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GRIB2
THE WMO STANDARD FOR THE TRANSMISSION OF GRIDDED DATA
CURRENT STATUS AND NWS PLANS

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1. INTRODUCTION

For more than a decade the GRIdded Binary (GRIB) code defined in the World Meteorological Organization's (WMO) Manual on Codes (WMO 1988) has been the international standard for the exchange of meteorological gridpoint data, especially those data produced from numerical atmospheric models and their associated data assimilations. GRIB is also used for storage of data by some organizations, including the National Centers for Environmental Prediction (NCEP). GRIB furnishes a "message" structure that is self describing; that is, the metadata describing the field of data values, the gridpoint data, are contained in the message in a prescribed format.

Over the years, a number of deficiencies in GRIB were recognized, and the WMO has redefined GRIB as General Regularly distributed Information in Binary form and developed a revised code form (WMO 2001). In order to distinguish the two, in this paper we refer to the latter as GRIB2. This new code allows more flexibility in the metadata sections and more options for data compression. Care has been taken to make sure GRIB2 can accommodate radar and satellite data, and that oceanographic and hydrologic, as well as meteorologic, data can be well defined.

While there are commitments that require GRIB be used for certain products, it is expected that the National Weather Service (NWS), which makes extensive use of GRIB, will gradually migrate to GRIB2, especially for new products. To facilitate that migration, a GRIB2 encoder and decoder are furnished on the NWS web page:

http://205.156.54.206/tdl/iwt/

2. GRIB MESSAGE STRUCTURE

A GRIB2 message contains eight sections, each section having a specific responsibility in the overall definition of the gridded data product. These are the Indicator Section, the Identification Section, the Local Use Section, the Grid Definition Section, the Product Definition Section, the Data Representation Section, the Bit-map Section, the Data Section, and the End Section.

As a brief overview, the Indicator Section contains information that identifies the GRIB2 message, the scientific discipline that the data within the file represents, and the overall length, in bytes, of the message. The Identification Section encompasses information about where the data has originated, the reference time of the data, and the type of data (i.e. are the values in the data grid integers or are they floating point numbers). The Local Use Section is an optional section in which data may be placed that are specific to the product and are not easily accommodated in other sections. The Grid Definition Section is comprised of templates and code tables which detail the map projection the gridded data are in reference to. The Product Definition Section consists of information that specifies exactly the physical element to which the data pertain. The Data Representation Section specifies which packing method was used to compress the field of binary data. The Bit-map Section provides an optional bitmap which can be used to indicate the locations of missing values in the data grid which is stored in the Data Section. The End Section simply indicates

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the end of the GRIB2 message with an alphanumeric code.

3. NEW FEATURES AND FUNCTIONALITY IN GRIB2

GRIB2 offers numerous refinements and improvements over the original GRIB format. The overall structure of the message containing the gridded data has been modified to include the Identification Section, the Local Use Section, and the Data Representation Section; this provides a better abstraction of the many parameters that are required to define a gridded data product. By providing the Local Data Section to contain originating center defined data, GRIB2 offers a degree of flexibility that was not present in the original GRIB. At the heart of GRIB2 lies the data compression algorithms. The "simple" and "complex" packing terminology has been carried over from GRIB. While the simple packing method has remained unchanged, the complex method has had some revolutionary modifications made to it. These modifications have been demonstrated to improve data compression ratios which, as a result, lead to smaller GRIB2 message sizes. These upgrades change how missing values in the data grid are represented which obviates the need for a bit-map. Second order spatial differences and the boustrophedonic ordering of data points have also been added to the complex data compression method, and with smooth data fields these additions have proven to bolster data compression efficiency.

GRIB2 offers an augmented number of different gridded binary data products that can be represented. Most notable from the perspective of the National Weather Service is the new functionality to process ensemble forecasts and clusters of ensemble forecasts, radar products, and satellite images. Additional products from the oceanographic and hydrological disciplines are also supported making GRIB2 more well-rounded in terms of meeting the needs of the scientific community.

4. PACKING SCHEMES IN GRIB2

Three methods are defined:

Simple--Exactly the same as GRIB. The minimum value in a grid of values is subtracted from all values, making all values ≥ 0. Then each value is placed in the number of bits required to hold the largest value at a specified binary and decimal accuracy. If there are "missing" values, those points are not packed, but their locations in the grid are indicated in a bit map.

Complex--Considerably different from Complex in GRIB. As with the Simple method, the minimum value is subtracted, making all values ≥ 0. Then, consecutive values in the grid (proceeding through the grid in the manner defined in the metadata), are formed into groups which are similar in magnitude. These "groups" are then packed with the simple method--each value is placed into the number of bits required to hold the largest value after subtracting the group minimum. Group size, number of bits per value, and group minimum must be packed along with the actual gridpoint values. Missing values can be accommodated with a bit map, but also with an alternate method. In the alternate method, two types of missing values are possible--a "primary" and a "secondary." A primary is indicated in a group with all bits for that datum set to 1, this largest value being reserved for that purpose. A secondary value is indicated in a group with all bits for that datum set to one except the rightmost, this configuration being reserved for that purpose. A primary missing value can represent a point for which data would normally be present; a secondary missing value can represent a point for which data would never be present, such as snow cover over the open ocean.

Complex With Spatial Differencing--Similar to Complex, but the packed values are actually second order differences rather that the original values, and those differences are packed boustrophedonically to make "consecutive" values more redundant.

In the last two methods, the method of defining groups is critically important. A method of doing this is explained in Glahn(1994). There are many details that must be considered in implementation, of course. For these, the reader can refer to WMO (2001) or the software documentation on the NWS web page referred to above.

5. EFFICIENCY

Several studies were done in which the complex method with spatial differencing was compared to techniques currently in use. Gridpoint data from NCEP models at various resolutions and precisions were compressed with this new complex packing method, and the results were compared to the original GRIB as implemented by NCEP (Simple

GRIB). Radar data were compared to the radar run-length encoding scheme normally used with radar data. Satellite data were compared to the existing practice of using one byte per value on the AWIPS Satellite Broadcast Network (SBN). For satellite, gridpoint, and radar data, the new product sizes were about 60, 45, and less than 50 percent of the old, respectively, the variance in size from product to product being rather large. These experiments are documented in Glahn (1997, 1998).

6. CURRENT STATUS OF GRIB2

GRIB2 was tested over the past couple of years by data being packed by one organization (e.g., NCEP and the European Center for Medium-range Weather Forecasting) and transmitted and the unpacked by another organization (e.g., MDL and Meteo France). Different pairs tested different parts of the functionality such as packing methods and templates. As of this writing, the WMO expects to take GRIB2 from the experimental stage to the operational stage in November 2001. It is likely, even with this testing, a few problems will arise, either in documentation or software, and will be corrected.

As stated earlier, the official NWS GRIB2 encoder and decoder pair developed by MDL is on a web page and readily accessible to anyone. This software was developed under the auspices of an Integrated Work Team chartered by the NWS Director, and is to be used within the NWS for GRIB2 encoding and decoding.

7. FUTURE PLANS FOR USING GRIB2 IN THE NWS

It is expected that the NWS will gradually transition from GRIB to GRIB2. Already, the official gridded forecast data produced by individual Weather Forecast Offices are being sent to a central server via the AWIPS Wide Area Network in GRIB2. Eventually, such grids mosaiced into a national product will flow over the AWIPS SBN in GRIB2 and be available to anyone with a NOAAPORT receiver. For some period of time, data in both GRIB and GRIB2 may be available to effect a transfer from one code form to another. Under an ICAO agreement, specific products must be maintained in GRIB for several years after GRIB2 is made operational.

6. Summary

GRIB has been redefined and a new code form developed that is better structured and contains better packing algorithms. Certain deficiencies in the original GRIB have been corrected. An official NWS encoder and decoder (both software and documentation) are provided on a web page for downloading. It is expected the NWS will gradually transition to the new code.

6. REFERENCES

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