P3.3 CHARACTERISTICS AND STORM EVOLUTION ASSOCIATED WITH THE 30 MAY 2003 TORNADIC EVENT OVER CENTRAL ILLINOIS

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1. INTRODUCTION

During the early evening of May 30, 2003, Low Precipitation (LP) Supercells developed across parts 0f Central Illinois. The Lincoln WSR-88D (KILX) revealed that these storms developed rapidly across west-central Illinois, along an apparent moisture discontinuity, or dry line. These storms were responsible for at least seven tornadoes and scattered reports of wind damage across the WFO Lincoln county warning area (CWA). Many of these storms along the dry line produced intense centers of rotation (mesocyclones). In particular, the southern most supercell spawned five separate tornadoes and caused F0 to F2 damage. Another supercell northeast of the southern storm spawned a tornado and produced F2 damage. Damage associated with the southern storm across Logan and De Witt counties exceeded 9.7 million dollars. Several National Weather Service (NWS) staff members observed one of the five tornadoes northwest of the office. This tornado briefly produced F0 damage in an open field. However, another larger tornado developed four miles north-northeast of Lincoln Illinois and became a multiple vortex tornado and caused structural damage to house trailers, homes, outbuildings and significant tree damage. This tornado traveled southeastward across east-central Logan through central De Witt counties. The greatest impact from this tornado was F2 damage extending from the town of Hallsville to the south side of Clinton Illinois in De Witt County where numerous homes and businesses were severely damaged and seven businesses destroyed. Four individuals were injured with this storm. A preliminary map of the tornadic damage is shown in figure 1.

This study investigates several components of this event including: 1) an analysis of the mesoscale and near-storm environments, and 2) discuss initial findings of the Logan and De Witt County tornadic storm hereafter referred to as the Logan-De Witt storm) and its evolution and associated circulation characteristics preceding and during the time of tornado occurrence.

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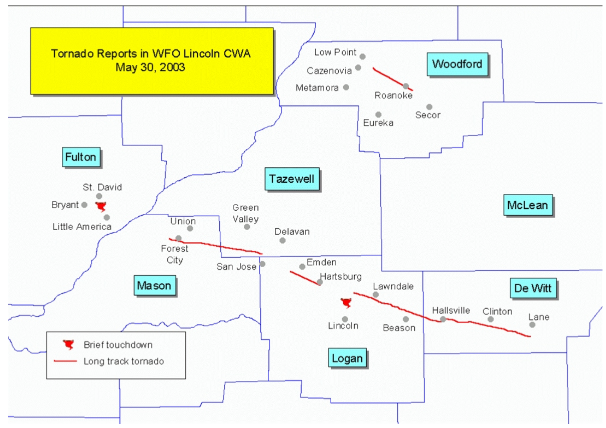

Figure. 1. Damage Map of tornadic damage tracks associated with the Logan-DeWitt Storm.

Satellite, upper air and surface observations will be used to reveal the environment associated with these storms. WSR-88D Doppler data from KILX and preliminary Doppler data from the Naval Research Laboratory (NRL) P3 aircraft will be used to investigate the storm reflectivity and circulation characteristics of the Logan - De Witt storm.

2. SYNOPTIC ENVIRONMENT

The 0000 UTC (hereafter all times are UTC) 31 May 2003 synoptic environment showed a progressive 500 mb trough axis extending from central Wisconsin through northwest Missouri. Diffluent flow at 500 mb was evident across much of central and southern Illinois into Indiana and parts of Kentucky. The 0100 surface analysis showed a dry line extending across southern Wisconsin into west central Illinois (Fig. 2). A narrow axis of 16 C (60 F) or greater dew points extended from Saint Louis Missouri northeast to just north of Peoria, Illinois along and ahead of the dry line. The Local Analysis Prediction System (LAPS) available on the NWS Advanced Weather Interactive Weather Processing System (AWIPS) at 0100 showed magnitudes of Convective Available Potential Energy (CAPE) from 1500 to 3000 J kg-1 within the axis of 16C or higher dewpoints. One particular note of interest at 0100 was the significant gradient of surface dewpoints across the dryline. Dew points of 4 C were reported at Galesburg, while dew points of 22 C occurred at Peoria (PIA), only 70 km to the southeast. Sounding data at 0000 from (KILX) downstream of the storms showed an isothermal layer from 860 to 800 mb and a strong subsidence inversion from 660 to 630 mb. This elevated subsidence layer was also evident on the 2100 sounding from WFO Davenport Iowa (KDVN) and appeared to be associated with an upper-level front on the anticyclonic shear side of the upper-level jet. The magnitude of the surface-based CAPE at KILX was 614 J kg-1; Lifted Index was 0, and the 0-3 km storm-relative helicity was 307 m2/s2 (Fig. 3). Based on the 0000 sounding the environment at KILX appeared to be a low CAPE - highly sheared environment. At KDVN the 0000 sounding (not shown) was launched just preceding the passage of the dry line and revealed surface-based CAPE values of 2350 J kg-1.

The Bow Echo and MCV Experiment (BAMEX) was occurring over the Midwest during this period and as part of the experiment special soundings were released across parts of central Illinois (Przybylinski and Schmocker 2003). Dropsondes were launched by the WMI_Lear Jet preceding and during the period of severe convective activity. One sounding was taken by WMI_Lear Jet at 0047 just northeast of Lincoln, Illinois (Fig.4). This data also showed the strong subsidence inversion, identified earlier from KILX and KDVN, was located between 600 mb to 550 mb. This inversion was at a higher altitude than indicated by the 0000 KILX sounding revealing the slope of the upper-level front.

3. STORM EVOLUTION

During the period of 0030 through 0200, three supercells were identified across North Central Illinois as they traveled eastward at speeds of 15 to 18 m s-1. Our discussions will focus on the storm characteristics and evolution of the southern-most supercells referred to as the Logan-De Witt storm. This storm was investigated by the NRL P3 during the period when a strong tornado (F2 damage) occurred over parts of northeast Logan County.

At 0002, the planview reflectivity image (KILX) showed a line of discrete storms extending from north-central Illinois through west central sections of the state. The initial echo of the Logan-Dewitt storm was observed approximately 100 km west-northwest of KILX or 15 km west of Canton Illinois in Fulton county.

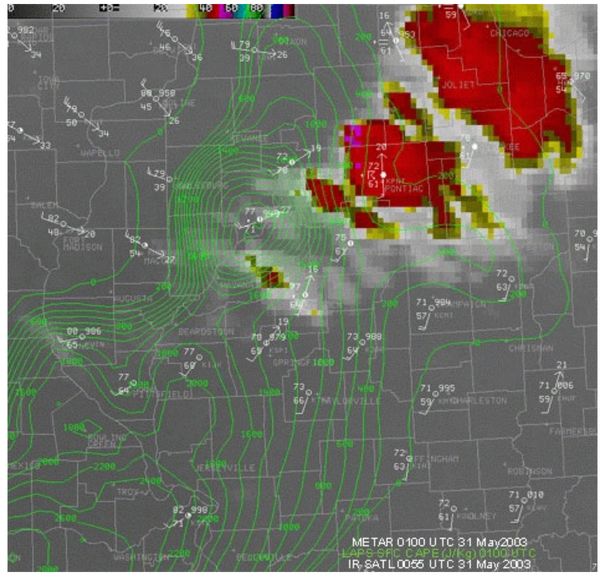

Figure 2. GOES IR Satellite Imagery for 0000 UTC 31 May 2003. Surface data plots and CAPE contours are overlaid.

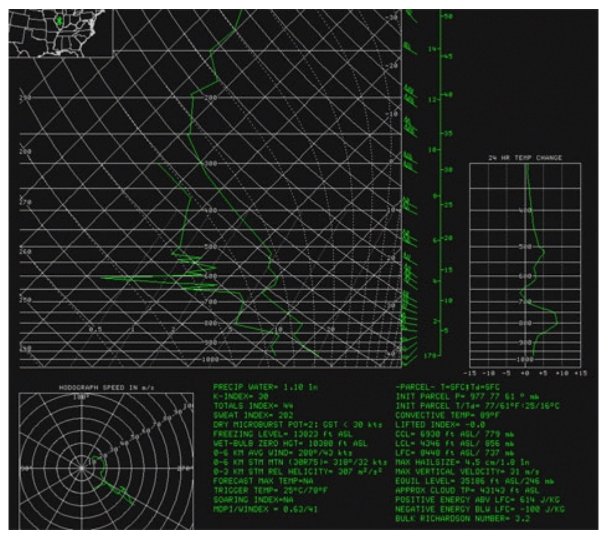

Figure 3. Skew-T Log-P Sounding from Lincoln Illinois (KILX) 0000 UTC 31 May 2003.

Reflectivity values of 10 to 15 dBz were observed (Fig. 5). This storm rapidly developed during the subsequent fifteen minutes as it moved into the eastern part of Fulton County. At 0017, (not shown), reflectivity magnitudes of 45 to 50 dBz were noted with the strongest core. However, an area of weaker reflectivities 10 to 15 dBz were detected just upwind of the strongest core. The first detection of weak cyclonic rotation (not shown) was noted at an altitude of 2.0 - 3.0 km and 5 km upshear of the high

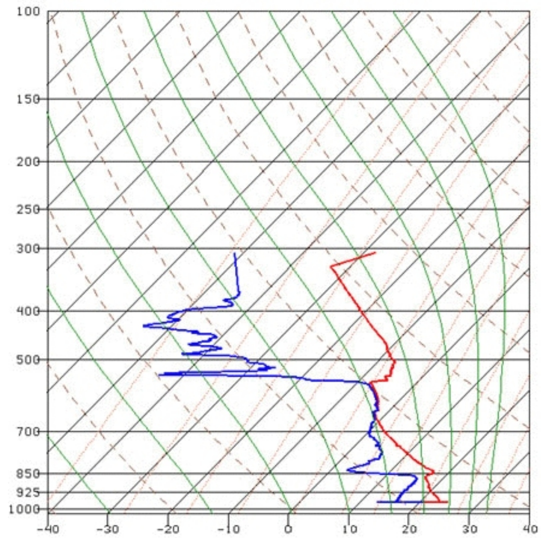

Figure. 4. Skew-T Log-P sounding from a dropsonde released by the WMI Lear Jet taken at 0047 UTC 31 May 2003.

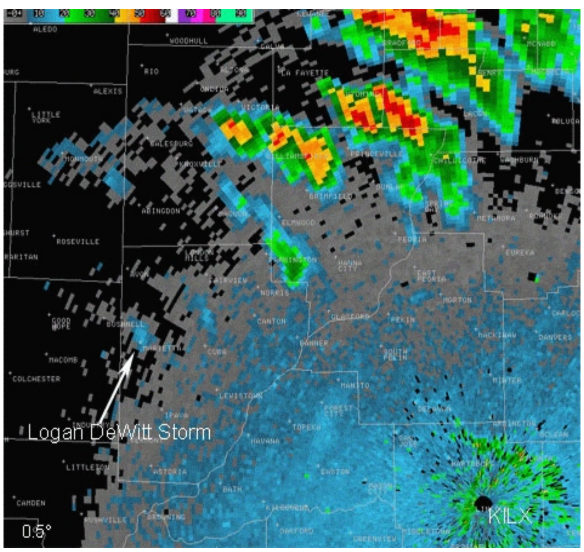

Figure. 5. WSR-88D plan view reflectivity image from Lincoln IL (KILX) (0.5 slice) for 0002 UTC 31 May 2003.

reflectivity core in the vicinity of the weaker reflectivities. This rotation rapidly evolved into a mesocyclone we defined as Circulation 1 (C1). The overall storm structure resembled that of a *low-precipitation* supercell (Bluestein and Parks 1983).

After 0027 (not shown) an impending storm split occurred with the left moving storm revealing an inverted "U" shaped reflectivity structure while the right moving storm showed a more linear reflectivity pattern with the strongest low-level reflectivity gradients observed along the southern flank of the storm. A "V" notch reflectivity pattern was noted along the upwind flank during the period when the left and right moving storms were splitting. This "V" notch pattern has been documented Woodall and Bluestein (1990) and Glass and Truett (1993) during a split of a severe storm. Volumetric storm-relative velocity data for the period of 0027 to 0036 showed a cyclonic (C1) /anticyclonic couplet (C2). The stronger cyclonic couplet was associated with the weakly reflective pendant echo near the upshear flank of the right moving (RM) storm. In contrast, a relatively broad anti-cyclonic couple was coupled with the left-moving (LM) storm. The stronger cyclonic vortex deepened and intensified between 0022 and 0036 with the strongest rotation identified between 3.0 and 4.5 km. Burgess (1982) has shown that mesocyclones often deepen and intensify from mid-levels during the early part of supercell evolution. The first of several tornado touchdowns occurred at 0036, five miles south of Canton in eastern Fulton county. The tornadic damage was brief and rated F0 intensity.

Further intensification of the left and right moving storms were evident in the reflectivity field at 0056 compared to the storm structure noted earlier. Strong low-level reflectivity gradients on the southern (northern) flanks of the right (left) moving storms continued to signify the location of strong updrafts with each storm (Fig. 6). However, the right moving storm continued to reveal LP supercell characteristics as Circulation 1 was displaced (4 km west) upshear from the storm's low-level high-reflectivity core region. C1 was embedded within the weak reflectivity (15 - 30 dBz) pendant echo region of the storm upshear from the LP's high reflectivity core region. A small 40 - 45 dBz echo embedded within the pendant echo may have been suggestive of possible debris with the vortex. Another interesting feature with this storm was the growth of short-lived discrete weak reflectivity cores upshear from LP's pendant echo region. The new weak cell growth suggested that updrafts were immediately presented upshear of the LP storm and downshear of the dryline. One of these weaker cells persisted through 0115. Overall the storm structure continued to suggest the presence of multicell traits.

Storm-relative velocity data (0056) showed C1 as a strong mesocyclone within the region of the pendant echo. Magnitudes of rotational velocities (Vr) at 1.5 degree elevation were 20 m s-1 with stronger rotation noted at the 0.5 degree elevation (21 m s-1). A gate-to-gate couplet was also observed at the 0.5 degree elevation with a delta-V value of 30 m s-1. C1 spawned a second tornado at 0056 and caused F1 damage along a eight mile path. Several homes in the town of Forest City in Mason County Illinois sustained varying degrees of damage. Several outbuildings along with numerous trees were also damaged by this tornado.

A rotational velocity time-height trace was constructed for Circulation 1 for the period of 0017 through 0116 from the KILX Doppler radar (Fig. 7). Due to archive problems, the four lowest elevations slices were only captured with this event. The trace between 0017 and 0032 showed that C1 originated between 1.2 and 3.0 km with the strongest rotational identified around 2.8 km (agl). C1 rapidly deepened and intensified between 0022 and 0032 with the strongest cyclonic rotation detected at 3.5 km. The early part of the trace revealed nearly similar characteristics to observations of the 'Organizing Stage (OS)' of mesocyclone evolution described by Burgess (1982) where supercell mesocyclones form from mid-level beginnings and deepen upward and downward during this stage. A brief tornado occurred at 0036 during the later part of vortex deepening. However, the magnitude of rotation at the lowest two elevation was weak with values of 10 and 13 m s-1. C1 intensified during the subsequent volume scans with increasing magnitudes of Vr throughout the lower part of the vortex. A gate-to-gate couplet was briefly detected for one volume scan at 0041 (0.5 slice) with magnitudes of delta-V of 50 m s-1. A tornadocyclone was detected within the larger vortex from 0051 through 0116. Magnitudes of delta-V equal or exceeded 33 m s-1 at the lowest two elevation slices at 0051 and preceded the second tornado touchdown by five minutes. Rotation of the larger mesocyclone significantly intensified within the lowest two slices at 0056 at the beginning of the second tornado touchdown with values 20 m s-1 or greater. This tornado produced damage of F1 intensity over sections of northern Mason County Illinois. The tornadocyclone further intensified a second time at 0101 with values of 45 m s-1 or greater within the lowest 2.5 km and a values of 67 m s-1 at 0.5 slice. Delta-V values remained strong for the following two volume scans Between 0056 and 0136 Logan-DeWitt storm evolved into a classic supercell structure. Moller et al. 1990; Doswell et al. 1990; and Moller et al. 1994 have shown that supercells can evolve from LP to Classic and then to High-Precipitation supercell structures. The storm at 0136 shown in figure 8 was located approximately 10 km north and northeast of the KILX radar site. Storm-relative velocity data showed an instantaneous view of a relatively new and intense mesocyclone (C3) associated with the classic supercell. The overall vortex structure was *'cyclonic convergent'* with magnitudes of delta-V exceeding 55 m s-1. Preceding this time the velocity structure at low-levels revealed a nearly pure *convergent* pattern similar to observations documented by Burgess and Magsig (1998); Glass and Britt (2000). A second long track tornado formed at 0138 continued to 0151. C3 evolved into a tornadocyclone at 0141 as it's core diameter significantly decreased to less than 1km while delta-V values equal or exceeded 51 m s-1 (see Vr trace in Fig. 9). Damage rated F2 occurred between 0141 and 0146 over northeast Logan county. (10 km northeast of Lincoln Illinois). The tornadocyclone maintained this structure through 0206. Since the tornadocyclone was within 25 km of the WSR-88D, we were able to capture a brief weakening and second rapid intensification of the vortex. At 0151, the tornadocyclone briefly weakened with the strong rotation only detected at or above the third elevation slice (above 0.7 km). Witnesses and video showed the demise of the first tornado and formation of a second tornado with this tornadocyclone near the town of Hallsville at this time. The tornadocyclone intensified a second time at 0156 with delta-V magnitudes equal or exceeding 47 m s-1. The overall reflectivity pattern of the supercell at 0201 showed a classic highly reflective hook echo nearly wrapped within the storm. Corresponding storm-relative velocity data showed at the 2.4 degree slice revealed an intense tornadocyclone with delta-V magnitudes exceeding 60 m s-1 (Fig. 10). The second tornado caused a 6 mile path of F2 damage from east of Hallsville to the south side of Clinton Illinois in DeWitt County. The tornado lifted 10 km southeast of Clinton during the period of vortex weakening. Numerous trees and outbuildings were destroyed while several homes sustained varying degrees of damage.

In addition to the 0047 dropsonde release, additional dropsondes were released by the WMI Lear Jet during and after the period of tornadic activity over Logan and DeWitt counties in central Illinois. Another dropsonde was launched at 0209 upshear of the supercell over northeast Logan county near the proximity of the dropsonde released at 0047 (Fig. 11.) The sounding revealed a much drier layer of air between 700-500mb compared to the earlier sounding. The 0209 sounding indicated that the very early stages of the dry line had moved east through northeast Logan County with a northwest wind near the surface while relatively moist west-southwest flow existed above 950 and 700 mb. Approximately seven minutes later, a second nearby dropsonde was released approximately 30 km north of the Logan-DeWitt supercell (not shown). The sounding revealed significantly different characteristics in the moisture profile showing a deep moist layer between the surface and 550 mb. The dropsonde occurred east of the dryline. However the degree of instability was greater with the 0209 release over northeast Logan which occurred right at the interface of the dryline and narrow ribbon of moist unstable air. Limited wind data from the 0216 release did reveal the transport of moist unstable air within the lowest 75 mb of the sounding as winds within this layer were from the southwest at 20 m s-1.

4. Summary

An investigation of the Logan - DeWitt tornadic supercell is underway. This study is to look at a storm that produced at least five confirmed tornadoes during it's life cycle across Illinois. During the storm's peak it produced a tornado causing F2 damage that exceeded 9.7 million dollars in damage. The storm took on the characteristics of low-precipitation supercell and gradually evolved into a storm with a classic supercell structure. The early stages of the first mesocyclone (C1) was located approximately four kilometers upshear from the storm's high reflectivity core region within the vicinity of a pendant echo which exhibited weak reflectivities (10 to 15 dBz). The cyclonic vortex persisted in this region of weak reflectivities for over a period of forty minutes.

A second mesocyclone (C3) formed northwest of KILX and moved east-southeastward across northeast Logan and central DeWitt counties. The C3 Vr trace showed a reflection of brief weakening at 0151 and then rapid intensification at 0156. The period of brief weakening correlated well with eyewitnesses who observed the demise of the first tornado and rapid development of a second tornado near the town of Hallsville over extreme western DeWitt county. The second tornado over central DeWitt county eventually becoming rain wrapped and eventually lifted between 0211 and 0215. The C3 Vr trace revealed a significant weakening trend in rotation after 0206 as the mesocyclone became wrapped in heavy precipitation. As the storm continued east to the Indiana border, only funnel clouds were reported and no additional tornado touchdowns. This particular case is of great interest to the authors, as one participated in the NWS operations and the other was involved with BAMEX analysis during the event. Future efforts may include the study of additional mesocyclones which did not spawn tornadoes as the storm traveled to the Indiana border.

5. Acknowledgements

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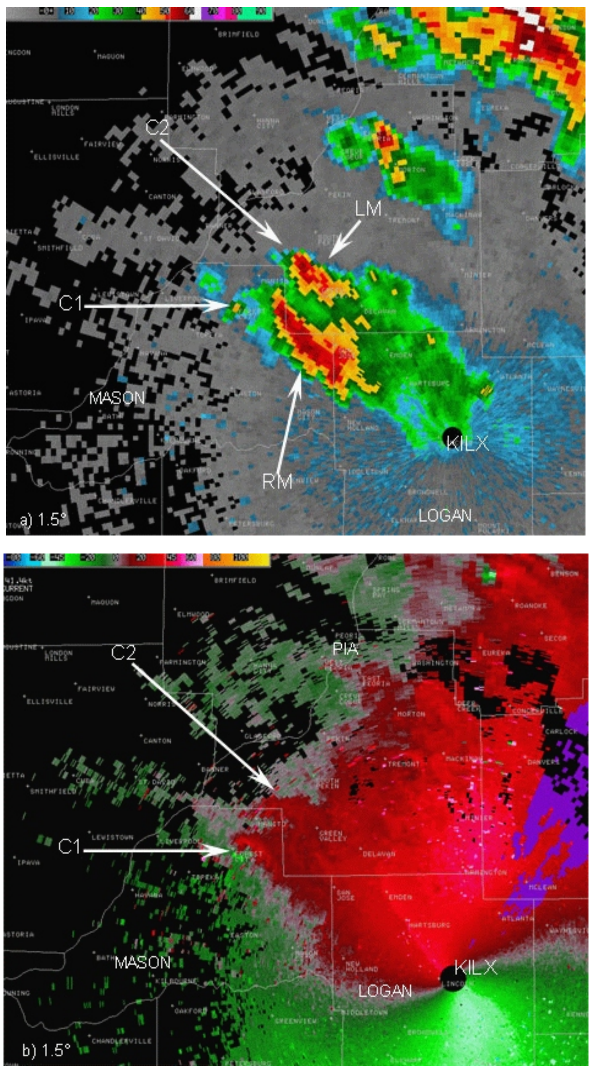

Figure 6. WSR-88D plan-view reflectivity and storm-relative velocity image from KILX (1.5 degree elevation slice) at 0056; 31 May 2003.

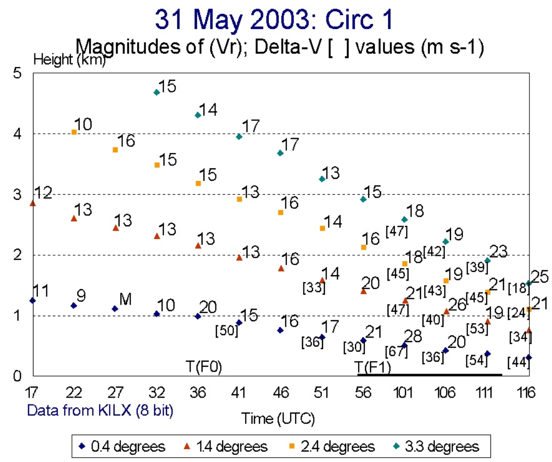

Figure. 7. Time-height cross-section of Rotational Velocities (Vr) of Circulation 1 for the period of 0017 - 0116. Magnitudes of Vr and Delta-V are in m s-1.

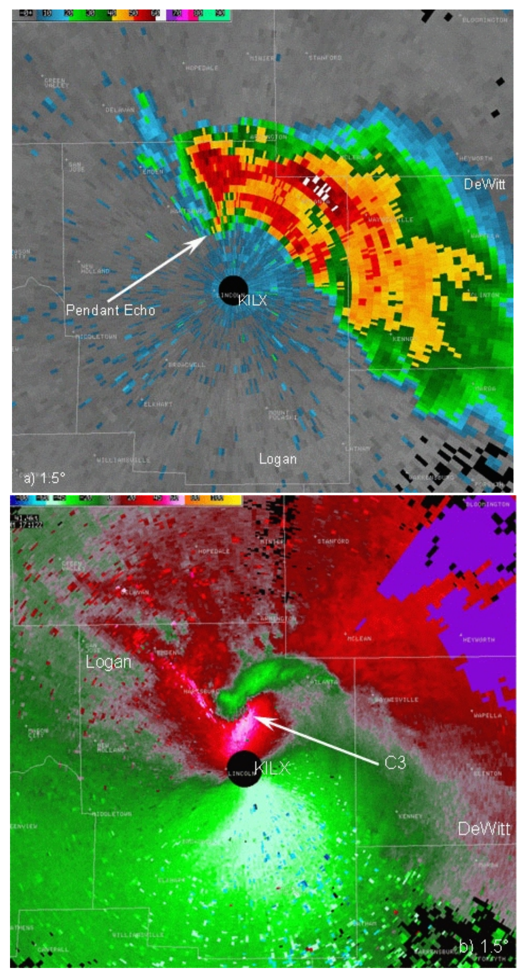

Figure. 8. Same as Fig. 6 except for 0136.

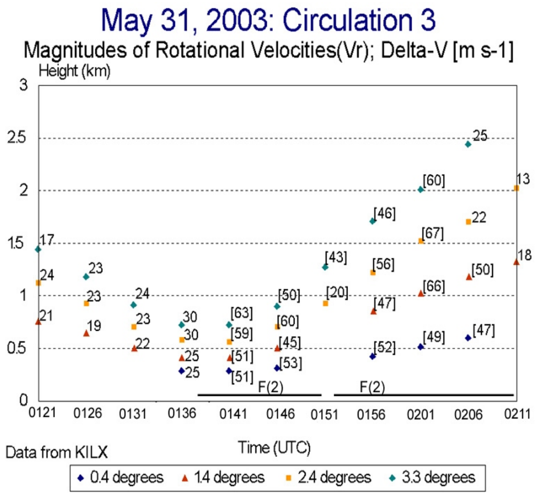

Figure 9. Same as Fig 7 except for Circulation 3. (0121- 0211 UTC).

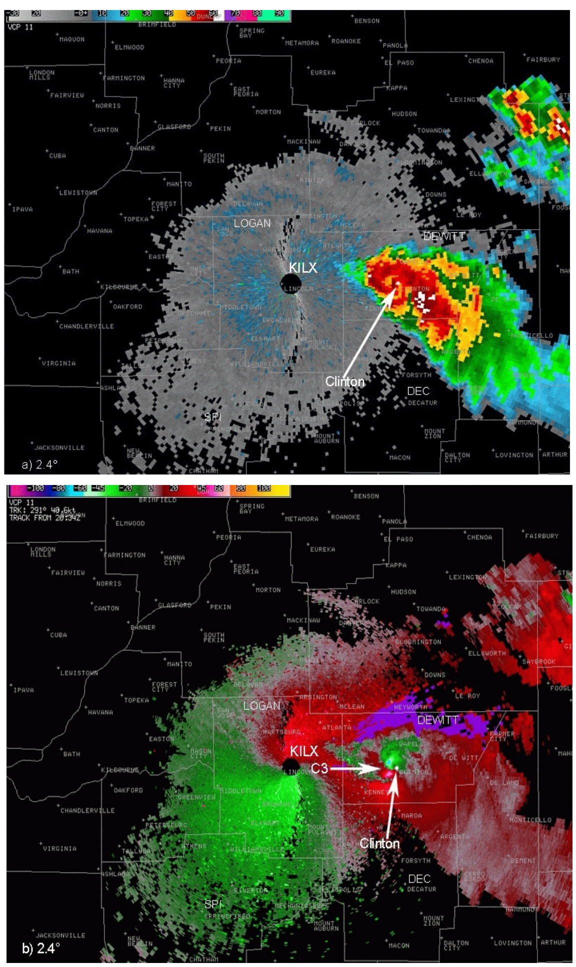

Figure.10. Same as Fig. 6 except for 0201.

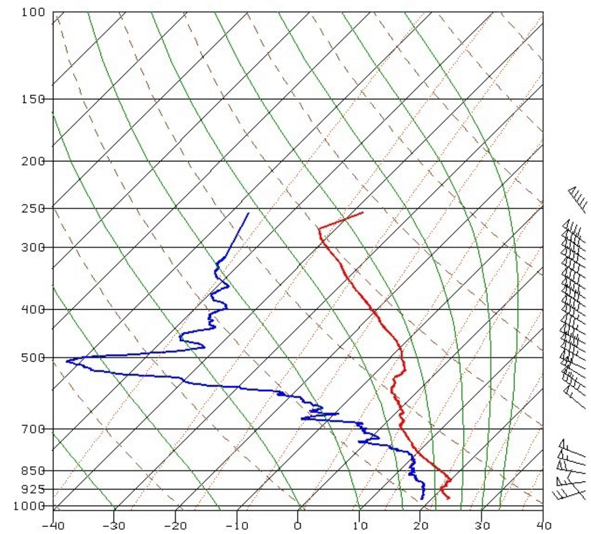

Figure 11. Same as Fig. 4 except for 0209 UTC.