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The Father's Day 2002 Severe Weather Outbreak across New York and Western New England

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1. Introduction

On 16 June 2002, a substantial severe weather outbreak occurred across the northeast, United States (US). This was the third major outbreak in three weeks across eastern New York and western New England during the 2002 severe weather season. Severe thunderstorms developed that produced large hail, strong winds and tornadoes. The two tornadoes that developed in the Mohawk and Hudson River Valleys were F0's and F1's. A 500 hPa closed low that moved across the northern Great Lakes region on 15 June helped initiate the severe weather on Father's Day (16 June). The midlevel cold pool associated with the 500 hPa low sparked a second day of severe weather for eastern New York and western New England. Several large hail (greater than 1.9 cm) producing thunderstorms on Monday, 17 June 2002 developed, as the trough continued moving east across the Northeast.

Convective initiation occurred early in the afternoon on 16 June with thunderstorms developing over central New York. Steep midlevel lapse rates, moderately high surface dewpoints and Convective Available Potential Energy (CAPE) values coupled with a vigorous 500 hPa short wave trough helped trigger the convection. A 500 hPa southwesterly jet streak greater than 25 ms^{-1} (50 knots) was moving across upstate New York and New England during this outbreak. Wind profiles from soundings across eastern New York and New England indicated the possibility of supercell thunderstorm development conducive for potential tornadoes. The tornado that developed in the mid-Hudson River Valley was associated with a well-defined supercell that formed in Dutchess County, New York and moved into Litchfield County, Connecticut.

This poster will focus on an investigation of the evolution of the large-scale synoptic pattern associated with the severe weather outbreak, and the mesoscale environment that generated the convection. The role of jet streaks at various levels will also be examined. The purpose of this case study analysis is to understand why severe weather occurred. Severe weather was not anticipated on these days. This case study is very intriguing that it produced so much severe weather across New York and western New England. The operational forecast challenges of 500 hPa closed lows across the Northeast will also be addressed in the poster.

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2. Data

Data analyzed include 80-km Eta model grids, surface observations (will be shown in poster), upper air data, satellite imagery (will be shown in poster), and Weather Surveillance Radar – 1988 Doppler (WSR-88D) radar data. The WSR-88D data is high resolution archive IV data from KENX (Albany). The sounding analysis was done with the Skew-T Hodograph Analysis and Research Program (SHARP) software (Hart and Korotky 1991).

3. Synoptic Overview

A closed 500 hPa low was moving through the northern Great Lakes and southern Ontario on 15 June 2002 continued its slow eastward progression to the border of Ontario and Quebec, just north of Lake Ontario by 1200 UTC 16 June (Fig. 1). This vertically stacked system had a very intense midlevel cold pool with 500 hPa temperatures of -20°C upstream of Albany over Buffalo and Maniwaki (southern Quebec), as shown in Fig. 1 and 2a. This is a typical closed low track moving through the Great Lakes region, established in a 21-year subjective climatology in the months of May to September 1980-2000 (Novak et al. 2002; Najuch et al. 2004).

A very strong 500 hPa jet streak of 25 to 30 ms^{-1} (50 to 60 knots) was moving through eastern Ohio, Pennsylvania, New York, New Jersey and New England at 1200 UTC 16 June. Much of eastern New York and western New England was located on the left front quadrant of the midlevel jet streak. This area is usually conducive for cyclone development or severe weather development with the right moisture and instability parameters in place. A strong 500 hPa absolute vorticity maxima was pivoting around the closed low into central and eastern New York on 1200 UTC 16 June (Fig. 2b). The 850 hPa flow was westerly at 12.5 ms^{-1} to 15 ms^{-1} (25 to 30 knots) over New York and Pennsylvania with dewpoints of approximately 8 to 10°C (not shown). A 250 hPa jet streak of 40 to 50 ms^{-1} (80 to 100 knots) was moving through the Ohio Valley and Pennsylvania with good upper-level divergence on the morning of 16 June (Fig. 3). Again, eastern New York and New England was located left front quadrant of the upper-level jet streak (Uccellini and Kocin 1987; Nemeth Jr. and Farina 1994). By 1800 UTC the Eta model forecast showed, this upper-level jet streak strengthened to greater than 50 m s^{-1} (>100 knots) over New Jersey, Pennsylvania and Maryland with a large area of upper-level divergence just off the New England Coast (not shown).

At the surface, a trough began to generate scattered showers and thunderstorms over central NY in the late morning. However, most of eastern NY and western New England had substantial surface based heating by 1600 UTC. Surface temperatures in the Hudson River Valley rose into the 17°C to 20°C range (60's) with surface dewpoints in the 12°C to 15°C range (mid to upper 50's°F; not shown). The diurnal heating ahead of the cloud cover upstream helped destabilize the atmosphere to spark the severe convection that began over the central Mohawk Valley and spread into the Greater Capital Region between 1600 and 1700 UTC. Also, the Eta model continued to forecast strong upward vertical motion (large values of omega) at 700 hPa coupled with cyclonic vorticity advection ahead of the surface trough and the 500 hPa vorticity maxima associated with the closed low (shown on poster).

4. Sounding and Radar Analysis

Upper air analysis showed good support for convective activity 16 June. Eastern New York and western New England were in an area of instability as shown by the SHARP modified Albany, NY sounding at 1200 UTC 16 June. The sounding was modified to a high temperature of 20.9°C and a peak surface dewpoint temperature of 15.0°C, which produced a surface based CAPE value of 1581 J kg^{-1} (range across the forecast area was 500-2000 J kg^{-1} The lifted index calculated was very unstable at -5. The freezing level and wet bulb zero level were very low at 8.4 kft and 6.8 kft respectively, which is a good indicator of potential large hail, if severe thunderstorms develop. Also the 700-500 hPa lapse rate was 6.5°C km^{-1} and the 850 hPa-500 hPa lapse rates were also approaching 6.5-7°C km^{-1}. The midlevel lapse rates were very steep. Shallow low-level veering was evident in the sounding between the surface and 900 hPa. The low-level veering in the Hudson River Valley with strong southwesterly flow aloft (500 hPa to 250 hPa) is a favorable shear profile for supercell development potentially spawning tornadoes. Although the Energy Helicity Index (EHI) was reasonably low at 0.6 and the 0-3 km storm relative helicity was a mere -57 $(m/s)^2$. These parameters are usually much higher for potential tornado development. The precipitable water value off the Albany sounding was 2.06 cm (0.81 inches), which indicated that heavy rainfall would not be a problem. The Vertically Integrated Liquid (VIL) of the Day (VOD) was calculated to be around 35 kg m^2. The forecast thinking was for small hail and not a significant severe weather event on Father's Day. Despite, these conducive sounding parameters, NOAA's Storm Prediction Center (SPC) did not issue severe thunderstorm or tornado watch boxes, since the severe weather occurred in a small area. Also, the significant surface heating and destabilization of the atmosphere was not anticipated by forecasters.

The convection rapidly developed over the southern Adirondacks, central Mohawk Valley and northern Catskills (Fig. 5a) shortly before noon. By 1650 UTC, a line of thunderstorms developed and was moving over the KENX radar (Fig. 5b). However, multi-cellular convection was developing in the cooler air north/northwest of the line. At 1650 UTC, a hook signature (Fig. 6a) had developed over northeastern Montgomery County near the city of Amsterdam. This hook was approximately 25 nautical miles (nm) from the radar with a measured gate to gate 0.5 nm rotational velocity of 21.0 knots and a shear value of 0.022 s^{-1} (Fig. 6b) . This falls below the local warning threshold criteria, but an F0 tornado was reported at 1650 UTC. This tornadic cell was evident in the two previous radar scans with similar weak rotational and shear values. The forecaster focus was on 1) the line of thunderstorms emerging from the KENX radar data acquisition (RDA) site that were producing damaging winds and large hail and 2) multi-cellular convection in the warmer, more unstable air to the south of this line.

The shallow low-level veering in the lower 2-3 kft was the primary mechanism for the tornadic development. The Albany sounding and VAD wind profile from the KENX radar (not shown) were very representative of this shallow veering signature.

By 1749 UTC, a line of thunderstorms had moved into western New England with a history of producing damaging winds and large hail (Fig. 7). A supercell began to develop well south of the line east of the Catskills. This supercell moved into the mid-Hudson Valley and produced an F1 tornado near Pawling in Dutchess County at around 1848 UTC (Fig. 8). It continued to produce F0/F1 damage into Litchfield County, Connecticut near Salisbury.

5. Summary

A potent 500 hPa closed low moving through the Great Lakes region helped initiate a convective outbreak on Fathers Day 2002 across New York and western New England. A surface trough coupled with steep midlevel lapse rates (cold pool aloft), low wet bulb zero heights, moderately high surface based CAPE values and dewpoints in the 10 to 15°C (50-59°F) helped fuel organized low-topped multicellular convection that coalesced into a line with a supercell to the south of it. The area hit by the severe convection was on the cyclonic exit region/left front quadrant of the 500 and 250 hPa jet streaks. Tornadic development was aided by large instability (CAPE) and shallow low-level veering from the surface to about 850 hPa. The predominant flow in the mid and upper-levels was southwesterly.

Much can be learned from this case study. Forecasters should not underestimate the strength of the midlevel cold pool with closed lows, especially if significant surface heating occurs, which aids in destabilizing the air mass. This case shows the wide variety of severe weather generated by warm season closed lows in the Northeast and how challenging they can be to forecast.

6. Acknowledgements

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7. References

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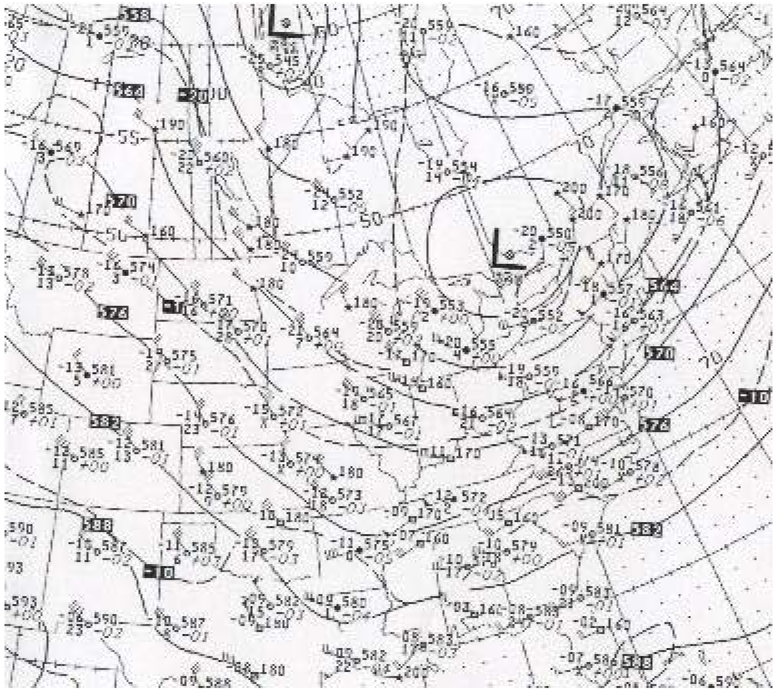

Fig. 1: 500 hPa Radiosonde Observational (RAOB) analysis of height (dam), temperature (°C) and winds (knots) at 1200 UTC 16 June 2002.

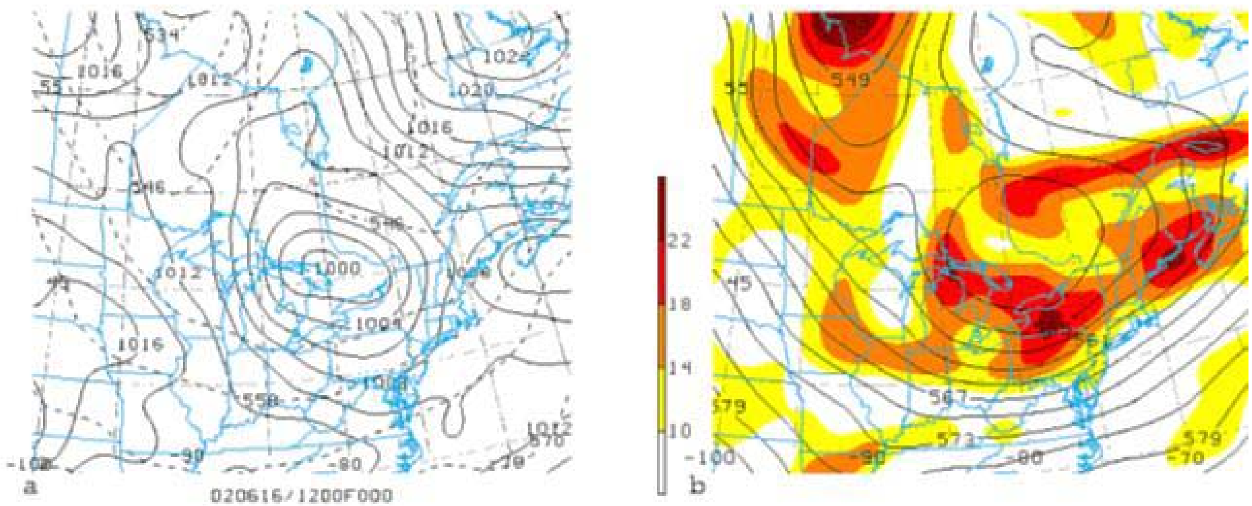

Fig. 2: a) Mean sea level pressure (hPa, solid), 1000-500 hPa thickness (dam, dashed), b) 500 hPa height (dam, solid) and absolute vorticity (x 10^{-5} s^{-1}; shaded above 10 x 10^{-5} s^{-1}), valid 1200 UTC 16 June.

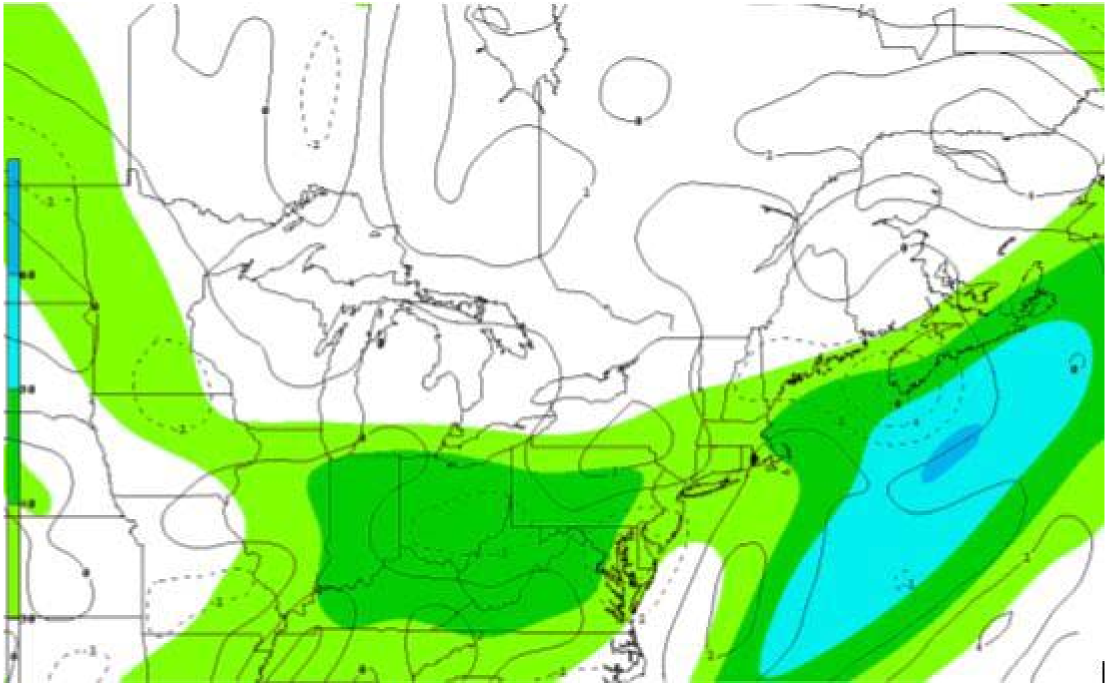

Fig. 3: 250 hPa Divergence (x10^{-5} s^{-1}) solid contours and Isotachs (m s^{-1}) shaded every 10 m s^{-1} valid 1200 UTC 16 June.

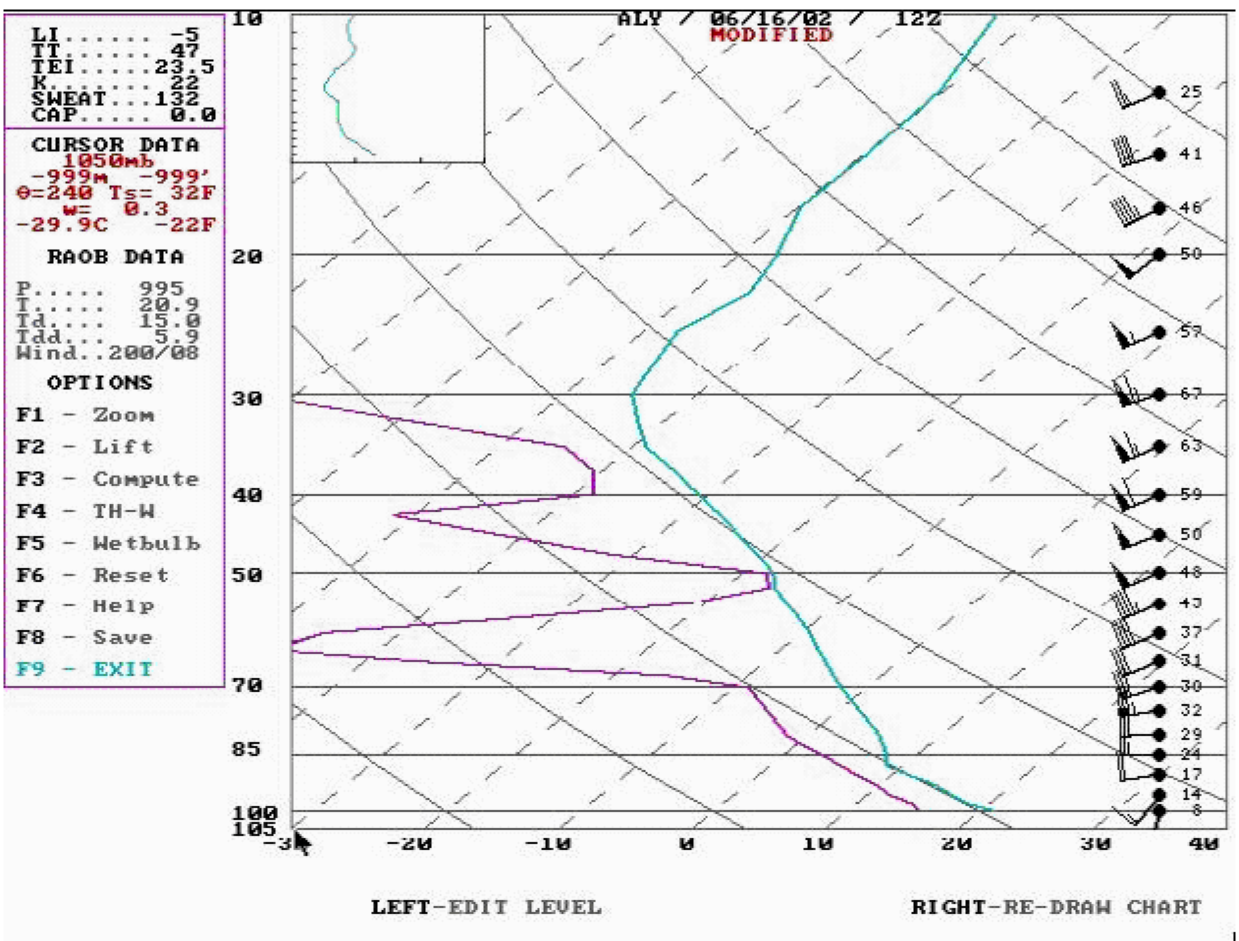

Fig. 4: Albany modified 1200 UTC 16 June sounding in SHARP for peak temperature (20.9°C) and dewpoint (15°C) before the severe weather. Winds are in knots on the sounding.

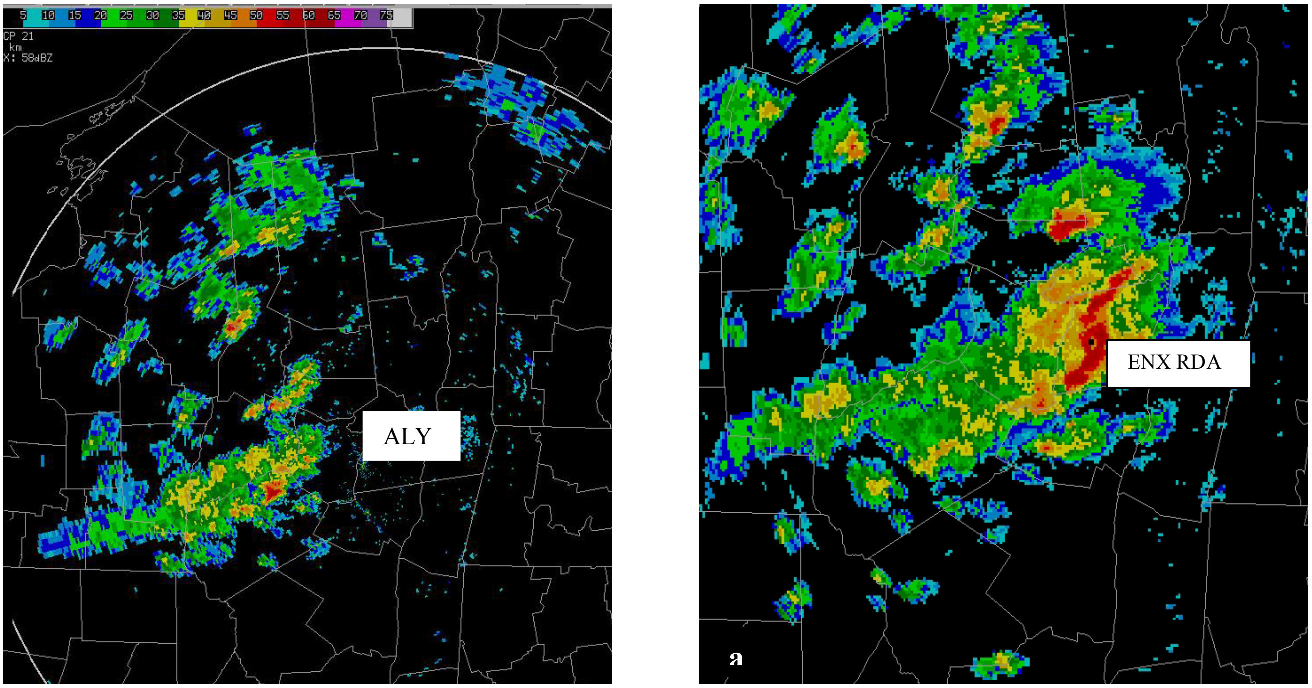

Fig. 5 KENX 0.5° Base Reflectivity (dBZ) at a) 1557 UTC 16 June and b) 1650 UTC 16 June where convection is moving over ENX (Albany) RDA.

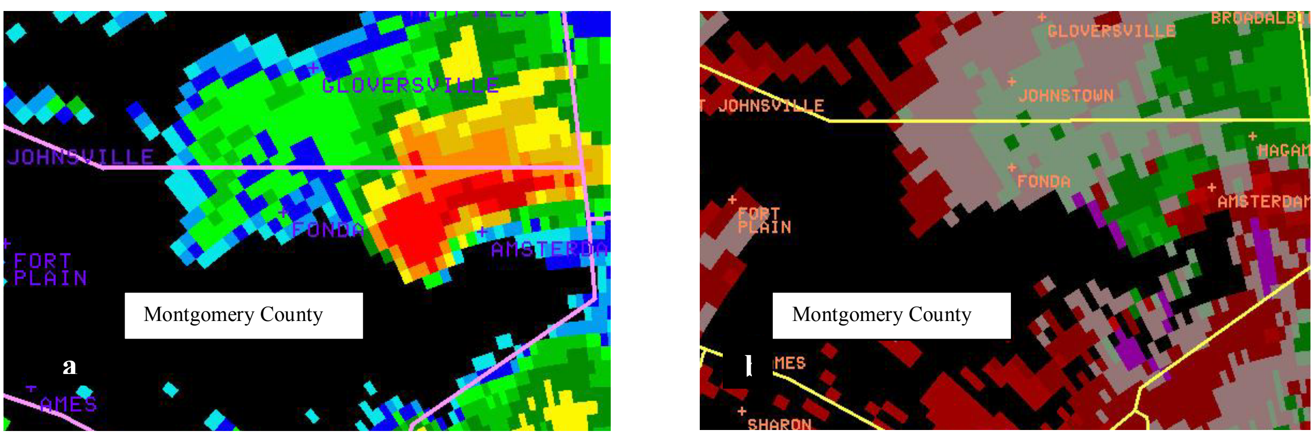

Fig. 6: a) 1650 UTC 16 June KENX 0.5° Base Reflectivity (dBZ) for F0 tornado over Amsterdam, Montgomery County b) 1650 UTC 16 June KENX 0.5° Storm Relative Motion (SRM; knots) for F0 tornado over Amsterdam, Montgomery County. The hook signature was about 25 nm from the radar with a 0.5 nm gate-to-gate rotational velocity of 21.0 knots and a shear value of 0.022 s^{-1}.

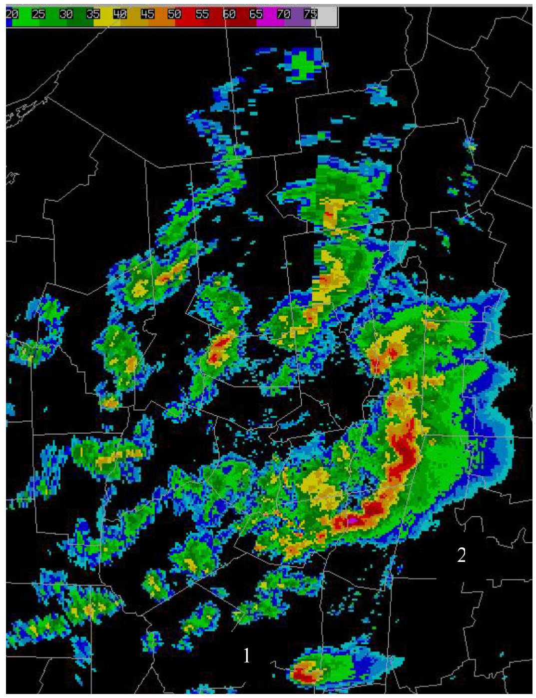

Fig. 7: 1749 UTC 16 June KENX Composite Reflectivity (dBZ). Number 1 shows a supercell moving into southwestern Dutchess County. Number 2 shows a line of convection moving into western New England.

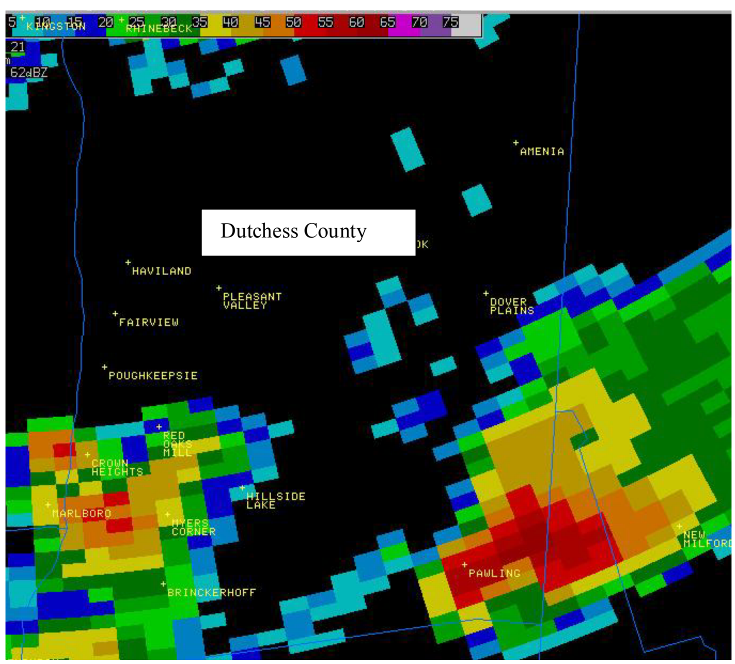

Fig. 8: 1848 UTC 16 June KENX 0.5° Base Reflectivity (dBZ) with hook signature of F1 tornado near Pawling, Dutchess County.