FORMATS OF DISTRIBUTED DATA

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ECMWF

Formats of distributed data

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1. Introduction

Data are distributed daily from the ECMWF Meteorological Operational Suite (EMOS) directly to Member States along dedicated telecommunication links, and also worldwide by injection into the WMO Global Telecommunications System (GTS) via the regional telecommunication hubs at the United Kingdom Meteorological Office, Bracknell and at the Deutscher Wetterdienst, Offenbach. Analysis and forecast fields are sent in digital grid point form in a number of standard codes and projections. Current ECMWF operational usage of codes and formats is described in this paper. Full and detailed descriptions can be found in a series of ECWMF Meteorological Bulletins and in an ECMWF explanatory note on GTS products given as references in Section 5.

2. Disseminated products

2.1 Fields

The basic unit for dissemination of data is a product, which is an array of values of an analysis or forecast field at points of a regular, rectangular grid. One field can give rise to many products since the grids are small subsets of the full global coverage. Normally only one field value is given at each grid point, although for wind fields, this is interpreted to mean both the direction and speed together at the grid point. A product is defined in a catalogue according to:

(a) its verifying time
- for analysis, this is 1200 GMT on the day of the EMOS run
- for forecasts, this is the time in hours since the starting analysis

(b) its meteorological parameter
- for upper air fields, a combination of standard pressure level and physical parameter such as wind component, temperature, geopotential height at 1000mb, 850mb and so on.
- for other two-dimensional fields; generally surface fields such as 'temperature at 2 metres', but also others such as cloudcover.

(c) its standard grid and area

- one of a standard set of latitude/longitude or polar stereographic areas for direct transmission to Member States.

- a Member State defined standard area.

- one of a standard set of latitude/longitude areas for GTS dissemination.

Each of the characteristics (a), (b) and (c) has a unique two-digit number in the product catalogue, so that a product's data content can be uniquely defined by a six-digit catalogue number. The range of verifying times and meteorological parameters in use are shown in diagram 1.

2.2 Latitude/longitude grids for Member States

These are based on a regular rectangular grid of interval $1\frac{1}{2}^{o} \times 1\frac{1}{2}^{o}$, or a multiple thereof, such as $3^{o} \times 3^{o}$; the geographical area and grid interval are defined by the area catalogue number. Areas are given as latitude rows, starting at the northernmost latitude and proceeding southwards; within a row, points run eastwards. Diagram 2 shows the order of presentation of values within a grid array. For north and south pole latitudes, the pole value is repeated along the latitude row to preserve the rectangular nature of a grid.

2.3 Polar stereographic grids for Member States

These are subsets of a regular rectangular grid overlayed on a northern or southern hemisphere polar stereographic projection. The overlaying grid had a mesh width corresponding to 150km at the projection standard latitude 60^{o} and has the pole at its centre; the 0^{o}E longitude runs vertically downwards. Subsets of the grid may take successive points, or alternate points or every third point to give equivalent mesh widths of 150km, 300km, or 450km; they are aligned with edges parallel to the main mesh edges. The order of presentation of points in the grid array is shown in diagram 2 as for the latitude/longitude grids, with rows now proceeding from the top to the bottom of the area and points within a row running from left to right.

Diagram 1 - Verifying times and parameters used to define fields

Transmission to Member States

H + 0 - analysis 12GMT

H + 6 to (by 6 hour steps) H + 84 to (by 12 hour steps) H + 240) forecasts

Upper air levels - 1000, 850, 700, 500, 400, 300, 250, 150, 100, 70, 50 millibars

Upper air parameters - geopotential height, temperature, wind, vertical velocity (850-500mb only), humidity mixing ratio (1000-300mb only)

Surface parameters - mean sea level pressure, temperature, total rainfall, snowfall, snowcover, wind at 10 metres, cloudcover

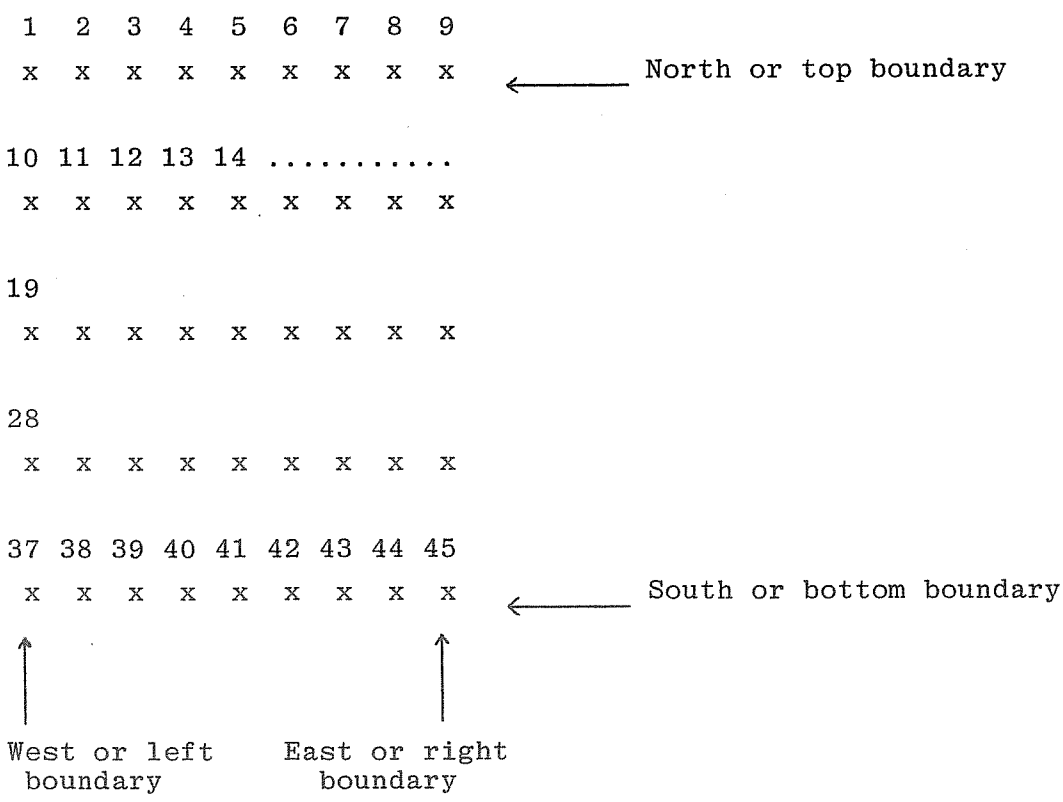
GTS transmission

H + 0 - analysis 12GMT

H + 24 to (by 24 hour steps) H + 120) forecasts

Mean sea level pressure
500mb geopotential
200mb winds
700mb winds) tropical belt analysis only

Diagram 2 - Ordering of grid-point values in an array



a) Numbers indicate the order of data presentation in the array.

b) For latitude-longitude areas, arrays are presented in lines of latitude, starting at the northernmost latitude and going southwards. (Exceptionally, areas 1, 2, 3 and 4 for GTS dissemination start with the southernmost latitude and go northwards.) Within each line of latitude, data start at the western boundary and go eastward. Latitude 90^{o} is represented in the same way as other latitudes, with multiple identical values.

c) For polar stereographic areas, arrays are presented in rows starting at the top of the overlayed grid and going towards the bottom. Within each row, data starts at the left of the area and goes to the right.

2.4 Latitude/longitude grids for GTS dissemination

GTS products are given on a regular rectangular mesh of resolution $5^{o} \times 5^{o}$. Generally the order of presentation of points in an array is the same as for grids sent to Member States. However, four areas covering the northern hemisphere from 90°N to 20°N have rows running from south to north. Pole values are sent as repeated identical values along the pole latitude row. Diagram 3 shows the standard GTS product areas and the ordering of rows; note that the areas are those used by the National Meteorological Centre, Washington for the dissemination of GRID code data on the GTS.

2.5 Field units and scaling

Units and scaling factors used for disseminated products are predefined and can be uniquely determined from their catalogue number (see reference 5.3 for details). A reference value is subtracted from each grid point value which is then multiplied by a scale factor to give a resultant integer value which is coded into the product. In the WMO GRID code versions of products, the reference value and scale factor are coded explicitly.

For some fields, the use of a reference value introduces the need for a sign indicator for some subsets of a field but not necessarily all subsets. The codes allow a sign indicator to be included with each grid point value, or implied for the whole product; this can cause product sizes to vary.

3. Codes

3.1 Messages

Each product is coded into a message and put into a file for dissemination. A file can contain more than one message. Three code types are in use with corresponding message formats:

(a) an ECMWF bit-oriented code

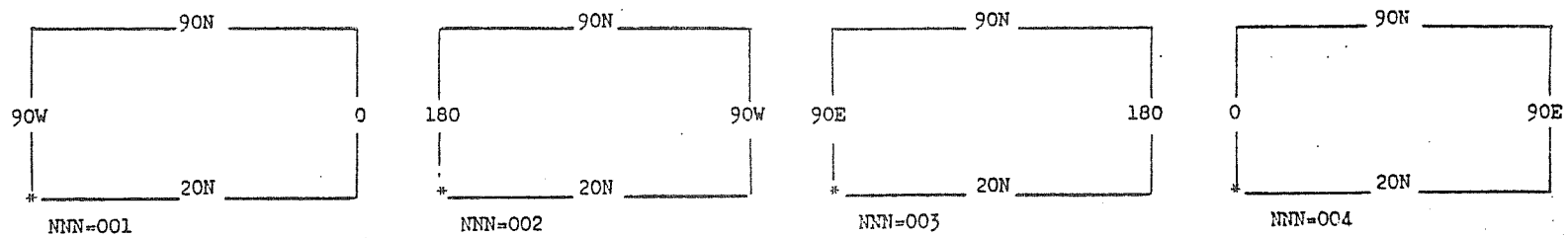
(b) WMO GRID code in WMO message format for Member States

(c) WMO GRID code in WMO message format for the GTS

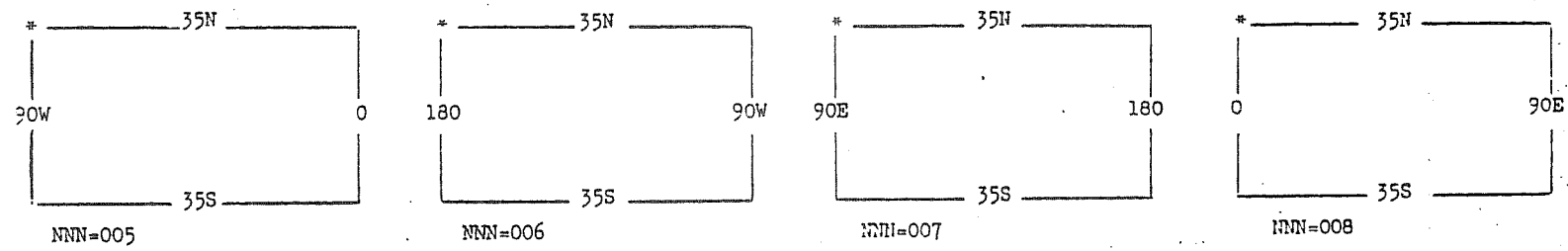
Products in a file are all in the same code.

Diagram 3 - Areas and Catalogue Numbers currently used for G.T.S. transmissions by ECMWF for the dissemination of its products in grid-point form

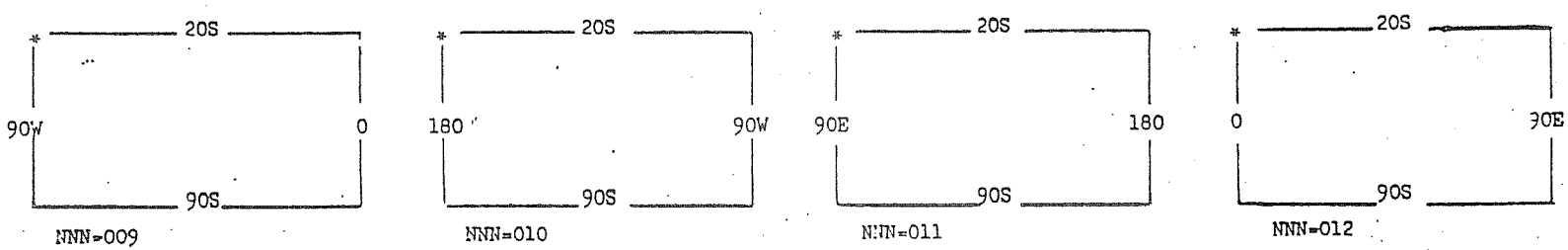
NORTHERN HEMISPHERE



TROPICAL



SOUTHERN HEMISPHERE



* = Reference point
Grid points at 5°latitude/longitude intersections

3.2 ECMWF bit-oriented code messages

Data in this format are disseminated only on medium-speed lines under the control of ECMWF telecommunications procedures so no external message identification is used at the telecommunication level. Messages are fully self-contained and self-defining, being uniquely identified by a 6-digit catalogue number. The messages consist entirely of a bit-stream without separators between groups, lines or sections. The length of a message is given in one of the early groups inside the message. Typically, a message in this code will be one quarter to one fifth the size of the same message in WMO GRID code.

3.3 WMO GRID code in WMO message format for Member States

WMO GRID code messages for Member States are distributed on low speed lines in CCITT alphabet number 2 or alphabet number 5, and on medium speed lines in alphabet number 5. The format follows the definition in the WMO manual on the GTS (see reference 5.6), so that a message comprises:

Starting line
Abbreviated heading
Text (= array of points for a field)
End-of-message signal

The formats of the starting line, the abbreviated heading and the end-of-message signal are defined in the WMO manual on the GTS and in the ECMWF Meteorological Bulletin M3.1 (see references 5.6 and 5.1). Bulletin identifiers have been agreed between ECMWF and Member States and are in one-to-one correspondence with the message six-digit catalogue numbers. The text of the message is the scaled array of data points for one field. Conventions in the text, such as the use of space characters and scaling and reference value for fields, and the units for reporting parameters have been agreed between ECMWF and Member States, and follow practices established by WMO.

3.4 WMO GRID code in WMO message format for the GTS

Messages are sent by medium speed lines to the regional telecommunications hubs at the U.K. Meteorological Office at Bracknell and the Deutscher Wetterdienst in Offenbach for injection into the GTS. Bulletin identifiers have been defined by WMO and CCITT alphabet number 5 is used. Messages follow practices laid down in the WMO manual on the GTS (see reference 5.6).

3.5 Symbolic form of the codes

3.5.1 ECMWF bit code

Diagram 4 shows the symbolic form of the bit oriented ECMWF code. At present, only sections 1, 4 and 5 of the code are in use; sections 2 and 3 are available for special areas and grids. Groups in sections 1 and 5 are six-digit integer groups represented as twenty-bit binary groups. Array values in section 4 are scaled integers in N-bit binary groups where N is predefined for each field; the field itself is identified in section 1 by the group 'nnnnnn'. Padding zero bits are inserted into the data section to ensure that the total message length is an integral multiple of 40 bits (i.e. five octets of bits).

3.5.2 WMO GRID code

Diagram 5 illustrates the version of WMO GRID code used by ECMWF for dissemination to Member States and via the GTS. The complete code format is given in the WMO Manual on Codes FM47-V GRID, pages 1-A-84 to 1-A-86 (see reference 5.7).

The data section contains the field array values in scaled integers expressed in CCITT alphabet number 2 or 5 character form with blanks between groups and with carriage return and linefeed control characters used to limit lines of text to a maximum of 72 characters.

4. Examples

4.1 WMO GRID code

A typical (but small) example of a disseminated 500mb geopotential forecast field (H + 24) is given below in alphabet CCITT 2 format for standard area 82 (a 5 x 5 grid). The catalogue number for the product is 080382:

```
ZCZC 001 89999
HJD150 ECMF 011200
GRID 00082 10101
111 10200 25099 68110 70112 81024
333 10212 23001 31000 00500
548 583 608 612 609 546 587 626 641 641 554 600 649 679 693 586 629
682 718 738 648 681 726 759 776
444 14656 20000 34846 40000 56119
555 00082 10101
777=
NNNN
```

Diagram 4 - Symbolic form of ECMWF bit-oriented code

Section 1 022200 nnnnnn JJYYY4 0LLLLL

Section 4 DDD.....D

Section 5 027700 nnnnnn JJYYY4 0LLLLL

(Two sections not currently in use are:

Section 2 - which allows 'non-standard' product dissemination
Section 3 - a bit map to describe irregular fields)

Section 1

Groups are six digits coded as twenty bits each.

nnnnnn - ECMWF catalogue number of the product

JJ - tens and units digits of the year (GMT), e.g. 1981 = 81, etc.

YYY - day of the year (GMT), e.g. Jan 1 = 001, etc.

LLLLL - total length of the message in octets. Forced to be a multiple of 5 by adding nonsignificant zero bits at the end of the data (Section 4).

Section 4

DD...D - values of parameter at grid points. Values are scaled differences from reference value. Number of bits fixed for parameter; leading bit used as sign bit for some defined parameters.

Section 5

As Section 1 with modified first group.

Diagram 5 - Symbolic form of WMO GRID code used by ECMWF

GRID section	GRID FFNNN 10101
Section 1	111 1aaaa (2pppp) (3HHHH) (5bbbb) 6JJMM 7YY12 (81ttt)
Section 3	333 1nnli 2NM01 3u0rr rrrrr (S)III....(S)III
Section 4	444 1CCCC 2000 3DDDD 4000 5EEEE
Section 5	FFNNN 10101 777

Optional groups are shown in brackets

(Section 2 is omitted, since the geometry of disseminated grids is predefined.)

GRID section

FF	00 for Member State dissemination 98 for GTS dissemination
NNN	catalogue number of grid used by ECMWF

Section 1

aaaa	defines up to 2 parameters per group; except for GTS winds, only one is used.
pppp	defines up to 2 pressure levels; only one currently used.
HHHH	altitude level reference; only used for mean sea level (=0000).
bbbb	type of special level
JJMMYY	year/month/day (GMT) of data analysis time
ttt	time interval between analysis and forecast

Section 3

nn	number of data lines in section 3 after the 333 line.
i	indicator to show whether data is all positive/negative or if sign bit included with each point.
NM	number of digits in group; normally M=0 but for GTS winds where direction and speed are distinguished NM=23.
u	scaling factor, indicates power of 10.
rr rrrrr	unscaled reference value
(S)III	data values separated by a blank character. (S) is the sign bit if present, III... is the scaled difference of the grid point value and the reference value.

Section 4

cccc	checksum for section 1
DDDD	checksum for section 3
EEEE	checksum for section 4

4.2 ECMWF bit code

Part of an ECMWF bit code product is given below. It is a 500mb geopotential analysis field for a latitude/longitude area. The example shows the beginning and end of the product in octal format; the product catalogue number is 040314.

Units for field = decametres
Reference value = 500 decametres
Scaling factor = 10
Sign bit is included
Grid point value requires 11 bits (including sign bit)

```
0126560047275306331O 0004204200040010002O 0040010002000400100O
2000400100020004002O 0020004001000200040O 1000200040010002000 4
0010002000400100020O 0310062014443110624 1 4603160640151032506 5
                                  |
                                  |
                                  |
                                  |
5605341670516123416 7 0216023406677156333 2 4662554232746551527 3
2606551540330265715 3 3326265400000000000 0 1541500472753063310
0004204000000000000
```

5. References

5.1 ECMWF Meteorological Bulletin M3.1/1 - The formats and headings of messages for the dissemination of ECMWF products.

5.2 ECMWF Meteorological Bulletin M3.2/1 - Codes used in the dissemination of ECMWF products.

5.3 ECMWF Meteorological Bulletin M3.3/1 - The presentation of ECMWF products to Member States.

5.4 ECMWF Meteorological Bulletin M3.4/1 - ECMWF current product catalogue.

5.5 Explanatory note to be distributed to WMO members regarding the availability of products from the European Centre (prepared by ECMWF 17 July 1981 for distribution by WMO).

5.6 Manual on the Global Telecommunications System - WMO No. 386

5.7 Manual on codes - WMO No. 306

5.8 WMO publication No. 9, Volume B.