4B.2 A PRELIMINARY INVESTIGATION OF THE 27 JUNE 2008 DAMAGING WIND EVENT IN THE OMAHA METROPOLITAN AND SURROUNDING AREAS

Barbara E. Mayes*[1], Brian E. Smith, and Catherine M. Zapotocny
National Weather Service Forecast Office, Omaha/Valley, NE

1. INTRODUCTION

In the late afternoon on 27 June 2008, a damaging thunderstorm wind event swept across parts of east central Nebraska into west central Iowa, including the Omaha metropolitan area. The storms initiated just behind a seasonably strong cold front in north central Nebraska, then increased in intensity and pushed ahead of the front as they reached eastern Nebraska. The storms produced a swath of non-tornadic convective wind damage that was 4 to 6 miles wide and nearly 90 miles long, with wind speeds estimated up to 49 to 51 m s^{-1} (110 to 115 mph) in the post-storm damage survey. A series of downbursts were noted both on radar and in the subsequent damage survey, contributing to areas of enhanced damage along the swath. The downburst signatures were consistent with previous literature investigating the scale (Fujita 1981), radar presentation (Klimkowski et al., 2003), and mechanisms (Wakimoto et al., 2006) of this type of convective wind event.

Many features of interest were noted in the radar signatures and damage survey of the storm, as well as in the impact to a storm-weary Omaha metropolitan area. This preliminary study will investigate some of the meteorological factors that contributed to the unusually strong convective wind event, as well as the radar presentation of the event and the correspondence of radar signatures to areas of enhanced damage noted in the storm survey. The study will also touch on the impacts of this event to the Omaha area as one of a series of severe weather episodes affecting the city in 2008.

2. SYNOPTIC AND MESOSCALE OVERVIEW

RUC II (40 km horizontal resolution) analysis at 2100 UTC indicates an upper-level shortwave progressing into central South Dakota and north central Nebraska as the main upper low slid into southern Saskatchewan (Fig. 1b). The front at 850 hPa was positioned from northern Minnesota through eastern Nebraska and toward north central Kansas, with a dry pocket lingering ahead of the front in eastern and southern Nebraska (Fig. 1c). The dry pocket was also evident at the surface (Fig. 1d), with dewpoint temperatures less than 60 °F also near the Missouri River in east central Nebraska and west central Iowa. The upper-level jet streak had pushed into the High Plains, with the favorable left exit region near northeast Nebraska and southeast South Dakota (Fig. 1a).

Looking more closely at the surface, at 2100 UTC, surface observations indicated that the cold front extended from central Minnesota into central Iowa, then from near KDSM (Des Moines, Iowa) southwestward to near KOMA (Omaha, Nebraska) and into north central Kansas (Fig. 2a). Higher equivalent potential temperatures had pooled in central Iowa and far southeastern Nebraska into Kansas, with a sharp decline toward the northwest of the axis along the approaching cold front (Fig. 2d). Though surface convergence and pressure falls were not remarkable ahead of the front, surface divergence and pressure rises were more robust behind the front (Figs. 2b and 2c).

A 2100 UTC RUC II point sounding at KOAX (Fig. 3), modified with the 2100 UTC KOMA surface observation, indicated a virtually uncapped and unstable environment, with 1214 J/kg of mixed-layer convective available potential energy (MLCAPE) and zero mixed-layer convective inhibition (MLCIN). The profile was dry in the 700-500 hPa layer and was distinctly dry below the lifting condensation level (LCL) at 796 hPa. Wind shear was largely unidirectional and strong, particularly above the LCL, with 0 to 6 km bulk shear at 21 m s^{-1} (41 kt). A regional view at 2100 UTC (RUC II analysis; Fig. 4)) indicates MLCAPE of 1000 J kg-1 or greater along and south of the surface front, with zero CIN across much of eastern Nebraska into west central Iowa.

The analyzed environment was supportive of convection across east central Nebraska and west central Iowa, with adequate MLCAPE and 0-6 km bulk shear to support organized convection with a potential for severe thunderstorms. Anticipating the extreme nature of the convective winds, however, was not as readily apparent in 2100 UTC mesoscale analysis. Low-level shear profiles were supportive of damaging winds, but not extreme. The low-level thermodynamic profile was also supportive of damaging wind, particularly with the nearly inverted-V profile below the LCL indicating the potential for strong wind gusts to reach the surface. Also, the dry layer around 700-500 hPa was conducive to producing

[1] *Corresponding author address:* Barbara E. Mayes, National Weather Service, 6707 N. 288th St., Valley, NE 68064; e-mail: Barbara.Mayes@noaa.gov

hail, with much of the instability within the profile occurring in that layer, as well. Further investigation will be required to determine the possible influence of evaporative cooling in the profile due to rain and hail, with the creation of negatively buoyant air within the thunderstorm, as well as the strength and depth of the cold pool developed with this convective segment.

3. STORM EVOLUTION AND IMPACTS

Elevated non-severe thunderstorms initiated in the early afternoon on 27 June in northeast Nebraska, behind the surface cold front. At 2000 UTC, elevated post-frontal thunderstorm activity was noted in northeast Nebraska, well aligned with 800 hPa frontogenesis (Fig. 5). Thunderstorms moved southeastward into the axis of greater instability and stronger wind shear, with the first severe thunderstorm warning issued at 2055 UTC and the first severe thunderstorm report at 2112 UTC. Both large hail and high winds were reported with the thunderstorm event, with several reports of golf ball size hail in addition to the widespread wind damage. The event moved out of the eastern side of the National Weather Service (NWS) Omaha/Valley County Warning Area (CWA) by around 2300 UTC.

3.1 Storm Evolution and Radar Interpretation

As the cluster of thunderstorms moved into the unstable airmass in eastern Nebraska, one updraft became dominant, and the convection organized into a linear complex. Fig. 6 depicts a time sequence of KOAX radar reflectivity images as the line crossed the CWA. Note that by around 2133 UTC, a bowing segment could be discerned, becoming more distinct as it moved across the city of Omaha. The corresponding radial velocity images (Fig. 7) display an intense core of winds as the line moved through the region. Wind speeds of 52.9 m s^{-1} (102.9 kt) were noted at 2129 UTC just 37 m (120 ft) above ground level; at 2142 UTC, as convection reached the city of Omaha, 53.4 m s^{-1} (103.9 kt) winds were indicated by radar 66 m (217 ft) above ground level.

Storm-relative velocity images between 2120 and 2203 UTC displayed divergent signatures (Fig. 8), a classic indicator of a downburst, corresponding well to the more intense swaths of damage noted in the post-storm damage survey. Cross-sections of radar reflectivity utilizing the Four-dimensional Storm Investigator (FSI) software within AWIPS indicates a series of core updrafts pulsed upwards, then collapsed down. Fig. 9 includes a time-series of cross sections across one pulsing segment of the storm, between 2203 and 2216 UTC. The times and locations of collapsing updrafts are consistent with both the downburst signatures in the velocity data as well as with the areas of enhanced damage. While the line was over the Omaha area, it also exhibited a distinct rear-inflow jet notch (Fig. 10). The line continued to produce wind damaged for only a short time as it moved into Iowa and into the NWS Des Moines CWA, with more minor wind damage just east of the NWS Omaha/Valley CWA.

3.2 Damage Survey and Storm Impacts

Widespread wind and hail damage was reported across a swath of east central Nebraska and west central Iowa in the wake of the 27 June 2008 convection. Two fatalities resulted when a tree fell on a car in Council Bluffs, Iowa, and several minor injuries were noted. The damage path was roughly 90 miles long and averaged 4 to 6 miles wide. A post-storm damage assessment by NWS Omaha/Valley found evidence of winds as strong as 49-51 m s-1 (110 to 115 mph), producing damage equivalent to an EF2 rating on the Enhanced Fujita Scale of damage. Within the swath of damage, several areas of enhanced damage were noted by the damage assessment team; these are outlined as an overlay of the radar images in Figs. 6 and 7.

The event occurred on a Friday afternoon, with several scheduled outdoor events, including a large outdoor concert (50,000 expected attendees), several “music in the park” concerts, and an outdoor arts festival. In addition, preliminary exercises to the 2008 United States Olympic swim team trials were being held at the Qwest Center, a large arena in downtown Omaha. The storms swept across the Omaha metropolitan area at up to 60 mph, with a quick transition from a pleasant day to severe thunderstorm conditions in the city of Omaha and in surrounding areas. The event was also the last in a series of significant severe weather episodes to affect the Omaha metropolitan area in June 2008 (Mayes et al., 2009).

Impacts from the 27 June event were widespread across the region. Numerous power outages were reported; the local power company, Omaha Public Power District (OPPD), indicated that this was a particularly disruptive event. OPPD deemed the storm the worst in its history, primarily due to the more than 126,000 customers without power and the loss of 78 transmission poles. OPPD declared a “Level Two” emergency, the highest on their scale. A Level Two emergency is declared when 40 or more circuits are locked out, the system load drops 30% or more, the “Emergency” has caused damage to more than 50% of the service area, and the service restoration is projected to last longer than 72 hours or more. This type of emergency has only been declared one other time in OPPD’s 62 year history (the October snowstorm of 1997). The storm allowed OPPD to employ new technology that it had implemented since the 1997 storm, including a new call center, an operations management system, automated digital meter reading technology, and updated outage maps and blogs on their web site.

Damages in Douglas County, Nebraska (where Omaha is located) reached at least $53 million, with damage to the roofs, fences, exterior siding, and windows of numerous residences, as well as significant tree damage across the area and outbuilding damage in rural locations. $3.5 million in damage was reported in Pottawattamie County, Iowa, just across the Missouri River. Crop damage was also reported in the damage swath, as quarter to golf ball size hail driven by winds of 70 to 80 mph or greater shredded fields of growing corn. The most significant crop damage occurred in Saunders County, with $30 million in damage reported.

On 27 June 2008, the siren policy in Douglas County did allow the sirens to be sounded by the 911 center for non-tornadic thunderstorms if winds were expected to reach or exceed 90 mph. The county indeed sounded the sirens, which likely prompted more action from the public on the heels of other significant events in and around Omaha in June 2008. A new siren activation policy was drafted as a direct result of the June 2008 storms. In addition to the National Weather Service initiated tornado warning and a trained-storm spotter sighting of a rotating funnel cloud or tornado, the new policy to sound the sirens lowers the wind criteria to hurricane-force sustained winds equal to or greater than "hurricane force." Nearby Sarpy County, Nebraska, also adjusted their outdoor warning siren activation policy to be similar to Douglas County.

In addition to the siren policy change, as a result of the storm, Douglas County added staffing to their Emergency Management team. Douglas County accelerated their scenario planning and reorganized cleanup-crews. Although Dodge County, Nebraska, did not experience any significant damage, due to their proximity to Douglas and Saunders County, they did experience a heavy workload due to false reports of damage, numerous calls, and office visits. An unexpected impact of the storm for nearby Sarpy County occurred with the dispersion of hazardous materials; fireworks were scattered about when two large fireworks tents were destroyed.

4. SUMMARY

Meteorologically, the synoptic and mesoscale environment on 27 June 2008 appeared favorable for convection, though the high-end nature of the wind damage was less apparent in forecast mode. The dry atmosphere below the LCL, combined with strong unidirectional shear, contributed to the capability of the thunderstorm to produce severe wind damage. In addition, collapsing thunderstorm cores created downbursts through the life cycle of the event, enhancing wind damage where these occurred. Still, the factors in creating an enhanced damaging wind event, rather than a more common severe convective wind event, remain unclear. Large hail and flash flooding were also reported with the event as it moved across east central Nebraska into west central Iowa.

The wind event left a swath of widespread and significant damage across eastern Nebraska and western Iowa. Impacts of the winds lasted for months, with ongoing repairs well into the rest of the year. The event resulted in changes in policy by local government and emergency management agencies, including changes to siren and staffing policies.

Acknowledgments
Josh Boustead (NWS WFO Omaha/Valley, NE) contributed several images for this preprint and associated presentation

REFERENCES

Fujita, T.T., 1981: Tornadoes and downbursts in the context of generalized planetary scales. *J. Atmos. Sci.*, **38**, 1511-1534.

Klimkowski, B.A., M.J. Bunkers, M.R. Hjelmfelt, and J.N. Covert, 2003: Severe convective windstorms over the northern High Plains of the United States. *Wea. Forecasting*, **18**, 502-519.

Mayes, B.E., J.T. Martinelli, and D. Nietfeld, 2009: A detailed analysis of the nocturnal QLCS tornadoes that moved through Omaha, Nebraska, on 8 June 2008. Preprints, *23rd Conference on Weather Analysis and Forecasting*, Omaha, NE, Amer. Meteor. Soc.

Wakimoto, R.M., H.V. Murphey, A. Nester, D.P. Jorgensen, and N.T. Atkins, 2006: High winds generated by bow echoes. Part 1: Overview of the Omaha bow echo 5 July 2003 storm during BAMEX. *Mon. Wea. Rev.*, **134**, 2793-2812.

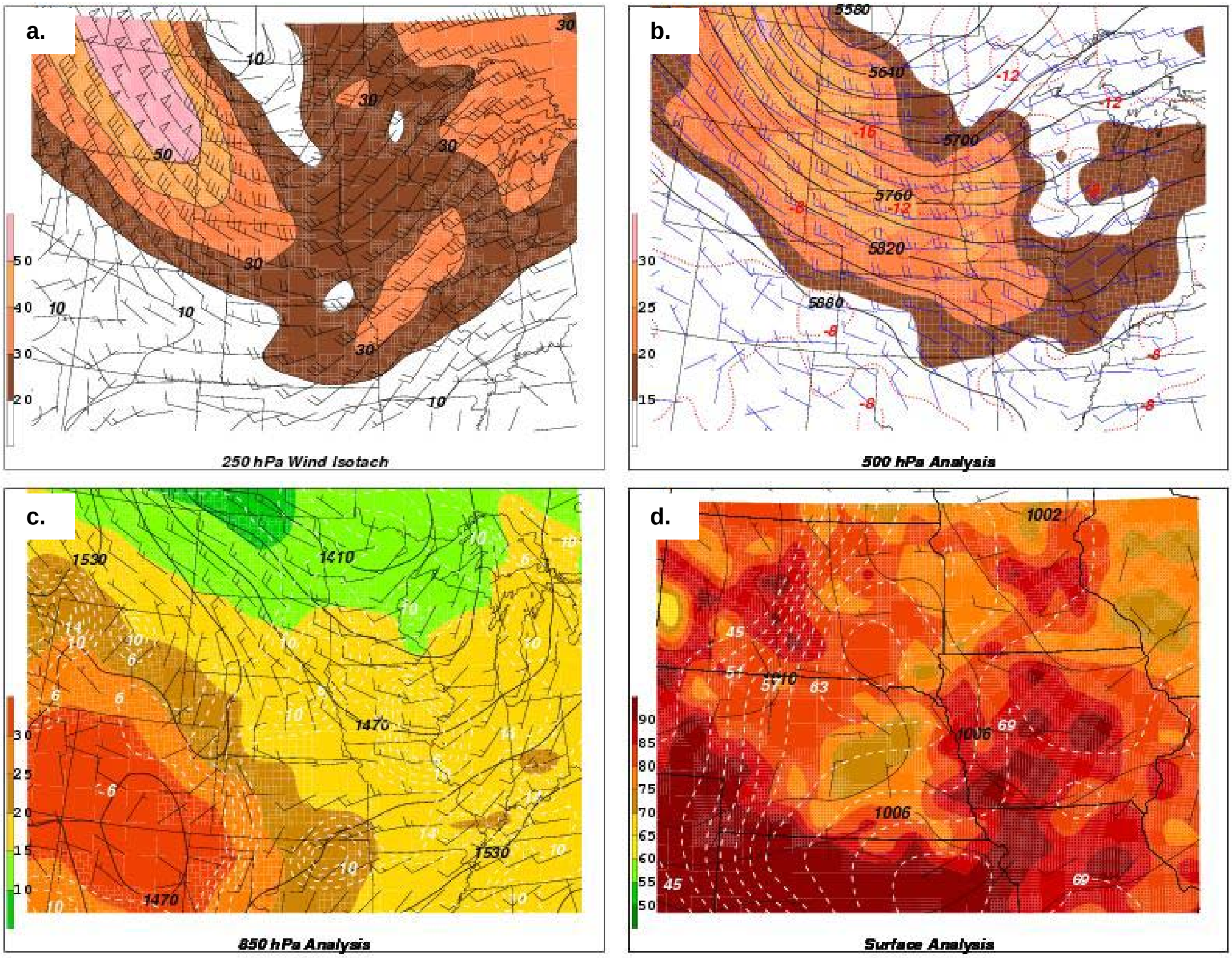


Figure 1. 2100 UTC 27 June 2008 40 km RUC analysis of (a) 250 hPa wind barbs (m s^{-1}) and isotachs (m s^{-1}, shaded); (b) 500 hPa geopotential height (m, black contours), wind barbs, isotachs, and temperatures (°C, red dashed contours); (c) 850 hPa geopotential height, wind barbs, temperatures (°C, shaded), and dewpoint temperatures (°C, white dashed contours); and (d) surface mean sea level pressure (hPa, black contours), temperature (°F, shaded), and dewpoint temperature (°F, white dashed contours).

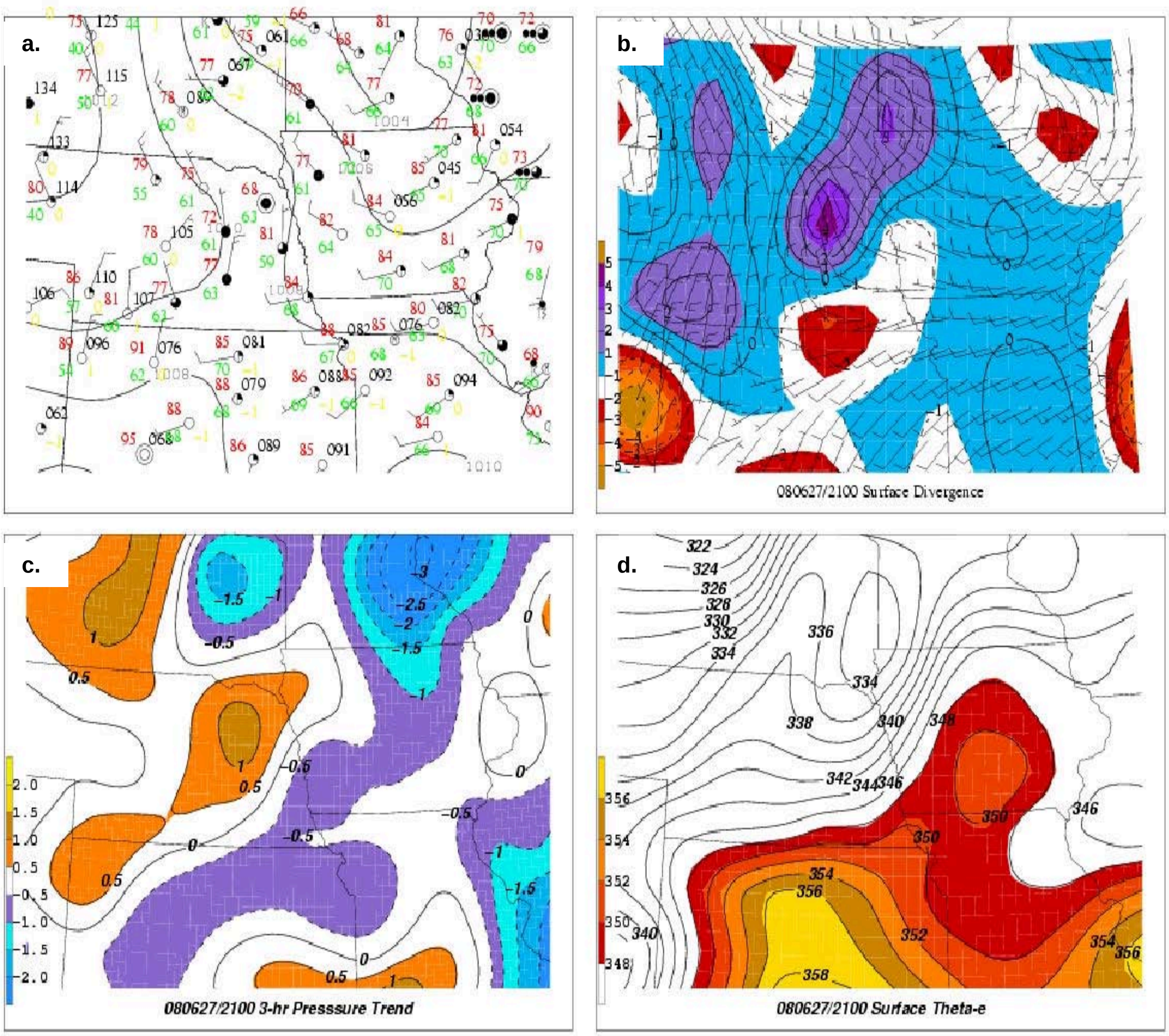
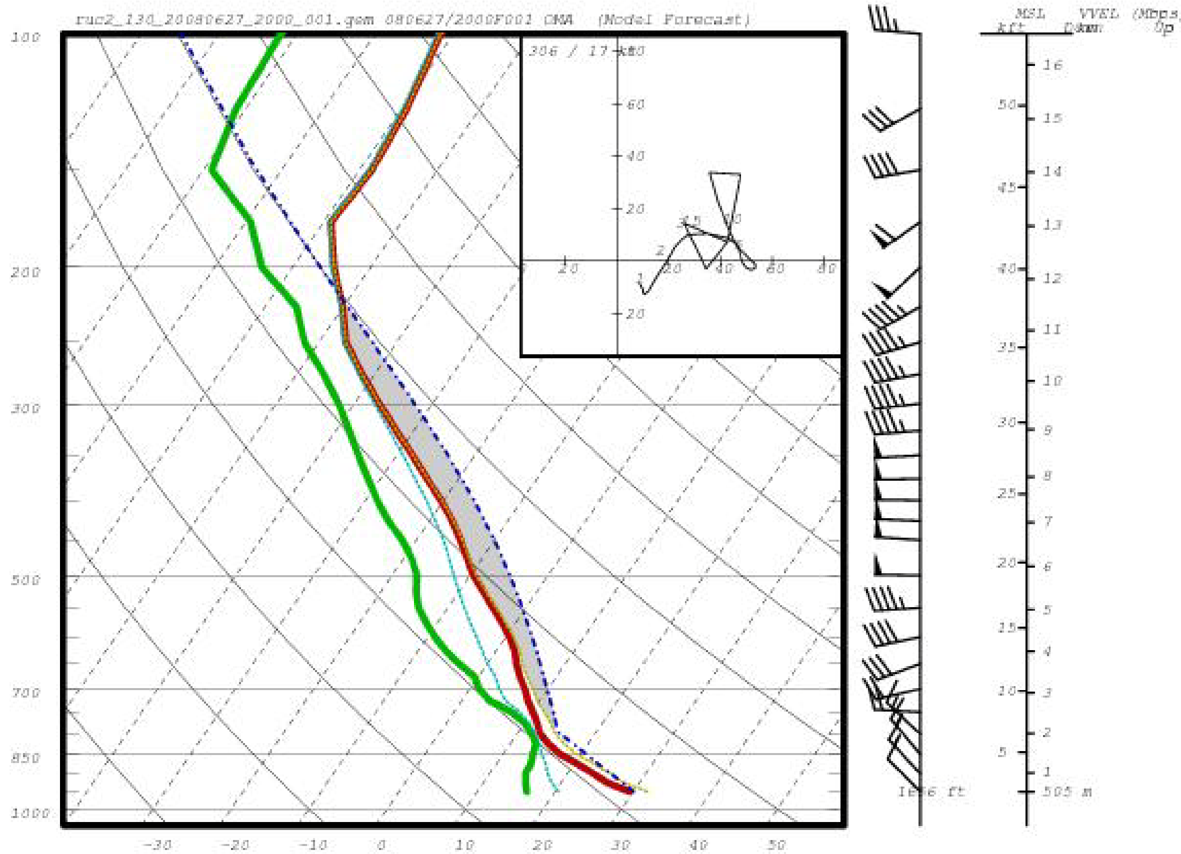


Figure 2. Surface observations at 2100 UTC, plotted in GEMPAK: (a) METAR observations and mean sea level pressure (hPa); (b) surface wind barbs (m s^{-1}) and divergence (m s^{-1}, shaded); (c) 3-hour mean sea level pressure trend (hPa); and (d) equivalent potential temperature (K).



THERMODYNAMIC PARAMETERS

MEAN MIXING LAYER PARCEL

LPL: 950mb	28C/ 16C	82F/ 60F	
CAPE: 1214 J/kg	LI:	-5 C @	500mb
BFZL: 146 J/kg	LImin:	-5 C @	325mb
CINH: 0 J/kg	CAP:	0 C @	775mb

LEVEL	PRES	HGT (AGL)	TEMP
LCL	796mb	4994ft	
LFC	796mb	4994ft	13 C
EL	215mb	36917ft	-52 C
MPL	144mb	45234ft	

Precip Water:	1.40 in	Mean RH:	48 %
Mean Q:	12.0 g/kg	Mean LRH:	67 %
Top of Moist Layer:		M / M	

700-500mb Lapse Rate:	17 C / 6.4 C/km
850-500mb Lapse Rate:	29 C / 6.6 C/km

Total Totals:	50	K-Index:	35
SWEAT Index:	272	Max Temp:	84 F
ThetaE Diff:	16 C	*Conv Temp:	85 F
FRZ Level:	12869 ft	WBZ Level:	10516 ft

Output produced by Unidata postscript driver:
NSHARP (SkewT-Hodograph Analysis and Research Program)

KINEMATIC PARAMETERS

Sfc - 6 km Mean Wind:	263 / 28 kt	(14 m/s)
LFC - EL Mean Wind:	266 / 35 kt	(18 m/s)
850 - 300 Mean Wind:	270 / 32 kt	(16 m/s)
Sfc - 2km Shear:	12 kt	(6 m/s)
Sfc - 6km Shear:	42 kt	(21 m/s)
*BRN Shear:		30 m2/s2

STORM STRUCTURE PARAMETERS

Sfc - 3km SREH:	5 m2/s2		
Effective SREH:	5 m2/s2	from 0 m.	
0-2 km SRW:	3 kt	EHI:	0.0
4-6 km SRW:	36 kt	BRN:	40
6-10 km SRW:	38 kt		

Figure 3. 2100 UTC 27 June 2008 40 km RUC point sounding at Omaha, Nebraska, with surface conditions modified to 2100 KOMA observation.

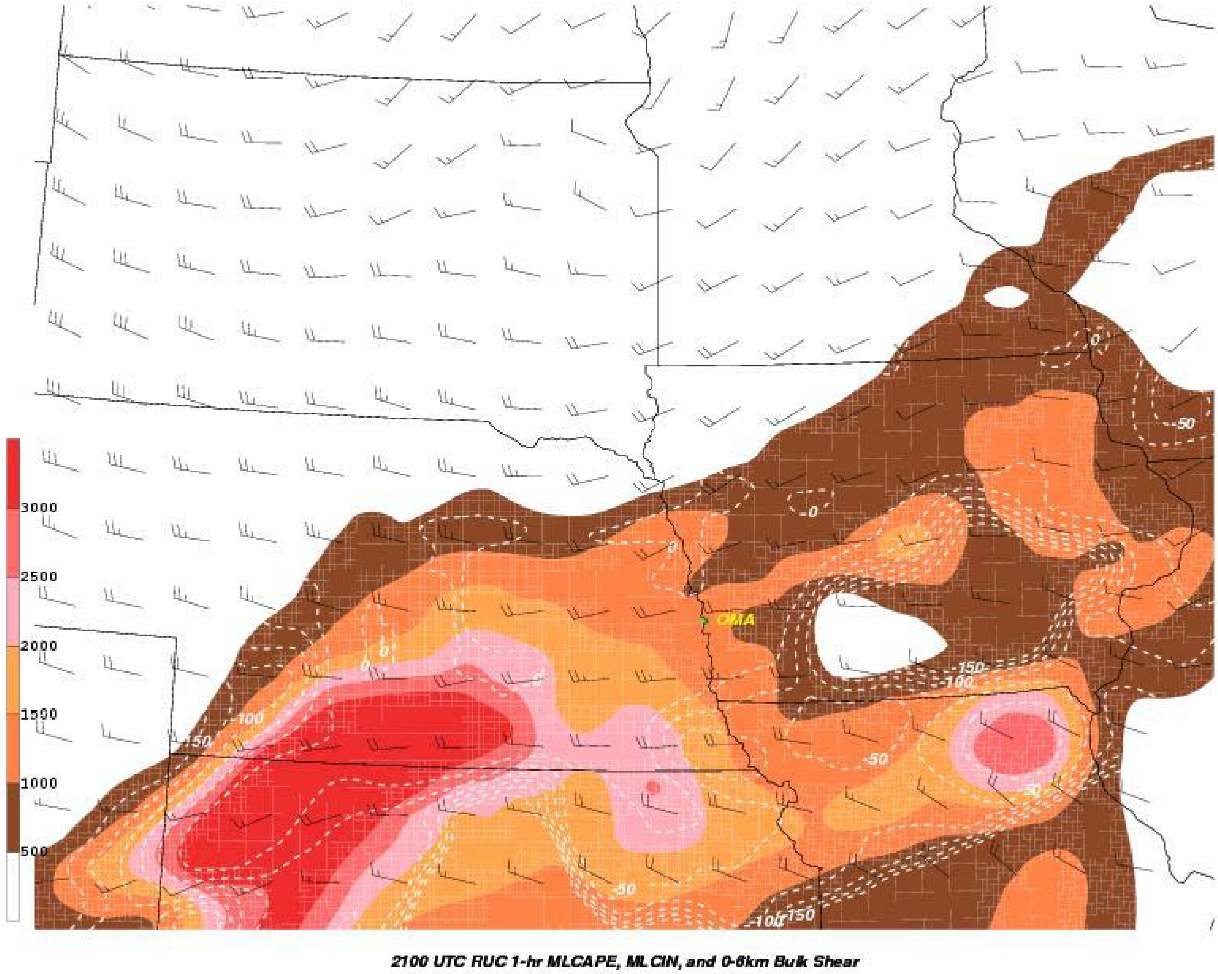


Figure 4. 2100 UTC 27 June 2008 40-km RUC mixed-layer CAPE (J kg^{-1}, shaded), mixed-layer CIN (J kg^{-1}), and 0-6 km bulk shear (m s^{-1}).

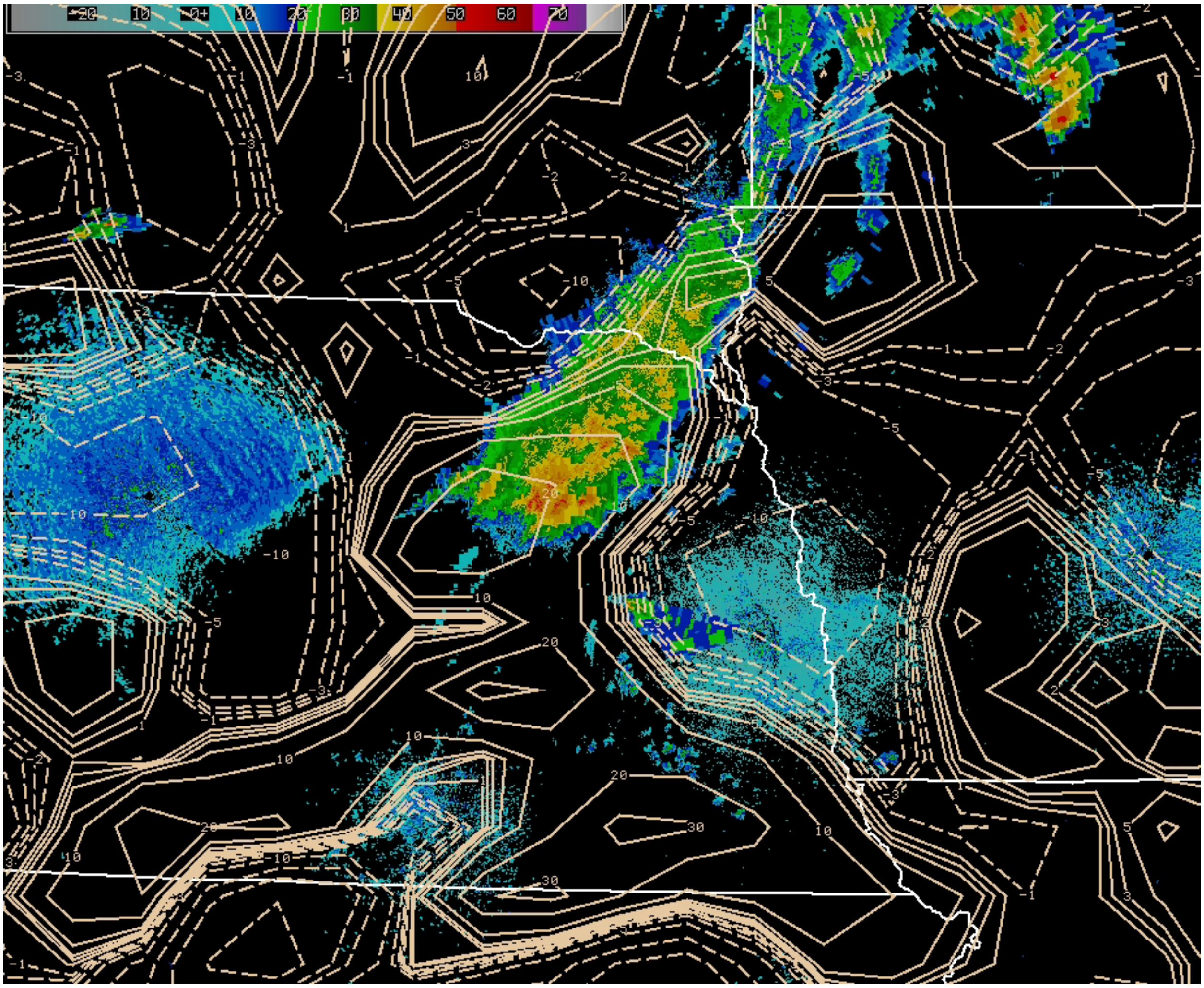


Figure 5. 2000 UTC 27 June 2008 regional composite 0.5 reflectivity, with 2000 UTC 40 km RUC frontogenesis at 800 hPa.

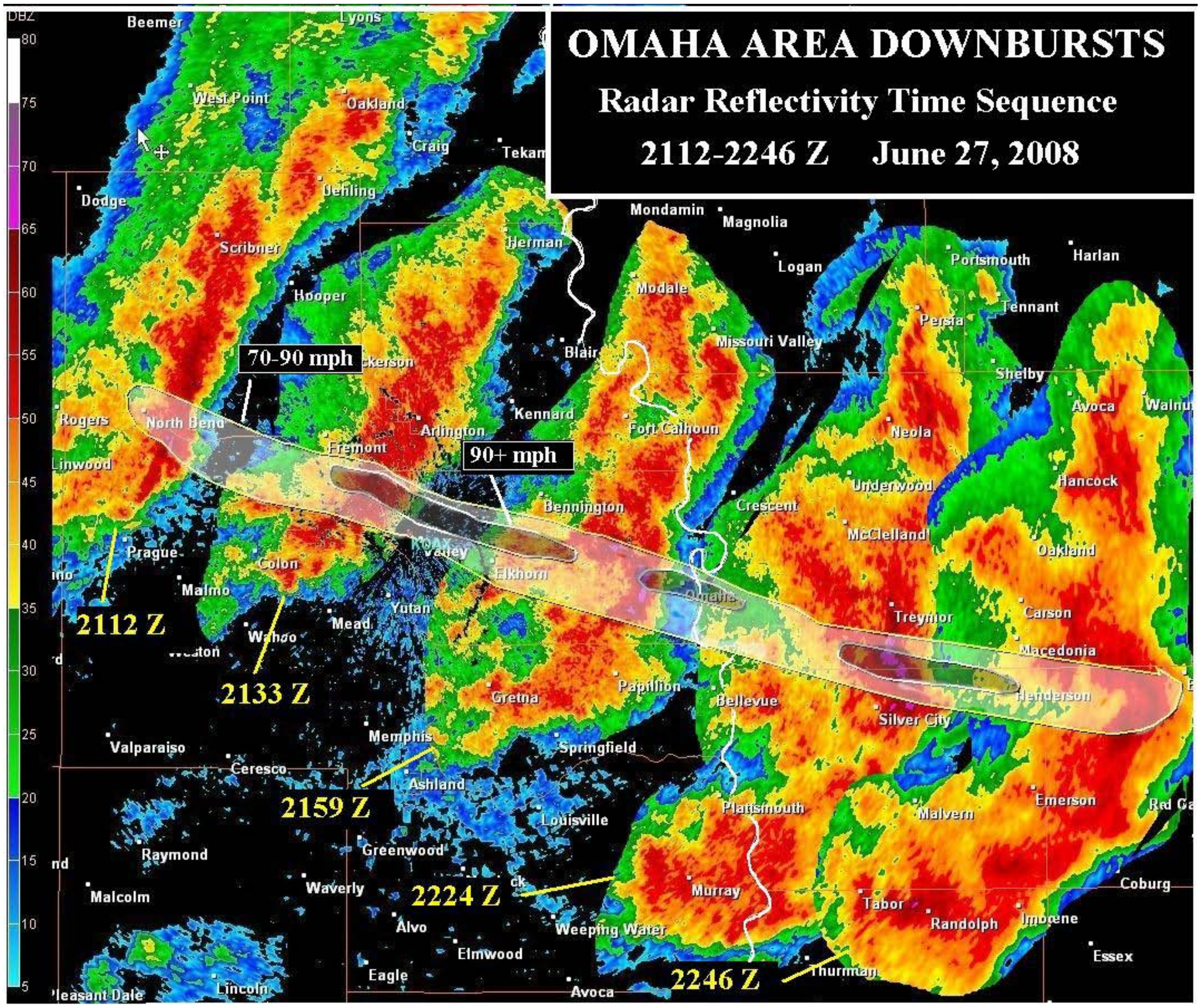


Figure 6. Composite image of KOAX reflectivity as the event moved across eastern Nebraska into western Iowa. Shaded overlay indicates path of convective wind damage, including cores of enhanced wind damage.

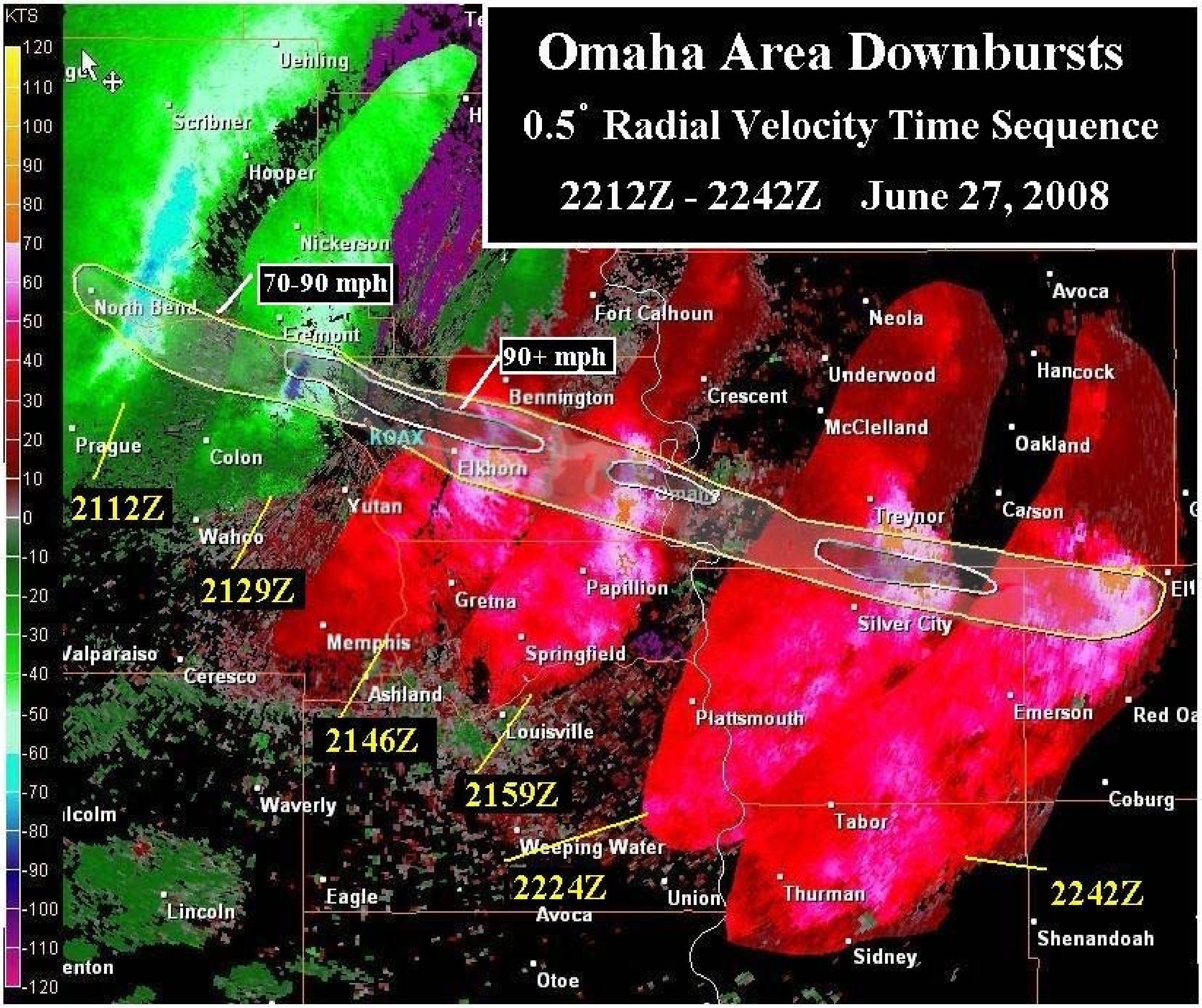


Figure 7. Composite image of KOAX velocity as the event moved across eastern Nebraska into western Iowa. Shaded overlay indicates path of convective wind damage, including cores of enhanced wind damage.

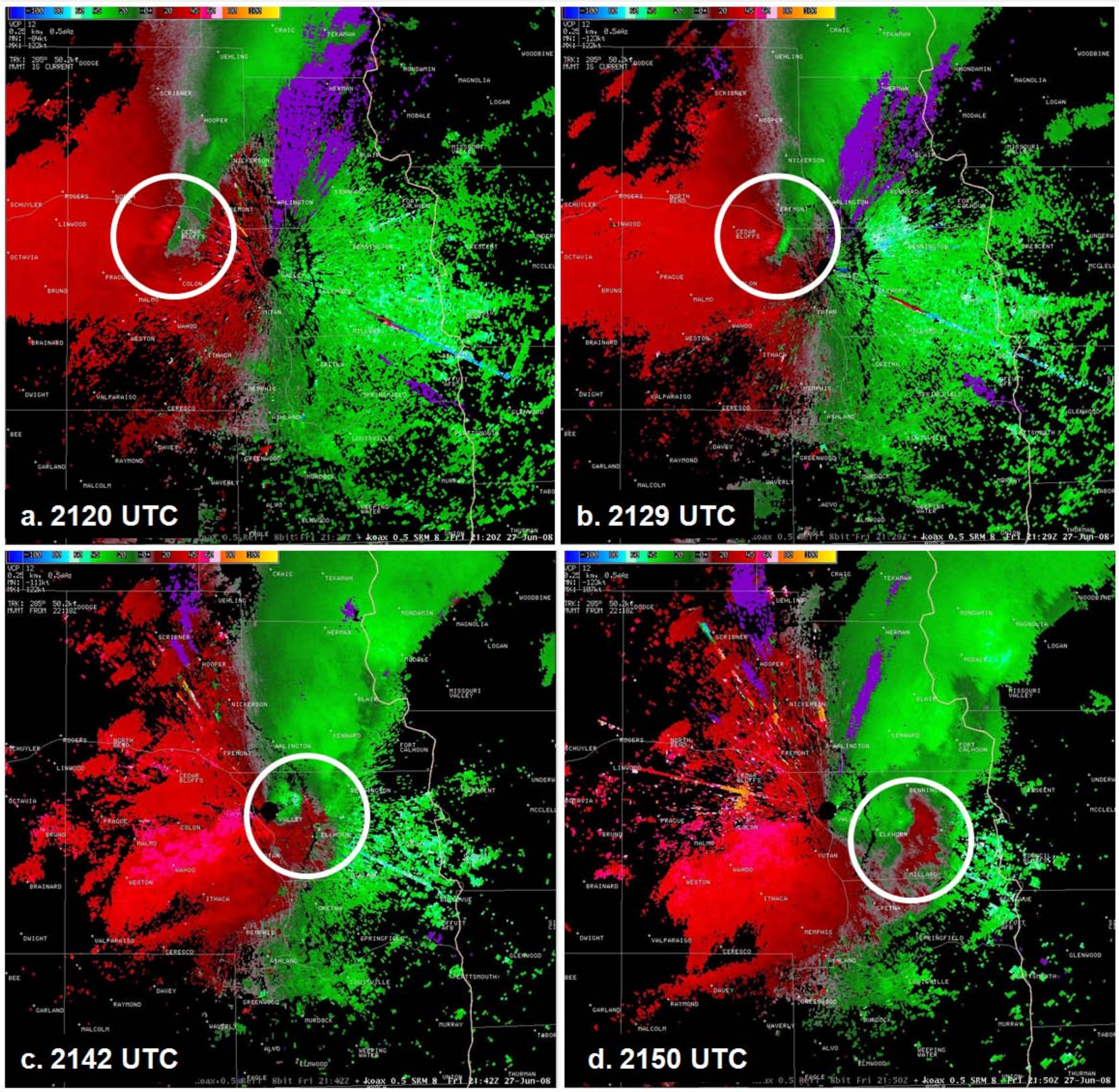


Figure 8. KOAX storm-relative velocity at (a) 2120 UTC, (b) 2129 UTC, (c) 2142 UTC, and (d) 2150 UTC. Downburst signatures are denoted by a white circle in each image.

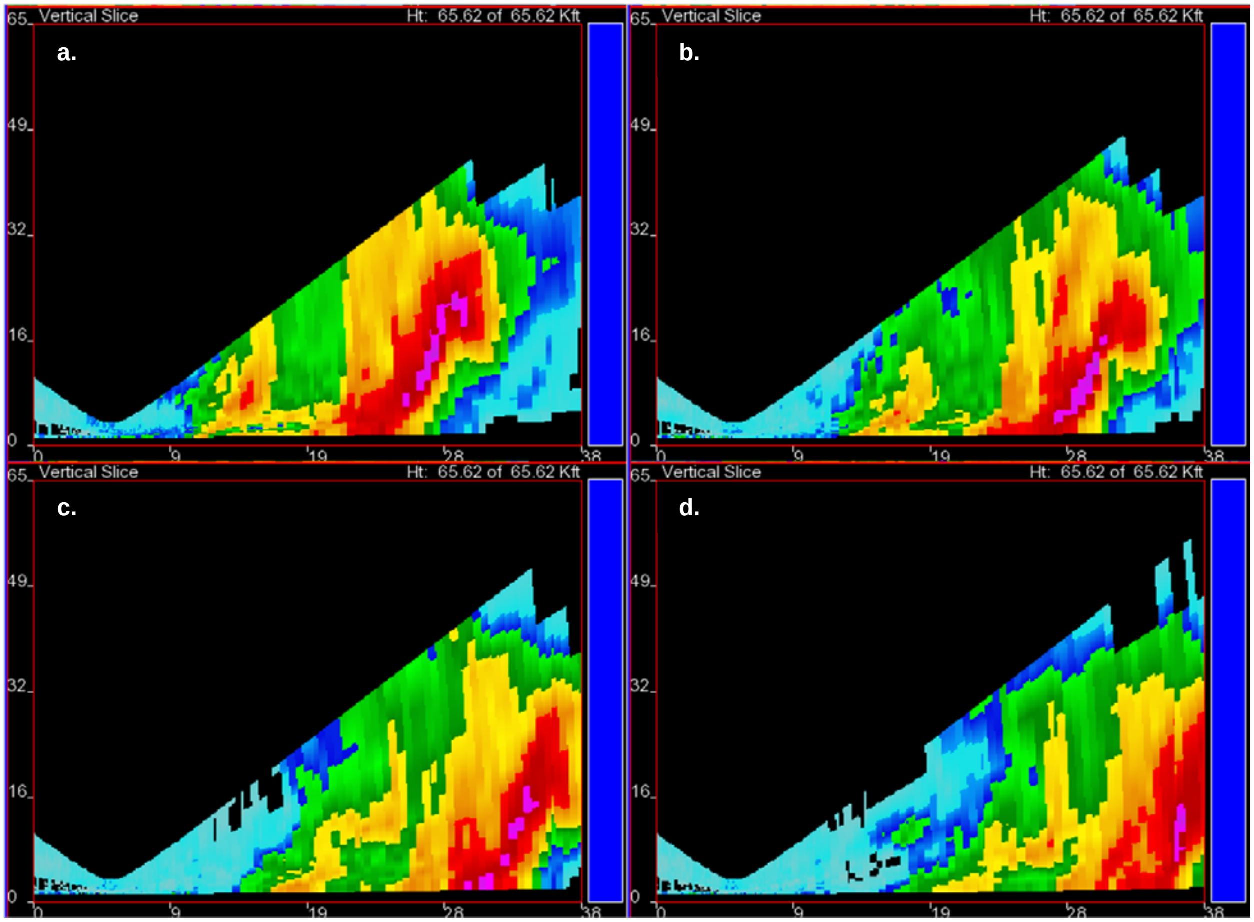


Figure 9. KOAX FSI reflectivity cross-section through the bowing segment at (a) 2203 UTC, (b) 2207 UTC, (c) 2211 UTC, and (d) 2216 UTC, as the segment crossed eastern Douglas County, Nebraska, into western Pottawattamie County, Iowa. Note the collapsing reflectivity core with time.

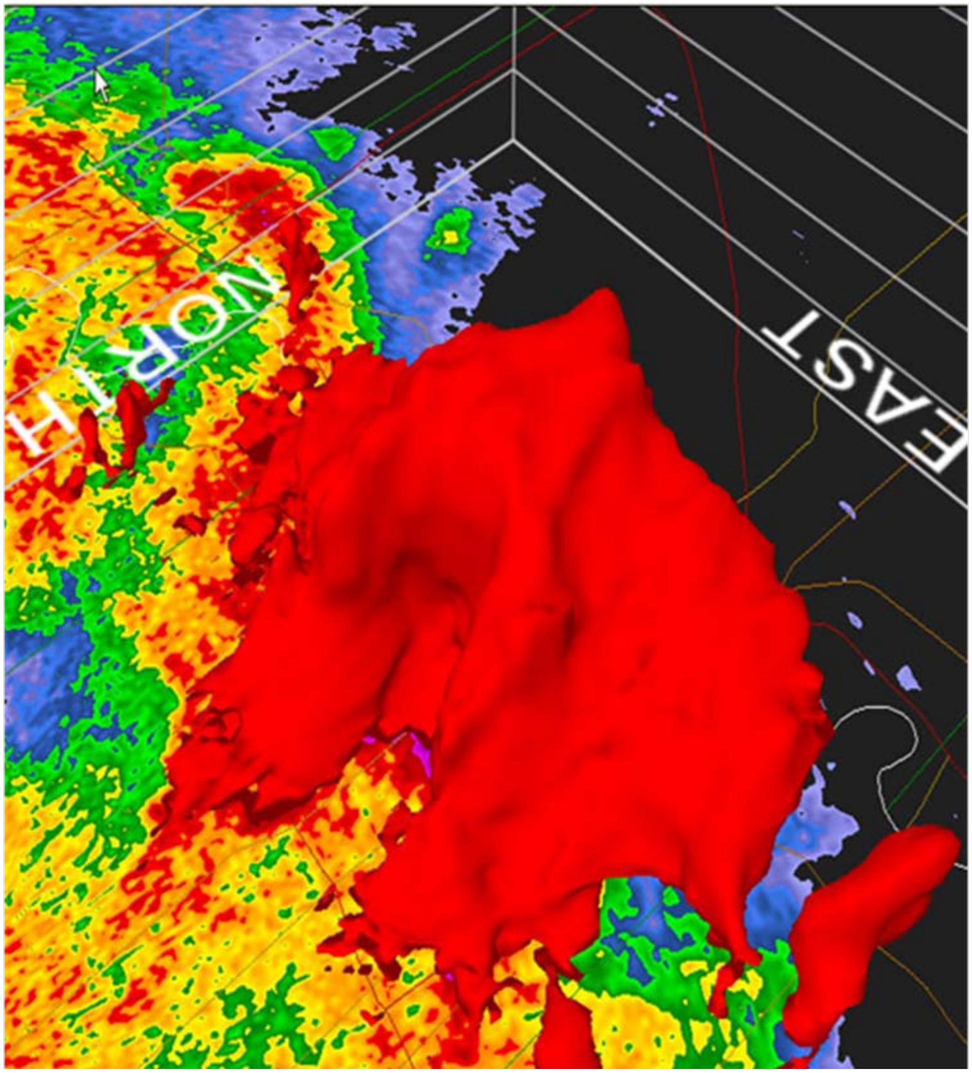


Figure 10. Three-dimensional 50 dBz surface, from the KOAX radar at 2159 UTC and displayed in GR2Analyist software, depicting the distinct rear-inflow jet notch.