The 17 February 2006 Severe Weather and High Wind Event across Eastern New York and New England

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1. Introduction

Severe thunderstorms across New York (NY) and New England, are very uncommon in the Winter. For example, Albany only averages about 1 thunderstorm day every decade in the month of February (Fig. 1). A rare one-two punch wind event occurred 17 February 2006. First, a line of severe thunderstorms producing damaging winds in excess of 50 knots (58 mph) and large hail (greater than 1.9 cm) occurred along an arctic cold front between 1200 UTC (7 am LT) and 1800 UTC (1 pm LT) over much of eastern New York and New England (Storm Data). Sounding data revealed little or no instability ahead of the cold frontal passage, which made short term forecasting of the severe convection a few hours in advance extremely difficult. The severe convection was followed by widespread wind damage due to the strong horizontal surface pressure gradient (numerous gusts in excess of 50 kts.) in the wake of an arctic cold front.

This presentation will take a multi-scale approach analyzing the event from the synoptic-scale to the storm scale, in order to understand the environment that caused the anomalous and under-forecasted cool season severe weather over the Northeast. It will be shown that a narrow cold frontal rainband developed from the strongly forced low-instability severe convective line.

2. Data

Observational data used in the analyses include surface (MSAS and LAPS) and upper air observations, satellite imagery, and KENX WSR-88D data. The WSR-88D data is high resolution 8-bit data from KENX. SPC upper air charts and soundings will also be used (www.spc.noaa.gov) from the severe weather thunderstorm archive. A variety of deterministic and ensemble model guidance including the NCEP or NCAR Global Reanalysis dataset (1961-1990 mean and standardized anomalies), NAM 80 and NAM 12km data will be shown in the presentation.

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3. Synoptic Overview

A strong negatively tilted 500 hPa short wave trough was approaching from the eastern Great Lakes region and the Ohio Valley at 1200 UTC 17 February 2006 (Fig. 2). A cutoff low or the polar vortex was over the northern Plains and south-central Canada with -42ºC air at the core of the low. A potent 500 hPa jet streak in excess of 100 kts. was moving through the Ohio Valley into western NY at 1200 UTC. Most of eastern NY and New England were in a warm sector that morning with surface temperatures in the 10-15°C (surface map not shown) range prior to the strong cold frontal passage. Eastern NY and New England were located in the favorable left front quadrant of mid- and upper-level jet streaks (Uccellini and Kocin, 1987; Nemeth and Farina, 1994) with strong divergence aloft (Fig. 3). A very strong low-level thermal gradient was over the Northeast extending westward into the central Great Lakes region. Temperatures were well above normal at 850 hPa that morning (not shown). An anomalous low-level jet of 45-60 kts. was from the Mid Atlantic region northeast into New England allowing warm air ranging from 6-8ºC to be over eastern NY and New England (not shown). At 1200 UTC, 850 hPa temperatures in the wake of the arctic cold front were -15ºC over central and western MI (not shown). Tremendous low-level cold air advection and powerful post frontal winds would occur with the frontal passage in the late morning.

The Global Reanalysis anomalies were impressive with the strong surface wave and arctic front (Fig. 4). These anomalies are calculated from the NCEP/NCAR 30-year baseline climatology from 1961-1990. The surface wave would track north of the Saint Lawrence River Valley with mean sea level pressure values 2-3 standard deviations lower than normal. Anomalous precipitable water air would be over NY and New England. Precipitable water anomalies would be 2 to 4 standard deviations greater than normal. The low-level wind anomalies were generally 2-3 standard deviations greater than normal due to the strength of the low-level jet ahead of the front. Past research has shown these low-level wind anomalies coupled with a sharp 25 K theta-e gradient or greater at the 1000, 925, or 850 hPa levels over $\leq$ 400 km are associated with exceptionally strong frontal boundaries (Stuart and Grumm, 2006; Stuart

2004). The theta-e difference at 850 hPa from eastern NY near Albany (310 K) west to eastern Michigan near Detroit (275 K) was 35 K at 1200 UTC 17 FEB (not shown).

3. Sounding and Mesoscale Analysis

The upstream sounding at Buffalo at 1200 UTC 17 February 2006 had Mixed Layer Convective Available Potential Energy (MLCAPE) values of less than 50 J kg^{-1} but had a 0-6 km deep shear value of 85 kts. Downstream, the Rapid Update Cycle (RUC) model forecasted 700-500 hPa lapse rates in excess of 7ºC km^{-1} over eastern NY and New England. The 1200 UTC February 2006 KALB sounding (Fig. 5) showed a tremendous amount of shear (0-6 km shear of 64 kts.) with little or no instability. Low-level veering wind flow was evident in the surface to 850 hPa layer, while from the 850 hPa to 300 hPa layer it was nearly unidirectional. 0-1 and 0-3 km SRH values were 202 and 219 $(m/s)^2$. The degree of low-level moisture in the boundary layer, the amount of surface heating and instability were highly in question for severe convection, despite the highly sheared atmosphere. It would have been a potential tornadic supercell environment if more MLCAPE was present (Thompson et al., 2003). A prefrontal trough focused an area of showers that helped moisten the boundary layer ahead of the arctic front. Convection early that morning west of Lakes Erie and Ontario weakened with no further cloud to ground lightning activity, which lowered the operational forecaster situational awareness at the local and national level. The Albany forecast office removed thunderstorms from the forecast and SPC didn't even have general thunderstorms over the Northeast in the 1300 UTC Day 1 Outlook.

Satellite imagery showed significant mid- and upper-level drying was occurring at 1415 UTC over central PA and NY ahead of the vigorous short wave trough. The leading edge of this drying was ~200 km ahead of the surface cold front. An east-west cross-section at 1400 UTC from the RUC (Fig. 6) showed a 6 K θe gradient in the 600-700 mb layer ~200 km ahead of the surface cold front, leading to the diagnosis of a Cold Front Aloft (CFA; Hobbs et al. 1990). The CFA allowed for clearing just ahead of the surface cold front (allowing for surface heating), while also creating potential instability through differential θe advection.

Convective initiation via the water vapor image and lightning mosaic began between 1400-1430 UTC over the NY-PA border (Fig. 7a). The visible satellite picture at 1445 UTC (Fig. 7b) shows a line of convection developing over central NY with a clear slot over much of southern NY including the Hudson River Valley in the wake of the CFA. The 1200 UTC 12 km NAM indicated an area of Most Unstable CAPE (MUCAPE) of up to 200 J kg^{-1} over central-eastern NY with bulk shear values in the 0-6 km layer of 65-85 kts. for 1500 UTC (not shown). The MUCAPE is calculated from 0-10 km. Furthermore, a cross-section from the 1200 UTC 12 km NAM up the Hudson River Valley of ascent, equivalent potential temperature (θe), and winds showed weak potential instability (θe decreasing with height in the troposphere). Even the LAPS analysis at 1600 UTC showed less than 200 J kg^{-1} of surface based instability from Albany south and west with best lifted index stability values around -2ºC (not shown). However, a small amount of instability was all that was needed with an explosive dynamic environment impacting the region.

4. Storm Scale Radar Analysis

Rapid destabilization occurred between 14-1600 UTC with a developing narrow cold-frontal rain band of intense convection sweeping across central and eastern NY. A line of intense low-topped (radar derived echo tops product showed tops at 15-20 kft) convection with a tight leading reflectivity gradient reached the upper Hudson River Valley and Lake George Region between 1445-1515 UTC. Numerous bowing convective elements occurred along the line at 1453 UTC (Fig. 8). A bow echo and a shallow mesocyclone north of ALY prompted the first severe thunderstorm warning to be issued at 1454 UTC. The mesocyclone near the tip of the bowing segment hit the town of Edinburgh tearing a roof off a home with the Saratoga County airport reporting a wind gust of 85 kts. (Fig. 9). A bowing segment on the south side of the line produced a gust to 62 kts. with some tree damage. It should be noted the velocity values near southern Saratoga County were in excess of 55 kts. above 3 kft AGL. An elevated reflectivity core of 45 dBZ to approximately 10 kft produced penny size hail just east/northeast of Albany at 1510 UTC (not shown). The damaging winds continued east of Albany into western New England with several gusts in excess of 50 kts. The operational forecasters continued with severe thunderstorm warnings. No tornadoes were reported with this event, but several microbursts occurred.

The next problem to deal with was the strong gradient winds in the wake of the strongly forced convective line. Numerous trees continued to come down. The strong isallobaric couplet with the strong low pressure system tied to the arctic front had pressure rises up to 14 hPa in 3 hours via the 1600 UTC MSAS observational data (Fig. 10). Gradient level winds continued to gust across upstate NY and New England in the 50-70 kt range during the afternoon. Over 100, 000 people were without power across NY and New England with the greatest outages due to tree and utility pole damage north of Albany in the upper Hudson Valley and Lake George region.

5. Discussion and Summary

A historic low-topped severe weather outbreak occurred with eastern NY and western New England in a high shear, extremely low CAPE environment. The region was in the left front quadrant/cyclonic exit region of a vigorous mid- and upper-level jet streak with strong divergence aloft (Wasula and LaPenta, 2006). A strong thermal gradient (35 K at 850 hPa) existed ahead of the deep trough and its associated arctic cold front. The convective environment was conducive for bowing segments and isolated low topped supercells. This difficult severe environment became more apparent less than 3 hours before the storm damage. The high wind environment in the wake of the arctic front was well anticipated with high wind warnings posted more than 24 hours in advance.

Anticipation of severe weather with this case was a challenge for operational forecasters days in advance due to the seasonality and time of the day for the severe convection. The severe event was a low probability – high impact situation. A dry air intrusion associated with a CFA seen on the water vapor loop was critical for the clearing of the clouds (to destabilize the boundary layer) and create potential instability, which was forced along by the arctic front. SPC issued a Slight Risk in their Day 1 Outlook update at 1630 UTC for most of New England based on the developed strongly forced low-instability convective line and its associated lightning production (Van Den Broeke et al., 2005) that formed over eastern NY. Despite the extreme difficulty of the early awareness of the event, the ALY forecast office was able to yield timely severe thunderstorm warnings (16.2 min lead time average) with an excellent probability of detection (0.85), only two missed events out of thirteen and a zero false-alarm ratio. Cool season severe events will always be a challenge in the Northeast. Future work, should focus on a climatology and further case study analyses of such events across NY and New England to understand the synoptic and convective parameters that produce them to improve forecaster awareness at greater lead times.

6. Acknowledgements

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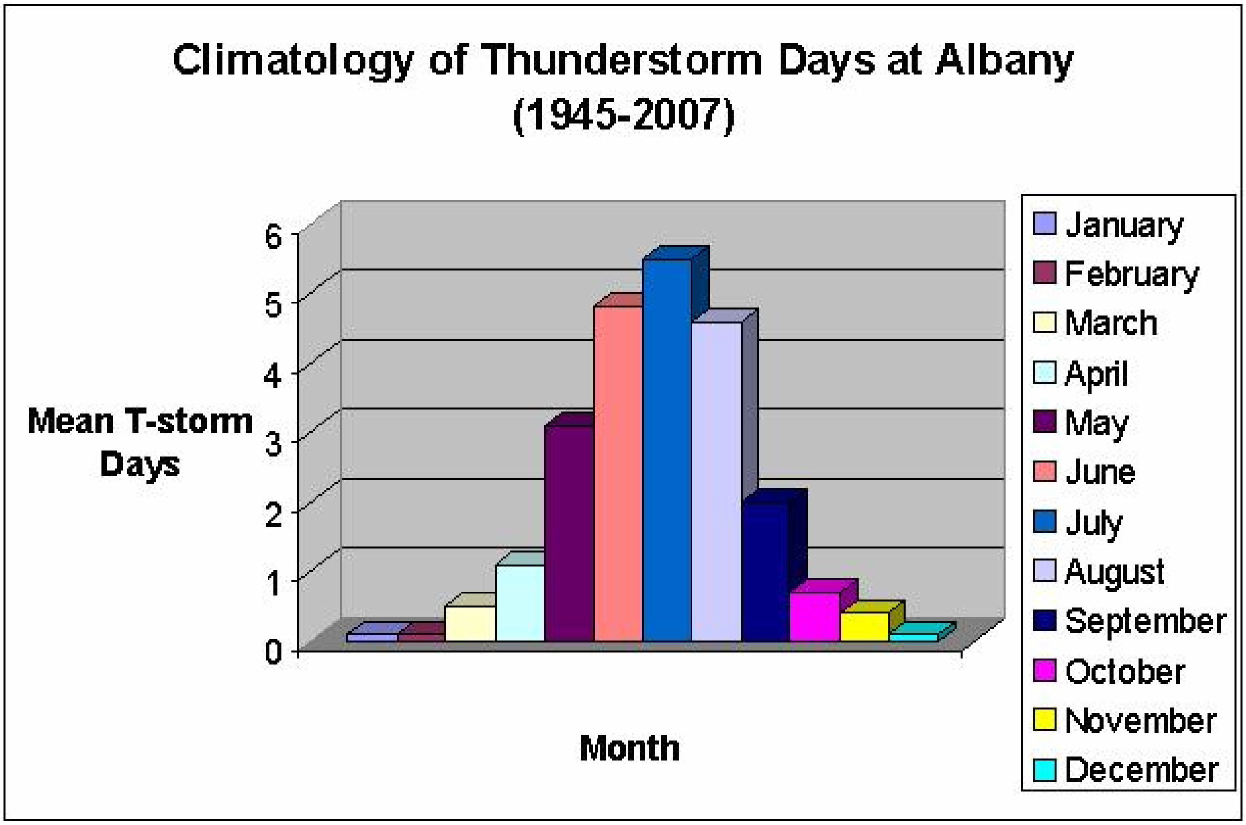


Figure 1: Climatology of thunderstorm days at Albany. The x-axis is the calendar month and the y-axis is the mean thunderstorm days (NCDC).

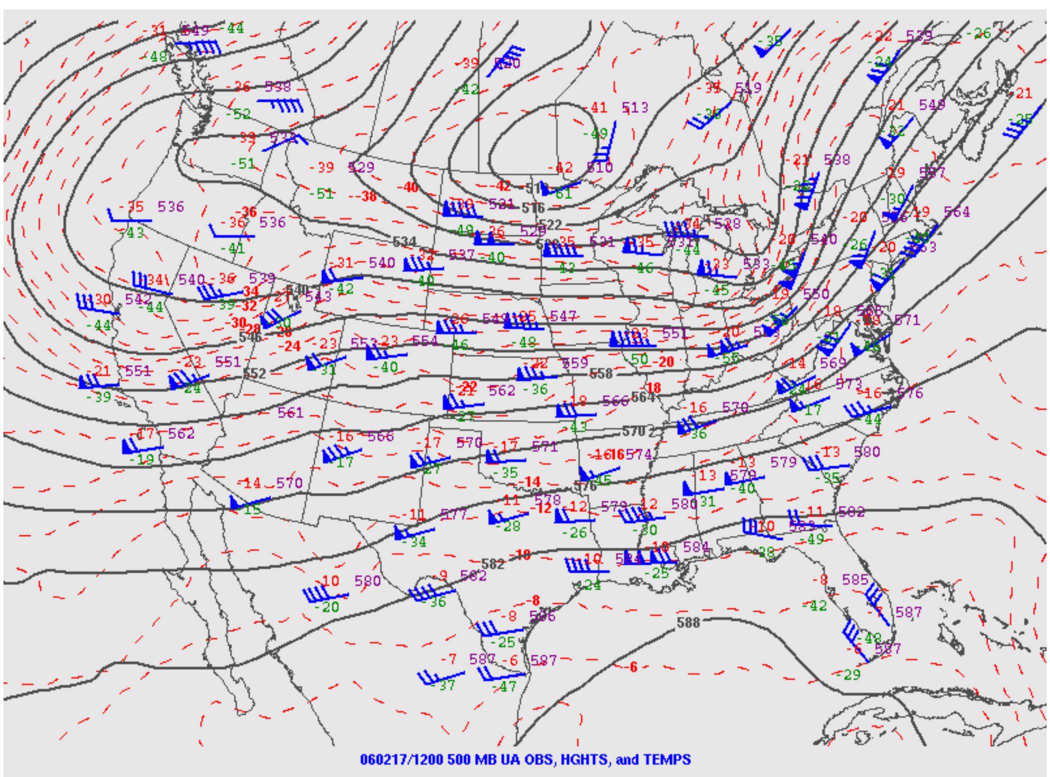


Figure 2: 500 hPa height (dam, solid), temperatures (°C, dashed red), winds (knots) and dewpoint depression from RAOB (green), valid 1200 UTC 17 February 2006.

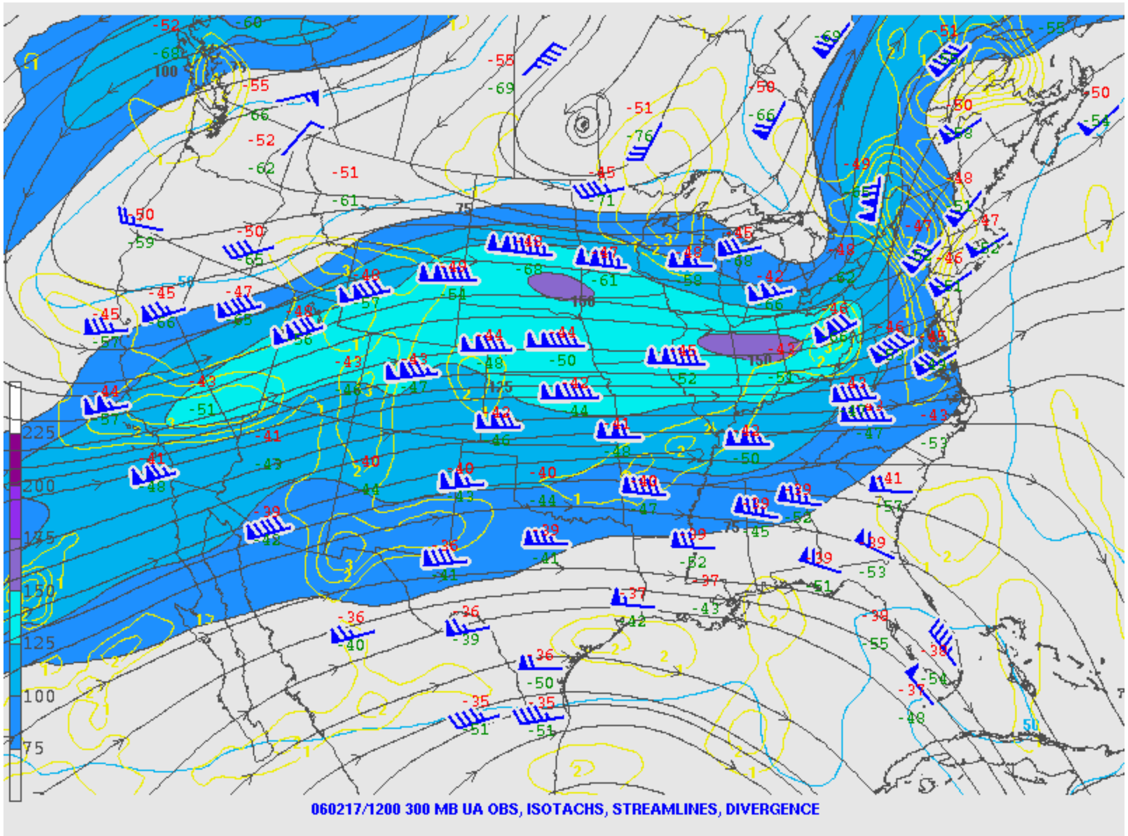
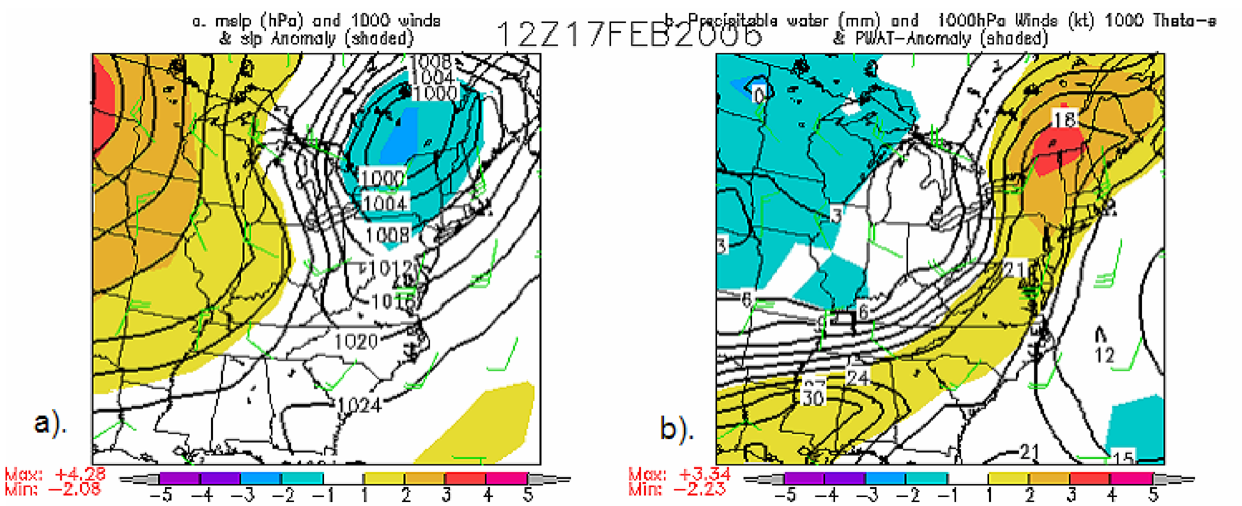


Figure 3: 300 hPa streamlines (black), temperatures and dewpoint depressions from RAOB (°C, red and green digits), isotachs (shaded, knots), winds (blue barbs, knots) and divergence (yellow), valid 1200 UTC 17 February 2006.



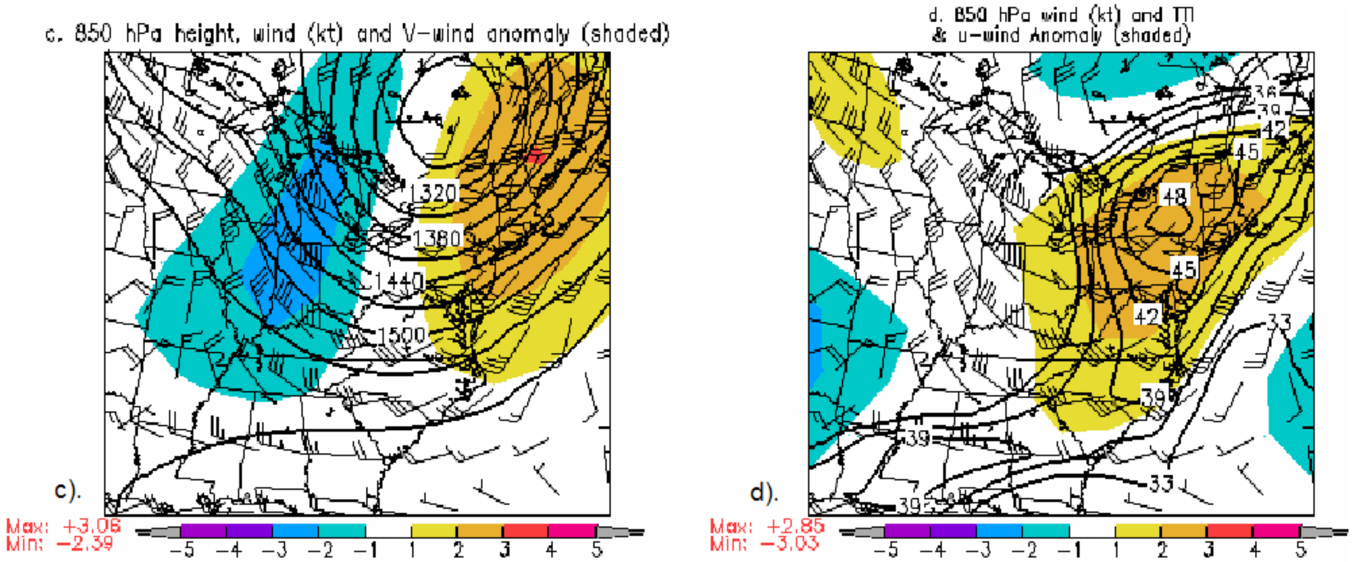


Figure 4: 1200 UTC 17 FEB 2006 Standardized Global Reanalysis Anomalies based on 1961-1990 climatology: a). Mean Sea Level Pressure (hPa), 1000 hPa winds with MSLP anomalies shaded, b). Precipitable Water (mm), 1000 hPa winds (Green barbs, kts.), 1000 hPa theta-e (ºC) and Precipitable Water Anomalies (shaded) c). 850 hPa heights (dark lines), winds (barbs; kts.), v-component winds anomalies (shaded), d). 850 hPa heights (dark lines), winds (barbs; kts.), u-component winds anomalies (shaded).

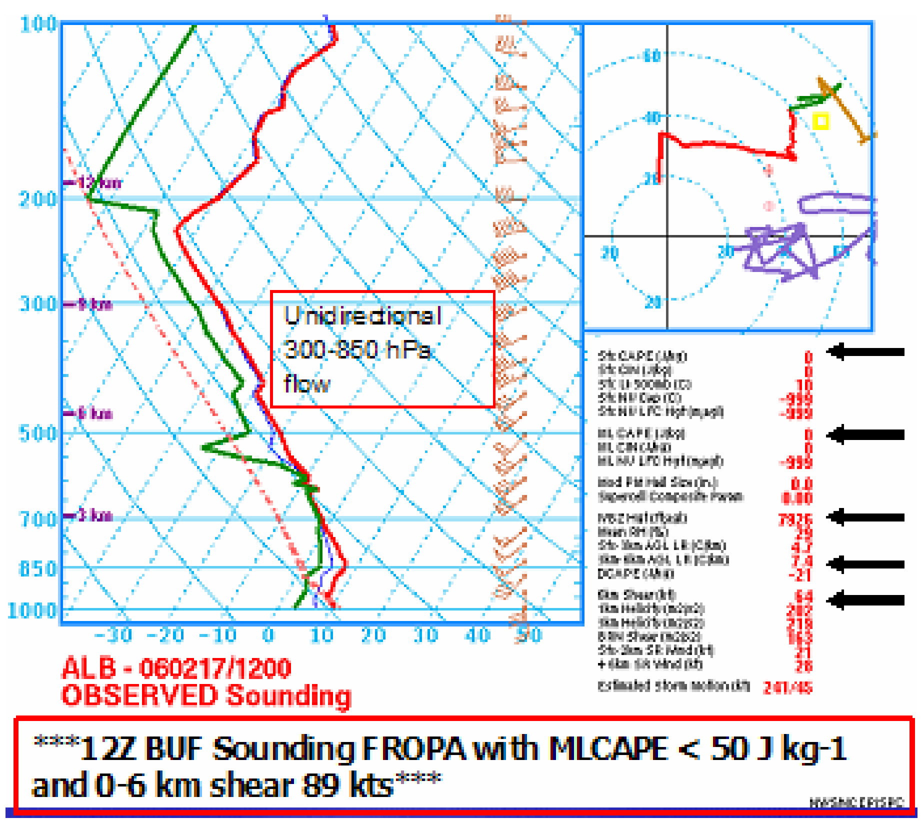


Figure 5: 1200 UTC 17 February 2006 Albany Sounding (http://www.spc.noaa.gov).

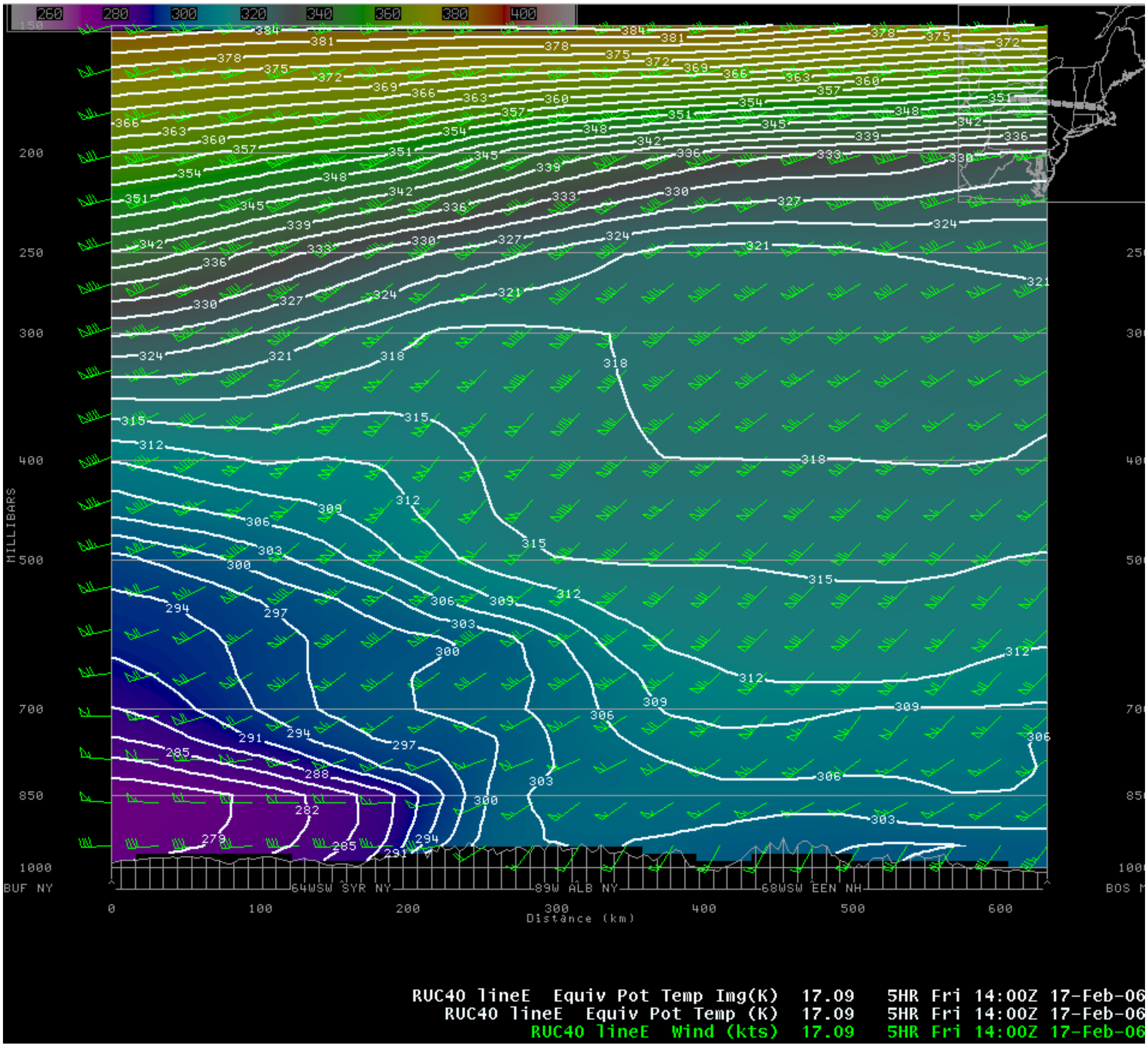


Figure 6: A 40-km RUC Cross-section from KBUF to KBOS of Winds (kts.) and Θ_e (K).

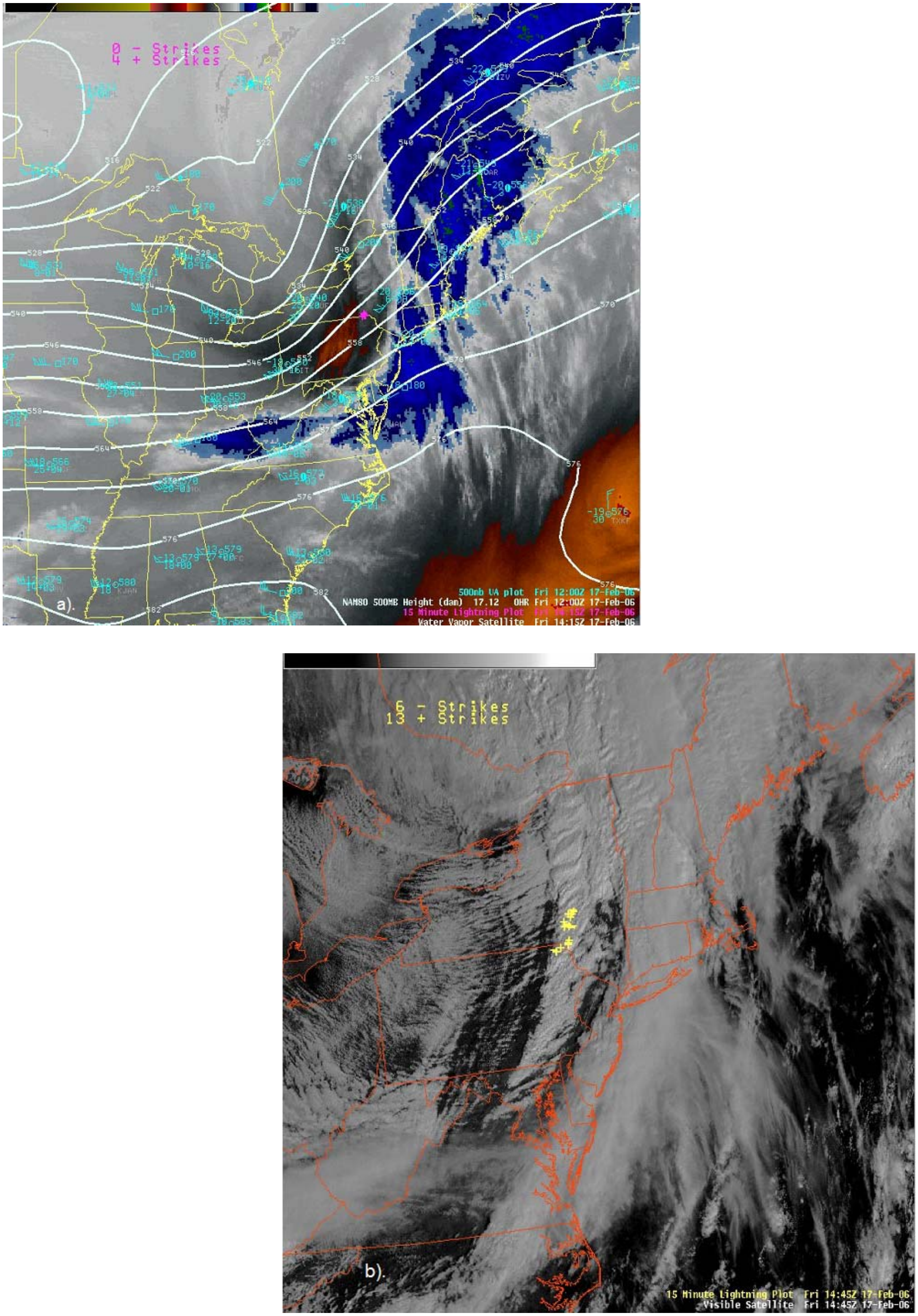


Figure 7a). 1415 UTC 17 February 2006 Water Vapor and b). 1445 UTC Visible Satellite images with Lightning (purple, yellow).

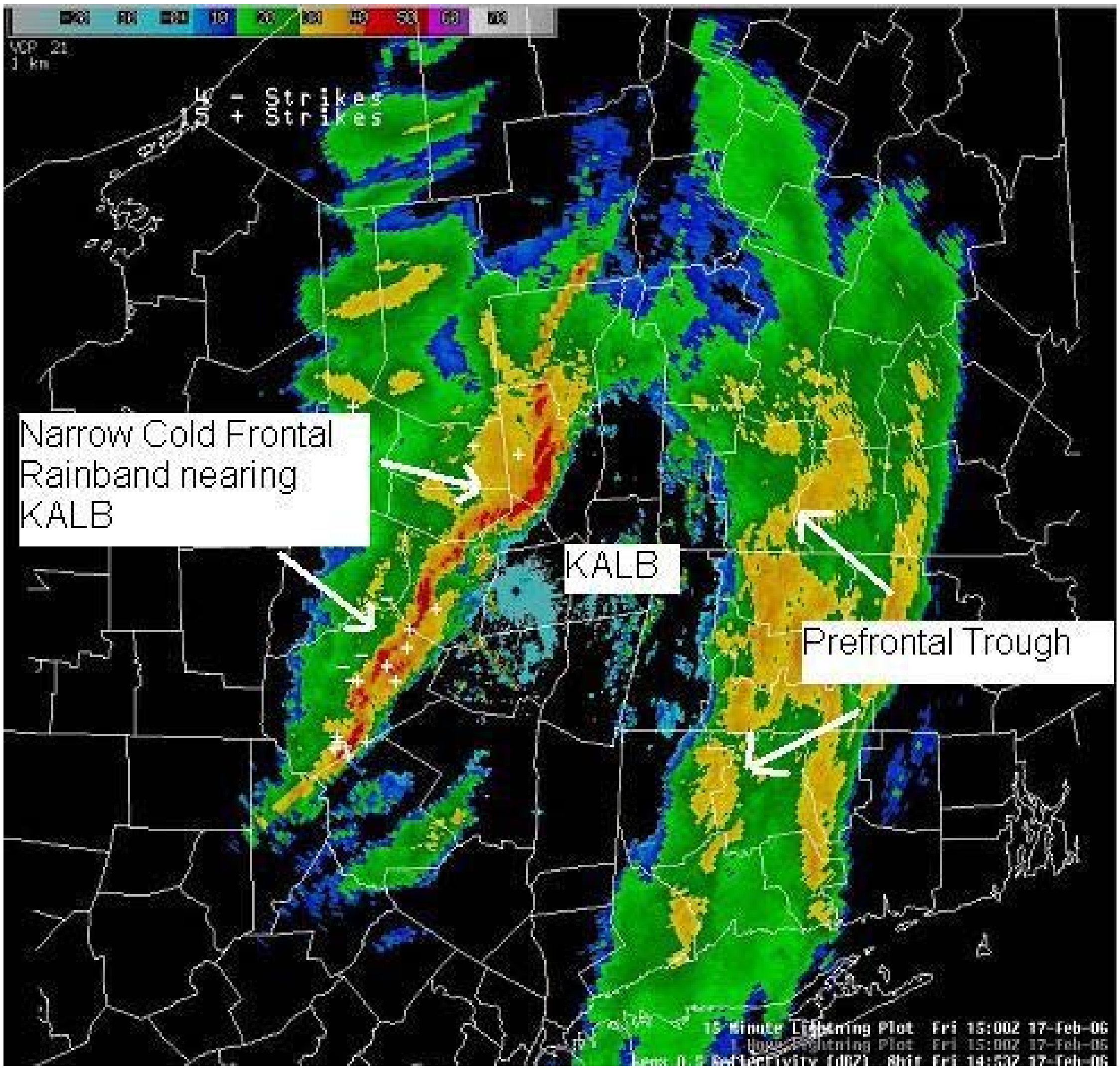


Figure 8: 1453 UTC 17 February 2006 0.5º KENX Base Reflectivity (dBZ) and 15-min Lightning.

Figure 9a). 1459 UTC 17 February KENX Reflectivity (dBZ), MESO and Lighting b). KENX Velocity (kts.) and MESO, and Lightning.

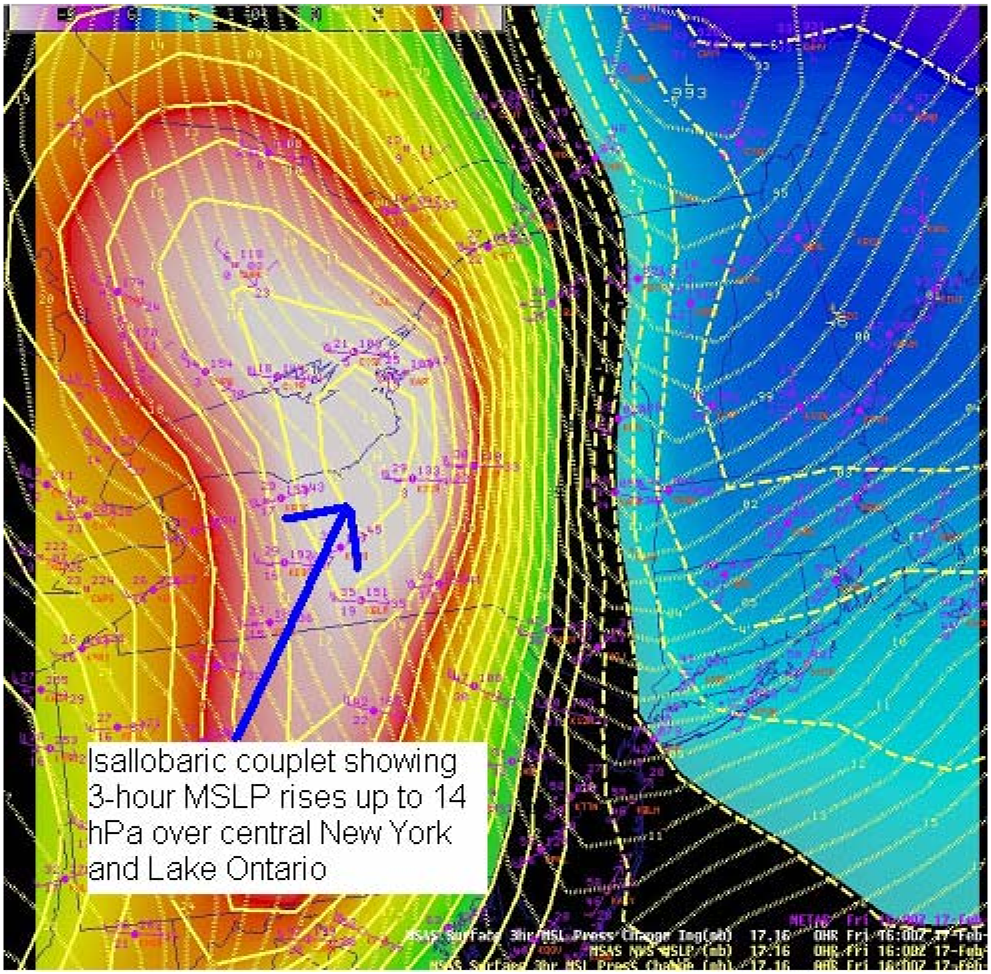


Figure 10: 1600 UTC 17 February 2006 MSAS MSLP (hPa) 3-hour pressure change and surface observations.