

## Challenges Associated with the October 7, 2020 Derecho in New York State and New England



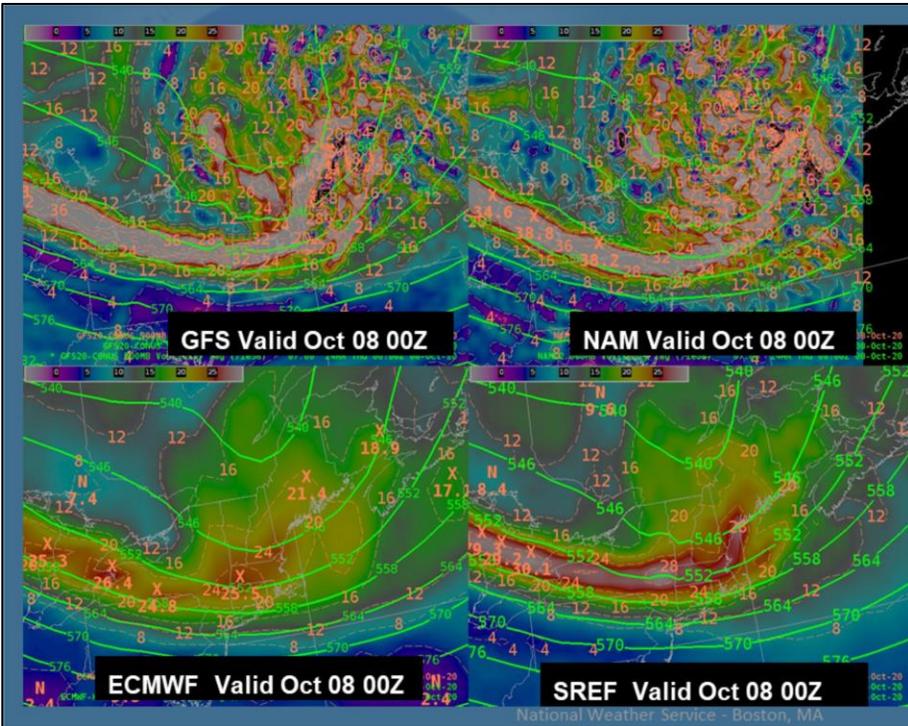
Fall, 2020 CSTAR Meeting

National Weather Service - Boston, MA

The following slides are from a presentation developed collaboratively by National Weather Service forecast offices at Albany, Boston (Norton), and Portland (Grey), along with the Storm Prediction Center. This presentation was shown at a meeting with the State University of New York at Albany on December 10, 2020.

## Overview

- ★ A strong cold front along with a 150 kt 250 mb jet provided the dynamics for a high and potentially damaging wind event for S New England.
- ★ Instead, there was enough instability to generate a QLCS which impacted much of eastern New York and New England.
- ★ After reviewing the radar/environment information and preliminary storm reports, SPC determined on Oct 12 that the event met the serial derecho criteria established and modified by Johns and Hirt (1987) based on length (~320 miles) and report distribution (including significant severe gusts).



500 MB HT:  
Valid 00z 10/8/2020:

All guidance indicated a potent/vigorous northern stream shortwave. This is often a key player in low Cape severe weather events.

Strong shortwave energy steepens lapse rates and increases the amount of forcing.

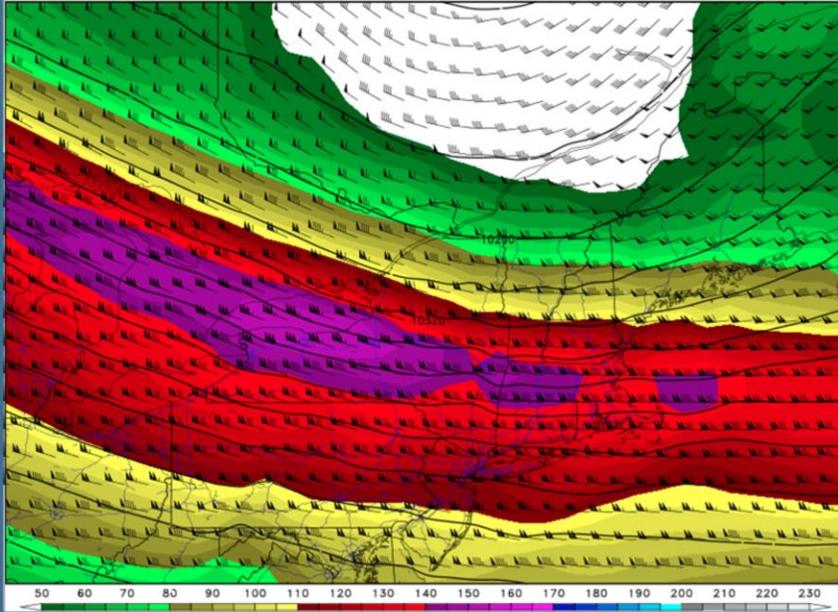
The cold front/low level convergence was also important.

WFO BOX Table Oct 6, 2020 00Z Run							
Back	U	200	500	700	850	1000	
0	Tue	00Z	97.5	AVG	AVG	AVG	AVG
6	6th	06Z	AVG	AVG	AVG	AVG	AVG
12		12Z	AVG	AVG	AVG	AVG	AVG
18		18Z	90	AVG	AVG	AVG	AVG
24		Wed	00Z	97.5	AVG	AVG	90
30	7th	06Z	90	AVG	90	90	97.5
36		12Z	97.5	97.5	97.5	97.5	97.5
42		18Z	99	MAX	MAX	99.5	99
48		Thu	00Z	97.5	MAX	MAX	MAX
54	8th	06Z	97.5	MAX	MAX	99.5	MAX
60		12Z	97.5	MAX	90	90	97.5
66		18Z	90	99	90	AVG	90
72		Fri	00Z	90	97.5	90	AVG
78	9th	06Z	90	90	90	AVG	90

The u-component of the wind field at all levels are outside of NAEFS model climatology for S New England!

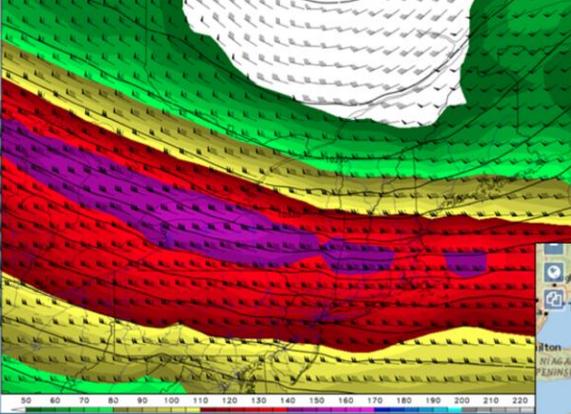
This lends confidence to the *potential* of a highly anomalous event.

This chart shows the rarity of the east-west component of the wind in this case for southern New England. Areas in the table highlighted in red correspond to times and levels where the east-west component of the wind was stronger than any other time on that day in the climatological database for southern New England. In this case, wind values were above these historical values from 850-500 mb during the period from 18z on the 7<sup>th</sup> to 06z on the 8<sup>th</sup>.



The nose of the 250mb 150 kt jet was pointed straight at S New England. This ensured that the jet dynamics more than compensated for the lack of stability and moisture (dew pt in the 40s).

The result is an intensifying QLCS as it moved into S New England.



## WFO ALY Perspective

Low CAPE / high shear event

High uncertainty until storm attained a well-organized linear mode

New York Mesonet aided warnings at the onset of the event

High-confidence warnings issued for much of the event with very strong velocity values sampled on radar associated with bowing, linear system.

Difficult tornado warning decision with a storm east of Albany (very strong rear inflow notch, not much storm relative rotation)

A briefing for wind and marginal severe potential issued, but overall customers did not have much advance warning until SVR's issued.

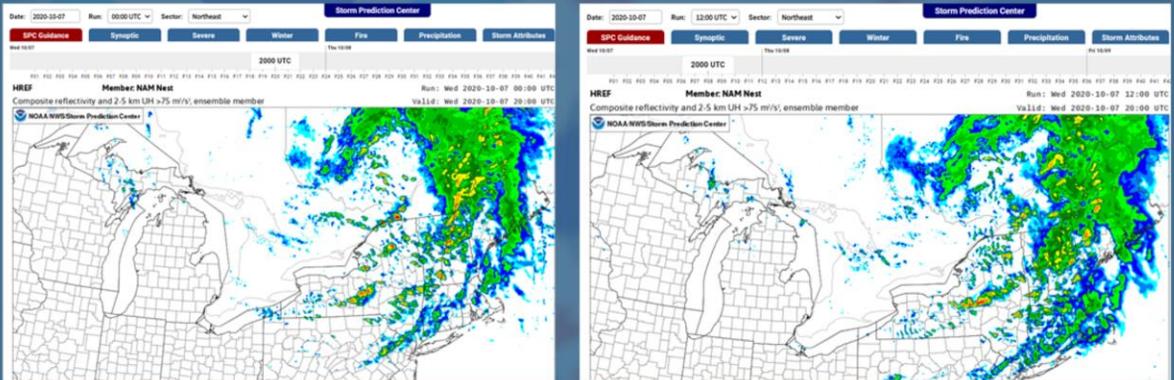
# High resolution models - 00z and 12z HRRR valid 20z



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Reflectivity forecasts from the HRRR model valid at 20z on the 7<sup>th</sup> indicated the potential for some convection over eastern New York and New England, however an organized squall line was not indicated.

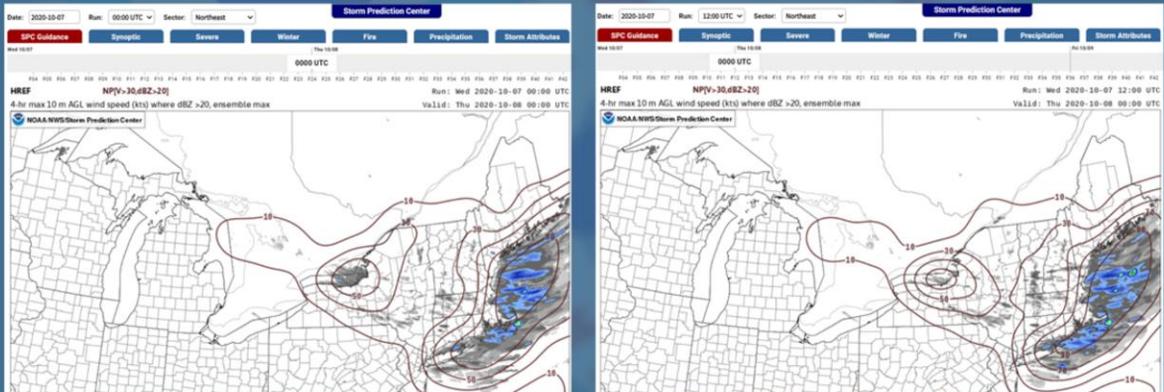
# High resolution models - 00z and 12z NAM valid 20z



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Likewise, reflectivity forecasts from the 3 km NAM nest model also indicated the potential for some convection, but not an organized squall line.

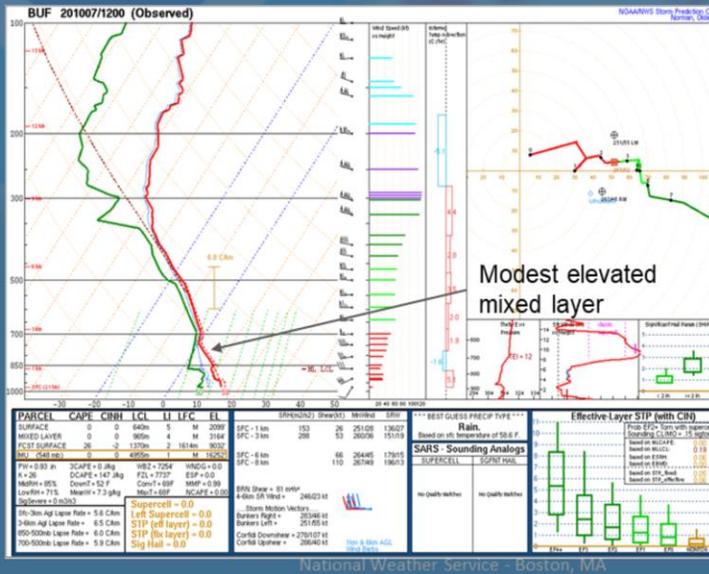
# HREF max wind gust - 00z and 12z runs thru 00z 10/8



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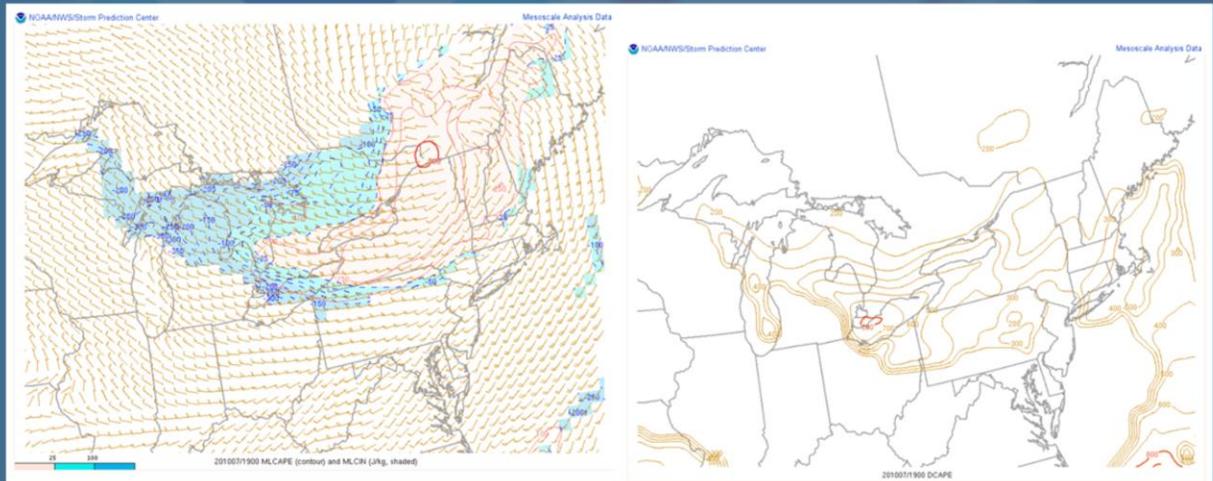
Maximum wind gusts forecast through 00z on the 8<sup>th</sup> from the high resolution ensemble forecast (HREF) were 20 to 30 kts.

# 12z BUF sounding shows a modest elevated mixed layer



The observed sounding at Buffalo at 12z on the 7<sup>th</sup> indicated a strong, mostly westerly wind field. In addition, a modest elevated mixed layer can be seen from 850 to 700 mb.

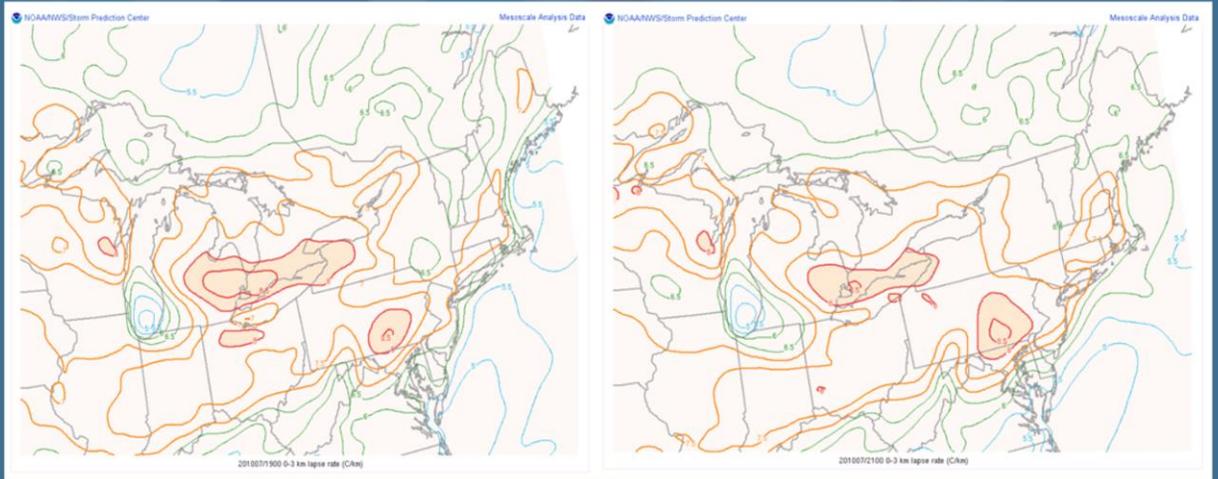
# Modest MLCAPE / DCAPE from SPC meso-analysis



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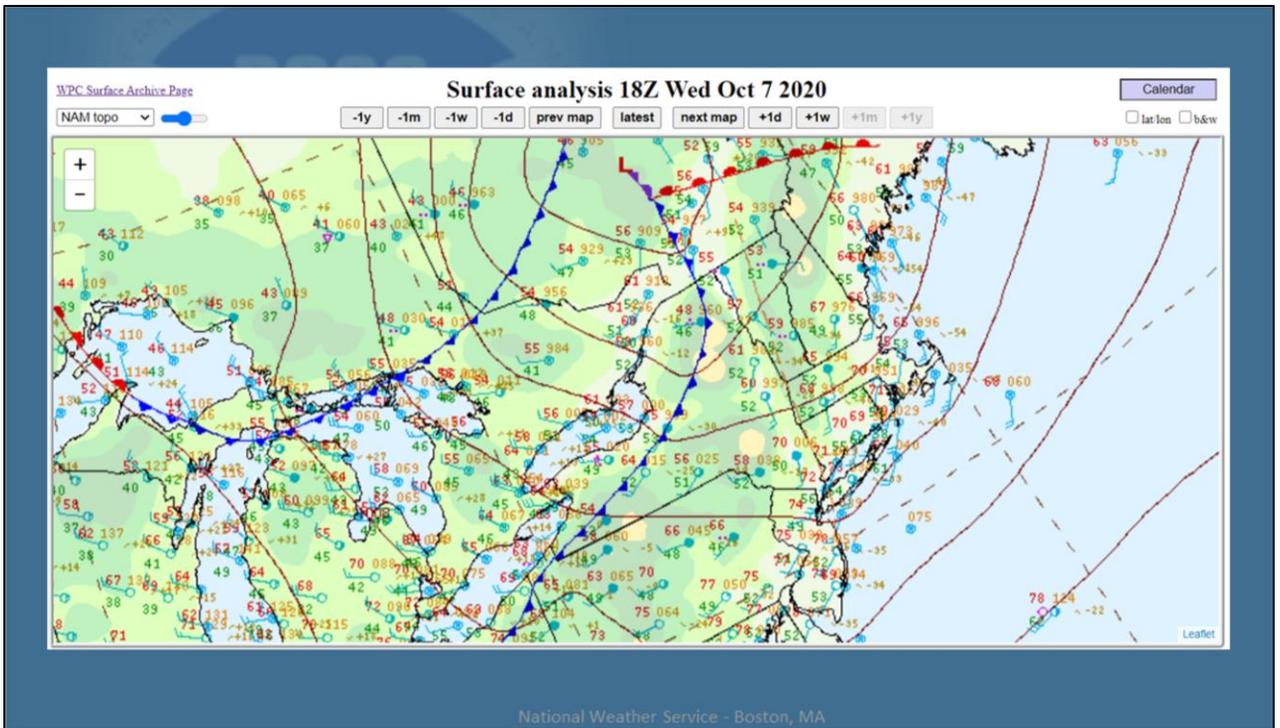
SPC meso-analysis graphics at 19z indicated MLCAPE values from 250 to 500 J/kg across the area, and downdraft CAPE values less than 500 J/kg.

SPC meso-analysis low-level lapse rates - min over eastern NY associated initially with a late morning period of light rain.



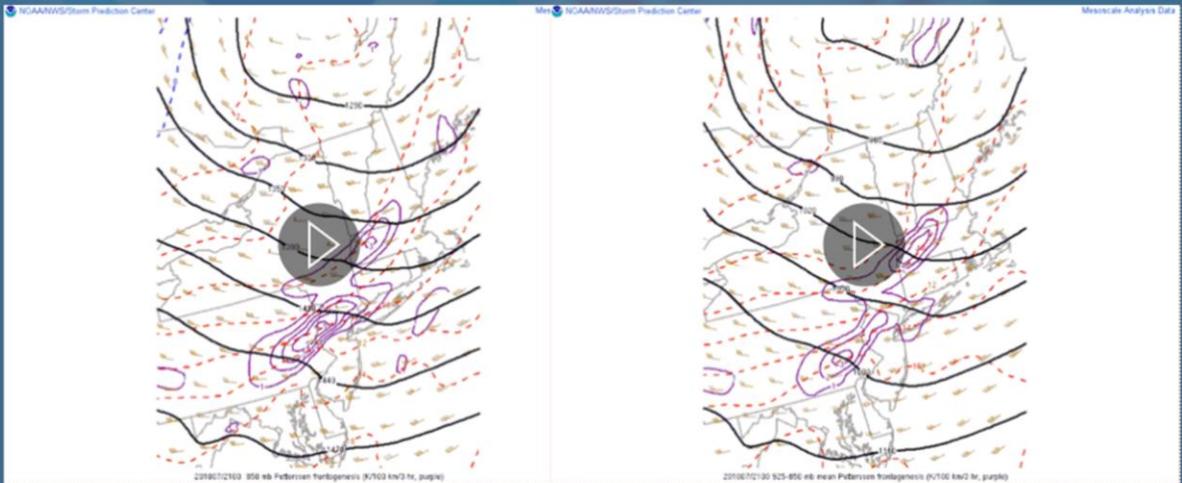
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Low level lapse rates were greater than 7 degrees C per km across western NY and eastern New England, however a minimum of around 6.5 degrees C per km can be seen over eastern NY. This was likely due to an area of light rain that moved across the area during the late morning.



- A surface plot at 18z, just prior to the development of the squall line indicated a cold front moving east across upstate NY. Temperatures ahead of the front were in the mid 50s to near 70 with dew points climbing into the 50s.

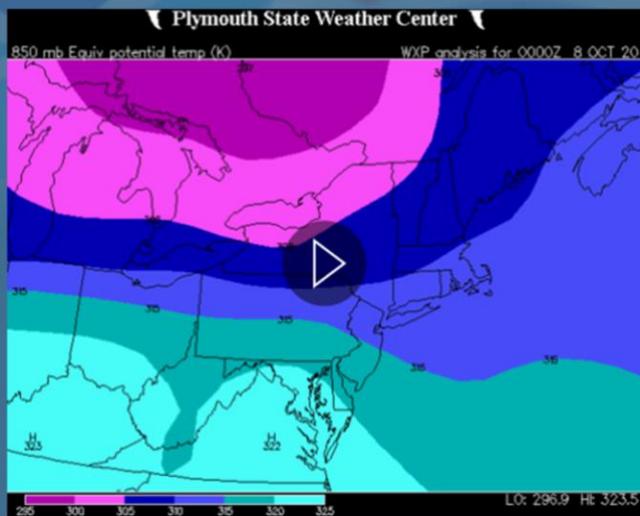
SPC meso-analysis loops of 850 hPa frontogenesis (left) and 925-850 hPa frontogenesis (right), showing increasing low level frontogenesis as the derecho tracked east and south



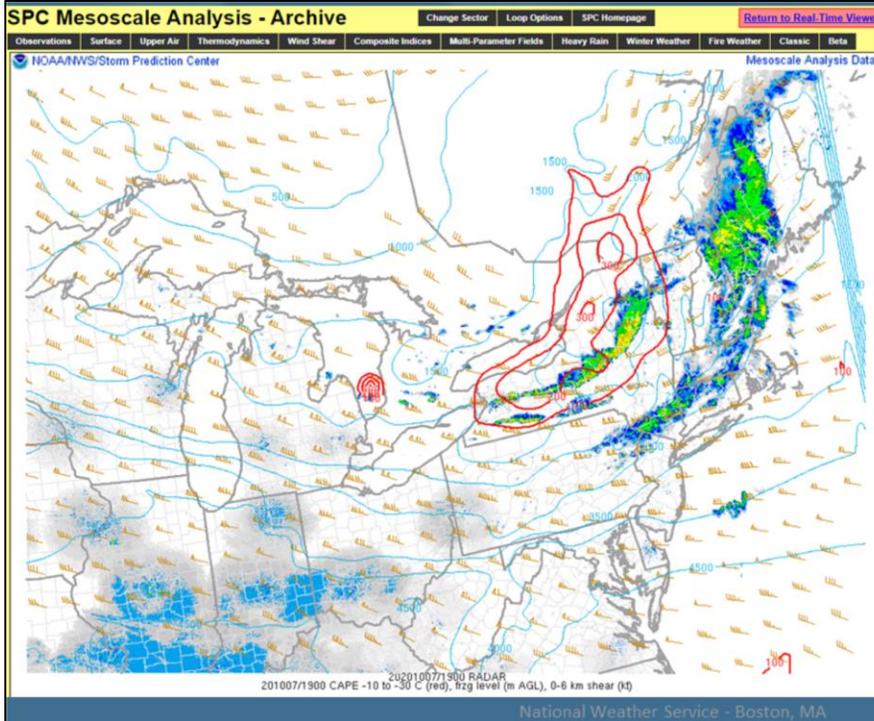
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A band of enhanced low-level frontogenesis corresponded to the passage of a surface trough and associated squall line for this case.

850 hPa equivalent potential temperature at 00z 8 October. Note the ~20K gradient that tracked east and south through the region, implying strong forcing associated with the leading edge of cold advection and dry air above the friction layer



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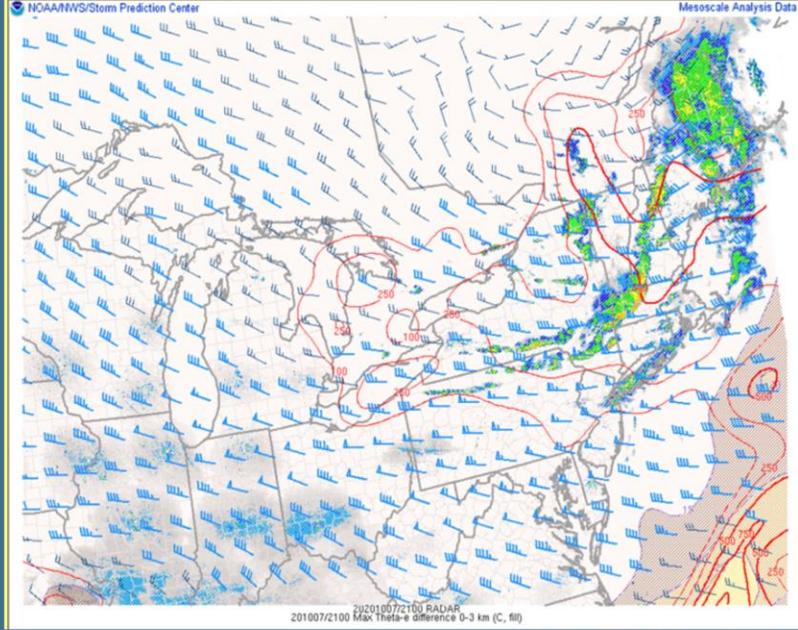
Local ALY  
Lightning study shows Hail Cape (amount of cape between -10C and -30C) to be an important parameter when considering potential for lightning. Sufficient instability was present in this layer (>200 J/Kg)

## SPC Mesoscale Analysis - Archive

Change Sector Loop Options SPC Homepage

[Return to Real Time View](#)

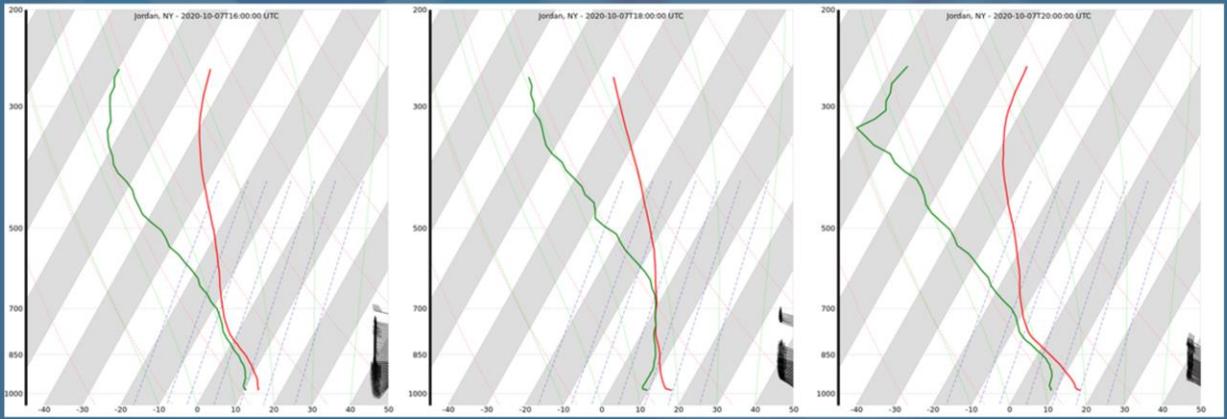
Observations Surface Upper Air Thermodynamics Wind Shear Composite Indices Multi-Parameter Fields Heavy Rain Winter Weather Fire Weather Classic Data



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0-3km bulk shear vectors ranged 40 - 50kts and remained perpendicular to the updraft downdraft convergence zone (UDCZ, as indicated by the reflectivity on this slide).

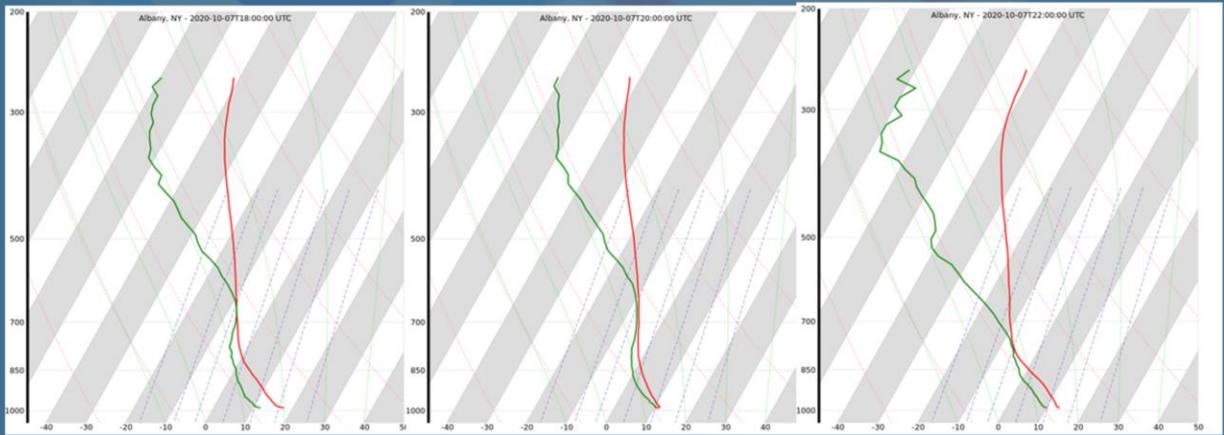
## Profiler data from Jordan in central NY - 16z, 18z, 20z



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Profiler data from the New York State Mesonet showed the development of moderately steep low-level lapse rates at Jordan, NY in central NY during the afternoon on the 7<sup>th</sup>.

## Profiler data from Albany - 18z, 20z and 22z



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Steep low-level lapse rates could also be seen developing on the New York State meso-net Albany profiler.

Radar 1830z - TYX out - line forming, inbounds 40-50 kts at 6 kft (sampling environmental winds?). Watching for possible linear development.



National Weather Service - Boston, MA

Looking at the radar, storms had developed south and east of Lake Ontario by early afternoon. Meteorologists were watching for upscale linear development at this time, and a few warnings were being issued upstream in central NY.

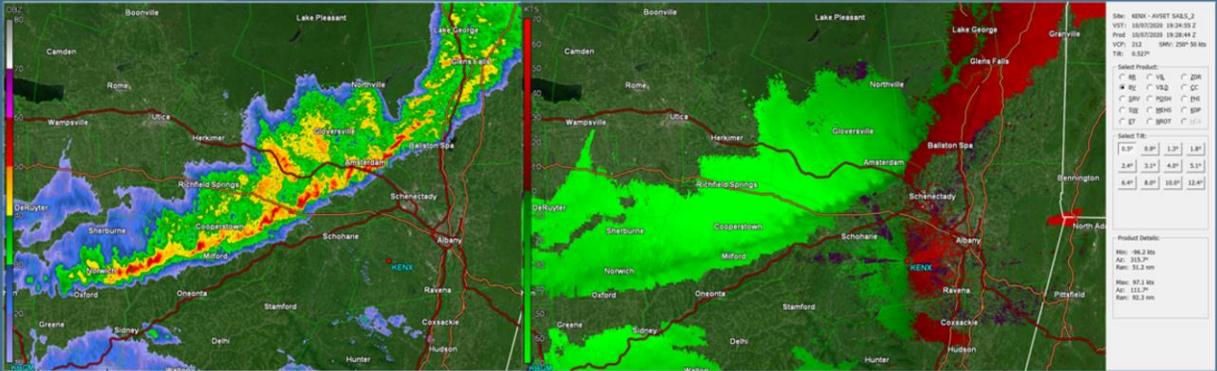
Radar at 19z - linear development occurring - inbound velocity 60-70 kt at 5000 ft, watching the meso-net, first warning at 1846z, watch?



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Linear development gradually occurred through 19z. A mesonet report of wind speeds greater than 50 mph was received from the western Mohawk Valley, and the NWS began issuance of severe thunderstorm warnings for the Mohawk Valley around this time.

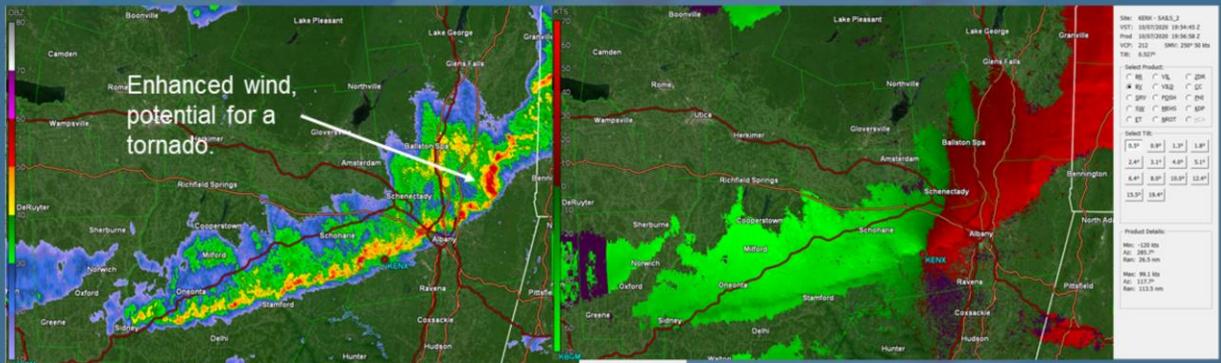
Radar at 1930z - linear mode, v inbounds 60-70 kts at 2500 feet, high confidence warnings going out, collaboration with SPC near this time.



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By 1930 UTC, a linear squall line was well-established. Severe thunderstorm warnings were being issued, and damaging winds were being reported along the squall line.

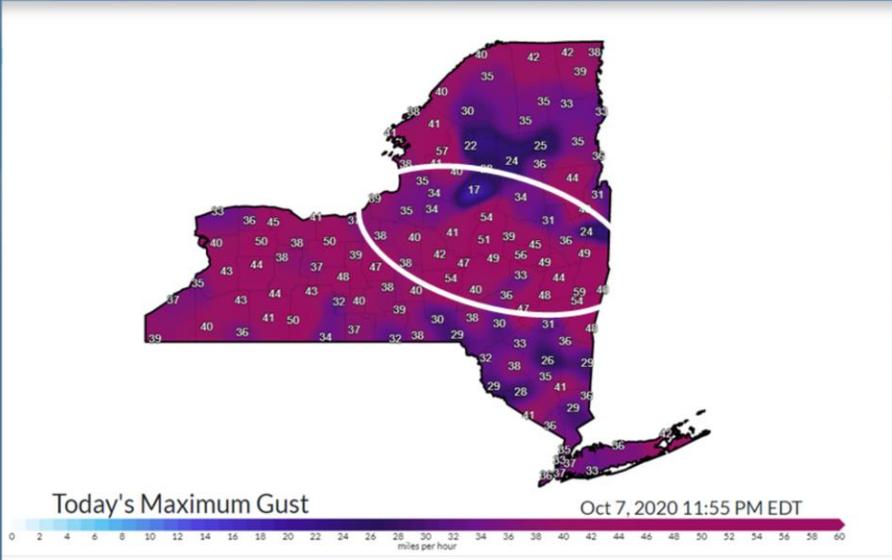
Radar at 20z - QLCS with inflow notches, considering a tornado warning with storm east of Albany, strong rear inflow, weak rotational couplet.



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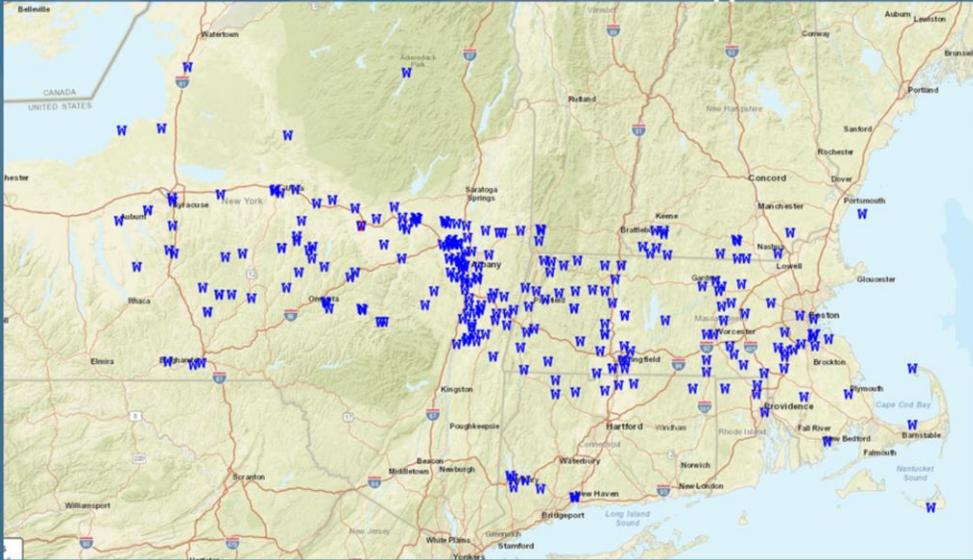
The squall line and associated damaging winds continued as storms moved through the Capital District around 20 UTC. The cell northeast of Albany was monitored for a potential tornado warning, note the indications of a strong rear-inflow notch with that cell, along with weak rotation in the velocity field.

# NYS Mesonet Maximum Wind Gusts



National Weather Service - Boston, MA

# Wind Damage & Tornado Reports across NY and New England



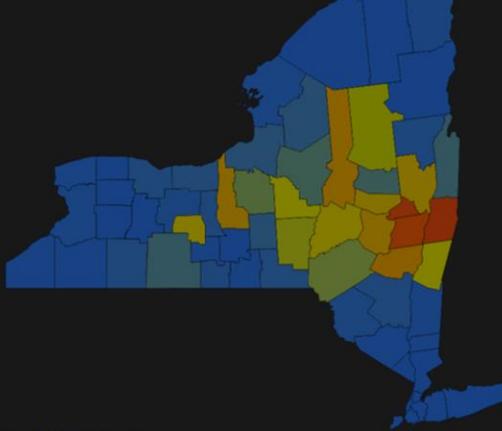
# Power Outages across NY and MA

## New York

Customers Tracked: 8,248,492

State Outages: 216,365

Last Updated: 10/7/2020, 5:06:26 PM



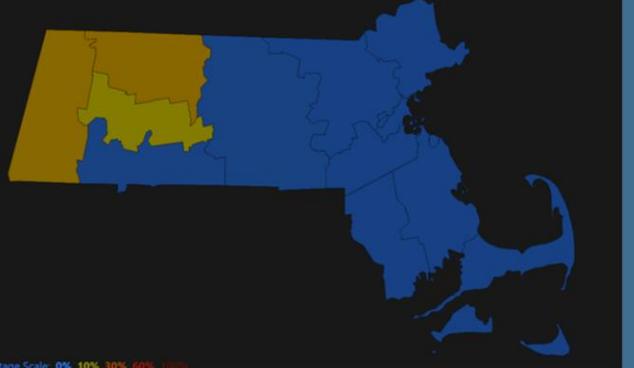
Outage Scale: 0% 10% 30% 60% 100%

## Massachusetts

Customers Tracked: 2,532,072

State Outages: 29,372

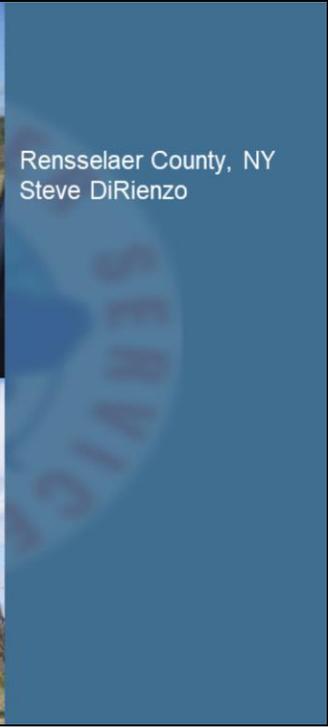
Last Updated: 10/7/2020, 5:22:50 PM



National W Outage Scale: 0% 10% 30% 60% 100%

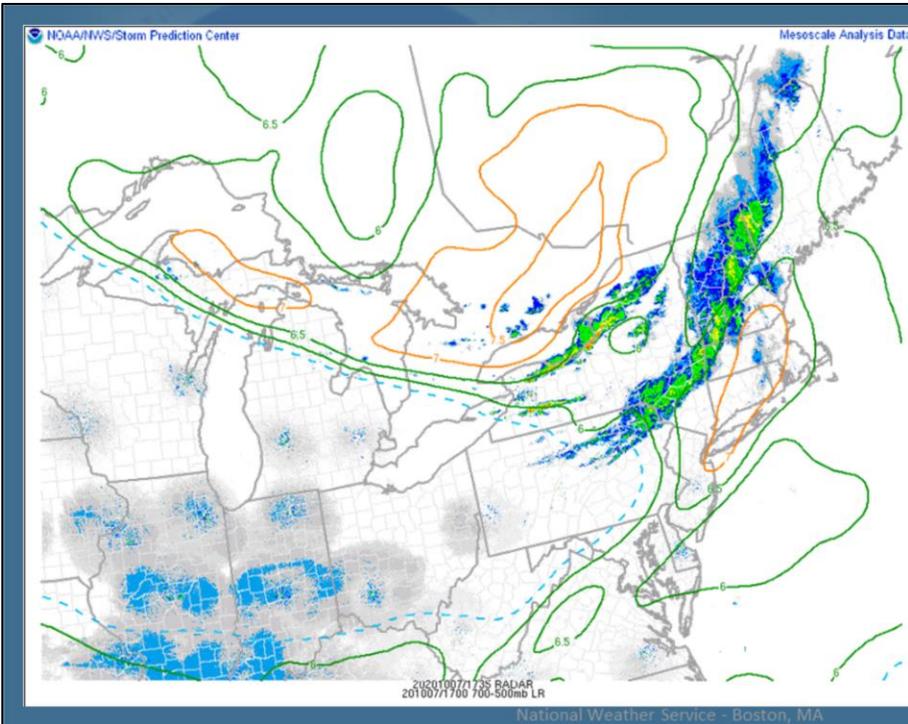


Rensselaer County, NY  
Steve DiRienzo

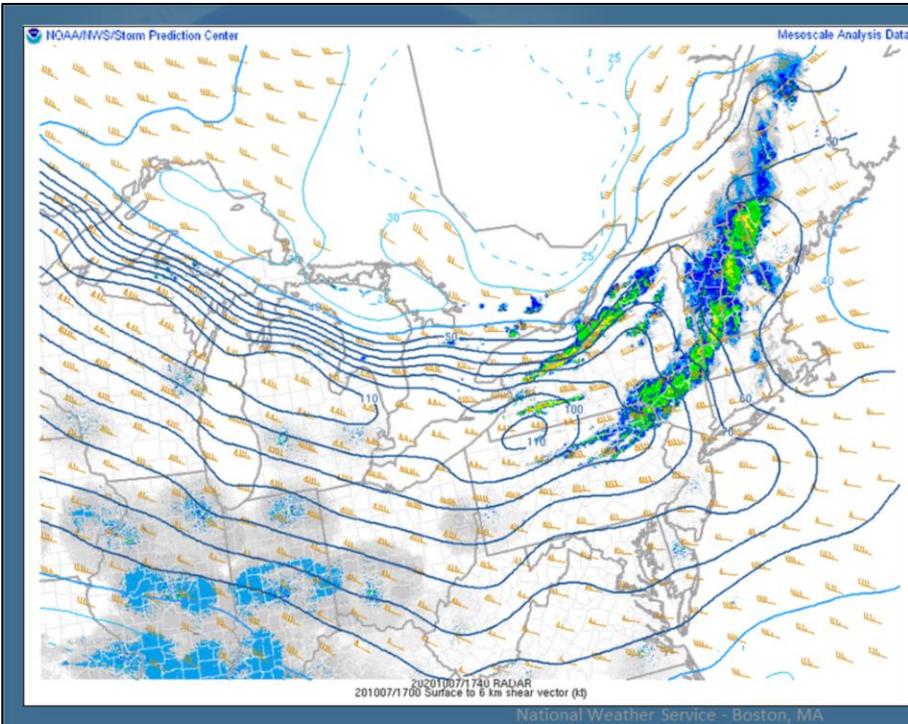


## WFO BOX Perspective

- Models did not capture amount of low level instability (0-3 km CAPE), thus limiting convective development. Expectation was for “gradient” high winds.
- High Wind Watch/Warning raised the awareness of partners and public. Provided 12-24 hours of preparation time
  - EM feedback: Wind Advisories do not lead to proactive decision-making since they are issued often during the cool season. Many were caught off guard prior to 9/30 high wind event in southeast MA and RI.
- If the convective threat was better anticipated the day before, we could have coordinated with SPC and our neighbors to have a Slight/Enhanced Risk, then had SPC issue a Severe Thunderstorm Watch the day of the event. Messaging the day before would have been able to communicate the threat.
- *In hindsight, having the wind headlines in advance worked out, but it was for the wrong reason.*



Thanks to an anomalous cold pool aloft, mid level lapse rates were very steep, helping to bring down some of the strong winds aloft.

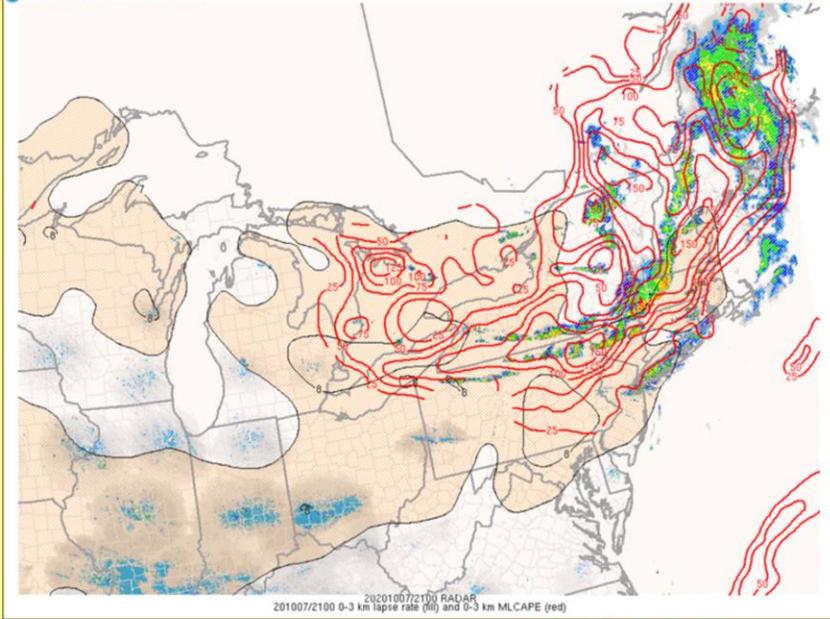


50-60 kt 0-6km shear further contributed to the favorable dynamics for a high-end damaging wind event. Notice that the shear values were approaching 100 kts just to our West!

# SPC Mesoscale Analysis - Archive

[Change Sector](#) [Loop Options](#) [SPC Homepage](#) [Return to Real-Time Viewer](#)

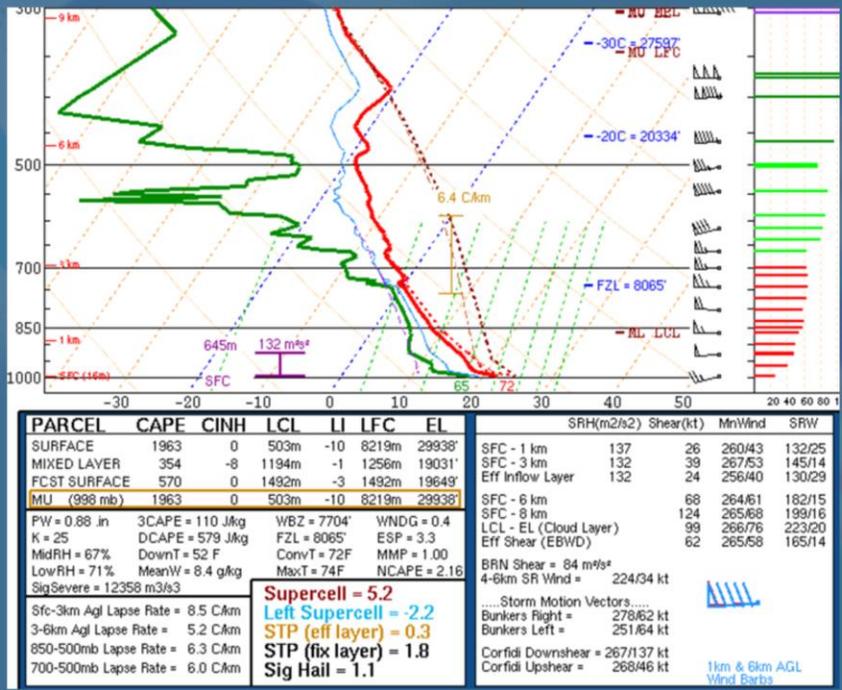
[Observations](#) [Surface](#) [Upper Air](#) [Thermodynamics](#) [Wind Shear](#) [Composite Indices](#) [Multi-Parameter Fields](#) [Heavy Rain](#) [Winter Weather](#) [Fire Weather](#) [Classic](#) [Beta](#)



National Weather Service - Boston, MA

Sufficient 0-3 km CAPE helped to maintain the line of storms as it crossed into southern New England.

10/8/2020  
00 UTC  
Sounding,  
Chatham, MA



National Weather Service - Boston, MA

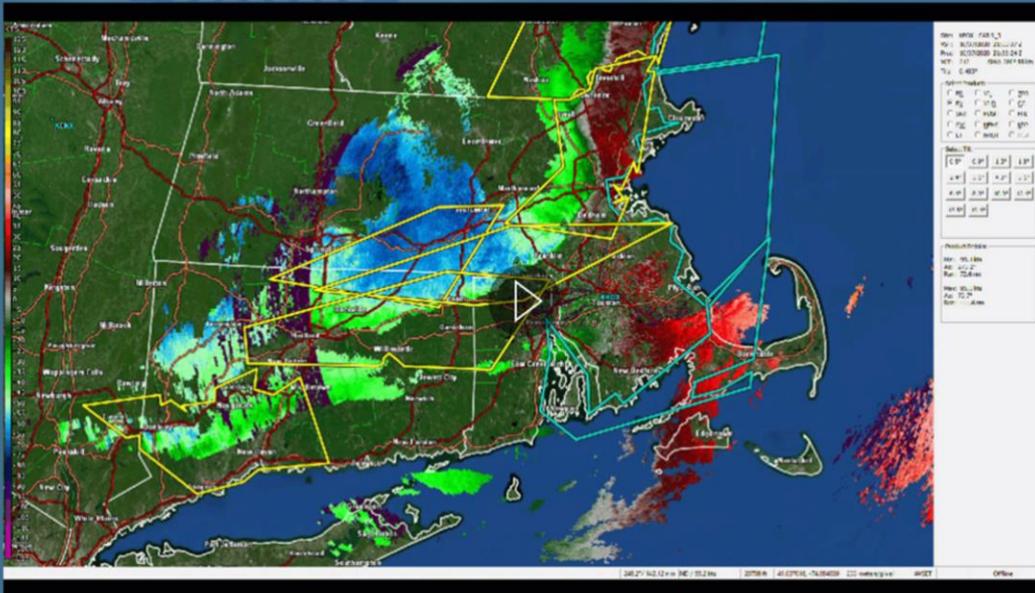
Radar data from the BOX WSR-88D



National Weather Service - Boston, MA

The squall line continued eastward, moving rapidly across eastern Massachusetts, northern Connecticut and Rhode Island through the late afternoon.

## BOX WSR-88D velocity at 22 UTC



National Weather Service - Boston, MA

A surge of strong velocity values exceeding 60 kts was shown moving across the region during the late afternoon. Severe thunderstorms were issued for these storms, and widespread wind damage was reported.



## 12HR Peak Winds (mph)

**Mt. Tom**  
Hampden 55ft

**88**

Westfield-Barnes AP	74	Courageous Sailing Center	70
Worcester AP	70	Chapin	69
Deer Island	68	Blue Hill ASOS	68
Hull YC	67	Woods Hole	66
Scituate	66	Logan AP	66
West Island	65	43.0 SE Chatham (MARITIME)	65
East Boston	64	Dread Ledge	64
Bradley AP	64	Dennis	64
Westover AFB	63	Conimicut Light	63
Hatch Beach	62	Carson Beach	62
Fogland	60	Plymouth AP	60
Fitchburg AP	60	Nantucket AP	60
New Bedford	60	Point Judith	59
Rose Island	58	Halfway Rock	58
Children's Island	58	Bristol Harbor (Castle Island)	58
Norwood AP	58	Mendon	58
Wrentham	58	Pleasure Bay	57
Duxbury	57	Dog Bar Breakwater	57
Rockport	57	Vineyard Station	56

valid as of Wed Oct 7th 11:00 pm - NWS Boston  
photo by: By Osman Rana via Unsplash

National Weather Service - Boston, MA



Scott Nogueira, Weymouth, MA



Paul Shea, Worcester, MA

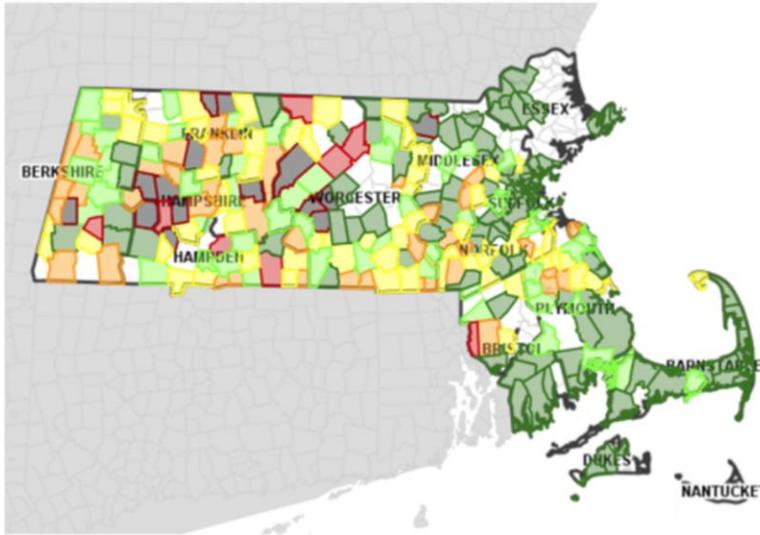


Brendon,  
East Longmeadow, MA

**Power Outages:**

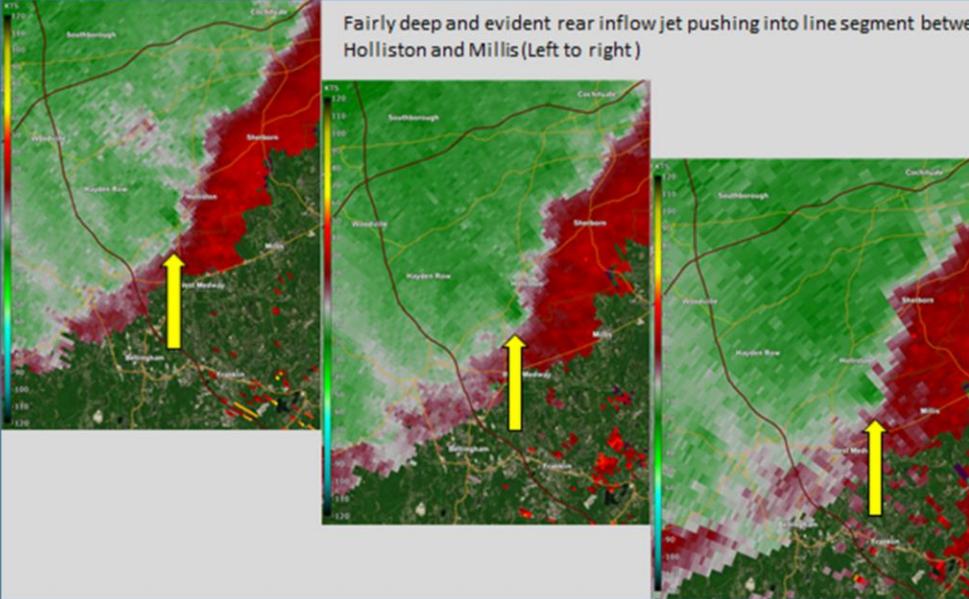
As of 10:00 PM, there are a total of 184,958 customer outages, down from a peak of 246,743 outages at 8:00 PM.

**Power Outage Map:**



National Weather Service - Boston, MA

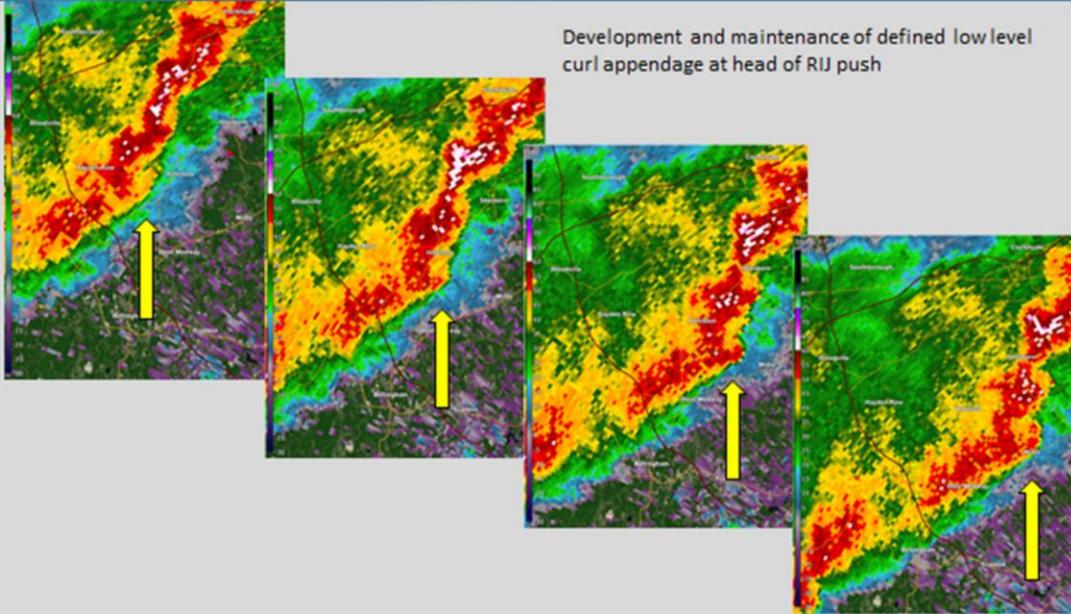
Fairly deep and evident rear inflow jet pushing into line segment between Holliston and Millis (Left to right)



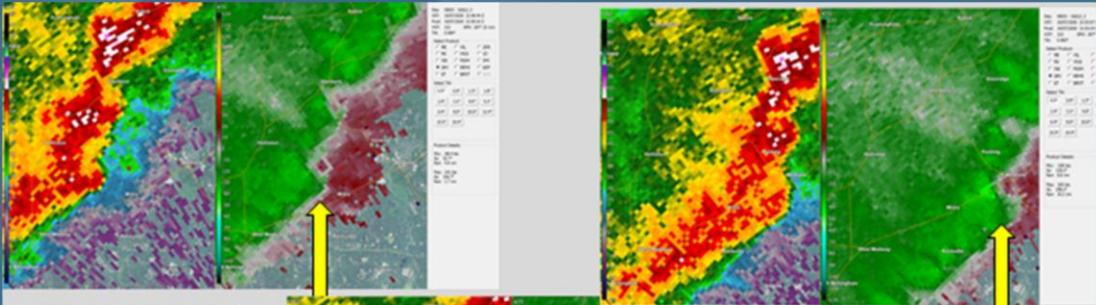
Slide courtesy of Bryan Mroczka, SOO, NWS Tampa Bay

National Weather Service - Boston, MA

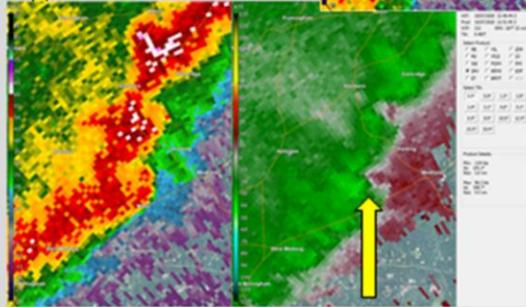
Development and maintenance of defined low level curl appendage at head of RIJ push



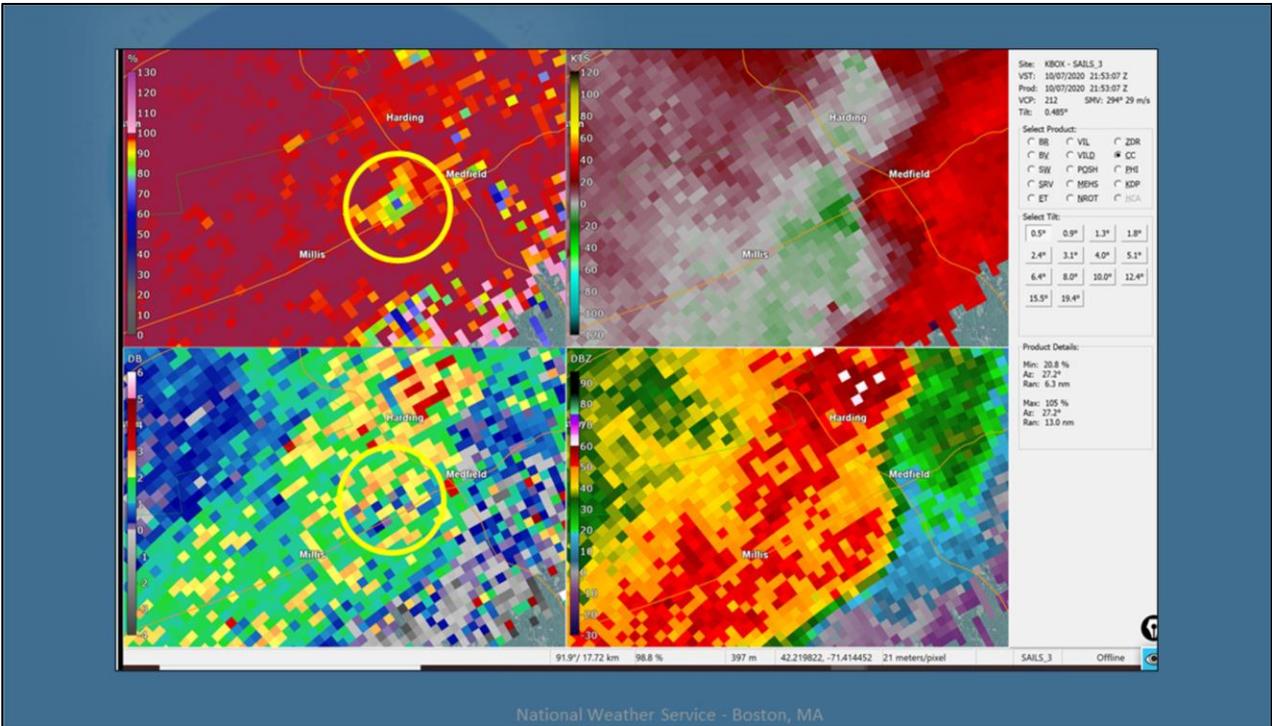
Slide courtesy of Bryan Mrocza, SOO, NWS Tampa Bay  
National Weather Service - Boston, MA



SRM couplet associated with curl. Narrow corridor of significant tree damage occurred along the path with this couplet and reflectivity curl through the town of Millis. Several main roadways as of Thursday afternoon remain closed to due the amount of fallen trees across them.



Slide courtesy of Bryan Mroczka, SOO, NWS Tampa Bay  
National Weather Service - Boston, MA



A tornadic debris signature (TDS) was identified, collocated with the inflow notch and rotational couplet west of Medfield.



Notice the orientation of the downed trees vs. the lamppost

QLCS EF-0 Tornado confirmed in Millis, MA

National Weather Service - Boston, MA

## WFO GYX Perspective

- Hi-res guidance forecast lead light rain/cloud cover quickly followed by any convection
  - Little time for recovery
- Satellite and radar observations show larger spacing between those features in reality
  - Provided the key third variable from Sherburn/Parker - low level lapse rates
  - We knew we already had the mid level lapse rates and plenty of shear
- Low level lapse rates were consistently under forecast by guidance
  - Evidenced by calculations from BufoKit soundings ~ 6 C/km when SPC objective analysis placed them closer to 7 or 7.5 C/km
  - May have led CAMs to underestimate convective potential in addition to shallow nature of storms

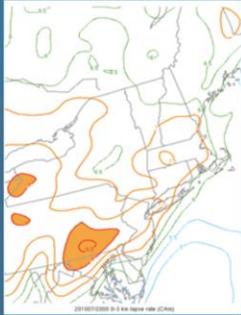
# Utility of SHERBE Parameter - Overlap!

$$\text{SHERBE} = (\text{LR}_{0-3}/5.2) * (\text{LR}_{75}/5.6) * (\text{EBWD}/27)$$

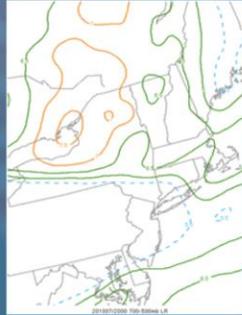
where the lapse rate (LR) terms apply to the 0-3 km and 700-500 mb layers ( $^{\circ}\text{C km}^{-1}$ ), respectively, and the EBWD is the effective bulk wind difference ( $\text{m s}^{-1}$ ).



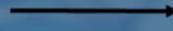
20 UTC  
Effective Bulk  
Shear



20 UTC  
0-3 km  
Lapse Rate



20 UTC  
H7-5 km  
Lapse Rate

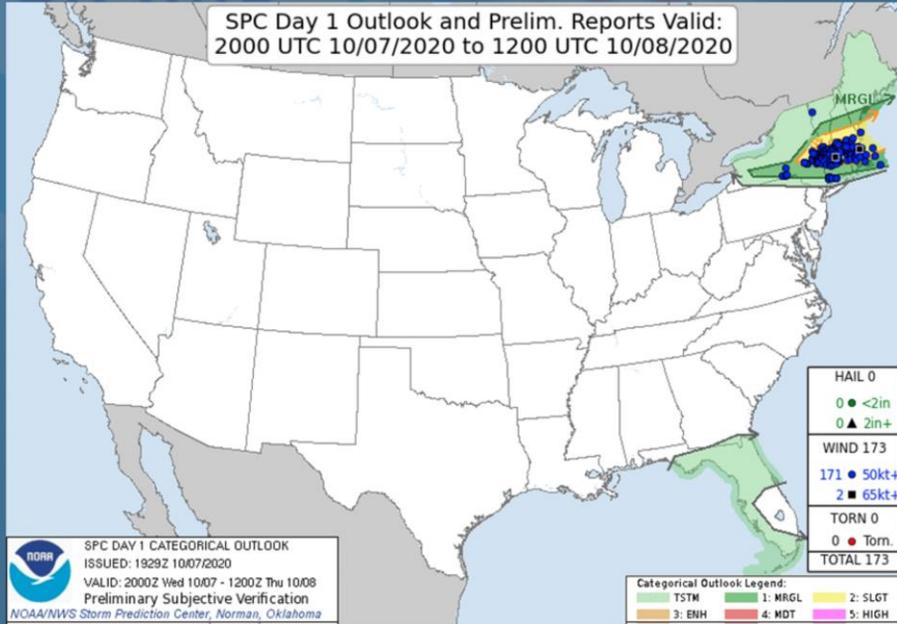


SHERBE  
Values of  $\geq 1.5$   
18-22 UTC

## WFO GYX Perspective - Science and Service

- There was an over-estimation of the predictability horizon of this event
  - Perceived was 15-24+ hours (High Wind Warning/Wind Advisory Lead Time)
  - Actual was <6 hours
- Science Question: How do we better anticipate the predictability horizon such that we can use the most appropriate (convective vs non convective) service model?

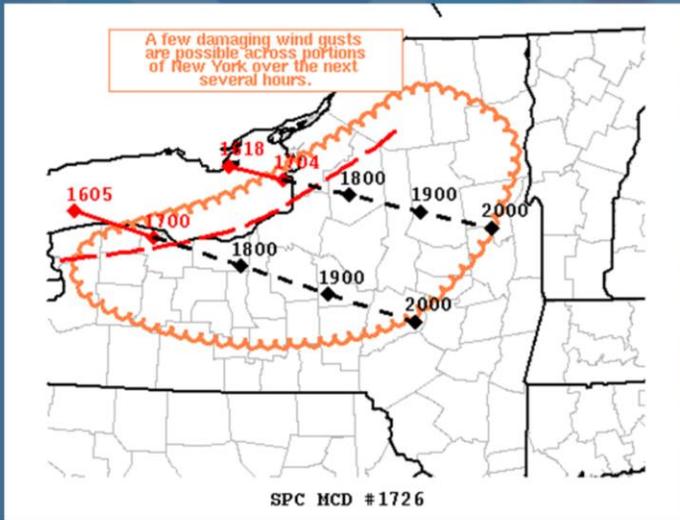
# SPC Perspective



A marginal risk for severe weather was initially forecast for the northeast U.S. by the Storm Prediction Center. The marginal risk was expanded southward to include much of southern New England several hours prior to the event, and an upgrade to a slight risk was provided as the storms were moving across eastern New York.

NOAA

WEATHER

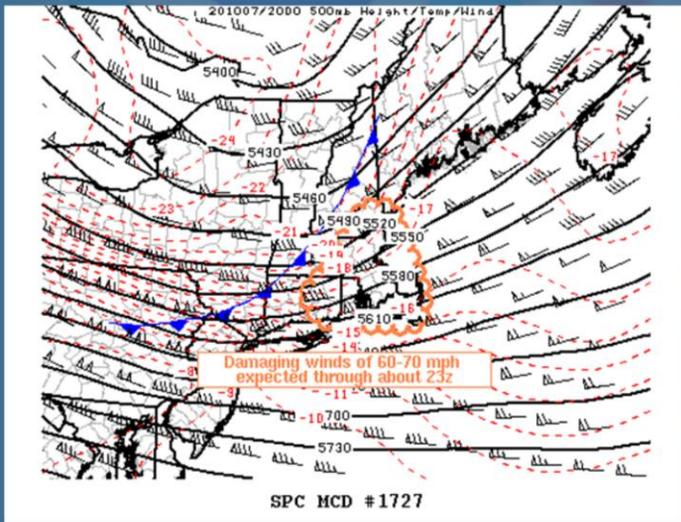


Developing storms were expected to persist, but any severe threat (50+ kt convective gusts) was expected to remain isolated due to shallow updrafts/weak buoyancy. A Severe Thunderstorm Watch was considered unlikely at the time of this Mesoscale Discussion (1728z).

National Weather Service - Boston, MA

The storm prediction center produced a meso-scale convective discussion for upstate New York as storms were developing and moving east across the region during the afternoon on the 7<sup>th</sup>.

NARR



SPC initiated a conference call at 1933z to discuss a potential Severe Thunderstorm Watch (near the time of the SLGT risk outlook upgrade), but the resulting decision was to not issue a watch. A follow-up Mesoscale Discussion at 2120z focused on the last 1-1.5 hours of the severe-wind threat across southeast New England.



## Forecast Concerns

Substantial uncertainty in the forecast regarding the degree of buoyancy and storm coverage + storm organization, hence the MRGL outlook from D3 to D1.

Weak buoyancy was a primary concern, but the main forecast problem was not accurately anticipating the evolution of a coherent squall line.

The bowing line of storms resulted in efficient downward momentum transfer and widespread damaging winds.

## Final Summary - Science & Service

- Convection greatly exceeded expectations - Science Question
- Gradient winds fell below expectations - Science Question
- Partners liked how the long fused warning product messaged what became a widespread / short-lived hazard. Why? Lead time.
- The “mis-anticipation” of the gradient wind event led to headline confusion internally which later hampered the potential utility of a watch
- A perfect prog would have provided ample lead time through SPC outlooks and subsequent watches / warnings thus our belief that we need to concentrate on the science questions