Technical Regulations

Basic Documents No. 2

Volume I – General Meteorological Standards and Recommended Practices

2023 edition

Updated in 2025

WEATHER CLIMATE WATER

WORLD METEOROLOGICAL ORGANIZATION

WMO-No. 49

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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 https://wmo.int/wmo-community/meteoterm.

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NOTE

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PUBLICATION REVISION TRACK RECORD

Date	*Part/chapter/ section*	*Purpose of amendment*	*Proposed by*	*Approved by*
December 2024	Part III	Changes arising from Resolution 18 (EC-78)	INFCOM-3	EC-78
April 2025	Part V	Changes arising from Resolution 11 (Cg-19)	SERCOM-2	Cg-19

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GENERAL PROVISIONS

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

Volume I – General Meteorological Standards and Recommended Practices
Volume II – Meteorological Service for International Air Navigation
Volume III – Hydrology.

Note: The publication of Parts I and II of Volume II was discontinued on 31 December 2023. The publication of Parts III and IV of Volume II will be discontinued upon incorporation of material of continuing relevance into the International Civil Aviation Organization (ICAO) Procedures for Air Navigation Services – Meteorology (PANS-MET) (Doc 10157) (provisionally in 2027). WMO Technical Regulations pertaining to meteorological service for international air navigation are also contained in Annex 3 to the Convention on International Civil Aviation (ICAO Annex 3) – Meteorological Service for International Air Navigation.

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, *recommended* practices and procedures, and references to constants, definitions, formulas and specifications.

5. The characteristics of these three 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.

References to constants, definitions, formulas and specifications:

Members should use the definitions, formulas, values of constants and specifications indicated in the relevant Guides published by the Organization.

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 101 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 of such practices and procedures.

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 and III), also called Manuals, are published separately and contain regulatory material. They were established by a decision of Congress and are intended to facilitate the application of the Technical Regulations to specific fields. Manuals may contain both *standard* and *recommended* practices and procedures:

I *International Cloud Atlas* (WMO-No. 407) – Manual on the Observation of Clouds and Other Meteors, sections 1, 2.1.1, 2.1.4, 2.1.5, 2.2.2, 1 to 4 in 2.3.1 to 2.3.10 (for example, 2.3.1.1, 2.3.1.2, etc.), 2.8.2, 2.8.3, 2.8.5, 3.1 and the definitions (in grey-shaded boxes) of 3.2;
II *Manual on Codes* (WMO-No. 306), Volume I;
III *Manual on the Global Telecommunication System* (WMO-No. 386);
IV *Manual on the WMO Integrated Processing and Prediction System* (WMO-No. 485);
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);
IX *Manual on the High-quality Global Data Management Framework for Climate* (WMO-No. 1238).

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 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 commission;

(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 the appropriate technical commission at one of its sessions, 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 Regulation*s proposed by the appropriate technical commission 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 8 (5) of the General Regulations.

Note: A fast-track procedure may be used for amendments to technical specifications as defined in the *Rules of Procedure for Technical Commissions* (WMO-No. 1240).

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 amendments between sessions of Congress, Volumes I and III 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.

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 2018".

18. Through Resolution 12 (Cg-19), Congress approved the discontinuation of Part I and Part II of the *Technical Regulations* (WMO-No. 49), Volume II, with effect from 31 December 2023, and the discontinuation of Part III and Part IV of the *Technical Regulations* (WMO-No. 49), Volume II, when material of continuing relevance has been transferred to ICAO *Procedures for Air Navigation Services – Meteorology* (PANS-MET) (Doc 10157), provisionally in 2026.

WMO Guides

19. 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 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, as well as other guidance materials that correspond to the regulatory framework, shall normally be approved by the technical commissions.

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 WMO Integrated Processing and Prediction System* (WMO-No. 485)), Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)) and other WMO publications.

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

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; this is usually carried out at several points in the instrument's measurement range.

Certification of compliance. Certification is achieved through an audit by an accredited external (third party) conformity assessment body.

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.

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.

Cryosphere. The component of the Earth system that contains ice, including solid precipitation, snow, glaciers and ice caps, ice sheets, ice shelves, icebergs, sea ice, lake ice, river ice, permafrost, and seasonally frozen ground, or even "dry" material in the case of permafrost. The cryosphere includes elements 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.

Customer (in a quality management system context). Within WMO, "clients" and "customers" are generally referred to as "users". However, the International Organization for Standardization (ISO) family of standards exclusively uses the term "customers".

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

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.

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 Cryosphere Watch (GCW) Surface Observing Network. A network of stations that observe one or more components of the cryosphere and follow GCW best practices.

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 (WWW).

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 WWW.

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.

Level I data. In general, these data are instrument readings expressed in appropriate physical units; they are referred to using geographical coordinates. They require conversion to the normal meteorological and other variables of the physical environment. Level I data are in many cases obtained from the processing of electrical signals such as voltages, referred to as raw data.

Level II data. The data recognized as meteorological or other variables of the physical environment. They may be obtained directly from instruments (as is the case for many simple instruments) or derived from Level I data.

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 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.

National Meteorological Centre (NMC). A centre responsible for carrying out the required functions to meet the national and international requirements and commitments of the Member under the WMO Integrated Processing and Prediction System (WIPPS).

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.

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

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

Observing network. More than one observing station/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 stations and platforms, whether surface-based or space-based, on land, sea, lakes or rivers, or in the air, fixed or mobile, and making in situ or remote observations, using one or more sensors, instruments or types of 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 system. One or more stations/platforms, acting together to provide a coordinated set of observations.

Note: This definition is generic. For specific observing systems, such as GOS and GCOS, see the relevant definitions in this section.

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.

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.

Products and services. For the purposes of the ISO 9000 family of standards, any reference to products also includes services.

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 the 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).

Quality. Quality is defined by ISO as "the degree to which a set of inherent characteristics fulfils requirements".

Note: There are many definitions and interpretations of "quality"; however, all have one element in common – the perception of the extent to which a product or service meets the expectations of customers. It should be noted that "quality" has no explicit meaning unless it is related to a specific set of requirements.

Quality assurance. Activities undertaken to instil confidence that quality requirements have been met. It involves the systematic monitoring and evaluation of the processes associated with the generation of a product or service.

Quality control. Activities undertaken to ensure that quality requirements have been fulfilled prior to the dissemination of a product or the delivery of a service.

Quality management. A process that focuses not only on the quality of the product but also on the means to achieve it and is centred on the following four activities: quality planning, quality control, quality assurance and quality improvement.

Quality management system (QMS). The organizational structure, procedures, processes and resources needed to ensure the delivery of an organization's products and services.

Note: The QMS terminology, vocabulary and definitions used within these *Technical Regulations* are those of ISO, in particular, *ISO 9000:2015 – Quality management systems – Fundamentals and vocabulary*. They are also taken from the *Guide to the Implementation of Quality Management Systems for National Meteorological and Hydrological Services and Other Relevant Service Providers* (WMO-No. 1100) and *ISO 9001:2015 – Quality management systems – Requirements.*

Radar wind profiler observation. A vertical profile of the horizontal wind vector and, under some conditions, the vertical wind component, determined by transmitting radar signals and analysing the information contained in the backscattered electromagnetic wave using system-specific data-processing techniques.

Radar wind profiler station. A surface-based station at which radar wind profiler observations are made.

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.

Regional Basic Observing Network (RBON). A network of surface-based meteorological, hydrological and related observing stations/platforms defined and adopted by the responsible WMO regional association or by the Executive Council/World Meteorological Congress.

Regional Training Centre (RTC). A national education and training institution, or group of institutions, recognized by Congress or the Executive Council (following the 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 (NMHSs); (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.

Space-based subsystem. A complementary part of GOS 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.

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

Surface land observation. An observation, other than an upper-air observation, made at an observing station situated on land.

Surface land station. A station at which surface land observations are made.

Surface marine observation. An observation, other than an upper-air or subsurface observation, made at an observing station situated at a marine location.

Surface marine station. A station at which surface marine observations are made.

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

Upper-air station. A surface location from which upper-air observations are made.

Validation (in a QMS context). Validation in quality management terms focuses on the product or services provided post their delivery. That is, the provider validates that the product or service met the identified needs of the customer.

Verification (in a QMS context). In general, verification is considered by WMO Members as a post-delivery activity. However, in quality management terms, a product is verified prior to delivery. That is, it meets all the specified requirements for that product or service in terms of content.

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

Weather radar observation. The evaluation of atmospheric characteristics obtained by transmitting electromagnetic waves (radar signals) and analysing of the information reflected from the targets in the sample volume.

Note: Such an evaluation is typically repeated over a sequence of samples, as determined by the scan strategy, and reported as a spatially continuous dataset.

Weather radar station. A surface-based station at which weather radar observations are made.

WMO Hydrological Observing System (WHOS). A combination of hydrological data, models and tools used for decision-making in water resources management, in operational applications as well as in research and education.

WMO Integrated Global Observing System (WIGOS). A framework for all WMO observing systems including WMO contributions to co-sponsored observing systems in support of all WMO Programmes and activities.

WMO Integrated Processing and Prediction System (WIPPS). The coordinated global system of centres operating under established arrangements to analyse, forecast, process, store and retrieve meteorological, climatological, hydrological, oceanographic and environmental-related information. This was previously known as the Global Data-processing and Forecasting System (GDPFS).

WIPPS Designated Centre (WIPPS-DC). A centre that specializes in an activity of WIPPS with the primary purpose of providing tailored-made information and products to serve users in a particular area of activity.

WIPPS Centre Network. An association of WIPPS Centres participating in an identified activity of WIPPS.

WMO observing station/platform. Any observing station/platform with a WMO identifier.

WMO observing system. Any observing system that consists of WMO observing stations/platforms.

World Meteorological Centre (WMC). A WIPPS centre that has the primary purpose of issuing meteorological analyses and prognoses, including probabilistic information and long-range forecasts on a global scale.

World Weather Watch. The worldwide, coordinated, dynamic system of meteorological facilities and services provided by Members to ensure that all Members obtain the

meteorological information they require both for operational work and for research. The essential elements of WWW are: GOS, the part of WIPPS dealing with meteorological analyses and prognoses, and GTS.

PART I. THE WMO INTEGRATED GLOBAL OBSERVING SYSTEM

1. INTRODUCTION

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) and the Global Ocean Observing System (GOOS), which are 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 Science Council.

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 among meteorological, hydrological, marine and oceanographic services and related academic and research institutions at the national level in order to meet the goal set out in 1.1.3.

1.1.6 The WMO Integrated Global Observing System shall focus on the integration of governance and management functions, mechanisms and activities to be accomplished by contributing observing systems at the global, regional and national levels.

1.2 WIGOS component observing systems

The component observing systems of WIGOS shall comprise the Global Observing System (GOS) of the World Weather Watch (WWW) Programme, the observing component of the Global Atmosphere Watch (GAW) Programme, the WMO Hydrological Observing System (WHOS) of the Hydrology and Water Resources Programme 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 WWW Programme.

1.2.2 *The observing component of the Global Atmosphere Watch*

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 shall comprise hydrological observations 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 the *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 and historical hydrological data received from participating National Meteorological and Hydrological Services.**

1.2.3.3 **Members providing hydrological observations to 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 observing component of the Global Cryosphere Watch*

1.2.4.1 **The observing component of the Global Cryosphere Watch (GCW), which includes the GCW Surface Observing Network, shall be a coordinated system of observing stations and platforms, methods, techniques, facilities and arrangements encompassing monitoring activities and related scientific assessments of the cryosphere.**

1.2.4.2 **The purpose of GCW shall be to provide observational data, information and analyses related to the past, current and future state of the cryosphere, from the local to the global scale, to improve understanding of its behaviour, of its interactions with other components of the Earth system, and of impacts on society.**

1.2.4.3 **Members providing cryospheric observations for international exchange shall operate their observing stations and platforms in accordance with the Technical Regulations.**

Notes:

1. For more information, see the GCW Implementation Plan available at http://globalcryospherewatch.org/reference/documents/.
2. Existing cryosphere observing programmes include those carried out within WMO, the co-sponsored programmes (GCOS and GOOS), and programmes coordinated by other entities, such as the International Permafrost Association (IPA), the World Glacier Monitoring Service – a service of the International Association of Cryospheric Sciences (IACS), the Scientific Committee for Antarctic Research (SCAR), the Global Precipitation Climatology Centre (GPCC), and the US National Snow and Ice Data Center (NSIDC).

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 should implement cooperation and coordination arrangements at the national level among those bodies that contribute to GFCS, GCOS, GOOS, GEOSS and other relevant observing systems.

Note: Such arrangements will at least enable good communication among the relevant bodies, for example, through meetings or newsletters. Further examples of national arrangements are given in the *Guide to the WMO Integrated Global Observing System* (WMO-No. 1165).

1.4 Governance and management

Members shall implement their national observing systems and manage their evolution in accordance with the relevant policies, practices and procedures adopted by WMO, including those specified in the *Technical Regulations* (WMO-No. 49), Volumes I and III, and in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

Notes:

1. The implementation of WIGOS is an integrating activity for all WMO and co-sponsored observing systems; it supports all WMO Programmes and activities. The World Meteorological Congress, the Executive Council and the regional associations, supported by their respective working bodies, have a governing role in the implementation of WIGOS. The technical aspects of WIGOS implementation are guided by the technical commissions.
2. The provision by Members of sufficient resources, including competent staff, is a prerequisite for the successful implementation of WIGOS.

2. COMMON ATTRIBUTES OF WIGOS COMPONENT SYSTEMS

2.1 Requirements

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

2.2 Design, planning and evolution

2.2.1 Members shall ensure that global and regional plans adopted by WMO are considered when they are planning the evolution of their national observing systems.

2.2.2 Members shall maintain close coordination with their national telecommunication authorities to register their radio 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 detailed in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

2.4 Operation

2.4.1 *General requirements*

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

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

Note: Safety practices and procedures are intended to ensure the welfare of staff while promoting the overall efficiency and effectiveness of the National Meteorological and Hydrological Service (NMHS). Such practices and procedures conform to national laws, regulations and requirements for occupational health and safety.

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

Note: While observations are Level II data, in some circumstances it may also be valuable to record and share the Level I data from which the observations were derived. A further description of some of these circumstances is provided in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)) and related guidance material.

2.4.2 *Observations*

2.4.2.1 Members shall ensure the 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)).

Note: The WMO application areas are detailed in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), Appendix 2.3.

2.4.2.2 Members should place special emphasis on meeting the requirements of numerical weather prediction since many application areas depend on it.

2.4.2.3 Members should pay special attention to climate monitoring, including the observational requirements of GFCS.

Note: The Global Framework for Climate Services, which has five components: the User Interface Platform, the Climate Services Information System, Observations and Monitoring, Research, Modelling and Prediction, and Capacity Development, described in the annexes to the *Implementation Plan of the Global Framework for Climate Services*, provides the observational requirements to be addressed.

2.4.2.4 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: Further guidance and technical specifications and details are given in the *Guide to Instruments and Methods of Observation* (WMO-No. 8), the *Guide to Climatological Practices* (WMO-No. 100), the *Guide to Hydrological Practices* (WMO-No. 168), Volume I, and the *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 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)), section 2.6.

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

2.4.4 *Quality control*

2.4.4.1 Members shall ensure that all WMO observations under their responsibility are subject to quality control.

2.4.4.2 Members not able to implement quality control on their own should establish agreements with other Members, or appropriate regional or global organizations, to perform the necessary quality control on their behalf.

2.4.5 *Calibration*

Members shall perform calibrations 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 of the *Technical Regulations* and in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), section 2.6.

2.7 Capacity development in support of WIGOS

2.7.1 *General*

Members should include in their capacity development programme activities to support the sustainability and evolution of their observing systems and compliance with the *Technical Regulations*.

Note: Guidance on approaches to capacity development can be found in the *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 *Education and training*

Members shall ensure that 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 the present volume of the *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 the 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 the 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 (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 on the basis of the standard and recommended practices and procedures as stated in the *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 adopt a composite approach to their networks, with 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 approach here means using various types of observing systems or sources 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 by assessing the available metadata, including identifying the source. Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), section 2.5, describes the required metadata.

3.2.1.3 **Members shall establish and manage Regional Basic Observing Networks (RBONs) in their respective region(s) and in the Antarctic.**

Note: The Regional Basic Observing Network is a subset of the surface-based component of WIGOS which provides observations for international exchange to address the requirements of WMO application areas. It is described further in the *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160), section 3.2.3.

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 the *Technical Regulations* (WMO-No. 49), Volumes I and III, and detailed in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

3.4 Operation

Members should ensure that operators of observing systems comply with the *Technical Regulations* (WMO-No. 49), Volumes I and III, 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 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 Organization 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 2.2.4) 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)). The data shall be expressed in environmental quantities in accordance with 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 WWW.**

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 address the requirements of the WMO application areas associated with WWW by providing surface-based meteorological observations from the following types of observing stations/platforms:**

(a) Surface land stations;

(b) Surface marine stations;

(c) Upper-air stations;

(d) Aircraft meteorological stations;

(e) Radar wind profiler stations;

(f) Weather radar stations.

Note: The requirements to be met by these observations include those of weather forecasting, climatology, agricultural meteorology and aeronautical meteorology, with application areas increasing over time as meteorological science and operations evolve. Further details are provided in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

5.5 **The space-based subsystem shall be composed of three elements: (a) a space segment; (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 VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), and in Annex I (*International Cloud Atlas: Manual on the Observation of Clouds and Other Meteors* (WMO-No. 407)).**

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 the capabilities of Members to predict climate, weather and air quality;

(c) Contribute to scientific assessments in support of environmental policy;

by:

(i) Maintaining and applying global, long-term observations of the chemical composition and selected physical characteristics of the atmosphere;

(ii) Emphasizing quality assurance and quality control;

(iii) Delivering integrated products and services of relevance to users.

6.2 Members shall develop and implement the GAW observing network in accordance with the provisions set out in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), section 6.

6.3 Members shall carry out GAW observations in accordance with the provisions set out in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)), section 6.

Notes:

1. Members may perform observations of any of the parameters included in the GAW focal areas: ozone, greenhouse gases, reactive gases, aerosols, ultraviolet (UV) radiation and precipitation chemistry, using observation modes such as in situ observation, vertical distribution and total column.
2. Members may use different platforms, 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 world data centre.

Note: The world data centres are listed at https://gawsis.meteoswiss.ch.

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 hydrological 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.

7.3 Members shall develop and implement WHOS and obtain hydrological observations 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 observing component shall be to provide observations and other information on the cryosphere, from the local to the global scale, and to improve understanding of its behaviour, interactions with other components of the Earth system, and impacts on society.

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

8.3 Members shall develop and implement the GCW surface observing network in accordance with the provisions set out in Annex VIII (*Manual on the WMO Integrated Global Observing System* (WMO-No. 1160)).

PART II. THE WMO INFORMATION SYSTEM

1. INTRODUCTION

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 Observation, Infrastructure and Information Systems (INFCOM), coordinated with the Commission for Weather, Climate, Hydrological, Marine and Related Environmental Services and Applications (SERCOM) and the relevant 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 a comprehensive search of the catalogues through collaboration among 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 the 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, mentioned in this Part under section 2.1, shall be as given in Annex II (*Manual on Codes* (WMO-No. 306)), Volume I.

PART III. THE WMO INTEGRATED PROCESSING AND PREDICTION SYSTEM

1. OUTLINE OF THE SYSTEM

1.1 Purpose and scope

1.1.1 **The WMO Integrated Processing and Prediction System (WIPPS) shall:**

(a) Be a worldwide network of operational centres operated by WMO Members;

(b) Make operationally available, among WMO Members and relevant international organizations, agreed products and services for applications related to weather, climate, water and the environment;

(c) Enable scientific and technological advances made in meteorology and related fields to be accessible to and exploitable by WMO Members;

(d) Support all WMO Programmes and related programmes of other international organizations in accordance with decisions of the Organization.

1.1.2 **WIPPS shall be systematically designed in accordance with Members' needs and their ability to contribute to, and benefit from, the system in an efficient manner and with a minimum of duplication.**

1.1.3 **WIPPS shall be established and operated in accordance with procedures and practices set out in Annex IV (*Manual on the WMO Integrated Processing and Prediction System* (WMO-No. 485)).**

1.2 Organization

1.2.1 **WIPPS shall be organized in such a way as to ensure the discharge of the required operational data-processing and forecasting functions. It shall also incorporate real-time and non-real-time functions.**

1.2.2 **WIPPS shall be organized as a system with three activity categories as follows:**

(a) General-purpose activities are those that provide real-time analyses and predictions required for a wide range of end use;

(b) Specialized activities are those that make forecasting products tailored for a specific type of application or user community (e.g. guidance based on human interpretation);

(c) Non-real-time coordination activities are those that provide consistent presentations of results of verification and monitoring needed for appropriate use of WIPPS products, while not providing real-time forecasts.

1.2.3 **WIPPS shall be structured as a three-level system composed of:**

(a) National Meteorological Centres (NMCs);

(b) WIPPS Designated Centres (WIPPS-DCs);

(c) World Meteorological Centres (WMCs).

1.2.4 **Each Member shall designate an NMC.**

1.2.5 **WMCs, WIPPS-DCs and WIPPS Centre Networks shall be designated by a decision of the World Meteorological Congress or the WMO Executive Council. The designation of such centres shall include the specification of the activity/function (or activities/functions) to be carried out.**

1.2.6 **An association of centres constituted to undertake an identified WIPPS activity shall be designated as an WIPPS Centre Network.**

Note: Details of the designation process and procedure are specified in Annex IV (*Manual on the WMO Integrated Processing and Prediction System* (WMO-No. 485)).

1.2.7 The performance of WMCs, WIPPS-DCs and WIPPS Centre Networks should be regularly reviewed by relevant WMO bodies.

1.2.8 Any deficiencies or non-conformities with requirements identified during the performance review should be resolved immediately by the responsible Member. The designation of a centre should be reconsidered in case of systematic deficiencies or non-compliance with the requirements.

Note: Details of the performance assessment procedure for WMCs, WIPPS-DCs and WIPPS Centre Networks are given in Annex IV (*Manual on the WMO Integrated Processing and Prediction System* (WMO-No. 485)).

1.2.9 **The functions and operation of WIPPS shall be based on catalogues provided by Members operating WMCs, WIPPS-DCs and WIPPS Centre Networks on their websites. The catalogues shall contain the technical characteristics of the operational systems and products these centres deliver across WMO and the metadata describing dissemination and access options as part of the WMO Information System (WIS). WIPPS centres shall be linked to WIS.**

Note: Standard procedures and recommended practices with respect to metadata description are specified in Annex VII (*Manual on the WMO Information System* (WMO-No. 1060)).

1.3 Functions and responsibilities of centres

1.3.1 *National Meteorological Centres*

1.3.1.1 **An NMC shall carry out functions to meet the national and international requirements of the Member concerned.**

Note: To fulfil their national and international obligations, NMCs need to be adequately staffed and equipped to enable them to play their part in the World Weather Watch system.

1.3.1.2 **The functions of an NMC shall include the preparation of forecasts and warnings at all ranges necessary to meet the requirements of the Member.**

1.3.1.3 Depending on the context, other activities of an NMC should include the production of:

(a) Special-application products, including climate and environmental quality-monitoring and prediction products;

(b) Non-real-time climate-related products.

1.3.2 *WMO Integrated Processing and Prediction System Designated Centres*

A Member, having accepted the responsibility for providing an WIPPS-DC, shall arrange for this centre to carry out operationally at least one of the general-purpose or specialized activities.

Notes:

1. A list of general-purpose and specialized activities is given in Annex IV (*Manual on the WMO Integrated Processing and Prediction System* (WMO-No. 485)).

2. A WIPPS-DC can be also referred to as a Regional Specialized Meteorological Centre (RSMC) as appropriate.

1.3.3 *World Meteorological Centres*

A Member, having accepted the responsibility for providing a WMC, shall arrange for this centre to carry out at least the following activities:

(a) Global deterministic numerical weather prediction;

(b) Global ensemble numerical weather prediction;

(c) Global numerical long-range prediction.

1.3.4 *WMO Integrated Processing and Prediction System Centre Networks*

1.3.4.1 **A WIPPS Centre Network shall follow the same specifications and adhere to the same criteria and commitments as individual WIPPS-DCs carrying out the same activity.**

1.3.4.2 **Appropriate documentation shall be produced and made available by Members having accepted the responsibility to contribute to the WIPPS Centre Network to distribute the tasks and responsibilities among the participating WIPPS Centres . A unique focal point shall be designated to answer requests from users of the WIPPS Centre Network products.**

Note: Details on the real-time and non-real-time functions of WMCs, WIPPS-DCs, NMCs and WIPPS Centre Networks are given in Annex IV (*Manual on the WMO Integrated Processing and Prediction System* (WMO-No. 485)).

1.3.5 **Members operating NMCs, WIPPS-DCs and WMCs shall:**

(a) Monitor their performance and provide information about the current implementation of their systems;

(b) Report non-compliance between the mandatory minimum specifications and their actual implementation to the WMO Secretariat; if this non-compliance is expected to persist for more than two months, a schedule for returning to compliance shall be provided.

1.3.6 **Members operating WMCs, WIPPS-DCs and WIPPS Centre Networks shall provide guidance information, including training materials, on the interpretation, performance characteristics, strengths and limitations of their products.**

1.4 Practices, procedures and specifications

Members operating NMCs, WIPPS-DCs, WMCs and WIPPS Centre Networks shall maintain the standardized weather forecasting process, including the use of units, graphical representation of observations, analyses and forecasts.

Note: The description of the standardized weather forecasting process (including units, graphical representation of observations, analyses and forecasts) is specified in Annex IV (*Manual on the WMO Integrated Processing and Prediction System* (WMO-No. 485)).

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). Requirements concerning the qualifications, competencies, education and training of meteorological personnel in marine meteorology are given in Parts V and VI and Appendix A of the present publication.

1.1 General

1.1.1 The objective of a marine meteorological service shall be to contribute to the safety, regularity and efficiency of:

(a) International shipping, fishing and other marine activities on the high seas;

(b) Various activities that take place in coastal and offshore areas, ports, lakes and on the coast.

1.1.2 This objective shall be achieved by making available to marine users at sea or on the coast the required marine meteorological and related geophysical information to the extent technically possible.

1.1.3 To the extent possible, Members with Marine Meteorological Services shall provide maritime users with the meteorological and related oceanographic information (warnings, forecasts, charts, expert advice and climatological data) required for safe navigation and efficient operations using adequate modes of dissemination. The Services shall provide guidance and training in a coherent manner.

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

1.2 Marine meteorological services for the high seas, in particular to support the Worldwide Met-Ocean Information and Warning Service

1.2.1 *General*

1.2.1.1 Marine meteorological services for the high seas are part of the International Maritime Organization (IMO)/WMO Worldwide Met-Ocean Information and Warning Service (WWMIWS) disseminated to Safety of Life at Sea (SOLAS) ships through the Global Maritime Distress Safety System (GMDSS).

Marine meteorological services shall include the provision of:

(a) Meteorological warnings;

(b) Marine forecasts;

(c) Sea-ice information services.

1.2.1.2 Marine meteorological services shall be disseminated on approved satellite service provider platforms and NAVTEX in accordance with the GMDSS Master Plan.

1.2.2 *Principles and procedures*

The preparation and issuing of marine meteorological services for the high seas are guided by six principles and several procedures, as outlined in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I, Part I.

1.3 Marine meteorological services for coastal, offshore and local areas

1.3.1 *General*

1.3.1.1 Marine meteorological services are important for the operation and management of vessel traffic in ports and harbours and in coastal areas (for both international and national communities). Services are also required for people living right on the coast, who are subject to frequent marine and weather hazards such as winds, gales and coastal inundation.

1.3.1.2 Members should ensure the rapid dissemination of information, in particular warnings, by means appropriate for the users, including existing and emerging communication technologies.

1.3.2 *Coordination with neighbouring countries*

Members should coordinate services for coastal, offshore and local areas, wherever possible, with those of neighbouring countries.

1.3.3 *Coordination with services for the high seas*

1.3.3.1 **Members shall ensure that coastal, offshore and local services do not conflict with those for the high seas, in accordance with the procedures laid out in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I, Part I.**

1.3.3.2 **Members responsible for METAREA coordination shall ensure that services are coordinated nationally and internationally in accordance with the procedures described in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I, Part I.**

1.3.4 *Principles and procedures*

The principles and procedures for the provision of marine meteorological services for coastal, offshore and local areas are described in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I, Part II.

1.4 Support services for search and rescue

1.4.1 *General*

1.4.1.1 Members should prepare meteorological services in support of search and rescue (SAR) following internationally specified requirements.

1.4.1.2 Under GMDSS, Joint Rescue Coordination Centres (JRCCs) are responsible for coordinating the search and rescue of ships in distress in each NAVAREA. The success of a search and rescue operation depends to a large extent on the meteorological information available to the JRCC.

1.4.1.3 Requirements for maritime SAR services are contained in the *International Aeronautical and Maritime Search and Rescue Manual (IAMSAR Manual),* jointly issued by the International Civil Aviation Organization (ICAO) and IMO.

1.4.2 ***Principles and procedures***

1.4.2.1 Members should prepare meteorological services in support of SAR as a high priority for timely response, taking into account the specific requirements for both aircraft and maritime operations.

1.4.2.2 **Members shall provide meteorological services for SAR in accordance with national overall coordination procedures for SAR, taking into account the international recommendations and the requirements in force.**

1.4.2.3 The procedures for the provision of marine meteorological services to support maritime search and rescue are described in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I, Part III.

1.5 Support to the Worldwide Navigational Warning Service

1.5.1 ***General***

1.5.1.1. Maritime safety information is disseminated in accordance with IMO Resolution A.705(17) – Promulgation of maritime safety information, as amended. Navigational warnings are issued under the auspices of the International Hydrographic Organization (IHO)/IMO Worldwide Navigational Warning Service (WWNWS) in accordance with IMO Resolution A.706(17) – Worldwide Navigational Warning Service, as amended.

1.5.1.2 Navigational warnings are issued in accordance with SOLAS Chapter V, Regulation 4 – Navigational warnings and carry information that may have a direct bearing on the safety of life at sea. Some of the subjects of concern for navigational warnings rely on NMHS sources. Appropriate coordination and information-sharing agreements should be established with NAVAREA coordinators to facilitate an effective warning service.

1.5.1.3 **The IMO/WMO Worldwide Met-Ocean Information and Warning Service shall have the capability to provide relevant metocean information as input to NAVAREA warnings issued by NAVAREA coordinators.**

1.5.1.4 **Members shall issue navigational warnings in response to international requirements.**

1.5.2 ***Guidance***

Guidance for the provision of support to WWNWS is provided in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I, Part IV.

1.6 Support services for marine environmental emergency response

1.6.1 ***General***

1.6.1.1 Incidents involving the spilling of oil or other pollutants constitute a hazard for coastal areas and communities. Actions needed to contain the area of pollution, to minimize its effects and to clean up the affected area require specific meteorological services. Such pollution incidents usually call for immediate action, and it is essential that prior arrangements be made between the meteorological service and the pollution control authority so that the NMHS can be alerted and the required information provided with minimum delay.

1.6.1.2 There are a number of IMO conventions and resolutions concerned with the prevention of pollution at sea. The main one is the International Convention for the Prevention of Pollution from Ships (MARPOL Convention).

1.6.1.3 **The Integrated Processing and Prediction System (WIPPS) shall be a framework to help develop and enhance the capacity of Members to provide a consistent level of metocean and drift information in the event of a range of marine environmental incidents.**

1.6.1.4 Members should provide specialized services at the request of national response agencies.

1.6.2 *Procedures*

The procedure for the provision of support to marine environmental emergency response is explained in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I, Part V.

1.7 Training in marine meteorology

1.7.1 *General*

1.7.1.1 Marine meteorological personnel require training in both general and marine meteorology up to the various standards required for their particular tasks.

1.7.1.2 The types of personnel requiring training in marine meteorology are:

(a) Meteorological personnel engaged in observational, forecasting and climatological duties for marine purposes;

(b) Port Meteorological Officers (PMOs);

(c) Seafarers.

1.7.2 *Principles and procedures*

The principles and procedures governing the training of all classes of meteorological personnel engaged in marine meteorological activities, together with PMOs and seafarers, are described in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I, Part VI.

1.8 Marine meteorological services for marine climatology

1.8.1 *General*

1.8.1.1 Marine climatology today provides data, information and products about marine meteorological conditions to a wide range of research and science applications in support of industry and national interests in coastal and offshore regions.

1.8.1.2 General information on the purpose of marine climatology and societal applications can be found in the *Manual on Marine Meteorological Services* (WMO-No. 558), Volume I, Part VII. In addition, a comprehensive account of the uses of marine climatology can be found in the *Guide to the Applications of Marine Climatology* (WMO-No. 781) and in that Guide's dynamic part, *Advances in the Applications of Marine Climatology*, JCOMM Technical Report No. 13 (WMO/TD-No. 1081).

1.8.2 *Guidance*

1.8.2.1 To obtain the highest quality climate data and products, Members contributing to the Marine Climate Data System should closely follow, or propose where not available, appropriate international standards and best practices. These should be applicable to the full

range of marine meteorological and oceanographic data-processing activities, including data rescue and collection, and quality control, documentation, archiving, distribution and mirroring of data, metadata and products.

1.8.2.2 An explanation of services for marine climatology is given in Annex VI (*Manual on Marine Meteorological Services* (WMO-No. 558)), Volume I, Part VII.

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 these data 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, and so forth) 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 the 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 the 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 can be found in Annex 3 to the Convention on International Civil Aviation (ICAO Annex 3) – Meteorological Service for International Air Navigation and in the *Technical Regulations* (WMO-No. 49), Volume II, Parts III and IV. In accordance with the stipulations of Resolution 12 (Cg-19), upon discontinuation of the *Technical Regulations* (WMO-No. 49), Volume II, Parts III and IV, material of continuing relevance will be incorporated into the International Civil Aviation Organization (ICAO) Procedures for Air Navigation Services – Meteorology (PANS-MET) (Doc 10157) (provisionally in 2026).

4. HYDROLOGICAL SERVICES

Note: Regulations concerning hydrological services are to be found in the *Technical Regulations* (WMO-No. 49), Volume III.

5. PUBLIC WEATHER SERVICES

5.1 General

5.1.1 Members should provide public weather services to cover:

(a) Forecasts and related services in the areas of weather, climate and water to aid citizens in their day-to-day activities;

(b) Warnings of high-impact weather and extremes of climate, and other information to government authorities, as appropriate, in pursuance of their mission to protect the lives, livelihoods and property of citizens.

5.1.2 The purpose of public weather services provided by Members should be to support decision-making related to:

(a) The protection of life, livelihood and property;

(b) The welfare and well-being of the population;

(c) Social and economic development in response to the wide spectrum of requirements of the public and weather-sensitive user groups.

5.2 Public weather service delivery

5.2.1 *User focus*

Members should identify users and understand their needs for weather, climate, water and environmental-related information in their decision-making practices. Close coordination should be maintained with users, and effective feedback mechanisms should be established.

5.2.2 *Quality*

Members should establish a properly organized quality management system (QMS) comprising the procedures, processes and resources necessary to provide for public weather services of sustainable quality and level to be supplied to users.

Note: Quality management systems in conformity with ISO 9000 standards are considered as good practice.

5.2.3 *Dissemination and communication of products*

5.2.3.1 Members should ensure the preparation and timely dissemination, to relevant users, of public weather information, including warning information concerning the occurrence and evolution of severe weather phenomena. Such information should be fit for purpose for integration into decision-making processes and procedures related to the protection of life and property and the general welfare of the public.

5.2.3.2 Members should routinely utilize the Common Alerting Protocol (CAP) of the International Telecommunication Union (ITU) for the dissemination of warning information.

Note: CAP is contained in Series X: Data Networks, Open System Communications and Security of the Telecommunication Standardization Sector of ITU.

5.2.4 *Preparation of warnings*

5.2.4.1 Warning information intended for decision-making related to the protection of life, livelihood and property should be provided by bodies designated and mandated by government.

5.2.4.2 Members should provide warning information through the implementation of an early warning system.

5.2.4.3 Warning information should incorporate, to the extent possible, information about the impacts of weather hazards on individuals and communities.

5.2.5 *Socioeconomic benefits of meteorological and hydrological services*

Members should perform socioeconomic benefit assessments to both measure and demonstrate the value of their services to the public and other users.

5.2.6 *Public education and outreach*

Members should engage in education, awareness and preparedness activities aimed at helping citizens make the best use of forecast and warning information, understand the potential threats of high-impact weather and extremes of climate, and be aware of the appropriate mitigating actions.

5.3 Organization

Members should ensure that their NMHSs are properly equipped to provide essential public weather services, especially severe weather warnings.

5.4 Competency

Members should ensure that the competency requirement of personnel engaged in the provision of public weather services is in accordance with the requirements indicated in Part V of the present publication.

PART V. QUALIFICATIONS AND COMPETENCIES OF PERSONNEL INVOLVED IN THE PROVISION OF METEOROLOGICAL, CLIMATOLOGICAL, HYDROLOGICAL, MARINE AND RELATED ENVIRONMENTAL SERVICES

1. QUALIFICATIONS AND COMPETENCIES

1.1 General

1.1.1 The qualifications and competencies required of personnel involved in the provision of meteorological, climatological, hydrological, marine and related environmental services should be established by Members in accordance with sections 1.2–1.8.

Note:
"Qualification" in this context refers to the completion of formal learning or courses of study which provide the underlying skills and knowledge required to support competency.

1.1.2 Members should, based on the relevant national, regional and/or global requirements, determine the necessary level of qualification(s) required for each category of operational personnel.

1.1.3 Members should keep records of the applicable qualifications of all personnel involved in the provision of meteorological, climatological, hydrological, marine and related environmental services, in accordance with quality management good practices and/or applicable requirements.

1.1.4 The competencies of Members' personnel should be demonstrated through job performance and assessed through competency assessment procedures, as appropriate.

Note: Guidance on competency implementation procedures is provided in *Guide to Competency* (WMO-No. 1205).

1.1.5 Members should establish competency assessment procedures for each category 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 competencies for personnel, taking due account of their local, national and regional conditions, regulations, requirements and procedures.

Note: Only top-level competencies are included in the Technical Regulations, while more detailed second-level competencies are provided in additional guidance material, as noted. National adaptations of the WMO competencies will require careful consideration of the applicability of second-level information.

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

1.2 Personnel providing aeronautical meteorological services

Notes:
1. Aeronautical meteorological forecasters and observers in the following context include personnel responsible for providing an aeronautical meteorological service at the national, regional or global level.

2. The necessary level of qualifications required for each category may differ by Member, recognizing that Members may require additional and/or higher levels of qualification(s) for operational aeronautical meteorological personnel.

3. Aeronautical meteorological service delivery specialisms such as (but not limited to) volcanic hazards and space weather, may require the successful completion of additional and/or alternative qualification frameworks to underpin the required competencies of the personnel delivering operational services in such specialist areas.

1.2.1 *Qualifications*

1.2.1.1 **Members shall ensure, taking into consideration the area and airspace of responsibility, aviation user requirements, international regulations and local procedures and priorities, that the qualification(s) necessary to underpin the required competencies of operational aeronautical meteorological forecasters is (are) consistent with the relevant educational frameworks, background skills and knowledge requirements described in the Basic Instruction Package for Meteorologists, as defined in Appendix A.**

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 SERCOM. Supplementary second-level competency information is published in the *Compendium of WMO Competency Frameworks* (WMO-No. 1209). Additional guidance and access to aeronautical meteorology training and guidance material sourced from around the world is available through the WMO Aviation Training Repository.

1.2.2.1 Aeronautical meteorological forecaster

Members shall ensure that for the area and airspace of responsibility, given the impact of meteorological and other relevant environmental 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 continually monitor meteorological and/or other relevant environmental situations;

(b) Forecast meteorological and/or other relevant environmental phenomena and parameters;

(c) Warn of hazardous meteorological and/or other relevant environmental phenomena;

(d) Ensure the quality of meteorological and/or other relevant environmental information and services supplied to users;

(e) Communicate meteorological and/or other relevant environmental information to internal and external users.

Note: Other relevant environmental situations, phenomena, parameters and information in this context may include, for example, the presence of volcanic ash, the release of radioactive material or toxic chemicals into the atmosphere and space weather.

1.2.2.2 Aeronautical meteorological observer

Members shall ensure that for the area and airspace of responsibility, given the impact of meteorological and/or other relevant environmental 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) Continually monitor meteorological and/or other relevant environmental situations;

(b) Observe and record meteorological and/or other relevant environmental phenomena and parameters;

(c) Ensure the quality of the observing system performance and of meteorological and/or other relevant environmental information supplied to users;

(d) Communicate meteorological and/or other relevant environmental information to internal and external users.

Note: Other relevant environmental situations, phenomena, parameters and information in this context may include, for example, the presence of volcanic ash and space weather.

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: See *Guidelines for Trainers in Meteorological, Hydrological and Climate Services* (WMO-No. 1114) for additional guidance, including second-level competency information. The competency standards for providers of education and training for meteorological, hydrological and climate services 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

1.4.1 *Qualifications*

Members should define, in light of their national circumstances, the specific qualifications required of personnel supporting WIS.

1.4.2 *Competencies*

Note: The competency standards for WIS personnel are maintained by INFCOM. Supplementary second-level competency information is published in the *Manual on the WMO Information System* (WMO-No. 1060). Additional guidance is available in the *Guide to the WMO Information System* (WMO-No. 1061).

1.4.2.1 The provision of WIS services within NMHSs or related services can be accomplished by a variety of skilled personnel, including project managers, engineers, technicians and information technology staff. Third-party organizations, such as universities, international and regional institutions and centres, private sector companies and other providers can also supply data, products and information for the WIS service(s).

1.4.2.2 Members should ensure that institutions providing WIS services have the personnel and resources to:

(a) Manage the physical infrastructure;

(b) Manage the operational applications;

(c) Manage the data flow;

(d) Manage data discovery;

(e) Manage interaction among WIS centres;

(f) Manage external user interactions;

(g) Manage the operational service.

1.5 Personnel providing climate services

1.5.1 *Qualifications*

Members should define, in light of their national circumstances, the specific qualifications required of personnel providing climate services.

1.5.2 *Competencies*

Note: The competency standards for climate services provision are maintained by SERCOM. Supplementary second-level competency information is published in the Compendium of WMO Competency Frameworks (WMO-No. 1209). Additional guidance is available in the *Guidelines for the Assessment of Competencies for Provision of Climate Services* (WMO-No. 1285).

In a given institution, the list of the competencies to be met and the associated performance criteria should 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 the 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.

1.5.2.1 **Competencies and associated performance criteria:**

(a) Creating and managing climate datasets;

(b) Deriving products from climate data;

(c) Creating and/or interpreting climate forecasts, climate projections and model output;

(d) Ensuring the quality of climate information and services;

(e) Communicating climatological information to users.

1.6 Personnel providing marine meteorological services

1.6.1 *Qualifications*

Members should ensure that a marine weather forecaster has successfully completed the Basic Instruction Package for Meteorologists as defined in Appendix A.

1.6.2 *Competencies*

Note: The competency standards for marine weather forecasters are maintained by SERCOM. Supplementary second-level competency information is published in the *Compendium of WMO Competency Frameworks* (WMO-No. 1209).

Members should ensure that for the given area of responsibility, in consideration of the impact of meteorological phenomena, variables and parameters on marine operations, and in compliance with marine user requirements, international regulations, local procedures and priorities, a marine weather forecaster is able to:

(a) Analyse and continually monitor the marine weather situation;

(b) Forecast marine weather phenomena, variables and parameters;

(c) Warn of hazardous marine meteorological phenomena;

(d) Ensure the quality of marine meteorological information and services;

(e) Communicate marine meteorological information to internal and external users.

1.7 Personnel providing public weather services

1.7.1 *Qualifications*

A public weather services forecaster should have successfully completed the Basic Instruction Package for Meteorologists as defined in Appendix A.

1.7.2 *Competencies*

Note: The competency standards for public weather services delivery are maintained by SERCOM. Supplementary second-level competency information is published in the *Compendium of WMO Competency Frameworks* (WMO-No. 1209).

1.7.2.1 Public weather forecaster

Members should ensure that for the nationally defined public weather services areas of responsibility, meteorological and hydrological impacts on society, and meteorological and hydrological user requirements, local procedures and priorities, a public weather forecaster is able to:

(a) Analyse and continually monitor the evolving meteorological and hydrological situation;

(b) Forecast meteorological and hydrological phenomena and parameters;

(c) Warn of hazardous meteorological and hydrological phenomena;

(d) Communicate meteorological and hydrological information to internal and external users;

(e) Ensure the quality of meteorological and hydrological information and services.

1.7.2.2 Public weather broadcasters and communicators

Members should ensure that for the geographical areas of responsibility, meteorological and hydrological impacts on society, and meteorological and hydrological user requirements, local procedures and priorities, a public weather broadcaster and communicator is able to:

(a) Maintain awareness of the evolving meteorological and/or hydrological situation, updated forecasts and warnings, and impacts of anticipated conditions;

(b) Assemble meteorological and hydrological information that meets user needs for communication and delivery;

(c) Communicate meteorological and hydrological information and potential impacts via broadcast and other media;

(d) Ensure the quality of meteorological and hydrological information and services.

1.7.2.3 Persons engaged in the development and delivery of meteorological and hydrological products and services

Members should ensure that for the nationally defined areas of responsibility, meteorological and hydrological impacts on society, and meteorological and hydrological user requirements, local procedures and priorities, a person engaged in the development and delivery of meteorological and hydrological products and services is able to:

(a) Maintain awareness of developments in technology and science which facilitate the development and improvement of products and services to meet user requirements;

(b) Develop applications, products and services that meet user requirements;

(c) Develop and manage relationships with users and other stakeholders, in particular by providing documentation and delivering training on new products and services;

(d) Ensure the quality of meteorological and hydrological information and services.

1.7.2.4 Public weather services adviser supporting disaster prevention and mitigation and other user services

Members should ensure that for the nationally defined public weather service areas of responsibility, meteorological and hydrological impacts on society, and meteorological and hydrological societal requirements, local procedures and priorities, a public weather services adviser supporting disaster prevention and mitigation and other user services is able to:

(a) Continually monitor the evolving meteorological and hydrological situation, updated forecasts and warnings, and impacts of anticipated conditions;

(b) Develop and adopt procedures and services to meet user needs and facilitate impact assessments;

(c) Develop and manage relationships with disaster prevention and mitigation users and other stakeholders;

(d) Communicate meteorological and hydrological information and potential impacts to internal and external users and engage in outreach activities;

(e) Ensure the quality of meteorological and hydrological information and services.

1.8 Personnel responsible for instruments, observations, and observing programmes and networks

1.8.1 *Qualifications*

Members should define, in light of their national circumstances, the specific qualifications required of personnel performing meteorological observations, installing, maintaining and calibrating instrumentation, and managing observing programmes and networks.

1.8.2 *Competencies*

Note: The competency standards for personnel performing meteorological observations, installing and maintaining instrumentation, performing instrument calibrations, and managing observing programmes and networks are maintained by INFCOM. Supplementary second-level competency information and additional guidance are published as the *Guide to Instruments and Methods of Observation* (WMO-No. 8), Volume V, Chapter 5: Training of Instrument Specialists and its annexes.

1.8.2.1 Personnel performing meteorological observations

1.8.2.1.1 Members should ensure that institutions providing meteorological observations have the personnel and resources to:

(a) Monitor the meteorological situation;

(b) Perform a surface observation;

(c) Perform a balloon-borne upper air observation;

(d) Utilize remote sensing technology in making observations;

(e) Monitor the performance of instruments and systems;

(f) Maintain the quality of observational information;

(g) Maintain a safe work environment.

1.8.2.2 **Personnel installing and maintaining instrumentation**

1.8.2.2.1 Members should ensure that institutions installing and maintaining instrumentation have the personnel and resources to:

(a) Install instruments and communications systems;

(b) Maintain instrument and system performance;

(c) Diagnose faults;

(d) Repair faulty instruments and systems;

(e) Maintain a safe work environment.

1.8.2.3 **Personnel performing instrument calibrations**

1.8.2.3.1 Members should ensure that institutions providing instrument calibration services have the personnel and resources to:

(a) Calibrate instruments;

(b) Check instrument performance;

(c) Manage the laboratory work programme;

(d) Manage the laboratory infrastructure;

(e) Develop and maintain standard operating procedures;

(f) Manage the archiving* of data and records;

(g) Maintain a safe work environment and laboratory security.

Note: *"Archiving" in this context is the function of storing, keeping secure and ensuring the discoverability, accessibility and retrievability of data and information.

1.8.2.4 **Personnel managing observing programmes and networks**

1.8.2.4.1 Members should ensure that institutions managing observing programmes and networks have the personnel and resources to:

(a) Plan the observing programme;

(b) Procure equipment;

(c) Select and acquire sites;

(d) Install network components;

(e) Manage the network operation;

(f) Manage the observing programme.

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 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 (QMS), 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

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 (BIP-M) shall be used by Members to ensure that the meteorological personnel in the category Meteorologist are provided with the underlying knowledge to acquire skills common to all professionals in this category, which they can use as a platform to develop the necessary competencies for specific roles and continue to learn throughout their careers.

Note: BIP-M establishes a common understanding of the abilities required for individuals to be recognized as Meteorologists, as defined in Appendix A. BIP-M is presented in its entirety in the *Guide to the Implementation of Education and Training Standards in Meteorology and Hydrology* (WMO-No. 1083), Volume I, which contains guidance on how to implement the learning outcomes presented in Appendix A.

1.4 The Basic Instruction Package for Meteorological Technicians

The Basic Instruction Package for Meteorological Technicians (BIP-MT) shall be used by Members to ensure that the meteorological personnel in the category Meteorological

Technician are provided with the underlying knowledge to acquire skills common to all professionals in this category, which they can use as a platform to develop the necessary competencies for specific roles and continue to learn throughout their careers.

Note: BIP-MT establishes a common understanding of the abilities required for individuals to be recognized as Meteorological Technicians, as defined in Appendix A. BIP-MT is presented in its entirety in the *Guide to the Implementation of Education and Training Standards in Meteorology and Hydrology* (WMO-No. 1083), Volume I, which contains guidance on how to implement the learning outcomes presented in Appendix A.

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 the *Guide to the Management and Operation of WMO Regional Training Centres and Other Training Institutions* (WMO-No. 1169).

Regional association

- Prioritize the 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 communication 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 the 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 the 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.

PART VII. QUALITY MANAGEMENT

1. QUALITY MANAGEMENT SYSTEMS

Note: The *Guide to the Implementation of Quality Management Systems for National Meteorological and Hydrological Services and Other Relevant Service Providers* (WMO-No. 1100) contains detailed guidance on the provision of meteorological, hydrological and climatological services within the framework of *ISO 9001:2015 – Quality management systems – Requirements*.

1.1 General

Members should ensure that their organizations responsible for the provision of meteorological, hydrological, climatological or other environmental services establish and implement a properly organized quality management system (QMS), comprising procedures, processes and resources needed to provide for the quality management of the information and services to be delivered to users.

1.2 World Meteorological Organization international centres and facilities

Members undertaking to host either global or regional centres, or facilities on behalf of WMO Programmes, should establish and implement a QMS that covers the entire scope of services for which the centre or facility has been designated. **Compliance requirements for related services shall be defined by the programme responsible for the functions and services being provided**. Certification of such compliance should follow the principles defined in section 1.4.3 below.

1.3 Establishing a quality management system

1.3.1 The QMS established in accordance with 1.1 above should:

(a) Demonstrate the commitment of the organization's leadership to a quality management approach to the delivery of its products and services;

(b) Clearly identify the organization's role within the environment (national and international) in which it operates;

(c) Establish a quality policy that:

  (i) Supports the organization's strategic direction and objectives;

  (ii) Commits to meeting stakeholder needs;

  (iii) Promotes continual improvement;

(d) Clearly articulate roles and responsibilities within the organization;

(e) Adopt a risk-based approach to the organization's activities;

(f) Have plans and associated objectives and performance indicators;

(g) Be appropriately resourced to ensure the viability and long-term sustainability of the QMS;

(h) Ensure that all staff are competent to undertake their roles and, as appropriate, implement specific competence frameworks;

(i) Adhere to internationally recognized document control procedures and practices;

(j) Have a strong customer focus through effective communication and sound planning practices to meet the identified needs of customers;

(k) Establish verification and validation activities to ensure that the outputs meet the identified needs of customers and users;

(l) Monitor, measure, analyse and evaluate the QMS through a rigorous audit schedule and regular reviews by management;

(m) Promote a culture within the organization of continual improvement.

1.3.2 The QMS established in accordance with 1.1 above should provide customers with assurance that the products and services provided comply with the stated requirements in terms of geographical and spatial coverage, format and content, time and frequency of issuance and period of validity, as well as with the required accuracy of measurements, observations and forecasts.

Note: Such requirements are normally included in relevant service-level agreements, contracts or other frameworks that establish the provider/customer relationship.

1.4 Recognition of compliance of a quality management system

1.4.1 A QMS established in accordance with 1.1 above should be in conformity with the current standard, *ISO 9001:2015 – Quality management systems – Requirements*.

Note: The ISO 9001:2015 standard provides an internationally recognized framework for QMSs.

1.4.2 Demonstration of compliance of the QMS, centre or service should be by audit. All audits should be performed by qualified quality management auditors and should be appropriately documented and retained. If non-conformities are identified during the audit, remedial action should be initiated to determine and correct the cause.

Note: Additional guidance on the methodology and procedures for internal and external audits relating to the quality management system is provided in the *Guide to the Implementation of Quality Management Systems for National Meteorological and Hydrological Services and Other Relevant Service Providers* (WMO-No. 1100).

1.4.3 **Audits conducted within the WMO operational centre certification process shall be along the lines defined in the annex to this paragraph.**

1.4.4 An ISO 9001 certificate of compliance issued by an appropriately accredited conformity assessment body, covering the information and services provided, should be considered as sufficient demonstration of compliance of the established QMS.

ANNEX. AUDIT PROCESSES

(See Part VII, 1.4.3)

1. INTRODUCTION

The audit processes for certifying centres or services include a full-scope audit and a limited-scope audit.

The responsibility for a full- or limited-scope audit belongs to the body in charge of the activity of the centre or service.

Note: The typical cases where a full-scope audit could apply include:

1. The first audit of a new centre or a centre delivering new services;
2. An audit scheduled by the responsible body to be full-scope;
3. Where a full-scope audit is required;
4. The centre failed a previous audit.

The typical cases where a limited-scope audit could apply include:

1. A recurring audit of an existing centre or service;
2. Where the schedule may not allow a full-scope audit to be performed by a certain deadline;
3. When a recent full-scope audit has been undertaken;
4. To review any follow-up actions from a previous audit.

2. THE GENERIC AUDIT PROCESS

Introduction

1. The generic demonstration and reporting process for the assessment and auditing of any WMO Member's centre is based on the experience of the WMO initial audit programme.

2. At a high level, the audit process consists of four phases:

Phase 1: Notification/request to audit a centre, accompanied by a completed self-assessment questionnaire;

Phase 2: Pre-audit capability assessment;

Phase 3: Audit and validation by the audit and certification team;

Phase 4: Audit report and recommendation.

3. This process assumes that the audit and certification team has previously been informed of the intention to certify one or more centres by the body responsible for the activity of the centre or service.

4. Phase 3 of the audit process will be carried out on-site or off-site, according to the needs of the responsible body. The audit period is defined by the responsible body, but it should not exceed two days, excluding auditor travel time to and from the audit site in case of an on-site audit.

5. The audit and certification team will conduct the audits in accordance with the guidelines published by the International Organization for Standardization (ISO) in *ISO 19011:2018: Guidelines for auditing management systems*.

In particular, the following audit principles apply:

(a) Integrity, fair representation, due professional care, confidentiality, independence, use of an evidence- and risk-based approach;

(b) Geographic diversity (ensuring that auditors do not audit centres within their country) to ensure the necessary impartiality of audit teams.

6. The entire audit process, including all documentation, site assessments, discussions and reporting, is to be conducted in English.

7. Audits will be undertaken by audit teams consisting of at least two persons: a lead auditor with audit experience and a subject matter expert.

PHASE 1: Notification/request to audit a centre, accompanied by a completed self-assessment questionnaire

1. Phase 1 commences when the audit and certification team receives a formal request, via the Secretary-General, from a centre's Permanent Representative with WMO to undertake the audit of that centre. Such a request will be accompanied by all relevant contact point information to allow the team to liaise with the centre management and experts.

2. The centre will also provide a completed self-assessment questionnaire that gives preliminary evidence of the centre's capabilities based upon the audit criteria provided by the centre's system owner.

3. The self-assessment information should be provided in English, in a style that can be easily understood by an auditor, avoiding the use of highly technical language unless it is necessary.

4. The audit and certification team, in consultation with the system owner's group responsible for the activity of the centre or service, will assign a team of auditors, with the lead auditor being responsible for ensuring that each audit delivers clear and concise findings upon which informed decisions can be made.

5. Since transparency of the audit process is key to ensuring a successful audit, all participants in the process need to understand their role and responsibilities. To ensure clarity, the process should be clearly set out, and the documentation provided to all stakeholders should include:

(a) The audit objective;

(b) The audit process;

(c) The applicable guiding principles found in ISO 19011:2018;

(d) Information concerning the composition of the audit team, including their contact details and relevant skills, experience and competence;

(e) Confirmation that all the documentation needed for the audit is in place.

In case of an on-site audit, the following items will be included:

(a) Documentation (including security and health and safety requirements) enabling the auditors to visit all the sites and facilities required by the audit;

(b) Details of what expenses are being met by the host organization;

(c) Confirmation that the host organization will provide logistical support to facilitate auditor travel arrangements, including assistance with visa applications as required.

PHASE 2: Pre-audit capability assessment

1. Phase 2 commences with the audit team undertaking an assessment of the information provided by the centre in its self-assessment questionnaire.

2. The auditors will advise the centre whether the self-assessment information is sufficient for the audit team to move to the third phase.

3. Should further information be required to make this initial assessment, the audit team will correspond with the candidate centre's point(s) of contact to request such information or to clarify specific matters to the audit team's own satisfaction.

4. Should the audit team not receive sufficient information to complete the pre-audit assessment, the team will advise the centre and the system owner's group responsible for the activity of the centre or service that a site assessment should not take place, with an explanation of the reasons for that recommendation.

5. Should such a situation occur, the audit team will move to Phase 3 only if sufficient preliminary evidence is subsequently supplied, again to the satisfaction of the audit team.

PHASE 3: Audit and validation by the audit and certification team

1. Phase 3 commences with the assessment and audit by the audit team to verify the centre's capabilities against the predetermined assessment criteria.

2. In line with professional audit practice, the assessment will commence with a formal opening meeting, during which the audit team provides an overview of its activities, and it will finish with a formal closing meeting, at which the team informally presents a short summary of its findings and its provisional assessment.

3. The auditors will then undertake the assessment and audit by means of discussion, interviews, review of documents and/or records, and observation of appropriate operational functions. They will apply predetermined assessment criteria and will gather evidence to assess whether the centre has in place the necessary means of compliance with the audit criteria.

4. Certain tests or simulations may also be requested by the audit team or suggested by the candidate centre to verify the correct operation of a system or application.

5. It should be noted that the audit team may not be able to assess all organizational, technical or scientific aspects of the centre's programme during the audit, but may, at its discretion, selectively sample particular aspects of the operation to support its assessment of the centre's capability.

6. The audit team will base its conclusions solely on the evidence collected during the assessment and will determine whether the centre is:

(a) Compliant: the centre has demonstrated to the satisfaction of the audit team that at the time of observation, it fulfils the relevant assessment criteria without any qualification;

(b) Compliant, but with qualification: the centre has demonstrated to the satisfaction of the audit team that, at the time of observation, it fulfils the relevant assessment criteria, but with qualification; the qualification will be in the form of a concise statement;

(c) Not compliant: the centre has not demonstrated to the satisfaction of the audit team that, at the time of observation, it fulfils the relevant assessment criteria.

PHASE 4: Audit report and recommendation

1. Phase 4 commences at the end of Phase 3 with the preparation of the audit report and its submission to the appropriate WMO body, ideally within five business days of returning from the audit, but within a maximum of one month of returning.

2. The report will provide additional details on the strengths, weaknesses, opportunities for improvement, non-compliance and areas of concern, as well as recommendations based on the overall assessment of the centre.

3. The report will be confidential and available only to the centre being audited and to authorized individuals within WMO and the responsible body.

4. The body responsible for the activity of the centre or service will finalize each audit report and will forward it to its own predefined distribution list, including the centre or site audited.

5. Evidence collected during the site assessments and audits will be forwarded to the WMO Secretariat. Any hard or soft copies held by the auditors will be destroyed or deleted.

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 Overarching attributes and skills of Meteorologists

1.1.1 To satisfy the requirements of the Basic Instruction Package for Meteorologists, Members shall ensure that Meteorologists are able:

(a) To combine available sources of relevant observational data in a systematic way to produce coherent analyses of the state of the atmosphere at the spatial and temporal scales under consideration;

(b) To generate reasonable hypotheses for the evolution of the atmosphere in the region of interest in terms of relevant dynamic and physical processes and in terms of conceptual models;

(c) To predict the evolution of the state of the atmosphere and the degree of uncertainty in those predictions, combining relevant numerical model products with physical and dynamical thinking and empirical methods to a level of precision that is appropriate to the spatial and temporal scales under consideration and the known sources of uncertainty;

(d) To compare predictions with observations, using qualitative or quantitative methods to assess hypotheses and to ensure the quality of services, including through evidencing changes needed in hypotheses, products and services;

(e) To clearly and accurately communicate relevant information with colleagues, customers and other stakeholders using a range of media in a manner that reflects uncertainty and impacts;

(f) To determine the sensitivities of society to weather and climate phenomena, drawing on other disciplines where necessary, to ensure that the identification and warning of weather and climate impacts are central to the meteorologists' work;

(g) To evaluate their work outputs against relevant standards, take corrective action if needed, and contribute to the development of work systems and processes;

(h) To reflect on their learning and working practices, critically evaluate their performance and use a range of approaches to continuously develop their professional knowledge and competence.

1.1.2 To satisfy the prerequisite mathematics and physics requirements of the Basic Instruction Package for Meteorologists, Members shall ensure that Meteorologists are able:

(a) To interpret and apply the mathematical language, concepts and techniques used in introductory meteorological literature and teaching materials;

(b) To use their mathematical knowledge to make logical and reasoned problem-solving decisions; to recognize incorrect reasoning; and to communicate their reasoning clearly using the language of mathematics;

(c) To apply and interpret the basic statistical measures used to summarize meteorological data and forecast output and to analyse errors;

(d) To represent physical and meteorological situations mathematically, understanding the relationship between the real world and the mathematical model and making reasonable interpretations of results;

(e) To use basic physical laws to solve problems related to mechanics, thermodynamics, wave motion and electromagnetic radiation.

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.

1.1.3 **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 may be satisfied in a number of ways, such as: completion of a university degree in meteorology; completion of postgraduate study or a programme at an RTC or NMHS training centre in meteorology, having already completed studies in the prerequisite mathematics and physics; accessing education and training from institutions as part of the WMO Global Campus. What matters is that providers of education and training can evidence how their programmes of study aid students in achieving the learning outcomes defined above.

1.1.4 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 Essential 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 weather systems and services, and climate science and services.

1.2.1 *Physical meteorology*

Members shall ensure that a Meteorologist is able:

(a) To use their knowledge of atmospheric composition and radiative transfer to explain the structure of the atmosphere, global energy balance and the greenhouse effect, and common optical phenomena;

(b) To use the laws of thermodynamics to explain the stable stratification of the atmosphere and the effects of adiabatic and non-adiabatic processes, including the effects of water; to use a thermodynamic diagram to assess the properties and stability of the atmosphere;

(c) To summarize the microphysical processes involved in the formation of clouds, precipitation and electrical phenomena and use a thermodynamic diagram to diagnose and predict these phenomena;

(d) To use knowledge of turbulence and surface fluxes to explain the structure and characteristics of atmospheric boundary layers and the behaviour of contaminants;

(e) To select instruments to observe surface and upper-air atmospheric phenomena, considering their physical principles of operation, sources and characteristics of error and uncertainty, and quality-control practices in use;

(f) To use relevant Earth- and space-based remote sensing to observe atmospheric and surface phenomena qualitatively and quantitatively; to explain how radiation measurements are made, how they are turned into atmospheric data, and what the uses and limitations of these data are.

1.2.2 *Dynamic meteorology*

Members shall ensure that a Meteorologist is able:

(a) To outline the application of the concepts of force, acceleration and frames of reference to a physics of atmospheric dynamics, as exemplified in the equations of motion;

(b) To apply conceptual models derived from dynamic meteorology to explain and predict the evolution of the atmosphere in the area of interest;

(c) To evaluate the extent to which conceptual models resemble reality;

(d) To use numerical model outputs to represent phenomena of interest based on knowledge of the characteristics of the modelling system, the spatial and temporal scales under consideration and the need to represent uncertainty.

1.2.3 *Weather systems and services*

Members shall ensure that a Meteorologist is able:

(a) To apply conceptual models of synoptic, mesoscale and convective-scale phenomena to integrate observed and forecast data into coherent structures; to explain the formation, evolution and characteristics of these phenomena using knowledge of physical and dynamical meteorology;

(b) To detect situations where real-world weather systems deviate from the conceptual models using knowledge of the models' limitations and suggest reasons for the deviations;

(c) To predict occurrences of extreme or hazardous weather conditions associated with synoptic, mesoscale or convective-scale phenomena and monitor observed data to verify the predictions;

(d) To generate analyses and basic forecasts using observed and forecast real-time or historical data, including the monitoring and observing of the weather;

(e) To summarize the role of national meteorological services and other providers using knowledge of society's needs, the impacts of severe weather, the products and services used to meet users' needs and the processes used to manage quality.

1.2.4 *Climate science and services*

Members shall ensure that a Meteorologist is able:

(a) To apply conceptual models of the Earth's global circulation, climate system and the interactions between the land, ocean, atmosphere and cryosphere to explain the mean state of the climate;

(b) To interpret products and services based on climate information, taking into account their inherent uncertainty;

(c) To describe the observed variability in the climate system and the causes and impacts of that variability; to use this knowledge to interpret products such as climate predictions and monthly to seasonal forecasts;

(d) To communicate the results of monthly, seasonal and climate predictions based on an understanding of probability, uncertainty and predictability at different scales and the sensitivities of the audience;

(e) To explain the long-term changes occurring in the climate system using knowledge on how these changes are observed, what the drivers for change are, including feedback within the system, what the potential impacts of climate change are, and what adaptation and mitigation strategies are possible.

2. BASIC INSTRUCTION PACKAGE FOR METEOROLOGICAL TECHNICIANS

2.1 Overarching attributes and skills of Meteorological Technicians

2.1.1 **To satisfy the requirements of the Basic Instruction Package for Meteorological Technicians, Members shall ensure that Meteorological Technicians are able:**

(a) To apply basic knowledge of meteorology, geography and related sciences to observe and monitor the atmosphere;

(b) To interpret available sources of observational data and commonly used meteorological diagrams and products to produce coherent descriptions of the state of the atmosphere at the spatial and temporal scales under consideration;

(c) To identify, analyse and resolve the issues involved in setting up and maintaining meteorological instrumentation in the area of responsibility;

(d) To communicate with colleagues, customers and other stakeholders using a range of media with relevance, clarity and precision;

(e) To determine the sensitivities of society to weather and climate phenomena, drawing on other disciplines where necessary, to ensure that the impacts of weather and climate on people and society are central to their work;

(f) To evaluate their work outputs against relevant standards, take corrective action if needed and contribute to the development of work systems and processes;

(g) To reflect on their learning and working practices, critically evaluate their performance and use a range of approaches to continuously develop their professional knowledge and competence.

2.1.2 **To satisfy the prerequisite mathematics and physics requirements of the Basic Instruction Package for Meteorological Technicians, Members shall ensure that Meteorological Technicians are able:**

(a) To demonstrate the knowledge of mathematics and physics required to successfully complete the meteorological components of the BIP-MT.

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.

2.1.3 **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 usually be 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 Essential 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 geography, oceanography and hydrology, basic physical and dynamic meteorology, basic synoptic and mesoscale meteorology, global and local climatology, cloud formation, meteorological parameters, instruments and methods of observation, and basic climate-data quality control.

2.2.1 *Basic geography, oceanography and hydrology*

Members shall ensure that a Meteorological Technician is able to describe the basic geographical, oceanographical, and hydrological features of the region of responsibility.

2.2.2 *Basic physical and dynamic meteorology*

Members shall ensure that a Meteorological Technician is able:

(a) To explain the basic physical and dynamical processes that take place in the atmosphere;

(b) To 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:

(a) To describe the formation, evolution and characteristics of synoptic-scale and mesoscale tropical, mid-latitude and polar weather systems, to analyse weather observations;

(b) To describe the forecast process and the use made of the associated products and services.

2.2.4 *Global and local climatology*

Members shall ensure that a Meteorological Technician is able:

(a) To describe the global circulation of the atmosphere, the climates in the region of responsibility, and key climate products and services;

(b) To outline the basic concepts behind climate variability and climate change.

2.2.5 *Cloud formation*

Members shall ensure that a Meteorological Technician is able to describe the formation and characteristics of the main cloud and precipitation types.

2.2.6 *Meteorological parameters, instruments and methods of observation*

Members shall ensure that a Meteorological Technician is able:

(a) To describe how weather phenomena are measured from ground-, air- and space-based instruments;

(b) To make a basic weather observation based on the evaluation and interpretation of data from ground-, air- and space-based instruments.

2.2.7 *Basic climate-data quality control*

Members shall ensure that a Meteorological Technician is able to describe and apply climate-data quality control procedures.

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 the 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 institution 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 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 12 months and on its plan for the next 12 months, with an outlook for future years;**

– **The RTC component: (a) is open to students from all countries in the region and, subject to the availability of resources, to students from interested countries in other regions; and (b) has appropriate services in place to support international/regional students.**

For more information, please contact:

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