U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL WEATHER SERVICE
NATIONAL METEOROLOGICAL CENTER

OFFICE NOTE 388

G R I B

(Edition 1)

THE WMO FORMAT

FOR

THE STORAGE OF WEATHER PRODUCT INFORMATION

AND

THE EXCHANGE OF WEATHER PRODUCT MESSAGES

IN GRIDDED BINARY FORM

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Revised
(see overleaf)

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This is an unreviewed manuscript,
primarily intended for informal exchange of information
among NMC staff members

NMC Office Note 388 -- GRIB

REVISION HISTORY

since the last full revision/reprinting
dated November 18/19, 1993

All revisions in the text, of any substance, are marked by a vertical bar to the left of the correction location, in the same manner as this paragraph. Insertions, deletions, and alterations are all so marked. Deleted text will not appear, of course, in the printed pages, but the location of the deleted material is marked by the sinister bar.

Please insert (or replace) the indicated pages in your copy of this document.

Date	Section	Page	Nature of change
Dec. 14, 1993	0	5	Clarification of Indicator Section content
Dec. 21, 1993	A	5	Correction of forecast hour typos
Dec. 22, 1993	4	4	Clarification of count of second order values

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REVISION HISTORY

since the last full revision/reprinting

dated March 3, 1993

November 18, 1993

p.6: Added orig center for NWS/NMC/Reanal and corrected DeBilt number.
p.7: Added gen code 70 for QLM hurricane changed spectral model to 28 layers
p.9: Added grids 75,76,77 for QLM
p.13,14: Reoriented Grids 37-44 (WAFC/ICAO) such that left hand column is at 330E (30W)
p.13,13.1: Added table of number of points in lat circles of grids 37-44
p.15: Added description of Grid 1
p.18: Corrected long grid spacing in degrees and corrected location of Map 204
p.20 Adjusted location of map 208 to conform to change in map 204
p.28: Added MSL variants 128 & 129; Added lat. lon. as parameters 176 & 177; added parameters 204, 205, 211, 212, 218;
added 156, convective inhibition
added 175, model layer number

p.29: Added Note 4
p.48: Clarification of table 11.

Appendix A. Revised to include "Z" as first character in WMO header. Used for "off-hour" forecast hours.

Many Pages: Updates to reflect changes introduced by WMO in September 1993 plus didactic material drawn from other sources.

Then reprinted in entirety with all updates included and all new section by section pagination.

INTRODUCTION

The World Meteorological Organization (WMO) Commission for Basic Systems (CBS) Extraordinary Meeting Number VIII (1985) approved a general purpose, bit-oriented data exchange format, designated FM 92-VIII Ext. GRIB (GRIdded Binary). It is an efficient vehicle for transmitting large volumes of gridded data to automated centers over high speed telecommunication lines using modern protocols. By packing information into the GRIB code, messages (or records - the terms are synonymous in this context) can be made more compact than character oriented bulletins, which will produce faster computer-to-computer transmissions. GRIB can equally well serve as a data storage format, generating the same efficiencies relative to information storage and retrieval devices.

Changes and extensions to GRIB were approved at the regular meeting of the WMO/CBS in February, 1988; additional changes were introduced at the CBS/WGDM/Sub-Group on Data Representation (SGDR) meetings in May 1989 and in October 1990. The 1990 changes were of such structural magnitude as to require a new Edition of GRIB, Edition 1, which this document describes. Further augmentations and interpretations were made by the SGDR in September 1993, with approval by the WGDM in February 1994. These changes did not result in a new Edition to GRIB, but did change some of the Tables, resulting a new Version number for them. This brings us now to Table Version 2. The changes from Version 1 were mainly additions of new parameters or more precise definition of existing ones.

It is not anticipated that there will be any large-scale structural changes to GRIB for at least four to five years, or more. The SGDR is undertaking a thorough review of the present and future requirements that GRIB is supposed to satisfy. The plan is to design a major revision of GRIB capable of accommodating these requirements and more, without "straining" the structure of the data representation form. Some things are getting a little strained even now. See below.

Note: the Edition number is placed in the same location, relative to the start of the GRIB message, for all Editions. Thus, decoding programs can detect which Edition was used to construct a particular GRIB message and behave accordingly. This is useful for archives of messages encoded in earlier Editions or during transition periods. Of course, this requires that data centers retain copies of older editions of the code, and older versions of the parameter tables.

Each GRIB record intended for either transmission or storage contains a single parameter with values located at an array of grid points, or represented as a set of spectral coefficients, for a single level (or layer), encoded as a continuous bit stream. Logical divisions of the record are designated as "sections", each of which provides control information and/or data. A GRIB record consists of six sections, two of which are optional:

(0) Indicator Section

(1) Product Definition Section (PDS)

(2) Grid Description Section (GDS) - optional

(3) Bit Map Section (BMS) - optional

(4) Binary Data Section (BDS)

(5) '7777' (ASCII Characters)

Although the Grid Description Section is indicated as optional, it is highly desirable that it be included in all messages. That way there will be no question about just what is the "correct" geographical grid for a particular field.

Most centers require bulletin headers to enable them to receive, identify, and switch messages; NMC is no exception. The standard WMO abbreviated heading for GRIB is described in Appendix A.

In this documentation, certain symbols are used to clarify the contents of octets (groups of eight consecutive binary bits, "bytes" in American usage). If unadorned letters are used, they are symbolic and their meanings are described in the text; a decimal number is simply printed as is; a character or string of characters is represented inside single quote marks. International Alphabet No. 5, which is identical in its essential elements to the U.S. National Standard 7-bit ASCII, is used for character representation in the GRIB code.

Octets are numbered consecutively from the start of each section; bits within an octet are also numbered from left (the most significant bit) to right (the least significant bit). Thus an octet with bit 8 set to the value 1 would have the integer value 1; bit 7 set to one would have a value of 2, etc.

The numbering of Tables in the following text corresponds to the description of GRIB in the WMO Manual on Codes[1]. Some additional tables not found in the WMO Manual are indicated by letters. These, generally, contain information unique to the NWS or NOAA.

A caveat: The Official International Documentation for GRIB is the just referenced Manual on Codes. This document is, in part, intended to be a guide to the use of GRIB and may not include all of the features currently found in the Manual. It does, however, represent the full set of features used by the National Weather Service, in particular in the AWIPS project, and by the National Meteorological Center. The features described here are intended to be a completely consistent sub-set of the full WMO documentation; if there are any discrepancies the Manual on Codes is the final authority.

DATA PACKING METHODS.

The code form represents numeric data as a series of binary digits (bits). Such data representation is independent of any particular machine representation; by convention data lengths are measured in octets. Data are coded as binary integers using the minimum number of bits required for the desired precision. Numeric values, with units as shown in Table 2, may first be scaled by a power of ten to achieve an appropriate decimal precision, a reference value is subtracted from them to reduce redundancy and eliminate negative values, and they may then be further scaled by a power of two to pack them into a pre-selected word length. The two scaling operations are independent; which, or both, are used in any given case depends upon choices made as to the method of packing. See below.

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1 World Meteorological Organization publication No. 306, Manual on Codes, Vol. 1, Part B, Secretariat of the WMO, Geneva, Switzerland, 1988, plus Supplements No. 1, 2, & 3 (with more to come)

The representation of a single value is such that:

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

where

Y = original or unpacked value; units as in Table 2;
D = decimal scale factor, to achieve desired precision
(sign bit, followed by a 15-bit integer);
R = reference value (32 bits);
X = internal value (No. of bits varies for each record);
E = binary scale factor for variable bit word length packing
(sign bit, followed by a 15-bit integer).

The reference value (R) is the minimum value of the (possibly) decimally scaled data that is being encoded.

R is placed in the Binary Data Section in four octets as a single precision floating-point number:

sAAAAAAA BBBBBBBB BBBBBBBB BBBBBBBB

where s = sign bit, encoded as 0 => positive
1 => negative
A...A = 7-bit binary integer, the characteristic
B...B = 24-bit binary integer, the mantissa.

The appropriate formula to recover the value of R is:

$$R = (-1)^s * 2^{(-24)} * B * 16^{(A-64)}$$

This formula is the standard IBM representation for a single precision (real) floating point number. (Consideration is being given to using the IEEE floating point representation in the future, in a later Edition of GRIB.)

If second order (or "complex") packing is used (see the description of that later on) the internal value, X, will be made up of two values, a "local minimum value", Xi, and a "second order packed value", Xj. There will be one Xj for each grid point and a variable number of Xi values. This will all come clear later on when we get to the description of second-order packing.

What follows is a description, slightly simplified, of the process that one would go through to pack a (meteorological) field into a GRIB message, using "simple packing". It includes some explanations of why certain steps are taken, some of the consequences, and what choices have to be made. Some of the choices are interrelated; the relationships should be clear when the explanation is done. The additional features of complex or "second order" packing will be dealt with in a later section.

Give that a full field is available, the first step, if necessary, is to convert the units of the parameter into those shown in Table 2, the SI standard units, also known as the mks system. Some of the units may seem a little peculiar (kg/m^2, for example, for precipitation - 1 kg/m^2 is equivalent to a water depth of 1 mm); others may seem inappropriate (Pa for pressure, for example, implies substantially greater precision than is typical in meteorological usage; inverse seconds are not nearly precise enough for divergence and vorticity) but they are all self consistent. The precision of the parameters, as actually packed in a message, can be set to any desired degree through the appropriate use of the power-of-10 ("D") scaling and the power-of-2 ("E") scaling. Just how this comes about will be described momentarily.

At this point there is a choice to be made. If it is desired to use a pre-selected bit word length for the packed variables, then just proceed on to the next step. However, if a variable bit word length is to be used, where the word length is adjusted to accommodate the data values, then it is necessary to undertake the power-of-ten scaling. The D value should be selected such that, when the original data, in the SI units of Table 2, is multiplied by 10^D, the integer part of the result will have enough precision to contain all the appropriate information of the variable. Anticipating things a little bit, the (scaled) value will be rounded to an integer as a part of the packing process; thus the "significant part" of the value of the variable has to be moved to the left of the decimal point prior to the rounding. Temperature might be scaled with D=1, thus changing the units to deci-degrees; pressure, on the other hand, might be scaled with D=-2, thus actually reducing the precision to hectoPascals (mb), a more reasonable meteorological precision; vorticity would be scaled up by D=8, and so on.

The second step in the packing operation is to scan through the field, which may or may not have been "D-scaled" at this point, find the minimum value of the parameter, and subtract that minimum - the reference value, R - from all the data points, leaving a residual of non-negative numbers. This step has two benefits. The first of these is convenience - making all the data points non-negative bypasses problems with different computer hardware that represent negatives in various ways: 1's complement, 2's complement, signed positive integers, whatever. The GRIB message is rendered just that much more machine independent by being non-negative throughout.

The second benefit is more consequential: it can result in a substantial compression of the bulletin size without any loss of information content. If a field has an appreciable bias away from zero, the residuals formed by the minimum removal operation will all be much smaller numbers than otherwise. Thus they will need fewer bits to contain them when they are, eventually, packed as integers.

The third step is simply to scan through the field of residuals and find the maximum value.

At this point another choice must be made, similar to the one made previously. This time, if a variable bit word length is to be used, then it is necessary to calculate how many bits (per word or per data gridpoint) are going to be needed to contain that largest data value, when the latter has been rounded to an integer. Recall that at the previous decision point, the variables were power-of-ten ("D") scaled such that a rounding operation will preserve all the significant part of the information. Discovering how many bits are needed is a simple scan through a table of powers of two, of course. The power-of-two-scaling is not employed and E is set equal to 0. Then go on to the fourth step.

If, alternatively, it is desired to use a pre-selected bit word length for the packed variables, the data must now be scaled, this time by a power of two (the "E" scaling), sufficient to either reduce the maximum value down to just fit into the available number of bits, or enlarge the value to just fit. This latter step takes care of the problem of small numbers where the precision is all in the fractional part of the number. How much precision is retained, for the eventual rounding, is a function of the preselected bit word length and the "typical" range, or maximum value with the minimum removed, of the particular variable. The choice of bit word length, which is made ahead of time, must be made with full knowledge of the characteristics of the particular variable that is to be packed and a prior assumption of how much precision needs to be retained for the largest likely value.

The fourth step is then to round all the values to integers, now that they have all been scaled to appropriate units, and pack them in the specified bit length words.

The last step is then to set up the various identification fields and put the GRIB bulletin in proper form. We shall turn to this "proper form" in the next section.

We have ended up with two alternate ways to construct a GRIB messages: a fixed bit word length method and a variable bit word length method. What are the relative advantages or disadvantages, or at least the differences, of one with respect to the other?

Message length: the fixed word length bulletins are always the same length, for a given parameter; the variable word length bulletins are, naturally, variable. The variation is driven by the range of the value of the parameter over the field (or the maximum value) which can change from day to day. Whether variations in message length is a problem or not depends on the computer systems used to work with the GRIB records.

Precision: The variable word length bulletins have a fixed and unchanging precision, determined by the "D" scaling. This assures that the same information content is available day after day. It is straightforward to change the precision in a familiar manner, that is, simply by orders of magnitude, just by altering the D value. This comes at a cost, of course; increasing the precision by a power of 10 adds about 3.3 bits (average) to each data point in the message.

The fixed word length bulletins show a variable precision which is case by case data driven and is determined by the "E" (power-of-two) scaling that was used to fit the numbers into the available space. This can happen even with the same data, on the same date, but at adjacent grid areas. If one area shows a low variability and the neighboring one a high variability such that a different power-of-two scaling is needed in the two areas, then, unfortunately, the values on a common boundary will not be exactly equal after they are unpacked. This can be disconcerting and a cause for confusion. It will not happen if D-scaling (only) is employed. On the other hand, the variable precision can be viewed as a strength: a data field with a low variability will be encoded at a higher precision, thus preserving the character of the field; a high variability field will be represented with less precision, but that is not a problem as the small, and possibly lost, variations will not matter in the presence of the large ones. The precision of the encoded field can be increased by adding bits to the fixed word length, but the degree of change (a power of 2 for each bit) may not be as easy to deal with (or explain to people) as the simple order of magnitude change afforded by the "D" scaling method.

No mater which packing method was employed, a proper GRIB decoding program, that took account of the transmitted values of both "D" and "E", would return the correct unpacked numbers, regardless of which packing method was employed. It would be transparent to the user except for the questions of precision outlined above.

GRIB CODE FORM.

With the exception of the first four octets of the Indicator Section, and the End Section, all octets contain binary values. All sections contain an even number of octets; the variable length sections are padded with zero values as necessary. These extra bits must be accounted for in finding one's way through the sections; their content should be ignored.

SECTION 0: THE INDICATOR SECTION (IS)

The indicator section serves to: identify the start of the record in a human readable form, indicate the total length of the message, and indicate the Edition number of GRIB used to construct or encode the message. The section is always eight octets long.

Octet no.	IS Content
1-4	'GRIB' (Coded CCITT-ITA No. 5) (ASCII);
5-7	Total length, in octets, of GRIB message (including Sections 0 & 5);
8	Edition number - currently 1

SECTION 1: THE PRODUCT DEFINITION SECTION (PDS).

The PDS contains indicators for the Parameter table Version, the originating center, the numerical model (or "generating process") that created the data, the geographical area covered by the data, the parameter itself, the values for the appropriate vertical level or layer where the data reside, the decimal scale factor, and date/time information. The PDS is normally 28 octets long but it may be longer if an originating center chooses to make it so. Users of GRIB messages are strongly urged to use the length-of-section portion of the PDS to determine where the next section begins. Never assume a fixed octet length in this, or any other, section.

Octet no.	PDS Content	
1 - 3	Length in octets of the Product Definition Section	
4	Parameter Table Version number. Currently Version 2 for international exchange. (Parameter table version numbers 128-254 are reserved for local use.)	
5	Identification of center (Table 0 - Part 1)	
6	Generating process ID number (allocated by the originating center; See Table A)	
7	Grid Identification (geographical location and area; See Table B)	
8	Flag specifying the presence or absence of a GDS or a BMS (See Table 1)	
9	Indicator of parameter and units (Table 2)	
10	Indicator of type of level or layer (See Tables 3 & 3a)	
11-12	Height, pressure, etc. of the level or layer (See Table 3)	
13	Year of century	Initial (or Reference) time of forecast - UTC
14	Month of year	or
15	Day of month	Start of time period
16	Hour of day	for averaging or accumulation of
17	Minute of hour	analyses
18	Forecast time unit (see Table 4)	
19	P1 - Period of time (Number of time units) (0 for analysis or initialized analysis.) Units of time given by content of octet 18.	

Octet no.	PDS Content (cont.)
20	P2 - Period of time (Number of time units) or Time interval between successive analyses, successive initialized analyses, or forecasts, undergoing averaging or accumulation. Units given by octet 18.
21	Time range indicator (See Table 5)
22-23	Number included in average, when octet 21 (Table 5) indicates an average or accumulation; otherwise set to zero.
24	Number Missing from averages or accumulations.
25	Century of Initial (Reference) time (=20 until Jan. 1, 2001)
26	Identification of sub-center (Table 0 - Part 2)
27-28	The decimal scale factor D A negative value is indicated by setting the high order bit (bit No. 1) in octet 27 to 1 (on).
29-40	Reserved (need not be present)
41-...	Reserved for originating center use.

Note: Octet 8 may indicate the presence of the Grid Description Section (GDS) even though octet 7 specifies a predefined grid. In this case the GDS must describe that grid - this device serves as a mechanism for transmitting new "predefined" grids to users prior to their formal publication in this or the official WMO documentation. It is, however, the desired practice to always include the GDS in GRIB bulletins.

Another Note: The use of octet 26 to indicate a "sub-center" is not (yet) an officially sanctioned WMO practice. The Manual indicates the octet is to be "reserved", and set to 0. The use arises out of an upcoming change in the Manual in which the "originating centers" for both GRIB and BUFR (FM 94) will reference a single common table. The difficulty is that BUFR has two octets available for an originating center number while GRIB has only one. The compromise solution is to allow the use of octet 26 as the "second" octet for GRIB, but only in a national context. The WMO will coordinate the assignment of the numbers for octet 5 for national and international centers (for both GRIB and BUFR), while each national center will then be free to assign sub-center numbers at will to be placed in the octet 26. A zero value in octet 26 will serve as the default indicating that there is no sub-center associated with a particular center. Table 0, in this document, shows, in Part 1, a selection of the WMO recognized originating centers (those that are currently active) as would be found in octet 5, and, additionally, in Part 2, some sub-centers' numbers that are or soon will be in use in the U.S.

TABLES FOR THE PDS

TABLE 0 - Part 1

NATIONAL/INTERNATIONAL
ORIGINATING CENTERS
(Assigned By The WMO)
(PDS Octet 5)

VALUE	CENTER
07	US Weather Service - National Met. Center
08	US Weather Service - NWS Telecomms Gateway
09	US Weather Service - Field Stations
34	Japanese Meteorological Agency - Tokyo
52	National Hurricane Center, Miami
54	Canadian Meteorological Service - Montreal
57	U.S. Air Force - Global Weather Center
58	US Navy - Fleet Numerical Oceanography Center
59	NOAA Forecast Systems Lab, Boulder CO
74	U.K. Met Office - Bracknell
85	French Weather Service - Toulouse
97	European Space Agency (ESA)
98	European Center for Medium-Range Weather Forecasts - Reading
99	DeBilt, Netherlands

TABLE 0 - Part 2

NATIONAL
SUB-CENTERS
(Assigned By The Nation)
(PDS Octet 26)

The following are sub-center values for Center 7, the US National Meteorological Center

VALUE	CENTER
1	NMC Re-Analysis Project

The following are sub-center values for Center 9, the US National Weather Service Field Stations...

VALUE	CENTER
150	ABRFC - Arkansas-Red River RFC, Tulsa OK
151	Alaska RFC, Anchorage, AK
152	CBRFC - Colorado Basin RFC, Salt Lake City, UT
153	CNRFC - California-Nevada RFC, Sacramento, CA
154	LMRFC - Lower Mississippi RFC, Slidel, LA
155	MARFC - Middle Atlantic RFC, State College, PA
156	MBRFC - Missouri Basin RFC, Kansas City, MO
157	NCRFC - North Central RFC, Minneapolis, MN
158	NERFC - Northeast RFC, Hartford, CT
159	NWRFC - Northwest RFC, Portland, OR
160	OHRFC - Ohio Basin RFC, Cincinnati, OH
161	SERFC - Southeast RFC, Atlanta, GA
162	WGRFC - West Gulf RFC, Fort Worth, TX
170	OUN - Norman OK WFO

TABLE A. Generating Process or Model (PDS Octet 6)

VALUE	MODEL
10	Global Wind-Wave Forecast Model
19	Limited-area Fine Mesh (LFM) analysis
25	Snow Cover Analysis
39	Nested Grid forecast Model (NGM)
42	Global Optimum Interpolation Analysis (GOI) from "Aviation" run
43	Global Optimum Interpolation Analysis (GOI) from "Final" run
44	Sea Surface Temperature Analysis
53	LFM-Fourth Order Forecast Model
64	Regional Optimum Interpolation Analysis (ROI)
68	80 wave triangular, 18-layer Spectral model from "Aviation" run
69	80 wave triangular, 18 layer Spectral model from "Medium Range Forecast" run
70	Quasi-Lagrangian Hurricane Model (QLM)
73	Fog Forecast model - Ocean Prod. Center
74	Gulf of Mexico Wind/Wave
75	Gulf of Alaska Wind/Wave
76	Bias corrected Medium Range Forecast
77	126 wave triangular, 28 layer Spectral model from "Aviation" run
78	126 wave triangular, 28 layer Spectral model

TABLE A. Generating Process or Model (PDS Octet 6)(cont.)

VALUE	MODEL
	from "Medium Range Forecast" run
79	Backup from the previous run
80	62 wave triangular, 18 layer Spectral model from "Medium Range Forecast" run
81	Spectral Statistical Interpolation (SSI) analysis from "Aviation" run.
82	Spectral Statistical Interpolation (SSI) analysis from "Final" run.
83	ETA Model - 80 km version
84	ETA Model - 40 km version
85	ETA Model - 30 km version
86	MAPS Model, from Forecast Systems Lab (Isentropic; scale: 60km at 40N)
87	CAC Ensemble Forecasts from Spectral (ENSMB)
150	NWS River Forecast System (NWSRFS)
151	NWS Flash Flood Guidance System (NWSFFGS)
152	WSR-88D Stage II Precipitation Analysis
153	WSR-88D Stage III Precipitation Analysis

TABLE B. GRID IDENTIFICATION (PDS Octet 7)

MASTER LIST OF NMC STORAGE GRIDS

VALUE	GRID	GRID INCREMENT
1	1679-point (73x23) Mercator grid with (1,1) at (0W,48.09S), (73,23) at (0W, 48.09N); I increasing eastward, Equator at J=12.	5 degs of longitude
2	10512-point (144x73) global longitude-latitude grid. (1,1) at 0E, 90N, matrix layout. N.B.: prime meridian not duplicated.	2.5 deg
3	65160-point (360x181) global longitude-latitude grid. (1,1) at 0E, 90N, matrix layout. N.B.: prime meridian not duplicated.	1.0 deg
4	259920-point (720x361) global lon/lat grid. (1,1) at 0E, 90N; matrix layout; prime meridian not duplicated	0.5 deg

5	3021-point (53x57) N. Hemisphere polar stereographic grid oriented 105W; Pole at (27,49). (LFM analysis)	190.5 km at 60N
6	2385-point (53x45) N. Hemisphere polar stereographic grid oriented 105W; Pole at (27,49). (LFM Forecast)	190.5 km at 60N
21-26	International Exchange and Family of Services (FOS) grids - see below	
27	4225-point (65x65) N. Hemisphere polar stereographic grid oriented 80W; Pole at (33,33).	381 km at 60N
28	4225-point (65x65) S. Hemisphere polar stereographic grid oriented 100E; Pole at (33,33).	381 km at 60S
29	5365-point (145x37) N. Hemisphere longitude/latitude grid for latitudes 0N to 90N; (1,1) at (0E,0N).	2.5 degs
30	5365-point (145x37) S. Hemisphere longitude/latitude grid for latitudes 90S to 0S; (1,1) at (0E,90S).	2.5 degs
33	8326-point (181x46) N. Hemisphere longitude/latitude grid for latitudes 0N to 90N; (1,1) at (0E,0N).	2 degs
34	8326-point (181x46) S. Hemisphere longitude/latitude grid for latitudes 90S to 0S; (1,1) at (0E,90S).	2 degs
37 - 44	Eight lat-long 1.25x1.25 "thinned" grids, covering the globe by octants of 3447 points. Full GRIB specifications below. For WAFC, ICAO, Family of Services (FOS), and International exchange.	
50	Family of Services "regional grid" - see below.	
55	6177-point (87x71) N. Hemisphere polar stereographic grid oriented 105W; Pole at (44,38). (2/3 bedient NH sfc anl)	254 km at 60N
56	6177-point (87x71) N. Hemisphere polar stereographic grid oriented 105W; Pole at (40,73). (1/3 bedient NA sfc anl)	127 km at 60N
61-64	International Exchange & FOS grids - see below.	

75	12321-point (111x111) N. Hemisphere Lambert Conformal grid. No fixed location; used by QLM Hurricane model.	40 km at 30&60 deg N
76	12321-point (111x111) S. Hemisphere Lambert Conformal grid. No fixed location; used by QLM Hurricane model.	40 km at 30&60 deg S
77	12321-point (111x111) N. Hemisphere Mercator grid. No fixed location; used by QLM Hurricane model.	40 km at 22.5 deg N&S
85	32400-point (360x90) N. Hemisphere longitude/latitude grid; longitudes: 0.5E to 359.5E (0.5W); latitudes: 0.5N to 89.5N; origin (1,1) at (0.5E,0.5N)	1 deg
86	32400-point (360x90) S. Hemisphere longitude/latitude grid; longitudes: 0.5E to 359.5E (0.5W); latitudes: 89.5S to 0.5S; origin (1,1) at (0.5E,89.5S)	1 deg
87	5022 point (81x62) N. Hemisphere polar stereographic grid oriented at 105W. Pole at (31.91, 112.53) Used for RUC. (60 km at 40N). See below for GRIB specification.	68.153 km at 60N
90	12902 point (92x141 semi-staggered) lat. long., rotated such that center located at 52.0N, 111.0W; LL at 37.5W, 35S Unfilled E grid for 80 km ETA model	lat.14/26 deg lon.15/26 deg
91	25803 point (183x141) lat. long., rotated such that center located at 52.0N, 111.0W; LL at 37.5W,35S Filled E grid for 80 km ETA model	lat.14/26 deg lon.15/26 deg
92	24162 point (127x191 semi-staggered) lat. long., rotated such that center located at 41.0N, 97.0W; LL at 35W,25S Unfilled E grid for 40 km ETA model	lat. 15/57 deg lon. 5/18 deg
93	48323 point (253x191)lat. long., rotated such that center located at 41.0N, 97.0W; LL at 35W ,25S Filled E grid for 40 km ETA model	lat.15/57 deg lon.5/18 deg
98	Global Gaussian T62 grid. See GRIB specifications below	

100	6889-point (83x83) N. Hemisphere polar stereographic grid oriented 105W; Pole at (40.5,88.5). (NGM Original C-Grid)	91.452 km at 60N
101	10283-point (113x91) N. Hemisphere polar stereographic grid oriented 105W; Pole at (58.5,92.5). (NGM "Big C-Grid")	91.452 km at 60N
103	3640-point (65x56) N. Hemisphere polar stereographic grid oriented 105W; Pole at (25.5,84.5) (used by ARL)	91.452 km at 60N
104	16170-point (147x110) N. Hemisphere polar stereographic grid oriented 105W; pole at (75.5,109.5). (NGM Super C grid)	90.75464 km at 60N
105	6889-point (83x83) N. Hemisphere polar stereographic grid oriented 105W; pole at (40.5,88.5). (U.S. area subset of NGM Super C grid, used by ETA model)	90.75464 km at 60N
106	19305 point (165x117) N. Hemisphere stereographic grid oriented 105W; pole at (80,176) Hi res. ETA (2 x resolution of Super C)	45.37732 km at 60N
107	11040 point (120x92) N. Hemisphere stereographic grid oriented 105W; pole at (46,167) subset of Hi res. ETA; for ETA & MAPS/RUC	45.37732 km at 60N
126	Global Gaussian T126 grid. See GRIB specifications below	
201-nnn	AWIPS grids. See specifications below.	
255	(non-defined grid - specified in the GDS)	

NOTE ON NMC STORAGE GRIDS:

On the polar stereographic grids, the vector wind is resolved into u and v components with respect to the grid coordinates, i.e., u represents motion in the direction of increasing x (i) coordinate, v in the direction of increasing y (j). On the latitude-longitude grids, u and v are true eastward and northward components, respectively. However, take note of Table 7, below, which allows for the specification of other possibilities when the Grid Description Section is included in the message.

INTERNATIONAL EXCHANGE AND FAMILY OF SERVICES (FOS) GRIDS

VALUE	RESOLUTION (degrees) lon x lat	AREA COVERAGE (degrees)	GRID SHAPE cols	rows	GRID POINTS
21	5.0 x 2.5	0-180E, 0-90N	37	36 + pole	1333
22	5.0 x 2.5	180W-0, 0-90N	37	36 + pole	1333
23	5.0 x 2.5	0-180E, 90S-0	pole + 37	36	1333
24	5.0 x 2.5	180W-0, 90S-0	pole + 37	36	1333
25	5.0 x 5.0	0-355E, 0-90N	72	18 + pole	1297
26	5.0 x 5.0	0-355E, 90S-0	pole + 72	18	1297
50	2.5 x 1.25	(see note iv)			964
61	2.0 x 2.0	0-180E, 0-90N	91	45 + pole	4096
62	2.0 x 2.0	180W-0, 0-90N	91	45 + pole	4096
63	2.0 x 2.0	0-180E, 90S-0	pole + 91	45	4096
64	2.0 x 2.0	180W-0, 90S-0	pole + 91	45	4096
255	(non-standard grid - defined in the GDS)				

NOTES ON INTERNATIONAL EXCHANGE/FOS GRIDS:

(i) The grid points are laid out in a linear array such that the longitude index (the columns) is the most rapidly varying. For the northern hemisphere grids the first point in the record is at the intersection of the western-most meridian and southern-most circle of latitude; the last point is the single polar value (see note iii, below). For the southern hemisphere grids the first point in the record is the single polar value (see note iii, below); the last point is at the intersection of the eastern-most meridian and northern-most circle of latitude. For those familiar with FORTRAN subscripting conventions, longitude is the first subscript, latitude the second.

(ii) In grids 21 through 26, and 61 through 64, the values on the shared boundaries are included in each area.

(iii) The datum for the pole point is given only once in each grid. The user must expand, if desired, the single pole point value to all the pole "points" at the pole row of a latitude-longitude grid. Scalar quantity values are the same for all pole points on a the grid. Wind components at the poles are given by the formulae:

$$u = -speed * \sin(dd) \quad \& \quad v = -speed * \cos(dd)$$

where dd is the direction of the wind as reported according to the specification of wind direction at the poles (refer to WMO Manual on Codes, code table 878).

The WMO convention can be given this operational definition: At the North Pole, face into the wind and report the value of the west longitude meridian along which the wind is coming at you; at the South Pole do likewise but report the east longitude meridian value. This is equivalent to placing the origin of a right-handed Cartesian coordinate system on the North Pole with the y-axis pointing to the prime (0 degree) meridian and the x-axis pointing to the 90 degrees west meridian, and then resolving any vector wind at the pole point into components along those axes. At the South Pole the coordinate axes are oriented such that the y-axis points toward 180 degrees west. Those components are the u- and v-values given as the single pair of pole point winds in the GRIB format.

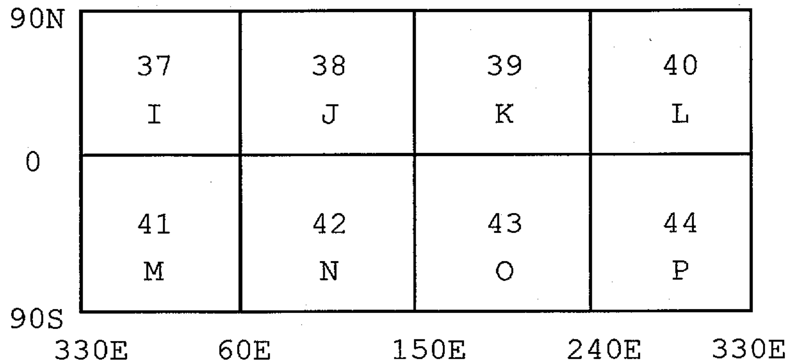
In terms of a longitude/latitude grid these are the wind components for the pole point at the 180 degree meridian. For example, on a 2.5x2.5 degree northern hemisphere grid (145x37 points), with the abscissa along the equator and the ordinate along the prime meridian, the transmitted north pole wind components are those that belong at the gridpoint (73,37). The wind components at the other grid points along the pole row may be obtained through suitable rotation of the coordinate system. All the components at the pole row are, of course, simply representations of the same vector wind viewed from differing (rotated) coordinate systems. In the southern hemisphere the analogous situation holds; the single set of transmitted pole point wind components belong at the gridpoint (73,1).

(iv) Grid 50 is a set of points over the contiguous United States and environs on a grid extending from 20N (row No. 1) to 60N (row No. 33) in 1.25 degree intervals. The grid increases in longitudinal extent from south to north in the following manner:

ROWS	NO. POINTS	LONGITUDINAL EXTENT
1-4	22	122.5W - 70.0W
5-8	24	125.0W - 67.5W
9-12	26	127.5W - 65.0W
13-16	28	130.0W - 62.5W
17-20	30	132.5W - 60.0W
21-24	32	135.0W - 57.5W
25-28	34	137.5W - 55.0W
29-33	36	140.0W - 52.5W

WAFS/ICAO/INTERNATIONAL EXCHANGE/FOS GRIDS

(Grids 37 - 44)



Global Coverage of Grids
Octants of the Globe

In the figure the coordinates indicate the location of the octants of the globe, the numbers are the corresponding grid identification numbers (PDS Octet 7), and the letters are the grid identification used in the WMO heading (see Appendix A).

The left and right meridional columns of each octant/grid are shared with the neighbors.

The basic grid point separation is 1.25x1.25 deg. on a latitude/longitude array, but the grid is "thinned" by reducing the number of points in each row as one goes northward (or southward) away from the equator. In GRIB terms, this is referred to as a "quasi-regular" grid.

The latitudinal increment is always 1.25 deg.; this results in 73 rows where the pole is included as a "row", not a single gridpoint.

The longitudinal spacing at the equator is also 1.25 deg.; thus there will be 73 gridpoints at the equator in each octant.

The number of points on each latitudinal row, other than the equator, is given by (using FORTRAN notation):

NPOINTS = IFIX(2.0 + (90.0/1.25) * COS(LATITUDE))

Thus at the pole there will be two gridpoints, one each at the meridians that delineate the edges of the octant. The formula was worked out so that there is (approximately) equal geographic separation between the grid points uniformly across the globe.

Because of variations in precision and roundoff error in different computers, the value of NPOINTS may vary by 1 at "critical" latitudes when calculated on various hardware platforms. Here is a table of the exact values of NPOINTS as a function of latitude as used in the internationally exchanged grids. These numbers will, of course, be found in the Grid Description Section of each GRIB bulletin.

Table B: GRIDS (cont.)

Latitude Range inclusive (north or south)	NPOINTS	Latitude Range inclusive (north or south)	NPOINTS
0.00 - 8.75	73	55.00	43
10.00 - 12.50	72	56.25	42
13.75 - 16.25	71	57.50	40
17.50 - 18.75	70	58.75	39
20.00 - 21.25	69	60.00	38
22.50	68	61.25	36
23.75 - 25.00	65	62.50	35
30.00	64	63.75	33
31.25	63	65.00	32
32.50	62	66.25	30
33.75	61	67.50	29
35.00 - 36.25	60	68.75	28
37.50	59	70.00	26
38.75	58	71.25	25
40.00	57	72.50	23
41.25	56	73.75	22
42.50	55	75.00	20
43.75	54	76.25	19
45.00	52	77.50	17
46.25	51	78.75	16
47.50	50	80.00	14
48.75	49	81.25	12
50.00	48	82.50	11
51.25	47	83.75	9
52.50	45	85.00	8
53.75	44	86.25	6
		87.50	5
		88.75	3
		90.00	2

When all this is put together the result is that there are 3447 points of data actually transmitted in any individual GRIB bulletin containing one octant of the globe.

In the GRIB bulletins all of this information will be included in the Grid Description Section (GDS); the GDS must be included in order to describe the thinned or "quasi-regular" grid structure. See Section 2 and Table C for the general description of the GDS; what follows are the specific values of the variables in the GDS that describe these eight grids.

GDS Contents

Octets	Value or variable
1-3	178 (length of GDS)
4	0 (or 255, either indicating no PV)
5	33 (pointer to start of PL list)
6	0
7-32	Grid description - see below
33-178	number of points in each of 73 rows (2 octets per point)

Details of Octets 7-32 - Grid Description

Octets	Variable & Value
7-8	Ni = all bits set to 1 (missing)
9-10	Nj = 73

	GRID:	37	38	39	40	41	42	43	44
11-13	La1 =	0	0	0	0	90S	90S	90S	90S
14-16	Lo1 =	330	60	150	240	330	60	150	240

17 Resolution & Component Flag = [10000000] (binary)

	GRID:	37	38	39	40	41	42	43	44
18-20	La2 =	90N	90N	90N	90N	0	0	0	0
21-23	Lo2 =	60	150	240	330	60	150	240	330

24-25	Di = all bits set to 1 (missing)
26-27	Dj = 1.25 deg
28	Scan Mode = [01000000] (binary)
29-32	Set to 0 (unused)

Note that the scanning direction is from the bottom (south edge) to the top of the octant grids, regardless of the hemisphere. Thus in the northern hemisphere the first 73 data points (in the BDS) will be the equatorial values and the last two will be the polar values. The PL counts in the GDS octets 33-178 will, of course, indicate contain these numbers.

In the southern hemisphere, the first two data points will be the south pole values, and the last 73 points will be the equatorial values. Octets 33-34 in the GDS will contain "2", octets 35-36 will contain a "3", and so on to octets 177-178 which will contain "73".

SELECTED NMC GRIDS DEFINED USING GRIB SPECIFICATIONS
(See Table C, in Section 2, for definition of symbols)

VALUE	GRID DESCRIPTIONS	
1	Tropical Strip (Mercator)	
	Ni =	73
	Nj =	23
	La1 =	48.09S
	Lo1 =	0.0E
	Res. & Comp. flag =	1 0 0 0 0 0 0 0
	La2 =	48.09N
	Lo2 =	0.0W
	Latin =	22.5
	Scanning Mode (Bits 1 2 3) = 0 1 0	
	Di = Dj = 513.669 km	

The longitudinal grid spacing is 5.00 degrees.

VALUE	GRID DESCRIPTIONS	
3	Global Latitude/Longitude 1 deg Resolution	
	Ni =	360
	Nj =	181
	La1 =	90.000N
	Lo1 =	0.0E
	Res. & Comp. flag =	1 0 0 0 0 0 0 0
	La2 =	90.000S
	Lo2 =	359.000E = 1.000W
	Di =	1.000 degrees
	Dj =	1.000 degrees
	Scanning Mode = 00000000(NB:matrix style)	

87 U.S. Area; used in MAPS/RUC
(60km at 40N)
(N. Hem. polar stereographic)

Nx =	81
Ny =	62
La1 =	22.8756N
Lo1 =	239.5089E = 120.4911W
Res. & Comp. flag = 0 0 0 0 1 0 0 0	
Lov =	255.000E = 105.000W
Dx = Dy =	68.153 km
Projection Flag (Bit 1) = 0	
Scanning Mode (Bits 1 2 3) = 0 1 0	

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	22.8756N, 120.4911W
(1,62) =	52.4887N, 136.5458W
(81,62) =	46.0172N, 60.8284W
(81,1) =	20.1284N, 81.2432W

The pole point is at (I,J) = (31.91,112.53)

---

90 Arakawa semi-staggered E-grid on rotated latitude/longitude grid
(used by the 80 km eta model)

Ni =	12902
Nj =	1
La1 =	0.182N
Lo1 =	210.113E = 149.887W
Res. & Comp. flag =	1 0 0 0 1 0 0 0
La2 =	92
Lo2 =	141
Di =	577 millidegrees (=15/26 deg)
Dj =	538 millidegrees (=14/26 deg)
Scanning Mode = 01000000	

Note: The rotation of the coordinates is such that the intersection of the "prime meridian" and the "equator" is located at the central latitude and longitude of the grid, 52.0N, 111.0W.

91 Arakawa filled E-grid on rotated latitude/longitude grid
(used by the 80 km eta model)

Ni =	25803
Nj =	1
La1 =	0.182N
Lo1 =	210.113E = 149.887W
Res. & Comp. flag =	1 0 0 0 1 0 0 0
La2 =	183
Lo2 =	141
Di =	577 millidegrees (=15/26 deg)
Dj =	538 millidegrees (=14/26 deg)
Scanning Mode =	01000000

Note: The rotation of the coordinates is such that the intersection of the "prime meridian" and the "equator" is located at the central latitude and longitude of the grid, 52.0N, 111.0W.

---

92 Arakawa semi-staggered E-grid on rotated latitude/longitude grid
(used by the 40 km eta model)

Ni =	24162
Nj =	1
La1 =	9.678N
Lo1 =	231.174E = 128.826W
Res. & Comp. flag =	1 0 0 0 1 0 0 0
La2 =	127
Lo2 =	191
Di =	278 millidegrees (=5/18 deg)
Dj =	263 millidegrees (=15/57 deg)
Scanning Mode =	01000000

Note: The rotation of the coordinates is such that the intersection of the "prime meridian" and the "equator" is located at the central latitude and longitude of the grid, 41.0N, 97.0W.

93 Arakawa filled E-grid on rotated latitude/longitude grid (used by the 40 km eta model)

Ni =	48323
Nj =	1
La1 =	9.678N
Lo1 =	231.174E = 128.826W
Res. & Comp. flag =	1 0 0 0 1 0 0 0
La2 =	253
Lo2 =	191
Di =	278 millidegrees (=5/18 deg)
Dj =	263 millidegrees (=15/57 deg)
Scanning Mode =	01000000

Note: The rotation of the coordinates is such that the intersection of the "prime meridian" and the "equator" is located at the central latitude and longitude of the grid, 41.0N, 97.0W.

---

98 Global Gaussian Latitude/Longitude T62 Resolution

Ni =	192
Nj =	94
La1 =	88.542N
Lo1 =	0.0E
Res. & Comp. flag =	1 0 0 0 0 0 0 0
La2 =	88.542S
Lo2 =	358.125E = 1.875W
Di =	1.875 degrees
N =	47 (number of lat. circles, pole to equator)
Scanning Mode =	00000000(NB:matrix style)

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	88.542N, 0.0E (upper left)
(1,190) =	88.542S, 0.0E
(384,190) =	88.542S, 359.0625E
(384,1) =	88.542N, 359.0625E

126 Global Gaussian Latitude/Longitude T126 Resolution

Ni =	384
Nj =	190
La1 =	89.277N
Lo1 =	0.0E
Res. & Comp. flag =	1 0 0 0 0 0 0 0
La2 =	89.277S
Lo2 =	359.0625E = 0.9375W
Di =	0.9375 degrees
N =	95 (# of lat circles pole to equator)
Scanning Mode =	00000000(NB:matrix style)

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	89.277N, 0.0E (upper left)
(1,190) =	89.277S, 0.0E
(384,190) =	89.277S, 359.0625E
(384,1) =	89.277N, 359.0625E

AWIPS-90 STORAGE AND TRANSMISSION GRIDS

Note: The following grids are intended for use in the U.S. Weather Service's Advanced Weather Information Processing System for the 1990s (AWIPS-90). Their definition is subject to change as the AWIPS-90 requirements are further refined. The parenthetical letters adjacent to the numeric values are the WMO header identification of the grid. See appendix A.

VALUE — AWIPS GRID DESCRIPTIONS (See Table C for definition of symbols)

201 (A)

Hemispheric
(polar stereographic)

Nx =	65
Ny =	65
La1 =	-20.826N = 20.826S
Lo1 =	210.000E = 150.000W
Res. & Comp. flag =	0 0 0 0 1 0 0 0
Lov =	255.000E = 105.000W
Dx = Dy =	381.000 km

Projection Flag (Bit 1) = 0
Scanning Mode (Bits 1 2 3) = 0 1 0

The pole point is at (I,J) = (33,33)

Map 201 is the same as NMC storage grid 27, except it is rotated to 105 deg. orientation.

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202 (I)

National - CONUS
(polar stereographic)

Nx =	65
Ny =	43
La1 =	7.838N
Lo1 =	218.972E = 141.028W
Res. & Comp. flag =	0 0 0 0 1 0 0 0
Lov =	255.000E = 105.000W
Dx = Dy =	190.500 km

Projection Flag (Bit 1) = 0
Scanning Mode (Bits 1 2 3) = 0 1 0

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	7.838N, 141.028W
(1,43) =	35.616N, 168.577E
(65,43) =	35.617N, 18.576W
(65,1) =	7.838N, 68.973W

The pole point is at (I,J) = (33,45)

203 (J)

National - Alaska
(polar stereographic)

Nx =	45
Ny =	39
La1 =	19.132N
Lo1 =	174.163E = 185.837W
Res. & Comp. flag =	0 0 0 0 1 0 0 0
Lov =	210.000E = 150.000W
Dx = Dy =	190.500 km
Projection Flag (Bit 1) = 0	
Scanning Mode (Bits 1 2 3) = 0 1 0	

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	19.132N, 174.163E
(1,39) =	44.646N, 115.601E
(45,39) =	57.634N, 53.660W
(45,1) =	24.361N, 123.434W

The pole point is at (I,J) = (27,37)

---

204 (K)

National - Hawaii
(Mercator)

Ni =	93
Nj =	68
La1 =	25.000S
Lo1 =	110.000E
Res. & Comp. flag =	1 0 0 0 0 0 0 0
La2 =	60.644N
Lo2 =	109.129W
Latin =	20.000
Scanning Mode (Bits 1 2 3) = 0 1 0	
Di = Dj = 160.000 km	

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	25.000S, 110.000E
(1,68) =	60.644N, 110.000E
(93,68) =	60.644N, 109.129W
(93,1) =	25.000S, 109.129W

The longitudinal grid spacing is 1.531 degrees.

205 (L)

National - Puerto Rico
(polar stereographic)

Nx =	45
Ny =	39
La1 =	0.616N
Lo1 =	275.096E = 84.904W
Res. & Comp. flag =	0 0 0 0 1 0 0 0
Lov =	300.000E = 60.000W
Dx = Dy =	190.500 km
Projection Flag (Bit 1) = 0	
Scanning Mode (Bits 1 2 3) = 0 1 0	

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	0.616N, 84.904W
(1,39) =	36.257N, 115.304W
(45,39) =	45.620N, 15.000W
(45,1) =	3.389N, 42.181W

The pole point is at (I,J) = (27,57)

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206 (M)

Regional - Central US MARD
(Lambert Conformal)

Nx =	51
Ny =	41
La1 =	22.289N
Lo1 =	242.009E = 117.991W
Res. & Comp. flag =	0 0 0 0 1 0 0 0
Lov =	265.000E = 95.000W
Dx = Dy =	81.2705 km
Projection Flag = 0 (not bipolar)	
Scanning Mode (Bits 1 2 3) = 0 1 0	
Latin 1 = 25.000N	
Latin 2 = 25.000N (tangent cone)	

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	22.289N, 117.991W
(1,41) =	50.081N, 124.898W
(51,41) =	51.072N, 73.182W
(51,1) =	23.142N, 78.275W

The Dx, Dy grid increment (at 25 deg north) was selected so that the grid spacing would be exactly 80.000 km at 35 deg north; the intersection of 35N & 95W falls on point (30,16).

207 (N)

Regional - Alaska
(polar stereographic)

Nx =	49
Ny =	35
La1 =	42.085N
Lo1 =	184.359E = 175.641W
Res. & Comp. flag =	0 0 0 0 1 0 0 0
Lov =	210.000E = 150.000W
Dx = Dy =	95.250 km
Projection Flag (Bit 1) = 0	
Scanning Mode (Bits 1 2 3) = 0 1 0	

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	42.085N, 175.641W
(1,35) =	63.976N, 153.689E
(49,35) =	63.976N, 93.689W
(49,1) =	42.085N, 124.359W

The pole point is at (I,J) = (25,51)

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208 (O)

Regional - Hawaii
(Mercator)

Ni =	29
Nj =	27
La1 =	9.343N
Lo1 =	192.685E = 167.315W
Res. & Comp. flag =	1 0 0 0 0 0 0 0
La2 =	28.092N
Lo2 =	145.878W
Latin =	20.000
Scanning Mode (Bits 1 2 3) = 0 1 0	
Di = Dj =	80.000 km

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	9.343N, 167.315W
(1,27) =	28.092N, 167.315W
(29,27) =	28.092N, 145.878W
(29,1) =	9.343N, 145.878W

The longitudinal grid spacing is 0.766 degrees. The grid is positioned such that the odd-numbered rows and columns coincide with the National grid, No. 204; the lower left corner of the regional grid is located at National (204) grid-point (55,24) and the upper right corner is located at (69,37).

209 (S)

Regional - Central US MARD - Double Res.
(Lambert Conformal)

Nx =	101
Ny =	81
La1 =	22.289N
Lo1 =	242.00962E = 117.991W
Res. & Comp. flag =	0 0 0 0 1 0 0 0
Lov =	265.000E = 95.000W
Dx = Dy =	40.63525 km
Projection Flag =	0 (not bipolar)

Scanning Mode (Bits 1 2 3) = 0 1 0
Latin 1 = 25.000N
Latin 2 = 25.000N (tangent cone)

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	22.289N, 117.991W
(1,81) =	50.081N, 124.898W
(101,81) =	51.072N, 73.182W
(101,1) =	23.142N, 78.275W

The Dx, Dy grid increment (at 25 deg north) was selected so that the grid spacing would be exactly 40.000 km at 35 deg north; the intersection of 35N & 95W falls on point (59,31).

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210 (P)

Regional - Puerto Rico
(Mercator)

Ni =	25
Nj =	25
La1 =	9.000N
Lo1 =	283.000E = 77.000W
Res. & Comp. flag =	1 0 0 0 0 0 0 0
La2 =	26.422N
Lo2 =	58.625W
Latin =	20.000
Di = Dj =	80.000 km

Scanning Mode (Bits 1 2 3) = 0 1 0

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	9.000N, 77.000W
(1,25) =	26.422N, 77.000W
(25,25) =	26.422N, 58.625W
(25,1) =	9.000N, 58.626W

The longitudinal grid spacing is 0.766 degrees

211 (Q) — Regional - CONUS
(Lambert Conformal)

Nx =	93
Ny =	65
La1 =	12.190N
Lo1 =	226.541E = 133.459W
Res. & Comp. flag =	0 0 0 0 1 0 0 0
Lov =	265.000E = 95.000W
Dx = Dy =	81.2705 km
Projection Flag = 0 (not bipolar)	
Scanning Mode (Bits 1 2 3) = 0 1 0	
Latin 1 =	25.000N
Latin 2 =	25.000N (tangent cone)

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	12.190N, 133.459W
(1,65) =	54.536N, 152.856W
(93,65) =	57.290N, 49.385W
(93,1) =	14.335N, 65.091W

The Dx, Dy grid increment (at 25 deg north) was selected so that the grid spacing would be exactly 80.000 km at 35 deg north; the intersection of 35N & 95W falls on point (53,25).

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212 (R) — Regional - CONUS - double resolution
(Lambert Conformal)

Nx =	185
Ny =	129
La1 =	12.190N
Lo1 =	226.541E = 133.459W
Res. & Comp. flag =	0 0 0 0 1 0 0 0
Lov =	265.000E = 95.000W
Dx = Dy =	40.63525 km
Projection Flag = 0 (not bipolar)	
Scanning Mode (Bits 1 2 3) = 0 1 0	
Latin 1 =	25.000N
Latin 2 =	25.000N (tangent cone)

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	12.190N, 133.459W
(1,129) =	54.536N, 152.856W
(185,129) =	57.290N, 49.385W
(185,1) =	14.335N, 65.091W

The Dx, Dy grid increment (at 25 deg north) was selected so that the grid spacing would be exactly 40.000 km at 35 deg north; the intersection of 35N & 95W falls on point (105,49).

213 (H)

National - CONUS - Double Resolution
(polar stereographic)

Nx =	129
Ny =	85
La1 =	7.838N
Lo1 =	218.972E = 141.028W
Res. & Comp. flag =	0 0 0 0 1 0 0 0
Lov =	255.000E = 105.000W
Dx = Dy =	95.250 km
Projection Flag (Bit 1) = 0	
Scanning Mode (Bits 1 2 3) = 0 1 0	

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	7.838N, 141.028W
(1,85) =	35.617N, 168.577E
(129,85) =	35.617N, 18.577W
(129,1) =	7.838N, 68.973W

The pole point is at (I,J) = (65,89)

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214 (T)

Regional - Alaska - Double Resolution
(polar stereographic)

Nx =	97
Ny =	69
La1 =	42.085N
Lo1 =	184.359E = 175.641W
Res. & Comp. flag =	0 0 0 0 1 0 0 0
Lov =	210.000E = 150.000W
Dx = Dy =	47.625 km
Projection Flag(Bit 1) = 0	
Scanning Mode (Bits 1 2 3) = 0 1 0	

For reference here are the lat/lon values of the corners of the grid:

(1,1) =	42.085N, 175.641W
(1,69) =	63.975N, 153.690E
(97,69) =	63.975N, 93.689W
(97,1) =	42.085N, 124.358W

The pole point is at (I,J) = (49,101)

TABLE 1. FLAG FOR GDS OR BMS
(PDS Octet 8)

The bit flag indicates the omission or inclusion of the Grid Description and/or Bit Map Sections.

BIT	VALUE	MEANING
1	0	GDS Omitted
	1	GDS Included
2	0	BMS Omitted
	1	BMS Included
3-8	0	reserved

TABLE 2. PARAMETERS & UNITS
Version 2
(PDS Octet 9)

VALUE	PARAMETER	UNITS	ABBREV.
000	Reserved		
001	Pressure	Pa	PRES
002	Pressure reduced to MSL	Pa	PRMSL
003	Pressure tendency	Pa/s	PTEND
004			
005			
006	Geopotential	m^2/s^2	GP
007	Geopotential height	gpm	HGT
008	Geometric height	m	DIST
009	Standard deviation of height	m	HSTDV
010			
011	Temperature	K	TMP
012	Virtual temperature	K	VTMP
013	Potential temperature	K	POT
014	Pseudo-adiabatic potential temperature or equivalent potential temperature	K	EPOT
015	Maximum temperature	K	T MAX
016	Minimum temperature	K	T MIN
017	Dew point temperature	K	DPT
018	Dew point depression (or deficit)	K	DEPR
019	Lapse rate	K/m	LAPR
020	Visibility	m	VIS
021	Radar Spectra (1)	-	RDSP1
022	Radar Spectra (2)	-	RDSP2
023	Radar Spectra (3)	-	RDSP3
024			
025	Temperature anomaly	K	TMP A
026	Pressure anomaly	Pa	PRESA
027	Geopotential height anomaly	gpm	GP A
028	Wave Spectra (1)	-	WVSP1
029	Wave Spectra (2)	-	WVSP2
030	Wave Spectra (3)	-	WVSP3
031	Wind direction (from which blowing)	deg true	WDIR
032	Wind speed	m/s	WIND
033	u-component of wind	m/s	U GRD
034	v-component of wind	m/s	V GRD
035	Stream function	m^2/s	STRM
036	Velocity potential	m^2/s	V POT
037	Montgomery stream function	m^2/s^2	MNTSF
038	Sigma coord. vertical velocity	/s	SGCVV
039	Pressure Vertical velocity	Pa/s	V VEL
040	Geometric Vertical velocity	m/s	DZDT

TABLE 2.(cont.)

VALUE	PARAMETER	UNITS	ABBREV.
041	Absolute vorticity	/s	ABS V
042	Absolute divergence	/s	ABS D
043	Relative vorticity	/s	REL V
044	Relative divergence	/s	REL D
045	Vertical u-component shear	/s	VUCSH
046	Vertical v-component shear	/s	VVCSH
047	Direction of current	deg true	DIR C
048	Speed of current	m/s	SP C
049	u-component of current	m/s	UOGRD
050	v-component of current	m/s	VOGRD
051	Specific humidity	kg/kg	SPF H
052	Relative humidity	%	R H
053	Humidity mixing ratio	kg/kg	MIXR
054	Precipitable water	kg/m^2	P WAT
055	Vapor pressure	Pa	VAPP
056	Saturation deficit	Pa	SAT D
057	Evaporation	kg/m^2	EVP
058	Cloud Ice	kg/m^2	C ICE
059	Precipitation rate	$kg/m^2/s$	PRATE
060	Thunderstorm probability	%	TSTM
061	Total precipitation	kg/m^2	A PCP
062	Large scale precipitation (non-conv.)	kg/m^2	NCPCP
063	Convective precipitation	kg/m^2	ACPCP
064	Snowfall rate water equivalent	$kg/m^2/s$	SRWEQ
065	Water equiv. of accum. snow depth	kg/m^2	WEASD
066	Snow depth	m	SNO D
067	Mixed layer depth	m	MIXHT
068	Transient thermocline depth	m	TTHDP
069	Main thermocline depth	m	MTHD
070	Main thermocline anomaly	m	MTH A
071	Total cloud cover	%	T CDC
072	Convective cloud cover	%	CDCON
073	Low cloud cover	%	L CDC
074	Medium cloud cover	%	M CDC
075	High cloud cover	%	H CDC
076	Cloud water	kg/m^2	C WAT
077			
078	Convective snow	kg/m^2	SNO C
079	Large scale snow	kg/m^2	SNO L
080	Water Temperature	K	WTMP
081	Land-sea mask(land=1;sea=0) (see note)	fraction	LAND
082	Deviation of sea level from mean	m	DSL M
083	Surface roughness	m	SFC R
084	Albedo	%	ALBDO
085	Soil temperature	K	TSOIL
086	Soil moisture content	kg/m^2	SOIL M

TABLE 2.(cont.)

VALUE	PARAMETER	UNITS	ABBREV.
087	Vegetation	%	VEG
088	Salinity	kg/kg	SALTY
089	Density	kg/m^3	DEN
090	Water runoff	kg/m^2	WATR
091	Ice concentration (ice=1;no ice=0) (see note)	fraction	ICE C
092	Ice thickness	m	ICETK
093	Direction of ice drift	deg. true	DICED
094	Speed of ice drift	m/s	SICED
095	u-component of ice drift	m/s	U ICE
096	v-component of ice drift	m/s	V ICE
097	Ice growth rate	m/s	ICE G
098	Ice divergence	/s	ICE D
099	Snow melt	kg/m^2	SNO M
100	Significant height of combined wind waves and swell	m	HTSGW
101	Direction of wind waves (from which)	deg true	WVDIR
102	Significant height of wind waves	m	WVHGT
103	Mean period of wind waves	s	WVPER
104	Direction of swell waves	deg true	SWDIR
105	Significant height of swell waves	m	SWELL
106	Mean period of swell waves	s	SWPER
107	Primary wave direction	deg true	DIRPW
108	Primary wave mean period	s	PERPW
109	Secondary wave direction	deg true	DIRSW
110	Secondary wave mean period	s	PERSW
111	Net short-wave radiation (surface)	W/m^2	NSWRS
112	Net long wave radiation (surface)	W/m^2	NLWRS
113	Net short-wave radiation (top of atmos.)	W/m^2	NSWRT
114	Net long wave radiation (top of atmos.)	W/m^2	NLWRT
115	Long wave radiation	W/m^2	LWAVR
116	Short wave radiation	W/m^2	SWAVR
117	Global radiation	W/m^2	G RAD
118			
119			
120			
121	Latent heat net flux	W/m^2	LHTFL
122	Sensible heat net flux	W/m^2	SHTFL
123	Boundary layer dissipation	W/m^2	BLYDP
124	Momentum flux, u component	N/m^2	U FLX
125	Momentum flux, v component	N/m^2	V FLX
126	Wind mixing energy	J	WMIXE
127	Image data		IMG D

128 - 254 Reserved for use by originating center

VALUE	PARAMETER	UNITS	ABBREV.
	NWS/NMC usage as follows...		
128	Mean Sea Level Pressure (Standard Atmosphere Reduction)	Pa	MSLSA
129	Mean Sea Level Pressure (MAPS System Reduction)	Pa	MSLMA
130	Mean Sea Level Pressure (ETA Model Reduction)	Pa	MSLET
131	Surface lifted index	K	LFT X
132	Best (4 layer) lifted index	K	4LFTX
133	K index	K	K X
134	Sweat index	K	S X
135	Horizontal moisture divergence	kg/kg/s	MCONV
136	Vertical speed shear	1/s	VW SH
137	3-hr pressure tendency Std. Atmos. Reduction	Pa/s	TSLSA
138	Brunt-Vaisala frequency (squared)	$1/s^2$	BVF 2
139	Potential vorticity (density weighted)	1/s/m	PV MW
140	Categorical rain (yes=1; no=0)	non-dim	CRAIN
141	Categorical freezing rain (yes=1; no=0)	non-dim	CFRZRN
142	Categorical ice pellets (yes=1; no=0)	non-dim	CICEPL
143	Categorical snow (yes=1; no=0)	non-dim	CSNOW
150	Covariance between meridional and zonal components of the wind. Defined as [uv]-[u][v], where "[]" indicates the mean over the indicated time span.	m^2/s^2	COVMZ
151	Covariance between temperature and zonal component of the wind. Defined as [uT]-[u][T], where "[]" indicates the mean over the indicated time span.	K*m/s	COVTZ
152	Covariance between temperature and meridional component of the wind. Defined as [vT]-[v][T], where "[]" indicates the mean over the indicated time span.	K*m/s	COVTM
155	Ground Heat Flux	W/m^2	GFLUX
156	Convective inhibition	J/kg	CIN
157	Convective Available Potential Energy	J/kg	CAPE
158	Turbulent Kinetic Energy	J/kg	TKE
159	Condensation pressure of parcel lifted from indicated surface	Pa	CONDP
160	Clear Sky Upward Solar Flux	W/m^2	CSUSF
161	Clear Sky Downward Solar Flux	W/m^2	CSDSF
162	Clear Sky upward long wave flux	W/m^2	CSULF
163	Clear Sky downward long wave flux	W/m^2	CSDLF
164	Cloud forcing net solar flux	W/m^2	CFNSF

TABLE 2.(cont.)

VALUE	PARAMETER	UNITS	ABBREV.
165	Cloud forcing net long wave flux	W/m^2	CFNLF
166	Visible beam downward solar flux	W/m^2	VBDSF
167	Visible diffuse downward solar flux	W/m^2	VDDSF
168	Near IR beam downward solar flux	W/m^2	NBDSF
169	Near IR diffuse downward solar flux	W/m^2	NDDSF
172	Momentum flux	N/m^2	M FLX
173	Mass point model surface	non-dim	LMH
174	Velocity point model surface	non-dim	LMV
175	Model layer number (from bottom up)	non-dim	MLYNO
176	latitude (-90 to +90)	deg	NLAT
177	east longitude (0-360)	deg	ELON
181	x-gradient of log pressure	1/m	LPS X
182	y-gradient of log pressure	1/m	LPS Y
183	x-gradient of height	m/m	HGT X
184	y-gradient of height	m/m	HGT Y
201	Ice-free water surface	%	ICWAT
204	downward short wave rad. flux	W/m^2	DSWRF
205	downward long wave rad. flux	W/m^2	DLWRF
207	Moisture availability	%	MSTAV
208	Exchange coefficient	$(kg/m^3)(m/s)$	SFEXC
209	No. of mixed layers next to surface	integer	MIXLY
211	upward short wave rad. flux	W/m^2	USWRF
212	upward long wave rad. flux	W/m^2	ULWRF
213	Amount of non-convective cloud	%	CDLYR
214	Convective Precipitation rate	$kg/m^2/s$	CPRAT
215	Temperature tendency by all physics	K/s	TTDIA
216	Temperature tendency by all radiation	K/s	TTRAD
217	Temperature tendency by non-radiation physics	K/s	TTPHY
218	precip.index(0.0-1.00)(see note)	fraction	PREIX
219	Std. dev. of IR T over 1x1 deg area	K	TSD1D
220	Natural log of surface pressure	ln(kPa)	NLGSP
222	5-wave geopotential height	gpm	5WAVH
223	Plant canopy surface water	kg/m^2	C WAT
226	Blackadar's mixing length scale	m	BMIXL
227	Asymptotic mixing length scale	m	AMIXL
228	Potential evaporation	kg/m^2	PEVAP
229	Snow phase-change heat flux	W/m^2	SNOHF
231	Convective cloud mas flux	Pa/s	MFLUX
232	Downward total radiation flux	W/m^2	DTRF
233	Upward total radiation flux	W/m^2	UTRF
234	Baseflow-groundwater runoff	kg/m^2	BGRUN
235	Storm surface runoff	kg/m^2	SSRUN
238	Snow cover	percent	SNO C
239	Snow temperature	K	SNO T
241	Large scale condensat. heat rate	K/s	LRGHR

TABLE 2.(cont.)

VALUE	PARAMETER	UNITS	ABBREV.
242	Deep convective heating rate	K/s	CNVHR
243	Deep convective moistening rate	kg/kg/s	CNVMR
244	Shallow convective heating rate	K/s	SHAHR
245	Shallow convective moistening rate	kg/kg/s	SHAMR
246	Vertical diffusion heating rate	K/s	VDFHR
247	Vertical diffusion zonal acceleration	m/s^2	VDFUA
248	Vertical diffusion meridional accel	m/s^2	VDFVA
249	Vertical diffusion moistening rate	kg/kg/s	VDFMR
250	Solar radiative heating rate	K/s	SWHR
251	long wave radiative heating rate	K/s	LWHR
252	Drag coefficient	non-dim	CD
253	Friction velocity	m/s	FRICV
254	Richardson number	non-dim.	RI
255	Missing		

Notes:

1) By convention, downward net fluxes of radiation or other quantities are assigned negative values; upward net fluxes of radiation or other quantities are assigned positive values.

2) Unidirectional flux values, where the direction of flow is indicated in the name of the parameter (e.g., 204,205,211,212), shall all have positive values irrespective of the direction of flow. Net (vertical) fluxes shall be calculated by subtracting the downward flux values from the upward flux values.

2) The u and v components of vector quantities are defined with reference to GDS Octet 17 and Table 7. However, if the GDS is **not** included in a message, then any wind components are assumed to be resolved relative to the grid specified in the PDS with u and v defined as positive in the direction of increasing x and y (or i and j) coordinates respectively.

3) Provision is made for three types of spectra:

    1) Direction and Frequency
    2) Direction and radial number
    3) Radial number and radial number

4) Parameters 81 and 91 show the units as "fraction", thus allowing for a range of coverage. It is up to the user to employ the D (power of ten) scaling to assure that the necessary precision is retained in the numeric values.

5) Precipitation index (#218) defined as the fraction of satellite observed pixels with temperatures <235K over 1.0x1.0 box, centered at the gridpoint.

TABLE 3. TYPE AND VALUE OF LEVEL
(PDS Octets 10, 11, & 12)

Octet Number 10 VALUE	MEANING	Number 11 CONTENTS	Number 12 CONTENTS
0 - 99	special codes, see Table 3a	0	0
100	isobaric level	pressure in hectoPascals (hPa) (2 octets)	
101	layer between two isobaric levels	pressure of top (kPa)	pressure of bottom (kPa)
102	mean sea level	0	0
103	fixed height level	height above mean sea level (MSL) in meters	
104	layer between two height levels above msl	height of top (hm) above mean sea level	height of bottom (hm) above mean sea level
105	fixed height above ground	height in meters (2 octets)	
106	layer between two height levels above ground	height of top (hm) above ground	height of bottom (hm) above ground
107	sigma level	sigma value in 1/10000 (2 octets)	
108	layer between two sigma levels	sigma value at top in 1/100	sigma value at bottom in 1/100
109	Hybrid level	level number (2 octets)	
110	layer between two hybrid levels	level number of top	level number of bottom
111	depth below land surface	centimeters (2 octets)	
112	layer between two depths below land surface	depth of upper surface (cm)	depth of lower surface (cm)

TABLE 3. TYPE AND VALUE OF LEVEL
(continued)

Octet Number 10		Number 11	Number 12
VALUE	MEANING	CONTENTS	
113	isentropic (theta) level	Potential Temp. degrees K (2 octets)	
114	layer between two isentropic levels	475K minus theta of top in Deg. K	475K minus theta of bottom in deg. K
121	layer between two isobaric surfaces (high precision)	1100 hPa minus pressure of top, in hPa	1100 hPa minus pressure of bottom, in hPa
125	Height level above ground (high precision)	centimeters (2 octets)	
128	layer between two sigma levels (high precision)	1.1 minus sigma of top, in 1/1000 of sigma	1.1 minus sigma of bottom, in 1/1000 of sigma
141	layer between two isobaric surfaces (mixed precision)	pressure of top, in kPa	1100hPa minus pressure of bottom, in hPa
160	depth below sea level	meters (2 octets)	
200	entire atmosphere considered as a single layer	0 (2 octets)	
201	entire ocean considered as a single layer	0 (2 octets)	

See Table 3a for additional special levels & layers

Note: The numbering allows for additions within this framework:

100-119	normal precision
120-139	high precision
140-159	mixed precision

TABLE 3a. SPECIAL LEVELS
(PDS Octet 10)

VALUE	LEVEL
00	reserved
01	surface (of the Earth, which includes sea surface)
02	cloud base level
03	cloud top level
04	0 deg (C) isotherm level
05	adiabatic condensation level (parcel lifted from surface)
06	maximum wind speed level
07	tropopause level
08	Nominal top of atmosphere
09	Sea bottom
10-99	reserved

NMC Special Levels & Layers:

212	Low cloud bottom level
213	Low cloud top level
214	Low cloud layer
222	Middle cloud bottom level
223	Middle cloud top level
224	Middle cloud layer
232	High cloud bottom level
233	High cloud top level
234	High cloud layer

TABLE 4. FORECAST TIME UNIT
(PDS Octet 18)

VALUE	TIME UNIT
0	minute
1	hour
2	day
3	month
4	year
5	decade
6	normal (30 years)
7	century
8-253	reserved
254	second

TABLE 5.
TIME RANGE INDICATOR
(PDS Octet 21)

VALUE	MEANING
0	Forecast product valid at reference time + P1 (P1>0), or Uninitialized analysis product for reference time (P1=0). or Image product for reference time (P1=0)
1	Initialized analysis product for reference time (P1=0).
2	Product with a valid time ranging between reference time + P1 and reference time + P2
3	Average (reference time + P1 to reference time + P2)
4	Accumulation (reference time + P1 to reference time + P2) product considered valid at reference time + P2
5	Difference (reference time + P2 minus reference time + P1) product considered valid at reference time + P2
6-9	reserved
10	P1 occupies octets 19 and 20; product valid at reference time + P1
11-50	reserved

TABLE 5.
TIME RANGE INDICATOR
(PDS Octet 21)

VALUE	MEANING
51	Climatological Mean Value: multiple year averages of quantities which are themselves means over some period of time (P2) less than a year. The reference time (R) indicates the date and time of the start of a period of time, given by R to R + P2, over which a mean is formed; N indicates the number of such period-means that are averaged together to form the climatological value, assuming that the N period-mean fields are separated by one year. The reference time indicates the start of the N-year climatology. N is given in octets 22-23 of the PDS. If P1 = 0 then the data averaged in the basic interval P2 are assumed to be continuous, i.e., all available data are simply averaged together. If P1 = 1 (the units of time - octet 18, code table 4 - are not relevant here) then the data averaged together in the basic interval P2 are valid only at the time (hour, minute) given in the reference time, for all the days included in the P2 period. The units of P2 are given by the contents of octet 18 and Table 4.
52-112	reserved
113	Average of N forecasts (or initialized analyses); each product has forecast period of P1 (P1=0 for initialized analyses); products have reference times at intervals of P2, beginning at the given reference time.
114	Accumulation of N forecasts (or initialized analyses); each product has forecast period of P1 (P1=0 for initialized analyses); products have reference times at intervals of P2, beginning at the given reference time.

TABLE 5.
TIME RANGE INDICATOR
(PDS Octet 21)

VALUE	MEANING
115	Average of N forecasts, all with the same reference time; the first has a forecast period of P1, the remaining forecasts follow at intervals of P2.
116	Accumulation of N forecasts, all with the same reference time; the first has a forecast period of P1, the remaining follow at intervals of P2.
117	Average of N forecasts, the first has a period of P1, the subsequent ones have forecast periods reduced from the previous one by an interval of P2; the reference time for the first is given in octets 13-17, the subsequent ones have reference times increased from the previous one by an interval of P2. Thus all the forecasts have the same valid time, given by the initial reference time + P1.
118	Temporal variance, or covariance, of N initialized analyses; each product has forecast period P1=0; products have reference times at intervals of P2, beginning at the given reference time.
119 -122	reserved
123	Average of N uninitialized analyses, starting at the reference time, at intervals of P2.
124	Accumulation of N uninitialized analyses, starting at the reference time, at intervals of P2.
125-254	reserved

TABLE 5. (cont.)
TIME RANGE INDICATOR
(PDS Octet 21)

NOTES:

1) For analysis products, or the first of a series of analysis products, the reference time (octets 13 to 17) indicates the valid time.

2) For forecast products, or the first of a series of forecast products, the reference time indicates the valid time of the analysis upon which the (first) forecast is based.

3) Initialized analysis products are allocated numbers distinct from those allocated to uninitialized analysis products.

4) A value of 10 allows the period of a forecast to be extended over two octets; this accommodates extended range forecasts.

5) Where products or a series of products are averaged or accumulated, the number involved is to be represented in octets 22-23 of Section 1, while any number missing is to be represented in octet 24.

6) Forecasts of the accumulation or difference of some quantity (e.g. quantitative precipitation forecasts), indicated by values of 4 or 5 in octet 21, have a product valid time given by the reference time + P2; the period of accumulation, or difference, can be calculated as P2 - P1.

A few examples may help to clarify the use of Table 5:

For analysis products P1 is zero and the time range indicator is also zero; for initialized products (sometimes called "zero hour forecasts") P1 is zero, but octet 21 is set to 1.

For forecasts, typically, P1 contains the number of hours of the forecast (the unit indicator given in octet 18 would be 1) and octet 21 contains a zero.

Value 51 allows for the identification of the most common climatological entities. With P1=0, it could represent (or identify) the multiple year climatology of anything from daily means (or less) to semi-annual means (or more, up to a full year). The assumption is that all the available values within the basic period P2 are averaged together. (An "annual mean climatology" would just be an average over the total climatological period - Table 5, entry 3.) P1=1 allows for a diurnal sub-stratification of the data within the P2 period, such as 30-year climatology of February mean 00Z temperature starting at a date certain, or all the 12Z surface radiation fluxes averaged for all the days in a season, or whatever. If other sub-stratifications are appropriate they could be identified by different values of P1. Value 115 would be used, typically, for multiple day mean forecasts, all derived from the same initial conditions.

Value 117 would be used, typically, for Monte Carlo type calculations: many forecasts valid at the same time from different initial (reference) times.

Averages, accumulations, and differences get a somewhat specialized treatment. If octet 21 (Table 5) has a value between 2 and 5 (inclusive) then the reference time + P1 is the initial date/time and the reference time + P2 is the final date/time of the period over which averaging or accumulation takes place. If, however, octet 21 has a value of 113, 114, 115, 116, 117, 118, 123, or 124 then P2 specifies the time interval between each of the fields (or the forecast initial times) that have been averaged or accumulated. These latter values of octet 21 require the quantities averaged to be equally separated in time; the former values, 3 and 4 in particular, allow for irregular or unspecified intervals of time between the fields that are averaged or accumulated.

SECTION 2: GRID DESCRIPTION SECTION (GDS)

The purpose of the (optional) GDS is to provide a grid description for grids not defined by number in Table 3.

Octet no.	GDS Content
1 - 3	Length in octets of the Grid Description Section
4	NV, the number of vertical coordinate parameters
5	PV, the location (octet number) of the list of vertical coordinate parameters, if present or PL, the location (octet number) of the list of numbers of points in each row (when no vertical parameters are present), if present or 255 (all bits set to 1) if neither are present
6	Data representation type (See Table 6)
7 - 32	Grid description, according to data representation type, except Lambert, Mercator or Space View.
or	
7 - 42 or	Grid description for Lambert or Mercator grid
7 - 44	Grid description for Space View perspective grid
PV	List of vertical coordinate parameters (length = NV x 4 octets); if present, then PL = 4 x NV + PV
PL	List of numbers of points in each row, used for quasi-regular grids (length = NROWS x 2 octets, where NROWS is the total number of rows defined within the grid description)

Note: NV and PV relate to features of GRIB not, at present, in use in the National Weather Service. See the WMO Manual on Codes for the descriptions of those features.

PL is used for "quasi-regular" or "thinned" grids; e.g., a lat/lon grid where the number of points in each row is reduced as one moves poleward from the equator. The reduction usually follows some mathematical formula involving the cosine of the latitude, to generate an (approximately) equally spaced grid array. The association of the numbers in octet PL (and following) with the particular row follows the scanning mode specification in Table 8.

TABLES FOR THE GDS

TABLE 6. DATA REPRESENTATION TYPE (GDS OCTET 6)

VALUE	MEANING
0	Latitude/Longitude Grid also called Equidistant Cylindrical or Plate Carree projection grid
1	Mercator Projection Grid
2	Gnomonic Projection Grid
3	Lambert Conformal, secant or tangent, conical or bipolar (normal or oblique) Projection Grid
4	Gaussian Latitude/Longitude Grid
5	Polar Stereographic Projection Grid
6 - 12	(reserved - see Manual on Codes)
13	Oblique Lambert conformal, secant or tangent, conical or bipolar, projection
14 - 49	(reserved - see Manual on Codes)
50	Spherical Harmonic Coefficients
51 - 89	(reserved - see Manual on Codes)
90	Space view perspective or orthographic grid
91 - 200	(reserved - see Manual on Codes)
201	Arakawa semi-staggered E-grid on rotated latitude/longitude grid-point array
202	Arakawa filled E-grid on rotated latitude/longitude grid-point array
203 - 254	(reserved - see Manual on Codes)

TABLE C. Sundry Grid Definitions

LATITUDE/LONGITUDE GRIDS INCLUDING GAUSSIAN (GDS OCTETS 7 - 32)

OCTET NO.	CONTENT & MEANING
7 - 8	Ni - No. of points along a latitude circle
9 - 10	Nj - No. of points along a longitude meridian
11 - 13	La_1 - latitude of first grid point units: millidegrees (degrees x 1000) values limited to range 0 - 90,000 bit 1 (leftmost) set to 1 for south latitude
14 - 16	Lo_1 - longitude of first grid point units: millidegrees (degrees x 1000) values limited to range 0 - 360,000 bit 1 (leftmost) set to 1 for west longitude
17	Resolution and component flags (Table 7)
18 - 20	La_2 - Latitude of last grid point (same units, value range, and bit 1 as La_1)
21 - 23	Lo_2 - Longitude of last grid point (same units, value range, and bit 1 as Lo_1)
24 - 25	Di - Longitudinal Direction Increment (same units as Lo_1) (if not given, all bits set = 1)
26 - 27	Regular Lat/Lon Grid: Dj - Latitudinal Direction Increment (same units as La_1) (if not given, all bits set = 1) or Gaussian Grid: N - number of latitude circles between a pole and the equator Mandatory if Gaussian Grid specified
28	Scanning mode flags (See Table 8)
29 - 32	Reserved (set to zero)

Notes:

1) The latitude and longitude of the first and last grid points should always be given, for regular grids.

2) If a quasi-regular grid is to be described, in which all the rows or columns do not necessarily have the same number of grid points, either Ni (octets 7-8) or Nj (octets 9-10) and the corresponding Di (octets 24-25) or Dj (octets 26-27) shall be coded with all bits set to 1 (missing).

3) A quasi-regular grid can be defined only for rows or columns, but not both simultaneously. The first point in each row (column) shall be positioned at the meridian (parallel) indicated in octets 11-16. The grid points shall be evenly spaced in latitude (longitude).

4) For Gaussian grids only the rows can be rendered quasi-regular; the first point shall be located at the meridian given in octets 14-16 and the last point at the meridian given in octets 21-23.

TABLE C. Sundry Grid Descriptions
(continued)

ARAKAWA SEMI-STAGGERED E-GRID ON ROTATED LATITUDE/LONGITUDE GRID (GDS OCTETS 7 - 32)

OCTET NO.	CONTENT & MEANING
7 - 8	Ni - Total number of actual data points included on grid
9 - 10	Nj - Dummy second dimension; set = 1
11 - 13	La_1 - latitude of first grid point units: millidegrees (degrees x 1000) values limited to range 0 - 90,000 bit 1 (leftmost) set to 1 for south latitude
14 - 16	Lo_1 - longitude of first grid point units: millidegrees (degrees x 1000) values limited to range 0 - 360,000 bit 1 (leftmost) set to 1 for west longitude
17	Resolution and component flags (Table 7)
18 - 20	La_2 - Number of mass points along southernmost row of grid
21 - 23	Lo_2 - Number of rows in each column
24 - 25	Di - Longitudinal Direction Increment (same units as Lo_1; value must be supplied)
26 - 27	Dj - Latitudinal Direction Increment (same units as La_1; value must be supplied)
28	Scanning mode flags (See Table 8)
29 - 32	Reserved (set to zero)

Note: The rotation of the latitude/longitude grid is such that the intersection of the "prime meridian" and the "equator" has been located at the central latitude and longitude of the area represented.

TABLE C. Sundry Grid Descriptions
(continued)

ARAKAWA FILLED E-GRID ON ROTATED LATITUDE/LONGITUDE GRID (GDS OCTETS 7 - 32)

OCTET NO.	CONTENT & MEANING
7 - 8	Ni - Total number of actual data points included on grid
9 - 10	Nj - Dummy second dimension; set = 1
11 - 13	La_1 - latitude of first grid point units: millidegrees (degrees x 1000) values limited to range 0 - 90,000 bit 1 (leftmost) set to 1 for south latitude
14 - 16	Lo_1 - longitude of first grid point units: millidegrees (degrees x 1000) values limited to range 0 - 360,000 bit 1 (leftmost) set to 1 for west longitude
17	Resolution and component flags (Table 7)
18 - 20	La_2 - Number of (zonal) points in each row
21 - 23	Lo_2 - Number of (meridional) points in each column
24 - 25	Di - Longitudinal Direction Increment (same units as Lo_1; value must be supplied)
26 - 27	Dj - Latitudinal Direction Increment (same units as La_1; value must be supplied)
28	Scanning mode flags (See Table 8)
29 - 32	Reserved (set to zero)

Note: The rotation of the latitude/longitude grid is such that the intersection of the "prime meridian" and the "equator" has been located at the central latitude and longitude of the area represented.

POLAR STEREOGRAPHIC GRIDS
(GDS Octets 7 - 32)

OCTET NO.	CONTENT & MEANING
7 - 8	Nx - Number of points along x-axis
9 - 10	Ny - Number of points along y-axis
11 - 13	La1 - Latitude of first grid point
14 - 16	Lo1 - Longitude of first grid point
17	Resolution and component flags (see Table 7)
18 - 20	Lov - The orientation of the grid; i.e., the east 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. (Note: The orientation longitude may, or may not, appear within a particular grid.)
21 - 23	Dx - the X-direction grid length (see Note 2)
24 - 26	Dy - the Y-direction grid length (see note 2)
27	Projection center flag (see note 5)
28	Scanning mode (see Table 8)
29 - 32	Set to 0 (reserved)

NOTES:

1. Latitude and longitude are in millidegrees (thousandths)

2. Grid lengths are in units of meters, at the 60 degree latitude circle nearest to the pole in the projection plane.

3. Latitude values are limited to the range 0 - 90,000. Bit 1 is set to 1 to indicate south latitude.

4. Longitude values are limited to the range 0 - 360,000. Bit one is set to 1 to indicate west longitude.

5. Octet 27:
Bit 1 set to 0 if the North pole is on the projection plane.
Bit 1 set to 1 if the South pole is on the projection plane.

6. The first and last grid points may not necessarily be the same as the first and last data points if the bit map section (BMS) is used.

7. The resolution flag (bit 1 of Table 7) is not applicable.

LAMBERT CONFORMAL SECANT OR TANGENT CONE GRIDS
(GDS Octets 7 - 42)

OCTET NO.	CONTENT & MEANING
7 - 8	Nx - Number of points along x-axis
9 - 10	Ny - Number of points along y-axis
11 - 13	La1 - Latitude of first grid point
14 - 16	Lo1 - Longitude of first grid point
17	Resolution and component flags (see Table 7)
18 - 20	Lov - The orientation of the grid; i.e., the east 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. (Note: The orientation longitude may, or may not, appear within a particular grid.)
21 - 23	Dx - the X-direction grid length (see note 2)
24 - 26	Dy - the Y-direction grid length (see Note 2)
27	Projection center flag (see note 5)
28	Scanning mode (see Table 8)
29 - 31	Latin 1 - The first latitude from the pole at which the secant cone cuts the spherical earth. (See Note 8)
32 - 34	Latin 2 - The second latitude from the pole at which the secant cone cuts the spherical earth. (See Note 8)
35 - 37	Latitude of southern pole (millidegrees)
38 - 40	Longitude of southern pole (millidegrees)
41 - 42	Reserved (set to 0)

NOTES:

1. Latitude and longitude are in millidegrees (thousandths)

2. Grid lengths are in units of meters, at the intersection latitude circle nearest to the pole in the projection plane.

3. Latitude values are limited to the range 0 - 90,000. Bit 1 is set to 1 to indicate south latitude.

4. Longitude values are limited to the range 0 - 360,000. Bit one is set to 1 to indicate west longitude.

5. Octet 27:
Bit 1 set to 0 if the North pole is on the projection plane.
Bit 1 set to 1 if the South pole is on the projection plane.

TABLE C. Sundry Grid Descriptions
(continued)

Bit 2 set to 0 if only one projection center used
Bit 2 set to 1 if projection is bipolar and symmetric

6. The first and last grid points may not necessarily be the same as the first and last data points if the bit map section (BMS) is used.

7. The resolution flag (bit 1 of Table 7) is not applicable.

8. If Latin 1 = Latin 2 then the projection is on a tangent cone.

MERCATOR GRIDS
(GDS Octets 7 - 42)

OCTET NO.	CONTENT & MEANING
7 - 8	Ni - Number of points along a latitude circle
9 - 10	Nj - Number of points along a longitude meridian
11 - 13	La1 - Latitude of first grid point
14 - 16	Lo1 - Longitude of first grid point
17	Resolution and component flags (see Table 7)
18 - 20	La2 - latitude of last grid point
21 - 23	Lo2 - longitude of last grid point
24 - 26	Latin - The latitude(s) at which the Mercator projection cylinder intersects the earth.
27	Reserved (set to 0)
28	Scanning mode (see Table 8)
29 - 31	Di - the longitudinal direction increment (see Note 2)
32 - 34	Dj - the latitudinal direction increment (see note 2)
35 - 42	Reserved (set to 0)

NOTES:

1. Latitude and longitude are in millidegrees (thousandths)
2. Grid lengths are in units of meters, at the circle of latitude specified by Latin.
3. Latitude values are limited to the range 0 - 90,000. Bit 1 is set to 1 to indicate south latitude.
4. Longitude values are limited to the range 0 - 360,000. Bit one is set to 1 to indicate west longitude.
5. The latitude and longitude of the last grid point should always be given.
6. The first and last grid points may not necessarily be the same as the first and last data points if the bit map section (BMS) is used.

SPACE VIEW PERSPECTIVE OR ORTHOGRQAPHIC
(GDS Octets 7-44)

OCTET NUMBER	CONTENTS
7-8	Nx - number of points along x axis (columns)
9-10	Ny - number of points along y axis (rows or lines)
11-13	Lap - latitude of sub-satellite point
14-16	Lop - longitude of sub-satellite point
17	Resolution and component flags (Table 7)
18-20	dx - apparent diameter of earth in grid lengths, in x direction
21-23	dy - apparent diameter of earth in grid lengths, in y direction
24-25	Xp - X-coordinate of sub satellite point
26-27	Yp - Y-coordinate of sub-satellite point
28	Scanning Mode (Table 8)
29-31	the orientation of the grid; i.e., the angle in millidegrees between the increasing y axis and the meridian of the sub-satellite point in the direction of increasing latitude (see Note 3).
32-34	Nr - the altitude of the camera from the earth's center, measured in units of the earth's (equatorial) radius (See Note 4).
35-44	reserved

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) Octet 32-34 shall be set to all ones (missing) to indicate the orthographic view (from infinite distance).

(3) It is the angle between increasing y axis and the meridian 180 degrees east if the sub-satellite point is the North pole; or the meridian 0 degrees, if the sub-satellite point is the south pole.

(4) The apparent angular size of the earth will be given by 2 * asin (1/Nr).

(5) The horizontal and vertical angular resolutions of he sensor (Rx and Ry), needed for navigation equations, can be calculated from the following

$$Rx = 2 * \operatorname{asin}(1/Nr) / dx$$

$$Ry = 2 * \operatorname{asin}(1/Nr) / dy$$

TABLE C. Sundry Grid Descriptions
(continued)

SPHERICAL HARMONIC COEFFICIENTS (GDS OCTETS 7 - 32)

OCTET NO.	CONTENT & MEANING
7 - 8	J - Pentagonal Resolution Parameter
9 - 10	K - Pentagonal Resolution Parameter
11 - 12	M - Pentagonal Resolution Parameter
13	Representation Type (See Table 9)
14	Coefficient Storage Mode (See Table 10)
15 - 32	Set to zero (reserved)

TABLE 7 - RESOLUTION AND COMPONENT FLAGS (GDS OCTET 17)

Bit	Value	Meaning
1	0	Direction increments not given
	1	Direction increments given
2	0	Earth assumed spherical with radius = 6367.47 km
	1	Earth assumed oblate spheroid with size as determined by IAU in 1965: 6378.160 km, 6356.775 km, f = 1/297.0
3-4		reserved (set to 0)
5	0	u- and v-components of vector quantities resolved relative to easterly and northerly directions
	1	u and v components of vector quantities resolved relative to the defined grid in the direction of increasing x and y (or i and j) coordinates respectively
6-8		reserved (set to 0)

Note: If the GDS is **not** included in a message then any wind components are assumed to be resolved relative to the grid specified in the PDS with u and v defined as positive in the direction of increasing x and y (or i and j) coordinates respectively.

TABLE 8. SCANNING MODE FLAG (GDS OCTET 28)

BIT	VALUE	MEANING
1	0	Points scan in +i direction
	1	Points scan in -i direction
2	0	Points scan in -j direction
	1	Points scan in +j direction
3	0	Adjacent points in i direction are consecutive (FORTRAN: (I,J))
	1	Adjacent points in j direction are consecutive (FORTRAN: (J,I))
4-8		reserved; set = 0

Note: i direction is defined as west to east along a parallel of latitude, or left to right along an x axis.

j direction is defined as south to north along a meridian of longitude, or bottom to top along a y axis.

TABLE 9. SPECTRAL REPRESENTATION TYPE (GDS OCTET 13)

VALUE	MEANING
1	Associated Legendre Polynomials of the First Kind with normalization such that the integral equals 1

TABLE 10. COEFFICIENT STORAGE MODE (GDS OCTET 14)

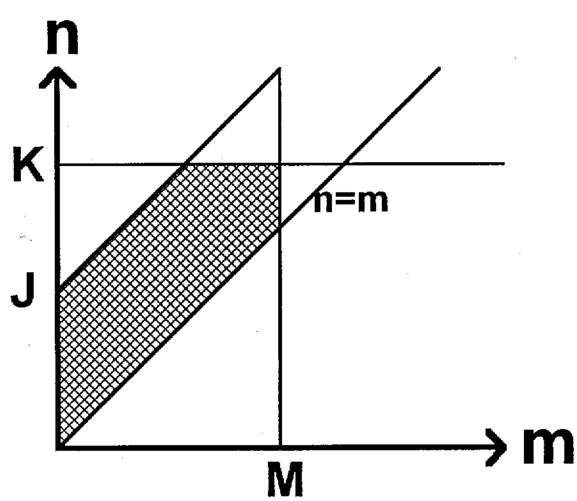
VALUE	MEANING
1	The complex coefficients X_n^m are stored for $m \geq 0$ as pairs of real numbers $Re(X_n^m)$, $Im(X_n^m)$ ordered with n increasing from m to N(m), first for m = 0 and then for m = 1, 2, 3,...M. The real part of the (0,0) coefficient is stored in octets 12-15 of the BDS, as a floating point number in the same manner as the packing reference value, with units as in Table 2. The remaining coefficients, starting with the imaginary part of the (0,0) coefficient, are packed according to the GRIB packing algorithm, with units as given in Table 5, in octets 16 and onward in the BDS.

NOTES ON SPECTRAL TRUNCATION:

Using the associated Legendre Polynomials of the First Kind, P_n^m, as typical expansion functions, any variable x(λ,μ), which is a function of longitude, λ , and sin(latitude), μ , can be represented by

$$x(\lambda,\mu) = \sum_{m=-M}^{M} \sum_{n=|M|}^{N(m)} X_n^m P_n^m(\mu) e^{m\lambda i}$$

In the summations, M is the maximum zonal wave number that is to be included, and K & J together define the maximum meridional total wave number N(m), which, it should be noted, is a function of m. A sketch shows the relationships:



In this figure, the ordinate is n the zonal wave number, the abscissa, m, is the total meridional wave number, the vertical line at m = M is the zonal truncation, and the diagonal passing through (0,0) is the line n = m. The Legendre Polynomials are defined only on or above this line, that is for $n \geq m$. On the n-axis, the horizontal line at n = K indicates the upper limit to n values, and the diagonal that intersects the n-axis at n = J indicates the upper limit of the area in which the Polynomials are defined. The shaded irregular pentagon defined by the n-axis, the diagonal from n = J, the horizontal n = K, the vertical m = M, and the other diagonal n = m surrounds the region of the (n x m) plane containing the Legendre Polynomials used in the expansion.

This general pentagonal truncation reduces to some familiar common truncations as special cases:

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

In all of the above m can take on negative values to represent the imaginary part of the spectral coefficients.

SECTION 3: BIT MAP SECTION (BMS).

The purpose of the (optional) BMS is to provide either a bit map or a reference to a bit map pre-defined by the center. The bit map consists of contiguous bits with a bit-to-data-point correspondence as defined in the grid description. A bit set equal to 1 implies the presence of a datum for that grid point in the BDS; a value of zero implies the absence of such. This is useful in shrinking fields where fair portions of the field are not defined. An example would be global grids of sea surface temperature; the bit map would be used to suppress the "data" at grid points over land. One would not want to use the BMS if the data were undefined at only a small number of grid points as the overhead of adding the bit map array (one bit for each grid point) might add more bits to the overall message that were subtracted by the removal of a few data values.

Octet no.

1 - 3 Length in octets of Bit Map Section

4 Number of unused bits at end of Section 3.

5 - 6 Numeric:

= 0:	a bit map follows;
otherwise:	the numeric refers to a predefined bit map provided by the center

7 - nnn Bit map, zero filled to an even number of octets

SECTION 4: BINARY DATA SECTION (BDS).

The BDS contains the packed data and the binary scaling information needed to reconstruct the original data from the packed data. The required decimal scale factor is found in the PDS, above. The data stream is zero filled to an even number of octets.

Octet no.	
1 - 3	Length in octets of binary data section
4	Bits 1 through 4: Flag - See Table 11 Bits 5 through 8: Number of unused bits at end of Section 4.
5 - 6	The binary scale factor (E). A negative value is indicated by setting the high order bit (bit No. 1) in octet 5 to 1 (on).
7 - 10	Reference value (minimum value); floating point representation of the number.
11	Number of bits into which a datum point is packed
12 -nnn	Variable, depending on octet 4; zero filled to an even number of octets.
14	Optionally, may contain an extension of the flags in octet 4. See Table 11.

Here are some of the various forms the binary data can take; the flag table in BDS octet 4, possibly extended into octet 14, identifies which variant is in use.

Grid-point data - Simple packing

Here the data simply begin in octet 12 and continue, packed according to the simple packing algorithm described above, without any particular regard for computer "word" boundaries, until there is no more data. There may be some "zero-fill" bits at the end.

If all the data in a grid point field happen to have the same value, then all of the deviations from the reference value are set to zero. Since a zero value requires no bits for packing, octet 11 is set to zero, thus indicating a field of constant data, the value of which is given by the reference value. Under these circumstances, octet 12 is set to zero (the required "zero fill to an even number of octets") and bits 5-8 of octet 4 contain an 8. The number of data points in the field is implied by the grid identification given in the PDS and/or the GDS and BMS.

Spherical Harmonic Coefficients - Simple packing

Octets 12-15 contain the real part of the (0.0) coefficient in the same floating point format as the reference value in octets 7-10. The imaginary part of the (0.0) coefficient, mathematically, is always equal zero. Octets 16 to the end contain the remaining coefficients packed up as binary data with the same sort of scaling, reference value, and the like, as with grid-point numbers. Excluding the (0,0) coefficient, which is usually much larger than the others, from the packing operation means that the remaining coefficients can be packed to a given precision more efficiently (fewer bits per word) than would be the case otherwise.

Grid-Point Data - Second Order or Complex Packing

Before laying out where the various second order values, sub-parameters, counters, and what have you, go, it is appropriate to describe the second order packing method in an algorithmic manner.

Referring back to the description of simple packing, the encoding method is the same up to part way through the fourth step, stopping just short of the actual packing of the scaled integers into the "words" of either a pre-specified or calculated bit length.

The basic outline of second order packing is to scan through the array of integers (one per grid point, or possibly less than that if the Bit Map Section has been employed to discard some of the null value points) and seek out sub-sections exhibiting relatively low variability within the sub-section. One then finds the (local) minimum value in that sub-section and subtracts it from the ("first order") integers in that sub-section, which leave a set of "second order" integers. These numbers are then scanned to find the maximum value, which in turn is used to specify the minimum bit width for a "word" necessary to contain the sub-section set of second order numbers.

The term "first order" in this context refers to the integer variables that result from subtracting the overall (global) minimum from the original variables and then doing all scaling and rounding; "second order" refers to the variables that result from subtracting the local minimum from the sub-set of first order variables. No further scaling is necessary or appropriate.

The sub-section set of numbers are then packed into "words" of the just determined bit length. The overall savings in space comes about because the second order values are, usually, smaller than their first order counterparts. They have, after all, had two minima subtracted from the original values, the overall minimum and the local minimum, where the first order values have had only the overall minimum subtracted out. There is no guarantee, however, that the second order packing will compress a given field to a greater degree than the first order packing. If the first order field of integers is highly variable, or generally close to zero, then there will be no gain in compression. But if the field shows long runs of small variation, particularly if some of the runs are constant (zero variability), then the second order packing will contribute to the compression.

The process then repeats and a whole collection of sub-sections are found, their local minima are subtracted, etc. One of the tricky parts of this process is defining just what is meant by a "sub-section of low variability". The WMO Manual is silent on this as it only describes how the sub-sections and their ancillary data are to be packed in the message. The U.S. National Weather Service, the U.K. Meteorological Office, the European Centre for Medium-Range Weather Forecasts, and probably other groups have, independently, designed selection criteria and built them into GRIB encoders. It is beyond the scope of this document to attempt to describe them in any detail. These groups have all expressed their willingness to share their GRIB encoders with any who ask for them.

Before laying out where the second order values, etc., are placed in a message, we had best review just what information has to be saved. We need to include the following information:

1) How many sub-sections there are;

2) Where does each sub-section begin;

3) Where does each sub-section end; or,
how many data points are in each sub-section;

4) What is the local minimum value (a first order value) that was found for each sub-section;

5) What is the bit width of the collection of first order values (the local minima) found for each sub-section;

6) What are the second order values for each sub-section;

7) What are the bit widths of the second order values appropriate for all the sub-section; and, finally,

8) Sufficient information to specify where the above information is located.

A moments consideration (a long moment, perhaps) will satisfy the reader that the information given will be sufficient to reconstruct the original data field.

The information needed for points 2) and 3), the beginning and end of the sub-sections, is presented in the form of a bit map, called a "secondary bit map" to distinguish it from the bit map (optionally) contained in the BMS. There is one bit for each grid point containing data, ordered in the same way as the grid is laid out. The "primary" bit map, the BMS bit map, may have been used to eliminate data at points where the data are meaningless - only the remaining "real" data points are matched by the bits in the secondary bit map. This possibility is understood to exist throughout the following discussion. The start of each sub-section is indicated by the corresponding bit set to "on" or to a value of 1. Clearly, the first bit in the secondary bit map will always be set on, since the first data point must be the start of the first sub-section. (If it is not, then something is wrong somewhere. Unfortunately it is not always easy to tell just where the error occurred.) The secondary bit map is then no more than a collection of 1s and 0s, indicating the start and the extent of each sub-section. It would be possible to scan through the secondary bit map and determine how many sub-sections there are; however, this number is explicitly included in the GRIB message to save one the trouble, and to serve as an internal self-checking mechanism.

At long last, then, here is the layout of the information, with further explanatory notes, when second order packing has been employed:

Octet no.	Content
1-3	Length in octets of binary data section
4	Bits 1 through 4: Flag - See Table 11 Bits 5 through 8: Number of unused bits at end of Section 4.
5-6	The binary scale factor (E). A negative value is indicated by setting the high order bit(bit No. 1) in octet 5 to 1 (on).
7-10	Reference value (minimum value); floating point representation of the number. This is the overall or "global" minimum that has been subtracted from all the values.

11	Number of bits into which a datum point is packed. This width now refers to the collection of first order packed values that serve as the local minimum values, one for each sub-section. It is determined in the same manner as for the simple (first order) packing.
12-13	N1 - Octet number, relative to the start of the BDS, at which the collection of first order packed numbers begins, i.e. the collection of local minimum values.
14	The flags that are an extension of octet 4. See Code Table 11.
15-16	N2 - Octet number, relative to the start of the BDS, at which the collection of second order packed numbers begins.
17-18	P1 - The number of first order packed values, the local minima. This number is the same as the number of sub-sections.
19-20	P2 - The number of second order packed values actually in the message. This is the number of data points as (possibly) modified by the bit map in the BMS, if any, and/or reduced by the number of identical points collapsed together by the run-length encoding (see below).
21	Reserved
22-(xx-1)	Width(s), in bits, of the second order packed values; each width value is contained in 1 octet. There are as many width values, or octets, as there are sub-sections, P1 of them. However, there may be but one such value under special circumstances; see below. Also, the width value for a particular sub-section may perfectly well be zero.
xx-(N1-1)	Secondary bit map, one bit for each data point. It will be P2 bits long, then padded to an even number of octets with binary 0.
N1-(N2-1)	P1 first order packed values, the local minima, each held in a "word" of bit-length found in octet 11, then padded to a whole number of octets with 0s.
N2-...	P2 second order packed values. There is no "marking" of the sub-sections here; all the sub-section second order values are placed in a continuous string of bits. The bit-length of the "words" holding the values will change from place to place but again this has to be determined by reference to the other information. As usual, there may be padding by binary 0 bits sufficient to bring the entire section to an even number of octets.

There are a small number of special cases and variations on the above layout:

If the bit-width for a sub-section is zero, then no second order values for that sub-section are included in the part of the message starting at octet N2. The value of P2 will reflect the absence of those points. This will happen if all the first order values in the sub-section are identical. This is a form of "run-length encoding" and contributes greatly to packing efficiency if the original data contains strings of constant value (including zero).

Under some circumstances, it may turn out that there is no need to use different bit-widths for each of the sub-sections. In that case, a flag is set in bit 8 of the extended flags found in octet 14 (see table 11) indicating that all the sub-sections are packed with the same bit-width, and that the single value will be found in octet 22.

Row by row packing is defined as selecting entire rows (or columns) to serve as sub-sections, without regard to "variability" determinations. It can have some compression value. If row by row packing is employed, this is indicated by setting a flag in bit 7 of the extended flags found in octet 14 (see table 11) and NOT including the secondary bit map in the message. It is unnecessary since the length of the rows (columns) is known from the grid specifications given elsewhere in the message.

TABLES FOR THE BDS

TABLE 11. FLAG
(BDS Octet 4 and, optionally, 14)

Bit	Value	Meaning
1	0	Grid point data
	1	Spherical Harmonic Coefficients
2	0	Simple packing
	1	Second order ("Complex") Packing
3	0	Original data were floating point values
	1	Original data were integer values
4	0	No additional flags at octet 14
	1	Octet 14 contains flag bits 5 - 12

The following gives the meaning of the bits in octet 14 ONLY if bit 4 is set to 1. Otherwise octet 14 contains regular binary data.

Bit	Value	Meaning
5		Reserved (set to 0)
6	0	Single datum at each grid point
	1	Matrix of values at each grid point
7	0	No secondary bit maps
	1	Secondary bit maps present
8	0	Second order values have constant width
	1	Second order values have different widths
9-12		Reserved (set to 0)

Notes:

(1) Bit 3 is set to 1 to indicate that the original data were integers; when this is the case any non-zero reference values should be rounded to an integer value prior to placing in the GRIB BDS.

(2) Bit 4 is set to 1 to indicate that bits 5 to 12 are contained in octet 14 of the data section.

(3) Although GRIB is not capable of representing a matrix of data values at each grid point, the meaning of bit 6 is retained in anticipation of a future capability.

(4) When secondary bit maps are present in the data (used in association with second order packing) this is indicated by setting bit 7 to 1.

(5) When octet 14 contains the extended flag information octets 12 and 13 will also contain "special" information; the actual data will begin in a subsequent octet. See above.

At present, the "extension" of Table 11 into octet 14 and the associated "advanced" features of GRIB are limited to spherical harmonics and second order("complex") packing in the National Weather Service. Additional variations are included in the WMO Documentation.

SECTION 5: END SECTION

The end section serves a human readable indication of the end of a GRIB record. It can also be used for computer verification that a complete GRIB record is available for data extraction. It should not be used as a search target since a '7777' bit combination could exist anywhere in the binary data stream.

Octet no.		
1-4	'7777'	(Coded CCITT-ITA No. 5) (ASCII)

APPENDIX A

OUTLINE OF WMO BULLETIN HEADERS

USED WITH

G R I B

WMO BULLETIN HEADER

The WMO abbreviated heading is used to identify the NMC GRIB messages; however, it is not a complete description of their content. The user is cautioned against using the header as the sole determiner of the record content; she should, of course, rely on the Product Definition Section for that purpose.

Note: In the following, a hexadecimal number is enclosed in parentheses followed by the designation "hex".

The information needed to identify the NMC product is contained in 21 octets. The characters are encoded using the CCITT-ITA No. 5, also known (in the US) as ASCII characters, and are defined as follows:

Octet no.	Header Content
1	The character 'H' for GRIB bulletins sent to the NWS Family of Services, used for the WAFS program, and for general International Exchange or The characters 'Y' or 'Z' for GRIB bulletins intended for the NWS AWIPS program.
2	A letter character specifying the type parameter as shown in Table A.1.
3	A letter character specifying the grid area as defined in Table A.2.
4	A letter or numeric character indicating the time difference between the reference time and valid time of the data as listed in Table A.3, i.e., the forecast length.
5-6	Numeric characters as defined in Table A.4. Usually the pressure level, sometimes just a sequence number. Some values have special level or layer meanings.
7	Blank (20)hex
8-11	Four characters identifying the originating center. These are always 'KWBC' for NMC-produced messages.
12	Blank (20)hex
13-14	Two numeric characters providing the reference day of the month (01-31) of the data.
15-18	Four numeric characters providing the reference hour and minute of the data.
19-22	Four OPTIONAL characters: one blank (20)hex, then 'Pxx', where xx=AA, AB, AC ... AY, AZ, BA, BB, BC ... etc. Used to indicate sequential parts of a very long message that has been subdivided. The **last** part of the message will have xx=Zn, where n is the next letter in the appropriate sequence. Example: a five part message would have the parts indicated by PAA, PAB, PAC, PAD, PZE.
19-21 or 23-25	Two ASCII carriage returns and a line feed, (0D0D0A)hex.

The first six characters are commonly referred to as

$T_1\ T_2\ A_1\ A_2$ ii

In summary...

Generic Meaning of $T_1\ T_2\ A_1\ A_2$ ii:

T_1: Type of bulletin: "H" for GRIB messages for Family of Services, WAFS, and International Exchange; "Y" or "Z" for AWIPS GRIB messages

T_2: Type of data/parameter

A_1: Grid

A_2: Analysis or forecast hour

ii: Numeric. Usually the pressure level, sometimes just a sequence number. Some values have special level or layer meanings.

In the following tables, the columns headed AWIPS are augmentations to the common Family of Services (FOS),National, and International Exchange variables. FOS, National and International GRIB messages (with H as the initial character) draw upon the left hand columns only. AWIPS GRIB messages (with Y or Z as the initial character) use letters from both columns. If both columns contain entries for the same designator, the T_1 character (H, Y, or Z) indicates which entry to use.

TABLE A.1 TYPE PARAMETERS - T_2
(Header Octet 2)

DESIGNATOR	PARAMETER Usage: FOS & International (H)	PARAMETER Usage: AWIPS (Y or Z)
A		
B		Vertical Wind Shear
C		Vorticity
D		Thunderstorm probability
E	Total Precipitation	
F	Long Wave Radiation	Precipitable Water
G		Convective Precip.
H	Height (geopotential)	
I		
J		
K	Primary Wave Period	
L	Primary Wave Direction	
M	Secondary Wave Period	
N	Secondary Wave Direction	
O	Vertical velocity	
P	Pressure	
Q		Stability Index (Best 4-layer index)
R	Relative humidity	
S	Snow	
T	Temperature	
U	u wind component	
V	v wind component	
W		
X	Surface Lifted index	
Y		
Z		

TABLE A.2 GRID DESIGNATOR - A_1
(Header Octet 3)

DESIGNATOR	GRID Number (See Table B) FOS & International (H)	AWIPS (Y or Z)
A	21	201 - Northern Hemisphere
B	22	
C	23	
D	24	
E	25	
F	26	
G	50	
H		213 - National CONUS with Double Resolution
I	37	202 - National CONUS
J	38	203 - National Alaska
K	39	204 - National Hawaii
L	40	205 - National Puerto Rico
M	41	206 - Regional MARD
N	42	207 - Regional Alaska
O	43	208 - Regional Hawaii
P	44	210 - Regional Puerto Rico
Q		211 - Regional CONUS
R		212 - Regional CONUS with Double Resolution
S		209 - Regional MARD with Double Resolution
T	61	214 - Regional Alaska with Double Resolution
U	62	
V	63	
W	64	
X	(Used for experimental transmissions)	
Y		
Z		

TABLE A.3 FORECAST HOUR DESIGNATOR - A_2
(Header Octet 4)

DESIGNATOR	HOUR	
	FOS & International (H)	
A	00	hour analysis
B	06	hour fcst
C	12	"
D	18	"
E	24	"
F	30	"
G	36	"
H	42	"
I	48	"
J	60	"
K	72	"
L	84	"
M	96	"
N	108	"
O	120	"
P	132	"
Q	144	"
R	156	"
S	168	"
T	180	"
U	192	"
V	204	"
W	216	"
X	228	"
Y	240	"
Z	Reserved for special purposes	

Note: The following designators are used for AWIPS only, with "Z" as the first character in the header.

DESIGNATOR	HOUR
A	2 hour fcst
B	3 "
C	4 "
D	8 "
E	9 "
F	10 "
G	14 "
H	15 "
I	16 "
J	20 "
K	21 "
M	54 "
N	66 "

TABLE A.4 LEVEL DESIGNATORS - ii
(Header Octets 5 and 6)
(H, Y, or Z)

DESIGNATOR	LEVEL or LAYER
00	Entire Atmosphere
99	1000 hPa
98	Air Properties at Surface of Earth
97	Level of the tropopause
96	Level of the maximum wind
95	950 hPa
94	Level of 0 deg C isotherm
93	Land/Water Properties at Surface of Earth/Ocean
92	Boundary Layer
91	Any parameter reduced to Sea Level

Note: The following levels are used to indicate geometric height for aviation flight levels, not pressure levels

81	810 hPa ~ 1828 m = 6000 ft FL
73	730 hPa ~ 2743 m = 9000 ft FL
64	640 hPa ~ 3658 m = 12000 ft FL

Otherwise, the designator given is the hundreds and tens digits of the hPa level in the atmosphere, e.g. 70=700hPa; 03=30hPa, etc..

SPECIAL NOTE

The following version of Table A.4 contains changes recently approved by the WMO. They are **NOT** in effect as yet but were scheduled to go into effect on **November 3, 1993**. However, it is very unlikely that these changes will start any time soon. Much notification and table changes will be necessary, little of which has even started. The table is presented here for your edification, so you can make proper preparations, so I won't have to print a new copy of this document after Nov. 3, and so I can say "I told you so!" when all your codes fail some time after you get an official notification of the actual change date.

TABLE A.4 LEVEL DESIGNATORS - ii
(Header Octets 5 and 6)
(H, Y, or Z)

DESIGNATOR	LEVEL or LAYER
00	Entire Atmosphere
99	1000 hPa
98	Air Properties at Surface of Earth
97	Level of the tropopause
96	Level of the maximum wind
95	950 hPa
94	Level of 0 deg. C isotherm
93	Not assigned
92	925 hPa
91	Not assigned
90	900 hPa
89	Any parameter reduced to Sea Level
88	Land/Water Properties at Surface of Earth/Ocean
87	Not assigned
86	Boundary Layer

Note: The following levels are used to indicate geometric height for aviation flight levels, not pressure levels

81	810 hPa ~ 1828 m = 6000 ft FL
73	730 hPa ~ 2743 m = 9000 ft FL
64	640 hPa ~ 3658 m = 12000 ft FL

Otherwise, the designator given is the hundreds and tens digits of the hPa level in the atmosphere, e.g. 70=700hPa; 03=30hPa, etc.