Mesoanalysis – Operational Perspective

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ATM 362: Forecasting and NWS Operations Course
February 3, 2020

WFO ALY Severe Weather Operating Plan

Severe Weather Mesoscale Analyst (Duties)

- Monitoring mesoscale, near-storm environment and short range trends
- Briefing warning teams and the Short Term Forecaster on the current and expected environment, while monitoring "big picture" radar trends (acceleration, vortices, deviate motion, etc.)
- Utilize SPC Mesoanalyses page, LAPS, Four Dimensional Storm-scale Investigator (FSI), high resolution models/CAMs (3-km HRRR, 3-km NAMnest, NSSL WRF, etc.), and the NYS Mesonet
- Update the Hazardous Weather Outlook and Area Forecast Discussion to explain the evolving situation
- Issue graphical NOWcasts via social media (Facebook or Twitter)
- Time permitting, assist decision makers and the general public with a time line when the severe weather (significant winter weather) is expected

Outline

- Why do (Surface) Mesoanalysis?
- SPC Mesoanalysis Page (Rapid Refresh) Overview and some Convective Parameters Defined
- Mesoscale Snowbanding – 2 March 2018 Case
- Winter Weather Case – Snow Squall Event in Albany forecast area: 30 Jan 2019
- Severe Weather WFO ALY Case Example:

  18 May 2017 Severe Weather Event

Why do “Surface” Mesoanalysis

(from Dave Imy SPC early 2000’s archived presentation)

- Forecast = Diagnosis + trend
- Incorrect diagnosis of the atmosphere reduces the probability of making an accurate forecast
- Mesoanalysis facilitates our ability to synthesize data from a variety of observational sources
- Gain an improved perspective of actual environmental conditions
- Critical to track and identify mesoscale boundaries

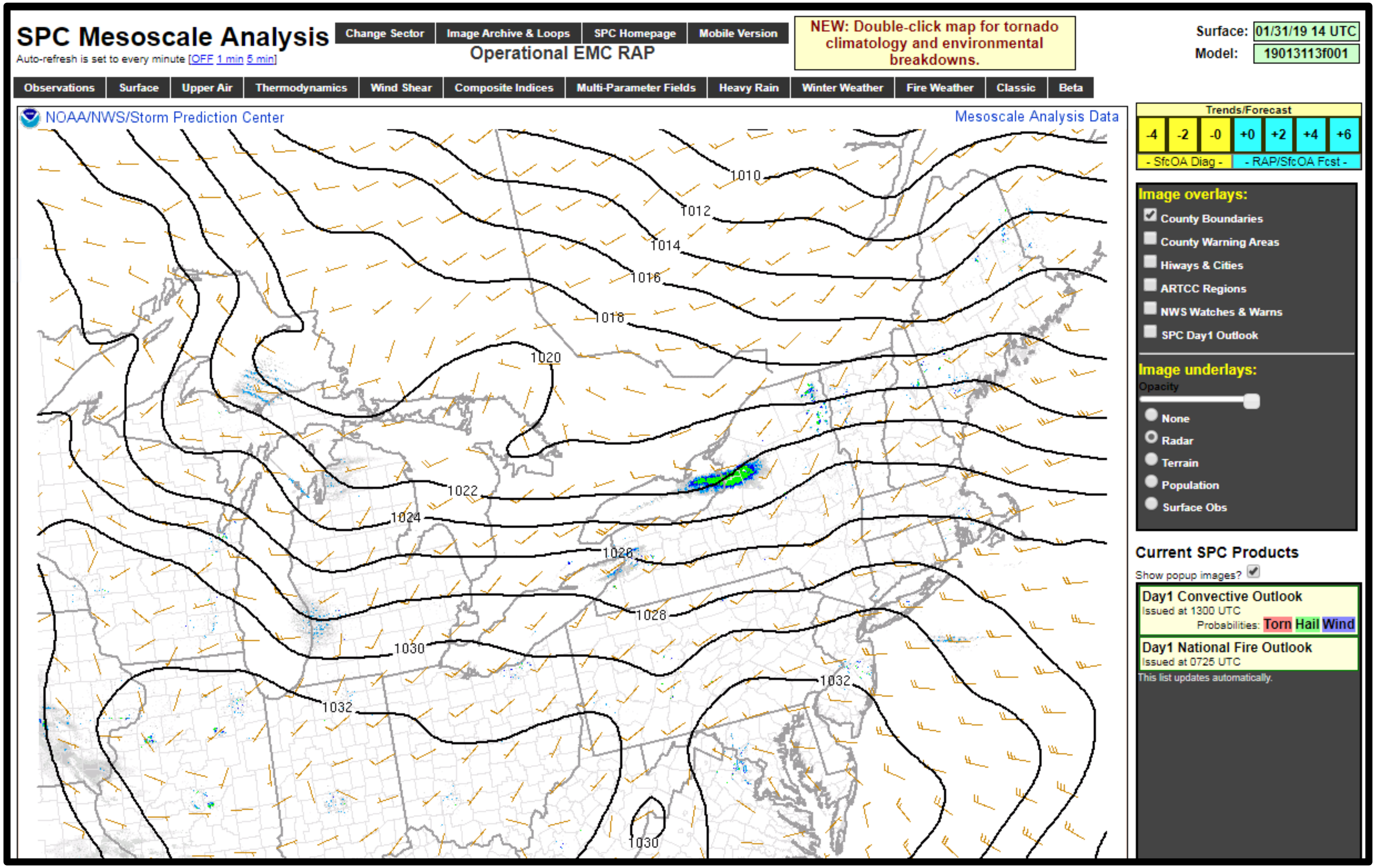
Observational Sources used in Mesoanalysis

- Surface observations, including mesonets (i.e. NYS Mesonet)
- Upper Air/Sounding data & Profilers
- Satellite imagery (newer GOES-16 data)
- Radar (local and regional)
- Loops/animations of radar/satellite data
- Lightning Data (NLDN, Lightning Mapping Arrays, Geostationary Lightning Mapper)

Tracking Mesoscale Boundaries

- Incorporate all available data
- Continuity is important (hour by hour analysis)
- Thermal or moisture gradients track
- Pressure/Wind Data (i.e. 1 or 2 hPa analyses), streamline analysis (convergence/divergence), wind shifts, rise/fall pressure couplets)
- Severe/Significant Weather Forecast Parameters (Indices)/Tools

SPC Mesoanalysis Page (RAP data)



Thermodynamics – Instability (CAPE)

- SBCAPE – Convective Available Potential Energy (CAPE) calculated from a Surface-Based Parcel (J/kg)
- MUCAPE – CAPE calculated using the Most Unstable parcel in the lowest 300 hPa (0-10 km)
- MLCAPE – Mixed Layer CAPE calculated using a parcel consisting of Mean Layer temp and moisture in the lower 100-hPa, when lifted to the Level of Free Convection (LFC)
- DCAPE – Downdraft CAPE can be used to estimate the potential of rain-cooled downdrafts with deep convection. Larger DCAPE -> Stronger Downdrafts!

SPC Guidelines: Degree of Instability (MLCAPE)

- 0-1000 J/kg: Weakly Unstable
- 1000-2500 J/kg: Moderately Unstable
- 2500-3500 J/kg: Very Unstable
- 3500+ J/kg: Extremely Unstable

Deep Layer Shear (0-6 km Bulk Shear)

- Deep Layer Shear -> 0-6 km shear vector
- Thunderstorms tend to become more organized and persistent as vertical shear increases
- Supercells are commonly associated with vertical shear values of 35-40+ kts
- 25-35 kts some supercells with sufficient instability, but can be multi-cells in Northeast

Effective Bulk Shear (EBS)

- Defined as the vertical wind shear through a percentage of the "storm depth", as defined by the vertical distance from the effective inflow base to the Equilibrium Level (EL) associated with the Most Unstable parcel (max ϴ-e value) in the lowest 300 hPa
- Effective Bulk Wind Difference (kts) is another way at looking at the potential for severe convection (Effective Storm Relative Helicity (ESRH) is similar to EBS but based on theshold values of lifted parcel CAPE (100 J/kg) and CIN (-250 J/kg))

Effective Bulk Wind Difference (EBWD)

- Defined as the magnitude of the vector wind difference from the effective wind flow based upward to 50% of the EL height for the Most Unstable parcel in the lowest 300 hPa
- Similar to bulk wind difference, though it accounts for storm depth (effective inflow base to the EL), and is defined to identify both Surface-Based and "Elevated" supercell environments
- Supercell environments more probable as EBWD increases in magnitude through range of 25-40 kts and greater

Supercell Composite Parameter (SCP)

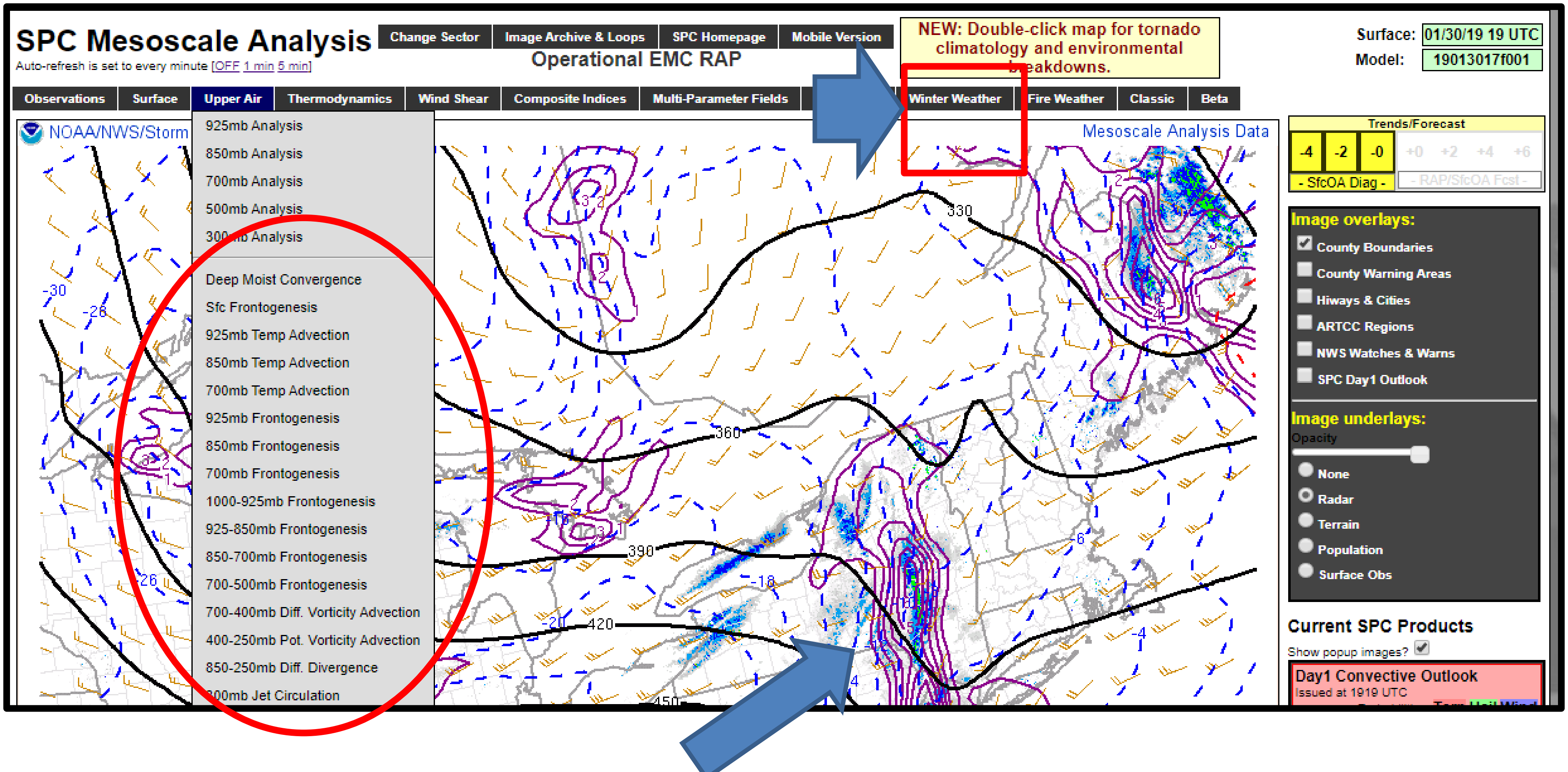
(Thompson et al. 2003)

- SCP is a multiple ingredient composite index that includes: Effective Storm-Relative Helicity (ESRH), MUCAPE, and EBWD
- Each ingredient is normalized to supercell thresholds
- Larger values of SCP's indicate greater overlay in supercell "ingredients"
- Positive values displayed (right moving supercells) and looking for SCP > 1

$SCP = (muCAPE / 1000\ J\ kg^{-1}) * (ESRH / 50\ m^2\ s^{-2}) * (EBWD / 20\ m\ s^{-1})$

EBWD is divided by 20 m s^{-1} in the range of 10-20 m s^{-1}. EBWD less than 10 m s^{-1} is set to zero, and EBWD greater than 20 m s^{-1} is set to one.

Winter Weather - Mesoanalysis



1000-925 hPa FGEN: 1900 UTC 30 JAN 2019 – Snow Squalls

CSTAR I (Novak et al. 2004): Mesoscale Snowband Flow Charts &Conceptual Models

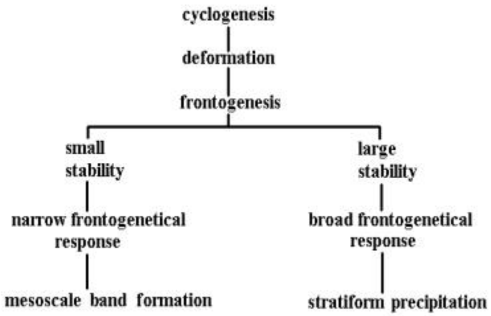


Fig. 4.7. Flow chart of the key components and interactions involved in band formation.

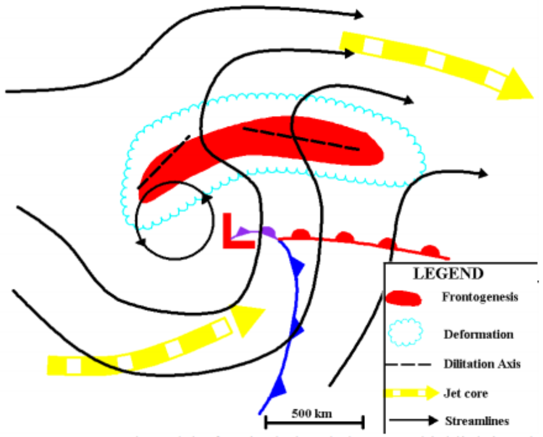
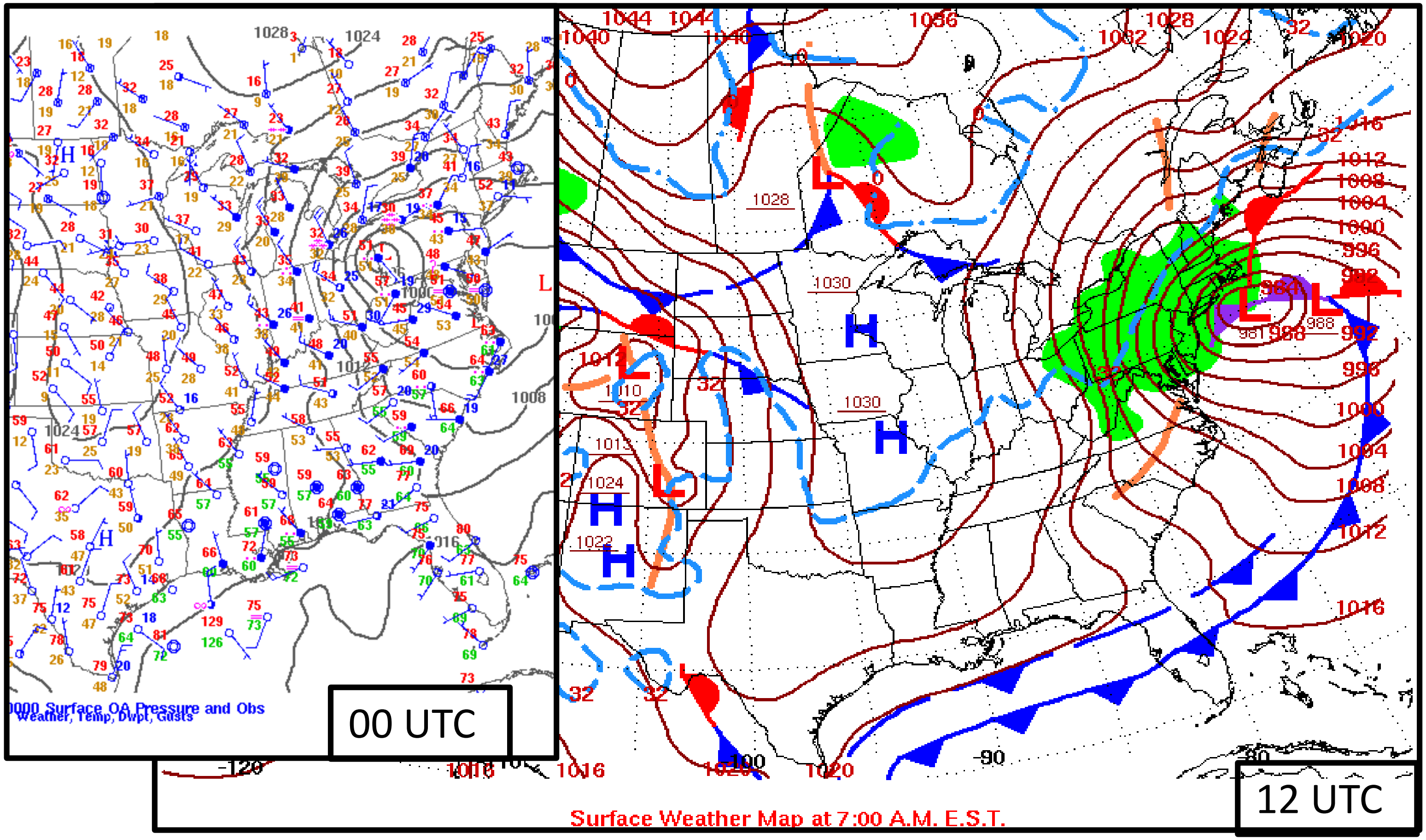


Fig. 4.1. Conceptual model of a single-banded system highlighting the key parameters. Features drawn include 700 hPa frontogenesis (shaded), 700 hPa deformation zone (encompassed by scalloped line) and associated primary dilatation axes (dashed line), 700 hPa streamlines (black lines), and 300 hPa jet cores (wide dashed arrows).

Frequently cited in NWS Area Forecast Discussions, refereed literature & used in the warning decision making

0000 & 1200 UTC 2 March 2018 Surface Maps



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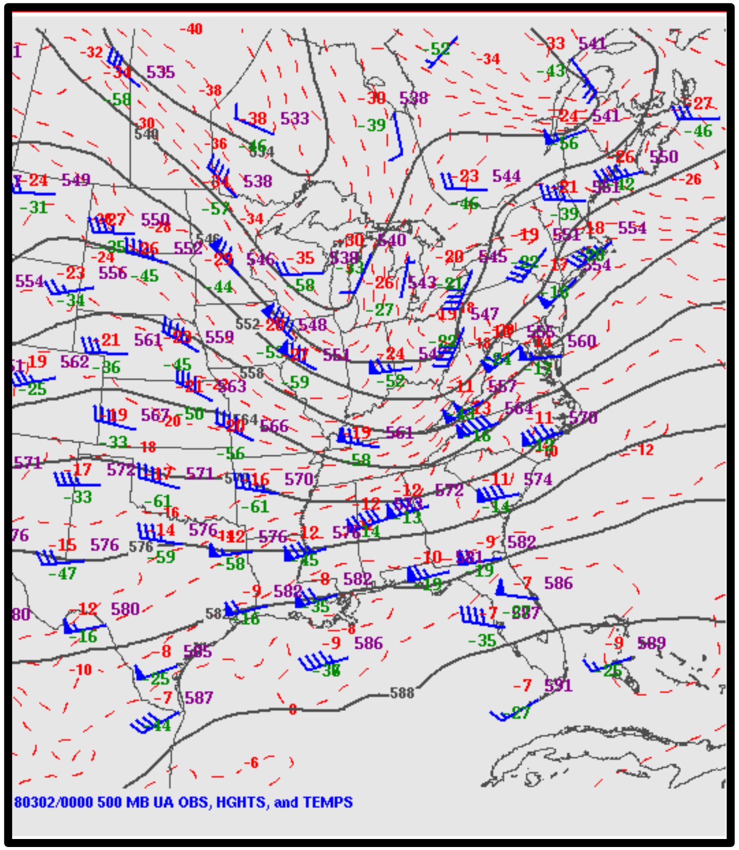
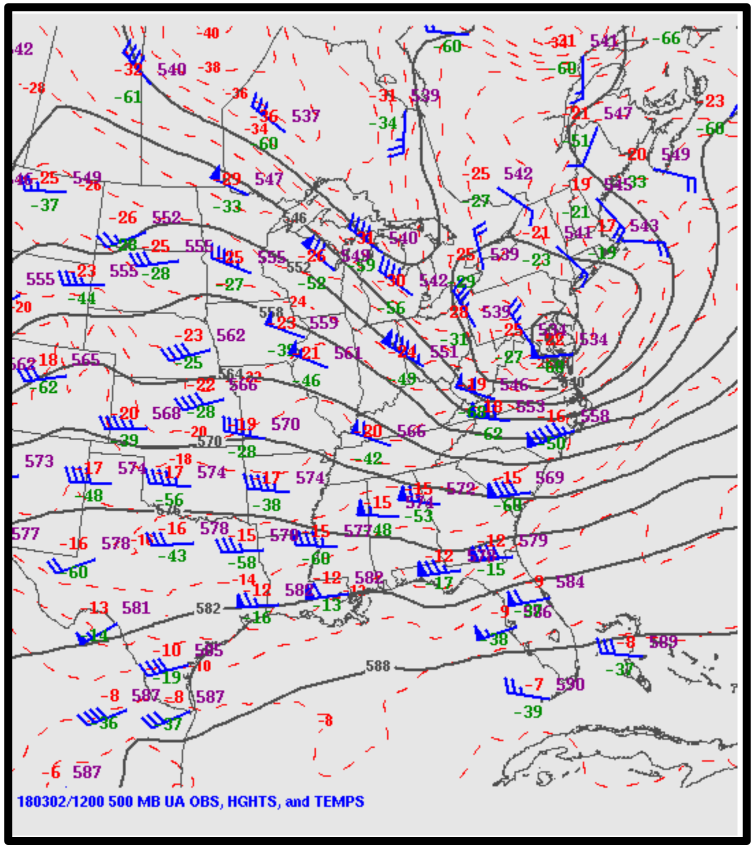
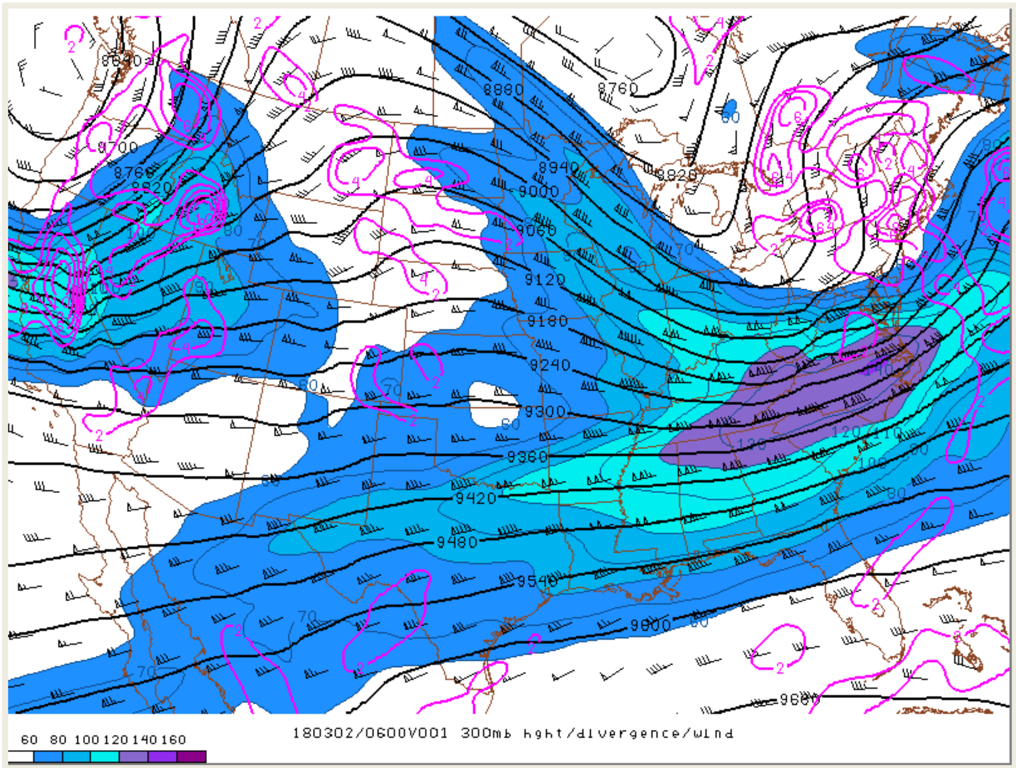
00 & 12 UTC 2 MAR 2018 500 hPa Upper Air Analysis





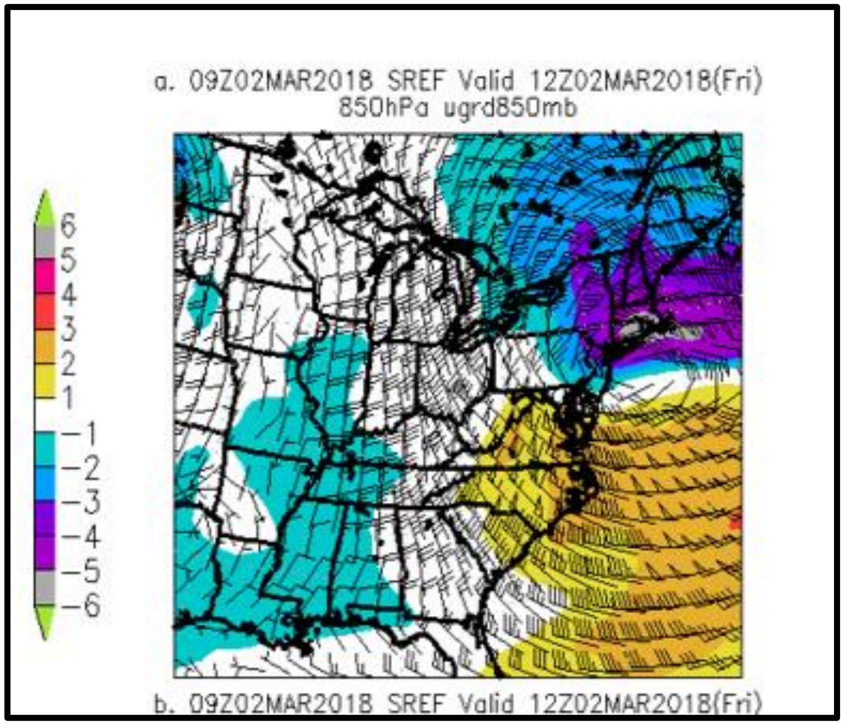
0600 UTC 2 MAR 2018 Rapid Refresh
300 hPa Heights, Divergence and Winds (kts)



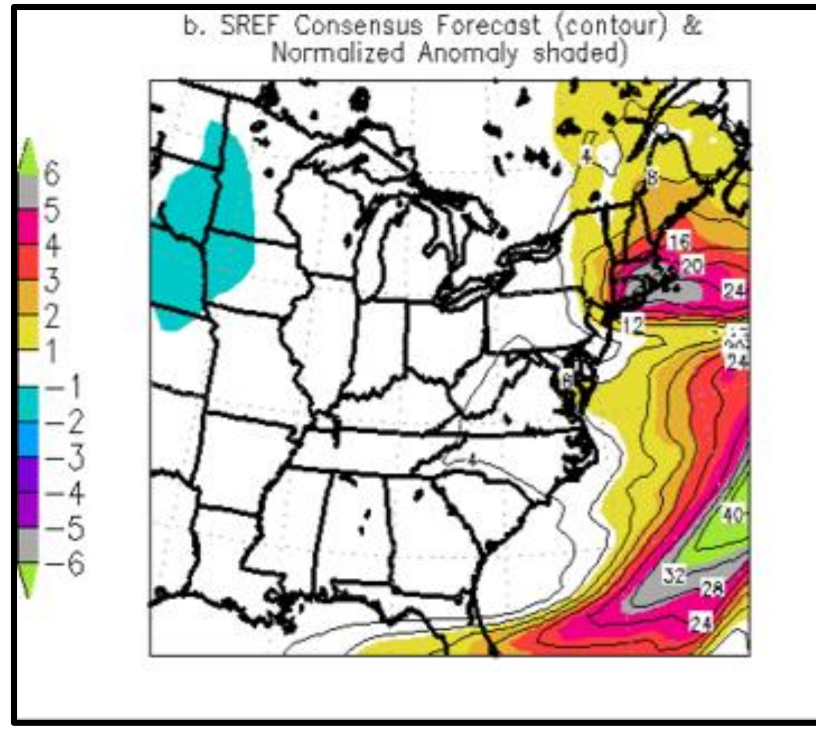
Poleward jet streak lifting out (equatorward entrance region) while dominate 120-140 kt poleward left exit region jet streak is approaching Northeast

0900 UTC SREF F1200 UTC 2 MAR 2018

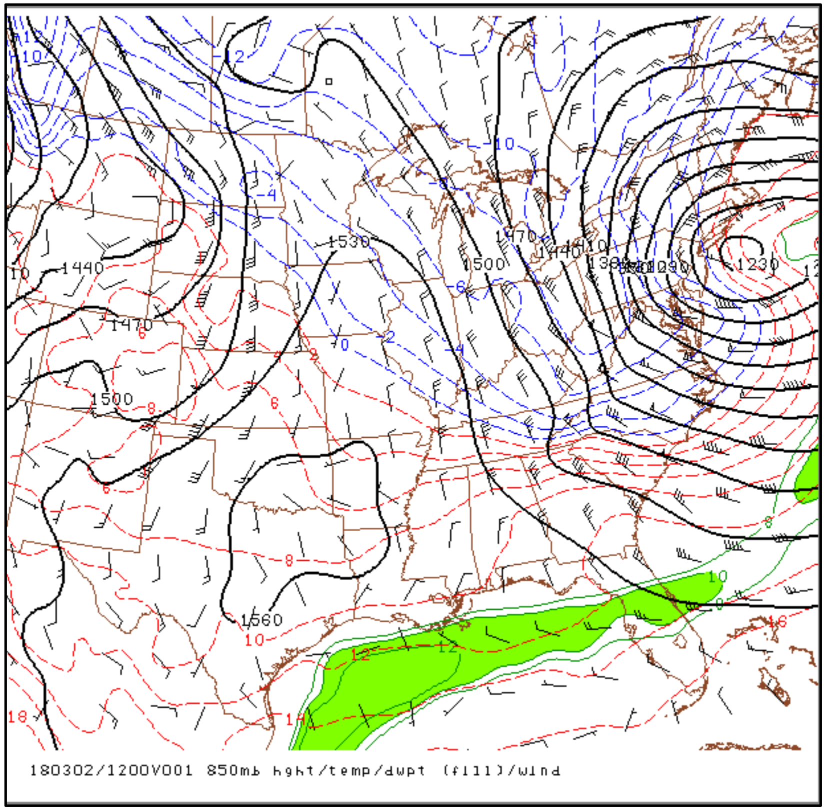
850 hPa u-wind anomalies (easterlies)



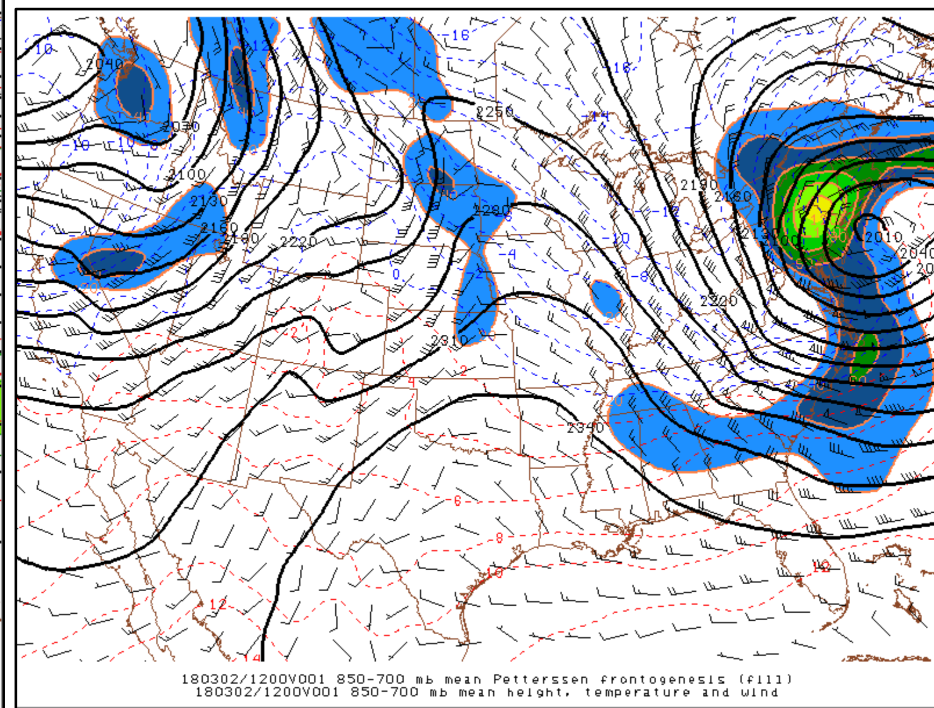
850 hPa Moisture Flux anomalies



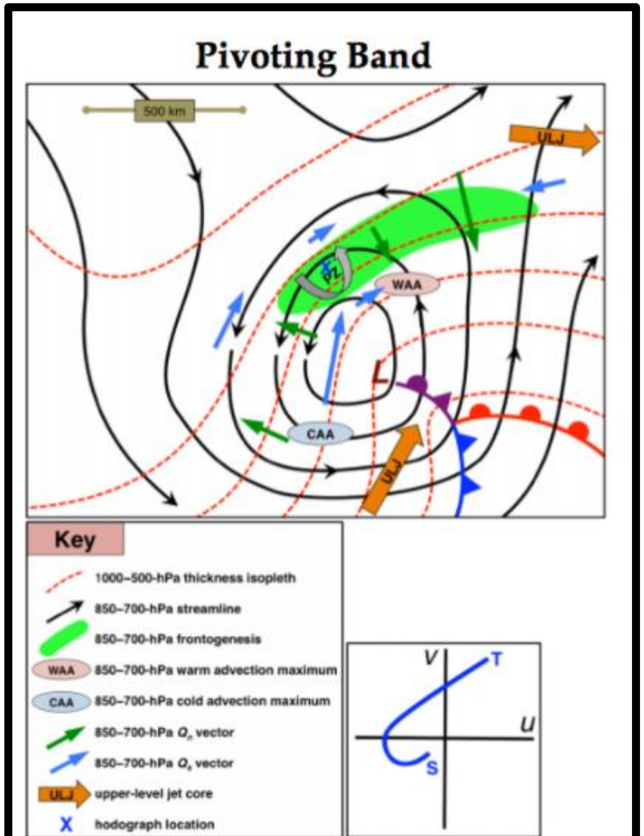
1200 UTC 2 MAR 2018: 850 hPa Height,Temps (˚C) and Winds (kts)



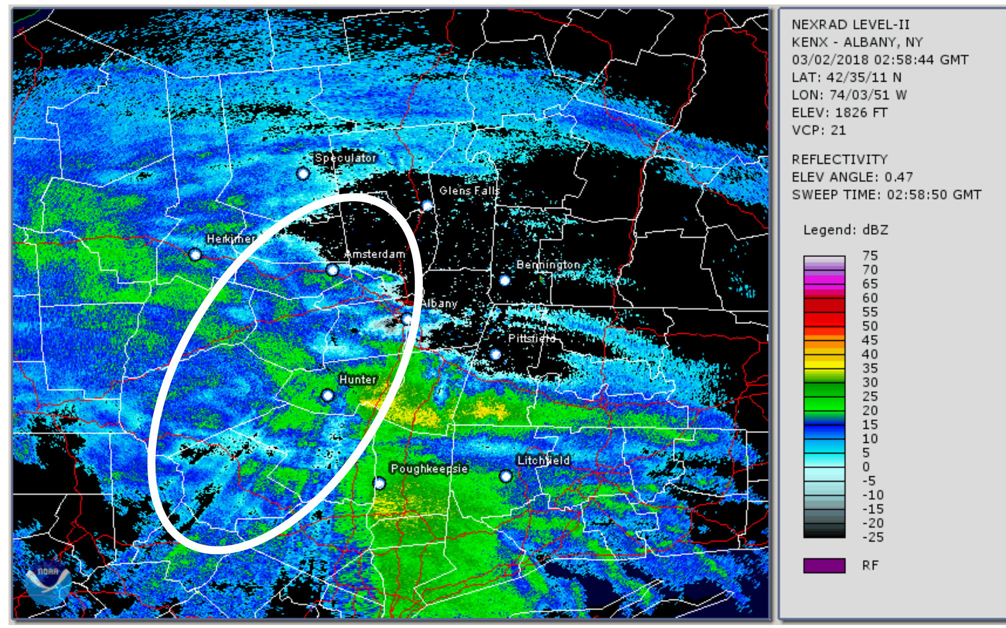
1200 UTC 2 MAR 2018: 850 – 700 hPa Rapid Refresh 2-D Petterssen Mean FGEN & Heights



Kenyon Pivoting Band Conceptual Model (2013)

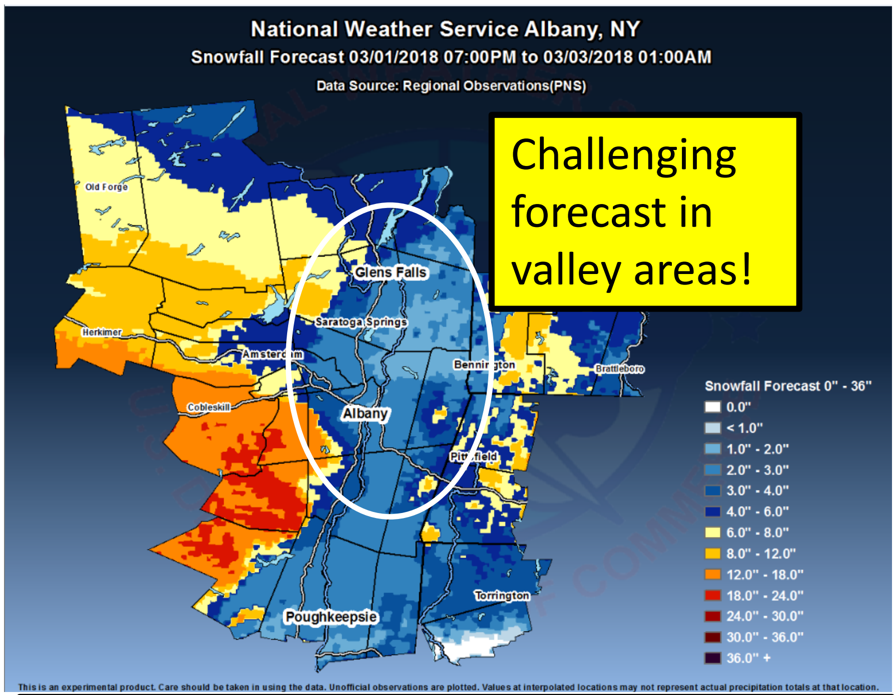


0600 UTC 2 MAR to 0000 UTC 3 MAR 2018

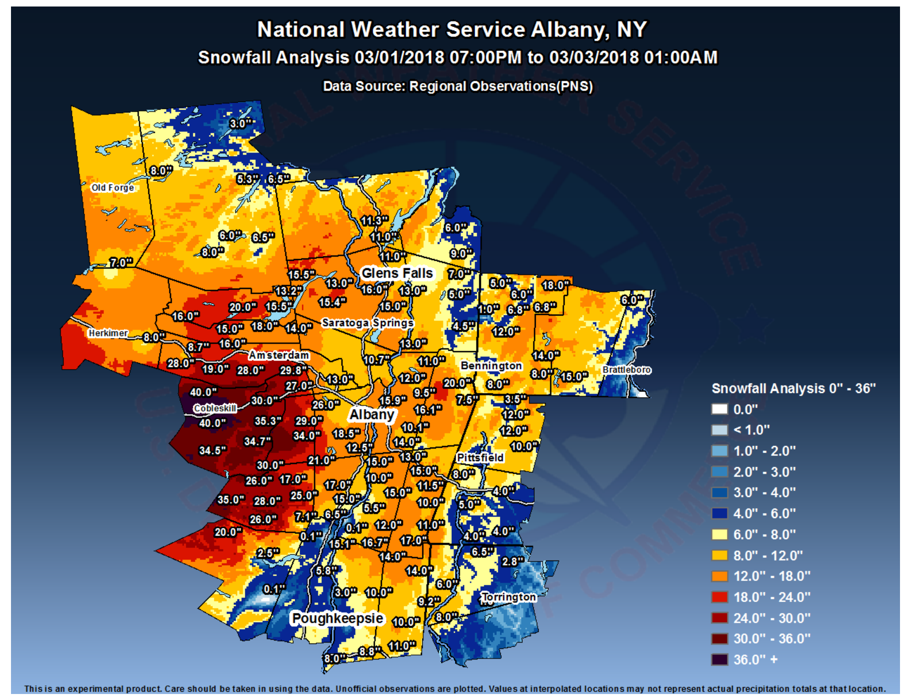


Mega-Band with Hourly Snowfall rates 2-4+"/hr

NWS forecast (12-24 hrs before) vs. observed snowfall

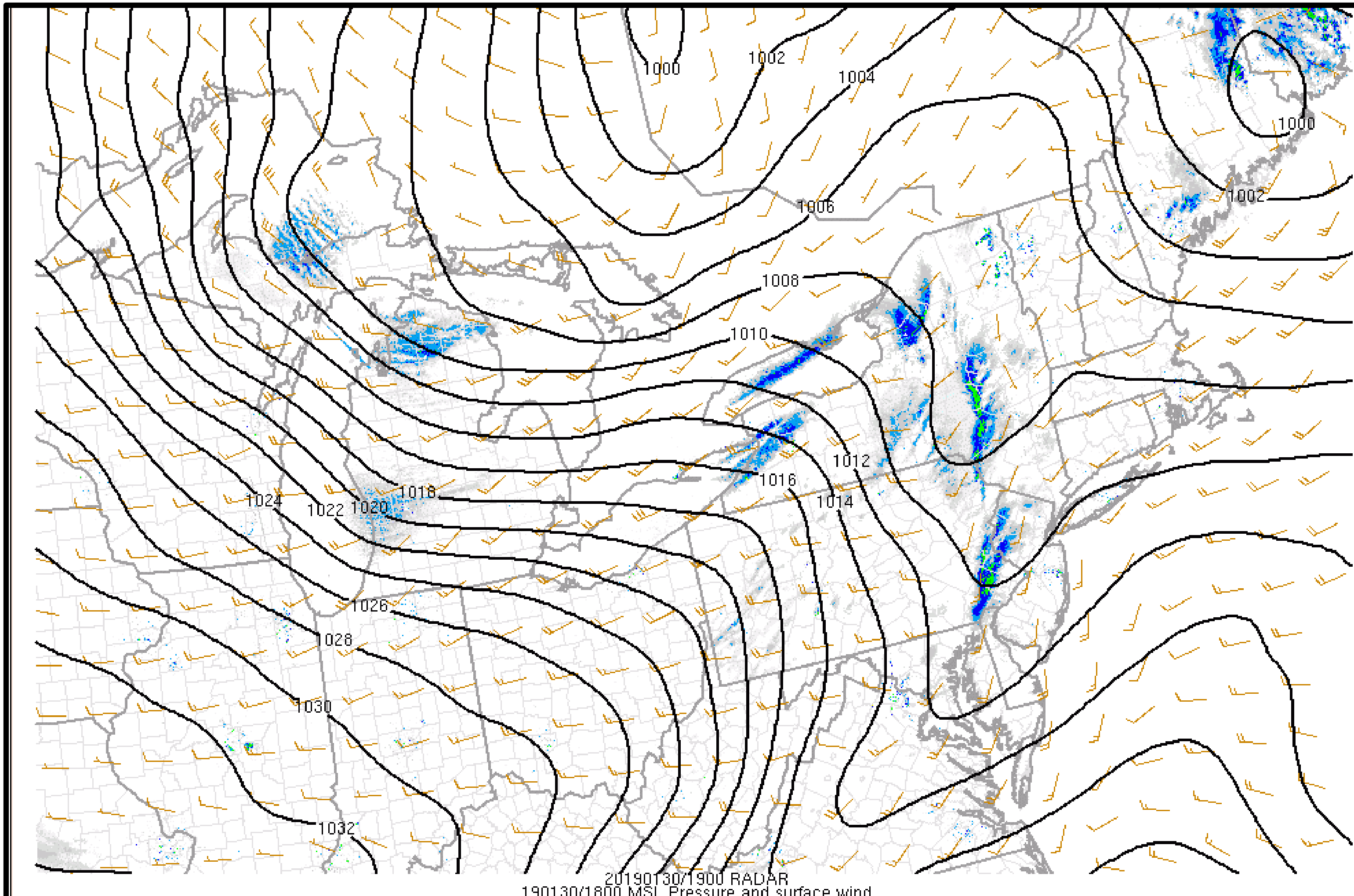


1 March 2018 4 pm Initial Forecast Totals

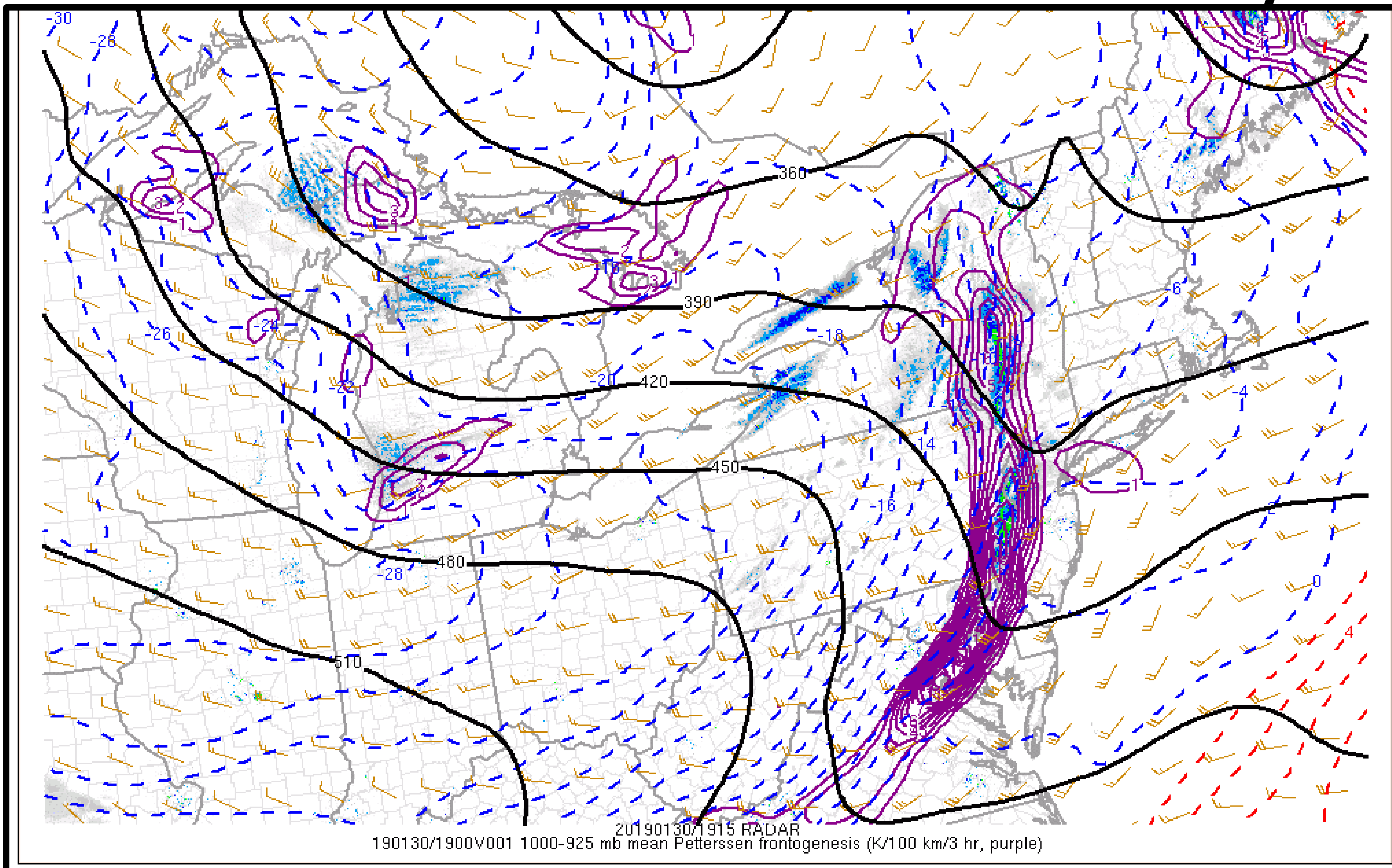


2 March 2018 Observed Snowfall Amounts

1800 UTC 30 JAN 2019
MSLP and SFC Wind & 1900 UTC radar overlayed



1900 UTC 30 JAN 2019 RAP
1000-925 hPa FGEN & 1915 UTC Radar Overlay



Snow Squall Parameter

Snow Squall Parameter

A non-dimensional composite parameter that combines 0-2 km AGL relative humidity, 0-2 km AGL potential instability (theta-e decreases with height), and 0-2 km AGL mean wind speed (m/s). The intent of the parameter is to identify areas with low-level potential instability, sufficient moisture, and strong winds to support snow squall development. Surface potential temperatures (theta) and MSL pressure are also plotted to identify strong baroclinic zones which often provide the focused low-level ascent in cases of narrow snow bands.

The index is formulated as follows:

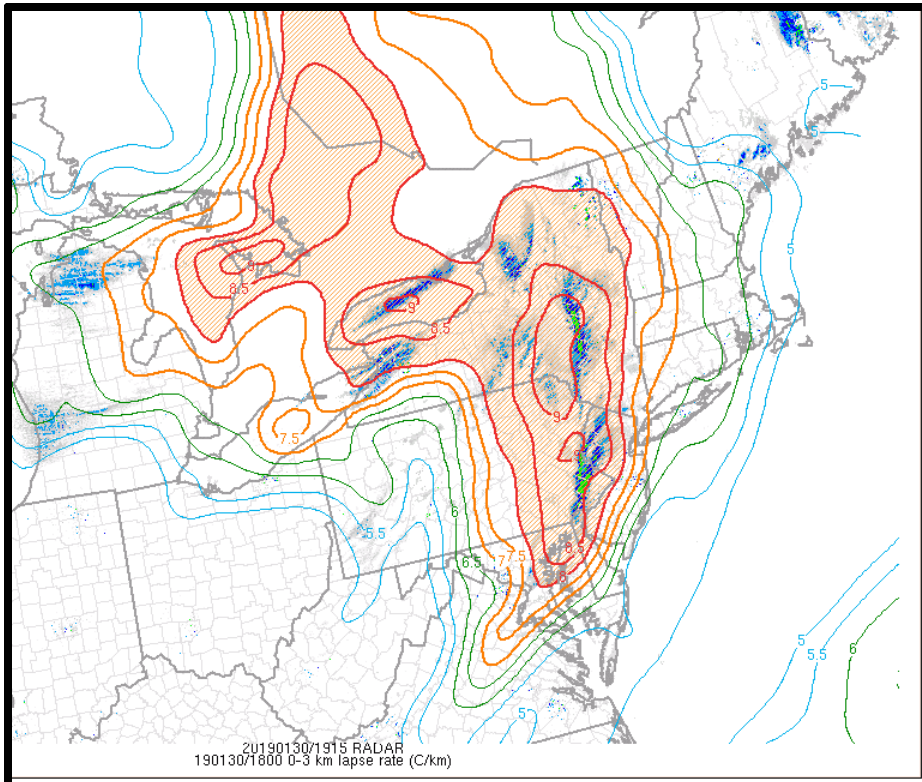
Snow Squall = ((0-2km mean RH - 60%) / 15%) * ((4 - 2km_delta_theta-e) / 4) * (0-2km mean wind / 9 m s^{-1})

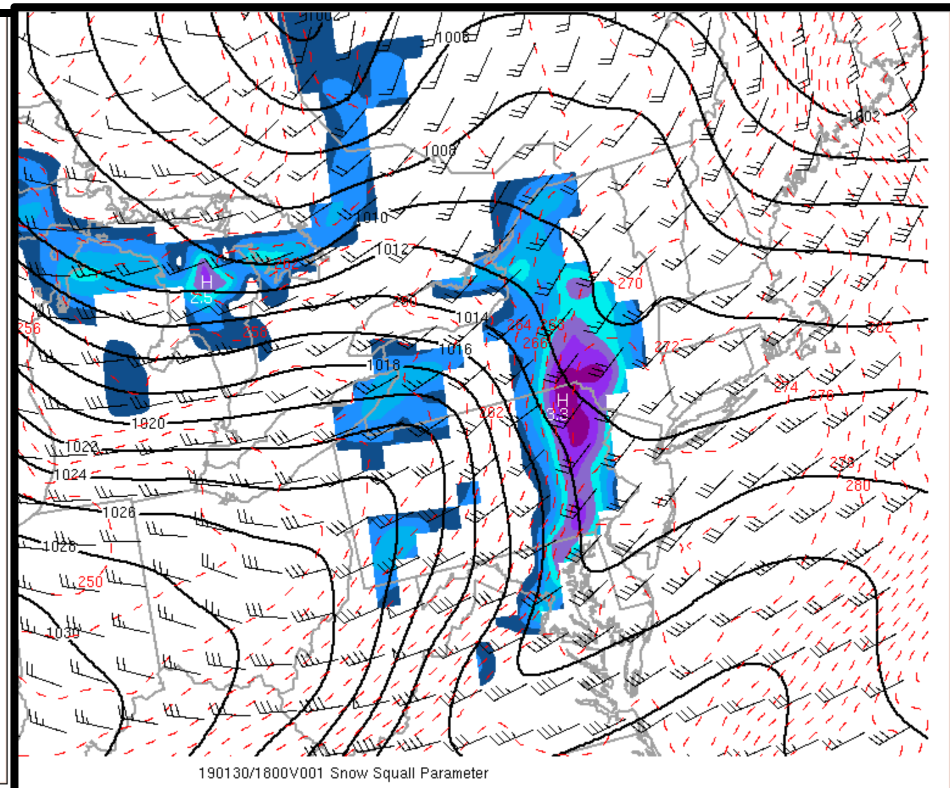
The 2km_delta_theta-e term is the change in theta-e (K) from the surface to 2km AGL, where negative values represent potential instability. Areas with 0-2 km RH < 60% are filtered out in the color fill plots.

Additional information can be found here (PowerPoint presentation). (Please open this link in another browser window.)

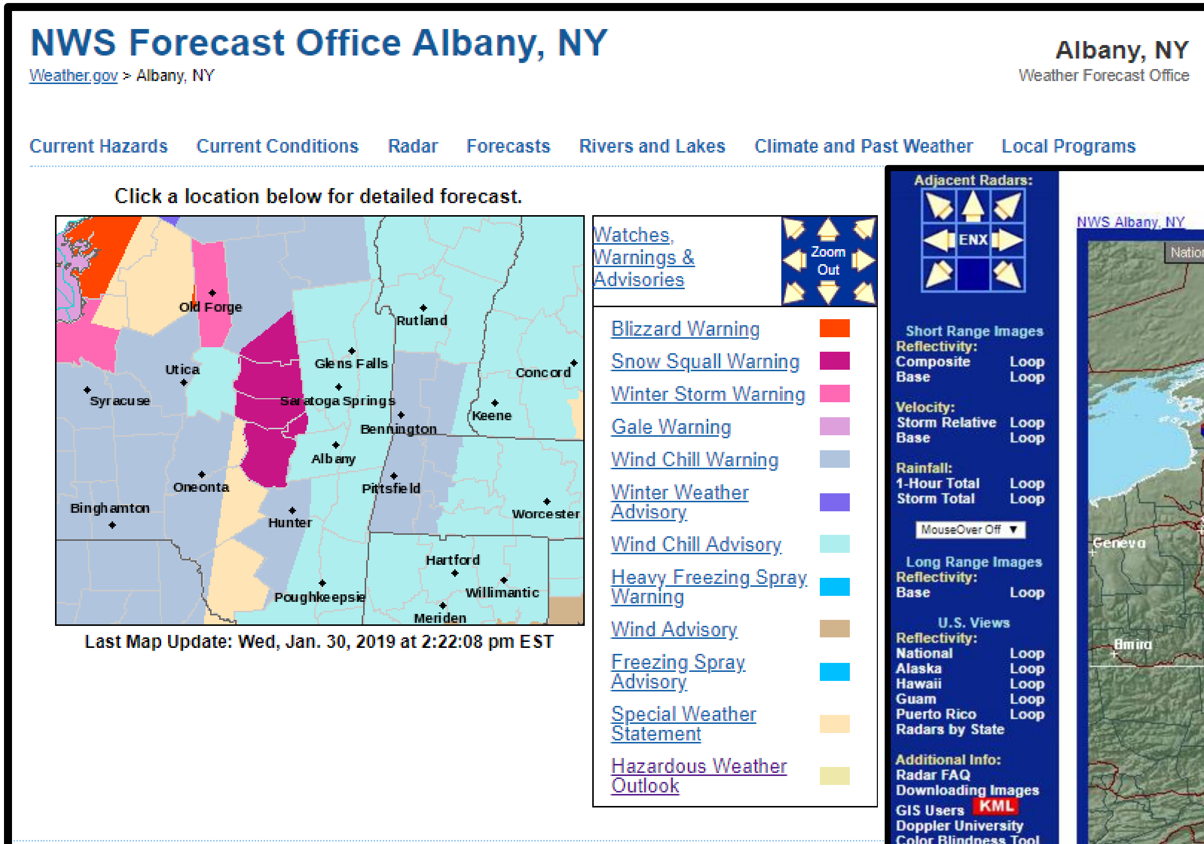
Reference: (Banacos, Loconto, Devoir 2014)

1800 UTC 30 Jan 2019
0-3 km Lapse Rates (°C/km) & Snow Squall Parameter



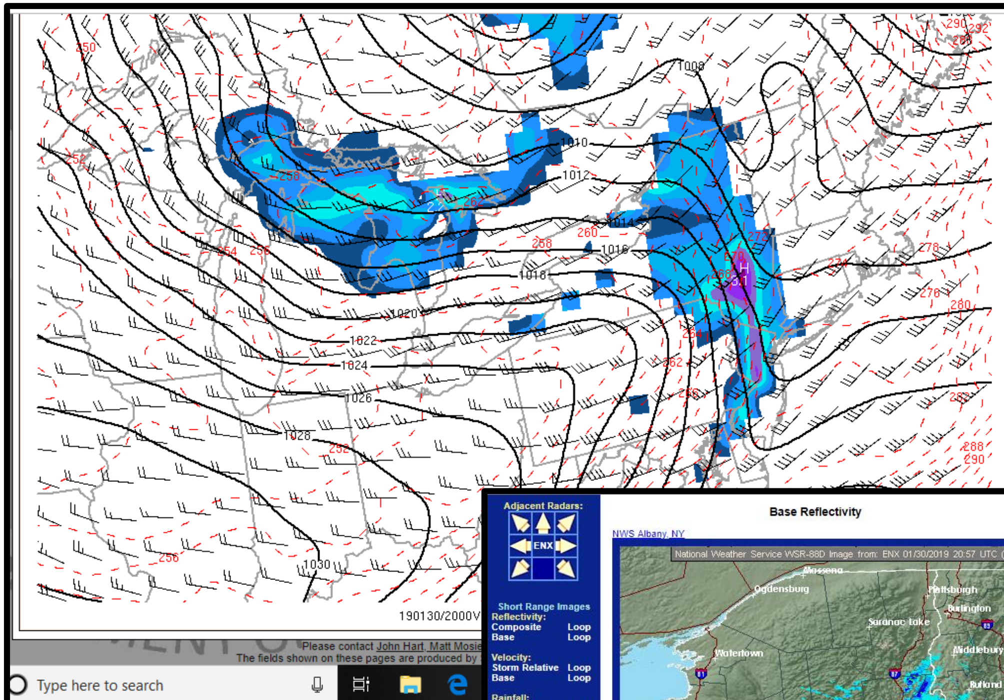


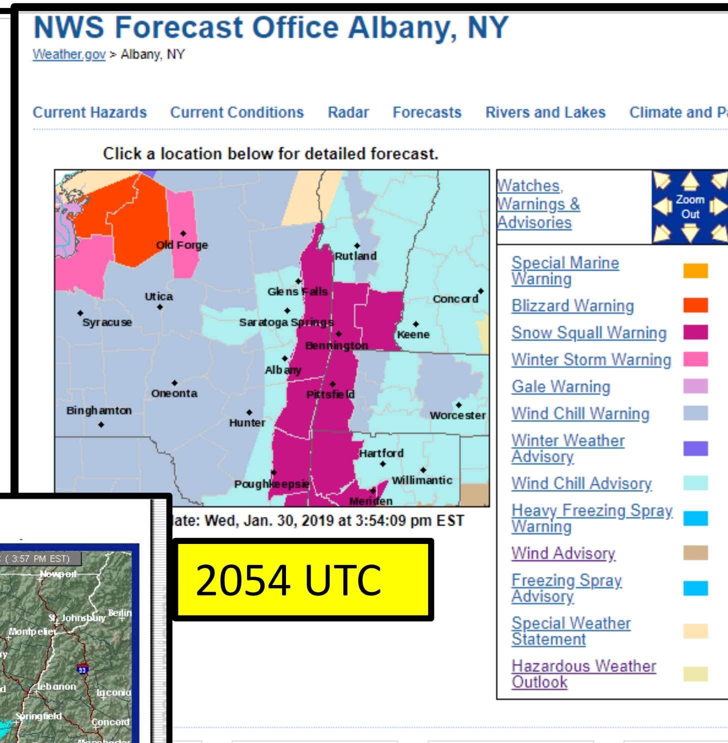
1922 UTC: Snow Squall Warnings



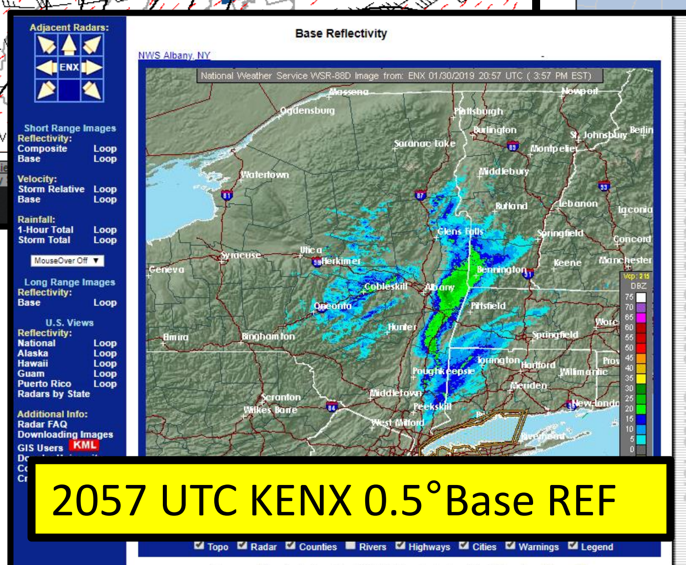
1927 UTC KENX 0.5 °Base REF

2000 UTC 30 Jan 2019
Snow Squall Parameter





2054 UTC



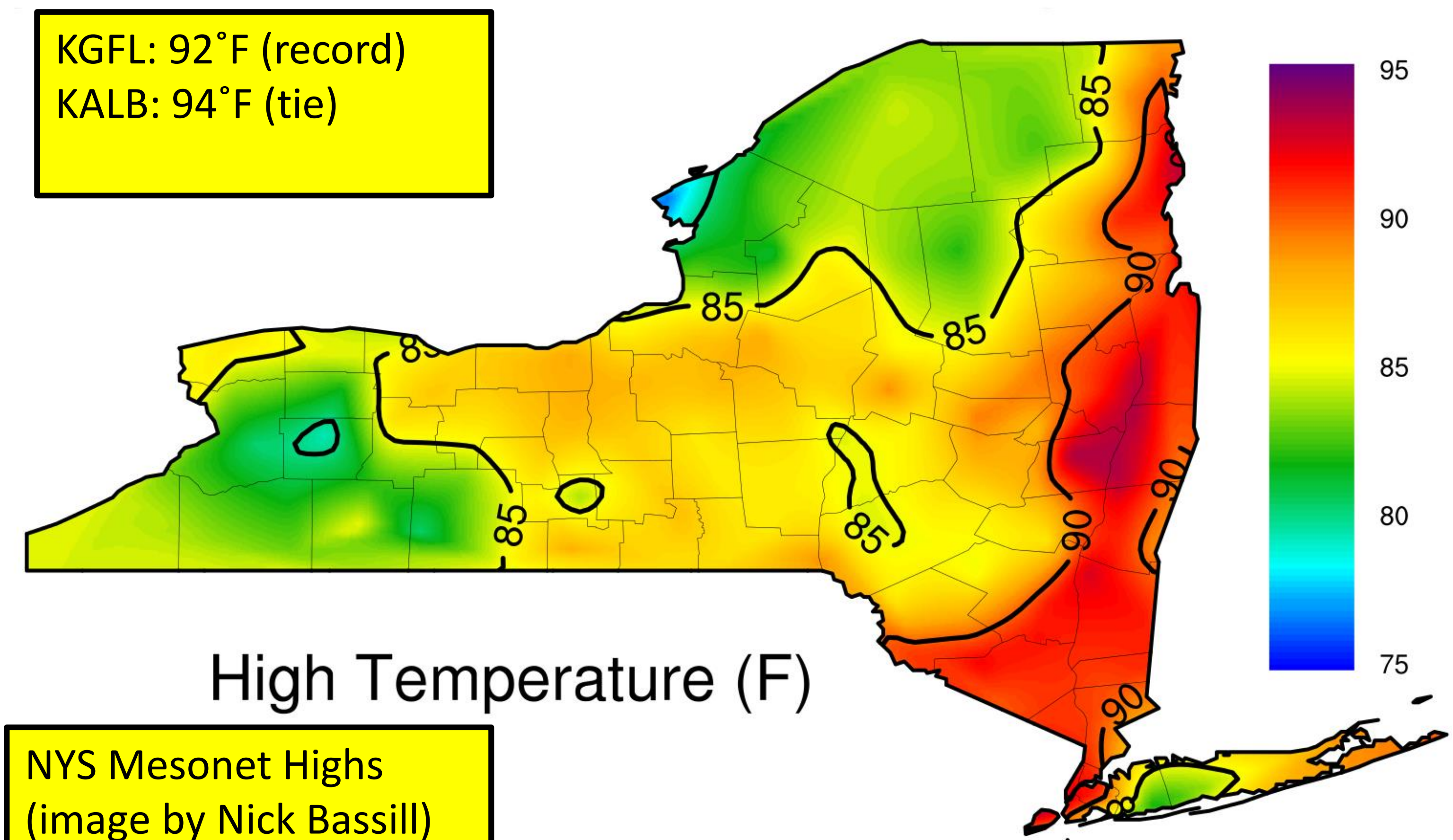
2057 UTC KENX 0.5°Base REF

Snow squall parameter indicated Capital District and Hudson River Valley would get hit hard!

18 May 2017:
NY and New England Severe Weather Case

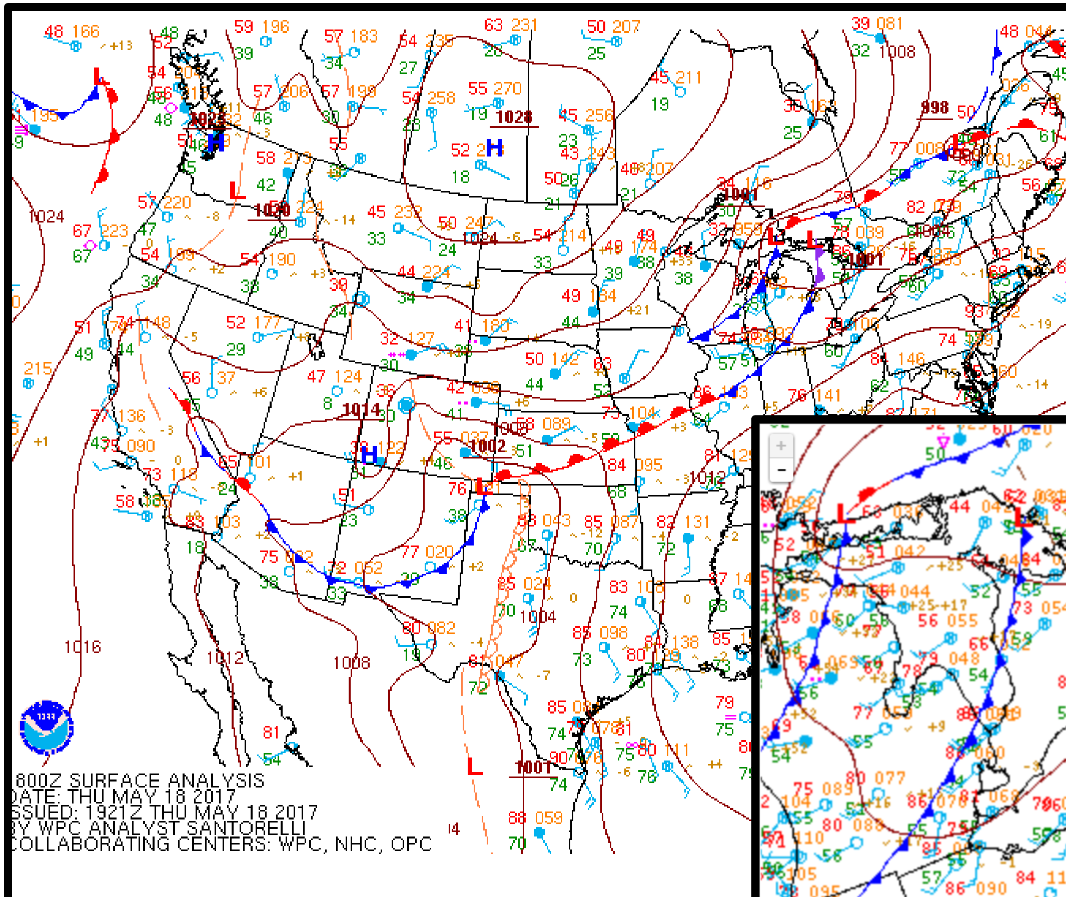
Hot/Record Breaking Max Temps 18 May 2017

KGFL: 92˚F (record)
KALB: 94˚F (tie)



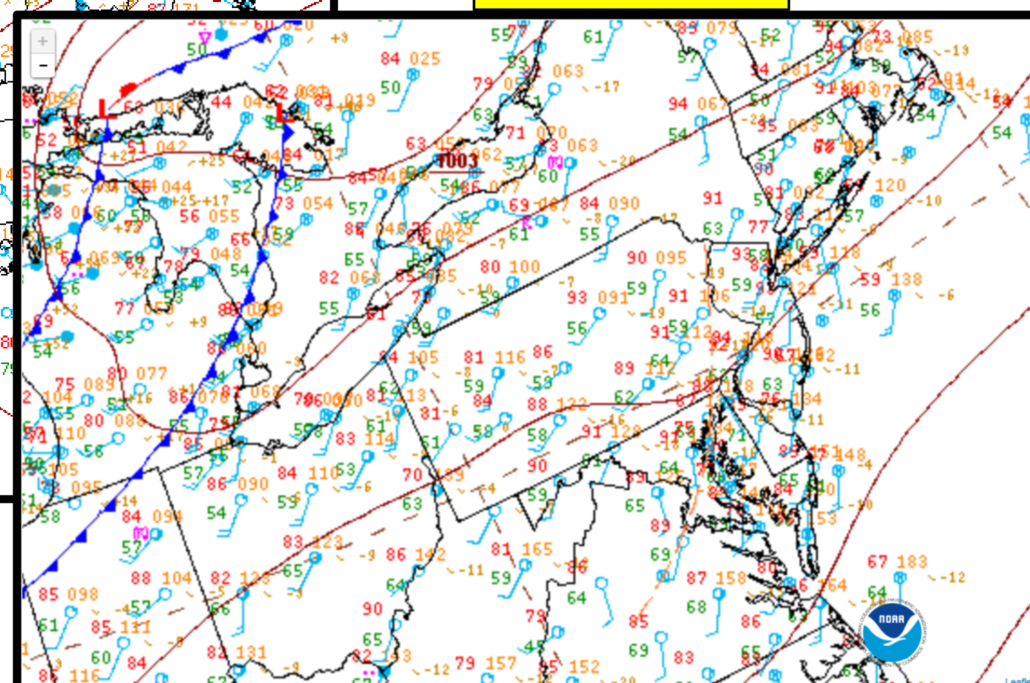
NYS Mesonet Highs (image by Nick Bassill)

1800 UTC and 2100 UTC 18 May 2017 WPC Surface Maps

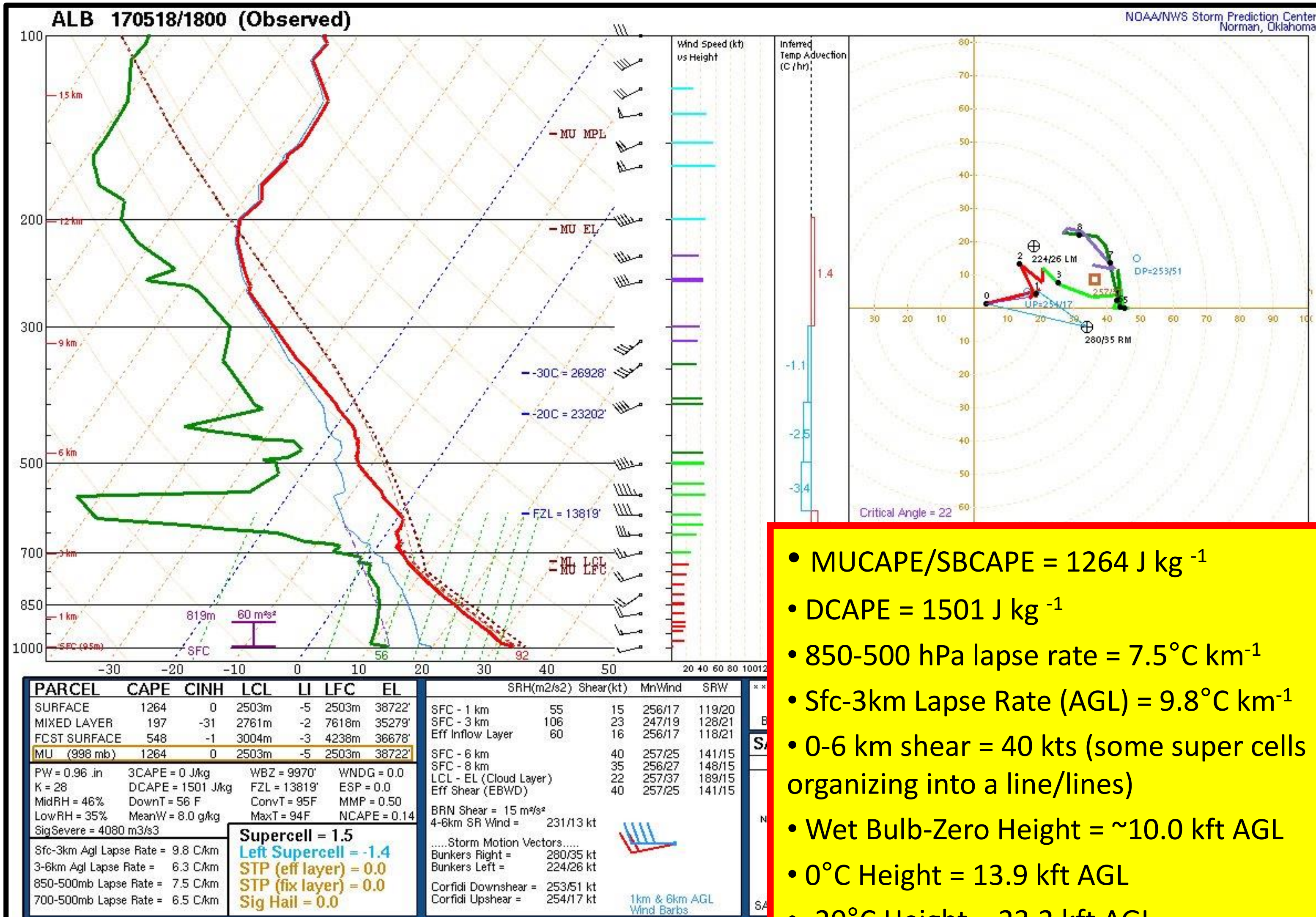


1800 UTC

2100 UTC



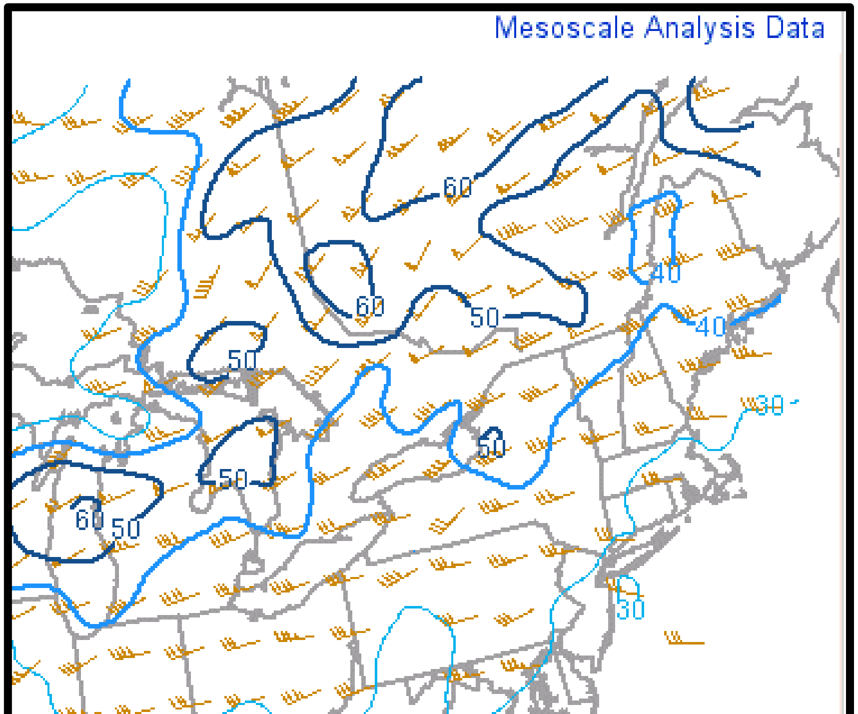
1800 UTC KALB Sounding



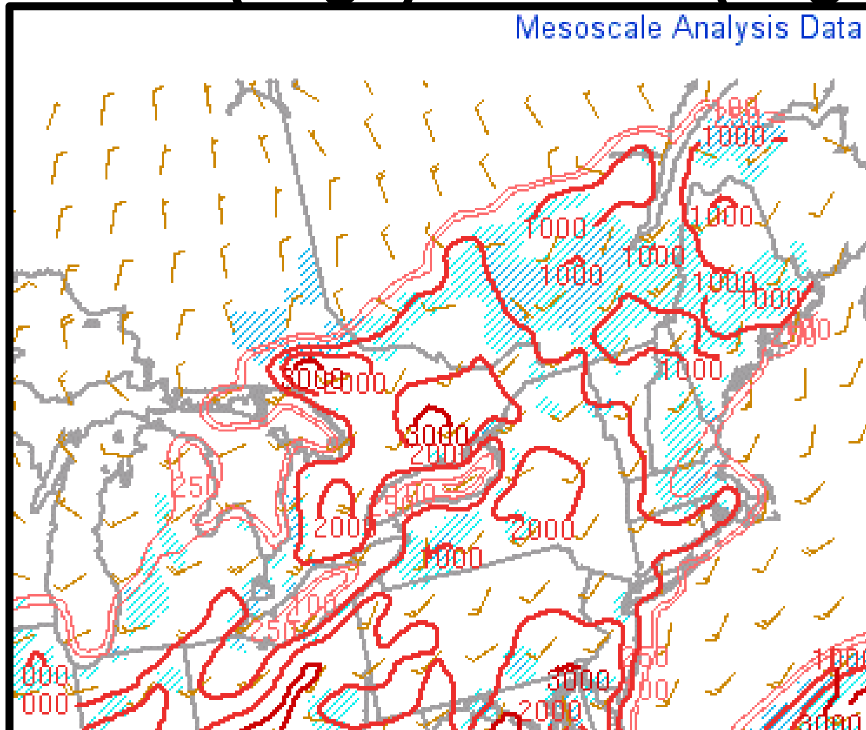
- MUCAPE/SBCAPE = 1264 J kg $^{-1}$
- DCAPE = 1501 J kg $^{-1}$
- 850-500 hPa lapse rate = 7.5°C km^{-1}
- Sfc-3km Lapse Rate (AGL) = 9.8°C km^{-1}
- 0-6 km shear = 40 kts (some super cells organizing into a line/lines)
- Wet Bulb-Zero Height = ~10.0 kft AGL
- 0°C Height = 13.9 kft AGL
- -20°C Height = 23.2 kft AGL

2000 UTC 18 May 2017

RAP 0-6 km Bulk Shear SBCAPE (J kg^{-1}) & SBCIN (J kg^{-1})



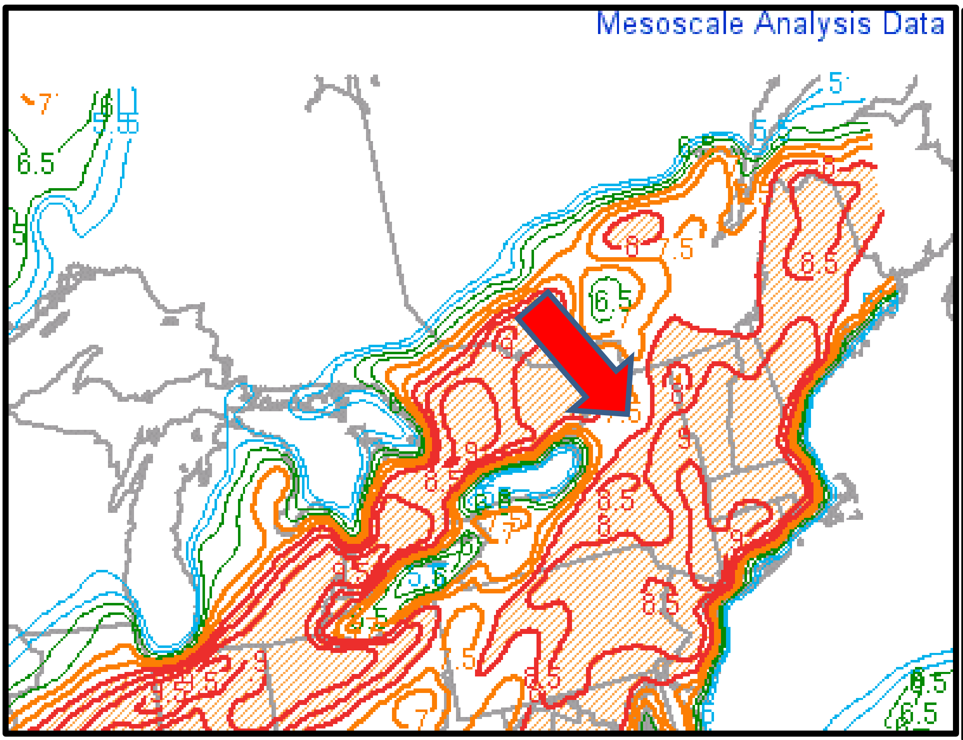
Best 0-6 km Bulk Shear from Capital Region north and west ~40 kts or greater

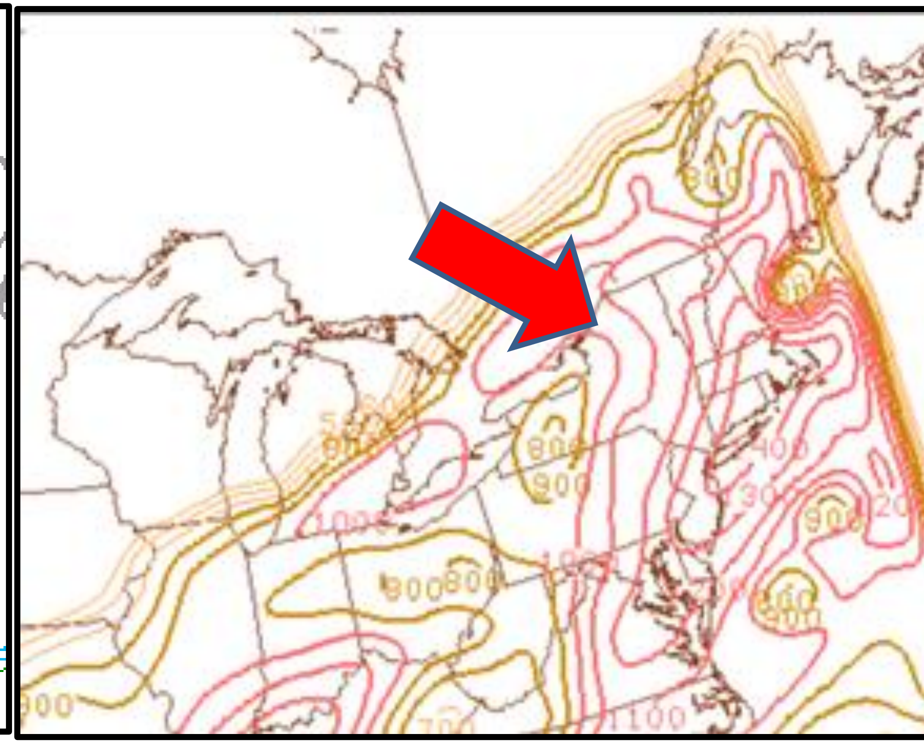


1000-2000 J kg^{-1} of SBCAPE over eastern NY and western New England (moderate instability)

www.spc.noaa.gov

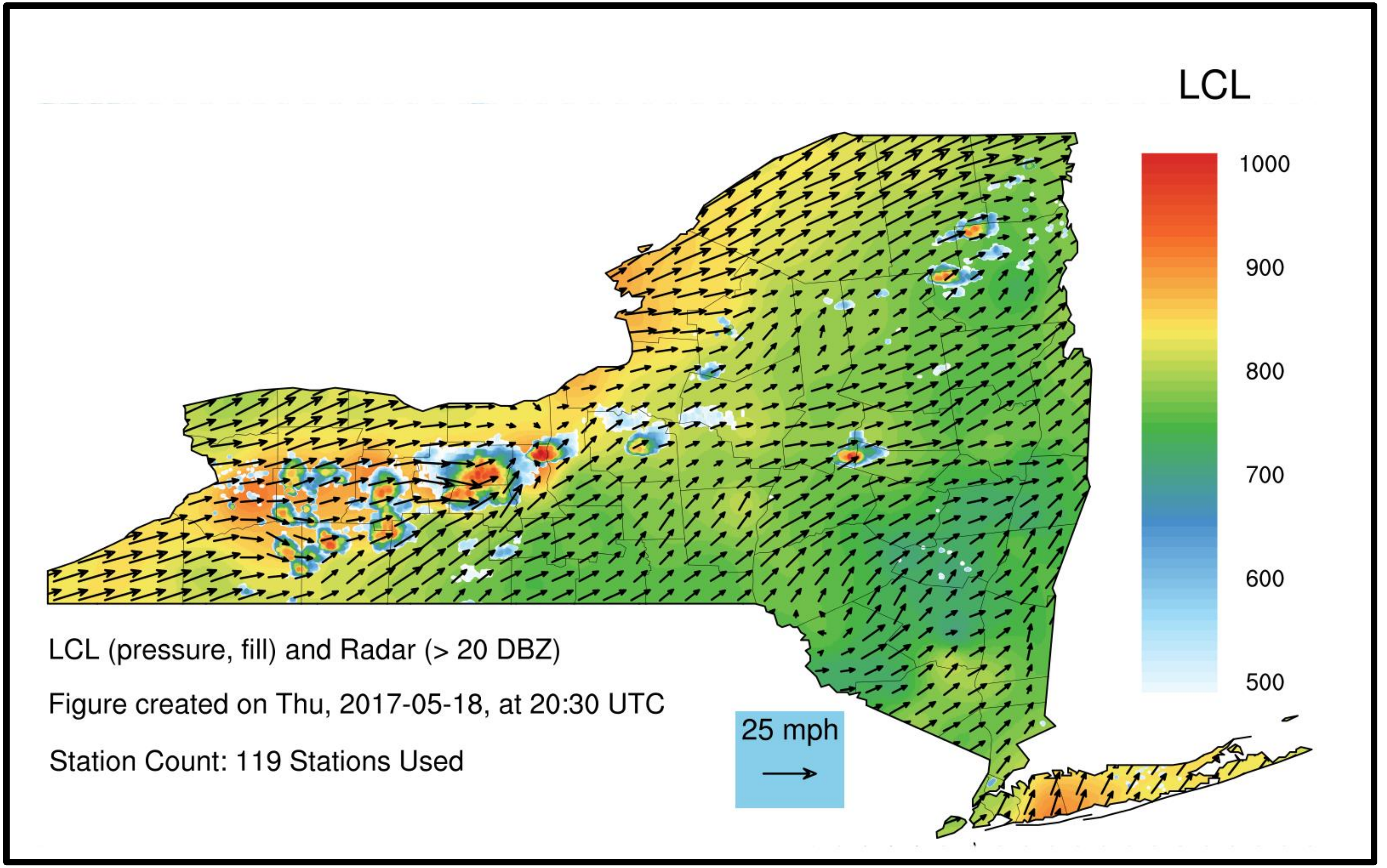
2000 UTC 18 May 2017 RAP
0-3 km Lapse Rates (˚C km^{-1}) and DCAPE(J kg^{-1})



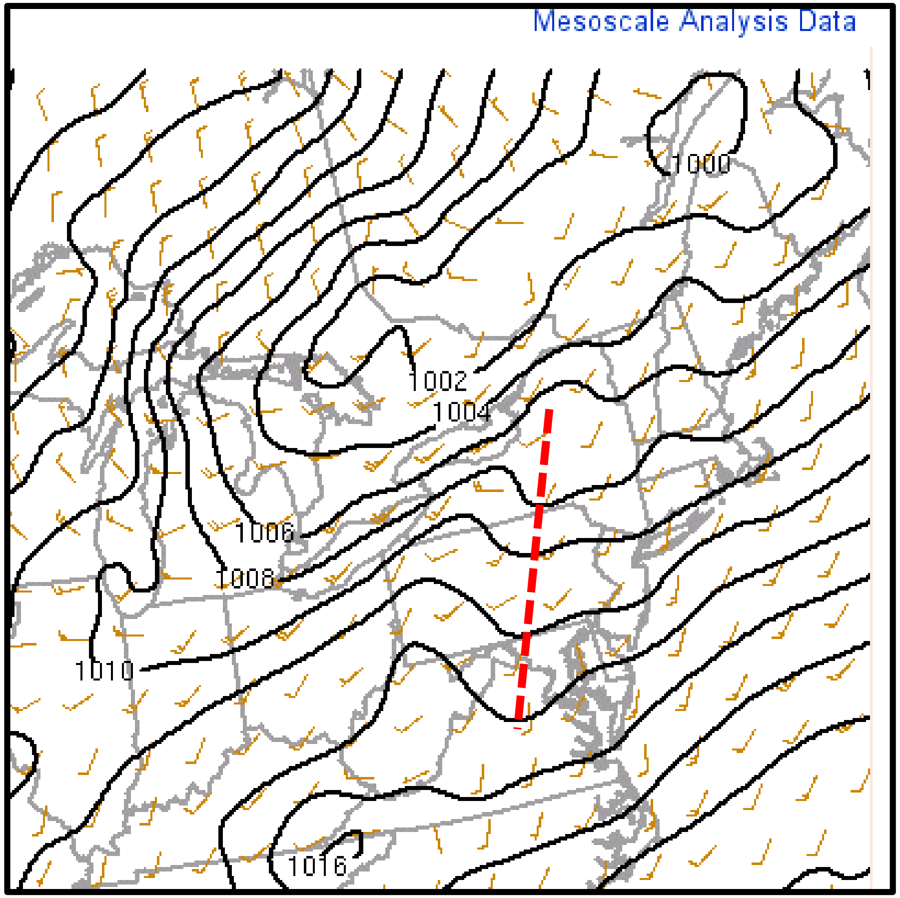


The low-level lapse rates were steep 8.5-9˚+C km^{-1} and the best DCAPE of 1000-1400 J kg^{-1} was over the forecast area. Not shown, the mid level lapse rates 6.5-7+ ˚C km^{-1}

2030 UTC NYS Mesonet LCL (hPa) and Radar (>20 dBZ)with Winds overlayed

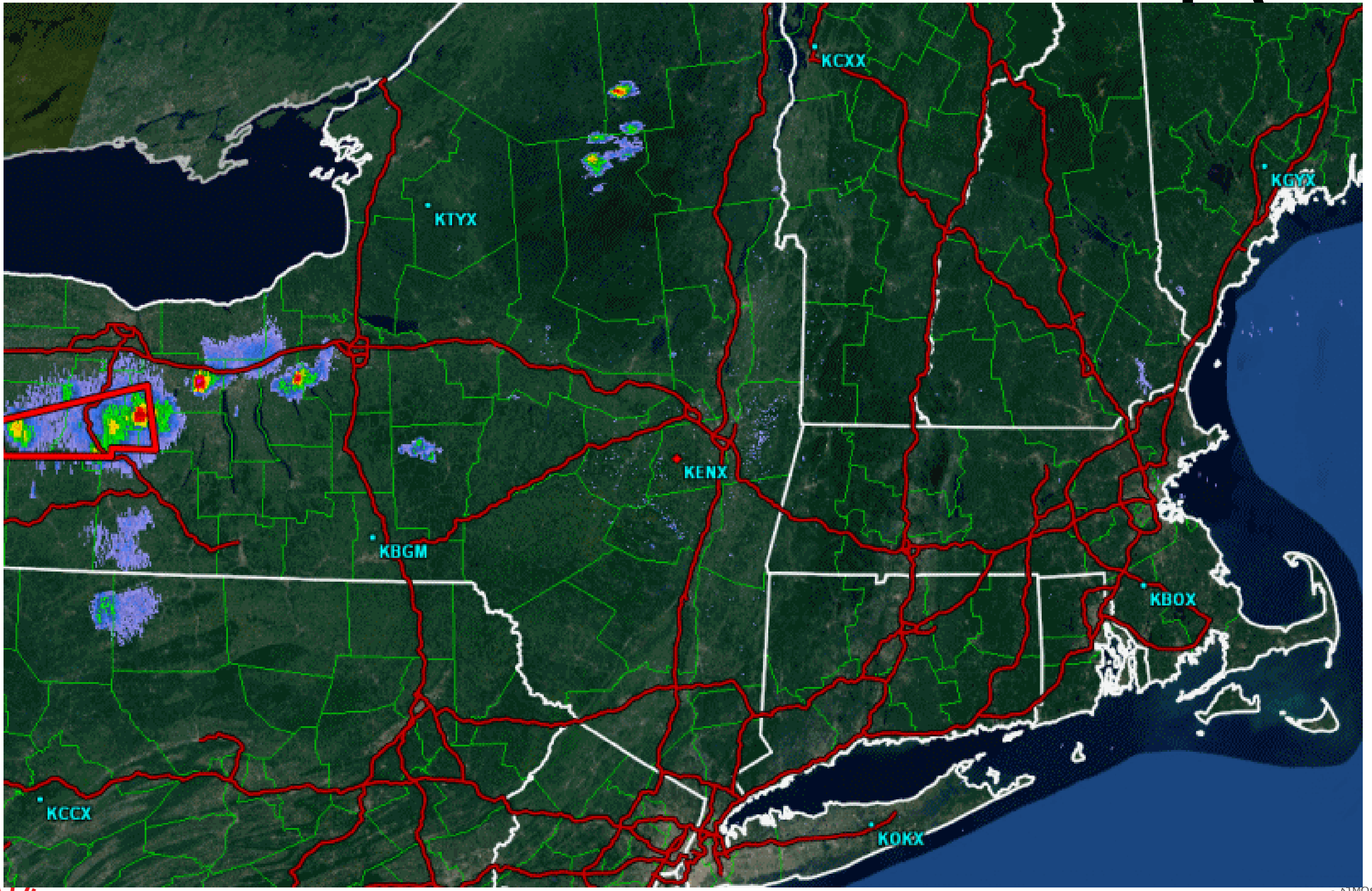


2100 UTC RAP MSLP (hPa) & Winds(kts)

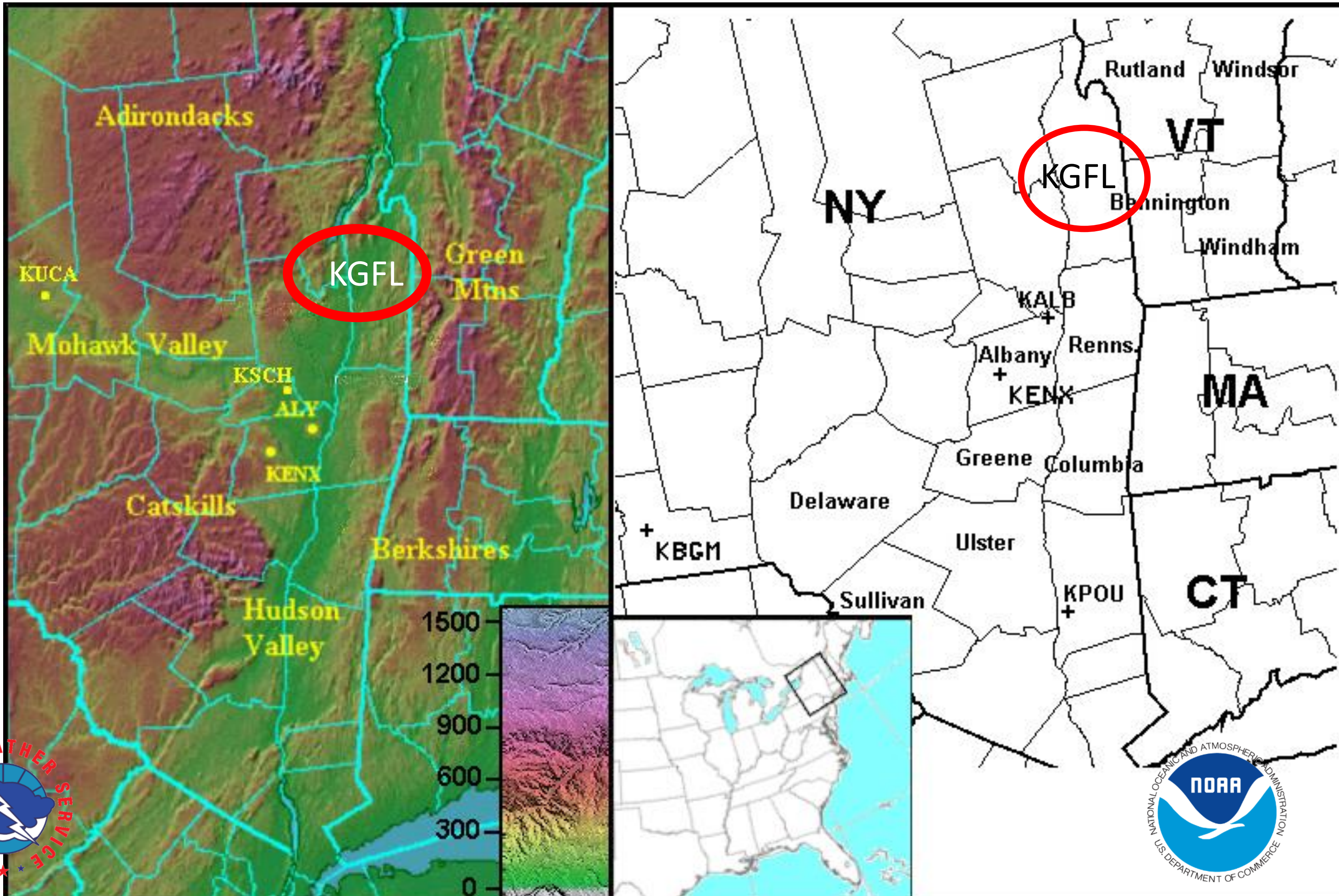


Lake breeze and outflow boundaries race ahead prefrontal trough and cold front

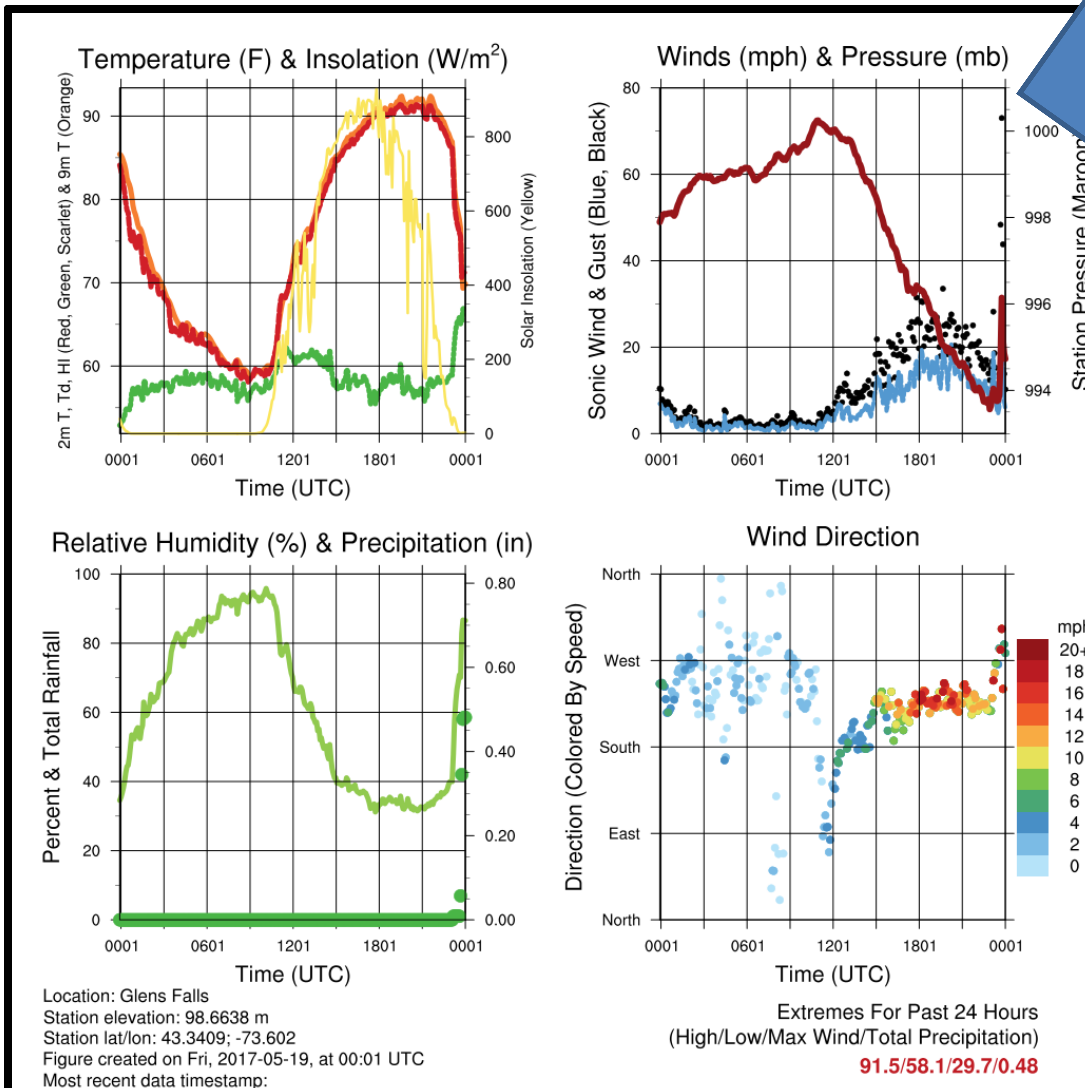
2000-0200 UTC KENX Base REF loop (dBZ)



NWS at Albany Forecast Area



18 May 2017 NYS Mesonet Glen Falls Meteogram



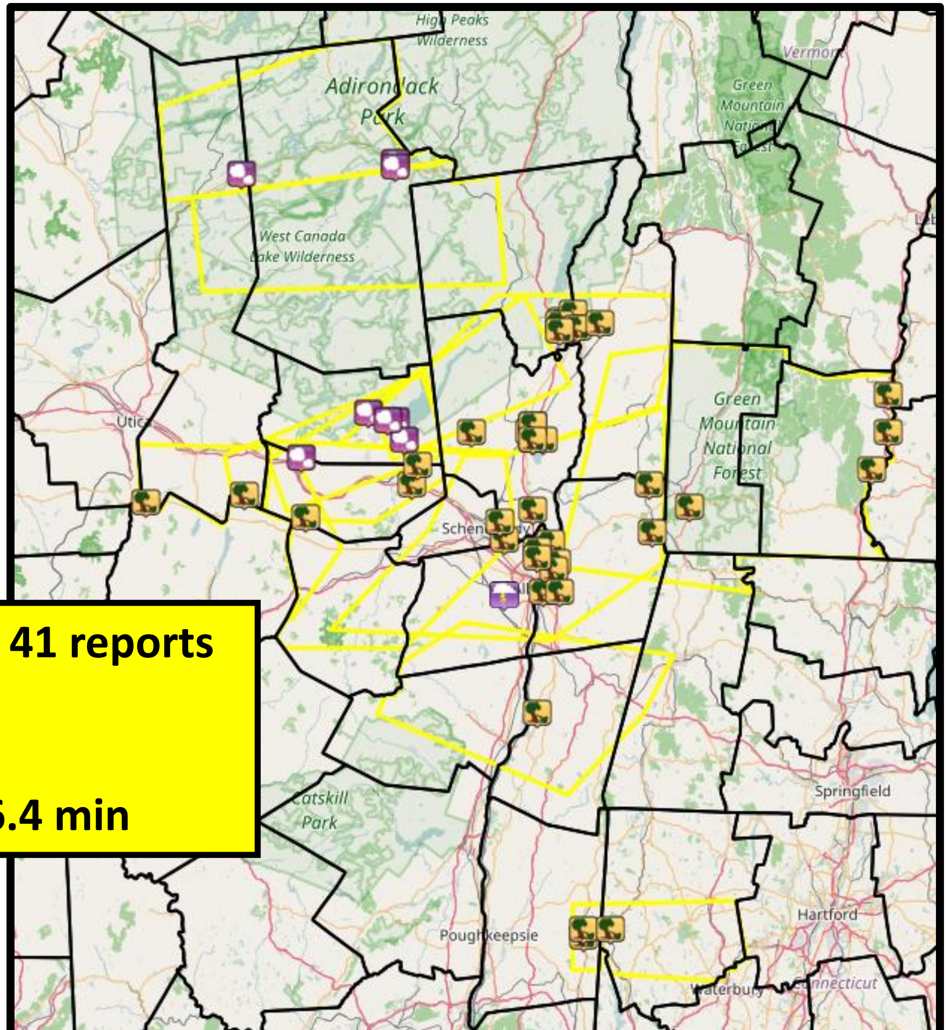
Sonic Anemometer wind gust looked close to 70 mph !!! Occurred between 730-740 pm

Macroburst near KGFL

- **Maximum Estimate Wind Speed**: 90 mph
- **Estimate Time**: 730-740 pm (2330-2340 UTC)
- NYS Mesonet site in Glen Falls measured a wind gust of 59 Knots (68 mph)
- **Path Length** 3 miles, and **path width** 1.5 miles extending from Queensbury in Warren Co. to northern Washington Co.
- Extensive tree damage, a few roofs damaged and a barn destroyed

Washington Co. Emergency Management (Tim Hardy) Photos

18 May 2017 Storm Reports



ALY Forecast Area: 41 reports
POD: 1.0 (100%)
FAR: 0.17 (17%)
Avg. Lead Time: 26.4 min

Mesoanalysis Results

- Anomalous hot air mass for mid-May (NYS mesonet)
- Moderate instability and 0-6 km bulk shear (40 kts or greater) supported discrete mini-supercells evolving into QLCS and finally a squall line
- Impressive/extreme DCAPE coupled with steep low-level lapse rates (inverted-V signature) supported significant damaging wind threat

Final Thoughts on Mesoanalysis

- Use all available data: surface, upper air, mesonet, profiler, radar, lightning and satellite data
- Try to keep continuity and do your analysis on an hour by hour basis
- Look for boundaries and gradients
- Incorporate convective parameters in the severe and winter weather analysis (very important)
- Don’t always run to the HiRES mesoscale models or CAMs for the answer (important to use still)

Journal References

- Banacos, P.C., A.N. Loconto, and G.A. Devoir, 2014: Snow squalls: Forecasting and hazard mitigation. *J. Operational Meteor.*, **2** (12), 130-151, doi: http://dx.doi.org/10.15191/nwajom.2014.2012.

- Thompson, R.L., R. Edwards, J.A. Hart, K.L. Elmore and P.M. Markowski, 2003: Close proximity soundings within supercell environments obtained from the Rapid Update Cycle. *Wea. Forecasting*, **18**, 1243-1261.