W O R L D M E T E O R O L O G I C A L O R G A N I Z A T I O N

MANUAL ON THE GLOBAL OBSERVING SYSTEM

VOLUME I
(Annex V to the WMO Technical Regulations)

GLOBAL ASPECTS
2002 Edition

WMO No. 544

Secretariat of the World Meteorological Organization - Geneva - Switzerland

CONTENTS

Page

———

INTRODUCTION

Purpose and scope

1. The Manual is designed:

(a) To facilitate co-operation in observations between Members;

(b) To specify obligations of Members in the implementation of the World Weather Watch (WWW) Global Observing System (GOS);

(c) To ensure adequate uniformity and standardization in the practices and procedures employed in achieving (a) and (b) above.

2. The first edition of the Manual on the Global Observing System was issued in 1980 in accordance with the decisions of Seventh Congress. Since then it has undergone a number of revisions and amendments. These have been consolidated into this new revised edition approved by Resolution [ ].

3. The Manual is composed of Volumes I and II, which contain the regulatory material for the global and regional aspects, respectively. The regulatory material stems from recommendations of the Commission for Basic Systems and resolutions of regional associations, as well as from decisions taken by Congress and the Executive Council.

4. Volume I of the Manual - Global Aspects - forms part of the Technical Regulations and is referred to as Annex V to the Technical Regulations.

5. Volume II of the Manual - Regional Aspects - does not form part of the Technical Regulations.

6. In essence, the Manual specifies what is to be observed where and when in order to meet the relevant observational requirements of Members. The *Guide on the Global Observing System* (WMO-No. 488) provides detailed guidance on how to establish, operate and manage networks of stations to make these observations. While some regulatory material concerning instruments and methods of observation is contained in a special short section of the Manual, a full description of how and with what observations are made is contained in the *Guide to Instruments and Methods of Observation* (WMO-No. 8). The *International Cloud Atlas* describes the classification of clouds. The subsequent step of how observations are to be reported and encoded is specified in the *Manual on Codes* (WMO-No. 306). Further guidance on observations for special applications is given in WMO publications such as *the Guide on Meteorological Observation and Information Distribution Systems at Aerodromes* (WMO-No. 731), *Guide to Marine Meteorological Services* (WMO-No. 471), *Guide to Climatological Practices* (WMO-No. 100), *Guide to Agricultural Meteorological Practices* (WMO-No. 134) and various publications of the Global Atmosphere Watch Programme.

Types of regulation

7. Volume I of the Manual comprises standard practices and procedures and recommended practices and procedures. The definitions of these two types are as follows:

The standard practices and procedures:

(a) Are those practices and procedures for which it is necessary that Members follow or implement them; and therefore

(b) Have the status of requirements in a technical resolution in respect of which Article 9(b) of the Convention is applicable; and

(c) Are invariably distinguished by the use of the term ***shall*** in the English text and by suitable equivalent terms in the French, Russian and Spanish texts.

The recommended practices and procedures:

(a) Are those practices and procedures which it is desirable that Members follow or implement; and therefore

(b) Have the status of recommendations to Members to which Article 9(b) of the Convention shall not be applied; and

(c) Are distinguished by the use of the term ***should*** in the English text (except where specifically otherwise provided by decision of Congress) and by suitable equivalent terms in the French, Russian and Spanish texts.

8. In accordance with the above definitions, Members shall do their utmost to implement the standard practices and procedures. In accordance with Article 9 of the Convention and in conformity with the provisions of Regulation 127 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 Manual, 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 of the effective date of the change.

9. With regard to the recommended practices and procedures, Members are urged to comply with these, but it is not necessary to notify the Secretary-General of non-observance.

10. In order to clarify the status of the various regulatory material, 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.

Notes, attachments and (Volume I) and Volume II

11. Certain notes are included in the Manual for explanatory purposes. They do not have the status of the annexes to the Technical Regulations.

12. A number of specifications and formats of observing practices and procedures are included in the Manual. Taking into account the rapid development of observing techniques and the increasing requirements of the WWW and other WMO programmes, these specifications, etc., are given in "attachments" to the Manual and do not have the status of the annexes to the Technical Regulations. This will enable the Commission for Basic Systems to update them as necessary.

13. The words "shall" and "should" in the attachments, notes, and Volume II have their dictionary meanings and do not have the regulatory character mentioned in paragraph 7 above.

_____

PART I

GENERAL PRINCIPLES REGARDING THE ORGANIZATION AND IMPLEMENTATION OF THE GLOBAL OBSERVING SYSTEM

1. PURPOSE OF THE GLOBAL OBSERVING SYSTEM

1.1 The purpose of the Global Observing System (GOS) shall be to provide, from all parts of the globe and from outer space, high-quality standardised observations of the state of the atmosphere, land and ocean surface for the preparation of weather analyses, forecasts and warnings and for other applications in support of WMO programmes and related environmental programmes of other organizations.

1.2 The GOS should provide supplementary observations required internationally for special purposes, provided this would not be detrimental to achieving the primary purposes of the WWW.

2. ORGANIZATION AND DESIGN OF THE GLOBAL OBSERVING SYSTEM

2.1 The GOS shall be organized as part of the World Weather Watch (WWW), in conjunction with the Global Data-processing System (GDPS) and the Global Telecommunication System (GTS).

2.2 The GOS shall be constituted as a coordinated system of methods, techniques and facilities for making observations on a world-wide scale and as one of the main components of the WWW, taking into account to the extent feasible the requirements of other international programmes.

2.3 The GOS shall consist of facilities and arrangements for making observations at stations on land and at sea, from aircraft, from environmental observation satellites and other platforms.

2.4 For convenience in the planning and coordinating of the system, taking into account various criteria for observational data requirements, the GOS shall be considered as composed of three levels: global, regional and national.

2.5 The GOS shall be designed as a flexible and developing system capable of continuous improvement, on the basis of the latest achievements of technological and scientific progress and in accordance with changing requirements for observational data.

2.6 The planning and coordination of the GOS shall be realized through recommendations of the WMO Commission for Basic Systems (CBS), in consultation and co-ordination with Members, regional associations and other technical commissions concerned.

2.7 The GOS shall consist of two subsystems: the surface-based sub-system and the space-based sub-system.

2.8 The GOS surface-based subsystem shall be composed of surface synoptic land and sea stations, upper-air stations, climatological stations, agricultural meteorological stations, aircraft meteorological stations, and special stations as detailed in Part III, paragraphs 1(a) to 1(h) of this Manual.

2.9 The main elements of the GOS surface-based sub-system shall consist of networks of synoptic stations on land and sea and aircraft meteorological stations as detailed in Part III, paragraphs 1 (a) to 1 (c) of this Manual.

2.10 Other elements of the GOS surface-based sub-system shall consist of aeronautical meteorological stations, climatological stations, agricultural meteorological stations, research and special- purpose vessel stations and special stations (as listed in Part III, paragraphs 1 (d) to 1 (h)).

2.11 The GOS space-based sub-system shall comprise satellites of ~~two~~ three types: ~~near-~~ operational polar-orbiting and geostationary operational satellites and research and development satellites.

3. IMPLEMENTATION OF THE GLOBAL OBSERVING SYSTEM

3.1 All activities connected with the implementation of the GOS on the territories of individual countries should be the responsibility of the countries themselves and should, as far as possible, be met from national resources.

3.2 Implementation of the GOS on the territory of developing countries should be based on the principle of the utilization of national resources but, where necessary and so requested, assistance may be provided in part through:

(a) The WMO Voluntary Cooperation Programme (VCP);

(b) Other bilateral or multilateral arrangements including the United Nations Development Programme which should be used to the maximum extent possible.

3.3 Implementation of the GOS in regions outside the territories of individual countries (e.g. outer space, oceans, the Antarctic) should be based on the principle of voluntary participation of countries that desire and are able to contribute by providing facilities and services, either individually or jointly from their national resources, or by having recourse to collective financing. The assistance sources described in 3.2 above may also be used.

3.4 In the implementation of the GOS, maximum use should be made of existing arrangements, facilities, and personnel.

3.5 Existing elements of the GOS, as defined in Part III, shall not be removed before the reliability of a new element has been proven, and relative accuracy and representativeness of the observational data have been examined and found acceptable.

NOTES:

(1) The setting-up and operation of the new and improved facilities and services require a considerable amount of scientific research, development engineering, coordination of procedures, standardization of methods, and implementation coordination.

(2) The further development of the GOS is an important feature of the WWW plan which provides for:

(a) Continued development of the GOS as a cost-effective composite system comprising operationally reliable surface-based and space-based (satellite) sub-systems. It is expected that, within the surface-based sub-system, new systems measuring both large and local scales of atmospheric phenomena will be deployed operationally on a wider scale. Increasing use will be made of the rapidly growing fleet of aircraft with automated observing and reporting systems to supply observation of data at cruising levels and during ascent and descent. Mobile sea stations will continue to be the main source for surface synoptic observations over the oceans. Through increased use of automatic observing and (satellite) transmission equipment, the quality and quantity of the data will increase. The number of ships equipped with automated upper-air sounding facilities (ASAP) will increase and the deployment of more cost-effective systems will be accelerated. Drifting buoys, deployed outside the main shipping routes will continue to supply surface atmospheric and oceanographic parameters from the data-void ocean areas. It is also expected that the operational space-based sub-system will include a new generation of polar-orbiters and geostationary satellites with improved and new sensing systems.

(b) Coordination, integration and sustainability of composite surface and space-based systems and development of observing networks that are adaptable to changing requirements. This will include the planning for a new composite upper-air observing system making the most effective use of new and emerging technology, in order to develop a cost-effective, truly global system with the density of in-situ observations required for operational purposes as well as to complement and calibrate observations from satellites. The new composite system will utilise a range of technologies and techniques some of which could become operational only after a long-term development effort. The introduction of new

technology should be as and when proven and must be consistent with existing systems and supporting structures.

(c) Development of new strategies to facilitate closer cooperation between Meteorological Services and research programmes so that the available observing systems and programmes can be of use to operational meteorology and the research community.

(d) Exploring new ways for Members to contribute to the GOS, including joint funding and innovative arrangements to ensure adequate observations in remote and data-sparse areas.

PART II

REQUIREMENTS FOR OBSERVATIONAL DATA

1. CLASSIFICATION OF REQUIREMENTS

NOTE: A classification of the scales of meteorological phenomena is given in Attachment II.1.

1.1 Global requirements

Global requirements shall refer to observational data needed by Members for a general description of large-scale and planetary-scale meteorological phenomena and processes.

1.2 Regional requirements

Regional requirements shall be related to the observations needed by two or more Members to describe in greater detail the large- and planetary-scale atmospheric phenomena, as well as to describe the smaller ones on the mesoscale and small scale as may be agreed by regional associations.

1.3 National requirements

National requirements shall be determined by each individual Member in the light of its own interests.

1.4 Special requirements for environmental emergency response activities [EITHER REMOVE OR ADD OBSERVATIONAL DATA REQUIREMENTS FOR ERNA TO THE ET DATABASE AND INCLUDE ALL OTHER APPLICATION AREAS]

In order for the designated Regional Specialised Meteorological Centres (RSMC) to be in a position to provide Members with transport model products for environmental emergency response, meteorological and non-meteorological (radiological) data requirements need to be met. They are specified in Attachment II.2. These data, particularly from the site of an accident, are also needed by Members in order that they may take appropriate preventive and remedial action in case of an accidental release of radioactive material into the environment. Data should be made available promptly in accordance with the Convention on Early Notification of a Nuclear Accident (Article 5(e)).

Requirements in the event of volcanic eruptions

Requirements in the event of volcanic activity potentially hazardous to aviation should be related to the observational data needed by Members for taking appropriate action; these data are specified in Attachment II.3.

2. PROCEDURE FOR ELABORATION OF REQUIREMENTS [THIS SECTION NEEDS TO BE REPLACED WITH A DESCRIPTION OF THE ROLLING REVIEW OF REQUIREMENTS PROCESS. THE COMPLETE ROLLING REVIEW OF REQUIREMENTS PROCESS SHOULD BE CONTAINED IN THE GUIDE FOR THE GOS.]

2.1 The formulation of observational data requirements is a complicated process which consists of several stages. At various levels this process involves groups of end-users, regional associations, WMO technical commissions and other bodies. In order to rationalise the formulation of the observational data requirements the following procedures (schematically shown in Figure II.1) are applied.

2.2 Users present to WMO Members their needs for observational data for various applications (e.g. meteorological services for aviation, marine navigation, industry, agriculture,

climate research, etc.). Meteorological data might be used in two ways: directly in the provision of meteorological services, and in the preparation of meteorological products (weather analysis and prognoses) by GDPS centres. In the latter case, GDPS centres are considered as users.

2.3 WMO technical commissions are responsible for the consolidation of data needs presented by Members and for the formulation, on their basis, of a statement on observational data requirements/goals (usually in the form of tables) in various WMO Programmes. This should include explanatory notes and a rationale for the requirements/goals and, if possible, a statement on the incremental value of partially meeting these goals (in terms of accuracy, density, frequency, etc.). Often this will include a feedback process with users to ensure that enough information and understanding about users' needs are available. If a statement on requirements/goals is addressed to the World Weather Watch, and in particular to its Global Observing System, it should be presented to the Commission for Basic Systems for consideration.

2.4 The Commission for Basic Systems:

(a) Evaluates the feasibility of stated requirements/goals. The evaluation of technical and instrumental feasibility should be conducted in collaboration with the Commission for Instruments and Methods of Observation, the WMO body responsible for the Instruments and Methods of Observation Programme (IMOP). The evaluation process will result in the formulation (in the form of tables) of what portion of the statement of requirements/goals is feasible and can be achieved;

(b) Formulates system requirements to provide observational data to meet the requirements/goals defined by the technical commissions;

(c) Develops any amendments to the WMO regulatory and guidance publications on the basis of system requirements and submits them (in case of regulatory publications) to the Executive Council.

NOTE: The primary responsibility for the evaluation of the feasibility of meeting stated observational data requirements related to the global atmosphere watch, and for the development of associated guidance material rests with the Commission for Atmospheric Sciences.

2.5 The Executive Council approves the amendments and requests the Secretary-General to incorporate them in appropriate WMO Manuals.

2.6 The Members will be advised on the performance of observing systems and programmes through updated WMO Manuals and Guides to meet users' needs for observational data.

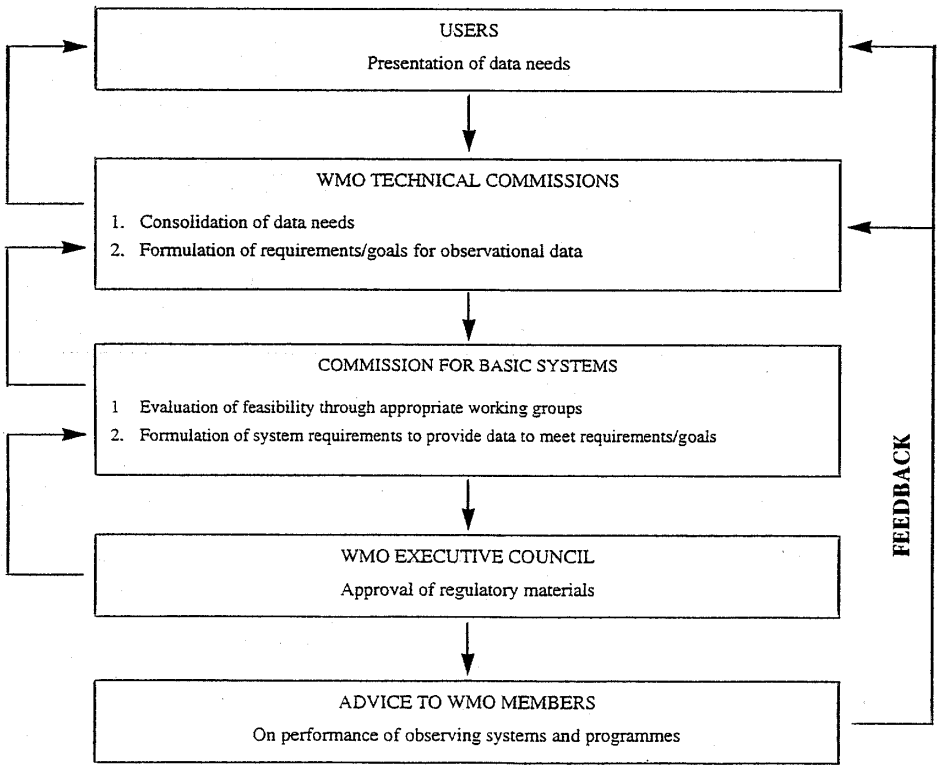

FIGURE II.I – Procedure for the elaboration of observational data requirements
[FIGURE II.I SHOULD BE REPLACED WITH A DESCRIPTION OF THE ROLLING REVIEW OF REQUIREMENTS PROCESS DIAGRAM

3. SYSTEMS FOR MEETING REQUIREMENTS

The surface-based subsystem and the space-based subsystem shall complement each other in providing the observational data required

ATTACHMENT II.1

CLASSIFICATION OF SCALES OF METEOROLOGICAL PHENOMENA

(a) Small scale (less than 100 km; for example, thunderstorm, local winds, tornadoes);

(b) Mesoscale (100-1 000 km; for example, fronts and cloud clusters);

(c) Large scale (1 000-5 000 km; for example, depressions and anticyclones);

(d) Planetary scale (more than 5 000 km; for example, long upper-troposphere waves).

NOTE: The requirements for observational data shall be determined in part by these scales of meteorological phenomena. Many phenomena overlap between two of the classes indicated, and there is also dynamic interaction between the phenomena in different scales.

Scales (b) and (c) should be considered as roughly corresponding to the regional level within the WWW, and (c) and (d) can be combined within the global level.

ATTACHMENT II. 2

SPECIAL OBSERVATIONAL REQUIREMENTS FOR ENVIRONMENTAL EMERGENCY RESPONSE ACTIVITIES

A. Meteorological data requirements

1. Data needed to run transport models are the same as specified for the production of weather for models and are given in Attachment II.2 of the *Manual on the GDPS* and Attachment II.I of the *Guide on the GOS.*

2. Additional data[1] are desirable from the accident site[2] and potentially affected area[3] and should be available to the designated RSMC to improve the quality of information about the transport of pollutants. These should include:

(a) Wind, temperature and humidity, upper-air data;

(b) Precipitation data (type and amount);

(c) Surface air temperature data;

(d) Atmospheric pressure data;

(e) Wind direction and speed (surface and stack height) data;

(f) Humidity data.

3. The data needed from the accident site may be provided by the following systems in combination as necessary and possible:

(a) At least one radiosonde station should be located at a suitably safe distance to enable continued emergency situation and to be representative of conditions at or near the accident site;

(b) In an emergency situation, at two or three stations closest to the site of the accident (within 500 km) frequency should be increased to every three hours for the duration of the emergency. Stocks of consumables should be stored for use in emergency situations;

(c) At least one surface station should be located at the accident site or, if not possible, at a nearby site. It should be convertible to an hourly automated mode for both operations and telecommunications in case of emergency;

(d) Additional information should be provided at or near the accident site by instrumented towers or masts (up to 100 km) and conventional or Doppler radars, Sodars and boundary layer sondes with automatic transmission of data.

4. The data needed from the potentially-affected area should be provided as follows:

---

[1] The words "additional data" are used with their usual meaning and not as in Resolution 40 (Cg-XII)

[2] Due to the highly variable types of nuclear accidents, a precise definition of "accident site" is not possible. The accident site should be understood as the location where the accident occurred and the immediate surrounding zone within a range of a few kilometers.

[3] The potentially affected area is dependent on the state and evolution of the atmosphere over an extended area around the accident site, as well as on the nuclear event itself and cannot be precisely defined in advance. It should be understood as the area where, using all the information available including the air transport pollution products if already issued, the nuclear pollutants are likely to be transported in the air or on the ground at a significant level over the natural (background) radioactivity. Advice in this area may be obtained from the RSMC concerned.

(a) All upper-air stations within the potentially-affected area should make observations every six hours of the emergency;

(b) Where possible, one or more additional observing systems, including wind profilers, mobile radiosounding equipment, and ascent/descent data from aircraft should be provided;

(c) All surface stations within the potentially-affected area including those which are not normally exchanged data internationally on a routine basis should provide observational data to designated RSMCs. Platforms and buoys should also provide observational data to ensure adequate coverage over sea areas;

(d) A series of best estimates of precipitation should be made by combining information from direct measurements (automated or manual) of surface stations, composite radar information extending over the whole WMO Region, and satellite-derived data.

B. Non-meteorological data requirements

1. In case of emergency, non-meteorological data to be provided to designated RSMCs from the accident site should include:

(a) Start of release (date, time);

(b) Duration;

(c) Radionuclide species;

(d) Total release quantity or pollutant release rate;

(e) Effective height of release.

Points (a) and (b) are necessary information for running transport models, while (c), (d) and (e) are desirable additional information.

2. In order to calibrate and validate the atmospheric transport model forecasts processed, radiological data from potentially affected areas are needed. The most suitable radiological data required are:

(a) Time-integrated air pollutant concentration;

(b) Total deposition.

3. The required data from the accident site and potentially-affected area may be obtained by the following means:

(a) Fixed radiological monitoring stations;

(b) Mobile surface units;

(c) Radiological sounding/or;

(d) Instrumental aircraft.

The frequency of observations should be increased from one hour to 10 minutes during the accident (routine frequency of observations varies from one to six hours).

C. Exchange of meteorological and non-meteorological data

1. Non-meteorological data and, to some extent, additional meteorological data are likely to be provided by non-meteorological national authorities. The NMSs should encourage the provision of these data by non-meteorological agencies/operators to NMCs for onward transmission to their associated RSMCs.

2. For the exchange of relevant meteorological and non-meteorological (radiological) data, a complete list of abbreviated heading bulletins, including all the regional meteorological and radiological observations should be sent by Members to the WMO Secretariat for insertion into the *Catalogue of Meteorological Bulletins* (WMO-No.9), Volume C1.

3. Radiological data available in the early phase of a nuclear accident (containment radiation, reading, on-site radiation levels, etc.) which assist in characterising the nuclear accident, should be provided by national authorities to the IAEA as soon as practicable via the most reliable communication means. The IAEA will verify and assess the information and then provide these data to the appropriate RSMC, which should distribute them to NMCs via the GTS. In case of environmental emergencies, all relevant observational (meteorological and non-meteorological) data should be transmitted to both RSMC and NMSs through the GTS as quickly as possible.

4. End-to-end testing of procedures for data acquisition, quality control, communication use, and product dissemination should be carried out periodically to assure system performance.

ATTACHMENT II.3

OBSERVATIONAL REQUIREMENTS IN THE EVENT OF A VOLCANIC ACTIVITY

[THIS ATTACHMENT SHOULD BE EXPANDED TO INCLUDE DESCRIPTIONS COMPARABLE TO THOSE FOUND FOR EMERGENCY RESPONSE ACTIVITIES. IT IS SUGGESTED THAT THE VOLCANIC ASH ADVISORY WATCH ACTIVITY PROVIDE MORE DETAILED DESCRIPTION]

Because of the potential hazard to aviation, the occurrence of pre-eruption volcanic activity, volcanic eruptions, and volcanic ash clouds should be reported without delay to the designated meteorological watch office and associated air-traffic services unit. The report in plain language should be made in the form of a volcanic activity report comprising the following information, if available, in the order indicated:

(a) Message type, VOLCANIC ACTIVITY REPORT;

(b) Station identifier, location indicator, or name of station;

(c) Date/time of message;

(d) Location of volcano and name if known;

(e) Concise description of event including, as appropriate, level of intensity of volcanic activity, occurrence of an eruption and its date and time, the existence of a volcanic ash cloud in the area with the direction of ash cloud movement and height as best estimated.

NOTE: Pre-eruption volcanic activity in this context means unusual and/or increasing volcanic activity, which could presage an eruption.

PART III

SURFACE-BASED SUB-SYSTEM

1. COMPOSITION OF THE SUBSYSTEM

The main elements of the surface-based subsystem are:

(a) Surface synoptic stations

(i) Land stations:
- Manned surface stations;
- Automatic surface stations;*

(ii) Sea stations
- Fixed sea stations:
  - Ocean weather stations;
  - Lightship stations
  - Fixed platform stations
  - Anchored platform stations
  - Island and coastal stations;
- Mobile sea stations:
  - Selected ship stations;
  - Supplementary ship stations;
  - Auxiliary ship stations;
  - Ice-floe stations;
- Automatic sea stations:*
  - Fixed sea stations;
  - Mobile sea stations;
  - Drifting buoy stations;

(b) Upper-air stations

- Rawinsonde stations;
- Radiosonde stations;
- Radiowind stations;
- Pilot-balloon stations;

(c) Aircraft meteorological stations

Other elements of the sub-system are:

(d) Aeronautical meteorological stations;
(e) Research and special-purpose vessel stations;
(f) Climatological stations;
(g) Agricultural meteorological stations;
(h) Special stations, which include:

(i) Weather radar stations;
(ii) Radiation stations;
(iii) Atmospherics detection stations;
(iv) Meteorological reconnaissance aircraft stations
(v) Meteorological rocket stations;
(vi) Global Atmosphere Watch stations;
(vii) Planetary boundary-layer stations;
(viii) Tide-gauge stations.

NOTES: (1) Definitions of stations listed above will be found in the Appendix to this Manual.
(2) Any station may fall under more than one of the above categories.

* Data may be asynoptic when collected via satellite

2. IMPLEMENTATION OF ELEMENTS OF THE SUBSYSTEM

2.1. NETWORKS OF OBSERVING STATIONS

2.1.1 General

2.1.1.1 Corresponding to the three levels of requirements for observational data, three types of networks of observing stations - global, regional and national - shall be established.

2.1.1.2 The networks should be interdependent with selected stations of the national networks within a Region comprising the corresponding regional network, and with selected stations of the regional network forming the global network. Therefore, a station of the global network should be part of a regional network and a national network.

2.1.1.3 The frequency and spacing of the observations should be adjusted to the physical scales of the meteorological phenomena to be described.

NOTE: See Figure II.1 in the *Guide on the Global Observing System* (WMO-No. 488).

2.1.2 Global networks

2.1.2.1 A global synoptic network shall be established, based upon the Regional Basic Synoptic Networks (RBSNs).

NOTE: See paragraph 2.1.1.3

2.1.2.2 The observational programme of the global synoptic network should provide meteorological data which have the necessary accuracy, spatial and temporal resolutions to describe the state of temporal and spatial changes in the meteorological phenomena and processes occurring on the large and planetary scales.

NOTE: Guidance as to the determination of requirements for accuracy and time and spatial resolution of the observational data is given in the *Guide on the Global Observing System* (WMO-No. 488).

2.1.2.3 The global synoptic network should be as homogeneous and as uniform as possible all over the globe, and the observations should be made at the main standard times of observation.

2.1.2.4 Members should implement the GCOS Surface Network (GSN) - the global reference network of some 1000 selected surface observation stations established to monitor daily global and large-scale climate variability.

2.1.2.5 Members should implement the GCOS Upper-air Network (GUAN) - the global baseline network of about 150 selected upper-air stations established with relatively homogenous distribution to meet requirements of GCOS.

2.1.2.6 Members should also establish a network of Global Atmosphere Watch (GAW) stations designed to meet the need for monitoring, on a global and regional basis, the chemical composition and related characteristics of the atmosphere.

NOTE: For further information on the location of GAW stations, see WMO Technical Regulations (WMO-No. 49) Volume I, Chapter B2, as well as the appropriate Global Atmosphere Watch technical publications, and the Guide on the Global Observing System (WMO-No. 488)

2.1.3 Regional networks

2.1.3.1 Regional networks shall be established in relation to the regional requirements.

NOTE: Regional associations are responsible for the determination and coordination of the composition of these networks within the general framework established by CBS.

2.1.3.2 Regional Basic Synoptic Networks of both surface and upper-air stations shall be established to meet the requirements laid down by the regional associations

2.1.3.3 Together, the Regional Basic Synoptic Networks shall form the main part of the surface-based global synoptic network

NOTES: (1) The regional associations will continue to examine their plans to meet any new international requirements.
(2) Details of known regional requirements are given in Volume II.

2.1.3.4 Members shall implement the regional basic synoptic networks

2.1.3.5 The horizontal spacing of observing stations and the frequency of their reporting should be in accordance with the requirements laid down in Volume I, Part II, and Volume II of this Manual.

2.1.4 National networks

2.1.4.1 National networks shall be established by Members to satisfy their own requirements. When implementing these national networks, Members shall take into account the needs to complete the global and regional networks.

NOTE: A complete list of all surface and upper-air stations in operation which are used for synoptic purposes is given in *Weather Reporting* (WMO-No. 9), Volume A - Observing Stations.

2.2 Observing Stations

2.2.1 General

2.2.1.1 The implementation and operation of each of the above elements should be as laid down by decisions of Congress, the Executive Council, the technical commissions and regional associations concerned.

NOTE: These decisions are reflected in the Technical Regulations (WMO No. 49) and its annexes (e.g. this Manual, the Manual on Codes). Other relevant WMO publications such as the Guide on the Global Observing System (WMO-No. 488) and the Guide to Meteorological Instruments and Methods of Observation (WM0-No. 8,) which set forth the technical and meteorological aspects in detail.

2.2.1.2 In implementing the GOS surface-based sub-system, Members should ensure that the observing system meets the requirements placed on the sub-system.

2.2.1.3 In implementing the surface-based subsystem, Members should strive to meet the provisions indicated in 2.1.1 above as closely as possible, in particular as regards the main elements of the surface-based sub-system.

2.2.1.4 Each station should be located at a site that permits correct exposure of the instruments and satisfactory non-instrumental observations.

2.2.1.5 In general, observing stations shall be spaced at an interval and with observations taken frequently enough to permit an accurate description of the atmosphere for users of the observations for the purpose intended.

2.2.1.6 If in certain desert and other sparsely populated areas it is not possible to establish networks with the recommended densities, networks with densities as near as possible to those recommended should be established. Special efforts should be made to establish an adequate network in such an area when it borders a populated area or is traversed by a regularly used air route.

2.2.1.7 Asynoptic observations should be taken when necessary to supplement observations from the synoptic networks and in a manner which increases their spatial or temporal frequency.

2.2.1.8 Observations should be taken in areas where special phenomena are occurring or expected to develop. As many elements of standard observations as possible should be reported. Information should be communicated in real time.

NOTES: Drifting buoys and aircraft may also report at asynoptic times.

2.2.1.9 Members shall ensure that a record of all surface and upper-air observations is made and preserved.

2.3 Surface synoptic stations

2.3.1 General

2.3.1.1 Surface synoptic stations may be manned or partly or fully automated and shall include land stations and fixed and mobile sea stations.

2.3.1.2 Each synoptic station shall be located so as to give meteorological data representative of the area in which it is situated.

2.3.1.3 The main standard times for surface synoptic observations shall be 0000, 0600, 1200 and 1800 UTC.

2.3.1.4 The intermediate standard times for surface synoptic observations shall be 0300, 0900, 1500 and 2100 UTC.

2.3.1.5 Atmospheric pressure observations should be made at exactly the standard time while the observation of other elements should be made within the ten minutes preceding the standard time.

2.3.1.6 Every effort should be made to obtain surface synoptic observations four times daily at the main standard times, with priority being given to the 0000 and 1200 UTC observations required for global exchanges.

2.3.1.7 When it is difficult for any reason to provide sufficient staff for 24-hour operations, partially or fully automated stations should supplement or replace manned surface stations including those in the basic synoptic network to provide observations at least at the main standard times.

2.3.2 Land-stations

General

2.3.2.1 A synoptic station on land shall be identified by a station index number assigned by the Member concerned within the allocations made to that Member, in compliance with the scheme prescribed in the Manual on Codes (WMO-No. 306).

2.3.2.2 When a Member establishes a synoptic station on land (or a fixed weather station at sea) the Member shall send the following information to the Secretariat at least two months before the station becomes operational:

(a) Name, and where appropriate, station index number (stating whether the station is automatic or manned and, if both, the time of each);

(b) Geographical coordinates in degrees and minutes of arc and elevation in whole metres;

(c) Geopotential of the datum level in whole metres to which the pressure is reduced, or the reference isobaric surface the geopotential of which is reported;

(d) Times at which synoptic observations are made and reported;

(e) Topographical situation;

(f) Any other information required for completion of the entries in Weather Reporting (WMO-No. 9), Volume A – Observing Stations.

2.3.2.3 Members shall send the necessary amendments to the information supplied under 2.3.2.2 (a) – (f) above to the Secretariat as soon as possible.

2.3.2.4 Any change in index number of synoptic stations included in the international exchanges should be notified to the Secretariat at least six months before becoming effective.

2.3.2.5 Each Member should publish a description, in sufficient detail to enable departures from the representativeness of observations to be assessed, of each of its synoptic stations whose reports are included in international exchanges.

2.3.2.6 All changes in the station index number of a synoptic station shall be effective from 1 January or 1 July.

2.3.2.7 Each Member of WMO shall designate a national focal point to communicate with the WMO Secretariat on matters regarding the contents of Volume A1 and A2. The national focal point shall be authorised to act in these matters on behalf of the Permanent Representative concerned.

Location and composition

2.3.2.8 Surface land stations, including those in the regional basic synoptic network, should be spaced at intervals not exceeding the minimum horizontal resolution required by applications areas supported by the network and as prescribed in the Rolling Review of Requirements process. During the first decade of the twenty-first century, the interval, in general, should not exceed 250 km (or 300 km in sparsely populated areas).

2.3.2.9 Surface synoptic observations recorded at a synoptic land station shall consist of observations of the following elements:

(a) Present weather;
(b) Past weather;
(c) Wind direction and speed;
(d) Amount of cloud;
(e) Type of cloud;
(f) Height of cloud base;
(g) Visibility;
(h) Air temperature;
(i) Humidity;
(j) Atmospheric pressure;

together with such of the following elements as are determined by regional association resolutions:

(k) Pressure tendency;
(l) Characteristic of pressure tendency;
(m) Extreme temperature;
(n) Amount of precipitation;
(o) State of ground;

(p) Direction of cloud movement;
(q) Special phenomena.

2.3.2.10 A surface synoptic observation at an automatic land station shall consist of observations of the following elements:

(a) Atmospheric pressure;
(b) Wind direction and speed;
(c) Air temperature;
(d) Precipitation, yes or no (at least in tropical areas);

together with the following elements which should be included if possible:

(e) Amount of precipitation;
(f) Humidity;
(g) Intensity of precipitation;
(h) Visibility;
(i) Height of cloud base;
(j) Special phenomena.

Frequency and timing of observations

2.3.2.11 At synoptic land stations the frequency of surface synoptic observations should be eight per day at the main and intermediate standard times in extra-tropical areas and four times per day at the main standard times in the tropics.

2.3.2.12 At a (manned or automatic) land station, surface synoptic observations shall be made and reported at least at the main standard times.

2.3.3 Sea stations

General

2.3.3.1 When more economic means are not available, ocean weather stations and some other fixed sea stations should provide essential and detailed meteorological and oceanographic data from critical locations or ocean areas.

NOTES: (1) In this role, these stations are an integral part of regional and national networks.

(2) Fixed sea stations also provide reference-level data and a basis for calibration of soundings by remote sensing from satellites and are thus important in the analysis of phenomena on a large or planetary scale.

(3) A fixed sea station other than an ocean weather station or a moored buoy may be identified by a station index number if considered to be in the same category as a land station.

2.3.3.2 Members shall recruit as mobile ship stations as many ships as possible that traverse data-sparse areas and regularly follow routes through areas of particular interest.

2.3.3.3 Members concerned shall provide the Secretariat, not later than 1 March each year, with a list of their selected and supplementary ship stations in operation at the beginning of the year or with amendments to the previous list giving the name, call sign and route or route designator of each ship.

2.3.3.4 Members shall include in the lists of selected and supplementary ship stations information on the method of obtaining sea-surface temperature, type of barometer, psychrometer, barograph, radio equipment and other instruments aboard the ship and radiowatch hours.

2.3.3.5 Members should consider using fixed or mobile automatic sea stations or drifting buoy stations in the data-sparse areas of persistent cloudiness, where remote sounding by satellite is hampered.

NOTE: These stations are located on fixed or mobile ships, fixed or anchored platforms and on drifting platforms and icefloes.

2.3.3.6 Environmental data buoy stations shall be identified by the International Identifier System.

NOTE: This identifier system is used by the Intergovernmental Oceanographic Commission and WMO universally

Location and composition

2.3.3.7 Each fixed sea station should be located so as to provide data which are representative of the marine area. As a minimum, observations should be taken at the main synoptic times. The observations should include as many elements of a full synoptic report as possible.

2.3.3.8 Members should establish, either individually or jointly, ocean weather stations or other suitable observational facilities in ocean areas where there are large gaps in the global network.

NOTE: Information describing the station should be sent to the Secretariat as for synoptic land stations (see paragraph 2.2.2.2)

2.3.3.9 In its recruitment programme, each Member should aim at making the maximum possible contribution from mobile sea stations towards attaining an adequate density of observations in all oceanic areas.

NOTE: An adequate density of surface reports in oceanic areas is one per 250 km.

2.3.3.10 It shall be possible to determine the position of a fully automated mobile sea station.

2.3.3.11 At ocean weather stations, a surface synoptic observation shall consist of observations of the following elements:

(a) Present weather;
(b) Past weather;
(c) Wind direction and speed;
(d) Amount of cloud;
(e) Type of cloud;
(f) Height of cloud base;
(g) Visibility;
(h) Air temperature
(i) Humidity;
(j) Atmospheric pressure;
(k) Pressure tendency;
(l) Characteristic of pressure tendency;
(m) Ship's course and speed;
(n) Sea temperature;
(o) Direction of movement of waves;
(p) Period of waves;
(q) Height of waves;
(r) Sea ice and/or icing of ship superstructure, when appropriate;
(s) Special phenomena.

2.3.3.12 At a selected ship station, a surface synoptic observation should consist of observations of elements *(a)* to *(r)* in 2.3.3.11 above.

2.3.3.13 At a supplementary ship station, a surface synoptic observation should consist of observations of elements *(a)* to (*h*), (*i*) and *(r)* in 2.3.3.11 above.

2.3.3.14 At an auxiliary ship station, a surface synoptic observation should consist of observations of elements *(a)* to (*d*), (*g*), (*h*) (*j*) and *(r)* in 2.3.3.11 above.

2.3.3.15 At a lightship, a manned platform, and coastal and island stations a surface synoptic observation should consist of observations of the elements *(a)* to *(r),* with the exception of *(m),* in 2.3.3.11 above.

2.3.3.16 At a fixed automatic sea station, surface synoptic observations shall consist of observations of the following elements:

(a) Atmospheric pressure;
(b) Wind direction and speed;
(c) Air temperature;
(d) Sea temperature*.*

In addition to the elements listed above, a surface synoptic observation made at a fixed automatic sea station should include, if possible, the following elements:

(e) Precipitation, yes or no (especially in tropical areas);
(f) Waves.

2.3.3.17 At a drifting automatic sea station (drifting buoy) a surface synoptic observation should consist of as many as possible of the elements *(a)* to *(d)* and (*f*) in paragraph 2.3.3.16 above.

NOTE: The position of the drifting buoy shall also have to be determined.

2.3.3.18 Members should endeavour to equip mobile ships to make sub-surface observations and report them in the BATHY/TESAC code form.

NOTE: Guidance on steps to be taken while recruiting a selected, supplementary or auxiliary observing ship, on the organization needed to collect ships' weather reports and on the use of marine meteorological logs on board ships, is contained in the Guide to Marine Meteorological Services WM0-No.471).

Frequency and timing of observations

2.3.3.19 At an ocean weather station surface synoptic observations shall be made and reported at both the main and intermediate standard times.

2.3.3.20 At lightship stations, fixed and anchored platform stations, and at automatic sea stations, surface synoptic observations shall be made and reported at least at the main standard times.

2.3.3.21 At a mobile sea station surface synoptic observations should be made and reported at the main standard times.

2.3.3.22 When operational difficulties on board ship make it impracticable to make a surface synoptic observation at a main standard time, the actual time of observation should be as near as possible to the main standard time.

2.3.3.23 Whenever storm conditions threaten or prevail, surface synoptic observations should be made and reported from a mobile sea station more frequently than at the main standard times.

2.3.3.24 When sudden and dangerous weather developments are encountered at sea stations, surface observations should be made and reported as soon as possible without regard to the standard time of observation.

NOTE: For specific instructions relative to the furnishing by ships of special reports, in accordance with the International Convention for Safety of Life at Sea, see Weather Reporting (WMO-No.9).

2.3.3.25 Members should arrange for timely transmission of observations.

NOTE: Details of observing and reporting programmes are described in Chapter 5 of the Guide to Marine Meteorological Services (WM0-No.471). In case of difficulties resulting from fixed radiowatch hours on board single-operator ships, the procedures given in the Manual on the Global Telecommunication System WM0-No.386), Attachment ł1, should be followed.

2.4 Upper-air synoptic stations

General

2.4.1 Upper-air synoptic stations shall be identified as provided under 2.3.2.2 to 2.3.2.6 above.

2.4.2 The standard times of upper-air synoptic observations shall be 0000, 0600, 1200 and 1800 UTC.

2.4.3 As upper-air data from the ocean areas are particularly sparse, Members should give consideration to equipping suitable ships to make soundings and, if possible, to measure upper winds.

2.4.4 In the tropics priority should be given to upper-wind observations.

2.4.5 Upper-air stations making observations of pressure, temperature, humidity, and wind should be spaced at intervals not exceeding 250 km or 1000 km in sparsely populated and ocean areas.

Location and composition

2.4.6 An upper-air synoptic observation shall consist of observations of one or more of the following elements:

(a) Atmospheric pressure;
(b) Air temperature;
(c) Humidity;
(d) Wind speed and direction.

Frequency and timing of observations

2.4.7 At an upper-air synoptic station, the frequency of synoptic observations should be four per day at the standard times of upper-air synoptic observations.

2.4.8 At an upper-air synoptic station, upper-air observations shall be made and reported at least at 0000 UTC and 1200 UTC.

2.4.9 At ocean weather stations, upper-air synoptic observations should comprise rawinsonde observations at 0000 and 1200 UTC and/or radiowind observations at 0600 and 1800 UTC.

2.4.10 The actual time of regular upper-air synoptic observations should be as close as possible to (H-30) and should not fall outside the time range (H-45) to H.

NOTE: The actual time of a pilot-balloon observation may deviate from the range indicated above if, by doing so, wind observations to considerably greater heights can be expected.

2.4.11 In areas where it is not possible to meet the frequency requirements mentioned above, every effort should be made to obtain at least the following observations:

(a) Upper-air observations from the regional basic synoptic networks and other networks of stations on land and at sea, twice daily, at 0000 and 1200 UTC;

(b) In the tropics, at stations where two complete radiosonde/radiowind observations are not made, priority should be given to the implementation

of one complete radiosonde/radiowind observation and one radiowind observation daily.

2.5 Aircraft meteorological stations

General

2.5.1 Each Member shall arrange for observations to be made by aircraft of its registry operating on international air routes and for the recording and reporting of these observations.

NOTE: Further information on aircraft observations and reports may be found in the Technical Regulations (WMO-N0.49), Volume II - Meteorological Service for International Air Navigation, [C.3.1.] 5.

2.5.2 Members accepting responsibility for collecting aircraft reports for synoptic purposes shall promptly make these available, in agreed code forms, to other Members.

2.5.3 Members should give special consideration to the use of an automated aircraft meteorological observing and reporting system.

2.5.4 Aircraft reports shall, at a minimum, satisfy the requirements of International Air Navigation (for details see WMO Technical Regulations (WMO-No. 49), Vol. 99 [C.3.1.] 5):

Location and composition

2.5.5 The following aircraft observations shall be made:

(a) Routine aircraft observations during en-route and climb-out phases of the flight; and

(b) Special and other non-routine aircraft observations during any phase of the flight.

Frequency and timing of observations

2.5.6 Routine air reports shall contain the following meteorological elements:

(a) Air temperature;
(b) Wind direction and speed;
(c) Turbulence;
(d) Aircraft icing;
(e) Humidity (if available).

In addition, reports of any volcanic activity observed by the flight crew shall be included.

2.5.7 Special aircraft reports shall be made whenever any of the following conditions are observed:

(a) Severe turbulence;
(b) Severe icing;
(c) Severe mountain wave;
(d) Thunderstorms, with or without hail, that are obscured, embedded; widespread or in squall lines;
(e) Heavy duststorm or heavy sandstorm;
(f) Volcanic ash cloud;
(g) Pre-eruption volcanic activity or a volcanic eruption;

In addition, in the case of transonic and supersonic flights:

(h) Moderate turbulence;
(i) Hail;
(j) Cumulonimbus clouds.

2.5.8 Routine aircraft observations should be made at the designated ATS/MET reporting points;

NOTE: Lists of designated ATS/MET reporting points are prepared by and available from ICAO Regional Offices.

2.5.9 When automated observing and reporting systems are available, routine observations should be made every 15 minutes during the en-route phase and every 30 seconds during the climb-out phase for the first 10 minutes of the flight.

2.5.10 When voice communications are used, routine observations shall be made during the en-route phase in relation to those air traffic services reporting points or intervals:

(a) At which the applicable air traffic services procedures require routine position reports; and

(b) Which are those separated by distances corresponding most closely to intervals of one hour of flying time.

2.5.11 Observations shall be made by all aircraft of meteorological conditions encountered during the climb out or approach phases of flight, not previously reported to the pilot-in-command, which in his opinion are likely to affect the safety of other aircraft operations.

2.5.12 Observations shall also be made by aircraft:

(a) If a meteorological office providing meteorological service for a flight makes a request for specific data; or

(b) By agreement between a Meteorological Authority and an operator.

2.6 Aeronautical meteorological stations

General

2.6.1 Members should establish an adequate network of aeronautical meteorological stations to meet the requirements of aviation.

NOTE: Detailed information on aeronautical meteorological stations, observations and reports is given in the WMO Technical Regulations WM0-No.49), Volume II - Meteorological Service for International Air Navigation [C.3.I.] 4.

2.6.2 The data relating to the elevation of an aeronautical meteorological station on land shall be specified in whole metres.

2.6.3 An aeronautical meteorological station on land shall be identified by a station index number assigned by the Member concerned in compliance with the scheme prescribed in Annex 99 of the WMO Technical Regulations – Manual on Codes (WMO-No. 306), Volume 9.

2.6.4 If a change of index number of an aeronautical meteorological station on land, the reports of which are included in international exchanges, is necessary, such change should be made effective on 1 January or 1 July.

Location and composition

2.6.5 Aeronautical meteorological stations shall be established at aerodromes and other points of significance to international air navigation.

2.6.6 Aeronautical observations should consist of the following elements:

(a) Surface wind direction and speed;
(b) Visibility;
(c) Runway visual range, when applicable;
(d) Present weather;
(e) Cloud amount, type and height of base;
(f) Air temperature;
(g) Dew point temperature;
(h) Atmosphere pressure (QNH and/or QFE);
(i) Supplementary information.

NOTE: For further information on what is to be reported under “supplementary information”, see WMO-No. 49, Volume II [C.3.1] 4.12

Frequency and timing of observations

2.6.7 Routine observations shall be made at intervals of one hour, or, if so determined by regional air navigation agreement, at intervals of one half-hour. Special observations shall be made in accordance with criteria established by the Meteorological Authority in consultation with the appropriate Air Traffic Services Authority.

2.7 Research and special-purpose vessel stations

General

2.7.1 Members operating research and special-purpose vessels should do their utmost to ensure that all such vessels make meteorological observations.

Location and composition

2.7.2 In addition to as many as possible of the elements of surface and upper-air observations, subsurface temperature observations, down to the thermocline, should also be made and transmitted (in real time), in accordance with the procedures agreed between WMO and the Intergovernmental Oceanographic Commission.

Frequency and timing of observations

2.7.3 In addition to meeting requirements for research, special-purpose vessels should, when possible, make surface and upper-air observations that meet and supplement basic synoptic requirements.

2.8 Climatological stations

General

2.8.1 Each Member shall establish in its territory a network of climatological stations.

2.8.2 The network of climatological stations should give a satisfactory representation of the climate characteristics of all types of terrain in the territory of the Member concerned (e.g. plains, mountainous regions, plateaux, coasts, islands, etc.).

2.8.3 Each Member shall establish and maintain at least one reference climatological station.

2.8.4 Each Member shall establish and maintain an up-to-date directory of the climatological stations in its territory, giving the following information, often referred to as metadata, for each station:

(a) Name and geographical co-ordinates;
(b) Elevation of station;
(c) A brief description of the local topography;
(d) Category of station and details of observing programmes;
(e) Exposure of instruments, including height above ground of thermometers, raingauges and anemometers;
(f) A station history (date of beginning of records, changes of site, closure or interruption of records, changes in the name of the station and important changes in the observing programme);
(g) The name of the supervising organization or institution;
(h) The datum level to which atmospheric pressure data of the station refer.

Location and composition

2.8.5 Each climatological station should be located at a place and under an arrangement that will provide for the continued operation of the station for at least ten years, and for the exposure to remain unchanged over a long period, unless it serves a special purpose that justifies its functioning for a shorter period.

2.8.6 Each reference climatological station should be sited with an adequate and unchanged exposure where the observations can be made in representative conditions. The surroundings of the station should not alter in time to such an extent as to affect the homogeneity of the series of observations.

2.8.7 The data relating to the elevation of a climatological station should be specified at least to the nearest five metres, except that for a station with a barometer the elevation should be specified to the nearest metre.

2.8.8 At a principal climatological station, observations shall be made of all or most of the following elements:

(a) Weather
(b) Wind;
(c) Amount of cloud;
(d) Type of cloud;
(e) Height of cloud base;
(f) Visibility;
(g) Air Temperature (including extreme temperatures);
(h) Humidity;
(i) Atmospheric pressure;
(j) Precipitation;
(k) Snow cover;
(l) Sunshine duration and/or solar radiation;
(m) Soil temperature.

2.8.9 At a principal climatological station, soil temperature should be measured at some or all of the following depths: 5, 10, 20, 50, 100, 150 and 300 cm.

2.8.10 At an ordinary climatological station, observations shall be made of extreme temperatures and amount of precipitation and, if possible, of some of the other elements listed in 2.7.8 above.

2.8.11 At an automatic climatological station, records should be made of elements selected from those in 2.8.8 above.

Frequency and timing of observations

2.8.12 Each Member should arrange that observations at any climatological station are made at fixed hours, according to either UTC or Local Mean Time, which remain unchanged throughout the year.

2.8.13 When two or more observations are made at a climatological station, they should be arranged at times that reflect the significant diurnal variations of the climatic elements.

2.8.14 When changes are made in a network of the times of climatological observations, simultaneous observations should be carried out at a skeleton network of representative stations for a period covering the major climatic seasons of the area at the old times of observation and at the new ones.

2.9 Global Climate Observing System Surface Network (GSN) stations

2.9.1 In implementing the observing programme at GSN stations, Members should comply with the following best practices:

(a) Long-term continuity should be provided for each GSN station: this requires the provision of the necessary resources, including well-trained staff, and keeping changes of location to a minimum. In the case of significant changes in sensor-devices or station location, Members should provide for a sufficiently long period of overlap (at least one but preferably two years) with dual operation of old and new systems to enable comparisons to be made and the identification of inhomogeneities and other measurement characteristics;

(b) CLIMAT data should be provided in an accurate and timely manner: CLIMAT reports should be transmitted by the fifth day of the month but not later than the eighth day of the month;

(c) Rigorous quality control should be exercised on the measurements and their message encoding: CLIMAT reports require quality control of the measurements themselves and their message encoding to ensure their accurate transmission to national, regional and world centres for their use. Quality-control checks should be made on site and at a central location designed to detect equipment faults at the earliest stage possible. The Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8) provides the appropriate recommendations;

(d) The site layout should follow the recommended form: the layout of the site should follow the recommendations in the Guide on the Global Observing System (WMO-No. 488);

(e) The site and instruments should be inspected regularly and maintained according to WMO recommended practices: to obtain homogeneous datasets, maintenance should be carried out as is documented in the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8). The quality of the measured variables should be guaranteed by appropriate inspection of sites, instruments and exposure to be based on the procedures given in the Guide. As part of the maintenance, the necessary calibration practices should be traceable to the standards provided by the Guide;

(f) A national plan should be developed to archive daily data from GSN stations for climate and climate research purposes: the archive should include both observational data and metadata pertaining to each climate station. Metadata should include data concerning a station’s establishment, subsequent maintenance and changes in exposure, instrumentation and

staff. The data and metadata should be in its original form as well as in digital format;

(g) Detailed metadata and historical climate data for each GSN station should be provided: a GSN Data Centre should have an up-to-date digital copy of the historical climate data and all types of metadata for GSN stations. A current copy of the long-term series of data and metadata from GSN stations should be made available.

2.10 Global Climate Observing System Upper-air Network (GUAN) stations

2.10.1 In implementing observing programmes at GUAN stations, Members should comply with the following best practices:

(a) Long-term continuity should be provided for each GUAN station: this requires the provision of the necessary resources, including well-trained staff, and keeping changes of location to a minimum. Changes of bias caused by changes in instrumentation should be evaluated by a sufficient overlapping period of observation (perhaps as much as a year) or by making use of the results of instrument intercomparisons made at designated test sites;

(b) Soundings should preferably be made twice per day and should reach as high as possible, noting the GCOS requirements for ascents up to a height of 5hPa. Since climate data are needed in the stratosphere to monitor changes in the atmospheric circulation and to study the interaction between stratospheric circulation, composition and chemistry, every effort should be made to maintain soundings regularly up to a level as high as possible noting the above GCOS requirement;

(c) CLIMAT TEMP data should be provided in an accurate and timely manner: CLIMAT TEMP reports should be transmitted by the fifth day of each month, but not later than the eighth day of the month;

(d) Rigorous quality control should be exercised at each GUAN site: periodic calibration, validation and maintenance of the equipment should be carried out to maintain the quality of the observations;

(e) Basic checks should be made before each sounding to ensure accurate data: the accuracy of a radiosonde's sensors should be checked in a controlled environment immediately before the flight. Checks should also be made during and/or at the end of each sounding to assure that incomplete soundings, or soundings containing errors are corrected before transmission;

(f) Back-up radiosondes should be released in cases of failure: in the event of failure of a sounding instrument or incomplete sounding resulting from difficult weather conditions, a second release should be made to maintain the record from the GUAN station;

(g) Detailed metadata for each GUAN station should be provided: the batch identifier on the radiosondes should be logged for each flight, so that faulty batches can be identified and the data amended or eliminated from the climate records, if necessary. Up-to-date records of metadata in a standard format should be provided to the GUAN Data Centre so that shifts in the data will not be mistaken for climate change. The metadata should include detailed information about the station, such as location, elevation, operating

instruments and their changes over time. Changes to operating and correction procedures should also be recorded. Both the corrected and uncorrected upper-air observation should be archived. Climate change studies require extremely high stability in the systematic errors of the radiosonde measurements.

2.11 Agricultural meteorological stations

General

2.11.1 Each Member should establish in its territory a network of agricultural meteorological stations.

2.11.2 The desirable density of the network of each category of agricultural meteorological stations should be adequate to delineate weather parameters on the scale required for agrometeorological planning and operation, taking into account the agricultural features of the country.

2.11.3 Each Member should maintain an up-to-date directory of the agricultural meteorological stations in its territory, giving the following information, often referred to as metadata, for each station:

(a) Name and geographical co-ordinates;
(b) Elevation of station;
(c) A brief description of the local topography;
(d) Natural biomass, main agrosystems and crops of the area;
(e) Types of soil, physical constants and profile of soil;
(f) Category of station, details of observing programme and reporting schedule;
(g) Exposure of instruments, including height above ground of thermometers, raingauges and anemometers;
(h) A station history (date of beginning of records, changes of site, closure or interruption of records, changes in the name of the station and important changes in the observing programme);
(i) The name of the supervising organization or institution.

Location and composition

2.11.4 Each agricultural meteorological station should be located at a place that is representative of agricultural and natural conditions in the area concerned, preferably:

(a) At experimental stations or research institutes for agriculture, horticulture, animal husbandry, forestry, hydrobiology and soil sciences;
(b) At agricultural and allied colleges;
(c) In areas of present or future importance for agricultural and animal husbandry;
(d) In forest areas;
(e) In national parks and reserves.

2.11.5 At an agricultural meteorological station, the observing programme should, in addition to the standard climatological observations, include some or all of the following:

(a) Observations of physical environment:

(i) Temperature and humidity of the air at different levels in the layer adjacent to the ground (from ground level up to about ten metres above the upper limit of prevailing vegetation), including extreme values of these elements;
(ii) Soil temperature at depths of 5, 10, 20, 50 and 100 cm and at additional depths for special purposes and in forest areas;
(iii) Soil water (volumetric content) at various depths, with at least three replications when the gravimetric method is used;
(iv) Turbulence and mixing of air in the lower layer (including wind measurements at different levels);
(v) Hydrometeors and water-balance components (including hail, dew, fog, evaporation from soil and from open water, transpiration from crops or plants, rainfall interception, runoff and water table);
(vi) Sunshine, global and net radiation as well as the radiation balance over natural vegetation, and crops and soils (over 24 hours);
(vii) Observations of weather conditions producing direct damage to crops, such as frost, hail, drought, floods gales and extremely hot dry winds;
(viii) Observations of damage caused by sandstorms and duststorms, atmospheric pollution and acid deposition as well as forest, bush and grassland fires.

(b) Observations of a biological nature:

(i) Phenological observations;
(ii) Observations on growth (as required for the establishment of bioclimatic relationships);
(iii) Observations on qualitative and quantitative yield of plant and animal products;
(iv) Observations of direct weather damage on crops and animals (adverse effects of frost, hail, drought, floods, gales);
(v) Observations of damage caused by diseases and pests;
(vi) Observations of damage caused by sandstorms and duststorms and atmospheric pollution, as well as forest, bush and grassland fires.

Frequency and timing of observations

2.11.6 Observations of a physical nature should be made at the main synoptic times. Observations of a biological nature should be made regularly or as frequently as significant changes occur and should be accompanied by meteorological observations.

2.12 Global Atmosphere Watch (GAW) stations

General

2.12.1 Members should cooperate in the establishment of a minimum of 30 global GAW stations and at least 300 regional GAW stations.

Location and composition

2.12.2 GAW stations should be established only at sites where direct pollution effects can be avoided.

2.12.3 GAW stations should be co-located with or located near a surface and/or an upper-air synoptic station.

NOTE: For further information on the location of GAW stations, see WMO Technical Regulations (WMO-No.49), Volume 1, Chapter B.2, as well as the appropriate Global Atmosphere Watch technical publications and the Guide on the Global Observing System (WMO-No. 488).

2.12.4 At each global GAW station, measurements should be carried out on all or most of the following variables:

(a) Greenhouse gases (concentration near the surface, total column density and vertical profile): carbon dioxide; chlorofluorocarbons, their substitutes, intermediates and final products; methane; nitrous oxide; tropospheric ozone;

(b) Ozone (concentration near the surface, total column density and vertical profile) and related precursor gases, e.g. volatile organic compounds ((VOCs) NO_x);

(c) Radiation and the optical depth or transparency of the atmosphere: turbidity, solar radiation, ultraviolet B radiation, visibility, total aerosol load (concentration near the surface, in a marine or continental background, and, where possible, vertical profile up to the tropopause);

(d) Chemical composition of precipitation;

(e) Reactive gas species (concentration near the surface, total column density and vertical profile): sulphur dioxide, reduced sulphur species, oxides of nitrogen, reduced nitrogen species, carbon monoxide, VOCs, peroxyacetyl nitrate (PAN), hydrogen peroxide (H_2O_2) and others;

(f) Physical and chemical characteristics of atmospheric particles, including mineral aerosols and their vertical distribution;

(g) Radionuclides, krypton-85, radon, tritium, isotopes of selected substances;

(h) Routine measurements of the classical meteorological elements (in particular wind direction and speed, wet- and dry-bulb air temperature, relative humidity, atmospheric pressure, present weather, aerological soundings);

(i) Chemical composition of water in the soil and plants, in collaboration with other interested organizations;

(j) Integrated air samples for archiving.

2.12.5 At regional GAW stations, measurements should be made of as many of the variables listed in 2.12.4 (a) to (j) above as possible and others as the needs of the region or country dictate. However, the following variables should constitute the core measurement programme at GAW regional stations, with the highest priority given to the first five:

(a) Ozone concentration near the surface;
(b) Precipitation chemistry;
(c) Carbon black (in precipitation and in aerosols);
(d) Meteorological parameters;
(e) Solar radiation (visible, ultraviolet B);
(f) Methane;
(g) Carbon monoxide;

(h) Total ozone;
(i) Aerosol composition.

Frequency and timing of observations

2.12.6 At GAW stations, observations of most parameters should be continuous with reports prepared on an hourly basis.

2.13 Special stations

2.13.1 General

2.13.1.1 In addition to the stations discussed previously, Members should establish special stations.

NOTE: In some cases, these special stations are co-located with surface or upper-air stations of the regional basic synoptic networks.

2.13.1.2 Members should co-operate in the establishment of special stations for particular purposes.

2.13.1.3 Special stations shall include:

(a) Weather radar stations;
(b) Radiation stations;
(c) Wind profiler stations;
(d) Atmospherics detection stations;
(e) Meteorological reconnaissance aircraft stations;
(f) Meteorological rocket stations;
(g) Global Atmosphere Watch stations
(h) Planetary boundary-layer stations;
(i) Tide-gauge stations.

2.13.1.4 A special station should be identified by its name and geographical co-ordinates, and elevation.

2.13.2 Weather radar stations

General

2.13.2.1 Members should establish an adequate network of weather radar stations, either nationally or in combination with other Members of the Region, in order to secure information about areas of precipitation and associated phenomena and about the vertical structure of cloud systems, for both operational meteorology and research.

Location and composition

2.13.2.2 Weather radars shall be located in such a manner as to minimize interference from surrounding hills, buildings and electromagnetic sources. They should provide good coverage of population centres and geographic features affecting stream and river flows, major thoroughfares and other facilities of importance.

Frequency and timing observations

2.13.2.3 As a minimum, observations should be taken and reported at hourly intervals. Observations should be more frequent when heavy convective activity or heavy widespread precipitation is occurring.

2.13.3 Radiation stations

General

2.13.3.1 Members should establish at least one principal radiation station in each climatic zone of their territory.

2.13.3.2 Members should maintain a network of radiation stations of sufficient density for the study of radiation climatology.

2.13.3.3 Each Member should maintain an up-to-date directory of the radiation stations in its territory, including ordinary and principal stations, giving the following information for each station:

(a) Name and geographical co-ordinates in degrees and minutes of arc;
(b) Elevation of station in whole metres;
(c) A brief description of local topography;
(d) Category of station and details of the observing programme;
(e) Details of radiometers in use (type and serial number of each instrument, calibration factors, dates of any significant changes);
(f) Exposure of radiometers, including height above ground, details of the horizon of each instrument and nature of the surface of the ground;
(g) A station history (date of beginning of records, changes of site, closure or interruption of records, changes in the name of the station and important changes in the observing programme);
(h) Name of the supervising organization or institution.

Location and composition

2.13.3.4 Each radiation station shall be sited, as far as possible, with an adequate exposure, where the observations can be made in representative conditions.

NOTE: The exposure and surroundings of the stations should not alter in time to such an extent as to affect the homogeneity of the series of observations.

2.13.3.5 At principal radiation stations, the observing programme should include:

(a) Continuous recording of global solar radiation and sky radiation, using pyranometers of the first or second class;
(b) Regular measurements of direct solar radiation;
(c) Regular measurements of net radiation (radiation balance) over natural and crop soil cover (throughout 24 hours);
(d) Recording of duration of sunshine.

NOTE: The terminology of radiation qualities and measuring instruments and the classification of pyranometers is given in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8, Sixth edition, 1996).

2.13.3.6 At ordinary radiation stations, the observing programme should include;

(a) Continuous recording of global solar radiation;
(b) Recording of duration of sunshine.

2.13.3.7 Pyrheliometric measurements shall be expressed in accordance with the World Radiometric Reference (WRR).

Frequency and timing of observations

2.13.3.8 When automatic recording is not available, measurements of direct solar radiation should be made at least three times a day, provided the sun and the sky in the vicinity are free from cloud, corresponding to three different solar heights, one of them being near the maximum.

2.13.3.9 During clear-sky conditions, measurements of long-wave effective radiation should be made every night, one of them being made soon after the end of the evening civil twilight.

2.13.4 Wind profiler stations

General

2.13.4.1 Members should consider the establishment of wind profilers.

Location

2.13.4.2 Wind profiler stations should be located so as to measure wind profiles in the troposphere. The spacing of stations should be consistent with the requirements for the observations.

2.13.5 Atmospherics detection stations

General

2.13.5.1 Members should establish atmospherics detection stations.

NOTE: Methods in use are described in the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, Sixth edition, 1996).

Location and composition

2.13.5.2 Atmospherics (spherics) detection stations should be located so as to measure this phenomenon in areas of frequent convective activity. The spacing and number of ground stations should be in keeping with the technique used, coverage and accuracy of location desired.

Frequency and timing of observations

2.13.5.3 Continuous monitoring by the station should be maintained, with an indication of direction and distance, at about 10-minute intervals.

2.13.6 Meteorological reconnaissance aircraft stations

General

2.13.6.1 Members are encouraged to organize and communicate, either individually or jointly, routine and special aircraft weather reconnaissance flights.

Location and composition

2.13.6.2 Aircraft reconnaissance facilities should be located near prevalent storm tracks in data-sparse areas. Reconnaissance flights should be initiated in locations where additional observational information is required for the investigation and prediction of developing or threatening storms.

2.13.6.3 Meteorological reconnaissance flight observations should include:

(a) Altitude and position of aircraft;
(b) Observations made at frequent intervals during a horizontal flight at low level;
(c) Observations made during flights at higher levels, as near as possible to standard isobaric surfaces;
(c) Vertical soundings, either by aircraft or by dropsonde.

2.13.6.4 The elements to be observed during meteorological reconnaissance flights should include:

(a) Atmospheric pressure at which the aircraft is flying;
(b) Air temperature;
(c) Humidity;
(d) Wind velocity (type of wind, wind direction and speed);
(e) Present and past weather;
(f) Turbulence;
(g) Flight conditions (cloud amount);
(h) Significant weather changes
(i) Icing and contrails.

NOTES: (1) For detailed guidance regarding observations made during meteorological reconnaissance flights, see the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, Sixth edition, 1996).

(2) Type of wind refers to how the wind was determined and whether it was a mean or a spot wind.

Frequency and timing of observations

2.13.6.5 Reconnaissance flights should be scheduled in response to requirements for data from data-sparse areas, or in response to special phenomena.

2.13.6.6 Flight times and frequency should be selected so that reconnaissance information supplements upper-air information.

2.13.7 Meteorological rocket stations

General

2.13.7.1 Members are encouraged to establish meteorological rocket stations.

NOTE: When establishing and operating these stations, appropriate safety precautions are considered necessary and need to be coordinated with the relevant air traffic control authorities.

Location and composition

2.13.7.2 Members establishing rocket stations should coordinate their locations through WMO so that continuous networks can be maintained. Elements to be measured include:

(a) Wind direction and speed;
(b) Air temperature;
(c) Solar radiation;
(d) Electrical variables;
(e) Minor chemical constituents.

Frequency and timing of observations

2.13.7.3 Because of cost, the frequency and timing of launches should be coordinated among Members concerned to allow simultaneous sampling at rocket network stations. Information on launches should be communicated to the WMO Secretariat.

2.13.8 Planetary boundary-layer stations

General

2.13.8.1 Members should establish an adequate network of stations for making measurements in the planetary boundary layer.

Location and composition

2.13.8.2 Members should, whenever possible, provide a capability to obtain detailed knowledge of the profiles of temperature, humidity, pressure and wind in the lowest 1 500 m of the atmosphere.

NOTES: (1) This information is required in the study of diffusion of atmospheric pollution, the transmission of electromagnetic signals, the relation between free-air variables and boundary-layer variables, severe storms, cloud physics, convective dynamics, etc.

(2) The accuracy of measurements of several variables and the height intervals at which they are required depend upon the nature of the problems under study.

(3) Some of the vertical and horizontal sounding systems which could be applied to specific problems for limited periods in a variety of locations are described in the Guide on the Global Observing System (WMO-No. 488).

2.13.9 Tide-gauge stations

General

2.13.9.1 Members should establish an adequate network of tide-gauge stations along coasts subject to storm surges.

Location and composition

2.13.9.2 Gauges should be placed in a manner that allows determination of the full range of water heights.

Frequency and timing of observations

2.13.9.3 Observations of tide height should be made at the main synoptic times, 0000, 0600, 1200 and 1800 UTC. In coastal storm situations, hourly observations should be made.

3 EQUIPMENT AND METHODS OF OBSERVATION

3.1 General requirements of a meteorological station

3.1.1 All stations shall be equipped with properly calibrated instruments and adequate observational and measuring techniques, so that the measurements and observations of the various meteorological elements are accurate enough to meet the needs of synoptic meteorology, aeronautical meteorology, climatology and of other meteorological disciplines.

NOTE: For detailed guidance on instruments and methods of observation, see the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, Sixth edition, 1996) and Weather Reporting (WMO-No. 9), Volume D - Information for Shipping.

3.1.2 To satisfy data requirements, primary data from surface-based instruments and observing systems shall be converted into meteorological variables.

3.1.3 The exposure of instruments for the same type of observation at different stations shall be similar in order that observations may be compatible.

3.1.4 A reference height shall be established at each meteorological station.

3.1.5 In order to ensure maintenance of a high standard of observations and the correct functioning of instruments stations shall be inspected periodically.

3.1.6 Station inspections should be carried out by experienced personnel and should ensure that:

(a) The siting and exposure of instruments are known, recorded and acceptable;

(b) Instruments have approved characteristics, are in good order and regularly verified against relevant standards;

(c) There is uniformity in the methods of observation and in the procedure for reduction of observations;

(d) The observers are competent to carry out their duties.

3.1.7 All synoptic land stations should be inspected not less than once every two years.

3.1.8 Agricultural meteorological and special stations should be inspected at least once every year.

3.1.9 Principal climatological stations should be inspected at least once every year; ordinary climatological and precipitation stations should be inspected at least once every three years. If possible, relevant inspections should occasionally be carried out during the winter season.

3.1.10 Automatic stations should be inspected not less than once every six months.

3.1.11 At sea stations, barometers should be checked at least twice a year with reference to a standard barometer.

3.2 General requirements of instruments

3.2.1 Meteorological instruments should be reliable and accurate.

3.2.2 Instruments in operational use shall be periodically compared directly or indirectly with the relevant national standards.

3.2.3 Where automated instrument systems are employed reference (or check) values shall be measured additionally.

3.2.4 At reference climatological stations, any change in instrumentation should be such as not to decrease the degree of accuracy of any observations as compared with the earlier observations, and any such change should be preceded by an adequate overlap (at least two years) with the earlier instrumentation.

3.2.5 Unless otherwise specified, instruments designated as regional and national standards should be compared by means of travelling standards at least once every five years.

3.2.6 In order to control effectively the standardization of meteorological instruments on a national and international scale, a system of national and regional standards, as adopted by the World Meteorological Organization, shall be applied in the GOS. (See Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, Sixth edition, 1996, Part I, Chapter II)

3.3 Surface observations

3.3.1 General

3.3.1.1 An observation should be made in such a way that;

(a) A representative temporally smoothed value of the variable can be found in the vicinity of the station;

(b) All representative extreme value (or other indicator of dispersion) can be determined, if required;
(c) All synoptic-scale discontinuities (e.g. fronts) can be identified as soon as possible after the observation is made.

3.3.1.2 To satisfy these requirements, observational methods should be selected so as to achieve:

(a) Suitable temporal and/or spatial samples of each variable;
(b) A justifiable accuracy for the measurement of each variable;
(c) A representative observation height above the ground.

3.3.1.3 To avoid the effect of small-scale fluctuations, the meteorological variable should be sampled continuously or repeatedly over a suitable time for the purpose of observing representative mean and extreme values. Alternatively, instruments with a suitable lag or damping effect should be used to eliminate or substantially reduce high-frequency noise.

3.3.1.4 The averaging time should be short compared with the temporal scale of such discontinuities as fronts or squall lines, which usually delineate air masses of different characteristics whilst removing the effects of small-scale disturbance. For example, for synoptic purposes an average taken over one to ten minutes will suffice for the measurement of atmospheric pressure, air temperature, air humidity, wind, sea-surface temperature and visibility.

3.3.1.5 Instrumental readings shall be corrected and reduced as appropriate.

3.3.2 Atmospheric pressure

3.3.2.1 Barometric readings shall be reduced from local acceleration of gravity to standard (normal) gravity. The value of standard (normal) gravity (symbol g_n) shall be regarded as a conventional constant.

$$g_n = 9.806\ 65\ \text{m s}^{-2}$$

3.3.2.2 The hectopascal (hPa), equal to 100 pascals (Pa), shall be the unit in which pressures are reported for meteorotogical purposes**.**

NOTE: One hectopascal (hPa) is physically equivalent to one millibar (mb) and thus no changes are required to scales or graduations made in millibars in order to read them in hectopascals;

3.3.2.3 Atmospheric pressure shall be determined either from a mercury barometer or by other sensors (aneroid, electronic barometer) of equal accuracy.

3.3.2.4 In order for mercury barometer readings made at different times and at different places to be comparable, the following corrections should be made:

(a) Correction for index error;
(b) Correction for gravity;
(c) Correction for temperature.

3.3.2.5 Whenever it is necessary to compute the theoretical local value of the acceleration due to gravity, each Member shall follow the procedure given in Annex 3A of the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, Sixth edition, 1996)

3.3.2.6 Atmospheric pressure at a station shall be reduced to mean sea-level, except at those stations where regional association resolutions prescribe otherwise.

3.3.2.7 The results of comparisons of national and regional reference standard barometers shall be reported to the Secretariat for communication to all Members concerned.

3.3.2.8 Regional comparisons of national standard barometers with a regional standard barometer shall be arranged at least once every ten years.

3.3.2.9 Reference standards for comparison purposes may be provided by mercury barometers or by reference pressure sources of equivalent or better accuracy. Using such comparisons, the calibration of the station barometer shall be directly traceable to a national or regional primary standard for atmospheric pressure.

3.3.2.10 In calibration against a standard barometer whose index errors are known and allowed for, tolerances for a station barometer stated in the *Guide to Meteorological Instruments and Methods of Observation* (WMO-No. 8, Sixth edition, 1996) should not be exceeded.

3.3.3 Air temperature

3.3.3.1 One of the following three main types of thermometer should be used:

(a) liquid-in-glass thermometer;
(b) resistance thermometer;
(h) thermocouples.

All temperature shall be reported in degrees Celsius.

3.3.3.2 An instrument height of between 1.25 and 2.0 m above ground is considered satisfactory to obtain representative air temperature measurements. However, at a station where considerable snow cover may occur, a greater height is permissible or, alternatively, a moveable support can be used allowing the thermometer housing to be raised or lowered in order to keep the correct height above the snow surface.

3.3.3.3 Thermometer screens should be constructed so as to minimize radiation effects and at the same time allow free influx and circulation of air.

3.3.3.4 Thermometers should be checked against a reference standard instrument every two years.

NOTE: The required accuracies are given in the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, Sixth edition, 1996).

3.3.3.5 For psychrometric purposes thermometers shall be read to at least 0.1°C.

3.3.4 Humidity

NOTE: Definitions and specifications of water vapour in the atmosphere are given in Annex 4 A of the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, Sixth edition, 1996).

3.3.4.1 In surface observations, at temperatures above 0°C values of humidity should be derived from the readings of a psychrometer or other instrument of equal or greater accuracy.

3.3.4.2 If forced ventilation of psychrometers is used the airflow past the thermometer bulbs should be between 2.5 m s^{-1} and 10 m s^{-1}.

3.3.4.3 In surface observations the height requirements for humidity measurements shall be the same as for air temperature measurements.

3.3.5 Surface wind

3.3.5.1 The exposure of wind instruments over level, open terrain shall be ten metres above the ground.

NOTE: Open terrain is defined as an area where the distance between the anemometer and any obstruction is at least ten times but preferably 20 times the height of the obstruction.

3.3.5.2 At aeronautical stations the wind sensors should be exposed to provide measurements representative of conditions six to ten metres above the runway at the average lift-off and touch-down areas.

3.3.5.3 Wind speed should be measured to the nearest unit (metres per second, kilometres per hour or knots), and should represent, for synoptic reports, an average over ten minutes or, if the wind changes significantly in the ten-minute period, an average over the period after the change.

NOTE: In observations used at an aerodrome for aircraft taking off and landing, the averaging period is two minutes and the speed is reported in metres per second, kilometres per hour or knots with an indication of the unit used.

3.3.5.4 Wind direction should be measured in degrees and reported to the nearest ten degrees and should represent a scalar average over ten minutes or, if the wind changes significantly in the ten-minute period, an average over the period after the change.

3.3.5.5 "Calm" should be indicated when the average wind speed is less than 0.5 m s^{-1}. The direction in this case is not measured for synoptic purposes.

3.3.5.6 In the absence of an anemometer, the wind speed may be estimated using the Beaufort scale.

NOTE: The Beaufort scale is given in the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, Sixth edition, 1996, Chapter 5).

3.3.5.7 At sea stations, in the absence of appropriate instruments, the wind speed may be estimated by reference to the Beaufort scale and the wind direction by observing the motion of sea waves.

3.3.6 Clouds

3.3.6.1 For all cloud observations, the tables of classification, definitions and descriptions of general species and varieties of clouds as given in the International Cloud Atlas (WMO-No. 407), Volume I - Manual on the Observation of Cloud and other Meteors - (Annex I to the Technical Regulations), shall be used.

3.3.6.2 Height of cloud base should preferably be determined by measurement.

3.3.7 Weather

3.3.7.1 See Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, Sixth edition, 1996 Para 14.2).

3.3.8 Precipitation

3.3.8.1 The amount of precipitation shall be the sum of the amounts of liquid precipitation and the liquid equivalent of solid precipitation.

3.3.8.2 Daily amounts of precipitation should be measured to the nearest 0.2 mm and, if feasible, to the nearest 0.1 mm. Daily measurements of precipitation should be made at fixed times.

3.3.8.3 The design and exposure of a raingauge should be such as to minimize the effects of wind, evaporation and splashing, these being the most frequent sources of error.

NOTE: In general, objects should not be closer to the gauge than a distance twice their height above the gauge orifice.

3.3.9 Sea temperature

3.3.9.1 The method used at manned sea stations for measuring sea-surface temperature shall be entered in the relevant meteorological logbook.

3.3.10 Waves

3.3.10.1 When separate wave systems are clearly distinguishable, each of them should be recorded.

3.3.11 Radiation

3.3.11.1 The comparison of radiation instruments on a regional or a global level should be performed at least once every five years. The calibration of radiation instruments should be checked and recalibrated, if necessary, at least once a year against existing standards.

NOTE: For details of calibration of other radiation sensors, refer to *the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8, Sixth edition, 198396), Chapter 7.*

3.3.12 Soil temperature

3.3.12.1 Measurements should be made to detect diurnal variations of soil temperature at depths of 5, 10, 20 and, in some cases, 50 cm.

3.3.12.2 Soil-surface temperature measurements are recommended for special purposes.

3.3.13 Soil moisture

3.3.13.1 Gravimetric estimation of soil moisture should be taken as the average of at least three samples from each depth.

3.3.13.2 Gravimetric water content should be expressed as the grams of soil moisture contained in a gram of dry soil.

3.3.14 Evapotranspiration

3.3.14.1 Observations of evapotranspiration should be representative of the plant cover and moisture conditions of the general surroundings of the station. Separate statements of evapotranspiration from irrigated areas should be provided.

3.3.15 Evaporation

3.3.15.1 Evaporation should be measured by means of evaporation tanks. The design and exposure of the evaporation tanks should ensure the required comparability of observations.

3.3.15.2 Water temperature and wind run records should be taken at each observation.

3.3.15.3 The amount of evaporation should be read in millimetres.

3.3.16 Sunshine duration

3.3.16.1 The threshold value for bright sunshine should be 120 W m–2 of direct solar irradiance.

3.4 Upper-air observations

3.4.1 At a synoptic upper-air station, atmospheric pressure, temperature and humidity (PTU) observations shall be made by means of a radiosonde attached to a fast-ascending free balloon.

NOTE: For detailed guidance on the radiosonde and balloon techniques, see the Guide to Meteorological Instruments and Methods of Observation (WMO-No. 8), Chapters 13 and 14.

3.4.2 Computations of upper-air observations shall be based on the relevant definitions of physical functions and values of constants given in Technical Regulations, Appendix A.

3.4.3 At a synoptic upper-air station, upper-wind observations should be made by tracking of the fast-ascending free balloon by electronic means (e.g. radio theodolite, radar or NAVAID).

NOTE: At stations where the skies are generally clear, upper winds may be determined by optical tracking of a balloon.

3.4.4 Each upper-air station should have an appropriate manual of instructions.

3.4.5 Each synoptic upper-air station shall promptly report on any changes of the types of radiosonde and windfinding systems in operational use to the Secretariat for communication to all Members at least on a quarterly basis.

3.4.6 International comparisons of widely used radiosonde types shall be made at least once every four years.

3.4.7 New radiosonde types should be compared with sondes accepted as having the most stable and accurate performance before adoption for operational use.

3.4.8 At a meteorological reconnaissance aircraft station, electronic means (NAVAID) should be used when a vertical profile of upper winds is to be determined by means of a dropsonde.

P A R T IV

SPACE-BASED SUB-SYSTEM

1. COMPOSITION OF THE SUB-SYSTEM

The space-based sub-system shall be composed of a ground segment in addition to the space segment consisting of operational geostationary and polar-orbiting satellites and research and development satellites..

NOTE: Information on the characteristics, capabilities and uses of the current system of operational meteorological satellites is contained in the CGMS Directory of Meteorological Satellite Applications. Additional up-to-date information can be found via the WMO Satellite Activities Homepage: http://www.wmo.ch/hinsman/satsun.html. Information on Meteorological and Other Environmental Satellites ~~(WMO No. 411)~~ contains further relevant information and is available on the WMO Satellite Activities web pages for publications : http://www.wmo.ch/hinsman/Publications.html.

1.1 Space segment

The space segment shall provide for a global coverage.

NOTES: (1) The different capabilities of the ~~two groups of~~ operational and research and development satellites complement each other and are necessary parts of the space-based sub-system of the GOS.
(2) ~~Both groups~~ Operational, and to the extent possible research and development satellites, are also capable of accomplishing data-collection and data-dissemination missions.

1.1.1 Polar-orbiting satellites

1.1.1.1 Missions

The following missions should be performed:

(a) Visible, infra-red and micro-wave imagery missions;
(b) Infra-red and micro-wave sounding missions;
(c) Data-collection missions;
(d) Direct broadcast missions;
(e) Other missions as appropriate, e.g. scatterormeter, altimetric, etc..

1.1.2 Geostationary satellites

1.1.2.1 Missions

The following missions should be performed:

(a) Visible, infra-red and micro-wave imagery missions;
(b) Infra-red sounding missions;
(c) Data-collection missions;
(d) Dissemination missions~~:~~;
(e) Other missions as appropriate, e.g. earth radiation budget, etc..

1.1.3 Research and Development satellites

1.1.3.1 Missions

The following missions, to the extent possible, should be performed:

(a) Visible, infra-red and micro-wave imagery missions;
(b) Infra-red and/or micro-wave sounding missions;
(c) Dissemination missions;
(d) Missions capable of measuring parameters stated as WMO observational requirements.

1.2 Ground segment

Receiving and processing stations should provide for the reception of signals and DCP data from operational satellites and/or the processing, formatting and display of meaningful environmental observation information, with a view to further distributing it in a convenient form to local users, or over the GTS, as required.

2. IMPLEMENTATION OF THE SUB-SYSTEM

Members operating environmental observation satellite programmes shall make the satellite data reliably available to other Members and shall inform the Members of the means of obtaining these data.

2.1 Space segment

Members operating environmental observation satellites should meet, to the extent possible, the accuracy, timeliness and the time and space resolution requirements of the GOS.

2.1.1 Number, distribution and availability of operational spacecraft

2.1.1.1 The number of satellites in polar orbit should be sufficient to provide global coverage at least four times per day for instruments with horizon-to-horizon scanning. Typically this will require one satellite in ante-meridian (a.m.) orbit and one in post-meridian (p.m.) orbit.

2.1.1.2 The number of satellites in geostationary orbit should be sufficient to obtain observations, typically at 30 or 15 minute intervals~~,~~ and throughout ~~the~~ a field of view between ~~50°~~ 60^0 S and ~~50°~~ 60^0 N. This implies the availability of at least six satellites, near-equally spaced around the equator.

2.1.1.3 Data from polar satellites should be acquired on a global basis, without gaps (blind orbits), and delivered to users to meet timeliness requirements. Imagery and sounding data should be available from at least one polar orbiting satellite, in a.m. or p.m. orbit, on not less than 99% of occasions. The system design should provide for ground segment, instrument and satellite redundancy, and rapid call up of replacement launches or AM and PM spares, to achieve this.

2.1.1.4 Imagery from at least six equi-spaced geostationary satellites should be accessible on not less than 90% of occasions and from four such satellites on 99% of occasions. Contingency plans, involving the use of in-orbit stand-by flight models and rapid call up of replacement systems and launches, should be in place to maximise the utility of the available data.

2.1.2 Missions

2.1.2.1 The satellites should be equipped at a minimum to provide the following missions:

(a) Imagery and sounding missions: satellites should be equipped to provide characteristics (including spatial and temporal resolution, accuracy and timeliness) meeting user requirements to the greatest extent possible, independently or in conjunction with surface-based observations, quantitative data and qualitative information to enable determination of:

(i) Fields of atmospheric temperature and humidity;
(ii) Temperatures of sea and land surfaces;
(iii) Wind fields at the surface and aloft;
(iv) Cloud amount, cloud type, cloud top height and temperature, and cloud water content
(v) Precipitation
(vi) Snow and ice cover;

(vii) Total column ozone
(viii) Vegetation cover
(ix) Radiation balance data.

NOTES: (1) The movements of clouds and water vapour features provide a useful determination of the wind field but only at one or two levels in the vertical and only when suitable tracers exist.

(2) Operational environmental satellites have made useful contributions to many of the information types listed in 2.1.4.

(b) Direct broadcast, data-dissemination missions and alternative dissemination methods : All operational environmental observation satellites should be equipped to provide direct broadcast or near-real-time data dissemination of the cloud imagery and, to the extent possible, of other real-time data of interest to Members. Additionally:

(i) Members responsible for satellites with these facilities should ensure the greatest possible compatibility between their different systems, and publish details of the technical characteristics of their instrumentation, data processing and transmissions, as well as the dissemination schedules.
(ii) Frequencies, modulations, formats and orbital de-phasing between the a.m. and p.m. satellites should be such as to allow a particular user to acquire data from either satellite by a single antenna and signal processing hardware. To the extent possible, the existing frequency bands should continue to be used.
(iii) Direct broadcast should be provided in two data streams as follows:
- a high data rate stream, such as the present HRPT and its planned evolution, to provide large and medium-sized meteorological centres with all the data required for Nowcasting and NWP, when required, and other real-time applications;
- a low data rate stream, such as in the present APT and WEFAX services and their planned evolution to LRPT and LRIT services, to convey an essential volume of data for Nowcasting and short period forecasting to low-cost receiving stations.
(iv) Alternative dissemination methods (ADM) should complement and supplement direct broadcast services with the ultimate goal for transition to the full use of the ADM broadcast services.

(c) Data-collection missions: All operational environmental observation satellites should be equipped to provide for the collection and relay of data from various kinds of observing and data-collection platforms (DCP);

(i) Members responsible for satellites with this capability should establish and maintain the necessary technical and operational co-ordination, in order to ensure compatibility. A number of channels should be identical on all geostationary satellites to allow movement of mobile platforms between their individual footprints.
(ii) The satellite operators should publish details of the technical characteristics and operational procedures of their data-collection missions, including the admission and certification procedures.

NOTE: ARGOS, based on polar orbiting satellites, provides an operational system for locating low power transmitters and relaying small amounts of data from them.

2.1.2.2 Global data coverage should be provided for the benefit of the WMO World Meteorological Centres and a number of Regional Specialized Meteorological Centres engaged in global NWP. Availability of global data is required without gaps in coverage or time. For Global NWP applications, data are required no later than 4 hours, and with a goal of 1 hour, after the instrument ~~gas~~ has made the observation. This may be achieved by on-board storage and successive transmission when in view of Command and Data Acquisition stations, or by using Data Relay Satellites, or by a combination of the two systems.

2.1.2.3 The above missions make a useful contribution to the monitoring of climate, but to maximise their effectiveness for this purpose data records possessing long term consistency are essential. Members responsible for operational environmental satellites should consider this requirement when planning their launch, calibration, validation, processing and archival strategies.

2.1.3 Contingency arrangements

2.1.3.1 The satellite operators, working together under the auspices of CGMS or otherwise, should ensure the continuity of operation, and the data dissemination and distribution services of the satellites comprising the Baseline Space Segment.

2.1.4 Research and development satellites

NOTE: Research and development satellites provide, when possible, information for operational use. The purposes of research and development satellites are to acquire a defined set of research data, to test new instrumentation and/or to improve existing sensors and satellite systems.

Although neither long term continuity of service nor a reliable replacement policy are assured, these satellites provide such information as:

(a) Improved information on atmospheric temperature and humidity fields;
(b) Improved information on wind fields, including at the ocean surface;
(c) Soil moisture distribution;
(d) Improved information on sea ice type and extent;
(e) Improved information on snow cover and on snow water content;
(f) Wave heights, directions and spectra;
(g) Improved accuracy and frequency in rainfall monitoring;
(h) Three-dimensional cloud water/ice fields;
(i) Cloud-base height;
(j) Improved monitoring of the Earth radiation budget;
(k) Sea-surface temperatures of improved accuracy;
(l) Distribution of particulate matter in the atmosphere, including volcanic ash;
(m) Ocean surface height;
(n) Ocean surface salinity;
(o) Ocean colour, related to marine pollution and biological properties;
(p) Sea and land ice topography;
(q) Improved information on ozone distribution;
(r) Improved information on land cover and vegetation mapping;
(s) Flood and forest fire monitoring;
(t) Information on fields of chemically-active atmospheric constitutents;
(u) Information on carbon dioxide and other greenhouse gases

2.2 Ground segment

2.2.1 Central stations

2.2.1.1 In order to guarantee that comparable meteorological parameters or information are obtained, all Members operating central stations should do their utmost in co-ordinating the extraction of meteorological information.

2.2.1.2 The satellite operators should establish dissemination schedules that take into account the requirements of users.

2.2.2 Users' stations

(a) Receiving stations

(i) All Members should endeavour to install in their territory at least one direct broadcast receiving station for cloud imagery data from the polar satellite

constellation and at least one such station for receiving data from a geostationary satellite;

(ii) When real-time use is planned of the high-resolution imagery transmission, or the high-resolution digital data from the sounding instruments, Members shall install a station capable of receiving data in the appropriate direct broadcast frequency.

(iii) Members requiring access to data from the direct broadcast service on research and development satellites will need to install an appropriate user station which may be different from the user station for the operational satellites.

(b) Data-collection platforms : In order to extend the Global Observing Systems by the use of the data-collection and relay capability of the environmental observation satellites, Members should establish fixed or moving DP/ARGOS systems, in particular to cover data-sparse areas.

2.2.3 Archiving strategy

2.2.3.1 Satellite data should be archived at CEOS Level 1B, together with all relevant metadata pertaining to the location, orbit and calibration procedures used. The archiving system should be capable of providing a browse facility, generating summaries and allowing users to develop new products by refining current or developing new algorithms or products.

2.2.4 Education and Training strategy

2.2.4.1 The highest priority should be given to the education and training of instructors in the use of satellite data and capabilities at a sub-set of RMTCs, in order to build up expertise and facilities at a number of regional growth points. In order to help bring this about, individual environmental satellite operators should focus their assistance, to the extent possible, on one or more of these RMTCs within their service areas.

NOTE (1) The aim of this strategy is to systematically improve the use of satellite data for meteorology and operational hydrology, with a focus on meeting the needs of developing countries.

(2) It is designed to focus the participation of all organizations that have a vested interest in improving the use of satellite data and recognises that the satellite operators are one such, with ready access to much of the necessary infrastructure and expertise.

(3) Implementation requires access to appropriate receiving and processing facilities at the RMTCs but training can be carried out through seminars and/or Internet based communication.

PART V

QUALITY CONTROL

1. Basic characteristics of quality control

1.1 The purpose of quality control of observational data is error detection, possible error correction and, therefore, error prevention, in order to ensure the highest possible standard of accuracy for the optimum use of these data by all possible users.

1.1.1 Within the framework of the GOS, quality control shall be a real-time activity which has to be performed prior to the transmission of the observational data on the GTS.

NOTE: See Guide to Meteorological Instruments and Methods of Observations, Part III (WMO - No. 8)

1.1.2 Quality control shall also be performed on a non-real-time basis, prior to forwarding the observational data for archiving.

NOTES: (1) Quality control on a real-time basis shall also take place in the GDPS, prior to the use of the observational data in data processing (i.e. objective analysis and forecasting).

(2) See the Manual on the Global Data-processing System (WMO-No. 485), Volume 1.

1.2 Quality control shall be applied to all observational data obtained from either the surface-based or the space-based sub-system.

2. General principles

2.1 Responsibility

2.1.1 The primary responsibility for quality control of all observational data shall rest with the Members from whose Services the observations originated.

NOTE: Members should pay due attention to the quality control of observational data at the national level, aiming at the prevention of errors at the observational site, as well as the National Meteorological Centres.

2.1.2 Members shall inform the Secretary-General (for general dissemination) of any special features of their observing systems which may be important in the correct interpretation of the data provided.

2.2 Relay of data

2.2.1 Quality control of observational data needed for operational use shall not cause any significant delay in onward transmission on the GTS.

2.3 Minimum standards

2.3.1 Members shall implement minimum standards of quality control at all levels for which they are responsible (e.g. observing stations, NMCs, RMCs WMCs).

NOTE: (1) Recommended minimum standards of quality control at the level of the observing station and at that of the NMC are given in the Manual on the Global Data-processing System (WMO-No. 485), Volume I, Appendix II-1, Table I.

2.3.2 Members not capable of implementing these standards should establish agreements with an appropriate RMC or WMC to perform the necessary quality control.

_____

DEFINITIONS

The following terms, when used in the Manual on the Global Observing System, have the meanings given below. Composite terms have not been defined in this section when their meanings can easily be deduced from those of the elements constituting them. For example, the meaning of the term "synoptic land station" can be constructed logically from the meaning of the terms "synoptic station" and "land station". Other definitions can be found in the Manuals on Codes, on the GDPS, on the GTS and other WMO publications.

A – METEOROLOGICAL OBSERVING FACILITIES AND RELATED SERVICES

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

Agricultural meteorological station: A station that provides meteorological and biological information for agricultural and/or biological applications. Agricultural meteorological stations are classified as follows:

- ***Principal agricultural meteorological station***: A station that provides detailed simultaneous meteorological and biological information and where research in agricultural meteorology is carried out. The instrumental facilities, the range and frequency of observations in both meteorological and biological fields, and the professional personnel are such that fundamental investigations into agricultural meteorological questions of interest to the countries or Regions concerned can be carried out.

- ***Ordinary agricultural meteorological station***: A station that provides, on a routine basis, simultaneous meteorological and biological information and may be equipped to assist in research into specific problems; in general the programme of biological or phenological observations for research will be related to the local climatic regime of the station.

- ***Auxiliary agricultural meteorology station***: A station that provides meteorological and biological information. The meteorological information may include such items as soil temperature, soil moisture, potential evapotranspiration, detailed information on the very lowest layer of the atmosphere; the biological information may cover phenology, onset and spread of plant diseases, etc.

- ***Agricultural meteorological station for specific purposes***: A station set up temporarily or permanently that provides meteorological data for specific agricultural purposes.

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

Alternative dissemination methods (ADM): Dissemination services other than through direct broadcast for satellite sensor, data and products. These alternatives include: the use of data relay between satellite systems; the use of commercially provided higher data rate services; and the use of services such as the Internet. ADM should complement and supplement direct broadcast services.

AMDAR : Aircraft Meteorological Data Relay

Anchored platform station: An observing station on a platform anchored in deep water.

ASDAR : Aircraft to Satellite Data Relay

Atmospherics detection station: A station contributing observations to an atmospheric detection system.

Atmospherics detection system: An instrumental system consisting of a number of stations for the detection and location of atmospherics.

Automated aircraft meteorological system: A series of devices integrated into the instrumentation of an aircraft, which records and/or transmits observations automatically.

Automatic station: A station at which instruments make and either transmit or record observations automatically, the conversion to code form, if required, being made either directly or at an editing station.

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

Climatological station: A station whose observations are used for climatological purposes. Climatological stations are classified as follows:

- ***Reference climatological station***: A climatological station the data of which are intended for the purpose of determining climatic trends. This requires long periods (not less than 30 years) of homogeneous records, where man-made environmental changes have been and/or are expected to remain at a minimum. Ideally, the records should be of sufficient length to make possible the identification of secular changes of climate.

- ***Principal climatological station***: A climatological station at which hourly readings are taken, or at which observations are made at least three times daily in addition to hourly tabulation from autographic records.

- ***Ordinary climatological station***: A climatological station at which observations are made at least once daily, including daily readings of extreme temperature and of amount of precipitation.

- ***Climatological station for specific purposes***: A climatological station established for the observation of a specific element or elements.

Coastal station: A station on a coast that may be able to make some observations of conditions at sea.

Data-collection platform (DCP): A fixed or moving platform on land, sea or in the air that transmits data via satellite to a collection centre.

Direct broadcast service: A broadcast service, provided by some operational environmental observation satellites, that transmits satellite sensor data and products in real-time for reception by ground stations within radio range of the satellite.

Direct readout service: A service provided by meteorological satellites that allows the reception of satellite data in real-time by ground stations within radio range of the satellite

Drifting automatic sea (drifting buoy) station: A floating automatic surface synoptic station that is free to drift under the influence of wind and current.

Environmental data buoy station: A fixed or drifting buoy which records or transmits environmental and/or marine data.

Environmental observation satellite: An artificial Earth satellite providing data on the Earth system which are of benefit to WMO Programmes.

NOTE: These data support a variety of disciplines including, but not limited to, meteorology, hydrology, climatology, oceanography, climate and global change related disciplines.

Research and development satellite: An environmental observation satellite with the primary purpose of acquiring a defined set of research data; testing new instrumentation and/or improving existing sensors and satellite systems; and/or it may provide information for operational use, but has limitations due to the lack of a commitment to ensure continuity of service or a reliable satellite replacement policy; and also due to non-consistent modes of operations.

Fixed platform station: An observing station on a platform at a fixed site in shallow water.

Fixed sea station: An ocean weather ship or a station situated an a lightship, a fixed or anchored platform, or a small island, or in certain coastal areas.

Geostationary satellite: A type of environmental observation satellite orbiting in the Earth's equatorial plane at an altitude of approximately 36 000 km and with the angular velocity of Earth, thus providing nearly continuous environmental information in an area within a range of about 65° from the sub-satellite point at the Equator.

Global Data-processing System (GDPS): The coordinated global system of meteorological centres and arrangements for the processing, storage and retrieval of meteorological information within the framework of the World Weather Watch.

Global Atmosphere Watch station: A station which provides observational data and other information on the chemical composition and physical characteristics of the background atmosphere.

Global Climate Observing System Surface Network (GSN) station: A land station included the specially selected network of stations to monitor daily and large scale climate variability on a global basis.

Global Climate Observing System Upper-air Network (GUAN) station: An upper-air station included in the specially selected global baseline network of upper-air stations to meet the requirements of the GCOS.

Global Observing System (GOS): The coordinated system of methods and facilities for making meteorological and other environmental observations on a global scale in support of all WMO Programmes, particularly the World Weather Watch and the World Climate Programme; the system is comprised of operationally reliable surface-based and space-based sub-systems. The objective is to assure continuity of service.

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

Ice-floe station: An observing station on an ice floe.

Island station: A station on a small island on which conditions are similar to those in the marine environment and from which some observations of conditions at sea can be made.

Land station: An observing station situated on land.

Lightship station: A surface synoptic station situated aboard a lightship.

Meteorological element: One of the atmospheric variables or phenomena which characterize the physical state of the atmo-sphere at a specific place at a given time. (See section B)

Meteorological observation (Observation): The evaluation or measurement of one or more meteorological elements.

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

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

Meteorological reconnaissance aircraft station: A meteorological station on an aircraft equipped and assigned for the specific purpose of making meteorological observations.

Meteorological reconnaissance flight: An aircraft flight for the specific purpose of making meteorological observations.

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

Meteorological rocket station: A station equipped to make atmospheric soundings by rockets.

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

Mobile sea station: A station aboard a mobile ship or an ice floe.

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

Near-polar-orbiting satellite: A type of environmental observation satellite with nearly circular, nearly polar orbit. The combination of satellite motion and the Earth's rotation beneath the orbit enables the collection of overlapping strips of satellite data (swaths up to 3 000 km wide) from pole to pole. The satellite's altitude or inclination defining the orbit may be selected in such a way to be sun-synchronous and provide global coverage. Sun-synchronous implies that the satellite will pass over a given geographic position at the same local sun-time each day.

Observing station: Any station making meteorological and related environmental observations.

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

Operational satellite: One of series of environmental observation satellites with the primary purpose to routinely provide observations and services of a consistent standard over a long period. Resources are committed to ensure continuity of services thus permitting the establishment of a reliable satellite replacement policy.

NOTE: The terminology of radiation quantities and measuring instruments is given in the *Guide to Meteorological Instrument and Methods of Observation* – Sixth Edition (WMO –N°8).

Ozone sounding station: A station at which observations of atmospheric ozone are made.

Pilot-balloon observation: A determination of upper winds by optical tracking of a free balloon.

Pilot-balloon station: A station at which upper winds are determined by optical tracking of a free balloon.

Planetary boundary layer: The lowest layer in the atmosphere, usually taken to be up to 1 500 m, in which meteorological conditions are affected significantly by the Earth's surface.

Planetary boundary-layer station: A station equipped to provide detailed meteorological data on the planetary boundary layer.
Precipitation station: A station at which observations of precipitation only are made.

Radiation station: A station at which observations of radiation are made.

- ***Principal radiation station***: A radiation station the observing programme of which includes at least the continuous recording of global solar radiation and of sky radiation and regular measurements of direct solar radiation.

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

Radiosonde observation: An observation of meteorological elements in the upper air, usually atmospheric pressure, temperature and humidity, by means of a radiosonde.

NOTE: The radiosonde may be attached to a balloon, or it may be dropped (dropsonde) from an aircraft or a rocket.

Radiosonde station: A station at which observations of atmospheric pressure, temperature and humidity in the upper air are made by electronic means.

Radiowind observation: A determination of upper winds by tracking of a free balloon by electronic means.

Radiowind station: A station at which upper winds are determined by the tracking of a free balloon by electronic means.

Rawinsonde observation: A combined radiosonde and radiowind observation.

Rawinsonde station: A combined radiosonde and radiowind station.

Reference level data: Data for a specified level, normally 1 000 hPa, which enable absolute heights to be ascribed to satellite temperature-sounding data.

Regional basic synoptic network: A network composed of synoptic stations with a specified observational programme within a WMO Region, which is a minimum regional requirement to permit Members to fulfil their responsibilities within the World Weather Watch and in the application of meteorology.

Research and special-purpose vessel station: A vessel making voyages for research or other purposes and which is recruited to make meteorological observations during the voyages.

RMC : A centre of the Global Data Processing System which has the primary purpose of issuing meteorological analyses and prognoses on a regional scale.

RSMC : A centre of the Global Data Processing System which has the primary purpose of issuing meteorological analyses and prognoses on a regional scale for a specified geographical area or of providing products and related information in a designated field of activity specialization.

Satellite communication services requirements: Requirements for services using environmental observation satellites including, but not limited to, direct broadcast of data, radio relay of environmental data collected by automatic sensor platforms, and search and rescue transmissions.

Satellite data requirements: Those data specified as performance goals for an operational environmental observation satellite system. At a minimum, environmental observation satellite data requirements are defined in terms of spatial, spectral and temporal resolution, geographic extent, timeliness, and measurement and location accuracy.

NOTE: These data requirements are routinely reviewed to identify common needs in order to consolidate the design of the satellite's instrument payload, and to identify requirements that could be met more effectively either by surface or space-based observing systems.

Satellite operator: An entity (Member of WMO or international organisation) that manages, and/or operates environmental observation satellites which are of benefit to WMO Programmes.
Sea station: An observing station situated at sea.

Selected ship station: A mobile ship station that is equipped with sufficient certified meteorological instruments for making observations and that transmits the required observations in the appropriate code form for ships.

Space-based subsystem: One of the two major components of the Global Observing System composed primarily of environmental observation satellites in near-polar and geostationary orbits.

Special report: A report made at a non-standard time of observation when specified conditions or changes of conditions occur.

Special station: A station for a special purpose as specified in Part III, paragraph 1, of the Manual.

Standard time of observation: A time specified in the Manual on the Global Observing System for making meteorological observations.

NOTE: The term Greenwich Mean Time, abbreviated as GMT, is used in this Manual as a synonym of the term "Coordinated Universal Time" (UTC).

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

Surface-based subsystem: One of the two major components of the Global Observing System composed of all non-spaced-based observing stations.

Surface observation: A meteorological observation, other than an upper-air observation, made on the Earth’s surface.

Surface station: A surface location from which surface observations are made.

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

Synoptic station: A station at which synoptic observations are made.

Tide-gauge station: A station at which tidal measurements are made.

Upper-air observation: A meteorological observation made in the free atmosphere either directly or indirectly.

Upper-air report: A report of an upper-air observation.

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

Upper-wind observation: An observation at a given height or the result of a complete sounding of wind speed and direction in the atmosphere.

Weather radar station: A station making observations by weather radar.

WMC : A centre of the Global Data Processing System which has the primary purpose of issuing meteorological analyses and prognoses on a global scale.

World Weather Watch (WWW): The world-wide, coordinated, developing system of meteorological facilities and services provided by Members for the purpose of ensuring that all Members obtain the meteorological and other environmental information they require both for operational work and for research. The essential elements of the World Weather Watch are:

The Global Observing System;
The Global Data-processing System; and
The Global Telecommunication System.

B – METEOROLOGICAL ELEMENTS AND OTHER OBSERVED VARIABLES

[THE DESCRIPTION OF GEOPHYSICAL PARAMETERS IN THIS SECTION SHOULD BE INTERNALLY CONSISTENT AS WELL AS CONSISTENT WITH THOSE USED IN THE DATABASE OF OBSERVATIONAL DATA REQUIREMENTS FOR WMO AND SUPPORTED PROGRAMMES. AS AN EXAMPLE OF INTERNAL INCONSISTENCY, THERE IS A DESCRIPTION FOR SOLAR RADIATION BUT NONE FOR EITHER SHORT OR LONG WAVE RADIATION. AT THE END OF SECTION B, IS THE COMPLETE LIST OF GEOPHYSICAL PARAMETERS AS CONTAINED IN THE DATABASE.

Aerosol: Substances, divided into solid particles or liquid droplets, held in suspension in the atmosphere.

Air temperature: The temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation.

Aircraft icing: Formation of ice, *rime* or *hoar frost* on an aircraft.

Atmospheric Pressure: Pressure (force per unit area) exerted by the atmosphere on any surface by virtue of its weight; it is equivalent to the weight of a vertical column of air extending above a surface of unit area to the outer limit of the atmosphere.

- ***Pressure tendency***: Character and amount of a station pressure change over three hours (over 24 hours in tropical regions).

- ***Characteristic of pressure tendency***: Shape of the curve recorded by a barograph during the three-hour period preceding an observation.

Dew point: Temperature to which a volume of air must be cooled at constant pressure and constant moisture in order to reach saturation.

Cloud: A hydrometeor consisting of minute particles of liquid water of ice, or of both, suspended in a free air and usually not touching the ground.

- ***Cloud amount***: The fraction of the sky covered by the clouds of a certain genus, species, variety, layer, or combination of clouds.

- Height ***of cloud base***: Height above the Earth suffers of the base of the lower cloud layer whose amount exceeds a specific value.

- Direction ***and speed of cloud movement***: Direction from which the cloud is coming and the horizontal component of its speed.

- Cloud ***type (classification)***: Type or variety of cloud as described and classified in the International Cloud Atlas.

Contrail: Cloud which forms in a wake of an aircraft when the air at flight level is sufficiently cold and moist.

Humidity: Water vapour content of the air.

Precipitation: Hydrometeor consisting of a fall of an ensemble of particles. The forms of precipitation are: rain, drizzle, snow, snow grains, snow pellets, diamond dust, hail and ice pellets.

Precipitation chemistry: Nature and amount of the impurities dissolved or suspended in the precipitation.

Sea ice: Any form of ice found at sea which has originated from the freezing of sea water.

Sea surface temperature: Temperature of the surface layer of the sea.
Soil temperature: Temperature observed at different depths in the soil.

Soil moisture: Moisture contained in that portion of the soil which lies above the water table, including the water vapour contained in the soil pores.

Solar radiation: Energy emitted by the sun considered as short-wave radiation with wavelengths between 0.29 and 4µm.

State of ground: The characteristics of the surface of the ground, especially resulting from the effect of rain, snow, and temperatures near freezing point.

Sunshine duration: The sum of the time, during a given period, for which the direct solar irradiance exceeds $120 Wm^{-2}$.

Turbidity: Reduced transparency of the atmosphere to radiation (especially visible) caused by absorption and scattering by solid or liquid particles other than clouds.

Turbulence: Random and continuously changing air motion which are superposed on the mean motion of the air.

Upper-wind: The winds speed and direction at various levels in the atmosphere, above the domain of surface weather.

Visibility: Greatest distance at which a black object of suitable dimensions can be seen and recognised against the horizon sky during daylight or could be seen and recognised during the night if the general illumination were raised to the normal daylight level.

Wave height*:* The vertical distance between the trough and crest of the wave.
Wave period: Time between the passage of two successive wave crest past a fixed point.
Waves, direction of movement of: Direction from which the waves arrive at a given point.

Weather: State of the atmosphere at a particular time, as defined by the various meteorological elements.

- ***Present weather :*** Weather existing at a station at a time of observation.
- ***Past weather :*** Predominant characteristic of the weather which had existed at an observing station during a given period of time.

Wind direction: Direction from which the wind blows.
Wind speed: Ratio of the distance covered by the air to the time taken to cover it.

LIST OF GEOPHYSICAL PARAMETERS (with definitions and comments)

- Atmospheric temperature profile - Air temperature at surface is addressed separately. [Unit of measurement - K, database abbreviation T(p)]
- Wind profile (horizontal component) - Surface winds are addressed separately. [Unit of measurement - m/s, database abbreviation UV(p)]
- Wind profile (vertical component) - Vertical component of wind at surface is not addressed. [Unit of measurement - cm/s, database abbreviation W(p)]
- Specific humidity profile - Air humidity at surface is addressed as specific humidity. [Unit of measurement - g/kg, database abbreviation Q(p)]
- Cloud water profile (< 100 μm) - Water in liquid phase with droplets generally too small to precipitate. Droplet size distribution is addressed as cloud drop size at cloud top. Surface cloud water (fog) is one of the cloud types. [Unit of measurement - g/kg, database abbreviation CLWS(p)]
- Cloud water profile (>100 μm) - Water in liquid phase with droplets generally too small to precipitate. For liquid precipitation reaching the ground, see precipitation rate at the ground (liquid). [Unit of measurement - g/kg, database abbreviation CLWL(p)]
- Cloud ice profile - Water in solid phase. For solid precipitation reaching the ground, see precipitation rate at the ground (solid). Fractional ice content at cloud top is addressed under cloud ice content at cloud top. [Unit of measurement - g/kg, database abbreviation CI(p)]
- Aerosol profile - Any liquid or solid suspended particle (other than water in the cloud water (< 100 μm or > 100 μm), or cloud ice profiles in the air. [Unit of measurement - g/kg, database abbreviation AERO(p)]
- Ozone profile - [Unit of measurement - molecule/molecule, database abbreviation O_3(p)]
- Trace gas profile: CH_4 - [Unit of measurement - molecule/molecule, database abbreviation CH_4(p)]
- Trace gas profile: CO_2 - [Unit of measurement - molecule/molecule, database abbreviation CO_2(p)]
- Trace gas profile: CO - [Unit of measurement - molecule/molecule, database abbreviation CO(p)]
- Trace gas profile: CFC 11 - [Unit of measurement - molecule/molecule, database abbreviation CFC 11(p)]
- Trace gas profile: CFC 12 - [Unit of measurement - molecule/molecule, database abbreviation CFC 12(p)]
- Trace gas profile: OH - [Unit of measurement - molecule/molecule, database abbreviation OH(p)]
- Trace gas profile: NO - [Unit of measurement - molecule/molecule, database abbreviation NO(p)]
- Trace gas profile: NO_2 - [Unit of measurement - molecule/molecule, database abbreviation NO_2(p)]
- Trace gas profile: N_2O - [Unit of measurement - molecule/molecule, database abbreviation N_2O(p)]
- Trace gas profile: HNO_3 - [Unit of measurement - molecule/molecule, database abbreviation HNO_3(p)]
- Trace gas profile: HCl - [Unit of measurement - molecule/molecule, database abbreviation HCl(p)]
- Trace gas profile: BrO - [Unit of measurement - molecule/molecule, database abbreviation BrO(p)].
- Trace gas profile: ClO - [Unit of measurement - molecule/molecule, database abbreviation ClO(p)]
- Trace gas profile: $ClONO_2$ - [Unit of measurement - molecule/molecule, database abbreviation $ClONO_2$(p)]
- Trace gas profile: SO_2 - [Unit of measurement - molecule/molecule, database abbreviation SO_2(p)]
- Cloud imagery - Intended for observation of features (cloud occurrence, pattern, frontal bands, cyclones, volcanic ash plumes,). [Database abbreviation CLDIMG]

- Cloud type - Processed from cloud imagery by assigning identified cluster(s) within a given area to specific cloud type(s). [Unit of measurement - classes, database abbreviation CLDTYP]
- Cloud cover - Fractional extension of each cloud type identified within a given area. [Unit of measurement - %, database abbreviation CLDCVR]
- Cloud ice content (at cloud top) - Fraction of ice within the cloud cover of a specific type. [Unit of measurement - %, database abbreviation CLDICE]
- Cloud top height - Height of the top surface of each cloud type identified within a given area. [Unit of measurement - km, database abbreviation CLDTOPH]
- Cloud top temperature - Temperature of the top surface of each cloud type identified within a given area. [Unit of measurement - K, database abbreviation CLDTOPT]
- Cloud base height - Height of the bottom surface of each cloud type identified within a given area. [Unit of measurement - km, database abbreviation CLDBASH]
- Precipitation rate (liquid) at the surface - Intensity of liquid rain observed on land or water over a short period. [Unit of measurement - mm/h, database abbreviation PRECIPL]
- Precipitation rate (solid) at the surface - Intensity of snowfall or hail observed on land or water over a short period. [Unit of measurement - mm/h, database abbreviation PRECIPS]
- Precipitation index (daily cumulative) - Generic term to indicate a family of indirect methods to infer precipitation. [Unit of measurement - mm/d, database abbreviation PRECIPI]
- Atmospheric stability index - Generic term to indicate a family of methods to infer the temperature difference between an air parcel affected by vertical motion and the surrounding environment. Supportive of temperature profile and specific humidity profile). [Unit of measurement - K, database abbreviation ASI]
- Height of tropopause - Discontinuity between troposphere and stratosphere. [Unit of measurement - km, database abbreviation TROPH]
- Temperature of tropopause - Temperature at the discontinuity between troposphere and stratosphere. [Unit of measurement - K, database abbreviation TROPT]
- Height of the top of the Planetary Boundary Layer- [Unit of measurement - m, database abbreviation PBLTOPH]
- Downwelling solar radiation at TOA - Incoming solar radiation at Top Of Atmosphere. [Unit of measurement - W/m^2, database abbreviation DSRTOA]
- Outgoing short-wave radiation at TOA. - Flux of solar radiation reflected by the Earth system (surface + atmosphere) towards space. [Unit of measurement - W/m^2, database abbreviation OSRTOA]
- Outgoing long-wave radiation at TOA. - Flux of radiation emitted by the Earth system (surface + atmosphere) towards space. [Unit of measurement - W/m^2, database abbreviation OLRTOA]
- Outgoing spectral radiance at TOA – Outgoing radiance at the top of the atmosphere. Expected performances should specify wave band(s) in the comments. [Unit of measurement – $W/m^2/sr/\mu m$, database abbreviation TOARO
- Aerosol (total column) size - Dominant size of the distribution spectrum. [Unit of measurement - µm, database abbreviation AEROSIZ]
- Cloud drop size (at cloud top) - Dominant size of the distribution spectrum. [Unit of measurement - µm, database abbreviation CLDDRPSIZ]
- Cloud optical thickness - [Unit of measurement - dimensionless, database abbreviation CLDOPTH]
- Short-wave cloud reflectance - Fraction of solar radiation reflected back to space, changing with geometry. Expected performances should specify spectral interval(s) in the comments. [Unit of measurement - dimensionless, database abbreviation CLDSWR]
- Long-wave cloud emissivity - Fraction of emitted radiation in respect of a black-body at the same temperature as the cloud top. Varies with wave-length. [Unit of measurement - dimensionless, database abbreviation LWCLDEMISS]
- Downwelling short-wave radiation at the Earth surface - Flux of incoming short wave radiation at the surface. [Unit of measurement - W/m2, dbase abbreviation DSWRSFC]
- Downwelling long-wave radiation at the Earth surface - Flux of incoming long wave radiation at the surface. [Unit of measurement - W/m^2, dbase abbreviation DLWRSFC]

- Short-wave Earth surface bi-directional reflectance - Fraction of solar radiation reaching the surface and reflected back to the atmosphere as a function of geometry and wave length. [Unit of measurement - dimensionless, database abbreviation BDR]
- Outgoing long-wave Earth surface radiation - Flux of emitted radiation from the Earth surface to the atmosphere. [Unit of measurement - W/m^2, database abbreviation OLRSFC]
- Long-wave Earth surface emissivity - Varies with wave-length. [Unit of measurement - dimensionless, database abbreviation LWSFCEMISS]
- Water-leaving spectral radiance – Upwelling radiance from the ocean surface. Expected performances should specify wave band(s) in the comments. [Unit of measurement $W/m^2/sr/\mu m$, database abbreviation WLRO]
- Air pressure over land surface - Conventionally measured at 2 m height. [Unit of measurement - hPa, database abbreviation PSFCL]
- Air pressure over sea surface - Conventionally measured at 2 m height. [Unit of measurement - hPa, database abbreviation PSFCS]
- Air temperature (at surface) - Conventionally measured at 2 m height. [Unit of measurement - K, database abbreviation TSFC]
- Air specific humidity (at surface) - Conventionally measured at 2 m height. [Unit of measurement - g/kg, database abbreviation QSFC]
- Wind speed over land surface (horizontal) - Conventionally measured at 10 m height. [Unit of measurement - m/s, database abbreviation SSFCL]
- Wind speed over sea surface (horizontal) - Conventionally measured at 10 m height. For expected performances and in case the measurement is made at a different height or in case it is corrected to 10m, indicate in the comments the exact height of the instrument as well as whether correction to 10 m has been applied. [Unit of measurement - m/s, database abbreviation SSFCS]
- Wind vector over land surface (horizontal) - Conventionally measured at 10 m height. Accuracy is the modulus of the vector difference between measured and true vectors. [Unit of measurement - m/s, database abbreviation UVSFCL]
- Wind vector over sea surface (horizontal) - Conventionally measured at 10 m height. For expected performances and in case the measurement is made at a different height or in case it is corrected to 10m, indicate in the comments the exact height of the instrument as well as whether correction to 10 m has been applied. Accuracy is the modulus of the vector difference between measured and true vectors. [Unit of measurement - m/s, database abbreviation UVSFCS]
- Sea surface bulk temperature - Temperature measured within the top 10 metres. Expected performances should specify measurement depth in the comments [Unit of measurement - K, database abbreviation SSTB]
- Sea surface skin temperature – Temperature at the atmosphere-ocean interface. Expected performances should specify whether for physical or radiometric temperature. [Unit of measurement – K, database abbreviation SSTS]
- Sub-surface ocean temperature – An ocean temperature or a profile of ocean temperatures below 10 metres. [Unit of measurement – K, database abbreviation SSOT]
- Sub-surface ocean salinity – An ocean salinity of a profile of ocean salinities below 10 metres. [Unit of measurement – psu, database abbreviation SSOS]
- Ocean velocity profile (horizontal component) – Ocean velocity at depth or a profile. Ocean surface currents addressed separately [Unit of measurement – cm/s, database abbreviation – OVP]
- Significant wave height - Average height of the top third highest waves. [Unit of measurement - m, database abbreviation SWH]
- Dominant wave period - Period refers to the most energetic wave. Wavelength is not explicitly addressed. [Unit of measurement - s, database abbreviation DWP]
- Dominant wave direction - Direction refers to the most energetic wave. Wavelength is not explicitly addressed. [Unit of measurement - degrees, database abbreviation DWD]
- Sea level - Actual, local sea level inclusive of mean sea level and perturbations (tides, etc.). [Unit of measurement - cm, database abbreviation LSL]
- Ocean chlorophyll - Indicative of living phytoplankton biomass. Limited to the ocean surface layer. [Unit of measurement - mg/m^3, database abbreviation CHLOROC]

- Ocean suspended sediment concentration - Indicative of river outflow, re-suspension or pollution of other-than-biological origin. Limited to the ocean surface layer. Expected performances should specify measurement bands in the comments. [Unit of measurement - g/m^3, database abbreviation SSOC]
- Ocean yellow substance absorbance - Indicative of biomass undergoing decomposition processes (local or advected). Limited to the ocean surface layer. Comment: Absorption units are m^{-1}, and this is the relevant unit for remote sensing applications. It is generally not possible to convert CDOM absorption to concentration units. [Unit of measurement - m^{-1}, database abbreviation YSOC]
- Ocean salinity - Limited to the ocean surface layer within the top 10 metres. Expected performances should specify measurement depth in the comments. [Unit of measurement - psu (practical salinity units), database abbreviation SALOC]
- Ocean dynamic topography - Ocean dynamic topography is the deviation of sea level from the geoid caused by ocean currents (that is after corrections for tides and atmospheric pressure effects). [Unit of measurement - cm, database abbreviation OCNTOPO]
- Ocean surface currents (vector) – Expected performances should specify measurement depth in the comments. [Unit of measurement - m/s, database abbreviation UVOC]
- Wind stress – The shear force per unit area exerted by wind blowing over the sea surface. [Unit of measurement – Pa, database abbreviation WNDST]
- Sea surface imagery - Generic term reserved for observations of sea surface features (thermal fronts, eddies, internal waves, ...) [Database abbreviation SSIMG]
- Bathimetry - Sea-bottom depths. [Unit of measurement - m, database abbreviation BATHI]
- Sea-ice cover - Fraction of an area covered by sea-ice. [Unit of measurement - %, database abbreviation SICECVR]
- Sea-ice type - Related to age and other factors. [Unit of measurement - classes, database abbreviation SICETYP]
- Sea-ice thickness - As derived from type, elevation and assumptions on ice density. [Unit of measurement - cm, database abbreviation ICETHCK]
- Sea-ice surface temperature - [Unit of measurement - K, database abbreviation SICEST]
- Ice-sheet topography - Ice topography is the map of ice elevations found in the Antarctic and Greenland. [Unit of measurement - cm (in the vertical), database abbreviation ICETOP]
- Sea ice elevation - Used to derive sea ice thickness along with assumptions on ice density. [Unit of measurement - cm, database abbreviation SICEELE]
- Iceberg fractional cover - [Unit of measurement - %, database abbreviation ICEBCVR]
- Iceberg height - [Unit of measurement - m, database abbreviation ICEBHT]
- Snow cover - Fraction of an area covered by snow. [Unit of measurement - %, database abbreviation SNOCVR]
- Snow melting conditions - Fraction of liquid water within the snow cover. Accuracy requirement is limited to number of classes. [Unit of measurement - classes, database abbreviation SNOMELT]
- Snow water equivalent - Total-column water if reduced to liquid. Linked to snow depth through assumptions or observation on density. [Unit of measurement - mm, database abbreviation SNOEQ]
- Glacier cover - Fraction of an area covered by permanent ice. [Unit of measurement - %, database abbreviation GLACVR]
- Glacier motion - Variation of glacier boundary in a specific direction. [Unit of measurement - m/y, database abbreviation GLAMOT]
- Glacier topography - Relates to glacier thickness typically found in mid to high latitudes with a volume/area coverage much smaller than an ice-sheet. [Unit of measurement - cm, database abbreviation GLATOP]
- Permafrost - Fraction of an area covered by persistent (up to one year) frozen soil. [Unit of measurement - %, database abbreviation PFCVR]
- Land surface temperature - [Unit of measurement - K, database abbreviation LST]
- Soil moisture - Fractional content of water in a mass of wet soil. Accuracy is specified as grams of water in a kilogram of wet soil. In this context, it is only referred to surface layer. [Unit of measurement - g/kg, database abbreviation SOILM]

- Normalized Differential Vegetation Index (NDVI) - Normalised difference between maximum (NIR) and minimum (Red) vegetation reflectance. [Unit of measurement - dimensionless, database abbreviation NDVI]
- Leaf Area Index (LAI) - One half of the total projected green leaf fractional area in the plant canopy within a given area. Representative of total biomass and health of vegetation. [Unit of measurement - dimensionless, database abbreviation LAI]
- Photosynthetically Active Radiation (PAR) - Radiation flux in the 400-700 nm spectral range reaching the ground. [Unit of measurement - W/m^2, database abbreviation PAR]
- Fractional Photosynthetically Active Radiation (FPAR) - The fraction of PAR absorbed by vegetation. [Unit of measurement - dimensionless, database abbreviation FPAR]
- Vegetation type - Processed from land surface imagery by assigning identified cluster(s) within a given area to specific vegetation type(s). [Unit of measurement - classes, database abbreviation VEGTYP]
- Fire area - The areal extent of burning. [Unit of measurement - km^2, database abbreviation FIRECVR]
- Fire temperature - The maximum temperature of a fire. [Unit of measurement - K, database abbreviation FIRETEMP]
- Land cover - Processed from land surface imagery by assigning identified cluster(s) within a given area to specific classes of objects. [Unit of measurement - classes, database abbreviation LNDCVR]
- Soil type - Processed from land surface imagery by assigning identified cluster(s) within a given area to soil type(s) of specific physical/chemical properties. [Unit of measurement - classes, database abbreviation SOILTYP]
- Land surface imagery - Generic term reserved for observations of land surface features (alignments, textures, volcanic activities, river basins, erosion, internal waters, ...). [Database abbreviation LNDIMG]
- Coastlines - Location of coastlines. [Unit of measurement – Lat/Long, database abbreviation COAST]
- Land surface topography - Map of land surface heights. [Unit of measurement - m, database abbreviation LNDTOP]
- Geoid - The Earth gravity field equipotential surface at mean sea level. [Unit of measurement - cm, database abbreviation GEOID]
- Gravity field - Significant of lithosphere and mantle features. [Unit of measurement - mGal, database abbreviation GRAVF]
- Gravity gradients - In-situ observation at satellite altitude. Supportive of Gravity field. [Unit of measurement – E (1 E equals 1 mGal/10km), database abbreviation GRAVGRAD]
- Magnetic field (vector) - In-situ observation at satellite altitude. In this context, the long-wave components are addressed, as significant of Earth interior processes and coupling processes between core, mantle, lithosphere and external field. [Unit of measurement - n tesla, database abbreviation MAGV]
- Magnetic field (scalar) - In-situ observation at satellite altitude. In this context, the long-wave components are addressed, as significant of Earth interior processes and coupling processes between core, mantle, lithosphere and external field. [Unit of measurement – n tesla, database abbreviation MAGS]
- Earth rotation - Determining the length of the day and the motion of the pole. Significant of momentum exchanges (core/mantle, solid Earth/ocean, Earth/Moon). The accuracy is specified to detect variations. [Unit of measurement - arcsec/century, database abbreviation EROT]
- Crustal plates positioning - Significant of lithosphere dynamics. [Unit of measurement - cm, database abbreviation CRUSTP]
- Crustal motion (horizontal) - Significant of lithosphere dynamics. Changes in time are indicated in this list whenever their observation constitutes a dominant objective in respect of other (static) characteristics. [Unit of measurement - mm/y, database abbreviation CRUSTMH]
- Crustal motion (vertical) - Significant of lithosphere dynamics. Changes in time are indicated in this list whenever their observation constitutes a dominant objective in respect of other (static) characteristics. [Unit of measurement - mm/y, database abbreviation CRUSTMV]
- Visibility – Horizontal distance at which an object of suitable dimensions can be seen and recognized. [Unit of measurement - m, database abbreviation VIS]

- Lightning detection - The location of air-to-air and air-to-ground lightning strikes. [Unit of measurement – Lat/Long), database abbreviation LITDET]
- Volcanic ash – The location of a volcanic ash cloud. [Unit of measurement – Lat/Long, database abbreviation VOLASH]
- Turbulence – Random and continuously changing air motions which are superposed on the mean motion of the air. [Unit of measurement – classes, database abbreviation TURB]
- Icing – Any deposit or coating of ice on an object caused by the impact of liquid hydrometeors, usually super-cooled. [Unit of measurement – classes, database abbreviation ICING]
