P11.9 A CASE OF SUPERCELL INTENSIFICATION ALONG A PREEXISTING BOUNDARY – CLAY COUNTY NEBRASKA TORNADO OF 22 SEPTEMBER 2001

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1. INTRODUCTION

During the early evening hours of 22 September 2001, a supercell thunderstorm developed in south central Nebraska along an advancing cold front. The supercell initially produced an F1 tornado (Fujita 1971) in northern Clay County, Nebraska.

As the supercell propagated southeastward through Clay County, it rapidly intensified and produced a second, much stronger, tornado. The tornado produced F3 damage to three farmsteads in rural Clay County, Nebraska, along a 13 km path. The tornado was over one half km in diameter for much of its lifetime.

In accordance with research involving low-level boundaries and tornadic storms (Maddox et al. 1980; Rasmussen et al. 1994; Markowski et al. 1998; Rasmussen et al. 2000), it appears the rapid intensification of this supercell and subsequent tornadogenesis was ultimately dependent upon a preexisting mesoscale outflow boundary, and possibly other storm-scale processes. The ambient environment was otherwise characterized by relatively weak mid- to upper-level flow (~20 ms^{-1}) and nearly unidirectional deep layer (0-6 km) shear (Figure 1 and Table 1).

2. SYNOPTIC AND MESOSCALE OVERVIEW

During the early morning hours of 22 September, a Mesoscale Convective System (MCS) had developed across eastern Nebraska, eventually decaying as it pushed through eastern Kansas and western Missouri later that morning. In its wake, the MCS left several outflow boundaries across southern Nebraska and northern Kansas.

By the afternoon hours of 22 September 2001, a mid- to upper-level tropospheric short-wave trough was advancing from Saskatchewan into the Northern Plains of North Dakota and Minnesota. An associated cold front extended through central Nebraska and northern Kansas. Furthermore, a remnant outflow boundary from the early morning convection extended from south central Nebraska into northeast Kansas.

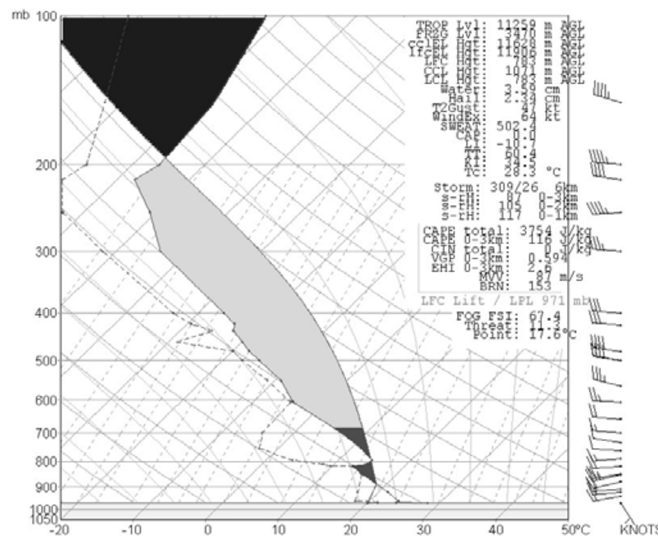

Figure 1 and Table 1. 00 UTC 23 September 2001 KOAX observed sounding modified with 23 UTC KHSI surface observation.

Surface Based CAPE	3754 J/Kg
0-3 km CAPE	116 J/Kg
CIN	0 J/Kg
LCL Height	783 m
LFC Height	783 m
0-3 km Storm Relative Helicity (SRH)	87 m^2/s^2
0-3 km Energy Helicity Index (EHI)	2.6

3. RADAR DISCUSSION

First, it should be noted that the complete life cycle of this supercell occurred within 50 km of the Hastings-Blue Hill (KUEX) WSR-88D. Archive Level IV data was reviewed for this case.

Thunderstorms began developing in south central Nebraska around 2315 UTC in northern Clay County, approximately 45 km to the southeast of Grand Island (KGRI). These storms exhibited a slow southeastward movement (around 5 ms^{-1}) through the

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northern part of Clay County. The first tornado was observed at 0007 UTC near Saronville, Nebraska. At this time, two distinct supercells were noted. The storms exhibited low precipitation supercell characteristics and their associated high-based updrafts remained relatively disorganized between 0002 UTC and 0022 UTC.

Intensification began to occur between 0022 UTC and 0042 UTC as the storms congealed and the resultant supercell storm seemingly became anchored to the remnant outflow boundary (Figure 2).

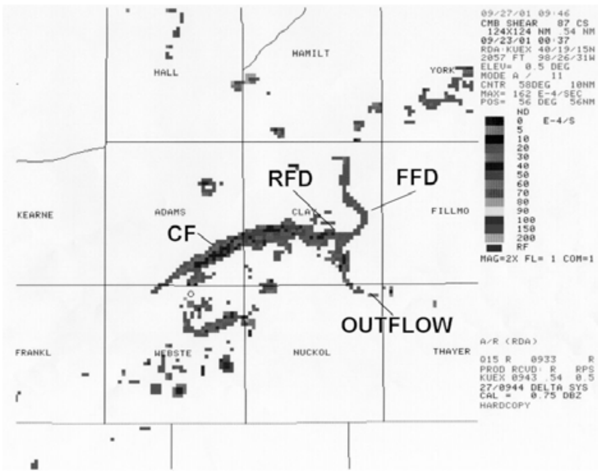

Figure 2. KUEX 0.5 degree Combined Shear at 0037 UTC on 23 September 2001. *CF* denotes location of cold front, *RFD* indicates rear flank downdraft gust front, *FFD* denotes forward flank downdraft; and *OUTFLOW* indicates outflow boundary.

The supercell thunderstorm ultimately produced a second tornado around 0042 UTC. This tornado formed approximately 11 km south of the original and weaker tornado. The tornado moved southeast, east, and finally northeast on its 13 km long path, seeming to coincide with the position of the outflow boundary.

Rotational velocities (Vr) associated with this supercell doubled in the lowest 3 km (~10000 feet) between 0042 UTC and 0047 UTC (Figures 3 and 4). In the 0.5 degree elevation, Vr increased from 13 ms^{-1} (26 kts) at 0042 UTC to >26 ms^{-1} (>50 kts) at 0047 UTC. The rapid intensification of low-level rotational velocity is consistent with previous research of tornadoes associated with boundaries.

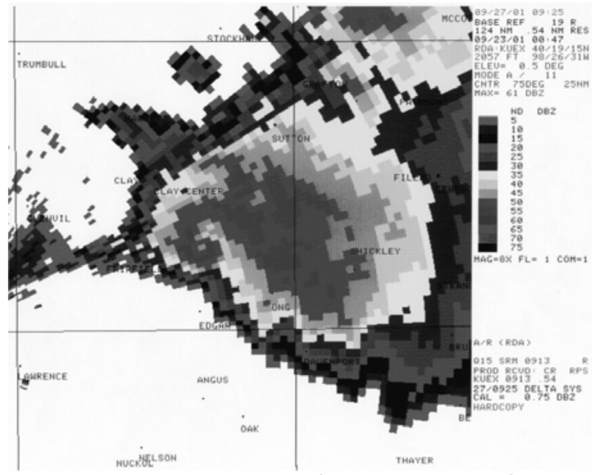

Figure 3. KUEX 0.5 degree Reflectivity at 0047 UTC on 23 September 2001.

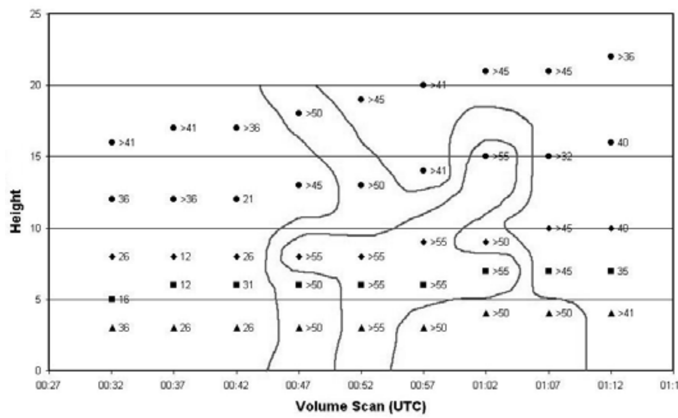

Figure 4. Time vs. height (thousands of feet) of Rotational Velocity (Vr). Values of 50 knots and 55 knots are contoured.

In addition, this event further emphasizes the possibilities for operational usage of the WSR-88D Combined Shear (CS) product (Herald and Drozd 2001). The CS product is derived by taking the square root of the radial shear squared plus the azimuthal shear squared (Operational Support Facility 1997).

When utilized with other observational means, the CS product was useful for determining a more precise placement of the sub-synoptic boundaries in close proximity (~50 km or less) to the Doppler radar (Figure 2). These boundaries were otherwise unable to be resolved in the observational network across south central Nebraska and north central Kansas.

CS was also found to be useful for examining the possibilities of storm and boundary interactions. In combination with other WSR-88D products (e.g. Base Reflectivity and Velocity), each of the forward flank downdraft (FFD) and rear flank downdraft (RFD) gust fronts were evident in the CS product.

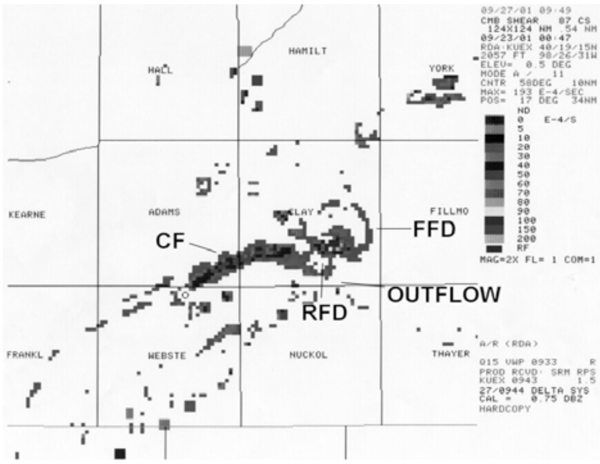

Figure 5. KUEX 0.5 degree Combined Shear (CS) at 0047 UTC on 23 September 2001. Labels same as Figure 2.

Specifically, the CS image clearly portrays both the initial stages of the RFD gustfront (0047 UTC; Figure 5), and the eventual RFD gustfront occlusion with the FFD gustfront (0057 UTC; Figure 6), concurrent with the demise of the tornadic circulation. Maximum CS values coinciding with the supercell were 0.0177 sec^{-1} at 0052 UTC (not shown).

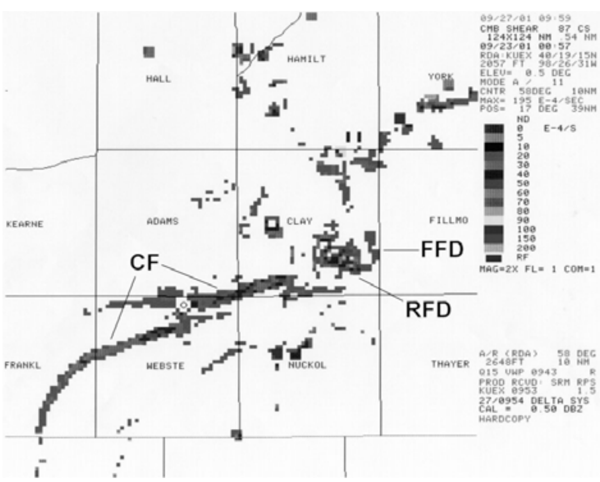

Figure 6. KUEX 0.5 degree Combined Shear (CS) at 0057 UTC on 23 September 2001. Labels same as Figure 2.
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4. SUMMARY AND CONCLUSIONS

Prior research studies have shown that preexisting boundaries can influence storm development and intensity (Maddox et al. 1980). Maddox et al. found these boundaries to be regions of enhanced convergence and low-level vorticity. Markowski et al. (1998) found that of all significant tornadoes during VORTEX, nearly 70 percent occurred within 30 km of the boundaries, most often on the cool side of these boundaries.

The Clay County tornado appears to be another case where the stretching of low-level vorticity along a preexisting boundary played a predominant role in the development of this supercell and subsequent tornado in otherwise non-favorable conditions. It is possible relatively cool outflow associated with the original cells may have intensified the thermal characteristics of the outflow boundary and/or eventual forward flank downdraft (FFD) of the storm.

5. ACKNOWLEGEMENTS

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