P3.10 EVALUATION OF A 2 HOUR REFLECTIVITY NOWCAST USING A CROSS CORRELATION TECHNIQUE COMPARED TO PERSISTENCE

Steven Vasiloff[1]

[1]National Severe Storms Laboratory, Norman, OK

1. INTRODUCTION

A very short term forecast, often referred to as a “nowcast,” has shown utility for winter weather predictions with the Weather Support to Deicing Decision Making (WSDDM) system (Rasmussen et al 2003). In this study, a 30 min nowcast determined by a cross correlation technique (CCT) was better than a persistence nowcast. A persistence (PER) nowcast assumes that the current condition will persist forever. This study extends such a verification experiment by using performing a CCT nowcast out to 2 hours and, again, comparing that to a persistence forecast. Particular emphasis is placed on relating various echo types to their predictability. Two nowcast scenarios are expected to produce more or less predictable results. A 0 – 2 h nowcast during the onset and offset of storms will very most likely be better than persistence. Less predictable is the performance of a nowcast after a storm is in progress.

2. METHODOLOGY

A CCT is used as implemented in the Weather Decision Support System – Integrated Information under development at the National Severe Storms Laboratory. This technique is very similar to the method used in the Tracing Radar Echoes with Correlation (TREC) used in the WSDDM system. Composite reflectivity fields from the NSSL National Mosaic and Quantitative Precipitation Estimation (NMQ) system are used to determine the nowcasts (Seo et al 2003; Zhang et al 2005). The data are produced on large tiles that can be combined to produce reflectivity data for the entire U.S (Fig. 1). These data sets are routinely used by several FAA Weather Research Program Product Development Teams. The Mosaic grids have a 1 km x 1 km resolution and were smoothed by a 3x3 pixel Gaussian weighting function. Data values less than 10 dBZ are set to zero

Winter storms from several days in early February 2005 are used in the study.

Radar echoes from a variety of storms structures are investigated. Echoes configurations studied include various sizes of cells, areas and bands from various parts of classic synoptic systems as well as echoes in weakly forced situations.

The area of focus is the upper Midwest, particularly Tiles 3 and 9 from the NMQ grid (Fig. 1). Figure 2 shows locations for verification including SE North Dakota (JST), western Wisconsin (FND), Iowa-Nebraska border (X), Chicago (ORD), Green Bay (GBB), northern Iowa (HMP), Grand Rapids (GRR), and Detroit (DTW). Nowcasts using both the CCT and PER are determined for 30, 60, 90 and 120

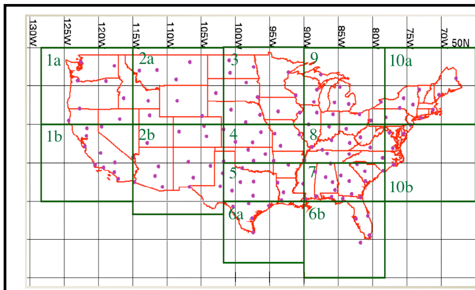

Figure 1. Layout of tiles for the CONUS 3-D radar Mosaic.

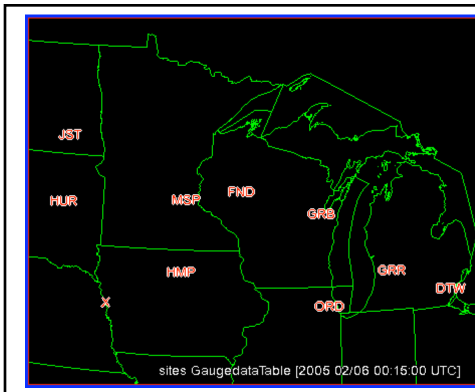

Figure 2. Location of points used in the nowcasts.

min intervals. Each prediction is validated against the composite reflectivity fields valid at the nowcast time. Correlation coefficients (CC’s) and standard deviations (STD’s) of

Corresponding author: Steve Vasiloff, 1313 Halley Circle, Norman, OK, 73069. email: steven.vasiloff @noaa.gov.

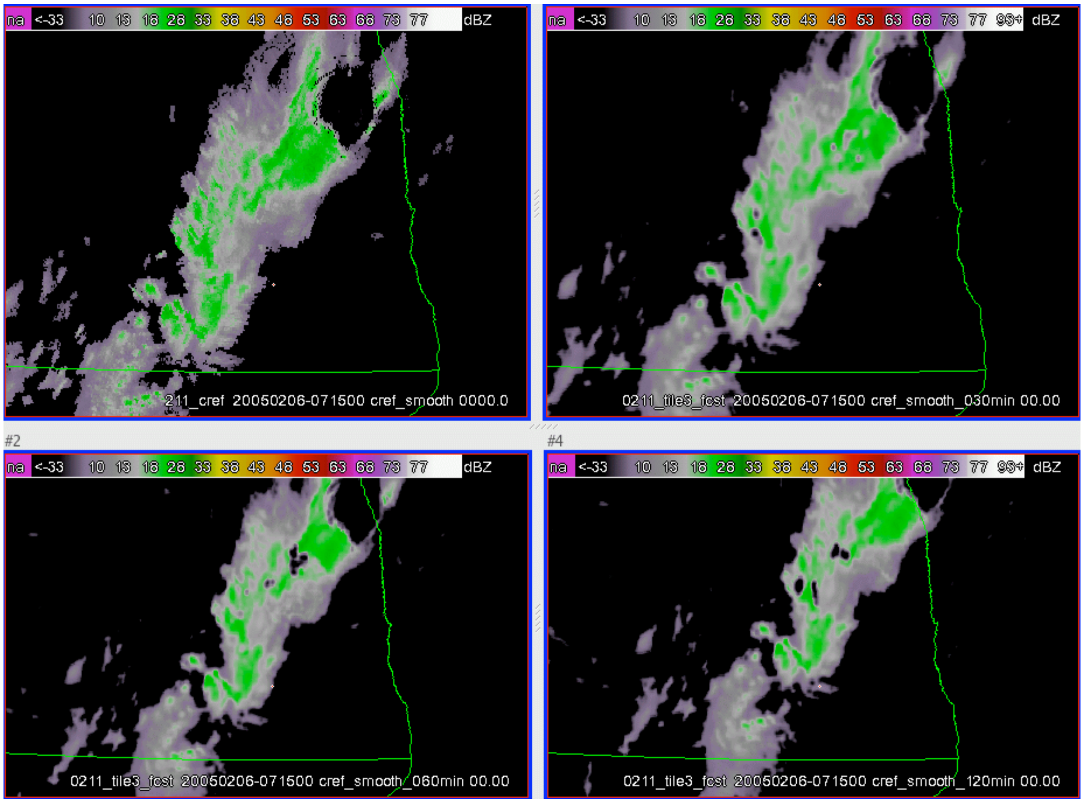

Figure 3. 4 panel of composite reflectivity for JST on 2/06/05. Upper left is initial composite at 0715 UTC. 30, 60, and 120 min CCT nowcasts are shown in the upper right, lower left, and lower right, respectively.

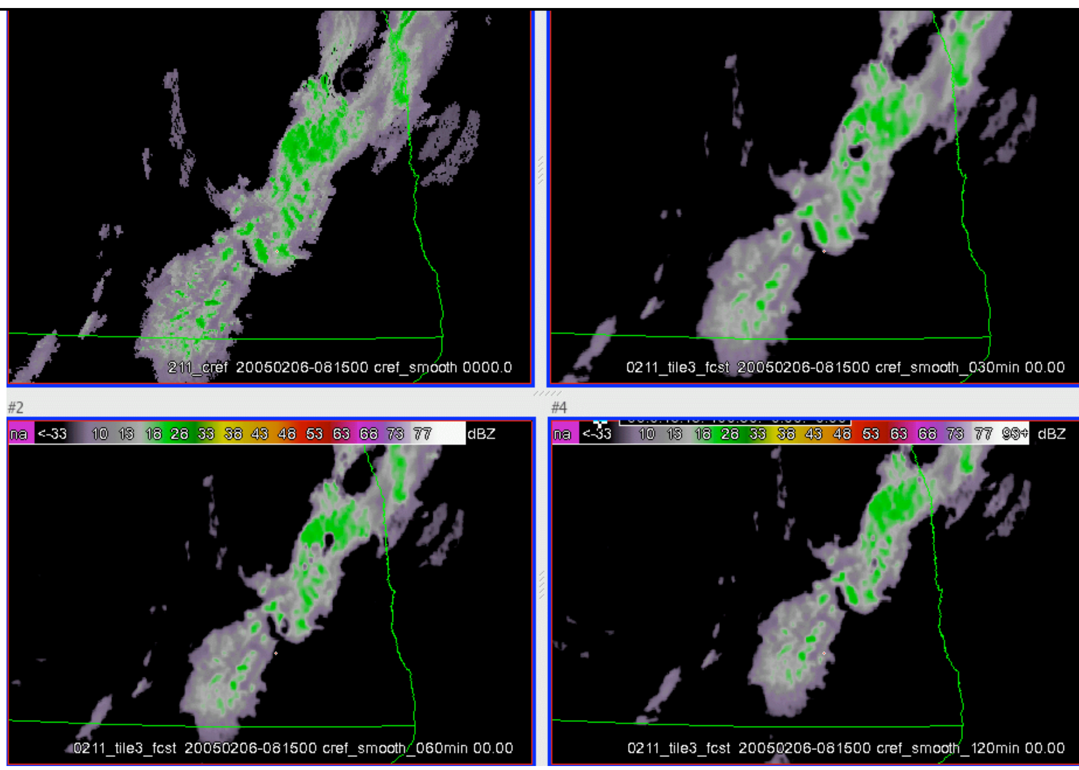

Figure 4. As in Fig. 3 except for 0815 UTC.

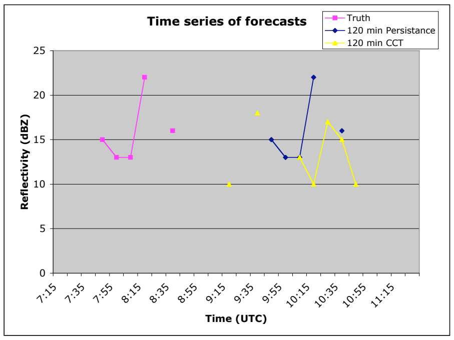

Figure 5. Time series of 120 min CCT and PER nowcasts for JST on 2/06/05.

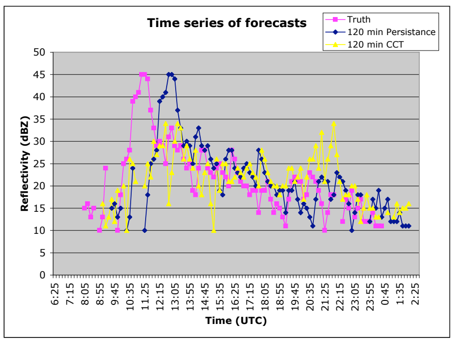

Figure 6. As in Fig. 5 except for HMP.

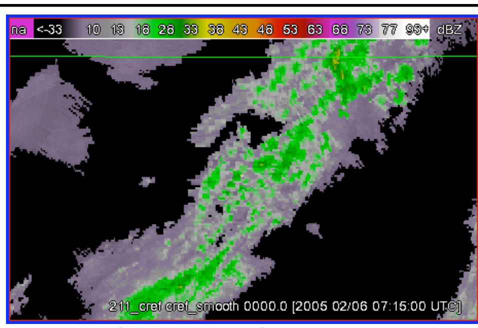

Figure 7. Composite reflectivity at 0715 UTC showing band of echoes forming over HMP (small white dot in center).

nowcasts versus verification are used to determine skill. In addition, time series are used to illustrate timing offsets of nowcasts as well as the chaotic nature of the echoes.

3. CASE STUDIES

An example of a weak band of echoes with differential motion is shown in Figs. 3 and 4. At 0715 UTC on 2/6/05 a band of weak echo is positioned to the west of the site JST and the echoes are nowcast to move to the NE. The CCT and PER nowcasts are shown in Fig. 5. At 0715 there are no echoes to the SW of JST so the nowcasts are all zero. However, as seen in Fig. 13, the band moves to the SE with new echoes forming to the SW of JST. The new echoes are forecast to move over JST and result in nowcast errors from previous time periods.

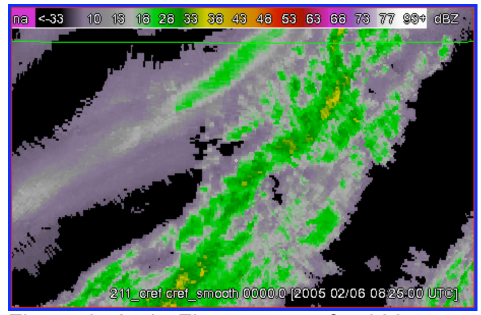

Figure 8. As in Fig. 7 except for 0835 UTC.

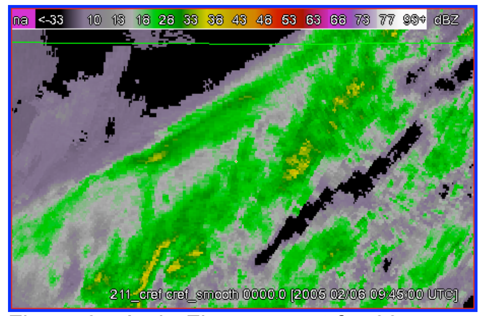

Figure 9. As in Fig. 7 except for 0945 UTC.

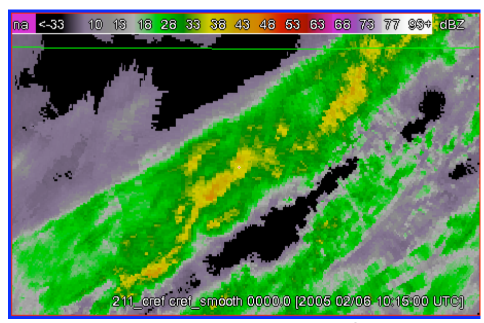

Figure 10. As in Fig. 7 except for 1015 UTC.

Farther to the southeast, a more intense band is forming over northern Iowa (HMP) around 0715 UTC. Initial echoes are small, localized and cellular in structure. CCT nowcasts move the echoes toward the northeast resulting in highly variable time series (Fig. 6). Over the next several hours several bands form over the area and consolidate into a narrow intense band by 1015 UTC (Figs. 7-10). The band dissipated in place, not actually moving off, resulting in false 120 min nowcasts neat 1200 UTC.

Several different echo structures were evident in western Wisconsin (FND) at 1815

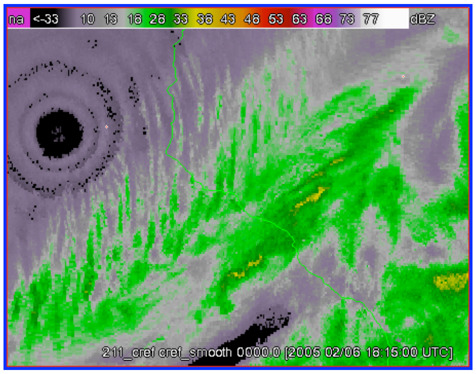

Figure 11. As in Fig. 7 except over eastern Minnesota and western Wisconsin near FND (small white dot in upper right corner) at 1815 UTC. Small white dot in eastern Minnesota is MSP.

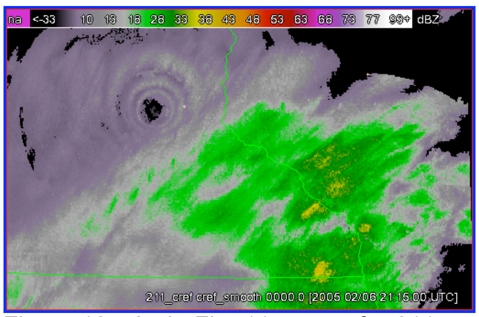

Figure 12. As in Fig. 11 except for 2115 UTC.

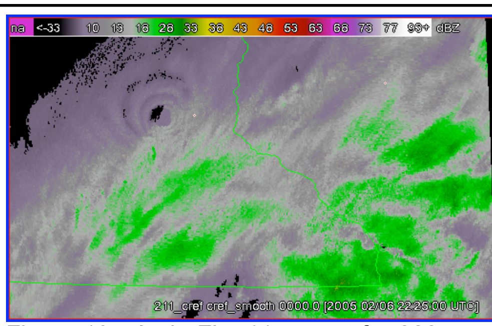

Figure 13. As in Fig. 11 except for 2225 UTC.

UTC on 02/06/05 (Fig. 11). Point nowcasts were not made for the small north-south bands but would have been obviously problematic since they developed and dissipated very rapidly. The small bands soon dissipated and a large echo mass was left southwest of FND at 2115 UTC. The mass was nowcast to move northeast but instead dissipated resulting in over-forecasts. Figures 12 and 13 show that the nowcast echo was dissipating resulting in over-nowcasts in the time series (Fig. 14).

Many various types of echoes moved over the Chicago area on 2/15/05. The time series of 120 min nowcasts is shown in Fig. 15.

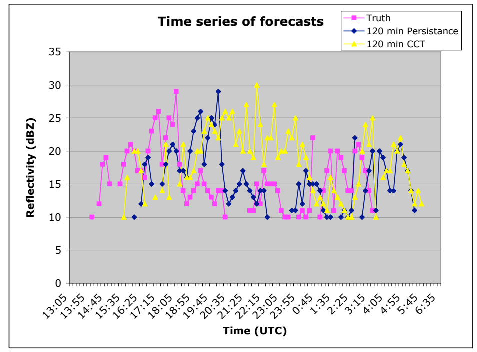

Figure 14. As in Fig. 5 except for FND.

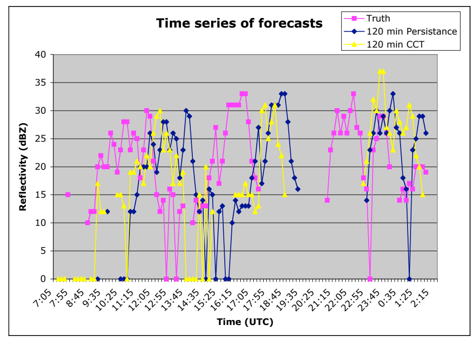

Figure 15. As in Fig. 5 except for ORD.

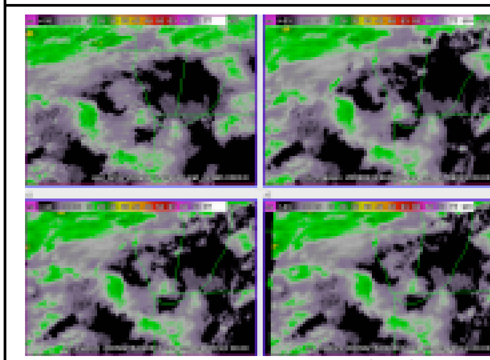

Figure 16. As in Fig. 3 except for ORD at 0905 UTC on 2/15/05.

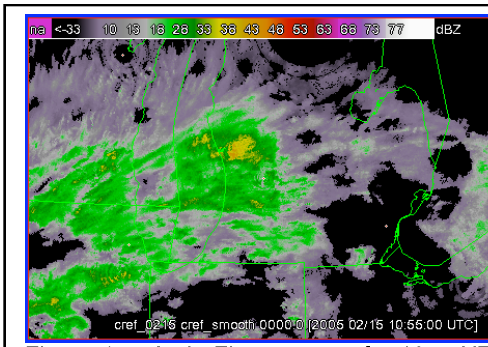

Figure 17. As in Fig. 7 except for 1055 UTC on 2/15/05. White dots represent ORD, GRR, and DTW.

The CCT did somewhat better than PER at the onset of the event. However, echoes were developing making the nowcasts error-prone with very poor correlation between 120 min nowcasts and verification. Figs. 16 and 17 show the small-scale structure and variable nature of the radar echoes. Fig. 17 shows the echoes used in the verification at GRR and DTW.

4. OVERALL RESULTS

Figures 18 - 25 show scatter plots of nowcasts versus verification. Each plot has

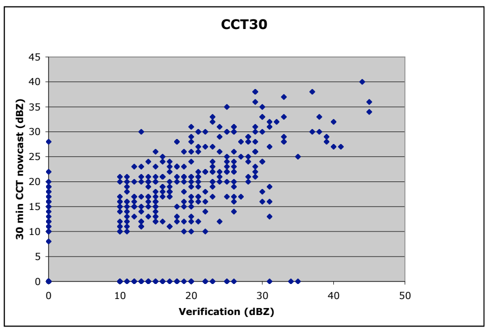

Fig. 18. Scatter plot showing 30 min CCT nowcasts vs. verification. CC = .64; STD = 10.85.

410 data points and, as mentioned earlier, represent a variety of storms and radar echoes. Standard deviations (STDs) and correlation coefficients (CC's) for each plot are shown in

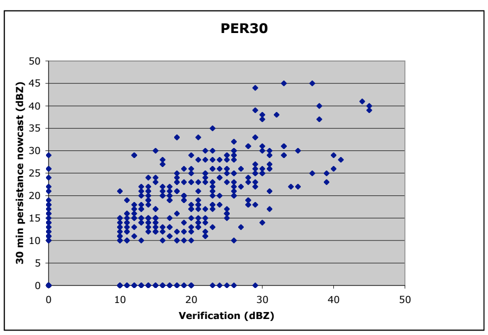

Fig. 19. As in Fig. 18 except for PER. CC = .65; STD = 10.92.

the figure captions. Several overall features of these plots warrant discussion. First, note the many zeroes for nowcasts and verification. The zeroes contribute significantly to the high STD's for each data set. The zeroes are mostly the result of instances of echo development and dissipation; situations that echo tracking methods are not equipped to deal with. Specifically, echoes often develop at a site after a nowcast of nothing. The opposite happened as well where echoes dissipated after a nowcast of echo. A secondary source of the zeroes is erroneous echo motion vector calculations. There are many factors involved in determining these vectors. As seen in the previous section, overall it was observed that echo evolution "fooled" the CCT.

Visually, the 30 min nowcasts show

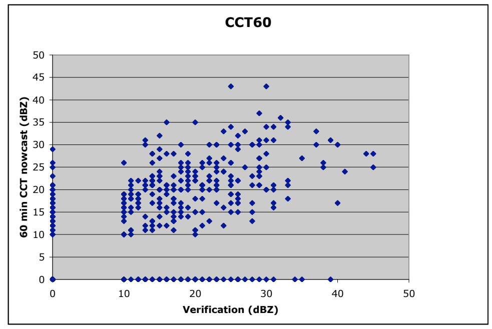

Fig. 20. As in Fig.18 except for 60 min CCT nowcasts. CC = .42; STD = 10.71.

the least scatter while each increasing nowcast times exhibit more and more scatter. The 30 min nowcasts show measurable skill with nearly identical CC's. However, statistically, there is no measurable difference in CC's between the

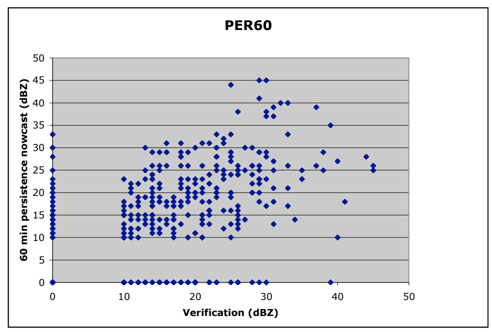

Fig. 21. As in Fig 18 except for 60 min PER nowcasts. CC = .46; STD = 10.9.

CCT and PER methods for each nowcast time period. The 90 and 120 min nowcasts had no skill having CC's less than .3. The 60 min nowcasts have moderate CC's (between .3 and .6). Interestingly, the differences between the CCT and PER STD's increase with increasing time of the nowcast.

4. DISCUSSION & CONCLUSION

A variety of radar echoes from winter storms were examined to test the performance of a cross correlation technique compared to a persistence nowcast. Nowcassts at 30, 60, 90 and 120 min were evaluated for nearly 70 h of data across the northern Midwest US. Data are from many weak to moderate snow cells and bands from early February 2005. The radar echoes were rarely, if at all, steady state resulting in a significant scatter in the results

Statistically there was no difference between the CCT and PER nowcast methods.

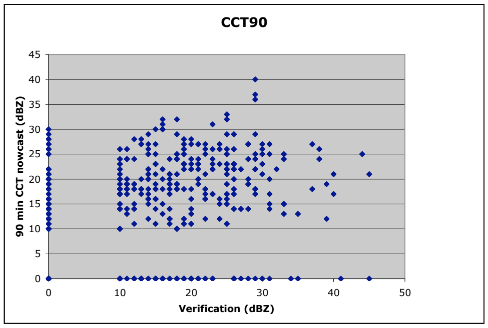

Fig. 22. As in Fig. 18 except for 90 min CCT nowcasts. CC = .24; STD = 10.3.

However, the 30 and 60 min nowcasts showed skill when compared to validation. These results are dominated by time periods during precipitation events as well as the highly variable nature of the storm echoes. The CCT method does show improved skill over all PER forecasts for both the onset and offset of echoes, for all nowcast times.

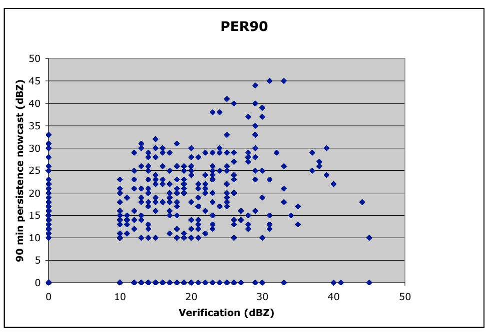

Fig. 23. As in Fig. 18 except for 90 min PER nowcasts. CC = .27; STD = 10.9.

The highly chaotic nature of the winter radar echoes examined in this study cannot be overstated. Detailed examination of various techniques is recommended and should include various smoothing schemes and possible growth and decay algorithms.

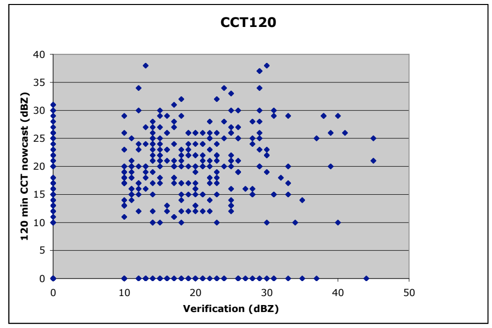

Fig. 24. As in Fig. 18 except for 90 min CCT nowcasts. CC = .17; STD = 10.5.

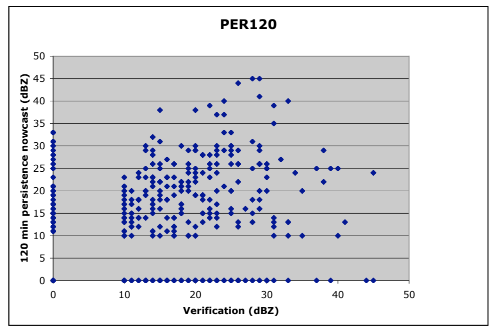

Fig. 25. As in Fig. 18 except for 120 min PER nowcasts. CC = .15; STD = 11.

5. REFERENCES

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