

Technical Regulations

Basic Documents No. 2

Volume I – General Meteorological Standards and
Recommended Practices

2015 edition

Updated in 2016

WEATHER CLIMATE WATER



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METEOROLOGICAL
ORGANIZATION

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EDITORIAL NOTE

The following typographical practice has been followed: Standard practices and procedures have been printed in **bold**. Recommended practices and procedures have been printed in regular font. Notes have been printed in smaller type.

METEOTERM, the WMO terminology database, may be consulted at <http://public.wmo.int/en/resources/meteoterm>.

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WMO-No. 49

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ISBN 978-92-63-10049-8

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GENERAL PROVISIONS

1. The *Technical Regulations* (WMO-No. 49) of the World Meteorological Organization are presented in four volumes:

Volume I – General meteorological standards and recommended practices

Volume II – Meteorological service for international air navigation

Volume III – Hydrology

Volume IV – Quality management

Purpose of the Technical Regulations

2. The Technical Regulations are determined by the World Meteorological Congress in accordance with Article 8 (d) of the Convention.

3. These Regulations are designed:

- (a) To facilitate cooperation in meteorology and hydrology among Members;
- (b) To meet, in the most effective manner, specific needs in the various fields of application of meteorology and operational hydrology in the international sphere;
- (c) To ensure adequate uniformity and standardization in the practices and procedures employed in achieving (a) and (b) above.

Types of Regulations

4. The Technical Regulations comprise *standard* practices and procedures and *recommended* practices and procedures.

5. The definitions of these two types of Regulations are as follows:

The *standard* practices and procedures:

- (a) Shall be the practices and procedures that Members are required to follow or implement;
- (b) Shall have the status of requirements in a technical resolution in respect of which Article 9 (b) of the Convention is applicable;
- (c) Shall invariably be distinguished by the use of the term *shall* in the English text, and by suitable equivalent terms in the Arabic, Chinese, French, Russian and Spanish texts.

The *recommended* practices and procedures:

- (a) Shall be the practices and procedures with which Members are urged to comply;
- (b) Shall have the status of recommendations to Members, to which Article 9 (b) of the Convention shall not be applied;
- (c) Shall be distinguished by the use of the term *should* in the English text (except where otherwise provided by decision of Congress) and by suitable equivalent terms in the Arabic, Chinese, French, Russian and Spanish texts.

6. In accordance with the above definitions, Members shall do their utmost to implement the *standard* practices and procedures. In accordance with Article 9 (b) of the Convention and in conformity with Regulation 128 of the General Regulations, Members shall formally notify the Secretary-General, in writing, of their intention to apply the *standard* practices

and procedures of the Technical Regulations, except those for which they have lodged a specific deviation. Members shall also inform the Secretary-General, at least three months in advance, of any change in the degree of their implementation of a *standard* practice or procedure as previously notified and the effective date of the change.

7. Members are urged to comply with *recommended* practices and procedures, but it is not necessary to notify the Secretary-General of non-observance except with regard to practices and procedures contained in Volume II.

8. In order to clarify the status of the various Regulations, the *standard* practices and procedures are distinguished from the *recommended* practices and procedures by a difference in typographical practice, as indicated in the editorial note.

Status of annexes and appendices

9. The following annexes to the *Technical Regulations* (Volumes I to IV), also called Manuals, are published separately and contain regulatory material having the status of *standard* and/or *recommended* practices and procedures:

- I *International Cloud Atlas* (WMO-No. 407), Volume I – Manual on the Observation of Clouds and Other Meteors, Part I; Part II: paragraphs II.1.1, II.1.4, II.1.5 and II.2.3; subparagraphs 1, 2, 3 and 4 of each paragraph from II.3.1 to II.3.10; paragraphs II.8.2 and II.8.4; Part III: paragraph III.1 and the definitions (in italics) of paragraph III.2;
- II *Manual on Codes* (WMO-No. 306), Volume I;
- III *Manual on the Global Telecommunication System* (WMO-No. 386);
- IV *Manual on the Global Data-processing and Forecasting System* (WMO-No.485), Volume I;
- V *Manual on the Global Observing System* (WMO-No. 544), Volume I;
- VI *Manual on Marine Meteorological Services* (WMO-No. 558), Volume I;
- VII *Manual on the WMO Information System* (WMO-No. 1060);
- VIII *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).

These annexes (Manuals) are established by decision of Congress and are intended to facilitate the application of Technical Regulations to specific fields. Annexes may contain both *standard* and *recommended* practices and procedures.

10. Texts called appendices, appearing in the *Technical Regulations* or in an annex to the *Technical Regulations*, have the same status as the Regulations to which they refer.

Status of notes and attachments

11. Certain notes (preceded by the indication “Note”) are included in the *Technical Regulations* for explanatory purposes; they may, for instance, refer to relevant WMO Guides and publications. These notes do not have the status of Technical Regulations.

12. The *Technical Regulations* may also include attachments, which usually contain detailed guidelines related to *standard* and *recommended* practices and procedures. Attachments, however, do not have regulatory status.

Updating of the *Technical Regulations* and their annexes (Manuals)

13. The *Technical Regulations* are updated, as necessary, in the light of developments in meteorology and hydrology and related techniques, and in the application of meteorology and operational hydrology. Certain principles previously agreed upon by Congress and applied in the selection of material for inclusion in the Technical Regulations are reproduced below. These principles provide guidance for constituent bodies, in particular technical commissions, when dealing with matters pertaining to the Technical Regulations:

- (a) Technical commissions should not recommend that a Regulation be a *standard* practice unless it is supported by a strong majority;
- (b) Technical Regulations should contain appropriate instructions to Members regarding implementation of the provision in question;
- (c) No major changes should be made to the Technical Regulations without consulting the appropriate technical commissions;
- (d) Any amendments to the Technical Regulations submitted by Members or by constituent bodies should be communicated to all Members at least three months before they are submitted to Congress.

14. Amendments to the *Technical Regulations* – as a rule – are approved by Congress.

15. If a recommendation for an amendment is made by a session of the appropriate technical commission and if the new regulation needs to be implemented before the next session of Congress, the Executive Council may, on behalf of the Organization, approve the amendment in accordance with Article 14 (c) of the Convention. Amendments to annexes to the *Technical Regulations* proposed by the appropriate technical commissions are normally approved by the Executive Council.

16. If a recommendation for an amendment is made by the appropriate technical commission and the implementation of the new regulation is urgent, the President of the Organization may, on behalf of the Executive Council, take action as provided by Regulation 9 (5) of the General Regulations.

Note: A simple (fast-track) procedure may be used for amendments to technical specifications in Annexes II (*Manual on Codes* (WMO-No.306)), III (*Manual on the Global Telecommunication System* (WMO-No.386)), IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No.485)), V (*Manual on the Global Observing System* (WMO-No.544)), VII (*Manual on the WMO Information System* (WMO-No.1060)) and VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No.1160)). Application of the simple (fast-track) procedure is defined in those Annexes.

17. After each session of Congress (every four years), a new edition of the *Technical Regulations*, including the amendments approved by Congress, is issued. With regard to the amendments between sessions of Congress, Volumes I, III and IV of the *Technical Regulations* are updated, as necessary, upon approval of changes thereto by the Executive Council. The *Technical Regulations* updated as a result of an approved amendment by the Executive Council are considered a new update of the current edition. The material in Volume II is prepared by the World Meteorological Organization and the International Civil Aviation Organization working in close cooperation, in accordance with the Working Arrangements agreed by these Organizations. In order to ensure consistency between Volume II and Annex 3 to the Convention on International Civil Aviation – *Meteorological Service for International Air Navigation*, the issuance of amendments to Volume II is synchronized with the respective amendments to Annex 3 by the International Civil Aviation Organization.

Note: Editions are identified by the year of the respective session of Congress whereas updates are identified by the year of approval by the Executive Council, for example “Updated in 2012”.

WMO Guides

18. In addition to the *Technical Regulations*, appropriate Guides are published by the Organization. They describe practices, procedures and specifications which Members are invited to follow or implement in establishing and conducting their arrangements for compliance with the Technical Regulations, and in otherwise developing meteorological and hydrological services in their respective countries. The Guides are updated, as necessary, in the light of scientific and

technological developments in hydrometeorology, climatology and their applications. The technical commissions are responsible for the selection of material to be included in the Guides. These Guides and their subsequent amendments shall be considered by the Executive Council.

DEFINITIONS

A definition does not have independent status but is an essential part of each standard and recommended practice in which the term is used, since a change in the meaning of the term would affect the specification. The following terms, when used in Volume I of the *Technical Regulations*, have the meanings given below.

Note: Other definitions may be found in Annex II (*Manual on Codes* (WMO-No. 306)), Annex III (*Manual on the Global Telecommunication System* (WMO-No. 386)), Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I, Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)) and other WMO publications.

Aeronautical meteorological station. A station designated to make observations and meteorological reports for use in international air navigation.

Agricultural meteorological station. A station that provides meteorological data for agricultural and/or biological purposes and makes other meteorological observations under programmes of Agrometeorological Research Centres and other relevant organizations.

Aircraft meteorological station. A meteorological station situated on an aircraft.

Altitude. The vertical distance of a level, a point or an object considered as a point, measured from mean sea level.

Antarctic Observing Network. A regional network of surface and upper-air stations of all operational and scientific networks in Antarctica.

Auxiliary ship station. A mobile ship station, normally without certified meteorological instruments, that transmits reports in code form or in plain language, either as a routine or on request, in certain areas or under certain conditions.

Bulk density. The ratio of mass to volume of an undisturbed sample of oven-dried soil expressed in grams per cubic centimetre.

Calibration (rating). (1) The experimental determination of the relationship between the quantity to be measured and the indication of the instrument, device or process that measures it; (2) the process of relating the indicated response of an instrument to its actuating signal or to the true value obtained independently; it is usually carried out at several points in the instrument's measurement range.

Climatological data. Various types of data – instrumental, proxy or historical – which constitute the major source of climate study and theory.

Climatological record. Any record made of meteorological events in alphanumerical, graphical or map form.

Climatological standard normals. Averages of climatological data computed for the following consecutive periods of 30 years: 1 January 1981–31 December 2010, 1 January 1991–31 December 2020, and so forth.

Note: When data are not continuous, adjusted normals may be computed.

Climatological station. A station whose observations are used for climatological purposes.

Compatibility. A state in which two things are able to exist and be used together without problems or conflict.

Competency. The knowledge, skills and behaviours required to perform specific tasks in the fulfilment of a job responsibility.

Note: Competencies are often acquired and assessed on the job or through a variety of training opportunities.

CryoNet. The core of the WMO Global Cryosphere Watch (GCW) observing network that applies GCW agreed observing practices. It comprises sites in cold climate regions, on land or sea, operating a sustained, standardized programme for observing and monitoring as many cryospheric variables as possible. CryoNet is being structured in two different categories of observational sites: Basic Sites and Integrated Sites. CryoNet sites contain one or more CryoNet stations: Primary Stations and Baseline Stations.

Cryosphere. A component of the Earth system that includes solid precipitation, snow cover, sea ice, lake and river ice, glaciers, ice caps, ice sheets, permafrost and seasonally frozen ground.

Note: While elements of the cryosphere are often defined as containing frozen water, permafrost can be “dry”. The GCW definition includes elements of the cryosphere that occur on or beneath the Earth’s surface, or that are measured at the surface in the case of solid precipitation. It, therefore, excludes ice clouds.

Discovery metadata. Metadata consistent with the standard that is used within WMO Information System (WIS) for discovery of information shared through WIS.

Elevation. The vertical distance of a point or a level on, or affixed to, the surface of the Earth, measured from mean sea level.

Field capacity. Water content that a given soil reaches and maintains after it has been thoroughly wetted and allowed to drain freely for a day or two.

Fixed-ship station. An ocean weather station or a station situated aboard a lightship.

Geostationary Earth Orbit (GEO). Satellites in geostationary Earth orbits are often referred to as GEOs.

Geostationary satellite. A meteorological satellite orbiting the Earth at an altitude of approximately 36 000 km with the same angular velocity as the Earth and within the equatorial plane, thus providing nearly continuous information in an area within a range of about 50° from a fixed sub-satellite point at the Equator.

Global Climate Observing System (GCOS). A long-term, user-driven operational system capable of providing the comprehensive observations required for monitoring the climate system, detecting climate change and assessing its impacts, and improving understanding, modelling and prediction of the climate system.

Global Climate Observing System (GCOS) Upper-Air Network (GUAN). The global baseline network of about 150 selected upper-air stations, within the Regional Basic Synoptic Network, established with relatively homogeneous distribution to meet the requirements of GCOS for the compilation of long-term climate records.

Global Cryosphere Watch (GCW) Observing Network. A network of GCW sites with varying capabilities built on existing observing programmes and promoting the addition of standardized cryospheric observations to existing facilities. It covers all components of the cryosphere: glaciers, ice shelves, ice sheets, snow, permafrost, sea ice, river/lake ice and solid precipitation.

Global Data-processing and Forecasting System. The coordinated global system of meteorological centres and arrangements for meteorological analyses and forecasting, and for the processing, storage and retrieval of meteorological information within the framework of the World Weather Watch.

Global Observing System (GOS). The coordinated system of methods, techniques and facilities for making observations on a worldwide scale within the framework of the World Weather Watch.

Global Telecommunication System (GTS). The coordinated global system of telecommunication facilities and arrangements for the rapid collection, exchange and distribution of observations and processed information within the framework of the World Weather Watch.

Height. The vertical distance of a level, a point or an object considered as a point, measured from a specified datum.

Note: The datum may be specified in the relevant publication, either in the main text or in an explanatory note.

In situ observation. An observation made by a device that is in physical or direct contact with the object or phenomenon under study.

Interoperability. The ability of diverse systems to work together.

Land station. A meteorological observing station situated on land.

Low Earth Orbit (LEO). An orbit at an altitude between 160 km (99 mi), with a period of about 88 minutes, and 2 000 km (1 200 mi), with a period of about 127 minutes.

Meteorological analysis (Analysis). A statement of analysed meteorological conditions for a specified time or period, and for a specified area or portion of airspace.

Meteorological bulletin. A text comprising meteorological information preceded by an appropriate heading.

Meteorological forecast (Forecast). A statement of expected meteorological conditions for a specified time or period, and for a specified area or portion of airspace.

Meteorological message. A message comprising a single meteorological bulletin, preceded by a starting line and followed by end-of-message signals.

Note: Details on the starting line, the end-of-message signals and the structure of a meteorological bulletin are contained in Annex III (*Manual on the Global Telecommunication System* (WMO-No. 386)), Part II, chapter 2.

Meteorological observation. The evaluation or measurement of one or more meteorological elements.

Meteorological observing network. A group of meteorological observing stations spread over a given area for a specific purpose.

Meteorological observing station (Meteorological station). A place where meteorological observations are made with the approval of the WMO Member or Members concerned.

Meteorological report (Report). A statement of observed meteorological conditions related to a specified time and location.

Meteorological satellite. An artificial Earth satellite making meteorological observations and transmitting them to Earth.

Meteorological technician. A person who has successfully completed the requirements of the Basic Instruction Package for Meteorological Technicians.

Meteorologist. A person who has successfully completed the requirements of the Basic Instruction Package for Meteorologists at university degree level.

Mobile ship station. A station aboard a mobile ship.

National Meteorological Centre (NMC). A centre responsible for carrying out national functions including those under the World Weather Watch.

Near-polar orbiting satellite. A type of meteorological satellite with nearly circular, nearly polar orbit. The combination of satellite motion and the Earth's rotation beneath the orbit provides overlapping strips of satellite data covering swathes (of up to 3 000 km) from pole to pole. The satellite's altitude can be chosen within a wide range (between 600 and 1 500 km) in order to provide data over the entire globe twice a day.

Near-real-time observation. An observation that is available to a user soon after it has been completed.

Note: The time lags considered to be "real-time", "near-real-time" or "non-real-time" are different in different situations and depend on several factors. A near-real-time observation is essentially a real-time observation with an identifiable delay which reduces its value to some users.

Nephanalysis. The graphical depiction of analysed cloud data on a geographical map.

Non-real-time observation. An observation that is not available to a user immediately or soon after it has been completed, but some time later. It informs the user of conditions that prevailed at an earlier time.

Note: The time lags considered to be "real-time", "near-real-time" or "non-real-time" are different in different situations and depend on several factors such as the user application, the dissemination method, intervening quality control or other processing steps, the frequency and sampling time of the observation and the variability of the physical element observed.

Normals. Period averages computed for a uniform and relatively long period comprising at least three consecutive ten-year periods.

Observation. The evaluation of one or more elements of the physical environment.

Note: Observations are Level II data and may be obtained directly or derived, as defined in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.

Observational data. The result of the evaluation of one or more elements of the physical environment.

Observational metadata. Descriptive data about observational data: information that is needed to assess and interpret observations or to support design and management of observing systems and networks.

Observation network. One or more sensors, instruments or types of observation at more than one station or platform, acting together to provide a coordinated set of observations.

Observing station/platform. A place where observations are made; this refers to all types of observing station and platform, whether surface-based or space-based, on land, sea, lake or river, or in the air, fixed or mobile, and making in-situ or remote observations.

Note: The owner and operator of an observing platform may be a National Meteorological and/or Hydrological Service, another agency or organization (governmental, non-governmental or commercial) or an individual.

Observing (or Observation) system. A coordinated system of methods, techniques and facilities for making observations using one or more sensors, instruments or types of observation at one or more stations and platforms, acting together to provide a coordinated set of observations.

Ocean weather station. A station aboard a suitably equipped and staffed ship that endeavours to remain at a fixed sea position and that makes and reports surface and upper-air observations and may also make and report sub-surface observations.

Operational personnel. Personnel involved in the production and provision of services (for example, meteorological, hydrological, climatological and related services) and decision support information intended for users including the general public.

Ordinary radiation station. A radiation station whose observing programme includes at least the continuous recording of global solar radiation.

Note: The terminology of radiation quantities and measuring instruments is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No.8).

Period averages. Averages of climatological data computed for any period of at least ten years starting on 1 January of a year ending with the digit 1.

Permanent wilting point. The point reached by a plant when the moisture content of the soil is reduced and the plant wilts and does not recover its turgidity when placed in a humid atmosphere.

Principal radiation station. A radiation station whose observing programme includes at least the continuous recording of global solar radiation and of sky radiation, and regular measurements of direct solar radiation.

Prognosis. A representation of the future state of the atmosphere.

Note: This representation can be obtained from the integration of a numerical prediction model, from the judgment of a forecaster, or from any other appropriate method or combination of several methods.

Qualification. The minimum core knowledge, usually acquired through education, required to enter a profession.

Note: Qualifications are frequently based on successful completion of a formal course of study or examination through an institution endorsed for such purposes at the national level (for example, a university).

Real-time observation. An observation that is available to a user immediately after it has been completed. It informs the user of the current conditions.

Note: The time lags considered to be "real-time", "near-real-time" or "non-real-time" are different in different situations and depend on several factors such as the user application, the dissemination method, intervening quality control or other processing steps, the frequency and sampling time of the observation and the variability of the physical element observed.

Reanalysis data. Data obtained by reanalysis – a method for constructing a high-quality record of past climate conditions by combining observations with model information.

Reference climatological station. A climatological station whose data are used for determining climatic trends. This requires long periods (not less than thirty years) of homogeneous records, where man-made environmental changes have been and/or are expected to remain at a minimum. Ideally the records should be of sufficient length to enable the identification of secular changes of climate.

Regional Basic Climatological Network (RBCN). A network of climatological stations with a specified observational programme within a WMO Region. This is a minimum regional requirement to allow Members to fulfil their responsibilities within the World Weather Watch (WWW); it also serves as a target list for WWW monitoring of climatological data. The RBCN is based primarily on Regional Basic Synoptic Network stations and includes all GCOS Surface Network and GUAN stations.

Regional Basic Synoptic Network (RBSN). A network of synoptic stations with a specified observational programme within a WMO Region. This is a minimum regional requirement to allow Members to fulfil their responsibilities within the World Weather Watch and in the application of meteorology.

Regional Specialized Meteorological Centre (RSMC). A centre that specialises either in an activity or in a geographical area of the Global Data-processing and Forecasting System:

- (a) The Regional Specialized Meteorological Centre with activity specialization has the primary purpose of providing tailored-made products to service users in a particular area of activity;
- (b) The Regional Specialized Meteorological Centre with geographic specialization has the primary purpose of issuing meteorological analyses and prognoses on a regional scale for a specified geographical area.

Regional Training Centre (RTC). A national education and training institution, or group of institutions, recognized by Congress or the Executive Council (following recommendation of the relevant WMO regional association) as (a) providing education and training opportunities for WMO Members in the Region, particularly staff of National Meteorological and Hydrological Services; (b) providing advice and assistance on education and training to other WMO Members; and (c) promoting education and training opportunities in weather, water and climate for WMO Members.

Remote sensing. Observations made by a device that is not in physical or direct contact with the object or phenomenon under study.

Satellite system. A space system using one or more artificial satellites orbiting the Earth.

Sea station. An observing station situated at sea.

Selected ship station. A mobile ship station equipped with sufficient certified meteorological instruments for making observations, which transmits the required observational data in the appropriate code form.

Space-based subsystem. A complementary part of the Global Observing System composed of near-polar orbiting meteorological satellites and geostationary satellites.

Standard isobaric surface. An isobaric surface used on a worldwide basis for representing and analysing the conditions in the atmosphere.

Standard time of observation (Standard time). A time specified in Annex V (*Manual on the Global Observing System* (WMO-No.544)), Volume I, for making meteorological observations.

Supplementary ship station. A mobile ship station that is equipped with a limited number of certified meteorological instruments for making observations and that transmits the required observations in an abbreviated code form for ships.

Surface observation. An observation, other than an upper-air observation, made on the Earth's surface.

Synoptic observation. A surface or upper-air observation made at a standard time.

Synoptic station. An observing station where synoptic observations are made.

Upper-air observation. An observation made in the free atmosphere either directly or indirectly.

Upper-air synoptic station. A station where upper-air synoptic observations are made.

Weather chart. A geographical map on which meteorological conditions or elements are represented by figures, symbols or isopleths.

WMO observing station/platform. Any observing station/platform currently issued with a valid WMO identifier.

WMO observing system/observations network. An observing system/observations network consisting of WMO stations and platforms.

WMO observation. An observation made at a WMO observing station/platform.

World Meteorological Centre (WMC). A centre of the Global Data-processing and Forecasting System which has the primary purpose of issuing meteorological analyses and prognoses on a global scale.

World Weather Watch (WWW). The worldwide, coordinated, developing system of meteorological facilities and services provided by Members to ensure that all Members obtain the meteorological information they require both for operational work and for research. The essential elements of the World Weather Watch are: the Global Observing System, the Global Data-processing and Forecasting System, and the Global Telecommunication System.

PART I. THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM

1. INTRODUCTION TO THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM

1.1 Purpose and scope

1.1.1 The WMO Integrated Global Observing System (WIGOS) shall be a framework for all WMO observing systems and for WMO contributions to co-sponsored observing systems in support of all WMO Programmes and activities.

Note: The co-sponsored observing systems are the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS), all joint undertakings of WMO and the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the International Council for Science.

1.1.2 The WMO Integrated Global Observing System shall facilitate the use by WMO Members of observations from systems that are owned, managed and operated by a diverse array of organizations and programmes.

1.1.3 The principal purpose of WIGOS shall be to meet the evolving requirements of Members for observations.

Note: The assessment of requirements and plans to meet them come under the Rolling Review of Requirements (RRR) in accordance with Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), section 2.2.

1.1.4 Within WIGOS, Members shall collaborate to advance the state of observing systems, their compatibility and the worldwide exchange of observations.

Note: Additional benefits will emerge as the concept is adopted by entities beyond WMO and its partner organizations.

1.1.5 Members should enhance collaboration and cooperation amongst meteorological, hydrological, marine and oceanographic services and related academic and research institutions at the national level, in order to meet the goals listed in 1.1.3.

1.1.6 The WIGOS framework shall focus on the integration of governance and management functions, mechanisms and activities to be accomplished by contributing observing systems at a global, regional and national level.

1.2 WIGOS component observing systems

The component observing systems of WIGOS shall comprise the Global Observing System (GOS) of the World Weather Watch Programme, the observing component of the Global Atmosphere Watch (GAW) Programme, the WMO Hydrological Observing System (WHOS) of the Hydrology and Water Resources Programme and the observing component of the Global Cryosphere Watch (GCW), including their surface-based and space-based components.

Note: The above component systems include all WMO contributions to the co-sponsored systems, to the Global Framework for Climate Services (GFCS) and to the Global Earth Observation System of Systems (GEOSS).

1.2.1 **The Global Observing System of the World Weather Watch**

The Global Observing System shall be a coordinated system of networks of observing stations and platforms, including methods, techniques, facilities and arrangements for making observations on a worldwide scale and shall be one of the main components of the World Weather Watch Programme.

1.2.2 **The Global Atmosphere Watch (observing component)**

The Global Atmosphere Watch shall be a coordinated system of networks of observing stations, methods, techniques, facilities and arrangements encompassing the many monitoring activities and scientific assessments devoted to the investigation of the changing chemical composition and physical characteristics of the global atmosphere.

1.2.3 **The WMO Hydrological Observing System**

1.2.3.1 The WMO Hydrological Observing System (WHOS) shall comprise hydrological observations, initially focusing on water level and discharge, and shall include the World Hydrological Cycle Observing System (WHYCOS) which is intended to improve basic observation activities, strengthen international cooperation and promote the free exchange of data in the field of hydrology.

Note: The composition of WMO hydrological observations is provided in *Technical Regulations* (WMO-No. 49), Volume III – Hydrology, Chapter D.1.2.

1.2.3.2 The purpose of WHOS shall be to provide real-time streamflow data (both water level and discharge) from participating National Hydrological Services.

1.2.3.3 Members providing hydrological observations to the WHOS shall operate in accordance with the procedures and practices set out in the present volume, Part I, sections 2, 3, 4 and 7.

1.2.4 **The Global Cryosphere Watch (observing component)**

1.2.4.1 The Global Cryosphere Watch shall be a coordinated system of networks of observing stations, methods, techniques, facilities and arrangements encompassing monitoring activities and scientific assessments devoted to the investigation of the changing cryosphere.

1.2.4.2 The GCW observing network and its standardized core network (CryoNet) shall build on existing observing programmes and promote the addition of standardized cryospheric observations to existing facilities.

Notes:

1. For more information, see the GCW Implementation Plan available at: <http://globalcryospherewatch.org/reference/documents/>.
2. Existing cryosphere observing programmes include cryospheric observational programmes carried out within WMO such as those of the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology, the co-sponsored Programmes (GCOS, GTOS, GOOS), and observational programmes of the International Permafrost Association (IPA), the World Glacier Monitoring Service – a service of the International Association of Cryospheric Sciences, the Scientific Committee for Antarctic Research, the Global Precipitation Climatology Centre and the US National Snow and Ice Data Center.

1.3 **Collaboration with partners responsible for co-sponsored and non-WMO observing systems**

1.3.1 **Members shall support the collaboration between WMO and its international partners responsible for co-sponsored and non-WMO observing systems.**

1.3.2 **Members shall implement similar cooperation and coordination arrangements among National Meteorological and Hydrological Services (NMHSs) and through national mechanisms for GFCS, GCOS, GOOS, GTOS, and GEOSS.**

1.4 **Governance and management**

Note: The implementation of WIGOS is an integrating activity for all WMO and co-sponsored observing systems: it supports all WMO Programmes and activities. The Executive Council and regional associations, supported by their respective working bodies, have a governing role in the implementation of WIGOS. Technical aspects of WIGOS implementation are guided by the technical commissions, with leadership provided through the Commission for Basic Systems and the Commission for Instruments and Methods of Observation.

Members shall implement and manage their national observing systems in accordance with the provisions laid out in this Volume, Part I, and in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

2. **COMMON ATTRIBUTES OF WIGOS COMPONENT SYSTEMS**

2.1 **Requirements**

2.1.1 **Members shall establish, operate and maintain their national observing systems to address observational requirements in an integrated, coordinated and sustainable manner.**

2.1.2 **Members shall convey their user observational requirements, for each of the WMO application areas, to the Rolling Review of Requirements.**

Note: Details of the RRR process and the WMO application areas are given in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), section 2.2 and Appendix 2.3.

2.2 **Design, planning and evolution**

2.2.1 **Members, both directly and through the participation of their experts in the activities of regional associations and technical commissions, shall contribute to the RRR process.**

2.2.2 **Members should implement the plans published by WMO for evolution of WIGOS component observing systems when planning and managing their observing systems.**

2.2.3 **Members shall maintain close coordination with their national telecommunication authorities to register their frequencies for adequate protection and to defend the availability of frequencies for all WIGOS component observing systems.**

2.3 **Instrumentation and methods of observation**

Note: Standard and recommended practices and procedures with respect to instruments and methods of observation across and within all WIGOS component observing systems are specified in the *Technical Regulations* (WMO-No. 49), Volumes I–III, and detailed in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No.1160)).

2.4 **Operations**

2.4.1 **General requirements**

2.4.1.1 **Members shall install, operate and maintain their WIGOS component observing systems in accordance with the *Technical Regulations* (WMO-No. 49), Volumes I–IV, and Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).**

2.4.1.2 **Members shall ensure the continuity of operation and availability of observations generated by the observing systems under their responsibility.**

2.4.1.3 **Members shall ensure that proper safety practices and procedures for operation of observing systems are specified, documented and utilized.**

Note: Safety practices and procedures are concerned with ensuring the welfare of staff while promoting overall efficiency and effectiveness of the NMHS and respond to national laws, regulations and requirements for occupational health and safety.

2.4.2 **Observations**

2.4.2.1 **Members shall ensure overall availability of observations for all WMO application areas in accordance with the Regulations laid out in this Volume and in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).**

Notes:

1. The WMO application areas are detailed in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), Appendix 2.3.
2. Special emphasis should be placed on meeting the requirements of numerical weather prediction since many application areas depend on it.
3. Special attention should be paid to climate monitoring, including the observational requirements of the GFCS, which is one of the priority areas for WMO.

2.4.2.2 **Members should ensure timely, quality-assured, quality-controlled and well-documented, compatible long-term observations in accordance with the practices and procedures specified in these *Technical Regulations* and in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).**

Note: Technical specifications and details are given mainly in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), *Guide to Climatological Practices* (WMO-No. 100), *Guide to Hydrological Practices* (WMO-No. 168), Volume I, *Guide on the Global Data-processing System* (WMO-No. 305) and *Guide to the Global Observing System* (WMO-No. 488).

2.4.3 **Performance**

2.4.3.1 **Members shall continuously monitor the performance of their observing systems.**

2.4.3.2 **Members should maintain records of the performance monitoring as part of their Quality Management System, for auditing purposes, where appropriate, in accordance with section 2.6 of these *Technical Regulations* and Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).**

Note: Technical specifications and details are given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), *Guide to Climatological Practices* (WMO-No. 100), *Guide to Hydrological Practices* (WMO-No. 168), Volume I, and *Guide to the Global Observing System* (WMO-No. 488).

2.4.4 **Quality control**

2.4.4.1 **Members shall implement quality control for all observations for which they are responsible.**

Note: Minimum standards of quality control for meteorological data are specified in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.

2.4.4.2 Members not able to implement quality control should establish agreements with an appropriate national, regional or global organization or centre to perform the necessary quality control.

2.4.5 **Calibration**

Members shall perform calibration of their systems and instruments traceable to an international standard in accordance with Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

2.5 **Observational metadata**

Members shall record, retain and make available internationally the observational metadata as specified in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), section 2.5.

2.6 **Quality management**

With regard to the quality of WIGOS observations and observational metadata, Members shall comply with the standard and recommended practices and procedures detailed in this Volume and in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

2.7 **Capacity development**

2.7.1 **General**

Members should undertake capacity development to ensure that their observing systems comply with the standard and recommended practices and procedures specified in these *Technical Regulations*.

Note: Guidance on approaches to capacity development can be found in *WMO Capacity Development Strategy and Implementation Plan* (WMO-No. 1133). Such guidance includes consideration of institutional, infrastructural and procedural capacity and human resources.

2.7.2 **Training**

Members shall ensure that their personnel involved in carrying out WIGOS-related activities are educated and trained to comply with the WIGOS standard and recommended practices and procedures.

Note: Extensive provisions applicable to the education and training of personnel are defined in Part V and Part VI of these *Technical Regulations* and in the *Guide to the Implementation of Education and Training Standards in Meteorology and Hydrology* (WMO-No. 1083), Volume I.

2.7.3 **Infrastructural capacity development**

Members should regularly review their observing infrastructure and pursue capacity development activities to upgrade it, as required, to address the priorities for evolution of observing systems identified through the RRR process as well as any additional national priorities.

Note: Details on the RRR process, the WMO application areas and the resulting priorities for evolution of observing systems are given in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), section 2.2 and Appendix 2.3.

3. **ATTRIBUTES SPECIFIC TO THE SURFACE-BASED SUBSYSTEM OF WIGOS**

3.1 **Requirements**

3.1.1 **General**

3.1.1.1 The WIGOS surface-based subsystem shall be composed of stations and platforms within the component networks (i.e. GOS, GAW, GCW and WHOS) as described in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

3.1.1.2 Members should establish and operate their surface-based subsystem as a single composite system of observing stations and platforms.

3.1.2 **Observational requirements**

Members shall establish, operate and maintain surface-based observing systems to meet the requirements of the WMO application areas, in accordance with Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), section 2.1.

3.2 **Design, planning and evolution**

3.2.1 **General**

3.2.1.1 Members shall plan, implement, operate and maintain national networks and observing programmes based on the standard and recommended practices and procedures as stated in the WMO Technical Regulations, including Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

Note: Members are urged to take into account various plans and strategies developed by WMO for WIGOS and its component observing systems.

3.2.1.2 Members should cooperate to address regional implementation of observing networks or systems.

3.2.1.3 Members should adopt a composite network approach to their networks and include observations from a range of sources, including NMHSs and other government agencies, academic and research institutes, the commercial sector and the public.

Notes:

1. A composite network approach here means the use of various types of observing system or source of observations to deliver a combined set of observations.
2. In all cases users are to judge the suitability of observations for their intended application through assessment of available metadata, which includes the identification of the source. Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), section 2.5, describes the required metadata.

3.3 **Instrumentation and methods of observation**

Note: Standard and recommended practices and procedures with respect to instruments and methods of observation for all WIGOS surface-based subsystems are specified in *Technical Regulations*, Volumes I–III, and detailed in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

3.4 **Operations**

Members should ensure that operators of observing systems comply with the *Technical Regulations*, Volumes I–IV, and Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

Note: System operators are generally, but not always, NMHSs or other organizations within WMO Member countries.

4. **ATTRIBUTES SPECIFIC TO THE SPACE-BASED SUBSYSTEM OF WIGOS**

4.1 **Scope, purpose and operation of the space-based subsystem**

4.1.1 **General**

Note: Space-based observations, that is to say data obtained from satellite systems, are a fundamental asset for meteorology, climatology and hydrology, for both operational and research applications.

4.1.2 **Observational requirements**

4.1.2.1 Satellite operators shall establish, operate, maintain and ensure the continuation of satellite systems, providing observational information as specified in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

Notes:

1. The term “satellite operators” is used in this Volume to refer to Members or a coordinated group of Members operating environmental satellites.
2. A coordinated group of Members operating environmental satellites is a group of Members acting jointly to operate one or more satellites through an international space agency such as the European Space Agency or the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT).

4.1.2.2 To ensure global coverage and contingency support, and to meet further requirements, as stated in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), satellite operators shall cooperate and arrange an optimal constellation of satellite systems, including but not restricted to near-polar-orbiting and geostationary platforms.

Note: These requirements are compiled through the RRR process (see the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), section 2.2) and are expressed in terms of coverage, continuity, resolution, uncertainty, frequency and observational variables.

4.1.2.3 Satellite operators shall process observational data as specified in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)) and shall do so in a timely manner for dissemination in near-real time.

4.1.2.4 Satellite operators shall report data as observed variables, defined in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), expressed in environmental quantities in accordance with the International System of Units (SI) standards.

5. **ATTRIBUTES SPECIFIC TO THE GLOBAL OBSERVING SYSTEM OF THE WORLD WEATHER WATCH**

5.1 The purpose of GOS shall be to provide the meteorological and related environmental observations from all parts of the globe that are required by Members for operational and research purposes.

5.2 The Global Observing System shall be a coordinated system of methods, techniques and facilities for making observations on a worldwide scale and shall be one of the main components of the World Weather Watch.

5.3 The Global Observing System shall be composed of integrated subsystems: the surface-based subsystem and the space-based subsystem.

5.4 The surface-based subsystem shall be composed of the Regional Basic Synoptic Networks (RBSNs) and the Antarctic Observing Network of surface and upper-air stations; climatological stations; Global Climate Observing System stations; aircraft meteorological stations; and other types of station and special station, as detailed in Annex V (*Manual on the Global Observing System* (WMO-No. 544)), Volume I.

5.5 The space-based subsystem shall be composed of three elements: (a) a space segment with: (i) operational satellites on geostationary Earth orbit; (ii) operational satellites on distributed, sun-synchronous, low Earth orbits; (iii) other operational or sustained satellites or instruments on appropriate orbits; and (iv) research and development satellites; (b) an associated ground segment for data reception, dissemination and stewardship; and (c) a user segment.

5.6 The Global Observing System shall be established and operated in accordance with the provisions set out in Annex V (*Manual on the Global Observing System* (WMO-No. 544)), Volume I; Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)); and in the *International Cloud Atlas* (WMO-No. 407), Volume I.

6. **ATTRIBUTES SPECIFIC TO THE OBSERVING COMPONENT OF THE GLOBAL ATMOSPHERE WATCH**

6.1 The purpose of GAW shall be to:

- (a) Reduce environmental risks to society and meet the requirements of environmental conventions;
- (b) Strengthen capabilities to predict climate, weather and air quality;
- (c) Contribute to scientific assessments in support of environmental policy;

through:

- (a) Maintaining and applying global, long-term observations of the chemical composition and selected physical characteristics of the atmosphere;
- (b) Emphasizing quality assurance and quality control;
- (c) Delivering integrated products and services of relevance to users.

6.2 The GAW observational network shall be developed and implemented in accordance with the provisions set out in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

6.3 The GAW observations shall be carried out in accordance with the provisions set out in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)) and Annex V (*Manual on the Global Observing System* (WMO-No. 544)), Volume I.

Notes:

1. Members may perform observations of any of the parameters included in the GAW focal areas: ozone, greenhouse gases, reactive gases, aerosols, UV radiation and precipitation chemistry, using observation modes such as in situ observation, vertical distribution and total column.
2. Members may use different platforms or their combinations, for example, fixed stations, mobile platforms and remote sensing to perform atmospheric composition measurements.

6.4 Members shall register their contribution in the GAW Station Information System (GAWSIS) and submit their observations to the relevant GAW Data Centre.

Note: The GAW Data Centres are listed at: <http://www.wmo.int/gaw> and <http://gaw.empa.ch/gawsis>.

7. ATTRIBUTES SPECIFIC TO THE WMO HYDROLOGICAL OBSERVING SYSTEM

7.1 The purpose of WHOS shall be to provide the hydrological observing component in fulfilment of the WIGOS objective by facilitating online access to already available real-time and historical data, drawing from the water information systems of Members that make their data available on a free and unrestricted basis.

7.2 The WMO Hydrological Observing System shall be a coordinated system of methods, techniques and facilities for making hydrological observations on a worldwide scale.

Note: The WMO Hydrological Observing System is currently under development, hence not yet operational.

7.3 The WMO Hydrological Observing System and the practice of obtaining hydrological observations shall be developed and implemented in accordance with the provisions set out in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

8. ATTRIBUTES SPECIFIC TO THE OBSERVING COMPONENT OF THE GLOBAL CRYOSPHERE WATCH

8.1 The purpose of the GCW shall be to provide data and other information on the cryosphere, from the local to the global scale, to improve understanding of its behaviour, interactions with other components of the climate system and impacts on society.

8.2 The observing component of the GCW shall be a coordinated system of observing stations, facilities and arrangements encompassing monitoring and related scientific assessments devoted to the cryosphere.

8.3 The development of the GCW observing network and its core network (CryoNet) that applies GCW agreed practices and standards shall build on existing observing programmes and promote the addition of standardized cryospheric observations to existing facilities.

8.4 The GCW observing network shall be developed and implemented in accordance with the provisions set out in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

Notes:

1. Members may perform observations of any of the parameters describing the state of the GCW cryospheric components (snow, solid precipitation, permafrost, glaciers and ice caps, ice sheets, sea ice, and lake and river ice).
2. Members may use different platforms or their combinations (fixed stations, mobile platforms, virtual sites and remote sensing) to perform cryospheric measurements.

8.5 Members shall register all stations and platforms that provide GCW observations in the GCW station information system on the GCW website (www.globalcryospherewatch.org), and submit those observations to the GCW portal.

PART II. THE WMO INFORMATION SYSTEM

1. INTRODUCTION TO THE WMO INFORMATION SYSTEM

1.1 Purpose and scope

Note: WMO recognizes that its mission in weather, climate, water and related environmental issues depends upon the collection, distribution and open sharing of information, often using rapid and highly reliable methods. The WMO Information System is a key tool for optimizing the efficiency and effectiveness of WMO.

1.1.1 The WMO Information System shall:

- (a) Be used for the collection and sharing of information for all WMO and related international programmes;**
- (b) Provide a flexible and extensible data management and data communication structure that allows the participating centres to enhance their capabilities as their national and international responsibilities grow;**
- (c) Make use of international standards for relevant practices, procedures and specifications.**

1.1.2 The basic engineering principles adopted for the WMO Information System data communication networks shall provide for the integration of global, regional and national data communication systems to ensure transmission of the required information within the specified acceptable time delays.

1.2 Organization

1.2.1 The WMO Information System shall be organized primarily by data management functions and shall also incorporate the required information exchange functions. The WMO Global Telecommunication System shall be incorporated into the WMO Information System and be operated as part of it.

1.2.2 Centres participating in the WMO Information System shall be categorized as follows:

- (a) Global Information System Centres;**
- (b) Data Collection or Production Centres;**
- (c) National Centres.**

1.2.3 On the basis of the recommendations of the Commission for Basic Systems, coordinated with relevant technical commissions and regional associations, as appropriate, the Congress and Executive Council shall:

- (a) Consider the designation of Global Information System Centres and Data Collection or Production Centres;**
- (b) Regularly review previously designated Global Information System Centres and Data Collection or Production Centres, and reconsider their designation.**

1.2.4 Members shall designate National Centres.

1.2.5 The WMO Information System functions and operation shall be based on catalogues that contain metadata for data and products available across WMO, and metadata describing dissemination and access options. These catalogues shall be maintained by WMO Information System Centres.

1.2.6 Members operating Global Information System Centres shall:

- (a) Provide comprehensive search of catalogues, through collaboration amongst all Global Information System Centres;
- (b) Provide access to and disseminate WMO data and products intended for global exchange;
- (c) Be associated with Data Collection or Production Centres and National Centres within their area of responsibility.

1.2.7 Members operating Data Collection or Production Centres shall:

- (a) Use WMO Information System to collect, disseminate, provide access to and store relevant regional or programme-specific data and products;
- (b) Maintain catalogues of their holdings and services, and provide appropriate parts of these catalogues to the Global Information System Centres to ensure a comprehensive catalogue of WMO Information System holdings.

1.2.8 Members operating National Centres shall:

- (a) Use the WMO Information System to provide data and products in accordance with their programme responsibilities;
- (b) Provide associated metadata to other WMO Information System Centres as part of the comprehensive catalogue of WMO Information System holdings.

1.2.9 Members operating Global Information System Centres, Data Collection or Production Centres and National Centres shall monitor the performance of the WMO Information System.

1.2.10 The WMO Information System shall feature data communication network management that includes dedicated data network services, especially for mission-critical information exchange, and public data network services such as the Internet, to ensure the efficiency and effectiveness of the required information exchange.

1.3 **Responsibilities**

1.3.1 Members operating Global Information System Centres, Data Collection or Production Centres, and National Centres shall ensure that all appropriate measures are taken for the installation and good functioning of their centres and of the required data communication systems and services, in relation to their needs and the roles which they have accepted.

1.3.2 Members shall ensure that their national information collecting systems allow not only national but also international needs to be met.

1.4 **Practices, procedures and specifications**

1.4.1 The WMO Information System data management and information exchange functions shall be established and operated in accordance with the practices, procedures and specifications set out in Annex VII (*Manual on the WMO Information System* (WMO-No. 1060)).

1.4.2 The Global Telecommunication System shall be operated in accordance with the practices, procedures and specifications set out in Annex III (*Manual on the Global Telecommunication System* (WMO-No. 386)).

Note: The *Manual on the WMO Information System* (WMO-No. 1060) complements the *Manual on the Global Telecommunication System* (WMO-No. 386). The latter will eventually be replaced by the *Manual on the WMO Information System* which will incorporate the relevant material.

2. INTERNATIONAL DATA REPRESENTATION AND CODES

2.1 General – Code forms

Coded information exchanged for international purposes shall be in the appropriate international code forms specified in Annex II (*Manual on Codes* (WMO-No. 306)), Volume I.

Note: Coded information intended exclusively for exchange between two Members may be in other forms by bilateral agreement.

2.2 Symbolic words, groups and letters

2.2.1 The symbolic words, groups and letters (or groups of letters) used in international code forms and their meanings or specifications shall be as given in Annex II (*Manual on Codes* (WMO-No. 306)), Volume I.

2.2.2 Symbolic words, groups and letters (or groups of letters) required for regional or national purposes only shall be selected so as not to duplicate those used in international code forms.

2.3 Code figures

Specifications of code figures (code tables) used in international code forms specified in in this Part, under section 2.1 shall be as given in Annex II (*Manual on Codes* (WMO-No. 306)), Volume I.

PART III. DATA PROCESSING AND FORECASTING

1. GLOBAL DATA-PROCESSING AND FORECASTING SYSTEM

1.1 Organization and functions of the Global Data-processing and Forecasting System

1.1.1 General

1.1.1.1 The Global Data-processing and Forecasting System shall include World Meteorological Centres, Regional Specialized Meteorological Centres and National Meteorological Centres.

1.1.1.2 Members that have accepted the responsibility of establishing and operating World Meteorological Centres and Regional Specialized Meteorological Centres specified in the World Weather Watch plan shall:

- (a) Prepare and make available to other Members processed meteorological information;
- (b) Archive and process data for research and applications;
- (c) Provide opportunities for training, conducting of both basic and applied research and publishing of selected data.

1.1.1.3 The Global Data-processing and Forecasting System shall be established and operated in accordance with procedures and practices set out in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.

1.1.2 Functions of centres

Real-time and non-real-time functions of World Meteorological Centres, Regional Specialized Meteorological Centres and National Meteorological Centres should be as given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.

1.2 Analysis and forecasting practices

1.2.1 General – Constants, definitions and specifications

1.2.1.1 If the formula for a function or the value of a constant is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8), Members shall use that formula or value, when required, for meteorological purposes.

1.2.1.2 Each Member shall use the definitions and specifications of water vapour in the atmosphere given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8).

1.2.2 Units

1.2.2.1 Members should use the International System of Units (SI), as defined by the International Organization for Standardization (ISO), in scientific publications and documents, except where otherwise indicated by WMO or ICAO.

Note: Guidance on the use of these units is given by ISO.

1.2.2.2 The hectopascal shall be used as the unit of atmospheric pressure for both the operational and research work of WMO.

1.2.3 **Standard atmosphere**

Members should use as the standard atmosphere that which has been defined by ISO and specified in ISO 2533.

1.2.4 **Weather charts – Projections, scales and symbols**

1.2.4.1 Appropriate projections and scales along the standard parallels used for weather charts should be as given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.

1.2.4.2 The symbols used on weather charts for the pictorial representation of observed data and for analysis and prognosis should be those set out in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I, Appendix II.4.

1.2.5 **Properties of aerological diagrams – General requirements**

1.2.5.1 Diagrams used for representation and analysis of upper-air observations of pressure, temperature and humidity should be as given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.

1.2.5.2 Diagrams used for the accurate computation of geopotential from upper-air observations of pressure, temperature and humidity should possess the features given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.

1.2.6 **Upper-air analyses – Reference surfaces**

1.2.6.1 Rules and procedures for representing and analysing the conditions in the free atmosphere, including standard isobaric surfaces to be used (except above 100 hPa), shall be as given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.

1.2.6.2 The standard isobaric surfaces for representing and analysing the conditions in the atmosphere above 100 hPa should be as given in Annex IV (*Manual on the Global Data-processing and Forecasting System* (WMO-No. 485)), Volume I.

1.2.7 **General – Publication of synoptic observations**

Each Member should publish, with as little delay as possible, a daily or monthly bulletin consisting, if so desired, of reports in the international code form, including:

- (a) Reports made at main standard times by its surface land stations included in the RBSN, or a selection of them if the network is dense;
 - (b) Reports from all its upper-air stations;
 - (c) Reports from sea stations, or a selection of them if the network is dense.
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PART IV. METEOROLOGICAL, HYDROLOGICAL AND CLIMATOLOGICAL SERVICES

1. METEOROLOGICAL SERVICES FOR MARINE ACTIVITIES

Note: Detailed guidance is given in the *Guide to Marine Meteorological Services* (WMO-No. 471).

1.1 General

1.1.1 Members shall provide, to the extent possible, marine meteorological, climatological and other related geophysical information for all activities on the high seas, in offshore and coastal areas and in main ports and harbour areas, required for the safety of life and for the promotion of efficiency and economy of marine operations.

1.1.2 The marine meteorological and related geophysical information shall be provided in accordance with internationally or regionally established procedures, in order to achieve the required uniformity.

1.2 Marine meteorological services for the high seas

Note: In this context, the term "high seas" applies to open oceans or sea areas for which Members bear the responsibility of issuing weather and sea bulletins, governed by the procedures given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I, Part I.

1.2.1 General responsibilities

1.2.1.1 For the regular issuing of warnings, synopses and forecasts for shipping, fishing and other marine activities in the high seas, Members shall establish defined geographical areas of responsibility to ensure complete coverage of these services.

1.2.1.2 Geographical areas of responsibility and procedures concerning their allocation shall be as given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I.

1.2.1.3 Members having accepted the responsibility of issuing marine meteorological information for the high seas shall:

- (a) Issue weather and sea bulletins comprising warnings, synopses and forecasts, for the areas for which they have assumed responsibility;
- (b) Provide, in addition to the regular weather and sea bulletins, sea ice information and forecasts and, to the extent possible, other marine meteorological information, as required, for the areas for which they have assumed responsibility;
- (c) Maintain a close liaison with users in order to ensure that the information provided meets user requirements.

Note: Details concerning the action to be taken in the case of discontinuance of weather and sea bulletins are given in the *Guide to Marine Meteorological Services* (WMO-No. 471).

1.2.2 **Provision of weather and sea bulletins**

International procedures concerning the form, content and issue of weather and sea bulletins, comprising warnings, synopses and forecasts, shall be as given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I.

1.2.3 **Marine meteorological support to maritime search and rescue**

1.2.3.1 Members shall arrange to provide, to the extent possible, any marine meteorological information requested by a Rescue Coordination Centre.

1.2.3.2 Marine meteorological services to maritime search and rescue shall be as given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I.

1.2.4 **Provision of information by radio-facsimile**

1.2.4.1 Members should endeavour to issue radio-facsimile charts containing marine meteorological information and covering areas of interest to mariners.

1.2.4.2 Members issuing radio-facsimile charts for marine use shall ensure that these charts as regards projection, scale, symbols and information content meet the requirements as given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I.

1.2.5 **Marine Climatological Summary Scheme**

1.2.5.1 Members operating fixed ship stations and selected, supplementary and auxiliary ship stations should ensure that all surface observations from these stations are put on magnetic tape in accordance with the layout of the international maritime meteorological tape format and despatched at quarterly intervals to the Members (Global Collection Centres) that have accepted the responsibility for processing these data.

1.2.5.2 Members having accepted the responsibility for the preparation of yearly marine climatological summaries, for a number of selected representative areas in their area of responsibility, shall make these summaries available in the internationally agreed formats.

1.2.5.3 Procedures for international arrangements for the Marine Climatological Summary Scheme shall be as given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I.

1.2.6 **Special marine climatological information**

1.2.6.1 Members operating fixed ship stations and selected, supplementary and auxiliary ship stations should arrange through cooperative action for the provision of climatological information on the occurrence and magnitude of special phenomena of importance to the safety of marine operations, such as sea ice, ocean waves and ocean currents as well as information on factors relevant to the preservation of the marine environment, such as floating pollutants, oil films and slicks.

1.2.6.2 Procedures for international arrangements regarding the collection, storage and eventual processing of observations of specified phenomena shall be as given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I.

1.2.7 **Provision of marine meteorological information and expert advice**

1.2.7.1 Members should arrange for the provision, on request, of meteorological and related oceanographic information and expert advice on the use and interpretation of marine meteorological data for special applications such as marine engineering or marine operational planning, and for questions requiring marine meteorological expertise.

1.2.7.2 **Procedures for the provision of marine meteorological information and expert advice shall be as given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I.**

1.3 **Marine meteorological services for coastal and offshore areas**

Note: In this context, the term “coastal and offshore areas” applies to areas for which Members issue weather and sea bulletins, governed by the procedures given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I, Part II.

1.3.1 **International responsibilities**

1.3.1.1 **Members shall issue warnings, synopses and forecasts for general use in international marine activities, such as shipping, in coastal and offshore areas.**

1.3.1.2 **Procedures for the provision of marine meteorological services for international activities in coastal and offshore areas shall be as given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I.**

1.3.2 **Regional cooperation**

In servicing coastal or offshore activities that are of interest to more than one country bordering the same sea basin, Members should arrange for mutual exchange of marine meteorological information including observational data, warnings and forecasts that might contribute in any way to the safety of human life and preservation of the marine environment.

1.3.3 **National responsibilities**

Services provided in response to national requirements should follow, as far as possible, international procedures.

Note: Requirements for services and possible ways of implementation are given in the *Guide to Marine Meteorological Services* (WMO-No. 471).

1.4 **Marine meteorological services for main ports and harbour areas**

Note: In this context, the term “main ports and harbour areas” applies to areas for which Members issue port weather and sea bulletins, governed by the procedures given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I, Part III.

1.4.1 **International responsibilities**

1.4.1.1 **Members should arrange for marine meteorological services based on international procedures to be provided for main ports frequented by international shipping.**

1.4.1.2 **Members establishing marine meteorological services shall designate forecasting offices or facilities responsible for the provision of services for main ports and harbour areas.**

1.4.1.3 **International procedures for marine meteorological services for main ports and harbour areas shall be as given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I.**

1.4.2 **General services**

1.4.2.1 **Members shall issue warnings, synopses and forecasts, where appropriate and to the extent possible, for main ports and harbour areas.**

1.4.2.2 Members establishing marine meteorological services for main ports and harbour areas should:

- (a) Make available facilities for the provision of oral briefings;
- (b) Arrange for the provision of climatological information pertaining to the port or harbour areas;
- (c) Maintain a close liaison with users in order to ensure that the information provided meets user requirements.

1.4.3 **Port meteorological officer services**

Port meteorological officer services shall include at least those specified in Annex V (*Manual on the Global Observing System* (WMO-No. 544)), Volume I, Part III.

1.5 **Training in marine meteorology**

1.5.1 **General**

1.5.1.1 Members supplying marine meteorological services should provide opportunities for training of meteorological personnel in marine meteorology and relevant subjects of physical oceanography.

1.5.1.2 **Members concerned shall ensure that attention is given to meteorology in their navigation schools, taking into account international requirements and recommendations with respect to the training and certification of seafarers.**

1.5.1.3 **Members concerned shall provide facilities for the training in marine meteorology of port meteorological officers, seafarers whilst at sea and marine observers on board ships.**

1.5.1.4 **Procedures for training in marine meteorology shall be as given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I.**

2. METEOROLOGICAL SERVICES FOR AGRICULTURE

Note: In addition to the regulations contained in this chapter, detailed advice is given in the *Guide to Agricultural Meteorological Practices* (WMO-No. 134).

2.1 Presentation of agricultural meteorological data

2.1.1 Publication of agricultural meteorological data

2.1.1.1 Each Member should periodically publish its agricultural meteorological data, when the need for this information is not met by other climatological publications, and should make them available to users.

2.1.1.2 Published agricultural meteorological data should include the following:

- (a) Frequency, duration and threshold values of the different elements;
- (b) Mean values and such statistical parameters (standard deviation, mean error, quintiles, etc.) as are necessary for determining the probability of different values.

2.1.1.3 Published soil-temperature data should include information concerning:

- (a) Soil type;
- (b) Soil cover and surface management;
- (c) Degree and direction of slope of ground.

Whenever possible, the following information should also be included with published soil-temperature data:

- (a) Physical soil constants such as bulk density, thermal conductivity at field capacity and moisture content at field capacity;
- (b) Level of water table if it is within five metres of the surface.

2.1.1.4 When soil-moisture data are published, the following information should be given:

- (a) Soil type;
- (b) Soil cover;
- (c) Physical constants of the soil, including bulk density, moisture content at field capacity and moisture content at permanent wilting point.

2.1.1.5 Published potential or actual evapotranspiration data should include:

- (a) Short description of equipment or method used;
- (b) Type of soil in the area of observation;
- (c) Vegetation cover and surrounding conditions.

2.2 **Agricultural meteorological reports**

2.2.1 ***Crop-weather reports***

2.2.1.1 Members should arrange for reports on weather development and state of crops and pastures (crop-weather reports) to be prepared and issued at intervals of five, seven or ten days, or at longer intervals, as convenient.

2.2.1.2 The contents of crop-weather reports should include the following:

- (a) State of development and prospects of principal crops;
- (b) Favourable and unfavourable weather factors;
- (c) Data on significant meteorological elements or derived parameters.

2.3 **Forecasts for agriculture**

2.3.1 ***Forecasting programme***

2.3.1.1 Members should ensure that special forecasts are issued for agricultural purposes.

2.3.1.2 The forecasting programme for agricultural purposes should include:

- (a) Regular and detailed forecasts for agriculturists and foresters and seasonal to interannual predictions of the likelihood of climatic anomalies, including temperature, rainfall and other climate variables, specifying local variations in weather to the greatest possible extent;
- (b) Forecasts related to the selection of the most favourable weather conditions for preparing the soil, planting, cultivating and harvesting crops, and for other agricultural operations;
- (c) Forecasts for the control of crop and animal pests and diseases;
- (d) Warnings of hazardous weather conditions such as hail, frost, droughts, floods, gales, tornadoes and tropical cyclones.

3. **METEOROLOGICAL SERVICES FOR INTERNATIONAL AIR NAVIGATION**

Note: Regulations concerning meteorological services for international air navigation are to be found in *Technical Regulations* (WMO-No. 49), Volume II.

4. **HYDROLOGICAL SERVICES**

Note: Regulations concerning hydrological services are to be found in *Technical Regulations* (WMO-No. 49), Volume III (currently under review by the Commission for Hydrology).

PART V. QUALIFICATIONS AND COMPETENCIES OF PERSONNEL INVOLVED IN THE PROVISION OF METEOROLOGICAL (WEATHER AND CLIMATE) AND HYDROLOGICAL SERVICES

1. QUALIFICATIONS AND COMPETENCIES

1.1 General

1.1.1 The qualifications and competencies required of personnel involved in the provision of (operational) meteorological, hydrological, climatological and related services should be as described below, in sections 1.2–1.5.

Notes:

1. A specific qualification is typically acquired once and remains valid throughout a person's career.
2. Qualifications and competencies for personnel in additional service areas will be developed in due course and subsequently included in this chapter.

1.1.2 Members should keep records of the qualifications of all personnel involved in the provision of (operational) meteorological, hydrological, climatological and/or related services.

1.1.3 Members should decide, in light of their national circumstances, whether higher or more specific qualification requirements than those described below should be established for certain categories of operational personnel.

1.1.4 Competency should be demonstrated through job performance and assessed through competency assessment procedures, as appropriate.

Note: Guidance on competency development and assessment procedures is provided in *Guide to the Development and Implementation of Competency-based Frameworks in Support of Meteorological, Hydrological and Climatological Services* (in preparation).

1.1.5 Members should establish competency assessment programmes for different categories of operational personnel; competency assessments should be repeated at regular intervals defined by the quality management practice of each Member.

1.1.6 Members should implement WMO global-level competency provisions taking due account of their local conditions, regulations, requirements and procedures.

1.1.7 Members should ensure that their operational personnel undertake continuous professional development to maintain competence.

1.2 Personnel providing aeronautical meteorological services

1.2.1 Qualifications

1.2.1.1 Members, taking into consideration the area and airspace of responsibility; the impact of meteorological phenomena and parameters on aviation operations; aviation user requirements; international regulations and local procedures and priorities, should ensure that an Aeronautical Meteorological Forecaster has successfully completed the Basic Instruction Package for Meteorologists as defined in [Appendix A](#).

Note: This provision, which defines the required qualifications, will become a standard practice on 1 December 2016.

1.2.1.2 Members should decide whether their national circumstances require specific qualifications of Aeronautical Meteorological Observers.

1.2.2 **Competencies**

Note: The competency standards for aeronautical meteorological personnel are maintained by the Commission for Aeronautical Meteorology.

1.2.2.1 **Members shall ensure that for the area and airspace of responsibility, given the impact of meteorological phenomena and parameters on aviation operations, and in compliance with aviation user requirements, international regulations and local procedures and priorities, an Aeronautical Meteorological Forecaster is able to:**

- (a) Analyse and monitor continually the weather situation;
- (b) Forecast aeronautical meteorological phenomena and parameters;
- (c) Warn of hazardous phenomena;
- (d) Ensure the quality of meteorological information and services;
- (e) Communicate meteorological information to internal and external users.

1.2.2.2 **Members shall ensure that for the area and airspace of responsibility, given the impact of meteorological phenomena and parameters on aviation operations, and in compliance with aviation user requirements, international regulations and local procedures and priorities, an Aeronautical Meteorological Observer is able to:**

- (a) Monitor continually the weather situation;
- (b) Observe and record aeronautical meteorological phenomena and parameters;
- (c) Ensure the quality of system performance and of meteorological information;
- (d) Communicate meteorological information to internal and external users.

1.3 **Personnel providing education and training for meteorological, hydrological and climate services**

1.3.1 **Qualifications**

Members should define, in light of their national circumstances, the specific qualifications required of personnel providing education and training in meteorology, hydrology and climatology.

1.3.2 **Competencies**

Note: The Competency Standards for Providers of Education and Training for Meteorological, Hydrological and Climate Services (March, 2014) are maintained by the Executive Council Panel of Experts on Education and Training.

Members should ensure that institutions providing education and training for meteorological, hydrological and climate services have the personnel and resources to:

- (a) Analyse the organizational context and manage the training processes;
- (b) Identify learning needs and specify learning outcomes;

- (c) Determine a learning solution;
- (d) Design and develop learning activities and resources;
- (e) Deliver training and manage the learning event;
- (f) Assess learning and evaluate the learning process.

Note: The performance criteria and knowledge requirements that support the competencies should be customized based on the particular context of an organization.

1.4 **Personnel supporting the WMO Information System**

The competency framework for personnel supporting the WMO Information System can be found in the *Manual on the WMO Information System* (WMO-No. 1060), Appendix E, and in the *Guide to the WMO Information System* (WMO-No. 1061).

1.5 **Personnel providing climate services**

In a given institution, the list of the competencies to be met and the associated performance criteria would be determined by its infrastructural capacity. Competencies falling in the areas of quality of climate information and services as well as communication of climatological information to users are considered cross-cutting and should be met, at least at basic levels, by all institutions providing climate services.

Note: The competency framework is conditioned by:

- (a) The organizational mission and priorities, and stakeholder requirements.
- (b) The way in which internal and external personnel are engaged in the provision of climate services.
- (c) The available resources and capabilities (financial, human and technical).
- (d) National and institutional legislation, rules, organizational structure, policies and procedures.
- (e) WMO guidelines, policies and procedures for climate data and products.
- (f) The dominant weather and climate influences, and extremes experienced.

1.5.1 **Competencies and associated performance criteria:**

Competency 1: Creating and managing climate data sets

Climate data and metadata and climate data products shall be gathered and stored in datasets, quality controlled and assessed for homogeneity. Hence staff shall:

- (a) Conduct climate data preservation and rescue procedures;
- (b) Assess the location and characteristics of the observation sites against the requirements for a climate observation reference network;
- (c) Collect and store climate data and metadata in relational databases;
- (d) Apply quality control processes to climate data and resulting time series
- (e) Assess climate data homogeneity and adjust inhomogeneous time series;
- (f) Create, archive and document climate datasets;
- (g) Apply spatial and temporal interpolation to ensure data continuity.

Competency 2: Deriving products from climate data

Climate data products for science and user applications are derived from different sources of climate data (such as observed and reconstructed time series, reanalysis, satellite and modelled data) applying statistics which describe their spatial and temporal characteristics. Staff should:

- (a) Identify and retrieve climate data from different sources to generate climate products;
- (b) Compute basic climate products, normals and averages, or anomalies defined relative to a reference period;
- (c) Compute climate indices for monitoring climate change, climate variability and climate extremes;
- (d) Compute sector-specific climate indices and other sector-oriented climate products;
- (e) Apply statistical and geo-statistical analysis to monitor the spatial distribution and temporal evolution of climate;
- (f) Create value-added products such as graphics, maps and reports to explain climate characteristics and evolution, according to the needs of specific sectors such as health, agriculture, water, energy and disaster management.

Competency 3: Creating and/or interpreting climate forecasts, climate projections and model output

Climate data, climate data products and climate model outputs are operated and used to create sub-seasonal and seasonal climate forecasts and future climate projections. Staff should:

- (a) Locate, select and retrieve climate forecasts and climate model outputs generated by Regional Climate Centres, Global Producing Centres and other institutions;
- (b) Create sub-seasonal, seasonal and longer-scale forecast products;
- (c) Create future climate projections using climate models in a selected domain for different scenarios and parametrization;
- (d) Apply statistical and geo-statistical analysis, including downscaling, to monitor the spatial distribution and temporal evolution of model outputs;
- (e) Evaluate the performance of climate model outputs and quantify the associated uncertainties;
- (f) Create value-added products, such as graphics, maps and reports to communicate climate forecasts and climate model information to users.

Competency 4: Ensuring the quality of climate information and services

Climate information and services should be defined and routinely updated. Best practices should be followed and/or guidelines and quality management procedures for climate information should be created and routinely maintained. Monitoring processes of climate services should be documented and used in quality control activities. Hence the institution's management should:

- (a) Create and apply quality management processes and procedures for climate services;
- (b) Recruit competent personnel and organize the workforce so that it can develop and deliver climate services;

- (c) Ensure that the infrastructural capacity of the institution meets the requirements of the competency framework and that there is a strategy for sustainable capabilities;
- (d) Provide training to staff so that they can fulfil their job requirements and expand their capabilities;
- (e) Define and implement a catalogue of climate datasets, products and services to meet user requirements at the national/regional level;
- (f) Monitor the functions of climate services, including validation of data, products and services;
- (g) Evaluate the impacts and benefits for customers of climate services, by gathering customers' comments, suggestions and complaints;
- (h) Make decisions for service improvement based on evaluation results;
- (i) Build partnerships with science and service providers and end users to improve products and service delivery.

Competency 5: Communicating climatological information to users

Climate science, data and products should be communicated to policymakers, stakeholders and the general public. The institution's management should:

- (a) Prioritize the communication of climatological information according to social, political and economic relevance;
- (b) Establish effective communication channels with users of climate services and build outreach capacities, such as Regional Climate Outlook Forums;
- (c) Conduct analyses of customer needs on a regular basis and evaluate the results;
- (d) Review climate services and their communication strategy on the basis of user feedback;
- (e) Formulate and deliver, in partnership with users, specific applications to facilitate understanding and use of climate products and services;
- (f) Comply with the interfacing requirements of the GFCS and the WMO Information System.

1.6 Personnel providing marine meteorological services (in preparation)

PART VI. EDUCATION AND TRAINING OF METEOROLOGICAL PERSONNEL

1. EDUCATION AND TRAINING REQUIREMENTS

1.1 General

1.1.1 Each Member shall ensure that, in the fulfilment of its national and international responsibilities as prescribed in other chapters of these *Technical Regulations*, the personnel involved are educated and trained to the standards recognized by WMO for their respective duties. The education and training requirements shall apply both to initial recruitment and to continuing professional development and be in line with advances in science and technology, changing service requirements and responsibilities, and the ongoing need for refresher training.

Note: The education standards are outlined below and job specific competencies are included in the relevant chapters of these *Technical Regulations*.

1.1.2 Members should maintain records of the education and training of their personnel as part of their Quality Management System, for their human resource development activities and for auditing purposes, where appropriate, in accordance with the *Guide to the Implementation of Education and Training Standards in Meteorology and Hydrology* (WMO-No. 1083), Volume I.

1.2 Categories of personnel

The meteorological personnel shall be classified as follows:

- (a) Meteorologist;
- (b) Meteorological technician.

Note: The definitions of “meteorologist” and “meteorological technician” are given in the Definitions section of this volume.

1.3 The Basic Instruction Package for Meteorologists

The Basic Instruction Package for Meteorologists, as defined in [Appendix A](#), shall be used by Members to ensure that the meteorological personnel in the category Meteorologist are provided with a robust and broad range of knowledge of atmospheric phenomena and processes, together with skills related to the application of this knowledge.

1.4 The Basic Instruction Package for Meteorological Technicians

The Basic Instruction Package for Meteorological Technicians, as defined in [Appendix A](#), shall be used by Members to ensure that the meteorological personnel in the category Meteorological Technician are provided with basic knowledge of atmospheric phenomena and processes, together with skills related to the application of this knowledge.

1.5 Meteorological education and training facilities

1.5.1 Members should endeavour to provide national facilities, or participate in regional facilities, for the education and training of their personnel.

1.5.2 As not all national training facilities are recognized as regional training facilities, the criteria given in [Appendix B](#) to this volume apply to each institution designated as being part of a WMO Regional Training Centre (RTC). Each of those institutions is referred to as an RTC component.

Note: In recognizing, reconfirming and managing an RTC component, the regional association, the Permanent Representative of the host country, the Director of the RTC component and the Coordinator of the RTC with multiple components take shared responsibility for the performance and ongoing status of the institution(s) as an RTC. Guidance on the roles and responsibilities of each of the parties is provided in *Guide to the Management and Operation of WMO Regional Training Centres and Other Training Institutions* (in preparation).

Regional association

- Prioritize education and training needs of the regional association and communicate them to the RTCs at least every four years;
- Keep abreast of the activities and plans of each RTC and its components through the annual report they provide;
- Provide RTCs, Members and the Secretary-General with feedback on whether the RTCs are meeting the needs of the regional association;
- Contribute to quadrennial reviews of the RTCs arranged by the Executive Council in order to address the extent to which the RTCs are meeting the identified education and training needs of the regional association;
- At each session of the regional association, recommend RTCs to the WMO Executive Council for possible confirmation, based on performance against the established criteria;
- Promote the activities and use of the RTCs by members of the regional association;
- Seek funding and resource opportunities to support and expand the work of the RTCs in addressing the education and training needs of the regional association.

Permanent Representative of the host country

- Inform the Secretary-General and the regional association of the contact details of the Coordinator of an RTC and the Director of an RTC component and of any changes thereto;
- Where the RTC is made up of multiple components, ensure ongoing communication and coordination between the components to maximize education and training opportunities for Members;
- Facilitate coordination between the RTC and the regional association concerned regarding regional education and training needs, funding and resource opportunities;
- Promote the resourcing of the RTC through support from government and other national and international funding bodies;
- Provide the regional association and the Secretary-General with annual reports about the RTC's activities in the previous 12 months and its plans for the next 12 months with an outlook for future years;
- Collaborate with other Permanent Representatives hosting RTCs to promote collaboration between the RTCs;
- Oversee and act as an advocate for the RTC to (a) comply with national and WMO standards and guidelines and (b) keep pace with evolving technological and educational developments.

Director of an RTC component

- Monitor and plan the activities of the RTC component in accordance with the expressed education and training needs of the regional association;
- For vocational training activities, use processes within the RTC component that are consistent with ISO 29990:2010, *Learning services for non-formal education and training – Basic requirements for service providers*;
- Monitor the skills and capabilities of the RTC staff informing the appropriate authorities of the requirements to develop and maintain the professional and training expertise of staff and to ensure the availability and maintenance of an adequate infrastructure for training and for information and communications technology;
- Submit to the Permanent Representative annual reports about the activities of the RTC component in the previous 12 months and plans for the next 12 months with an outlook for future years;
- Inform Members, through regular communication, of the benefits of the services offered by the RTC component and provide them with easy access to the RTC's education and training programme and contact information;
- Work with other RTC components to (a) coordinate activities and (b) share resources and experience in addressing regional education and training needs;
- Seek additional funding and resource opportunities to expand the ability of the RTC component to address the regional education and training needs.

Coordinator of an RTC with multiple components

- Coordinate the overall activities of the RTC components in accordance with the expressed education and training needs of the regional association;
- Coordinate preparation of annual reports about the RTC's activities in the previous 12 months and plans for the next 12 months with an outlook for future years, for submission to the Permanent Representative;
- Coordinate arrangements for (a) promoting and providing information about the RTC's services to Members through regular communication, and (b) the sharing of resources and experience among the RTC components in addressing regional education and training needs;
- Ensure that the RTC components collaborate and that each is apprised of the other's education and training activities;
- Support the RTC components in seeking additional funding and resource opportunities to expand the ability of the RTC to address the regional education and training needs.

1.6 Status of meteorological personnel

Each Member should ensure that meteorological personnel referred to in 1.1.1 above are accorded status, conditions of service and general recognition within that country commensurate with the technical and other qualifications required for the fulfilment of their respective duties.

APPENDIX A. BASIC INSTRUCTION PACKAGES

(See Part V, 1.2.1.1, and Part VI, 1.3 and 1.4)

1. BASIC INSTRUCTION PACKAGE FOR METEOROLOGISTS

1.1 General

1.1.1 To satisfy the requirements of the Basic Instruction Package for Meteorologists, Members shall ensure that the meteorological personnel achieve the following learning outcomes:

- (a) The acquisition of knowledge concerning physical principles and atmospheric interactions, methods of measurement and data analysis, behaviour of weather systems (through the synthesis of current weather data with conceptual models), and the general circulation of the atmosphere and climate variations;**
- (b) The ability to apply knowledge based on the use of scientific reasoning to solve problems in atmospheric science and to participate in the analysis, prediction and communication of the impacts of weather and climate on society.**

Note: It is intended that satisfying the requirements of the Basic Instruction Package for Meteorologists will provide meteorological personnel with the knowledge, skills and confidence to develop their expertise and with a basis for further specialization.

1.1.2 Members shall ensure that meteorologists wishing to work in areas such as weather analysis and forecasting, climate modelling and prediction, and research and development, undertake further education and training to meet the specialized job competencies in these areas. In addition, Members shall ensure that meteorologists enhance their knowledge and skills by participating in continuous professional development throughout their careers.

Note: The requirements of the Basic Instruction Package for Meteorologists will usually be satisfied through the successful completion of a university degree in meteorology or a postgraduate programme of study in meteorology following a university degree that includes the foundation topics in mathematics and physics – such topics are typically covered in science, applied science, engineering or computational courses. Where this is not the case, educational institutions will have to demonstrate that their programme of study provides the characteristic learning outcomes associated with a university degree course.

1.1.3 Members should take the lead in consulting with the appropriate national and regional bodies to define the academic qualifications required of meteorologists in their country. Members should also work with their national education and training establishments to ensure that meteorological graduates achieve all the learning outcomes of the Basic Instruction Package for Meteorologists as part of the academic qualification.

1.2 Components of the Basic Instruction Package for Meteorologists

Note: The aim is to ensure that a meteorologist has the underlying knowledge and expertise that supports the learning outcomes associated with physical meteorology, dynamic meteorology and numerical weather prediction, synoptic and mesoscale meteorology, and climatology.

1.2.1 Foundation topics

Members shall ensure that a meteorologist is able to:

- (a) Demonstrate the knowledge of mathematics and physics that is required to successfully complete the meteorological components of the Basic Instruction Package for Meteorologists;
- (b) Demonstrate the knowledge of other sciences and related topics that complements the meteorological expertise covered in the Basic Instruction Package for Meteorologists;
- (c) Analyse and utilize data, and communicate and present information.

1.2.2 ***Physical meteorology***

Members shall ensure that a meteorologist is able to:

- (a) Explain the structure and composition of the atmosphere, the processes affecting the radiative transfer in the atmosphere and global energy balance, and the causes of optical phenomena in the atmosphere;
- (b) Apply the laws of thermodynamics to atmospheric processes, use a thermodynamic diagram to assess the properties and stability of the atmosphere, identify the effect of water on thermodynamic processes and explain the processes leading to the formation of water droplets, clouds, precipitation and electrical phenomena;
- (c) Use knowledge of turbulence and surface energy exchanges to explain the structure and characteristics of the atmospheric boundary layer and the behaviour of contaminants;
- (d) Compare, contrast and explain the physical principles used in conventional instruments to make surface and upper-air measurements of atmospheric parameters, and explain the common sources of error and uncertainty and the importance of applying standards and using best practices;
- (e) Describe the range of meteorological data obtained from remote-sensing systems, explain how radiation measurements are made and the processes by which atmospheric data are derived from those measurements, and outline the uses and limitations of remote-sensing data.

1.2.3 ***Dynamic meteorology***

Members shall ensure that a meteorologist is able to:

- (a) Explain the physical basis of the equations of motion in terms of forces and frames of reference, apply scale analysis to identify the dynamic processes in balanced flows, describe the characteristics of balanced flows, and use the equations of motion to explain quasi-geostrophy, ageostrophy, and the structure and propagation of waves in the atmosphere;
- (b) Describe and explain the scientific basis, characteristics and limitations of numerical weather prediction for short-, medium- and long-range forecasting, and explain the applications of numerical weather prediction.

1.2.4 ***Synoptic and mesoscale meteorology***

Members shall ensure that a meteorologist is able to:

- (a) Use physical and dynamical reasoning to describe and explain the formation, evolution and characteristics (including extreme or hazardous weather conditions)

of synoptic-scale weather systems in mid-latitude and polar regions and in tropical regions, and assess the limitations of theories and conceptual models of these weather systems;

- (b) Use physical and dynamical reasoning to describe and explain the formation, evolution and characteristics (including extreme or hazardous weather conditions) of convective and mesoscale phenomena, and assess the limitations of theories and conceptual models of these phenomena;
- (c) Monitor and observe the weather situation, and use real-time or historical data, including satellite and radar data, to prepare analyses and basic forecasts;
- (d) Describe service delivery in terms of the nature, use and benefits of the key products and services, including warnings and assessment of weather-related risks.

1.2.5 ***Climatology***

Members shall ensure that a meteorologist is able to:

- (a) Describe and explain the Earth's general circulation and climate system in terms of the physical and dynamical processes that are involved, and describe the key products and services based on climate information and their inherent uncertainty and use;
- (b) Apply physical and dynamical reasoning to explain the mechanisms responsible for climate variability and climate change (including the influence of human activity); describe the impacts in terms of possible changes to the global circulation, primary weather elements and potential effects on society; outline the adaptation and mitigation strategies that might be applied; and describe the application of climate models.

2. **BASIC INSTRUCTION PACKAGE FOR METEOROLOGICAL TECHNICIANS**

2.1 **General**

2.1.1 To satisfy the requirements of the Basic Instruction Package for Meteorological Technicians, Members shall ensure that the meteorological personnel achieve the following learning outcomes:

- (a) The acquisition of basic knowledge concerning physical principles and atmospheric interactions, methods of measurement and data analysis, a basic description of weather systems, and a basic description of the general circulation of the atmosphere and climate variations;
- (b) The ability to apply basic knowledge to observe and monitor the atmosphere and interpret commonly used meteorological diagrams and products.

Note: It is intended that satisfying the requirements of the Basic Instruction Package for Meteorological Technicians will provide meteorological personnel with the knowledge, skills and confidence to develop their expertise and with a basis for further specialization.

2.1.2 Members shall ensure that meteorological technicians wishing to work in areas such as weather observation, climate monitoring, network management, and provision of meteorological information and products to users, undertake further education and training to meet the specialized job competencies in these areas. In addition, Members shall ensure

that meteorological technicians enhance their knowledge and skills by participating in continuous professional development throughout their careers.

Note: The requirements of the Basic Instruction Package for Meteorological Technicians will be usually satisfied through the successful completion of a post-secondary programme of study at an establishment such as a training institution of a National Meteorological and Hydrological Service or college of further education.

2.2 Components of the Basic Instruction Package for Meteorological Technicians

Note: The aim is to ensure that a meteorological technician has the underlying knowledge and expertise that supports the learning outcomes associated with basic physical and dynamic meteorology, basic synoptic meteorology, basic climatology, and meteorological instruments and methods of observation.

2.2.1 Foundation topics

Members shall ensure that a meteorological technician is able to:

- (a) Demonstrate the knowledge of mathematics and physics that is required to successfully complete the meteorological components of the Basic Instruction Package for Meteorological Technicians;
- (b) Demonstrate the knowledge of other sciences and related topics that complements the meteorological expertise covered in the Basic Instruction Package for Meteorological Technicians;
- (c) Analyse and utilize data, and communicate and present information.

2.2.2 Basic physical and dynamic meteorology

Members shall ensure that a meteorological technician is able to:

- (a) Explain the basic physical and dynamic processes that take place in the atmosphere;
- (b) Explain the physical principles used in instruments to measure atmospheric parameters.

2.2.3 Basic synoptic and mesoscale meteorology

Members shall ensure that a meteorological technician is able to:

- (a) Describe the formation, evolution and characteristics of synoptic-scale and mesoscale tropical, mid-latitude and polar weather systems, and analyse weather observations;
- (b) Describe the forecast process and the use made of the associated products and services.

2.2.4 Basic climatology

Members shall ensure that a meteorological technician is able to:

- (a) Describe the general circulation of the atmosphere and the processes leading to climate variability and change;
- (b) Describe the use made of products and services based on climate information.

2.2.5 Meteorological instruments and methods of observation

Members shall ensure that a meteorological technician is able to:

- (a) Explain the physical principles used in instruments to measure atmospheric parameters;
 - (b) Make basic weather observations.
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APPENDIX B. CRITERIA FOR THE DESIGNATION OF WMO REGIONAL TRAINING CENTRES

(See Part VI, 1.5.2)

A Regional Training Centre (RTC) is a national education and training institution, or group of institutions, recognized by Congress or the Executive Council (following recommendation of the relevant WMO regional association(s) as:

- (a) Providing education and training opportunities for WMO Members in the Region, particularly staff of National Meteorological and Hydrological Services (NMHSs);
- (b) Providing advice and assistance on education and training to WMO Members;
- (c) Promoting education and training opportunities in weather, water and climate for WMO Members.

These activities are undertaken in accordance with WMO regulations and guidelines. An institute supported by several Members to provide such services could also be recommended by the relevant regional association as an RTC.

Each institution forming part of an RTC is considered to be an RTC component.

When a Member proposes an institution or a group of institutions to the relevant regional association for recommendation as an RTC, the proposal shall meet the following criteria:

- (a) An RTC or its component is established only to meet the expressed requirements of more than half of the Members of the regional association that cannot be met by existing resources;
- (b) An RTC or its component is designed to meet the requirements of the Region, as expressed in a decision of the regional association and recorded in a resolution or statement in the general summary of the abridged final report of the regional association session. However, it is recognized that some RTCs or their components might also take on a broader international remit;
- (c) The RTC is located within the Region concerned, its location decided by the Executive Council in the light of the recommendation of the regional association, the advice of the relevant technical commission and the Executive Council Panel of Experts on Education and Training, and the comments of the Secretary-General.

A Member hosting the institution to be designated as an RTC component shall ensure it has the human and financial resources and facilities to satisfy the following:

Identifying learning needs:

The RTC component has processes in place to gain information about the education and training needs of the Region.

Designing the learning service:

- The RTC component selects methods of learning that respond to the aims and requirements of the curriculum and learning outcomes, and are appropriate for the learners;
- The RTC component ensures that its courses of instruction and other activities, such as delivering or developing e-learning, running off-site activities and providing advice or support, are carried out in a way that is consistent with the standards and guidance material issued by WMO;

- The RTC component provides courses and other resources and activities that address the expressed education and training needs of the Region.

Delivering the learning service:

- The RTC component demonstrates that, during the previous four years, it has contributed to meeting the education and training needs identified by the regional association;
- The RTC component delivers training: (a) with competent instructors in terms of their scientific/technical ability and training expertise; and (b) in an environment that is conducive to learning, with adequate learning resources, buildings, information and communication technology systems and training facilities.

Assessing learning and evaluating the learning service:

- The RTC component assesses the knowledge and competency of students, documents this information in a fashion suitable for a recognized quality management system, and provides students with a record of the education and training that has been successfully completed;
- The RTC component has processes for measuring the effectiveness and quality of the learning service, including obtaining feedback from stakeholders.

Administering and managing the learning service:

- The RTC component has adequate arrangements for administration, governance, planning, staffing, continuous professional development, reporting and self-assessment;
 - If the RTC component has no national accreditation as a provider of vocational training, it can demonstrate that it carries out its training activities in accordance with the requirements of ISO 29990:2010;
 - The RTC component produces an annual report on activities carried out in the previous twelve months, and on its plan for the next 12 months with an outlook for future years;
 - The RTC component is: (a) open to students from all countries in the Region and, subject to availability of resources, to interested countries in other Regions; and (b) has appropriate services in place to support international/regional students.
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