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A STUDY OF THE NEXRAD PRECIPITATION PROCESSING SYSTEM ON A WINTER-TYPE OKLAHOMA RAINSTORM

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1. INTRODUCTION

The Next Generation Weather Radar (NEXRAD) "on-site" Precipitation Processing System (PPS) was developed by the Hydrologic Research Laboratory (HRL) of the National Weather Service (NWS) to provide accurate and reliable rainfall estimates for the co-terminous United States from a network of more than 100 high resolution 10 centimeter radars. The PPS is described in detail by Ahnert et al. (1983) and a complete functional specification is contained in the NEXRAD Algorithm Report (1985). The radar estimated rainfall is to be adjusted for the mean field bias in real-time using a number of telemetered rain gage reports. Adjusted rainfall values will be available as NEXRAD graphics products and as a high resolution (100 data levels, approximately 4 km x 4 km) data array product for input to flash flood and river forecast models and procedures.

A report on the validation of the NEXRAD PPS using radar and gage data from a Colorado thunderstorm event was presented at the 22nd AMS Radar Conference (Ahnert, et al., 1984). Further validation on other data sets was recommended by the NEXRAD Joint Systems Program Office (JSPO) in order to determine the performance of the Kalman filter bias adjustment and the effect of certain algorithm adaptable parameter changes in different weather regimes. This paper presents the results of tests on an Oklahoma winter rain event.

2. DATA COLLECTION

The NEXRAD Interim Operational Test Facility (IOTF) has implemented the PPS on a Perkin-Elmer 3242 computer. A data set was collected on February 22, 1985, using the National Severe Storms Laboratory's (NSSL) 10 centimeter radar and concurrent rain gage information from the Oklahoma City National Weather Service office's cooperative network. Data were collected for a period of 4.5 hours (from 1140 to 1610 CST). A total of 29 accumulator and incremental type rain gages were used in the hourly adjustment of the radar totals, however, less than 10 of the gages reported measurable precipitation during any one hour period. In addition 20 three-hourly incremental rain gages which were not used in the bias computation were used in final gage/radar comparisons.

3. WEATHER PATTERN

The weather charts on February 22, 1985, (Fig. 1) show a stationary front oriented Northeast/Southwest across the state of Oklahoma

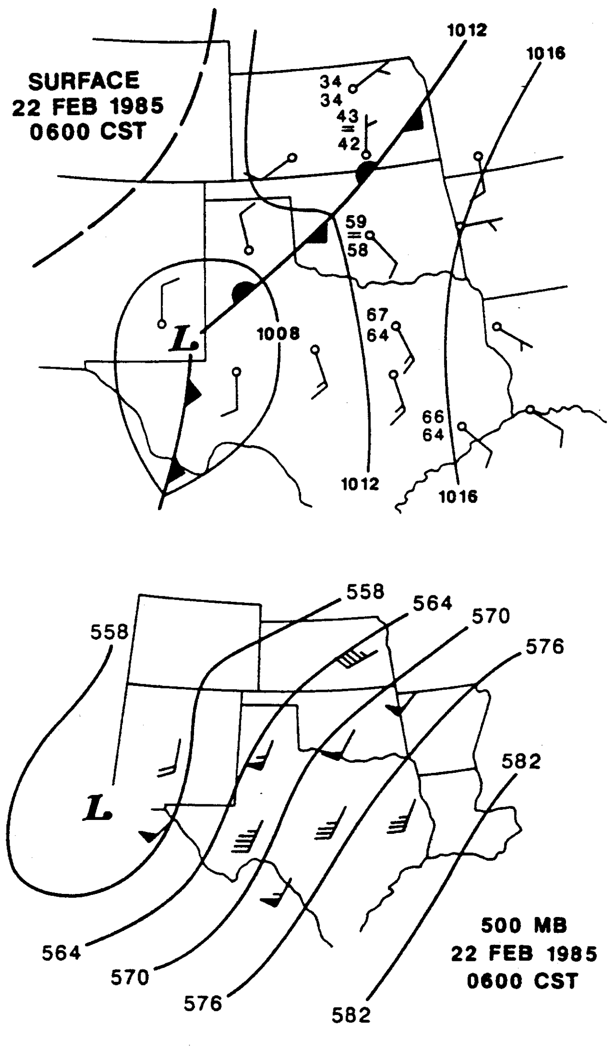

Fig. 1. Surface and 500 millibar synoptic weather at 0600 CST, February 22, 1985.

with southeasterly surface winds bringing abundant Gulf of Mexico moisture into the state and raising the Oklahoma City dewpoint to 58 degrees. Dynamic instability over Oklahoma was enhanced by strong southwesterly winds aloft, nearly parallel to the stationary surface front.

Rainfall became widespread across the state during the morning hours with some areas of moderate to heavy rain occurring in the data collection area. In the three hours ending at 1600 CST, a rainfall accumulation of over two inches was recorded at two of the gage locations. Fig. 2 shows the three hour rain gage accumulation pattern at 1600.

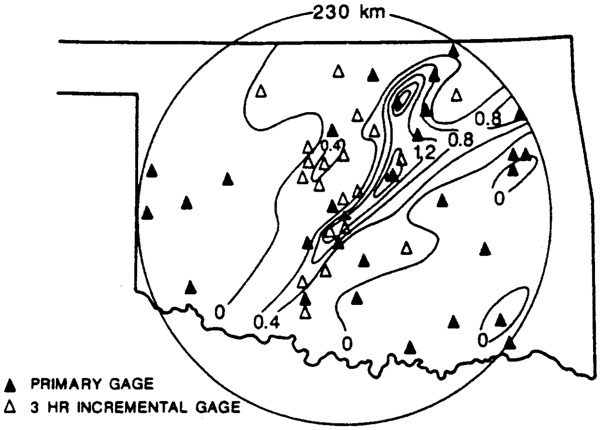

Fig. 2. Rain gage distribution and three-hour rainfall accumulation in inches ending 1600 CST. Note that two small areas northeast of the radar exceeded two inches.

4. HYBRID SCAN RESULTS

The hybrid scan is a single reflectivity scan composed of data from the low 4 tilts. Closer in, higher tilts are used to reduce clutter. At further ranges either the maxima from the low two tilts are used (Bi-scan maximization) or the second tilt values are used alone (whenever the tilt test rejects the low tilt.) Initial results with the February 22 data set were very encouraging. Ground clutter effects were diminished due to the hybrid scan technique and removal of strong point values. The hybrid technique also decreased the effect of range biasing by using the maximum of the first or second elevation angle reflectivity value between a range of 40 and 110 kilometers. The plot of average hourly accumulation versus range (Fig. 3) shows the effect of the hybrid scan technique compared to using the lowest elevation angle only.

5. BIAS ADJUSTMENT

The adjusted radar estimates of rainfall accumulation totals appeared to be significantly lower than comparable gage accumulations. A factor which probably contributed to this underestimation is rainfall intensification below the radar beam as a result of coalescence within low stratus and fog. However, the system includes a Kalman filter adjustment technique that computes a mean field multiplicative bias correction factor using hourly rain gage data. This technique is described by Ahnert et al., 1986, in a paper presented elsewhere in these preprints.

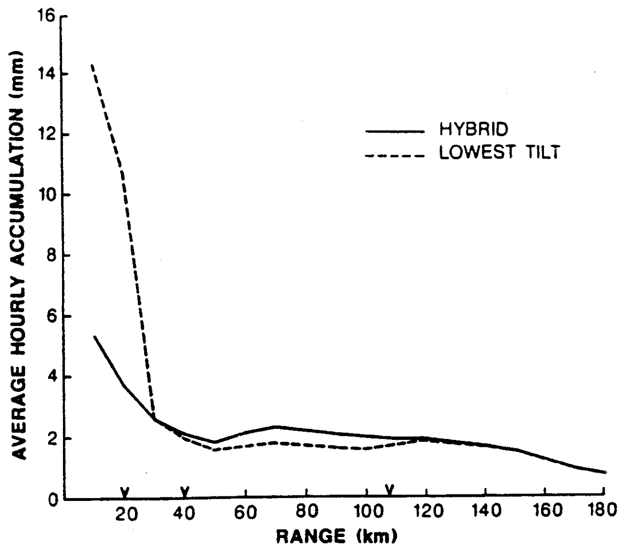

Fig. 3. Average hourly radar estimated rainfall accumulation versus range. The hybrid scan uses the fourth tilt inside 20 kilometers, the third tilt between 20 and 40 kilometers and the maximum reflectivity from the first or second tilt beyond 40 kilometers.

5.1 SYSTEM NOISE

The lower three curves in Figure 4 show the effect of changes in one of the adaptable parameters important in the calculation of the bias. The estimated system noise (Q) specifies

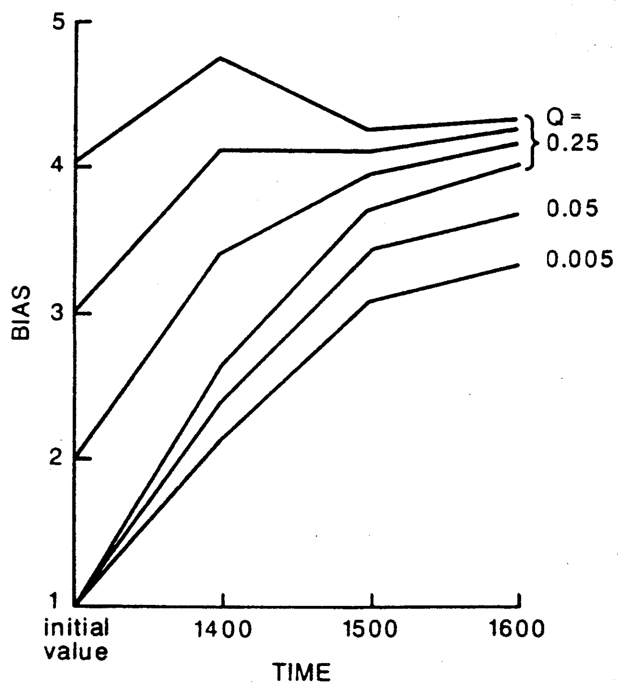

Fig. 4. Calculated hourly radar rainfall bias versus time. The lower three curves show the effects of varying the system noise parameter. The upper three curves show the effects of varying the reset bias parameter.

the estimated mean square error of the drift in the radar bias from one hour to the next. Raising the Q value allows the bias correction to respond more quickly to gage values, however, Q values greater than 0.25 (not shown) had only slight effect on the bias response.

5.2 RESET BIAS

The reset bias (initial value) is generally expected to be 1.0 (no bias) if the radar is properly calibrated and a climatologically appropriate Z-R relationship is used. Unfortunately, this data set begins in the middle of a rain event and there is only enough data for 3 bias calculations. Since the actual bias is significantly greater than 1.0 (unadjusted radar is underestimating the rainfall) starting the bias at 1.0 (lower 3 curves in Figure 4) results in a monotonically increasing bias indicating that there is insufficient time for the bias to catch up to actual values. Under continuous operations as planned with NEXRAD, it is very likely that earlier bias calculations for this storm would have raised the estimated bias. To simulate the effect of earlier bias calculations, runs were made with reset biases of 2.0, 3.0, and 4.0 (upper 3 curves in Figure 4). Using a reset bias of 4.0 results in a bias which is not monotonically increasing and probably represents more nearly the bias which would have been had computed data from the complete storm been available.

6. OVERALL PERFORMANCE

In the rainfall area versus depth plot (Fig. 5) the curved based on the PPS estimated three hour accumulations with a system noise of 0.25 and reset bias of 4.0 is very close to the curve based on the three hour gage analysis. With the lower values of Q (0.005) and reset bias (1.0) the resulting accumulations are considerably lower.

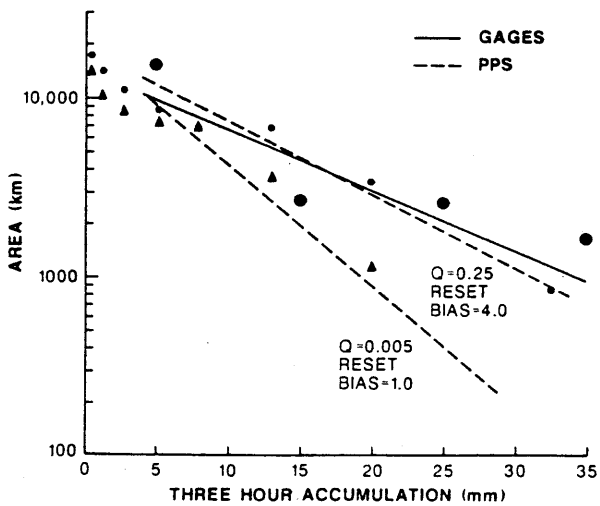

Fig. 5. Area versus rainfall accumulation for three-hour accumulation ending 1600 CST.

Figure 6 is a black and white version of the NEXRAD graphical three-hour precipitation accumulation product (2 x 2 kilometer) ending at 1600 CST on February 22. Actual NEXRAD graphical precipitation products will be in color with 15 distinct data levels. A comparison with Fig. 2 clearly shows the increased resolution of the radar derived precipitation field over the use of the gages alone. Overall, the bias adjustment procedure appears to have performed reasonably well on this particular case. A larger value (0.25) of the system noise parameter seemed to produce better results. Further testing with longer data sets is needed to optimize the procedures performance.

7. ACKNOWLEDGEMENTS

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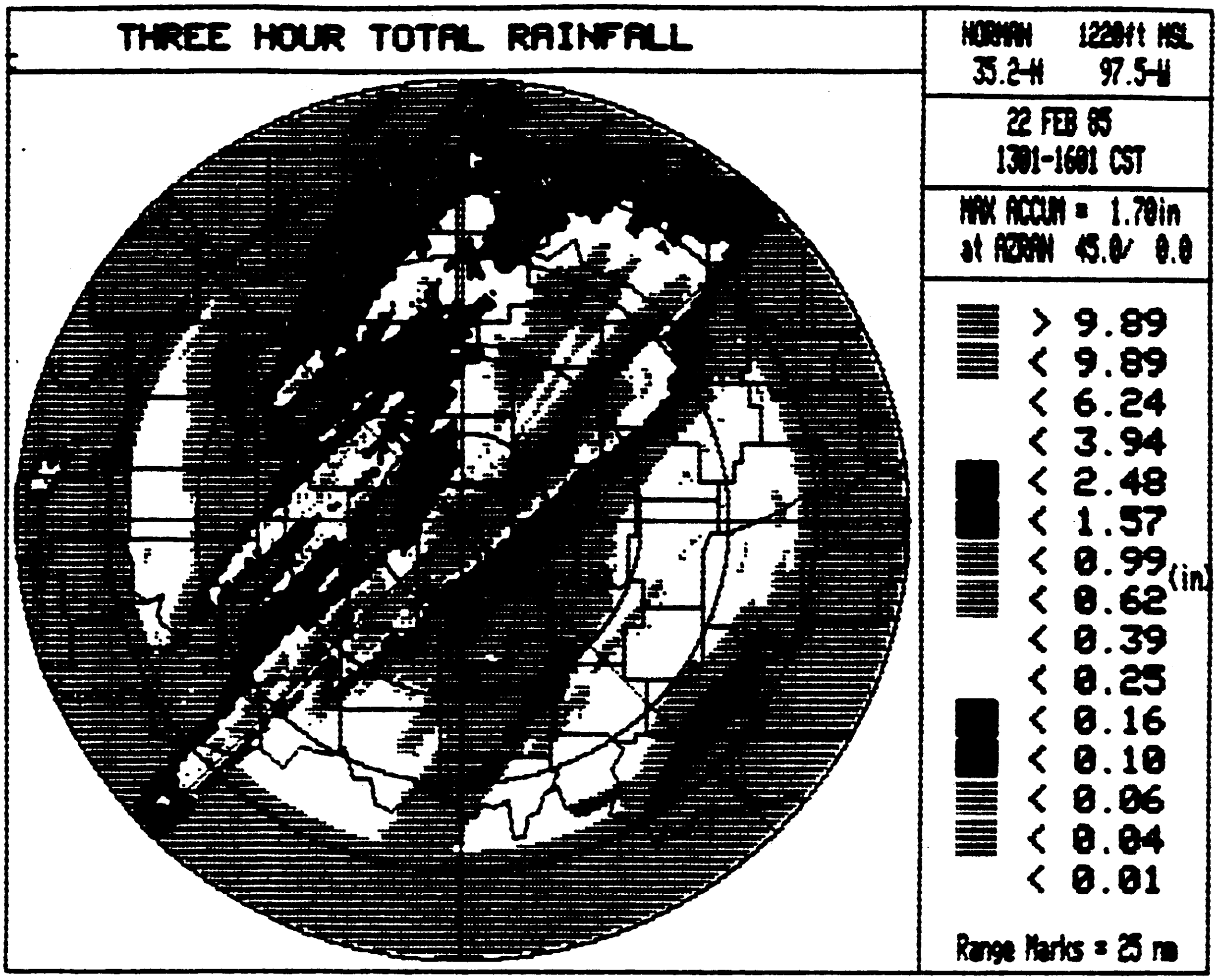

Fig. 6. Graphical NEXRAD three-hour rainfall accumulation product.