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NOAA Technical Memorandum NWS ER-59



DIGITAL RADAR DATA AND ITS APPLICATION IN
FLASH FLOOD FORECASTING

David D. Sisk
WSFO Pittsburgh, Pa.

Scientific Services Division
Eastern Region Headquarters
March 1975

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DIGITAL RADAR DATA AND ITS APPLICATION IN
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David G. Stet
4520 Pittsburgh, Pa.

Scientific Services Division
Eastern Region Headquarters
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NOVA Technical Information
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DIGITAL RADAR DATA AND ITS APPLICATION IN
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David G. Stet
4520 Pittsburgh, Pa.

INTRODUCTION

This paper describes Digitized Radar Experiments (D/RADEX) now being conducted at the Weather Service Meteorological Observatory in Pittsburgh (WSMO PIT). In these experiments, development, testing and evaluation of techniques are in progress for automatic processing and presentation of weather radar data in real-time for operational applications. Basically, a minicomputer and its related processing and interface equipment are used to take over control of the radar for approximately twenty seconds to collect radar video returns for archiving and printout displays. D/RADEX is a project of the Systems Development Office, National Weather Service.

WORKING CONCEPT OF D/RADEX

A WSR-57 PPI (Plan Position Indicator) scope is scanned automatically every twelve minutes, at H+00, H+12...H+48, by the minicomputer. The information can also be collected every six minutes if needed. The radar video returns are collected as observed for each 2° of azimuth and for each one nautical mile (n.m.) (1.852 Km.) of range from 11 to 125 n.m. (20-232 Km.), at an antenna elevation of 1/2°. The data are stored in the computer's memory, and then archived on magnetic tape for future use. Since the radar operator at all times can have complete manual control of the radar and thus can prevent a scheduled D/RADEX observation, D/RADEX has been designed to "retry" automatically, within a five-minute wait period, to perform its twenty-second scan function.

After each observation various printout digital displays can be routinely requested and obtained at WSMO PIT. Among these are:

1. A standard digital IJ MATRIX printout of the radar video returns as observed from the WSR-57 PPI console, with circular 25 n.m. (46 Km.) range marks indicated out to a 100 n.m. (185 Km.) radius (Figure 1). This display became effective March 1975. The WSMO site is located at grid point 0,0 with grid point interval increments of 5 n.m. (9.3 Km.) north to south and 3 n.m. (5.6 Km.) east to west. Each digit represents the maximum Video Integration and Processor (VIP) level (1-6) occurring within each square of size 3 x 5 n.m. (15 sq. n.m.). The first 10 n.m. (18.5 Km.) radius is blanked out. Ground clutter, which cannot be distinguished from precipitation in the program, appears within approximately the first 25 n.m. (46 Km.). Echo returns of the mountain ridges also appear 45 - 55 n.m. (82 - 101 Km.) to the southeast. Figure 2 displays radar video returns (VIP levels) to the north and east of Pittsburgh. The blackened areas represent ground clutter and mountain ridge echo returns. Under certain atmospheric conditions anomalous propagation (AP) echoes appear and cannot be distinguished as such.

2. Tops Map Grid, consisting of a 25 row x 25 column Matrix with each grid point representing a square of size 10 x 10 n.m. (18.5 x 18.5 Km.). The highest echo top reported in each grid square is printed to the nearest 1,000 feet (305 meters). The azimuth and range for the five highest tops are also displayed thus assisting the radar operator in his RHI (range-height indicator) scan.
3. A hydrological printout for a 120 n.m. (222 Km.) range, consisting of a 25 row x 25 column Matrix, each square representing an area 10 x 10 n.m. (18.5 x 18.5 Km.). A printed coded value represents the average accumulated rainfall over a three-hour period, as estimated by radar, for each grid square. This information is automatically transmitted at three-hourly intervals to RFC CIN via high speed dial-up teletype.

Further development of the DVIP (Digital Video Integrator and Processor) and its incorporation into the WSR-57 radar is underway at WSMO PIT. The DVIP will allow a choice of range increments from 1/4, 1/2, 1 or 2 miles, and choice of beam width increments from 1/2°, 1°, 2° or 4°. Thus the IJ Matrix printout will allow presentation of maximum intensity levels occurring within varying grid square size (i.e., 1 x 1, 2 x 2 n.m. etc.). Further details on operation of DVIP are described by Shreeve (1974).

CASE STUDY

A case study illustrates how D/RADEX can assist in determining areas of potential flash flooding. The D/RADEX hydrological printout is used and illustrated (Figure 3).

In this hydrological printout a 30 n.m. (55 Km.) radius area from the radar site is blanked out and echo returns of the mountains to the south-east are blanked out. The code values used, 1-4, reflect the three-hour accumulated rainfall estimated by radar within each 10 x 10 n.m. grid square. Table 1 presents the range of average rainfall amounts in inches and millimeters (mm) represented by each code value. The estimated rainfall rate was obtained by increasing the Marshall and Palmer (1948) equation by a factor of 2, based on results from past D/RADEX experience. The equation thus becomes $Z=66R^{1.6}$ (Greene, 1975) where Z is the reflectivity measured and R is the rainfall rate. This Z-R relation will continue to be adjusted as further research and experimentation is conducted. Echo intensity is normalized for range before solving the equation.

Table 1.

D/RADEX HYDROLOGICAL CODE

<u>Code Value</u>	<u>Rainfall Amount</u>
1	trace (T) - 0.49" (T - 12 mm)
2	0.50 - 0.99" (13 - 25 mm)
3	1.00 - 1.49" (25 - 38 mm)
4	1.50 - 1.99" (38 - 50 mm)

This case deals with echoes over Southeastern Ohio having two characteristics of a flash flood producing storm; echoes of moderate to very strong intensity (VIP levels 2-4) and slow movement. Precipitation that resulted from this storm is described in the following message which was transmitted by Grant Vaughan (Hydrologist, WSO Akron):

SEVERE THUNDERSTORMS OCCURRED OVER MUSKINGUM GUERNSEY AND MORGAN COUNTIES IN OHIO THE NIGHT OF JUNE 20 21 1974. MAXIMUM RAINFALL 5.03 INCHES FELL AT NORWICH WHICH IS 12 MI EAST OF ZANESVILLE. 3.22 FELL AT CAMBRIDGE AND 3.3 AT MCCONNELSVILLE AND 3.52 AT RINGOLD WHICH IS 10 SW OF MCCONNELSVILLE. THE TWO INCH ISOHYET COVERS MOST OF THE THREE COUNTIES. NUMEROUS ROADS WERE FLOODED AND WASHED OUT. THE LOCAL RESIDENTS CALL THE STORM... THE SEVEREST EVER.

Very heavy rainfall that produced flash flooding occurred between 0500Z and 0800Z, and within two of the present 40 x 40 n.m. (74 x 74 Km) grid square boxes used in the manually digitized radar (MDR) system of the National Weather Service (Moore, Cummings and Smith, 1974). In particular the southern half of the MDR grid square box that includes Zanesville (ZZV) and northern half of the adjacent grid box to the south of ZZV. The MDR values, presented in Table 2, were in this case an excellent indicator of heavy rain producing echoes, although lacking the resolution of D/RADEX data.

Table 2.

MDR VALUES AND OBSERVED PRECIPITATION AMOUNTS - JUNE 21, 1974

MDR Grid Box That Includes ZZV
Reported Precipitation 00Z to 12Z

ZZV	2.90" (73.7 mm)
Norwich	5.03" (127.8 mm)
Cambridge	3.22" (81.8 mm)

MDR Grid Box South of ZZV
Reported Precipitation 00Z to 12Z

McConnelsville	3.30" (83.8 mm)
Ringold	3.52" (89.4 mm)
Tom Jenkins Lake	2.77" (70.4 mm)

MDR Values

2	} 22-(4 hour sum)
4	
6	
6	
6	
20	
2	

Time

- 0335Z -
- 0435Z -
- 0535Z -
- 0635Z -
- 0735Z -
- 0835Z -

MDR Values

4	} 22-(4 hour sum)
4	
6	
6	
6	
20	
2	

The three-hourly D/RADEX hydrological code values for 0601Z to 0901Z are presented in Figure 3.

The grid location on Figure 3 of the six precipitation observing sites listed in Table 2 are presented in Table 3 below. Also presented in Table 3 is the sum of the average precipitation totals estimated by D/RADEX for four consecutive 3-hourly periods, from 00Z to 12Z, for each 10 x 10 n.m. (18.5 x 18.5 Km.) square grid that includes the precipitation observing station. The upper limit of the range represented by each code number (Table 1) was used to arrive at this D/RADEX estimated precipitation.

The three three-hour D/RADEX hydrological printouts for 00-03Z, 03-06Z and 09-12Z, 21 June (not illustrated here) each showed a code value of 1 (T-0.49"), for the grid square areas of concern in southeastern Ohio:

Table 3.

D/RADEX ESTIMATED PRECIPITATION VERSUS OBSERVED PRECIPITATION

	D/RADEX Printout		Average Precipitation Estimated by D/RADEX <u>21/00Z-12Z</u>	Precipitation Observed <u>21/00Z-12Z</u>
	Location	Column		
Zanesville	16	5-6	2.5 - 3.0"	2.90"
Norwich	16	6	3.0"	5.03"
Cambridge	16	7	3.0"	3.22"
McConnelsville	18	6	3.0"	3.30"
Ringold	19	5-6	2.5 - 3.0"	3.52"
Tom Jenkins Lake	19	5	2.5"	2.77"

The manually prepared radar overlays and MDR indicated the heaviest rains occurred after 0435Z and prior to 0835Z. Although the heavy rain that fell approximately 60-90 n.m. (111 - 167 Km.) west southwest of WSMO PIT was depicted accurately in time and location by D/RADEX, the three-hour D/RADEX hydrological information arrived too late to use operationally in issuing flash flood warnings before the flooding occurred. It is now possible, however, to acquire this output for shorter periods (0-1 hour, 0 - 1 1/2 hours, 0-2 hours) essential in identifying potential flash flood areas quickly. Also, the hydrological grid will soon be changed from the present 25 x 25 Matrix to a 51 x 51 Matrix, and made available to forecasters at the Weather Service Forecast Office in Pittsburgh. Each square in the new Matrix will represent a 5 x 5 n.m. (9.3 x 9.3 Km.) area, thus increasing the area resolution of the present system by a factor of four.

Research and evaluation of real-time situations will provide a better correlation between hydrological code values and observed rainfall. Limited telemetered and DARDC (Device for Automatic Remote Data Collection) rain gage data in the future will be fed into the D/RADEX system. Analysis of the combined data can be performed, in real time, to provide operational

people with best estimates of the area and time distribution of rainfall amounts. This information, when compared to the predetermined amounts of precipitation required for flash flooding, will improve our warning services. Under the National Weather Services future concept for the Automation of Field Operations and Services (AFOS), D/RADEX data along with telemetered and DARDC data will be merged.

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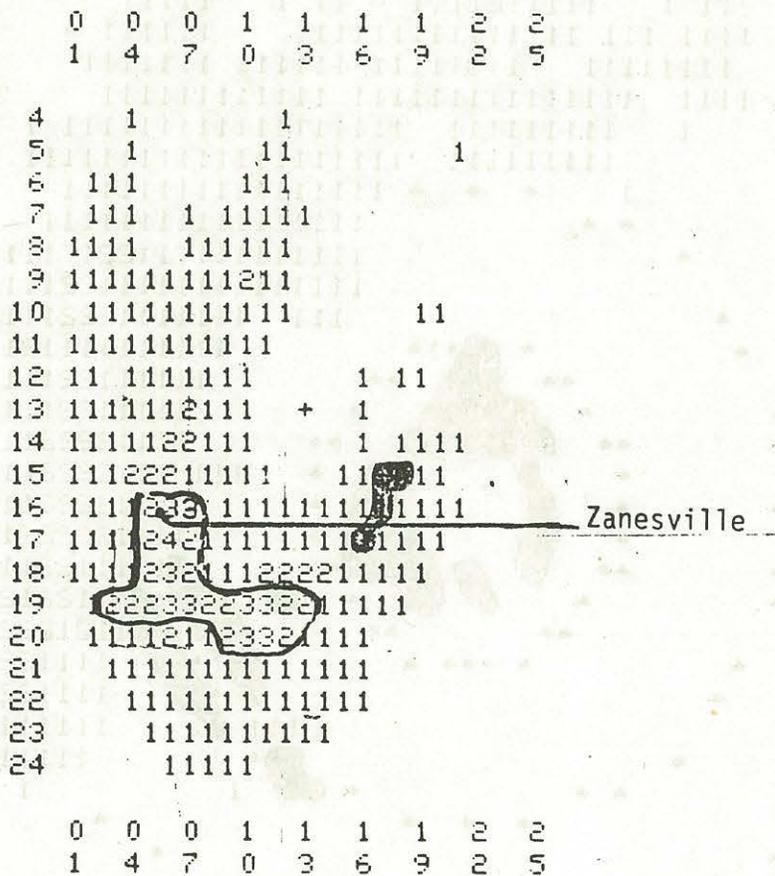


Figure 3

D/RADEX hydrological printout for 0601Z to 0901Z June 21, 1974. See text for explanation of printout. Outlined area includes Southeastern Ohio, where heavy rain occurred.