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# AN EXAMINATION OF THREE DERECHO EVENTS DURING THE FIRST WEEK OF JULY 2003 CONCURRENT WITH BAMEX

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## 1. INTRODUCTION

Mesoscale convective systems (MCSs) have long been established as being important rain producers across the central United States (e.g., Fritsch et al. 1986). In addition to merely producing stratiform rainfall, MCSs often have an attendant area of convective precipitation. A majority of MCSs that contain a convective line are organized with the convection ahead of a stratiform precipitation region (e.g., Parker and Johnson 2000). At times, this convection can produce long-lived windstorms known as derechos (Johns and Hirt 1987). The convection associated with these derechos often takes on the form of a bow echo on radar displays as first described by Fujita (1978). When this convection develops in the warm season, bow echoes often produce "progressive" swaths of damage (Johns and Hirt 1987). Long-lived bow echoes that occur during the warm season often traverse regions where the maximum convective available potential energy (CAPE) values are near 4500 J kg$^{-1}$ (Johns 1993). Evans and Doswell (2003) showed, using proximity soundings, that derechos are able to form with shear and instability conditions that are wide ranging. If the derechos are subdivided by the strength of their synoptic scale forcing, this range narrows.

While extensive observational and numerical research has been conducted on MCSs, bow echoes and derechos, until the Bow Echo and Mesoscale Convective Vortex Experiment (BAMEX) an in depth study detailing the life cycles of these phenomenon from a multiscale perspective had yet to take place (the field phase of BAMEX took place between 20 May and 6 July 2003; Davis et al. 2004).

The purpose of this presentation is to examine a derecho subset from MCSs that formed during the 30 June–7 July 2003 period. This paper will concentrate on the 3–4 July 2003 derecho that traversed the upper Midwest. Particular attention will be paid to the dynamic and thermodynamic environments prior to derecho formation and throughout the lifecycle of the derecho. A brief discussion highlighting the interactions between two derechos and two other MCSs in the 4–5 July 2003 period will follow the 3-4 July 2003 derecho presentation.

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## 2. DATA AND METHODS

Analyses produced in this manuscript were created using the 32 km North American Regional Reanalysis (NARR; Mesinger et al. 2005). The dynamic tropopause (DT) analyses are defined at the 1.5 potential vorticity unit (PVU) surface (where 1 PVU is 1.0 x 10$^{-6}$ K m$^{2}$ kg$^{-1}$ s$^{-1}$; e.g., Bosart and Lackmann 1995). Severe reports were obtained using Severe Plot Version 2.0 software (Hart 1993). The soundings were obtained from the University of Wyoming webpage (http://weather.uwyo.edu/upperair/sounding.html). The Iowa Mesonet analyses were obtained through the Joint Office for Science Support/UCAR (JOSS) BAMEX field catalogue (http://www.joss.ucar.edu/bamex/catalog/).

Twelve MCSs were identified during the 30 June–7 July period. These MCSs grew to at least meso-α (200–2000 km) in size, contained a temporarily consistent leading 45 dBZ line on consecutive 2-h radars and entered the BAMEX domain (Davis et al 2004) at some point during their lifecycle. Out of these twelve MCSs, three[1] were derechos as defined by Johns and Hirt (1987).

## 3. RESULTS

### *a) 3-4 July 2003 derecho (derecho B)*

The initial precursor convection to derecho B (the second derecho in the 30 June–7 July 2003 period) formed as discrete cells in two separate locations at 22 UTC 3 July (Fig. 1). An inspection of potential temperature (θ) on the DT shows the

[1] Figures for the other two derecho cases are available at: http://www.atmos.albany.edu/student/nmetz/ATL06.html

formation of the northern area of convection was dynamically driven. At 00 UTC 4 July, the northern cells began to merge into a convective line slightly downstream of a weak disturbance on the DT (Fig. 2). The southern area of convection initiated beneath a ridge in southwest Nebraska. Inspection of 850 hPa equivalent potential temperature ($\theta_e$) shows the thermodynamic environment in this region was favorable for development as the convection was in a region of high $\theta_e$ (near 360K). By 06 UTC 4 July, the two lines of convection had become a derecho and had nearly merged (Fig. 1). At this time, the derecho began to move away from the disturbance on the DT (Fig. 3). However, now the derecho was positioned on the anticyclonic shear side of the 200 hPa jet in the broad right entrance region. Additionally, the derecho formation occurred near the nose of a 25 m $s^{-1}$ jet at 850 hPa. As the derecho moved eastward, it remained within the 850 hPa $\theta_e$ maximum. Figure 3 shows that the 700 hPa ascent associated with the convection was collocated with the highest values of 850 hPa $\theta_e$. At 06 UTC 4 July, the southern portion of the derecho tapped into surface-based CAPE values near 5000 J $kg^{-1}$ (the NARR CAPE values appear to overestimate environmental CAPE by ~ 500 J $kg^{-1}$), while the northern portion traversed environmental 1000–500 hPa shear values near 50 knots. By 12 UTC 4 July (Fig. 4), the derecho moved eastward of the low-level jet and was still located on the anticyclonic shear side of the 200 hPa jet. The thermodynamic environment associated with the derecho continued to be favorable for convection as the associated 850 hPa $\theta_e$ value was in excess of 350 K. Six hours later, the derecho began its weakening as it moved eastward of the highest CAPE, 1000–500 hPa shear and 850 hPa $\theta_e$ (Fig. 5).

*b) 4-5 July 2003 derecho/MCS interaction*

As derecho B proceeded eastward at 09 UTC 4 July (Fig. 6), it laid down a strong cold pool (Corfidi 2003), causing a quasi-stationary boundary to form over south-central Iowa (Fig. 7). By 15 UTC, derecho B had moved eastward over Lake Michigan. At the same time, a weak area of convection (MCS 1) intersected the cold pool and collapsed. This left behind an outflow boundary and gravity waves (Fig. 6). Stable layers can be seen in the DVN sounding prior (12 UTC) and subsequent to (18 UTC) gravity wave passage in this region (Fig. 8). When the gravity waves and outflow boundary intersected the quasi-stationary boundary in northwest Indiana at 21 UTC, new convection was triggered which resulted in the formation of MCS 2 (Fig. 6). Also at 21 UTC, derecho B was weakening as it outran the 850 hPa moisture axis and jet support (Fig. 5). Six hours later, derecho C formed in a dynamically favorable region and moved southwestward though Iowa. The Iowa Mesonet data showed that the cold pool from this system aided in reinforcing the quasi-stationary boundary over Iowa (Fig. 9). By 09 UTC 5 July, MCS 2 had reorganized as more convection fired along the stationary boundary in Indiana. Derecho C moved eastward and began to interact with a backbuilding MCS 2 (Fig. 6). At 15 UTC, the combined system of derecho C and MCS 2 began to weaken. This weakening occurred as the jet dynamics became more unfavorable once the combined system outran the favored equatorward 200 hPa jet-entrance ascent region. Additionally, the limited extent of moisture the system now encountered contributed to its weakening.

## 4. DISCUSSION

The environment during the 30 June–7 July 2003 period was conducive to severe convective development in the upper Midwest. Derecho B formed from merging MCSs. The northern (southern) MCS was embedded in a dynamic (thermodynamic) environment that was more favorable for deep convection. A triggering disturbance on the DT appears to have aided in the development of the northern convection in a region of relatively minimal CAPE and 850 hPa $\theta_e$. Advection of lower $\theta$ values on the DT, often a proxy for ascent, occurred in the vicinity of the northern MCS development at the time of convective initiation. Once the derecho formed, it moved eastward away from a triggering disturbance on the DT. When this occurred, the derecho was situated in the broad equatorward entrance region of the 200 hPa jet and near the nose of the 850 hPa jet. The derecho continued moving eastward from this favorable dynamic position. However, high CAPE and 850 hPa $\theta_e$ values continued to be coincident with the derecho until its demise.

Derecho B preconditioned the environment for subsequent convection as it laid down a strong cold pool. The southern extent of the cold pool led to the formation of a quasi-stationary boundary that acted as the focus for new convection long after derecho B dissipated.

Derecho B had many commonalities with the other two derechos that formed during this period (not shown). All three derechos formed in the vicinity of a disturbance, of varying intensities, on the DT. Following convective initiation, the derechos all moved into a dynamically linked, favorable ascent region of the 850 hPa and 200 hPa jets. At the same time, 850 hPa $\theta_e$ values associated with each derecho were high throughout their lifecycles. Robust CAPE and 1000-500 hPa shear values also coincided with each of the three derechos.

## 5. ACKNOWLEDGEMENT

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## 6. REFERENCES

Bosart, L.F., and G.L. Lackmann, 1995: Postlandfall tropical cyclone reintensification in a weakly baroclinic environment: A case study of Hurricane David (September 1979). *Mon. Wea. Rev.* **123**, 3268–3291.

Corfidi, S.F, 2003: Cold pools and MCS propagation: Forecasting the motion of downwind-developing MCSs. *Wea. Forecasting,* **18**, 997-1017.

Davis, C. and Coauthors, 2004: The bow echo and MCV experiment: Observations and opportunities. *Bull. Amer. Meteor. Soc.,* **85**, 1075–1093.

Evans, J.S., and C.A. Doswell III, 2001: Examination of derecho environments using proximity soundings. *Wea. Forecasting,* **16**, 329–342.

Fritsch, J.M., R.J. Kane, and C.R. Chelius, 1986: The contribution of mesoscale convective weather systems to warm-season precipitation in the United States. *J. Climate Appl. Meteor.,* **25**, 1333–1345.

Fujita, T.T., 1978: Manuel of downburst identification for project Nimrod. Satellite and Mesometeorology Research Paper 156, Dept. of Geophysical Sciences, University of Chicago, 104 pp. {NTIS PB-286048.]

Hart, J.A., 1993: SVRPLOT: A new method of assessing and manipulating the NSSFC Severe Weather data base. Preprints, *15th Conf. on Severe Local Storms,* Baltimore, MD, Amer. Meteor. Soc., 40–41.

Johns, R.H., 1993: Meteorological conditions associated with bow echo development in convective storms. *Wea. Forecasting,* **8**, 294–299.

———, and W.D. Hirt, 1987: Derechos Widespread convectively induced wind-storms. *Wea. Forecasting,* **8**, 32-49.

Mesinger, F. and Coauthors, 2005: North American Regional Reanalysis. Submitted to *Bull. Amer. Meteor. Soc.*

Parker, M.D., and R.H. Johnson, 2000: Organizational modes of midlatitude mesoscale convective systems. *Mon. Wea. Rev.,* **128**, 3413–3449.

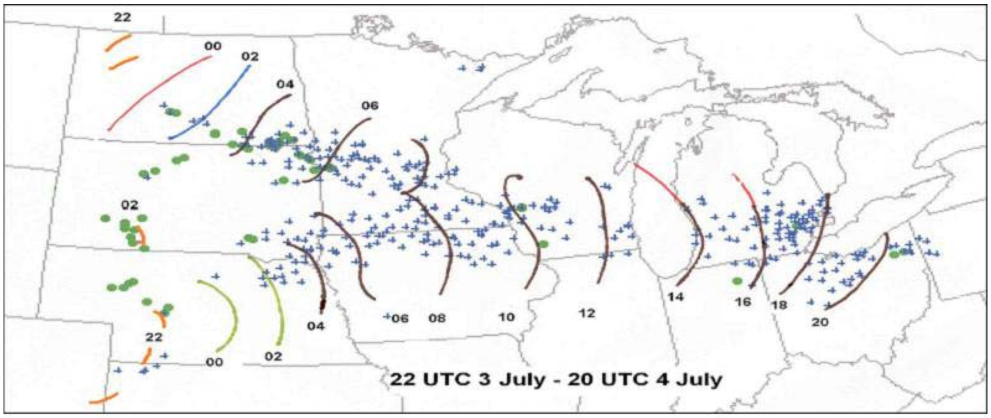


Figure 1: Isochrones of the leading 45 dBZ line from MCS convection associated with derecho B. Single cells are represented with orange, multicell lines with red, linear with blue, bowing lines with green and the derecho with brown. Severe reports are plotted using Severe Plot Version 2.0.

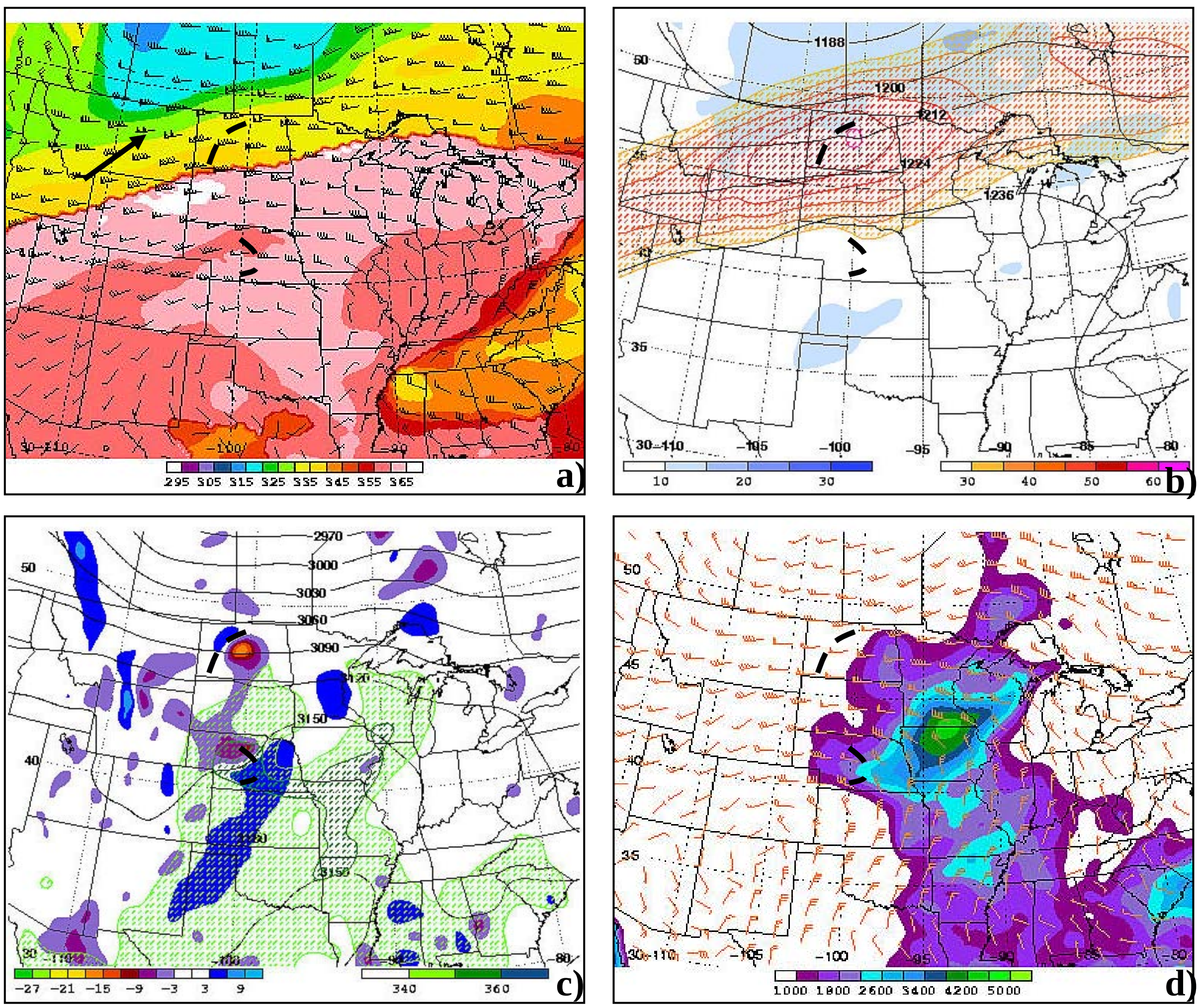


Figure 2: (a) Dynamic tropopause (1.5 PVU surface) θ (K) and wind barbs (knots), (b) 850 hPa isotachs (solid; m $s^{-1}$), 200 hPa isotachs (stippled; m $s^{-1}$) and 200 hPa heights (dam), (c) 850 hPa $\theta_e$ (stippled; K), 700 omega (solid; μb $s^{-1}$) and 700 hPa heights (dam) and (d) CAPE (J $kg^{-1}$) and 1000–500 hPa shear (knots) for 0000 UTC 4 July 2003. Black dashed lines show the leading 45 dBZ line of the convection. The black arrow points to the disturbance on the DT.

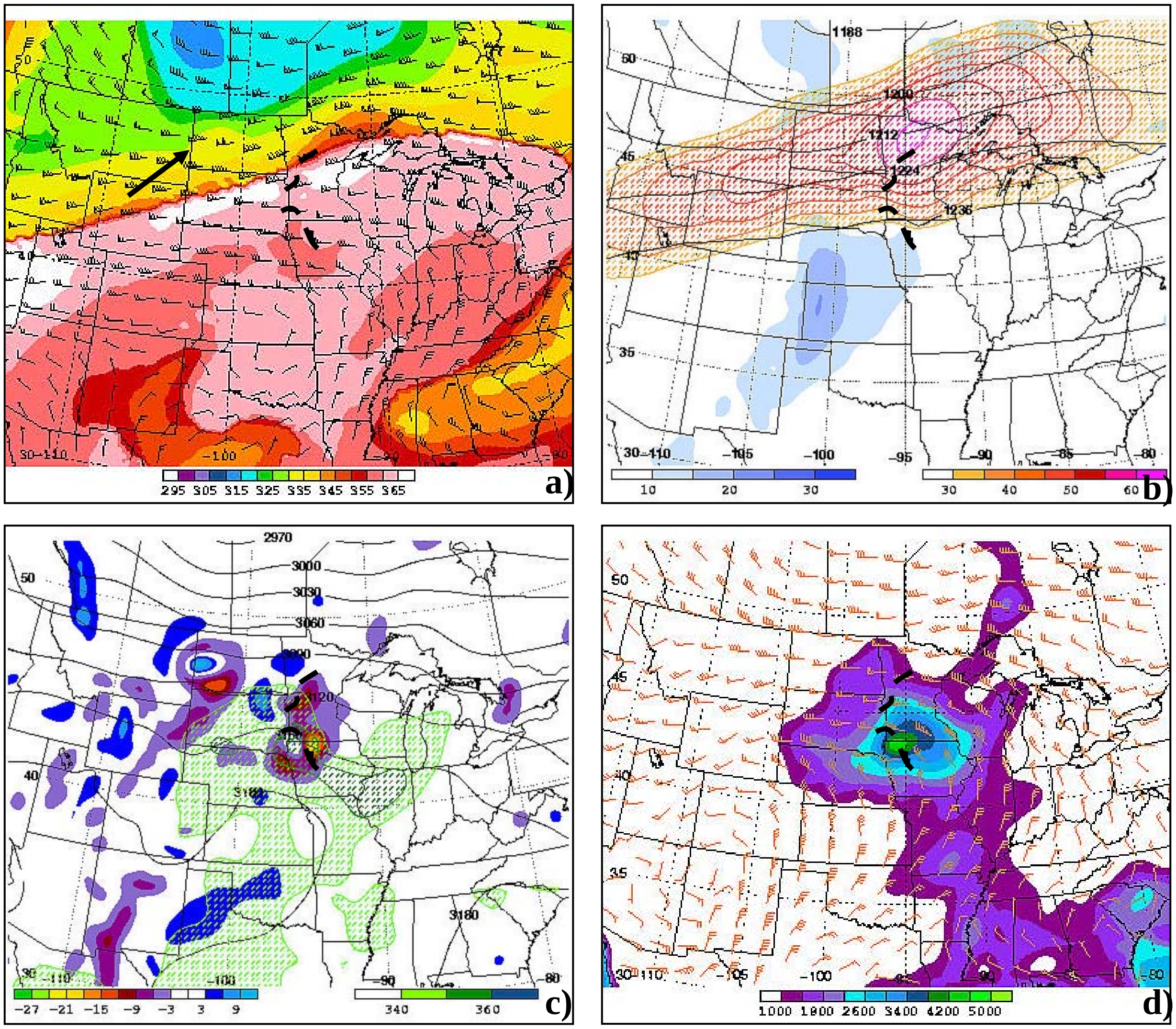

Figure 3: As in Fig. 2 except for 0600 UTC 4 July 2003.

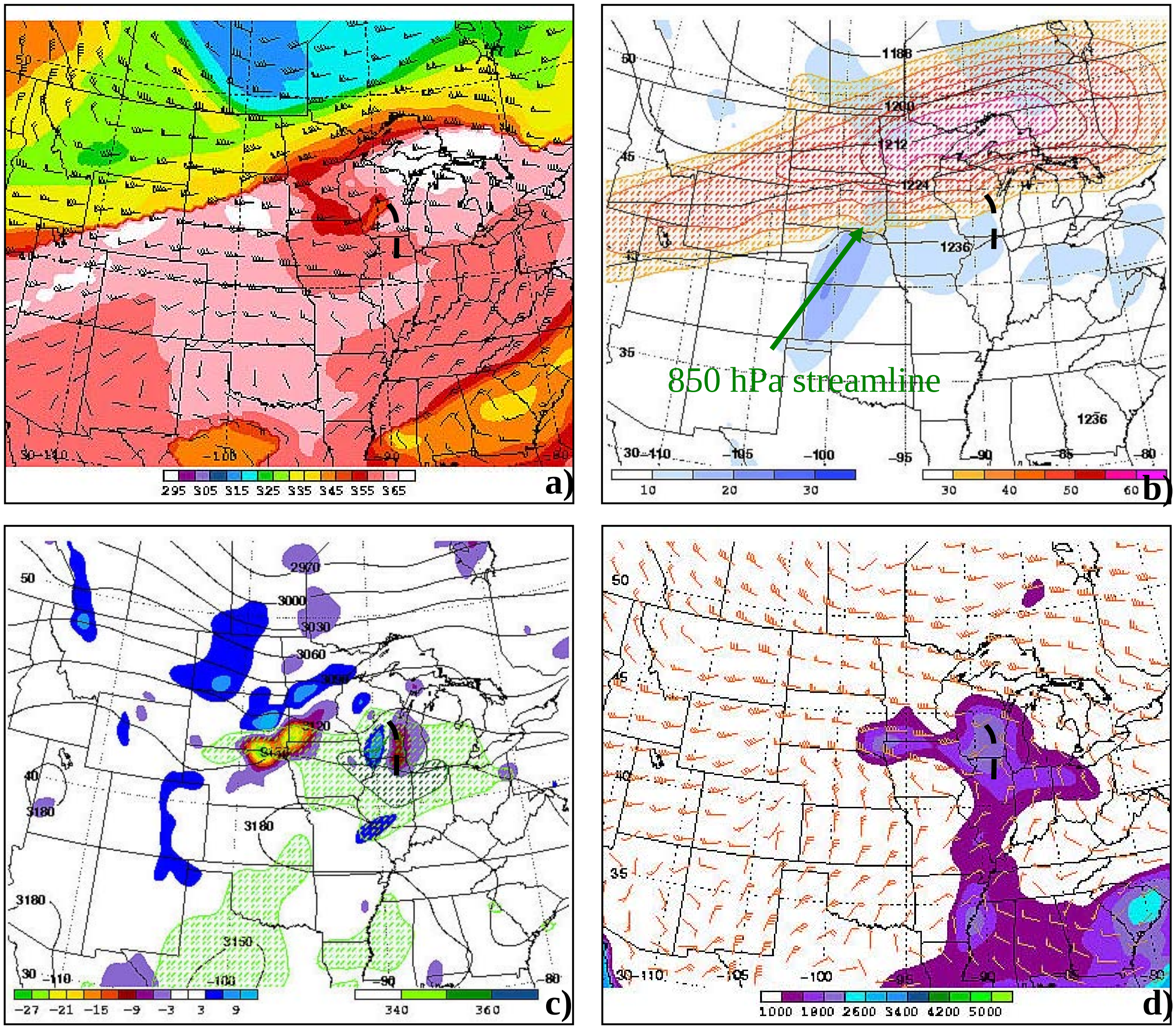


Figure 4: As in Fig. 2 except for 1200 UTC 4 July 2003. A representative 850 hPa streamline is shown in (b).

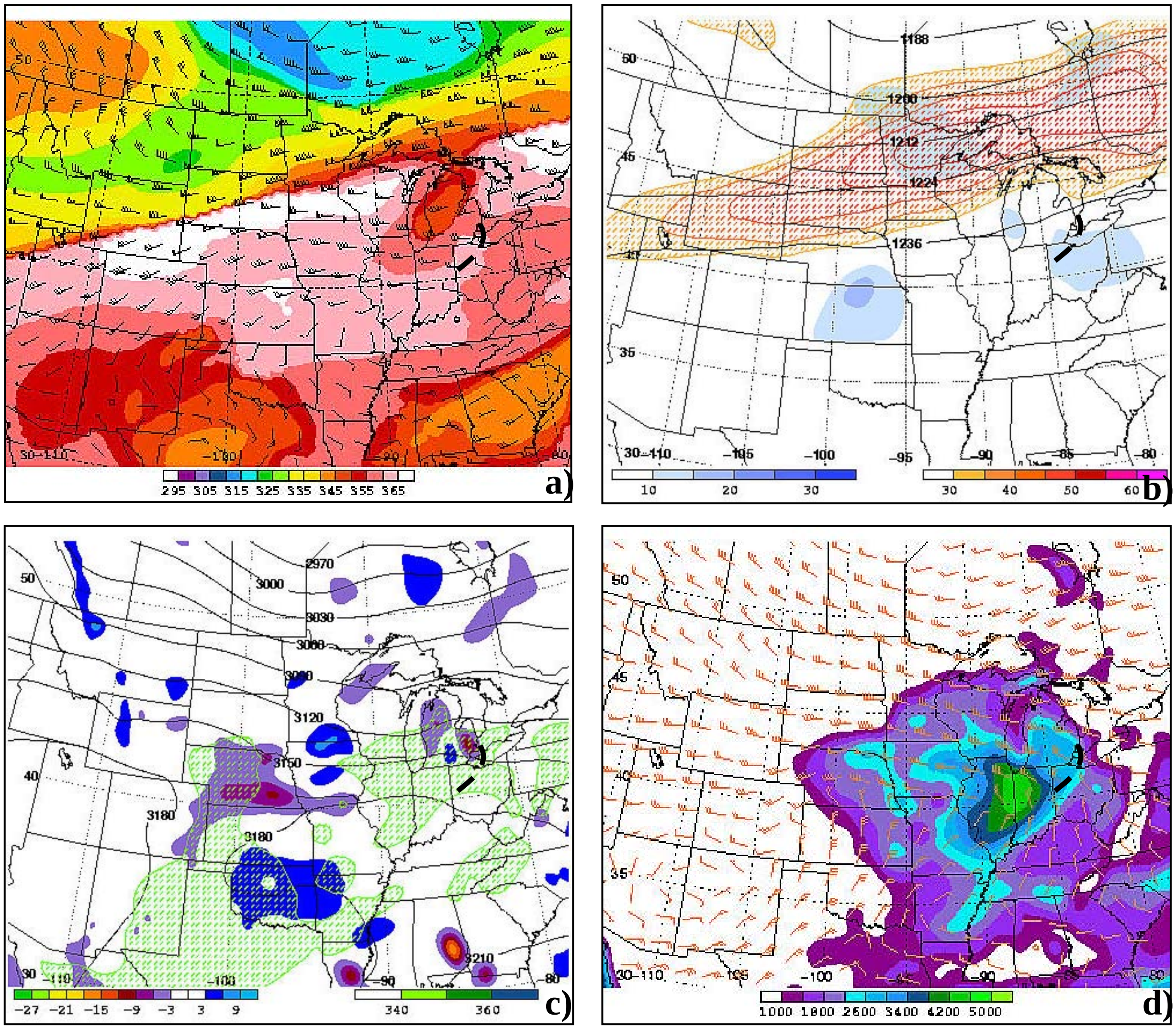

Figure 5: As in Fig. 2 except for 1800 UTC 4 July 2003.

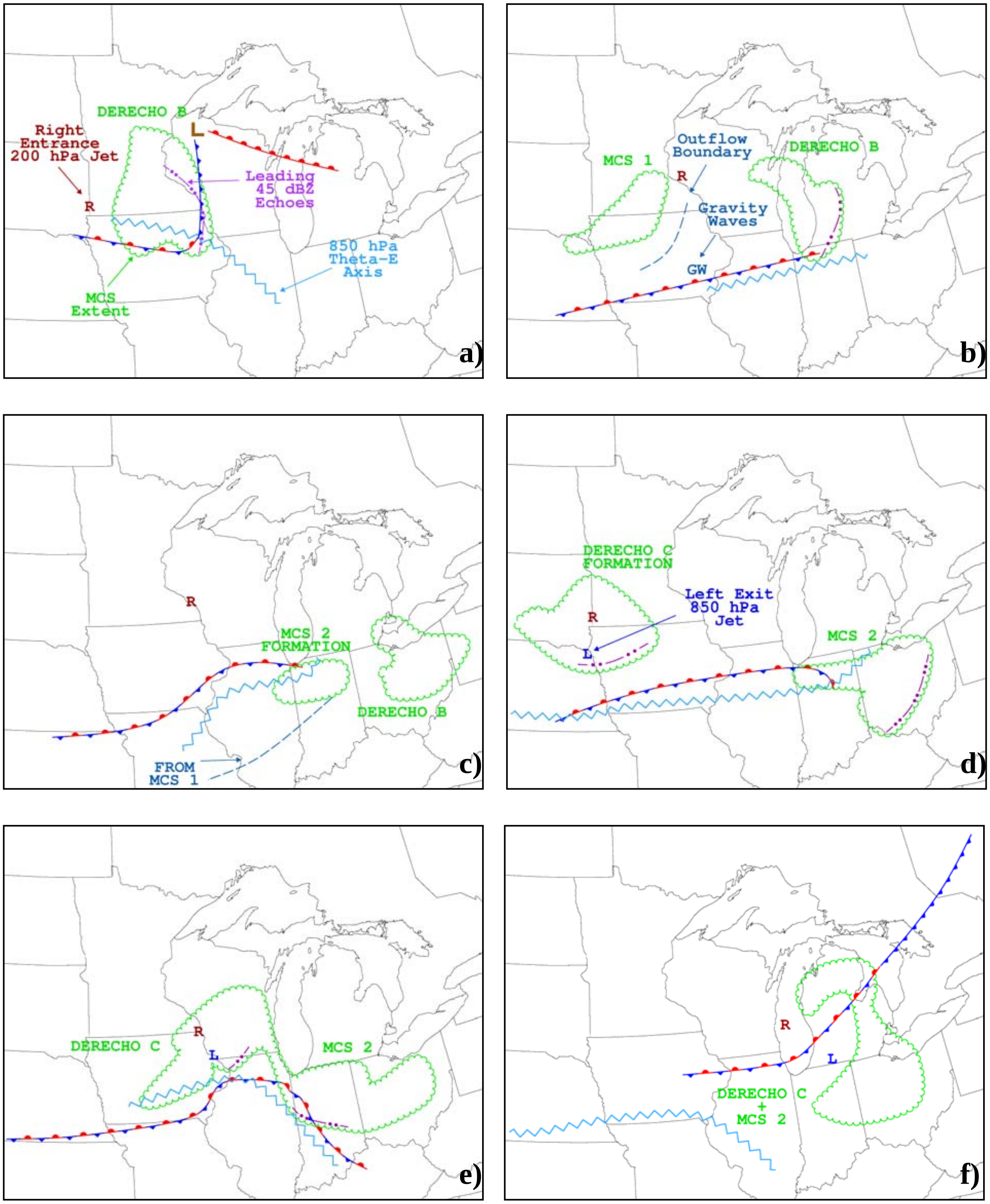


Figure 6: Surface boundaries, MCS positions (scalloped lines), 850 hPa $\theta_e$ ridge (jagged lines), leading edge of 45 dBZ echoes on MCSs (dotted-dashed lines), the position of the right entrance region of the 200 hPa jet (R) and the position of the left exit region of the 850 hPa jet (L) at a) 0900 b) 1500 c) 2100 d) 0300 e) 0900 f) 1500 UTC 4-5 July 2003.

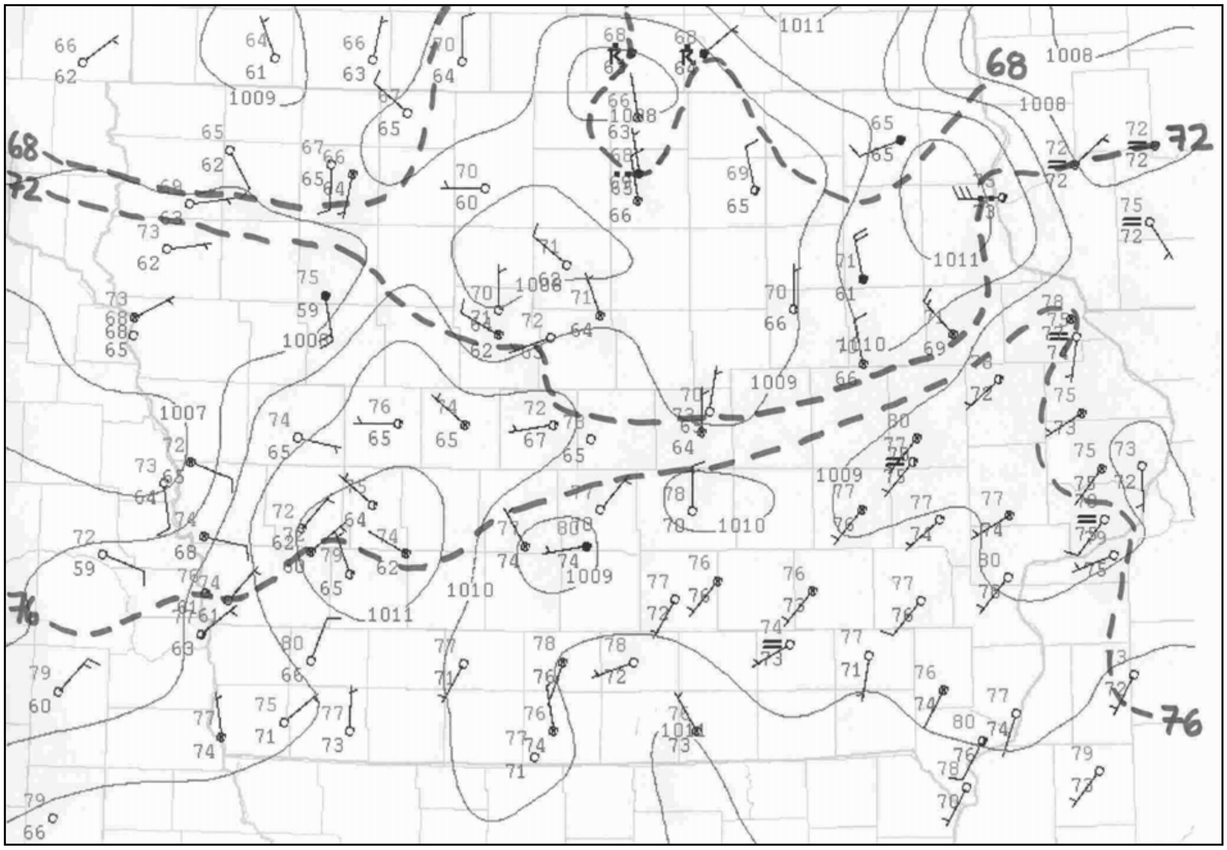

Figure 7: The Iowa Mesonet at 0900 UTC 4 July 2003. Temperature contoured every 4° F.

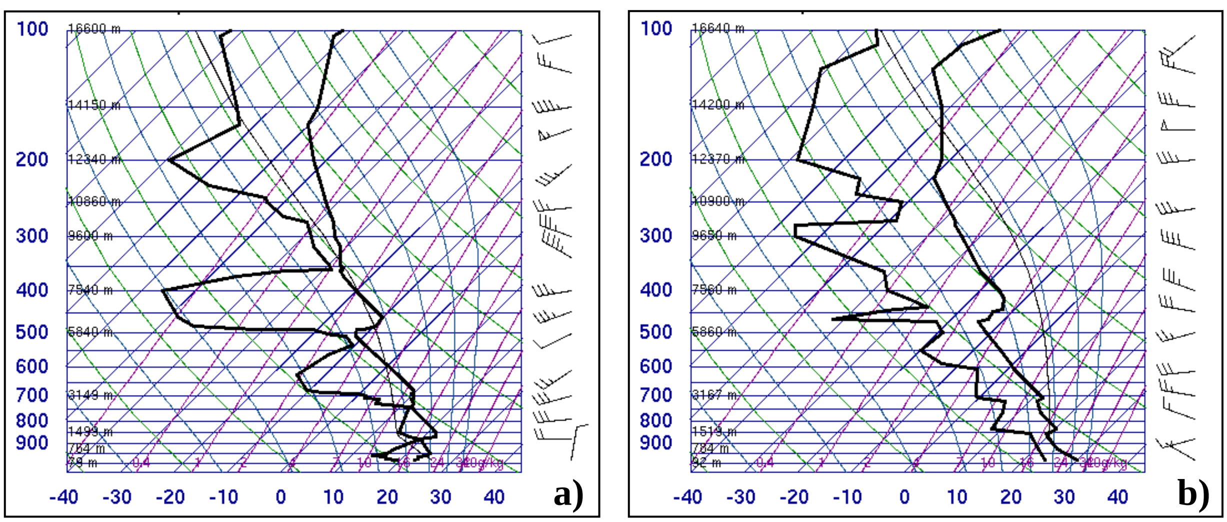


Figure 8: DVN (74455) sounding for (a) 1200 UTC and (b) 1800 UTC 4 July 2003.

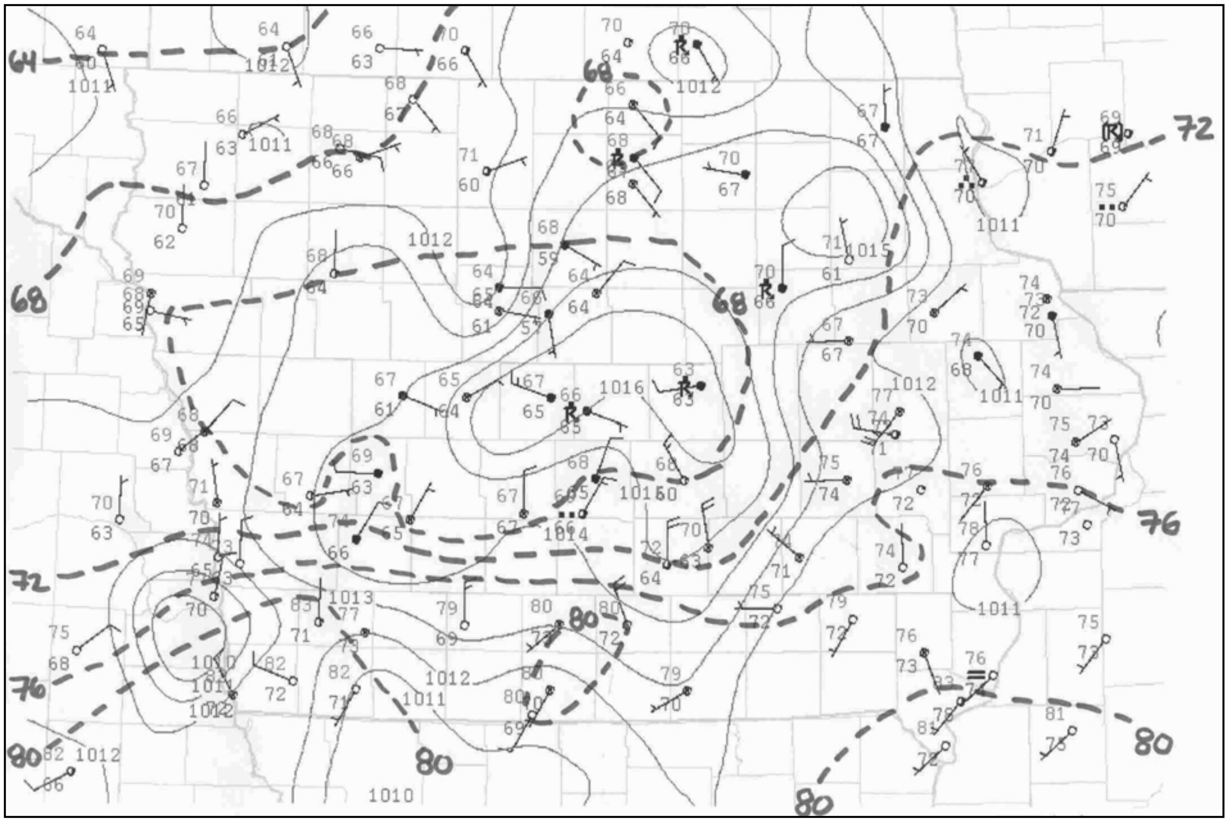

Figure 9: As in Fig. 7 except for 0700 UTC 5 July 2003.