July 24, 2022 Severe Event Across NY & New England

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Outline

- Background & Motivation
- Synoptic Overview
- Mesoscale/Meso-Analysis
- Soundings
- NYS Mesonet graphics
- Satellite
- HREF/CAM
- Radar/what happened
- Conclusion

Background & Motivation

- Severe thunderstorms on 24 July, 2022 caused multiple wind damage reports across NY/northern PA into southern New England.

- SPC predicted enhanced risk too far north and west of where majority of damage reports were.

→ Majority of severe weather reports were in the marginal risk area.

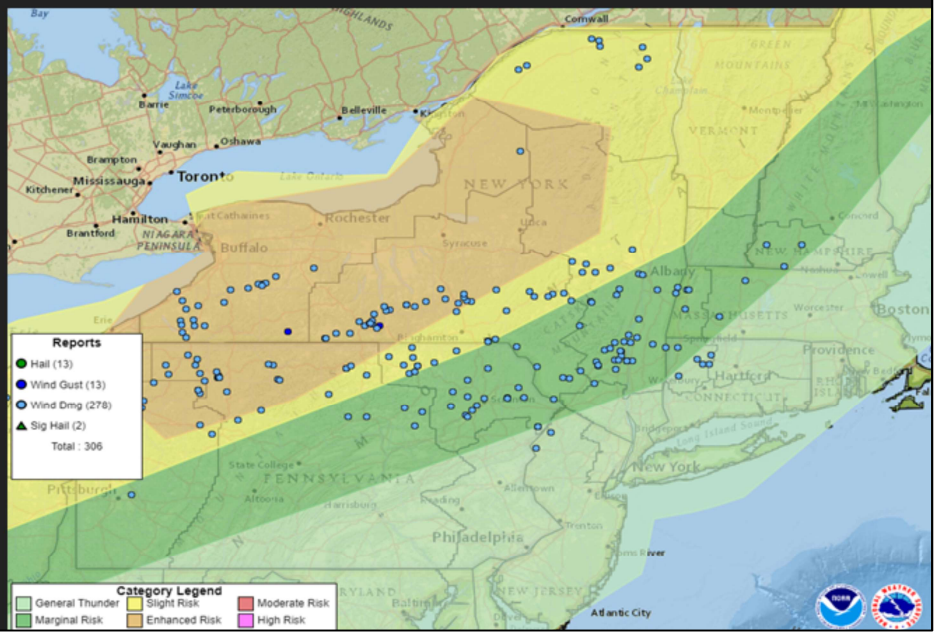
- We are trying to figure out what caused the forecast bust.

Background & Motivation

- SPC convective storm outlook from 7/24/22 at 16z.

- Most wind damage reports & a couple wind gust reports along the southern tier of NY and northern PA.

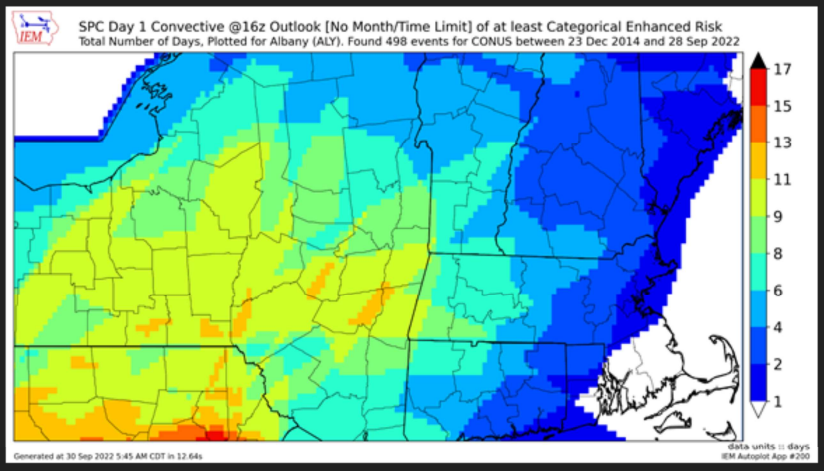
- Note: Albany radar was down during course of event.



Background & Motivation

- Most of the Albany forecast area averages between 1–2 enhanced risk days each year.

- There have been a few years where portions of the Adirondacks do not see an enhanced risk at any point during the year.



This plot, courtesy of the IA State automated data plotter (`https://mesonet.agron.iastate.edu/plotting/auto/`), shows the number of enhanced risk days over NY and western New England between December 2014 and September 2022. It is fairly rare to see an enhanced risk from the SPC in this part of the country, especially across the Northeast.

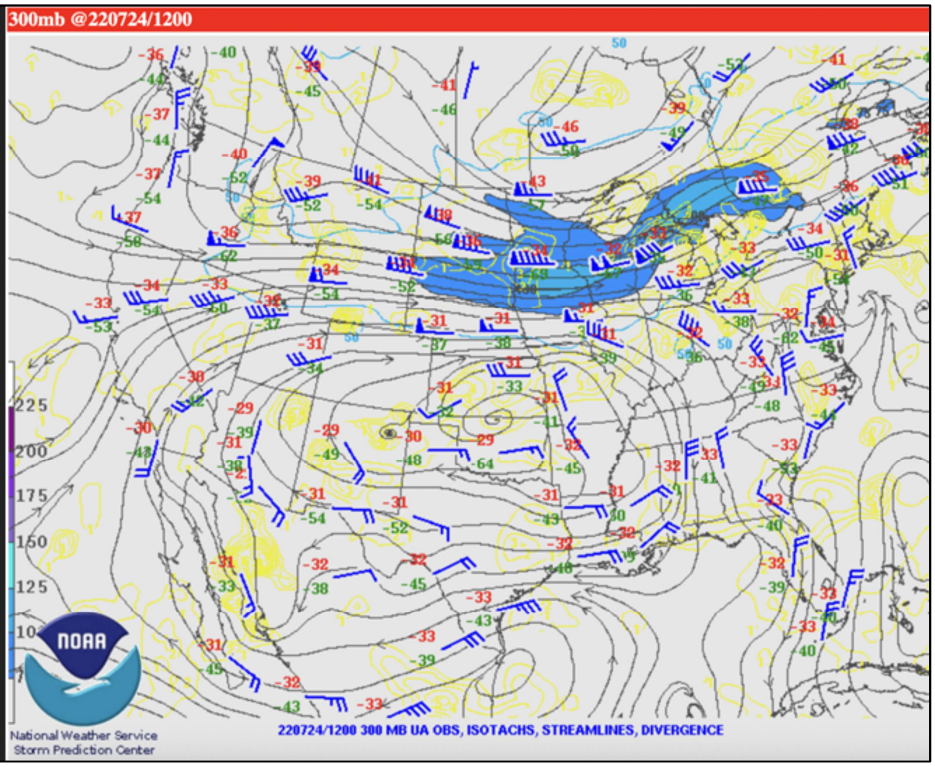
300mb

- 12z

- Large jet stream stretching from North/South Dakota to just north of NY with a jet streak over Minnesota/Great Lakes region (increased vertical wind shear).

- Downstream of trough: divergence aloft = forcing for ascent.
- Wind over PA up to 15 kts.

- Wind over NY up to 30 kts.



There was diffluent flow aloft over PA that would likely provide upper-level forcing for convective initiation later in the day. An area of upper level divergence would move over NY and New England at 300 hPa.

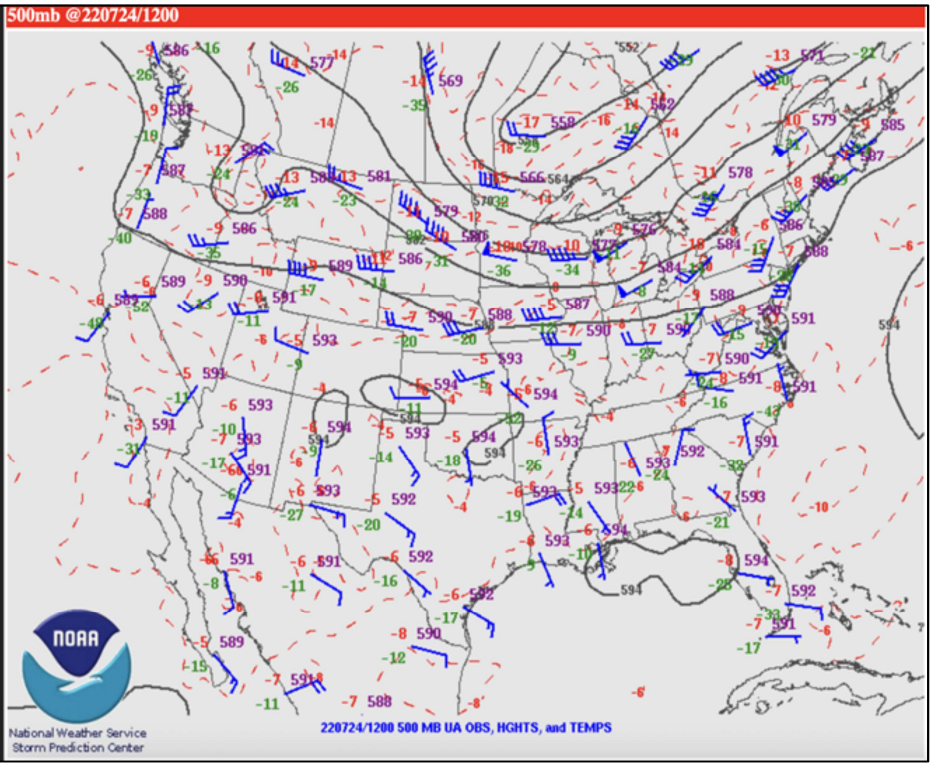
500mb

- 12z

- Large trough across northern U.S./southern Canada. NY is downstream of the trough.

→ Downstream of the trough = divergence (positive vorticity advection)

- Large height gradient over NY.

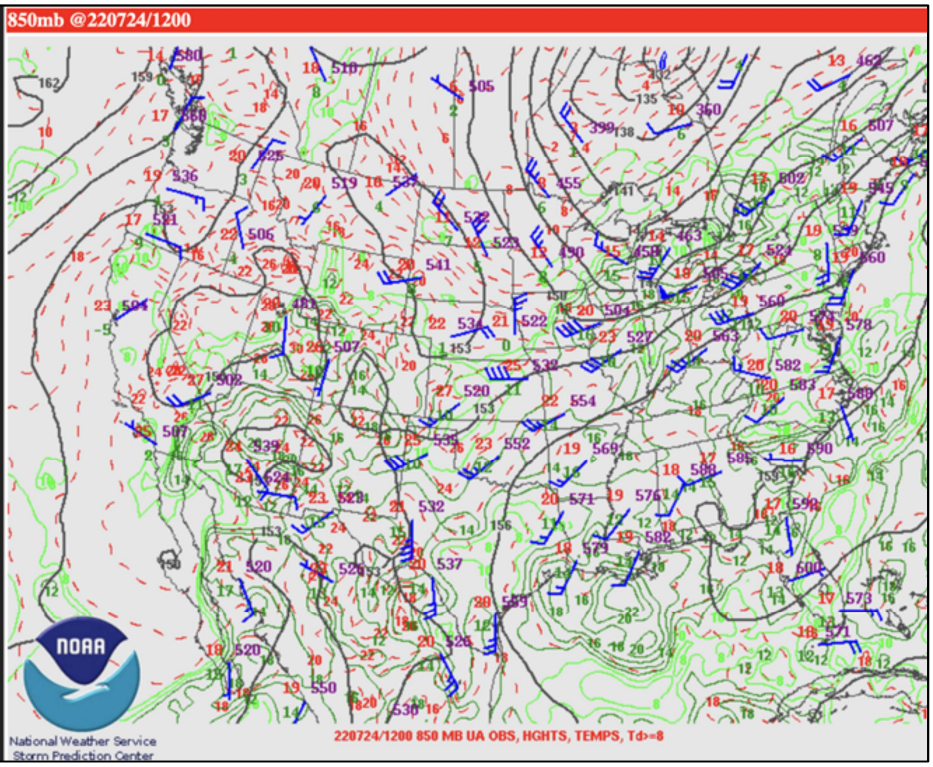


850mb

- 12z

- Moisture transport coming out of the Gulf of Mexico.

- Wind barbs orthogonal to the moisture gradient over NJ/southern NY indicate moist air being advected into the region.



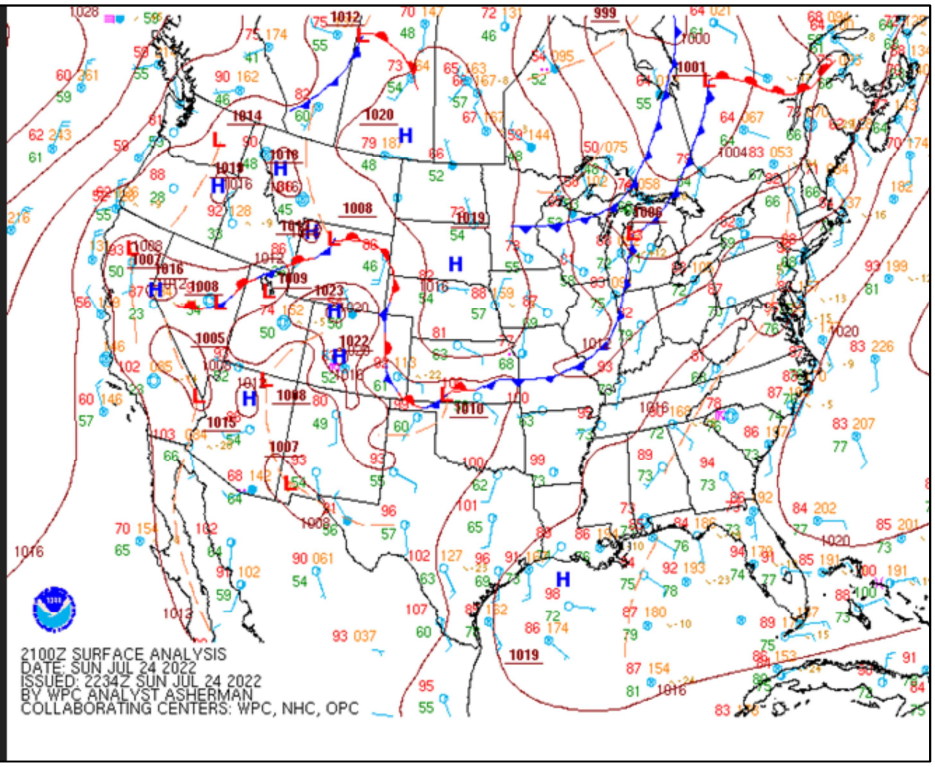
WPC Surface Analysis

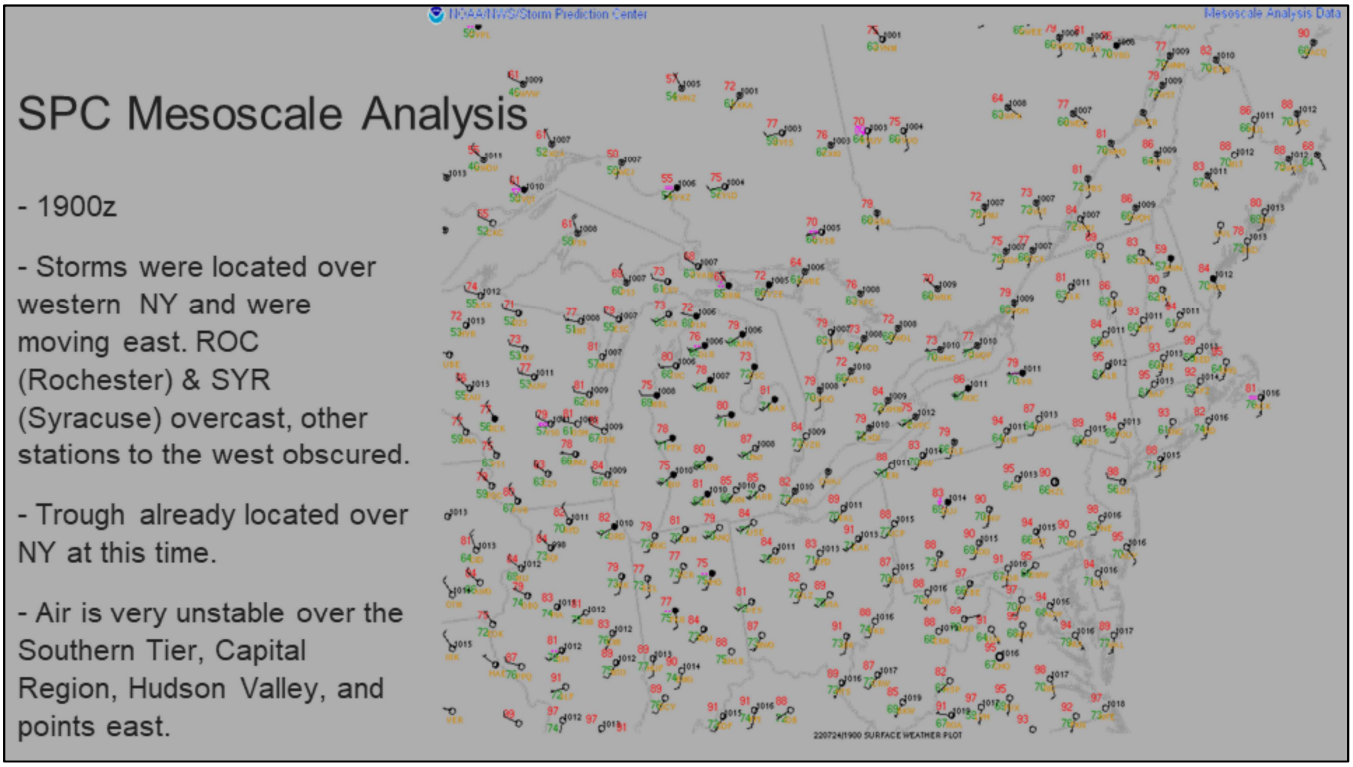
- 2100z

- Cold front west of NY over Michigan.

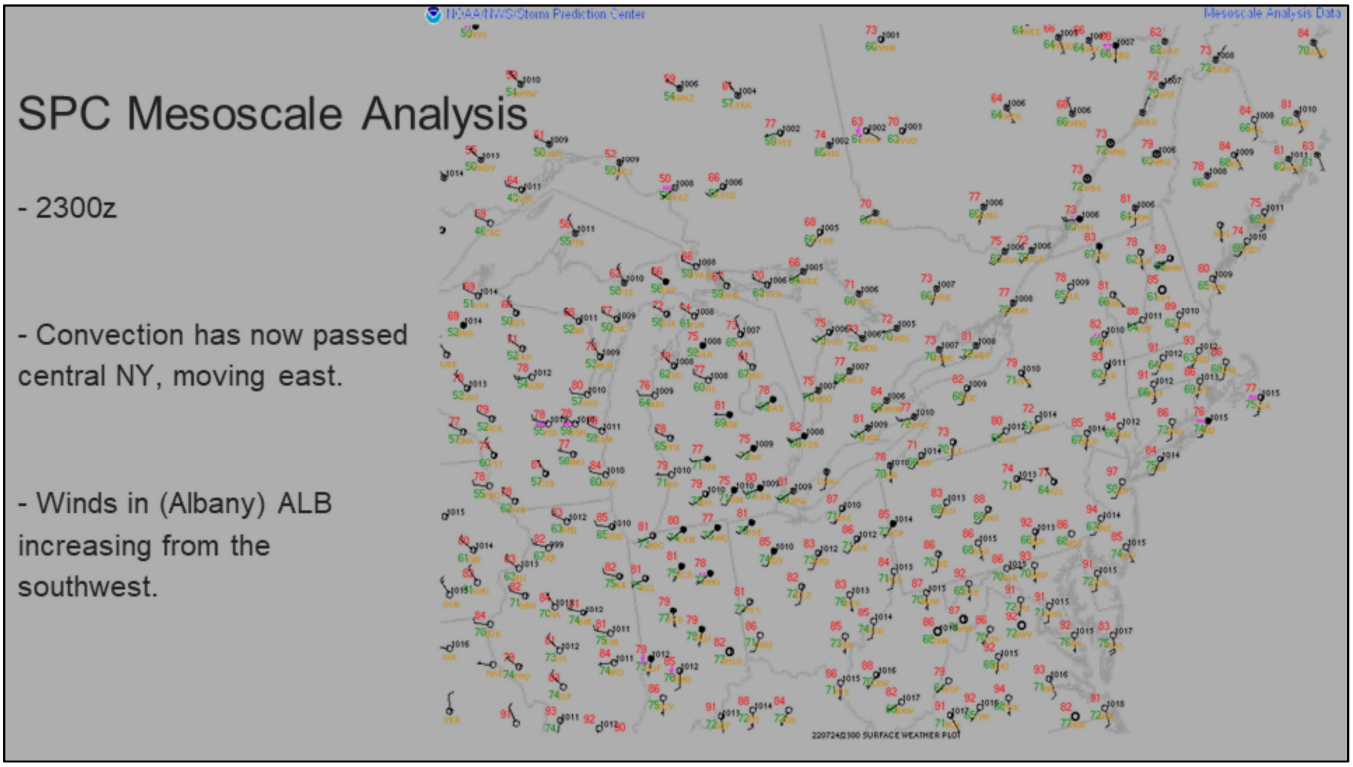
- Surface low centered over Michigan, another low up over Canada north of NY.

- Pre-frontal trough located over eastern NY.

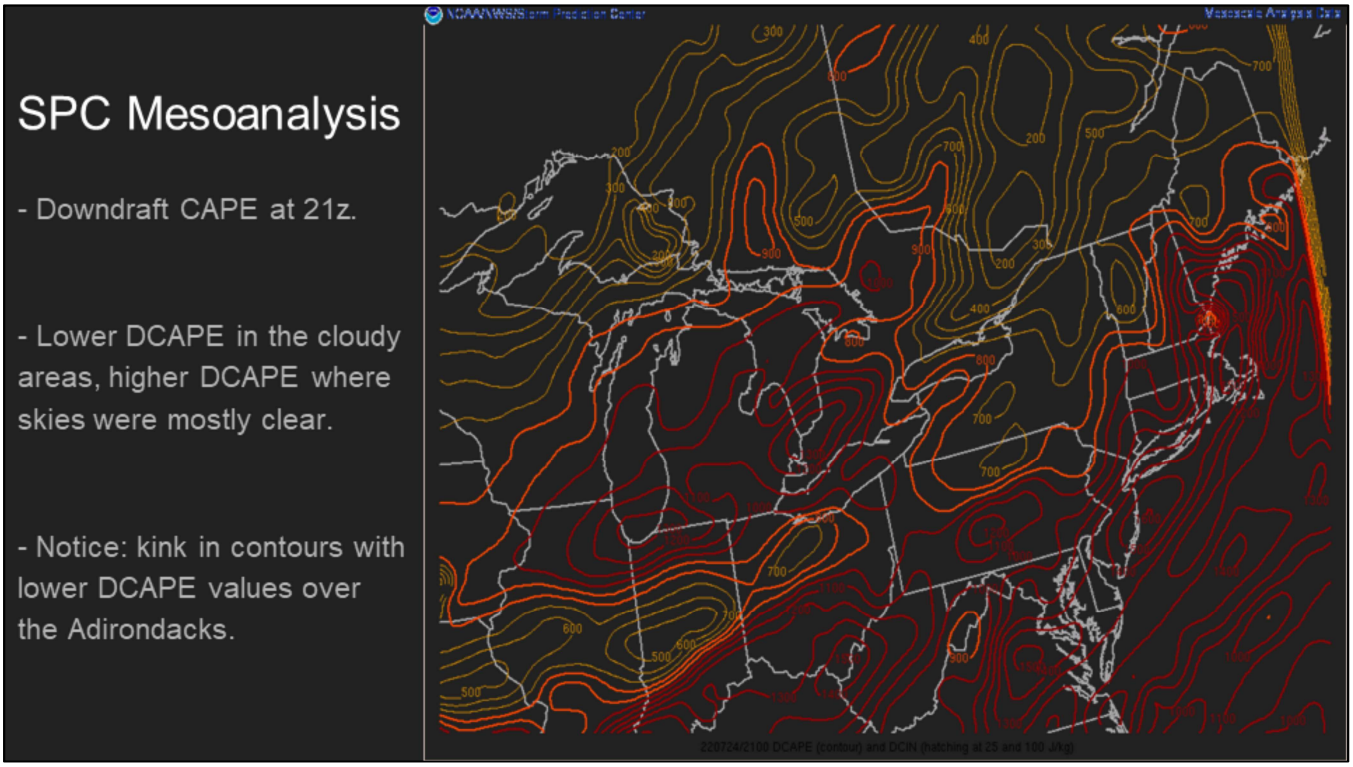




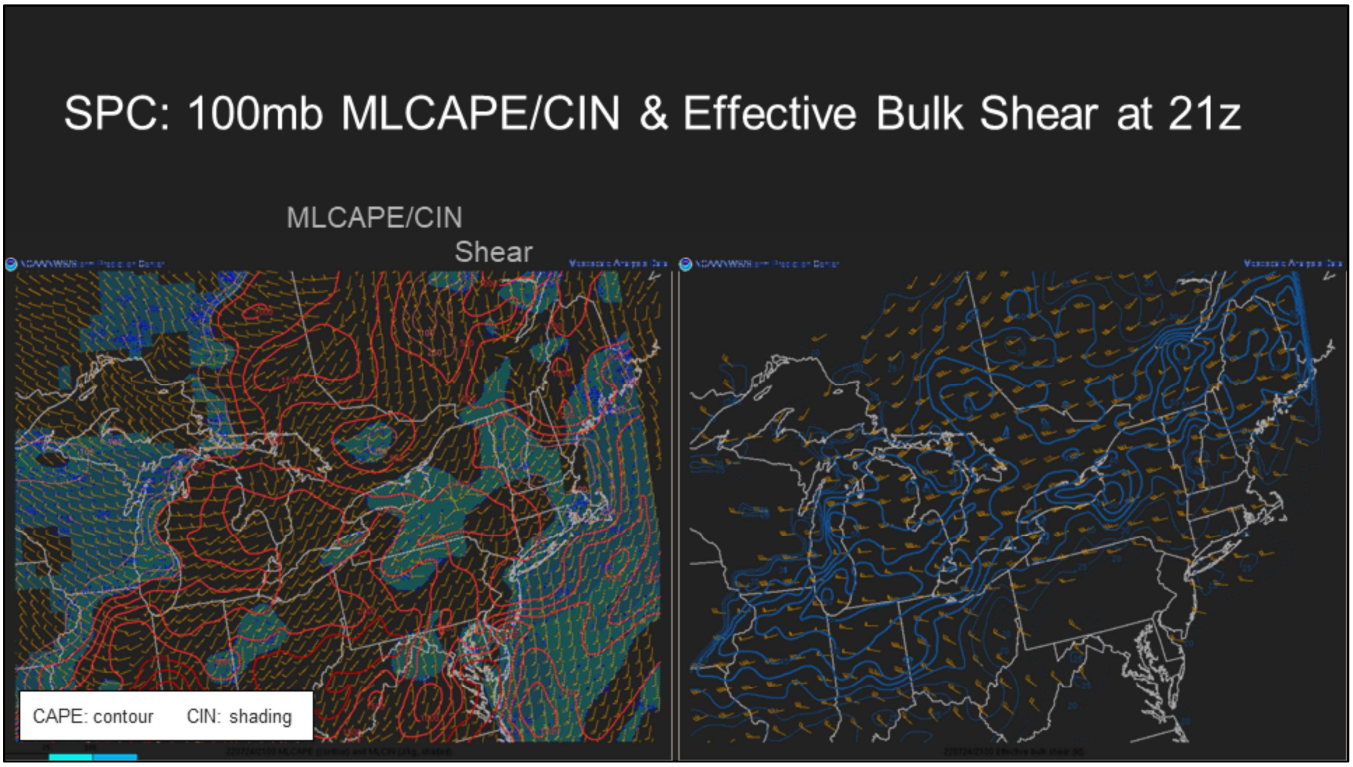
Observing the cloud cover, stations in western New York were mainly overcast, while skies were mainly clear further east. This would help the atmosphere across eastern NY and western New England to remain unstable into the evening.



The shift in wind direction shows the approximate location of convection over eastern New York at this time. Temperatures also decreased across western NY due to the convective downdrafts associated with the event, but the air mass remained very warm and unstable ahead of the storms in eastern NY and western New England.



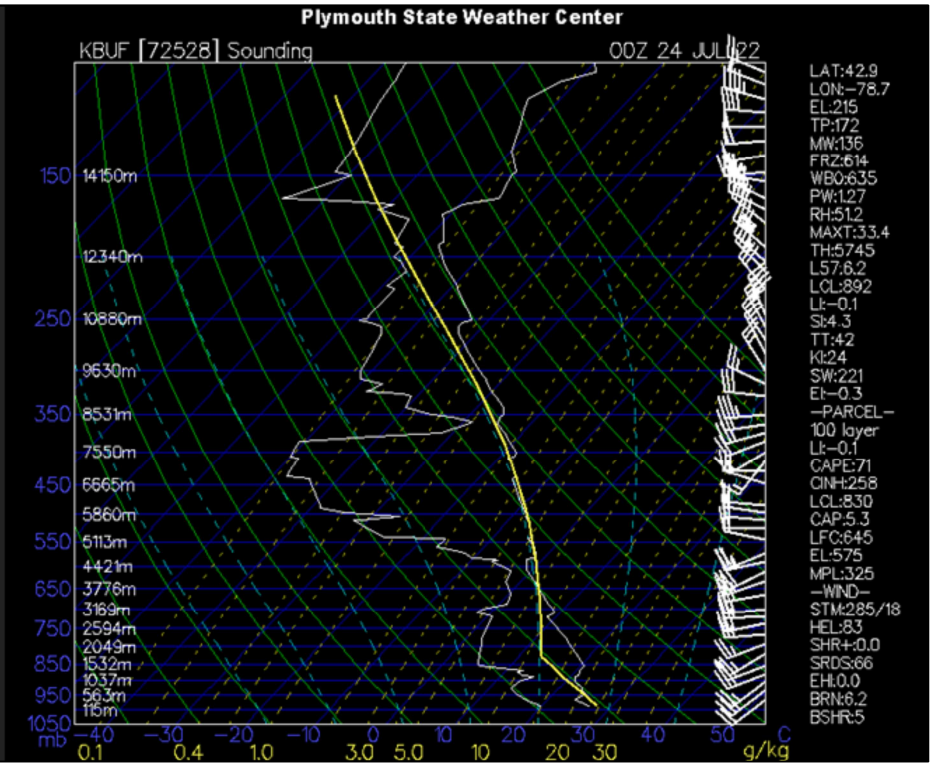
Higher DCAPE values suggest the potential for damaging winds or strong downdrafts with any convection that develops. DCAPE values of 1000+ J/kg were located in the Hudson Valley and southwestern New England in particular are notable here.



CIN values were high across western and central NY in areas that had already experienced thunderstorms, but there was little in the way of CIN out in front of these storms. CAPE values were on the order of 1000–2000 J/kg across most of eastern NY (SBCAPE which is not shown here was higher than MLCAPE). Effective bulk shear values were very impressive across most of NY, with up to 50 kts across western portions of the state. Shear values were slightly lower further south and east, but 30-40 kts of deep-layer shear here was still supportive of storm organization.

Soundings

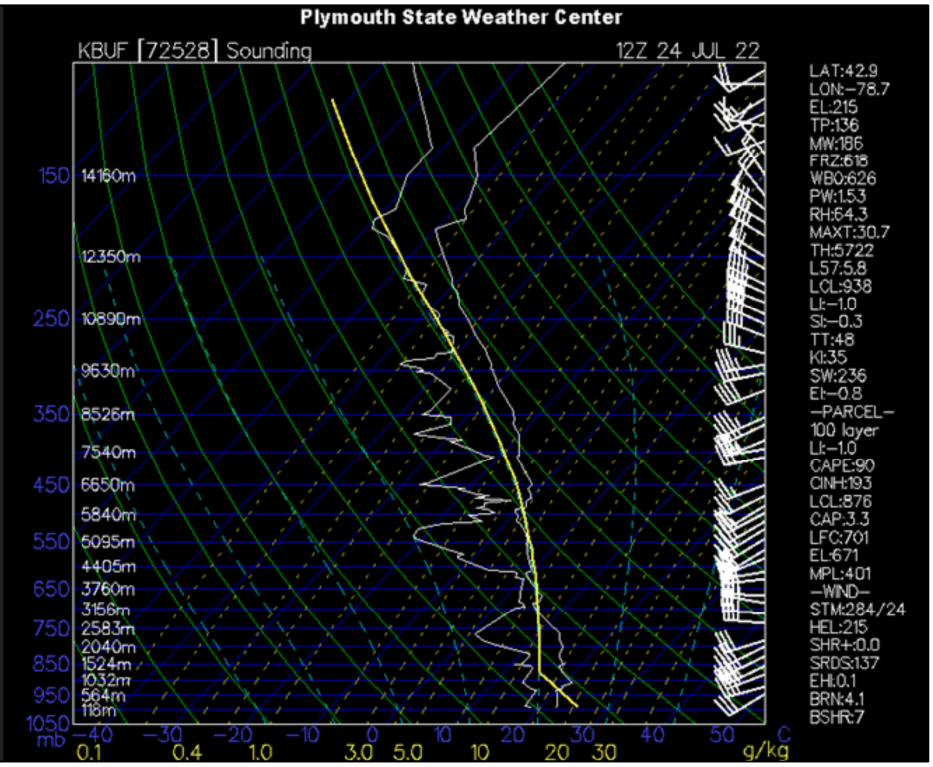
- KBUF (Buffalo) 00z sounding.
- Some backing in 250-100mb level.
- Winds mostly W/SW until about 300mb.
- Multiple cloud layers.
- Fairly low CAPE.
- CIN over 200 suggests low risk for storms.
- Dry layer at about 570-320mb.



This sounding was from Buffalo on 00z July 24, which was roughly 18 hours before convective initiation took place. There were some steep mid-level lapse rates in place, but overall this sounding does not look overly supportive of severe weather. The environment would improve over the next 12-18 hours with increasing moisture, instability and shear ahead of the approaching upper trough.

Soundings

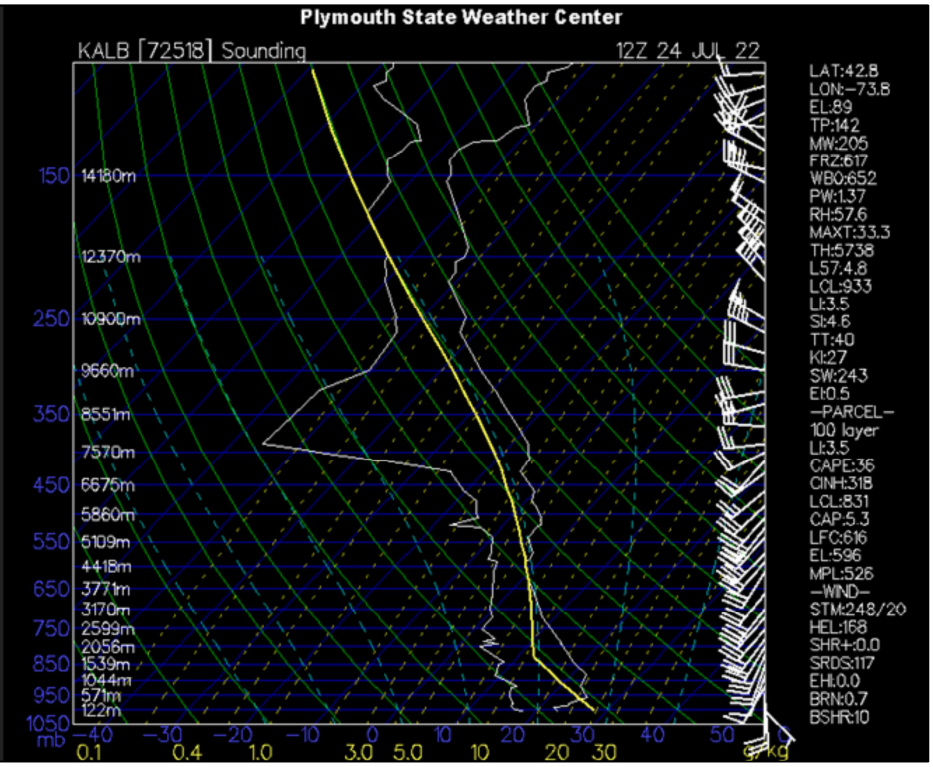
- KBUF (Buffalo) 12z sounding.
- Backing in 150-100mb layer.
- Again, CAPE is fairly low.
- Entire atmosphere is becoming more saturated & clouds are increasing.



CAPE remains meager at around 100 J/kg, but a moistening of the profile can be seen compared to the 00z sounding. CIN remains high, but with expected daytime heating this sounding shows better potential for severe weather, especially with steep mid-level lapse rates remaining in place. The presence of mid-level dry air is also a signal to the potential for damaging wind gusts due to convective downdrafts with any storm that develop.

Soundings

- KALY (Albany) 12z sounding.
- Veering at surface.
- Winds mostly southwesterly.
- Backing in the 150-100mb level.
- CAPE is very low.
- CIN is 318; fairly high, so low risk for storms to develop at this time.



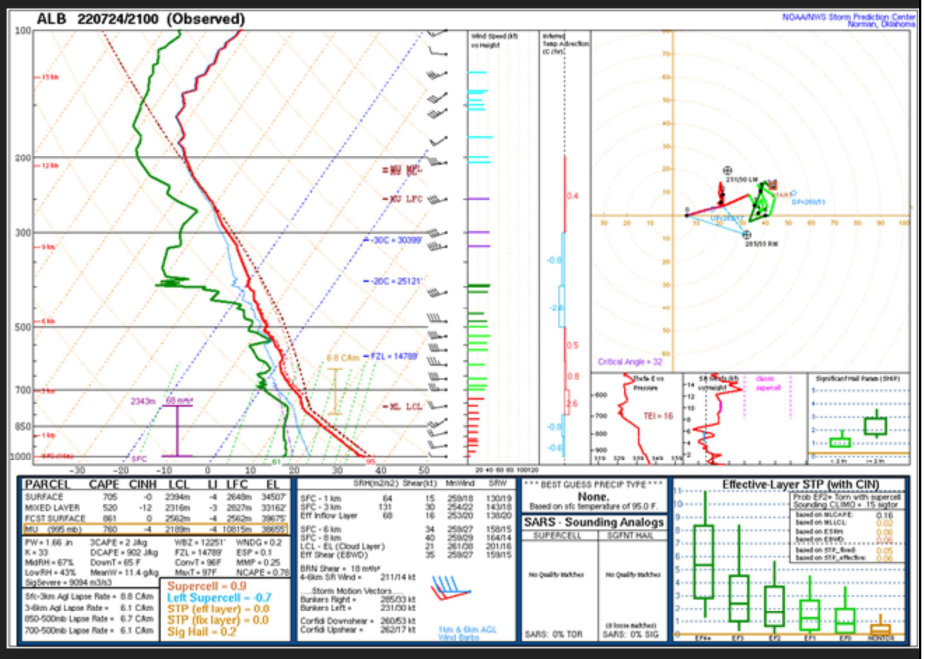
Overall, there are no significant differences between the ALY and BUF soundings from 1200 UTC 24 July. A high shear and low CAPE environment was in placed at KALY at this time.

Soundings

- KALY (Albany) 21z sounding.

- Unidirectional shear profile supports upscale growth

- DCAPE of ~900 J/kg is impressive, which in conjunction with the inverted "V" sounding suggests the potential for strong convective downdrafts.



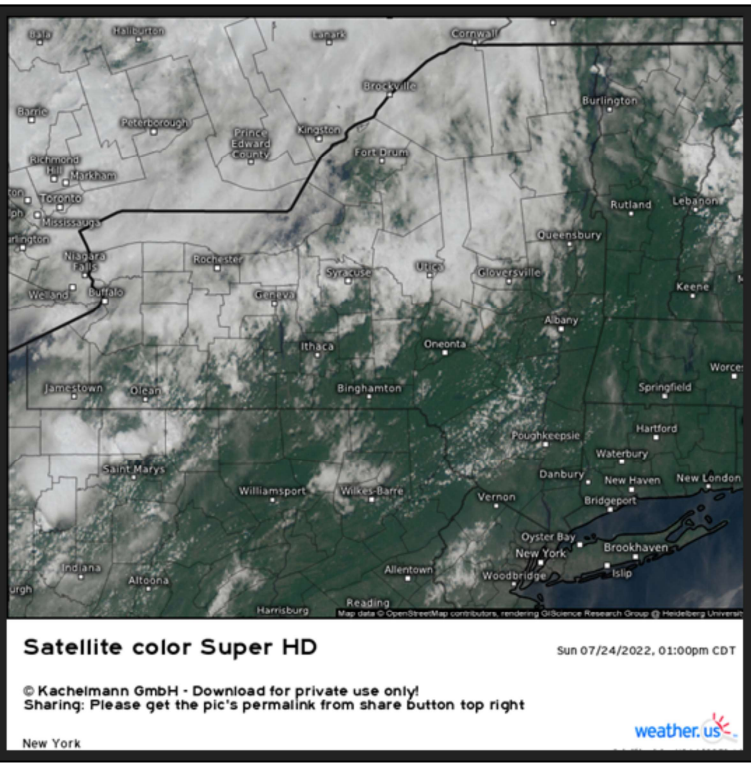
The 21z sounding from Albany shows an environment that is fairly supportive of severe convection and storm organization. However, this sounding was actually sucked into the updraft of a developing thunderstorm, so the data above the boundary layer are convectively contaminated. Therefore, it is likely that the true instability is much higher than the 750 J/kg here. Nevertheless, the well-mixed boundary layer and unidirectional shear profile both highlight the potential for cold pool organization, upscale growth, and damaging winds with any storms that developed.

Satellite Imagery

- 18z/2:00 PM EDT.

- Mid and high-level clouds located over the Adirondacks and Mohawk Valley

- Mainly clear skies across most of eastern NY and western New England



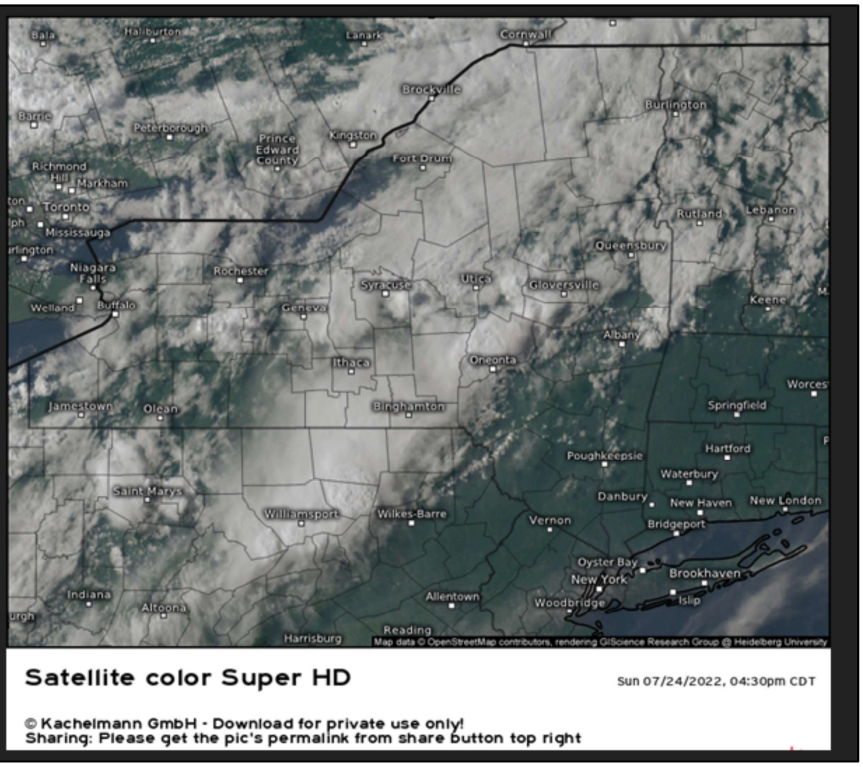
Areas of clouds moved into western and northern NY by early to mid afternoon. This would limit the amount of incoming solar irradiance (shown on the following few slides) and ultimately limit the amount of instability in these areas. This image, and the one on the following slide, were obtained from weather.us at the following link: https://weather.us/satellite/new-york/satellite-color-superhd-5min/20220724-1900z.html

Satellite Imagery

- 2130z/5:30 PM EDT.

- Clouds moving eastward.

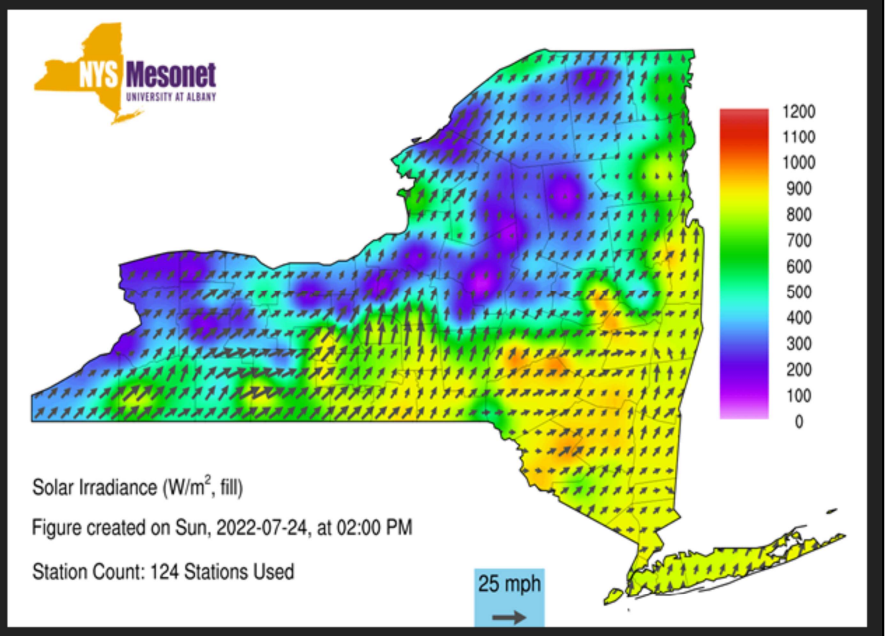
- Increased cloud cover over the Adirondacks and on the downstream of Lake Ontario.



Also noted are the clear skies from the Capital District south and east, which helped maintain an unstable environment ahead of the convection. Strong to severe thunderstorms easily developed in these locations in the late afternoon.

NYS Mesonet

- Solar Irradiance at 18z
- Clear delineation between cloudy skies over the Mohawk Valley and Adirondacks clear skies to the southeast.
- Low-level convergence can be seen along the gradient in solar irradiance



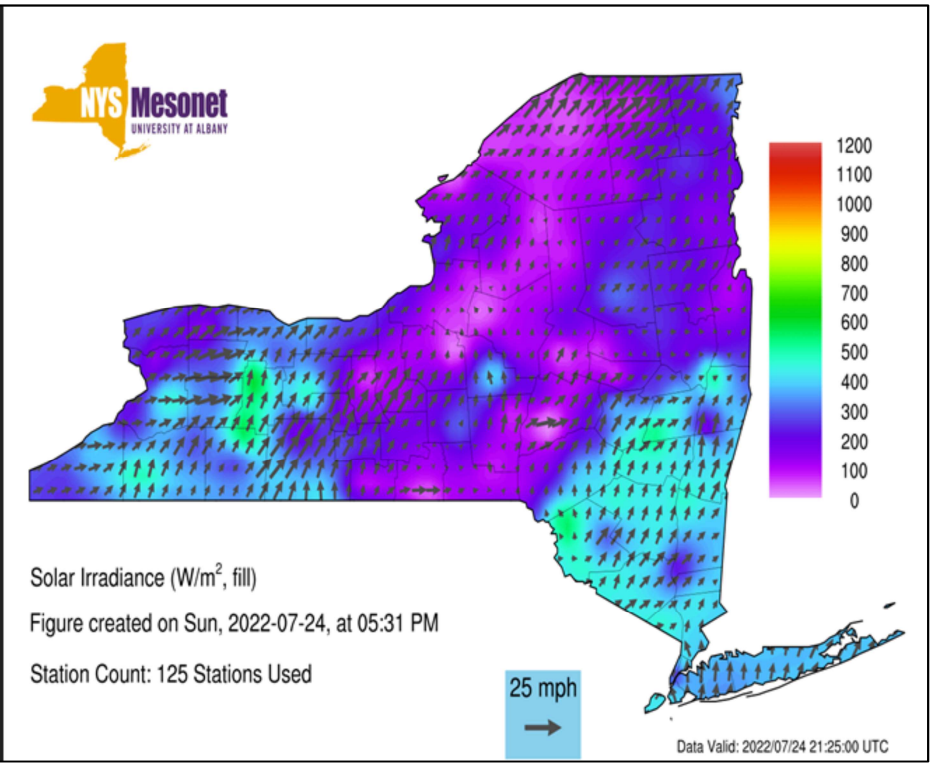
This NYS mesonet plot of solar irradiance at 18z shows why we did not see severe weather over the Adirondacks and Mohawk Valley. These areas were already cloudy by 18z, which limited the instability here (this can be seen when compared to CAPE as seen in the SPC mesoanalysis on previous slides). With mostly clear skies to the east, a differential heating boundary would develop across western NT and northwest PA. Low-level convergence along the differential heating boundary would serve as a source of lift and would lead to convective initiation (CI) along this differential heating boundary.

NYS Mesonet

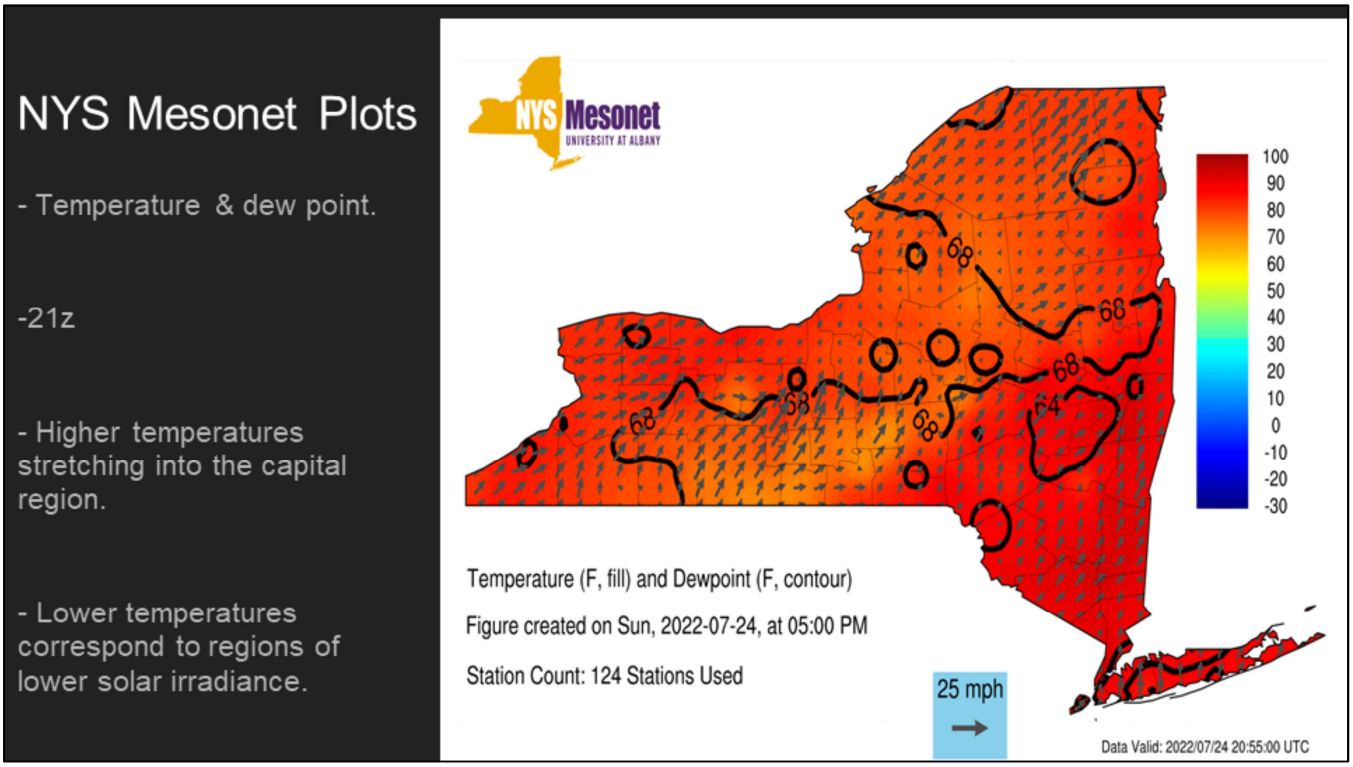
- Solar Irradiance at 2130z.

- The solar irradiance aligns with the satellite imagery showing cloud coverage over NY.

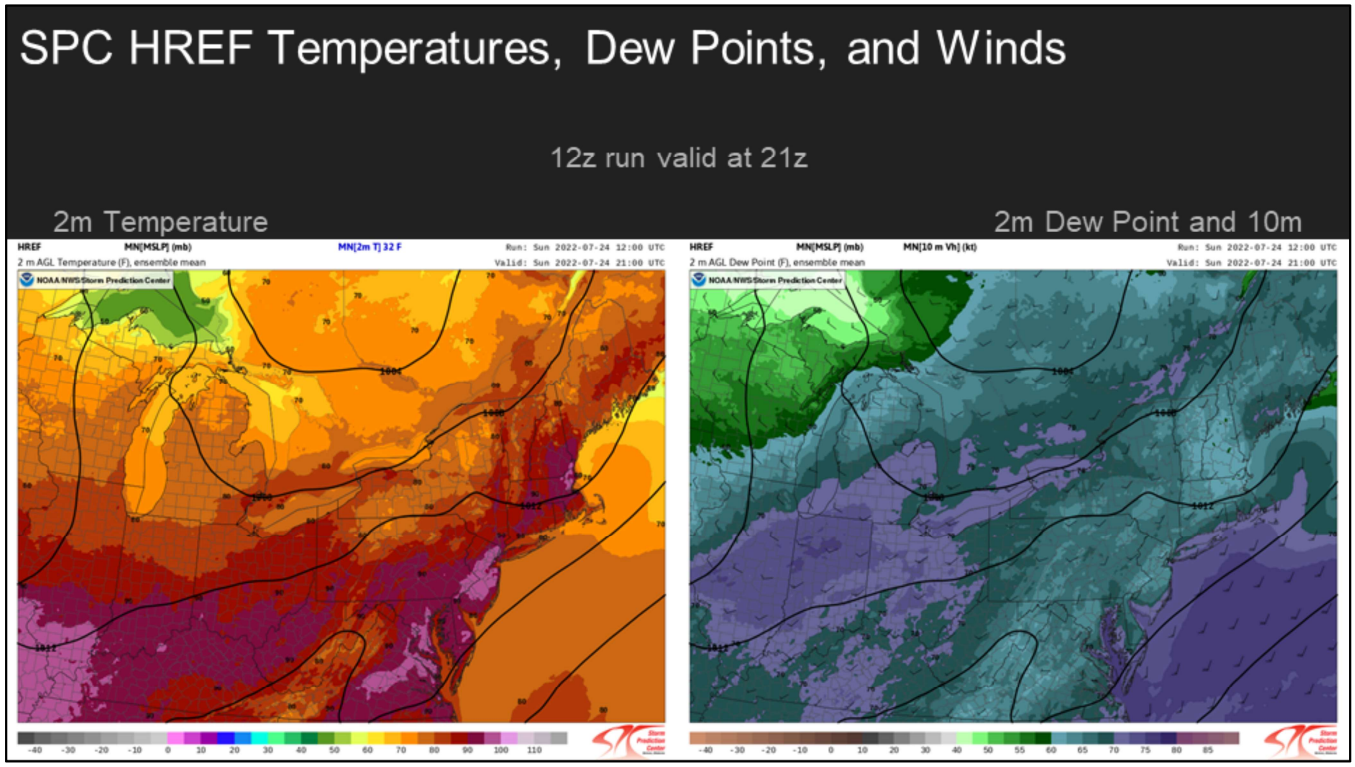
- Wind vectors indicate low-level convergence at areas of increased cloud cover.



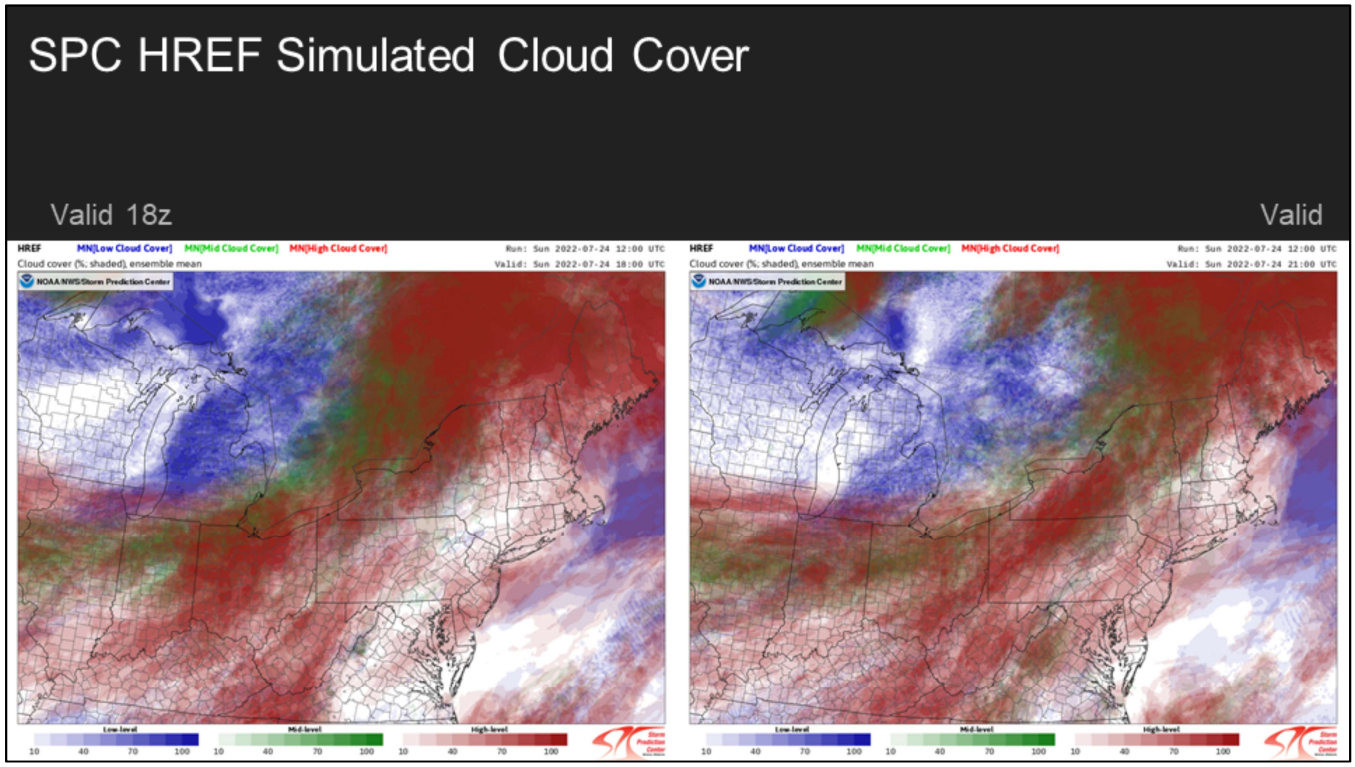
Looking a few hours later, the same general pattern can be seen as noted on the previous slide. By this point, cloud cover across central NY was thicker as convection had developed by this time. However, skies remained clear across the Catskills and Mid Hudson Valley, which helped to maintain greater instability here. Low-level convergence would help to maintain convection as it tracked eastwards.



The differential heating boundary can be seen from this NYS Mesonet temperature map as well, with cooler temperatures across the Adirondacks and Mohawk Valley where it was cloudy with higher temperatures from the Capital District south and east. Lower dew points over the Capital District also suggest deeper boundary-layer mixing here, which is another sign of the potential for strong convective downdrafts as storms moved into this environment.



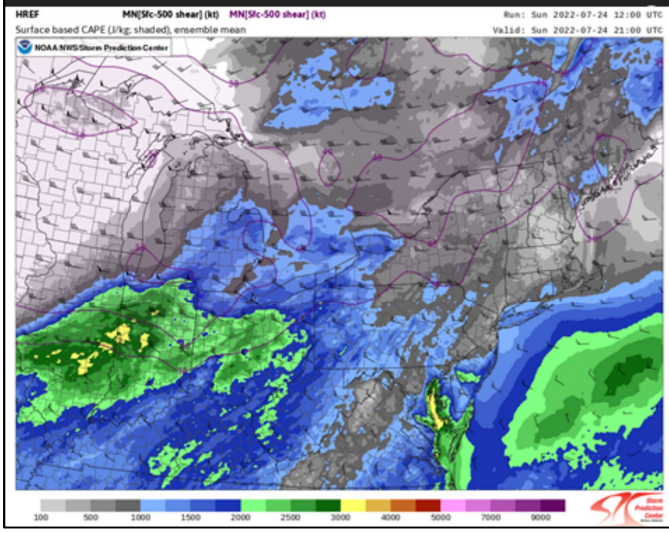
Retrieved from the SPC HREF model, 2-m temperatures and dew points at 21z are shown here. Temperatures were in the 80s across majority of the state and nearly into the 90s into the Capital Region and the Mid-Hudson Valley. Dew point values here were in the 60s and into the 70s. Overall, the HREF temperature and dew point forecasts were on the right track, although temperatures in the model were a few degrees too warm across the Adirondacks and Mohawk Valley where it had remained cloudy through most of the day. In addition, there is no signal for any sort of low-level convergence over NY state in the HREF forecast of winds, which are overlaid on the plot with dew points. Therefore, it is not surprising that the model struggled with the location of CI and locations where the resulting convection would track.



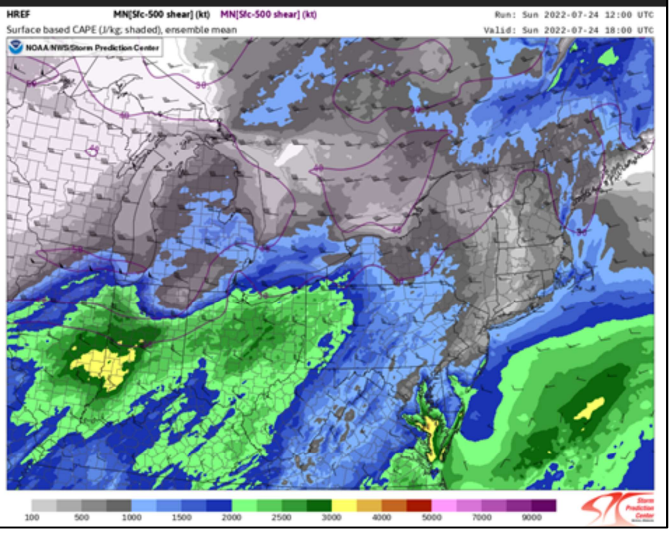
Comparing the model forecast of cloud cover to satellite imagery and the NYS Mesonet solar irradiance plots, it becomes clear that the model underpredicted the degree of cloud cover across the Adirondacks and Mohawk Valley. Skies here were overcast by 18z, while the model only predicted few to scattered high clouds. This was likely the reason for the over-estimate of temperatures here. It then follows that if the model was unable to resolve the degree of cloud cover, that it was unable to correctly diagnose the location and magnitude of the differential heating boundary that would ultimately serve as the focus for CI.

SPC HREF Instability and Shear

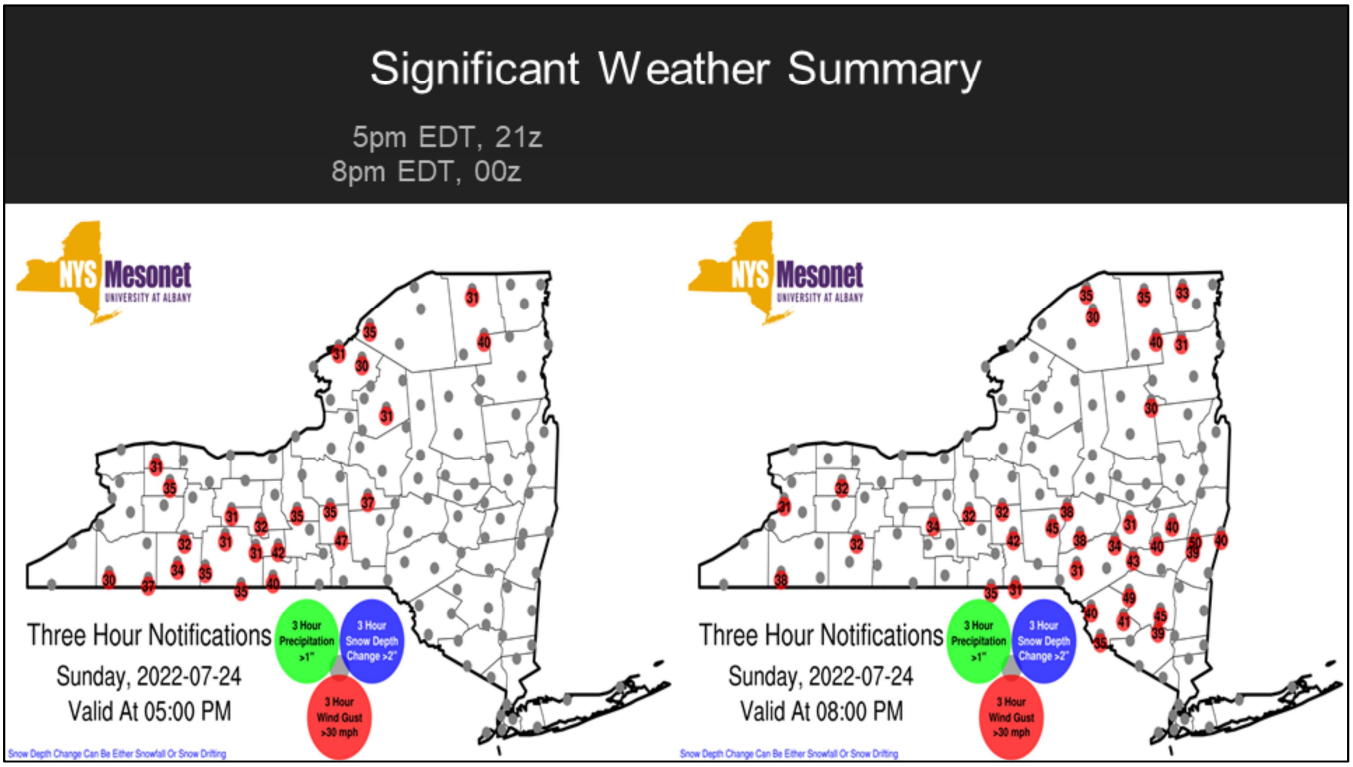
Valid at 18z



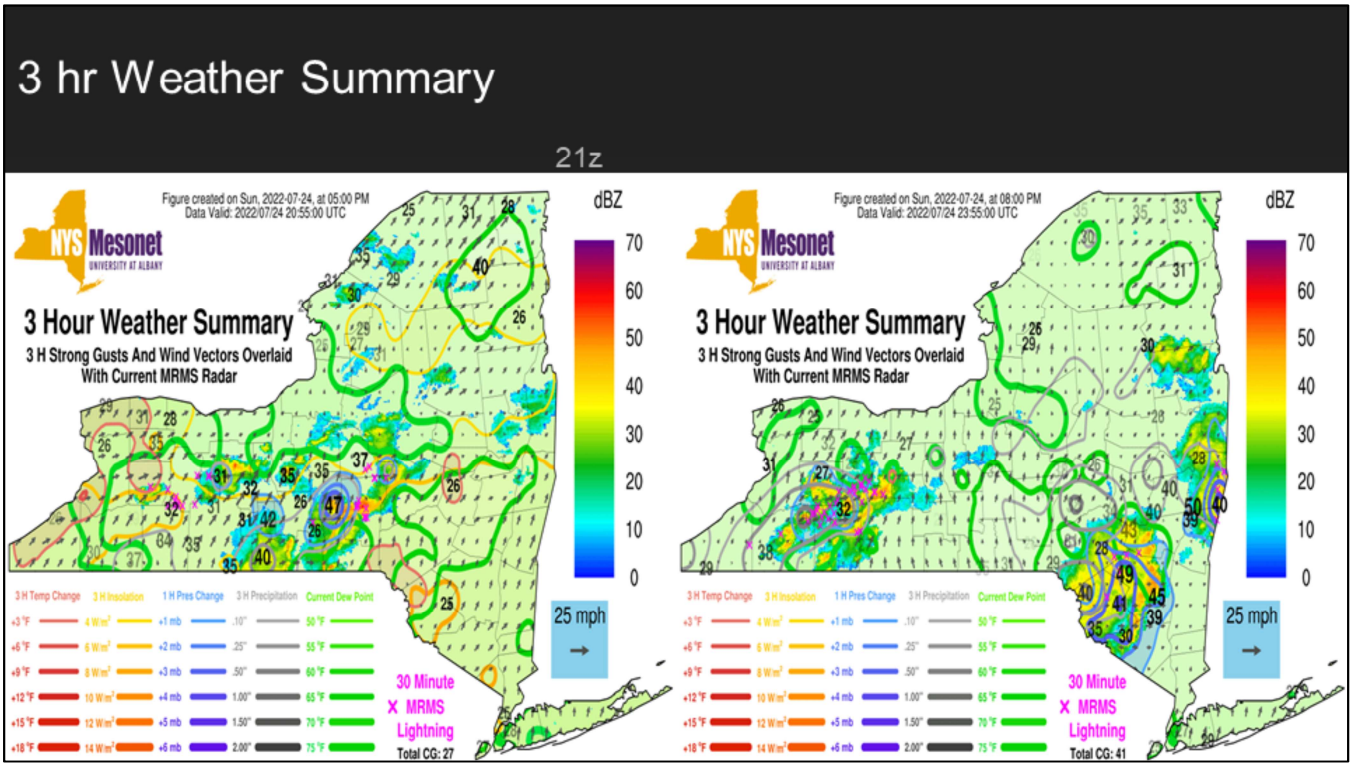
Valid at



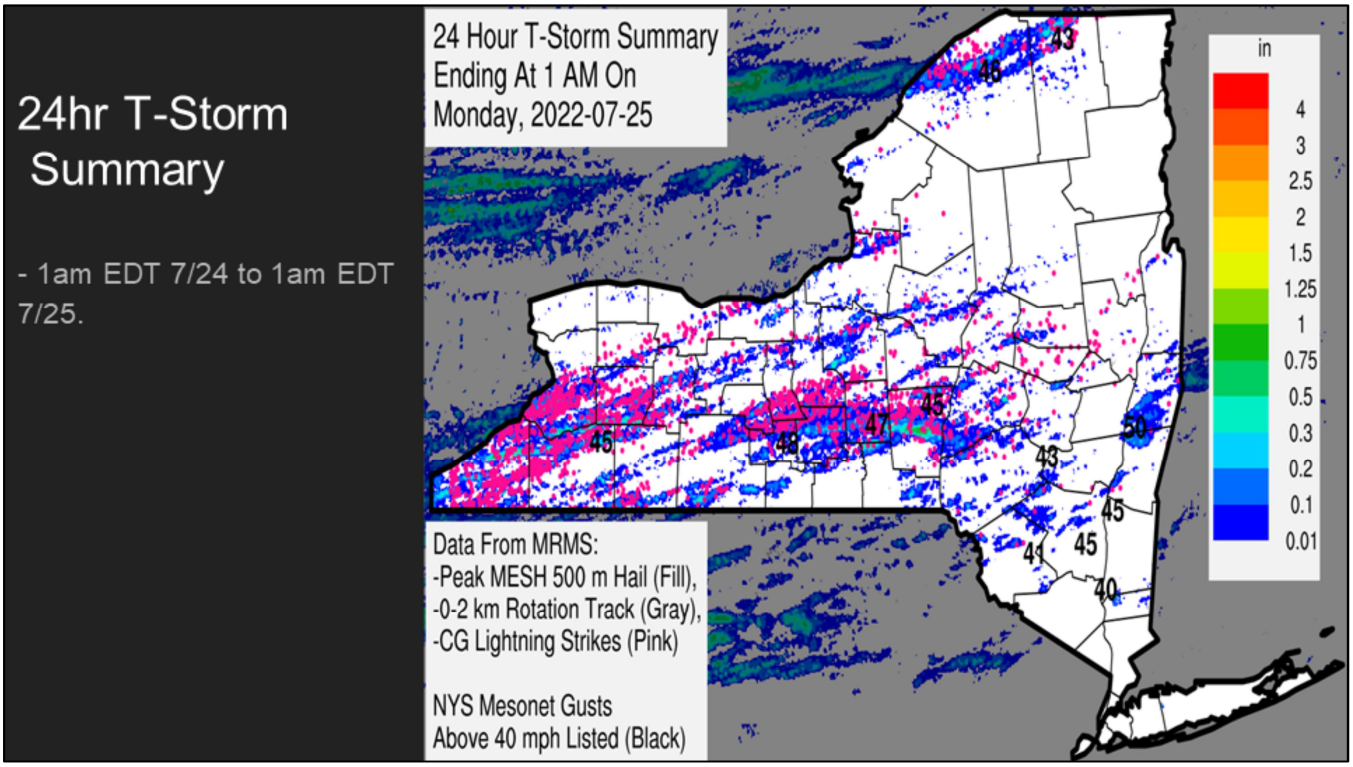
The HREF overestimated the amount of CAPE across the Adirondacks and Mohawk Valley, while also underestimating the amount of instability from the Capital District south and east. The SPC mesoanalysis valid at 21z showed between 1000 and 1500 J/kg of MLCAPE and up to 2000 J/kg of SBCAPE (not shown in these slides) across these areas, while the HREF was only predicting around 750 J/kg of SBCAPE at the same time. The HREF also underestimated the amount of vertical wind shear across the Mid Hudson Valley and portions of western New England. The overlap of impressive instability and 25-35kt of effective deep-layer shear likely contributed to the ability of these storms to maintain their intensity as they tracked from the Southern Tier and the Catskills across the Mid Hudson Valley and into western New England. Since the model underestimated the amount of instability and shear, it makes sense that the model did not accurately capture the eastward extend of the severe convection.



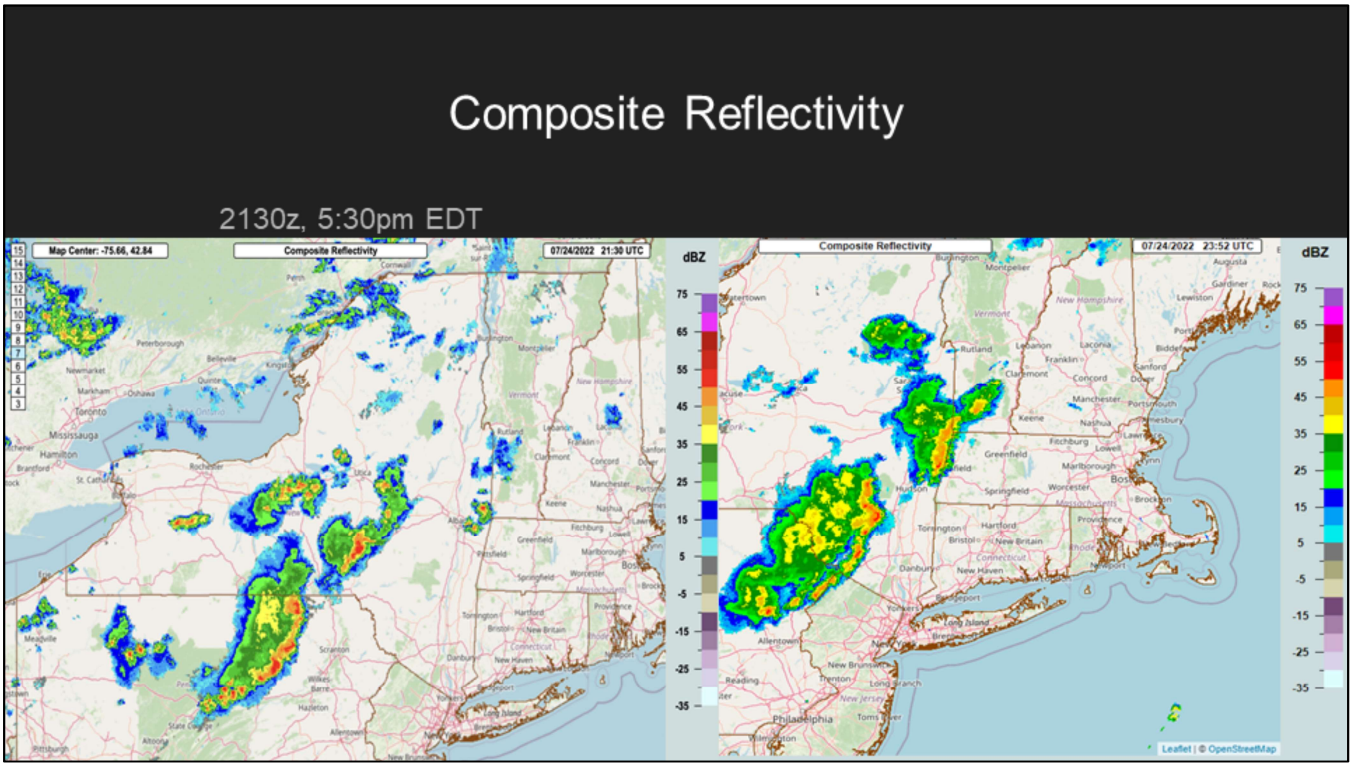
3-hour reports of wind gusts exceeding 30 mph are shown. Comparing the plot valid at 21z to 00z, the progression of the storm across the state and into New England is apparent. Highest wind gust values were recorded at 50 mph in the Capital Region.



3-hour weather summary shows the strongest wind gusts of up to 47 mph (21z) and 50 mph (00z) were measured in the southern tier of the state leading into the mid-hudson as the event progressed. Additionally, the pressure changes, solar insolation, precipitation, and lightning strikes highlight areas where severe convection tracked on this day.



24-hour thunderstorm summary over the course of the day of the event shows the track the storm system took, as it traveled across New York and into New England. The most lightning strikes were seen across the western part of the state and into the southern tier and central New York. However, even as lightning diminished, the storms remained strong enough to produce damaging wind gusts to the NY/New England border. Wind gusts on this map show that the highest gusts were in the Capital Region.



Composite reflectivity shows the structure of the storm system and its regions of highest intensity. As the storm system advances east, reflectivity decreases slightly, but the winds with the outflow ahead of these lines of storms remained severe. The image on the right shows a very impressive bowing line segment moving into western Ulster County. This bowing segment in particular was responsible for several of the wind damage reports across the Catskills and Mid Hudson Valley. The KENX radar was knocked offline as these storms moved into western Albany County at 22:56z. NWS Albany meteorologists used NYS mesonet data, spotter reports, neighboring radars, and satellite imagery to continue to issue warnings as these storms moved across eastern NY after the radar went down. There were 10 warnings issued by NWS ALY, of which 9 verified. THe FAR was thus 10% and POD was 91%. Average lead time for all events was almost 33 minutes.

Conclusions

- The SPC convective outlook overpredicted the northward extend of severe weather. COnvection tracked further southeast of lake Ontario, the Mohawk Valley & the Adirondacks compared to what was originally expected

- Comparing NYS Mesonet plots and model forecasts:
  - Most models predicted storms to track further north and west.
    - Why? Mesonet solar irradiance plots depict where there was significant cloud cover that lead to the development of a differential heating boundary.
    - This differential heating boundary led to low level convergence → served as the focus for the initiation of severe convection.
  - Instability and shear were also more impressive than modeled further south and east, allowing convection to remain severe as it tracked across the Mid Hudson Valley into western New England

- 25,000+ power outages across Ulster County (Times Union).

- Numerous wind damage reports sent in to SPC, stretching to eastern NY towards CT & the rest of New England.