# A Multiscale Analysis of the 15 May 2018 Significant Severe Weather Outbreak in the Northeast U.S.

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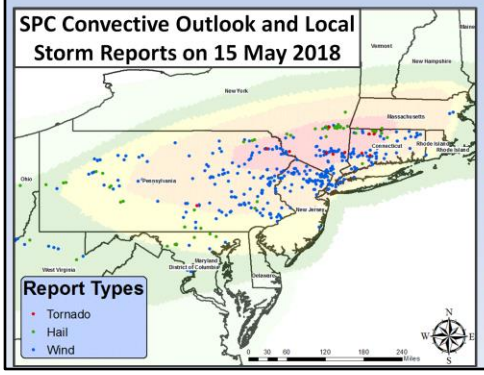
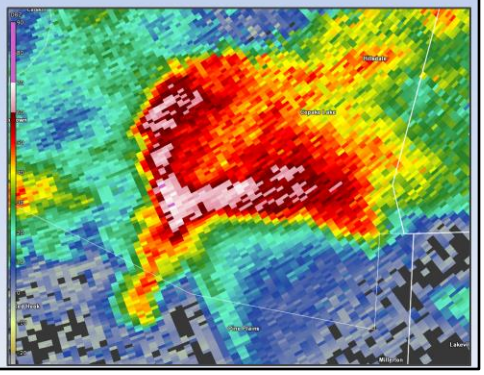
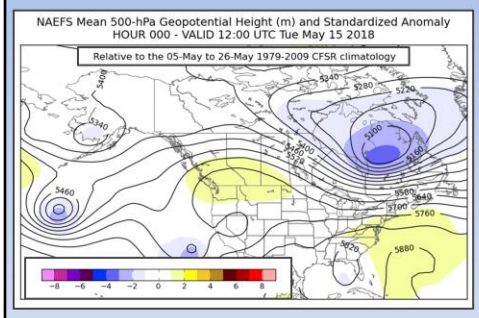
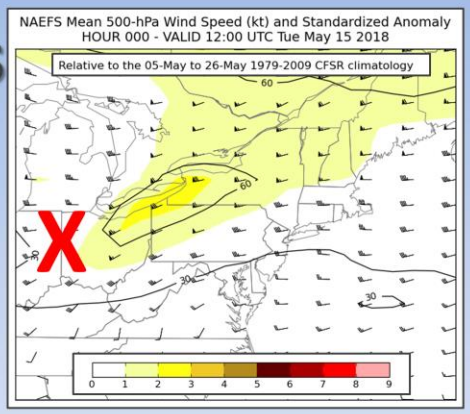


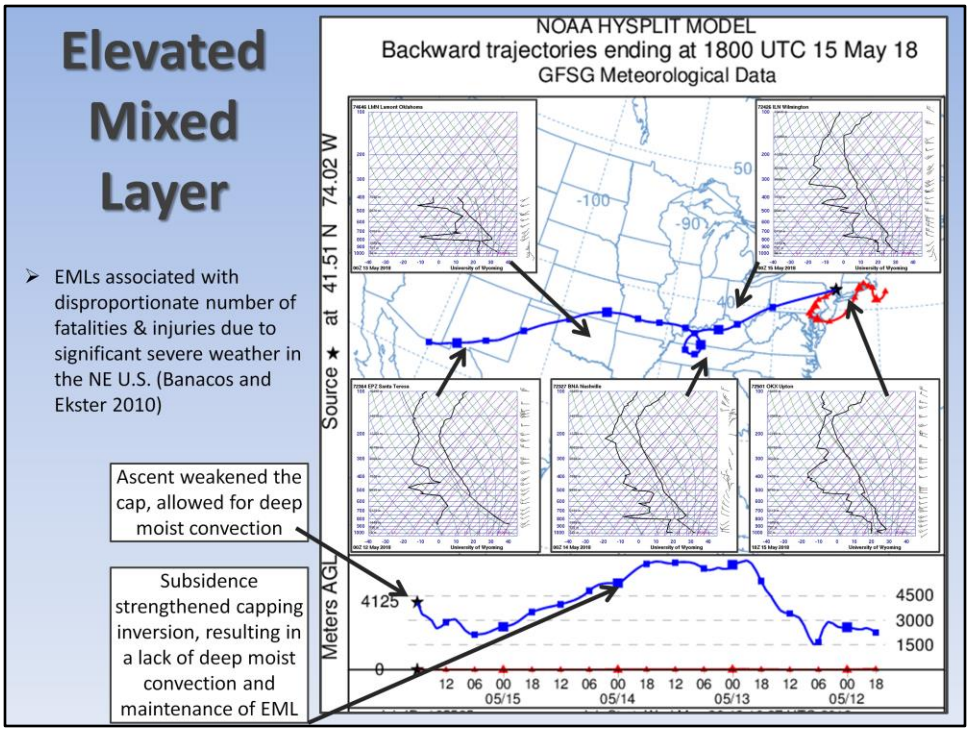
# Synoptic Characteristics



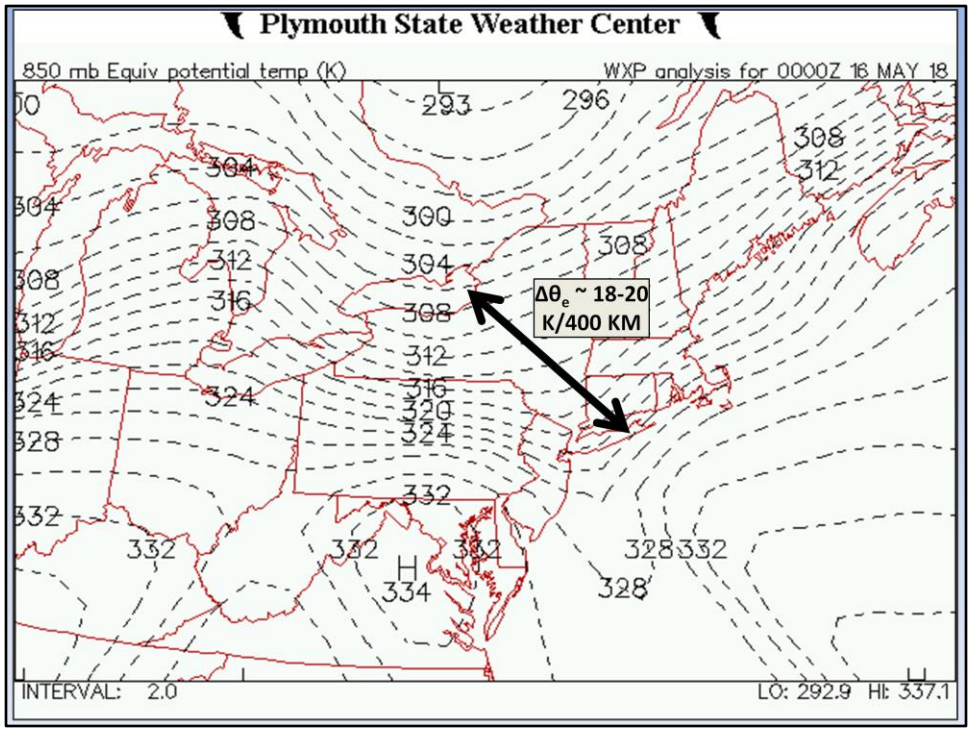




Anomalously strong 500-hPa flow existed between a deep low over eastern Canada and flat ridging over the mid-Atlantic. Red X marks location of MCV at 1200 UTC downstream of which a long-lived QLCS developed.

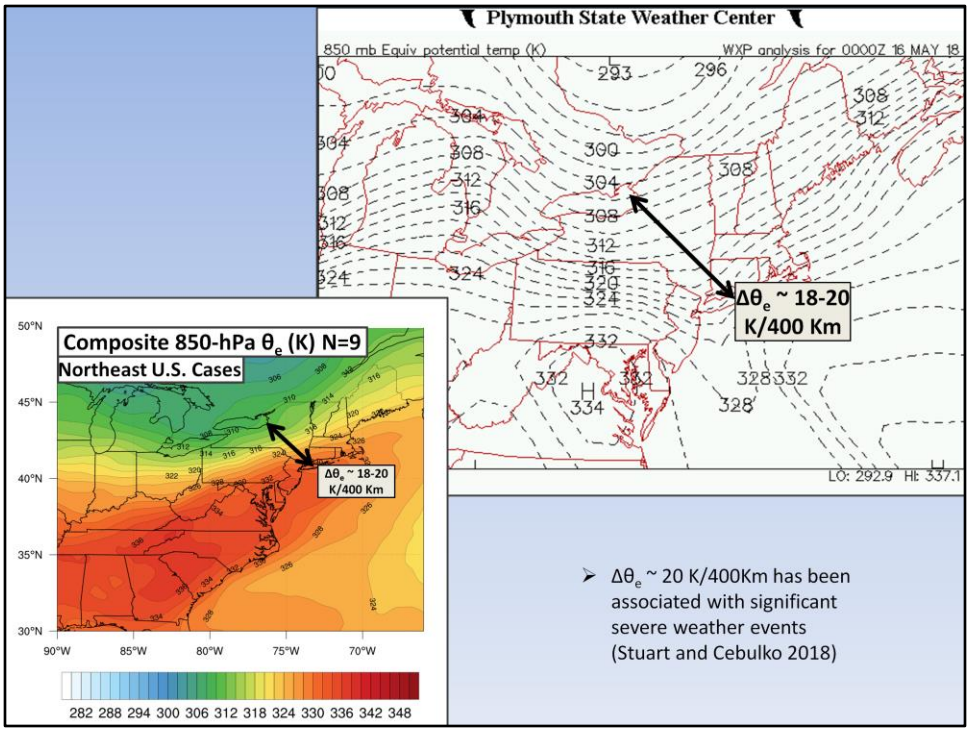
500 hPa jet and short wave trough approaching the region the morning of 15 May 2018



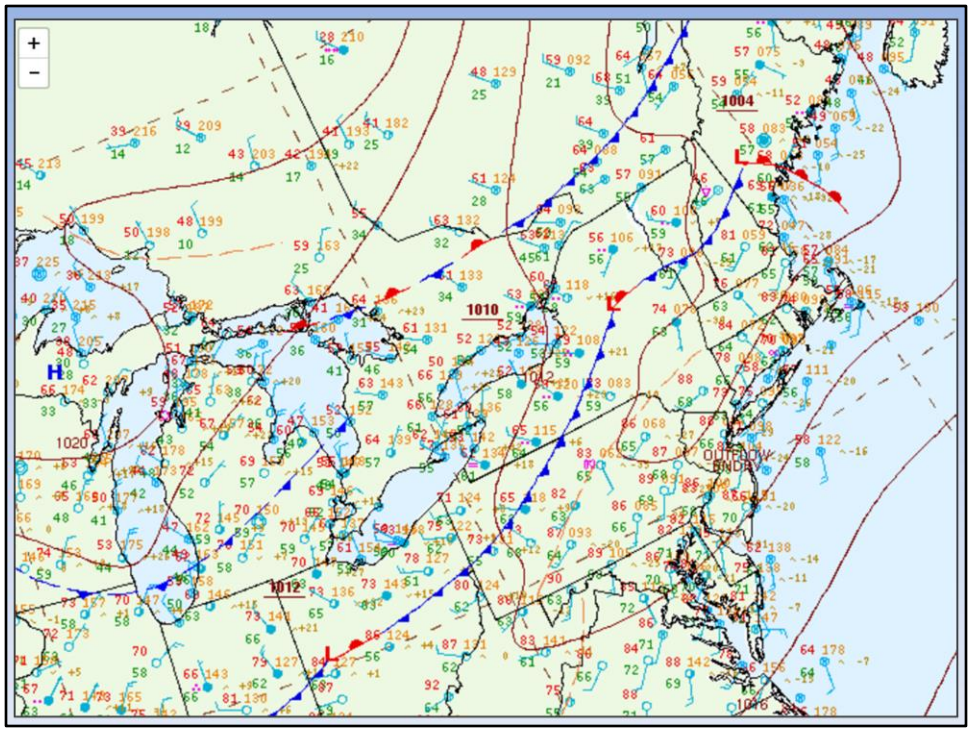

An elevated mixed layer originating from the Desert Southwest resulted in steep midlevel lapse rates over the Northeast




A change of theta-E over ~ 400km of >= 20-25 Kelvin suggests very strong density discontinuity/lifting mechanism. These large changes of Theta-E have been associated with significant severe weather events.

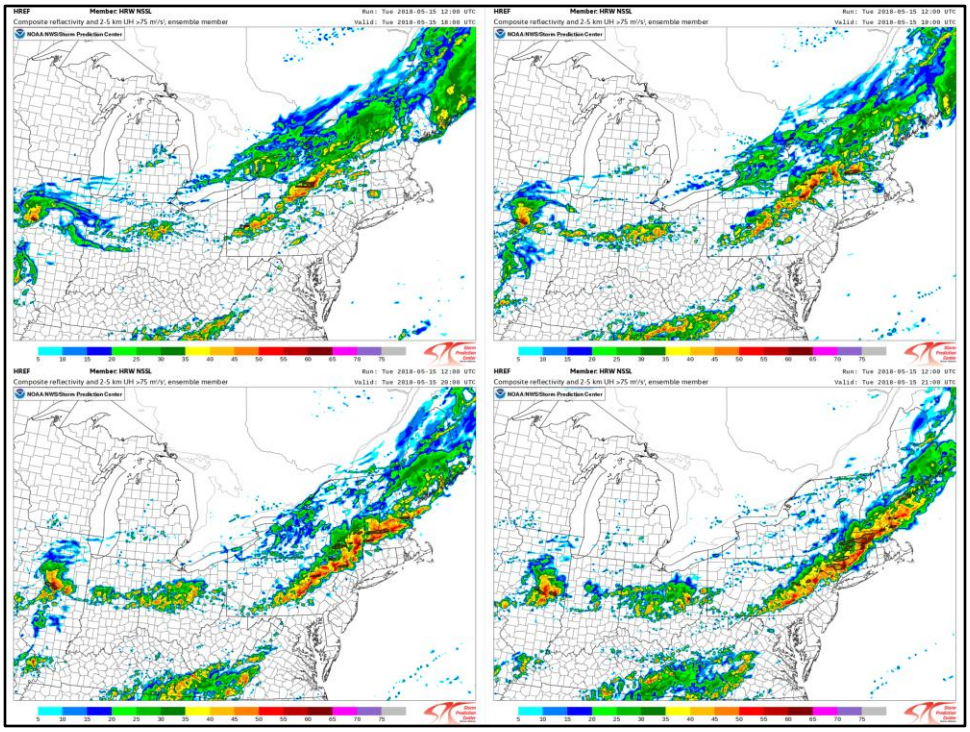



Note the similaries in magnitude and orientation. Change in Theta-E over ~ 400km of >= 20 Kelvin suggests very strong density discontinuity/lifting mechanism. Not shown here, but with this event and composites for the NE CONUS associated with significant severe weather events, there was strong theta-e ridging into the NE ahead of the boundary which seems to tighten up drastically right before the severe weather happens. These large changes of Theta-E have been associated with significant severe weather events.

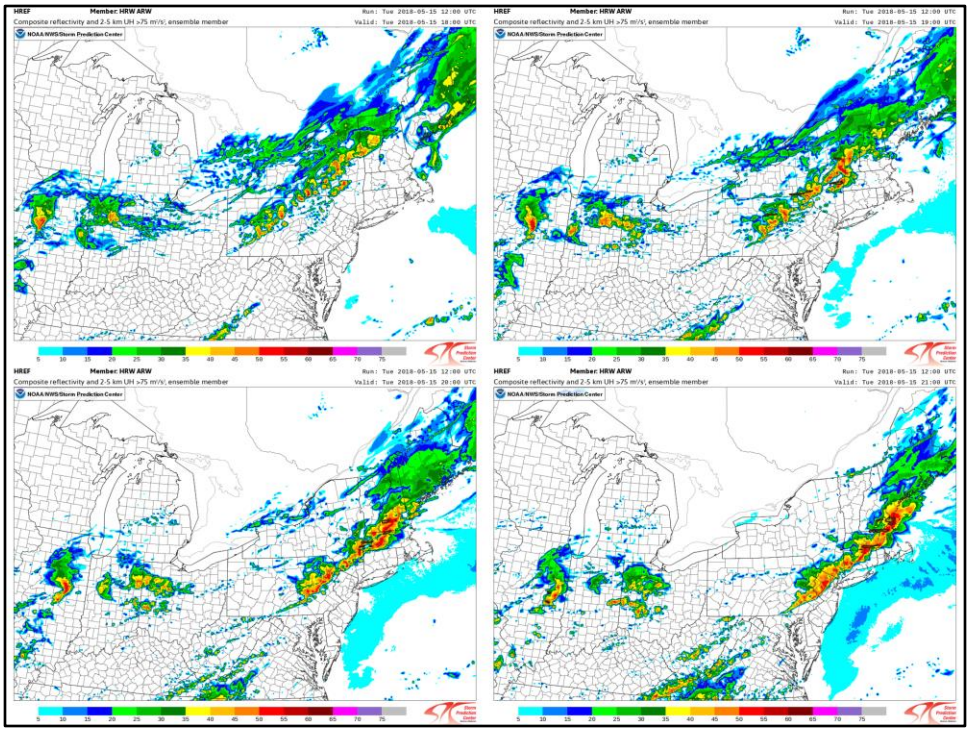



A surface cold front knocking on our doorstep at 2PM EDT. This boundary would provide the necessary convective initiation (plus the differential heating boundary) needed for thunderstorm development.

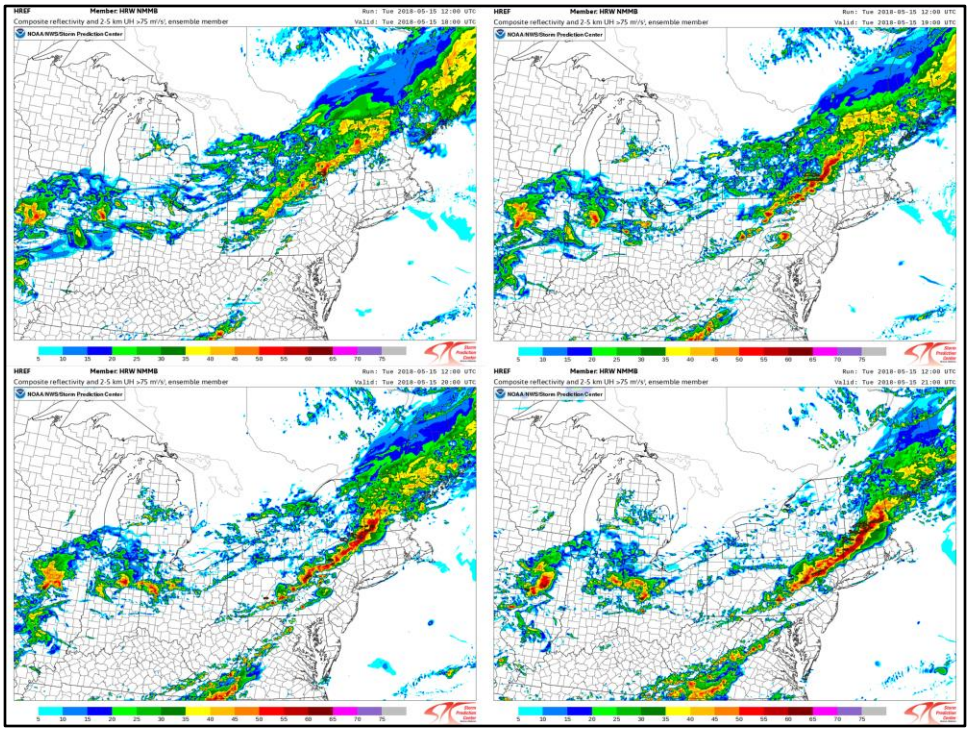
# HREF & HRRR Forecasts



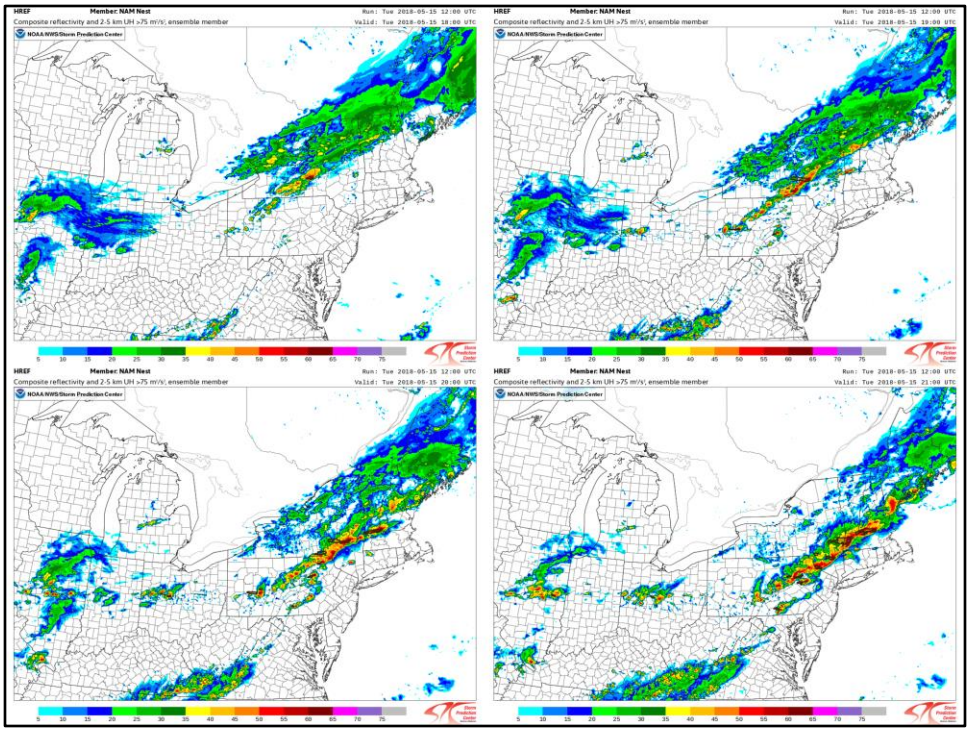

1200 UTC 2018-05-15 run of the HREF. Graphics depict the HRW NSSL HREF member forecast composite reflectivity and 2-5 km updraft helicity > 75 m^2/s^2 valid at 1800 (top left), 1900 (top right), 2000 (bottom left) and 2100 (bottom right) UTC. Convection is resolved further North than observed and supercells out ahead of the line are somewhat resolved.



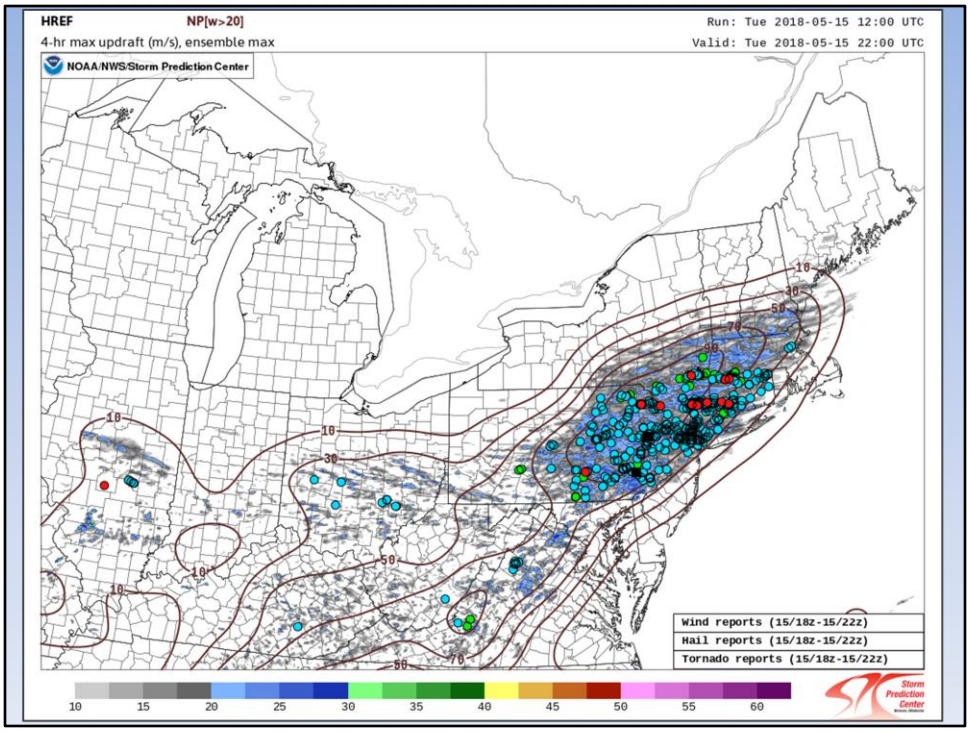

1200 UTC 2018-05-15 run of the HREF. Graphics depict the HRW ARW HREF member forecast composite reflectivity and 2-5 km updraft helicity > 75 m^2/s^2 valid at 1800 (top left), 1900 (top right), 2000 (bottom left) and 2100 (bottom right) UTC. Convection is resolved further North than observed. This member suggests discrete supercell development ahead of the line.



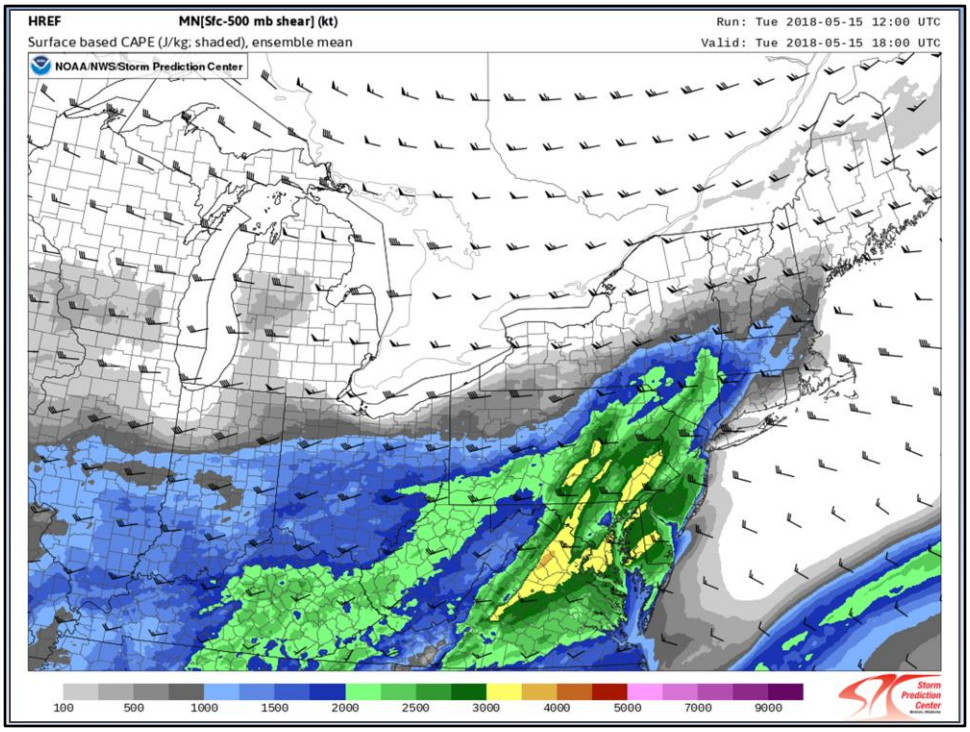
1200 UTC 2018-05-15 run of the HREF. Graphics depict the HRW NMMB HREF member forecast composite reflectivity and 2-5 km updraft helicity > 75 m^2/s^2 valid at 1800 (top left), 1900 (top right), 2000 (bottom left) and 2100 (bottom right) UTC. Convection is resolved further North than observed. Convection is resolved further North than observed and supercells out ahead of the line are not resolved at all.



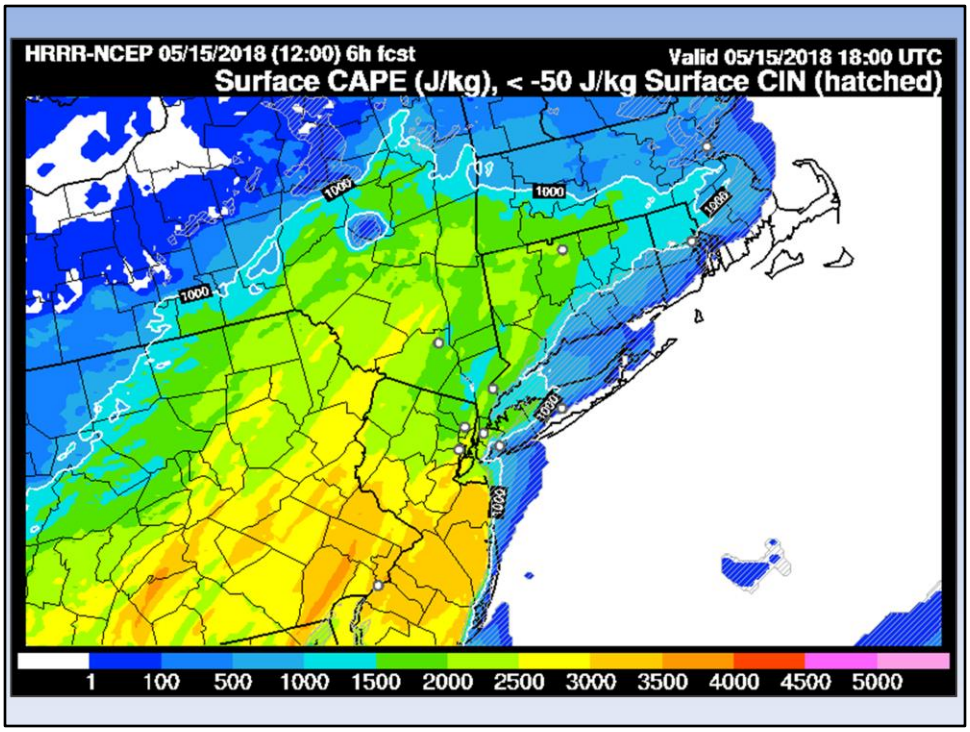
1200 UTC 2018-05-15 run of the HREF. Graphics depict the HRW NAM Nest HREF member forecast composite reflectivity and 2-5 km updraft helicity > 75 m^2/s^2 valid at 1800 (top left), 1900 (top right), 2000 (bottom left) and 2100 (bottom right) UTC. Convection is resolved further North than observed and supercells out ahead of the line are not resolved at all. The overall magnitude of convection is underdone as well.



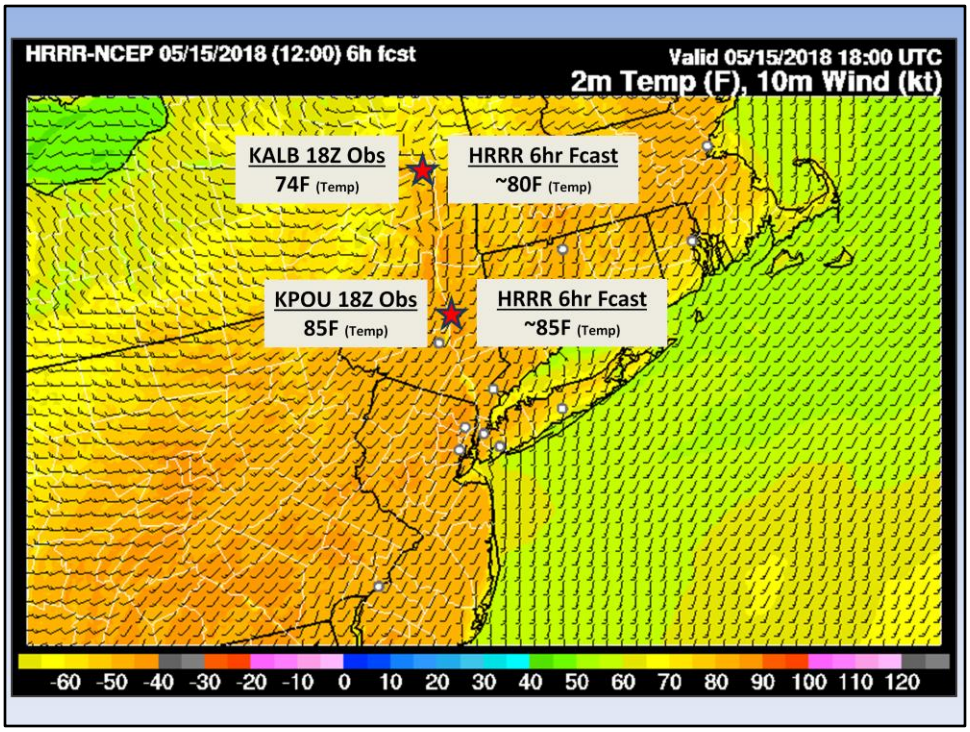

The forecast HREF 4-hr max updraft suggests that the strongest storms should remain south of capital district. Result of early morning rain cooling/stablizing the atmosphere over and north of the Capital Region perhaps?



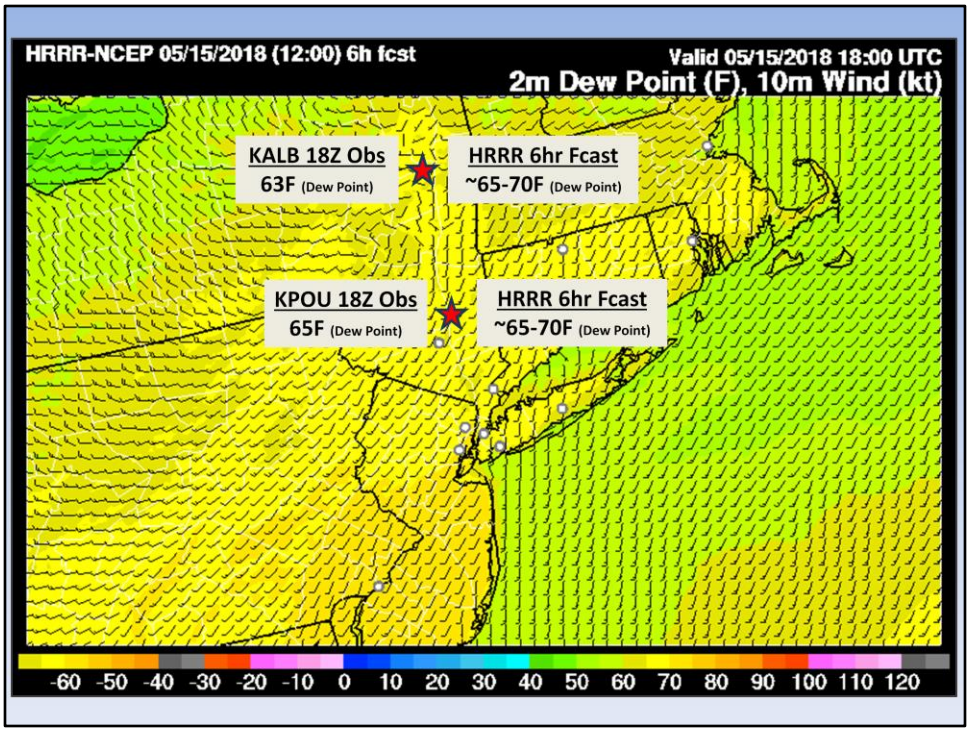

1200 UTC 2018-05-15 run of the HREF. HREF ensemble mean surface based cape values >= 1000 J/kg extended into the northern extent of the Capital Region with values > 2000 J/kg getting into Albany county.



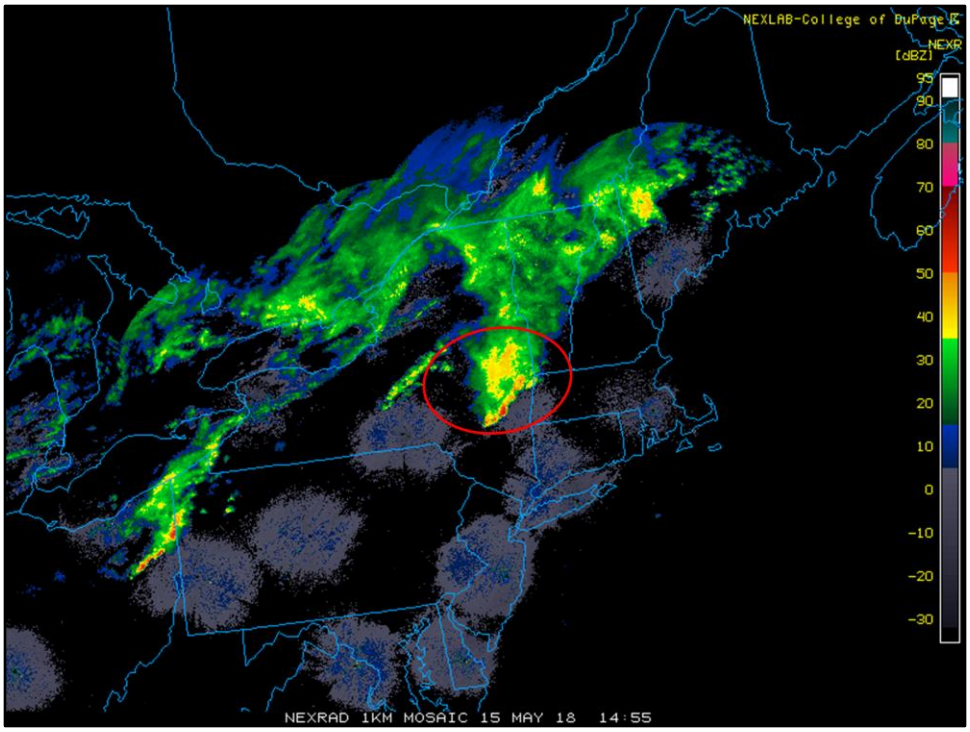

1200 UTC 2018-05-15 run of the HRRR. SBCAPE values of 1500 J/kg getting into the Capital Region with 1500-2500 J/kg further south over the Mid-Hudson Valley.



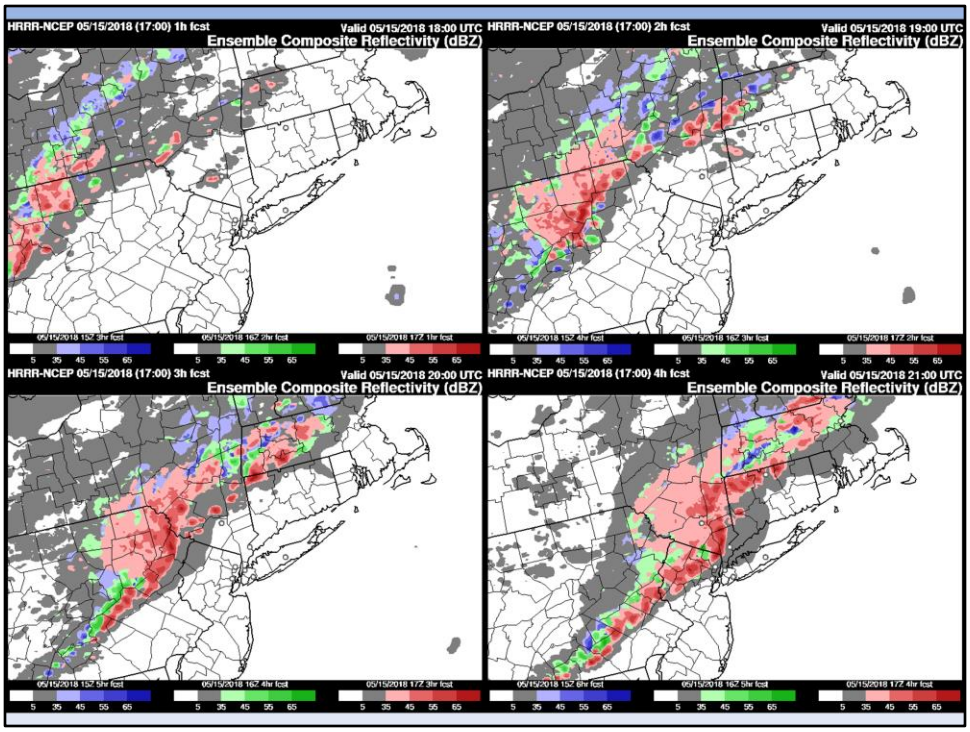

ALB 18z ob → 74F/63F (HRRR resolved the forecast temperatures too high too far north (around 80 F in ALB))
POU 18z ob → 85F/65F (HRRR forecast temperatures on target (~85 F in POU))



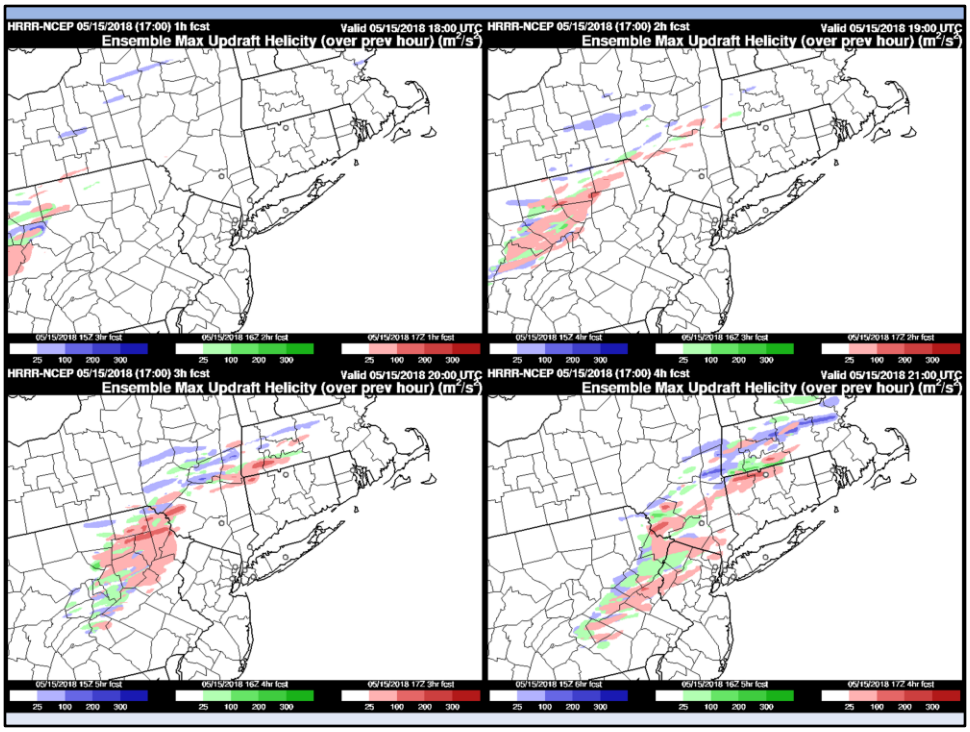

ALB 18z ob → 74F/63F (HRRR resolved the forecast dew points slightly too high too far north (~65-70 F in ALB))
POU 18z ob → 85F/65F (HRRR forecast dew points close to observations (~65-70 F in POU))



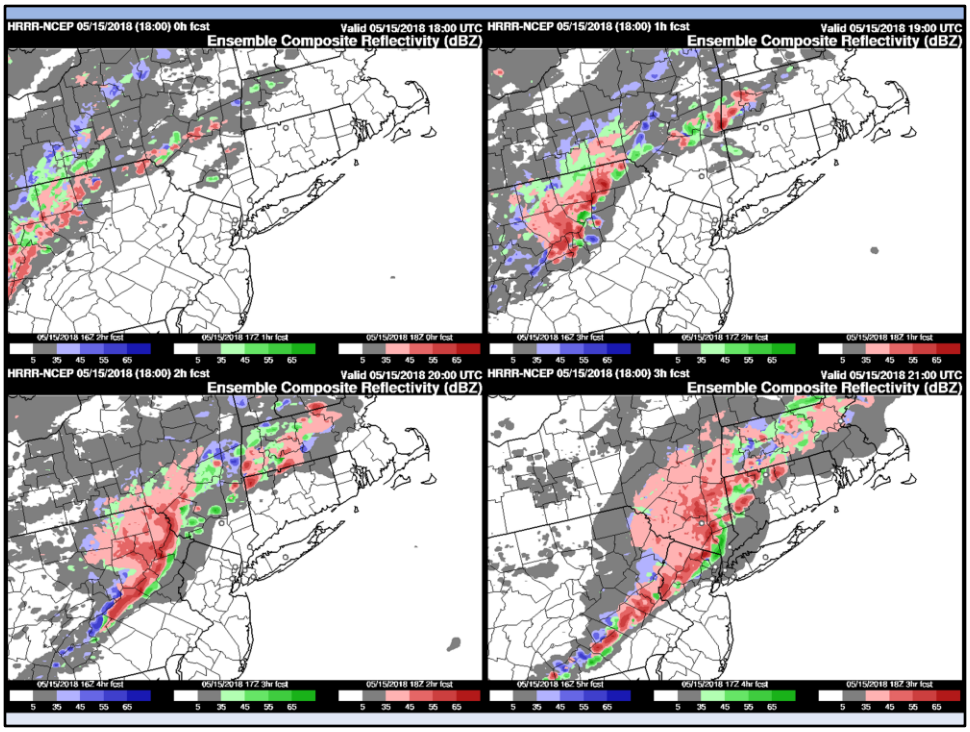

Morning rain = cooler & more stable air mass. Models might not have picked up on this, so this could help explain why the instability and convection was resolved in the model forecasts too far north.



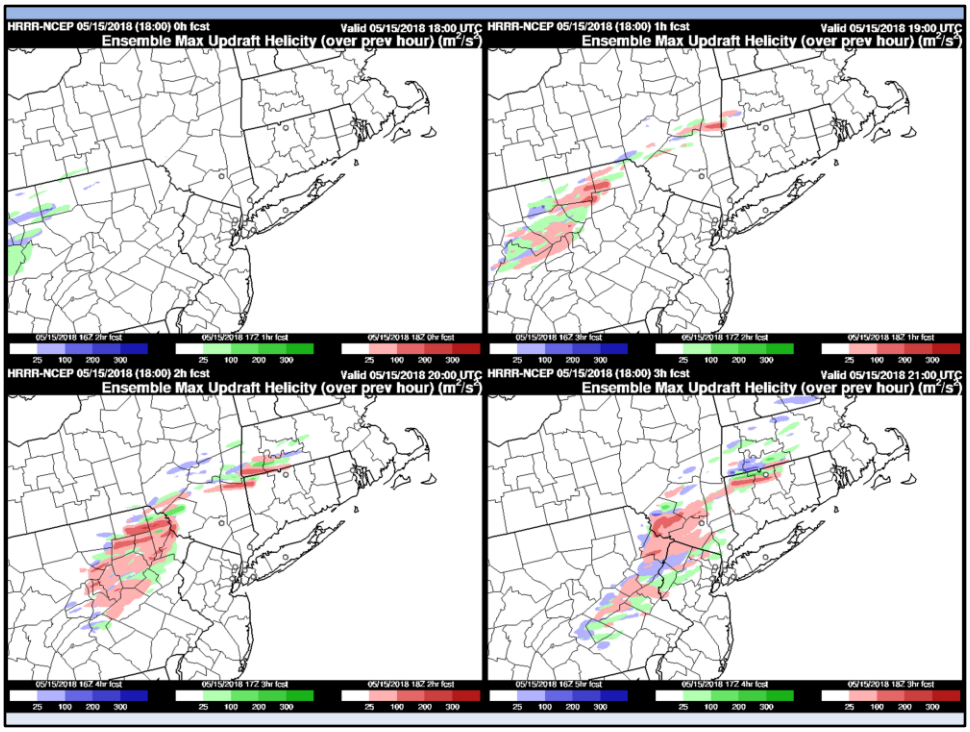

1700 UTC 2018-05-15 run of the HRRR. Ensemble composite reflectivity forecasts show that the 1500 UTC and 1600 UTC runs of the HRRR develop convection too far North with the 1700 UTC run developing the convection slightly further south. The 1700 UTC run 1-hour forecast valid at 1800 UTC is underdone with respect to the initial supercell convection.




1700 UTC 2018-05-15 run of the HRRR. Ensemble max updraft helicity (over previous hour) forecasts display updraft helicity swaths over the Mid-Hudson Valley into Massachusetts and northwest Connecticut. This suggests the potential for rotating thunderstorms over Greene, Columbia, northern Ulster, northern Dutchess, northern Litchfield, and Berkshire counties.

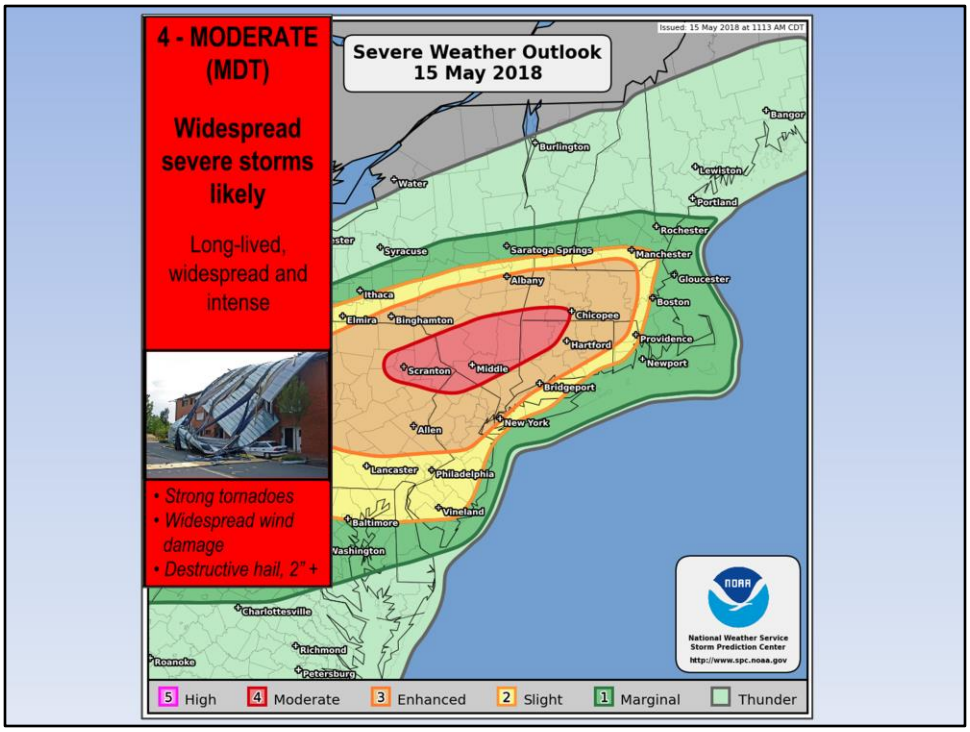



1800 UTC 2018-05-15 run of the HRRR. Ensemble composite reflectivity forecasts coming into better agreement in terms of placement and timing of convection. The 1800 UTC 0, 1, 2, and 3 hour forecasts suggest discrete thunderstorms over southern Greene and Columbia counties sagging into northern Litchfield county. A robust bowing segment is resolved over southern NY  by 2100 UTC. The discrete thunderstorms and bowing segment both ended up being observed.

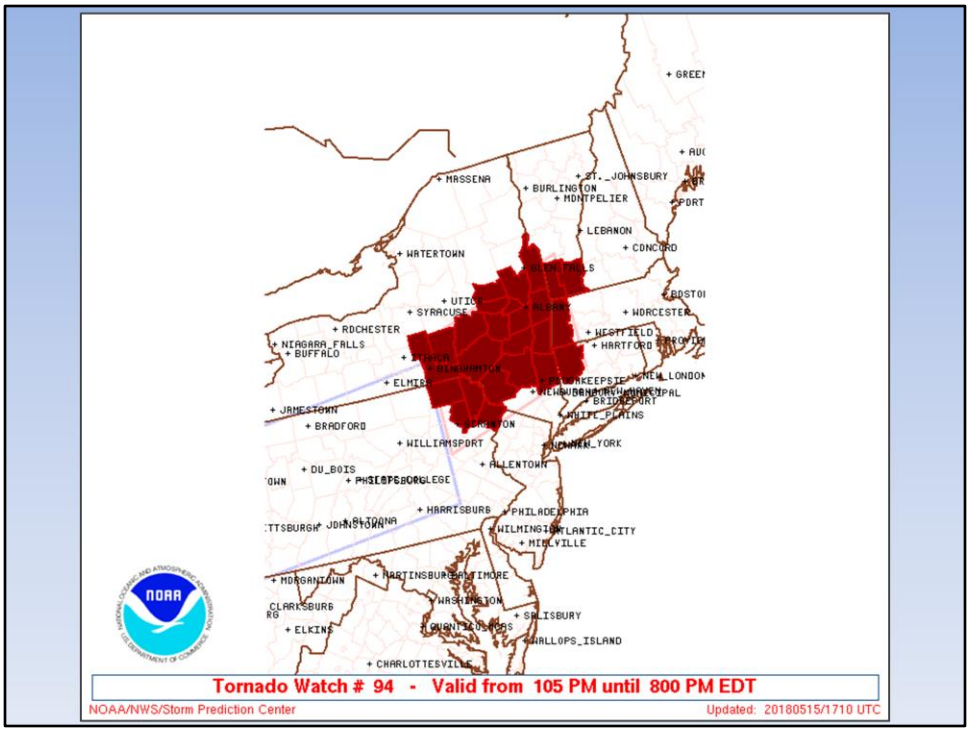



1800 UTC 2018-05-15 run of the HRRR. Ensemble max updraft helicity (over previous hour) forecasts display updraft helicity swaths over southern Greene/Columbia/Berkshire and northern Litchfield counties. This is where the model resolved the discrete thunderstorms suggesting discrete supercell development and a large hail and tornado threat. The 1800 UTC run of the HRRR did extraordinarily well highlighting the greatest threat regions. Tornadoes were verified along some of the aforementioned helicity swaths.

# Right Before the Action

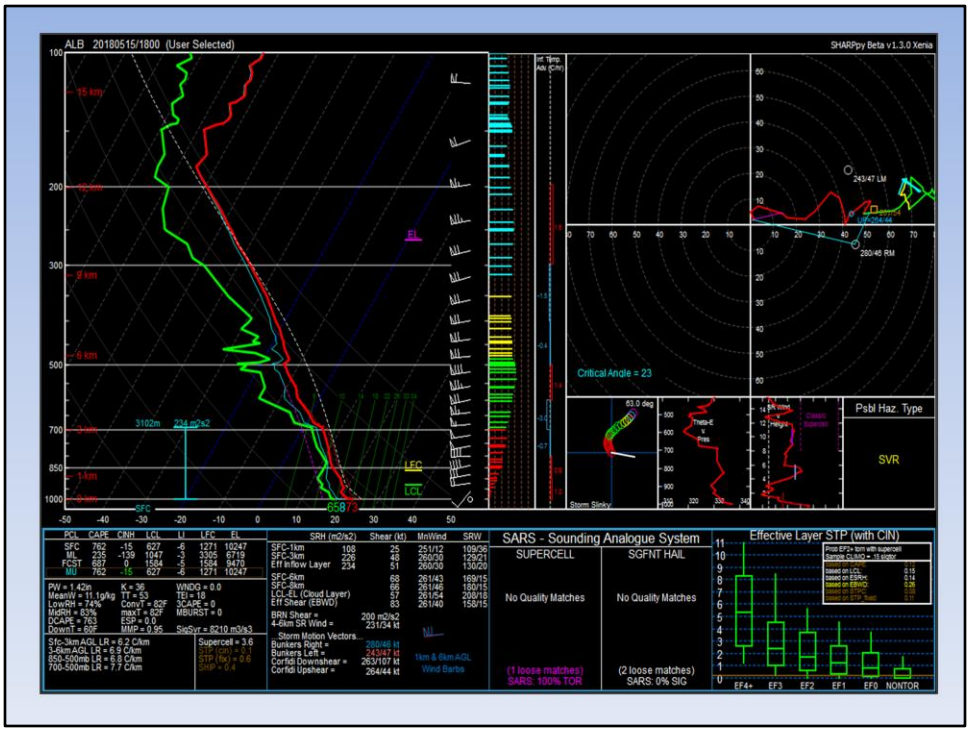



SPC upgraded a portion of the region to a Moderate Risk with the midday update.

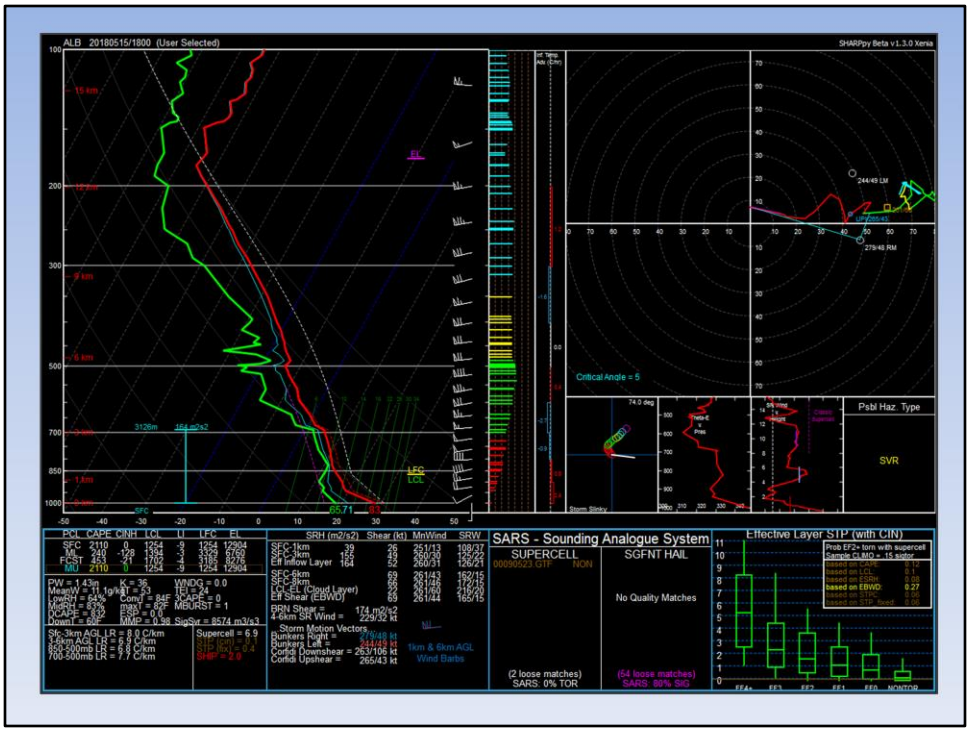



Are we too dependent to CAM output? TOR watch could have only extended to Albany county (east and west) at most, possibly even further south based on instability parameters on the SPC mesoanalysis.

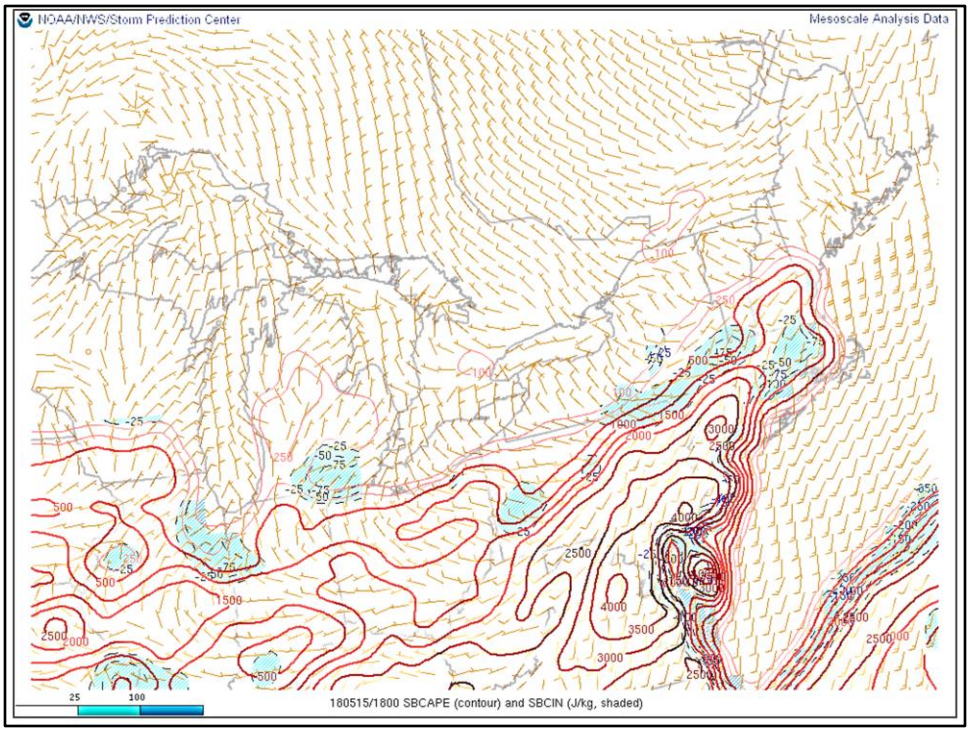
# Near Storm Environment



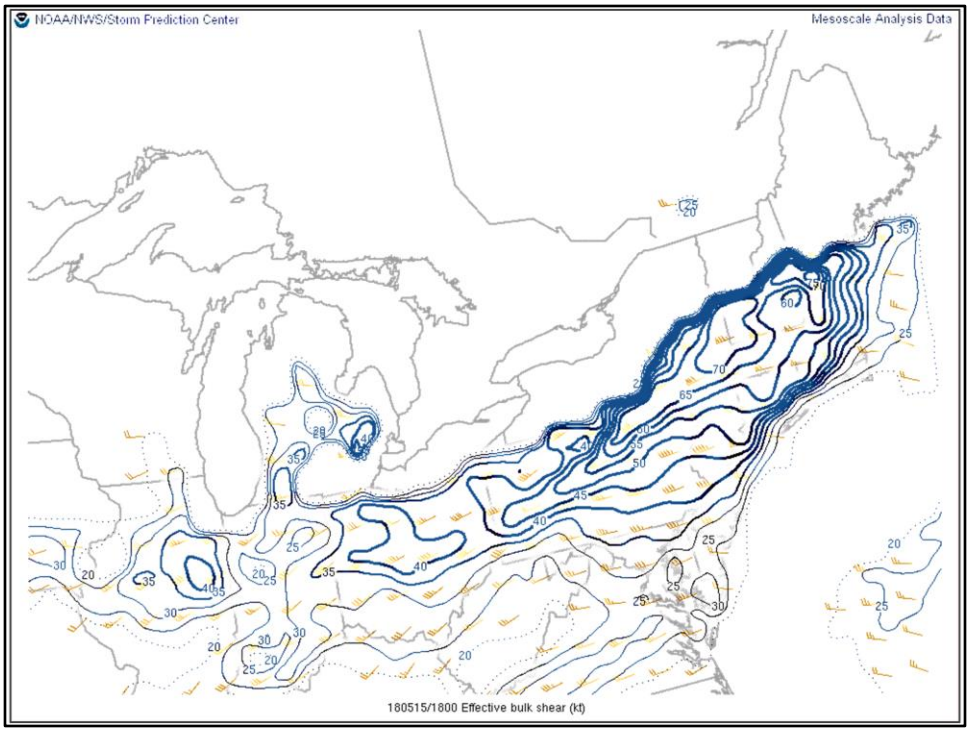

18Z sounding at Albany, NY displays CAPE < 1000 J/kg, effective shear > 80 kts, effective SRH > 200 m^2/s^2 and mid-level lapse rates > 7.5 C/km.



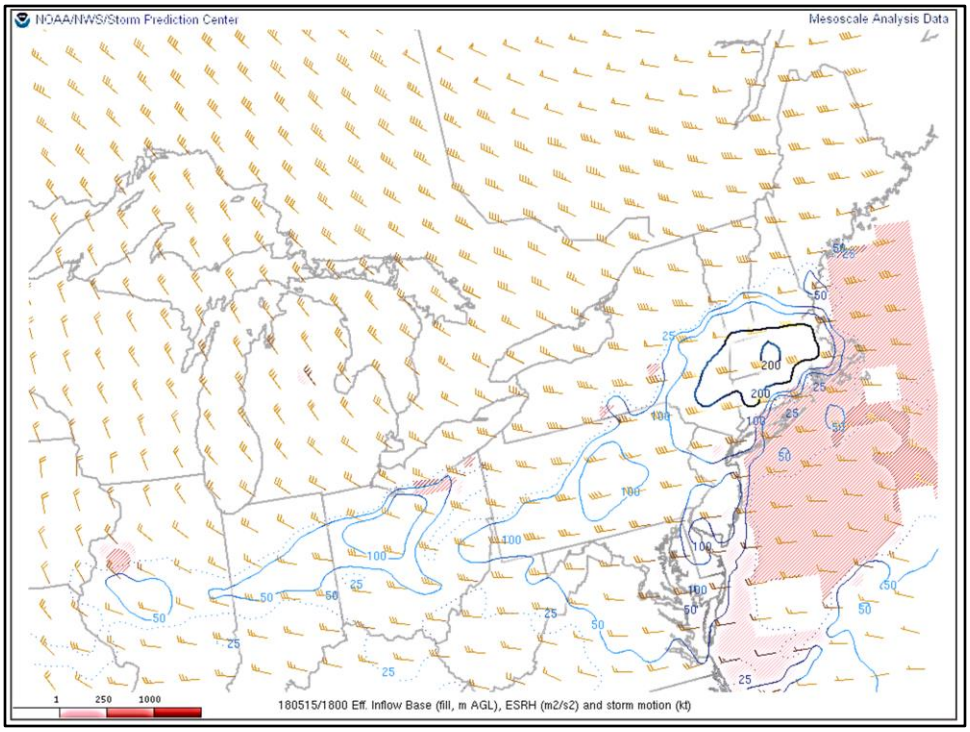

18Z sounding at Albany, NY modified with the 18Z KPOU surface observation data displays CAPE > 2000 J/kg, effective shear ~ 70 kts, effective SRH > 150 m^2/s^2, SHIP = 2 (suggesting potential for hail >= 2 inches) and mid-level lapse rates > 7.5 C/km. Surface to EL bulk shear > 47 kts suggesting potential for hail over 3 inches in diameter. This is a very favorable environment for supercells, large hail, damaging winds, and possibly tornadoes.



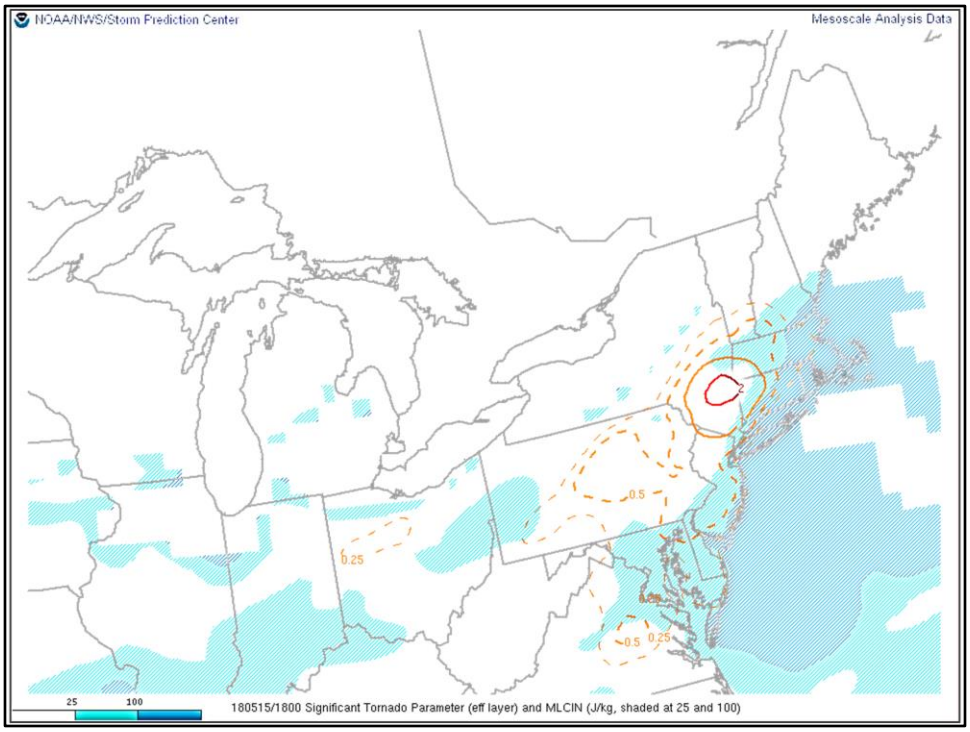

1800 UTC 15 May 2018 SPC Mesoanalysis SBCAPE (J/kg)



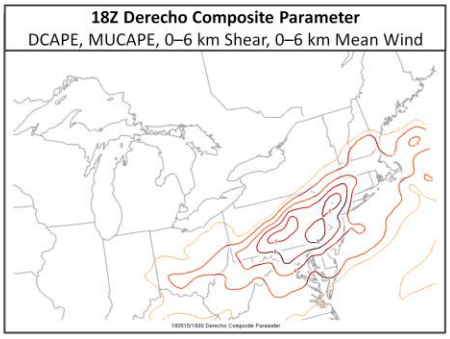

1800 UTC 15 May 2018 SPC Mesoanalysis Effective Bulk Shear (kt)

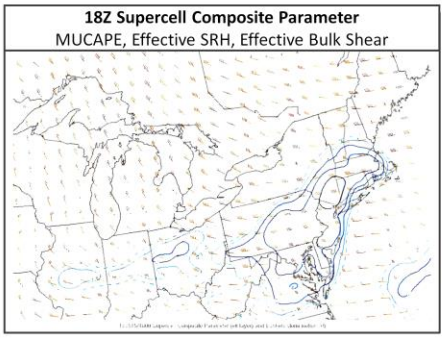


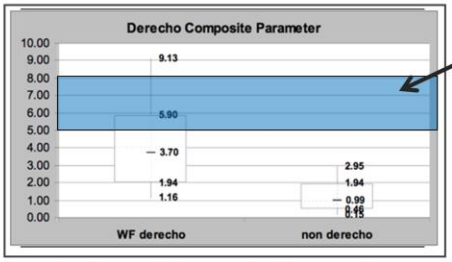

1800 UTC 15 May 2018 SPC Mesoanalysis Effective Storm Relative Helicity (m^2/s^2)



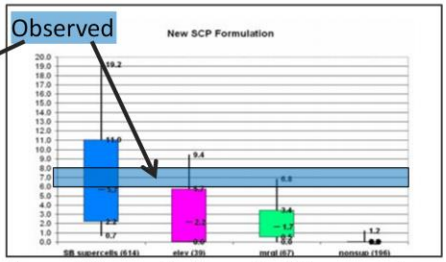

1800 UTC 15 May 2018 SPC Mesoanalysis Significant Tornado Parameter. A multiple ingredient, composite index that includes effective bulk wind difference (EBWD), effective storm-relative helicity (ESRH), 100-mb mean parcel CAPE (mlCAPE), 100-mb mean parcel CIN (mlCIN), and 100-mb mean parcel LCL height (mlLCL). A majority of significant tornadoes (F2 or greater damage) have been associated with STP values greater than 1 within an hour of tornado occurrence, while most non-tornadic supercells have been associated with values less than 1 in a large sample of RAP analysis proximity soundings.



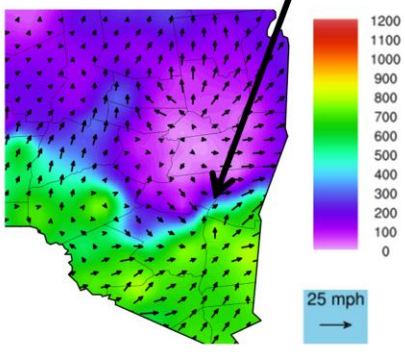



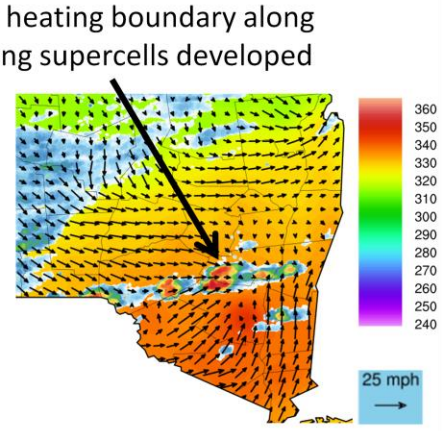

Derecho Composite Parameter (Evans and Doswell 2001) values of 5–8 were favorable for a sustained cold pool-driven wind event.




Supercell Composite Parameter (Thompson et al. 2003) values of 6–8 were favorable for right-moving supercells.

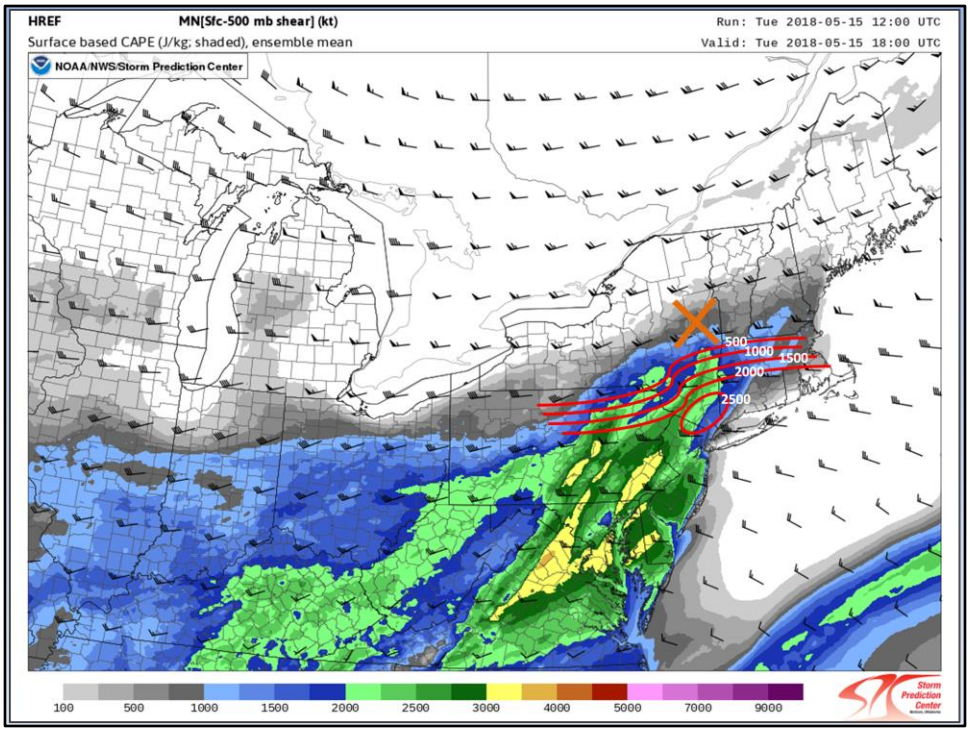



Solar irradiance (W $m^{-2}$, fill), and surface wind (arrows) at 15 UTC. Image created by Nick Bassill. Data provided by the NYS Mesonet.

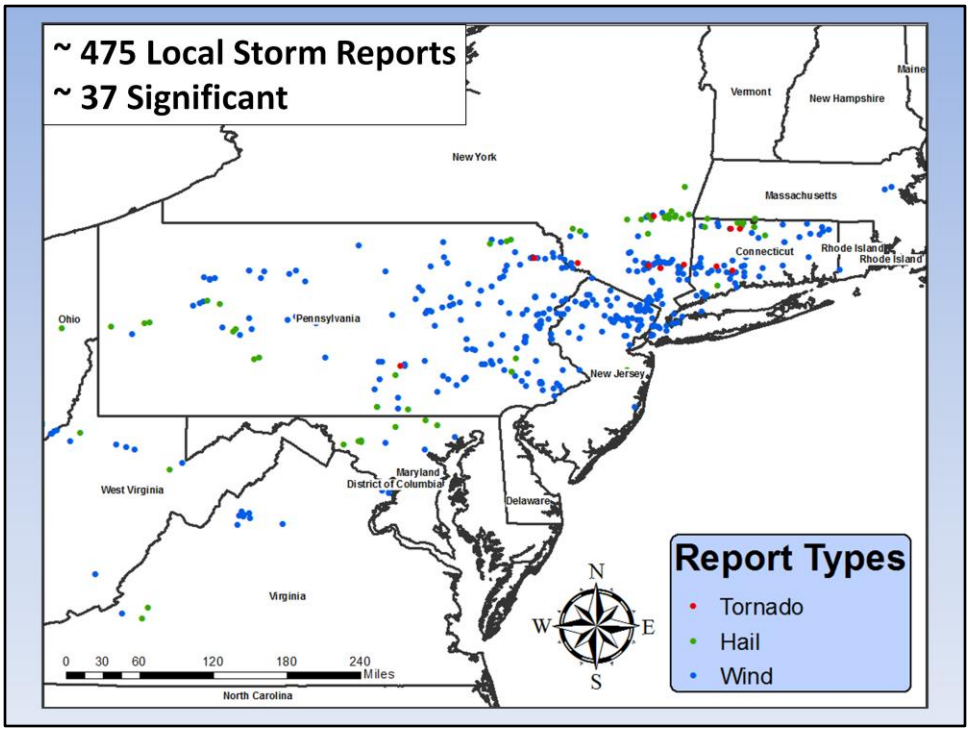



$\theta_e$ (K, fill), radar reflectivity > 20 dBZ (fill), and surface wind (arrows) at 18 UTC. Image created by Nick Bassill. Data provided by the NYS Mesonet.

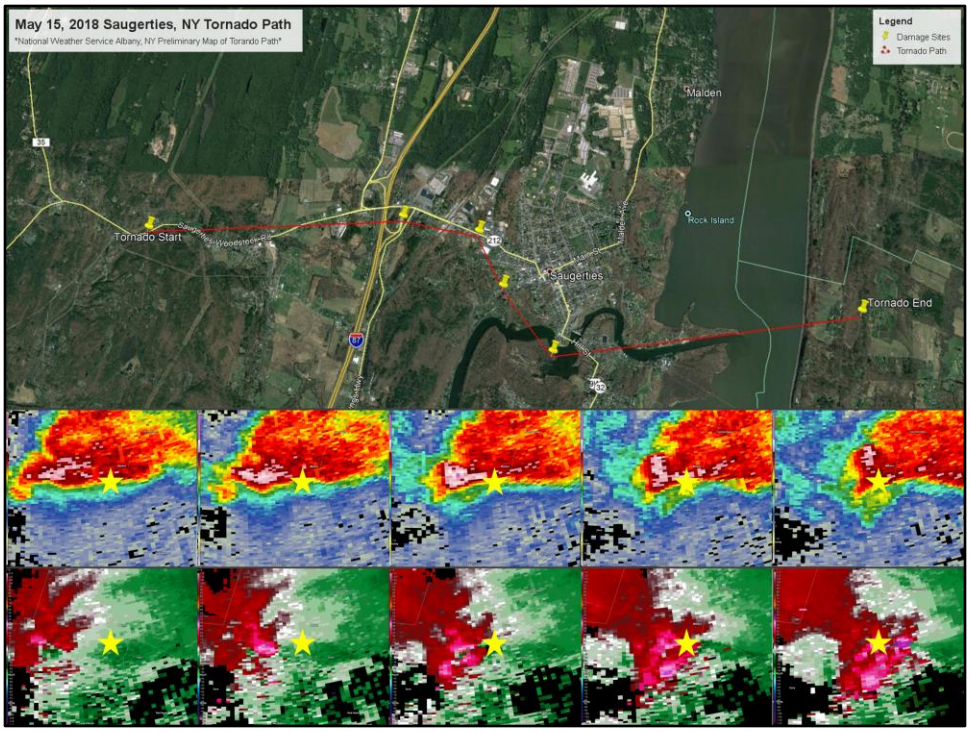
# What Happened?




Are we too reliable on CAM output? Mesoanaylsis is really important with respect to the watch/warning process. There was very little instability North of the Capital Region and the front was almost to the Capital Region already with no convection along it when the tornado watch came out. This resulted a disservice to Capital Region citizens which is a population center (>1 million people) of the state. The drawn red lines indicate the approximate observed SBCAPE values and the "X" denotes that the instability forecasts were overdone over and to the North of the Capital Region.



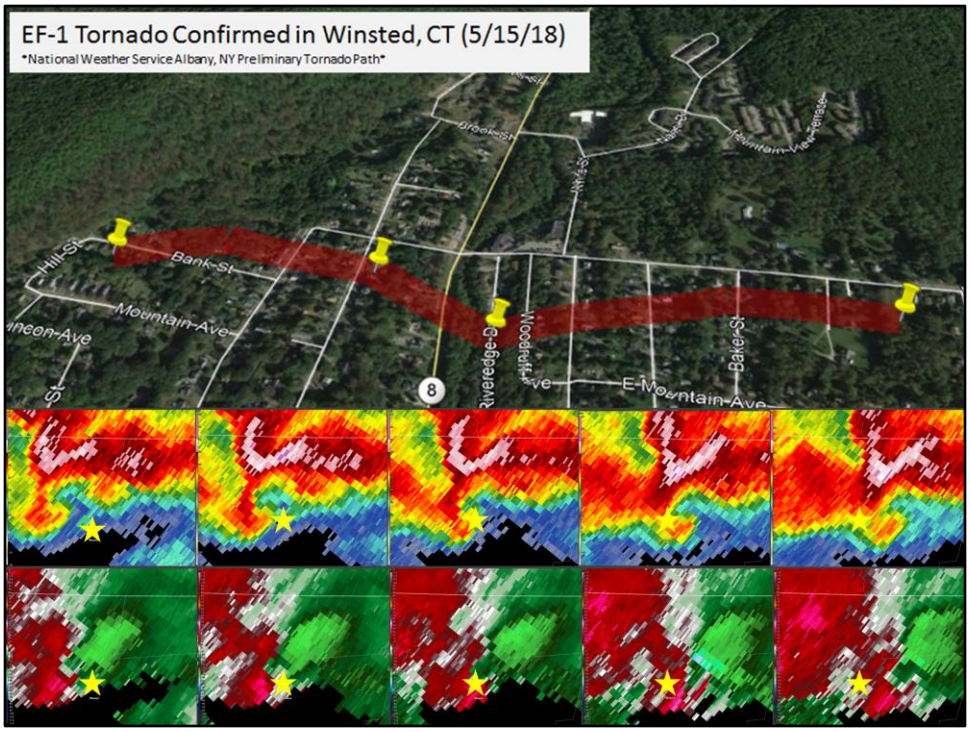

The tornado and hail reports over the Mid-Hudson Valley were associated with discrete long-lived supercells, while the swath of wind damage with embedded tornadoes (further south) was associated with the accelerating/bowing line of intense convection.



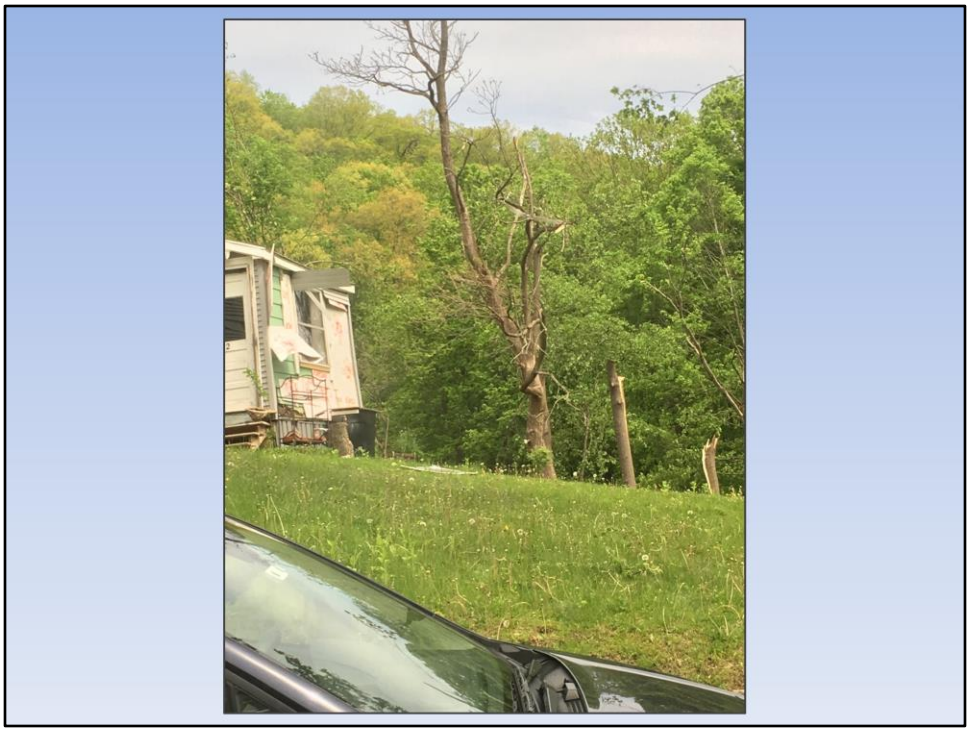

Saugerties, NY EF-1 tornado. KENX reflectivity/SRM and approximate tornado track

Saugerties, NY EF-1 tornado damage

Saugerties, NY EF-1 tornado damage

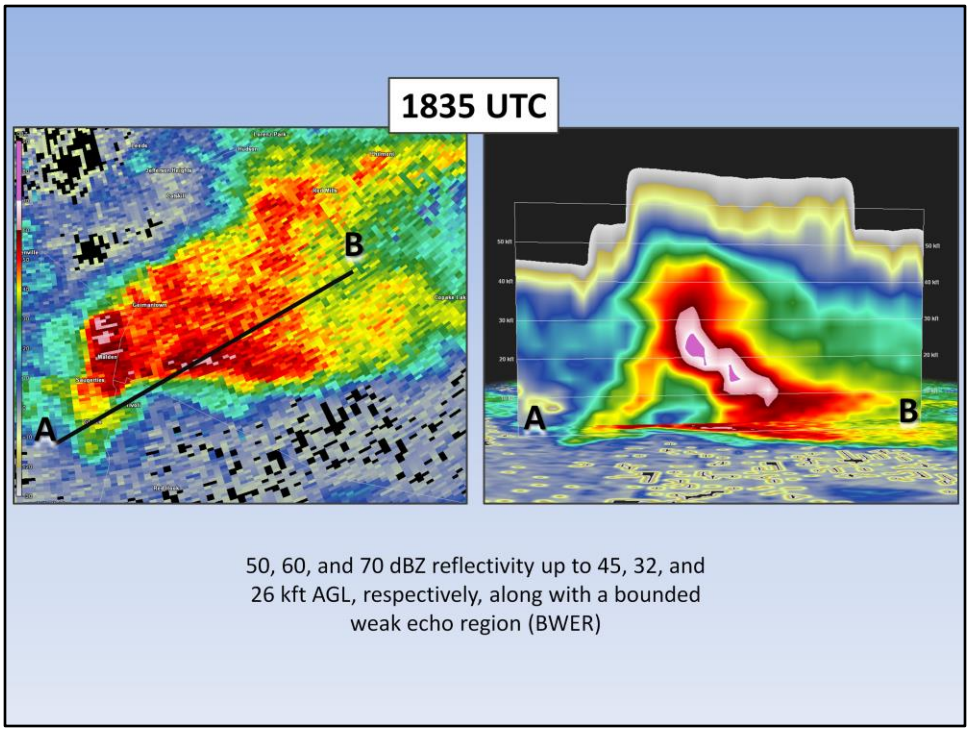



Winsted, CT EF-1 tornado. KENX reflectivity/SRM and approximate tornado track

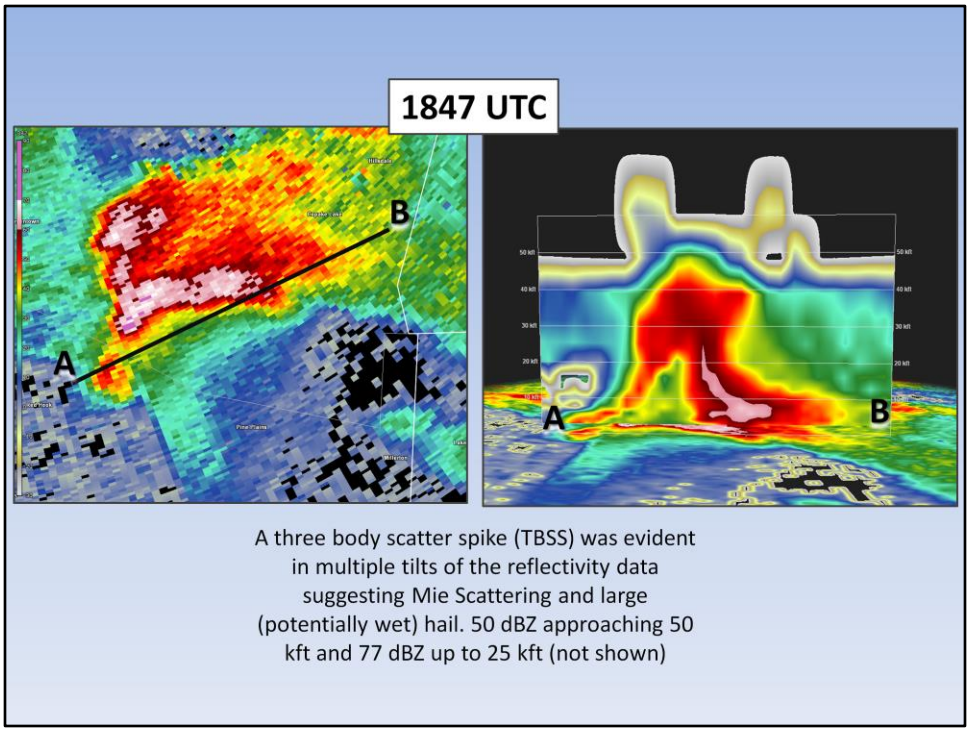


Winsted, CT tornado damage.

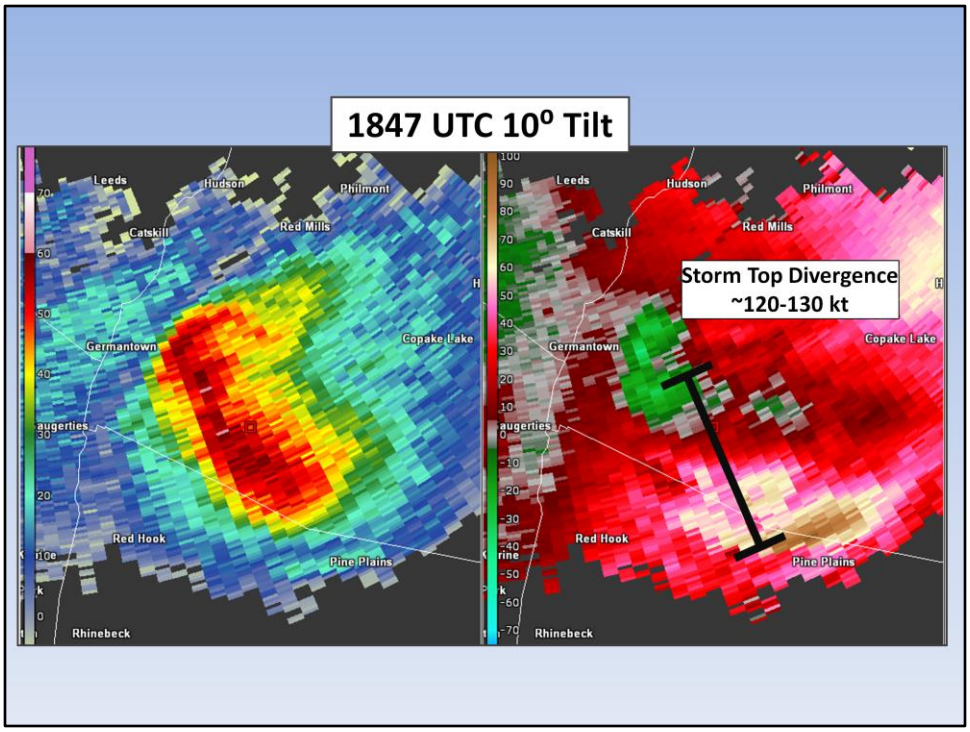
Winsted, CT tornado damage.




Isolated supercell over Columbia County, NY, that resulted in 2–2.75 in hail. KENX radar plan view of 0.5° reflectivity (left) and cross section (right). Cross section shows 50, 60, and 70 dBZ reflectivity up to 45, 32, and 26 kft AGL, respectively, along with a bounded weak echo region.



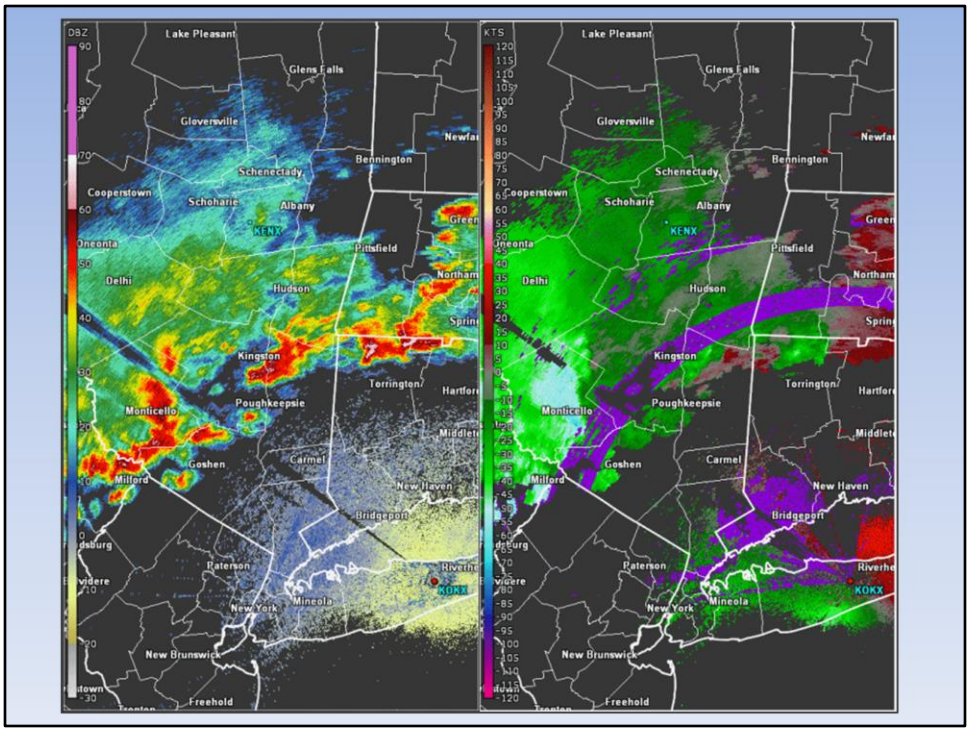

KENX reflectivity cross section of the Saugerties supercell at 1847Z reveals a bounded weak echo region (BWER) suggesting a very strong and persistent updraft. A three body scatter spike (TBSS) was evident in multiple tilts of the reflectivity data suggesting Mie Scattering and large (potentially wet) hail. 50 dbz approaching 50 kft and 77 dbz up to 25 kft (not shown).




Strong Storm Top Divergence suggest that there is a very strong updraft supportive of significant hail


Baseball sized hail (and many 2 inch hail reports) was reported with the Saugerties supercell

Columbia County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Delhi
Hudson
Kingston
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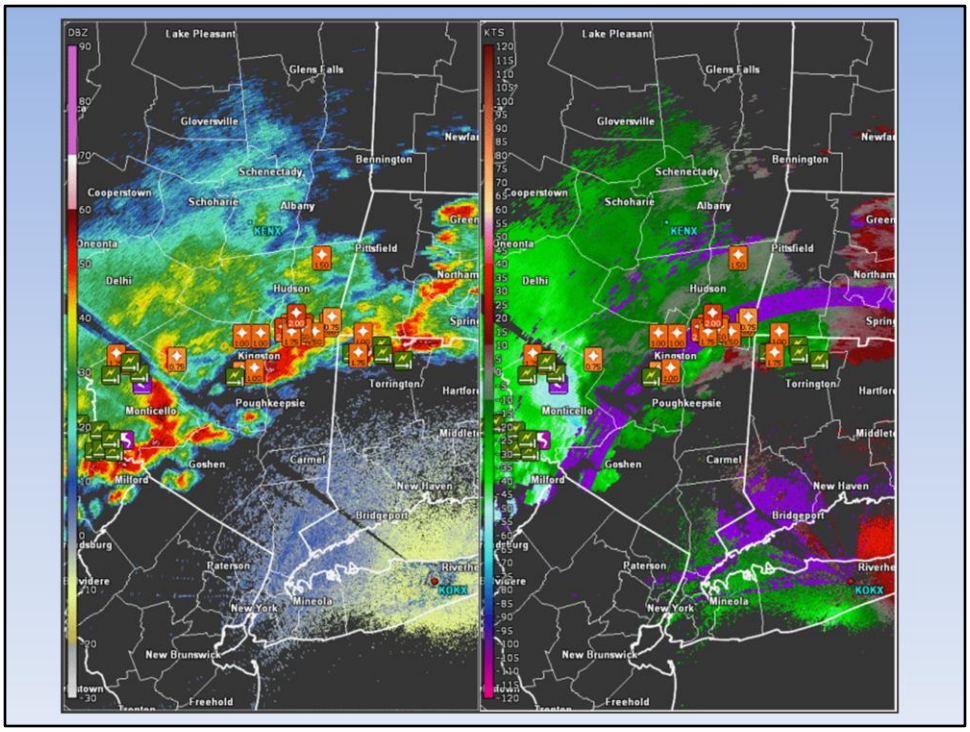
Milford
New Haven
Bridgeport
Paterson
New York
Mineola
KOKX
New Brunswick
Freehold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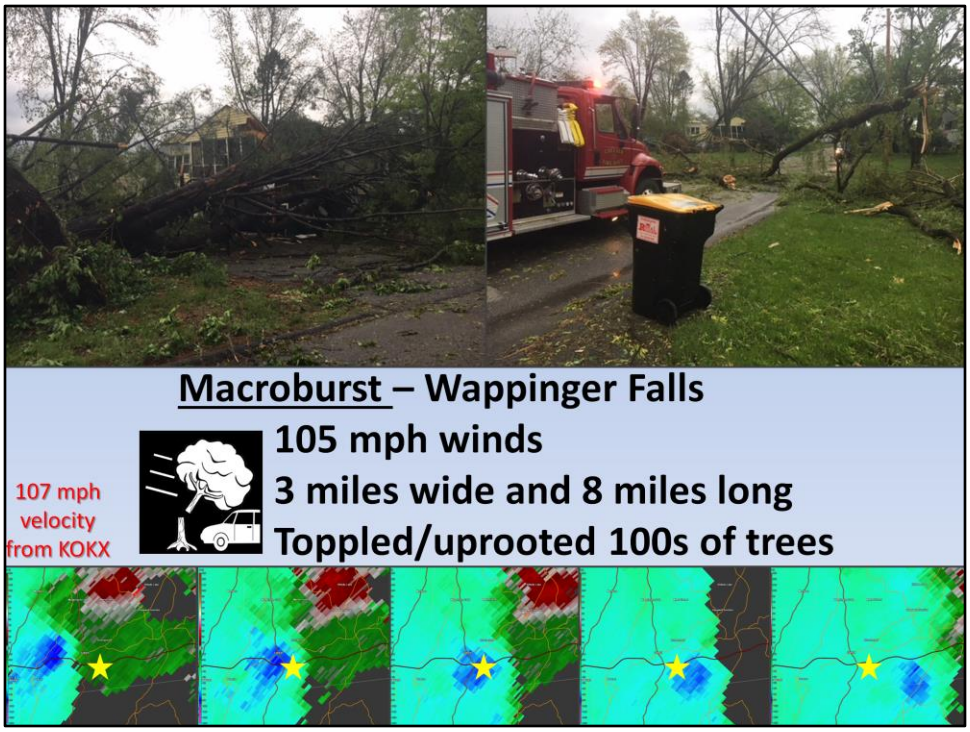
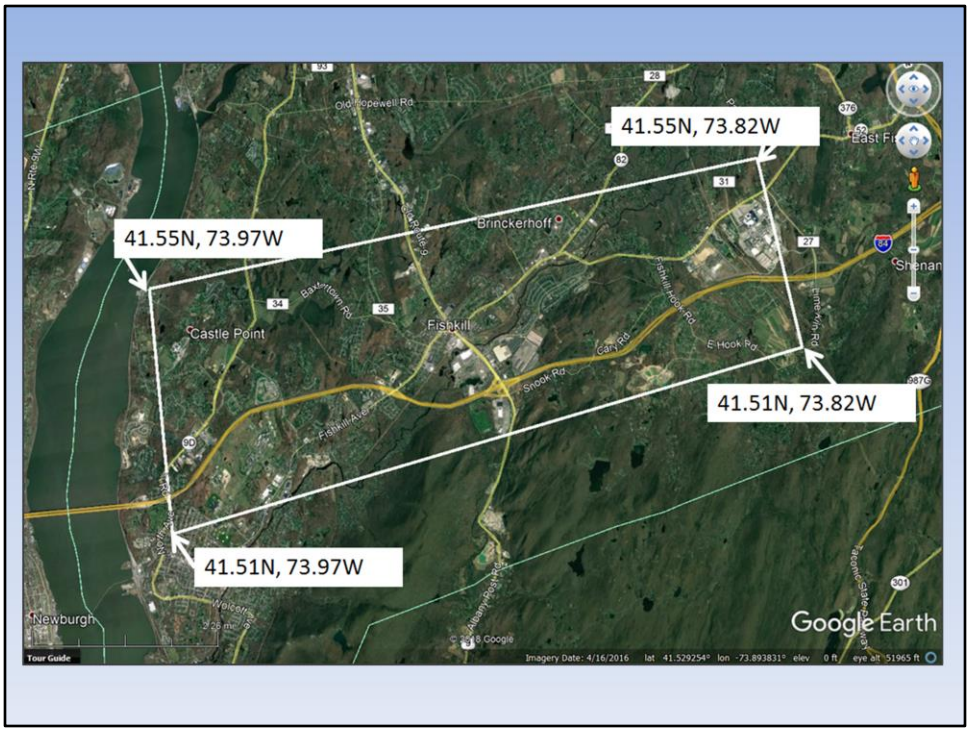
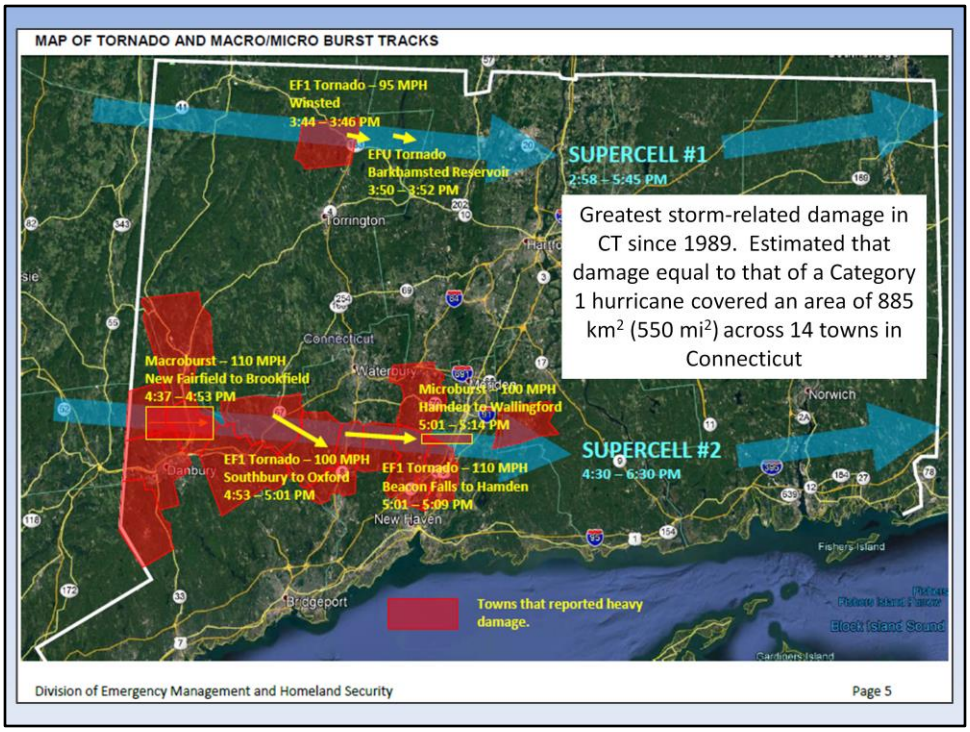
Mineola
KOKX
New Brunswick
Freehold




Wappinger Falls macroburst




Wappinger Falls macroburst




According to the Connecticut Department of Emergency Services and Public Protection, this event caused the greatest storm-related damage in the state since 1989. It was estimated that damage equal to that of a Category 1 hurricane covered an area of 885 $km^2$ (550 $mi^2$) across 14 towns in Connecticut.

# Summary

- ✓ Anomalously strong 500-hPa flow existed between a deep low over eastern Canada and flat ridging over the mid-Atlantic
- ✓ An elevated mixed layer originating from the Desert Southwest resulted in steep midlevel lapse rates over the Northeast
- ✓ Robust 850-hPa boundary represented by $\Delta\theta_e$ ~ 18-20 K/400 KM
- ✓ Effective storm-relative helicity > 200 $m^2$ $s^{-2}$ contributed to an environment favorable for supercells, which formed along a differential heating boundary in SE NY and resulted in 2–2.75 in hail and three tornadoes
- ✓ The steep midlevel lapse rates along with a warm and moist boundary layer in a relatively cloud-free area downstream of a MCV/QLCS contributed to a tongue of mixed-layer CAPE of 1000–2000 J $kg^{-1}$. This unstable airmass was collocated with 45–60 kt bulk shear which allowed the QLCS to strengthen as it moved east, resulting in numerous reports of wind damage
- ✓ A portion of the QLCS bowed and accelerated significantly over SE NY and W CT, resulting in six confirmed micro/macrobursts with winds up to 110 mph and five tornadoes. Winds with this portion of the QLCS resulted in four fatalities and at least two injuries. Impacts were likely magnified by these storms occurring during rush hour
- ✓ CAMs correctly identified leading supercells and accelerating bowing segment, but had convection far too North, impacted TOR watch
- ✓ 75% of the significant severe weather reports had impact-based warning tags > the base 60 mph wind/1 in hail, suggesting NWS warning forecasters were able to identify the high-end nature of the threat with these storms