The May 1, 2017 Bow Echo and Associated Northern New York Wind Damage

1.) Introduction:

During the evening hours on 1 May, 2017 a line of strong to severe thunderstorms swept through the St. Lawrence Valley and the Adirondack Mountains of northern New York. Numerous reports of wind damage were received, with areas in far southern St. Lawrence County near the town of Fine being most affected (Figure 1). Radar data along with storm damage pictures suggest winds from 60 to 80 mph occurred in this area. While reports of storm damage in southern Franklin County were not received, this area is largely rural and it is likely that scattered tree damage in forested areas also occurred. The thunderstorms were accompanied by a feature known as a bow echo, where a portion of the line “bows out” ahead of other sections of the line. Bow echoes are a particular concern to meteorologists as they tend to focus stronger convective winds toward the surface and can be long lived. As the storm progressed into Vermont they encountered a more stable environment and weakened accordingly.

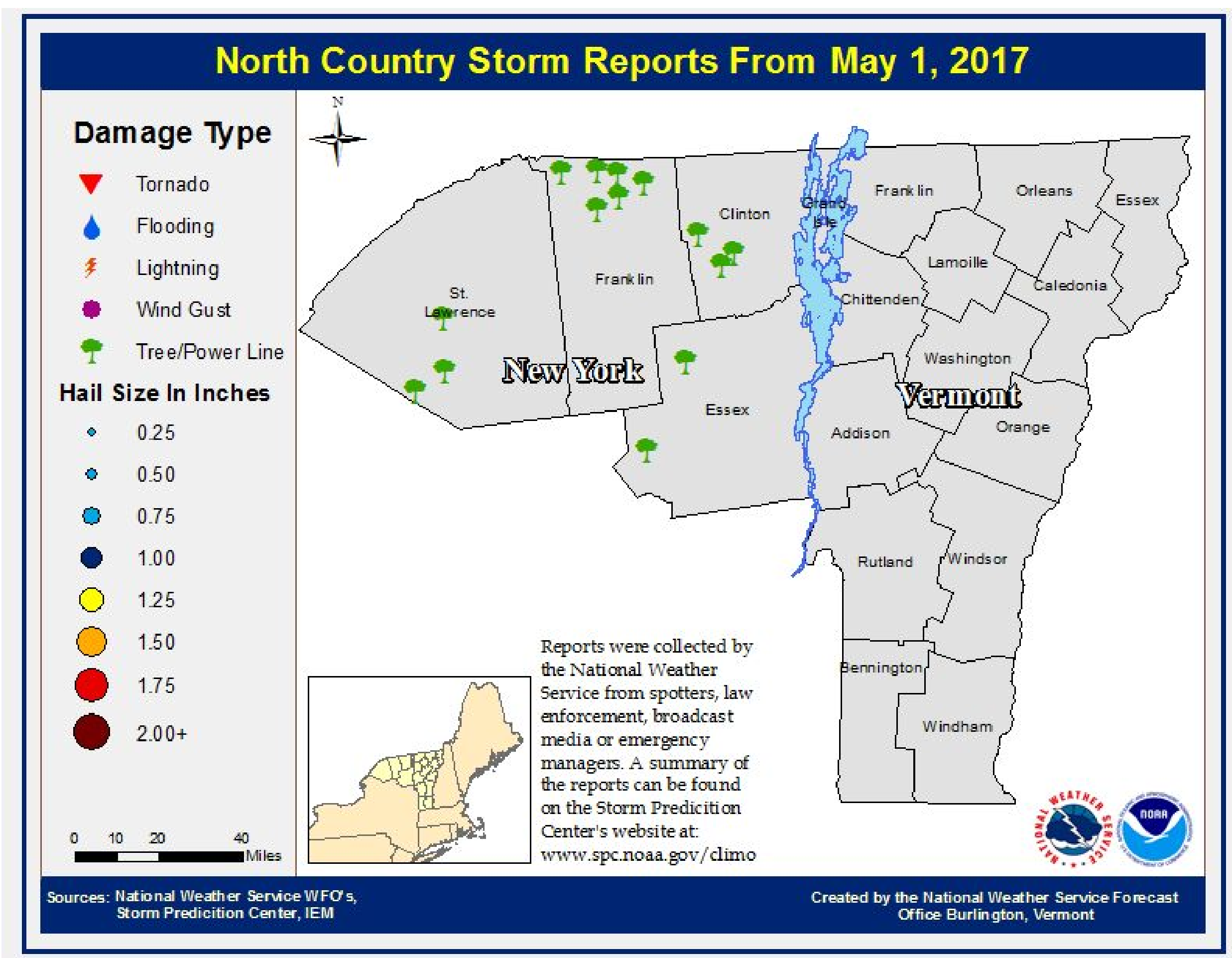

Figure 1: Wind damage reports from the evening of 1 May, 2017. Much of the Adirondack Mountain region is very rural and it is likely that unreported wind damage to forested areas also occurred.

Pre-Storm Environment:

a.) SPC Outlook:

In this section we will discuss the products issued by the Storm Prediction Center (SPC) leading up the event, which will include the Day 1 outlook. The image below shows the SPC Day 1 categorical outlook (left image) and day 1 probabilistic wind outlook (right image), on 1 May 2017 at 1200 UTC. All of the BTV forecast area was in a slight risk for severe thunderstorms, which implies well-organized severe thunderstorms are expected, but in small numbers and/or low coverage. Depending on the size of the area, approximately 5-25 reports of 1 inch or larger hail, and/or 5-25 wind events, and/or 1-5 tornadoes would be possible in slight risk. The probabilistic wind from SPC, showed a 15% chance of severe thunderstorm winds within 25 miles of a given point across northern New York into Vermont, with 30% just to our southwest over central and western New York associated with an enhanced risk for severe thunderstorms.

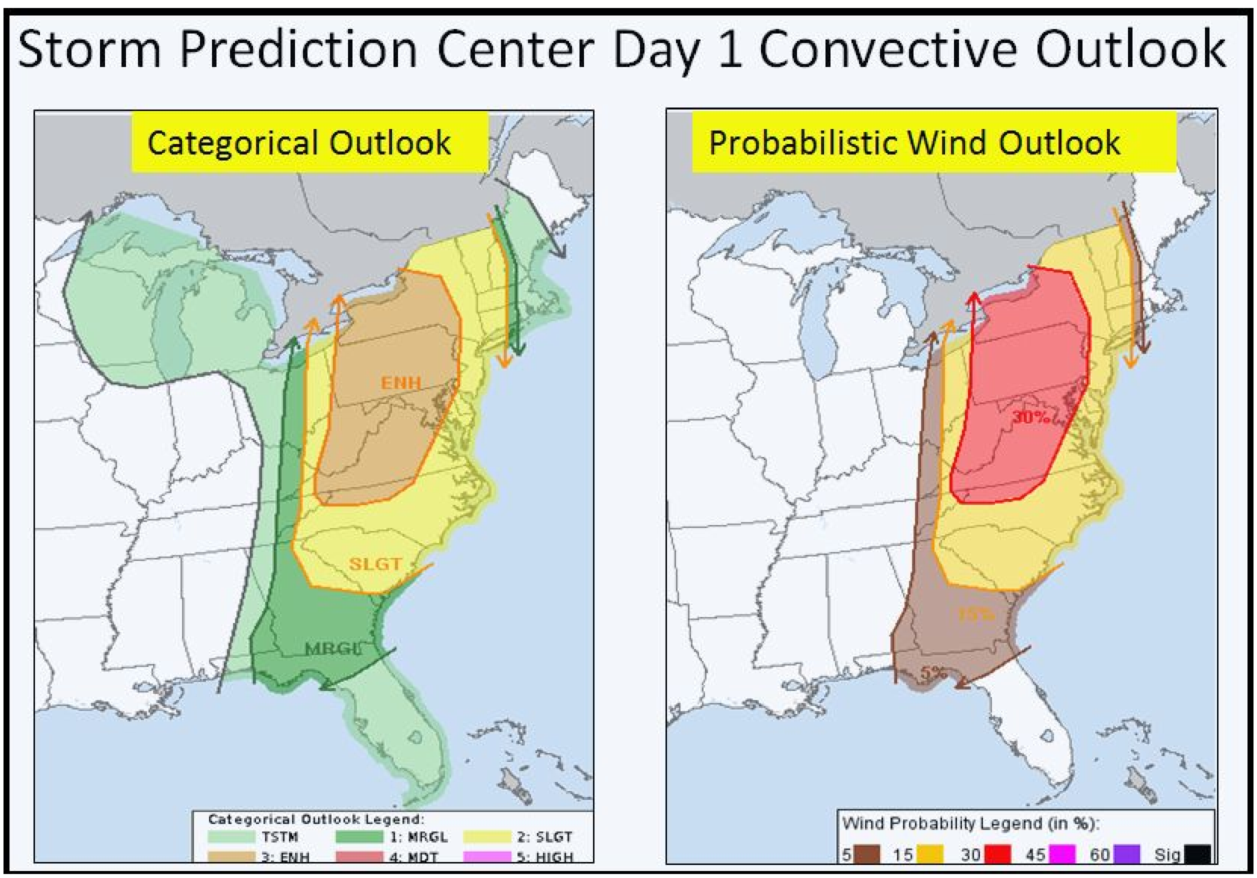

Figure 2: The Storm Prediction Center (SPC) Day 1 categorical outlook (left) and SPC Wind Outlook (right) issued at 1200 UTC 1 May 2017.

b.) Upper Air:

The 500 hPa (20,000 feet above ground level) showed deep closed trough across the western Great Lakes, with a ribbon of enhanced winds greater than 70 knots lifting from the Ohio Valley into the northeast United States, on 2 May 2017 at 00 UTC. In addition, the image below shows a potent shortwave trough across the eastern Great Lakes, which moved into the Saint Lawrence Valley by 03 UTC. This shortwave and classic upper level divergent pattern, helped to produce large-scale lift for thunderstorm development, while the stronger winds aloft aided in the organization of storms and provided the severe weather wind threat across the WFO BTV CWA.

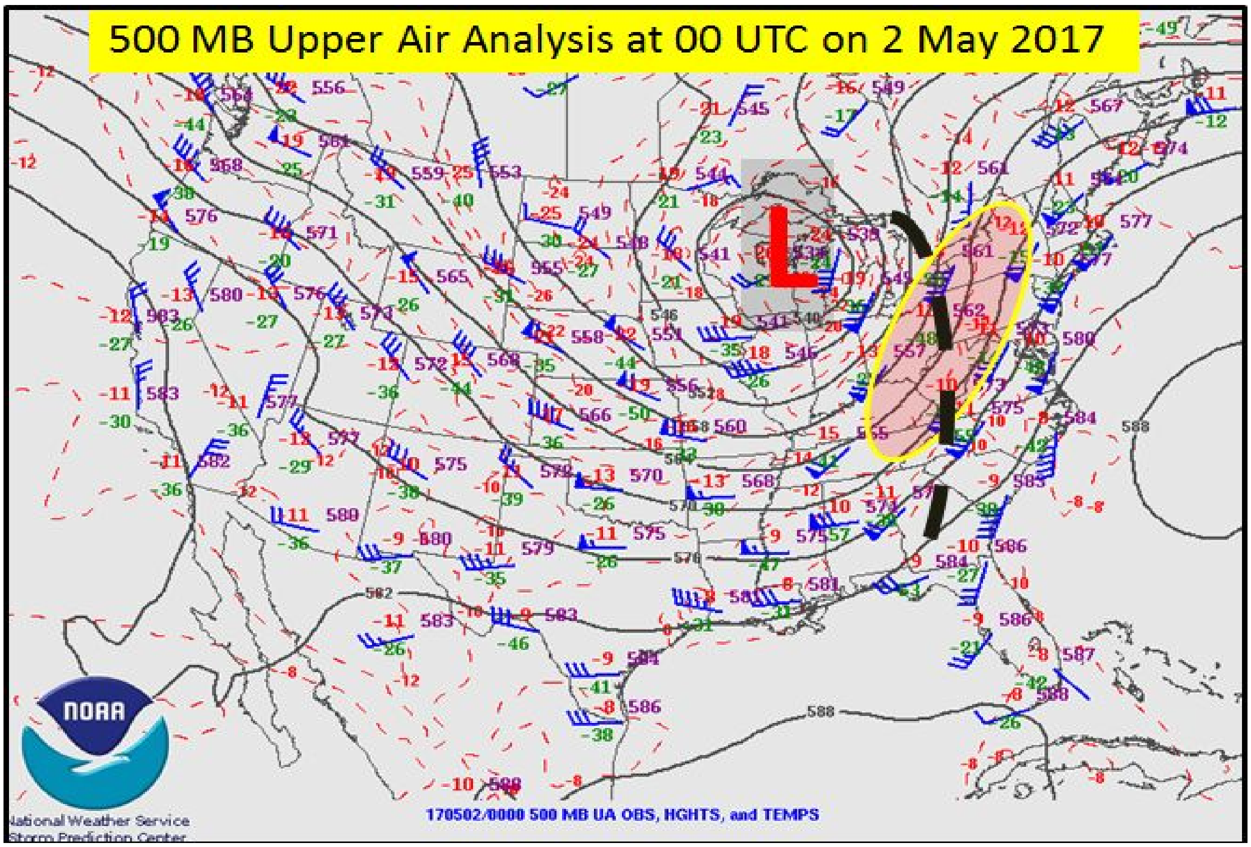

Figure 3: The 500 hPa (20,000 feet above ground level) upper air analysis on 2 May 2017 at 00 UTC. Wind barbs, (plotted in blue, 1 arrow=50 knots, 1 barb=10 knots, 1/2 barb=5 knots), 500 hPa heights (black lines), and temperatures (dotted red).

c.) Sounding:

The 12 UTC May 1st rawinsonde observation at Buffalo, NY (image below) shows very limited instability and strong deep layer shear, due to the placement of the powerful mid level winds across the Ohio Valley/western New York. The combination of surface temperatures in the 60s/lower 70s and dewpoints in the 50s created surface based convective available potential energy (CAPE) values of 168 J/kg, with a lifted index (LI) of -1C (Celsius). CAPE values greater than 1200 J/kg, suggests a moderately unstable environment, favorable for thunderstorm development.

Furthermore, the Buffalo sounding showed surface to 6km shear of 47 knots. This shear was a result of the approaching mid/upper level trough and the embedded jet streaks. Thunderstorms tend to become more organized and persistent as vertical shear increases. Supercells and organized convection, such as squall lines with bow echoes are commonly associated with vertical shear values of 35-40 knots and greater through this depth. Given the lack of significant CAPE profiles and relatively high freezing levels around 12,000 feet, severe hail was not expected. As temperatures warmed into the 60s and 70s, the mixing improved, helping to create an environment favorable for transporting stronger winds aloft to the surface associated with thunderstorm convection.

Finally, the 12 UTC Buffalo sounding showed a precipitable water value of 1.30 inches, which suggests the potential for thunderstorms to produce very heavy rainfall. Precipitable water is the depth of the amount of water in a column of the atmosphere if all the water in that column were precipitated as rain. Values greater than 1.2 inches, suggests a greater potential for heavy rainfall, especially during the summertime.

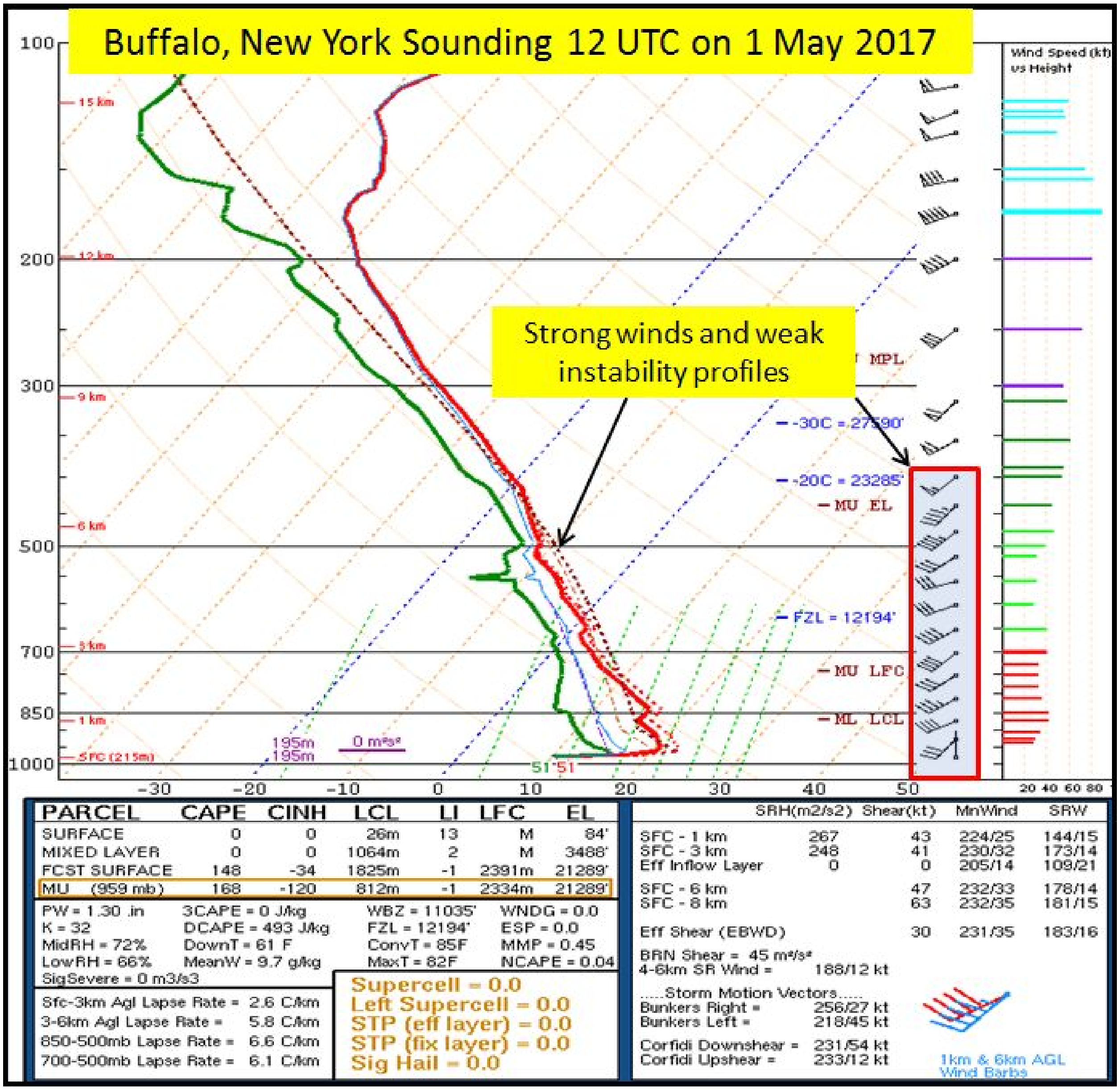

Figure 4: Buffalo, New York observed sounding on 1 May 2017 at 1200 UTC.

d.) CAPE/Shear:

Figure 6 shows Rapid Refresh (RAP) analysis of most unstable CAPE (Convective Available Potential Energy), 0 to 6 km effective shear, and CIN (Convective Inhibition) from SPC on 1 May 2017 at 2200 UTC. As the low to mid-level jet approached the region the deep layer shear increased to between 40 and 50 knots, while modest CAPE values ranged between 200 and 500 J/kg across northern New York. Note, the best combination of deep layer shear and modest instability (CAPE) was located across northern New York, including the southern Saint Lawrence Valley and closely matches the region of greatest concentration of wind damage. This very dynamic high shear/low CAPE pre-storm environment was conducive for organized and persistent convection to develop, capable of producing damaging winds associated with a bow echo storm structure.

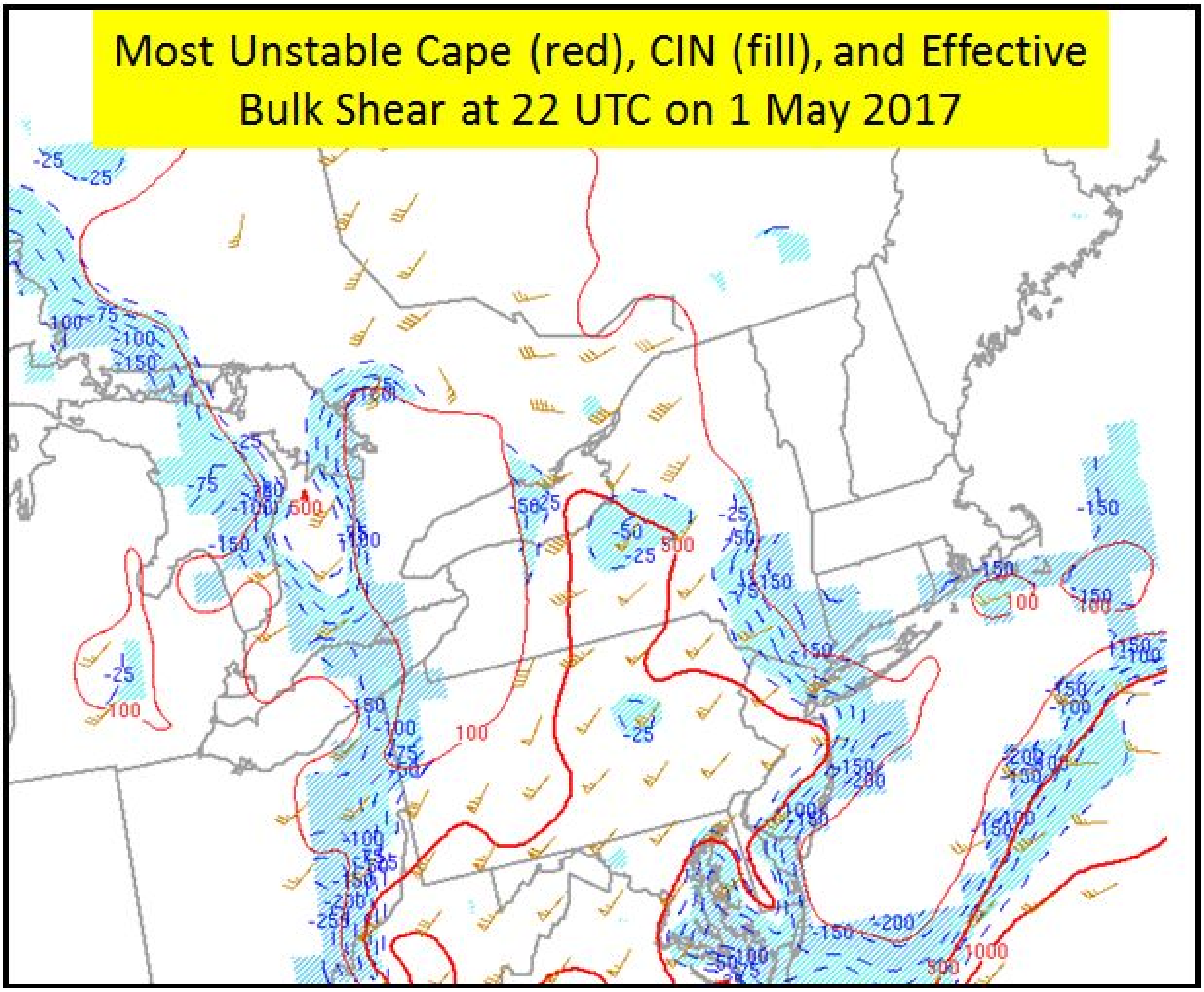

Figure 5: Storm Prediction Center (RAP) Rapid Refresh analysis of CAPE (red lines), 0 to 6 km effective shear (orange wind barbs), and Convective Inhibition (light blue shading) on 19 July 2013 at 2000 UTC.

e.) Surface Chart:

The evolution of surface features shows low pressure over the western Great Lakes with a complex warm front boundary lifting slowly north toward northern New York by 00 UTC on May 2nd. This boundary was highly influenced by terrain features and associated wind profiles, with the immediate Saint Lawrence Valley holding in the 50s with northeast winds, while the western Adirondacks broke into the warm sector with temperatures in the 70s and southwest winds. The surface heating produced just enough instability, which interacted with favorable deep layer shear and approaching dynamics to promote a line of thunderstorms with several bowing line segments of damaging winds.

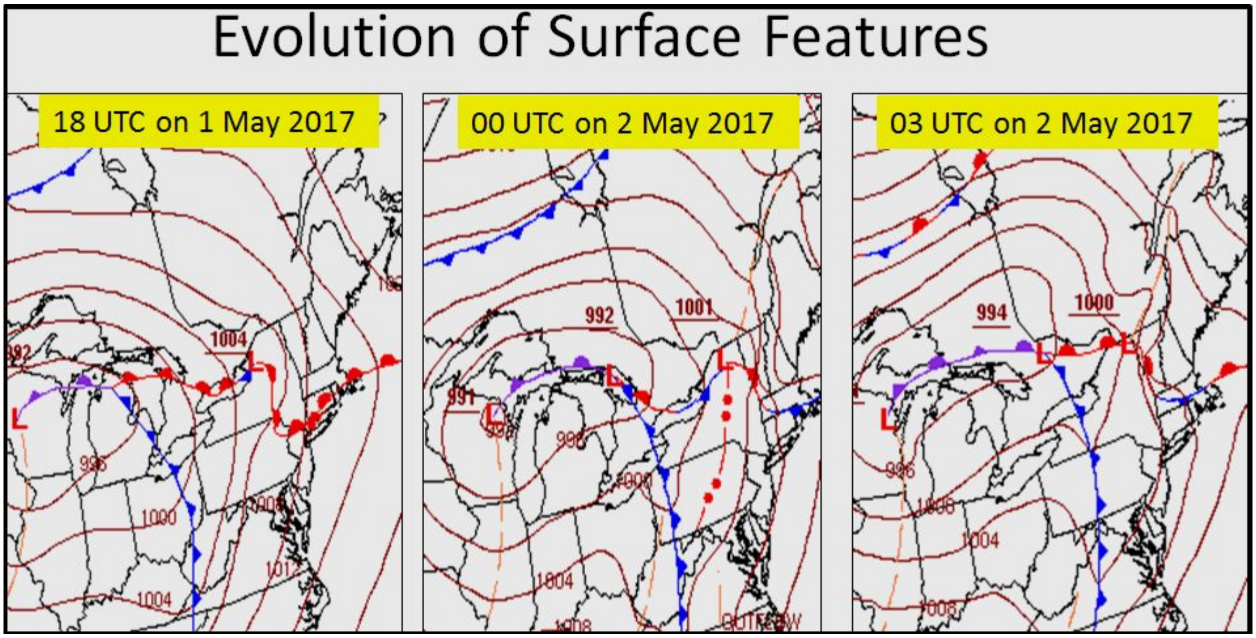

Figure 6: Evolution of surface features from 18 UTC on 1 May to 03 UTC on 2 May 2017.

2.) Radar Analysis:

In this section we will investigate the radar data, and storm structure associated with the thunderstorms that produces the significant wind damage on the evening of May 1, 2017. The first radar image, Figure 7, shows the MRMS composite radar from 5pm depicting a well-defined convective fine line tracking through New York. By this point, the system had already produced widespread damage across western New York and was moving rapidly across the state at approximately 50 mph with the most intense bow structure over Lake Ontario. In the WFO BTV forecast area, the most significant damage from this line was a bow echo that moved through the towns of Pitcarin and Fine in northern New York. This bow echo will be the focus of this radar analysis.

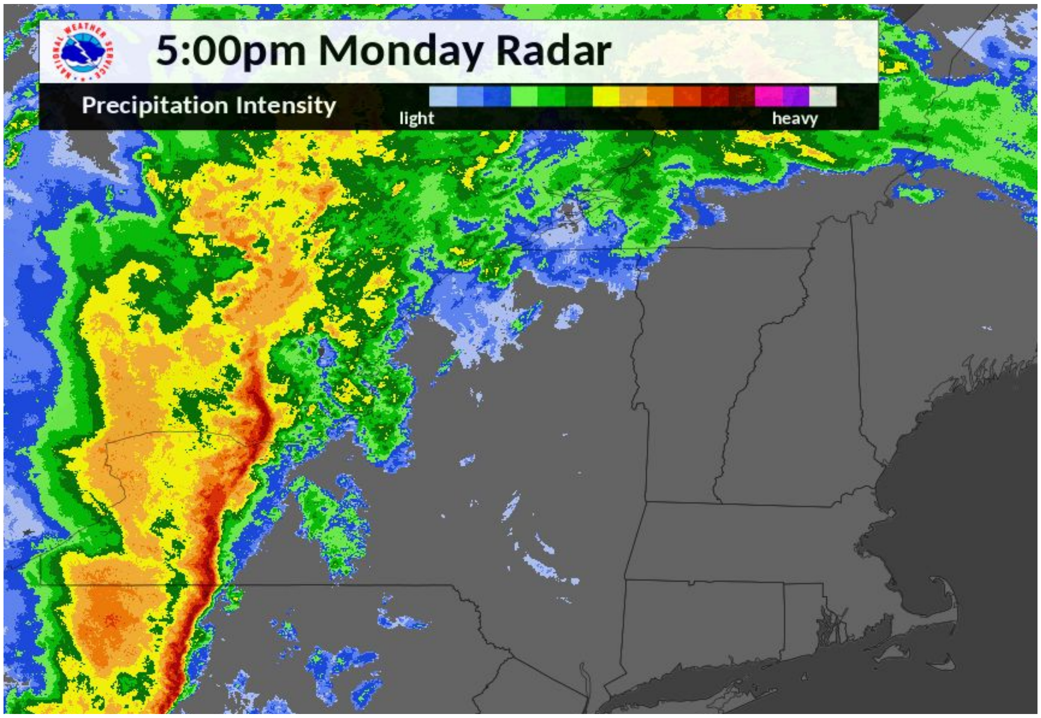

Figure 7: MRMS composite reflectivity at 5 PM on 1 May 2017.

At approximately 6:37 pm the line entered into extreme western Saint Lawrence county and continued its eastern track. By 6:55 pm a bow echo was beginning to develop on the line near Pitcarin, NY. This is shown in the radar image in Figure 8. At this point from the radar image we can see the rear inflow jet increasing in strength and causing the bow to begin protruding out. At the same time, in Figure 9,we can see a wind maximum develop at the apex of the bow which is consistent with studies of damaging wind from bow echos (Fujita 1978, Smull and Houze 1987, Jorgensen and Smull 1993). While not shown, the wind maximum continued along the apex of the bow from roughly 6:55 pm through 7:30 pm. From the 0.5 degree KTYX radar data the peak wind speeds were between 65-68 kts roughly 2,100 ft above the ground. Based on the damage, and the winds aloft, we estimate that the winds at ground level were in the 60 to 80 mph range which corresponds to EF0 damage on the Enhanced Fujita Wind Damage Scale.

When we look at a cross section of the radar at the same time several features become immediately apparently. When looking at the reflectivity cross section image in Figure 10, we can see the cloud tops were only 15,000-20,000 feet tall. We can also see strong tilting with height of the storm which is further evidence of very strong magnitudinal wind shear as the tops of the clouds are being blown ahead of the storm at the surface. These low topped storms are typical in fast flow, high shear, low instability environments which is what set up on the evening of May 1st, 2017. Next as we look at the velocity with height, the rear inflow can be seen descending from 10,000-14,000 feet all the way to the surface. This descending rear inflow jet is likely what produced the significant damage from Pitcarin to Fine NY.

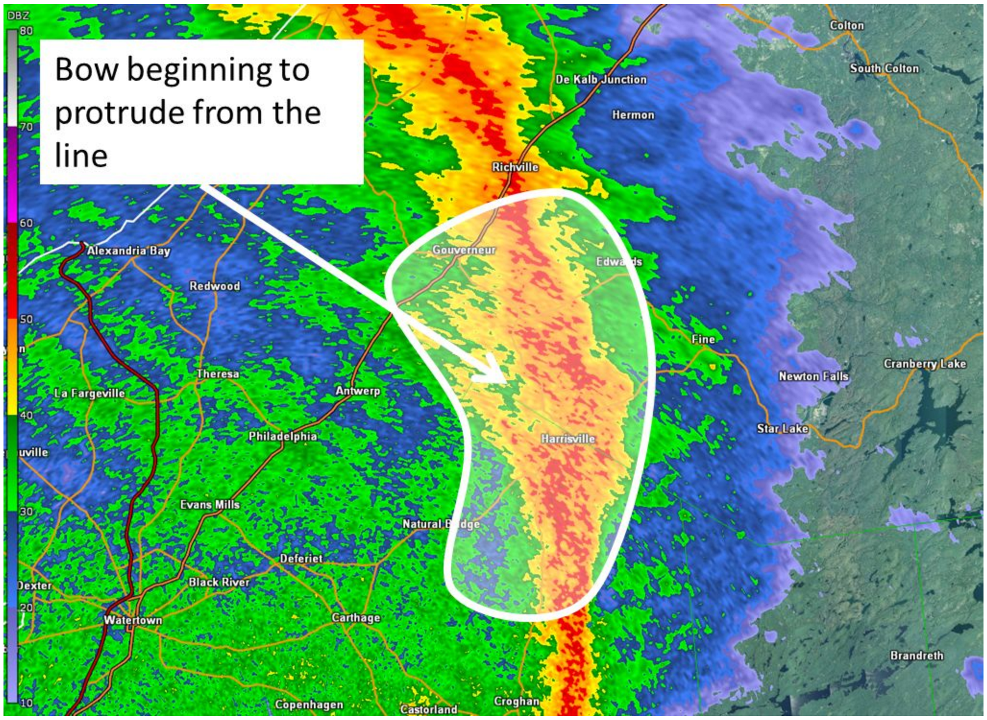

Figure 8: The bow echo is beginning to take shape at 6:55 pm as the rear inflow jet started to push out the leading edge of the bow echo.

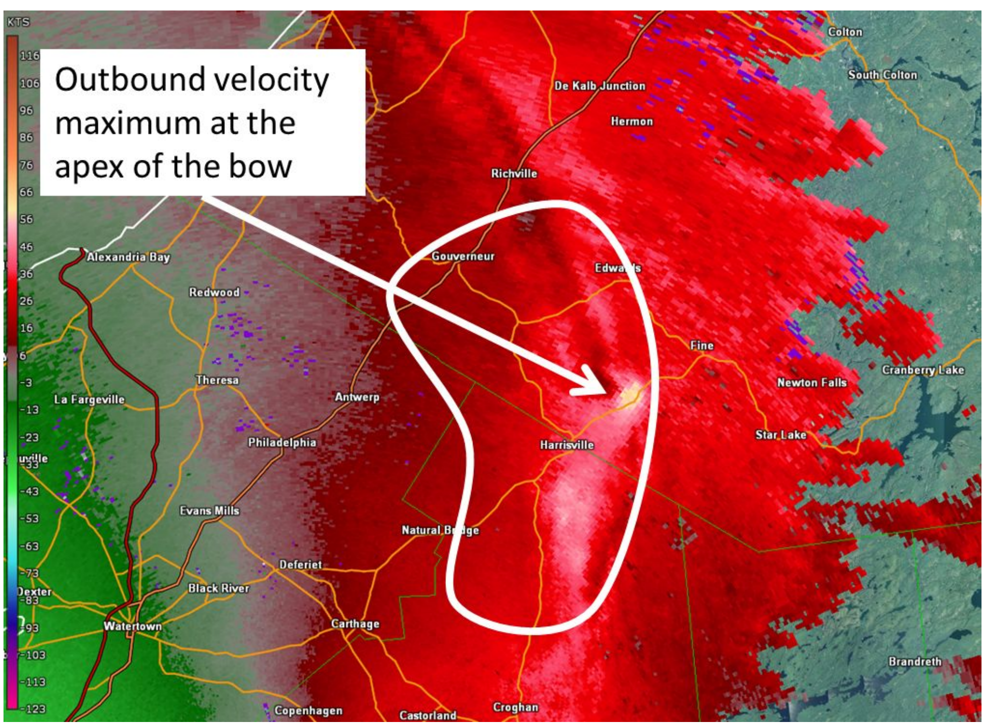

Figure 9: The maximum wind speeds were located just at the apex of the bow and reached 68 kts at 2,700 feet above ground level at the same time as Figure 8.

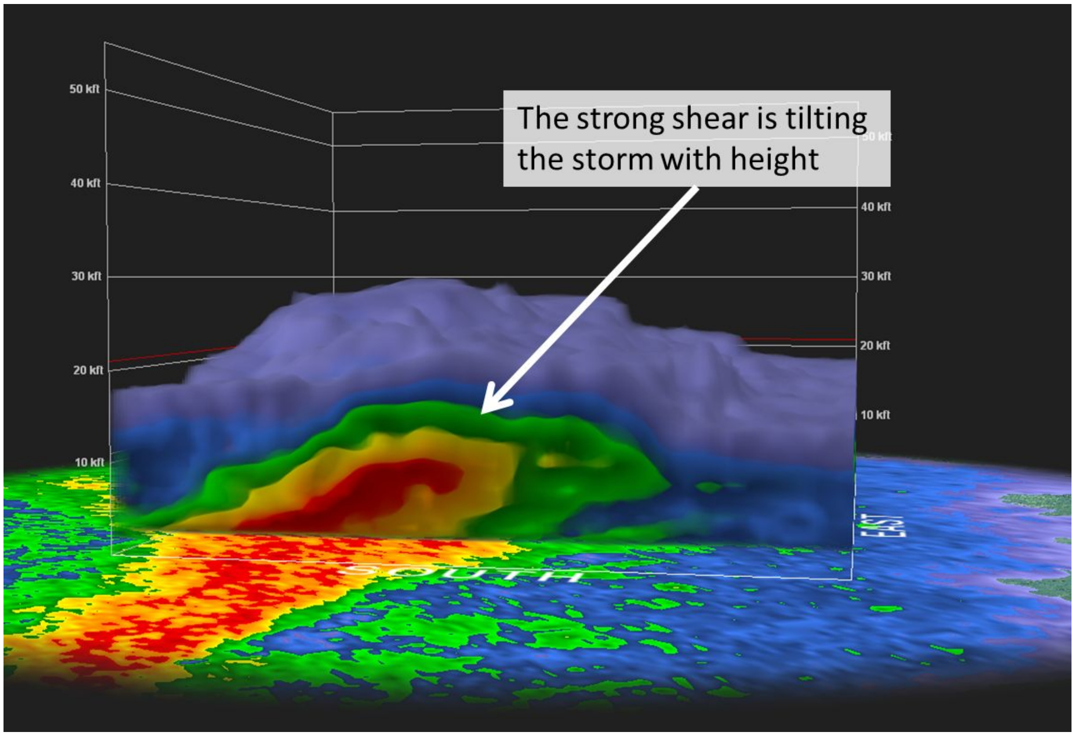

Figure 10: The bow echo is beginning to take shape at 6:55 pm as the rear inflow jet started to push out the leading edge of the bow echo.

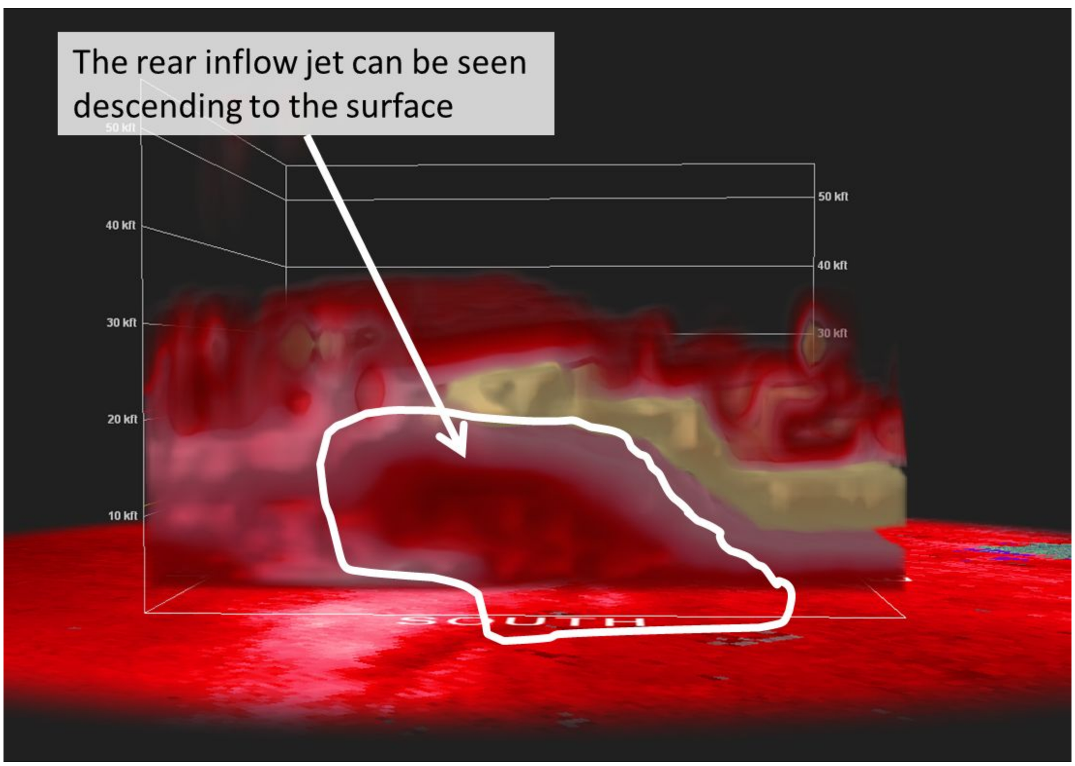

Figure 11: The bow echo is beginning to take shape at 6:55 pm as the rear inflow jet started to push out the leading edge of the bow echo.

3.) Conclusion/Event Pictures:

A line of severe thunderstorms with estimated wind gusts between 60 and 80 mph impacted northern New York, including the Saint Lawrence Valley and Adirondack Mountains between 7PM and 9PM on May 1st . These gusty thunderstorm winds produced numerous trees down with roof damage to several buildings in the town of Pitcairn along with scattered power outages and trees down in parts of Franklin, Essex, and Clinton counties in northern New York. The combination of just enough instability interacting with powerful mid level winds (high shear/low CAPE environment) and strong atmospheric lift produced these organized bowing line segments of damaging thunderstorm winds.