

# WIGOS CONCEPT OF OPERATIONS (CONOPS)

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## Foreword

There is a broadly recognized need for the integration of diverse space- and surface-based observing systems in a holistic approach. Various observing systems throughout WMO Programmes and WMO partner organizations have been developed, funded, managed and operated to meet their own specific purposes. By adopting the **WMO Integrated Global Observing System (WIGOS)** strategy, the Fifteenth World Meteorological Congress wished to establish a comprehensive, coordinated and sustainable system of observing systems in order to satisfy the observational requirements of all WMO and WMO co-sponsored Programmes in a cost-effective manner. Close cooperation and active collaboration is therefore needed among all partners to accomplish the broad integration objectives.

With this aim in view, WIGOS should define organizational, programmatic, procedural, and governance structures enabling a common standardized approach with uniform implementation of WMO regulations and practices, in order to ensure data integration and interoperability across all WMO observing systems. WIGOS should also provide a mechanism for interactions with WMO co-sponsored observing systems, respecting partnership, ownership and data-sharing policies of all observing components and partner organizations. WIGOS should significantly improve availability of observations and provide easier and wider access through the WMO Information System (WIS).

WIGOS will build on and add value to WMO's existing observing systems by coordinating their efforts, addressing shortcomings, supporting their interoperability, while meeting user requirements.

The WIGOS concept development and coordination initiative will stimulate the integration of WMO Member countries' observing capabilities into a worldwide composite system and architecture that improves overall system performance and efficiency.

The WIGOS integrated observation approach will provide a framework to support WMO Members' NMHSs and other relevant Institutions in the fulfilment of their national mandates including response to natural hazards, hydrological and environmental monitoring, climate observation, and adaptation to climate-change and human-induced environmental impacts. Together with WIS, WIGOS will significantly enhance Members' capabilities implementing WMO Programmes in developing and Least Developed Countries.

WIGOS development and implementation will proceed concurrently with the planning and implementation of WIS. The combination of both efforts will allow for an integrated WMO end-to-end system of systems designed to improve Members' capability to effectively provide a wide range of services and to better serve research programme requirements.

The agreed-upon standards and recommended practices, and procedures will apply to all WMO observing systems and Programmes. WMO will work with partner organizations to achieve maximum commonality of standards and practices across the co-sponsored observing systems. Strong cooperation and collaboration is needed among all partners. If WIGOS is to work for everyone, all relevant parties must work together in the implementation of the WIGOS concept.

The following Concept of Operations describes the end state of a fully operational WIGOS; it establishes the overall goals for WIGOS. In order to achieve them, a detailed WIGOS Development and Implementation Plan (WDIP) is being developed to provide for a logical transition from initial to full operational capabilities. To fully understand the WIGOS concept, these two principal documents must be considered together.

## **1. INTRODUCTION**

### **1.1 Vision**

WIGOS will benefit society through enhanced availability and integration of global weather, climate and water observations contributed by constituent systems.

### **1.2 Purpose**

The purpose of WIGOS is to create an effective organizational, programmatic, procedural and governance structure that will significantly improve the availability, usefulness, quality and utilization of observational data and products through a single focus for the operational and management functions of all WMO observing systems as well as a mechanism for interactions with WMO co-sponsored observing systems. Integration will lead to efficiencies and cost savings that can be reinvested to overcome known deficiencies and gaps in the present structure and working arrangements. In this way WIGOS will provide the capability to better utilize existing and emerging observation capabilities and so lead to:

- Improved availability of existing and future observational data;
- More, higher quality and a wider range of observations, environmental data and products;
- More efficient delivery of observational data and products to users;
- Maximising the return on investments in observations; and
- Optimization and full utilization of developments in future observing systems.

### **1.3 Integration**

1.3.1 Integration in the context of WIGOS should be defined as establishment of a comprehensive, coordinated and sustainable system of observing systems, ensuring interoperability between its component systems. It will be an organizational framework facilitating standardization and interoperability and ensuring availability and utilization of, and access to, good-quality data and products, and associated metadata.

1.3.2 The integration process should encompass four broad objectives:

- (a) Addressing the needs of the atmospheric, hydrologic, oceanographic, cryospheric and terrestrial domains within the operational scope of a comprehensive integrated system through standardization and network optimization;
- (b) Increasing interoperability between systems with particular attention given to space-based and *in-situ* components of the systems;
- (c) Ensuring that broader governance frameworks (e.g. inter-agency co-sponsorship of systems) and relationships with other international entities are sustained and strengthened;
- (d) Improving WMO management and governance (use of resources, planning, institutional and programme structures, and monitoring).

## **2. OVERVIEW**

### **2.1 Aim**

WIGOS aims to:

- (a) Address in the most cost-effective approach WMO Programme requirements with a view toward reducing the financial burden on Members, while maximizing administrative and operational efficiencies;

- (b) Ensure the availability of all required information produced within the various WMO observing systems (e.g. GOS, GAW, WHYCOS, etc.), and WMO components of co-sponsored systems (e.g. GCOS, GOOS, GTOS, etc.) including emphasis on information generated by satellite, radar, wind-profilers, airborne systems, *in-situ* ocean platforms, and other existing and future observing systems;
- (c) Facilitate the access, in real-time, near-real-time and delayed mode, of observations required to meet the needs of Members through WMO and WMO co-sponsored programmes, as well as relevant international conventions;
- (d) Ensure required data quality standards are met and sustained for all programme requirements;
- (e) Facilitate improved data management including archival and data retrieval capabilities;
- (f) Facilitate technological innovation opportunities;
- (g) Ensure collaboration with instrument manufacturers and scientific institutes in the development and testing of next generation observation instruments;
- (h) Develop appropriate regulatory documentation including organization and recommended practices, procedures and guidelines;
- (i) Link existing technologies in an integrated manner to provide societal benefits.

## 2.2 Characteristics

2.2.1 The concept of WIGOS is based on the premise that the general standards and recommended practices, as agreed-upon for WIGOS, will apply to all WMO observing systems and Programmes. WIGOS will foster increased collaboration with partner organisations towards the objective of harmonized standards including interoperability across all WMO co-sponsored observing systems.

2.2.2 The success of WIGOS will depend on data and metadata producers (i.e. mainly NMHSs) that are fully responsible for the quality of their own data and metadata, accepting and implementing a set of interoperability arrangements, including technical specifications for acquisition, collection, processing, management, storing, disseminating, and archiving shared data, metadata, and products. The owner of the observing system must accept the responsibility for implementing a quality management system that shall operate continuously at all points of the whole system, from planning and installation, operations, maintenance and inspection, test and calibration, quality and performance monitoring, evaluation and remedial procedures, training, to data pre-processing, dissemination, processing, management and archiving; performance monitoring, evaluation, feedback and follow-up actions are inseparable parts of this chain.

2.2.3 WIGOS characteristics include:

WIGOS will:

- Develop strategies to satisfy observational requirements of WMO Programmes and international partners through the WMO Rolling Requirements Review (RRR) Process;
- Develop strategies to guarantee system interoperability, including meeting documented standards for data quality of observing systems and instruments;
- Develop a strategy for the production, editing and management of metadata, including instrumentation/platform and data discovery;
- Evaluate existing and emerging capabilities before developing, acquiring, and or deploying new observing systems or sensors, and in the design of cost-effective composite observing systems;
- Exploit existing platforms and employ multi-sensor platform concept to the maximum possible extent;

- Coordinate the response to requirements, plans and activities with all technical commissions, regional associations and Programmes;
- Be built initially upon existing observing systems and provide an interoperable framework for new systems.

All WIGOS observational data, metadata and processed observational products will:

- Be exchanged via WIS using agreed upon data and metadata representation forms and formats;
- Use WIGOS compatible hardware and software;
- Adhere to WIGOS standards for instruments and methods of observation as well as standard observing network practices and procedures; and
- Be archived in WIGOS approved forms and resolutions at WMO agreed upon archival centres.

2.2.4 It must be emphasized that observing programmes of the WMO are actually carried out by WMO Member countries, either individually, or in some instances (notably for some satellite systems and oceanographic observing systems) cooperatively with consortia of countries operating a system jointly. Integration therefore will have a direct relationship to national programmes and activities as well as on coordination through the international organization.

### **3. ASSUMPTIONS**

#### **3.1 General**

WIGOS will provide a sustainable framework for the improvement of operations towards an integrated approach in support of WMO Member countries' national mandates including response to natural hazards, environmental monitoring, adaptation to climate change and man-made environmental impacts. It is consistent with the decision of the Fifteenth WMO Congress concerning enhanced integration between WMO Observing Systems and the WMO Strategic Plan.

#### **3.2 Key areas of standardization**

A key requirement for integration within a system of systems construct will be standardization in three key areas as shown schematically in Figure 1:

- Standardization of instruments and methods of observation;
- WIS information infrastructure;
- End-product quality assurance.

##### **3.2.1 Standardization of instruments and methods of observation**

WIGOS should encompass homogeneity, interoperability and, compatibility and traceability of observations from all WIGOS constituent observing systems. This should be based on guidance and studies and achieved through implementation of recommendations on methods of observation by the Instrument and Methods of Observation Programme (IMOP) and related programmes of partner organization within WIGOS constituent networks including tests, calibration and intercomparisons.

##### **3.2.2 WIS Information infrastructure**

3.2.2.1 The planning and implementation of WIGOS shall be coordinated with the WMO Information System (WIS). This will be accomplished through:

- Activities of the EC WG on WIGOS-WIS;
- EC WG on WIGOS-WIS Sub-Group on WIGOS (SG-WIGOS);

- Input from regional associations and technical commissions;
- Coordination role of the Secretariat, including the WIGOS Project Office.

3.2.2.2 Technologically, the key action leading to the desired integrated networks will be the generation of data and information from WIGOS constituent networks using a comprehensive, standardized data representation in compliance with WIS information exchange requirements for all WMO Programmes.

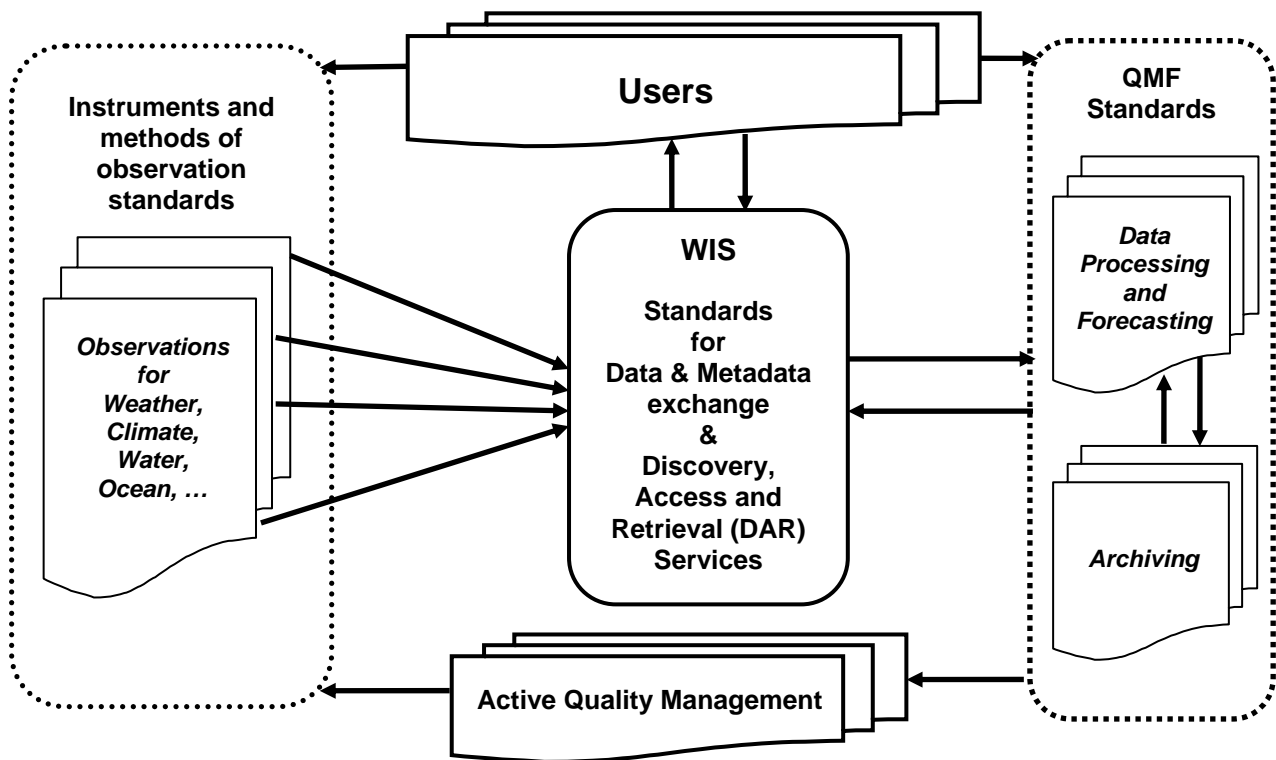
3.2.2.3 A role of WMO Information System (WIS) will be as follows:

- It will be used in the collection and sharing of information for all WMO and related international programmes;
- It will provide a flexible and extensible structure that will allow participating centres to enhance their capabilities as their national and international responsibilities grow;
- Implementation will build upon the most successful components of existing WMO information systems in an evolutionary process;
- Development will pay special attention to a smooth and coordinated transition;
- Communication networks will be based on communication links used within the World Weather Watch (WWW) for distribution of high priority real-time data;
- It will utilize international agreed-upon standards for protocols, hardware and software.

### **3.2.3 End-product quality assurance**

The third key area of standardization for WIGOS should embrace a quality management framework (QMF) and updated technical regulations to ensure the best possible products to be delivered to end users. This should be based on agreed-upon quality assurance and quality control standards, with the following goals:

- To ensure integrated/coordinated data acquisition efforts among NMHSs and other operators to minimize duplication;
- To reduce costs and maximize data and products availability and quality;
- To develop an integrated quality management system that delivers reliable and timely data streams with adequate quality control and relevant metadata.



**Figure 1: Key areas of WIGOS standardization**

The three areas of standardization of the WMO and co-sponsored observing systems contributing to WIGOS: standardization of instruments and methods of observation, WIS information infrastructure; and end product quality assurance.

**The first area of standardization:** a sustained, optimized, end-to-end WMO Integrated Global Observing System should encompass homogeneity, interoperability, compatibility, and traceability of observations from all WIGOS constituent observing systems. This should be achieved through meeting the requirements for instruments and methods of observation established by the Commission for Instruments and Methods of Observation (CIMO) and those promulgated by partner organizations including tests, calibration and intercomparisons.

**The second area of standardization:** Data and information generated by all WIGOS constituent networks should meet a comprehensive, standardized set of WIS data and metadata exchange requirements for all WMO Programmes and co-sponsored programmes.

**The third area of standardization:** Various end-products generated on the basis of observations/measurements by all WIGOS constituent observing systems and exchanged through WIS should meet quality management framework requirements to ensure the best possible products are delivered to end users.

#### 4. RESPONSIBILITIES

In order to commence efforts towards achieving full WIGOS operations, the following entities are considered to have essential responsibilities:

- Sponsors and co-sponsors of WIGOS constituent systems, both current and future;
- EC WG on WIGOS-WIS;
- SG WIGOS;
- Inter-Commission Coordination Group on WIS (ICG WIS);
- Regional associations and technical commissions;
- WMO Secretariat.

## **5. OPERATIONAL FRAMEWORK**

### **5.1 Overall approach**

This Concept of Operations covers the full spectrum of management and integration for WIGOS. In order for WIGOS to effectively and efficiently respond to user data needs, WIGOS will use WIS as a data exchange, discovery, access and retrieval mechanism.

### **5.2 WIGOS components**

The WIGOS constituents are (noting that the following are not necessarily complete):

- (a) The surface-based component of the Global Observing System (GOS) of the World Weather Watch (WWW) Programme;
- (b) Space-based component of the GOS including the geostationary meteorological satellite constellation, the core polar-orbiting meteorological constellation and R&D earth observation satellites;
- (c) Aircraft Meteorological Data Relay (AMDAR) systems including expansions of aircraft measurement capabilities for atmospheric composition constituents;
- (d) Marine meteorological and relevant oceanographic observing networks;
- (e) The relevant components of atmospheric, oceanographic and terrestrial observing systems contributing to GCOS;
- (f) Related terrestrial network;
- (g) Regional, river basin and global hydrological networks;
- (h) The Global Atmosphere Watch (GAW) networks and systems for observation of atmospheric chemical composition and related environmental parameters;
- (i) The various radiation networks both observing solar and net radiation (e.g. the BSRN);
- (j) The observing component of the proposed Global Cryosphere Watch approved by the fifteenth WMO Congress;
- (k) Other possible components yet to be defined.

### **5.3 Integration, Standardization and Interoperability**

It is envisioned that the integration process will bring about architectural and governance structures as well as processes for WIGOS development, implementation and sustainability. Standardization and interoperability, including data compatibility, are primary factors enabling integration. WIGOS will:

- Improve the production, use and application of data and information from across all WMO and co-sponsored observing systems, in a seamless way, to satisfy user requirements;
- Be designed to accommodate the diversity among Member countries with respect to their capabilities and needs;
- Strengthen the ability of all Member countries to access and utilize observations and analysis products from all WMO and co-sponsored observing systems;
- Ensure compatibility, connectivity and interoperability including interface arrangements within and among all WMO and co-sponsored observing systems components and externally with other users;
- Allow for the continuous review of the requirements placed on the integrated system and have the capability to effectively adjust and respond to changing requirements;

- Ensure the continuing sense of ownership by the various groups that have initiated and developed the individual observing system components through directly involving these groups in the planning and implementation of the WIGOS;
- Promote the development, testing and comparison of new observing capabilities and provide mechanisms to easily integrate them into WMO and co-sponsored operational observing systems;
- Ensure the optimum integration of the various components of all observing programmes;
- Increase efficiency and effectiveness by reducing as far as possible redundancies and overlaps of systems and the management activities supporting them;
- Facilitate more rapid and efficient assimilation of technological advances and apply them as far as possible across all observing programmes;
- Foster co-location of observing sites of complementary systems as far as practical thereby reducing redundancies; and
- Ensure the involvement of the various scientific and user communities in the activities of setting requirements, and monitoring and assessing system performance.

#### **5.4 Relation with the co-sponsored observing systems**

5.4.1 Effective implementation and operation of WIGOS will require close ongoing collaboration with several of WMO's partner organizations (UNESCO and its IOC, UNEP, FAO, and ICSU) with whom it co-sponsors the Global Ocean Observing System (GOOS), the Global Terrestrial Observing System (GTOS) and the cross-domain Global Climate Observing System (GCOS). This will be necessary in order to ensure essential interoperability and mutual support while also respecting and reinforcing the individual identities and mandates of both the partners and their co-sponsored observing systems. It will also require a clear understanding, at both international and national levels, as to how WIGOS, GOOS, GTOS and GCOS fit together within the overall framework of GEOSS.

5.4.2 By virtue of WMO's co-sponsorship of the IOC-led GOOS and the FAO-led GTOS, those parts of these systems which contribute to, or support, WMO research and service programmes, are appropriately regarded as part of WIGOS. Every effort should be made, therefore, to achieve full interoperability and mutually supportive advisory and coordination arrangements with both GOOS and GTOS.

5.4.3 Similarly, the jointly-sponsored, cross-cutting GCOS, which is made up primarily of the climate-relevant components of WIGOS, GOOS and GTOS, will need to be implemented and operated on the basis of maximum possible complementarity and mutual support between GCOS and its component systems, including WIGOS.

5.4.4 Coordination will be needed at policy, technical and Secretariat levels. Policy and technical coordination will be facilitated through cross representation at sessions of the advisory/steering committees and implementation bodies of the various systems supported by joint working groups and the like. The principal mechanisms for inter-Secretariat coordination will be the WMO-UNESCO-UNEP-FAO-ICSU Interagency Coordination and Planning Committee for Earth Observations (ICPC) which was established to ensure a well-coordinated UN system contribution to GEOSS.

5.4.5 The policy, technical and Secretariat coordination mechanisms may also need to be supported by a higher-level reconciliation mechanism defined through the WMO-UNESCO-IOC-UNEP-FAO-ICSU Memoranda of Understanding (MOU) in order to resolve possible conflicts on data policy, product delivery and other governance issues.

5.4.6 These interagency and inter-observing system coordination mechanisms at the international level will need to be complemented and supported through similar cooperation and coordination arrangements between NMHSs and their counterpart national implementation mechanisms for GOOS, GTOS, GCOS and GEOSS.

## **6. DATA POLICY**

6.1 WIGOS will respect the data policies of partner organizations and will adhere to the decisions of the Twelfth and Thirteenth World Meteorological Congresses (1995, 1999) that adopted Resolution 40 (Cg-XII) "WMO Policy and Practice for the Exchange of Meteorological and Related Data and Products including Guidelines on Relationships in Commercial Meteorological Activities", and Resolution 25 (Cg-XIII) "Exchange of Hydrological Data and Products", respectively.

6.2 WIGOS will strive to ensure that the conditions placed by the originator on the additional data and products are respected and made known to initial and subsequent recipients for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological and hydrological activities.

## **7. BENEFITS**

Across all WMO domains of activity, WMO Member countries and partner organizations will benefit from WIGOS through:

- Improved quality, traceability and consistency of observations for better products and services;
- Improved access to observations, whether real-time, or not;
- Optimization of observing network design and flexibility to incorporate new observing systems;
- Improved coordination, standardization and evaluation of national observing networks by National Meteorological and Hydrological Services (NMHSs);
- Improved data assimilation techniques to allow better exploitation of observations in Numerical Weather Predictions (NWP) in an integrated manner.

## **8. CHALLENGES**

Challenges and needs associated with embarking upon integration of WMO and co-sponsored observing systems include but are not limited to:

- Active collaboration, close cooperation and coordination by, and firm long-term commitment of all concerned;
- Timely and effective implementation of integration concept by individual Members;
- Differences in levels of development of national and regional systems and services;
- Achieving the timeline as laid out by Cg-XV and, in particular, the need for an early start to additional Pilot Projects and Demonstration Projects;
- The need for a comprehensive and costed development and implementation strategy for WIGOS that, inter alia:
  - (a) Fully outlines the technical challenges to be addressed and the roles and responsibilities of all players,
  - (b) Elucidates the process for capturing the lessons-learned from the Pilot Projects and Demonstration Projects,
  - (c) Outlines a capacity building strategy to ensure the benefits of WIGOS will reach all Member countries, and
  - (d) Designates clear responsibilities across the WMO system for the further development of WIGOS;
- The need to complete the full functionality of WIS so that WIGOS can exploit new data access and retrieval facilities;

- The importance of engaging the hydrological community in WIGOS activities;
- The need to clarify and communicate the relationship and intersection of WIGOS with the co-sponsored observing systems, (GOOS, GTOS and GCOS) and with GEOSS;
- Finding ways to demonstrate the opportunities of WIGOS to all potential partners and users to build their ongoing support, trust and collaboration; and
- Finding a way to more effectively incorporate all WMO observing activities into WIGOS and address their different requirements and priorities, especially the need to ensure WIGOS effectively supports all WMO applications programmes;
- Elaboration of a comprehensive implementation strategy that takes WIGOS from concept to reality, and its implementation;
- Technical challenges including:
  - (a) Documenting and validating requirements for operational weather, climate, water and related environmental observations (building on Rolling Requirements Review),
  - (b) Specifying relevant processes, procedures and relationships,
  - (c) Determining standards, procedures, practices and protocols,
  - (d) Step-by-step implementation of sets of standardization, interoperability and data compatibility arrangements into operational observing networks and systems, and
  - (e) Systematic and rigorous performance monitoring and evaluation (PM&E) of WIGOS capabilities;
- Adequately structured and resourced WMO Secretariat.

## **9. RISKS**

Associated risks are as follows:

- Resources will be a critical risk factor in achieving timely completion of WIGOS goals. Current low level allocation of resources, including the lack of a fully functioning WIGOS Project Office, is an impediment to progress;
- Effective and constructive cooperation, collaboration and coordination is not achieved;
- Long-term commitments by all players are not achieved;
- Timeframe for implementation of WIGOS is not understood and/or not achieved;
- Adequate resources and support are not available to players to achieve key elements of WIGOS implementation;
- Resource, coordination etc. requirements for ongoing operation of WIGOS are inadequately understood and/or provided for;
- Full implementation of agreed-upon standards, procedures and practices is not achieved across all WMO observation systems.

## **10. RESOURCES**

Implementation of WIGOS will require substantial resources and support at the national, regional and global levels as well as within the WMO Secretariat.

## LIST OF ACRONYMS

AMDAR	Aircraft Meteorological Data Delay
BSRN	Basic Surface Radiation Network
CONOPS	Concept of Operations
EC WG	Executive Council Working Group
FAO	Food and Agriculture Organization
GAW	Global Atmospheric Watch
GCOS	Global Climate Observing System
GEOSS	Global Earth Observation System of Systems
GOOS	Global Ocean Observing System
GOS	Global Observing System
GTOS	Global Terrestrial Observing System
ICG WIS	Inter-Commission Coordination Group on WIS
ICPC	Interagency Coordination and Planning Committee for Earth Observations
ICSU	International Council for Science
IOC	Intergovernmental Oceanographic Commission
QA	Quality Assurance
QC	Quality Control
QMF	Quality Management Framework
QMS	Quality Management System
R&D	Research and Development
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WDIP	WIGOS Development and Implementation Plan
WHYCOS	World Hydrological Cycle Observing System
WIGOS	World Integrated Global Observing System
WIS	WMO Information System
WWW	World Weather Watch