5A.2

THE UTILITY OF MESOSCALE OBSERVATIONS FOR THE SHORT-TERM PREDICTION OF CONVECTION

Dale A. Morris[1]
Oklahoma Climatological Survey
Norman, Oklahoma 73019

1. INTRODUCTION

In March 1994, the University of Oklahoma and Oklahoma State University commissioned the Oklahoma Mesonetwork (hereafter termed Mesonet; Brock *et al.* 1995). This permanent statewide network consists of 114 automated stations[2] (instrumented with 10 m towers) that observe over 20 parameters every 5 minutes and transmit its observations every 15 minutes to the Oklahoma Climatological Survey.

In this same time frame, the commissioning began for individual units in the network of WSR-88D (NEXRAD) Doppler radars. At least three of the early production units were located in Oklahoma. With the 5- or 6-minute update cycle of the volume coverage patterns for WSR-88Ds in precipitation mode, comparisons between radar signatures and detailed surface features as observed by the Mesonet are possible. While many studies were performed by the National Severe Storms Laboratory (e.g., Barnes 1974) in the late 1960's and 1970's, these studies were limited by the spatial extent of their mechanical mesonet and their single Doppler radar, which was not operated on a year-round basis. With statewide surveillance provided by four WSR-88D radars located within Oklahoma and with Mesonet stations located in every county, more comprehensive studies are now feasible.

Because the Mesonet was the "new kid on the block", it was deemed necessary to quantify the improvement of the resolution of surface features relative to the existing Federal network of surface stations. Five convective events (including supercells, squall lines, and mesoscale convective systems) were studied by the author; this manuscript presents details of two events. Composites of Mesonet and Federal observations were constructed relative to storm centroids analyzed from WSR-88D observations of these events. This manuscript presents a summary of comparisons between the storm-relative composites of the Mesonet and Federal observations.

2. METHODOLOGY

For each storm event considered in this study, objective analyses of both Mesonet and Federal observations were performed. To facilitate comparisons of these analyses, a series of storm centroids was produced from radar data as an indication of the true track taken by each system.

[1] *Corresponding Author's Address:* Dale A. Morris, Oklahoma Climatological Survey, Suite 1210, Norman, OK 73019. Telephone: 405-325-2541; e-mail: dmorris@ou.edu.

[2] The Mesonet consisted of 111 stations in 1994 when the data for this study was collected. Since that time, the network has been upgraded to 114 stations, and current plans call to augment all "core-parameter sites" with the full complement of "supplemental" sensors, including soil moisture sensors at each Mesonet site.

2.1 Objective Analysis

Observations from each network were analyzed using two separate but overlapping grids that were designed to be suitable for each network. Both grids had the same 12-km grid spacing, but the horizontal extent of each domain was limited to reduce "edge effects" of the Barnes (1994a-c) analysis scheme. The shape factors used to analyze each network's observations were chosen so that the response from each network after four passes of the Barnes scheme was identical at the Nyquist wavelength (twice the average station spacing) for the network (Fig. 1)

Because the Mesonet is completely automated, several quality assurance procedures were performed on Mesonet observations. These range and "bad parm" tests were similar to the routines used operationally by the Mesonet (Shafer and Hughes 1996). In addition, manual quality assurance was performed. Since the Federal observations in this study were primarily human produced, no additional quality control measures were applied to the Federal observations.

The results presented in this paper concentrate on the objective analysis of equivalent potential temperature (THTE), moisture flux divergence (MFLD), and surface winds. It should be noted that the Mesonet measures relative humidity using a sorption-type sensor. Thus, the mixing ratio and equivalent potential temperature were calculated for each station (from the Mesonet's temperature and relative humidity and from the Federal network's temperature and dew point measurements) and subsequently analyzed to the grid points.

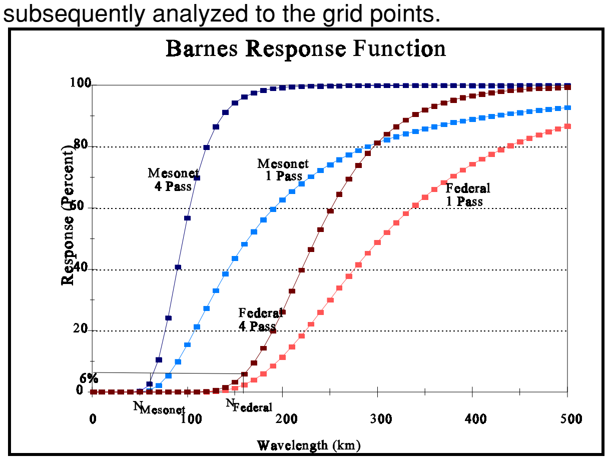

Figure 1. Predicted response from the Barnes objective analysis scheme using four passes for both the Mesonet and Federal network. The response after one pass is shown for reference. The response for the Nyquist wavelength for each network was defined to be 6%.

2.2 Analysis of Storm Centroids

For the cases presented in this manuscript, WSR-88D data in its "Level II" format were obtained from the

Oklahoma City (KTLX) and Tulsa (KINX) radars. Vertically Integrated Liquid (VIL) calculations were produced using the WSR-88D's VIL algorithm. The VIL data were resampled to each analysis grid by assigning the maximum VIL value (4 km by 4 km resolution) to the corresponding Federal or Mesonet grid cell (12 km by 12 km resolution). Some events were not massive hail producing storms; hence, they did not have significant VIL signatures. In those cases, the reflectivity from the 0.5` elevation scan was resampled to the analysis grids in a similar manner. A series of storm centroids was produced subjectively by tracking the maximum VIL and/or reflectivity values and noting the corresponding coordinate locations.

2.3 Creation of Storm-relative Composites

Composites of equivalent potential temperature and moisture flux divergence were produced for each event by time-averaging the analyzed fields. This procedure began using smaller sub-grids of the analyzed field, consisting of 21 grid points on a side, which were centered on the appropriate storm centroid and followed the moving storm through its evolution. Finally, the data in the sub-grids were averaged together (over time) to create a picture of the typical environmental conditions that were relative to the storm.

3. THE SUPERCELLS OF 2 APRIL 1994

Two thunderstorms that quickly gained supercellular characteristics were initiated along a dryline and the intersection of the dryline and a cold front at about 2130 UTC on the afternoon of 2 April 1994. The 500 mb flow at Oklahoma City was westerly at 30 knots at 1200 UTC on 2 April. Thus, the expected motion for these storms was toward the east. The storms in fact moved in a east-southeast direction (Fig. 2).

The composite of THTE as computed from Mesonet observations revealed considerably more details than the corresponding Federal composite (Fig. 3). The mesoscale composite revealed relatively cool, dry air located north and west of the storm. A well-defined tongue of warm, moist air was in place east of the storm. As a result, the storm was located on the leading edge of the THTE gradient. The THTE gradient northwest of the storm in the Mesonet composite seemed to be associated with the cold front. The maximum of THTE that was located south and east of the storm was likely a prime factor in the south and east motion of the storm, as the storm propagated to areas of greater moisture. Another local maximum shown in the Mesonet composite was located northeast of the main storm. This THTE maximum seemed to be related to the tendency for a series of left-moving storms that propagated northeast. The VIL contour located northeast of the storm represented the average location of these left-moving storms with respect to the main storm.

The Federal THTE gradient was much weaker than its Mesonet counterpart; it also was centered over the storm. In addition, the Federal THTE field was about 2-6` K than the Mesonet composite, since the Mesonet dew point field had moisture readings that were greater than the Federal dew point observations.

Two distinct areas of moisture flux convergence were observed in the composite of MFLD derived from Mesonet observations (Fig. 4). The storm was situated in an area

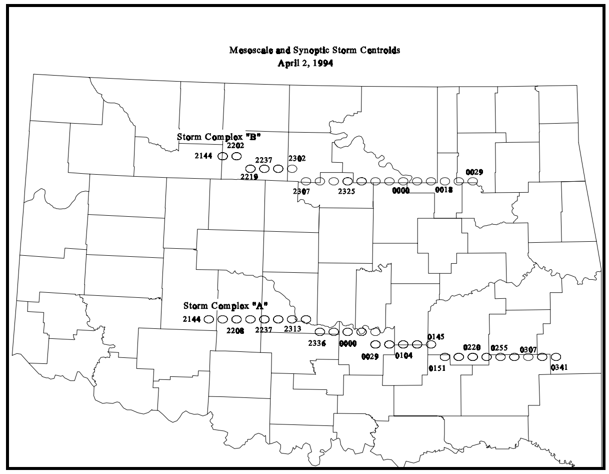

Figure 2. Grid point locations of storm centroids for the storms for 2-3 April 1994. All times are in UTC. This study focuses on Storm "A".

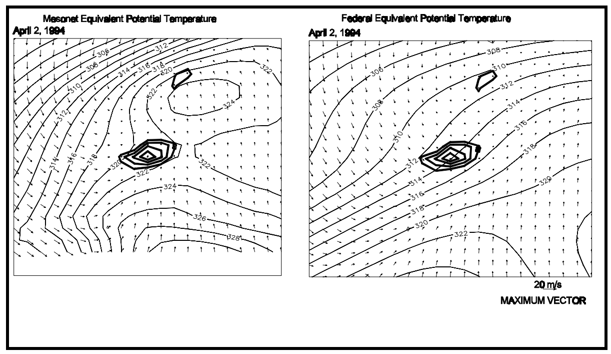

Figure 3. Composites of equivalent potential temperature for the Mesonet (left) and the Federal network (right). Contours of composite VIL (dark contours) and vectors of the composite wind field are shown for reference.

with a maximum gradient between the southern convergence center and a divergence maximum to the northeast. The northern convergence center stretched southwest-to-northeast, along the cold front, while the southern convergence maximum was associated with the dryline.

On the other hand, the composite of MFLD from Federal observations indicated that moisture flux convergence was occurring over the entire analysis domain, except for the extreme southeast portion. In

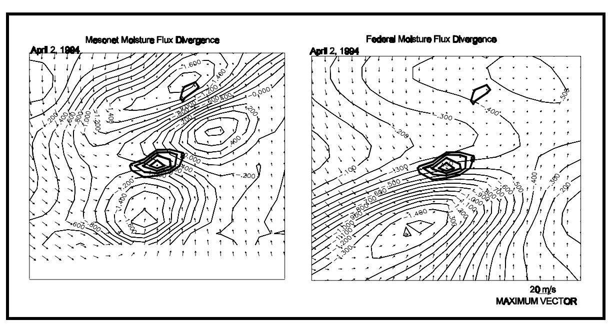

Figure 4. As in Fig. 3, except for moisture flux divergence.

addition, the Federal maximum was displaced about 36 km north of the southern convergence maximum center derived from Mesonet observations.

4. THE MCS OF 7 AUGUST 1994

A series of thunderstorms moved south over eastern Oklahoma during the pre-dawn and early morning hours of 7 August 1994. This study examines the second and strongest of four identified storms. This storm was responsible for wind damage in the town of Prague in Lincoln County This storm moved southeast during its lifetime (Fig. 5).

The THTE composite from Mesonet observations indicated very strong stability behind the storm (Fig. 6). This stability was associated the storm's cold pool. The Mesonet also detected a narrow plume of moisture southeast of the storm (not shown). Consequently, the Mesonet THTE composite had a more narrowly focused instability axis than did the Federal network. The orientation of the instability gradients in the Mesonet composites (*i.e.,* the stable area associated with the cold pool northwest of the storm and the moisture tongue southeast of the storm) clearly revealed the preferred direction of propagation by the storm. The broadly defined instability axis in the Federal network represented a general south to southeast motion. Yet, this feature was not as clearly defined as in the Mesonet composite.

An area of strong moisture flux divergence was centered about 30 km north of the storm in the Mesonet composite (Fig. 7). Convergence was well defined southwest and in an "apparent wake low" off to the northwest. A totally different pattern was portrayed by the Federal network. Centers of moisture flux convergence and divergence was located north and southeast of the storm. The centers of divergence and convergence were spaced much farther apart in the Federal composite, which placed the divergence gradient along the north side of the storm. In the Mesonet composite, the divergence gradient was centered on the storm. Finally, the area of maximum divergence in the Federal composite was located 100 km north of the storm, in an area where the Mesonet detected convergence.

5. CONCLUSIONS

It is not surprising that composites of storm environments produced from Mesonet observations reveal features with more detail than corresponding composites produced from Federal data. Moisture and instability axes revealed by Mesonet data were related to the propagation of the storms. Centers of moisture flux divergence were more clearly located by Mesonet data,

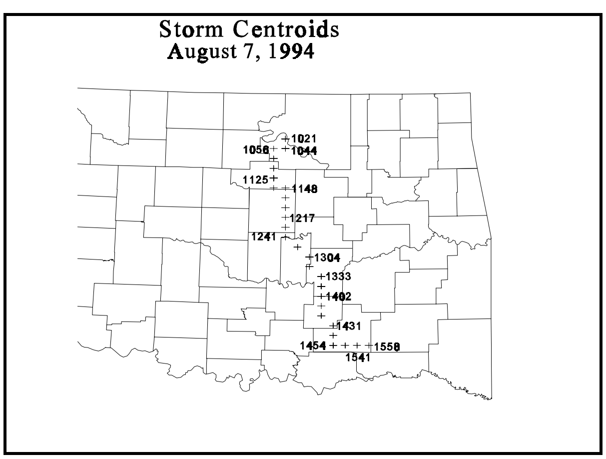

Figure 5. As in Fig. 2, except for 7 August 1994.

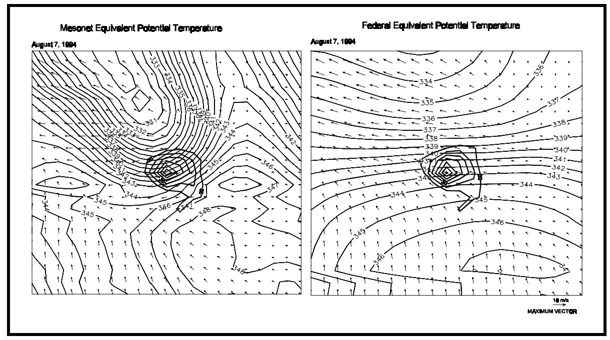

Figure 6. As in Fig. 3, except for 7 August 1994.

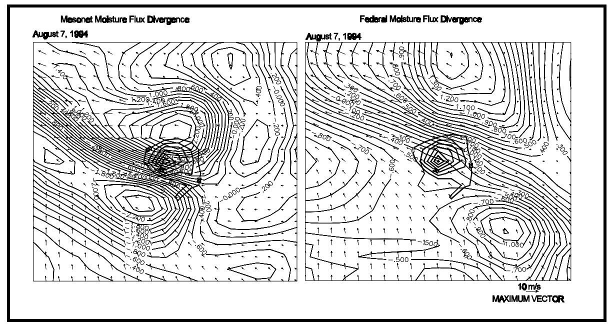

Figure 7. As in Fig. 4, except for 7 August 1994.

while the Federal network sometimes misplaced these centers.

The implications of these results suggest that numerical mesoscale models should be able to replicate these details as the horizontal resolution of the models increases.

6. REFERENCES

Barnes, S.L, Ed. 1974: Papers on Oklahoma thunderstorms, April 29-30, 1970. NOAA Tech. Memo. ERL NSSL-69, National Severe Storms Laboratory, Norman, Oklahoma, 233 pp.

_____, 1994a: Applications of the Barnes objective analysis scheme. Part I: Effects of under-sampling, wave position, and station randomness. *J. Atmos. Oceanic Tech.,* **11,**1433-1448.

_____, 1994b: Applications of the Barnes objective analysis scheme. Part II: Improving derivative estimates. *J. Atmos. Oceanic Tech.,* **11,** 1449-1458.

_____, 1994c: Applications of the Barnes objective analysis scheme. Part III: Tuning forminimum error. *J. Atmos. Oceanic Tech.,* **11,** 1459-1479.

Brock, F.V., K.C. Crawford, R.L. Elliott, G.W. Cuperus, S.J. Stadler, H.L. Johnson, and M.D. Eilts, 1995: The Oklahoma Mesonet: A technical overview. *J. Atmos. Oceanic Tech.,* **12,** 5-19.

Shafer, M.A., T. W. Hughes, and J.D. Carlson, 1993: The Oklahoma Mesonet: Site selection and layout. *Preprints, 8th Symposium on Meteorological Observations and Instrumentation*, Anaheim, California. Amer. Meteor. Soc., 231-236.