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 of 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 which 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 (U.S. DOC, 2003). 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. It caused structural damage to house trailers, homes, outbuildings and significant tree damage. This tornado traveled southeastward across east-central Logan County through central De Witt County. The greatest impact from this tornado was F2 damage extending from the town of Hallsville to the south side of Clinton in De Witt County where numerous homes and businesses were severely damaged and seven businesses destroyed. Four individuals were injured with this storm (U.S. DOC, 2003). A preliminary map of the tornadic damage is shown in figure 1.

This study investigates several components of the event including: 1) 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. Satellite, upper air and surface observations will be used to reveal the environment associated with these storms.

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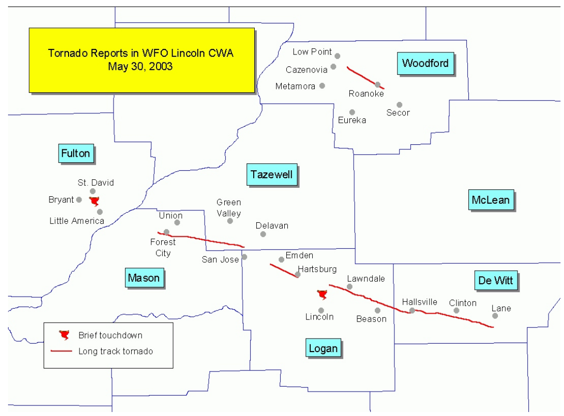

Figure. 1. Map of tornadic damage tracks associated with the Logan-DeWitt storm.

WSR-88D Doppler data from KILX and preliminary Doppler data from the Naval Research Laboratory (NRL) P3 aircraft, in the area for the Bow Echo and Mesoscale Convective Vortex Experiment (BAMEX), 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. Dewpoints of 4 C (39 F) were reported at Galesburg, while dew points of 22 C (71 F) 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 not shown) 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 s-2 (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 the WMI_Lear Jet at 0047 approximately 13 km east 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 supercell 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 plan view 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. Reflectivity values of 10 to 15 dBZ were observed (Fig. 5). The 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.

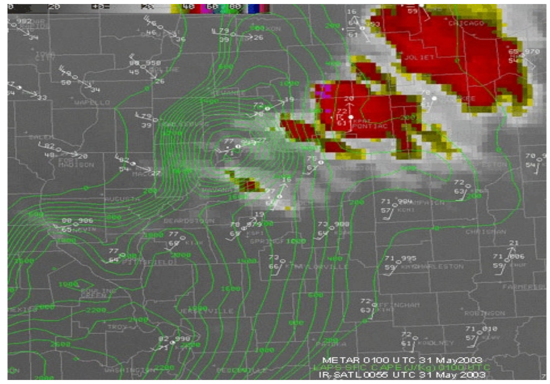

Figure 2. GOES IR Satellite Imagery for 0000 UTC 31 May 2003. Surface data plots and CAPE contours are overlaid.

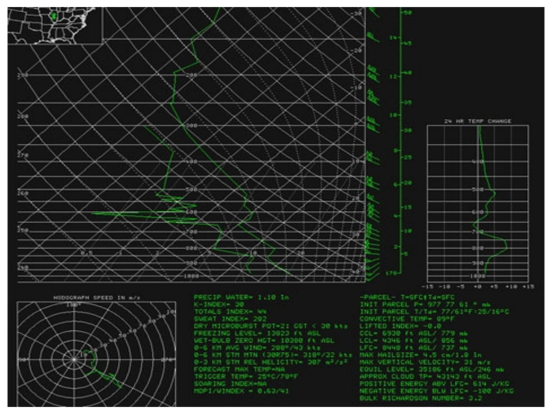

Figure 3. Skew-T Log-P Sounding from Lincoln Illinois (KILX) 0000 UTC 31 May 2003.

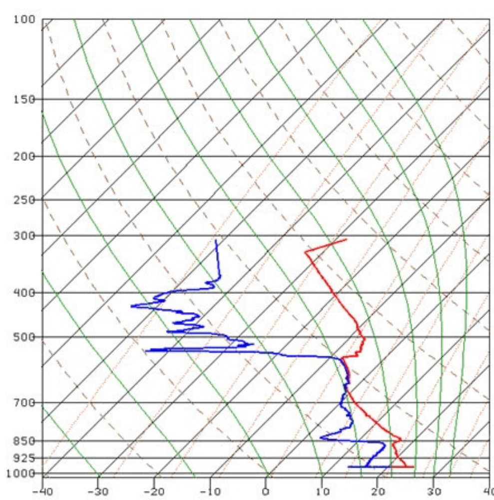

Figure. 4. Skew-T Log-P sounding from a dropsonde released by the WMI Lear Jet taken at 0047 UTC 31 May 2003.

However, an area of weaker reflectivities of 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 reflectivity core in the vicinity of the weaker reflectivities. This rotation rapidly evolved into a mesocyclone defined as Circulation 1 (C1). The overall storm structure resembled that of a *low-precipitation* (LP) supercell (Bluestein and Parks 1983). After 0017, the Logan-De Witt storm continued to intensify showing several small but high reflectivity cores within the overall storm suggesting some signs of multicelluar traits. The individual multiple high reflectivity cores were suggestive of multiple updraft centers along the southern and northern flanks of the storm.

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 by 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. At 0036 the plan-view reflectivity and Doppler velocity images continued to show the highest reflectivity cores well downshear (east) from the mesocyclone suggesting LP supercell characteristics (Fig. 6). The first of several tornado touchdowns occurred at this time two miles south of St. David (or five miles south of Canton) in eastern Fulton County. The tornadic damage was brief and rated F0 intensity.

By 0056 further intensification of the left and right moving storms were evident in the reflectivity field compared to the storm structure noted at 0036. Several small cores having reflectivities of 55 to 60 dBZ were observed at this time mainly with the southern right moving storm (Fig 7). 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. However, the right moving storm continued to reveal LP supercell characteristics as 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 the 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 ms-1 with stronger rotation noted at the 0.5 degree elevation (21 ms-1). A gate-to-gate couplet was also observed at the 0.5 degree elevation with a delta-V value of 30 ms-1. C1 spawned a second tornado at 0056 and caused F1 damage along an eight mile path. Several homes in the town of Forest City in Mason County sustained minor to major damage. Several outbuildings along with numerous trees were also damaged by this tornado.

During the subsequent forty minutes the 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 over a period of time. The storm at 0136 shown in figure 8 was located approximately 10 km north and northeast of the KILX radar site. The plan view reflectivity at 0136 (1.5 slice) showed a pendant echo immediately south of the high reflectivity core region (50 dBZ +) while strong low-level reflectivity gradients persisted along the storm's southern flank suggesting persistent strong updrafts. Storm-relative velocity data at 0136 showed an instantaneous view of a relatively new and intense mesocyclone (C3) associated with the classic supercell. The overall vortex structure was *'cyclonic convergent'* at 0136 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 relatively long-track tornado (11 miles) associated with this vortex initially touched down at 0138 and caused F2 damage over parts of northeast Logan and DeWitt counties. Numerous trees and outbuildings were destroyed while several homes sustained varying degrees of damage.

The 30 May 2003 severe storm event occurred during the Bow Echo and Mesoscale Convective Vortex Experiment (BAMEX) (Przybylinski and Schmocker 2003). The experiment included both airborne (NOAA P3; Naval Research Lab (NRL) P3; and Lear Jet) and ground-based vehicles to sample the near storm-environments and storm evolution of MCSs. The NRL P3 is equipped with a 3 cm Doppler radar located at the tail of the aircraft while the NOAA P3 is equipped with a 3 cm Doppler radar at the tail and a 5 cm Doppler radar beneath the belly of the aircraft to sample plan views of the storm reflectivity and Doppler velocity fields. The tail Doppler radars on both P3's using a fore/aft scanning technique (Jorgensen and Wakimoto 2002) of vertical slices. The horizontal wind can be estimated at beam intersection points. The NOAA P3 flew along the trailing side of the line of storms across north-central and central Illinois while the NRL P3 aircraft completed several passes along the southern flank of the Logan-DeWitt supercell between 0115 and 0145 at an altitude approximately 1.5 km agl (Fig. 9). Vertical reflectivity and Doppler velocity presentation of the supercell from the NRL P3 is shown in figure 10. The vertical reflectivity presentation from the NRL P3 showed a Bounded Weak Echo Region (BWER) along the storm's southern flank and a strong low-level reflectivity gradient immediately north of the BWER. The upper part of the storm's reflectivity field revealed an expanding precipitation canopy indicating the presence of strong upper-level divergence. The vertical cross-section of Doppler velocity data showed a local inbound velocity maximum near the storm's upper northern flank suggesting the intrusion of environmental lower theta-e air from the north and northwest. The feature was partially beneath a region of upper-level divergence near the storm's summit.

A rotational velocity time-height trace was constructed for Circulation 1 during the period of 0017 through 0116 from the KILX radar (Fig. 11). The four lowest elevation slices of storm-relative velocity data were only examined at this time. However, additional elevated slices for C1 and construction of Vr traces for C2 and C3 will be completed in the future. The Vr trace between 0017 and 0032 showed that C1 originated between 1.2 and 3.0 km with the strong rotation identified around 2.8 km (agl). C1 rapidly deepened and intensified during the subsequent three volume scans (0022 - 0032) with the strongest cyclonic rotation detected at 3.5 km. The early part of this Vr trace revealed nearly similar characteristics to observations of the 'Organizing Stage (OS) of mesocyclone evolution described by Burgess (1982) where 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 the period of vortex deepening. However, the magnitude of rotation at the lowest two elevation slices 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 ms-1. A tornadocyclone was detected within the larger vortex from 0051 through 0116. Magnitudes of delta-V equaled 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 ms-1 or greater. This tornado produced damage of F1 intensity over sections of northern Mason County. 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 value of 67 m s-1 at 0.5 slice. Delta-V values remained strong for the following two volume scans.

4. Summary

A preliminary investigation of the Logan - DeWitt tornadic supercell has just begun. This is an initial attempt to study 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 initially took on the characteristics of a 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 km 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.

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 surveying individuals in the path of this storm mainly in Macon, Piatt, and Champaign counties, where there were no reported tornado touchdowns but radar indications of a strong mesocyclone were present. Additional research in the future will focus on the entire life cycle of this storm in Illinois.

5. Acknowledgements

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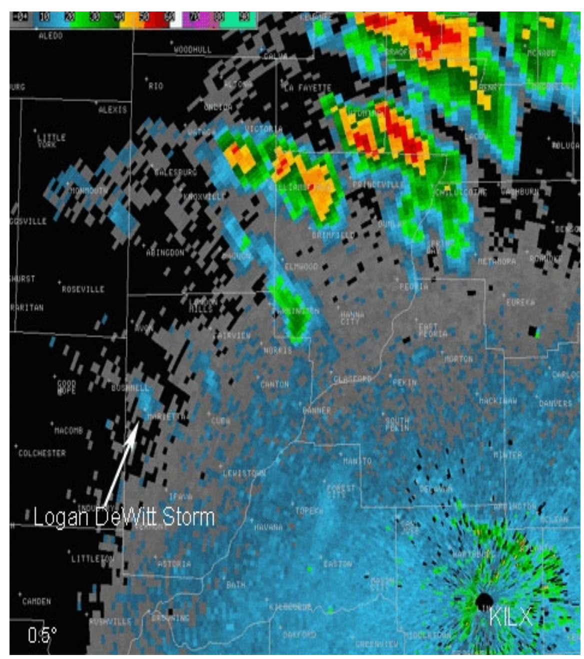


Figure. 5. WSR-88D plan view reflectivity image from Lincoln IL (KILX) (0.5 slice) for 0002 UTC 31 May 2003.

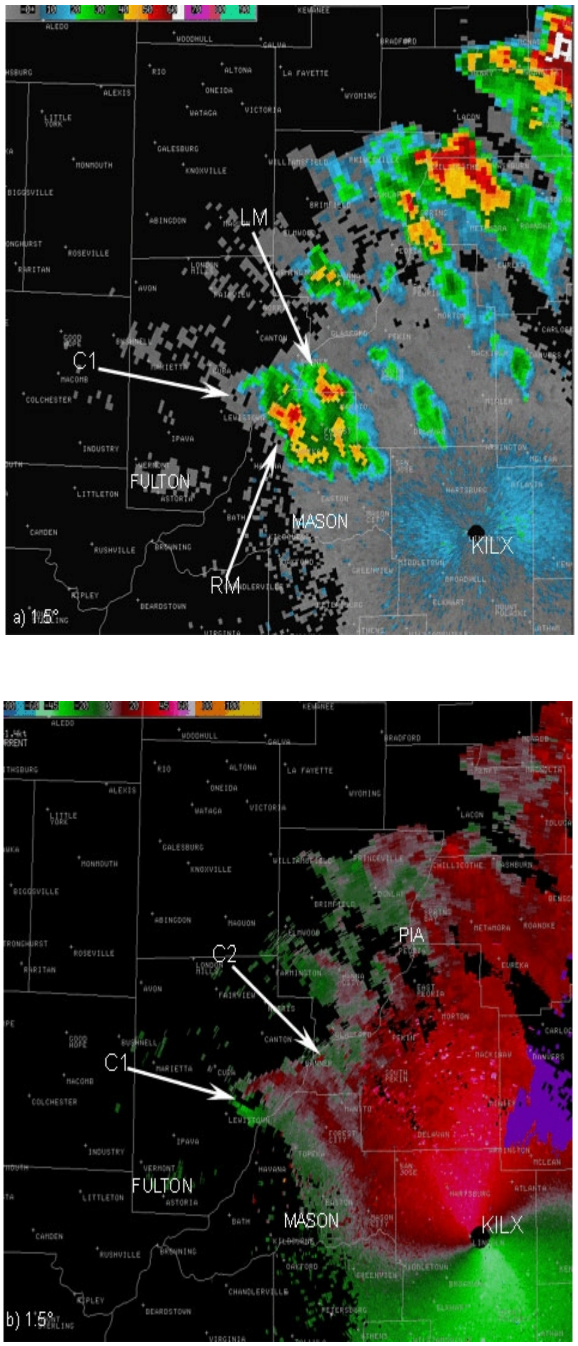


Figure 6. WSR-88D plan-view reflectivity and storm-relative velocity image from KILX (1.5 degree elevation slice) at 0036; 31 May 2003. .

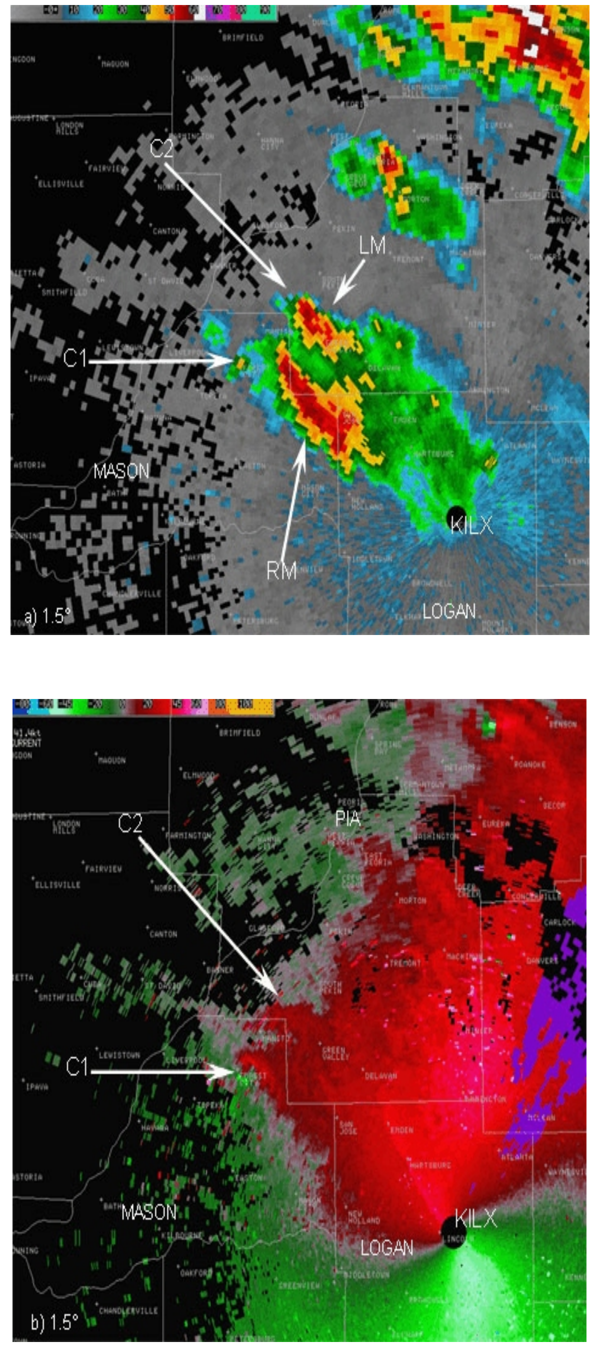
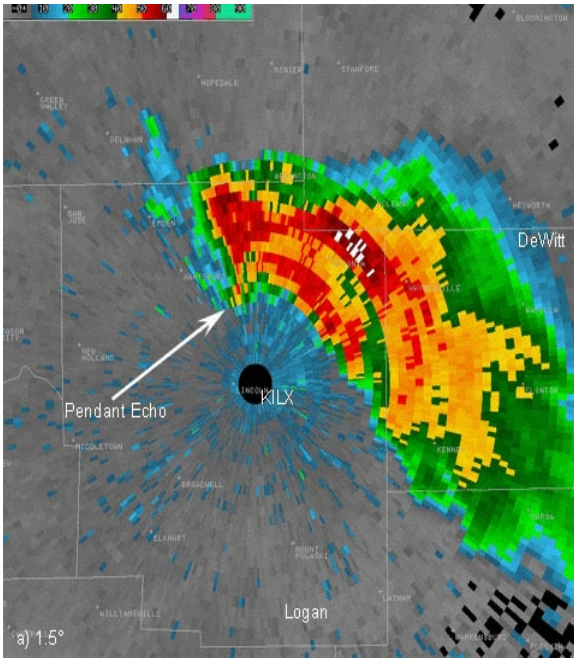


Figure. 7. Same as Fig. 6 except for 0056. Plan views of base reflectivity and storm-relative velocity are shown at 1.5 degree elevation slice.



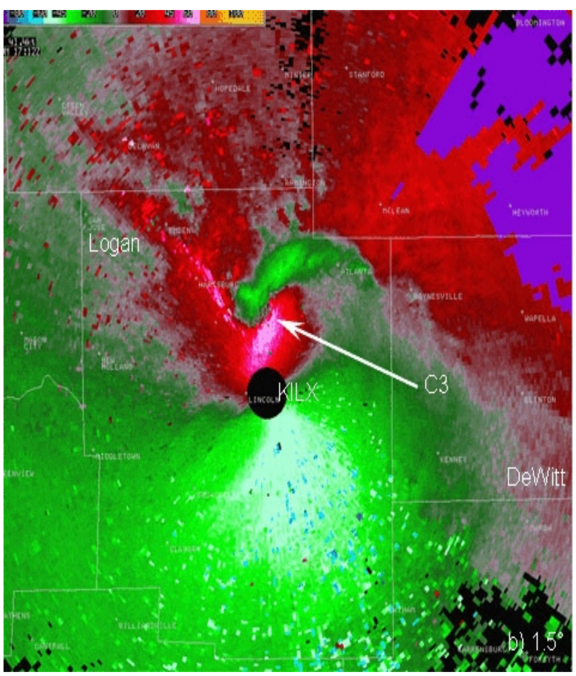


Figure. 8. Same as Fig. 7 except for 0136.

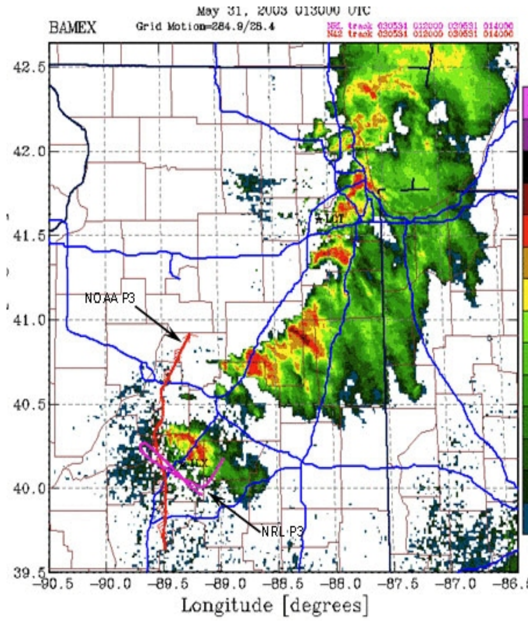


Figure 9. Plan view reflectivity image (dBZ) from NOAA P3 aircraft for 0135. Flight tracks from the NOAA P3 and NRL P3 are overlaid.

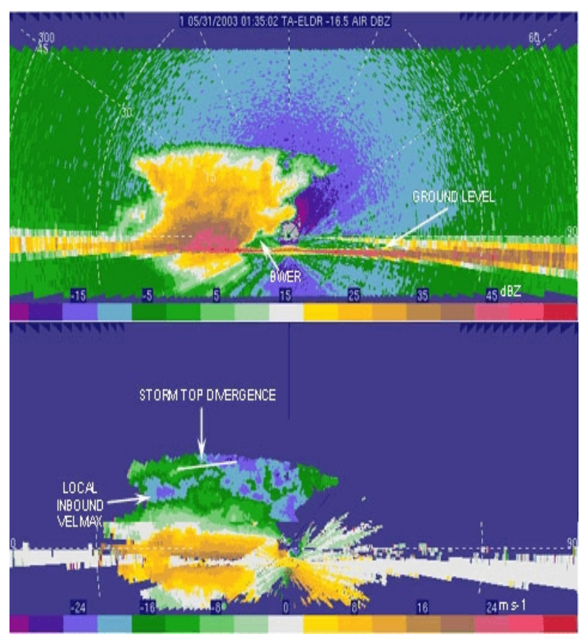


Figure 10. Reflectivity (a) and base velocity (b) cross-sections taken from the NRL-P3 at 0135.

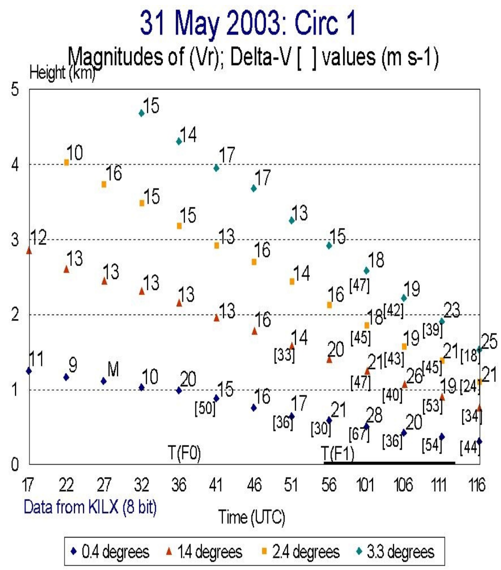


Figure 11. Time-height cross-section of Rotational Velocities (Vr) of Circulation 1 for the period of 0017 - 0116. Magnitudes of Vr and Delta-V are in m s-1.