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RADAR RAINFALL ESTIMATES FOR THE PITTSBURGH LITTLE PINE CREEK FLASH FLOOD OF MAY 1986[1]

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1. Introduction

Over a span of three hours on the afternoon of May 20, 1986, several thunderstorms developed over the drainage basin of Little Pine Creek in the northern suburbs of Pittsburgh. These thunderstorms remained stationary during their life cycles, producing small hail and up to 8 inches of total rainfall. The heavy rainfall led to a flash flood down Little Pine Creek, Broadhead Run, and Harts Run which took nine lives and caused extensive property damage. The affected area was covered by a National Weather Service (NWS) RADAP II (Radar Data Processor, version II) which computed real-time products from the Pittsburgh NWS network radar. This paper discusses the performance of the RADAP II rainfall accumulation algorithm, the use of these rainfall estimates within the context of the NWS Forecast Office responding to a potential flash flood, and some implications for the future NWS NEXRAD/AWIPS-90 environment. Some of the material presented in the paper has been excerpted from the NWS Disaster Survey Report dealing with this event.

2. Event Description

Scattered thunderstorms developed over eastern Ohio and western Pennsylvania during the early afternoon. Radar reports indicated cell strengths of 45-55 dbz and movement from the west-northwest at 15 knots. Severe thunderstorm warnings were issued for counties near Pittsburgh at 1345 EDT and at 1530 EDT. At about 1450 EDT, a cell began to develop just north of the Little Pine Creek basin. This cell grew rapidly and maintained reflectivities greater than 57 dbz from 1540 EDT to 1700 EDT while remaining stationary over the Little Pine Creek area. Although no official rain gages were located in the flood area, a disaster survey team retrieved gage estimates from 12 private citizens. An isohyetal analysis of these gage values revealed that the greatest concentration of rainfall, 4 to 8 inches, fell in only a 3 by 6 mi oval. This area, however, was situation directly over the headwaters of Little Pine Creek. The Little Pine Creek drainage area is very small (6.1

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square miles) and the resultant runoff produced flooding by 1615 EDT with a crest of 3.5 to 4 feet by 1700 EDT. Major flooding was over by 1800 EDT. The NWS issued a Special Weather Statement at 1645 EDT mentioning heavy rainfall over Allison Park and the possibility of minor flooding. At 1753 EDT, the NWS issued a flash flood warning, based primarily on reports of flooding.

3. RADAR II Rainfall Algorithm

RADAP II is a computer system that collects digital data from selected NWS radars, processes these data into hydrometeorological products, and services users' requests for these products in near real-time. The current version of the system is an outgrowth of the D/RADEX (Digital Radar Experiments) project (Saffle, 1976). One of the RADAP II algorithms estimates rainfall rates based on the Marshall-Palmer relationship $Z = 200R^{1.6}$, where Z is the radar reflectivity values have an areal resolution of 1 n mi by 2 deg and are collected for every even azimuth radial for ranges of 11 n mi through 126 n mi. Local ground clutter is partially removed by using data from the lowest elevation angle (usually 0.5 deg) at farther ranges and data from a higher elevation angle close in. The transition range and optimum higher elevation angle are site adaptable parameters but usually are about 30 n mi and 2.5 deg. The estimated rainfall rates over a particular period are then used to estimate the rainfall accumulations over that same period. For the Little Pine Creek event, RADAP II estimates reached 6.8 inches for the period 1400 to 1730 EDT. Figure 1 is a plot of the rain gage values for the event, isohyets of RADAP II rainfall estimates, and a geographical background of the Little Pine Creek area. Figure 2 is a graph showing the estimated rainfall accumulation in the area of maximum RADAP II rainfall estimation. From this graph it is seen that RADAP II estimations had reached 2 in by 1600 EDT and 4.2 in by 1630 EDT. These two figures together indicate that, in this instance, the unadjusted rainfall estimates from the radar data were both accurate and timely.

4. Use of RADAP II by NWS Forecasters

The RADAP II rainfall estimates were not used to issue a more timely flash flood warning for several reasons. These can be grouped as follows: (1) an erroneous flash flood guidance value (the amount of rainfall required, within a particular time interval and over a particular area, to produce flash flooding) from the River Forecast Center; (2) lack of flash flood guidance values for intervals less than 3 h; (3) lack of forecaster confidence in the RADAP II rainfall accuracy; and (4) lack of precise knowledge of the position of the RADAP II estimates in relation to known flash flood prone areas. The first factor was related to a problem in a change of computer software and will not be discussed further here (Disaster Survey Report, 1987). The other factors have significance for the future use of radar-rainfall estimates, however. With RADAP II, as will be the case with NEXRAD, rainfall accumulations are updated every 5 to 10 minutes, and very small scale, fast reacting flood events need flash flood guidance values for 1-h and 2-h intervals to take advantage of this new, automated radar capability.

Any occurrences of patently erroneous radar rainfall estimates tend to reduce forecasters' confidence in the product. With RADAP II, these erroneous

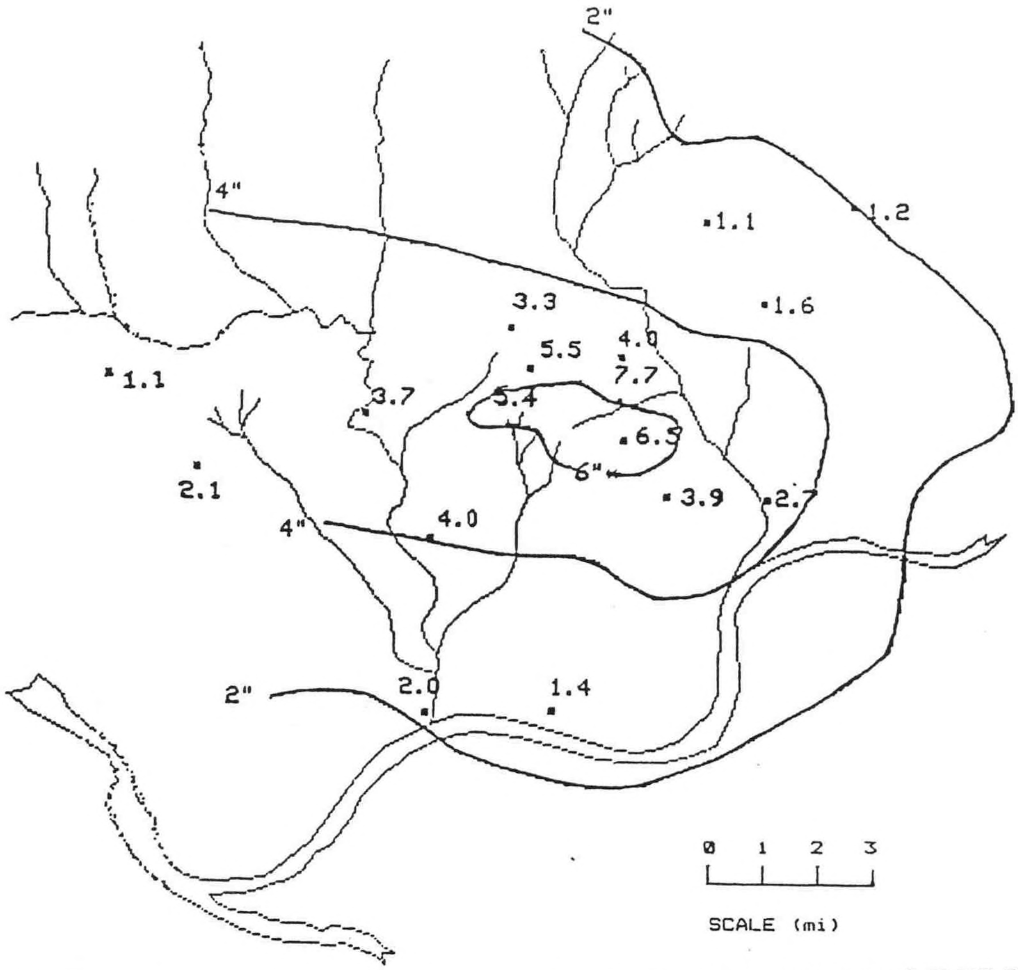

Figure 1. Little Pine Creek flash flood raingage values and isohyets of RADAP II.

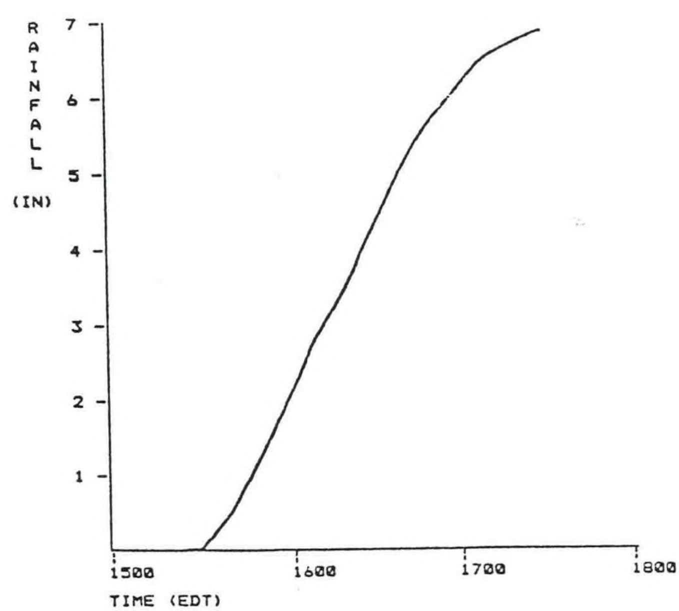

Figure 2. Estimated rainfall accumulation for the RADAP II area that had the greatest rainfall estimate for the Little Pine Creek flash flood.

values are often the result of anomalous propagation (AP) returns or residual normal ground clutter. Forecasters need a thorough knowledge of the meteorological conditions that are conducive to AP in order to properly evaluate radar rainfall estimations. Although, in retrospect, it can be seen that good mixing of the lower atmosphere precluded the formation of AP in the Little Pine Creek event, past instances of AP-contaminated RADAP II rainfall estimates caused the forecasters to seek confirmation of the Little Pine Creek estimates. This point is stressed because of the significance it has for NWS plans for NEXRAD training and the need for NEXRAD to automatically remove as much AP and ground clutter as possible. If NEXRAD is not able to completely eliminate ground clutter and AP, it would be very helpful to forecasters to have NEXRAD flag areas of suspect reflectivity. Another factor contributing to the Pittsburgh forecasters' suspicion of the RADAP II rainfall estimates was their feeling that RADAP II would likely over-estimate rainfall in cases where the storms contained significant amounts of hail. The hail effect mitigation technique in RADAP II (limiting estimated rainfall rates to no more than 4.5 inches per hour) has apparently not been adequately taught to RADAP II users.

Finally, unlike severe thunderstorms and tornadoes, identification of heavy rainfall is not sufficient in itself to issue a flash flood warning. Especially for small scale events, whether or not a flash flood occurs may depend on the degree of urbanization, on small scale local topography, and on local concentrations of antecedent precipitation. At the time of the Little Pine Creek flood, the smallest areal detail for readily available displays of RADAP II rainfall estimations was 3 by 5 n mi. NEXRAD will have much higher areal resolution rainfall products; these products should also, however, be able to be viewed with detailed map backgrounds of flash flood prone locations.

5. Summary

In summary, this flash flood event provided an opportunity to look at some of the problems the NWS may experience in the effective operational use of radar estimates of rainfall from NEXRAD. These problems will include AP and ground clutter contamination, forecaster assessment of the potential of small areas of heavy rainfall to cause flash floods, the building of forecaster confidence in the accuracy of radar estimates of rainfall, and the training of forecasters in the potential sources of errors in these estimates. The outlook is very promising, however. Events that have been captured by RADAP II data have shown that radar rainfall estimates are extremely useful operationally. Further, the NEXRAD environment will allow better quality control of the base reflectivity data (to include clutter reduction and some AP removal) as well as automated use of rain gage data to compute biases in the radar rainfall estimations. Finally, the effects of training are rapidly apparent; one year after the Little Pine Creek flood, another flash flood occurred in the Pine Creek watershed (Giordano and Davis, 1987). In this event, the radar data were effectively utilized along with other available data to provide timely statements and warnings as the event developed.

6. References

Disaster Survey Report, 1987: Little Pine Creek Flash Flood of May 30, 1986. National Weather Service Eastern Region (in press).

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