CRH SSD
NOVEMBER 1987

CENTRAL REGION TECHNICAL ATTACHMENT 87-28

DOPPLER DATA AT DENVER (1987)

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Doppler radar data were made available to the Denver WSFO beginning in April 1987. The data consisted of reflectivity and velocity PPI images at .2, .7, 1.8, 2.9 and 4.0 degree tilts which were derived from the NCAR CP-2 radar operating in an automatic volume scan mode. Also produced from the Doppler data were four NEXRAD algorithms. These algorithms were of storm identification, storm track, mesocyclone and hail/storm structure. All of the above were presented to the WSFO forecasters via the DAR^{3}E workstations at 3, 6, and 10 minute intervals depending on the mode of operations; e.g., storm, convective surveillance or clear air. All radar data could be viewed with the full DAR^{3}E capabilities, including zoom, roam, animation, and the ability to quickly change color enhancements. This suite of products is not the complete NEXRAD product set, and in particular is lacking any storm cross-section product or precipitation processing products. Nevertheless, this was a large difference for Denver which previously had only a remote KAVOURAS display of the Limon, Colorado WSR-57.

In order to prepare the Denver forecasts for real-time operations with this new data set, a five-phase training program was conducted. A two-part evaluation of the training was done in September 1987 in order to provide some guidance for future NEXRAD training needs throughout the NWS. These two parts consisted of a questionnaire for each forecaster and separate one-hour interviews with nine of the forecasters.

The first phase of the training began in January 1987 with the placement of a reading file of four articles at the WSFO. Three articles were about the principles of Doppler radar. The fourth covered thunderstorm morphology. The forecasters were asked to read this file during quiet times within their shifts.

The second phase was a full day of classroom lecture by NCAR Scientist Jim Wilson on Doppler principles and interpretation of products. This was held over two days with half the staff attending each day.

Phase III was done using four displaced real-time cases on a PROFS workstation. Each case was accompanied by a workbook. Forecasters were able to review each case at their own pace within the workbook. The workstation review cases were in the forecast office for two weeks. Forecasters were expected to review the cases on their own during quiet shifts, particularly swing and midnight shifts.

Phase IV was a similar review of cases on a workstation, but instead of a workbook, an "expert" on Doppler radar interpretation was leading the reviews. This phase took place outside of the office. Two or three forecasters were grouped to work with each instructor, and the training was about four hours in length.

The fifth phase was an attempt to pair forecasters with researchers who were expert at Doppler radar interpretation in real-time situations. This was done by having forecasters work with NCAR scientists at their facility during a real-time field experiment (CINDE - Convective Initiation and Downburst Experiment).

The evaluation of the training was conducted at the end of the convective season. In general, the forecasters were asked what they liked and disliked about the training, and how they would change it. Additionally, there were questions about the utility of the data and the impact on the real-time forecast problems.

All forecasters felt the training was successful in that they were provided with the needed knowledge and skills to interpret Doppler data. The most common suggestions for improving the training were:

1. Compress the time span for the phases into a period of about one month in order to maintain better continuity from phase to phase.

2. More case studies should be made available.

3. More time with instructors.

4. Do post-mortems of real cases that took place during the summer. These reviews should be conducted both soon after the event, and also in greater detail at a later date.

5. Repeat some of the training prior to the next convective season.

6. Experience with the data during winter cases is limited and needs to be improved.

7. All phases of training should be done off-shift.

This last point was a unanimous opinion. The forecasters felt <u>very</u> strongly that it was unrealistic to expect them to go through review cases while they were working forecast shifts, even if the weather was quiet.

Results of the evaluation pertaining to utility of the data are the subjective opinions of the forecasters. Rigorous verification of severe storm warnings is in progress, but results are not yet available. However, it should be noted that the Doppler data were used extensively for significant, but non-severe weather, and this will not be reflected in the verification statistics.

After training, forecasters felt they were much more confident in issuing short-range forecasts/nowcasts. This was particularly true of convective initiation. Each forecaster commented that they were able to follow outflow boundaries and taking environmental conditions into account, predict the formation of new convection due to boundary collisions. There was a consensus of having a much better understanding of why storms formed where and when they did. In the past this appeared nearly random to the forecasters. Along these same lines of short range forecasting, a great deal of confidence was expressed in the ability to make forecasts of wind shifts for the local airports. Up to 30 minute lead time with time accuracy within 5 minutes, and within 5 knots was a common statement by forecasters. This information was relayed to the Stapleton Tower via a hotline.

Confidence in determining which storms had large hail (>3/4" diameter) was not significantly improved. Although preliminary verification statistics indicate improvement in this area, the forecasters had several comments as to how the situation could be much better. The lack of a storm cross-section or RHI product made determining the storm structure very difficult. With a limited number of elevation angles, it was time-consuming just determining if a high reflectivity core was tilted. Another problem was the lack of any specific a priori thresholds as are used with WSR-57 (e.g., height of the VIP-5 core). The Doppler data was not only in dbz rather than VIP levels, but because the radar was of significantly higher resolution than the WSR-57, the reflectivity values appeared higher than the forecasters were used to seeing. The WSFO in Norman, Oklahoma has reported great success with VILS (vertically integrated liquid) from RADAP-II for determining which storms may be severe. Unfortunately, the conversion of this algorithm from RADAP-II to use with CP-2 proved very difficult and no reliable version of VIL products were available in 1987.

The NEXRAD hail/storm structure algorithm was of very little value according to the forecasters. This is not surprising because hail is very common on the High Plains of eastern Colorado, and the algorithm only provided "no hail," "probable hail," and "hail" guidance, while what the forecasters really wanted was help with hail size.

Using Doppler data for tornadoes got a mixed response from forecasters. Not all forecasters worked shifts in which tornadoes occurred. Some felt they were able to identify mesocyclones and even TVS (Tornado Vortex Signatures), while others were much less confident at identifying rotation in the data. The vast majority of tornadoes in Colorado are short-lived F0 and F1 events. Many tornadoes sighted by chase teams in 1987 came from high-based non-rotating cells. These types of storms would not be easily detected in velocity data. The mesocyclone algorithm was given low marks by the forecasters. When it was used, it was found to rarely indicate a mesocyclone. Forecasters quickly lost confidence in the product and stopped using it.

Numerous funnel cloud reports are phoned into the WSFO during the summer, many are false alarms by inexperienced observers. This is especially true in Colorado because of frequent high-based thunderstorms with virga shafts that may appear to the public to be funnel clouds. The velocity data allowed forecasters to verify rotation aloft when funnel clouds were reported. Forecasters felt this assistance in distinguishing between real reports and false alarms was very valuable.

Convective high winds were fairly easy to detect, according to the forecasters. The velocity data pointed to areas of strong gusts and outflows, and with animation, these features were tracked and forecasts issued. The utility of this technique declined with increasing distance from the radar, since the beam height increased at range and forecasters could no longer infer surface wind speeds beyond 50-75 km.

Conclusions

The overall response of the Denver forecast staff to the Doppler data was very positive. Forecasters definitely felt like they could issue warnings and other short-range forecasts with greater confidence than in the past. They indicated that if the Doppler data were always available, they could get along without the WSR-57 data from Limon, and, in fact, relied on the Limon data very little when Doppler data were available. The training program was viewed as successful even though not perfect and suggestions for improvement have been taken under advisement for possible applications to the generic problem NWS faces in the NEXRAD era.