# AUTOMATED RADAR OBSERVATIONS FROM WSR-88D RADAR CODED MESSAGES

David L. Keller
Research and Data Systems Corporation
Greenbelt, Maryland;
General Sciences Corporation
Beltsville, Maryland

David H. Kitzmiller
Techniques Development Laboratory
Office of Systems Development
National Weather Service
Silver Spring, Maryland

## 1. INTRODUCTION

Weather surveillance radar is extensively used in short-range forecasting operations. Historically, use of radar data has been concentrated on the information from the local radar unit itself, which until recently was limited to a 230-km or 460-km radial reflectivity plan-position indicator display.

However, it has also been a practice within the National Weather Service to disseminate a summary of observations from local radars, including the location, intensity, and movement of convective cells, the areal coverage of echoes, and a simple description of the reflectivity distribution on a standard map grid. This coded text information was disseminated in the form of Radar Observations (ROBs), which were prepared by manually by technicians. With the deployment of the WSR-88D network, the manual ROB was replaced by the automatically-generated and more detailed Radar Coded Message (RCM). To maintain continuity of services, a program was instituted to create Automated Radar Observations (AUTOROBs). They are disseminated under WMO bulletin header SDUS4*x* KWBC, where *x* ranges from 1 to 6, depending upon the location of the source radar.

The AUTOROBs are intended primarily to serve users external to the NWS who require radar information in the historic text format. While automated quality control has been applied to remove nonprecipitation echo features from the AUTOROBs, users should be aware that such features still appear, and they are strongly advised to consult full-resolution reflectivity radar displays and other data sources when there is doubt as to the validity of echo features in the AUTOROBs.

## 2. HISTORY

The National Weather Service (NWS) implemented centralized collection and dissemination of radar observations in the 1960's. These operations were based on collection and compositing of text and digital information manually produced and then transmitted from individual radar sites (NWS 1980; Departments of Commerce and Defense 1981). The manual radar observations (ROB's) included descriptions of echo regions, convective-scale phenomena (e.g. hook echoes, line-echo wave patterns), and radar-relative echo

velocities. Nonprecipitation echoes due to ground clutter (GC), anomalous propagation (AP), or aerial targets such as aircraft, insect swarms or birds were eliminated by the operator based on other data and personal experience. A 40-km national Manually-Digitized Radar (MDR) mosaic was also created by compositing local gridded data reported by radar operators (Sadowski 1979).

With the deployment of the WSR-88D network, the ROB was replaced by the automatically-produced Radar Coded Message (RCM). The RCM contains the local portion of a national 10-km reflectivity mosaic, a description of convective echoes including maximum reflectivity, echo tops and mesocyclone phenomena, and the local Velocity-Azimuth Display Wind Profile (OFCM 1991).

In order to maintain continuity in the dissemination of publicly-available products, it is necessary to transform the RCM's into the older ROB format through a purely automated process. These AUTOROB's contain echo descriptions in the same format as those in the original ROB's, and a local reflectivity grid reduced from the 10-km RCM projection to the older 40-km MDR projection.

Though it would be possible to produce a national mosaic and the AUTOROB's directly from the original RCM's, the RCM reflectivity data may still feature nonmeteorological echoes. In practice, most of these echoes can be reliably identified by the absence of other observations that suggest precipitation, particularly clouds as indicated by infrared satellite data, lightning strikes observed by radio detection networks, and reflectivity from neighboring radars. The national mosaic and AUTOROB's are produced following the removal of echoes that appear to be from sources other than precipitation.

The first national program for the production of AUTOROBs was implemented within the NWS National Centers for Environmental prediction, at the Aviation Weather Center (Lewis and Mosher 1992; Cope 1994). This operation relied on communications systems and proprietary system software due to be eliminated with the introduction of the Advanced Weather Interactive Processing System (AWIPS). Accordingly, it was decided to rehost the program within NWS Telecommunications Gateway facility. This bulletin describes the implementation by the Techniques Development Laboratory of the AUTOROB production process, and the resulting products. A companion bulletin (Office of Meteorology 2000) describes the production of the RCM mosaic which is the primary input for the AUTOROBs. Both the radar mosaic and AUTOROB operations are described in greater detail by Keller and Kitzmiller (2000).

## 3. AUTOMATED RADAR OBSERVATIONS

The AUTOROB is a text description of radar echo areas as seen from an individual radar site. Radar echo features described are the echo shape (either ‘area’, ‘cell’, or ‘line’), the maximum reflectivity level, the percentage of echo coverage, movement of echo centroids, and the maximum storm height. The local portion of a 40-km national reflectivity grid is also coded as part of the message.

Historically, radar information was exchanged between sites in real time by technicians who interpreted the display of a radar scope and manually

transmitted text codes to indicate the location, intensity, shape characteristics, and movement of the echoes. Data from these Radar Observations (ROB's) were centrally mosaicked and plotted on facsimile charts. To supply users with data in this historical format, both reflectivity field and storm cell information from the RCM's are analyzed to reproduce the contents of the manual ROB in the AUTOROB. An AUTOROB for a given radar site is 'simulated' by limiting information to within 230 km of that site.

An example of an AUTOROB appears in Fig. 1. The first two lines are the WMO message header and message source information. The first non-header line shows that station MXX (Maxwell AFB) has at 1945 (UTC) a LN (line) of thunderstorms (TRW) that are 'extreme' (XX) in intensity. The line has been approximated by a rectangle 20 nautical miles wide, with one end of the rectangle at azimuth 248, distance 131 nm to the west-southwest of the radar. The other end is at azimuth 202, range 110 nm to the south-southwest of the radar. The '5' in '5TRWXX' indicates that 50% of this rectangle has precipitation.

The next line of the AUTOROB: **LN5TRWXX 61/54 92/65 5W C1716**, has an echo centroid that is moving from 170 degrees at 16 nautical miles per hour (C1716). Echoes are listed in decreasing order of their maximum reflectivity level.

The "^" symbol indicates the beginning of the local portion of the national MDR grid. The MDR grid is 1/4th the resolution of the RCM grid. The MDR grid value is equal to the highest of the 16 RCM grid values within the MDR box.

By convention, the radar is situated at local column/row coordinates MM. Letters A through T indicate positions relative to the central grid box, with AA at the upper right-hand corner and higher-position letters further right or down. For example, KP indicates the box two columns left and three rows below the central box. These letter combinations indicate the leftmost (generally, westernmost) positions of nonzero reflectivity runs. In Fig. 1, the letters HK5 KH2555421 indicate a Level 5 echo at box HK, and a sequence of boxes with levels 2555421 beginning with box KH. A full explanation of MDR codes is presented in National Weather Service (1980).

The national mosaic is projected on a polar stereographic grid with the following characteristics:

Orientation: 105°W (255°E)
Reference latitude: 60°N
Mesh length at reference latitude: 47625 m
Lower-left corner position: 120.23°W, 23.75°N
Number of rows: 89
Number of columns: 113

This grid is coaligned with the Radar Coded Message grid and the Hydrologic Research and Applications Program (HRAP) grid, which have reference mesh lengths of 11906 m and 4762.5 m, respectively.

The reflectivity data within the grid describe the largest value observed within the box. The reflectivity values are coded as follows:

| | |
|---|---|
| 0: < 15 dBZ | 4: 45-49 dBZ |
| 1: 15-29 dBZ | 5: 50-54 dBZ |
| 2: 30-39 dBZ | 6: ≥ 55 dBZ |
| 3: 40-44 dBZ | |

## 4. AUTOROB GENERATION PROCEDURES

The TDL version of the AUTOROB is intended to be an accurate re-hosting of the AWC version (Cope, 1993).

An AUTOROB message is generated for every WSR-88D radar site. If a site within a list of all radars has not reported, a 'PPINA' (Plane Position Indicator Not Available) message is generated for that site. The AUTOROB is generated from the QC'ed national mosaic. To simulate what would have been seen from the single radar, the AUTOROB is generated from RCM gridpoints that are within 230 km of the radar site. If no precipitation, or only light precipitation covering a small fraction of the umbrella, is indicated, a 'PPINE' (Plan Position Indicator No Echoes) message is generated for the site.

Elementary image processing is used to categorize RCM reflectivity levels into 'echo families'. An echo family is a geographically connected area of echoes. An RCM gridpoint echo is 'connected' to another echo if they are separated by 4 RCM gridpoints or less.

Each echo family is numbered, and information is stored in FORTRAN arrays. A rectangle is fit to each echo family that approximately fits the outside edges of the precipitating area. Based on this rectangle, calculations are done for the echo family: the size, shape, maximum reflectivity level, and percent coverage with echoes.

At this point it is determined whether any of the maximum tops or centroid motions are within an echo family. Raw maximum top and centroid motion is contained within the RCM text message (OFCM 1991).

When this is done, each echo family is written to a file, with the highest reflectivity values being written first.

Some cases of light precipitation are ignored. If an echo family has only level 3 or less precipitation and is not large, it is ignored. Also echo families with less than 5% coverage are ignored.

An attempt is made to differentiate rain from snow according to temperatures at the surface and at the 850-mb level. If the 850-mb temperature is ≤ 0°C and the surface temperature is ≤ 4°C, then the precipitation is assumed to be snow and renamed as such in the AUTOROB. No attempt is made to identify freezing precipitation (ice pellets or freezing rain).

The AUTOROB generation procedure may be summarized as follows:

For each site in the radar list:

If no RCM or and RCM with noncurrent data were reported, generate a PPINA message;

If little or no precipitation was indicated within the local portion of the national grid, after quality-control, then generate a PPINE message;

For umbrellas with precipitation:

Identify echo families;

Determine coverage percentage within the echo family;

Identify convective cells contained in the RCM and remove those in areas flagged by the QC algorithms;

Determine motion of echo areas as the mean of the motions of storm cells within them;

Tag an area or the storm cell containing the RCM's maximum echo top with that top's magnitude, azimuth, and range;

Check the surface and 850-mb temperatures for rain/snow criteria, and rename the precipitation characteristic if conditions are sufficiently cold;

Write out the location, coverage, velocity, and characteristics of all echo families and convective cells;

Reduce the local portion of the RCM national grid to the MDR grid;

Relocate the MDR grid to the local radar-centered coordinate system and write out strings describing nonzero values.

## 5. ACKNOWLEDGMENTS

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ZCZCXXROBMXX ALL
TTAA00 KWBC DDHHMM
|MXX 1945 LN 5TRWXX 248/131 202/110 20W
LN 5TRWXX 61/54 92/65 5W C1716
AREA 1TRWX 339/108 0/82 37W
AREA 5TRWX 188/109 179/120 13W C1716
CELL TRWX 167/137
AREA 4RW++ 245/154 170/144 71W
AREA 2RW++ 334/110 135/141 117W
AREA 3R- 300/111 279/56 14W
AUTO
^HK5 IH2555421 HJ22544422 KM2562 LM2135 JM1 MO31 NP11 OO1 OQ1 PI2 PR2 QC2666
QN4 RH222564555 SI2133232 TK24=
NNNN
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Figure 1. Sample of an Automated Radar Observation (AUTOROB) for Maxwell AFB, Alabama, 1945 UTC.