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PACKING OF RADAR MOSAICS

Harry R. Glahn

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1. INTRODUCTION

This office note is a follow-on to a recent one on a similar subject--"Satellite, Gridpoint, and Vector Data Packing (Glahn 1997). That office note presented results of packing and unpacking those three kinds of data by two different options of GRIB (simple and complex) and a more efficient scheme, called TDLPACK for want of a better name.

It has been a long-standing AWIPS requirement for a 10-km radar reflectivity mosaic to be produced and distributed over the AWIPS Satellite Broadcast Network (SBN) (U.S. Government 1989). Plans are now underway to fulfill this requirement by AWIPS Build 5.0. This will pave the way for more and/or improved national gridded radar products as suggested by the National Weather Service (NWS) Office of Meteorology--more spatial resolution, more precision than the current 0 through 6 scale, products other than reflectivity, etc.[1]

Because this is a gridded product, one would expect it to be packed, especially since the range of values in the grid is so small. This office note, like the previous one, compares simple and complex GRIB and TDLPACK in terms of product size and packing and unpacking computer time, and also considers whether the "missing" indicator should actually be used or the missing value just be included as a value of "7."

2. DESCRIPTION OF PACKING METHODS

The description here will be very brief; other references can be consulted for more detail (WMO 1988; Dey 1996; Glahn 1997, 1992, 1993, 1994, 1995).

A. Simple GRIB

GRIB, in this simple form, does basically two things: (1) the overall minimum value is subtracted from the field (the values at the gridpoints), making all values non-negative and having no larger magnitude than necessary, and (2) only as many bits per value are used as the largest value in the field (after subtraction of the overall minimum) requires, both after the desired decimal and/or binary scaling is done.[2] Missing values, if there are any,

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[1]The current radar mosaic, which will initially be provided on the SBN, is a 3-bit resolution product, the values ranging from 0 through 6. The AWIPS requirement specifies a 4-bit product (16 levels). The resolution and map projection of the current product matches the AWIPS requirement, and the grid extent is essentially the same.

[2]Decimal (binary) scaling means that the data values are multiplied by a power of 10 (2) before packing them as integer values.

can be designated by a "0" in a bit map,[3] and the packed grid will then not include a value for that point.

B. Complex GRIB

Complex GRIB, in addition to doing what simple GRIB does, packs "groups" of "adjacent" values with only the number of bits required for that group after the minimum for the group (as well as the overall minimum) is subtracted. The definition of the groups is left to the originating organization. The groups can be of constant size (such as defined by grid row or column, which for fields covering a large area is not very useful) or the group size can vary. Unfortunately, the way GRIB carries variable group sizes is quite inefficient[4] (see Glahn 1992, 1993), but not enough so to offset the advantage of "grouping." However, the groups must be picked with care (see Glahn 1994).

C. TDLPACK

TDLPACK takes advantage of the second-order spatial difference scheme defined by the Office of the Federal Coordinator for Meteorology (OFCM 1990), and a more efficient packing algorithm. Groups are defined and packed in much the same manner as in complex GRIB, but the way the groups are identified in the product is more efficient. Missing values can be designated by reserving the largest value in a group for a missing indicator. This is (almost) guaranteed to be more efficient than the GRIB schemes--usually considerably so.

3. RESULTS

Several 10-km radar mosaics originally prepared by the Aviation Weather Center (AWC) have been archived for development within the Techniques Development Laboratory (TDL). These are what would be transmitted over the SBN, except missing values had to be added by using the individual Radar Coded Messages (RCMs); the mosaics obtained from AWC treat missing and zero reflectivity the same.[5] These grids were saved because of their interesting data--therefore, they generally contain more non-zero values than average.

Fourteen such grids were packed by simple and complex GRIB, both with a missing value designated by a bit map and without, and by TDLPACK with and without a missing value defined as such. The results are shown in Table 1.

In Table 1, "No Missing" means that a value of 7 representing missing was used just like any other value; "Missing" means that the value 7 was omitted and rather missing was represented by a 0 in a bit map for GRIB and the largest value in a group for TDLPACK. That is, "No Missing" means that no specific provision was made for missing values.

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[3]A bit map is itself a grid of the same size as the grid of values being packed, in which each value occupies one bit and is either a 1 or 0 indicating, respectively, whether or not a data value is actually present for that corresponding gridpoint.

[4]Actually requires <u>another</u> bit map that indicates where each group starts.

[5]David Kitzmiller, private communication.

Table 1. Statistics associated with packing and unpacking radar mosaics. The times and packed sizes are the average of the 14 mosaics. See text for definition of "Missing" and "No Missing."

Packing Method	Average Product Size (Bytes)	Bits Per Point	Packing Time Per Product (sec)	Unpacking Time Per Product (sec)
Simple GRIB				
(No Missing)	62,724	3.00	0.250	0.116
(Missing)	53,207	2.55	0.218	0.138
Complex GRIB				
(No Missing)	26,597	1.27	0.402	0.107
(Missing)	34,726	1.66	0.294	0.143
TDLPACK				
(No Missing)	8,190	0.39	0.510	0.048
(Missing)	16,942	0.81	0.647	0.093

Consistent with the earlier report by Glahn (1995), the adjustable parameters MINPK and INC for TDLPACK were used as 14 and 1, respectively (see Glahn 1994). For determining processing times, a Hewlett Packard (HP) 755[6] was used that was otherwise only performing "housekeeping" chores with about 1 to 2 percent of its cp cycles. The timing software available was precise, but gives clock time, not actual cp time. Timing results were quite consistent, as shown by replication, but differences of only 1 or 2 percent between values are in the noise level.

As expected, use of a bit map to define a missing value in the case of GRIB is not very productive (the "missing" option), the results depending on whether simple or complex GRIB is used. Rather, <u>in this special case</u>, since the range of values is known and the missing value (7) can be designated in the same number of bits (3) as the largest data value (6), no special provision need be made for missing values. (Of course the user must be aware of how the data were packed.) This is, in effect, reserving the largest value possible with 3 bits (7) for missing as is currently done with 8-bit satellite data (256) (see Glahn 1997).

For TDLPACK, the missing value is best carried as a 7 rather than designating it as missing. In the latter case, the maximum value in each group is reserved for a missing value, and since many large groups have a data value of zero, one bit instead of none has to be used for that group. By not designat-

[6]No endorsement of specific equipment or companies is expressed or implied in this document.

ing a 7 as missing, strings of zeros can be packed with zero bits and also strings of 7's, once the value of 7 is packed as the (single) value of the group.

The product sizes range over almost an order of magnitude, being just 0.39 bits/point for "no missing" TDLPACK to 3.00 for "no missing" simple GRIB. Product size for complex GRIB without a missing designator is still over three times TDLPACK.

Packing time for TDLPACK is larger than for GRIB, but all times are fractions of a second per product. TDLPACK unpacking is most efficient, being 41% (67%) of simple GRIB--the packing method currently used at the National Centers for Environmental Prediction for model gridpoint data--with no missing (missing) specified. Unpacking will have to be done at each receiving station (where TDLPACK is most efficient), while packing need be done only once per product (where simple GRIB is most efficient).

The product size for the "no missing" TDLPACK ranged from 5,937 to 10,597 bytes--a factor of 2. The largest product was for October 26, 1997, at 2135 UTC; the mosaic for this time is shown in Fig. 1. There were 82,935 missing values, 74,610 values of zero, and 9,495 non zero reports for a total of 167,040 points in the 464 X 360 grid.

The smallest product was for October 30, 1997, at 1135 UTC; the mosaic is shown in Fig. 2. There were 78,786 missing values, 86,396 zero values, and 1,858 non zero reports.

An intermediate sized product of 8,599 bytes for October 24, 1997, at 1135 UTC, is shown in Fig. 3. Note from the figures that the number of missing values is always large because of the large areas not covered by radar, but varies somewhat because sometimes there are no data for a particular radar.

The packing of these radar data is a quite special case, because (1) there are always many missing values, (2) there are always many zero values, and (3) the missing value can be specified in the same number of bits as the known range of data values. None of these three points generally hold for model gridpoint data, and generally only the last may hold for satellite data. Also, for much smaller grids of radar data that may be sent among Weather Forecast Offices, the percentage of missing points would likely be much smaller.

4. CONCLUSIONS

It has been shown that TDLPACK is much more efficient in product size than GRIB. It has also been shown, that for this special case, treating a missing value the same as a non-missing value is much preferred to either a bit map in the case of GRIB or using the largest value in the group in the case of TDLPACK. While the total volume of the 10-km radar mosaics twice per hour is not great, future national products could multiply this considerably. Even with, say, 256 levels of data rather than 6, the large strings of zeros will allow very efficient packing by TDLPACK. Also on the horizon are mosaics on a finer grid for individual WFO's that may need to be exchanged with neighboring

WFOs over the AWIPS Wide Area Network (WAN). An efficient packing scheme should be defined now and used for all radar gridded products.

ACKNOWLEDGEMENTS

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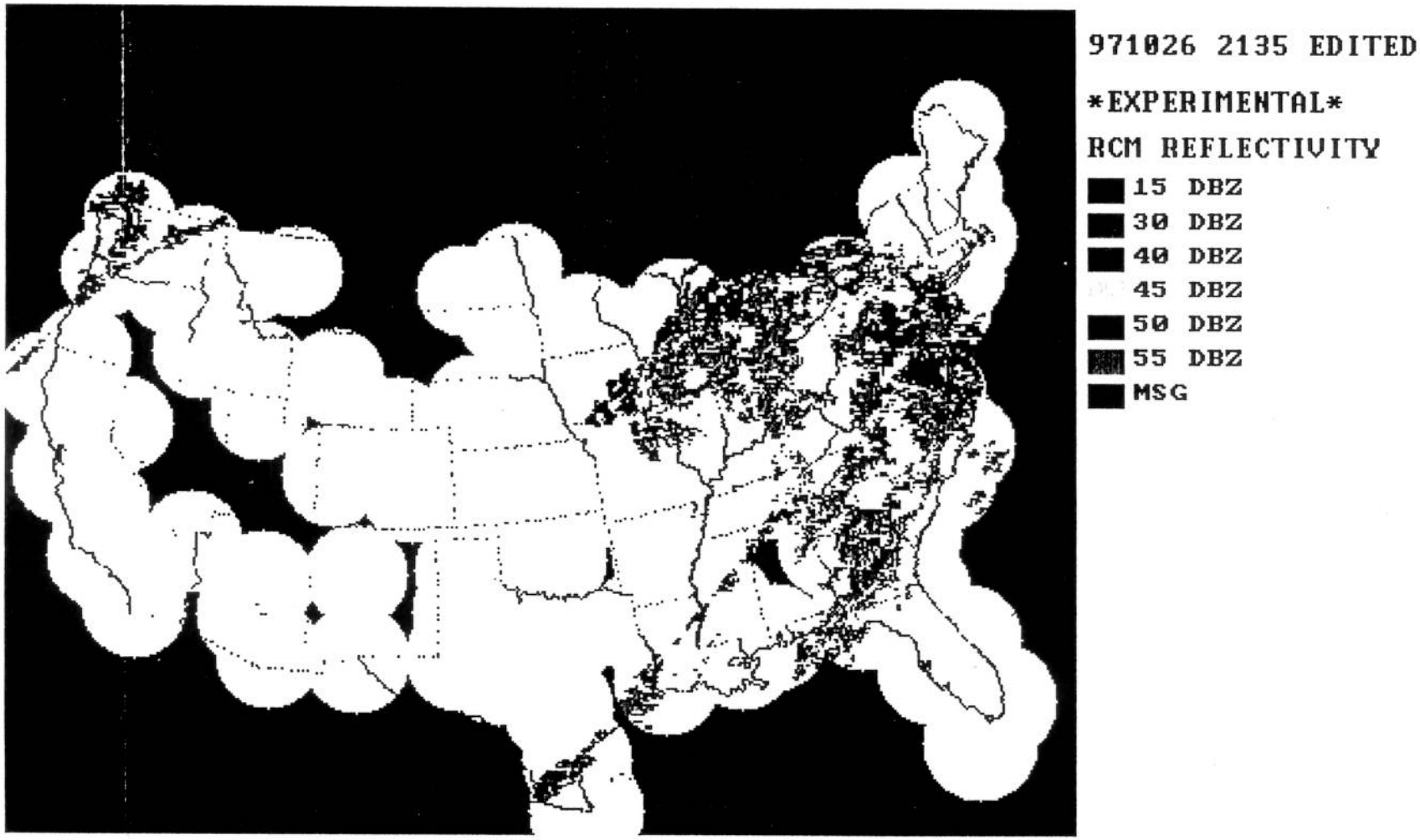

Figure 1. Radar mosaic for 1235 UTC on October 26, 1997.

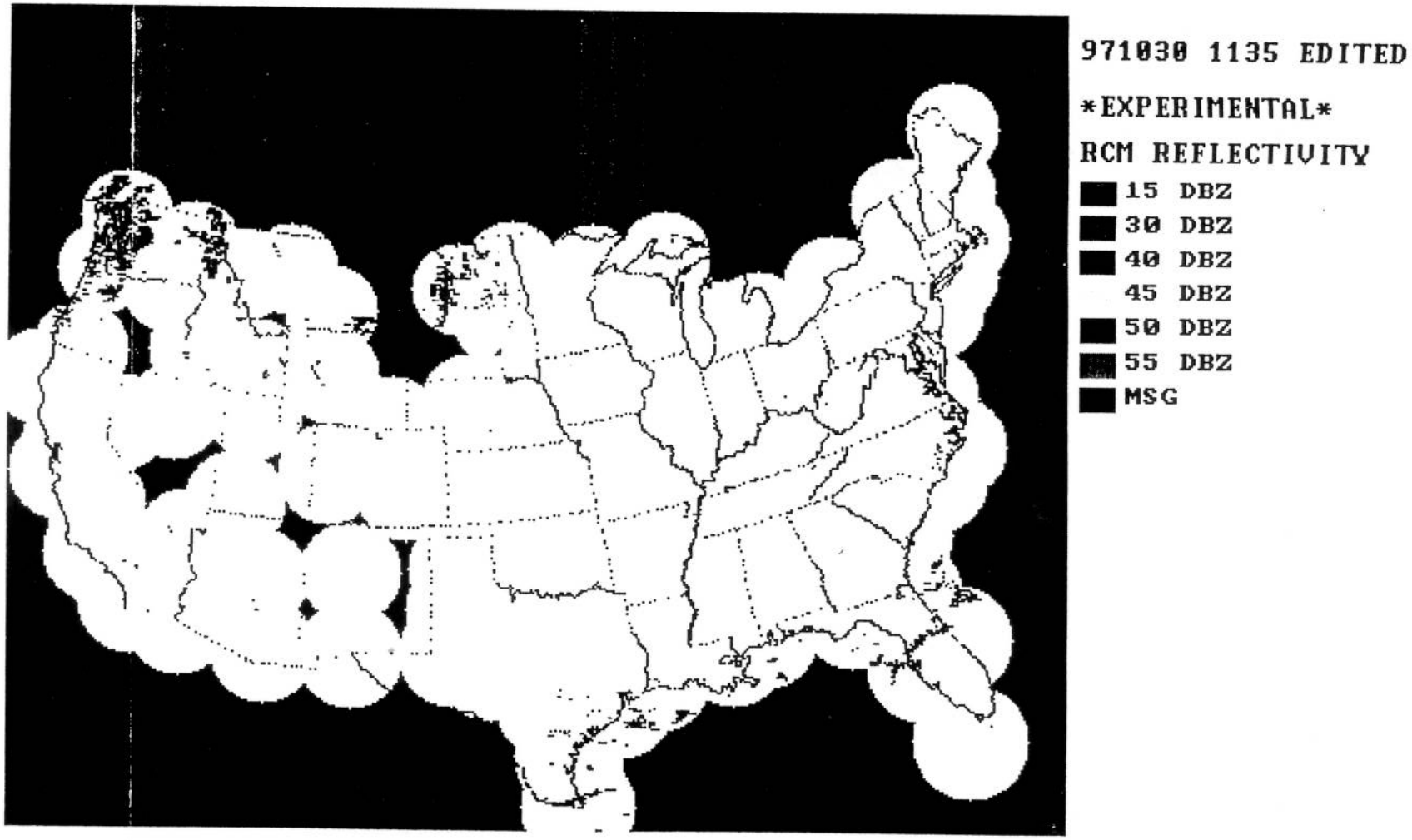

Figure 2. Radar mosaic for 1135 UTC on October 30, 1997.

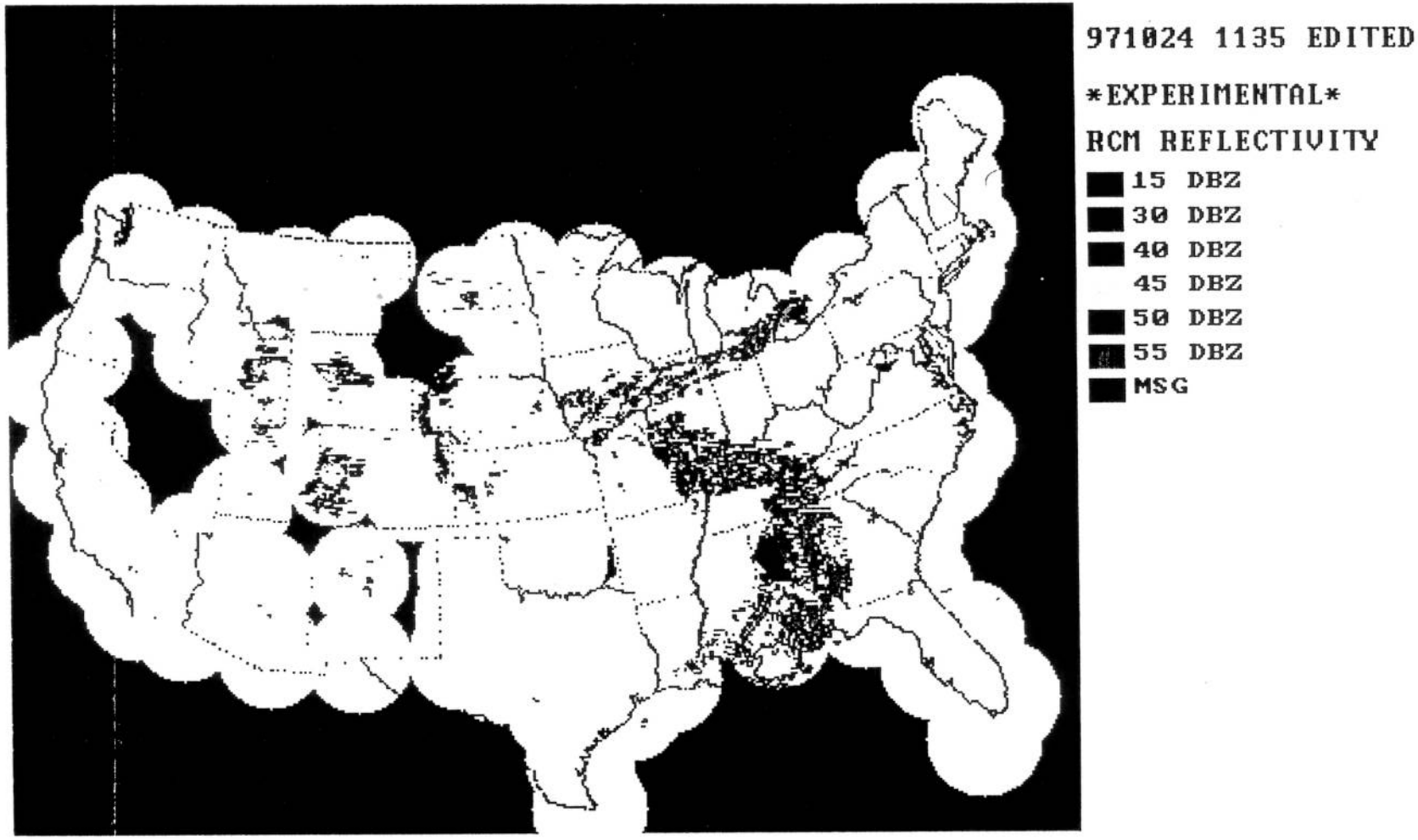

Figure 3. Radar mosaic for 1135 UTC on October 24, 1997.