National Climatic Data Center

DATA DOCUMENTATION

FOR

DATA SET 9939 (DSI-9939)

WORLD AREA FORECAST SYSTEM

January 3, 2003

National Climatic Data Center
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Asheville, NC 28801-5001 USA

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1. **Abstract**: WAFS is a system for the world wide broadcast of aviation related weather information via satellite. It is a joint effort of the International Civil Aviation Organization (ICAO), the U.S. Federal Aviation Administration (FAA), NOAA/National Weather Service (NWS), with additional contributions from (to name the most prominent) the World Meteorological Organization (WMO), the United Kingdom, Finland, and Canada. The WAFS communications are through commercial satellites--NOAA uses INTELSAT VI and INTELSAT V. The United Kingdom uses a satellite over the Indian Ocean to reach Europe, Africa, and the rest of Asia. NOAA's World Data Center of Washington collects aviation-related observations, forecasts, and other messages from the WMO's Global Telecommunication System (GTS), and adds charts and computer forecasts of temperature, winds, humidity, and other elements over the entire globe. These products are transferred as soon as they are available to MCI/WorldCom, Inc. (the communications contractor), who puts them into the WAFS satellite broadcast stream immediately. The alphanumeric data that could be delivered to a meteorological station via the old communications system in an hour can now be received in less than a minute. In addition, the WAFS system provides, in a couple of hours, special digital data files for world-wide aviation forecasts that would take days to deliver on the old system. The WAFS satellite broadcasts have been operational since 1996, but NCDC only has data from 2002 onward.

2. **Element Names and Definitions**: Data are stored as GRIB files on the HDSS. See Appendices A and B.

3. **Start Date**: 20020701

4. **Stop Date**: Ongoing

5. **Coverage**: Global coverage.

   a. Southernmost Latitude: 90S
   b. Northernmost Latitude: 90N
   c. Westernmost Longitude: 180W
   d. Easternmost Longitude: 180E

6. **How to Order Data**:

   Ask NCDC’s Climate Services about the cost of obtaining this data set.
   Phone: 828-271-4800
   FAX: 828-271-4876
   E-mail: NCDC.Orders@noaa.gov

7. **Archiving Data Center**:

   National Climatic Data Center
   Federal Building
   151 Patton Avenue
   Asheville, NC 28801-5001

8. **Technical Contact**:

   National Climatic Data Center
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Phone: (828) 271-4800.

National Center for Environmental Prediction
Environmental Modeling Center
5200 Auth Road
Camp Springs, Maryland 20746-4304

9. Known Uncorrected Problems: No information provided with original documentation.

10. Quality Statement: No information provided with original documentation.

11. Essential Companion Data Sets: None.

12. References: See the sites below.

http://www.emc.ncep.noaa.gov/index.html
http://www.emc.ncep.noaa.gov/gmb/
http://www.nco.ncep.noaa.gov/pmb/docs/on388/tableb.html#WAFS

Appendix A

(last update: 14/09/2001)
FM 92-XII GRIB - General Regularly-distributed Information in Binary form

CODE FORM:

SECTION 0	**Indicator Section**			
SECTION 1	**Identification Section**			
SECTION 2	**(Local Use Section)**			}
SECTION 3	**Grid Definition Section**		}	}
SECTION 4	**Product Definition Section**	}	}	} (*repeated*)
SECTION 5	**Data Representation Section**	} (*repeated*)	} (*repeated*)	}
SECTION 6	**Bit-map Section**	}	}	}
SECTION 7	**Data Section**	}	}	}
SECTION 8	**End Section**			

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 into sections:

Section Number	*Section Name*	*Section Contents*
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 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 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 mmmmmmmm mmmmmmmm

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 are 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 formulae.

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. 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. 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: (1) 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.

92.2 **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 reserved for future use and need not be present.

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.

92.7 **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 sign), especially for large wave numbers. The first principle is to not 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) can be recovered with the formula:

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

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 (XI) 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".

SPECIFICATION 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-1)	
8-9	Identification of originating/generating sub-centre (allocated by originating/generating Centre)	
10	GRIB Master Tables Version Number (see Code Table 1.0) (currently 1)	
11	GRIB Local Tables Version Number (see Code Table 1.1)	
12	Significance of Reference Time (see Code Table 1.2)	
13-14	Year (4 digits)	
15	Month	
16	Day	Reference time of data
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 - nn	Reserved: need not be present	

SECTION 2 - LOCAL SECTION USE

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 defining number of points (see Note 2)
12	Interpretation of list of numbers defining number of points (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 Grid Definition Template Number.

2. An optional list of numbers defining number of points is used to document a quasi-regular grid, where the number of points may vary from one row to another (row being defined as adjacent points in a coordinate line, so this is dependent from data layout). In such a case, octet 11 is non zero, and gives the number of octets on which each number of points is encoded. 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 Grid Definition Template (or directly after Grid Definition Template Number if 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 defining number of points corresponds either to the coordinate lines as given in the grid definition, or to a full circle.

SECTION 4 - PRODUCT DEFINITION SECTION

Octet Number(s)	Contents
1-4	Length of section in octets (nn)
5	Number of section ("4")
6-7	Number of coordinates values after Template (see Note 1)
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 coordinates values (see Notes 2 and 3)

Notes:

1. Coordinates values are intended to document the vertical discretisation 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 the 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.

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 Note 1)
7-nn	Bit-map

Note: (1) 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 Number(s)	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.)

TEMPLATE DEFINITIONS

TEMPLATE DEFINITIONS USED IN SECTION 3

Grid Definition Template 3.0: Latitude/longitude (or equidistant cylindrical, or Plate Carree)

Octet Number(s)	Contents
15	Shape of the earth (see Code Table 3.2)
16	Scale factor of radius of spherical earth
17-20	Scaled value of radius of spherical earth
21	Scale factor of major axis of oblate spheroid earth
22-25	Scaled value of major axis of oblate spheroid earth
26	Scale factor of minor axis of oblate spheroid earth
27-30	Scaled value of minor axis of oblate spheroid earth
31-34	Ni - number of points along a parallel
35-38	Nj - number of points along a meridian
39-42	Basic angle of the initial production domain (see Note 1)
43-46	Subdivisions of basic angle used to define extreme longitudes and latitudes, and direction increments (see Note 1)
47-50	La1 - latitude of first grid point (see Note 1)
51-54	Lo1 - longitude of first grid point (see Note 1)
55	Resolution and component flags (see Flag Table 3.3)
56-59	La2 - latitude of last grid point (see Note 1)
60-63	Lo2 - longitude of last grid point (see Note 1)
64-67	Di - i direction increment (see Note 1)
68-71	Dj - j direction increment (see Note 1)
72	Scanning mode (flags - see Flag Table 3.4)

Notes: (1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes, and direction increments. For these last six descriptors, unit is equal to the ratio of the basic angle and the subdivisions number. For ordinary cases, zero and missing values should be coded, equivalent to respective values of 1 and 10^6 (10^{-6} degrees unit).

(2) For data on a quasi-regular grid, in which all the rows or columns do not necessarily have the same number of grid points, either Ni (Octets 31-34) or Nj (Octets 35-38) and the corresponding Di (Octets 64-67) or Dj (Octets 68-71) shall be coded with all bits set to 1 (missing). The actual number of points along each parallel or meridian shall be coded in the octets immediately following the Grid Definition Template (Octets [xx+1] – nn), as described in the description of the Grid Definition Section.

(3) A quasi-regular grid is only defined for appropriate grid scanning modes. Either rows or columns, but not both simultaneously, may have variable numbers of points. The first point in each row (column) shall be positioned at the meridian (parallel) indicated by Octets 47-54. The grid points shall be evenly spaced in latitude (longitude).

Grid Definition Template 3.1: Rotated Latitude/longitude (or equidistant cylindrical, or Plate Carree)

Octet Number(s)	Contents
15-72	Same as Grid Definition Template 3.0 (see Note 1)
73-76	Latitude of the southern pole of projection
77-80	Longitude of the southern pole of projection
81-84	Angle of rotation of projection

Notes:

(1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes, and direction increments. For these last six descriptors, unit is equal to the ratio of the basic angle and the subdivisions number. For ordinary cases, zero and missing values should be coded, equivalent to respective values of 1 and 10^6 (10^{-6} degrees unit).

(2) Three parameters define a general latitude/longitude coordinate system, formed by a general rotation of the sphere. One choice for these parameters is:
   (a) The geographic latitude in degrees of the southern pole of the coordinate system, Thetap for example.
   (b) The geographic longitude in degrees of the southern pole of the coordinate system, Lambdap for example.
   (c) The angle of rotation in degrees about the new polar axis (measured clockwise when looking from the southern to the northern pole) of the coordinate system, assuming the new axis to have been obtained by first rotating the sphere through Lambdap degrees about the geographic polar axis, and then rotating through (90 + Thetap) degrees so that the southern pole moved along the (previously rotated) Greenwich meridian.

Grid Definition Template 3.2: Stretched Latitude/longitude (or equidistant cylindrical, or Plate Carree)

Octet Number(s)	Contents
15-72	Same as Grid Definition Template 3.0 (see Note 1)
73-76	Latitude of the pole of stretching
77-80	Longitude of the pole of stretching
81-84	Stretching factor

Notes:

(1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes, and direction increments. For these last six descriptors, unit is equal to the ratio of the basic angle and the subdivisions number. For ordinary cases, zero and missing values should be coded, equivalent to respective values of 1 and 10^6 (10^{-6} degrees unit).

(2) The stretching is defined by three parameters:

(a) The latitude in degrees (measured in the *model* coordinate system) of the "pole of stretching";
(b) Longitude in degrees (measured in the *model* coordinate system) of the "pole of stretching"
(c) The stretching factor C in units of 10^{-6} represented as an integer.

The stretching is defined by representing data uniformly in a coordinate system with longitude Y and latitude X1, where:

$$X1 = \sin^{-1} \frac{(1 - C^2) + (1 + C^2) \sin X}{(1 + C^2) + (1 - C^2) \sin X}$$

and Y and X are longitude and latitude in a coordinate system in which the "pole of stretching" is the northern pole. C = 1 gives uniform resolution, while C > 1 give enhanced resolution around the pole of stretching.

Grid Definition Template 3.3: Stretched and Rotated Latitude/longitude (or equidistant cylindrical, or Plate Carree)

Octet Number(s)	Contents
15-72	Same as Grid Definition Template 3.0 (see Note 1)
73-76	Latitude of the southern pole of projection
77-80	Longitude of the southern pole of projection
81-84	Angle of rotation of projection
85-88	Latitude of the pole of stretching
89-92	Longitude of the pole of stretching
93-96	Stretching factor

Notes:

(1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes, and direction increments. For these last six descriptors, unit is equal to the ratio of the basic angle and the subdivisions number. For ordinary cases, zero and missing values should be coded, equivalent to respective values of 1 and 10^6 (10^{-6} degrees unit).

(2) See Note (2) under Grid Definition Template 3.1 - Rotated Latitude/longitude (or equidistant cylindrical, or Plate Carree)

(3) See Note (2) under Grid Definition Template 3.2 - Stretched Latitude/longitude (or equidistant cylindrical, or Plate Carree)

Grid Definition Template 3.10: Mercator

Octet Number(s)	Contents
15	Shape of the earth (see Code Table 3.2)
16	Scale factor of radius of spherical earth
17-20	Scaled value of radius of spherical earth
21	Scale factor of major axis of oblate spheroid earth
22-25	Scaled value of major axis of oblate spheroid earth
26	Scale factor of minor axis of oblate spheroid earth
27-30	Scaled value of minor axis of oblate spheroid earth
31-34	Ni - number of points along a parallel
35-38	Nj - number of points along a meridian
39-42	La1 - latitude of first grid point
43-46	Lo1 - longitude of first grid point
47	Resolution and component flags (see Flag Table 3.3)
48-51	LaD - Latitude(s) at which the Mercator projection intersects the Earth (Latitude(s) where Di and Dj are specified)
52-55	La2 - latitude of last grid point
56-59	Lo2 - longitude of last grid point
60	Scanning mode (flags - see Flag Table 3.4)
61-64	Orientation of the grid, angle between i direction on the map and the equator (see Note 1)
65-68	Di - longitudinal direction grid length (see Note 2)
69-72	Dj - latitudinal direction grid length (see Note 2)

Notes:

(1) Limited to the range of 0 to 90 degrees; if the angle of orientation of the grid is neither 0 nor 90 degrees, Di and Dj must be equal to each other.

(2) Grid lengths are in units of 10^{-3} m, at the latitude specified by LaD.

Grid Definition Template 3.20: Polar stereographic projection

Octet Number(s)	Contents
15	Shape of the earth (see Code Table 3.2)
16	Scale factor of radius of spherical earth
17-20	Scaled value of radius of spherical earth
21	Scale factor of major axis of oblate spheroid earth
22-25	Scaled value of major axis of oblate spheroid earth
26	Scale factor of minor axis of oblate spheroid earth
27-30	Scaled value of minor axis of oblate spheroid earth
31-34	Nx - number of points along X-axis
35-38	Ny - number of points along Y-axis
39-42	La1 - latitude of first grid point
43-46	Lo1 - longitude of first grid point
47	Resolution and component flag (see flag table 3.3 and Note 1)
48-51	LaD - Latitude where Dx and Dy are specified
52-55	LoV - orientation of the grid (see Note 2)
56-59	Dx - X-direction grid length (see Note 3)

60-63	Dy - Y-direction grid length (see Note 3)
64	Projection centre flag (See Flag Table 3.5)
65	Scanning mode (see flag table 3.4)

Notes:

(1) The resolution flag (bit 3-4 of Flag table 3.3) is not applicable.

(2) LoV is the longitude value of the meridian which is parallel to the Y-axis (or columns of the grid) along which latitude increases as the Y-coordinate increases (the orientation longitude may or may not appear on a particular grid).

(3) Grid length is in units of 10^{-3} m at the latitude specified by LaD.

(4) Bit 2 of the projection flag is not applicable to the polar stereographic projection.

Grid Definition Template 3.30: Lambert conformal

Octet Number(s)	Contents
15	Shape of the earth (see Code Table 3.2)
16	Scale factor of radius of spherical earth
17-20	Scaled value of radius of spherical earth
21	Scale factor of major axis of oblate spheroid earth
22-25	Scaled value of major axis of oblate spheroid earth
26	Scale factor of minor axis of oblate spheroid earth
27-30	Scaled value of minor axis of oblate spheroid earth
31-34	Nx - number of points along the X-axis
35-38	Ny - number of points along the Y-axis
39-42	La1 - latitude of first grid point
43-46	Lo1 - longitude of first grid point
47	Resolution and component flags (see Flag Table 3.3)
48-51	LaD - Latitude where Dx and Dy are specified
52-55	LoV - Longitude of meridian parallel to Y-axis along which latitude increases as the Y-coordinate increases
56-59	Dx - X-direction grid length (see Note 1)
60-63	Dy - Y-direction grid length (see Note 1)
64	Projection centre flag (see Flag Table 3.5)
65	Scanning mode (see Flag Table 3.4)
66-69	Latin 1 - first latitude from the pole at which the secant cone cuts the sphere
70-73	Latin 2 - second latitude from the pole at which the secant cone cuts the sphere
74-77	Latitude of the southern pole of projection
78-81	Longitude of the southern pole of projection

Notes:

(1) Grid lengths are in units of 10^{-3} m, at the latitude specified by LaD.

(2) If Latin 1 = Latin 2, then the projection is on a tangent cone.

(3) The resolution flags (bits 3-4 of Flag Table 3.3) are not applicable

(4) LoV is the longitude value of the meridian which is parallel to the Y-axis (or columns of the grid) along which latitude increases as the Y-coordinate increases (the orientation longitude may or may not appear on a particular grid).

Grid Definition Template 3.40: Gaussian latitude/longitude

Octet Number(s)	Contents
15	Shape of the earth (see Code Table 3.2)
16	Scale factor of radius of spherical earth
17-20	Scaled value of radius of spherical earth
21	Scale factor of major axis of oblate spheroid earth
22-25	Scaled value of major axis of oblate spheroid earth
26	Scale factor of minor axis of oblate spheroid earth
27-30	Scaled value of minor axis of oblate spheroid earth
31-34	Ni - number of points along a parallel

35-38	Nj - number of points along a meridian
39-42	Basic angle of the initial production domain (see Note 1)
43-46	Subdivisions of basic angle used to define extreme longitudes and latitudes, and direction increments (see Note 1)
47-50	La1 - latitude of first grid point (see Note 1)
51-54	Lo1 - longitude of first grid point (see Note 1)
55	Resolution and component flags (see Flag Table 3.3)
56-59	La2 - latitude of last grid point (see Note 1)
60-63	Lo2 - longitude of last grid point (see Note 1)
64-67	Di - i direction increment (see Note 1)
68-71	N - number of parallels between a pole and the equator (see Note 2)
72	Scanning mode (flags - see Flag Table 3.4)

Notes:

(1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes, and direction increments. For these last six descriptors, unit is equal to the ratio of the basic angle and the subdivisions number. For ordinary cases, zero and missing values should be coded, equivalent to respective values of 1 and 10^6 (10^{-6} degrees unit).

(2) The number of parallels between a pole and the equator is used to establish the variable (Gaussian) spacing of the parallels; this value must always be given.

Grid Definition Template 3.41: Rotated Gaussian latitude/longitude

Octet Number(s)	Contents
15-72	Same as Grid Definition Template 3.40 (see Note 1)
73-76	Latitude of the southern pole of projection
77-80	Longitude of the southern pole of projection
81-84	Angle of rotation of projection

Notes:

(1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes, and direction increments. For these last six descriptors, unit is equal to the ratio of the basic angle and the subdivisions number. For ordinary cases, zero and missing values should be coded, equivalent to respective values of 1 and 10^6 (10^{-6} degrees unit).

(2) The number of parallels between a pole and the equator is used to establish the variable (Gaussian) spacing of the parallels; this value must always be given.

(3) See Note (2) under Grid Definition Template 3.1 - Rotated Latitude/longitude grid (or equidistant cylindrical, or Plate Carree)

Grid Definition Template 3.42: Stretched Gaussian latitude/longitude

Octet Number(s)	Contents
15-72	Same as Grid Definition Template 3.40 (see Note 1)
73-76	Latitude of the pole of stretching
77-80	Longitude of the pole of stretching
81-84	Stretching factor

Notes:

(1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes, and direction increments. For these last six descriptors, unit is equal to the ratio of the basic angle and the subdivisions number. For ordinary cases, zero and missing values should be coded, equivalent to respective values of 1 and 10^6 (10^{-6} degrees unit).

(2) The number of parallels between a pole and the equator is used to establish the variable (Gaussian) spacing of the parallels; this value must always be given.

(3) See Note (2) under Grid Definition Template 3.2 -Stretched Latitude/longitude (or equidistant cylindrical, or Plate Carree)

Grid Definition Template 3.43: Stretched and rotated Gaussian latitude/longitude

Octet Number(s)	Contents
15-72	Same as Grid Definition Template 3.40 (see Note 1)
73-76	Latitude of the southern pole of projection
77-80	Longitude of the southern pole of projection
81-84	Angle of rotation of projection
85-88	Latitude of the pole of stretching
89-92	Longitude of the pole of stretching
93-96	Stretching factor

Notes:

(1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes, and direction increments. For these last six descriptors, unit is equal to the ratio of the basic angle and the subdivisions number. For ordinary cases, zero and missing values should be coded, equivalent to respective values of 1 and 10^6 (10^{-6} degrees unit).

(2) The number of parallels between a pole and the equator is used to establish the variable (Gaussian) spacing of the parallels; this value must always be given.

(3) See Note (2) under Grid Definition Template 3.1 -Rotated Latitude/longitude (or equidistant cylindrical, or Plate Carree)

(4) See Note (2) under Grid Definition Template 3.2 -Stretched Latitude/longitude (or equidistant cylindrical, or Plate Carree)

Grid Definition Template 3.50: Spherical harmonic coefficients

Octet Number(s)	Contents
15-18	J - pentagonal resolution parameter
19-22	K - pentagonal resolution parameter
23-26	M - pentagonal resolution parameter
27	Representation type indicating the method used to define the norm (see Code Table 3.6).
28	Representation mode indicating the order of the coefficients (see Code Table 3.7)

Note: The pentagonal representation of resolution is general. Some common truncations are special cases of the pentagonal one:

Triangular	M = J = K
Rhomboidal	K = J + M
Trapezoidal	K = J, K > M

Grid Definition Template 3.51: Rotated spherical harmonic coefficients

Octet Number(s)	Contents
15-28	Same as Grid Definition Template 3.50
29-32	Latitude of the southern pole of projection
33-36	Longitude of the southern pole of projection
37-40	Angle of rotation of projection

Notes:

(1) See Note (1) under Grid Definition Template 3.50 - Spherical harmonic coefficients

(2) See Note (2) under Grid Definition Template 3.1 - Rotated Latitude/longitude grid (or equidistant cylindrical, or Plate Carree)

Grid Definition Template 3.52: Stretched spherical harmonic coefficients

Octet Number(s)	Contents
15-28	Same as Grid Definition Template 3.50
29-32	Latitude of the pole of stretching
33-36	Longitude of the pole of stretching
37-40	Stretching factor

Notes:

(1) See Note (1) under Grid Definition Template 3.50 - Spherical harmonic coefficients

(2) See Note (2) under Grid Definition Template 3.20 - Stretched Latitude/longitude grid (or equidistant cylindrical, or Plate Carree)

Grid Definition Template 3.53: Stretched and rotated spherical harmonic coefficients

Octet Number(s)	Contents
15-28	Same as Grid Definition Template 3.50
29-32	Latitude of the southern pole of projection
33-36	Longitude of the southern pole of projection
37-40	Angle of rotation of projection
41-44	Latitude of pole of stretching
45-48	Longitude of pole of stretching
49-52	Stretching factor

Notes: (1) See Note (1) under Grid Definition Template 3.50 - Spherical harmonic coefficients

(2) See Note (2) under Grid Definition Template 3.1 -Rotated Latitude/longitude (or equidistant cylindrical, or Plate Carree)

(3) See Note (2) under Grid Definition Template 3.2 -Stretched Latitude/longitude (or equidistant cylindrical, or Plate Carree)

Grid Definition Template 3.90: Space view perspective or orthographic

Octet Number(s)	Contents
15	Shape of the earth (see Code Table 3.2)
16	Scale factor of radius of spherical earth
17-20	Scaled value of radius of spherical earth
21	Scale factor of major axis of oblate spheroid earth
22-25	Scaled value of major axis of oblate spheroid earth
26	Scale factor of minor axis of oblate spheroid earth
27-30	Scaled value of minor axis of oblate spheroid earth
31-34	Nx - number of points along X-axis (columns)
35-38	Ny - number of points along Y-axis (rows or lines)
39-42	Lap - latitude of sub-satellite point
43-46	Lop - longitude of sub-satellite point
47	Resolution and component flags (see Code Table 3.3)
48-51	dx - apparent diameter of Earth in grid lengths, in X-direction
52-55	dy - apparent diameter of Earth in grid lengths, in Y-direction
56-59	Xp - X-coordinate of sub-satellite point (in units of 10-3 grid length expressed as an integer)
60-63	Yp - Y-coordinate of sub-satellite point (in units of 10-3 grid length expressed as an integer)
64	Scanning mode (flags - see Flag Table 3.4)
65-68	Orientation of the grid; i.e., the angle between the increasing Y-axis and the meridian of the sub-satellite point in the direction of increasing latitude (see Note 3)

69-72	Nr - altitude of the camera from the Earth's centre, measured in units of the Earth's (equatorial) radius multiplied by a scale factor of 10^6 (see Notes 4 and 5)
73-76	Xo - X-coordinate of origin of sector image
77-80	Yo - Y-coordinate of origin of sector image

Notes:

(1) It is assumed that the satellite is at its nominal position, i.e., it is looking directly at its sub-satellite point.

(2) Octets 69-72 shall be set to all ones (missing) to indicate the orthographic view (from infinite distance)

(3) It is the angle between the increasing Y-axis and the meridian 180°E if the sub-satellite point is the North Pole; or the meridian 0o if the sub-satellite point is the South Pole.

(4) The apparent angular size of the Earth will be given by 2 * Arcsin (10^6)/Nr).

(5) For orthographic view from infinite distance, the value of Nr should be encoded as missing (all bits set to 1).

(6) The horizontal and vertical angular resolutions of the sensor (Rx and Ry), needed for navigation equation, can be calculated from the following:

Rx = 2 * Arcsin (10^6)/Nr)/ dx

Ry = 2 * Arcsin (10^6)/Nr)/ dy

Grid Definition Template 3.100: Triangular grid based on an icosahedron *(see Attachment I.2-GRIB-Att.)*

Octet Number(s)	Contents
15	n2 - exponent of 2 for the number of intervals on main triangle sides
16	n3 - exponent of 3 for the number of intervals on main triangle sides
17-18	ni - number of intervals on main triangle sides of the icosahedron
19	nd - Number of diamonds
20-23	Latitude of the pole point of the icosahedron on the sphere
24-27	Longitude of the pole point of the icosahedron on the sphere
28-331	Longitude of the center line of the first diamond of the icosahedron on the sphere
32	Grid point position (see Code table 3.8)
33	Numbering order of diamonds (flag - see Flag table 3.9)
34	Scanning mode for one diamond (flags - see Flag table 3.10)
35-38	nt - total number of grid points

Notes:

(1) For more details see *Attachment I.2-GRIB-Att* to the Manual of Codes, Vol. I, Part B-definition of the triangular grid based on an icosahedron

(2) The origin of the grid is an icosahedron with 20 triangles and 12 vertices. The triangles are combined to nd quadrangles, the so-called diamonds (e.g. if nd = 10, two of the icosahedron triangles form a diamond, and if nd = 5, 4 icosahedron triangles form a diamond). There are two resolution values called n2 and n3 describing the division of each triangle side. Each triangle side is divided into ni equal parts where ni = 3**n3 * 2**n2 with n3 either equal to 0 or to 1. In the example of *Attachment I.2-GRIB-Att*, the numbering order of the rectangles is anti-clockwise with a view from the pole point on both hemispheres. Diamonds 1 to 5 are northern hemisphere and diamonds 6 to 10 are Southern Hemisphere.

(3) The exponent of 3 for the number of divisions of triangle sides is used only with a value of either 0 or 1.

(4) The total number of grid points for one global field depends on the grid point position. If e.g. the grid points are located at the vertices of the triangles nt = (ni + 1) * (ni + 1) * nd since grid points at diamond edges are contained in both adjacent diamonds and for the same reason the pole points are contained in each of the five adjacent diamonds.

Grid Definition Template 3.110: Equatorial azimuthal equidistant projection

Octet Number(s)	Contents
15	Shape of the earth (see Code Table 3.2)
16	Scale factor of radius of spherical earth
17-20	Scaled value of radius of spherical earth

21	Scale factor of major axis of oblate spheroid earth
22-25	Scaled value of major axis of oblate spheroid earth
26	Scale factor of minor axis of oblate spheroid earth
27-30	Scaled value of minor axis of oblate spheroid earth
31-34	Nx - number of points along X-axis
35-38	Ny - number of points along Y-axis
39-42	La1 - latitude of tangency point (center of grid)
43-46	Lo1 - longitude of tangency point
47	Resolution and component flag (see flag table 3.3)
48-51	Dx - X-direction grid length in units of 10^{-3} m as measured at the point of the axis
52-55	Dy - Y-direction grid length in units of 10^{-3} m as measured at the point of the axis
56	Projection center flag
57	Scanning mode (see flag table 3.4)

Grid Definition Template 3.120: Azimuth-range projection

Octet Number(s)	Contents
15-18	Nb - number of data bins along radials (see Note 1)
19-22	Nr - number of radials
23-26	La1 - latitude of center point
27-30	Lo1 - longitude of center point
31-34	Dx - spacing of bins along radials
35-38	Dstart - offset from origin to inner bound
39	Scanning mode (flags - see Flag table 3.4)
40 - (39+4Nr)	For each of Nr radials:

(40+4(X-1)) - (41+4(X-1)) Azi - starting azimuth, degree x 10 (degrees as north)
(42+4(X-1)) - (43+4(X-1)) Adelta - azimuthal width, degrees x 100, (+ clockwise, - counterclockwise)
with X = 1 to Nr

Note:

(1) A data bin is a data point representing the volume centered on it.

Grid Definition Template 3.1000: Cross-section grid, with points equally spaced on the horizontal

Preliminary Note: This template is simply experimental, was not validated at the time of publication and should be used only for bi-lateral previously agreed tests.

Octet Numbers(s)	Contents
15	Shape of the earth (see Code Table 3.2)
16	Scale factor of radius of spherical earth
17-20	Scaled value of radius of spherical earth
21	Scale factor of major axis of oblate spheroid earth
22-25	Scaled value of major axis of oblate spheroid earth
26	Scale factor of minor axis of oblate spheroid earth
27-30	Scaled value of minor axis of oblate spheroid earth
31-34	Number of horizontal points
35-38	Basic angle of the initial production domain (see Note 1)
39-42	Subdivisions of basic angle used to define extreme longitudes and latitudes (see Note 1)
43-46	La1 - latitude of first grid point (see Note 1)
47-50	Lo1 - longitude of first grid point (see Note 1)
51	Scanning mode (flags – see Flag Table 3.4)
52-55	La2 - latitude of last grid point (see Note 1)
56-59	Lo2 - longitude of last grid point (see Note 1)
60	Type of horizontal line (see Code Table 3.20)
61-62	Number of vertical points
63	Physical meaning of vertical coordinate (see Code Table 3.15)
64	Vertical dimension coordinate values definition (see Code Table 3.21)

65-66	NC - Number of coefficients or values used to specify vertical coordinates
67-(66+NC*4)	Coefficients to define vertical dimension coordinate values in functional form, or the explicit coordinate values (IEEE 32-bit floating-point values)

Note: (1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes. For these last descriptors, unit is equal to the ratio of the basic angle and the subdivisions number. For ordinary cases, zero and missing values should be coded, equivalent to respective values of 1 and 10^{6} (10^{-6} degrees unit).

Grid Definition Template 3.1100: Hovmöller diagram grid, with points equally spaced on the horizontal

Preliminary Note: This template is simply experimental, was not validated at the time of publication and should be used only for bi-lateral previously agreed tests.

Octet Numbers(s)	Contents
15	Shape of the earth (see Code Table 3.2)
16	Scale factor of radius of spherical earth
17-20	Scaled value of radius of spherical earth
21	Scale factor of major axis of oblate spheroid earth
22-25	Scaled value of major axis of oblate spheroid earth
26	Scale factor of minor axis of oblate spheroid earth
27-30	Scaled value of minor axis of oblate spheroid earth
31-35	Number of horizontal points
35-38	Basic angle of the initial production domain (see Note 1)
39-42	Subdivisions of basic angle used to define extreme longitudes and latitudes (see Note 1)
43-46	La1 - latitude of first grid point (see Note 1)
47-50	Lo1 - longitude of first grid point (see Note 1)
51	Scanning mode (flags – see Flag Table 3.4)
52-55	La2 - latitude of last grid point (see Note 1)
56-59	Lo2 - longitude of last grid point (see Note 1)
60	Type of horizontal line (see Code Table 3.20)
61-64	NT – Number of time steps
65	Unit of offset from reference time (see Code Table 4.4)
66-69	Offset from reference of first time (negative value when first bit set)
70	Type of time increment (see Code Table 4.11)
71	Unit of time increment (see Code Table 4.4)
72-75	Time increment (negative value when first bit set)
76-82	*Last date/time*
76-77	Year
78	Month
79	Day
80	Hour
81	Minute
82	Second

Note: (1) Basic angle of the initial production domain and subdivisions of this basic angle are provided to manage cases where the recommended unit of 10^{-6} degrees is not applicable to describe the extreme longitudes and latitudes. For these last descriptors, unit is equal to the ratio of the basic angle and the subdivisions number. For ordinary cases, zero and missing values should be coded, equivalent to respective values of 1 and 10^{6} (10^{-6} degrees unit).

Grid Definition Template 3.1200: Time section grid

Preliminary Note: This template is simply experimental, was not validated at the time of publication and should be used only for bi-lateral previously agreed tests.

Octet Numbers(s)	Contents
15-18	NT – Number of time steps

19	Unit of offset from reference time (see Code Table 4.4)
20-23	Offset from reference of first time (negative value when first bit set)
24	Type of time increment (see Code Table 4.11)
25	Unit of time increment (see Code Table 4.4)
26-29	Time increment (negative value when first bit set)
30-36	*Last date/time*
30-31	Year
32	Month
33	Day
34	Hour
35	Minute
36	Second
37-38	Number of vertical points
39	Physical meaning of vertical coordinate (see Code Table 3.15)
40	Vertical dimension coordinate values definition (see Code Table 3.21)
41-42	NC - Number of coefficients or values used to specify vertical coordinates
43-(42+NC*4)	Coefficients to define vertical dimension coordinate values in functional form, or the explicit coordinate values (IEEE 32-bit floating-point values)

TEMPLATE DEFINITIONS USED IN SECTION 4

Product Definition Template 4.0: Analysis or forecast at a horizontal level or in a horizontal layer at a point in time

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1).
11	Parameter number (see Code Table 4.2).
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating centre)
14	Analysis or forecast generating processes identifier (defined by originating centre)
15-16	Hours of observational data cutoff after reference time (see Note 1)
17	Minutes of observational data cutoff after reference time
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18
23	Type of first fixed surface (see Code Table 4.5)
24	Scale factor of first fixed surface
25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface

Note:

(1) Hours greater than 65534 will be coded as 65534.

Product Definition Template 4.1: Individual ensemble forecast, control and perturbed, at a horizontal level or in a horizontal layer at a point in time

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1)
11	Parameter number (see Code Table 4.2)
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating Centre)
14	Forecast generating process identifier (defined by originating Centre)
15-16	Hours after reference time of data cutoff (see Note 1)
17	Minutes after reference time of data cutoff
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18
23	Type of first fixed surface (see Code Table 4.5)
24	Scale factor of first fixed surface

25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface
35	Type of ensemble forecast (see Code Table 4.6)
36	Perturbation number
37	Number of forecasts in ensemble

Note:

(1) Hours greater than 65534 will be coded as 65534.

Product Definition Template 4.2:Derived forecast based on all ensemble members at a horizontal level or in a horizontal layer at a point in time

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1)
11	Parameter number (see Code Table 4.2)
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating Centre)
14	Forecast generating process identifier (defined by originating Centre)
15-16	Hours after reference time of data cutoff (see Note 1)
17	Minutes after reference time of data cutoff
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18
23	Type of first fixed surface (see Code Table 4.5)
24	Scale factor of first fixed surface
25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface
35	Derived forecast (see Code Table 4.7)
36	Number of forecasts in ensemble

Note:

(1) Hours greater than 65534 will be coded as 65534.

Product Definition Template 4.3:Derived forecasts based on a cluster of ensemble members over a rectangular area at a horizontal level or in a horizontal layer at a point in time

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1)
11	Parameter number (see Code Table 4.2)
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating Centre)
14	Forecast generating process identifier (defined by originating Centre)
15-16	Hours after reference time of data cutoff (see Note 1)
17	Minutes after reference time of data cutoff
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18
23	Type of first fixed surface (see Code Table 4.5)
24	Scale factor of first fixed surface
25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface
35	Derived forecast (see Code Table 4.7)
36	Number of forecasts in the ensemble (N)
37	Cluster identifier
38	Number of cluster to which the high resolution control belongs

39	Number of cluster to which the low resolution control belongs
40	Total number of clusters
41	Clustering method (see Code Table 4.8)
42-45	Northern latitude of cluster domain
46-49	Southern latitude of cluster domain
50-53	Eastern longitude of cluster domain
54-57	Western longitude of cluster domain
58-(57+N)	List of N ensemble forecast numbers

Note:

(1) Hours greater than 65534 will be coded as 65534.

Product Definition Template 4.4: Derived forecasts based on a cluster of ensemble members over a circular area at a horizontal level or in a horizontal layer at a point in time

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1)
11	Parameter number (see Code Table 4.2)
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating Centre)
14	Forecast generating process identifier (defined by originating Centre)
15-16	Hours after reference time of data cutoff (see Note 1)
17	Minutes after reference time of data cutoff
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18
23	Type of first fixed surface (see Code Table 4.5)
24	Scale factor of first fixed surface
25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface
35	Derived forecast (see Code Table 4.7)
36	Number of forecasts in the ensemble (N)
37	Cluster identifier
38	Number of cluster to which the high resolution control belongs
39	Number of cluster to which the low resolution control belongs
40	Total number of clusters
41	Clustering method (see Code Table 4.8)
42-45	Latitude of central point in cluster domain
46-49	Longitude of central point in cluster domain
50-53	Radius of cluster domain
54-(53+N)	List of N ensemble forecast numbers

Note:

(1) Hours greater than 65534 will be coded as 65534.

Product Definition Template 4.5: Probability forecasts at a horizontal level or in a horizontal layer at a point in time

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1)
1 11	Parameter number (see Code Table 4.2)
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating Centre)
14	Forecast generating process identifier (defined by originating Centre)
15-16	Hours after reference time of data cutoff (see Note 1)
17	Minutes after reference time of data cutoff
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18
23	Type of first fixed surface (see Code Table 4.5)

24	Scale factor of first fixed surface
25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface
35	Forecast probability number
36	Total number of forecast probabilities
37	Probability type (see Code Table 4.9)
38	Scale factor of lower limit
39-42	Scaled value of lower limit
43	Scale factor of upper limit
44-47	Scaled value of upper limit

Note:

(1) Hours greater than 65534 will be coded as 65534.

Product Definition Template 4.6: Percentile forecasts at a horizontal level or in a horizontal layer at a point in time

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1)
11	Parameter number (see Code Table 4.2)
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating Centre)
14	Forecast generating process identifier (defined by originating Centre)
15-16	Hours after reference time of data cutoff (see Note 1)
17	Minutes after reference time of data cutoff
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18
23	Type of first fixed surface (see Code Table 4.5)
24	Scale factor of first fixed surface
25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface
35	Percentile value (from 100% to 0%)

Note:

(1) Hours greater than 65534 will be coded as 65534.

Product Definition Template 4.7: Analysis or forecast error at a horizontal level or in a horizontal layer at a point in time

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1)
11	Parameter number (see Code Table 4.2)
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating Centre)
14	Analysis or forecast generating process identifier (defined by originating Centre)
15-16	Hours after reference time of data cutoff (see Note 1)
17	Minutes after reference time of data cutoff
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18
23	Type of first fixed surface (see Code Table 4.5)
24	Scale factor of first fixed surface
25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface

Note:

(1) Hours greater than 65534 will be coded as 65534.

Product Definition Template 4.8: Average, accumulation, and/or extreme values or other statistically processed values at a horizontal level or in a horizontal layer in a continuous or non-continuous time interval

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1)
11	Parameter number (see Code Table 4.2)
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating Centre)
14	Analysis or Forecast generating process identifier (defined by originating Centre)
15-16	Hours after reference time of data cut-off (see Note 1)
17	Minutes after reference time of data cut-off
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18 (see Note 2)
23	Type of first fixed surface (see Code Table 4.5)
24	Scale factor of first fixed surface
25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface
35-36	Year |
37	Month |
38	Day |Time of end of overall time interval
39	Hour |
40	Minute |
41	Second
42	n - Number of time range specifications describing the time intervals used to calculate the statistically processed field
43-46	Total number of data values missing in statistical process.
	47-58 Specification of the outermost (or only) time range over which statistical processing is done
47	Statistical process used to calculate the processed field from the field at each time increment during the time range (see Code Table 4.10)
48	Type of time increment between successive fields used in the statistical processing (see Code Table 4.11)
49	Indicator of unit of time for time range over which statistical processing is done (see Code Table 4.4)
50-53	Length of the time range over which statistical processing is done, in units defined by the previous octet
54	Indicator of unit of time for the increment between the successive fields used (see Code Table 4.4)
55-58	Time increment between successive fields, in units defined by the previous octet (see Note 3)
	*59-nn These octets are included only if n>1, where nn = 46 + 12*n*
59-70	As octets 47 to 58, next innermost step of processing
71-nn	Additional time range specifications, included in accordance with the value of n. Contents as octets 47 to 58, repeated as necessary.

Notes:

(1) Hours greater than 65534 will be coded as 65534.

(2) The reference time in section 1 and the forecast time together define the beginning of the overall time interval.

(3) An increment of zero means that the statistical processing is the result of a continuous (or near continuous) process, not the processing of a number of discrete samples. Examples of such continuous processes are the temperatures measured by analogue maximum and minimum thermometers or thermographs, and the rainfall measured by a rain gauge.

(4) The reference and forecast times are successively set to their initial values plus or minus the increment, as defined by the type of time increment (one of octets 48, 60, 72 ...). For all but the innermost (last) time range, the next inner range is then processed using these reference and forecast times as the initial reference and forecast time.

Product Definition Template 4.9: Probability forecasts at a horizontal level or in a horizontal layer in a continuous or non-continuous time interval

Preliminary Note: *This template was not validated at the time of publication and should be used with caution. Please report any use to WMO Secretariat (World Weather Watch - Basic Systems Department) to assist for validation.*

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1)
11	Parameter number (see Code Table 4.2)
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating Centre)
14	Forecast generating process identifier (defined by originating Centre)
15-16	Hours after reference time of data cut-off (see Note 1)
17	Minutes after reference time of data cut-off
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18 (see Note 2)
23	Type of first fixed surface (see Code Table 4.5)
24	Scale factor of first fixed surface
25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface
35	Forecast probability number
36	Total number of forecast probabilities
37	Probability type (see Code Table 4.9)
38	Scale factor of lower limit
39-42	Scaled value of lower limit
43	Scale factor of upper limit
44-47	Scaled value of upper limit
48-49	Year of end of overall time interval
50	Month of end of overall time interval
51	Day of end of overall time interval
52	Hour of end of overall time interval
53	Minute of end of overall time interval
54	Second of end of overall time interval
55	n - Number of time range specifications describing the time intervals used to calculate the statistically processed field
56-59	Total number of data values missing in statistical process.
60-71	*Specification of the outermost (or only) time range over which statistical processing is done*
60	Statistical process used to calculate the processed field from the field at each time increment during the time range (see Code Table 4.10)
61	Type of time increment between successive fields used in the statistical processing (see Code Table 4.11)
62	Indicator of unit of time for time range over which statistical processing is done (see Code Table 4.4)

63-66 Length of the time range over which statistical processing is done, in units defined by the previous octet
67 Indicator of unit of time for the increment between the successive fields used (see Code Table 4.4)
68-71 Time increment between successive fields, in units defined by the previous octet (see Note 3)

*72-nn These octets are included only if n>1, where nn = 59 + 12*n*

72-83 As octets 60 to 71, next innermost step of processing
84-nn Additional time range specifications, included in accordance with the value of n. Contents as octets 60 to 71, repeated as necessary.

Notes:

(1) Hours greater than 65534 will be coded as 65534.

(2) The reference time in section 1 and the forecast time together define the beginning of the overall time interval.

(3) An increment of zero means that the statistical processing is the result of a continuous (or near continuous) process, not the processing of a number of discrete samples. Examples of such continuous processes are the temperatures measured by analogue maximum and minimum thermometers or thermographs, and the rainfall measured by a rain gauge. The reference and forecast times are successively set to their initial values plus or minus the increment, as defined by the type of time increment (one of octets 46, 58, 70 ...). For all but the innermost (last) time range, the next inner range is then processed using these reference and forecast times as the initial reference and forecast time.

Product Definition Template 4.10: Percentile forecasts at a horizontal level or in a horizontal layer in a continuous or non-continuous time interval

Preliminary Note: This template was not validated at the time of publication and should be used with caution. Please report any use to WMO Secretariat (World Weather Watch - Basic Systems Department) to assist for validation.

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1)
11	Parameter number (see Code Table 4.2)

12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating Center)
14	Forecast generating process identifier (defined by originating Center)
15-16	Hours after reference time of data cut-off (see Note 1)
17	Minutes after reference time for data cut-off
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by previous octet (see Note 2)
23	Type of first fixed surface (see Code Table 4.5)
24	Scale factor of first fixed surface
25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface
35	Percentile value (from 100% to 0%)
36-37	Year of end of overall time interval
38	Month of end of overall time interval
39	Day of end of overall time interval
40	Hour of end of overall time interval
41	Minute of end of overall time interval
42	Second of end of overall time interval
43	n - Number of time range specifications describing the time intervals used to calculate the statistically processed field
44-47	Total number of data values missing in statistical process

48-59 Specification of the outermost (or only) time range over which statistical processing is done

48	Statistical process used to calculate the processed field from the field at each time increment during the time range (see Code Table 4.10)
49	Type of time increment between successive fields used in the statistical processing (see Code Table 4.11)
50	Indicator of unit of time for time range over which statistical processing is done (see Code Table 4.4)
51-54	Length of the time range over which statistical processing is done, in units defined by the previous octet
55	Indicator of unit of time for the increment between the successive fields used (see Code Table 4.4)
56-59	Time increment between successive fields, in units defined by the previous octet (see Note 3)

*60-nn These octets are included only if n>1, where nn = 47 + 12 * n*

60-71	As octets 48-59, next innermost step of processing
72-nn	Additional time range specifications, included in accordance with the value of n. Contents as octets 48 to 59, repeated as necessary.

Notes:

(1) Hours greater than 65534 will be coded as 65534.

(2) The reference time in section 1 and the forecast time together define the beginning of the overall time interval.

(3) An increment of zero means that the statistical processing is the result of a continuous (or near continuous) process, not the processing of a number of discrete samples. Examples of such continuous processes are the temperatures measured by analogue maximum and minimum thermometers or thermographs, and the rainfall measured by rain gauge.

Product Definition Template 4.20: Radar product

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1).
11	Parameter number (see Code Table 4.2).
12	Type of generating process (see Code Table 4.3)
13	Number of radar sites used
14	Indicator of unit of time range
15-18	Site latitude (in 10^{-6} degree)
19-22	Site longitude (in 10^{-6} degree)
23-24	Site elevation (meters)
25-28	Site ID (alphanumeric)
29-30	Site ID (numeric)
31	Operating mode (see Code Table 4.12)
32	Reflectivity calibration constant (tenths of dB)
33	Quality control indicator (see Code Table 4.13)
34	Clutter filter indicator (see Code Table 4.14)
35	Constant antenna elevation angle (tenths of degree true)
36-37	Accumulation interval (minutes)
38	Reference reflectivity for echo top (dB)
39-41	Range bin spacing (meters)
42-43	Radial angular spacing (tenths of degree true)

Product Definition Template 4.30: Satellite Product.

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1)
11	Parameter number (see Code Table 4.2)
12	Type of generating process (see Code Table 4.3)
13	Observation generating process identifier (defined by originating Centres)
14	Number of contributing spectral bands (NB)

Repeat the following 10 octets for each contributing band (nb = 1,NB)

(15+10(nb-1)) - (16+10(nb-1))	Satellite series of band nb (code table defined by originating/generating Centre)
(17+10(nb-1)) - (18+10(nb-1))	Satellite numbers of band nb (code table defined by originating/generating Centre)
(19+10(nb-1))	Instrument types of band nb (code table defined by originating/generating Centre)
(20+10(nb-1))	Scale factor of central wave number of band nb
(21+10(nb-1)) - (24+10(nb-1))	Scaled value of central wave number of band nb (units: m^{-1})

Product Definition Template 4.254: CCITT IA5 character string

Octet Number(s)	Contents
10	Parameter category (see Code Table 4.1).
11	Parameter number (see Code Table 4.2).
12-15	Number of characters

Product Definition Template 4.1000: Cross section of analysis and forecast at a point in time

Preliminary Note: This template is simply experimental, was not validated at the time of publication and should be used only for bi-lateral previously agreed tests.

Octet Numbers(s)	Contents
10	Parameter category (see Code Table 4.1).
11	Parameter number (see Code Table 4.2).
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating centre)
14	Analysis or forecast generating processes identifier (defined by originating centre)
15-16	Hours of observational data cutoff after reference time (see Note 1)
17	Minutes of observational data cutoff after reference time
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18

Note:

(1) Hours greater than 65534 will be coded as 65534.

Product Definition Template 4.1001: Cross section of averaged or otherwise statistically processed analysis or forecast over a range of time

Preliminary Note: This template is simply experimental, was not validated at the time of publication and should be used only for bi-lateral previously agreed tests.

Octet Numbers(s)	Contents
10	Parameter category (see Code Table 4.1).
11	Parameter number (see Code Table 4.2).
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating centre)
14	Analysis or forecast generating processes identifier (defined by originating centre)
15-16	Hours of observational data cutoff after reference time (see Note 1)
17	Minutes of observational data cutoff after reference time
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18
23-26	Total number of data values missing in statistical process.
	27-38 Specification of the outermost (or only) time range over which statistical processing is done
27	Statistical process used to calculate the processed field from the field at each time increment during the time range (see Code Table 4.10)
28	Type of time increment between successive fields used in the statistical processing (see Code Table 4.11)
29	Indicator of unit of time for time range over which statistical processing is done (see Code Table 4.4)
30-33	Length of the time range over which statistical processing is done, in units defined by the previous octet
34	Indicator of unit of time for the increment between the successive fields used (see Code Table 4.4)
35-38	Time increment between successive fields, in units defined by the previous octet (see Note 2)

Notes:

(1) Hours greater than 65534 will be coded as 65534.

(2) An increment of zero means that the statistical processing is the result of a continuous (or near continuous) process, not the processing of a number of discrete samples. Examples of such

continuous processes are the temperatures measured by analogue maximum and minimum thermometers or thermographs, and the rainfall measured by a rain gauge.

Product Definition Template 4.1002: Cross-section of analysis and forecast, averaged or otherwise statistically processed over latitude or longitude

Preliminary Note: This template is simply experimental, was not validated at the time of publication and should be used only for bi-lateral previously agreed tests.

Octet Numbers(s)	Contents
10	Parameter category (see Code Table 4.1).
11	Parameter number (see Code Table 4.2).
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating centre)
14	Analysis or forecast generating processes identifier (defined by originating centre)
15-16	Hours of observational data cutoff after reference time (see Note 1)
17	Minutes of observational data cutoff after reference time
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18
23	Horizontal dimension processed (see Code Table 4.220)
24	Treatment of missing data (e.g. below ground) (see Code Table 4.221)
25	Type of statistical processing (see Code Table 4.10)
26-29	Start of range
30-33	End of range
34-35	Number of values

Note:

(1) Hours greater than 65534 will be coded as 65534.

Product Definition Template 4.1100: Hovmöller-type grid with no averaging or other statistical processing

Preliminary Note: This template is simply experimental, was not validated at the time of publication and should be used only for bi-lateral previously agreed tests.

Octet Numbers(s)	Contents
10	Parameter category (see Code Table 4.1).
11	Parameter number (see Code Table 4.2).
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating centre)
14	Analysis or forecast generating processes identifier (defined by originating centre)
15-16	Hours of observational data cutoff after reference time (see Note 1)
17	Minutes of observational data cutoff after reference time
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18
23	Type of first fixed surface (see Code Table 4.5)
24	Scale factor of first fixed surface
25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface

Note:

(1) Hours greater than 65534 will be coded as 65534.

Product Definition Template 4.1101: Hovmöller-type grid with averaging or other statistical processing

Preliminary Note: This template is simply experimental, was not validated at the time of publication and should be used only for bi-lateral previously agreed tests. (Octets 35-50 very similar to octets 43-58 of PDT 4.8, but meaning of some fields differs slightly)

Octet Numbers(s)	Contents
10	Parameter category (see Code Table 4.1).
11	Parameter number (see Code Table 4.2).
12	Type of generating process (see Code Table 4.3)
13	Background generating process identifier (defined by originating centre)
14	Analysis or forecast generating processes identifier (defined by originating centre)
15-16	Hours of observational data cutoff after reference time (see Note 1)
17	Minutes of observational data cutoff after reference time
18	Indicator of unit of time range (see Code Table 4.4)
19-22	Forecast time in units defined by octet 18 (see Note 2)
23	Type of first fixed surface (see Code Table 4.5)
24	Scale factor of first fixed surface
25-28	Scaled value of first fixed surface
29	Type of second fixed surface (see Code Table 4.5)
30	Scale factor of second fixed surface
31-34	Scaled value of second fixed surface
35-38	Total number of data values missing in the statistical process
39	Statistical process used to calculate the processed field from the field at each time increment during the time range (see Code Table 4.10)
40	Type of time increment between successive fields used in the statistical processing (see Code Table 4.11)
41	Indicator of unit of time for time range over which statistical processing is done (see Code Table 4.4)
42-45	Length of the time range over which statistical processing is done, in units defined by the previous octet
46	Indicator of unit of time for increment between the successive fields used (see Code Table 4.4)
47-50	Time increment between successive fields, in units defined by the previous octet (see Note 3)

Notes:

(1) Hours greater than 65534 will be coded as 65534.

(2) *Reference = reference time (section 1) + forecast range (PDT) + offset and increments from reference time (GDT).*

(3) An increment of zero means that the statistical processing is the result of a continuous (or near continuous) process, not the processing of a number of discrete samples. Examples of such continuous processes are the temperatures measured by analogue maximum and minimum thermometers or thermographs, and the rainfall measured by a rain gauge.

TEMPLATE DEFINITIONS USED IN SECTION 5

Data Representation Template 5.0: Grid point data - simple packing

Octet Number(s)	Contents
12-15	Reference value (R) (IEEE 32-bit floating-point value)
16-17	Binary scale factor (E)
18-19	Decimal scale factor (D)
20	Number of bits used for each packed value for simple packing, or for each group reference value for complex packing or spatial differencing
21	Type of original field values (see Code Table 5.1)

Data Representation Template 5.1: Matrix values at grid point -simple packing

Preliminary Note: *This template was not validated at the time of publication and should be used with caution. Please report any use to WMO Secretariat (World Weather Watch - Basic Systems Department) to assist for validation.*

Octet Number(s)	Contents
12-21	Same as Data Representation Template 5.0
22	0, no matrix bit maps present; 1 matrix bit maps present.
23-26	Number of data values encoded in Section 7
27-28	NR - first dimension (rows) of each matrix.
29-30	NC - second dimension (columns) of each matrix.
31	First dimension coordinate value definition (Code Table 5.2)
32	NC1 - number of coefficients or values used to specify first dimension coordinate function.
33	Second dimension coordinate value definition (Code Table 5.2)
34	NC2 - number of coefficients or values used to specify second dimension coordinate function
35	First dimension physical significance (Code Table 5.3)
36	Second dimension physical significance (Code Table 5.3)
37-(36+NC1*4)	Coefficients to define first dimension coordinate values in functional form, or the explicit coordinate values (IEEE 32-bit floating-point value)
(37+NC1*4)- (36+4(NC1+NC2))	Coefficients to define second dimension coordinate values in functional form, or the explicit coordinate values (IEEE 32-bit floating-point value)

Notes:

(1) This form of representation enables a matrix of values to be depicted at each grid point; the two dimensions of the matrix may represent coordinates expressed in terms of two elemental parameters (e.g. direction and frequency for wave spectra). The numeric values of these coordinates, beyond that of simple subscripts, can be given in a functional form, or as a collection of explicit numbers.

(2) Some simple coordinate functional forms are tabulated in Code Table 5.2. Where a more complex coordinate function applies, the coordinate values shall be explicitly denoted by the inclusion of the actual set of values rather than the coefficients. This shall be indicated by a code figure 0 from Code Table 5.2; the number of explicit values coded shall be equal to the appropriate dimension of the matrix for which values are presented and they shall follow octet 36 in place of the coefficients.

(3) Matrix bit maps will be present only if indicated by octet 22. If present, there shall be one bit map for each grid point with data values, as defined by the primary bit map in Section 6, each of length (NR*NC) bits: a bit set to 1 will indicate a data element at the corresponding location within the matrix. Bit maps shall be represented end-to-end, without regard for octet boundaries; the last bit map shall, if necessary, be followed by bits set to zero to fill any partially used octet.

(4) Matrices restricted to scanning in the + i direction (left to right) and in the -j direction (top to bottom).

Data Representation Template 5.2: Grid point data - complex packing

Octet Number(s)	Contents
12-21	Same as Data Representation Template 5.0
22	Group splitting method used (see Code Table 5.4)
23	Missing value management used (see Code Table 5.5)
24-27	Primary missing value substitute
28-31	Secondary missing value substitute
32-35	NG - Number of groups of data values into which field is split
36	Reference for group widths (see Note 12)
37	Number of bits used for the group widths (after the reference value in octet 36 has been removed)
38-41	Reference for group lengths (see Note 13)
42	Length increment for the group lengths (see Note 14)
43-46	True length of last group
47	Number of bits used for the scaled group lengths (after subtraction of the reference value given in octets 38-41 and division by the length increment given in octet 42)

Notes:

(1) Group lengths have no meaning for row by row packing, where groups are coordinate lines (so the Grid Description Section and possibly the Bit-map Section are enough); for consistency associated field width and reference should then be encoded as 0.

(2) For row by row packing with a bit-map, there should always be as many groups as rows. In case of rows with only missing values, all associated descriptors should be coded as zero.

(3) Management of widths into a reference and increments, together with management of lengths as scaled incremental values, are intended to save descriptor size (which is an issue as far as compression gains are concerned).

(4) Management of explicitly missing values is an alternative to bit-map use within Section 6; it is intended to reduce the whole GRIB message size.

(5) There may be two types of missing value(s), such as to make a distinction between static misses (for instance, due to a land/sea mask) and occasional misses.

(6) As an extra option, substitute value(s) for missing data may be specified. If not wished (or not applicable), all bits should be set to 1 for relevant substitute value(s).

(7) If substitute value(s) are specified, type of content should be consistent with original field values (floating-point -and then IEEE 32-bit encoded-, or integer).

(8) If primary missing values are used, such values are encoded within appropriate group with all bits set to 1 at packed data level.

(9) If secondary missing values are used, such values are encoded within appropriate group with all bits set to 1, except the last one set to 0, at packed data level.

(10) A group containing only missing values (of either type) will be encoded as a constant group (null width, no associated data) and the group reference will have all bits set to 1 for primary type, and all bits set to 1, except the last bit set to 0, for secondary type.

(11) If necessary, group widths and/or field width of group references may be enlarged to avoid ambiguities between missing value indicator(s) and true data.

(12) The group width is the number of bits used for every value in a group.

(13) The group length (L) is the number of values in a group.

(14) The essence of the complex packing method is to subdivide a field of values into NG groups, where the values in each group have similar sizes. In this procedure, it is necessary to retain enough information to recover the group lengths upon decoding. The NG group lengths for any given field can be described by Ln = ref + Kn * len_inc, n = 1,NG, where ref is given by octets 38-41 and len_inc by octet 42. The NG values of K (the scaled group lengths) are stored in the Data Section, each with the number of bits specified by octet 47. Since the last group is a special case which may not be able to be specified by this relationship, the length of the last group is stored in octets 43-46.

Data Representation Template 5.3: Grid point data - complex packing and spatial differencing

Octet Number(s)	Contents
12- 47	Same as Data Representation Template 5.2
48	Order of spatial differencing (see Code Table 5.6)

49	Number of octets required in the Data Section to specify extra descriptors needed for spatial differencing (octets 6-ww in Data Template 7.3)

Notes:

(1) Spatial differencing is a pre-processing before group splitting at encoding time. It is intended to reduce the size of sufficiently smooth fields, when combined with a splitting scheme as described in Data Representation Template 5.2. At order 1, an initial field of values f is replaced by a new field of values g, where $g_1 = f_1$, $g_2 = f_2 – f_1$, …, $g_n = f_n – f_{n-1}$. At order 2, the field of values g is itself replaced by a new field of values h, where $h_1 = f_1$, $h_2 = f_2$, $h_3 = g_3 – g_2$, …, $h_n = g_n – g_{n-1}$. To keep values positive, the overall minimum of the resulting field (either g_{min} or h_{min}) is removed. At decoding time, after bit string unpacking, the original scaled values are recovered by adding the overall minimum and summing up recursively.

(2) For differencing of order n, the first n values in the array that are not missing are set to zero in the packed array. These dummy values are not used in unpacking.

Data Representation Template 5.50: Spectral data - simple packing

Octet Number(s)	Contents
12-15	Reference value (R) (IEEE 32-bit floating-point value)
16-17	Binary scale factor (E)
18-19	Decimal scale factor (D)
20	Number of bits used for each packed value (field width)
21-24	Real part of (0,0) coefficient (IEEE 32-bit floating-point value)

Notes:

(1) Removal of the real part of (0,0) coefficient from packed data is intended to reduce the variability of the coefficients, in order to improve packing accuracy.

(2) For some spectral representations, the (0,0) coefficient represents the mean value of the parameter represented.

Data Representation Template 5.51: Spherical harmonics data - complex packing

Octet Number(s)	Contents
12-20	Same as Data Representation Template 5.50
21-24	P - Laplacian scaling factor (expressed in 10^{-6} units)
25-26	J_S - pentagonal resolution parameter of the unpacked subset (see Note 1)
27-28	K_S - pentagonal resolution parameter of the unpacked subset (see Note 1)
29-30	M_S - pentagonal resolution parameter of the unpacked subset (see Note 1)
31-34	T_S - total number of values in the unpacked subset (see Note 1)
35	Precision of the unpacked subset (see Code Table 5.7)

Notes:

(1) The unpacked subset is a set of values defined in the same way as the full set of values (on a spectrum limited to J_S, K_S and M_S), but on which scaling and packing are not applied. Associated values are stored in octets 6 onwards of Section 7.

(2) The remaining coefficients are multiplied by $(n*(n+1))^P$, scaled and packed. The operator associated with this multiplication is derived from the laplacian operator on the sphere.

(3) The retrieval formula for a coefficient of wave number n is then:

$Y = (R+X*2^E)*10^{-D}* (n*(n+1))^{-P}$ where X is the packed scaled value associated with the coefficient

TEMPLATE DEFINITIONS USED IN SECTION 7

Data Template 7.0: Grid point data - simple packing

Octet Number(s)	Contents
6-nn	Binary data values - binary string, with each (scaled) data value

Data Template 7.1: Matrix values at grid point -simple packing

Preliminary Note: This template was not validated at the time of publication and should be used with caution. Please report any use to WMO Secretariat (World Weather Watch - Basic Systems Department) to assist for validation

Octet Number(s)	Contents
6-nn	Binary data values - binary string, with each (scaled) data value

Note:
(1) Group descriptors mentioned above may not be physically present; if associated field width is 0.

Data Template 7.2: Grid point data - complex packing

Octet Number(s)	Contents
6-xx	NG group reference values (XI in the decoding formula), each of which is encoded using the number of bits specified in octet 20 of Data Representation Template 5.0. Bits set to zero shall be appended as necessary to ensure this sequence of numbers ends on an octet boundary.
[xx+1]-yy	NG group widths, each of which is encoded using the number of bits specified in octet 37 of Data Representation Template 5.2. Bits set to zero shall be appended as necessary to ensure this sequence of numbers ends on an octet boundary.
[yy+1]-zz	NG scaled group lengths, each of which is encoded using the number of bits specified in octet 47 of Data Representation Template 5.2. Bits set to zero shall be appended as necessary to ensure this sequence of numbers ends on an octet boundary. (see Note 14 of Data Representation Template 5.2)
[zz+1]-nn	Packed values (X2 in the decoding formula), where each value is a deviation from its respective group reference value.

Notes:
(1) Group descriptors mentioned above may not be physically present; if associated field width is 0.
(2) Group lengths have no meaning for row by row packing; for consistency associated field width should then be encoded as 0. So no specific test for row by row case is mandatory at decoding software level to handle encoding/decoding of group descriptors.
(3) Scaled group lengths, if present, are encoded for each group. But the true last group length (unscaled) should be taken from Data Representation Template.
(4) For groups with a constant value, associated field width is 0, and no incremental data are physically present.

Data Template 7.3: **Grid point data - complex packing and spatial differencing**

Octet Number(s)	Contents
6-ww	First value(s) of original (undifferenced) scaled data values, followed by the overall minimum of the differences. The number of values stored is 1 greater than the order of differentiation, and the field width is described at octet 49 of Data Representation Template 5.3. (see Note 1)
[ww+1]-xx	NG group reference values (X1 in the decoding formula), each of which is encoded using the number of bits specified in octet 20 of Data Representation Template 5.0. Bits set to zero shall be appended where necessary to ensure this sequence of numbers

	ends on an octet boundary.
[xx+1]-nn	Same as for Data Representation Template 7.2.

Notes:

(1) Referring to the notation in Note (1) of Data Representation Template 5.3, at order 1, the values stored in octets 6-ww are g_1 and g_{min}. At order 2, the values stored are h_1, h_2, and h_{min}.

(2) Extra descriptors related to spatial differencing are added before the splitting descriptors, to reflect the separation between the 2 approaches. It enables to share software parts between cases with and without spatial differencing.

(3) The position of overall minimum after initial data values is a choice that enables less software management.

(4) Overall minimum will be negative in most cases. First bit should indicate the sign: 0 if positive, 1 if negative.

Data Template 7.50: Spectral data - simple packing

Octet Number(s)	Contents
6-nn	Binary data values - binary string, with each (scaled) data value

Data Template 7.51: Spherical harmonics - complex packing

Octet Number(s)	Contents
6-(5+I*T_S)	Data values from the unpacked subset (IEEE floating-point values on I octets)
(6+I*T_S)-nn	Binary data values - binary string, with each (scaled) data value out of the unpacked subset

Notes:

(1) Values ordering within the unpacked subset is defined according to the source of grid definition associated with the data

(2) Number of octets associated with each value of the unpacked subset (I) is defined in Code Table 5.7, according to the actual value in octet 35 of Data Representation Template 5.51

(3) Values ordering within the packed data is done according to the source of grid definition, skipping the values processed in the unpacked subset

CODE AND FLAG TABLES

CODE TABLES USED IN SECTION 0

Code Table 0.0: Discipline of processed data in the GRIB message, number of GRIB Master Table

Code figure	Meaning
0	Meteorological products
1	Hydrological products
2	Land surface products
3	Space products
4-9	Reserved
10	Oceanographic products
11-191	Reserved
192-254	Reserved for local use
255	Missing

CODE TABLES USED IN SECTION 1

Code Table 1.0: GRIB Master Tables Version Number

Code figure	Meaning
0	Experimental
1	Initial operational version number
2-254	future operational version numbers
255	local table used

Code Table 1.1: GRIB Local Tables Version Number

Code figure	Meaning
0	Local tables not used
1-254	Number of local tables version used
255	Missing

Code Table 1.2: Significance of Reference Time

Code figure	Meaning
0	Analysis
1	Start of forecast
2	Verifying time of forecast
3	Observation time
4-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 1.3: Production status of data

Code figure	Meaning
0	Operational products
1	Operational test products
2	Research products
3	Re-analysis products
4-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 1.4: Type of data

Code figure	Meaning
0	Analysis products
1	Forecast products
2	Analysis and forecast products
3	Control forecast products
4	Perturbed forecast products
5	Control and perturbed forecast products
6	Processed satellite observations
7	Processed radar observations
8-191	Reserved
192-254	Reserved for local use
255	Missing

Note: An initialized analysis is considered a zero-hour forecast

CODE AND FLAG TABLES USED IN SECTION 3

Code Table 3.0: Source of Grid Definition

Code figure	Meaning	Comments
0	Specified in Code table 3.1	
1	Predetermined grid definition	Defined by originating centre
2-191	Reserved	
192-254	Reserved for local use	
255	A grid definition does not apply to this product	

Code Table 3.1: Grid Definition Template Number

Code figure	Meaning	Comments
0	Latitude/longitude	Also called equidistant cylindrical, or Plate Carree.
1	Rotated latitude/longitude	
2	Stretched latitude/longitude	
3	Stretched and rotated latitude/longitude	
4-9	Reserved	
10	Mercator	
11-19	Reserved	
20	Polar stereographic	can be south or north.
21-29	Reserved	
30	Lambert Conformal	can be secant or tangent, conical or bipolar. (Also called Albers equal-area.)
31-39	Reserved	
40	Gaussian latitude/longitude	
41	Rotated Gaussian latitude/longitude	
42	Stretched Gaussian latitude/longitude	
43	Stretched and rotated Gaussian latitude/longitude	
44-49	Reserved	
50	Spherical harmonic coefficients	
51	Rotated spherical harmonic coefficients	
52	Stretched spherical harmonic coefficients	
53	Stretched and rotated spherical harmonic coefficients	
54-89	Reserved	
90	Space view perspective orthographic.	
91-99	Reserved	
100	Triangular grid based on an icosahedron	
101-109	Reserved	
110	Equatorial azimuthal equidistant projection	
111-119	Reserved	
120	Azimuth-range projection	
121- 999	Reserved	
1000	Cross-section grid, with points equally spaced on the horizontal	
1001-1099	Reserved	
1100	Hovmöller diagram grid, with points equally spaced on the horizontal	
1101- 1199	Reserved	
1200	Time section grid	
1201-32767	Reserved	
32768-65534	Reserved for local use	
65535	Missing	

Code Table 3.2: Shape of the Earth

Code figure	Meaning
0	Earth assumed spherical with radius = 6367.47 km
1	Earth assumed spherical with radius specified by data producer
2	Earth assumed oblate spheroid with size as determined by IAU in 1965 (major axis = 6378.160 km, minor axis = 6356.775 km, f = 1/297.0)
3	Earth assumed oblate spheroid with major and minor axes specified by data producer
4	Earth assumed oblate spheroid as defined in IAG-GRS80 model (major axis = 6378137.0 m, minor axis = 6356752.314 m, f = 1/298.257222101)
5	Earth assumed represented by WGS84 (as used by ICAO since 1998)
6	Earth assumed spherical with radius of 6371229.0 m
7-191	Reserved
192-254	Reserved for local use
255	Missing

Note:
WGS84 is a geodetic system that uses IAG-GRS80 as basis.

Flag Table 3.3: Resolution and Component Flags

Bit Number	Value	Meaning
1-2		Reserved
3	0	i direction increments not given
	1	i direction increments given
4	0	j direction increments not given
	1	j direction increments given
5	0	Resolved u- and v- components of vector quantities relative to easterly and northerly directions
	1	Resolved u- and v- components of vector quantities relative to the defined grid in the direction of increasing x and y (or i and j) coordinates respectively
6-8		Reserved - set to zero

Flag Table 3.4: Scanning Mode

Bit Number	Value	Meaning
1	0	Points of first row or column scan in the +i (+x) direction
	1	Points of first row or column scan in the -i (-x) direction
2	0	Points of first row or column scan in the -j (-y) direction
	1	Points of first row or column scan in the +j (+y) direction
3	0	Adjacent points in i (x) direction are consecutive
	1	Adjacent points in j (y) direction is consecutive
4	0	All rows scan in the same direction
	1	Adjacent rows scans in the opposite direction
5-8		Reserved

Notes:
(1) i direction: west to east along a parallel or left to right along an X-axis
(2) j direction: south to north along a meridian, or bottom to top along a Y-axis
(3) If bit number 4 is set, the first row scan is as defined by previous flags

---

Flag Table 3.5: Projection Centre

Bit Number	Value	Meaning
1	0	North Pole is on the projection plane
	1	South Pole is on the projection plane
2	0	Only one projection centre is used
	1	Projection is bi-polar and symmetric

Code Table 3.6: Spectral data representation type

Code figure	Meaning
1	The Associated Legendre Functions of the first kind are defined by:

$$P_n^m(\mu) = \sqrt{(2n+1)\frac{(n-m)!}{(n+m)!}}\,\frac{1}{2^n\,n!}\left(1-\mu^2\right)^{\frac{m}{2}}\frac{d^{n+m}}{d\mu^{n+m}}(\mu^2-1)^n, m \geq 0$$

$$P_n^{-m}(\mu) = P_n^m(\mu)$$

A field $F(\lambda, \mu)$ is represented by:

$$F(\lambda,\mu) = \sum_{m=-m}^{M}\sum_{n=|m|}^{N(m)} F_n^m P_n^m(\mu) e^{im\lambda}$$

where λ is the longitude,
μ the sine of latitude,
and F_n^{-m} the complex conjugate of F_n^m

Code Table 3.7: Spectral data representation mode

Code figure	Meaning
0	Reserved
1	The complex numbers F_n^m (see code figure 1 in Code Table 3.6 above) are stored for m≥0 as pairs of real numbers $Re(F_n^m)$, $Im(F_n^m)$ ordered with n increasing from m to N(m), first for m=0 and then for m=1, 2, ... M. (see Note 1)
2-254	Reserved
255	Missing

Note:

(1) Values of N(m) for common truncations cases:

Triangular	M = J = K,	N(m) = J
Rhomboidal	K = J + M,	N(m) = J+m
Trapezoidal	K = J, K > M,	N(m) = J

Code table 3.8: Grid point position

Code Figure	Meaning
0	Grid points at triangle vertices
1	Grid points at centres of triangles
2	Grid points at midpoints of triangle sides
3-191	Reserved

192-254	Reserved for local use
255	Missing

Flag table 3.9: Numbering order of diamonds as seen from the corresponding pole

Bit No.	Value	Meaning
1	0	Clockwise orientation
	1	Anti-clockwise (i.e., counter-clockwise) orientation
2-8		Reserved

Flag table 3.10: Scanning mode for one diamond

Bit No.	Value	Meaning
1	0	Points scan in +i direction, i.e. from pole to equator
	1	Points scan in -i direction, i.e. from equator to pole
2	0	Points scan in +j direction, i.e. from west to east
	1	Points scan in -j direction, i.e. from east to west
3	0	Adjacent points in i direction are consecutive
	1	Adjacent points in j direction is consecutive
4-8		Reserved

Code table 3.11 Interpretation of list of numbers defining number of points

Code figure	Meaning
0	There is no appended list
1	Numbers define number of points corresponding to full coordinate circles (i.e. parallels), coordinate values on each circle are multiple of the circle mesh, and extreme coordinate values given in grid definition (i.e. extreme longitudes) may not be reached in all rows
2	Numbers define number of points corresponding to coordinate lines delimited by extreme coordinate values given in grid definition (i.e. extreme longitudes) which are present in each row
3-254	Reserved
255	Missing

Code table 3.15 Physical meaning of vertical coordinate

Code Figure	Meaning	Unit
0-19	Reserved	
20	Temperature	K
21-99	Reserved	
100	Pressure	Pa
101	Pressure deviation from mean sea level	Pa
102	Altitude above mean sea level	m
103	Height above ground (see Note 1)	m
104	Sigma coordinate	
105	Hybrid coordinate	
106	Depth below land surface	m
107	Potential temperature (theta)	K
108	Pressure deviation from ground to level	Pa
109	Potential vorticity	$K\ m^{-2}\ kg^{-1}\ s^{-1}$
110	Geometrical height	m
111	Eta coordinate (see Note 2)	
112	Geopotential height	gpm
113-159	Reserved	
160	Depth below sea level	m
161-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Notes:

(1) Negative values associated to this coordinate will indicate depth below ground surface. If values are all below surface, use of entry 106 is recommended, with positive coordinate values instead.

(2) The Eta vertical coordinate system involves normalizing the pressure at some point on a specific level by the mean sea level pressure at that point.

Code Table 3.20: Type of horizontal line

Code figure	Meaning
0	Rhumb
1	Great circle
2-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 3.21: Vertical dimension coordinate values definition

Code Figure	Meaning
0	Explicit coordinate values set
1	Linear coordinates f(1)=C1 f(n)=f (n-1)+C2
2-10	Reserved
11	Geometric coordinates f (1)=C1 f(n)=C2*f(n-1)
12-191	Reserved
192-254	Reserved for local use
255	Missing

CODE AND FLAG TABLES USED IN SECTION 4

Code Table 4.0: Product Definition Template Number

Number	Description
0	Analysis or forecast at a horizontal level or in a horizontal layer at a point in time
1	Individual ensemble forecast, control and perturbed, at a horizontal level or in a horizontal layer at a point in time
2	Derived forecast based on all ensemble members at a horizontal level or in a horizontal layer at a point in time
3	Derived forecasts based on a cluster of ensemble members over a rectangular area at a horizontal level or in a horizontal layer at a point in time
4	Derived forecasts based on a cluster of ensemble members over a circular area at a horizontal level or in a horizontal layer at a point in time
5	Probability forecasts at a horizontal level or in a horizontal layer at a point in time
6	Percentile forecasts at a horizontal level or in a horizontal layer at a point in time
7	Analysis or forecast error at a horizontal level or in a horizontal layer at a point in time
8	Average, accumulation, extreme values or other statistically processed values at a horizontal level or in a horizontal layer in a continuous or non-continuous time interval
9	Probability forecasts at a horizontal level or in a horizontal layer in a continuous or non-continuous time interval
10	Percentile forecasts at a horizontal level or in a horizontal layer in a continuous or non-continuous time interval
11-19	Reserved
20	Radar product
21-29	Reserved
30	Satellite product
31-253	Reserved
254	CCITT IA5 character string

255-999	Reserved
1000	Cross section of analysis and forecast at a point in time
1001	Gross section of averaged or otherwise statistically processed analysis or forecast over a range of time
1002	Cross section of analysis and forecast, averaged or otherwise statistically processed
1003-1099	Reserved
1100	Hovmöller-type grid with no averaging or other statistical processing
1101	Hovmöller-type grid with averaging or other statistical processing
1102-32767	Reserved
32768-65534	Reserved for local use
65535	Missing

Code Table 4.1: Category of parameters by product discipline

Product Discipline 0: Meteorological products

Category	Description
0	Temperature
1	Moisture
2	Momentum
3	Mass
4	Short-wave Radiation
5	Long-wave Radiation
6	Cloud
7	Thermodynamic Stability indices
8	Kinematic Stability indices
9	Temperature Probabilities
10	Moisture Probabilities
11	Momentum Probabilities
12	Mass Probabilities
13	Aerosols
14	Trace gases (e.g., ozone, CO2)
15	Radar
16	Forecast Radar Imagery
17	Electro-dynamics
18	Nuclear/radiology
19	Physical atmospheric properties
20-189	Reserved
190	CCITT IA5 string
191	Miscellaneous
192-254	Reserved for local use
255	Missing

Product Discipline 1: Hydrological products

Category	Description
0	Hydrology basic products
1	Hydrology probabilities
2-191	Reserved
192-254	Reserved for local use
255	Missing

Product Discipline 2: Land surface products

Category	Description
0	Vegetation/Biomass
1	Agri-/aquacultural Special Products

2	Transportation-related Products
3	Soil Products
4-191	Reserved
192-254	Reserved for local use
255	Missing

Product Discipline 3: Space Products

Category	Description
0	Image format products (see Note 1)
1	Quantitative products (see Note 2)
2-191	Reserved
192-254	Reserved for local use
255	Missing

Notes:

(1) Data are numeric without units, although they might be given quantitative meaning through a code table defined external to this document. The emphasis is on a displayable "picture" of some phenomenon, perhaps with certain enhanced features. Generally, each datum is an unsigned, one octet integer, but some image format products might have another datum size. The size of a datum is indicated in Section 5.

(2) Data are in specified physical units.

Product Discipline 10 - Oceanographic products

Category	Description
0	Waves
1	Currents
2	Ice
3	Surface Properties
4	Sub-surface Properties
5-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.2 Parameter number by product discipline and parameter category

Product Discipline 0: Meteorological products, Parameter Category 0: Temperature

Number	Parameter	Units
0	Temperature	K
1	Virtual temperature	K
2	Potential temperature	K
3	Pseudo-adiabatic potential temperature or equivalent potential temperature	K
4	Maximum temperature	K
5	Minimum temperature	K
6	Dew point temperature	K
7	Dew point depression (or deficit)	K
8	Lapse rate	$K\ m^{-1}$
9	Temperature anomaly	K
10	Latent heat net flux	$W\ m^{-2}$
11	Sensible heat net flux	$W\ m^{-2}$
12	Heat index	K
13	Wind chill factor	K
14	Minimum dew point depression	K
15	Virtual potential temperature	K
16-191	Reserved	

192-254	Reserved for local use	
255	Missing	

Product Discipline 0: Meteorological products, Parameter Category 1: Moisture

Number	Parameter	Units
0	Specific humidity	kg kg^{-1}
1	Relative humidity	%
2	Humidity mixing ratio	kg kg^{-1}
3	Precipitable water	kg $m-^{2}$
4	Vapor pressure	Pa
5	Saturation deficit	Pa
6	Evaporation	kg m^{-2}
7	Precipitation rate	kg m^{-2} s^{-1}
8	Total precipitation	kg m^{-2}
9	Large scale precipitation (non-convective)	kg m^{-2}
10	Convective precipitation	kg m^{-2}
11	Snow depth	m
12	Snowfall rate water equivalent	kg m^{-2} s^{-1}
13	Water equivalent of accumulated snow depth	kg m^{-2}
14	Convective snow	kg $m-^{2}$
15	Large scale snow	kg m^{-2}
16	Snow melt	kg $m-^{2}$
17	Snow age	day
18	Absolute humidity	kg m^{-3}
19	Precipitation type	code table (4.201)
20	Integrated liquid water	kg m^{-2}
21	Condensate	kg kg^{-1}
22	Cloud mixing ratio	kg kg^{-1}
23	Ice water mixing ratio	kg kg^{-1}
24	Rain mixing ratio	kg kg^{-1}
25	Snow mixing ratio	kg kg^{-1}
26	Horizontal moisture convergence	kg kg^{-1} s^{-1}
27	Maximum relative humidity	%
28	Maximum absolute humidity	kg m^{-3}
29	Total snowfall	m
30	Precipitable water category	code table (4.202)
31	Hail	m
32	Graupel (snow pellets)	kg kg^{-1}
33-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 0: Meteorological products, Parameter Category 2: Momentum

Number	Parameter	Units
0	Wind direction (from which blowing)	deg true
1	Wind speed	m s^{-1}
2	u-component of wind	m s^{-1}
3	v-component of wind	m s^{-1}
4	Stream function	m^2 s^{-1}
5	Velocity potential	m^2 s^{-1}
6	Montgomery stream function	m^2 s^{-2}
7	Sigma coordinate vertical velocity	s^{-1}
8	Vertical velocity (pressure)	Pa s^{-1}
9	Vertical velocity (geometric)	m s^{-1}
10	Absolute vorticity	s^{-1}
11	Absolute divergence	s^{-1}
12	Relative vorticity	s^{-1}

13	Relative divergence	s^{-1}
14	Potential vorticity	$K\ m^2\ kg^{-1}\ s^{-1}$
15	Vertical u-component shear	s^{-1}
16	Vertical v-component shear	s^{-1}
17	Momentum flux, u component	$N\ m$-^{2}
18	Momentum flux, v component	$N\ m^{-2}$
19	Wind mixing energy	J
20	Boundary layer dissipation	$W\ m^{-2}$
21	Maximum wind speed	$m\ s^{-1}$
22	Wind speed (gust)	$m\ s^{-1}$
23	u-component of wind (gust)	$m\ s^{-1}$
24	v-component of wind (gust)	$m\ s^{-1}$
25-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 0: Meteorological products, Parameter Category 3: Mass

Number	Parameter	Units
0	Pressure	Pa
1	Pressure reduced to MSL	Pa
2	Pressure tendency	$Pa\ s^{-1}$
3	ICAO Standard Atmosphere Reference Height	m
4	Geopotential	$m^2\ s^{-2}$
5	Geopotential height	gpm
6	Geometric height	m
7	Standard deviation of height	m
8	Pressure anomaly	Pa
9	Geopotential height anomaly	gpm
10	Density	$kg\ m^{-3}$
11	Altimeter setting	Pa
12	Thickness	m
13	Pressure altitude	m
14	Density altitude	m
15-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 0: Meteorological products, Parameter Category 4: Short-wave Radiation

Number	Parameter	Units
0	Net short-wave radiation flux (surface)	$W\ m^{-2}$
1	Net short-wave radiation flux (top of atmosphere)	$W\ m^{-2}$
2	Short wave radiation flux	$W\ m^{-2}$
3	Global radiation flux	$W\ m^{-2}$
4	Brightness temperature	K
5	Radiance (with respect to wave number)	$W\ m^{-1}\ sr^{-1}$
6	Radiance (with respect to wave length)	$W\ m^{-3}\ sr^{-1}$
7-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 0: Meteorological products, Parameter Category 5: Long-wave Radiation

Number	Parameter	Units
0	Net long wave radiation flux (surface)	$W\ m^{-2}$

1	Net long wave radiation flux (top of atmosphere)	W m^{-2}
2	Long wave radiation flux	W m^{-2}
3-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 0: Meteorological products, Parameter Category 6: Cloud

Number	Parameter	Units
0	Cloud Ice	kg m^{-2}
1	Total cloud cover	%
2	Convective cloud cover	%
3	Low cloud cover	%
4	Medium cloud cover	%
5	High cloud cover	%
6	Cloud water	kg m-^{2}
7	Cloud amount	%
8	Cloud type	code table (4.203)
9	Thunderstorm maximum tops	m
10	Thunderstorm coverage	code table (4.204)
11	Cloud base	m
12	Cloud top	m
13	Ceiling	m
14-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 0: Meteorological products, Parameter Category 7: Thermodynamic Stability Indices

Number	Parameter	Units
0	Parcel lifted index (to 500 hPa)	K
1	Best lifted index (to 500 hPa)	K
2	K index	K
3	KO index	K
4	Total totals index	K
5	Sweat index	numeric
6	Convective available potential energy	J kg^{-1}
7	Convective inhibition	J kg^{-1}
8	Storm relative helicity	J kg^{-1}
9	Energy helicity index	numeric
10-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 0: Meteorological products, Parameter Category 13: Aerosols

Number	Parameter	Units
0	Aerosol type	code table (4.205)
1-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 0: Meteorological products, Parameter Category 14: Trace Gases

Number	Parameter	Units
0	Total ozone	Dobson
1-191	Reserved	
192-254	Reserved for local use	

255	Missing	

Product Discipline 0 - Meteorological products, Parameter Category 15: Radar

Number	Parameter	Units
0	Base spectrum width	$m\ s^{-1}$
1	Base reflectivity	dB
2	Base radial velocity	$m\ s^{-1}$
3	Vertically-integrated liquid	$kg\ m^{-1}$
4	Layer-maximum base reflectivity	dB
5	Precipitation	$kg\ m^{-2}$
6	Radar spectra (1)	-
7	Radar spectra (2)	-
8	Radar spectra (3)	-
9-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 0: Meteorological products, Parameter Category 18: Nuclear/radiology

Number	Parameter	Units
0	Air concentration of Caesium 137	$Bq\ m^{-3}$
1	Air concentration of Iodine 131	$Bq\ m^{-3}$
2	Air concentration of radioactive pollutant	$Bq\ m^{-3}$
3	Ground deposition of Caesium 137	$Bq\ m^{-2}$
4	Ground deposition of Iodine 131	$Bq\ m^{-2}$
5	Ground deposition of radioactive pollutant	$Bq\ m^{-2}$
6-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 0: Meteorological products, Parameter Category 19: Physical atmospheric properties

Number	Parameter	Units
0	Visibility	m
1	Albedo	%
2	Thunderstorm probability	%
3	mixed layer depth	m
4	Volcanic ash	code table (4.206)
5	Icing top	m
6	Icing base	m
7	Icing	code table (4.207)
8	Turbulence top	m
9	Turbulence base	m
10	Turbulence	code table (4.208)
11	Turbulent kinetic energy	$J\ kg^{-1}$
12	Planetary boundary layer regime	code table (4.209)
13	Contrail intensity	code table (4.210)
14	Contrail engine type	code table (4.211)
15	Contrail top	m
16	Contrail base	m
17-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 0: Meteorological products, Parameter Category 253: ASCII character string.

Number	Parameter	Units
0	Arbitrary text string	CCITTIA5
1-191	Reserved	

192-254	Reserved for local use
255	Missing

Product Discipline 1: Hydrologic products, Parameter Category 0: Hydrology basic products

Number	Parameter	Units
0	Flash flood guidance *(Encoded as an accumulation over a floating subinterval of time between the reference time and valid time)*	kg m^{-2}
1	Flash flood runoff *(Encoded as an accumulation over a floating subinterval of time)*	kg m^{-2}
2	Remotely sensed snow cover	(code table 4.215)
3	Elevation of snow covered terrain	(code table 4.216)
4	Snow water equivalent percent of normal	%
5-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Notes:

(1) Remotely sensed snow cover is expressed as a field of dimensionless, thematic values. The currently accepted values are for no-snow/no-cloud, 50, for clouds, 100, and for snow, 250. See code table 4.215.

(2) A data field representing snow coverage by elevation portrays at which elevations there is a snow pack. The elevation values typically range from 0 to 90 in 100 m increments. A value of 253 is used to represent a no-snow/no-cloud data point. A value of 254 is used to represent a data point at which snow elevation could not be estimated because of clouds obscuring the remote sensor (when using aircraft or satellite measurements).

(3) Snow water equivalent percent of normal is stored in percent of normal units. For example, a value of 110 indicates 110 percent of the normal snow water equivalent for a given depth of snow.

Product Discipline 1: Hydrologic products, Parameter Category 1: Hydrology probabilities

Number	Parameter	Units
0	Conditional percent precipitation amount fractile for an overall period (*Encoded as an accumulation).*	kg m^{-2}
1	Percent precipitation in a sub-period of an overall period (*Encoded as per cent accumulation over the sub-period)*	%
2	Probability of 0.01 inch of precipitation (POP)	%
3-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 2: Land surface products, Parameter Category 0: Vegetation/Biomass

Number	Parameter	Units
0	Land cover (1=land, 2=sea)	Proportion
1	Surface roughness	m
2	Soil temperature	K
3	Soil moisture content	kg m^{-2}
4	Vegetation	%
5	Water runoff	kg m^{-2}
6	Evapotranspiration	kg $^{-2}$ s^{-1}

7	Model terrain height	m
8	Land use	code table (4.212)
9-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 2: Land surface products, Parameter Category 3: Soil Products

Number	Parameter	Units
0	Soil type	code table (4.213)
1	Upper layer soil temperature	K
2	Upper layer soil moisture	kg m^{-3}
3	Lower layer soil moisture	kg m^{-3}
4	Bottom layer soil temperature	K
5-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product discipline 3: Space products, Parameter Category 0: Image format products

Number	Parameter	Units
0	Scaled radiance	numeric
1	Scaled albedo	numeric
2	Scaled brightness temperature	numeric
3	Scaled precipitable water	numeric
4	Scaled lifted index	numeric
5	Scaled cloud top pressure	numeric
6	Scaled skin temperature	numeric
7-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 3: Space products, Parameter Category 1: Quantitative products

Number	Parameter	Units
0	Estimated precipitation	kg m^{-2}
1-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 10: Oceanographic products, Parameter Category 0: Waves

Number	Parameter	Units
0	Wave spectra (1)	-
1	Wave spectra (2)	-
2	Wave spectra (3)	-
3	Significant height of combined wind waves and swell	m
4	Direction of wind waves	Degree true
5	Significant height of wind waves	m
6	Mean period of wind waves	s
7	Direction of swell waves	Degree true
8	Significant height of swell waves	m
9	Mean period of swell waves	s
10	Primary wave direction	Degree true
11	Primary wave mean period	s

12	Secondary wave direction	Degree true
13	Secondary wave mean period	s
14-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 10: Oceanographic products, Parameter Category 1: Currents

Number	Parameter	Units
0	Current direction	Degree true
1	Current speed	$m\ s^{-1}$
2	u-component of current	$m\ s^{-1}$
3	v-component of current	$m\ s^{-1}$
4-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 10: Oceanographic products, Parameter Category 2: Ice

Number	Parameter	Units
0	Ice cover	Proportion
1	Ice thickness	m
2	Direction of ice drift	Degree true
3	Speed of ice drift	$m\ s^{-1}$
4	u-component of ice drift	$m\ s^{-1}$
5	v-component of ice drift	$m\ s^{-1}$
6	Ice growth rate	$m\ s^{-1}$
7	Ice divergence	s^{-1}
8-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 10: Oceanographic products, Parameter Category 3: Surface Properties

Number	Parameter	Units
0	Water temperature	K
1	Deviation of sea level from mean	m
2-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Product Discipline 10: Oceanographic products, Parameter Category 4: Sub-surface Properties

Number	Parameter	Units
0	Main thermocline depth	m
1	Main thermocline anomaly	m
2	Transient thermocline depth	m
3	Salinity	$kg\ kg^{-1}$
4-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Code table 4.3: Type of generating process

Code figure	Meaning
0	Analysis
1	Initialization
2	Forecast
3	Bias corrected forecast
4	Ensemble forecast
5	Probability forecast
6	Forecast error
7	Analysis error
8	Observation
9-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.4: Indicator of unit of time range

Code figure	Meaning
0	Minute
1	Hour
2	Day
3	Month
4	Year
5	Decade (10 years)
6	Normal (30 years)
7	Century (100 years)
8-9	Reserved
10	3 hours
11	6 hours
12	12 hours
13	Second
14-191	Reserved
192-254	Reserved for local use
255	Missing

Code table 4.5: Fixed surface types and units

Code Figure	Meaning	Units
0	Reserved	
1	Ground or water surface	-
2	Cloud base level	-
3	Level of cloud tops	-
4	Level of 0^{o} C isotherm	-
5	Level of adiabatic condensation lifted from the surface	-
6	Maximum wind level	-
7	Tropopause	-
8	Nominal top of the atmosphere	-
9	Sea bottom	-
10-19	Reserved	
20	Isothermal level	K
21-99	Reserved	
100	Isobaric surface	Pa
101	Mean sea level	
102	Specific altitude above mean sea level	m
103	Specified height level above ground	m
104	Sigma level	"sigma" value
105	Hybrid level	-

106	Depth below land surface	m
107	Isentropic (theta) level	K
108	Level at specified pressure difference from ground to level	Pa
109	Potential vorticity surface	$K\ m^2\ kg^{-1}\ s^{-1}$
110	Reserved	
111	Eta* level	-
112-116	Reserved	
117	Mixed layer depth	m
118-159	Reserved	
160	Depth below sea level	m
161-191	Reserved	
192-254	Reserved for local use	
255	Missing	

Note* The Eta vertical coordinate system involves normalizing the pressure at some point on a specific level by the mean sea level pressure at that point

Code Table 4.6: Type of ensemble forecast

Code figure	Meaning
0	Unperturbed high-resolution control forecast
1	Unperturbed low-resolution control forecast
2	Negatively perturbed forecast
3	Positively perturbed forecast
4-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.7: Derived forecast

Code figure	Meaning
0	Unweighted mean of all members
1	Weighted mean of all members
2	Standard deviation with respect to cluster mean
3	Standard deviation with respect to cluster mean, normalized
4-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.8: Clustering Method

Code figure	Meaning
0	Anomaly correlation
1	Root mean square
2-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.9: Probability Type

Code figure	Meaning
0	Probability of event below lower limit
1	Probability of event above upper limit
2	Probability of event between lower and upper limits. The range includes the lower limit but not the upper limit.
3	Probability of event above lower limit

4	Probability of event below upper limit
5-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.10: Type of statistical processing

Code figure	Meaning
0	Average
1	Accumulation
2	Maximum
3	Minimum
4	Difference (Value at the end of time range minus value at the beginning)
5	Root mean square
6	Standard deviation
7	Covariance (Temporal variance)
8	Difference (Value at the start of time range minus value at the end)
9	Ratio
10-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.11: Type of time intervals

Code figure	Meaning
0	Reserved
1	Successive times processed have same forecast time, start time of forecast is incremented
2	Successive times processed have same start time of forecast, forecast time is incremented
3	Successive times processed have start time of forecast incremented and forecast time decremented so that valid time remains constant
4	Successive times processed have start time of forecast decremented and forecast time incremented so that valid time remains constant
5	Floating subinterval of time between forecast time and end of overall time interval
6-191	Reserved
192-254	Reserved for local use
255	Missing

Note: Code figure 5 applies to instances where a single time subinterval was used to calculate the statistically processed field. The exact starting and ending times of the subinterval are not given, but it is known that it is contained inclusively between the beginning time and the ending time of the overall interval.

Code Table 4.12: Operating Mode

Code figure	Meaning
0	Maintenance Mode
1	Clear air
2	Precipitation
3 -191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.13: Quality Control Indicator

Code figure	Meaning
0	No quality control applied
1	Quality control applied
2-191	Reserved
192-254	Reserved for local use

255	Missing

Code Table 4.14: Clutter Filter Indicator

Code figure	Meaning
0	No clutter filter used
1	Clutter filter used
2-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.201: Precipitation Type

Code figure	Meaning
0	Reserved
1	Rain
2	Thunderstorm
3	Freezing rain
4	Mixed/ice
5	Snow
6-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.202: Precipitable water category

Code figure	Meaning
0-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.203: Cloud type

Code figure	Meaning
0	Clear
1	Cumulonimbus
2	Stratus
3	Stratocumulus
4	Cumulus
5	Altostratus
6	Nimbostratus
7	Altocumulus
8	Cirrostratus
9	Cirrocumulus
10	Cirrus
11	Cumulonimbus - ground based fog beneath the lowest layer
12	Stratus - ground based fog beneath the lowest layer
13	Stratocumulus - ground based fog beneath the lowest layer
14	Cumulus - ground based fog beneath the lowest layer
15	Altostratus - ground based fog beneath the lowest layer
16	Nimbostratus - ground based fog beneath the lowest layer
17	Altocumulus - ground based fog beneath the lowest layer
18	Cirrostratus - ground based fog beneath the lowest layer
19	Cirrocumulus - ground based fog beneath the lowest layer
20	Cirrus - ground based fog beneath the lowest layer
21-190	Reserved
191	Unknown
192-254	Reserved for local use

255	Missing

Note: Code figures 11-20 indicate all four layers were used and a ground-based fog is beneath the lowest layer.

Code Table 4.204: Thunderstorm coverage

Code figure	Meaning
0	None
1	Isolated (1% - 2%)
2	Few (3% - 15%)
3	Scattered (16% - 45%)
4	Numerous (> 45%)
5-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.205: Aerosol type

Code figure	Meaning
0	Aerosol not present
1	Aerosol present
2-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.206: Volcanic ash

Code figure	Meaning
0	Not present
1	Present
2-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.207: Icing

Code figure	Meaning
0	None
1	Light
2	Moderate
3	Severe
4-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.208: Turbulence

Code figure	Meaning
0	None (smooth)
1	Light
2	Moderate
3	Severe
4	Extreme
5-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.209: Planetary boundary layer regime

Code figure	Meaning
0	Reserved
1	Stable
2	Mechanically driven turbulence
3	Forced convection
4	Free convection
5-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.210: Contrail intensity

Code figure	Meaning
0	Contrail not present
1	Contrail present
2-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.211: Contrail engine type

Code figure	Meaning
0	Low bypass
1	High bypass
2	Non bypass
3-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.212: Land Use

Code figure	Meaning
0	Reserved
1	Urban land
2	Agriculture
3	Range land
4	Deciduous forest
5	Coniferous forest
6	Forest/wetland
7	Water
8	Wetlands
9	Desert
10	Tundra
11	Ice
12	Tropical forest
13	Savannah
14-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.213: Soil type

Code figure	Meaning
0	Reserved
1	Sand
2	Loamy sand
3	Sandy loam
4	Silt loam
5	Organic (redefined)
6	Sandy clay loam
7	Silt clay loam
8	Clay loam
9	Sandy clay
10	Silty clay
11	Clay
12-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.215: Remotely Sensed Snow Coverage

Code Figure	Meaning
0-49	Reserved
50	No-snow/no-cloud
51-99	Reserved
100	Clouds
101-249	Reserved
250	Snow
251-254	Reserved for local use
255	Missing

Code Table 4.216: Elevation of Snow Covered Terrain

Code Figure	Meaning
0-90	Elevation in increments of 100 m
91-253	Reserved
254	Clouds

255	Missing

Code Table 4.220: Horizontal dimension processed

Code figure	Meaning
0	Latitude
1	Longitude
2-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 4.221: Treatment of missing data

Code figure	Meaning
0	Not included
1	Extrapolated
2-191	Reserved
192-254	Reserved for local use
255	Missing

CODE AND FLAG TABLES USED IN SECTION 5

Code Table 5.0: Data Representation Template Number

Code figure	Meaning
0	Grid point data - simple packing
1	Matrix value - simple packing
2	Grid point data - complex packing
3	Grid point data - complex packing and spatial differencing
4-49	Reserved
50	Spectral data -simple packing
51	Spherical harmonics data - complex packing
52-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 5.1: Type of original field values

Code figure	Meaning
0	Floating point
1	Integer
2-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 5.2: Matrix coordinate value function definition.

Code Figure	Meaning
0	Explicit coordinate values set
1	Linear coordinates f(1)=C1 f(n)=f (n-1)+C2
2-10	Reserved
11	Geometric coordinates f (1)=C1 f(n)=C2*f(n-1)
12-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 5.3: Matrix coordinate parameter

Code Figure	Meaning
1	Direction Degrees true
2	Frequency (s^{-1})
3	Radial number (2pi/lambda) (m^{-1})
4-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 5.4: Group Splitting Method

Code figure	Meaning
0	Row by row splitting
1	General group splitting
2-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 5.5 Missing Value Management for Complex Packing

Code figure	Meaning
0	No explicit missing values included within data values
1	Primary missing values included within data values
2	Primary and secondary missing values included within data values
3-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 5.6: Order of Spatial Differencing

Code Figure	Meaning
0	Reserved
1	First-order spatial differencing
2	Second-order spatial differencing
3-191	Reserved
192-254	Reserved for local use
255	Missing

Code Table 5.7: Precision of floating-point numbers

Code figure	Meaning
0	Reserved
1	IEEE 32-bit (I=4 in Section 7)
2	IEEE 64-bit (I=8 in Section 7)
3	IEEE 128-bit (I=16 in Section 7)
4-254	Reserved
255	Missing

CODE AND FLAG TABLES USED IN SECTION 6

Code Table 6.0: Bit Map Indicator

Code figure	Meaning
0	A bit map applies to this product and is specified in this Section
1 - 253	A bit map pre-determined by the originating/generating Centre applies to this product and is not specified in this Section.
254	A bit map defined previously in the same "GRIB" message applies to this product.
255	A bit map does not apply to this product.

Attachment B

Definition of the Triangular Grid Based on an Icosahedron

Definition of the Triangular Grid Based on an Icosahedron

A triangular grid based on an icosahedron was first introduced in a meteorological model by **Sadourny et al.** (1968) and **Williamson** (1969). The approach outlined here, especially the code implementation, is based on the work of **Baumgardner** (1995).

To construct the triangular grid based on an icosahedron, the unit-sphere, i.e. a sphere with radius 1, is divided into 20 spherical triangles of equal size by placing a plane icosahedron into the sphere (Fig. 1). The 12 vertices of the icosahedron touch the sphere, one vertex coincide with the north pole (NP), the opposite one with the south pole (SP), for simplicity.

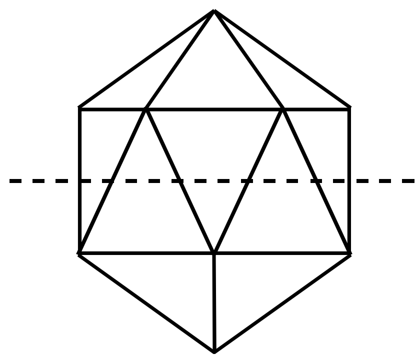

Figure 1 Plane icosahedron consisting of 20 plane triangles

The 12 vertices are connected by great circles to form 20 **main spherical triangles**. Since each of the 12 vertices is surrounded by 5 main spherical triangles (Fig. 2) the angles between two sides of the main triangles are $2\pi/5$ or 72°.

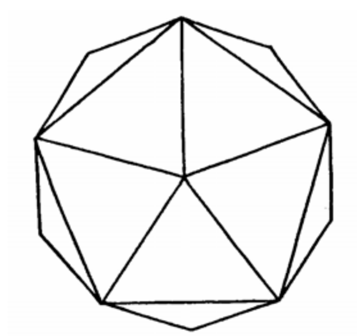

Figure 2 The five main spherical triangles at the north pole

The length w of a main triangle side follows from Fig. 3 and equation (1)

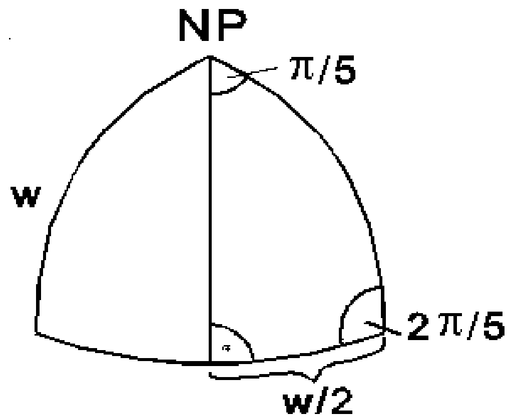

Figure 3 One main spherical triangle at the north pole

$$\cos\frac{1}{2}\,w = \frac{\cos\frac{\pi}{5}}{\sin 2\frac{\pi}{5}} = \frac{1}{2\sin\frac{\pi}{5}} \tag{1}$$

Thus w ~ 1.107149. On the unit-sphere, w is identical to $\pi/2 - \varphi$ with the latitude φ of the lower corner of the triangle. Thus w is a measure of the latitude of the lower vertices of the triangle in Fig. 3.

Two adjacent main spherical triangles are combined to form a "**diamond**", i.e. a logical square block. Five of the diamonds originate from the north pole, five from the south pole. The numbering and order of the diamonds are outlined in Fig. 4.

The diamonds 1 to 5 are the "northern" ones, i.e. they start at the north pole, diamonds 6 to 10 start at the south pole. The so called home vertex of each diamond (in the order 1, 6, 2, 7, 3, 8, 4, 9, 5, 10) is shifted by $\pi/5$ to the east starting at $-\pi/5$ for the first diamond. Thus the 10 home vertices have the following geographical co-ordinates (λ and φ) on the unit-sphere (Table 1).

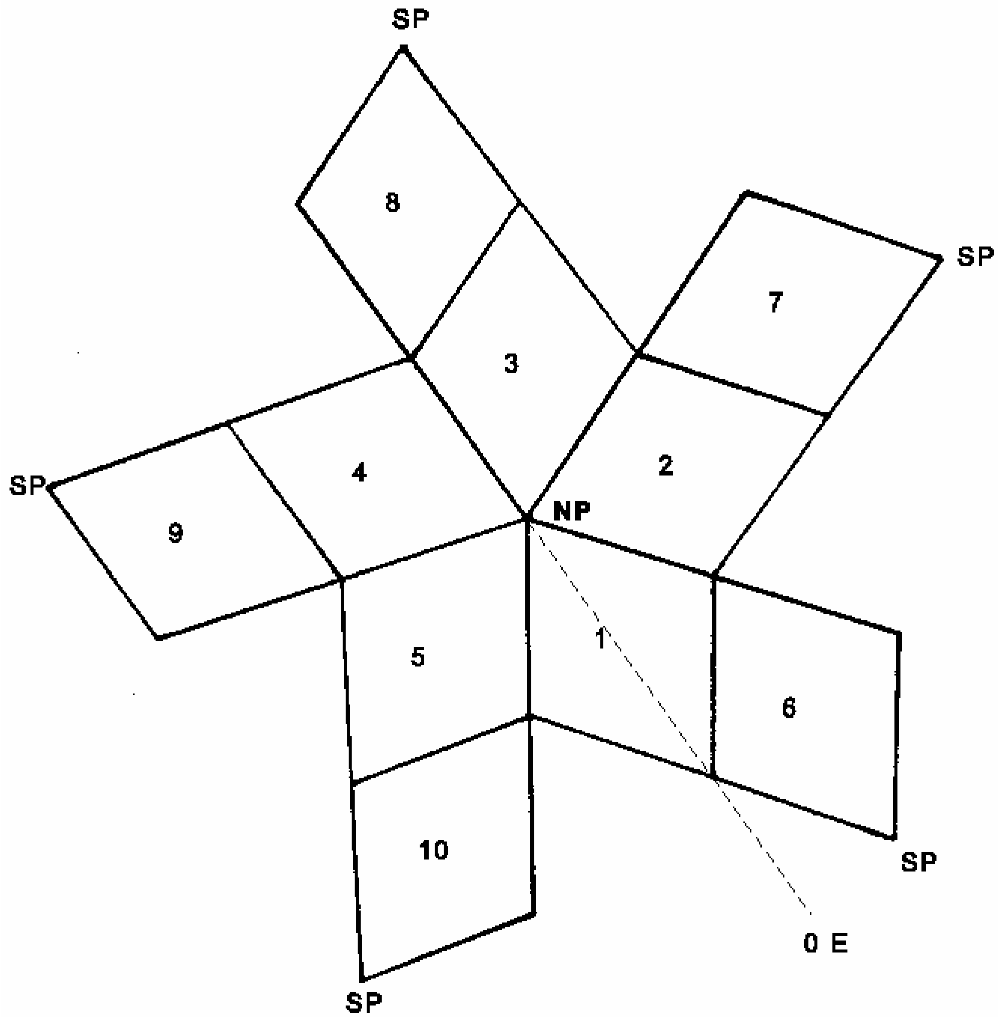

Figure 4 The 20 main spherical triangles combined to 10 diamonds

Table 1 Geographical co-ordinates (λ and φ) of the home vertices of the 10 diamonds

Diamond #	1	2	3	4	5
λ	$-\pi/5$	$\pi/5$	$3\pi/5$	$5\pi/5$	$-3\pi/5$
φ	$\pi/2$ - w	$\pi/2$ - w	$\pi/2$ - w	$\pi/2$ - w	$\pi/2$ - w

Diamond #	6	7	8	9	10
λ	0	$2\pi/5$	$4\pi/5$	$-4\pi/5$	$-2\pi/5$

φ	w - π/2	w - π/2	w - π/2	w - π/2	w - π/2

A Cartesian co-ordinate system is placed into the unit-sphere with the origin in the centre of the sphere, the z-axis towards the north pole and the x-axis into the direction of the Greenwich meridian. The Cartesian co-ordinates (x, y, z) of a point on the unit-sphere follow from (2).

$$
\begin{aligned}
x &= \cos\lambda \cos\varphi = \cos\lambda \sin w \\
y &= \sin\lambda \cos\varphi = \sin\lambda \sin w \\
z &= \sin\varphi = \cos w
\end{aligned}
\tag{2}
$$

Thus the two pole vertices have the Cartesian co-ordinates (0, 0, 1) and (0, 0, -1), respectively.

The geographical co-ordinates (λ, φ) of a point on the unit-sphere with the Cartesian co-ordinates (x, y, z) follow from (3) which may be derived from (2).

$$
\begin{aligned}
\lambda &= \arctan \frac{y}{x} \\
\varphi &= \arcsin z
\end{aligned}
\tag{3}
$$

For the grid generation, the sides w of the 20 main triangles are iteratively subdivided into **ni** equal parts to form sub-triangles. Each point in a main triangle is now surrounded by six triangles (Fig. 5) and is, therefore, in the centre of a hexagon (See also Fig. 6). However, the points which form the vertices of the icosahedron are surrounded by only five triangles and therefore these 12 special points are the centres of pentagons. For the first subdivision, w may be divided into **three** parts, later on, only **bisections** are allowed. This restriction is due to the use of a multigrid solver (MG) for the Helmholtz-equations in the semi-implicit time stepping. MG-solvers work efficiently with such mesh refinements. Thus the number **ni** of subdivisions of w is factorized according to (4).

$$
ni = 3^{n3}\, 2^{n2} \tag{4}
$$

with n3 = 0 or 1 and n2 $\geq$ 0.

Fig. 5 shows the resulting grids for ni = 1, 2, 4 and 8, i.e. n2 = 0, 1, 2, 3 with n3=0.

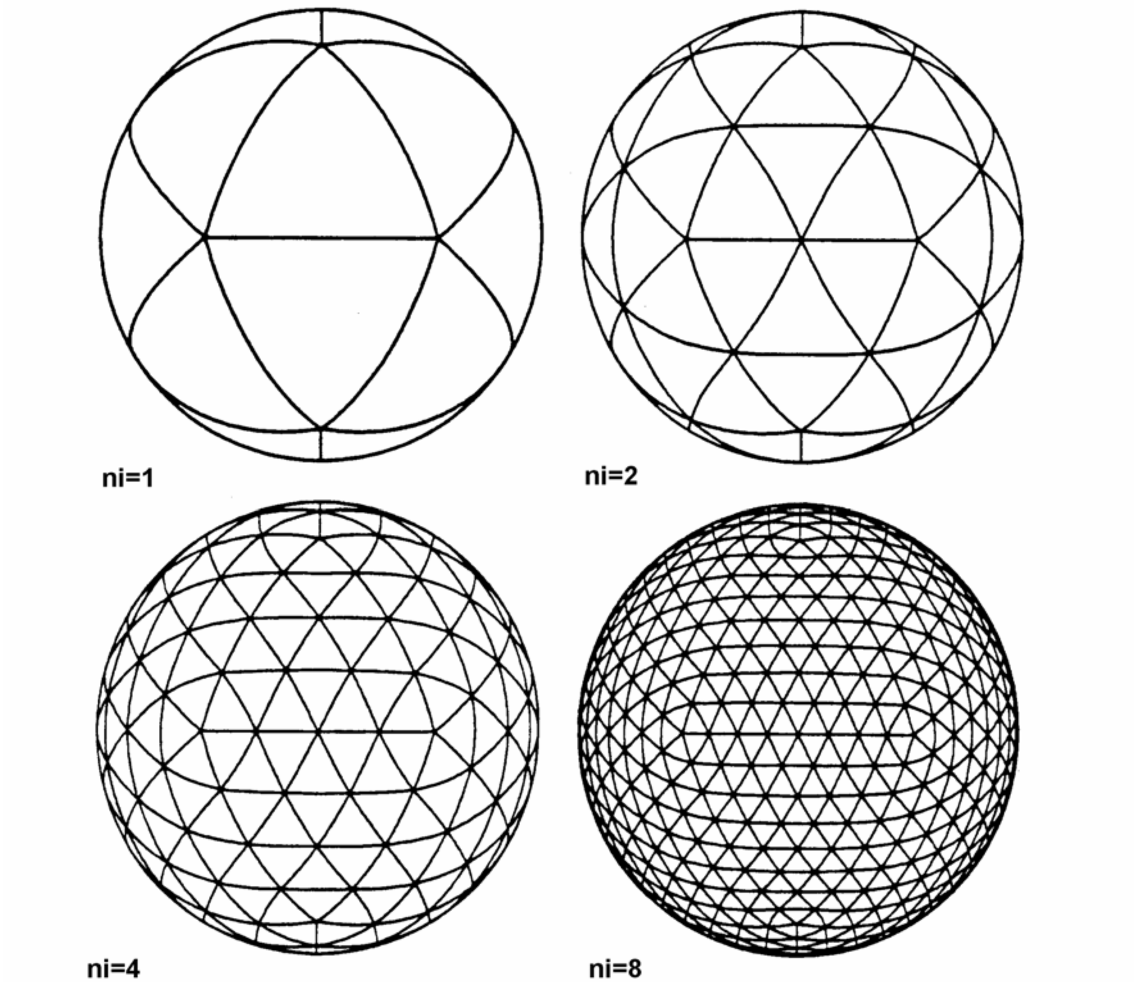

Figure 5 Spherical triangular grids for different values ni of the subdivision of the main spherical triangles

The model grid-points (nodes) are located at the vertices of the triangles; thus there are $(ni+1)^2$ grid-points within one diamond. Of these $(ni+1)^2$ grid-points, ni*ni are "uniquely" identified with each diamond, one extra row and column is shared between neighbouring diamonds.

On the earth with a mean radius R_E = 6371229 m the length L of a side of a main triangle is L = w R_E = 7053898 m. The mesh size Δ of the triangular grid with ni equal intervals on the side of a main triangle is not constant within a diamond but varies by 20 % at most on the sphere and is approximately given by (5). E.g., for ni = 32, Δ varies between 220 and 263 km, for ni = 64, Δ varies between 110 and 132 km, and for ni = 128, Δ varies between 55 and 66 km.

$$\Delta \approx \frac{w \ R_E}{ni} \qquad (5)$$

The number N of grid-points, not counting the common edges of the diamond, is given by (6).

$$N = 10\ ni^2 + 2 \tag{6}$$

Tab. 2a gives the mesh size Δ, the number N of grid-points and the time step Δt for different values of ni, if only bisections are performed, i.e. ni = 2^{n2}. The time step Δt is calculated under the assumption that an air parcel does not leave the region of the 6 surrounding triangles during the period of twice the time step, i.e. $2\ \Delta t < h/v_{Max}$ with the height h of the spherical triangle (which is the shortest distance for leaving a triangle) and v_{Max} the maximum wind speed ($\approx$125 m/s) assuming that the fast gravity waves are treated semi-implicitly. The height h of a spherical triangle approximately follows from (7) and is about 5% smaller than the mesh size Δ.

$$h \approx \arcsin\left(\sin\frac{w}{ni}\sin\frac{2\pi}{5}\right) R_E \tag{7}$$

Table 2a Mesh size Δ, height h, number N of grid-points and time step Δt for the spherical triangular mesh using only bisections

ni	16	32	64	128	256
Δ (km)	441	220	110	55	28
h (km)	420	210	105	52	26
N	2 562	10 242	40 962	163 842	655 362
Δt (s)	1 600	800	400	200	100

Table 2b Mesh size Δ, height h, number N of grid-points and time step Δt for the spherical triangular mesh using first a trisection followed by bisections

ni	12	24	48	96	192
Δ (km)	588	294	147	73	37
h (km)	559	279	140	69	35
N	1 442	5 762	23 042	92 162	368 642
Δt (s)	2 200	1 100	550	275	138

Each grid-point is representative for a spherical polygon with six vertices (Fig. 6) except the 12 vertices of the icosahedron which are surrounded by five triangles only.

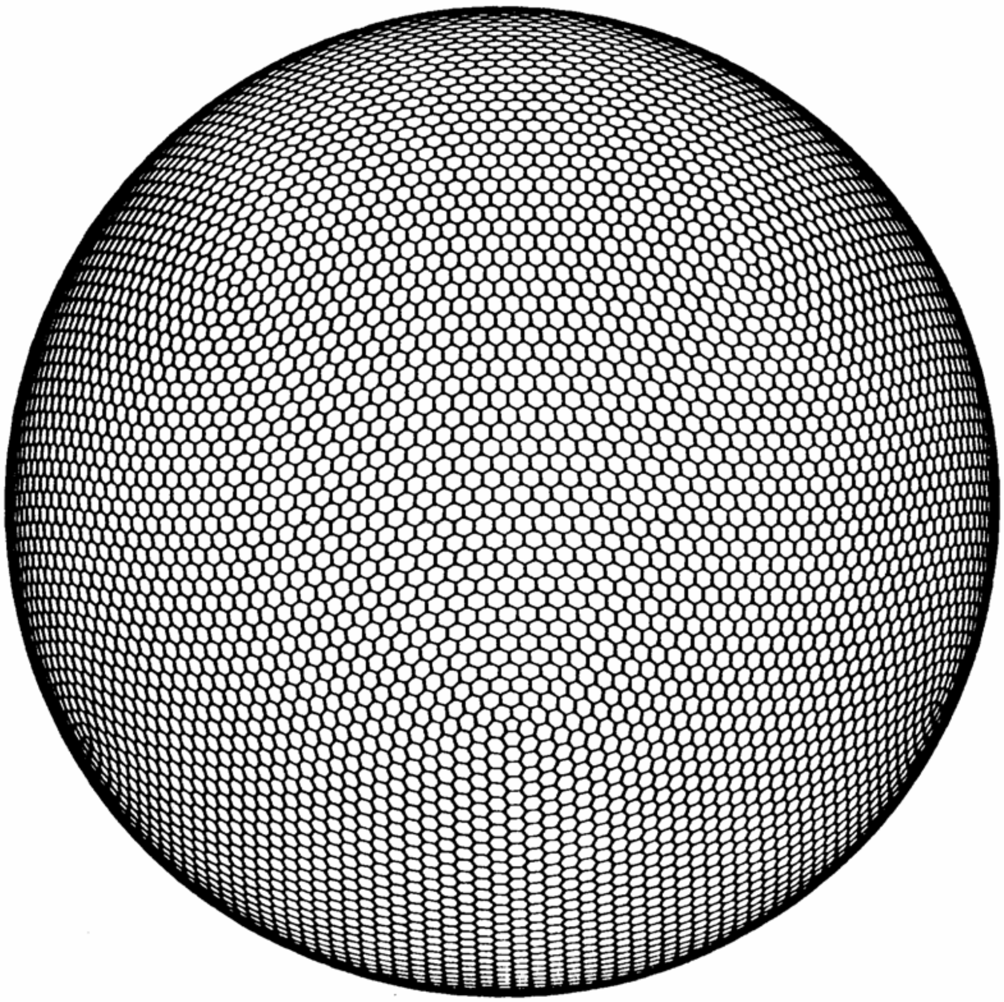

Figure 6 Polygons which represent the area of representativeness of a triangular grid-point

The grid-point indices are defined in the following way (Fig. 7).

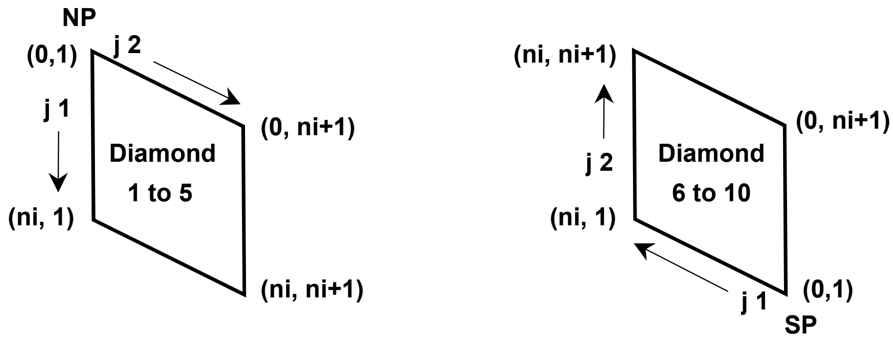

Figure 7 Grid-point indices for a northern (left) and southern (right) diamond.

The start address (0, 1) reflects the philosophy that the ni*ni grid-points which are "uniquely" identified within each diamond have the indices 1 to ni for rows and columns. The extra row and column needed for communication between neighbouring diamonds is lying in one case at the beginning of the first co-ordinate and in the other case at the end of the second. Thus points outside the range (1:ni, 1:ni) are belonging to the neighbouring diamonds and have to be communicated during each time step. Grid-point (0, 1), respectively is the north pole for the diamonds 1 to 5, and the south pole for the diamonds 6 to 10.

The calculation of the subdivision of the great circle between two points P_1 (with the location vector $\mathbf{x}_1$) and P_2 (with location vector $\mathbf{x}_2$) can be derived from Fig. 8.

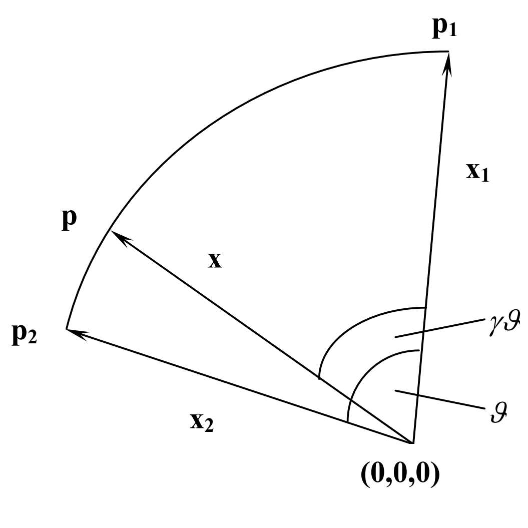

Figure 8 Calculation of the subdivision of the great circle through the points P_1 and P_2 on the unit-sphere.

Since $\mathbf{x}_1$ and $\mathbf{x}_2$ define the great circle plane through P_1 and P_2, all points P with the location vector $\mathbf{x}$ on the great circle may be written as a linear combination of $\mathbf{x}_1$ and $\mathbf{x}_2$.

$$x = \alpha\, x_1 + \beta\, x_2 \tag{8}$$

The coefficients α and β are derived from the condition that $\mathbf{x}$ is a vector on the unit-sphere and the angle between $\mathbf{x}$ and $\mathbf{x}_1$ is given by $\gamma\vartheta$ with γ between 0 and 1 and ϑ the angle between $\mathbf{x}_1$ and $\mathbf{x}_2$, i.e. the length of the great circle between P_1 and P_2.

$$\begin{aligned} x * x = 1 &= \alpha^2 + \beta^2 + 2\,\alpha\,\beta \cos\vartheta \\ x * x_1 = \cos(\gamma\,\vartheta) &= \alpha + \beta\cos\vartheta \end{aligned} \tag{9}$$

Substituting α from the second equation into the first one, the coefficients follow from (10).

$$\alpha = \frac{\sin((1-\gamma)\,\vartheta)}{\sin\vartheta} \qquad \beta = \frac{\sin(\gamma\,\vartheta)}{\sin\vartheta} \tag{10}$$

The angle ϑ between $\mathbf{x}_1$ and $\mathbf{x}_2$ follows from the scalar product $\mathbf{x}_1 * \mathbf{x}_2$ or by calculating the distance d between $\mathbf{x}_1$ and $\mathbf{x}_2$ and observing that $\sin \vartheta/2 = d/2$.

The grid-point co-ordinates (x, y, z) of all triangle vertices on the unit-sphere are derived with (8) using the coefficients of (10).

The $(ni+1)^2$ grid-points in a diamond form the vertices of $2\,ni^2$ triangles (Fig. 9) half of those point northward, half southward.

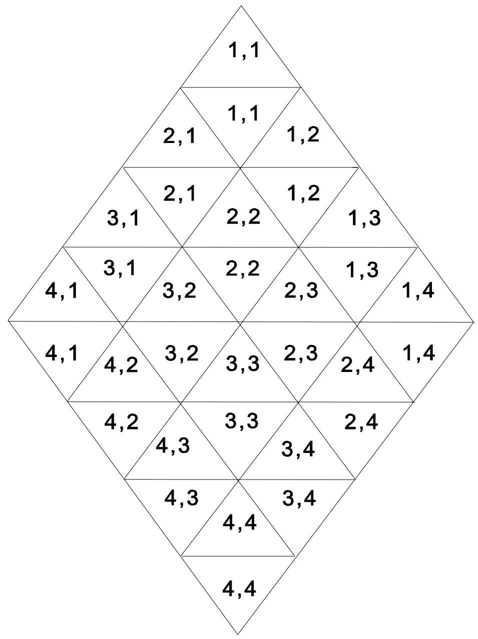

Figure 9 The 2 ni^2 triangles in a diamond defined by the $(ni+1)^2$ vertices for ni = 4

To calculate the co-ordinates (x_c, y_c, z_c) of the triangle centres P_c, the co-ordinates of the three triangles vertices P_1, P_2 and P_3 are summed and normalized.

$$
\begin{aligned}
x_c &= (x_1 + x_2 + x_3)\ x_N \\
y_c &= (y_1 + y_2 + y_3)\ x_N \\
z_c &= (z_1 + z_2 + z_3)\ x_N
\end{aligned}
\tag{11}
$$

with

$$x_N = \frac{1}{\sqrt{(x_1 + x_2 + x_3)^2 + (y_1 + y_2 + y_3)^2 + (z_1 + z_2 + z_3)^2}}$$

The area of the 2 ni^2 triangles in a diamond can be calculated by (12) which is due to Huilier. The triangle sides are denoted by a, b and c. On the unit-sphere, the excess angle
ε is equal to the area of the spherical triangle.

$$\tan\frac{\varepsilon}{4} = \sqrt{\tan\frac{s}{2}\tan\frac{s-a}{2}\tan\frac{s-b}{2}\tan\frac{s-c}{2}}$$

with (12)

$$s = \frac{1}{2}\,(a + b + c)$$

Since each grid-point is surrounded by six triangles (five triangles at the 12 special points), the grid-point is the centre of a hexagon (pentagon at the 12 special points) as is illustrated in Fig. 10. The co-ordinates of the vertices of the hexagon, i.e. the points Q_1, Q_2, ... , Q_6, are in a good approximation given by averaging the Cartesian co-ordinates of the three surrounding triangles vertices and normalizing to unit length, thus they follow from (11).

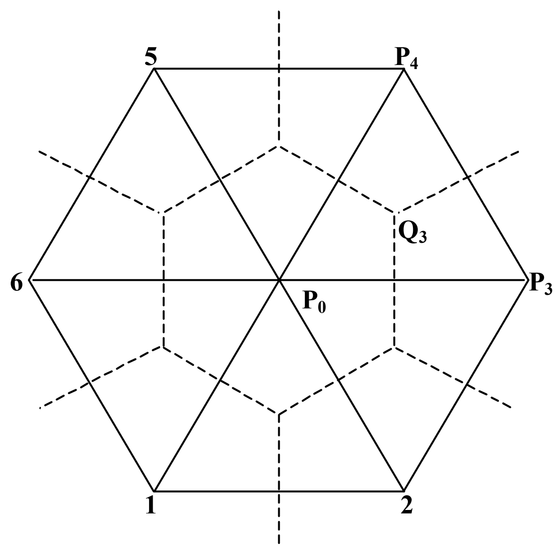

Figure 10 Hexagon connected to a grid-point of the triangular mesh

The grid-point in the centre of the hexagon is denoted by "0", the six surrounding triangles (and their vertices) by "1" to "6" counting counter-clockwise. We define the point Q_i, i.e. a vertex of the hexagon, equidistant from the three vertices P_0, P_i, and P_{i+1} such that Q_i and Q_{i+1} is the perpendicular bisection of the great circle P_0P_{i+1} (Fig. 10). The co-ordinates of Q_i are needed for the calculation of the topographical fields like orography, land fraction, roughness length as mean values over the area of the hexagons. Here, high-resolution data sets are averaged over the hexagon area.