmes.	All organizations operating component observing systems, following the best practices provided by CBS, CAS or other TCs and co-sponsored programmes	Continuous.	Extent to which user community concerns are captured.
C5	Ensure sustained funding for the key marine/ocean observing systems (e.g. tropical moorings, Argo, surface drifters with barometers, as well as altimeter, scatterometer, SST from microwave radiometry, sea ice measurements from research satellite missions).	NMSs, NMHSs and partner national institutions, in collaboration with international organizations, TCs responsible for observing system coordination (e.g. JCOMM, CBS, and CIMO) and space agencies.	Continuous.	Percentage of observing networks funded through sustained mechanism.
C6	For each observing system proposed for operation in adaptive mode (i.e. a process which would vary the observation set according to the meteorological situation), investigate the feasibility, cost-effectiveness and side effects on the continuity of climate data records.	Organizations operating observing networks on a routine basis. Process to be initiated and coordinated by CBS based on recommendations from CAS, other TCs, the RAs, and GCOS.	Continuous reviewing process of the feasibility and cost-effectiveness assessments.	Number of networks operated with some level of targeting.
C7	Ensure time continuity and overlap of key components of the observing system and their data records, in accordance with user requirements, through appropriate change-management procedures.	CBS to lead, in collaboration with other TCs, JCOMM, RAs, satellite agencies, NMSs and NMHSs, and organizations operating observing systems. RAs.	Continuous. Timetable to be decided on a case by case basis.	Continuity and consistency of data records.
C8	For WMO and co-sponsored observing systems, ensure continued adherence to WMO data sharing principles irrespective of origin of data, including data provided by commercial entities.	NMSs and NMHSs, and space agencies. Process monitored by CBS.	Continuous.	Continued availability of all essential observational data to all WMO members.

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
C9	Evaluate the future evolution of data volumes to be exchanged and handled, based on the projected data volumes generated by the future space-based and surface-based sources.	WMO/WIS to lead, in collaboration with TCs, JCOMM, RAs, satellite agencies, NMSs and NMHSs, all organizations operating observing systems.	Continuous.	Evolution of the data volumes handled and exchanged.
C10	Monitor the flow of all essential data to processing centres and to users and ensure timely flow of feedback information to observing network management from monitoring centres.	Data processing centres coordinated by appropriate TCs and international programmes (CBS to lead the process and initiate it when required).	Continuous.	Usual monitoring criteria
C11	Achieve improved homogeneity of data formats for international exchange, by reducing to a smaller number of internationally coordinated standards.	CBS to lead, in coordination with other TCs.	Continuous.	Number of data formats per data type
C12	Ensure a continuous monitoring of the radio frequencies which are needed for the different components of WIGOS, in order to make sure they are available and have the required level of protection.	WMO/SG-RFC to lead, in coordination with NMSs, NMHSs and national, regional and international organizations in charge of radio frequency management.	Continuous.	Observation frequency bands available/not available with required level of protection.
C13	Establish capacity building strategies for observing systems in developing countries through projects funded by international organizations, bilateral partnerships and facilitation of regional cooperation.	NMSs/NMHSs with RAs, CBS, other TCs, in collaboration with international programmes.	Continuous.	Substantial improvement in observational data return from developing countries.
G1	Ensure traceability of meteorological observations and measurements to SI or WMO standards.	NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs, and other relevant organizations. CBS and RAs to lead and supervise.	Continuous.	Number of stations that make measurements traceable to SI or WMO standards.
G2	Ensure, as far as possible, a global exchange of hourly data which are used in global applications, optimized to balance user requirements against technical and financial limitations.	NMSs/NMHSs, RAs, in coordination with CBS and international programmes and agencies. CBS to lead the action.	Continuous. Timetable to be decided for each observing system.	The standard monitoring indicators used in global NWP[17].
G3	Promote a global exchange of sub-hourly data in support of relevant application areas.	NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs, and other relevant organizations. CBS to lead the action.	Continuous. Timetable to be decided for each observing system.	A number of sub-hourly data types exchanged through WIS.
G4	Ensure exchange of observations from atmosphere, ocean, terrestrial observing system, according to the WIGOS standards. If needed, organize different levels of pre-processed observations in order to satisfy different user requirements.	NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs, and other relevant organizations. CBS to lead the action.	Continuous. Timetable to be decided for each observing system.	Statistics on the data made available to each application.

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
G5	Surface-based observing network operators should facilitate access to observations suitable to support validation of space-based derivation of surface parameters.	CBS to lead, in collaboration with NMSs and NMHSs.	Continuous.	Quantity of surface-data made available for the validation of satellite products.
G6	Surface-based observing network operators should consider using space-based observations/products to monitor quality of data from surface-based networks.	CBS, NMS, NMHS	Continuous.	Number of surface-based observing systems using satellite data for quality monitoring
G7	Expand radiosonde stations, or re-activate silent radiosonde stations, in the data sparse areas of Regions I, II and III which have the poorest data coverage. Make all possible effort to avoid closing of existing stations in these data sparse areas, where even a very small number of radiosonde stations can provide an essential benefit to all the users.	NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs, and other relevant organizations. CBS to lead the action together with the RAs.	Continuous.	The standard monitoring indicators used in NWP[17].
G8	Reconsider radiosonde network designs (e.g. by using isolated stations), taking into account other available sources of data, such as AMDAR and wind profilers.	CBS through NWP impact studies and network design studies, in coordination with NMSs/NMHSs, WMO own and co-sponsored programmes, other TCs, RAs and other relevant organizations. CBS and RAs to lead the action.	2015 (or earlier) for a first redesign.	Design developed and implemented.
G9	Continue the studies and tests on the usefulness of observations obtained by increasing the frequency of radiosonde launches at some observation sites, in relation with the meteorological situation in the area.	NMSs/NMHSs, research institutions and other organizations operating radiosonde networks or organizing field experiments, with the NWP centres. CBS and CAS to lead the action.	Continuous, with a time-table depending on regional campaigns.	A number of radiosonde sites able to become “adaptive” together with the number of observations made (standard monitoring).
G10	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.	NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs and other relevant organizations. CBS and RAs to lead the action.	2015, then continuous.	Standard monitoring indicators
G11	Improve quality, availability and sustainability of GUAN, ensuring maintenance of the existing network, and data quality.	CBS to lead in coordination with GCOS and with NMSs/NMHSs, TCs, RAs, and other relevant organizations.	Continuous.	The standard monitoring indicators used in NWP.
G12	Continue implementation of GRUAN through support and development of the initial 15 stations and eventual completion of the full 30-40 station network.	CBS to lead in coordination with GCOS and with NMSs/NMHSs, TCs, RAs, and other relevant organizations.	Continuous.	The standard monitoring indicators used in NWP and the indicators defined in the GRUAN Observation Requirements.

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
G13	Identify radiosonde stations that make regular measurements (including radiosondes operated during campaigns only), but for which data are not transmitted in real-time. Take actions to make data available.	NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs, and other relevant organizations. CBS and RAs to lead the action.	Continuous.	A number of the above radiosonde stations providing data to GTS, plus standard monitoring indicators on radiosonde data availability and timeliness.
G14	Ensure a timely distribution of radiosonde measurements at high vertical resolution, together with position and time information for each datum, and other associated metadata.	NMSs/NMHSs, in coordination with WMO own and co-sponsored programmes, TCs, RAs, and other relevant organizations. CBS and RAs to lead the action.	Continuous.	Number of radiosonde sites providing the high resolution profiles.
G15	Perform NWP impact studies to evaluate the impact of radiosonde data above 100hPa on global NWP, in the context of current observing systems (2012).	NWP centres, coordinated by CBS/ET-EGOS and CAS.	Before end of 2013.	A number of independent studies carried out.
G16	Perform OSSEs to evaluate the impact of improved information above 100hPa on the tropospheric forecasts.	NWP centres, coordinated by CBS/ET-EGOS and CAS	Before end of 2013.	A number of independent experiments of this kind carried out.
G17	Develop networks of remote-sensing profiling stations on the regional scale in order to complement the radiosonde and aircraft observing systems, mainly on the basis of regional, national and local user requirements (although part of the measured data will be used globally).	Organizations operating profiling stations in routine or research mode, in coordination with NMSs/NMHSs, RAs, TCs (mainly CAS, CBS and CIMO) and other regional institutions (e.g.: EUMETNET in Europe). CBS to lead the action with CIMO, CAS and RAs.	Continuous. Detailed timetables to be set up by RAs at the regional level.	A number of profiling stations providing quality-assessed data in real-time to WIS/GTS.
G18	Ensure, as far as possible, the required processing and the exchange of profiler data for local, regional and global use. When profiler data can be produced more frequently than 1 hour, a dataset containing only hourly observations can be exchanged globally following the WIS principles.	Organizations operating profiling stations in routine or research mode, in coordination with NMSs/NMHSs, RAs, TCs (mainly CAS, CBS and CIMO) and other regional institutions (e.g. EUMETNET in Europe). CBS to lead the action together with the RAs.	Continuous. Detailed timetables to be set up by RAs at the regional level.	A number of profiling stations exchanged globally.
G19	Improve AMDAR coverage over areas that currently have poor coverage, especially within Regions I and III, focussing on the provision of data at airports in the tropics and southern hemisphere where vertical profiles are most needed to complement current radiosonde data coverage and its likely evolution.	NMSs, NMHSs in collaboration with commercial and other airlines, RAs. AMDAR Programme Management to lead the action.	Continuous.	Number of airports where AMDAR measurements are taken. Amount of vertical profiles and AMDAR data in general, measured by the usual indicators of current AMDAR programmes.

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
G20	Extend the AMDAR Programme so as to equip and activate more internationally operating fleets and aircraft (i.e. fleets and aircraft flying to and between international airports outside the country of origin) and extend the use of data optimization systems in support of improved upper air observations coverage and efficiency, and also the adaptive functionality of the system.	NMSs, NMHSs in collaboration with commercial and other airlines, RAs, CBS and AMDAR Programme Management. AMDAR Programme Management to lead the action.	Continuous.	The number of airports where AMDAR measurements are taken and number of vertical profiles per day at each airport. The number of international airlines and aircraft equipped to provide AMDAR observations. The adaptability of the AMDAR programme.
G21	Given the nature of the aircraft observing system as an increasingly critical and basic component of the Global Observing System, seek to establish agreements with airlines and the aviation industry to ensure that the system, infrastructure, data and communications protocols are supported and standardized within relevant aviation industry frameworks so as to ensure continuity and reliability of the system.	NMSs, NMHSs in collaboration with national and other airlines and aviation industry, RAs, CBS and AMDAR Programme Management. AMDAR Programme Management to lead the action.	Continuous.	Agreements made with aviation industry partners and organizations.
G22	Continue the development and operational implementation of humidity sensors as an integrated component of the AMDAR system to ensure that humidity data is, processed and transmitted in the same way as wind and temperature.	NMSs, NMHSs in collaboration with commercial and other airlines and TCs (CBS, CIMO) and AMDAR Programme Management. AMDAR Programme Management to lead the action.	Continuous.	A number of aircraft providing humidity data in real-time.
G23	Enhance and extend the capability to report observations of atmospheric turbulence and icing variables as an integrated component of the AMDAR system and in line with the requirements of the relevant programme areas and data users.	NMSs, NMHSs in collaboration with airlines and TC (CBS, CIMO) and AMDAR Programme Management, RAs. AMDAR Programme Management to lead the action.	Continuous.	A number of aircraft providing atmospheric turbulence and icing data in real-time.
G24	Develop and implement operationally AMDAR systems which are adapted to small aircrafts operating at the regional scale and flying at low altitude in the troposphere.	Airlines operating small aircraft, NMSs, NMHSs in collaboration with RAs, CBS and AMDAR panel. AMDAR Programme Management to lead the action.	Continuous.	Number of small aircrafts providing AMDAR observations operationally in real-time.
G25	Encourage managers of national programmes of meteorological observations to extend the scope of these stations to include atmospheric chemistry observations.	NMSs/NMHSs and respective organizations and research agencies conducting atmospheric composition observations, in coordination with TCs (especially with CAS and CBS) and RAs. CAS and CBS to lead the action with RAs.	Continuous. Timetable to be defined for each RA.	Number of atmospheric composition stations.

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
G26	Derive greater benefit from the existing GNSS receiver stations by establishing collaborative arrangements with station owners and operators for access, processing, and sharing of real-time data to derive meteorological or ionospheric information (ZTD or IWV, TEC).	NMSs/NMHSs (individually or in multilateral groupings) will lead the Action and will need to collaborate with station owners/operators, with RAs (to determine exchange requirements), and with TCs (for relevant guidance).	Continuous.	Number of GNSS receiver stations making available their data in real-time; number of stations which can be used in NWP according to the usual monitoring criteria[17].
G27	Organize the global exchange of data from a subset of GNSS receiver stations, aiming at satisfying a frequency requirement of about one hour (for meeting requirements in global applications).	Organizations and research agencies operating GNSS receiver stations, in coordination with NMSs/ NMHSs, with RAs, TCs (especially CAS and CBS) and other international organizations (e.g., EUMETNET). CBS to lead the action with RAs.	Continuous.	A number of GNSS receiver stations whose data are exchanged globally in real-time.
G28	Optimize the upper-air water vapour observation over land, considering the collaborative establishment of additional GNSS receiver stations, and also the other humidity observing systems.	Organizations and research agencies operating GNSS receiver stations, in coordination with NMSs/ NMHSs, with RAs, TCs (especially CAS and CBS) and other international organizations (e.g. EUMETNET). NMSs/NMHSs to lead the action with RAs.	Continuous.	Number of GNSS receiver stations making available their data in real-time; number of stations which can be used in NWP according to the usual monitoring[17].
G29	Extend the BSRN to achieve global coverage.	NMSs/NMHSs, and Research organizations, RAs and TCs, coordinated by CBS.	Continuous.	Number of BSRN stations.
G30	Ensure, as far as possible, global exchange of variables measured by surface synoptic and climatological stations with at least one-hour frequency and in real-time.	NMSs/NMHSs, RAs and TCs, coordinated by CBS.	Continuous.	A percentage of observations exchanged globally with a one hour frequency (with respect to the number of stations observing hourly).
G31	Improve data compatibility, availability (also with higher frequency) and data coverage of surface synoptic and climatological observations through quality management, automation and exchange of data in real-time, as far as possible from all operational stations.	NMSs/NMHSs, RAs and TCs, coordinated by CBS.	Continuous.	A percentage of stations distributing quality-assessed observations in real-time over WIS/GTS (with respect to the number of stations producing observations).
G32	Ensure variables measured by surface synoptic and climatological stations are exchanged together with access to relevant metadata according to WIGOS and WIS standards. Special attention should be given to the barometer altitude uncertainty.	NMSs/NMHS, RAs and TCs, coordinated by CBS.	Continuous.	Usual monitoring indicators[17].

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
G33	Improve design of the Regional Basic Synoptic Network (RBSN) and the Regional Basic Climatological Network (RBCN), making every effort to retain climatically significant stations.	CBS leading the action through the appropriate NWP impact studies and network design studies, in coordination with NMSs/NMHSs, WMO own and co-sponsored programmes, other TCs, RAs and other relevant organizations.	2015.	Design developed and implemented.
G34	Implement as soon as possible a near-real-time exchange of the atmospheric composition observations which are made at surface stations. Follow the GAW recommendations and WIGOS and WIS practices for implementing this dissemination, and the standard quality assessment practices.	Organizations and research agencies operating atmospheric composition observations, in coordination with NMSs/NMHSs, the RAs and TCs. CAS and CBS to lead the action with RAs.	Continuous. Timetable to be established for each RA.	A number of surface atmospheric composition stations making quality-assessed data available in real-time.
G35	Implement as soon as possible a comprehensive cryosphere observing network of reference sites “CryoNet”.	Organizations, institutes and research agencies conducting cryosphere observation and monitoring, in coordination with NMSs/NMHSs, the RAs and TCs, as required. CryoNet Team will lead the action. GCW Advisory Board and Management Board will oversee the action.	2014.	Number of reference sites taking part in CryoNet.
G36	Provide, as far as possible, a real-time or near-real-time exchange of the cryospheric data from CryoNet. Follow the GCW, WIGOS and WIS practices for implementing this dissemination, and the standard quality assessment practices and archiving.	Organizations, institutes and research agencies conducting cryosphere observations and monitoring, in coordination with NMSs/NMHSs, the RAs and TCs, as required. CryoNet Team will lead the action; GCW Advisory Board and Management Board will oversee the action.	2014.	Number of CryoNet stations making quality-assessed data available.
G37	Improve global lightning detection efficiency by extending the deployment of long-range lightning detection systems and introducing more of these systems. Priorities should be given to filling gaps in populated areas and along commercial airline routes.	NMSs/NMHSs and agencies operating long-range lightning detection systems RAs and TCs, coordinated by CBS and CIMO, leading the action jointly.	Continuous.	Data coverage for this type of observations.
G38	Develop and implement techniques for the integration of lightning detection data from different systems, including from surface- and space-based systems, to enable composite products to be made available.	NMSs/NMHSs and agencies operating lightning detection systems, RAs and TCs, coordinated by CBS and CIMO, leading the action jointly.	Continuous.	Level of integration of the lightning systems.

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
G39	Improve the exchange of lightning detection data in real-time by establishing and implementing agreed protocols for the exchange of data.	NMSs/NMHSs and agencies operating lightning detection systems, NMSs, NMHS, RAs and TCs, coordinated by CBS and CIMO.	Continuous.	A percentage of observations exchanged regionally and globally.
G40	Ensure, as far as possible in real-time, exchange of observations, relevant metadata, including a measure of representativeness made by surface-based stations serving specific applications (road transport, aviation, agricultural meteorology, urban meteorology, etc.).	Agencies operating stations serving specific applications, NMSs / NMHSs, RAs and TCs, coordinated by CBS.	Continuous.	A percentage of observations from the above stations exchanged regionally and globally in real-time.
G41	Enhance observations in candidate areas to support studies associated with the development and operations of renewable energy installations, and also to understand the influence of these installations on local weather and climate phenomena related to the operation of the renewable technologies.	Agencies operating stations serving renewable energies, NMSs/NMHSs, RAs and TCs, coordinated by CBS.	Continuous.	Number of observations supporting of renewable energies.
G42	For climate purposes, maintain the existing hydrological stations of the GCOS/GTOS baseline network, and facilitate their global exchange.	All hydrological services operating these reference stations, TCs (CHy and CBS), GCOS. CBS and GCOS to lead the action.	Continuous.	Percentage of hydrological reference stations exchanging globally quality-assessed data.
G43	Include observations of key hydrological variables (liquid and solid precipitation, evaporation, snow depth, snow water content, lake and river ice thickness, water level, water flow, soil moisture) into an integrated system for a consistent observation, processing and exchange, following the WIGOS standards.	Hydrological services, GCOS, TCs (CHy and CBS) leading the action.	Continuous.	Percentage of hydrological data integrated in this system.
G44	To continue and expand existing programmes of ground water observation and monitoring, including expansion of the IGRAC.	Hydrological services in collaboration with WMO/CHy, the Food and Agriculture Organization (FAO) and GTOS (especially its Global Terrestrial Network for Groundwater – GTN-GW – component). WMO/CHy and GTOS to lead the action.	Continuous.	Number of ground water stations operating.
G45	Increase the deployment, calibration and use of dual polarization radars in those regions where it is beneficial.	CBS to lead the action in collaboration with CIMO, RAs and NMSs/NMHSs.	Continuous.	Data coverage obtained from this type of radar for each Region.
G46	Perform comparison of weather radar software with the objective to improve quality of the quantitative precipitation estimates (QPE).	CIMO in collaboration with NMSs/NMHSs and agencies operating weather radars.	Continuous.	Guidance provided to the operators and Members.
G47	For areas in developing countries which are sensitive to storms and floods, a special effort has to be made to establish and maintain weather radar stations.	NMSs/NMHSs, agencies operating weather radars, in collaboration with RAs and TCs (CBS, CIMO and CHy). CBS to lead the action with each RA.	Continuous.	The number of operational weather radar stations in the above areas.

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
G48	Define weather radar data to be exchanged at regional and global levels, propose frequency of exchange of those data and develop a weather radar data processing framework, in concert with development of products based on national, regional, global requirements.	CBS (leading the action), CIMO, CHy in coordination with NMSs/NMHSs, agencies operating weather radars, in collaboration with RAs.	Continuous.	Volume of radar data which are exchanged globally and regionally.
G49	Maintain and optimize the existing ASAP network over North Atlantic, and develop similar programmes for the North Pacific and the Indian Ocean.	NMSs, NMHSs, in collaboration with companies operating commercial ships, RAs, JCOMM, CBS and CAS. JCOMM to lead RAs	Continuous.	Volume of ASAP data available in real-time (usual NWP monitoring indicators).
G50	Ensure state-of-art technologies are employed to improve accuracy for all measurements made at sea stations. Develop visibility measurement capabilities over the ocean.	NMSs, NMHSs and national partner institutions, in collaboration with international organizations and space agencies. JCOMM, CBS, and CIMO to lead the action.	Continuous.	Usual monitoring indicators on availability and quality of marine observations.
G51	Improve the quality of ship observations by more regular interactions with the NWP monitoring centres and more regular checks on the instruments onboard.	Port Meteorological Officers (PMOs), NMSs, NMHSs and other NWP monitoring centres in collaboration with companies operating commercial ships. CBS and JCOMM to lead the action.	Continuous.	Usual NWP monitoring indicators.
G52	Support the DBCP in its mission to maintain and coordinate all components of the global network of over 1250 drifting buoys and 400 moored buoys, which provides measurements such as SST, surface current velocity, air temperature and wind speed and direction.	NMSs, NMHSs, national oceanographic institutions, in collaboration with JCOMM, international organizations and companies operating oceanic buoys, CBS and CIMO. CBS and JCOMM to lead the action.	Continuous.	Volume of quality-controlled moored and drifting buoy data available in real-time (usual NWP monitoring indicators).
G53	Install barometer on all newly deployed drifting buoys.	NMSs, NMHSs, national oceanographic institutions, in collaboration with JCOMM, international organizations and companies operating oceanic buoys, CBS and CIMO. CBS and JCOMM to lead the action.	Continuous.	Availability of surface pressure observations from drifting buoys.
G54	In the tropical Indian Ocean, extend the existing network of moored buoys to a data coverage similar to those of the Atlantic and Pacific tropics.	NMSs, NMHSs, national oceanography institutions, in collaboration with JCOMM, international organizations and companies operating oceanic buoys, CBS and CIMO. CBS and JCOMM to lead the action.	Continuous.	Number and data coverage of moored buoys available in the Indian Ocean tropics (usual monitoring indicators).

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
G55	Increase ice buoy data coverage on the northern polar cap through a regular deployment of new drifters.	NMSs, NMHSs, national oceanographic and polar institutions, in collaboration with JCOMM, international organizations and companies operating ice buoys, CBS and CIMO. CBS and JCOMM to lead the action.	Continuous.	Volume of ice buoy data available in real-time (usual NWP monitoring indicators).
G56	Ensure global availability of in situ sea level data (tide gauges, Tsunameters).	NMSs, NMHSs, and national partner institutions, in collaboration with international organizations and space agencies. JCOMM, CBS, and CIMO to lead the action.	Continuous.	Amount of tide gauge data available globally.
G57	For ocean and weather forecasting purposes, transition the Argo profiling float network from research to operational status, and ensure timely delivery and distribution of high vertical resolution data for sub-surface temperature and salinity.	NMSs, NMHSs, national oceanographic institutions, in collaboration with Argo project, JCOMM, international organizations and companies operating profiling floats, CBS and CIMO. JCOMM to lead the action in cooperation with CBS.	Continuous.	Volume of profiling float data available in real-time (usual monitoring indicators).
G58	For ocean and weather forecasting purposes, improve timely delivery and distribute high vertical resolution data for sub-surface temperature from Ships/XBT.	NMSs, NMHSs, national oceanographic institutions, in collaboration with JCOMM, international organizations and companies operating ships of opportunity, CBS and CIMO. JCOMM to lead the action in cooperation with CBS.	Continuous.	Volume of XBT data available in real-time (usual monitoring indicators).
G59	Where possible and appropriate, integrate atmospheric composition measurements together with the measurements of wind, temperature and humidity, with processing and dissemination performed according to the GAW and other relevant standards.	Organizations involved in atmospheric measurements from aircraft platforms, NMSs, NMHSs in collaboration with commercial and other airlines, TCs (CBS, CIMO, CAS) and AMDAR panel. CBS, CAS and AMDAR Panel to lead the action.	Continuous.	A number of aircraft producing both meteorological observations and atmospheric composition measurements in real-time.
S1	Enable Members, as appropriate, to fully benefit from evolving satellite capabilities through guidance on data reception and dissemination systems, including the necessary infrastructure upgrades.	CBS leading the action in consultation with CGMS and satellite operators.	Continuous.	Level of positive response to survey of Members' user needs
S2	Satellite operators to provide full description of all steps taken in the generation of satellite products, including algorithms used, specific satellite datasets used, and characteristics and outcomes of validation activities.	Satellite operators in CGMS and CEOS.	Continuous.	Number of products fully documented, adhering to the QMF procedure

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
S3	Satellite operators to ensure long-term data preservation and scientific stewardship of data, including regular reprocessing (roughly every five years).	Satellite operators, in coordination with GCOS.	Continuous.	Existence of long-term satellite data archives, with regular reprocessing
S4	Members should be enabled to benefit from evolving satellite capabilities through adequate, application-oriented education and training activities (including distance learning).	CGMS through its Virtual Laboratory (VLab), including Centres of Excellence, and partners.	Continuous.	Level of positive response to survey of Members' training needs
S5	Regions should determine and maintain requirements for satellite datasets and products.	RAs and satellite operators through their regional task teams and VLab Centres of Excellence.	Continuous.	Completeness and currency of set of regional requirements
S6	Maintain and develop the GSICS inter-comparisons and inter-calibrations between GEO and LEO sensors on an operational basis.	GSICS.	Continuous.	Number of instruments calibrated in accordance with GSICS standards.
S7	Ensure continuity and overlap of key satellite sensors, keeping in mind both real-time processing and processing in delayed mode for consistency of climate records, re-analyses, research, recalibration or case studies.	CGMS leading the action, with TCs, satellite agencies and satellite data processing centres.	Continuous.	Continuity and consistency of data records.
S8	Ensure and maintain a distribution of at least 6 operational geostationary satellites along the equator, ideally separated by no more than 70° of longitude. Improve the spatial and temporal coverage with GEO satellites over the Pacific.	CGMS leading the action, with TCs, satellite agencies and satellite data processing centres.	Continuous.	Quality of the global coverage by the different instruments of operational geostationary satellites.
S9	On each operational geostationary satellite, implement and maintain at least one visible/infra-red imager with at least 16 channels providing full disk coverage, with a temporal resolution of at least 15 minutes and a horizontal resolution of at least 2km (at sub-satellite point).	CGMS leading the action, with TCs and satellite agencies.	Continuous.	Number of geostationary satellites equipped with high resolution imagers.
S10	For each geostationary satellite, organize the scanning strategy and the processing of the imagery (together with other instruments or other sources of information) in order to produce AMV with at least a 1h frequency.	CGMS leading the action, with TCs, satellite agencies and data processing centres.	Continuous.	Number of geostationary satellites producing AMVs operationally.
S11	All meteorological geostationary satellites should be equipped with hyper-spectral infra-red sensors for frequent temperature and humidity soundings, as well as tracer wind profiling with adequately high resolution (horizontal, vertical, time).	CGMS leading the action, with TCs, satellite agencies and data processing centres.	Continuous for the mission planning and preparation; 2015–2025 for making the instruments operational.	Number of geostationary satellites equipped with hyper-spectral sounders.
S12	All meteorological geostationary satellites should be equipped with a lightning imager able to detect cloud-to-cloud and cloud-to-ground strokes.	CGMS leading the action, with TCs, satellite agencies and data processing centres.	Continuous for the mission planning and preparation; 2015–2025 for making the instruments operational.	Number of geostationary satellites equipped with a lightning imager.

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
S13	Ensure the orbit coordination for all core meteorological missions in LEO orbit, in order to optimize temporal and spatial coverage, while maintaining some orbit redundancy. The LEO missions should include at least 3 operational sun-synchronous polar orbiting satellites with ECT equal to 13:30, 17:30 and 21:30 (local time).	CGMS leading the action, with TCs and space agencies.	Continuous.	Number and orbit distribution of contributing LEO satellite missions.
S14	Improve timeliness of LEO satellite data, especially of the core meteorological missions on the three orbital planes, by developing communication and processing systems which achieve delivery in less than 30 minutes (as done with the RARS network for some data sets).	CGMS leading the action, with TCs, satellite agencies and data processing centres.	Continuous.	Timeliness of LEO satellite data, as judged by the usual monitoring scores.
S15	Improve local access in real-time to LEO satellite data, especially to the core meteorological missions on the three orbital planes, by maintaining and developing direct read-out communication and processing systems.	CGMS leading the action, with TCs, satellite agencies and data processing centres.	Continuous.	Volumes of LEO satellite data accessible by direct read-out.
S16	Design the ground segments for hyper-spectral infra-red sounders in order to define and implement a data reduction strategy which optimizes the information content accessible within the timeliness and cost constraints, whilst addressing the needs of different user communities.	CGMS leading the action, with TCs, satellite agencies and data processing centres.	Continuous.	Volume and timeliness of the different data sets distributed to the users of hyper-spectral sounders.
S17	Fill the gap in planned coverage of microwave sounders in the early morning orbit.	CGMS leading the action, with TCs and satellite agencies.	Continuous.	Number of microwave sounders planned for satellites in early morning orbit.
S18	Use the imagers of all operational polar orbiting platforms to produce AMVs from the tracking of clouds (or water vapour features)	CGMS leading the action, with TCs, satellite agencies and data processing centres.	Continuous.	Volume and timeliness of the different data sets produced operationally on the polar caps.
S19	Implement a water vapour channel (e.g. 6.7 µm) on the imager of all core meteorological polar-orbiting satellites to facilitate the derivation of polar winds from water vapour motion.	CGMS leading the action, with TCs, satellite agencies and data processing centres.	Continuous.	Number of core meteorological polar-orbiting satellites with a water vapour channel in its imager.
S20	Ensure availability of microwave imagers with all necessary channels to monitor SST.	CGMS with satellite operators.	Continuous.	Number of LEO satellites with a microwave SST sensor.
S21	Ensure and maintain a radio-occultation constellation of GNSS receivers onboard platforms on different orbits producing about 10000 occultations per day (order of magnitude to be refined by the next Action). Organize the real-time delivery to processing centres.	CGMS to lead the action, with TCs, satellite agencies and data processing centres.	Continuous.	Number of GNSS occultations per day that are processed in near-real-time.
S22	Perform an Observing System Simulation Experiment (OSSE) to evaluate the impact of different numbers of occultations per day, and to estimate the optimal number of daily occultations required.	NWP centres, in coordination with CBS (to lead the action) and CAS.	Before end 2013.	A number of OSSEs carried out.
S23	Implement an altimeter constellation comprising a reference mission on high-precision, not sun-synchronous, inclined orbit, and two instruments on well separated sun-synchronous orbits.	CGMS leading the action, with TCs, JCOMM, satellite agencies and data processing centres.	Continuous.	Number and orbit geometry of satellites providing altimetry in real-time.

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
S24	Ensure and maintain in operation at least one infra-red dual-angle view imager onboard a polar orbiting satellite in order to provide SST measurements of climate monitoring quality.	CGMS leading the action, with TCs, JCOMM, satellite agencies and data processing centres.	Continuous.	Operational availability of dual-angle view imagers.
S25	To implement at least one Precipitation Radar mission on an inclined orbit, and a follow-on operational mission.	CGMS leading the action, with TCs, JCOMM, satellite agencies and data processing centres.	2014 (initial) and continuous (follow-on).	Availability of one mission.
S26	In support of GPM, implement at least one passive MW mission on a low-inclination orbit.	CGMS leading the action, with TCs, satellite agencies and data processing centres.	Continuous.	Availability of one passive MW satellite mission on a low-inclination orbit.
S27	Organize the delivery of GPM data in real-time to support nowcasting and operational hydrology requirements.	CGMS leading the action, with TCs, satellite agencies and data processing centres.	Continuous.	Extent to which availability Requirements for nowcasting and operational hydrology are met.
S28	Ensure the continuity of ERB type global measurements by maintaining operational broad-band radiometers and solar irradiance sensors on at least one LEO polar orbiting satellite.	CGMS leading the action, with TCs, satellite agencies and data processing centres.	Continuous.	Number of polar orbiting satellites contributing to the ERB.
S29	For atmospheric chemistry applications including monitoring of ozone, reactive species relevant to air quality and air pollution, and of greenhouse gases, ensure the operational continuity of ultra-violet/ visible/near-infra-red sounders, including high spectral resolution ultra-violet/visible sounders on GEO, and at least one ultra-violet/visible sounder on 3 well-separated polar orbits. Ensure also the continuity of limb-sounding capability.	CGMS leading the action, with TCs, satellite agencies and data processing centres.	Continuous.	Number of GEO and LEO ultra-violet/ visible/infra-red sounders contributing to atmospheric chemistry.
S30	Use the experience of demonstration missions (like the ADM-AEOLUS one) to plan and design an operational observing system based on Doppler wind measurements (providing a global coverage of wind profiles).	CGMS leading the action, with TCs, ESA and other satellite agencies, data processing and NWP centres.	As soon as possible after data have been provided by demonstration missions.	Number and quality of Doppler wind lidar profiles (made from space) available to the users.
S31	Deliver cloud/aerosol lidar data produced from satellite missions to operational data processing centres and users. Use this experience to decide about a possible cloud/aerosol operational mission (integrated or not with an operational Doppler wind lidar mission).	CGMS leading the action, with TCs, satellite agencies, data processing centres, forecasting and atmospheric chemistry users.	Continuous with a special effort phased with the EARTH-CARE mission.	Data volume produced by space-based cloud/aerosol lidars and used by operational applications.
S32	Study the benefits brought by satellite demonstration missions like SMOS (missions based on low-frequency microwave radiometers) on atmospheric, hydrological and oceanic models, in a quasi operational context, and decide if a similar operational mission can be designed.	CGMS leading the action, with TCs, JCOMM, satellite agencies, data processing centres, meteorological, hydrological and oceanic modelling centres.	As soon as possible for impact studies, from 2013 onwards to decide on new missions.	Improvement brought by using these microwave data on different models.
S33	Plan and design a demonstration mission with microwave instruments onboard a geostationary satellite, aiming at a significant improvement in terms of real-time observation of clouds and precipitation.	CGMS leading the action, with TCs, satellite agencies, data processing centres, meteorological and hydrological modelling centres.	As soon as possible, taking into account the maturity of technology.	Success of a microwave instrument onboard a GEO satellite, then improvement brought by the data to meteorological and hydrological forecasting.

No.	Action	Agent for implementation	Time frame	Performance indicator(s)
S34	Plan and design a demonstration mission with high-resolution visible/near-infra-red instruments onboard a geostationary satellite, aiming at improving significantly the observation of ocean colour, vegetation, clouds and aerosols with multi-spectral narrow-band sensors.	CGMS leading the action, with TCs, satellite agencies, data processing centres, meteorological, oceanic and environmental centres.	As soon as possible, taking into account the maturity of technology.	Success of this type of instrument onboard a GEO satellite, then improvement brought by the data to meteorology, oceanography and environmental science.
S35	Plan and design a demonstration mission with visible/infra-red instruments onboard a HEO satellite with a highly elliptical orbit and a high inclination over the equator, in order to target a polar area. The aim is to obtain the same environmental observations with a quality similar to those obtained from GEO satellites.	CGMS leading the action, with TCs, satellite agencies, data processing centres, meteorological and environmental centres.	As soon as possible, taking into account the maturity of technology.	Success of a visible/infra-red instrument onboard a HEO satellite, then improvement brought by the data to meteorology and environmental science.
W1	To develop and implement a coordinated plan ensuring continuity of solar measurements, solar wind and interplanetary magnetic field measurements, and heliospheric imaging, including measurements at different locations such as at the L1 Lagrange point, the Sun-Earth line upstream from the L1 point, the L5 Lagrange point, as well as the required global network of ground-based antennas for data reception and processing.	ICTSW, CGMS and space agencies.	End 2014	Availability of coordinated plans for continuity until 2030
W2	To coordinate and to standardize the existing ground-based solar observation data, and to expand them where required for redundancy, and to develop a common data portal or virtual observatory within the WIS.	ICTSW and all Members performing solar observations from the surface.	Continuous.	Availability of data template for ground-based solar observation.
W3	To increase the spatial resolution of ground-based GNSS ionospheric observations (TEC and scintillation), either by deploying additional receivers in regions with sparse coverage (e.g. Africa), making the data from existing receivers accessible, or by utilizing different means of receiving GNSS data, such as aircraft-mounted receivers, to reduce gaps over the oceans.	ICTSW and all Members operating or planning Ground-based GNSS networks.	Continuous.	Number of ground-based GNSS receivers providing near-real-time data.
W4	To improve the timeliness of space-based GNSS measurements from LEO satellites to get near-real-time information about the 3D electron density distribution of the ionosphere/plasmasphere system. (e.g. by use of a RARS concept or other network of satellite ground stations for rapid transmission).	ICTSW, CGMS, relevant space agencies, and WMO Members who support ground stations.	Continuous.	Number of occultations per day available with a timeliness to meet user requirements.
W5	To foster sharing of ground-based GNSS data and GNSS Radio-Occultation among the meteorological and space weather communities, and to facilitate the near-real-time access to these data through WIS.	ICTSW, IROWG and WIGOS project office.	Continuous.	Agreement on data sharing.
W6	To coordinate the use of dual-frequency radar altimeter observations by Space Weather community to improve or validate ionospheric models and for operational TEC monitoring over the oceans.	ICTSW, WMO Space Programme and altimetry satellite operators.	Continuous.	Number of satellite altimeters providing data for space weather.

No.	*Action*	*Agent for implementation*	*Time frame*	*Performance indicator(s)*
W7	To increase the availability of ground-based magnetometer data with high timeliness. This can be accomplished by: (i) deployment of magnetometers in regions with limited coverage; (ii) dissemination of data from existing magnetometers within WIS; and (iii) agreement with data providers for their data to be used in space weather products.	ICTSW and magnetometer observatories.	Continuous.	Number of magnetometer data sources available with timeliness to meet user requirements.
W8	Develop a plan for maintaining and improving space weather observations of the plasma and energetic particle environment along the following priorities: (1) maintain long-term continuity, and if possible improve the spatial resolution, of measurements at all altitudes from LEO through GEO orbits; (2) improve the sharing of existing and planned plasma and energetic particle measurements; (3) include energetic particle sensors on HEO satellites; and (4) conduct research to incorporate the plasma and energetic particle data into numerical models to give flux estimates at all locations where our satellites are in orbit.	ICTSW, CGMS and space agencies.	End of 2014.	Availability of a plan for space weather observation of plasma and energetic particle environment.

ANNEX III – ACRONYMS

3D	Three Dimensional
AATSR	Advanced Along-Track Scanning Radiometer
ACM	Atmospheric Chemistry Model
ADM-Aeolus	Earth Explorer Atmospheric Dynamics Mission
AIRS	Atmospheric Infrared Sounder
ALADIN	Atmospheric Laser Doppler Instrument
ALOS	Advanced land observing Satellite "Daichi"
Altika	High accurate oceanography altimeter onboard SARAL mission
AMDAR	Aircraft Meteorological Data Relay Programme
AMMA	African Monsoon Multidisciplinary Analyses
AMSU	Advanced Microwave Sounding Unit
AMV	Atmospheric Motion Vector
AQUA	Aqua satellite mission – http://aqua.nasa.gov/
Argo	International profiling float programme (not an acronym)
ASAP	Automated Shipboard Aerological Programme
ASAR	Advanced Synthetic Aperture Radar
ASCAT	Metop's Advanced SCATterometer
ATLID	ATmospheric LIDar
ATOVS	Advanced TIROS Operational Vertical Sounder
ATSR	Along Track Scanning Radiometer
AWS	Automatic Weather Station
BSRN	Basic Surface Radiation Network
BUFR	FM 94 BUFR GTS format – Binary universal form for the representation of meteorological data
CALIOP	Cloud-Aerosol Lidar with Orthogonal Polarisation
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation
CAS	WMO Commission for Atmospheric Sciences
CBS	WMO Commission for Basic Systems
CCD	Charge-Coupled Device
CCl	WMO Commission for Climatology
CEOS	Committee on Earth Observation Satellites
CGMS	Coordination Group for Meteorological Satellites
CHAMP	CHAllenging Minisatellite Payload
CHRIS	Compact High Resolution Imaging Spectrometer
CHy	WMO Commission for Hydrology
CIMO	WMO Commission for Instruments and Methods of Observation
CLARREO	Climate Absolute Radiance and Refractivity Observatory
CLOUDSAT	NASA EOS mission to observe clouds
CNES	Centre National d'Études Spatiales (France)
COCTS	Chinese Ocean Colour and Temperature Scanner
COMS	Communication, Ocean and Meteorological Satellite (Republic of Korea)
Concordiasi	An international project of the THORPEX-IPY cluster within the International Polar Year effort to provide validation data to improve the usage of polar-orbiting satellite data over Antarctica
COSMIC	Constellation Observing System for Meteorology, Ionosphere and Climate
CPR	Cloud and Precipitation Radar
CREX	FM 95 CREX GTS format – Character form for the representation and exchange of data
CRYOSAT	ESA ice mission
DEMETER	Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions
DMSP	Defence Meteorological Satellite Program (USA)
EARS	EUMETSAT ATOVS Re-transmission Systems
EARTH-CARE	Earth Clouds, Aerosols and Radiation Explorer
E-ASAP	EUMETNET ASAP
EC	WMO Executive Council
ECT	Equatorial Crossing Time
ECV	Essential Climate Variable
EGOS-IP	Implementation Plan for the Evolution of Global Observing Systems

ENVISAT	ESA Environmental Satellite mission
EOS	NASA Earth Observing System
EPS-SG	EUMETSAT Polar System – Second Generation
ERB	Earth Radiation Budget
ERBS	The Earth Radiation Budget Satellite
ERS	Earth Resource Satellite (ESA)
ESA	European Space Agency
ET-EGOS	CBS Expert Team on the Evolution of Global Observing Systems
EUCOS	EUMETNET Composite Observing System
EUMETNET	Network of European Meteorological Services
FAO	Food and Agriculture Organization of the United Nations
FAPAR	Fraction of Absorbed Synthetically Active Radiation
FDHSI	Full Disk High Spectral resolution Imagery
FLS	fixed land station
FY-4	FengYun 4 Meteorological Satellite (China)
GAW	Global Atmosphere Watch Programme
GCMP	GCOS Climate Monitoring Principles
GCOS	Global Climate Observing System
GCOS-IP	Implementation Plan for the Global Climate Observing System
GDRC	Global Runoff Data Centre
GEO	Geosynchronous satellite
GEO	Group on Earth Observations
GEOS	Geostationary Operational Environmental Satellite (USA)
GEOSAT	GEOdetic SATellite
GEOSS	Global Earth Observing System of Systems
GFCS	Global Framework for Climate Services
GHG	Green-House Gas
GLAS	Geoscience Laser Altimeter System
GLOSS	Global Sea Level Observing System
GMES	Global Monitoring for Environment and Security
GNSS	Global Navigation Satellite Systems
GOCE	Gravity field and steady-state Ocean Circulation Explorer
GOCI	Geostationary Ocean Colour Imager
GOME	Global Ozone Monitoring Experiment
GOMOS	Global Ozone Monitoring by Occultation of Stars
GOMS	Geostationary Operational Meteorological Satellite (Russian Federation)
GOOS	WMO/IOC/UNEP/ICSU Global Ocean Observation System
GOS	Global Ocean Observing System
GOS	WMO Global Observing System
GOSAT	Greenhouse gas Observing Satellite
GPM	Global Precipitation Measurement
GRACE	Gravity Recovery And Climate Experiment
GRAS	Metop's GNSS Receiver for Atmospheric Sounding
GRUAN	GCOS Reference Upper-Air Network
GSICS	Global Space-based Inter-calibration System
GSM	Global System for Mobile Communications
GSN	GCOS Surface Network
GTN	Global Terrestrial Network
GTN-G	Global Terrestrial Network for Glaciers
GTN-GW	Global Terrestrial Network for Groundwater
GTN-H	Global Terrestrial Network for Hydrology
GTN-P	Global Terrestrial Network for Permafrost
GTOS	Global Terrestrial Observing System
GTS	WWW Global Telecommunication System
GUAN	GCOS Upper-Air Network
HEO	Highly Elliptical Orbit satellite
HF	High Frequency
HRFI	High Resolution Fast Imagery
HY-2A	HaiYang ocean satellite mission (China) 2A
IAGOS	Integration of routine Aircraft observations into a Global Observing System

IASI	Infra-red Atmospheric Sounding Interferometer
ICSU	International Council for Science
ICTSW	Inter-programme Coordinating Team on Space Weather
IGRAC	International Ground water Resources Assessment Centre
IOC	Intergovernmental Oceanographic Commission of UNESCO
IOS	Integrated Observing System
IROWG	International Radio Occultation Working Group
IRS	Infra-red Sounder
ISRO	Indian Space Research Organisation
ISS	International Space Station
ITU	International Telecommunication Union
IWV	Integrated Water Vapour
JASON	Ocean Surface Topography mission (USA/France)
JAXA	Japan Aerospace Exploration Agency
JCOMM	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
LAI	Leaf Area Index
LAM	Limited Area Model
LANDSAT	Earth-observing satellite missions (NASA/USGS)
LDC	Least Developed Countries
LEO	Low Earth Orbit satellite
MERIS	MEd Resolution Imaging Spectrometer
METEOSAT	EUMETSAT Geostationary Meteorological Satellite
Metop	EUMETSAT Polar Orbiting Operational Meteorological Satellite
MODIS	MODerate-resolution Imaging Spectrometer (onboard AQUA and TERRA satellites)
MSU	Microwave Sounding Unit
MTG	Meteosat Third Generation
MTM	CNES/ISRO Megha-Tropiques Mission to observe the water cycle and energy budget in the tropics
NASA	National Aeronautics and Space Administration
NMHS	National Meteorological and Hydrological Services
NMS	National Meteorological Services
NPOESS	National Polar-orbiting Operational Environmental Satellite System (USA)
NWP	Numerical Weather Prediction
OceanSites	Ocean Sustained Interdisciplinary Timeseries Environment observation System
OCS	Ocean Colour Scanner on the Russian Meteor Satellite
OLCI	Ocean Land Colour Imager
OMPS	Ozone Mapping and Profiler Suite
OPAG	Open Programme Area Group
OPAG-IOS	OPAG on the IOS
OPERA	Operational Programme for the Exchange of weather RAdar information
OSE	Observing System Experiment
OSSE	Observing System Simulation Experiment
PALSAR	Phased Array L-band Synthetic Aperture Radar
PILOT	FM-32 PILOT GTS format: Upper-wind report from a fixed land station
PMO	Port Meteorological Officer
POAM	Polar Ozone and Aerosol Measurement
PROBA	PRoject for OnBoard Autonomy
PUMA	Préparation à l'Utilisation de MSG en Afrique
QA	Quality Assurance
QM	Quality Management
QMF	Quality Management Framework
QMS	Quality Management System
QuickSCAT	Quick Scatterometer (NASA)
R&D	Research and Development
RA	WMO Regional Association
RBCN	Regional Basic Climatological Network
RBSN	Regional Basic Synoptic Network
RRR	Rolling Review of Requirements
SAR	Synthetic Aperture Radar
SARAL	Environment monitoring mission (India/France)

SBUV	Solar Backscatter Ultraviolet Radiometer
SCARAB	Scanning radiative budget instrument onboard MTM
SCIAMACHY	Scanning Imaging Absorption Spectrometer for Atmosphere Chartography
Sentinel-3	A multi-instrument ESA satellite mission contributing to GMES
SIA	Seasonal to Inter-Annual
SIDS	Small Island Developing States
SIRAL	Synthetic Aperture Interferometric Radar Altimeter
SLSTR	Sea and Land Surface Temperature Radiometer
SMOS	Soil Moisture and Ocean Salinity
SoG	Statement of Guidance
SPOT	Satellite Pour l'Observation de la Terre
SSH	Sea Surface Height
SSM-I	Special Sensor Microwave Imager
SSS	Sea Surface Salinity
SST	Sea Surface Temperature
SYNOP	FM-12 SYNOP GTS format – Report of surface observation from a fixed land station
TAMDAR	Tropospheric Airborne Meteorological Data Reporting
TC	WMO Technical Commission
TEC	Total Electron Content
TEMP	FM-35 TEMP GTS format – Upper-level pressure, temperature, humidity and wind report from a fixed land station
TERRA	Terra satellite mission – http://terra.nasa.gov/
THORPEX	The Observing system Research and Predictability Experiment
TOPC	Terrestrial Observation Panel for Climate
TOMS	Total Ozone Mapping Spectrometer
TRMM	Tropical Rainfall Measuring Mission
UAV	Unmanned Aeronautical Vehicle
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USA	United States of America
USGS	US Geological Survey
UTC	Coordinated Universal Time
UV	Ultra-violet
VCP	WMO Voluntary Cooperation Programme
VSRF	Very Short Range Forecasting
VOS	Voluntary Observing Ships Scheme
WCRP	World Climate Research Programme (WCRP)
WHYCOS	World Hydrological Cycle Observing System
WIGOS	WMO Integrated Global Observing System
WIP	WIGOS Implementation Plan
WIS	WMO Information System
WMO	World Meteorological Organization
WWW	WMO World Weather Watch
XBT	Expendable Bathythermograph
ZTD	Zenith Total Delay

Recommendation 7 (CBS-15)

RADIO FREQUENCIES FOR METEOROLOGICAL AND RELATED ENVIRONMENTAL ACTIVITIES

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 4 (Cg-XV) – Radio frequencies for meteorological and related environmental activities,

(2) Resolution 11 (EC-64) – Radio frequencies for meteorological and related environmental activities,

Considering:

(1) That radio frequency coordination is an essential cross-cutting function of all WMO observing systems,

(2) That the International Telecommunication Union (ITU) World Radiocommunication Conference 2015 (WRC-15) will address many issues that, on the one hand, provide opportunities for the further development of meteorological systems and, on the other hand, could affect the long-term sustainability of essential observing systems that underlie WMO Members' core activities and new initiatives such as the Global Framework for Climate Services,

(3) That the significant success at WRC-12 was achieved due to active participation of Members' representatives from all Regions and international organizations concerned, and long-term preparation,

Recommends:

(1) That all WMO Programmes and technical commissions should be aware of the important role of radio frequency coordination and participate in activities of the Steering Group on Radio-Frequency Coordination as well as global, regional and national spectrum management processes;

(2) That all Members be aware of radio frequency coordination and support the participation of relevant experts in activities of the Steering Group on Radio-Frequency Coordination as well as in worldwide, regional and national spectrum management processes;

(3) That Members endeavour to have experts on meteorological observations and systems to participate in national delegations to regional and global ITU-R meetings, in particular those related to the World Radiocommunication Conferences;

Requests the Secretary-General to continue to place a high priority on supporting radio frequency coordination activities, including proactively increasing the awareness of Members and partner organizations on the important role of the Commission for Basic Systems in this area and to encourage Members to support this activity.

Recommendation 8 (CBS-15)

AMENDMENTS TO THE *MANUAL ON THE WMO INFORMATION SYSTEM* (WMO-No. 1060)

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 1 (Cg-XVI) – World Weather Watch Programme for 2012–2015,

(2) Resolution 4 (Cg-XVI) – Report of the extraordinary session (2010) of the Commission for Basic Systems relevant to Technical Regulations concerning the Global Telecommunication System, data management and the WMO Information System,

(3) Resolution 51 (Cg-XVI) – Designation of Centres of the WMO Information System,

(4) Resolution 12 (EC-64) – Designation of Centres of the WMO Information System,

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

Noting further that some Regions are still resolving the centre and Global Information System Centre (GISC) associations,

Considering the recommendations from the Implementation Coordination Team on Information Systems and Services reflecting the experience of making the WMO Information System operational,

Recommends that the *Manual on the WMO Information System* be amended as given in Annexes 1 to 3 to the present recommendation, with effect from 1 July 2013;

Requests GISCs and National Centres, in consultation with regional associations, to review the list of principal GISCs in Appendix B of the Manual, and further requests GISCs to confirm in writing to the Secretariat their commitment to support those centres associated with them;

Requests the Secretary-General to make the amendments to the Manual, as given in Annexes 1 to 3 to the present recommendation;

Authorizes the Secretary-General:

(1) To update Appendix B of the Manual to incorporate written notifications from GISCs and regional associations;

(2) To make any consequent purely editorial amendments to the *Manual on the WMO Information System*.

Annex 1 to Recommendation 8 (CBS-15)

AMENDMENTS TO THE MAIN TEXT OF THE *MANUAL ON THE WMO INFORMATION SYSTEM* (WMO-No. 1060)

The following recommended amendments to the Manual on WIS are described in the report of the Fifth Session of the ET-WISC, online at:

http://www.wmo.int/pages/prog/www/ISS/Meetings/ET-WISC_Melbourne2012/FReport-ET-WISC2012.doc

(1) Insert new "note" following paragraph 2.3.4.1 as follows:

Note: An associated GISC is defined by a bilateral agreement between a centre and a GISC for the purposes of uploading or downloading data. A centre can have multiple associated GISCs but shall identify a principal GISC for uploading and management of metadata.

(2) Update paragraph 3.5.3.1 to clarify that information for global exchange shall be in all GISC caches.

3.5.3.1 Each GISC shall collect from its area information that is intended for global exchange and shall share such information with other GISCs so that all GISCs have a common holding of information available for global exchange. See also 3.5.5 (Maintain a 24-hour cache).and 3.5.8 (Coordinate telecommunications in a Global Information System Centre area).

(3) Insert text into paragraph 3.5.5.1 to clarify a purpose of the 24-hour cache is to support subscription services including the GTS.

3.5.5.1 Each GISC shall hold the information intended for global exchange for at least 24 hours to support subscription services, including but not limited to those for the GTS, and make the information available via WMO request/reply ("Pull") mechanisms. Information limited to regional or AMDCN exchange need only be held in those GISCs supporting the region or AMDCN for which the information is to be available. This requirement intersects the WIS DAR requirement (see 3.5.6).

(4) Make the following insertion and editorial changes (in red) to paragraph 3.5.6.1

3.5.6.1 In support of the DAR function, each GISC shall maintain and provide access to a comprehensive catalogue of information across all WMO programmes encompassed by WIS. This includes, but is not limited to, information intended for global exchange. In order to satisfy the DAR functional requirement, GISCs are required to support, in interactive and in batch modes:~~,~~ upload;~~,~~ change and deletion of metadata;~~,~~ user discovery of metadata;~~,~~ user access to metadata;~~,~~ and synchronization of the WIS comprehensive metadata catalogue with other GISCs.

(5) Make the following insertion and editorial changes (in red) to paragraphs 3.5.7 and 3.5.8

3.5.7 Data network connectivity of a Global Information System Centre

Each GISC shall provide around-the-clock connectivity to the public and dedicated communication networks at a capacity that is sufficient to meet its global, ~~and~~ regional and AMDCN responsibilities. Each GISC should ensure that every telecommunication facility it employs in support of WIS has the appropriate level of availability and capacity, including, as necessary, routing and backup arrangements. Each GISC should maintain service level agreements with the suppliers of its communication links and associated hardware.

3.5.8 Coordinate telecommunications in a Global Information System Centre area

Each GISC shall coordinate with the Centres in its area of responsibility to maintain a WIS telecommunications infrastructure that can meet the WIS requirements for information exchange within the area. In the case of particular global and/or regional agreements, a GISC could also support the exchange of agreed WIS time-critical and operation-critical information with other ~~areas~~ AMDCNs. The telecommunications infrastructure shall be implemented through various technologies and services (for example, the Internet, satellite based data distribution, dedicated data networks) in accordance with capacity and reliability requirements.

(6) Spilt paragraph 3.5.9 as follows; move (in blue), delete or add text (in red) as follows.

3.5.9 Recovery arrangements of a Global Information System Centre

3.5.9.1 Each GISC shall implement and operate proper procedures and arrangements to provide swift recovery or backup of its essential services in the event of an outage. ~~Each GISC shall maintain arrangements for its essential services to be taken up by another GISC in case of an incapacitating system failure.~~ Each GISC should maintain arrangements for system back up in case of total site failure (for example, an offsite Disaster Recovery Centre) and for partial back up in situations otherwise affecting WIS functions within the GISC.

3.5.9.2 Each GISC shall maintain arrangements with one or more back up GISCs that include at a minimum the collection and dissemination of information to/from its AMDCN to be taken up by another GISC in case of an incapacitating system failure.

Annex 2 to Recommendation 8 (CBS-15)

ADDITION OF PART V TO THE *MANUAL ON THE WMO INFORMATION SYSTEM* (WMO-No. 1060)

Add the following Part V to the Manual on the WIS

PART V. WIS DISCOVERY METADATA

5.1 All information to be exchanged through the WIS shall have a WIS Discovery Metadata record associated with it.

5.2 WIS Discovery Metadata Records shall be provided by the data custodian to the principal GISC for the centre to which the data custodian is attached. No change should be made to a WIS Discovery Metadata record without the express approval of the data custodian other than in the case that the principal GISC for the data custodian may alter or withdraw the WIS Discovery Metadata record if it is found to interfere with the correct operation of the WIS, in which case an emergency change should be made and the data custodian shall be requested to provide an appropriate corrected Discovery Metadata record.

5.3 WIS Discovery Metadata records shall conform to the ISO 19115 standard and as a minimum contain the information specified as mandatory in the WMO Core Metadata Profile of that standard as defined in Appendix C to this Manual.

5.4 The Commission for Basic Systems 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.

Add the following Appendix C to the Manual on the WIS

APPENDIX C: THE WMO CORE METADATA PROFILE OF THE ISO 19115 METADATA STANDARD

C.1 Implementation of the WMO Core Metadata Profile

C.1.1 The WMO Core Metadata Profile of the ISO 19115 Metadata Standard places constraints on the contents of a discovery metadata record that are additional to those in the ISO standard. Authors of WIS Discovery metadata records shall apply these constraints.

C.1.2 Specifications in this Manual shall take precedence over the specifications in ISO 19115.

C.1.3 The Secretariat shall publish guidance materials to assist authors of WIS Discovery Metadata maintain consistency between metadata records.

C.1.4 WIS Discovery Metadata records shall be provided to GISCs conformant with ISO 19136 and ISO 19139 expressed in Geographic Markup Language (GML).

C.2 Procedures for amending the WMO Core Metadata Profile

C.2.1 General validation and implementation procedures

C.2.1.1 Proposal of amendments

Amendments to the WMO Core Metadata Profile must be proposed in writing to the WMO Secretariat. The proposal shall specify the needs, purposes and requirements and include information on a contact point for technical matters.

C.2.1.2 Drafting recommendation

The Inter-Programme Expert Team on Metadata and Data Representation Development (IPET-MDRD[1]), supported by the Secretariat, shall validate the stated requirements (unless it is consequential to an amendment to the WMO Technical Regulations) and develop a draft recommendation to respond to the requirements, as appropriate.

C.2.1.3 Date of implementation

The IPET-MDRD should define a date of implementation in order to give sufficient time to the WMO Members to implement the amendments after the date of notification; the IPET-MDRD should document the reasons to propose a time span of less than six months except for the fast track procedure.

C.2.1.4 Procedures for approval

After a draft recommendation of the IPET-MDRD is validated in accordance with the procedure given in section C.6 below, depending on the type of amendments, the IPET-MDRD may select one of the following procedures for the approval of the amendments:

- Fast-track procedure (see C.2.2);
- Procedure for the adoption of amendments between CBS sessions (see C.2.3);
- Procedure for the adoption of amendments during CBS sessions (see C.2.4).

C.2.1.5 Urgent introduction

Regardless of the above procedures, as an exceptional measure, the following procedure accommodates urgent user needs to introduce new entries in the Code Lists and XML schema that support the WMO Core Metadata Profile or to correct errors in the metadata validation criteria.

(a) A draft recommendation developed by IPET-MDRD shall be validated according to C.2.6.1, C.2.6.2 and C.2.6.3;

(b) The draft recommendation for pre-operational use, which can be used in operational data and products, shall be approved by the chairpersons of IPET-MDRD and OPAG-ISS, and the president of CBS. The list of pre-operational entries is kept on-line on the WMO web server;

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[1] The IPET-MDRD, the ICT-ISS and the OPAG-ISS are the current bodies dealing with the WMO Core Profile within the Commission for Basic Systems (CBS). If they were replaced by other bodies performing the same function, the same rules would apply, by replacing the names of the entities appropriately.

(c) Pre-operational entries need to be approved by one of the procedures in C.2.1.4 for operational use;

(d) The lowest level of the version number of the metadata standard will be incremented (see C.2.1.6).

C.2.1.6 Issuing updated version

Once amendments to the WMO Core Metadata Profile are adopted, an updated version of the relevant part of the Manual on WIS shall be issued in the four languages: English, French, Russian and Spanish. The Secretariat shall inform all WMO Members of the availability of a new updated version of that part at the date of notification mentioned in C.2.1.3.

Version numbers of the WMO Core Metadata Profile have the form *a.b.c* where:

a shall be incremented if the change requires modifications to software (for example moving to a new version of the ISO 19115 standard). This is the top level of the version number. Such changes should follow the Changes during Sessions procedure in C.2.4.

b shall be incremented if changes to conformance checking rules or changes to Code Lists are introduced and are mandatory for compliant metadata records. This is the middle level of the version number. Such changes should follow the Changes Between Sessions procedure in C.2.3.

c shall be incremented if the changes have no impact on existing metadata records (for example adding a new entry to a Code List, or introducing a conformance checking rule that results in a warning rather than causing a metadata record to be declared invalid). This is the lowest level of the version number. Such changes should use the Fast Track procedure in C.2.2.

Note: development versions of the WMO Core Metadata Profile, not intended for operational use, are denoted by the digit 0 in second part of the version number. For example: 2.0.1. Development versions are intended to enable the development of a new version of the WMO Core Metadata Profile requiring changes to software systems.

C.2.2 Fast-track procedure

C.2.2.1 Scope

The fast-track procedure can be used for additions to Code Lists and validation rules that result only in warnings.

C.2.2.2 Endorsement

Draft recommendations developed by the IPET-MDRD, including a date of implementation of the amendments, must be endorsed by the chairperson of OPAG-ISS.

C.2.2.3 Approval

C.2.2.3.1 Minor adjustments

Correcting typographic errors in descriptive text in Code Lists is considered a minor adjustment, and will be done by the Secretariat in consultation with the president of CBS.

Note: a Code List is a list of valid entries that are permitted in a metadata field.

C.2.2.3.2 Other types of amendments

For other types of amendments, the English version of the draft recommendation, including a date of implementation, should be distributed to the focal points for Discovery Metadata matters for comments, with a deadline of two months for the reply. It should then be submitted to the president of CBS for consultation with the presidents of technical commissions and adoption on behalf of the Executive Council (EC).

C.2.2.4 Frequency

The implementation of amendments approved through the fast track procedure can be twice a year in May and November.

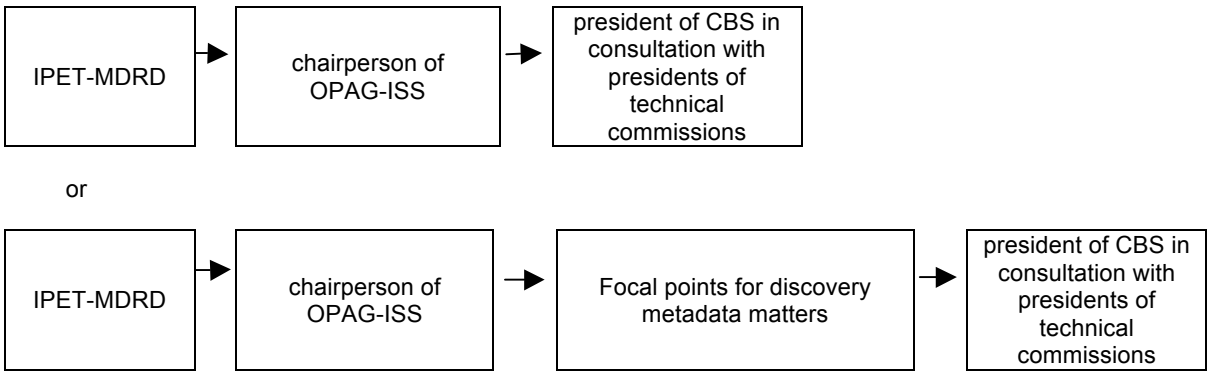

Figure 1. Adoption of amendments by fast track procedure

C.2.3 Procedure for the adoption of amendments between CBS sessions

C.2.3.1 Approval of draft recommendation

For the direct adoption of amendments between CBS sessions, the draft recommendation developed by the IPET-MDRD, including a date of implementation of the amendments, shall be submitted to the chairperson of OPAG-ISS and president and vice-president of CBS for approval. The president of CBS shall consult with the presidents of technical commissions.

C.2.3.2 Circulation to Members

Upon approval of the president of CBS, the Secretariat sends the recommendation in the four languages (English, French, Russian and Spanish), including a date of implementation of the amendments, to all WMO Members for comments to be submitted within two months following the dispatch of the amendments.

C.2.3.3 Agreement

Those WMO Members not having replied within the two months following the dispatch of the amendments are implicitly considered as having agreed with the amendments.

C.2.3.4 Coordination

WMO Members are invited to designate a focal point responsible to discuss any comments/ disagreements with the IPET-MDRD. If the discussion between the IPET-MDRD and the focal point cannot result in an agreement on a specific amendment by a WMO Member, this amendment will be reconsidered by the IPET-MDRD.

C.2.3.5 Notification

Once amendments are agreed by WMO Members, and after consultation with the chairperson of the OPAG-ISS and the president and vice-president of CBS, the Secretariat notifies at the same

time the WMO Members and the members of the Executive Council of the approved amendments and of the date of their implementation.

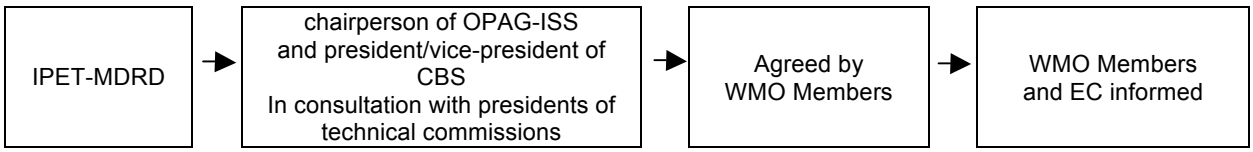

Figure 2. Adoption of amendments between CBS sessions

C.2.4 Procedure for the adoption of amendments during CBS sessions

For the adoption of amendments during CBS sessions, the IPET-MDRD submits its recommendation, including a date of implementation of the amendments, to the Implementation/ Coordination Team on Information Systems and Services (ICT-ISS) of the Open Programme Area Group on Information Systems and Services (OPAG-ISS). The recommendation is then passed to the presidents of technical commissions for consultation, and to a CBS session that shall be invited to consider comments submitted by presidents of technical commissions. The recommendation shall then be submitted to an EC session for decision.

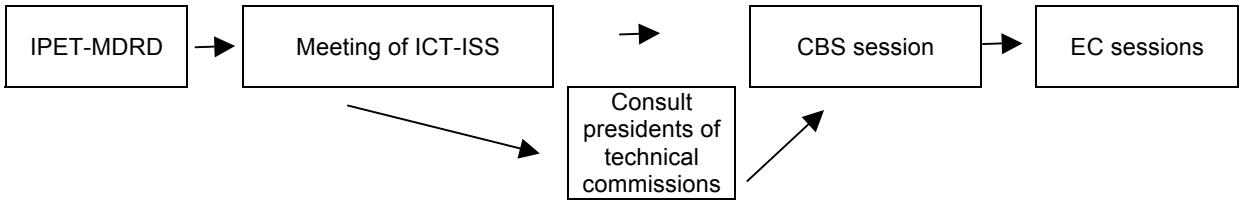

Figure 3. Adoption of amendments during CBS sessions

C.2.5 Procedure for the correction of existing entries in the Code Lists and validation rules

C.2.5.1 Correcting errors in the text describing a Code List entry

Where a minor error in the specification of a CodeList is found (e.g. typing error or incomplete definition) the CodeList entry shall be amended and re-published. The CodeList dictionary itself (the XML document) shall increment its version number. If, however, the error is in the meaning of the CodeList, then a new CodeList entry should be created and the existing (erroneous) entry marked as deprecated. Authors of metadata records should not use deprecated CodeList items. This situation is considered a minor adjustment according to C.2.3.1 above.

C.2.5.2 Correcting an error in a conformance checking rule

If an erroneous specification of a conformance checking rule is found, a new descriptor should preferably be added to the appropriate table through the fast-track procedure or the procedure for adoption of amendments between CBS sessions. The new conformance checking rule should be used instead of the old. An appropriate explanation shall be added to the description in the description of the conformance checking rule to clarify the practice along with the date of the change.

C.2.5.3 Submission of changes to Code List Entries or conformance checking rules as a result of correcting an error

Such changes shall be submitted through the fast-track procedure.

C.2.6 Validation procedure

C.2.6.1 Documentation of need and purpose

The need for, and the purpose of, the proposal for changes should be documented.

C.2.6.2 Documentation of result

This documentation shall include the results of validation testing of the proposal as described below.

C.2.6.3 Testing with WIS metadata applications

For new or modified Code List entries and validation rules, proposed changes should be tested by the use of at least two independently developed metadata editors and two independently developed GISC catalogues which incorporated the proposed change. Results should be made available to the IPET-MDRD with a view to verifying the technical specifications.

C.3 Contents of the WMO Core Metadata Profile

C.3.1 Each supported version of the WMO Core Metadata Profile is listed in C.4. Versions that are no longer supported by WIS are denoted as “obsolete” and their definitions should be retained on the WMO website. Definitions of the versions of the WMO Core Metadata Profile are in sub-appendices of this Appendix.

C.4 WMO Core Profile Versions

Note: Versions of the WMO Core Profile before 1.2 did not provide all the functionality required by the WIS and are no longer supported.

WMO Core Profile version 1.2. This is defined at http://wis.wmo.int/2010/metadata/version_1-2
Note: metadata created using profile version 1.2 is compatible with that created under version 1.3 other than that the records may have been completed inconsistently and therefore may fail the version 1.3 conformance checking rules.

WMO Core Profile Version 1.3. This is defined at http://wis.wmo.int/2012/metadata/version_1-3. This is described in Appendix C.1.3 to this Manual.

World Meteorological Organization
Organisation météorologique mondiale

Temps • Climat • Eau
Weather • Climate • Water

Commission for Basic Systems
OPAG on Information Systems and Services

WMO Core Metadata Profile version 1.3

Specification

Part 1 – Conformance Requirements

C.1.3-Part 1 to the Manual on the WMO Information System (WMO-No. 1060)

Document version: 0.9: FINAL FOR CBS

Date: 11 July 2012

1 SCOPE

This specification defines the content, structure and encoding of discovery metadata published within the WMO Information System (WIS) Discovery-Access-Retrieval (DAR) Catalogue.

The metadata standard defined herein is an informal category-1 profile[1] of the International Standard ISO 19115:2003 'Geographic information – Metadata'. This metadata standard shall be referred to as the **WMO Core Metadata Profile**.

WIS Discovery Metadata records shall be encoded in XML as defined by ISO/TS 19139:2007.

Part 1 of this specification defines the conformance requirements for the WMO Core Metadata Profile. Part 2 defines the Abstract Test Suite, Data Dictionary and Code Lists. Unless otherwise stated, references to "Part 1" and "Part 2" are to the relevant parts of this specification.

2 CONFORMANCE

Conformance requirements

The WIS Technical Regulations (WMO-No. 49) paragraph A.3.3 states:

> *A.3.3.4 WIS functions and operation shall be based on catalogues that contain metadata describing data and products available across WMO, plus metadata describing dissemination and access options. […]*

In this document:

- 6 describes the XML encoding requirements for the discovery metadata records published to the WIS DAR (Discovery, Access and Retrieval) Catalogue (e.g. a WIS Discovery Metadata records).
- 7 describes how compliance with this version of the WMO Core Metadata Profile is declared within a WIS Discovery Metadata record.
- 8 and 9 describe additional constraints applying to WIS Discovery Metadata records. These are organized into two groups to support the following Formal Requirements for WIS Discovery Metadata:
    - Metadata uniqueness and discovery within WIS DAR Catalogue;
    - Description of data for Global Exchange within WIS.

UML is used to describe the additional constraints defined in this Annex applying to WIS Discovery Metadata records within the context of ISO 19115:2003/Cor. 1:2006.

Where there are inconsistencies between the text description of a requirement and the UML (Unified Modelling Language) description, the UML version shall be considered authoritative.

Authors of discovery metadata records published within the WIS DAR Catalogue are required to comply with the WMO Core Metadata Profile. Thus WIS Discovery Metadata shall be compliant with:

- ISO 19115:2003 'Geographic information – Metadata';
- ISO 19115:2003/Cor. 1:2006 'Geographic information – Metadata – Corrigendum 1'; and
- Additional constraints described in this Manual.

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[1] A category-1 profile places additional restrictions on the use of an International Standard to meet the more specific requirements of a given community. Profiles of International Standards may be formally registered. The WMO profile of ISO 19115 has not been registered and thus remains an 'informal' profile.

Specifications in this Manual shall take precedence over the specifications in ISO 19115:2003 and ISO 19115:2003/Cor. 1:2006.

The Secretariat shall publish Guidance materials to assist authors of WIS Discovery Metadata maintain consistency between metadata records.

Note: see http://wis.wmo.int/MD_Index.

Conformance classes for WIS Discovery Metadata

Metadata records claiming conformance with the WMO Core Metadata Profile shall conform to the rules specified in Clauses 6 – 9 and pass all relevant test cases of the Abstract Test Suite in Part 2, 2.

Depending on the characteristics of a WIS Discovery Metadata record, 8 conformance classes are distinguished. Table 1 lists these classes and the corresponding Subclause of the Abstract Test Suite.

Table 1 – Conformance classes related to WMO Core Metadata Profile

Conformance class		Reference in Part 2
6.1	ISO/TS 19139:2007 compliance	2.1.1
6.2	Explicit identification of namespaces in XML	2.1.2
6.3	GML namespace	2.1.3
8.1	Unique identification of WIS Discovery Metadata records	2.2.1
8.2	Provision of information to support discovery within WIS DAR Catalogue	2.2.2, 2.2.3
9.1	Identifying the scope of distribution	2.3.1
9.2	Identifiers for metadata describing data published for global exchange	2.3.1
9.3	Defining WMO Data Policy and GTS Priority for data published for global exchange	2.3.2, 2.3.3

A WIS Discovery Metadata record may also be validated against Guidance published by the Secretariat.

Note: see http://wis.wmo.int/MD_Conform.

During such validation, a warning shall be issued for each occasion that a metadata record fails to comply with Guidance.

3 NORMATIVE REFERENCES

The following referenced documents are indispensable for the application of this specification. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 639-2, *Code for the representation of names of languages – Part 2: Alpha-3 code*

ISO 3166 (all parts), *Codes for the representation of names of countries and their subdivisions*

ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

ISO 19115:2003, *Geographic information – Metadata*

ISO 19115:2003/Cor. 1:2006, *Geographic information – Metadata – Corrigendum 1*

ISO/TS 19139:2007, *Geographic information – Metadata – XML schema implementation*

ISO/IEC 19757-3:2006 *Information technology – Document Schema Definition Language (DSDL) – Part 3: Rule-based validation – Schematron*

W3C XMLName, *Namespaces in XML. W3C Recommendation (14 January 1999)*

W3C XMLSchema-1, *XML Schema Part 1: Structures. W3C Recommendation (2 May 2001)*

W3C XMLSchema-2, *XML Schema Part 2: Datatypes. W3C Recommendation (2 May 2001)*

W3C XML, *Extensible Markup Language (XML) 1.0 (Second Edition). W3C Recommendation (6 October 2000)*

W3C XLink, *XML Linking Language (XLink) Version 1.1. W3C Recommendation (6 May 2010)*

4 TERMS AND DEFINITIONS

namespace
Collection of names, identified by a URI reference, which are used in XML documents as element names and attribute names.

WIS Discovery Metadata
Metadata consistent with this standard that is used within the WIS for discovery of information shared through the WIS.

5 SYMBOLS AND ABBREVIATED TERMS

5.1 Acronyms

DAR Discovery, Access and Retrieval; normally used to describe the WIS DAR Catalogue

DCPC Data Collection and Production Centre; part of the WIS

GISC Global Information System Centre; part of the WIS

NC National Centre; part of the WIS

UML Unified Modelling Language

URI Uniform Resource Identifier

URN Uniform Resource Name

WIS WMO Information System

WMO World Meteorological Organization

XML Extensible Markup Language

XPath XML Path Language

5.2 Namespace abbreviations

In the list below the item on the left describes the common namespace prefix used to describe the elements in the namespace. The second item is an English description of the namespace prefix and the item in parenthesis is the URN of the actual namespace. These URNs do not necessarily correspond to an effective location of the schemas, however, where available an authoritative location for the schema is provided.

The WMO Core Metadata Profile does not specify a namespace as it contains no XML schema extensions.

This list corresponds to external namespaces used by the WMO Core Metadata Profile.

gco	Geographic Common extensible markup language	(http://www.isotc211.org/2005/gco)
gmd	Geographic MetaData extensible markup language	(http://www.isotc211.org/2005/gmd)
gmx	Geographic Metadata Xml schema	(http://www.isotc211.org/2005/gmx)
gss	Geographic Spatial Schema extensible markup language	(http://www.isotc211.org/2005/gss)
gsr	Geographic Spatial Referencing extensible markup language	(http://www.isotc211.org/2005/gsr)
gts	Geographic Temporal Schema extensible markup language	(http://www.isotc211.org/2005/gts)
srv	geographic SeRVice metadata	(http://www.isotc211.org/2005/srv)
gml	Geography Markup Language	(http://www.opengis.net/gml/3.2)
xlink	Xml LINKing language	(http://www.w3.org/1999/xlink)
xsi	w3c Xml Schema Instance	(http://www.w3.org/2001/XMLSchema-instance)

5.3 External classes

All of the model elements used within the WMO Core Metadata Profile are defined in ISO geographic information standards. By convention with ISO/TC 211, names of UML classes, with the exception of basic data type classes, include a two- or three-letter prefix that identifies the International Standard and the UML package in which the class is defined. Table 2 lists the standards and packages in which UML classes used in the WMO Core Metadata Profile.

Table 2 – Sources of UML classes

Prefix	International Standard	Package
CI	ISO 19115:2003	Citation Information
EX	ISO 19115:2003	Extent Information
MD	ISO 19115:2003	Metadata Entity

6 XML ENCODING

WIS implementation is predicated on the publication of metadata records as XML documents.

6.1 ISO/TS 19139:2007 compliance

Compliance with this specification requires that WIS Discovery Metadata records shall validate without error against the XML schemas created from the UML model of ISO 19115:2003/Cor. 1:2006 using the encoding rules defined in ISO/TS 19139:2007 'Geographic information – Metadata – XML schema implementation' Clause 9.

WMO Core Metadata Profile requires that:

6.1.1 Each WIS Discovery Metadata record shall validate without error against the XML schemas defined in ISO/TS 19139:2007.

Note: not all XML validation tools implement the full W3C XML Schema recommendation and not all XML validation tools interpret the W3C XML Schema recommendation in the same manner. It is recommended that a tool with strict interpretation of XML Schema and full support for the W3C XML Schema recommendation be used to ensure conformance.

Note: WMO hosts a copy of the ISO/TS 19139:2007 XML schemas at: http://wis.wmo.int/2011/schemata/iso19139_2007/schema/. The directory structure in which the XML schemata are published mirrors that of the normative XML schema repository published by ISO at: http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/. For example, gmd.xsd can be found at http://wis.wmo.int/2011/schemata/iso19139_2007/schema/gmd/gmd.xsd.

XML 1.0 does not support the enforcement of certain types of constraints. For example, *gmd:CI_ResponsibleParty* shall include at least one of *gmd:individualName*, *gmd:organisationName* or *gmd:positionName*. As a result, it is imperative that implementers heed the constraints identified within the UML model defined in ISO 19115:2003 and the associated corrigendum. These are listed in ISO/TS 19139:2007 Annex A: 'Table A.1 – Conformance Rules not enforceable with XML Schema'.

WMO Core Metadata Profile requires that:

6.1.2 Each WIS Discovery Metadata record shall validate without error against the rule-based constraints listed in ISO/TS 19139:2007 Annex A (Table A.1).

Note: WMO provides an automated test suite including validation against the constraints listed in ISO/TS 19139:2007 Annex A. These are implemented as Schematron rules (ISO/IEC 19757-3:2006 'Information technology – Document Schema Definition Language (DSDL) – Part 3: Rule-based validation – Schematron') and can be found at the following location: http://wis.wmo.int/2012/metadata/validationTestSuite/.

6.2 Explicit identification of namespaces in XML

To support the provision of reusable XML validation test suites, it shall be mandatory to explicitly define XML namespaces used within a WIS Discovery Metadata record. Use of a default (implied) namespace may lead to misinterpretation of the XML document and failure to validate.

WMO Core Metadata Profile places the following additional restriction on ISO 19139:2007:

6.2.1 Each WIS Discovery Metadata record shall name explicitly all namespaces used within the record; use of default namespaces is prohibited.

6.3 GML namespace

ISO/TS 19139:2007 is dependent on ISO 19136:2007 'Geographic information – Geography Markup Language (GML)'. ISO 19136:2007 relates to GML version 3.2.1. The associated namespace URN is http://www.opengis.net/gml/3.2.

WMO Core Metadata Profile places the following additional restriction on ISO 19139:2007 –

6.3.1 Each WIS Discovery Metadata record shall declare the following XML namespace for GML: http://www.opengis.net/gml/3.2.

7 DECLARING COMPLIANCE WITH WMO CORE METADATA PROFILE

A WIS Discovery Metadata record may declare compliance with this version of the WMO Core Metadata Profile as follows:

- /gmd:MD_Metadata/gmd:metadataStandardName = "WMO Core Metadata Profile of ISO 19115 (WMO Core), 2003/Cor.1:2006 (ISO 19115), 2007 (ISO/TS 19139)"
- /gmd:MD_Metadata/gmd:metadataStandardVersion = "1.3"

8 METADATA UNIQUENESS AND DISCOVERY WITHIN WIS DAR CATALOGUE

8.1 Unique identification of WIS Discovery Metadata records

5.2 of the *Manual on WIS* (WMO-No. 1060; WIS-TechSpec-1: Uploading of Metadata for Data and Products) requires the use of the WMO Core Metadata Profile and the provision of a globally unique identifier for each WIS Discovery Metadata record:

5.2.1 This specification requires that each metadata record uploaded shall be represented in compliance with the WMO Core Metadata Profile of ISO 19115 with a unique identifier.

A WIS Discovery Metadata record shall be uniquely identified using the *gmd:MD_Metadata/gmd:fileIdentifier* attribute.

WMO Core Metadata Profile places the following additional restrictions on ISO 19115:2003/Cor. 1:2006 –

8.1.1 Each WIS Discovery Metadata record shall include one gmd:MD_Metadata/gmd:fileIdentifier attribute

8.1.2 The gmd:MD_Metadata/gmd:fileIdentifier attribute for each WIS Discovery Metadata record shall be unique within the WIS

(i.e. the attribute is mandatory in the WMO Core Metadata Profile and must be globally unique within the WIS).

Note that the *gmd:MD_Metadata/gmd:fileIdentifier* elements are treated as CASE-INSENSITIVE when assessing metadata records for duplication.

WMO Core Metadata Profile recommends the use of a URI structure for *gmd:fileIdentifier* attributes. The URI should be structured as follows:

- fixed string "urn:x-wmo:md:"
- citation authority based on the Internet domain name of the data-provider organisation, e.g. “int.wmo.wis”, “gov.noaa”, “edu.ucar.ncar”, “cn.gov.cma” or “uk.gov.metoffice”
- separator colon “:”
- unique identifier –
    - for metadata records describing GTS products in bulletins or named according to the WMO file-naming convention P-flag = “T” or P-flag= “A”, the unique identifier is “«TTAAii»«CCCC»”
    - for metadata records describing products named according to the WMO file-naming convention P-flag = “W”, the unique identifier should be a truncated version of the WMO product identifier field of the associated data-files, excluding the date-stamp and any other varying elements as necessary
    - for metadata records describing other products, the unique identifier may be assigned by the citation authority so as to be unique among the identifiers assigned by the citation authority

The Secretariat shall maintain a list of «c*itation authority*» and the associated organization.

Each «c*itation authority*» organization shall implement procedures that ensure that its authorized metadata authors can create unique values for the «*unique identifier*». Note that inclusion of «c*itation authority*» in *fileIdentifier* guarantees global uniqueness provided the organization has a procedure to ensure local uniqueness.

If the data custodian has their own methodology for assigning metadata identifiers and is able to guarantee the global uniqueness of the identifier, that identifier may be used.

Amendments to a WIS Discovery Metadata record shall not change the *gmd:MD_Metadata/gmd:fileIdentifier* attribute. Each amendment shall be published with an updated *gmd:MD_Metadata/gmd:dateStamp* attribute indicating the date of publication of the amended version of the metadata record.

gmd:MD_Metadata/gmd:dateStamp shall be specified using a single date as specified by ISO 8601 in the extended date format (YYYY-MM-DD), where YYYY is the year, MM is the month and

DD is the day. Time (hh:$m_m m_m$:$s_s s_s$, where hh is the hour, $m_m m_m$ the minutes and $s_s s_s$ the seconds) may be added if required, separated from the day by "T".

A set of WIS Discovery Metadata records with the same *gmd:MD_Metadata/gmd:fileIdentifier* shall be considered to be versions of the same WIS Discovery Metadata record. The sequence (time-order) of these records shall be determined from the *gmd:MD_Metadata/gmd:dateStamp*.

8.2 Provision of information to support discovery within WIS DAR Catalogue

Paragraph 5.9 of this Manual (WIS-TechSpec-8: DAR Catalogue Search and Retrieval) outlines the mechanisms by which WIS DAR Catalogue content may be searched according to indexed metadata attributes.

Search within the WIS DAR catalogue is based on terms from SRU (Search/Retrieval by URL, ISO 23950:1998).

At a minimum, for text-based searches, these shall include:

i. subject

ii. abstract

iii. title

iv. author

v. keywords

vi. format

vii. identifier

viii. type

ix. crs (coordinate reference system)

For date-based searches, these shall include:

i. creationDate

ii. modificationDate

iii. publicationDate

iv. beginningDate

v. endingDate

Finally, geographic search shall also be provided:

i. bounding box (specified in decimal degrees, north, west, south and east)

Table 3 provides a mapping from SRU terms to ISO 19115 attributes (defined via XPath):

Table 3 – Mapping from SRU search terms to ISO 19115 attributes

SRU term	ISO 19115 attribute
subject	**/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords//gmd:keyword**
abstract	/gmd:MD_Metadata/gmd:identificationInfo//gmd:abstract
title	/gmd:MD_Metadata/gmd:identificationInfo//gmd:citation//gmd:title
author	/gmd:MD_Metadata/gmd:contact
keywords	**/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords//gmd:keyword**
format	/gmd:MD_Metadata/gmd:distributionInfo//gmd:distributionFormat//gmd:name
identifier	/gmd:MD_Metadata/gmd:identificationInfo//gmd:citation//gmd:identifier
type	/gmd:MD_Metadata/gmd:identificationInfo//spatialRepresentationType
crs	/gmd:MD_Metadata//gmd:referenceSystemInfo/gmd:MD_ReferenceSystem/gmd:referenceSystemIdentifier/gmd:RS_Identifier/gmd:code
creationDate	/gmd:MD_Metadata/gmd:identificationInfo//gmd:citation//gmd:date//gmd:date /gmd:MD_Metadata/gmd:identificationInfo//gmd:citation//gmd:date//gmd:dateType="creation"
modificationDate	/gmd:MD_Metadata/gmd:identificationInfo//gmd:citation//gmd:date//gmd:date /gmd:MD_Metadata/gmd:identificationInfo//gmd:citation//gmd:date//gmd:dateType="revision"
publicationDate	/gmd:MD_Metadata/gmd:identificationInfo//gmd:citation//gmd:date//gmd:date /gmd:MD_Metadata/gmd:identificationInfo//gmd:citation//gmd:date//gmd:dateType="publication"
beginningDate	/gmd:MD_Metadata/gmd:identificationInfo//gmd:extent//gmd:temporalElement/gmd:extent
endingDate	/gmd:MD_Metadata/gmd:identificationInfo//gmd:extent//gmd:temporalElement/gmd:extent
boundingBox	**/gmd:MD_Metadata/gmd:identificationInfo//gmd:extent//gmd:geographicElement/gmd:EX_GeographicBoundingBox/gmd:northBoundLatitude** **/gmd:MD_Metadata/gmd:identificationInfo//gmd:extent//gmd:geographicElement/gmd:EX_GeographicBoundingBox/gmd:westBoundLatitude** **/gmd:MD_Metadata/gmd:identificationInfo//gmd:extent//gmd:geographicElement/gmd:EX_GeographicBoundingBox/gmd:southBoundLatitude** **/gmd:MD_Metadata/gmd:identificationInfo//gmd:extent//gmd:geographicElement/gmd:EX_GeographicBoundingBox/gmd:eastBoundLatitude**

The following elements from Table 3 are declared mandatory in ISO 19115:2003/Cor. 1:2006 –

- [abstract]
  /gmd:MD_Metadata/gmd:identificationInfo//gmd:abstract

- [title]
  /gmd:MD_Metadata/gmd:identificationInfo//gmd:citation//gmd:title

- [creationDate, modificationDate]
  /gmd:MD_Metadata/gmd:identificationInfo//gmd:citation//gmd:date

- [author]
  /gmd:MD_Metadata/gmd:contact

CI_ResponsibleParty entity */gmd:MD_Metadata/gmd:contact* element should use the *CI_RoleCode* "pointOfContact"; e.g.

- /gmd:MD_Metadata/gmd:contact//gmd:role = "pointOfContact"

Note that the abstract should provide a clear and concise statement that enables the reader to understand the content of the dataset. For guidance when completing the abstract, consider these points:

- State what the "things" are that are recorded.
- State the key aspects recorded about these things.
- State what form the data takes.
- State any other limiting information, such as time period of validity of the data.
- Add purpose of data resource where relevant (e.g. for survey data).
- Aim to be understood by non-experts.
- Do not include general background information.
- Avoid jargon and unexplained abbreviations.

It is recommended that */gmd:MD_Metadata/gmd:identificationInfo//gmd:pointOfContact* should provide a minimum of a name and an e-mail address.

In order to improve the consistency of WIS Discovery Metadata records in regards to search and discovery within the WIS DAR Catalogue, the **keyword** and **boundingBox** attributes are mandatory within the WMO Core Metadata Profile.

WMO Core Metadata Profile places the following additional restrictions on ISO 19115:2003/Cor. 1:2006:

8.2.1 Each WIS Discovery Metadata record shall include at least one keyword from the WMO_CategoryCode code list.

8.2.2 Keywords from WMO_CategoryCode code list shall be defined as keyword type "theme".

8.2.3 All keywords sourced from a particular keyword thesaurus shall be grouped into a single instance of the MD_Keywords class.

8.2.4 Each WIS Discovery Metadata record describing geographic data shall include the description of at least one geographic bounding box defining the spatial extent of the data.

A new Code List Dictionary is published as part of this specification defining the set of permissible values for WMO_CategoryCode (see Part 2, Table 16). Keywords from WMO_CategoryCode shall be of type 'theme'.

The GeographicBoundingBox is determined by four coordinates.

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:

- The total longitudinal span shall be greater than zero, and less than or equal to 360 degrees.
- Geographic points shall be designated with the northern-most and southern-most longitudes equal, and the western-most and eastern-most longitudes equal.
- 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.

Attribute */gmd:MD_Metadata/gmd:identificationInfo//gmd:citation//gmd:date//gmd:date* shall be expressed as an ISO 8601 compliant date. The extended date format (YYYY-MM-DD) should be used, where YYYY is the year, MM is the month and DD is the day. Time (hh:$m_m m_m$:s_s s_s, where hh is the hour, $m_m m_m$ the minutes and $s_s s_s$ the seconds) may be added if required, separated from the day by “T”.

The remaining elements from Table 3 are optional in this version of the WMO Core Metadata Profile:

- [format]
- [identifier]
- [type]
- [crs]
- [beginningDate]
- [endingDate]

Note: further guidance on the use of these elements is published by the Secretariat at http://wis.wmo.int/MD_OptElt

The primary language used in metadata conforming to the WMO Core Metadata Profile is English. Translations of English elements within the record may also be included.

8.2.5 All information contained within a metadata record shall, as a minimum, be provided in English within the metadata record.

Translations of all or part of the English content may also be included.

9 DESCRIPTION OF DATA FOR GLOBAL EXCHANGE WITHIN WIS

Within the WIS, it is important for GISCs to be able to identify which data are published for global exchange. This determines whether the data are incorporated into the GISC cache. The WIS Discovery Metadata record describing a given dataset may identify whether that dataset is published for global exchange within the WIS.

9.1 Identifying the scope of distribution

The scope of distribution for a dataset (e.g. whether it is published for global exchange within the WIS) may be specified using a keyword:

- /gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords//gmd:keyword

The semantics of a keyword are inferred from a specified keyword thesaurus. The thesaurus relating to a particular keyword may be cited using the following element:

- /gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords//gmd:thesaurusName

The scope of distribution for data within WIS shall be expressed using the following controlled vocabulary: "GlobalExchange", “RegionalExchange” and “OriginatingCentre”.

A new Code List Dictionary is published as part of this specification defining the set of permissible values for specifying the scope of distribution within the WIS: WMO_DistributionScopeCode; Part 2, Table 17 refers.

The type of keyword may be specified using the following element:

- /gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords//gmd:type

The keyword type associated with WMO_DistributionScopeCode thesaurus shall be ‘dataCentre’. Keyword type ‘dataCentre’ is taken from the MD_KeywordTypeCode class described in ISO/DIS 19115-1:2013.

WMO Core Metadata Profile places the following additional restriction on ISO 19115:2003/Cor. 1:2006:

9.1.1 A WIS Discovery Metadata record describing data for global exchange via the WIS shall indicate the scope of distribution using the keyword “GlobalExchange” of type “dataCentre” from thesaurus WMO_DistributionScopeCode.

9.2 Identifiers for metadata describing data published for global exchange

The identifier (*gmd:MD_Metadata/gmd:fileIdentifier*) for a WIS Discovery Metadata record that describes data published for global exchange via the WIS shall be formatted as follows:

- gmd:MD_Metadata/gmd:fileIdentifier = “urn:x-wmo:md:int.wmo.wis::{uid}”

where {uid} is a unique identifier derived from the GTS bulletin or file name.

Unique identifiers ({uid}) for globally exchanged data shall be defined as follows:

- If a GTS «TTAAii» and «CCCC» is allocated for the product (i.e. where the datasets described by the metadata record employ the WMO file-naming convention P-flag = “T” or P-flag=”A”) use «TTAAii»«CCCC» for the unique identifier; or

- Else if a WMO Product Identifier is allocated for the product (i.e. WMO file-naming convention P-flag="W") use a truncated WMO product identifier field of the associated data-files, excluding the date-stamp and any other varying elements as necessary.

WMO Core Metadata Profile places the following additional restriction on ISO 19115:2003/Cor. 1:2006:

9.2.1 A WIS Discovery Metadata record describing data for global exchange via the WIS shall have a gmd:MD_Metadata/gmd:fileIdentifier attribute formatted as follows (where {uid} is a unique identifier derived from the GTS bulletin or file name): urn:x-wmo:md:int.wmo.wis::{uid}.

Note: to assist readers, the following are examples of *gmd:fileIdentifier* attributes for data globally exchanged via the WIS –

- urn:x-wmo:md:int.wmo.wis::FCUK31EGRR

- urn:x-wmo:md:int.wmo.wis::FR-meteofrance-toulouse,GRIB,ARPEGE-75N10N-60W65E_C_LFPW

9.3 Defining WMO Data Policy and GTS Priority for data published for global exchange

The WMO Data Policy pertaining to Resolution 25 (Cg-XIII) and Resolution 40 (Cg-XII) and other regulations (e.g. ICAO Annex 3 Meteorological Services for International Air Navigation) shall be expressed using the following controlled vocabulary: "WMOEssential", and "WMOAdditional" and "WMOOther".

A new Code List Dictionary is published as part of this specification defining the set of permissible values for specifying the WMO Data Policy: WMO_DataLicenseCode; Part 2, Table 14 refers.

WMO Data Policy is considered to be a Legal Constraint applying to both usage and access.

Note: more details on WMO Data Policy (WMO Resolution 40 (Cg-XII) and Resolution 25 (Cg-XIII)) are described at http://www.wmo.int/pages/about/exchangingdata_en.html.

The WMO Data Policy shall be defined using the following element:

- /gmd:MD_Metadata/gmd:identificationInfo//gmd:resourceConstraints//gmd:otherConstraints

The presence of more than one WMO Data Policy statement in a single metadata record yields an ambiguous state; a WIS Discovery Metadata record describing data for global exchange shall declare only a single WMO Data Policy.

WMO Core Metadata Profile places the following additional restriction on ISO 19115:2003/Cor. 1:2006:

9.3.1 A WIS Discovery Metadata record describing data for global exchange via the WIS shall indicate the WMO Data License as Legal Constraint (type: "otherConstraints") using one and only one term from the WMO_DataLicenseCode code list.

Note: only exact matches to the terms from the codelist are acceptable; "wmo-essential", "WMO Essential", or "WmOaDdiTiOnaL" will all fail to validate.

Note: Where WMO Data Policies "WMOAdditional" or "WMOOther" are cited, a more precise definition of the additional access or usage restrictions may be provided by the data publisher.

Note: guidance on the provision of alternative data policies and access or usage restrictions is provided at: http://wis.wmo.int/MD_DataPolicy.

The GTS Priority (also known as GTS Product Category Code) shall be expressed using the following controlled vocabulary: "GTSPriority1", "GTSPriority2", "GTSPriority3" and "GTSPriority4".

A new Code List Dictionary is published as part of this specification defining the set of permissible values for specifying the WMO Data Policy: WMO_GTSProductCategoryCode; Part 2, Table 15 refers.

GTS Priority is considered to be a Legal Constraint applying to both usage and access.

The GTS Priority shall be defined using the following element:

- /gmd:MD_Metadata/gmd:identificationInfo//gmd:resourceConstraints//gmd:otherConstraints

The presence of more than one GTS Priority statement in a single metadata record yields an ambiguous state; a WIS Discovery Metadata record describing data for global exchange shall declare only a single GTS Priority.

WMO Core Metadata Profile places the following additional restriction on ISO 19115:2003/Cor. 1:2006:

9.3.2 A WIS Discovery Metadata record describing data for global exchange via the WIS shall indicate the GTS Priority as Legal Constraint (type: "otherConstraints") using one and only one term from the WMO_GTSProductCategoryCode code list.

Note: only exact matches to the terms from the code list are acceptable; "gts-priority-4", "GTS Priority 4", or "GtsPriority4" will all fail to validate.

The absence of both gmd:accessConstraints and gmd:useConstraints shall be interpreted such that the terms expressed in gmd:otherConstraints (e.g. WMO Data Policy and GTS Priority) apply to both access and use.

However, this should be made explicit by expressing *gmd:MD_LegalConstraints/gmd:accessConstraints* and *gmd:MD_LegalConstraints/gmd:useConstraints* using *gmd:MD_RestrictionCode* "otherRestrictions".

Note: example

```
<gmd:resourceConstraints>
        <gmd:MD_LegalConstraints>
                <gmd:accessConstraints>
                        <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:accessConstraints>
                <gmd:useConstraints>
                        <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>
                <gmd:otherConstraints>
                        <gco:CharacterString>WMOEssential</gco:CharacterString>
                </gmd:otherConstraints>
                <gmd:otherConstraints>
                        <gco:CharacterString>GTSPriority3</gco:CharacterString>
                </gmd:otherConstraints>
        </gmd:MD_LegalConstraints>
</gmd:resourceConstraints>
```

All statements regarding constraints originating from a single source should be grouped into a single gmd:resourceConstraints element.

Note: this practice aims to ensure forward compatibility with ISO 19115-1:2013 (currently in Draft International Standard status) where the amended gmd:MD_Constraints class is expected to include information about the source of a (set of) constraints.

10 SUMMARY OF ADDITIONAL RESTRICTIONS

The requirements defined in this specification are summarised below in Table 4, Table 5 and Table 6. They are grouped according to the encoding requirements expressed in 6 and the formal requirements expressed in 8 and 9.

Table 4 – XML Encoding (6)

	Encoding rule	Description	
1	ISO/TS 19139:2007 compliance	6.1.1	[MANDATORY obligation] Each WIS Discovery Metadata record shall validate without error against the XML schemas defined in ISO/TS 19139:2007.
		6.1.2	[MANDATORY obligation] Each WIS Discovery Metadata record shall validate without error against the rule-based constraints listed in ISO/TS 19139:2007 Annex A (Table A.1).
2	Explicit identification of namespaces in XML	6.2.1	[MANDATORY obligation] Each WIS Discovery Metadata record shall explicitly name all namespaces used within the record; use of default namespaces is prohibited.
3	Specification of GML namespace	6.3.1	[MANDATORY obligation] Each WIS Discovery Metadata record shall declare the following XML namespace for GML: http://www.opengis.net/gml/3.2.

Table 5 – Metadata uniqueness and discovery within WIS DAR Catalogue (8)

	Target element(s)	Description	
4	gmd:MD_Metadata/gmd:fileIdentifier	8.1.1	[MANDATORY obligation] Each WIS Discovery Metadata record shall include one *gmd:MD_Metadata/gmd:fileIdentifier* attribute.
		8.1.2	[MANDATORY obligation] The gmd:MD_Metadata/gmd:fileIdentifier attribute for each WIS Discovery Metadata record shall be unique within the WIS.
5	gmd:MD_Metadata/gmd:identificationInfo/ ↘gmd:MD_Identification/gmd:descriptiveKeywords	8.2.1	[MANDATORY obligation] Each WIS Discovery Metadata record shall include at least one keyword from the WMO_CategoryCode code list.
		8.2.2	[MANDATORY obligation] Keywords from WMO_CategoryCode code list shall be defined as keyword type “theme”.
		8.2.3	[MANDATORY obligation] All keywords sourced from a particular keyword thesaurus shall be grouped into a single instance of the MD_Keywords class.
6	gmd:MD_Metadata/gmd:identificationInfo/ ↘gmd:MD_DataIdentification/gmd:extent/ ↘gmd:EX_Extent/gmd:geographicExtent/	8.2.4	[CONDITIONAL obligation: geographic data only] Each WIS Discovery Metadata record describing geographic data shall include the description of at least one geographic bounding box defining the spatial extent of the data.

Table 6 – Description of data for global exchange via WIS (9)

	Target element(s)	Description	
7	gmd:MD_Metadata/gmd:identificationInfo/ ↘gmd:MD_Identification/gmd:descriptiveKeywords	9.1.1	[MANDATORY obligation] A WIS Discovery Metadata record describing data for global exchange via the WIS shall indicate the scope of distribution using the keyword “GlobalExchange” of type “dataCentre” from thesaurus WMO_DistributionScopeCode.
8	gmd:MD_Metadata/gmd:fileIdentifier	9.2.1	[CONDITIONAL obligation: data globally exchanged via WIS only] A WIS Discovery Metadata record describing data for global exchange via the WIS shall have a gmd:MD_Metadata/gmd:fileIdentifier attribute formatted as follows (where {uid} is a unique identifier derived from the GTS bulletin or file name): urn:x-wmo:md:int.wmo.wis::{uid}.
9	gmd:MD_Metadata/gmd:identificationInfo/ ↘gmd:MD_DataIdentification/ ↘gmd:resourceConstraints/ ↘gmd:MD_LegalConstraints/gmd:otherConstraints	9.3.1	[CONDITIONAL obligation: data globally exchanged via WIS only] A WIS Discovery Metadata record describing data for global exchange via the WIS shall indicate the WMO Data License as Legal Constraint (type: “otherConstraints”) using one and only one term from the WMO_DataLicenseCode code list.
		9.3.2	[CONDITIONAL obligation: data globally exchanged via WIS only] A WIS Discovery Metadata record describing data for global exchange via the WIS shall indicate the GTS Priority as Legal Constraint (type: “otherConstraints”) using one and only one term from the WMO_GTSProductCategoryCode code list.

11 AMENDMENTS TO CODE LISTS / NEW CODE LISTS

Table 7 the modifications and additions to the Code Lists defined in ISO 19115:2003. Please refer to Part 2, 4 for more information on Code List extensions.

Table 7 – Modifications and additions to the ISO 19115:2003 Code Lists

	Target Code List	Change	Description
1	CI_DateTypeCode	Amendment	Additional term «reference» [004] See Part 2, Table 8
2	MD_KeywordTypeCode	Amendment	Additional term «dataCentre» [006] – from ISO/DIS 19115-1:2013. See Part 2, Table 10
3	WMO_DataLicenseCode	new	WMO Data License applied to the data resource – derived from WMO Resolution 25 and Resolution 40 (http://www.wmo.int/pages/about/exchangingdata_en.html) See Part 2, Table 14
4	WMO_GTSProductCategoryCode	New	Product category used for prioritising messages on the WMO Global Telecommunications System (GTS) See Part 2, Table 15
5	WMO_CategoryCode	New	Additional topic categories for WMO community See Part 2, Table 16
6	WMO_DistributionScopeCode	New	Scope of distribution of data within the WMO Information System. See Part 2, Table 17

12 WMO CORE METADATA PROFILE UML MODEL

Metadata records compliant with the WMO Core Metadata Profile shall contain at a minimum the information defined in Figure 1. These are the “mandatory” elements of the record.

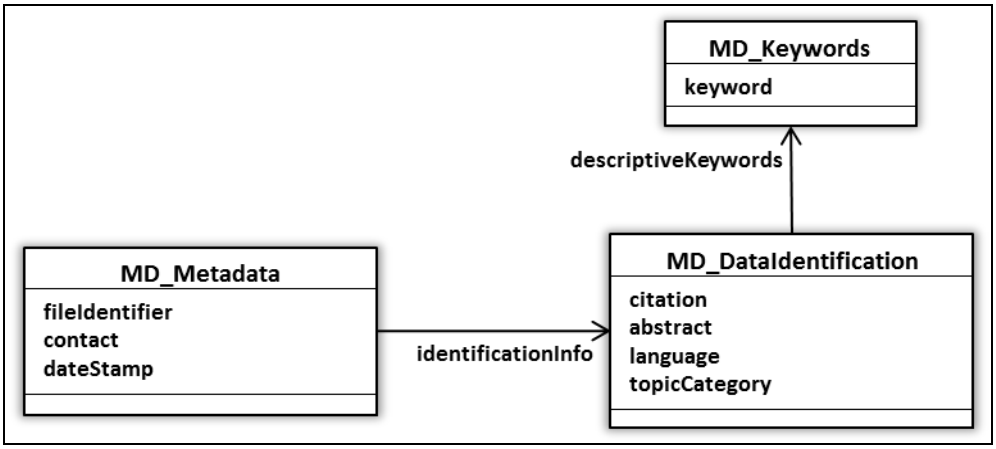

Figure 1 – Mandatory contents of a WIS Discovery Metadata record

The WMO Core Metadata Profile specification defines a further set of elements that shall be included in a WIS Discovery Metadata record under certain conditions. These are illustrated Figure 2.

Details of the UML classes and attributes are provided in Part 2, 3.

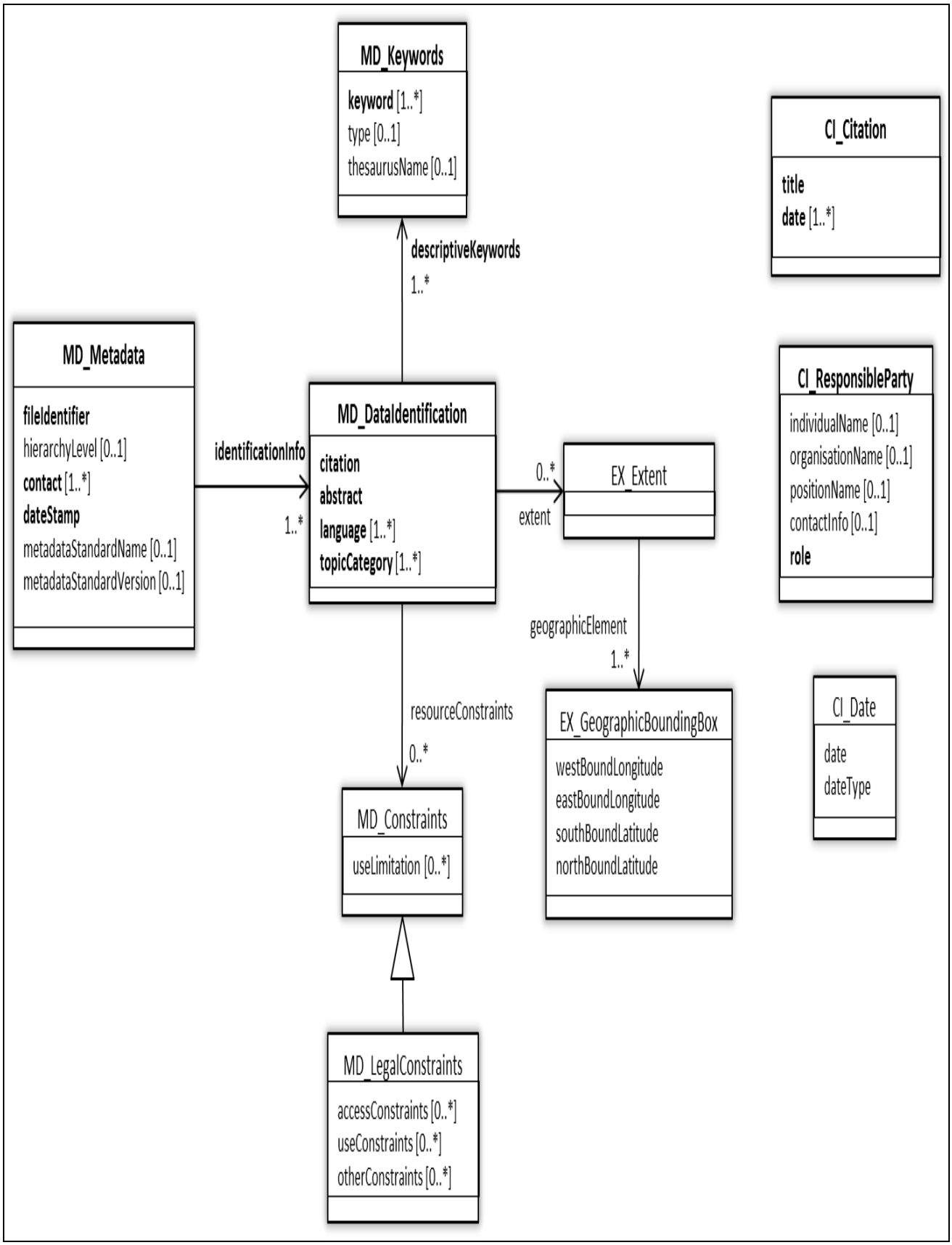

Figure 2 – Full specification of the WMO Core Profile including both optional and mandatory items

Note: for reference, the normative UML model for ISO 19115:2003/Cor. 1:2006 is published by ISO/TC 211 at: http://www.isotc211.org/hmmg/HTML/index.htm.

World Meteorological Organization
Organisation météorologique mondiale

Temps • Climat • Eau
Weather • Climate • Water

Commission for Basic Systems
OPAG on Information Systems and Services

WMO Core Metadata Profile version 1.3

Specification

Part 2 – Abstract Test Suite, Data Dictionary and Code Lists

Appendix C.1.3-Part 2 to the Manual on the WMO Information System (WMO-No. 1060)

Document version: 0.6: FINAL FOR CBS

Date: 11 July 2012
Approved on:

1 SCOPE

This specification defines the content, structure and encoding of discovery metadata published within the WMO Information System (WIS) Discovery-Access-Retrieval (DAR) Catalogue.

The metadata standard defined herein is an informal category-1 profile[1] of the International Standard ISO 19115:2003 'Geographic information – Metadata'. This metadata standard shall be referred to as the **WMO Core Metadata Profile**.

WIS Discovery Metadata records shall be encoded in XML as defined by ISO/TS 19139:2007.

Part 1 of this specification defines the conformance requirements for the WMO Core Metadata Profile. Part 2 defines the Abstract Test Suite, Data Dictionary and Code Lists. Unless otherwise stated, references to "Part 1" and "Part 2" are to the relevant parts of this specification.

2 ABSTRACT TEST SUITE (NORMATIVE)

Note: automated test suites for validating XML metadata records against both Formal Requirements and Guidance can be found from the WIS wiki: http://wis.wmo.int/MD_Conform.

Note: An authoritative copy of the automated test suite for validating against the Formal Requirements described in this specification can be found at: http://wis.wmo.int/2012/metadata/validationTestSuite/.

2.1 Abstract tests for XML encoding

2.1.1 ISO/TS 19139:2007 compliance

Test id: http://wis.wmo.int/2012/metadata/conf/ISO-TS-19139-2007-xml-schema-validation

Test purpose: **Requirement 6.1.1**: Each WIS Discovery Metadata record shall validate without error against the XML schemas defined in ISO/TS 19139:2007.

Test method: Using a tool with strict interpretation of XML Schema and full support for the W3C XML Schema, validate the instance document under test against the XML schemas created from the UML model of ISO 19115:2003/Cor. 1:2006 using the encoding rules defined in ISO/TS 19139:2007 'Geographic information – Metadata – XML schema implementation' Clause 9. The normative location for these XML schemata are hosted by ISO at: http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/.

A reference copy of these XML schemas is hosted by WMO at: http://wis.wmo.int/2011/schemata/iso19139_2007/schema/.

[1] A category-1 profile places additional restrictions on the use of an International Standard to meet the more specific requirements of a given community. Profiles of International Standards may be formally registered. The WMO profile of ISO 19115 has not been registered and thus remains an 'informal' profile.

Test id: http://wis.wmo.int/2012/metadata/conf/ISO-TS-19139-2007-rule-based-validation

Test purpose: **Requirement 6.1.2**: Each WIS Discovery Metadata record shall validate without error against the rule-based constraints listed in ISO/TS 19139:2007 Annex A (Table A.1).

Test method: Using a tool that supports Schematron (ISO/IEC 19757-3:2006 'Information technology – Document Schema Definition Language (DSDL) – Part 3: Rule-based validation – Schematron'), validate the instance document under test against the rule-based constraints listed in ISO/TS 19139:2007 Annex A (Table A.1). A reference set of Schematron rules for this purpose are hosted by WMO at: http://wis.wmo.int/2012/metadata/validationTestSuite/.

2.1.2 Explicit identification of namespaces in XML

Test id: http://wis.wmo.int/2012/metadata/conf/explicit-xml-namespace-identification

Test purpose: **Requirement 6.2.1**: Each WIS Discovery Metadata record shall explicitly name all namespaces used within the record; use of default namespaces is prohibited.

Test method: In the instance document under test inspect all 'xmlns' declarations to ensure that an XML namespace is provided; e.g.

```
<gmd:MD_Metadata xmlns:gmd="http://www.isotc211.org/2005/gmd" … >
```

The following 'xmlns' declaration is not permitted:

```
<MD_Metadata xmlns:="http://www.isotc211.org/2005/gmd" … >
```

2.1.3 Specification of GML namespace

Test id: http://wis.wmo.int/2012/metadata/conf/gml-namespace-specification

Test purpose: **Requirement 6.3.1**: Each WIS Discovery Metadata record shall declare the following XML namespace for GML: http://www.opengis.net/gml/3.2.

Test method: In the instance document under test inspect all 'xmlns' declarations to ensure that the GML namespace is specified as http://www.opengis.net/gml/3.2; e.g.

```
xmlns:gml="http://www.opengis.net/gmd/3.2"
```

2.2 Abstract tests for metadata uniqueness and discovery within WIS DAR Catalogue

2.2.1 Unique *gmd:fileIdentifier* attribute

Test id: http://wis.wmo.int/2012/metadata/conf/fileIdentifier-cardinality

Test purpose: **Requirement 8.1.1**: Each WIS Discovery Metadata record shall include one *gmd:MD_Metadata/gmd:fileIdentifier* attribute.

Test method: In the instance document under test, validate that there is one and only one instance of the element identified by the following XPath:

```
/gmd:MD_Metadata/gmd:fileIdentifier
```

Note: there is no abstract test for **Requirement 8.1.2**: The *gmd:MD_Metadata/gmd:fileIdentifier* attribute for each WIS Discovery Metadata record shall be unique within the WIS.

2.2.2 Mandatory WMO_CategoryCode keyword

Test id: http://wis.wmo.int/2012/metadata/conf/WMO_CategoryCode-keyword-cardinality

Test purpose: **Requirement 8.2.1**: Each WIS Discovery Metadata record shall include at least one keyword from the WMO_CategoryCode code list.

Test method: (i) Inspect the instance document under test to assess whether the WMO_CategoryCode code list is specified as a keyword thesaurus within an instance of *gmd:MD_Keywords* using the following XPath:

```
/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords/
    ↘gmd:MD_Keywords/gmd:thesaurusName/gmd:CI_Citation/gmd:title// =
    "WMO_CategoryCode"
```

A *gmx:Anchor* element may be used to specify the location of the Code List; e.g.

```
/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords/
    ↘gmd:MD_Keywords/gmd:thesaurusName/gmd:CI_Citation/gmd:title/
    ↘gmx:Anchor/@xlink:href =
    "http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#WMO_CategoryCode"
```

(ii) Inspect the associated *gmd:MD_Keywords* element to ensure that at least one instance of a keyword from the WMO_CategoryCode code list is present. A normative version of the WMO_CategoryCode code list is published by WMO at: http://wis.wmo.int/2012/codelists/WMOCodeLists.xml. Instances of keyword are identified by the following XPath:

```
/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords/
    ↘gmd:MD_Keywords/gmd:keyword
```

Test id: http://wis.wmo.int/2012/metadata/conf/WMO_CategoryCode-keyword-theme

Test purpose: **Requirement 8.2.2**: Keywords from WMO_CategoryCode code list shall be defined as keyword type "theme".

Test method: (i) Inspect the instance document under test to assess whether the WMO_CategoryCode code list is specified as a keyword thesaurus within an instance of *gmd:MD_Keywords* using the following XPath:

```
/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords/
    ↘gmd:MD_Keywords/gmd:thesaurusName/gmd:CI_Citation/gmd:title// =
    "WMO_CategoryCode"
```

A *gmx:Anchor* element may be used to specify the location of the Code List; e.g.

```
/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords/
    ↘gmd:MD_Keywords/gmd:thesaurusName/gmd:CI_Citation/gmd:title/
    ↘gmx:Anchor/@xlink:href =
    "http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#WMO_CategoryCode"
```

(ii) Inspect the associated *gmd:MD_Keywords* element to ensure that the keyword type is specified as "theme" from the MD_KeywordTypeCode code list; e.g.

```
/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords/
    ↘gmd:MD_Keywords/gmd:type/gmd:MD_KeywordTypeCode = "theme"
```

Test id: http://wis.wmo.int/2012/metadata/conf/keyword-grouping

Test purpose: **Requirement 8.2.3**: All keywords sourced from a particular keyword thesaurus shall be grouped into a single instance of the *MD_Keywords* class.

Test method: Inspect the instance document under test to assess whether each keyword thesaurus is specified once and once only. Keyword thesaurus title is specified using the following XPath:

```
/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords/
↘gmd:MD_Keywords/gmd:thesaurusName/gmd:CI_Citation/gmd:title//
```

2.2.3 Geographic data extent specification with bounding box

Test id: http://wis.wmo.int/2012/metadata/conf/geographic-bounding-box

Test purpose: **Requirement 8.2.4**: Each WIS Discovery Metadata record describing geographic data shall include the description of at least one geographic bounding box defining the spatial extent of the data.

Test method: (i) Inspect the instance document under test to assess whether the metadata record is describing geographic data; e.g.

```
/gmd:MD_Metadata/gmd:hierarchyLevel/gmd:MD_ScopeCode !=
“nonGeographicDataset”
```

(ii) Inspect the instance document under test to assess whether the geographic extent is specified using a bounding box. Abstract test http://wis.wmo.int/2012/metadata/conf/ISO-TS-19139-2007-rule-based-validation shall ensure that the bounding box is correctly specified. Geographic extent bounding box is specified using the following XPath:

```
/gmd:MD_Metadata/gmd:identificationInfo/gmd:MD_DataIdentification/
↘gmd:extent/gmd:EX_Extent/gmd:geographicExtent/gmd:EX_GeographicBoundi
ngBox
```

Note: there is no abstract test for **Requirement 8.2.5**: All information within a metadata record shall, as a minimum, be provided in English within the metadata record.

2.3 Description of data for global exchange via WIS

2.3.1 Identification of data for global exchange via WIS

Test id: http://wis.wmo.int/2012/metadata/conf/identification-of-globally-exchanged-data

Test purpose: **Requirement 9.1.1**: A WIS Discovery Metadata record describing data for global exchange via the WIS shall indicate the scope of distribution using the keyword “GlobalExchange” of type “dataCenterdataCentre” from thesaurus WMO_DistributionScopeCode.

Test method: (i) Inspect the instance document under test to assess whether the WMO_DistributionScopeCode code list is specified as a keyword thesaurus within an instance of *gmd:MD_Keywords* using the following XPath:

```
/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords/
↘gmd:MD_Keywords/gmd:thesaurusName/gmd:CI_Citation/gmd:title// =
“WMO_DistributionScopeCode”
```

A *gmx:Anchor* element may be used to specify the location of the Code List; e.g.

/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords/
↘gmd:MD_Keywords/gmd:thesaurusName/gmd:CI_Citation/gmd:title/
↘gmx:Anchor/@xlink:href =
"http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#WMO_DistributionScopeCode"

(ii) Inspect the associated *gmd:MD_Keywords* element to ensure that the keyword type is specified as "dataCentre" from the (amended) MD_KeywordTypeCode code list; e.g.

/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords/
↘gmd:MD_Keywords/gmd:type/gmd:MD_KeywordTypeCode = "dataCentre"

(iii) Inspect the associated *gmd:MD_Keywords* element to assess whether the keyword "GlobalExchange" from the WMO_DistributionScopeCode code list is present; e.g.

/gmd:MD_Metadata/gmd:identificationInfo//gmd:descriptiveKeywords/
↘gmd:MD_Keywords/gmd:keyword = "GlobalExchange"

Test id: http://wis.wmo.int/2012/metadata/conf/fileIdentifier-for-globally-exchanged-data

Test purpose: **Requirement 9.2.1**: A WIS Discovery Metadata record describing data for global exchange via the WIS shall have a gmd:MD_Metadata/gmd:fileIdentifier attribute formatted as follows (where {uid} is a unique identifier derived from the GTS bulletin or file name): urn:x-wmo:md:int.wmo.wis::{uid}.

Test method: In the instance document under test, validate that the *gmd:fileIdentifier* element conforms to the following regular expression:

/gmd:MD_Metadata/gmd:fileIdentifier// = "^urn:x-wmo:md:int.wmo.wis::"

2.3.2 Specification of WMO Data Policy for globally exchanged data

Test id: http://wis.wmo.int/2012/metadata/conf/WMO-data-policy-for-globally-exchanged-data

Test purpose: **Requirement 9.3.1**: A WIS Discovery Metadata record describing data for global exchange via the WIS shall indicate the WMO Data License as Legal Constraint (type: "otherConstraints") using one and only one term from the WMO_DataLicenseCode code list.

Test method: Inspect the instance document under test to assess whether one and only one instance of a term from the WMO_DataLicenseCode code list is specified using the following XPath:

/gmd:MD_Metadata/gmd:identificationInfo//gmd:resourceConstraints/
↘gmd:MD_LegalConstaints/gmd:otherConstraints//

A normative version of the WMO_DataLicenseCode code list is published by WMO at: http://wis.wmo.int/2012/codelists/WMOCodeLists.xml.

A *gmx:Anchor* element may be used to specify the location of the Code List; e.g.

/gmd:MD_Metadata/gmd:identificationInfo//gmd:resourceConstraints/
↘gmd:MD_LegalConstaints/gmd:otherConstraints/gmx:Anchor/@xlink:href =
"http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#WMO_DataLicenseCode"

2.3.3 Specification of GTS Product Category (GTS Priority) for globally exchanged data

Test id: http://wis.wmo.int/2012/metadata/conf/GTS-priority-for-globally-exchanged-data

Test purpose: **Requirement 9.3.2**: A WIS Discovery Metadata record describing data for global exchange via the WIS shall indicate the GTS Priority as Legal Constraint (type: “otherConstraints”) using one and only one term from the WMO_GTSProductCategoryCode code list.

Test method: Inspect the instance document under test to assess whether one and only one instance of a term from the WMO_GTSProductCategoryCode code list is specified using the following XPath:

```
/gmd:MD_Metadata/gmd:identificationInfo//gmd:resourceConstraints/
    ↘gmd:MD_LegalConstaints/gmd:otherConstraints//
```

A normative version of the WMO_GTSProductCategoryCode code list is published by WMO at: http://wis.wmo.int/2012/codelists/WMOCodeLists.xml.

A *gmx:Anchor* element may be used to specify the location of the Code List; e.g.

```
/gmd:MD_Metadata/gmd:identificationInfo//gmd:resourceConstraints/
    ↘gmd:MD_LegalConstaints/gmd:otherConstraints/gmx:Anchor/@xlink:href =
    “http://wis.wmo.int/2012/codelists/WMOCodeLists.xml#WMO_GTSProductCateg
    oryCode”
```

3 WMO CORE METADATA PROFILE DATA DICTIONARY

This data dictionary includes only mandatory elements from ISO 19115:2003 and associated corrigendum, and elements explicitly mentioned within this specification. Other elements are omitted. Please refer to ISO 19115:2003 and ISO 19115:2003/Cor. 1:2006 for further information. Note: note that additional guidance for metadata authors is provided at http://wis.wmo.int/MD_Index.

Table 1 to Table 7 are tabular representations of the UML diagrams for the section of the UML diagrams for the WMO Core Profile. Items marked with “M” in the “Obligation/Condition” column shall be present in a valid WMO Core Profile Metadata record. Those entries marked with “O” should be present if they are applicable. Entries marked “C” shall be present if the associated condition is met.

Line numbers match those defined in ISO 19115:2003 and the associated corrigendum.

Table 1 – Metadata entity set information

	Name / Role name	Definition	Obligation / Condition	Maximum occurrence	Data type	Domain
1	MD_Metadata	root entity which defines metadata about a resource or resources	M	1	Class	Lines 2-22
2	fileIdentifier	unique identifier for this metadata file	M	1	CharacterString	Free text See Part 1, 8.1 and Part 1, 9.2
6	hierarchyLevel	scope to which the metadata applies	O	1	Class	MD_ScopeCode «CodeList» SeeTable 12
8	contact	party responsible for the metadata	M	N	Class	CI_ResponsibleParty «DataType» See Table 6
9	dateStamp	date that the metadata was created or revised	M	1	Class	Date
10	metadataStandardName	name of the metadata standard (including profile name) used	O	1	CharacterString	Free text See Part 1, 7
11	metadataStandardVersion	version of the metadata standard (version of the profile) used	O	1	CharacterString	Free text See Part 1, 7
15	*Role name:* identificationInfo	basic information about the resource(s) to which the metadata applies	M	N	Association	MD_DataIdentification See Table 2

Table 2 – Identification information (includes data identification)

	Name / Role name	Definition	Obligation / Condition	Maximum occurrence	Data type	Domain
23	*MD_Identification*	basic information required to uniquely identify a resource or resources	Use obligation from referencing object	Use maximum occurrence from referencing object	Aggregated Class (MD_Metadata) «Abstract»	Lines 24-35.1
24	citation	information about citing the resource(s)	M	1	Class	CI_Citation«DataType» SeeTable 6
25	abstract	brief narrative summary of the content of the resource(s)	M	1	CharacterString	Free text
33	*Role name:* descriptiveKeywords	provides category keywords, their type, and reference source	M	N	Association	MD_Keywords See Table 3 See Part 1, 8.2 and Part 1, 9.1
35	*Role name:* resourceConstraints	provides information about constraints which apply to the resource(s)	O	N	Association	MD_Constraints See See Part 1, 9.3
36	MD_DataIdentification	basic information required to uniquely identify a dataset	Use obligation from referencing object	Use maximum occurrence from referencing object	Specified Class (MD_Identification)	Lines 37-46 and 24-35.1
39	language	language(s) used within the dataset	M	N	CharacterString	ISO 639-2 recommended
41	topicCategory	main theme(s) of the dataset	M	N	Class	MD_TopicCategoryCode«Enumeration» See Table 13
45	extent	extent information including the bounding box, bounding polygon, vertical, and temporal extent of the dataset	C	N	Association	EX_Extent«DataType» SeeTable 5 See Part 1, 8.2

Table 3 – Keyword information

	Name / Role name	Definition	Obligation / Condition	Maximum occurrence	Data type	Domain
52	MD_Keywords	Keywords, their type and source	Use obligation from referencing object	Use maximum occurrence from referencing object	Aggregated Class (MD_Identification)	Lines 53-55
53	keyword	commonly used word(s) or formalised word(s) or phrase(s) used to describe the subject	M	N	CharacterString	Free text See Part 1, 8.2 and Part 1, 9.1
54	type	subject matter used to group similar keywords	O	1	Class	MD_KeywordTypeCode «CodeList» See Table 10 See Part 1, 8.2 and Part 1, 9.1
55	thesaurusName	name of a formally registered thesaurus or a similar authoritative source of keywords	O	1	Class	CI_Citation «DataType» See Table 6 See Part 1, 8.2 and Part 1, 9.1

Table 4 – Constraint information (includes legal)

	Name / Role name	Definition	Obligation / Condition	Maximum occurrence	Data type	Domain
67	MD_Constraints	restrictions on the access and use of a resource or metadata	Use obligation from referencing object	Use maximum occurrence from referencing object	Aggregated Class (MD_Metadata and MD_Identification)	Line 68
68	useLimitation	limitation affecting the fitness for use of the resource or metadata. Example, “not to be used for navigation”	O	N	CharacterString	Free text
69	MD_LegalConstraints	restrictions and legal prerequisites for accessing and using the resource or metadata	Use obligation from referencing object	N	Specialised Class (MD_Constraints)	Lines 70-72 and 68
70	accessConstraints	access constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations or warnings on using the resource or metadata	O	N	Class	MD_RestrictionCode «CodeList» See Table 11
71	useConstraints	constraints applied to assure the protection of privacy or intellectual property, and any special restrictions or limitations or warnings on using the resource or metadata	O	N	Class	MD_RestrictionCode «CodeList» See Table 11
72	otherConstraints	other restrictions and legal prerequisites for accessing and using the resource or metadata	C / accessConstraints or useConstraints equal “otherRestrictions”	N	CharacterString	Free text or code table. See Part 1, 9.3

Table 5 – Extent information

	Name / Role name	Definition	Obligation / Condition	Maximum occurrence	Data type	Domain
334	EX_Extent	information about horizontal, vertical, and temporal extent	Use obligation from referencing object	Use maximum occurrence from referencing object	Class «DataType»	Lines 335-338
336	Role name: geographicElement	provides geographic component of the extent of the referring object	C	N	Association	EX_GeographicExtent «Abstract» See Table 5 See Part 1, 8.2
339	*EX_GeographicExtent*	geographic area of the dataset	Use obligation from referencing object	Use maximum occurrence from referencing object	Aggregated Class (EX_Extent and EX_SpatialTemporalExtent) «Abstract»	Line 340
343	EX_GeographicBoundingBox	geographic position of the dataset NOTE This is only an approximate reference so specifying the coordinate reference system is unnecessary	C See Subclause 8.2 (Part 1)	Use maximum occurrence from referencing object	Specialised Class (EX_GeographicExtent)	Lines 344-347 and 340
344	westBoundLongitude	western-most coordinate of the limit of the dataset extent, expressed in longitude in decimal degrees (positive east)	M	1	Class	Angle -180,0 <= West Bounding Longitude Value <= 180,0 See Part 1, 8.2
345	eastBoundLongitude	eastern-most coordinate of the limit of the dataset extent, expressed in longitude in decimal degrees (positive east)	M	1	Class	Angle -180,0 <= East Bounding Longitude Value <= 180,0 See Part 1, 8.2
346	southBoundLatitude	southern-most coordinate of the limit of the dataset extent, expressed in latitude in decimal degrees (positive north)	M	1	Class	-90,0 <= South Bounding Latitude Value <= 90,0; South Bounding Latitude Value <= North bounding Latitude Value See Part 1, 8.2
347	northBoundLatitude	northern-most, coordinate of the limit of the dataset extent expressed in latitude in decimal degrees (positive north)	M	1	Class	-90,0 <= North Bounding Latitude Value <= 90,0; North Bounding Latitude Value >= South Bounding Latitude Value See Part 1, 8.2

Table 6 – Citation and responsible party information

	Name / Role name	Definition	Obligation / Condition	Maximum occurrence	Data type	Domain
359	CI_Citation	standardized resource reference	Use obligation/condition from referencing object	Use maximum occurrence from referencing object	Class «DataType»	Lines 360-373
360	title	name by which the cited resource is known	M	1	CharacterString	Free text
362	date	reference date for the cited resource	M	N	Class	CI_Date «DataType» SeeTable 7
374	CI_ResponsibleParty	identification of, and means of communication with, person(s) and organizations associated with the dataset	Use obligation/condition from referencing object	Use maximum occurrence from referencing object	Class «DataType»	Lines 375-379
375	individualName	name of the responsible person surname, given name, title separated by a delimiter	C / organisationName and positionName not documented?	1	CharacterString	Free text
376	organisationName	name of the responsible organization	C / individualName and positionName not documented?	1	CharacterString	Free text
377	positionName	role or position of the responsible person	C / individualName and organisationName not documented?	1	CharacterString	Free text
378	contactInfo	contact information for the responsible party	O	1	Class	CI_Contact «DataType»
379	role	function performed by the responsible party	M	1	Class	CI_RoleCode «CodeList» See Table 9

Table 7 – Date information

	Name / Role name	Definition	Obligation / Condition	Maximum occurrence	Data type	Domain
393	CI_Date	reference date and event used to describe it	Use obligation/condition from referencing object	Use maximum occurrence from referencing object	Class «DataType»	Lines 119-120
394	date	reference date for the cited resource	M	1	Class	Date
395	dateType	event used for the reference date	M	1	Class	CI_DateTypeCode «CodeList» SeeTable 8

4 CODELISTS AND ENUMERATIONS

Table 8 to Table 13 describe the Code Lists defined in ISO 19115:2003 and ISO 19115:2003/Cor. 1:2006 that are referenced in the WMO Core Metadata Specification – including amendments for WMO Core Metadata Profile in **bold**.

Table 14 to Table 17 describe the new Code Lists defined in WMO Core Metadata Profile.

A GML CodeList Dictionary implementation of the new and amended Code Lists is published at: http://wis.wmo.int/2012/codelists/WMOCodeLists.xml.

Table 8 – CI_DateTypeCode «CodeList» (including amendment)

	Name	Domain Code	Definition
1.	CI_DateTypeCode	DateTypCd	identification of when a given event occurred
2.	creation	001	date identifies when the resource was brought into existence
3.	publication	002	date identifies when the resource was issued
4.	revision	003	date identifies when the resource was examined and improved or amended
5.	**reference**	**004**	**date identifies when the resource was referenced or accessed**

Table 9 – CI_RoleCode «CodeList»

	Name	Domain Code	Definition
1.	CI_RoleCode	RoleCd	function performed by the responsible party
2.	resourceProvider	001	party that supplies the resource
3.	custodian	002	party that accepts accountability and responsibility for the data and ensures appropriate care and maintenance of the resource
4.	owner	003	party that owns the resource
5.	user	004	party who uses the resource
6.	distributor	005	party who distributes the resource
7.	originator	006	party who created the resource
8.	pointOfContact	007	party who can be contacted for acquiring knowledge about or acquisition of the resource
9.	principalInvestigator	008	key party responsible for gathering information and conducting research
10.	processor	009	party who has processed the data in a manner such that the resource has been modified
11.	publisher	010	party who published the resource
12.	author	011	party who authored the resource

Table 10 – MD_KeywordTypeCode «CodeList» (including amendment)

	Name	Domain Code	Definition
1.	MD_KeywordTypeCode	KeyTypCd	methods used to group similar keywords
2.	discipline	001	keyword identifies a branch of instruction or specialised learning
3.	place	002	keyword identifies a location
4.	stratum	003	keyword identifies a the layer(s) of any deposited substance
5.	temporal	004	keyword identifies a time period related to the dataset
6.	theme	005	keyword identifies a particular subject or topic
7.	**dataCentre**	**006**	**keyword identifies a a repository or archive that manages and distributes data** (from ISO/DIS 19115-1:2013)

Table 11 – MD_RestrictionCode «CodeList»

	Name	Domain Code	Definition
1.	MD_RestrictionCode	RestrictCd	limitation(s) placed upon access or use of the data
2.	copyright	001	exclusive right to the publication, production, or sale of the rights to a literary, dramatic, musical or artistic work, or to the use of a commercial print or label, granted by law for a specified period of time to an author, composer, artist or distributor
3.	patent	002	government has granted exclusive right to make, sell, use or license an invention or discovery
4.	patentPending	003	produced or sold information awaiting a patent
5.	trademark	004	a name, symbol, or other device identifying a product, officially registered and legally restricted to the use of the owner or manufacturer
6.	license	005	formal permission to do something
7.	intellectualPropertyRights	006	Rights to financially benefit from and control of distribution of non-tangible property that is the result of creativity
8.	restricted	007	Withheld from general circulation or disclosure
9.	otherRestrictions	008	limitation not listed

Table 12 – MD_ScopeCode «CodeList»

	Name	Domain Code	Definition
1.	MD_ScopeCode	ScopeCd	class of information to which the referencing entity applies
2.	attribute	001	information applies to the attribute class
3.	attributeType	002	information applies to the characteristic of a feature
4.	collectionHardware	003	information applies to the collection hardware class
5.	collectionSession	004	information applies to the collection session
6.	dataset	005	information applies to the dataset
7.	series	006	information applies to the series
8.	nonGeographicDataset	007	information applies to non-geographic data
9.	dimensionGroup	008	information applies to a dimension group
10.	feature	009	information applies to a feature
11.	featureType	010	information applies to a feature type
12.	propertyType	011	information applies to a property type
13.	fieldSession	012	information applies to a field session
14.	software	013	information applies to a computer programme or routine
15.	service	014	information applies to a capability which a service provider entity makes available to a service user entity through a set of interfaces that define a behaviour, such as a use case
16.	model	015	information applies to a copy or imitation of an existing or hypothetical object
17.	tile	016	information applies to a tile, a spatial subset of geographic data

Table 13 – MD_TopicCategoryCode «Enumeration»

	Name	Domain code	Definition
1.	MD_TopicCategoryCode	TopicCatCd	high-level geographic data thematic classification to assist in the grouping and search of available geographic data sets, Can be used to group keywords as well. Listed examples are not exhaustive. NOTE It is understood there are overlaps between general categories and the user is encouraged to select the one most appropriate.
2.	farming	001	rearing of animals and/or cultivation of plants Examples: agriculture, plantations, herding, pests and diseases affecting crops and livestock
3.	biota	002	flora and/or fauna in natural environment Examples: wildlife, vegetation, biological sciences, ecology, sea-life, habitat
4.	boundaries	003	legal land descriptions Examples: political and administrative boundaries
5.	climatologyMeteorologyAtmosphere	004	processes and phenomena of the atmosphere Examples: weather, climate, atmospheric conditions, climate change, precipitation
6.	economy	005	economic activities, conditions and employment Examples: production, labour, revenue, commerce, industry, tourism and ecotourism, forestry, fisheries, commercial or subsistence hunting, exploration and exploitation of resources such as minerals, oil and gas
7.	elevation	006	height above or below sea level Examples: altitude, bathymetry, digital elevation models, slope, derived products
8.	environment	007	environmental resources, protection and conservation Examples: environmental pollution, waste storage and treatment, environmental impact assessment, monitoring environmental risk, nature reserves, landscape
9.	geoscientificInformation	008	information pertaining to earth sciences Examples: geophysical features and processes, geology, minerals, sciences dealing with the composition, structure and origin of the earth's rocks, risks of earthquakes, volcanic activity, landslides, gravity information, soils, permafrost, hydrogeology, erosion
10.	health	009	health, health services, human ecology, and safety Examples: disease and illness, factors affecting health, hygiene, substance abuse, mental and physical health, health services
11.	imageryBaseMapsEarthCover	010	base maps Examples: land cover, topographic maps, imagery, unclassified images, annotations
12.	intelligenceMilitary	011	military bases, structures, activities Examples: barracks, training grounds, military transportation, information collection
13.	inlandWaters	012	inland water features, drainage systems and their characteristics Examples: rivers and glaciers, salt lakes, water utilization plans, dams, currents, floods, water quality, hydrographic charts
14.	location	013	positional information and services Examples: addresses, geodetic networks, control points, postal zones and services, place names
15.	oceans	014	features and characteristics of salt water bodies (excluding inland waters) Examples: tides, tidal waves, coastal information, reefs

	Name	Domain code	Definition
16.	planningCadastre	015	information used for appropriate actions for future use of the land Examples: land use maps, zoning maps, cadastral surveys, land ownership
17.	society	016	characteristics of society and cultures Examples: settlements, anthropology, archaeology, education, traditional beliefs, manners and customs, demographic data, recreational areas and activities, social impact assessments, crime and justice, census information
18.	structure	017	man-made construction Examples: buildings, museums, churches, factories, housing, monuments, shops, towers
19.	transportation	018	means and aids for conveying persons and/or goods Examples: roads, airports/airstrips, shipping routes, tunnels, nautical charts, vehicle or vessel location, aeronautical charts, railways
20.	utilitiesCommunication	019	energy, water and waste systems and communications infrastructure and services Examples: hydroelectricity, geothermal, solar and nuclear sources of energy, water purification and distribution, sewage collection and disposal, electricity and gas distribution, data communication, telecommunication, radio, communication Networks

Table 14 – WMO_DataLicenseCode «CodeList»

	Name	Domain Code	Definition
1.	WMO_DataLicenseCode	WMODatLicCd	WMO Data License applied to the data resource – derived from WMO Resolution 25 and Resolution 40 (http://www.wmo.int/pages/about/exchangingdata_en.html)
2.	WMOEssential	001	WMO Essential Data: free and unrestricted international exchange of basic meteorological data and products.
3.	WMOAdditional	002	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.
4.	WMOOther	003	Data that are not covered by WMO Resolution 25 or WMO Resolution 40; e.g. aviation OPMET data. Data marked with “WMOOther” data policy are subject to data policy constraints; a 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.

Table 15 – WMO_GTSProductCategoryCode «CodeList»

	Name	Domain Code	Definition
1.	WMO_GTSProductCategoryCode	WMOGTSCatCd	Product category used for prioritising messages on the WMO Global Telecommunications System (GTS)
2.	GTSPriority1	001	GTS Priority 1 – highest priority products.
3.	GTSPriority2	002	GTS Priority 2.
4.	GTSPriority3	003	GTS Priority 3.
5.	GTSPriority4	004	GTS Priority 4.

Table 16 – WMO_CategoryCode «CodeList»

	Name	Domain Code	Definition
1.	WMO_CategoryCode	WMOCatCd	additional topic categories for WMO community
2.	weatherObservations	001	weather observations
3.	weatherForecasts	002	weather forecasts
4.	meteorology	003	Meteorology
5.	hydrology	004	Hydrology
6.	climatology	005	Climatology
7.	landMeteorologyClimate	006	land meteorology climate
8.	synopticMeteorology	007	synoptic meteorology
9.	marineMeteorology	008	marine meteorology
10.	agriculturalMeteorology	009	agricultural meteorology
11.	aerology	010	Aerology
12.	marineAerology	011	marine aerology
13.	oceanography	012	Oceanography
14.	landHydrology	013	land hydrology
15.	rocketSounding	014	rocket sounding
16.	pollution	015	Pollution
17.	waterPollution	016	water pollution
18.	landWaterPollution	017	land water pollution
19.	seaPollution	018	sea pollution
20.	landPollution	019	land pollution
21.	airPollution	020	air pollution
22.	glaciology	021	Glaciology
23.	actinometry	022	Actinometry
24.	satelliteObservation	023	satellite observation
25.	airplaneObservation	024	airplane observation
26.	observationPlatform	025	observation platform

Table 17 – WMO_DistributionScopeCode «CodeList»

	Name	Domain Code	Definition
1.	WMO_DistributionScopeCode	WMODisScoCd	Scope of distribution for data published for exchange within WIS
2.	GlobalExchange	001	Data are published for global exchange via the WIS. Data shall be incorporated into the GISC Cache.
3.	RegionalExchange	002	Data are published for regional exchange via a GISC.
4.	OriginatingCentre	003	Data are published for exchange directly via the originating centre.

Annex 3 to Recommendation 8 (CBS-15)

AMENDMENTS TO APPENDIX B, B.3 "NATIONAL CENTRES" OF THE *MANUAL ON THE WMO INFORMATION SYSTEM* (WMO-No. 1060)

Table 1. Insert content as Appendix B of Manual on WIS: "B.3 National Centres"

Note: TBD (To Be Decided) in the Principal GISC column can be changed according to decisions made by each Member at the next sessions of RA-II and RA-VI respectively.

Member / Organization	*Centre Name*	*GTS Function*	*Centre Location Region/City*	*Principal GISC*	*Constituent Body*
Afghanistan	Afghan Meteorological Authority	NMC	RA II / Kabul	TBD	CBS
Albania	The Hydrometeorological Institute	NMC	RA VI / Tirana	TBD	CBS
Algeria	Office National de la Météorologie	NMC	RA I / Algiers	Casablanca	CBS
Angola	Instituto Nacional de Hidrometeorologia e Geofísica	NMC	RA I / Luanda	Pretoria	CBS
Antigua and Barbuda	Antigua and Barbuda Meteorological Services	NMC	RA IV / St. John's	Washington	CBS
Argentina	Servicio Meteorológico Nacional	NMC	RA III / Buenos Aires	Brasilia	CBS
Armenia	Armenian State Hydrometeorological and Monitoring Service	NMC	RA VI / Yerevan	Moscow	CBS
Australia	Cocos and Christmas Island Field Office	WSO (Christmas Island)	RA V / Cocos Island	Melbourne	CBS
	National Meteorological and Oceanographic Centre	NMC	RA V / Melbourne	Melbourne	CBS
	Bureau of Meteorology Water Division	NHS	RA V / Canberra	Melbourne	CHy
Austria	Central Institute for Meteorology and Geodynamics	NMC	RA VI / Vienna	WE-VGISC Offenbach	CBS
Azerbaijan	National Hydrometeorological Department	NMC	RA VI / Baku	TBD	CBS
Bahamas	Department of Meteorology	NMC	RA IV / Nassau	Washington	CBS
Bahrain	Bahrain Meteorological Service	NMC	RA II / Manama	TBD	CBS
Bangladesh	Bangladesh Meteorological Department	NMC	RA II / Dhaka	New Delhi	CBS
Barbados	Meteorological Services	NMC	RA IV / Bridgetown	Washington	CBS
Belarus	Department of Hydrometeorology	NMC	RA VI / Minsk	Moscow	CBS
Belgium	Institut Royal Météorologique	NMC	RA VI / Brussels	TBD	CBS
Belize	National Meteorological Service	NMC	RA IV / Belize City	Washington	CBS
Benin	Service Météorologique National	NMC	RA I / Cotonou	Casablanca	CBS
Bhutan	Council for Renewable Natural Resources Research	NMC	RA II / Thimphu	TBD	CBS
Bolivia, Plurinational State of	Servicio Nacional de Meteorología e Hidrología	NMC	RA III / La Paz	Brasilia	CBS
Bosnia and Herzegovina	Meteorological Institute	NMC	RA VI / Sarajevo	WE-VGISC Offenbach	CBS

Member / Organization	*Centre Name*	*GTS Function*	*Centre Location Region/City*	*Principal GISC*	*Constituent Body*
Botswana	Botswana Meteorological Services	NMC	RA I / Gaborone	Pretoria	CBS
Brazil	Instituto Nacional de Meteorologia	NMC	RA III / Brasilia	Brasilia	CBS
British Caribbean Territories	Caribbean Meteorological Organization (Turks and Caicos Islands)	WSO (Turks and Caicos Islands)	RA IV / Cockburn Town	Washington	CBS
British Caribbean Territories	Caribbean Meteorological Organization (Montserrat)	WSO (Montserrat)	RA IV / Plymouth	Washington	CBS
British Caribbean Territories	Caribbean Meteorological Organization (Cayman Islands)	WSO (Cayman Islands)	RA IV / George Town	Washington	CBS
British Caribbean Territories	Caribbean Meteorological Organization	NMC	RA IV / Woodbrook	Washington	CBS
Brunei Darussalam	The Brunei Meteorological Service	NMC	RA V / Bandar Seri Begawan	Melbourne	CBS
Bulgaria	National Institute of Meteorology and Hydrology	NMC	RA VI / Sofia	WE-VGISC Offenbach	CBS
Burkina Faso	Direction de la Météorologie	NMC	RA I / Ouagadougou	Casablanca	CBS
Burundi	Institut Géographique du Burundi	NMC	RA I / Bujumbura	Casablanca	CBS
Cambodia	Department of Meteorology	NMC	RA II / Phnom Penh	TBD	CBS
Cameroon	Direction de la Météorologie Nationale	NMC	RA I / Douala	Casablanca	CBS
Canada	Meteorological Service of Canada	NMC	RA IV / Montreal	Washington	CBS
Cape Verde	Instituto Nacional de Meteorologia e Geofísica	NMC	RA I / Sal	Casablanca	CBS
Central African Republic	Direction Générale de l'Aviation Civile et de la Météorologie	NMC	RA I / Bangui	Casablanca	CBS
Chad	Direction des Ressources en Eau et de la Météorologie	NMC	RA I / N'Djamena	Casablanca	CBS
Chile	Dirección Meteorológica de Chile	NMC	RA III / Santiago	Brasilia	CBS
China	China Meteorological Administration	NMC	RA II / Beijing	Beijing	CBS
Colombia	Instituto de Hidrología, Meteorología y Estudios Ambientales	NMC	RA III / Bogotá	Brasilia	CBS
Comoros	Direction de la Météorologie Nationale	NMC	RA I / Moroni	Casablanca	CBS
Congo	Direction de la Météorologie Nationale	NMC	RA I / Brazzaville	Casablanca	CBS
Cook Islands	Cook Islands Meteorological Service	NMC	RA V / Avarua	Melbourne	CBS
Costa Rica	Instituto Meteorológico Nacional	NMC	RA IV / San José	Washington	CBS
Côte d'Ivoire	Direction de la Météorologie Nationale	NMC	RA I / Abidjan	Casablanca	CBS
Croatia	Meteorological and Hydrological Service	NMC	RA VI / Zagreb	WE-VGISC Offenbach	CBS
Cuba	Instituto de Meteorología	NMC	RA IV / Havana	Washington	CBS
Curaçao and Sint Maarten	Meteorological Department Curaçao	NMC	RA IV / Willemstad	Washington	CBS
Cyprus	Meteorological Service	NMC	RA VI / Nicosia	WE-VGISC Offenbach	CBS
Czech Republic	Czech Hydrometeorological Institute	NMC	RA VI / Prague	WE-VGISC Offenbach	CBS
Democratic People's Republic of Korea	State Hydrometeorological Administration	NMC	RA II / Pyongyang	TBD	CBS

Member / Organization	*Centre Name*	*GTS Function*	*Centre Location Region/City*	*Principal GISC*	*Constituent Body*
Democratic Republic of the Congo	Agence Nationale de Météorologie et de Télédétection par Satellite	NMC	RA I / Kinshasa	Casablanca	CBS
Denmark	Danish Meteorological Institute	NMC	RA VI / Copenhagen	TBD	CBS
Djibouti	Service de la Météorologie	NMC	RA I / Djibouti	Casablanca	CBS
Dominica	Dominica Meteorological Services	NMC	RA IV / Roseau	Washington	CBS
Dominican Republic	Oficina Nacional de Meteorologiá	NMC	RA IV / Santo Domingo	Washington	CBS
	Instituto Nacional de Recursos Hidráulicos (INDRHI)	NHS	RA IV / Santo Domingo	Washington	CHy
Ecuador	Instituto Nacional de Meteorología e Hidrología	NMC	RA III / Quito	Brasilia	CBS
Egypt	The Egyptian Meteorological Authority	NMC	RA I / Cairo	Casablanca	CBS
El Salvador	Servicio Nacional de Estudios Territoriales	NMC	RA IV / San Salvador	Washington	CBS
Eritrea	Civil Aviation Authority	NMC	RA I / Asmara	Casablanca	CBS
Estonia	Estonian Meteorological and Hydrological Institute	NMC	RA VI / Tallinn	TBD	CBS
Ethiopia	National Meteorological Services Agency	NMC	RA I / Addis Ababa	Casablanca	CBS
Fiji	Fiji Meteorological Service	NMC	RA V / Nadi	Melbourne	CBS
Finland	Finnish Meteorological Institute	NMC	RA VI / Helsinki	WE-VGISC Offenbach	CBS
France	Météo-France (Wallis and Futuna)	WSO (Wallis and Futuna)	RA V / Wallis and Futuna	WE-VGISC Toulouse	CBS
	Météo-France (Saint Pierre and Miquelon)	WSO (Saint Pierre and Miquelon)	RA IV / Saint Pierre and Miquelon	WE-VGISC Toulouse	CBS
	Météo-France (La Reunion)	WSO (Reunion)	RA I / La Reunion	WE-VGISC Toulouse	CBS
	Météo-France (Martinique)	WSO (Martinique)	RA IV / Martinique	WE-VGISC Toulouse	CBS
	Météo-France (Kerguelen Islands)	WSO (Kerguelen Islands)	RA V / Kerguelen	WE-VGISC Toulouse	CBS
	Météo-France (Guadeloupe, Saint Martin, Saint Barthélemy)	WSO (Guadeloupe, Saint Martin, Saint Barthélemy)	RA IV / Guadeloupe, Saint Martin, Saint Barthélemy	WE-VGISC Toulouse	CBS
	Météo-France (French Guiana)	WSO (French Guiana)	RA III / French Guiana	WE-VGISC Toulouse	CBS
	Météo-France (Clipperton)	WSO (Clipperton)	RA IV / Clipperton	WE-VGISC Toulouse	CBS
	Météo-France (Toulouse)	NMC	RA VI / Toulouse	WE-VGISC Toulouse	CBS
French Polynesia	Météo-France (Polynésie française)	NMC	RA V / Papeete	Melbourne	CBS
Gabon	Direction de la Météorologie Nationale	NMC	RA I / Libreville	Casablanca	CBS
Gambia	Department of Water Resources	NMC	RA I / Banjul	Casablanca	CBS
Georgia	Department of Hydrometeorology	NMC	RA VI / Tbilisi	TBD	CBS
Germany	Deutscher Wetterdienst	NMC	RA VI / Offenbach	WE-VGISC Offenbach	CBS
Ghana	Ghana Meteorological Services Department	NMC	RA I / Accra	Casablanca	CBS
Greece	Hellenic National Meteorological Service	NMC	RA VI / Athens	TBD	CBS

Member / Organization	*Centre Name*	*GTS Function*	*Centre Location Region/City*	*Principal GISC*	*Constituent Body*
Guatemala	Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología	NMC	RA IV / Guatemala	Washington	CBS
Guinea	Direction Nationale de la Météorologie	NMC	RA I / Conakry	Casablanca	CBS
Guinea-Bissau	Météorologie de Guinée-Bissau	NMC	RA I / Bissau	Casablanca	CBS
Guyana	Hydrometeorological Service	NMC	RA III / Georgetown	Brasilia	CBS
Haiti	Centre national de météorologie	NMC	RA IV / Port-au-Prince	Washington	CBS
Honduras	Servicio Meteorológico Nacional	NMC	RA IV / Tegucigalpa	Washington	CBS
Hong Kong, China	Hong Kong Observatory	NMC	RA II / Hong Kong	Beijing	CBS
Hungary	Meteorological Service of Hungary	NMC	RA VI / Budapest	WE-VGISC Offenbach	CBS
Iceland	Icelandic Meteorological Office	NMC	RA VI / Reykjavík	TBD	CBS
India	India Meteorological Department	NMC	RA II / New Delhi	New Delhi	CBS
Indonesia	Agency for Meteorology, Climatology and Geophysics	NMC	RA V / Jakarta	Melbourne	CBS
Iran, Islamic Republic of	Islamic Republic of Iran Meteorological Organization	NMC	RA II / Tehran	Tehran	CBS
Iraq	Iraqi Meteorological Organization	NMC	RA II / Baghdad	TBD	CBS
Ireland	Met Éireann	NMC	RA VI / Dublin	TBD	CBS
Israel	Israel Meteorological Service	NMC	RA VI / Tel Aviv	TBD	CBS
Italy	Servizio Meteorologico	NMC	RA VI / Rome	WE-VGISC Offenbach	CBS
Jamaica	Meteorological Service	NMC	RA IV / Kingston	Washington	CBS
Japan	Japan Meteorological Agency	NMC	RA II / Tokyo	Tokyo	CBS
Jordan	Jordan Meteorological Department	NMC	RA VI / Amman	TBD	CBS
Kazakhstan	Kazhydromet	NMC	RA II / Almaty	TBD	CBS
Kenya	Kenya Meteorological Department	NMC	RA I / Nairobi	WE-VGISC Offenbach	CBS
Kiribati	Kiribati Meteorological Service	NMC (Phoenix Islands)	RA V / South Tarawa	Melbourne	CBS
Kuwait	Department of Meteorology	NMC	RA II / Kuwait City	TBD	CBS
Kyrgyzstan	Main Hydrometeorological Administration	NMC	RA II / Bishkek	TBD	CBS
Lao People's Democratic Republic	Department of Meteorology and Hydrology	NMC	RA II / Vientiane	TBD	CBS
Latvia	Latvian Environment, Geology and Meteorology Agency	NMC	RA VI / Riga	WE-VGISC Offenbach	CBS
Lebanon	Service Météorologique	NMC	RA VI / Beirut	TBD	CBS
Lesotho	Lesotho Meteorological Services	NMC	RA I / Maseru	Pretoria	CBS
Liberia	Ministry of Transport	NMC	RA I / Monrovia	Casablanca	CBS
Libya	Libyan National Meteorological Centre	NMC	RA I / Tripoli	Casablanca	CBS
Lithuania	Lithuanian Hydrometeorological Service	NMC	RA VI / Vilnius	TBD	CBS

Member / Organization	*Centre Name*	*GTS Function*	*Centre Location Region/City*	*Principal GISC*	*Constituent Body*
Luxembourg	Administration de l'Aéroport de Luxembourg	NMC	RA VI / Luxembourg	TBD	CBS
Macao, China	Meteorological and Geophysical Bureau	WSO	RA II / Macau	TBD	CBS
Madagascar	Direction de la Météorologie et de l'Hydrologie	NMC	RA I / Antananarivo	Casablanca	CBS
Malawi	Malawi Meteorological Services	NMC	RA I / Lilongwe	Pretoria	CBS
Malaysia	Malaysian Meteorological Department	NMC	RA V / Kuala Lumpur	Melbourne	CBS
Maldives	Department of Meteorology	NMC	RA II / Male	TBD	CBS
Mali	Direction Nationale de la Météorologie du Mali	NMC	RA I / Bamako	Casablanca	CBS
Malta	Meteorological Office	NMC	RA VI / Valletta	TBD	CBS
Mauritania	Office National de Météorologie	NMC	RA I / Nouakchott	Casablanca	CBS
Mauritius	Mauritius Meteorological Services	NMC	RA I / Port Louis	Casablanca	CBS
Mexico	Servicio Meteorológico Nacional	NMC	RA IV / Mexico City	Washington	CBS
Micronesia, Federated States of	FSM Weather Station	N/A	RA V / Palikir	Melbourne	CBS
Monaco	Mission Permanente de la Principauté de Monaco	NMC	RA VI / Monaco	TBD	CBS
Mongolia	National Agency for Meteorology, Hydrology and Environment Monitoring	NMC	RA II / Ulaanbaatar	Beijing	CBS
Montenegro	Hydrometeorological Institute of Montenegro	NMC	RA VI / Podgorica	WE-VGISC Offenbach	CBS
Morocco	Direction de la Météorologie Nationale	NMC	RA I / Casablanca	Casablanca	CBS
Mozambique	Instituto Nacional de Meteorologia	NMC	RA I / Maputo	Pretoria	CBS
Myanmar	Department of Meteorology and Hydrology	NMC	RA II / Yangon	TBD	CBS
Namibia	Namibia Meteorological Service	NMC	RA I / Windhoek	Pretoria	CBS
Nepal	Department of Hydrology and Meteorology	NMC	RA II / Kathmandu	TBD	CBS
Netherlands	Royal Netherlands Meteorological Institute	NMC (includes European part of Netherlands, and Bonaire, Sint Eustatius, Saba)	RA VI / De Bilt	TBD	CBS
	Departamento Meteorologico Aruba	NMC	RA IV / Aruba	Washington	CBS
New Caledonia	Météo-France (Nouvelle-Calédonie)	NMC	RA V / Noumea	Melbourne	CBS
New Zealand	New Zealand National Meteorological Service (Tokelau)	NMC (Tokelau)	RA V / Tokelau	Melbourne	CBS
	New Zealand National Meteorological Service	NMC	RA V / Wellington	Melbourne	CBS
Nicaragua	Dirección General de Meteorología	NMC	RA IV / Managua	Washington	CBS
Niger	Direction de la Météorologie Nationale	NMC	RA I / Niamey	Casablanca	CBS
Nigeria	Nigerian Meteorological Agency	NMC	RA I / Lagos	Casablanca	CBS
Niue	Niue Meteorological Service	NMC	RA V / Alofi	Melbourne	CBS

Member / Organization	*Centre Name*	*GTS Function*	*Centre Location Region/City*	*Principal GISC*	*Constituent Body*
Norway	Norwegian Meteorological Institute	NMC	RA VI / Oslo	TBD	CBS
	Norwegian Meteorological Arctic Data Centre	Arctic Data Centre	RA VI / Oslo	TBD	CBS
Oman	Department of Meteorology	NMC	RA II / Muscat	TBD	CBS
Pakistan	Pakistan Meteorological Department (Karachi)	NMC	RA II / Karachi	Seoul	CBS
Panama	Hidrometeorología	NMC	RA IV / Panama City	Washington	CBS
Papua New Guinea	Papua New Guinea Meteorological Service	NMC	RA V / Port Moresby	Melbourne	CBS
Paraguay	Dirección de Meteorología e Hidrología	NMC	RA III / Asunción	Brasilia	CBS
Peru	Servicio Nacional de Meteorología e Hidrología	NMC	RA III / Lima	Brasilia	CBS
Philippines	Philippine Atmospheric Geophysical and Astronomical Services Administration	NMC	RA V / Manila	Melbourne	CBS
Poland	Institute of Meteorology and Water Management	NMC	RA VI / Warsaw	TBD	CBS
Portugal	Instituto de Meteorologia (Madeira)	NMC (Madeira)	RA I / Madeira	WE-VGISC Toulouse	CBS
	Instituto de Meteorologia	NMC	RA VI / Lisbon	TBD	CBS
Qatar	Qatar Meteorology Department	NMC	RA II / Doha	Jeddah	CBS
	Qatar Meteorology Department	Aviation Centre	RA II / Doha	Jeddah	CAeM
Republic of Korea	Korea Meteorological Administration	NMC	RA II / Seoul	Seoul	CBS
Republic of Moldova	Serviciul Hidrometeorologic de Stat Moldova	NMC	RA VI / Kishinev	Moscow	CBS
Romania	National Meteorological Administration	NMC	RA VI / Bucharest	WE-VGISC Offenbach	CBS
Russian Federation	Russian Federal Service for Hydrometeorology and Environmental Monitoring	NMC	RA VI / Moscow	Moscow	CBS
	Russian Federal Service for Hydrometeorology and Environmental Monitoring (Khabarovsk)	WSO Khabarovsk	RA II / Khabarovsk	Moscow	CBS
	Russian Federal Service for Hydrometeorology and Environmental Monitoring (Novosibirsk)	WSO Novosibirsk	Novosibirsk	Moscow	CBS
Rwanda	Rwanda Meteorological Service	NMC	RA I / Kigali	Casablanca	CBS
Saint Lucia	Saint Lucia Meteorological Service	NMC	RA IV / Castries	Washington	CBS
Samoa	Samoa Meteorology Division	NMC	RA V / Apia	Melbourne	CBS
Sao Tome and Principe	Institut National de Météorologie	NMC	RA I / Sao Tome	Casablanca	CBS
Saudi Arabia	Presidency of Meteorology and Environment	NMC	RA II / Jeddah	Jeddah	CBS
Senegal	Direction de la Météorologie Nationale	NMC	RA I / Dakar	Casablanca	CBS
Serbia	Republic Hydrometeorological Service of Serbia	NMC	RA VI / Belgrade	WE-VGISC Offenbach	CBS

Member / Organization	*Centre Name*	*GTS Function*	*Centre Location Region/City*	*Principal GISC*	*Constituent Body*
Seychelles	National Meteorological Services	NMC	RA I / Victoria	Casablanca	CBS
Sierra Leone	Meteorological Department	NMC	RA I / Freetown	Casablanca	CBS
Singapore	Meteorological Services Division	NMC	RA V / Singapore	Melbourne	CBS
Slovakia	Slovak Hydrometeorological Institute	NMC	RA VI / Bratislava	TBD	CBS
Slovenia	Meteorological Office	NMC	RA VI / Ljubljana	TBD	CBS
Solomon Islands	Solomon Islands Meteorological Service	NMC	RA V / Honiara	Melbourne	CBS
Somalia	Permanent Mission of Somalia	NMC	RA I / Mogadishu	Casablanca	CBS
South Africa	South African Weather Service	NMC	RA I / Pretoria	Pretoria	CBS
Spain	Agencia Estatal de Meteorología (Canary Islands)	NMC (Canary Islands)	RA I / Santa Cruz	Casablanca	CBS
	Agencia Estatal de Meteorología	NMC	RA VI / Madrid	TBD	CBS
Sri Lanka	Department of Meteorology	NMC	RA II / Colombo	TBD	CBS
Sudan	Sudan Meteorological Authority	NMC	RA I / Khartoum	Pretoria	CBS
Suriname	Meteorological Service	NMC	RA III / Paramaribo	Brasilia	CBS
Swaziland	Swaziland Meteorological Service	NMC	RA I / Manzini	Pretoria	CBS
Sweden	Swedish Meteorological and Hydrological Institute	NMC	RA VI / Norrköping	WE-VGISC Offenbach	CBS
Switzerland	MeteoSwiss	NMC	RA VI / Zurich	WE-VGISC Offenbach	CBS
Syrian Arab Republic	Ministry of Defence Meteorological Department	NMC	RA VI / Damascus	TBD	CBS
Tajikistan	Main Administration of Hydrometeorology and Monitoring of the Environment	NMC	RA II / Dushanbe	TBD	CBS
Thailand	Thai Meteorological Department	NMC	RA II / Bangkok	TBD	CBS
The former Yugoslav Republic of Macedonia	Republic Hydrometeorological Institute	NMC	RA VI / Skopje	WE-VGISC Offenbach	CBS
Timor-Leste	Direcção Nacional da Meteorologia e Geofísica	NMC	RA V / Dili	Melbourne	CBS
Togo	Direction de la Météorologie Nationale	NMC	RA I / Lomé	Casablanca	CBS
Tonga	Tonga Meteorological Service	NMC	RA V / Nuku'alofa	Melbourne	CBS
Trinidad and Tobago	Meteorological Service	NMC	RA IV / Port of Spain	Washington	CBS
Tunisia	National Institute of Meteorology	NMC	RA I / Tunis	Casablanca	CBS
Turkey	Turkish State Meteorological Service	NMC	RA VI / Ankara	TBD	CBS
Turkmenistan	Administration of Hydrometeorology	NMC	RA II / Ashgabat	TBD	CBS
Uganda	Department of Meteorology	NMC	RA I / Entebbe	Casablanca	CBS
Ukraine	Ukrainian Hydrometeorological Center	NMC	RA VI / Kiev	Moscow	CBS
United Arab Emirates	Meteorological Department	NMC	RA II / Abu Dhabi	TBD	CBS
United Kingdom of	Met Office (Saint Helena Island)	WSO (Saint Helena Island)	RA I / Jamestown	WE-VGISC Exeter	CBS

Member / Organization	*Centre Name*	*GTS Function*	*Centre Location Region/City*	*Principal GISC*	*Constituent Body*
Great Britain and Northern Ireland	Met Office (Pitcairn Islands)	WSO (Pitcairn Islands)	RA V / Adamstown	WE-VGISC Exeter	CBS
	Met Office (Gibraltar)	WSO (Gibraltar)	RA VI / Gibraltar	WE-VGISC Exeter	CBS
	Met Office (Bermuda)	WSO (Bermuda)	RA IV / Bermuda	WE-VGISC Exeter	CBS
	Met Office (Ascension Island)	WSO (Ascension Island)	RA I / Ascension	WE-VGISC Exeter	CBS
	Met Office (Exeter)	NMC	RA VI / Exeter	WE-VGISC Exeter	CBS
United Republic of Tanzania	Tanzania Meteorological Agency	NMC	RA I / Dar es Salaam	WE-VGISC Exeter	CBS
United States of America	National Oceanic and Atmospheric Administration, National Weather Service (Puerto Rico)	WSO (Puerto Rico)	RA IV / Puerto Rico	Washington	CBS
	National Oceanic and Atmospheric Administration, National Weather Service (Line Islands)	WSO (Line Islands)	RA V / Line Islands	Washington	CBS
	National Oceanic and Atmospheric Administration, National Weather Service (Guam)	WSO Guam	RA V / Guam	Washington	CBS
	National Oceanic and Atmospheric Administration, National Weather Service	NMC	RA IV / Silver Springs	Washington	CBS
Uruguay	Dirección Nacional de Meteorología	NMC	RA III / Montevideo	Brasilia	CBS
Uzbekistan	Uzhydromet	NMC	RA II / Tashkent	Seoul	CBS
Vanuatu	Vanuatu Meteorological Services	NMC	RA V / Port Vila	Melbourne	CBS
Venezuela, Bolivarian Republic of	Servicio de Meteorología de la Aviación	NMC	RA III / Maracay	Brasilia	CBS
Viet Nam	Hydrometeorological Service	NMC	RA II / Hanoi	TBD	CBS
Yemen	Yemen Meteorological Service	NMC	RA II / Sana'a	TBD	CBS
Zambia	Zambia Meteorological Department	NMC	RA I / Lusaka	Casablanca	CBS
Zimbabwe	Zimbabwe Meteorological Services Department	NMC	RA I / Harare	Pretoria	CBS

List of acronyms used in table b3
NMC National Meteorological Centre
WSO Weather Service Office
RA Regional Association

Recommendation 9 (CBS-15)

AMENDMENTS TO THE *MANUAL ON CODES* (WMO-No. 306), INTRODUCTION CHAPTER OF VOLUMES I.1 AND I.2

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) Resolution 45 (Cg-XVI) – Technical Regulations of the World Meteorological Organization,

(2) Resolution 1 (Cg-XVI) – World Weather Watch Programme for 2012–2015,

Considering:

(1) The requirements for the procedure to request amendments to the *Manual on Codes* (WMO-No. 306),

(2) The requirements for the procedure to validate proposed amendments to the Manual,

Recommends that the procedures for amending the Manual defined in the annex to the present recommendation be applied as from 1 July 2013;

Requests the Secretary-General to arrange for the inclusion of these amendments to the procedures in the introduction chapter of Volumes I.1 and I.2 of the *Manual on Codes*;

Authorizes the Secretary-General to make any consequent purely editorial amendments to the *Manual on Codes* – Introduction chapter of Volumes I.1 and I.2.

Annex to Recommendation 9 (CBS-15)

AMENDMENTS TO THE PROCEDURES FOR AMENDING THE *MANUAL ON CODES* (WMO-No. 306), VOLUMES I.1 AND I.2

[Editorial note: Meanings of marks below are as follows:

Text — No changes

Text — Addition or modification

~~Text~~ — Deletion or modification

Amend the articles 1.1 and 6.3 of the procedures as follows:

1.1 Proposal of amendments

Amendments to the *Manual on Codes* ~~must~~ shall be proposed in writing to the WMO Secretariat. The proposal shall specify the needs, purposes and requirements for the proposed amendment ~~and include information on a contact point for technical matters~~. A contact point for technical matters shall be identified to facilitate collaboration for validation and drafting recommendation.

6.3 Testing with encoder/decoder

For new or modified WMO code and data representation forms, proposed changes should be tested by at least two centres, using ~~the use of at least~~ two independently developed encoders and two independently developed decoders which incorporated the proposed change. Where the data originated from a necessarily unique source (for example, the data stream from an experimental satellite), the successful testing of a single encoder with at least two independent decoders would be considered adequate. Results should be made available to the IPET-DRC with a view to verifying the technical specifications.

Recommendation 10 (CBS-15)

AMENDMENTS TO THE *MANUAL ON THE GLOBAL TELECOMMUNICATION SYSTEM* (WMO-No. 386), VOLUME I, PART II

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The need for clarity on the centre from which data originate,

(2) That some centres convert data to Table Driven Code Forms representation on behalf of others to support the migration to Table Driven Code Forms,

Recommends that the procedures for defining the originating centres of bulletins on the Global Telecommunication System be clarified, with effect from 1 July 2013;

Requests the Secretary-General to arrange for the inclusion of these amendments to the procedures in Part II of Volume 1 of the *Manual on the Global Telecommunication* System (WMO-No. 386);

Authorizes the Secretary-General to make any consequent purely editorial amendments to the *Manual on the Global Telecommunication System,* Volume 1, Part II.

Annex to Recommendation 10 (CBS-15)

AMENDMENTS TO THE *MANUAL ON THE GLOBAL TELECOMMUNICATION SYSTEM* (WMO-No. 386), VOLUME I, PART II

Following the first paragraph at the top of page II-4:

“Once a bulletin has been originated or compiled, the CCCC must not be changed. If the contents of a bulletin is changed or recompiled for any reason, the CCCC should be changed to indicate the centre or station making the change.”

Insert the text:

When Traditional Alphanumeric Code (TAC) bulletins from one centre (NMHS1) are converted to Table Driven Code Form (TDCF) by another centre (NMHS2):

(a) The location indicator CCCC of NMHS1 (the producer of TAC bulletins) shall be used in the abbreviated headings of the converted bulletins;

(b) For each bulletin converted, the RTH responsible for NMHS1 shall ensure that the “remarks” column of Volume C1 of WMO Publication No. 9 – Catalogue of Meteorological Bulletins shows that the data are converted by NMHS2;

(c) In the case that NMHS1 and NMHS2 are in the zones of responsibility of two different RTHs, the RTH responsible for NMHS1 (the producer of TAC bulletins) shall send the required Advanced Notification form to the WMO Secretariat.

Recommendation 11 (CBS-15)

QUANTITATIVE MONITORING OF THE WMO INFORMATION SYSTEM

THE COMMISSION FOR BASIC SYSTEMS,

Noting that the WMO Information System (WIS) supports all WMO Programmes,

Noting further:

(1) That quantitative monitoring of the World Weather Watch has helped to identify and improve its performance,

(2) That a standard software tool has been used successfully by many Members to gather monitoring statistics for the Integrated World Weather Watch Monitoring (IWM),

(3) The confusion arising from use of different reporting practices for the Annual Global Monitoring and the IWM,

Considering the opportunity created by the introduction of the WIS,

Recommends that the *Manual on the WMO Information System* (WMO-No. 1060) be amended as given in the annex to the present recommendation, with effect from 1 October 2013;

Requests the Secretary-General to make the amendments, as given in the annex to the present recommendation, to the Manual;

Further requests the Secretary-General to update the *Guide to the WMO Information System* (WMO-No. 1061), as given in the annex to the present recommendation, consequent upon publication of the changes to the Manual;

Authorizes the president of the Commission, in consultation with the Secretary-General, to make any consequent purely editorial amendments to the *Manual on the WMO Information System* and the *Guide to the WMO Information System*.

Annex to Recommendation 11 (CBS-15)

AMENDMENTS TO THE *MANUAL ON THE WMO INFORMATION SYSTEM* (WMO-No. 1060) AND THE *GUIDE TO THE WMO INFORMATION SYSTEM* (WMO-No. 1061)

Typographic conventions used in the text:

~~Text that has been deleted from that in an existing translated document.~~

Text that has been added to that in an existing translated document.

AMENDMENTS TO THE *MANUAL ON THE WMO INFORMATION SYSTEM*

Modified paragraph

3.5.10.2. Monitoring of the collection and dissemination of WIS information (data and products) should include, as appropriate, ~~Integrated World Weather Watch Monitoring~~ WIS monitoring and monitoring related to WMO Programmes ~~other~~ ~~programme-related monitoring~~.

AMENDMENTS TO THE *GUIDE TO THE WMO INFORMATION SYSTEM*

Additional Section to be added

7. MONITORING OF THE WIS

7.1. Monitoring of the WIS is intended to improve the performance of the exchange of information by WMO Programmes and ensure the functions of WIS centres minimise the cost of operating WIS. It is also essential for planning and scaling of WIS components in order to meet changing user needs. It complements monitoring of the quality of the information being exchanged that is the responsibility of the Programmes sponsoring the information within WIS.

7.2. Management of the WIS needs three types of monitoring to answer four different questions:

(a) How do we exchange information?

(b) How much information do we exchange?

(c) How well do we meet the expected standards for information exchange?

(d) How does the performance of a WIS component affect the performance and cost effectiveness of WIS?

7.3. Network WIS Monitoring seeks to address the first question: how do we exchange information and is it performing cost effectively? It concentrates on determining the ability of the ICT systems underlying WIS to meet their performance targets. System managers of WIS centres will use this type of monitoring to identify problems in real time in addition to using analyses of the monitoring to report performance against Service Level Agreements. This will also identify weaknesses in WIS communication systems and detect changes in usage patterns for planning purposes. More details on the principles and practices of this type of monitoring are in the Plan for the Monitoring of Operation of the WIS.

7.4. Quantitative WIS monitoring seeks to address the second question: how much information do we exchange and is it exchanged as required? This type of monitoring compares the information available at WIS centres with the information that should be available. Managers of WMO Programmes will use this type of monitoring to verify that the information they need is being transferred by the WIS, and system managers of WIS centres will use the information to identify where there are issues with data flows that correspond to how WIS is being used, rather than because of underlying ICT infrastructure problems that are identified by Network WIS Monitoring. More details on the principles and practices of this type of monitoring are in the Plan for the Monitoring of Operation of the WIS.

7.5. Qualitative WIS monitoring seeks to address the third question: do we meet the expected standards for information exchange? It also addresses the fourth question about the effectiveness of WIS, but from a users subjective assessment, in particular, whether users are satisfied with the services and performance of WIS. This monitoring is primarily concerned with the quality of the representation of information that is being exchanged. Managers of WMO Programmes will use this type of monitoring to determine whether the processes used to create and discover the information are producing outputs that are of the expected standard. Details of this type of monitoring differ between information types and WMO Programmes, and the details of the principles and practices are described in the Manuals, Guides or Technical Documents of the WMO Programme responsible for the information content. WMO Programmes are responsible for monitoring the quality of the data and information being exchanged; this is not included in WIS Qualitative Monitoring.

Recommendation 12 (CBS-15)

ESTABLISHMENT OF THE SEVERE WEATHER FORECASTING DEVELOPMENT PROJECT OFFICE

THE COMMISSION FOR BASIC SYSTEMS,

Noting:

(1) The *Abridged Final Report with Resolutions of the Sixteenth World Meteorological Congress* (WMO-No. 1077), paragraphs 3.1.3.6 to 3.1.3.12,

(2) The *Abridged Final Report with Resolutions of the Sixty-fourth Session of the Executive Council* (WMO-No. 1092) paragraphs 4.3.6 to 4.3.9,

(3) The final report of the fourth meeting of the CBS Steering Group for the Severe Weather Forecasting Demonstration Project (Geneva, 28 February–2 March 2012), paragraphs 8.1.2 to 8.1.4,

Noting further:

(1) That the Sixteenth World Meteorological Congress approved a vision for the Severe Weather Forecasting Development Project (SWFDP) as an end-to-end, cross-programme collaborative activity led by the Global Data-processing and Forecasting System (GDPFS),

(2) That Sixteenth Congress requested the Commission for Basic Systems to continue to give high priority to the implementation of SWFDP and its expansion into all WMO Regions,

(3) That SWFDP has been either in implementation or in development in five regions (Southern Africa, South Pacific, Eastern Africa, South-East Asia and the Bay of Bengal), and in consideration in others (to be decided),

(4) The results of a study requested by the Steering Group for the Severe Weather Forecasting Demonstration Project to scope the resource requirements for ensuring effective implementation and long-term sustainability of the benefits gained with SWFDP, starting from an evaluation of the resources utilized by SWFDP thus far,

Considering:

(1) The significant increase of resources (both budgetary and human) required to ensure effective implementation of multiple, simultaneously running projects, including crucial regular training and coordination and support by the WMO Secretariat, and expansion of SWFDP to all WMO regional associations,

(2) That the expansion of SWFDP could only be realized with extrabudgetary contributions that have been provided either by Members or other organizations such as the World Bank and the United Nations Economic and Social Commission for Asia and the Pacific,

(3) That the WMO Resource Mobilization Office has been working with external partners in order to develop and sustain the appropriate extrabudgetary contributions in support of SWFDP, and that it has secured the necessary funds for the management and coordination of the regional SWFDP projects by the WMO Secretariat for at least the next three calendar years,

Considering also the request by the Executive Council at its sixty-fourth session to the Secretary-General and the Commission for Basic Systems to further develop these aspects in the strategy and planning of SWFDP, including possible options for supporting the effective and sustainable participation of global, regional and national centres in SWFDP, and the management and coordination of the regional projects, for consideration by the Executive Council at its sixty-fifth session,

Considering further:

(1) The need for dedicated human resources to coordinate and manage the WMO Secretariat support for regional SWFDP projects, including tracking their implementation,

(2) The need for pooling resources from the regular budget of different WMO Programmes, Voluntary Cooperation Programme accounts and external sources of funds,

Recommends:

(1) The establishment of a Severe Weather Forecasting Development Project Office, under the leadership of the GDPFS, in coordination with the Public Weather Services Programme, with the terms of reference provided in the annex to the present recommendation;

(2) The establishment of a Trust Fund for SWFDP;

Urges Members to continue to offer expert support to SWFDP, and to provide staff secondments and/or loans for enhancing the WMO Secretariat capacity;

Decides to re-establish the Steering Group for the Severe Weather Forecasting Development Project, chaired by the Chair of the Open Programme Area Group on Data-Processing and Forecasting System and comprising a Public Weather Services focal point, representatives of Global and Regional Centres, and representatives of other WMO Programmes as required, with the following terms of reference:

(1) Giving guidance and monitoring the further development of existing and new regional projects;

(2) Managing the integration of new components in SWFDP, including addressing synergies with other WMO Programmes;

(3) Developing recommendations to support the full and sustainable participation of National Meteorological and Hydrological Services, including those from least developed countries and small island developing States, in SWFDP;

Requests:

(1) The Secretary-General to make the appropriate arrangements for the establishment of:

(a) The SWFDP Office within the Secretariat, under the leadership of the GDPFS;

(b) The Trust Fund for the SWFDP;

(2) The Executive Council Working Group on Service Delivery to continue to guide the cross-programmatic integration in SWFDP, including engagement of users, addressing regional needs, and creating sustainable transitions to operations of SWFDP outcomes.

Annex to Recommendation 12 (CBS-15)

TERMS OF REFERENCE OF THE SEVERE WEATHER FORECASTING DEVELOPMENT PROJECT OFFICE

The Severe Weather Forecasting Development Project (SWFDP) Office should be established under the leadership of the Global Data-processing and Forecasting System (GDPFS), in collaboration with the Public Weather Services Programme, and with the cooperation of other relevant WMO Programmes (such as the Tropical Cyclone Programme, the WMO Satellite

Programme and the Education and Training Programme) and technical commissions. At least 1.5 professional and 0.5 administrative staff should be recruited for the SWFDP Office, to work in collaboration with the two full-time professional staff and one full-time administrative assistant provided from the WMO regular budget (2012–2015). The SWFDP Office should have the following functions:

(a) Work with the WMO Resource Mobilization Office to secure long-term sustainable funding, and to manage the effective use of funds so as to ensure the sustainability of regional projects;

(b) Assist where necessary the establishment of funding to enable the regional and global centres to transition their contributions from short-term demonstration to long-term sustainable services;

(c) Organize central training-of-trainers workshops to support the regions in providing up-to-date training;

(d) Plan and implement specific training and development activities in support of developing countries and least developed countries;

(e) Administer, manage and track the implementation of existing and the initiation of new regional projects, and provide such support as is required for regional projects to progress through to Phase 4 (the "Continuing Development Phase") including full transfer of the regional project management to the regional level;

(f) Provide technical support in developing regional and national SWFDP implementation plans;

(g) Manage and coordinate the cross-programme links of the SWFDP with other WMO Programmes and technical commissions;

(h) Provide technical support to, and facilitate the activities of, the Steering Group for the Severe Weather Forecasting Demonstration Project and the Regional Project Management Teams of each SWFDP region.

Recommendation 13 (CBS-15)

AMENDMENTS TO THE *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485)

THE COMMISSION FOR BASIC SYSTEMS,

Noting the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485),

Noting further:

(1) The *Abridged Final Report with Resolutions of the Sixteenth World Meteorological Congress* (WMO-No. 1077),

(2) The *Abridged Final Report with Resolutions of the Sixty-fourth Session of the Executive Council* (WMO-No. 1092),

(3) The final report of the meeting of the CBS Implementation Coordination Team on Data-processing and Forecasting System (Paris, 21–25 May 2012),

Considering:

(1) The need to include in the *Manual on the Global Data-processing and Forecasting System* new procedures for the designation of Centres related to Atmospheric Sandstorm and Duststorm Forecasts,

(2) The need to review in the Manual the standard verification of deterministic numerical weather prediction products,

(3) The need to include in the Manual the designation of Regional Climate Centres and Regional Climate Centre Networks,

Recommends that the amendments to the *Manual on the Global Data-processing and Forecasting System*, Volume I, Global Aspects, given in Annexes 1 to 3 to the present recommendation, be adopted for inclusion in the Manual, with effect from 1 July 2013;

Requests the Secretary-General to make the appropriate changes to the Manual, as given in Annexes 1 to 3 to the present recommendation;

Authorizes the president of the Commission for Basic Systems, in consultation with the Secretary-General, to make any consequential purely editorial amendments with respect to the *Manual on the Global Data-processing and Forecasting System*.

Annex 1 to Recommendation 13 (CBS-15)

PROPOSED AMENDMENTS TO THE *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485), VOLUME I, RELATED TO THE DEFINITION OF MANDATORY FUNCTIONS OF AND CRITERA TO BE RECOGNIZED AS A REGIONAL SPECIALIZED METEOROLOGICAL CENTRE FOR ATMOSPHERIC SANDSTORM AND DUSTSTORM FORECASTS

(Updates to the Manual are in shaded text and deleted parts are crossed out)

The proposed amendment to the *Manual on the GDPFS*, *Volume I*, relates to new procedures for the designation of Centres related to Atmospheric Sand and Dust storm Forecasts (ASDF): amendments to Part I, paragraph 4.1.2.2; Part I, Appendix I-1; Part II, paragraph 1.4.1.2; and new Appendix II-12.

PART I

4.1.2.2 *Centres with activity specialization*

The functions of RSMCs with activity specialization shall include, inter alia:

[...]

(c) Providing tailored specialized products to service users in a particular area, including atmospheric sand and dust storm forecasts;

(d) Providing trajectories and atmospheric transport modelling products, including backtracking, in case of environmental emergencies ~~or other incidents~~;

[...]

PART I, APPENDIX I-1

3. The RSMCs with activity specialization are the following:

[...]

RSMC European Centre for Medium-Range Weather Forecasts (RSMC ECMWF)

Provision of Atmospheric Sand and Dust storm Forecasts:
RSMC-ASDF Barcelona

Provision of atmospheric transport modelling (for environmental emergency response and/or backtracking):
[...]

PART II
1.4.1.2 *Regional Specialized Meteorological Centres (RSMCs) with activity specialization*
A Regional Specialized Meteorological Centre (RSMC) with activity specialization shall be designated, subject to the formal commitment by a Member or group of cooperating Members, to fulfil the required functions of the centre and meet the requirements for the provision of WWW products and services initiated and endorsed by the relevant WMO constituent body or bodies concerned. The centre should be capable of preparing independently or with the support of WMCs, and where appropriate, other GDPFS centres and disseminating to Members concerned:
[...]
(e) Atmospheric sand and dust storm forecasts in a particular geographical region;
NOTE: Centres producing regional atmospheric sand and dust storm forecasts and services, which are recognized as such by CBS following the guidance by CAS and at the request of the Regional Association(s) concerned, are called RSMC for Atmospheric Sand and Dust storm Forecasts (RSMC-ASDF). The definition and the list of designated RSMC-ASDF, mandatory functions of and criteria to be recognized as an RSMC-ASDF are given in Appendix II-12.
(~~e~~f) Regional LRF products, climate monitoring products, climate watches, drought monitoring products, climate data services, and tailored climate products.
[...]

APPENDIX II-12

DESIGNATION AND MANDATORY FUNCTIONS OF REGIONAL SPECIALIZED METEOROLOGICAL CENTRES WITH ACTIVITY SPECIALIZATION IN ATMOSPHERIC SAND AND DUST STORM FORECASTS

The mandatory function of the Regional Specialized Meteorological Centre(s) with activity specialization in Atmospheric Sand and Dust storm Forecasts (RSMC-ASDF) include creating, developing and maintaining a webportal to display forecast products as well as additional information, including a system to collect users' feedback. The goal is to provide guidance on the risk of sand and dust storm occurrence within an identified geographical domain of responsibility, and help the NMHSs concerned improve their warning services to the national authorities.

RSMC-ASDF are recognized as such by CBS following the guidance by CAS and at the request of the Regional Association(s) concerned, including for sensitive areas whose boundaries extend beyond or are outside those of a single Regional Association.

Designated RSMCs for the provision of Sand and Dust storm Forecasts, including their geographical region of responsibility, are:

RSMC-ASDF 'CITYNAME' (geographical area)

The RSMC-ASDF shall:

Real-time functions
– Prepare regional forecast fields using a dust forecast model continuously throughout the year on a daily basis. The model shall consist of a numerical weather prediction model incorporating on-line parameterizations of all the major phases of the atmospheric dust cycle.
– Generate forecasts, with an appropriate uncertainty information statement, of the following minimum 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 about 0.5x0.5 degrees.
- Disseminate through the GTS/WIS and provide on its Web portal the forecast products in pictorial form not later than 12 hours after the starting forecast time.
- Issue an explanatory note on the Web portal when operations are stopped due to technical problems.

Non-real-time functions

- Store the generated products in WMO GRIB format.
- Maintain the Web portal built to display forecast products as well as additional information.
- Perform seasonal and annual forecast evaluation based on available observational data.
- Issue annual activity reports.
- Support user training courses.
- Provide information on methodologies and product specifications and the guidance on their use.

Annex 2 to Recommendation 13 (CBS-15)

PROPOSED AMENDMENTS TO THE *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485), VOLUME I, RELATED TO STANDARD VERIFICATION PROCEDURES FOR DETERMINISTIC NUMERICAL WEATHER PREDICTION

(Updates to the Manual are in shaded text and deleted parts are crossed out)

The proposed amendment to the *Manual on the GDPFS*, *Volume I*, relates to the standard verification of deterministic NWP products: amendments to Part II, Attachment II.7, Table F.

I – STANDARDIZED VERIFICATION OF DETERMINISTIC NWP PRODUCTS

[...]

3. Parameters

Extra-tropics

Mandatory

- Mean sea-level pressure (verification against analysis only)
- [...]

[...]

6.2 Areas

[...]

Australia/New Zealand	10°S–55°S 90°E–180°E
Northern polar region	90°N – 60°N, inclusive, all longitudes
Southern polar region	90°S – 60°S, inclusive, all longitudes

Verification against analyses for grid points within each area, including points on the boundary.

7. Verification against observations

7.1 Observations

All parameters ~~listed~~ defined in section 3, except mean sea-level pressure, shall be verified against a common set of radiosondes. [...]

7.3 Areas

[...]

Australia/New Zealand	10°S–55°S 90°E–180°E
Northern polar region	90°N – 60°N, inclusive, all longitudes
Southern polar region	90°S – 60°S, inclusive, all longitudes

[…]

8. Scores

The following scores are to be calculated for all parameters against both analysis (except mean sea-level pressure) and observation.

Wind

Mandatory:

- rms vector wind error
- mean error of wind speed

Other parameters:

Mandatory

- [...]
- S1 score (only for MSLP and only against analysis)

Additional recommended

- mean absolute error
- rms forecast and analysis anomalies (not required for observations)
- standard deviation of forecast and analysis fields (not required for observations)

[…]

Annex 3 to Recommendation 13 (CBS-15)

PROPOSED AMENDMENTS TO THE *MANUAL ON THE GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM* (WMO-No. 485), VOLUMES I AND II, RELATED TO THE DESIGNATION OF REGIONAL CLIMATE CENTRES AND REGIONAL CLIMATE CENTRE NETWORKS

(Updates to the Manual are in shaded text and deleted parts are crossed out)

The proposed amendment to the *Manual on the GDPFS*, *Volumes I and II*, relates the designation of RCCs and RCC-Networks: amendments to Volume I, Part I, Appendix I-1 and Part II, Appendix II-10; Volume II, Region VI (Europe), Part I, new paragraph 4.6; and new Attachment IV.

VOLUME I, PART I, APPENDIX I-1

[...]

Regional Climate Centres providing regional long-range forecasts and other regional climate services:

RCC Beijing (RA II)
RCC Tokyo (RA II)
RCC Moscow (RA II[1])
RCC-Network (RA VI) AE De Bilt Node on Climate Data Services
Offenbach Node on Climate Monitoring
Toulouse and Moscow Node on Long-range Forecasting

VOLUME I, PART II, APPENDIX II-10

1. A multifunctional centre that fulfils all the required functions of an RCC for the entire region, or for a subregion to be defined by the regional association, may be designated by WMO as a WMO Regional Climate Centre (RCC). A group of centres performing climate-related activities that collectively fulfil all the required functions of an RCC may be designated by WMO as a WMO Regional Climate Centre Network (RCC-Network). ~~Each~~A centre(s) in a designated RCC-Network, that is charged with a specific function, will be referred to as a "node". The functions of a node may be shared among several partners. Each node can be supported by contributing centres that provide regional and/ or sub-regional products as agreed within their regional association.

[...]

3. Designated Regional Climate Centres and RCC-Networks are as follows:
RCC Beijing (RA II)
RCC Tokyo (RA II)
RCC Moscow (RA II)
RCC-Network (RA VI) AE De Bilt Node on Climate Data Services
Offenbach Node on Climate Monitoring
Toulouse and Moscow Node on Long-range Forecasting

VOLUME II, REGION VI, PART I, NEW PARAGRAPH 4.6

[...]

4.6 Regional Long-range Forecasting, Climate Monitoring, and Climate Data Services

The regional structure of the RA VI RCC-Network is given in Attachment IV.

NOTE: The list of mandatory functions of RCC-Networks can be found in Volume I, Part II, Appendix II-10.

VOLUME II, REGION VI, NEW ATTACHMENT IV

STRUCTURE OF THE RA VI RCC-NETWORK

RA VI RCC-Network consists of three nodes: (i) Climate Data Services led by KNMI, Netherlands; (ii) Climate Monitoring led by DWD, Germany; and (iii) Long-range Forecasting jointly led by Météo-France and ROSHYDROMET, Russian Federation. These lead centres have full responsibilities to satisfy the mandatory functions of RCC-Network, with the support of the following contributing NMHSs:

RA VI RCC node on Climate Data Services:

KNMI/ Netherlands (lead), Météo-France/France, OMSZ/Hungary, met.no/Norway, RHMS/Serbia, SMHI/ Sweden, TSMS/Turkey

[1] North Eurasian Climate Centre (NEACC).

RA VI RCC node on Climate Monitoring:

DWD/Germany (lead), Armstatehydromet/Armenia, Météo-France/France, KNMI/Netherlands, RHMS/Serbia, TSMS/Turkey

RA VI RCC node on Long-range Forecasting:

Météo-France/France and ROSHYDROMET/Russian Federation (joint lead), met.no/Norway, RHMS/Serbia, TSMS/Turkey.

Overall coordination:

The DWD/Germany is responsible for the overall coordination of the WMO RA VI RCC-Network.

ANNEXES

ANNEX I
Annex to paragraph 4.2.36 of the general summary

COMMISSION FOR BASIC SYSTEMS GUIDELINES FOR ENSURING USER READINESS FOR NEW GENERATION SATELLITES

In developing the guidelines for ensuring user readiness for new generation satellites, the Commission for Basic Systems noted the following:

(a) The essential importance of data from geostationary and low-earth orbiting satellites for operational activities of WMO Members;

(b) The planned introduction of several new generation satellite series by operators in the 2014–2018 timeframe, affecting all WMO Regions;

(c) The experience of extensive user preparedness projects undertaken by different satellite operators, e.g. the NOAA Proving Ground programme for GOES-R and JPSS missions, or the Prepare the Use of MSG in Africa (PUMA) project of EUMETSAT in RA I for Meteosat Second Generation;

(d) The Manual on GOS stipulating that, "*for smooth transition to new satellite capabilities, provisions should be made for appropriate preparation of the users through training, guidance to upgrade receiving equipment and processing software, and information and tools to facilitate the development and testing of applications*";[1]

(e) That the provisions of the Manual on the GOS are applicable to all satellite operators contributing to the Global Observing System;

(f) That optimal utilization of new operational satellite systems should be assured and the risk of disruption for operational users be mitigated.

All WMO Members and satellite operators should assist users in preparing them for using the new generation of operational satellites, through the following activities:

(a) Establishing and maintaining a dialogue between providers of the new generation satellites and prospective users, and raising awareness on new capabilities through user conferences, workshops and test beds;

(b) Maintaining portals for updated information on development status of the new systems, instrument and data format specifications, and technical documentation;

(c) User training, including the development of training material and training events, through the satellite provider–training centre partnerships established in the WMO-CGMS Virtual Laboratory, and other established mechanisms such as COMET, MetEd, and EUMETrain;

(d) Development of learning and decision-support tools, demonstrating the added value of new products;

(e) Provision of proxy datasets, tools, and products;

(f) Indication of the maturity status of products (operational, development, experimental);

(g) Guidance on the transition of receiving hardware;

[1] Manual on the GOS, Part IV: Space-based Subsystem, as updated in Recommendation 3 (CBS-15).

(h) Planning a parallel dissemination in old and new dissemination formats or protocols;

(i) Planning an appropriate overlap period between the operation of current and new satellites to allow intercomparison and validation of products, smooth migration of operational applications and downstream service delivery;

(j) Considering using multi-mission dissemination systems such as GEONETCast Systems, to allow for flexibility in accommodating new data streams, without the technical, financial, and schedule constraints related to setting up a receiving facility specific to the new satellite system;

(k) Establishment by each concerned NMHS or other operational user organization, of a user readiness project focused on the introduction of new satellite data streams into operations (to be initiated ~5 years prior to launch);

(l) Supporting user community-building through collaborative mechanisms, such as regular online briefings and social media.

ANNEX II
Annex to paragraph 4.2.46 and of the general summary

PROPOSED TOPICS FOR NUMERICAL WEATHER PREDICTION IMPACT STUDIES RELEVANT TO THE EVOLUTION OF GLOBAL OBSERVING SYSTEMS

A comprehensive proposal for OSEs and OSSEs of particular interest to ET-EGOS has been developed as part of the preparations for the fifth workshop on the Impact of Various Observing Systems on Numerical Weather Prediction. This new list of specific studies and science questions has been distributed widely as it formed part of the invitation to the workshop. The list is shown here in the table below.

Short name: Full name	*Science question*
Surface-based	
S1MarinePs: Surface pressure over ocean	What density of surface pressure observations over ocean is needed to complement high-density surface wind observations from satellites? Suggestions: (a) network density reduction OSE in N. Atlantic, (b) southern oceans OSSE.
S2Strat: In situ observations of the stratosphere	What network of in situ observations is needed in the stratosphere to complement current satellite observations (including radio occultation)? What about the tropics?
S3AMDAR: Coverage of AMDAR	What is the impact of current AMDAR observations? What are the priorities for expansion of the network?
S4ASAP: Coverage of ASAP	What is the impact of current coverage of profiles from the Automated Shipboard Aerological Programme (ASAP)? How might coverage be optimized for a given level of resources?

Short name: Full name	*Science question*
S5Radar: Radar observations	What are the impacts of current radar observations, including radial winds and reflectivities?
Space-based	
S6RO: Radio occultation saturation	At what level, in terms of profiles per day, does the impact of radio occultation observations start to saturate?
S7SatLand: Satellite radiances over land	What is the impact of new developments in the assimilation of radiance data over land?
S8Sounders: Impact of multiple satellite sounders	What benefits are found when data from more than one passive sounder are available from satellite in complementary orbits, e.g. multiple AMSU-As, AIRS + IASI?
S9AMVs: AMVs	What impacts are currently found from AMVs?
General	
S10Thinning: Data density and data thinning	What impacts/benefits are found from data density/thinning strategies from various observation types?
S11PBL: Observations of the PBL for regional / high-resolution NWP	What should be the focus of improvements for observations of the PBL in support of regional/high-resolution NWP? Which variables and what space-time resolution?
S12UA: EUCOS-like upper air OSEs	Can EUCOS-like upper air studies be performed for other regions?
S13AdjEns: Regional application and adjoint and ensemble methods	What insights can be gained from more tailored use of adjoint- and ensemble-based measures of observation impact, for example, in the tropics or at the mesoscale where metrics other than global energy may be appropriate?
S14ExtRange: Impact of observations on extended range forecasts	Which observations are particularly important for the 7–14 day forecast range?
S15Targeting: Targeted observations	What do experiments on targeted observations tell us about observing system design?
S16aAMMA, **S16bIPY**: AMMA and IPY legacy	What impacts/benefits could be expected by sustained components of the AMMA and IPY special observing systems?

ANNEX III
Annex to paragraph 4.2.50 of the general summary

REVISED TERMS OF REFERENCE OF THE COMMISSION FOR BASIC SYSTEMS LEAD CENTRES FOR THE GLOBAL CLIMATE OBSERVING SYSTEM

REVISED TERMS OF REFERENCE OF THE CBS LEAD CENTRES FOR GCOS

In support of the Global Framework for Climate Services, especially by improving quality and sustainability of climate data, the Lead Centres for GCOS will:

1. Diagnose problems in the Regional Basic Climatological Networks (RBCNs) and the Antarctic Observing Network (AntON), with the emphasis on the GSN and GUAN, by using the available monitoring reports, such as those produced by the GCOS Monitoring and Analysis Centers and major WMO NWP Centres;

2. Liaise with nominated National Focal Points for GCOS and related Climatological Data, and other responsible officials, to rectify identified problems so as to improve data and meta data availability and quality;

3. Coordinate activities with other GCOS Centers and/or other WMO Centres as appropriate;

4. ~~Monitor and r~~Report to CBS and GCOS on actions taken, progress achieved, concerns and recommendations on a yearly basis in a time frame that corresponds to planned AOPC and CBS meetings;

5. Assist AOPC in the ~~revisions~~design of GSN and GUAN and Regions in the design of RBCNs/AntON~~stations~~;

6. Assist the WMO Secretariat in maintaining the list of National Focal Points for GCOS and related Climatological Data.

Note: Additional text in red (underlined), deleted text in blue (strikeout)

AREAS OF RESPONSIBILITIES OF THE CBS LEAD CENTRES FOR GCOS

- **Morocco (RA I)** is responsible for ~~GSN and GUAN S~~ stations in: Algeria, Benin, Burkina Faso, Cameroon, Cape Verde, Central African Republic, Chad, Congo, Comoros Island, Côte d'Ivoire, Egypt, Gabon, Ghana, Gambia, Guinea, Guinea-Bissau, Guinea Equatorial, Liberia, Libya, Madagascar, Mali, Niger, Nigeria, Mauritania, Morocco, Senegal, Sierra Leone, Sao Tome and Principe, Sudan, Togo, Tunisia.

- **Mozambique (RA I)** is responsible for ~~GSN and GUAN S~~ stations in: Angola, Botswana, Burundi, Canary Islands, ~~Comoros Island,~~ Democratic Republic of the Congo, Djibouti, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, the Ocean Islands (Saint Helena Island, Ascension Island, Martin de Vivies, Iles Crozet, Iles Kerguelen), Rwanda, Seychelles, Somalia, South Africa, Swaziland, Uganda, United Republic of Tanzania, Zambia, Zimbabwe.

- **Islamic Republic of Iran (RA II and part of RA VI)** is responsible for ~~GSN and GUAN S~~ stations in: Afghanistan, Armenia, Azerbaijan, Bahrain, India, Islamic Republic of Iran, Jordan, Kazakhstan, Kyrgyzstan, Maldives, Nepal, Oman, Pakistan, Qatar, Russian Federation, Saudi Arabia, Sri Lanka, Syrian Arab Republic, Tajikistan, Turkey, United Arab Emirates, Yemen.

- **Japan (RA II)** is responsible for ~~GSN and GUAN S~~ stations in: Brunei Darussalam, Cambodia, China, Hong Kong, China, Japan, Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, Philippines, Republic of Korea, Singapore, Thailand, Viet Nam.

- **Chile (RA III)** is responsible for all ~~GSN and GUAN S~~ stations in RA III.

- **United States (RA IV)** is responsible for most ~~GSN and GUAN S~~ stations in RA IV plus Hawaii.

- **Australia (RA V)** is responsible for most stations in RA V, except those countries noted for Japan and Hawaii (United States).

- **Germany (RA VI)** is responsible for most stations in RA VI, except those countries noted for the Islamic Republic of Iran.

- **United Kingdom (British Antarctic Survey)** is responsible for ~~all GSN and GUAN~~ stations in Antarctica.

Note: Additional text in red (underlined), deleted text on blue (strikeout)

ANNEX IV
Annex to paragraph 4.3.15 of the general summary

TERMS OF REFERENCE FOR NATIONAL FOCAL POINTS FOR CODES AND DATA REPRESENTATION

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 responsibilities of the Focal Points are:

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

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

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

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

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

ANNEX V
Annex to paragraph 4.4.8 of the general summary

SUMMARY OF THE MAIN RESULTS OF THE STUDY ON RESOURSE REQUIREMENTS FOR ENSURING EFFECTIVE IMPLEMENTATION AND LONG-TERM SUSTAINABILITY OF THE BENEFITS GAINED WITH THE SEVERE WEATHER FORECASTING DEVELOPMENT PROJECT

A study was carried out to scope the resource requirements for ensuring effective implementation and long-term sustainability of the benefits gained with the SWFDP, which is available at ftp://ftp.wmo.int/Documents/PublicWeb/www/swfdp/. Main aspects identified by the study are summarized below:

(a) Since the initiation of the SWFDP in 2006, the Project continues to experience important benefits and significant growth, with 5 SWFDPs either in implementation or in development (i.e. from 5 countries in one regional association to presently 41 countries in three regional associations, with 29 that are LDCs/SIDSs), and others in consideration. No specific WMO Regular Budget was initially allocated to GDPFS for the coordination, management and implementation of the Project; however WMO surplus funds allowed the expansion of the first SWFDP in Southeast Africa to span 16 countries in Southern Africa, and to initiate a second Project in 2009. The initiation of the other 3 SWFDPs was only realized with extrabudgetary contributions that have been provided either by WMO Members through the VCP programme or by external organizations (such as the Word Bank and the UNESCAP);

(b) The support from advanced global centres that provide NWP/EPS and satellite-based products, and the roles played by the regional centres are critical components for the implementation of the SWFDPs, which consist of in-kind contributions by WMO Members;

(c) GDPFS has financially supported the SWFDP-related events, including training, while a number of WMO Programmes (e.g. ETR, PWS, TCP and SAT) have collaboratively provided limited funds to support expert participation at some of the SWFDP-related meetings;

(d) WMO staff assigned to GDPFS, in collaboration with PWS, has been involved with the coordination, management, tracking and implementation of the SWFDP and its 5 regional projects. In view of the limited resources available, in the short term, any new project initiation should be delayed until at least one of the existing sub-projects has reached Phase 4, i.e., continuing development phase, including full transfer of the project management to the regional level. The sustainable provision of the support to the existing and new sub-projects requires a dedicated Office;

(e) Noting the number of sources of funds which supports the SWFDP, a WMO Trust Fund for the SWFDP should be established to receive contributions from various sources of funding.

ANNEX VI
Annex to paragraph 4.5.3 of the general summary

PROVISION OF IMPACT-BASED INFORMATION, FORECASTS AND WARNING PRODUCTS AND SERVICES BY NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES

INTRODUCTION

The growing demand on NMHSs to provide impact-based forecast and warning products and services to assist the public and other users with decision making processes requires close collaboration with relevant partner agencies for formulating such information. Given that this is a relatively new area of work for most NMHSs, the following is offered as guidance to help them consider how they might apply this concept in their own Services.

Weather forecasts and warnings have traditionally been expressed in terms of changes in the atmospheric conditions. The responsibility of applying this information to their own context rested with users.

Increasingly, users demand that their weather service providers go beyond simple statements of expected weather conditions and to provide forecasts of the resulting impacts of such conditions. In order to respond to user requirements, weather forecasts and warnings should therefore be made available in impact-based formats tailored to user-defined thresholds. This ensures that critical weather information is communicated and expressed to users in terms of the societal impacts. This goes beyond describing the expected weather to include a translation of this information into how and when weather will affect the community, as described in the examples below. This information should be made available to the community in a variety of easy to understand formats.

In the case of hazardous weather, impact forecasting identifies areas and assets which are most vulnerable to the hazard, and allows prioritization of areas where responder services need to be deployed.

IMPACT-BASED FORECASTS

What are the essential differences between weather information and impact-based information? The nature of human activities and behaviour is such that the impact of a weather event will be different from time to time or from place to place. Impact forecasts attempt to capture the extra, non-weather-related variables which, when added to the weather, create the totality of impact. By putting these variables together with the weather, a message of greater simplicity and clarity can be created to enable people to take actions, which in case of hazardous weather will help mitigate the overall adverse effects of the weather.

We might express these concepts mathematically as follows:

Impact = Hazard * Vulnerability * Exposure

Where

Impact	=	Totality of impact (or risk, or effect) experienced
Hazard	=	Meteorological condition, which can vary with time
Vulnerability	=	The inherent sensitivity of the person or system to the hazard
Exposure	=	A time and space dependent variable which captures non-meteorological factors which affect the totality of the impact.

Take, for example, a severe convective rain event. The hazard, in meteorological terms, might be described as a 10% chance of rain exceeding 50 mm in one hour. If this event happens over an empty mountainous region, the impact may be almost zero, as the vulnerability is very low. If, however, it happens over a built-up, heavily populated area, the vulnerability is high, because of

the density of population and the nature of the environment (hard surfaces, fast run-off, etc.). Consider now the differences between the event happening on a weekend afternoon as against during morning rush-hour. The impacts will again be different, but because of other variables which are not related to weather.

Impact forecasts can translate weather variables into other factors which enable quicker and more focused decisions to be made by those who must manage the systems which are impacted. Examples might include:

Morning fog:	→	Flight delays
Low temperatures:	→	Surge in hospital admissions
Strong winds:	→	Wind energy outputs
Stormy seas:	→	Fish prices
Morning rain:	→	Commute times
Weekend sunshine:	→	Beach lifeguard provision

The need for this fundamental change in the delivery of hydrometeorological information is influenced by a number of factors:

(a) Significant population expansion is taking place in hydrometeorologically vulnerable areas, especially coastal regions. This increased vulnerability translates into increased potential impact. As a result, relevant information must be provided in terms that highlight risk to specific users, quickly delivered. Examples of threats for which such risk-based information is required include: flooding; extreme winds from tropical systems; and tsunami threats. The goal is for risk-based messages to contain necessary details regarding timing and also threshold levels for specific users and/or locations;

(b) Mobile devices are being increasingly employed to disseminate warnings and forecast information. Mobile devices are suited to short, simple and direct messages. These devices also enable the graphical representation of impact as colour-coded information and/or contour maps that depict varying levels of impacts from one geographic location to another. Examples of each of these types of information are provided in the next section;

(c) While the practice of different NMHSs in providing “advice” to the general public, based on the impact of the hazard varies according to their internal policies, there is a growing demand from government partners and the public to provide such advice where possible. Alternatively, some NMHSs use generalized slogans that they wish the public to associate with specific hazards, such as flooding or tornadoes. For example, the United States National Weather Service (NWS) uses the slogan “Turn Around – Don’t Drown” in advising the public not to drive through flooded roadways.

The remainder of this document contains examples of how impact-based information is delivered by a number of NMHSs and how, in some cases, additional advice is also issued for users.

I. EXAMPLES OF IMPACT-BASED INFORMATION

1. Individual NMHSs accomplish provision of impact-based information in a variety of ways. For example, the United States NWS and the Croatian Meteorological Service have made progress in clarifying impact-based information by placing such information directly within hazard messages. This ensures that the information goes beyond simply expressing the expected weather to an articulation of how the weather will impact the public and key partners. Examples of how these messages have evolved are provided in Table 1 via the columns indicated as *before – basic information only* and *after – impact included* messages provided. Table 2 shows the primary and secondary effects of a number of atmospheric phenomena.

Table 1. Examples of how the United States and Croatia have evolved hazard messaging to include impact-based information

Before – Basic Information Only	*After – Impact Information Included*
There is a 60 per cent chance of thunderstorms this afternoon	Thunderstorms between 2:00 and 4:00 p.m. will likely cause 30- to 60-minute flight delays
Thunderstorms will be in the response area this afternoon	Responders should shelter due to the possibility of lightning from 2:00 to 4:00 p.m.
Heavy snow with accumulations of 8 to 12 inches tonight	Interstate Highway 80 will likely become impassable after midnight due to heavy snowfall
Warning: sea state 4	Moderate sea, with waves reaching 1.25–2.5 metres of height, will likely present danger to smaller vessels (speed boats, excursion boats…)
Warning: gusts of Bora wind reaching over 100 km/h in Makarska region	It will likely cause interruption in the maritime traffic, especially the ferry line: Makarska-Sumartin (island Brač)
Warning: gusts of Bora wind reaching over 100 km/h in Dubrovnik region	It will likely cause interruption in road traffic on Dubrovnik Bridge and delays in air traffic as well as the impossibility of entering the port of Gruž for cruisers

Table 2. Example of interpreting weather conditions into resulting consequences: Met Office

Source	*Initial consequences*	*Knock-on consequences*
Storms and gales	Strong winds (gales) Tidal surge Snow Lightning Heavy rainfall Tornadoes Hail	River and costal flooding Surface water flooding Land instability Wildfire
Prolonged period of hot weather	Heat	Thunderstorms Drought Dust/Smog/haze Land instability Wildfire
Prolonged period of dry weather	Reduced rainfall	Dust/Smog/Haze/fog Reduced ground water flow Water quality Land instability Drought Wildfire
Excessive cold with snow	Cold snow	Ice Ice accretion Wind chill Fog Surface water and river flooding (snow melt)

2. Some NMHSs, such as the Australian Bureau of Meteorology and the United States National Weather Service utilize a categorical system for prioritizing hazards. These categories can (but need not necessarily) be based on variation in hydrometeorological parameters (such as increasing wind in the case of tropical cyclones) and clearly articulate expected impacts associated with each category.

Examples of the Australian categories for tropical cyclones and flooding can be found via the links below, respectively:

http://www.bom.gov.au/cyclone/about/intensity.shtml

http://www.bom.gov.au/hydro/flood/flooding.shtml

3. Similarly, the United States National Weather Service utilizes the Saffir–Simpson scale to categorize and convey the impacts of tropical systems based on increasing wind speed. The link below provides access to details regarding this scale:

http://www.nhc.noaa.gov/sshws.shtml

4. Another useful means of conveying expected impacts is via a colour-coded system. For example, the Hong Kong Observatory (HKO) uses a 3-level coded system which can be accessed through the link below to express how increasing rainfall will impact various members of the public, including school authorities, farmers, parents, employers and outdoor employees. Recommended action by these various user groups is clearly articulated in this manner.

http://www.weather.gov.hk/wservice/warning/rainstor.htm

5. Météo-France also combines impact and advice by using a colour-coded system via its *Vigilance* system, which can be accessed at the following link:

http://france.meteofrance.com/vigilance/Accueil

By clicking on areas of expected hazard, indicated by the yellow, orange or red colours, users can obtain useful impact information for specific areas of hazard. Examples of the types of information provided may include the following:

- *Road conditions may become very difficult all over the network, especially in forest areas where fallen wood may be an additional obstacle;*
- *Power and telephone networks may suffer damage for a significant duration;*
- *Significant flooding is likely at high tide near estuaries;*
- *Chimneys and roofing may suffer damage or destruction;*
- *Trees or branches are likely to break;*
- *Light structures may be blown down;*
- *Lightning may ignite some wildfires;*
- *Sewage networks may overflow.*

6. The European project Emma – METEOALARM provides weather warnings and impact-based information across all of Europe. These can be accessed via:

http://www.meteoalarm.eu

Details on this project are also contained in the PWS *Guidelines on International and Cross-border Collaboration in the Warning Process*, PWS-22, WMO/TD No. 1560, which describes efforts

underway to deliver weather information across country borders. This publication can be accessed via the following link:

http://www.wmo.int/pages/prog/amp/pwsp/documents/TD_1560_PWS22_en.pdf

7. Curaçao and Sint Maarten uses a colour-coded system to express expectation of weather hazards:

http://www.meteo.an/SpecialBulletin_SSS.asp

8. Effective cooperation between NMHSs and users as well as with partner agencies is an important precondition for improving impact-based information and warning services. Such cooperation may involve many areas such as sharing data with users and partner agencies, joint research and development on technical methods and standards, joint release of products, and establishing working mechanisms.

The China Meteorological Administration (CMA) and Ministry of Land and Resources singed a Framework Agreement in 2003 to jointly apply meteorological prediction and early warnings for mitigating impacts of geological hazards. Currently 30 meteorological offices at provincial (regional, municipal) level, 267 at prefecture level and 813 at county level are engaged in such operations in collaboration with local authorities on land and resources. These meteorological offices provide the public, governments at various levels and related partner agencies with prediction and early warning information about geological hazards via television, radio, SMS, Internet, electronic screen and grass root meteorological messengers. The cooperation modalities are as follows:

(a) Data sharing mechanism:
(i) Meteorological offices share 24-hour and 6-hour real-time rainfall data, 24-hour rainfall prediction data, 24-hour objective meteorological forecasting of geological hazard grade, rainfall prediction, and graphic files. (ii) local authorities on land and resources share prediction data of geological hazards of the day, and information about geological hazards of the month. (iii) Shared data are transmitted via FTP, with E-mail and fax as back-ups.

(b) Schedule for developing predictions and early warnings:
(i) During the flooding season (May 1–Sept. 30), the predictions and warnings are produced in the afternoon (15:30–17:30) for the spatial range and possibility of abrupt geological hazards such as landslides, mudslides and collapses triggered by rainfall in the upcoming 24 hours. In cases of heavy rainfall, meteorological offices will provide more frequent predictions and warnings as appropriate. (ii) During the non-flooding season if there are high-impact weather processes, CMA will contact Ministry of Land and Resources to jointly issue the prediction and warning information for geological hazards.

(c) Definition of the grades of warnings:
According to the protocol between the two departments, the meteorological forecasts and warnings for geological hazards are categorized into 5 grades: very unlikely, unlikely, slightly likely, likely and very likely.

(d) Consultation and discussion mechanism:
Forecasts are jointly released when the forecast and warning proposal made by CMA is accepted by the Ministry of Land and Resources. In the case that the two agencies have divergence on the areas and grades of the forecast or warning for a geological disaster, consultation and discussion will be carried out via telephone or videoconference to reach consensus between the two.

(e) Verification of warnings:
According to relevant technical and operational regulations, the two parties analyze and verify the effects of the warnings for geological hazards, and communicate and exchange their results and experiences. When necessary, the information on verified impacts of meteorological forecasts and warnings for geological disasters are released to the public in joint names of the two parties.

II. PROVISION OF ADVICE TO ACCOMPANY HAZARD MESSAGES

In addition to the weather and associated impacts, some NMHSs provide advice for users. Other NMHSs may not provide such advice depending on the nature of private/public partnership policies and the responsibilities of partner agencies, but they may offer additional information to the public and other key NMHSs' partners to provide value beyond the weather and impact information.

1. The Australian Bureau of Meteorology incorporates advice directly into weather hazard messages, per below:

Emergency Management Queensland advises that people should:

- *Move their car under cover or away from trees*;
- *Seek shelter, preferably indoors and never under trees*;
- *Beware of fallen trees and power lines; and,*
- *For emergency assistance dial 132500.*

2. The United States National Weather Service utilizes *Call to Action* statements in its warning messages, to provide recommended actions customized to individual hazard situations. An example from a winter storm situation follows:

If you must travel, exercise extreme caution and allow extra time to reach your destination. Let someone know your travel route and expected arrival time and have a working cell phone in case you become stranded. Keep a winter survival kit in your vehicle, including a flashlight, food, and water. If you chose to travel, be aware that you may become stranded and that it may take many hours for help to arrive.

3. Météo-France also provides advice on a variety of hazards. These can be accessed at the following web link:

http://france.meteofrance.com/html/vigilance/guideVigilance/consequence_conseil.html

Examples of advice provided includes:

- *Do not EVER walk or drive on a flooded road;*
- *If possible, stay at home, get organized with your neighbours, and listen to your local radio;*
- *Have a reserve of drinkable water and the means for emergency lighting;*
- *Power generators must not be operated indoors;*
- *Do not try and fix your roofing;*
- *Do not ever touch a fallen power line;*
- *Stay informed with your local authorities and be prepared to evacuate your home if such an order is given; and,*
- *Do not seek shelter under trees.*

4. The Met Office, United Kingdom, provides advice within its colour-coded system as shown at the following web link:

http://www.metoffice.gov.uk/weather/uk/advice/

The specific advice provided is designed to correspond with impact levels according to whether these impacts are high, medium or low.

5. Curaçao and Sint Maartin is currently developing a forecast system to enable dissemination of forecast and warning bulletins, which includes advice to the public, in three languages (English, Dutch and Papiamento). Examples of such bulletins follow:

- Heavy showers leading to local flooding are possible/likely over sections of the island(s). Residents are urged to avoid driving in flooded streets until the heavy rain has tapered off or ended and the flood waters have subsided;

- In case there are lightning strikes very close to your location (loud thunder, less than three seconds between lightning discharge and thunder), switch off and disconnect any sensitive electronic equipment. Also disconnect any phone line from your computer;

- A funnel cloud, reaching the ground was reported at (*time of occurrence*) on the islands of Sint Maarten/Saba/Sint Eustatius and was moving toward the west-northwest. It may move over the quarters of (*location 1*) and (*location 2*) at (*time of expected arrival*).

Residents in these areas are urged to take into account that strong to violent winds from varying directions are possible. These winds are capable of causing significant damage to constructions and severe injury to humans and animals. The public is strongly cautioned not to venture outside in case a funnel cloud is seen or heard. Instead, protection against injury must be found in a small room (bathroom) or below strong furniture, like a table.

6. The HKO provides advice to the public on the impacts of rainstorms via its *Rainstorm* Warning *System.* For example, when very heavy rain has fallen or is expected to fall generally over Hong Kong, China, and the amounts are expected to exceed 70 millimetres in an hour over a prolonged period, a *Black Rainstorm Warning* is issued and the following advice provided:

- Stay indoors or take shelter in a safe place until the heavy rain has passed;

- Employees working outdoors in exposed areas should stop work and take shelter;

- People having no safe place to go may take temporary refuge in any of the special temporary shelters opened by the Home Affairs Department;

- Employers are advised not to require their employees to go to work unless prior agreement on work arrangements during rainstorms has been made;

- People who are already at work should stay where they are unless it is dangerous to do so.

ANNEX VII
Annex to paragraph 5.1.2 of the general summary

TERMS OF REFERENCE FOR TEAMS AND RAPPORTEURS OF OPEN PROGRAMME AREA GROUPS

Open Programme Area Group on Integrated Observing Systems (OPAG-IOS)

TERMS OF REFERENCE OF THE 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 guidance from ICG-WIGOS and in coordination with other relevant WMO Programmes and TCs; 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 Rapporteurs and report on results to the Commission for Basic Systems;

(c) Monitor, report and make recommendations regarding the utilization of the composite observing systems under WIGOS and their capability to meet the requirements of all relevant WMO and co-sponsored programmes;

(d) Review deficiencies in coverage and performance of the existing GOS; make proposals to improve the availability of data to meet stated requirements; monitor and report on progress in the evolution of the GOS;

(e) Coordinate and consolidate the development of standardized high quality observing practices and prepare related recommendations;

(f) Assess the impacts of introducing new technology systems into the GOS on the status of regional observing networks, particularly those affecting the role of developing countries;

(g) Consider and report on the issues of costing, joint funding and management of the GOS;

(h) Contribute to strengthening the collaboration between CBS and the regional associations, by providing advice on possible solutions for newly identified requirements;

(i) Coordinate the work of the Steering Group on Radio-Frequency Coordination and report results, issues and provide recommendations regarding the work of this Group to the Commission for Basic Systems.

TERMS OF REFERENCE OF THE INTER-PROGRAMME EXPERT TEAM ON WIGOS FRAMEWORK IMPLEMENTATION MATTERS (IPET-WIFI)

(a) Address integration aspects of WIGOS as defined in the WIGOS Framework Implementation Plan;

(b) Provide technical advice, guidance, practices and procedures for WIGOS Framework Implementation; with priorities to be given to:

  (i) WIGOS Regulatory Material (such as WIGOS Manual, GOS Manual and Guide), in collaboration with the relevant WMO Programmes and TCs;

(ii) Standards for basic WIGOS metadata (e.g., those agreed for international exchange and for WIGOS Operational DB), including the access to WIGOS metadata;

(iii) WIGOS Quality Management Framework, including monitoring;

(iv) WIGOS Information Resource, i.e. WIGOS databases, web portal;

(v) In collaboration with CIMO, development of Guidance for WIGOS standards and best practices;

(vi) Capacity development, education and outreach strategy;

(c) At the outset the IPET WIFI is envisaged to encompass four sub-groups:

(i) Sub-group on Regulatory Material;

(ii) Sub-group on Metadata (expert to be proposed by CIMO);

(iii) Sub-group on QM;

(iv) Sub-group on Information resource.

TERMS OF REFERENCE OF THE INTER-PROGRAMME EXPERT TEAM ON OBSERVING SYSTEM DESIGN AND EVOLUTION (IPET-OSDE)

(a) Review and report on the observational data requirements of application areas[1] within the scope of WIGOS;

(b) 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;

(c) 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;

(d) 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;

(e) Carry out impact studies of real and hypothetical changes to observing systems with the assistance of NWP centres;

(f) Monitor and report progress against the new version of 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, including those of the observations and monitoring pillar of the GFCS;

(g) Promote activities which enhance progress against the Implementation Plan for Evolution of Global Observing Systems;

(h) Propose updates to the “Vision for the GOS in 2025”, in response to evolving user requirements and observing system capabilities;

(i) Propose guidance regarding observing system network design principles;

[1] WMO Application Areas include Global Numerical Weather Prediction (NWP), High Resolution NWP, Nowcasting and Very Short-Range Forecasting (NVSRF), Seasonal to Inter-Annual Climate Prediction (SIAF), Aeronautical Meteorology, Atmospheric Chemistry, Ocean Applications, Agricultural Meteorology, Hydrology and Water Resources, Climate monitoring (GCOS), Climate applications (other aspects, CCl), Space Weather, and GTOS (non GCOS requirements of GTOS).

(j) Prepare documents to assist Members, Technical Commissions, and Regional Associations, summarizing the results from the above activities;

(k) Provide advice and support to the Chair of OPAG-IOS on development and implementation of WIGOS.

TERMS OF REFERENCE OF THE EXPERT TEAM ON SURFACE-BASED OBSERVING SYSTEMS (ET-SBO)

(a) Contribute to the implementation of WIGOS by undertaking those tasks assigned to it by the OPAG IOS Chair from the WIGOS Framework Implementation Plan;

(b) Develop and update relevant elements of the Manual and the Guide to the GOS in the context of WIGOS, with initial priority on weather radar and AWSs;

(c) Monitor and assess the status of planned and operational surface-based observing systems and ensure this is adequately described in Volume A and metadata database(s) of Members' observing system capabilities;

(d) In collaboration with IPET-OSDE, assess the contribution of current and planned SBO systems to meeting user requirements for all Application Areas;

(e) Facilitate the delivery of those EGOS-IP actions identified as priorities for 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) Assess the potential contribution of new and emerging SBO technologies in meeting the Vision for the GOS in 2025, in collaboration with CIMO;

(h) Provide advice and support to the Chair of OPAG-IOS on the implementation of the WIGOS framework and its operational aspects.

TERMS OF REFERENCE OF THE EXPERT TEAM ON SATELLITE SYSTEMS (ET-SAT)

(a) Assist CBS in assessing the status of implementation of the space-based subsystem of WIGOS and the adequacy of implementation plans for meeting established requirements for satellite data and products;

(b) Provide technical advice with respect to both operational and R&D environmental satellites to assist in the implementation of integrated WMO-coordinated observing systems;

(c) Identify and assess opportunities and/or problem areas concerning satellite technology and plans of relevant satellite operators, and inform CBS timely and comprehensively through the ICT-IOS;

(d) Assess the prospects, plans and progress of R&D and demonstration satellite systems, technologies and mission with regard to their operational use or transition to operational service;

(e) Coordinate with other relevant CBS Teams on satellite related issues, programmes, systems and technologies;

(f) Coordinate with ET-SUP 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;

(g) Hold joint and/or overlapping meetings as appropriate with ET-SUP, to facilitate interaction between users and providers of satellite systems, data and products.

TERMS OF REFERENCE OF THE EXPERT TEAM ON SATELLITE UTILIZATION AND PRODUCTS (ET-SUP)

(a) 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;

(b) Provide advice and support to the development and implementation of WIGOS, from a satellite user's perspective and coordinate with ET-SAT and IPET-OSDE on the evolution of the space-based component of Global Observing Systems;

(c) 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 group(s), regional associations and with WIS activities;

(d) Review present and future R&D satellite data and products including their availability and potential applications, and provide advice with a view of increased utilization by WMO Members;

(e) 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;

(f) Promote development and harmonization of satellite data and products responding to WMO Members' needs;

(g) 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 2009–2013 Virtual Laboratory Training Strategy;

(h) Holding joint and/or overlapping meetings with ET-SAT as appropriate, to facilitate interaction between users and providers of satellite systems, data and products;

(i) 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.

TERMS OF REFERENCE OF THE EXPERT TEAM ON AIRCRAFT-BASED OBSERVING SYSTEMS (ET-ABO)

(a) Manage the programme for the aircraft observing system and the budget for the corresponding expenditure of the AMDAR Trust Fund in line with its ToR;

(b) Oversee the development and maintenance of the aircraft observations Quality Management System;

(c) Oversee the scientific and technical development and maintenance of the aircraft observing system;

(d) Oversee and assist in the enhancement and optimization of the aircraft observing system in line with the requirements of Members and the recommendations and actions of the EGOS-IP;

(e) Assist and provide support for training and outreach activities to support promotion and further development of the aircraft observing system;

(f) Provide advice and support to the Chair of OPAG-IOS on the implementation of the WIGOS framework and its operational aspects.

TERMS OF REFERENCE OF THE STEERING GROUP ON RADIO-FREQUENCY COORDINATION (SG-RFC)

(a) Keep under 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;

(b) 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;

(c) 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;

(d) Prepare and coordinate proposals and advice to WMO Members on radio regulation matters pertaining to meteorological activities with a view to ITU Radiocommunication Study Groups, Radiocommunication Assemblies (RA), World Radiocommunication Conferences (WRC) and related global and regional preparatory meetings;

(e) Facilitate the cooperation between 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 (e.g. meteorological aids and meteorological-satellite services (to provide compatibility between radiosondes and data collection platforms);

(f) 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);

(g) Assist WMO Members, upon request, in coordination of frequency assignments of radiocommunication systems sharing a frequency band with meteorological radiocommunication systems in the ITU;

(h) Increase the understanding of NMHS role 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, in particular GFCS, WIGOS and WIS.

TERMS OF REFERENCE OF THE RAPPORTEURS ON SCIENTIFIC EVALUATION OF IMPACT STUDIES (R-SEIS)

(a) 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 on IOS;

(b) Organize the Sixth Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction in 2016 and Chair the organizing committee;

(c) Provide input to the ICT-IOS and the IPET-OSDE regarding the evolution of the WIGOS observing system components;

(d) Provide advice and support to the Chair of OPAG on IOS on implementation of WIGOS.

TERMS OF REFERENCE OF THE RAPPORTEUR ON MARINE OBSERVING SYSTEMS (R-MAR)

(a) Collect information on the status of marine (i.e. marine meteorological and oceanographic) observations from the JCOMM approved sources;

(b) 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;

(c) Provide input to the Chair of OPAG-IOS and Chair of IPET-OSDE on issues related to the implementation of marine observing systems, and their contribution to WIGOS Implementation;

(d) Liaise with the RRR point of contact for Ocean Applications concerning user requirements and gap analysis;

(e) Keep abreast of developments in marine observing systems and advise on coordinated assessment and implementation developments.

Open Programme Area Group on Information Systems and Services (OPAG-ISS)

TERMS OF REFERENCE OF THE IMPLEMENTATION COORDINATION TEAM ON 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, including cross-cutting activities such as GFCS, WIS/WIGOS, THORPEX, DRR and GEOSS;

(d) Identify matters requiring the urgent 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;

(f) Provide guidance for the ISS teams on requirements and priorities for development of the WIS.

TERMS OF REFERENCE OF THE EXPERT TEAM ON TELECOMMUNICATIONS INFRASTRUCTURE (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 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) Review and amend as required the telecommunications components of the *Manual on WIS* (WMO-No 1060), the *Manual on the GTS* (WMO-No 386), their associated Guides and other guidance material;

(d) Provide guidance on the technical, operational, 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 and the Internet and co-ordinating cooperation with other organizations where appropriate to obtain operational benefits;

(e) 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;

(f) 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;

(g) 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;

(h) Advise the technical commissions on data communications issues, especially in respect of the WIS;

(i) Identify implementation issues requiring the urgent consideration of the OPAG on ISS.

TERMS OF REFERENCE OF THE 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 and criteria for interoperability, certification and Quality Management of WIS Centres;

(b) Operate the procedures for technical endorsement of WIS centres and advise CBS on centres' level of technical compliance with standards and procedures;

(c) Review and develop the *Manual on WIS* (WMO-No 1060), the *Guide to WIS* and associated informal guidance to better meet the needs of Members;

(d) Review, further develop and oversee 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;

(e) Review, develop and coordinate recommended practices and guidance on management of and access to operational information related to exchange of information through the WIS;

(f) Provide coordination and collaboration mechanisms for supporting the implementation and operation of WIS centres;

(g) Advise the technical commissions and partner organizations on roles, responsibilities and implementation of WIS Centres;

(h) Identify implementation and operational issues requiring the urgent consideration of the OPAG on ISS;

(i) Propose procedures for periodic assessment of the WIS centres, especially GISCs.

TERMS OF REFERENCE OF THE INTER-PROGRAMME EXPERT TEAM ON DATA REPRESENTATION MAINTENANCE AND MONITORING (IPET-DRMM)

(a) Review and further develop 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) 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;

(c) Review, develop and update the *Manual on Codes* (WMO-No 306) and associated reference and guidance material as required, and publish these in suitable electronic formats for human and automated use;

(d) 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;

(e) 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;

(f) Review and update the procedures used to maintain WMO data representations, taking into account opportunities presented by the WMO Logical Data Model;

(g) Monitor progress towards and coordinate actions to implement migration to Table Driven Codes Forms;

(h) Identify implementation issues requiring the urgent consideration of the OPAG on ISS.

TERMS OF REFERENCE OF THE INTER-PROGRAMME EXPERT TEAM ON METADATA AND DATA REPRESENTATION DEVELOPMENT (IPET-MDRD)

(a) Review and further develop the WMO Core Metadata Profile, WMO Logical Data Model ("METCE", Modèle pour l'Échange des informations sur le Temps, le Climat et l'Eau), and WMO standards for metadata and data exchange based on the ISO 19100 series of international standards (including XML) 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 *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;

(c) Review and update the procedures for maintaining and developing the WMO Core Metadata Profile, WMO Logical Data Model ("METCE") and WMO standards for metadata and data exchange based on the ISO 19100 series of international standards;

(d) Propose to ISO and OGC changes to their respective standards that are required to meet the needs of WMO Members;

(e) Advise Members, technical commissions and ICG-WIGOS on WMO Discovery Metadata, the WMO Logical Data Model ("METCE") and associated application schema and data interoperability issues;

(f) Identify implementation issues requiring the urgent consideration of the OPAG on ISS.

Open Programme Area Group on Data-Processing and Forecasting System (OPAG-DPFS)

TERMS OF REFERENCE OF THE 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 (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.

TERMS OF REFERENCE OF THE EXPERT TEAM ON OPERATIONAL WEATHER FORECASTING PROCESS AND SUPPORT (ET-OWFPS)

(a) Review the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485) to ensure that procedures for forecasting systems and verification are adequate and meet CBS needs; propose updates as necessary;

(b) Review GDPFS and Lead Centres' activities, support their developments and provide guidance as stated in the Manual;

(c) Assess applications for GDPFS Centres' status against the designation criteria and make recommendations on designation to CBS;

(d) Liaise with relevant WMO Programmes, Technical Commissions and international organizations as required to advise on requirements for practical implementations in operational systems;

(e) Review new developments and advances in NWP and related systems, particularly with regard to severe and high impact weather forecasting;

(f) Provide advice to NMHSs on NWP products, including EPS, for all forecast ranges, particularly with regard to severe and high impact weather forecasting;

(g) Liaise with the PWS programme to promote and support the use and communication of NWP, especially probabilistic, information available from the GDPFS Centres; develop interpretation guidance to facilitate their use, and encourage feedback on usefulness and application;

(h) Promote and support the education and training of forecasters on the use and interpretation of NWP products, including EPS, and their strengths and weaknesses;

(i) Provide guidance on capacity-building concerning the implementation of operational NWP systems, including verification systems, and/or the use of NWP products.

TERMS OF REFERENCE OF THE JOINT CBS-CCL EXPERT TEAM ON OPERATIONAL PREDICTIONS FROM SUB-SEASONAL TO LONGER-TIME SCALES (ET-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 and coordination of components in the production of Long-range Forecasts (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) In coordination with CCl, 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) 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;

(d) In consultation with relevant experts in CAS and CCI and with the ET-OWFPS, review developments in verification scores and practices with a view to updating the Standardized Verification System for Long-range Forecasts (SVSLRF);

(e) Assess applications for GPC status against the designation criteria and make recommendations on designation to CBS;

(f) Review the rules regarding user access to GPC and LC-LRFMME forecasts products;

(g) Review the status of sub-seasonal forecasting activities, and promote the availability and exchange of sub-seasonal forecasts and verification products;

(h) 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 CCI;

(i) Review the *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485) and propose updates as necessary concerning sub-seasonal and long-range forecasts.

The Expert Team shall comprise representatives from CBS and CCI to facilitate the necessary interactions and data flows between components of the CSIS. Team membership shall comprise representatives from GPCs and two CCI experts, one of which shall be the co-chair of CCI OPACE-3. In order to retain the existing focus on operational aspects, this team will report and propose amendments to the procedures and guidelines in the GDPFS to CBS through the ICT-DPFS. Reporting to the CCI management group will be through the co-chair of OPACE-3.

TERMS OF REFERENCE OF THE 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 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 the focal point of and liaise with relevant international organizations to advise on requirements for practical implementations in operational systems relevant to ERA;

(d) Identify and promote technical resources which can assist NMHSs in developing their ERA capabilities for supporting national agencies in their preparedness, planning, response and recovering activities;

(e) Review RSMC Environmental ERA's activities for various sources such as volcanic eruptions, dust storms, large fires, and nuclear and biological incidents, and provide guidance as stated in the Manual;

(f) 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;

(g) Explore the availability of atmospheric ash, dust, chemical, biological and radiological monitoring data and etc. for use in the RSMC operational environment.

Open Programme Area Group on Public Weather Services (OPAG-PWS)

TERMS OF REFERENCE OF THE IMPLEMENTATION COORDINATION TEAM ON PUBLIC WEATHER SERVICES (ICT-PWS)

(a) Coordinate the implementation of Congress, the Executive Council and the Commission for Basic Systems (CBS) decisions with respect to Public Weather Services, especially those relating to "The WMO Strategy on Service Delivery";

(b) Keep under review the work of the PWS Expert Teams and coordinate and guide their work programmes;

(c) Consult and collaborate to ensure coordination of the work of the Open Programme Area Group (OPAG) on PWS with that of other CBS OPAGs, Technical Commissions (TCs), EC Working Groups, Regional Associations (RAs) and WMO Programmes and initiatives;

(d) Continue to encourage stronger dialogue between National Meteorological and Hydrological Services (NMHSs) and development partners and users (e.g., media, health, emergency management) in areas relevant to PWS;

(e) Continue to encourage and provide guidance to Members to assert the authority of NMHSs as the sole providers of official high-impact weather warnings;

(f) Evaluate and report on the effectiveness of the information and guidance material produced by the PWS Programme, and the demonstration projects and other WMO initiatives to which the Programme contributes, in building the capacity of NMHSs;

(g) Develop and keep under review a competency framework appropriate to PWS forecasting and related activities;

(h) Collaborate with development partners and other WMO entities to assist NMHSs in the identification and assessment of societal, economic and environmental impacts and benefits of hydrometeorological services;

(i) Provide guidance to NMHSs in the provision of enhanced hydrometeorological support for major cultural and sporting events;

(j) Continue to promote awareness in the WMO community of material arising from the work of the OPAG.

TERMS OF REFERENCE OF THE EXPERT TEAM ON SERVICES AND PRODUCTS INNOVATION AND IMPROVEMENT (ET-SPII)

(a) Monitor and report on the progress of recent ET-SPII initiatives;

(b) In collaboration with other CBS OPAGs and other WMO Technical Commissions, contribute to the implementation of the WMO Strategy for Service Delivery through:

  (i) Reporting and advising on how to best assist Members, especially developing countries, with building an integrated approach to PWS products and services to improve their service delivery;

  (ii) Keep under review the needs for new and improved products and services with emphasis on key PWS user groups;

  (iii) Advise on the development, application and communication of probabilistic forecasts;

(iv) Continue to encourage the use of verification for PWS with an emphasis on user oriented methods;

(c) Review and advise on the implications of the service delivery strategy for the future role of the forecaster;

(d) Advise on and keep under review the development of World Weather Information Service (WWIS) and Severe Weather Information Centre (SWIC) Websites.

TERMS OF REFERENCE OF THE EXPERT TEAM ON MEETING USER NEEDS IN REDUCING THE IMPACTS OF HYDROMETEOROLOGICAL HAZARDS (ET-DPM)

(a) Monitor and report on the progress of recent initiatives of the Expert Team;

(b) Develop a template for an agreement document for fostering collaboration and partnership between National Meteorological and Hydrological Services (NMHSs) and respective national Disaster Management Authorities (DMA) organizations;

(c) Provide guidance to NMHSs on how to develop impact-based information, forecast, and warning services on various timescales for Weather, Climate and Water (WCW) hazards;

(d) Keep under review the development of cross-border exchange of warnings with reference to the published WMO Guidelines;

(e) Monitor and survey the usefulness of the work of the Expert Team in assisting NMHSs to deliver improved products and services in reducing impact of WCW hazards;

(f) Engage other WMO Programmes, PWS Expert Teams, CBS OPAGs and Technical Commissions (TCs) to determine common areas of interest and possible collaboration;

(g) Assist NMHSs with the definition and development of work force competencies needed to effectively interact with the user community in the context of reducing impact of WCW hazards;

(h) Develop and maintain a list of experts in PWS aspects of reducing impact of WCW hazards who are willing to contribute to PWS training and development activities;

(i) Report to and make recommendations, as appropriate, to the ICT-PWS.

TERMS OF REFERENCE OF THE EXPERT TEAM ON COMMUNICATION, OUTREACH AND PUBLIC EDUCATION ASPECTS OF PUBLIC WEATHER SERVICES DELIVERY (ET-COPE)

(a) Examine, report and advise on how best to measure the needs of users regarding communication, public education and outreach aspects of PWS delivery;

(b) Identify ways to meet the needs of NMHSs in their communication, outreach and public education relating to PWS delivery, with a view to ensuring more effective use of PWS and enhancing the usefulness of new products and services;

(c) Examine, report and recommend how best to foster partnerships with national and international media organizations, and of assisting NMHSs to improve relations with the media;

(d) Examine, report and advise on the application to PWS delivery of new developments in communication, public education and outreach;

(e) Promote awareness of the benefits to the image, visibility and attribution of NMHSs through effective delivery of high-quality and well-communicated public weather services;

(f) Monitor, report and advise on communication, outreach and public education aspects of service delivery that relate to other WMO activities, Programmes and priority areas, including collaboration with other PWS Expert Teams, CBS OPAGs, WMO Technical Commissions (TCs) and Regional Associations (RAs);

(g) Monitor and report on the progress and effectiveness of earlier initiatives of ET-COPE and make recommendations as appropriate to the ICT-PWS.

ANNEX VIII
Annex to paragraph 5.1.3 of the general summary

DESIGNATION OF CHAIRS, CO-CHAIRS, RAPPORTEURS AND COMMISSION FOR BASIC SYSTEMS REPRESENTATIVES

The Commission designated the following chairs, co-chairs and rapporteurs for its expert teams.

OPAG-IOS

Implementation Coordination Team

Chair: L.P. Riishojgaard (United States)

Co-Chair: J. Dibbern (Germany)

Inter-Programme Expert Team on WIGOS Framework Implementation Matters

Chair: J. Dibbern (Germany)

Co-Chair: R. Stringer (Australia)

Inter-Programme Expert Team on Observing System Design and Evolution

Chair: J. Eyre (United Kingdom)

Co-Chair: J. Lawrimore (United States)

Expert Team on Surface-Based Observing Systems

Chair: S. Goldstraw (United Kingdom)

Co-Chair: H.N. Karanja (Kenya)

Expert Team on Satellite Systems

Chair: To be selected by Space Agencies

Co-Chair: J. Yang (China)

Expert Team on Satellite Utilization and Products

Chair: A. Rea (Australia)

Co-Chair: T. Mostek (United States)

Expert Team on Aircraft-Based Observing Systems

Chair: F. Grooters (Netherlands)

Co-Chair: G. Fournier (Canada)

Steering Group on Radio-Frequency Coordination

Chair: J. De Sausa Brito (Brazil)

Co-Chair: G. Fournier (Canada)

Rapporteurs on Scientific Evaluation of Impact Studies

Rapporteur: E. Anderson (ECMWF)

Rapporteur: Y. Sato (Japan)

Rapporteur on Marine Observing Systems

Rapporteur: C. Clark (United States)

OPAG-ISS

Implementation Coordination Team

Chair: M. dell'Acqua (France)

Co-Chair: K. Tsunoda (Japan)

Expert Team on Telecommunications Infrastructure

Chair: R. Giraud (ECMWF)

Co-Chair: I. Glaser (Germany)

Expert Team on WIS Centres

Chair: X. Li (China)

Co-Chair: M. Heene (Germany)

Co-Chair: A. Kellie (United States)

Inter-Programme Expert Team on Data Representation Maintenance and Monitoring

Chair: S. Elliot (EUMETSAT)

Co-Chair: J. Hasegawa (Japan)

Co-Chair: J.M. de Rezende (Brazil)

Inter-Programme Expert Team on Metadata and Data Representation Development

Chair: J. Tandy (United Kingdom)

Co-Chair: E. Toyoda (Japan)

OPAG-DFPS

Implementation Coordination Team

Chair: K. Mylne (United Kingdom)

Co-Chair: Y. Honda (Japan)

Expert Team on Operational Weather Forecasting Process and Support

Chair: D. Richardson (ECMWF)

Co-Chair: H. Kabelwa (United Republic of Tanzania)

Co-Chair: J. Wang (China)

Expert Team on Operational Predictions from Sub-Seasonal to Longer-time Scales

Chair: R. Graham (United Kingdom)

Co-Chair: C. Coelho (Brazil)

Expert Team on Emergency Response Activities

Chair: R. Servranckx (Canada)

Co-Chair: J. Fraser (Australia)

OPAG-PWS

Implementation Coordination Team

Chair: G. Fleming (Ireland)

Co-Chair: M. Jiao (China)

Expert Team on Services and Products Innovation and Improvement

Chair: J. Guiney (United States)

Co-Chair: T. Xu (China)

Expert Team on Meeting User Needs in Reducing the Impacts of Hydrometeorological Hazards

Chair: J. Davidson (Australia)

Co-Chair: L.S. Lee (Hong Kong, China)

Expert Team on Communication, Outreach and Public Education Aspects of Public Weather Services Delivery

Chair: J. Gill (Australia)

Co-Chair: C. Martin (Canada)

ANNEX IX
Annex to paragraph 6.1 of the general summary

REVIEW OF PREVIOUS RESOLUTIONS AND RECOMMENDATIONS OF THE COMMISSION THAT REMAIN IN FORCE

A. Resolutions of CBS

Resolution	*Title*	*Comments and action proposed*
Res. 2 CBS-Ext.(98)	Working Structure of the Commission for Basic Systems	Replace with new Resolution 8 (CBS-15)
Res. 1 CBS-XII	Working Structure of the Commission	Replace with new Resolution 8 (CBS-15)
Res. 1 CBS-Ext.(06)	Participation of women in the work of the Commission	To be kept in force
Res. 1 CBS-XIV	CBS Management Group	Replace with new Resolution 8 (CBS-15)
Res. 2 CBS-XIV	Open Area Programme Groups	Replace with new Resolution 7 (CBS-15)

B. Recommendations of CBS

Recommendation	*Title*	*Comments and action proposed*
Rec. 1 CBS-XIV	Vision for the GOS in 2025	To be kept in force
Rec. 4 CBS-XIV	Revised list of CBS lead centres for GCOS, including their area of responsibility and their terms of reference	To be kept in force
Rec. 10 CBS-XIV	WMO Space Programme	To be kept in force
Rec. 1 CBS-Ext.(10)	Amendments to the *Manual on Codes* (WMO-No. 306), Introduction Chapter of Volumes I.1 and I.2	Not to be kept in force (implemented)
Rec. 2 CBS-Ext.(10)	Amendments to the *Manual on Codes* (WMO-No. 306), Volume I.1	Not to be kept in force (implemented)
Rec. 3 CBS-Ext.(10)	Amendments to the *Manual on the Global Telecommunication System* (WMO-No. 386), Volume I, Part II	Not to be kept in force (implemented)
Rec. 4 CBS-Ext.(10)	Designation of Centres of the WMO Information System	Not to be kept in force (implemented)
Rec. 5 CBS-Ext.(10)	Amendments to the *Technical Regulations* (WMO-No. 49), Volume I, Section A.3	Not to be kept in force (implemented)
Rec. 6 CBS-Ext.(10)	The *Manual on the WMO Information System* (WMO-No. 1060)	Not to be kept in force (implemented)
Rec. 7 CBS-Ext.(10)	Amendments to the *Manual on the Global Data-Processing and Forecasting System* (WMO-No. 485)	Not to be kept in force (implemented)
Rec. 8 CBS-Ext(10)	Terms of Reference of the Commission for Basic Systems	Not to be kept in force (implemented)
Rec. 9 CBS-Ext.(10)	Review of resolutions of the Executive Council based on previous recommendations of the Commission for Basic Systems or concerning the Commission	Not to be kept in force

ANNEX X
Annex to paragraph 6.2 of the general summary

REVIEW OF EXECUTIVE COUNCIL RESOLUTIONS OF CONCERN TO THE COMMISSION FOR BASIC SYSTEMS

Actions for Revision of Resolutions of the Executive Council Concerning the Commission for Basic Systems

Resolution	*Title*	*Comments and action proposed*
Res. 4 EC-LXI	Establishment of Regional Climate Centres	To be kept in force
Res. 7 EC-LXI	Report of the fourteenth session of the Commission for Basic Systems relevant to the WMO Information System	Not to be kept in force (the changes are now incorporated in Regulatory Materials)
Res. 8 EC-LXII	Amendment to the *Manual on the Global Data Processing and Forecasting System* (WMO-No. 485)	Not to be kept in force (the changes are now incorporated in Regulatory Materials)
Res. 12 EC-LXII	Schedule of Consultative Meetings on High-Level Policy on Satellite Matters	To be kept in force
Res. 4 EC-LXIII	Inter-Commission Co-ordination Group on the WMO Integrated Global Observing System	To be kept in force

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ANNEX XI
Annex to paragraph 8.1 of the general summary

REPORT ON THE TECHNICAL CONFERENCE

1. INTRODUCTION

A Technical Conference on **Implementation of WIGOS and Valuing Systems and Services** was organized in conjunction with CBS-15 in Jakarta, 12–13 September 2012.

2. STRUCTURE OF TECO

The TECO was chaired by the Vice President of CBS, joined by the President of CIMO as co-chair for Part 1 and by the CBS DRR Coordinator as co-chair for Part 2. It comprised presentations from representatives from across CBS and invited guests, as well as panel discussions.

The TECO was organized in two main parts, as elaborated below. As an extension to the technical discussions, some short daily ‘focus sessions’ were held to address topical issues across each of the OPAGs.

3. TECO PART 1: “UNDERSTANDING AND USING THE WIGOS IMPLEMENTATION PLAN”

This TECO session (Wednesday, 12 September, pm) focused primarily on WIGOS implementation and aimed to develop a better understanding of what will be required to implement WIGOS at both Member and regional levels, as well as through CBS and the ICG-WIGOS.

3.1 Outline of TECO Part 1

The list of speakers and topics for TECO Part 1 is in Table 1 of this Annex and the presentations can be viewed on the CBS-15 website. In summary, the session:

- Identified the global, regional and national context for WIGOS and emphasised the different roles and challenges of each of the different stakeholders in delivering WIGOS, from the ICG-WIGOS through technical commissions, regional associations and Members. It also highlighted the importance of engaging partner organizations at all levels, both in building WIGOS and in receiving its benefits.

- Reviewed the status of Regional WIGOS implementation Plans, which have now been initiated across all 6 regional associations, although only the most recent plan (RA-V) aligns with the EC-64 approved WIGOS framework Implementation Plan (WIP).

- Was informed on a number of case studies on some specific aspects of WIGOS implementation, one at a regional level (RA VI) and three at a national level (Australia, China, Germany), demonstrating how the WIGOS challenges are being addressed in some different contexts.

3.2 Key messages from TECO Part 1

The TECO Part 1 provided a valuable forum for exchanging views and some early experiences in how to understand, plan, implement and engage others in WIGOS. The use of practical examples took participants' understanding of WIGOS from 'theory into practice', while still acknowledging that there is a long way to go to make WIGOS operational. Some key messages to emerge from the presentations and discussion were:

- Even in advance of the EC-64 approval of the WIP, many regional associations and Members have commenced their planning for WIGOS implementation, with some emphasis already on increased coordination across different observing systems and engaging with partners for shared benefit, such as the RA-VI Adriatic Sub-regional marine observing network.

- The WIP, and in particular its 10 Key Activity Areas and 34 Implementation Activities, provides not just a structure for developing the overall WIGOS framework, but provides a good basis for developing regional and national implementation plans. This was illustrated by the RA-V approach to its draft implementation plan, noting that the emphasis against the different Key Activity Areas will vary from global to regional and from one region to another. The EUCOS QMS activity is an example of early action against Key Activity Area 5.

- The main investment in building and sustaining the component observing systems for WIGOS is at the Member level and ensuring that WIGOS addressed national priorities, in relation to WIGOS operation and delivery of benefits to users, is essential.

- Members will all be at different stages of their strategic planning, coordination, design and operation of their national observing systems. WIP structure provides a helpful basis for mapping current national activities against the 10 Key Activity Areas, and for developing comprehensive national plans that are traceable back to the overall WIGOS context at both regional and global levels. The national case studies from China and Australia both demonstrated this approach as well as the clarity it provides for mapping out future actions and priorities, and the German case study demonstrated progress against the metadata activity area.

- WIGOS provides a real opportunity for NMHSs to demonstrate their national leadership and build national partnerships, both through communication and engagement with users around making use of more standardized and quality-assured observations, and as a framework for encouraging greater contribution of observations from partner agencies. The

WIGOS and WIS focus on metadata and data access and retrieval, provides a non-threatening environment for sharing observations and potentially filling key data gaps, within a controlled and effective environment.

4. TECO PART 2: "UNDERSTANDING AND COMMUNICATING THE RETURN ON INVESTMENT THROUGH BASIC SYSTEMS AND SERVICES"

This TECO session (Thursday, 13 September, am) focused on informing CBS Members of benefits, methodologies and case studies associated with understanding the 'return on investment' in basic systems and services and communicating that information to others, especially governments and donors.

4.1 Outline of TECO Part 2

The list of speakers and topics for TECO Part 2 is Table 2 of this Annex and the presentations can be viewed on the CBS-15 website. In summary, the session:

- Provided some powerful illustrations of different methodologies for demonstrating the return on investment in modernization of NMHSs, drawing on several approaches such as benchmarking, as well as how to use this information in creating awareness at influential government levels of the importance and value of NMHSs.

- Demonstrated a selection of approaches to valuing the various links of the CBS 'value chain', from observations to information systems to data processing and forecasting systems to public weather services, with particular examples in each link of the chain, including:
  - Reviewed an approach to valuing observations, based on assumptions around the potential benefit that could be derived to the national (United States) economy of observations as part of the full services delivery package, and extended the analysis to the globally achievable return on investment.
  - Highlighted the relatively modest costs of operating the GTS/WIS compared to the significant benefits derived from its use.
  - Demonstrated methodologies for valuing investment in data processing and forecasting systems, focusing on technical achievements and economic returns.
  - Witnessed a case study on the application of socioeconomic analysis to the meteorological services in support of national transport services (Switzerland).
  - Considered the economic and social value of public weather services, looking at it from three different perspectives (value to society, brand value to NMHS and value in respect of NMHS mission) as well as the Disaster Risk Reduction component based on increased resilience of societies.

4.2 Key messages from TECO Part 2

The TECO presentations stimulated considerable discussion around the importance of robust and believable economic analyses of the value delivered by NMHSs to their users and their investors, and of the even greater importance of communicating that information to the right people in the right way. Some key messages to emerge from the presentations and discussions were:

- There was strong support for further CBS engagement, together with World Bank experts, in this topic through some focused activity as part of the CBS work programme. Given work underway within other technical commissions on social and economic benefit studies, such as CAS, a collaborative approach is appropriate, possibly leading to a high level forum in conjunction with a future Congress. Incorporation of value information in the RRR databases would strengthen the application and integration of this information to guide decisions on system design and evolution.

- Economic studies are powerful instruments for conveying the value delivered to societies and governments by NMHSs, but to extract the full benefit from the studies, they need to be well communicated, both to influential Ministers and funders, and to potential collaborators. Outreach programs should span all user interfaces and reach to the highest political levels.

- Formal documentation on methodologies and assessments, prepared collaboratively by experts from WMO and bodies such as the World Bank, would assist NMHSs in conducting relevant dialogue with governments.

- CBS is an intrinsic part of the modernization process of NMHSs. The SWFDP provides strong evidence of the benefit of the 'bottom-up' approach in building value and WMO's established cross-cutting programmes (e.g. DRR) have made significant progress in linking global, regional and national centres with organizations involved in global governance (top-down). Together, these provide effective communication vehicles for the 'value' message.

- Building on the brand of an NMHS provides valuable leverage both in ensuring the community is delivered with the service they need and in developing partnerships needed to extend NMHS capabilities, such as filling observational gaps and developing operational and research alliances.

- 'Return on investment' is improved both through increasing the 'return' and through decreasing the 'investment', and NMHSs should be actively working from both ends of this equation. 'Return' can be adversely impacted if sufficient effort is not also directed at ensuring the user is able to extract value from the services to meet their needs.

- WIGOS and the 10 Key Activity Areas highlighted in the WIP provide a ready mechanism for addressing the reduction of costs through more effective observing system design and planning, application of 'fit-for-purpose' practices and lifecycle management of systems, in line with documented user requirements via the rolling review of requirements process. The benefits of such improvements in the basic systems components flow to many more applications and services areas than Public Weather Services, noting especially the need to support delivery of the GFCS.

5. TECO FOCUS SESSIONS

In addition to the main TECO sessions, a one-hour focus session was scheduled during the lunch breaks of CBS-15, to provide an opportunity to discuss current issues of relevant to the work of the four OPAGs and to demonstrate recent outcomes.

- OPAG on IOS presented the results of the 5th WMO NWP Impact Workshop and information on the RRR databases.

- OPAG on PWS presented the Services Delivery Strategy and in particular outlined the elements of the SDS Implementation Plan.

- OPAG on DPFS presented a focus session on "Quality management/assurance of prediction systems".

- OPAG on ISS presented a session on the WIS, including the management of metadata and the use of web portals for managing data.

6. CONCLUSIONS

A strong message to emerge from all of the TECO sessions was the value of communications. At a very practical level, we demonstrated the benefit of sharing current technical information and achievements with Members in the session and of responding to questions.

In the case of the WIGOS and Value TECO sessions, communications and engagement were recognized as critical to ensuring that users, partners and investors are presented with the information that best helps NMHSs to achieve their goals and strengthen their national role.

Table 1. Agenda of TECO Day 1

Timing	*Topic*	*Speaker*
2.30 – 2.45 pm	Introduction WIGOS: What it means for Members, regions, partners	Sue Barrell, CBS Vice-president
2.45 – 3.00 pm	WIGOS framework Implementation Plan: Milestones, goals, strategy and the role of CBS – A simple guide	Fred Branski, CBS President
3.00 – 3.20 pm	Regional WIGOS Implementation Plans Status of Regional WIGOS Plans RA I, RA II, RA III, RA IV RA VI RA V	 Wenjian Zhang Director OBS Ivan Cacic, President RA VI Russell Stringer, Chair, RA V WG-Infrastructure
3.20 – 3.35 pm	Case Study – Regional – EUCOS QMS	Jochen Dibbern, DWD
3.35 – 3.50 pm	Coffee break	
3.50 – 4.10 pm	Case Study – National: Australia Framework for Implementing WIGOS	Russell Stringer, BoM
4.10 – 4.30 pm	Case Study – National: China	Meiyan Jiao, CMA
4.30 – 4.50 pm	Case Study – National: Germany WIGOS Metadata	Jochen Dibbern, DWD
4.50 – 5.25 pm	Panel Discussion and Questions	All above
5.25 – 5.30 pm	Close	Sue Barrell, CBS Vice-president

Table 2. Agenda for TECO Day 2

Timing	*Topic*	*Speaker*
9.00 – 9.10 am	Introduction – understanding value	Sue Barrell, BoM CBS Vice-president
9.10 – 9.35 am	Methodologies for valuing NMHS and communicating the message	Vladimir Tsirkunov, World Bank GFDRR Hydromet
9.35 – 9.55 am	Estimating the value/cost-benefit of observations	Lars Peter Riishojgaard, JCSDA, OPAG-IOS Co-Chair
9.55 – 10.10 am	Assessing the relative contribution to delivered value of different observing system components	Lars Peter Riishojgaard, JCSDA, OPAG-IOS Co-Chair
10.10 – 10.25 am	Break	
10.25 – 10.45 am	Estimating the value/cost-benefit of GTS/WIS	Hiroyuki Ichijo, JMA OPAG-ISS Co-Chair
10.45 – 11.05 am	Valuing investment in Data Processing and Forecasting Systems	Woo-Jin Lee, KMA
11.05 – 11.25 am	Return on investment through increased resilience of societies to meteorological disasters	Michel Jean, EC CBS DRR Coordinator
11.25 – 11.40 am	Social economic benefit of meteorology in Switzerland: Methods and Results	Estelle Grueter, MeteoSuisse
11.40 am – 12.00 pm	Economic and Social Value of Public Weather products and services	Gerald Fleming, Chair OPAG-PWS
12.00 – 12.30 pm	Panel Discussion	All of above
12.30 pm	Close	Sue Barrell, CBS Vice-president

APPENDIX

LIST OF PARTICIPANTS

1. Officers of the session

President	Fredrick R. BRANSKI (United States of America)
Vice-president	Sue L. BARRELL (Ms) (Australia)

2. Representatives of WMO Members

Algeria

Bachir HAMADACHE	Principal Delegate
Mustapha BOUAZIZ	Delegate

Argentina

Ernesto Emilio FACCINI	Delegate

Australia

Jon GILL	Alternate
Jim FRASER	Delegate
Weiqing QU	Delegate
Russell STRINGER	Delegate

Azerbaijan

Said SAFAROV	Delegate

Bahamas

Basil DEAN	Principal Delegate

Botswana

Penny M. LESOLLE (Ms)	Principal Delegate
Mompati BUTALE	Delegate

Brazil

José ARIMATÉA DE SOUSA BRITO	Principal Delegate

Canada

Michel JEAN	Principal Delegate
Michael MANORE	Alternate
Tony COLAVECCHIA	Delegate
Peter SILVA	Delegate
Camilla VOLD	Delegate

China

Meiyan JIAO (Ms)	Principal Delegate
Jiangping ZHENG	Alternate
Baogui BI	Delegate
Xiaozhong CAO	Delegate
Guang PENG	Delegate
Bo YU	Delegate
Jun YU	Delegate
Shunxi ZHANG	Delegate
Licheng ZHAO	Delegate

Croatia

Ivan CACIC	Principal Delegate
Kreso PANDZIC	Alternate

Czech Republic

Eva CERVENA (Ms)	Delegate

Denmark

Ellen Vaarby LAURSEN (Ms)	Delegate

Egypt

Hassan Mohamed HASSAN	Principal Delegate
Mohamed Saad MOHAMED ISMAIL	Alternate
Amr Mohamed AMR MAHMOUD	Delegate
Salama Mohamed GHONIEM SALAMA	Delegate

Fiji

Malakai TADULALA	Delegate

Finland

Keijo LEMINEN	Principal Delegate
Matti KERÄNEN	Delegate

France

Bernard STRAUSS	Principal Delegate
Matteo DELL'ACQUA	Alternate
Patrick BÉNICHOU	Delegate
Rémy GIBAULT	Delegate

Germany

Jochen DIBBERN	Principal Delegate
Stefan RÖSNER	Delegate
Dieter SCHRÖDER	Delegate

Hong Kong, China

Lap-shun LEE	Principal Delegate

Hungary

Ferenc DOMBAI	Delegate

India

L.R. MEENA	Principal Delegate

Indonesia

Sri Woro B. HARIJONO (Ms)	Principal Delegate
Tuwamin MULYONO	Alternate
Edvin ALDRIAN	Delegate
Arko Hananto BUDIADI	Delegate
Syamsul HUDA	Delegate
Arie Setiadi MOER WANTO	Delegate
Juriani NURHAYATI	Delegate
I. Putu PUDJA	Delegate
R. Mulyono RAHADI PRABOWO	Delegate
Juana RIMBA	Delegate
Widada SULISTYA	Delegate
Sunarjo SUNARIO	Delegate
Yunus Subagyo SWARINOTO	Delegate

Iran, Islamic Republic of

Arash SEYED HAGHIGHI	Principal Delegate
Hesam SAJDEH	Alternate

Iraq

Hussein DHAHIR	Delegate

Ireland

Sarah O'REILLY (Ms)	Principal Delegate
Gerald FLEMING	Delegate

Italy

Antonio VOCINO	Principal Delegate

Japan

Naoyuki HASEGAWA	Principal Delegate
Hiroyuki ICHIJO	Alternate
Yuki HONDA	Delegate
Kenji TSUNODA	Delegate

Kenya

Joseph R. MUKABANA	Principal Delegate

Malaysia

Tan HUVI VEIN	Delegate

Mauritius

Bhye Muslim HEETUN	Principal Delegate

Namibia

Franz UIRAB	Principal Delegate

Netherlands

G. Bert H.J. VAN DEN OORD	Principal Delegate

New Zealand

William VAN DIJK	Principal Delegate

Nigeria

Ifeanyi Daniel NNODU	Delegate
Philip Gbaja SALEH	Delegate

Norway

Roar SKALIN	Delegate
Cecilie STENERSEN	Delegate

Oman

Ahmed Hamood AL HARTHI	Principal Delegate
Sulaiman Yousuf ALSALMI	Alternate
Musallem Said ALMASHANI	Delegate
Sulaiman Yousuf ALSALMI	Delegate

Qatar

Abdul-Kareem EBRAHIM	Delegate
Ahmed WALID	Delegate

Republic of Korea

Ilsoo LEE	Principal Delegate
Woojin LEE	Alternate
Seong Hoon CHEONG	Delegate
Sunghoi HUH	Delegate
Jaedong JANG	Delegate
Suhee PARK	Delegate
Sunghwa SON (Ms)	Delegate
Jaegwang WON	Delegate

Romania

Marius MATREATA	Alternate

Russian Federation

Alexander GUSEV	Principal Delegate
Vladimir ANTSYPOVICH	Delegate
Sergey BELOV	Delegate
Leonid BEZRUK	Delegate
Roman VILFAND	Delegate

Saudi Arabia

Fahad ALAHMADI	Principal Delegate
Khalaf M. AL-GHAMDI	Delegate
Faiq Abdullah METWALLI	Delegate

Senegal

Sory DIALLO	Principal Delegate

South Africa

Mnikeli NDABAMBI	Principal Delegate
Tshepho NGOBENI	Alternate

Spain

Enric TERRADELLAS JUBABTENI	Principal Delegate

Sweden

Stefan NILSSON	Delegate

Switzerland

Estelle GRUETER (Ms)	Principal Delegate
Bertrand CALPINI	Delegate

Thailand

Kornrawee SITTHICHIVAPAK (Ms)	Principal Delegate
Sombhop WONGWILAI	Alternate
Nattawut DANDEE	Delegate
Phanumat LEWCHAROENTHRAP (Ms)	Delegate
Jongkonee MALERUS (Ms)	Delegate
Punjamaporn SIENGLERT (Ms)	Delegate
Kesaraporn TECHAPICHETVANICH (Ms)	Delegate
Oranut THONGSRI (Ms)	Delegate

Trinidad and Tobago

Marlon NOEL	Delegate

United Arab Emirates

Mohammed Abdullah AL EBRI	Principal Delegate
Abdulla AL ALI	Delegate
Naser ALBRAIKI	Delegate
Yousef ALKALBANI	Delegate

United Kingdom of Great Britain and Northern Ireland

Rob VARLEY	Principal Delegate
Simon GILBERT	Alternate

United Republic of Tanzania

Agnes L. KIJAZI (Ms)	Principal Delegate
Hamza A. KABELWA	Alternate
Augustine D. KANEMBA	Delegate

United States of America

Steven G. COOPER	Principal Delegate
William C. BOLHOFER	Alternate
Fredrick R. BRANSKI	Delegate
Michelle A. DETOMMASO	Delegate
Lars-Peter RIISHOJGAARD	Delegate

Yemen

Abdullatif ALHADA'A	Principal Delegate

3. Observers

China

Yong Qing CHEN	Observer

Indonesia

Juana RIMBA	Observer
Gyamsul H. MAKMUN	
Subardju KARTU DINOMU	

Japan

Naohisa KOIDE	Observer

Republic of Korea

Je Young RYU	Observer
Jong Yoon BAEG	

4. Invited experts

Brazil

José ARIMATÉA DE SOUSA BRITO	Invited expert

Thailand

Songkran AGSORN

Zimbabwe

Amos MAKARAU	Invited expert

5. Representatives of international organizations

Agency for Safety of Air Navigation in Africa and Madagascar (ASECNA)

Jean Blaise NGAMINI
Malamine SONKO

Association of Hydro-Meteorological Equipment Industry (HMEI)

Alim LING
Nonie SULIAMAN (Ms)
Robert B. WRIGHT

European Centre for Medium Range Weather Forecasts (ECMWF)

Walter ZWIEFLHOFER

European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)

Simon ELLIOTT
Mikael RATTENBORG

International Civil Aviation Organization (ICAO)

Greg BROCK

Lake Chad Basin Commission (LCBC)

Sanusi Imran ABDULLAHI
Michel DIMBELE-KOMBE

United Nations Educational, Scientific and Cutural Organization (UNESCO)

Giuseppe ARDUINO
Eva Mia SISKA

For more information, please contact:

World Meteorological Organization

Communications and Public Affairs Office

Tel.: +41 (0) 22 730 83 14/15 – Fax: +41 (0) 22 730 80 27

E-mail: cpa@wmo.int

7 bis, avenue de la Paix – P.O. Box 2300 – CH 1211 Geneva 2 – Switzerland

www.wmo.int

P-OBS_121541