

Manual on Codes

International Codes

Volume I.2

Annex II to the WMO Technical Regulations

Part B – Binary Codes

Part C – Common Features to Binary and Alphanumeric Codes

2019 edition

WEATHER CLIMATE



WMO-No. 306

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WORLD
METEOROLOGICAL
ORGANIZATION

WMO-No. 306

EDITORIAL NOTE

Considering that code forms, regulations, tables and notes in Volume I.2 form the basis for correct encoding/decoding, all these must be abided by regardless of the use of "shall" or "should".

Typefaces employed in this volume therefore do not signify standard or recommended practices, and are used solely for legibility.

Regardless of the above, the standard coding procedures are distinguished by the use of the term "shall" in the English text and by suitable equivalent terms in the French, Russian and Spanish texts in Part C, section d.

WMO-No. 306

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ISBN 978-92-63-10306-2

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PUBLICATION REVISION TRACK RECORD

<i>Date</i>	<i>Part/ chapter/ section</i>	<i>Purpose of amendment</i>	<i>Proposed by</i>	<i>Approved by</i>
2019	Part B, b. List of binary codes; Part C, b. List of table-driven alphanumeric codes, and c. Common code table	Consolidation of amendments	CBS/OPAG-ISS/ IPET-CM	Fast-track procedure in April and October 2019, and procedure for adoption of amendments between CBS sessions in April 2019 (03075/2019/OBS/WIS/DRMM/DRC)

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INTRODUCTION

Volume I of the *Manual on Codes* contains WMO international codes for meteorological data and other geophysical data relating to meteorology; it constitutes Annex II to the *Technical Regulations* (WMO-No. 49) and has therefore the status of a Technical Regulation. It is issued in three volumes: Volume I.1, containing Part A; Volume I.2, containing Part B and Part C; and Volume I.3 containing Part D.

Coded messages are used for the international exchange of meteorological information comprising observational data provided by the World Weather Watch (WWW) Global Observing System and processed data provided by the WWW Global Data-processing and Forecasting System. Coded messages are also used for the international exchange of observed and processed data required in specific applications of meteorology to various human activities and for exchanges of information related to meteorology.

The codes are composed of a set of CODE FORMS and BINARY CODES made up of SYMBOLIC LETTERS (or groups of letters) representing meteorological or, as the case may be, other geophysical elements. In messages, these symbolic letters (or groups of letters) are transcribed into figures indicating the value or the state of the elements described. SPECIFICATIONS have been defined for the various symbolic letters to permit their transcription into figures. In some cases, the specification of the symbolic letter is sufficient to permit a direct transcription into figures. In other cases, it requires the use of CODE FIGURES, the specifications of which are given in CODE TABLES. Furthermore, a certain number of SYMBOLIC WORDS and SYMBOLIC FIGURE GROUPS have been developed for use as code names, code words, symbolic prefixes or indicator groups.

Rules concerning the selection of code forms to be exchanged for international purposes, and the selection of their symbolic words, figure groups and letters, are laid down in the *Technical Regulations* (WMO-No. 49), Volume I, Part II, section 2 (2015 edition, updated in 2017). These code forms are contained in Volume I of the *Manual on Codes*, issued as Volume I.1 – Part A, Volume I.2 – Part B and Part C, and Volume I.3 – Part D.

Apart from these international codes, several sets of *regional codes* exist which are intended only for exchanges within a given WMO Region. These codes are contained in Volume II of the *Manual on Codes*, which also contains descriptions of the following:

- Regional coding procedures for the use of international code forms;
- National coding practices in the use of international or regional codes of which the WMO Secretariat has been informed;
- National code forms.

A number of special codes that are used in messages exchanged over the WWW Global Telecommunication System circuits, and which comprise ice and satellite ephemeris codes, are included in Volume II as an appendix.

VOLUME I.1:

Part A – Alphanumeric Codes consists of five sections. The standard coding procedures are distinguished by the use of the term “shall” in the English text, and by suitable equivalent terms in the French, Russian and Spanish texts. Where national practices do not conform with these regulations, Members concerned shall formally notify the Secretary-General of WMO for the benefit of other Members.

VOLUME I.2:

Part B – Binary Codes consists of the list of binary codes with their specifications and associated code tables. Explanatory notes are sometimes added to regulations.

Part C – Common Features to Binary and Alphanumeric Codes consists of the list of table-driven alphanumeric codes with their specifications and associated code tables, and of common code tables to binary and alphanumeric codes.

The attachments (yellow background) to Volume I.2 do not have the status of WMO Technical Regulations and are given for information only.

This edition of Volume I.2 of the *Manual on Codes* replaces the 2011 edition.

VOLUME I.3:

Part D – Representations derived from data models consists of the specification of the list of standard representations derived from data models, including those using extensible markup language (XML), with their specifications and associated code tables.

GENERAL PROVISIONS

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

Volume I – General meteorological standards and recommended practices

Volume II – Meteorological service for international air navigation

Volume III – Hydrology

Purpose of the Technical Regulations

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

3. These Regulations are designed:

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

Types of Regulations

4. The Technical Regulations comprise *standard* practices and procedures, *recommended* practices and procedures, and references to constants, definitions, formulas and specifications.

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

The *standard* practices and procedures:

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

The *recommended* practices and procedures:

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

References to constants, definitions, formulas and specifications:

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

6. In accordance with the above definitions, Members shall do their utmost to implement the *standard* practices and procedures. In accordance with Article 9 (b) of the Convention and in conformity with Regulation 101 of the General Regulations, Members shall formally notify the Secretary-General, in writing, of their intention to apply the *standard* practices and procedures of the Technical Regulations, except those for which they have lodged a specific deviation. Members shall also inform the Secretary-General, at least three months in advance, of any change in the degree of their implementation of a *standard* practice or procedure as previously notified and the effective date of the change.

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

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

Status of annexes and appendices

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

- I *International Cloud Atlas* (WMO-No. 407) – Manual on the Observation of Clouds and Other Meteors, sections 1, 2.1.1, 2.1.4, 2.1.5, 2.2.2, 1 to 4 in 2.3.1 to 2.3.10 (for example, 2.3.1.1, 2.3.1.2, etc.), 2.8.2, 2.8.3, 2.8.5, 3.1 and the definitions (in grey-shaded boxes) of 3.2;
- II *Manual on Codes* (WMO-No. 306), Volume I;
- III *Manual on the Global Telecommunication System* (WMO-No. 386);
- IV *Manual on the Global Data-processing and Forecasting System* (WMO-No. 485);
- VI *Manual on Marine Meteorological Services* (WMO-No. 558), Volume I;
- VII *Manual on the WMO Information System* (WMO-No. 1060);
- VIII *Manual on the WMO Integrated Global Observing System* (WMO-No. 1160).
- IX *Manual on the High-quality Global Data Management Framework for Climate* (WMO-No. 1238).

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

Status of notes and attachments

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

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

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

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

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

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

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

16. If a recommendation for an amendment is made by the appropriate technical commission and the implementation of the new regulation is urgent, the President of the Organization may, on behalf of the Executive Council, take action as provided by Regulation 8 (5) of the General Regulations.

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

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

Note: Editions are identified by the year of the respective session of Congress whereas updates are identified by the year of approval by the Executive Council, for example "Updated in 2018".

WMO Guides

18. In addition to the *Technical Regulations*, appropriate Guides are published by the Organization. They describe practices, procedures and specifications which Members are invited to follow or implement in establishing and conducting their arrangements for compliance with the Technical Regulations, and in otherwise developing meteorological and hydrological services in their respective countries. The Guides are updated, as necessary, in the light of scientific and technological developments in hydrometeorology, climatology and their applications. The technical commissions are responsible for the selection of material to be included in the Guides. These Guides and their subsequent amendments shall be considered by the Executive Council.

APPENDIX. PROCEDURES FOR AMENDING WMO MANUALS AND GUIDES THAT ARE THE RESPONSIBILITY OF THE COMMISSION FOR BASIC SYSTEMS

1. DESIGNATION OF RESPONSIBLE COMMITTEES

The Commission for Basic Systems (CBS) shall, for each Manual and Guide, designate one of its Open Programme Area Groups (OPAGs) as being responsible for that Manual and its associated technical guides. The Open Programme Area Group may choose to designate one of its Expert Teams as the designated committee for managing changes to all or part of that Manual; if no Expert Team is designated, the Implementation Coordination Team for the OPAG takes on the role of the designated committee.

2. GENERAL VALIDATION AND IMPLEMENTATION PROCEDURES

2.1 Proposal of amendments

Amendments to a Manual or a Guide managed by CBS shall be proposed in writing to the Secretariat. The proposal shall specify the needs, purposes and requirements and include information on a contact point for technical matters.

2.2 Drafting recommendation

The designated committee for the relevant part of a Manual or a Guide, supported by the Secretariat, shall validate the stated requirement (unless it is consequential to an amendment to the WMO Technical Regulations) and develop a draft recommendation to respond to the requirement, as appropriate.

2.3 Procedures for approval

After a draft recommendation of the designated committee is validated in accordance with the procedure given in section 7 below, depending on the type of amendments, the designated committee should select one of the following procedures for the approval of the amendments:

- (a) Simple (fast-track) procedure (see section 3 below);
- (b) Standard (adoption of amendments between CBS sessions) procedure (see section 4 below);
- (c) Complex (adoption of amendments during CBS sessions) procedure (see section 5 below).

2.4 Date of implementation

The designated committee should define an implementation date in order to give WMO Members sufficient time to implement the amendments after the date of notification. For procedures other than the simple (fast-track) one, if the time between the date of notification and implementation date is less than six months, the designated committee shall document the reasons for its decision.

2.5 Urgent introduction

Regardless of the above procedures, as an exceptional measure, the following procedure accommodates urgent user needs to introduce elements in lists of technical details, or to correct errors:

- (a) A draft recommendation developed by the designated committee shall be validated according to the steps defined in section 7 below;

- (b) The draft recommendation for pre-operational use of a list entry, which can be used in operational data and products, shall be approved by the chair of the designated committee and the chair of the responsible OPAG, and the president of CBS. A listing of pre-operational list entries is kept online on the WMO web server;
- (c) Pre-operational list entries shall then be submitted for approval by one of the procedures in 2.3 above for operational use;
- (d) Any version numbers associated with the technical implementation should be incremented at the least significant level.

2.6 Issuing updated version

Once amendments to a Manual or a Guide are adopted, an updated version of the relevant part of the Manual shall be issued in the languages agreed for its publication. The Secretariat shall inform all Members of the availability of a new updated version of that part at the date of notification mentioned in 2.4 above. If amendments are not incorporated into the published text of the relevant Manual or Guide at the time of the amendment, there should be a mechanism to publish the amendments at the time of their implementation and to retain a permanent record of the sequence of amendments.

3. SIMPLE (FAST-TRACK) PROCEDURE

3.1 Scope

The simple (fast-track) procedure shall be used only for changes to components of the Manual that have been designated and marked as “technical specifications to which the simple (fast-track) procedure for the approval of amendments may be applied”.

Note: An example would be the addition of code list items in the *Manual on Codes* (WMO-No. 306).

3.2 Endorsement

Draft recommendations developed by the responsible committee, including a date for implementation of the amendments, shall be submitted to the chair of the relevant OPAG for endorsement.

3.3 Approval

3.3.1 Minor adjustments

Correcting typographical errors in descriptive text is considered a minor adjustment, and will be done by the Secretariat in consultation with the president of CBS. See Figure 1.

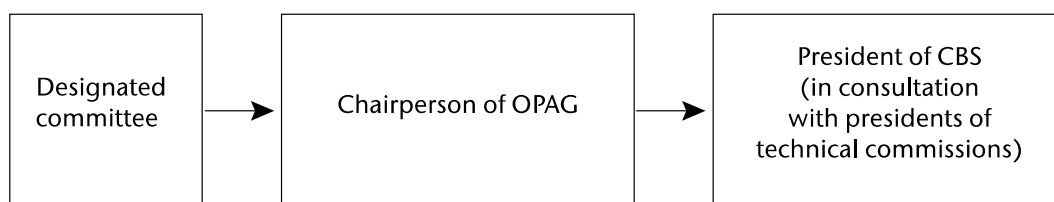


Figure 1. Adoption of amendments to a Manual by minor adjustment

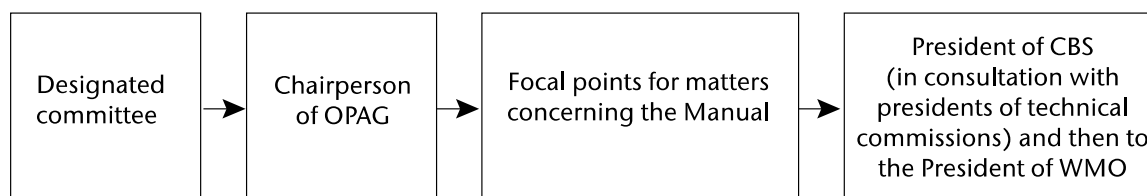


Figure 2. Adoption of amendments to a Manual by simple (fast-track) procedure

3.3.2 *Other types of amendments*

For other types of amendments, the English version of the draft recommendation, including a date of implementation, should be distributed to the focal points for matters concerning the relevant Manual for comments, with a deadline of two months for the reply. It should then be submitted to the president of CBS for consultation with presidents of technical commissions affected by the change. If endorsed by the president of CBS, the change should be passed to the President of WMO for consideration and adoption on behalf of the Executive Council (EC).

3.3.3 *Frequency*

The implementation of amendments approved through the simple (fast-track) procedure can be twice a year in May and November. See Figure 2.

4. **STANDARD (ADOPTION OF AMENDMENTS BETWEEN CBS SESSIONS) PROCEDURE**

4.1 **Scope**

The standard (adoption of amendments between CBS sessions) procedure shall be used for changes that have an operational impact on those Members who do not wish to exploit the change, but that have only minor financial impact, or that are required to implement changes in the *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation.

4.2 **Approval of draft recommendations**

For the direct adoption of amendments between CBS sessions, the draft recommendation developed by the designated committee, including a date of implementation of the amendments, shall be submitted to the chair of the responsible OPAG and president and vice-president of CBS for approval. The president of CBS shall consult with the presidents of technical commissions affected by the change. In the case of recommendations in response to changes in the *Technical Regulations* (WMO-No. 49), Volume II – Meteorological Service for International Air Navigation, the president of CBS shall consult with the president of the Commission for Aeronautical Meteorology.

4.3 **Circulation to Members**

Upon approval of the president of CBS, the Secretariat sends the recommendation to all Members, in the languages in which the Manual is published, including a date of implementation of the amendments, for comments to be submitted within two months following the dispatch of the amendments. If the recommendation is sent to Members via electronic mail, there shall be public announcement of the amendment process including dates, for example by WMO Operational Newsletter on the WMO website, to ensure all relevant Members are informed.

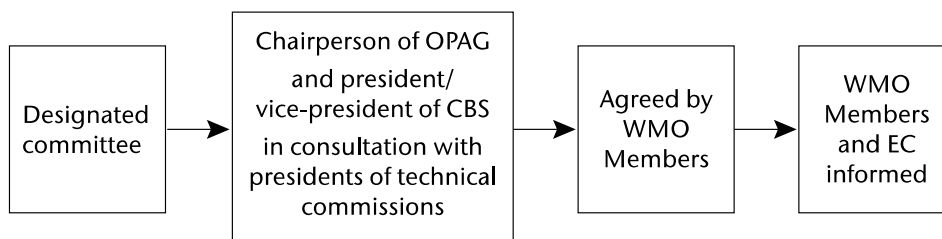


Figure 3. Adoption of between CBS sessions

4.4 Agreement

Those Members not having replied within the two months following the dispatch of the amendments are implicitly considered as having agreed with the amendments.

4.5 Coordination

Members are invited to designate a focal point responsible to discuss any comments/disagreements with the designated committee. If the discussion between the designated committee and the focal point cannot result in an agreement on a specific amendment by a Member, this amendment will be reconsidered by the designated committee. If a Member cannot agree that the financial or operational impact is minor, the redrafted amendment shall be approved by the complex (adoption of amendments during CBS sessions) procedure described in section 5 below.

4.6 Notification

Once amendments are agreed by Members, and after consultation with the chair of the responsible OPAG, the vice-president of CBS and the president of CBS (who should consult with presidents of other commissions affected by the change), the Secretariat notifies at the same time the Members and the members of the Executive Council of the approved amendments and of the date of their implementation. See Figure 3.

5. COMPLEX (ADOPTION OF AMENDMENTS DURING CBS SESSIONS) PROCEDURE

5.1 Scope

The complex (adoption of amendments during CBS sessions) procedure shall be used for changes for which the simple (fast-track) procedure or standard (adoption of amendments between CBS sessions) procedure cannot be applied.

5.2 Procedure

For the adoption of amendments during CBS sessions, the designated committee submits its recommendation, including a date of implementation of the amendments, to the Implementation Coordination Team of the responsible Open Programme Area Group. The recommendation is then passed to the presidents of technical commissions affected by the change for consultation, and to a CBS session that shall be invited to consider comments submitted by presidents of technical commissions. The document for the CBS session shall be distributed not later than 45 days before the opening of the session. Following the CBS session, the recommendation shall then be submitted to a session of the Executive Council for decision. See Figure 4.

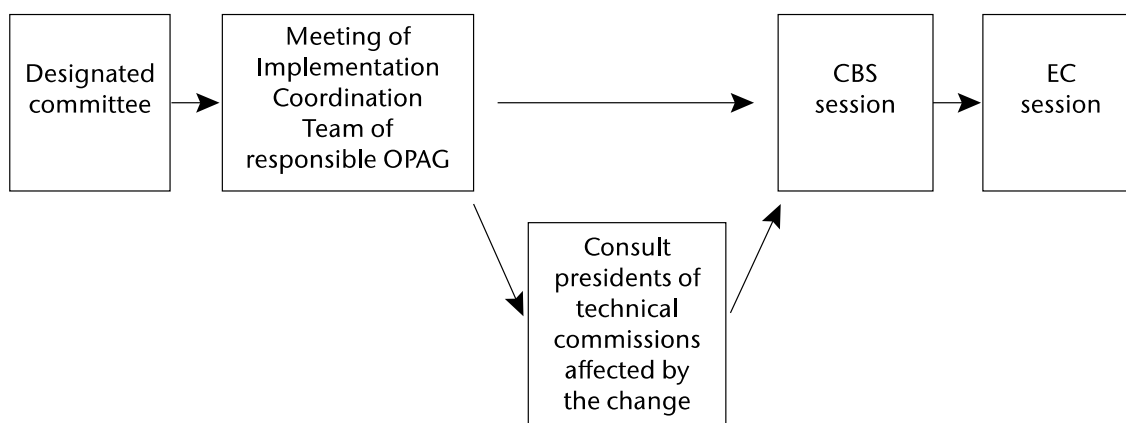


Figure 4. Adoption of amendments during CBS sessions

6. PROCEDURE FOR THE CORRECTION OF EXISTING MANUAL CONTENTS

6.1 Correcting errors in items within Manuals

Where a minor error in the specification of an item that defines elements within a Manual is found, for example, a typing error or an incomplete definition, the item shall be amended and re-published. Any version numbers associated with items edited as a result of the change should be incremented at their lowest level of significance. If, however, the change has an impact on the meaning of the item, then a new item should be created and the existing (erroneous) item marked as deprecated. This situation is considered a minor adjustment according to 3.3.1 above.

Note: An example of an item for which this type of change applies is a code list entry for the Table Driven Code Forms or WMO Core Metadata Profile, in which the description contains typographical errors that can be corrected without changing the meaning of the description.

6.2 Correcting an error in the specification of how conformance with the requirements of the Manual can be checked

If an erroneous specification of a conformance-checking rule is found, the preferred approach is to add a new specification using the simple (fast-track) procedure or standard (adoption of amendments between CBS sessions) procedure approach. The new conformance-checking rule should be used instead of the old. An appropriate explanation shall be added to the description of the conformance-checking rule to clarify the practice along with the date of the change.

Note: An example of such a change would be correcting a conformance-checking rule in the WMO Core Metadata Profile.

6.3 Submission of corrections to errors

Such changes shall be submitted through the simple (fast-track) procedure.

7. VALIDATION PROCEDURE

7.1 Documentation of need and purpose

The need for, and the purpose of, the proposal for changes should be documented.

7.2 Documentation of result

This documentation shall include the results of validation testing of the proposal as described in 7.3 below.

7.3 Testing with relevant applications

For changes that have an impact on automated processing systems, the extent of the testing required before validation should be decided by the designated committee on a case-by-case basis, depending on the nature of the change. Changes involving a relatively high risk and/or impact on the systems should be tested by the use of at least two independently developed tool sets and two independent centres. In that case, results should be made available to the designated committee with a view to verifying the technical specifications.

DEFINITIONS

Actual time of observation.

- (1) In the case of a surface synoptic observation, the time at which the barometer is read.
- (2) In the case of upper-air observations, the time at which the balloon, parachute or rocket is actually released.

All-components schema document. An XML schema document that includes, either directly, or indirectly, all the components defined and declared in a namespace.

Alpine glow. Pink or yellow colouring assumed by mountain tops opposite the Sun when it is only just below the horizon before it rises and after it sets. This phenomenon vanishes after a brief interval of blue colouring, when the Earth's shadow reaches these summits.

Anomalous propagation. Propagation of radio energy in abnormal conditions of vertical distribution of refractive index, in association with abnormal distribution of atmospheric temperature and humidity. Use of the term is mainly confined to conditions in which abnormally large distances of propagation are attained.

Application schema. A conceptual schema for data required by one or more applications. (Source: International Organization for Standardization (ISO) 19101:2002, definition 4.2)

Atmospheric – Sferic. Electromagnetic wave resulting from an electric discharge (lightning) in the atmosphere.

Automatic station. Meteorological station at which instruments make and transmit observations, the conversion to code form for international exchange being made either directly or at an editing station.

Aviation routine weather report. A statement of the observed meteorological conditions related to a specified time and location, issued on a routine basis for use in international air navigation.

BUFR – Binary universal form for the representation of meteorological data. BUFR is the name of a binary code for the exchange and storage of data.

BUFR message. A single complete BUFR entity.

Category. The lists of sequence descriptors tabulated in BUFR or CREX Table D are categorized according to their application; categories are provided for non-meteorological sequences, for various types of meteorological sequences, and for sequences which define reports, or major subsets of reports.

Class. A set of elements tabulated together in BUFR/CREX Table B.

Condensation trails (contrails). Clouds which form in the wake of an aircraft when the atmosphere at flying level is sufficiently cold and humid.

Coordinate class. Classes 0–9 inclusive in BUFR/CREX Table B define elements which assist in the definition of elements from subsequent classes; each of these classes is referred to as a coordinate class.

CREX – *Character form for the representation and exchange of data*. CREX is the name of a table-driven alphanumeric code for the exchange and storage of data.

Data description operator. Operators which define replication or the operations listed in BUFR or CREX Table C.

Data entity. A single data item.

Data subset. A set of data corresponding to the data description in a BUFR or CREX message; for observational data, a data subset usually corresponds to one observation.

Day darkness. Sky covered with clouds with very strong optical thickness (dark clouds) having a threatening appearance.

Descriptor. An entity entered within the Data description section to describe or define data; a descriptor may take the form of an element descriptor, a replication operator, an operator descriptor, or a sequence descriptor.

Dry thunderstorm. A thunderstorm without precipitation reaching the ground (distinct from a nearby thunderstorm with precipitation reaching the ground but not at the station at the time of observation).

Dust wall or sand wall. Front of a duststorm or sandstorm, having the appearance of a gigantic high wall which moves more or less rapidly.

Element descriptor. A descriptor containing a code figure reference to BUFR/CREX Table B; the referenced entry defines an element, together with the units, scale factor, reference value and data width to be used to represent that element as data.

Equatorial region. For the purpose of the analysis codes, the region between 30 °N and 30 °S latitudes.

Extensible markup language (XML). A markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. It is defined in the World Wide Web Consortium (W3C) [XML 1.0 Specification](#).

Geography markup language (GML). An XML encoding in compliance with ISO 19118 for the transport and storage of geographic information modelled in accordance with the conceptual modelling framework used in the ISO 19100 series of International Standards and including both the spatial and non-spatial properties of geographic features.

Geometric altitude. Vertical distance (Z) of a level, a point or an object considered as a point, measured from mean sea level.

Geopotential. That potential with which the Earth's gravitational field is associated. It is equivalent to the potential energy of unit mass relative to a standard level (mean sea level by convention) and is numerically equal to the work which would be done against gravity in raising the unit mass from sea level to the level at which the mass is located.

Geopotential ϕ at geometric height z is given by

$$\phi = \int_0^z g dz$$

where g is the acceleration of gravity.

Geopotential height. Height of a point in the atmosphere expressed in units (geopotential metres) proportional to $g/9.8$ the geopotential at that height. Geopotential height expressed in geopotential metres is approximately equal to times the geometric height expressed in (geometric) metres, g being the local acceleration of gravity.

GML application schema. An application schema written in XML schema in accordance with the rules specified in ISO 19136:2007.

GML document. An XML document with a root element that is one of the XML elements AbstractFeature, Dictionary or TopoComplex specified in the GML schema or any element of a substitution group of any of these XML elements.

GML schema. The XML schema components in the XML namespace <http://www.opengis.net/gml/3.2> as specified in ISO 19136:2007.

Haboob. A strong wind and duststorm or sandstorm in northern and central Sudan. Its average duration is three hours; the average maximum wind velocity is over 15 m s^{-1} . The dust or sand forms a dense whirling wall which may be 1 000 m high; it is often preceded by isolated dust whirls. Haboobs usually occur after a few days of rising temperature and falling pressure.

Ice crust (ice slick).

(1) A type of snow crust; a layer of ice, thicker than a film crust, upon a snow surface. It is formed by the freezing of melt water or rainwater which has flowed into it.

(2) See *Ice rind*.

Ice rind. A thin but hard layer of sea ice, river ice or lake ice. Apparently this term is used in at least two ways: (a) for a new encrustation upon old ice; and (b) for a single layer of ice usually found in bays and fjords where freshwater freezes on top of slightly colder sea water.

Instrumental wave data. Data on measured characteristics relating to period and height of the wave motion of the sea surface.

Inversion (layer). Atmospheric layer, horizontal or approximately so, in which the temperature increases with increasing height.

Isothermal layer. Atmospheric layer through which there is no change of temperature with height.

Jet stream. Flat tubular current of air, quasi-horizontal, whose axis is along a line of maximum speed and which is characterized not only by great speeds but also by strong transverse gradients of speed.

Line squall. Squall which occurs along a squall line.

Lithometeor. Meteor consisting of an ensemble of particles most of which are solid and non-aqueous. The particles are more or less suspended in the air, or lifted by the wind from the ground.

Mountain waves. Oscillatory motions of the atmosphere induced by flow over a mountain; such waves are formed over and to the lee of the mountain or mountain chain.

Namespace. A collection of names, identified by a uniform resource identifier reference, which are used in XML documents as element names and attribute names.

Normals. Period averages computed for over a uniform and relatively long period comprising at least three consecutive 10-year periods.

Obscured sky. Occasions of hydrometeors or lithometeors which are so dense as to make it impossible to tell whether there is cloud above or not.

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 subsurface observations.

Operator descriptor. A descriptor containing a code figure reference to BUFR or CREX Table C, together with data to be used as an operand.

Past weather. Predominant characteristic of weather which had existed at the station during a given period of time.

Persistent condensation trail. Long-lived condensation trails which have spread to form clouds having the appearance of cirrus or patches of cirrocumulus or cirrostratus. It is sometimes impossible to distinguish such clouds from other cirrus, cirrocumulus or cirrostratus.

Present weather. Weather existing at the time of observation, or under certain conditions, during the hour preceding the time of observation.

Prevailing visibility. The greatest visibility value, observed in accordance with the definition of "visibility", which is reached within at least half the horizon circle or within at least half of the surface of the aerodrome. These areas could comprise contiguous or non-contiguous sectors.

Note: This value may be assessed by human observation and/or instrumented systems. When instruments are installed, they are used to obtain the best estimate of the prevailing visibility.

Purple light. Glow with a hue varying between pink and red, which is to be seen in the direction of the Sun before it rises and after it sets and is about 3° to 6° below the horizon. It takes the form of a segment of a more or less large luminous disc which appears above the horizon.

Reference value. All data are represented within a BUFR or CREX message by positive integers; to enable negative values to be represented, suitable negative base values are specified as reference values. The true value is obtained by addition of the reference value and the data as represented.

Replication descriptor. A special descriptor is reserved to define the replication operation; it is used to enable a given number of subsequent descriptors to be replicated a given number of times.

Root element. Each XML document has exactly one root element. This element, also known as the document element, encloses all the other elements and is therefore the sole parent element to all the other elements. The root element provides the starting point for processing the document.

Runway visual range. The range over which the pilot of an aircraft on the centre line of the runway can see the runway markings or the lights delineating the runway or identifying its centre line.

Schematron. A definition language for making assertions about patterns found in XML documents, differing in basic concept from other schema languages in that it is not based on grammars but on finding patterns in the parsed document.

Sea station. An observing station situated at sea. Sea stations include ships, ocean weather stations and stations on fixed or drifting platforms (rigs, platforms, lightships and buoys).

Section. A logical subdivision of a BUFR or CREX message, to aid description and definition.

Sequence descriptor. A descriptor used as a code figure to reference a single entry in BUFR or CREX Table D; the referenced entry contains a list of descriptors to be substituted for the sequence descriptor.

Severe line squall. Severe squall which occurs along squall line (see *Line squall*).

Snow haze. A suspension in the air of numerous minute snow particles, considerably reducing the visibility at the Earth's surface (visibility in snow haze often decreases to 50 m). Snow haze is observed most frequently in Arctic regions, before or after a snowstorm.

Squall. Atmospheric phenomenon characterized by a very large variation of wind speed: it begins suddenly, has a duration of the order of minutes and decreases rather suddenly in speed. It is often accompanied by a shower or thunderstorm.

Squall line. Fictitious moving line, sometimes of considerable extent, along which squall phenomena occur.

Sun pillar. Pillar of white light, which may or may not be continuous, which may be observed vertically above or below the sun. Sun pillars are most frequently observed near sunrise or sunset; they may extend to about 20° above the Sun, and generally end in a point. When a sun pillar appears together with a well-developed parhelic circle, a sun cross may appear at their intersection.

Synoptic hour. Hour, expressed in terms of universal time coordinated (UTC), at which, by international agreement, meteorological observations are made simultaneously throughout the globe.

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

Synoptic surface observation. Synoptic observation, other than an upper-air observation, made by an observer or an automatic weather station on the Earth's surface.

Template. Description of the standardized layout of a set of data entities.

Tropical (Tropic). Pertaining to that region of the Earth's surface lying between the Tropic of Cancer and Tropic of Capricorn at 23° 30' N and S, respectively.

Tropical cyclone. Cyclone of tropical origin of small diameter (some hundreds of kilometres) with minimum surface pressure in some cases less than 900 hPa, very violent winds and torrential rain; sometimes accompanied by thunderstorms. It usually contains a central region, known as the "eye" of the storm, with a diameter of the order of some tens of kilometres, and with light winds and more or less lightly clouded sky.

Tropical revolving storm. Tropical cyclone.

Tropopause.

- (1) Upper limit of the troposphere. By convention, the "first tropopause" is defined as the lowest level at which the lapse rate decreases to 2 °C km⁻¹ or less, provided also the average lapse rate between this level and all higher levels within 2 km does not exceed 2 °C km⁻¹.

- (2) If, above the first tropopause, the average lapse rate between any level and all higher levels within 1 km exceeds $3\text{ }^{\circ}\text{C km}^{-1}$, then a “second tropopause” is defined by the same criterion as under (1). This second tropopause may be either within or above the 1-km layer.

Twilight glow. See *Purple light*.

Twilight glow in the mountains (Alpenglühen). See *Alpine glow*.

Uniform resource identifier (URI). A compact sequence of characters that identifies an abstract or physical resource. URI syntax is defined in the Internet Engineering Task Force (IETF) RFC 3986.

Unit of geopotential (H_m). 1 standard geopotential metre = 0.980 665 dynamic metre

$$H_m = \frac{1}{9.80665} \int_{\sigma}^z g(z) dz$$

where $g(z)$ = acceleration of gravity, in m s^{-2} , as a function of geometric height;

z = geometric height, in metres;

H_m = geopotential, in geopotential metres.

Vertical visibility. Maximum distance at which an observer can see and identify an object on the same vertical as himself, above or below.

Visibility (for aeronautical purposes). Visibility for aeronautical purposes is the greater of:

- (a) The greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognized when observed against a bright background;
- (b) The greatest distance at which lights in the vicinity of 1 000 candelas can be seen and identified against an unlit background.

Note: The two distances have different values in air of a given extinction coefficient, and the latter (b) varies with the background illumination. The former (a) is represented by the meteorological optical range (MOR).

Whiteout. Uniformly white appearance of the landscape when the ground is snow covered and the sky is uniformly covered with clouds. An atmospheric optical phenomenon of the polar regions in which the observer appears to be engulfed in a uniformly white glow. Neither shadows, horizon, nor clouds are discernible; sense of depth and orientation are lost; only very dark, nearby objects can be seen. Whiteout occurs over an unbroken snow cover and beneath a uniformly overcast sky, when, with the aid of the snowblink effect, the light from the sky is about equal to that from the snow surface. Blowing snow may be an additional cause. The phenomenon is experienced in the air as well as on the ground.

Wind (mean wind, spot wind). Air motion relative to the Earth's surface. Unless it is otherwise specified, only the horizontal component is considered.

- (1) *Mean wind:* For the purpose of upper air reports from aircraft, mean wind is derived from the drift of the aircraft when flying from one fixed point to another or obtained by flying on a circuit around a fixed observed point and an immediate wind deduced from the drift of the aircraft.
- (2) *Spot wind:* For the purpose of upper-air reports from aircraft, the wind velocity, observed or predicted, for a specified location, height and time.

XML attribute. A start tag delimiting an XML element may contain one or more attributes. Attributes are Name-Value pairs, with the Name in each pair referred to as the attribute name and the Value (the text between the quote delimiters, that is, ' or ") as the attribute value. The order of attribute specifications in a start-tag or empty-element tag is not significant.

XML document. A structured document conforming to the rules specified in Extensible Markup Language (XML) 1.0 (Second Edition).

XML element. Each XML document contains one or more elements, the boundaries of which are either delimited by start-tags and end-tags, or, for empty elements, by an empty-element tag. Each element has a type, identified by name, sometimes called its generic identifier (GI), and may have a set of attribute specifications. An XML element may contain other XML elements, XML attributes or character data.

XML schema. A definition language offering facilities for describing the structure and constraining the contents of XML documents. The set of definitions for describing a particular XML document structure and associated constraints is referred to as an XML schema document.

XML schema document (XSD). An XML document containing XML schema component definitions and declarations.

Zodiacal light. White or yellowish light which spreads out, in the night sky, more or less along the zodiac from the horizon on the side on which the Sun is hidden. It is observed when the sky is sufficiently dark and the atmosphere sufficiently clear.

PART B

BINARY CODES

- a. FM system of numbering binary codes**
- b. List of binary codes with their specifications and associated code tables**

FM 92 GRIB

Attachment I: Definition of a triangular grid based on an icosahedron

Attachment II: Arakawa grids

Attachment III: Distribution functions in GRIB

Attachment IV: Definition of "tiles" with time-dependent attributes

FM 94 BUFR

Attachment: Definition of FM 94 BUFR using Backus-Naur Form

a. FM SYSTEM OF NUMBERING BINARY CODES

Each binary code bears a number, preceded by the letters FM. This number is followed by a Roman numeral to identify the session of CBS which either approved the binary code as a new one or made the latest amendment to its previous version. A binary code approved or amended by correspondence after a session of CBS receives the number of that session.

Furthermore, an indicator term is used to designate the binary code colloquially and is therefore called a “code name”.

Notes on nomenclature:

- (a) Changes and augmentations to the structure of the GRIB data representation shall be identified as different “GRIB edition numbers”. The current edition number is 2.

Changes to the content of any of the tables, including the grid definitions, shall be identified as different “table versions”. Previous tables were Version 23; the version described in this edition is “Tables Version 24”. Further GRIB editions and table versions may be generated independently of one another in the future as requirements dictate;

- (b) Changes and augmentations to the structure of the BUFR data representation shall be identified as different “BUFR edition numbers”. The current edition number is 4.

Changes to the content of the parameter Tables A, B, C and D shall be identified as different “table versions”. The previous tables were Version 32; the changes described in this edition will become “Tables A, B, C and D, Version 33”. Further BUFR editions and table versions may be generated independently of one another in the future as requirements dictate.

The FM system of numbering the binary codes, together with the corresponding code names and their reference list of CBS approved decision, is the following:

FM SYSTEM OF BINARY CODES

FM 92–XIV GRIB

General regularly distributed information in binary form

Res. 4 (EC-LIII), Rec. 9 (CBS-01), approved by the President of WMO, Res. 8 (EC-LV), Res. 2 (EC-LVII), Res. 10 (EC-LIX), Res. 7 (EC-LXI) and adoption between CBS sessions (2010, 2012, 2013 and 2014)

FM 94–XIV BUFR

Binary universal form for the representation of meteorological data

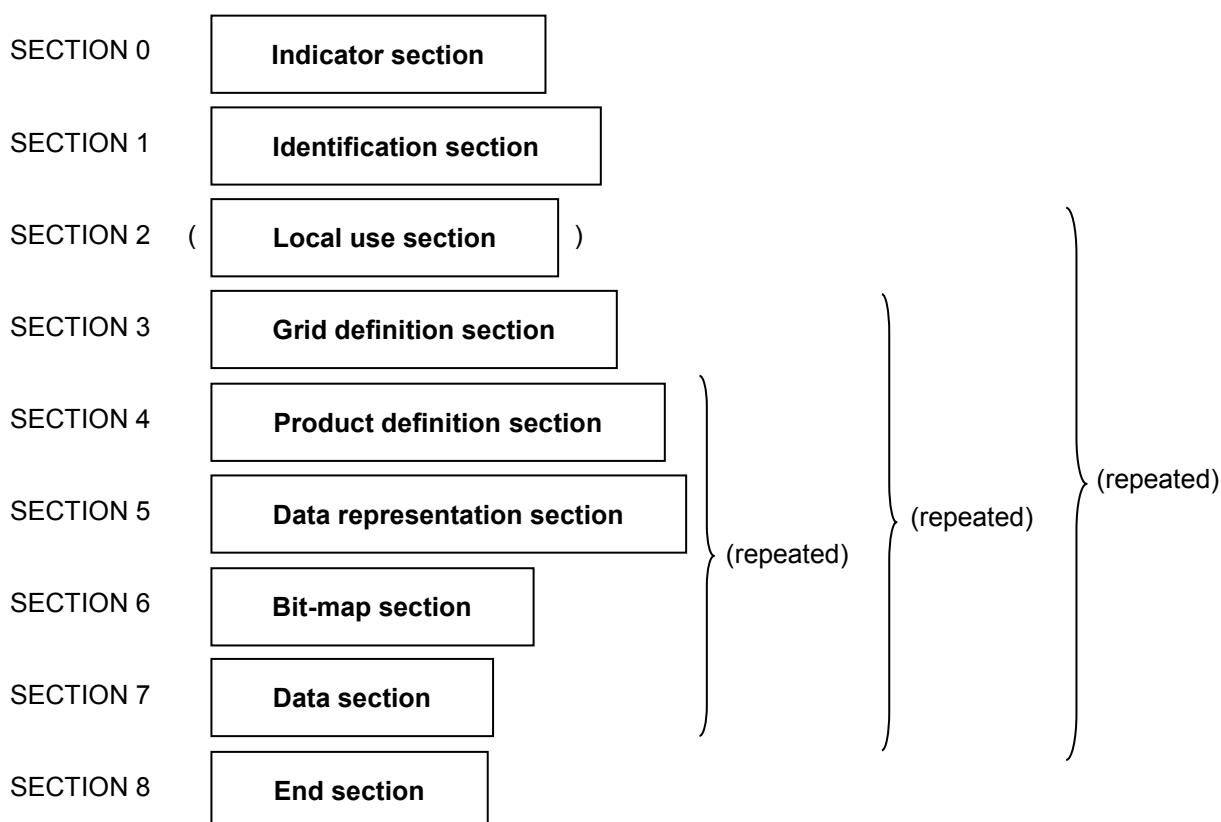
Res. 1 (EC-XL), Rec. 23 (CBS-89), approved by the President of WMO, Rec. 22 (CBS-91), approved by the President of WMO, Rec. 15 (CBS-93), approved by the President of WMO, Rec. 16 (CBS-94), approved by the President of WMO, Res. 4 (EC-XLVII), Rec. 14 (CBS-95), approved by the President of WMO, Rec. 15 (CBS-96), approved by the President of WMO, Res. 4 (EC-XLIX), Rec. 9 (CBS-97), approved by the President of WMO, Rec. 10 (CBS-98), approved by the President of WMO, Res. 8 (EC-LI), Rec. 8 (CBS-99), Rec. 9 (CBS-00), approved by the President of WMO, Res. 4 (EC-LIII), Rec. 9 (CBS-01), approved by the President of WMO, Res. 8 (EC-LV), Res. 2 (EC-LVII), Res. 10 (EC-LIX), Res. 7 (EC-LXI), and adoption between CBS sessions (2010, 2012 and 2013)

b. LIST OF BINARY CODES WITH THEIR SPECIFICATIONS AND ASSOCIATED CODE TABLES

FM 92–XIV GRIB

General regularly distributed information in binary form

CODE FORM :



Notes:

- (1) GRIB is the name of a data representation form for general regularly distributed information in binary.
- (2) Data encoded in GRIB consists of a continuous bit-stream made of a sequence of octets (1 octet = 8 bits).
- (3) The octets of a GRIB message are grouped in sections:

<i>Section number</i>	<i>Name</i>	<i>Contents</i>
0	Indicator section	"GRIB", discipline, GRIB edition number, length of message
1	Identification section	Length of section, section number, characteristics that apply to all processed data in the GRIB message
2	Local use section (optional)	Length of section, section number, additional items for local use by originating centres
3	Grid definition section	Length of section, section number, definition of grid surface and geometry of data values within the surface
4	Product definition section	Length of section, section number, description of the nature of the data
5	Data representation section	Length of section, section number, description of how the data values are represented
6	Bit-map section	Length of section, section number, indication of presence or absence

FM 92 GRIB

		of data at each of the grid points, as applicable
7	Data section	Length of section, section number, data values
8	End section	"7777"

- (4) Sequences of GRIB sections 2 to 7, sections 3 to 7 or sections 4 to 7 may be repeated within a single GRIB message. All sections within such repeated sequences must be present and shall appear in the numerical order noted above. Unrepeated sections remain in effect until redefined.
- (5) It will be noted that the GRIB code is not suitable for visual data recognition without computer interpretation.
- (6) The representation of data by means of a series of bits is independent of any particular machine representation.
- (7) Message and section lengths are expressed in octets. Octets are numbered 1, 2, 3, etc., starting at the beginning of each section. Therefore, octet numbers in a template refer to the respective section.
- (8) Bit positions within octets are referred to as bit 1 to bit 8, where bit 1 is the most significant and bit 8 is the least significant. Thus, an octet with only bit 8 set to 1 would have the integer value 1.
- (9) As used in "GRIB", "International Alphabet No. 5" is regarded as an 8-bit alphabet with bit 1 set to zero.
- (10) The IEEE single precision floating point representation is specified in the standard ISO/IEC 559-1985 and ANSI/IEEE 754-1985 (R1991), which should be consulted for more details. The representation occupies four octets and is:

seeeeeee emmmmmmm mmmmmmmmm mmmmmmmmm

where:

s is the sign bit, 0 means positive, 1 negative

e...e is an 8 bit biased exponent

m...m is the mantissa, with the first bit deleted.

The value of the number is given by the following table:

e...e	m...m	Value of number
0	Any	$(-1)^s (m...m)2^{-23}2^{-126} = (-1)^s (m...m)2^{-149}$
1...254	Any	$(-1)^s (1.0 + (m...m)2^{-23})2^{(e...e)-127}$
255	0	Positive (s=0) or Negative (s=1) infinity
255	>0	NaN (Not a valid Number, result of illegal operation)

Normally, only biased exponent values from 1 through 254 inclusive are used, except for positive or negative zero which is represented by setting both the biased exponent and the mantissa to 0.

The numbers are stored with the high-order octet first. The sign bit will be the first bit of the first octet. The low-order bit of the mantissa will be the last (eighth) bit of the fourth octet.

This floating point representation has been chosen because it is in common use in modern computer hardware. Some computers use this representation with the order of the octets reversed. They will have to convert the representation, either by reversing the octets or by computing the floating point value directly using the above formulas.

REGULATIONS:**92.1 General**

- 92.1.1 The GRIB code shall be used for the exchange and storage of general regularly distributed information expressed in binary form.
- 92.1.2 The beginning and the end of the code shall be identified by 4 octets coded according to the International Alphabet No. 5 to represent the indicators "GRIB" and "7777" in Indicator section 0 and End section 8, respectively. All other octets included in the code shall represent data in binary form.
- 92.1.3 Each section included in the code shall always end on an octet boundary. This rule shall be applied by appending bits set to zero to the section, where necessary.
- 92.1.4 All bits set to "1" for any value indicates that value is missing. This rule shall not apply to packed data.
- 92.1.5 If applicable, negative values shall be indicated by setting the most significant bit to "1".
- 92.1.6 Latitude, longitude and angle values shall be in units of 10^{-6} degree, except for specific cases explicitly stated in some grid definitions.
- 92.1.7 The latitude values shall be limited to the range 0 to 90 degrees inclusive. The orientation shall be north latitude positive, south latitude negative. Bit 1 is set to 1 to indicate south latitude.
- 92.1.8 The longitude values shall be limited to the range 0 to 360 degrees inclusive. The orientation shall be east longitude positive, with only positive values being used.
- 92.1.9 The latitude and longitude of the first grid point and the last grid point shall always be given for regular grids.
- 92.1.10 Vector components at the North and South Poles shall be coded according to the following conventions.
- 92.1.10.1 If the resolution and component flags in section 3 (Flag table 3.3) indicate that the vector components are relative to the defined grid, the vector components at the Pole shall be resolved relative to the grid.
- 92.1.10.2 Otherwise, for projections where there are multiple points at a given pole, the vector components shall be resolved as if measured an infinitesimal distance from the Pole at the longitude corresponding to each grid point. At the North Pole, the West to East (x direction) component at a grid point with longitude L shall be resolved along the meridian 90 degrees East of L, and the South to North (y direction) component shall be resolved along the meridian 180 degrees from L. At the South Pole, the West to East component at a grid point with longitude L shall be resolved along the meridian 90 degrees East of L and the South to North component shall be resolved along L.
- 92.1.10.3 Otherwise, if there is only one Pole point, either on a cylindrical projection with all but one Pole point deleted, or on any projection (such as polar stereographic) where the Pole maps to a unique point, the West to East and South to North components shall be resolved along longitudes 270° and 0°, respectively at the North Pole and along longitudes 270° and 180°, respectively at the South Pole.
- Note: This differs from the treatment of the Poles in the WMO traditional alphanumeric codes.
- 92.1.11 The first and last grid points shall not necessarily correspond to the first and last data points, respectively, if the bit-map is used.

- 92.1.12 Items in sections 3 and 4 which consist of a scale factor F and a scaled value V are related to the original value L as follows:

$$L \times 10^F = V$$

92.2 **Section 0 – Indicator section**

- 92.2.1 Section 0 shall always be 16 octets long.

- 92.2.2 The first four octets shall always be character coded according to the International Alphabet No. 5 as "GRIB".

- 92.2.3 The remainder of the section shall contain reserved octets, followed by the Discipline, the GRIB edition number, and the length of the entire GRIB message (including the Indicator section).

92.3 **Section 1 – Identification section**

- 92.3.1 The length of the section, in units of octets, shall be expressed over the group of the first four octets, i.e. over the first 32 bits.

- 92.3.2 The section number shall be expressed in the fifth octet.

- 92.3.3 Octets beyond 21 are for an Identification template. If no Identification template is used, optional section must not be present.

- 92.3.4 Calendar is assumed to be Gregorian unless otherwise stated in an Identification template.

92.4 **Section 2 – Local use section**

- 92.4.1 Regulations 92.3.1 and 92.3.2 shall apply.

- 92.4.2 Section 2 is optional.

92.5 **Section 3 – Grid definition section**

- 92.5.1 Regulations 92.3.1 and 92.3.2 shall apply.

92.6 **Section 4 – Product definition section**

- 92.6.1 Regulations 92.3.1 and 92.3.2 shall apply.

- 92.6.2 To maintain orthogonal structure of GRIB Edition 2, parameter names in Code table 4.2 should not contain surface type and statistical process as part of the name.

- 92.6.3 In product definition templates that refer to a forecast time or to offset from the reference time, this may be negative to refer to times or intervals that begin before the reference time, if this is applicable.

92.7 **Section 5 – Data representation section**

- 92.7.1 Regulations 92.3.1 and 92.3.2 shall apply.

92.8 **Section 6 – Bit-map section**

- 92.8.1 Regulations 92.3.1 and 92.3.2 shall apply.

92.9 **Section 7 – Data section**

- 92.9.1 Regulations 92.3.1 and 92.3.2 shall apply.

- 92.9.2 Data shall be coded using the minimum number of bits necessary to provide the accuracy required by international agreement. This required accuracy/precision shall be achieved by scaling the data by multiplication by an appropriate power of 10 (the power may be 0) before forming the non-negative differences, and then using the binary scaling to select the precision of the transmitted value.
- 92.9.3 The data shall be packed by the method identified in section 5.
- 92.9.4 Data shall be coded in the form of non-negative scaled differences from a reference value of the whole field plus, if applicable, a local reference value.

Notes:

- (1) A reference value is normally the minimum value of the data set which is represented.
- (2) For grid-point values, complex packing features are intended to reduce the whole size of the GRIB message (data compression without loss of information with respect to simple packing). The basic concept is to reduce data size thanks to local redundancy. This is achieved just before packing, by splitting the whole set of scaled data values into groups, on which local references (such as local minima) are removed. It is done with some overhead, because extra descriptors are needed to manage the groups' characteristics. An optional pre-processing of the scaled values (spatial differencing) may also be applied before splitting into groups, and combined methods, along with use of alternate row scanning mode, are very efficient on interpolated data.
- (3) For spectral data, complex packing is provided for better accuracy of packing. This is because many spectral coefficients have small values (regardless of the sign), especially for large wave numbers. The first principle is not to pack a subset of coefficients, associated with small wave numbers so that the amplitude of the packed coefficients is reduced. The second principle is to apply an operator to the remaining part of the spectrum: with appropriate tuning it leads to a more homogeneous set of values to pack.
- (4) The original data value Y (in the units of Code table 4.2, unless Notes in Code table 4.10 apply) can be recovered with the formula:

$$Y \times 10^D = R + (X1 + X2) \times 2^E$$

For simple packing and all spectral data

- E = Binary scale factor
- D = Decimal scale factor
- R = Reference value of the whole field
- X1 = 0
- X2 = Scaled (encoded) value.

For complex grid-point packing schemes, E, D and R are as above, but

- X1 = Reference value (scaled integer) of the group the data value belongs to
- X2 = Scaled (encoded) value with the group reference value (X1) removed.

92.10 Section 8 – End section

- 92.10.1 The end section shall always be 4 octets long, character coded according to the International Alphabet No. 5 as "7777".

SPECIFICATIONS OF OCTET CONTENTS

Section 0 – Indicator section

Octet No.	Contents
1–4	GRIB (coded according to the International Alphabet No. 5)
5–6	Reserved
7	Discipline – GRIB Master table number (see Code table 0.0)
8	GRIB edition number (currently 2)
9–16	Total length of GRIB message in octets (including Section 0)

Section 1 – Identification section

Octet No.	Contents
1–4	Length of section in octets (21 or nn)
5	Number of section (1)
6–7	Identification of originating/generating centre (see Common Code table C–11)
8–9	Identification of originating/generating subcentre (allocated by originating/ generating centre)
10	GRIB master table version number (see Common Code table C–0 and Note 1)
11	Version number of GRIB Local tables used to augment Master tables (see Code table 1.1 and Note 2)
12	Significance of reference time (see Code table 1.2)
13–14	Year (4 digits)
15	Month
16	Day
17	Hour
18	Minute
19	Second
20	Production status of processed data in this GRIB message (see Code table 1.3)
21	Type of processed data in this GRIB message (see Code table 1.4)
22–23	Identification template number (optional, see Code table 1.5)
24–nn	Identification template (optional, see template 1.X, where X is the identification template number given in octets 22–23)

Notes:

- (1) Local tables shall define those parts of the Master table which are reserved for local use except for the case described below. In any case, the use of Local tables in messages intended for non-local or international exchange is strongly discouraged.
- (2) If octet 10 contains 255 then only Local tables are in use, the Local table version number (octet 11) must not be zero nor missing, and Local tables may include entries from the entire range of the tables.
- (3) If octet 11 is zero, octet 10 must contain a valid Master table version number and only those parts of the tables not reserved for local use may be used.

Section 2 – Local use section

Octet No.	Contents
1–4	Length of section in octets (nn)
5	Number of section (2)
6–nn	Local use

Section 3 – Grid definition section

Octet No.	Contents
1–4	Length of section in octets (nn)
5	Number of section (3)
6	Source of grid definition (see Code table 3.0 and Note 1)
7–10	Number of data points
11	Number of octets for optional list of numbers (see Note 2)
12	Interpretation of list of numbers (see Code table 3.11)
13–14	Grid definition template number (= N) (see Code table 3.1)
15–xx	Grid definition template (see template 3.N, where N is the grid definition template number given in octets 13–14)
[xx+1]–nn	Optional list of numbers defining number of points (see Notes 2, 3 and 4)

Notes:

- (1) If octet 6 is not zero, octets 15–xx (15–nn if octet 11 is zero) may not be supplied. This should be documented with all bits set to 1 (missing value) in the grid definition template number.
- (2) An optional list of numbers may be used to document a quasi-regular grid. In such a case, octet 11 is non zero and gives the number of octets used per item on the list. For all other cases, such as regular grids, octets 11 and 12 are zero and no list is appended to the grid definition template.
- (3) If a list of numbers defining number of points is present, it is appended at the end of the grid definition template (or directly after the grid definition template number if the template is missing), the length of the list is given by the grid definition. When the grid definition template is present, the length is given according to bit 3 of scanning mode flag octet (length is Nj or Ny for flag value 0). List ordering is implied by data scanning.
- (4) Depending on code value given in octet 12, the list of numbers either:
 - corresponds to the coordinate lines as given in the grid definition, or
 - corresponds to a full circle, or
 - does not apply.

Section 4 – Product definition section

Octet No.	Contents
1–4	Length of section in octets (nn)
5	Number of section (4)
6–7	Number of coordinate values after template or number of information according to 3D vertical coordinate GRIB2 message (see Notes 1 and 5)
8–9	Product definition template number (see Code table 4.0)
10–xx	Product definition template (see template 4.X, where X is the product definition template number given in octets 8–9)
[xx+1]–nn	Optional list of coordinate values or vertical grid information (see Notes 2, 3, 4 and 5)

Notes:

- (1) Coordinate values are intended to document the vertical discretization associated with model data on hybrid coordinate vertical levels. A number of zero in octets 6–7 indicates that no such values are present. Otherwise the number corresponds to the whole set of values.
- (2) Hybrid systems, in this context, employ a means of representing vertical coordinates in terms of a mathematical combination of pressure and sigma coordinates. When used in conjunction with a surface pressure field and an appropriate mathematical expression, the vertical coordinate parameters may be used to interpret the hybrid vertical coordinate.
- (3) Hybrid coordinate values, if present, should be encoded in IEEE 32-bit floating point format. They are intended to be encoded as pairs.
- (4) Two distinct pressure-based hybrid coordinate formulations can be expressed in GRIB Edition 2. If the hybrid coordinate being used is based on pressure, then level type 105 (Code table 4.5) shall be used to specify the vertical level type. If the formulation is based on the natural logarithm of pressure then level type 113 (Code table 4.5) shall be used. In both cases Notes 1 to 3 (above) apply fully.

- (5) In the case of a generalized vertical height coordinate (fixed surface type 150), no pairs of coordinate values follow after the template, but six sets of additional information (each 4 octets long and encoded in IEEE 32-bit floating point format) follow, starting with the number of vertical levels and the identification number of the used vertical system in the additional GRIB2 message with the 3D vertical system. This identification number together with an UUID (Universally Unique Identifier) in four parts allows a unique identification of the grid.

[xx+1] – [xx+4]	Number of vertical levels
[xx+5] – [xx+8]	Identification number of 3D vertical grid GRIB2 message (defined by originating centre)
[xx+9] – [xx+12]	UUID part 1 of 4
[xx+13] – [xx+16]	UUID part 2 of 4
[xx+17] – [xx+20]	UUID part 3 of 4
[xx+21] – [xx+24]	UUID part 4 of 4

Section 5 – Data representation section

Octet No.	Contents
1–4	Length of section in octets (nn)
5	Number of section (5)
6–9	Number of data points where one or more values are specified in Section 7 when a bit map is present, total number of data points when a bit map is absent.
10–11	Data representation template number (see Code table 5.0)
12–nn	Data representation template (see template 5.X, where X is the data representation template number given in octets 10–11)

Section 6 – Bit-map section

Octet No.	Contents
1–4	Length of section in octets (nn)
5	Number of section (6)
6	Bit-map indicator (see Code table 6.0 and the Note)
7–nn	Bit-map – Contiguous bits with a bit to data point correspondence, ordered as defined in Section 3. A bit set to 1 implies the presence of a data value at the corresponding data point, whereas a value of 0 implies the absence of such a value.

Note: If octet 6 is not zero, the length of the section is 6 and octets 7–nn are not present.

Section 7 – Data section

Octet No.	Contents
1–4	Length of section in octets (nn)
5	Number of section (7)
6–nn	Data in a format described by data template 7.X, where X is the data representation template number given in octets 10–11 of Section 5.

Section 8 – End section

Octet No.	Contents
1–4	“7777” (coded according to the International Alphabet No. 5)