THE SEVERE WEATHER EVENT OF 21 AUGUST 2011 ACROSS THE CHAMPLAIN VALLEY & CENTRAL AND EASTERN VERMONT

During the afternoon and early evening hours of August 21st 2011, a significant severe weather episode took place across the North Country. One of the more notable aspects of this event was that severe weather took place in two parts: at first during the early afternoon, and then again by late afternoon into the early evening. On this day, several reports of hail were received, ranging from pea size (.25" diameter) to as high as golf ball size (1.75") as well as reports of damaging straight-line winds that resulted in numerous trees and power lines to fall. The most significant severe weather damage occurred in parts of southwestern Rutland County. Reports of significant damage in the town of West Pawlet in Rutland County prompted a National Weather Service (NWS) damage survey to be conducted on August 22nd. In this survey, it was found that estimated 70 to 90 mph winds were likely to have caused significant wind damage along a 2-mile length, half-mile path width along Button Falls Road in West Pawlet. For a complete look at the survey results from the public information statement click here. Significant flash flooding was also observed in parts of Essex County of New York. Click here to view the local storm report on August 21st 2011 across WFO (Weather Forecast Office) BTV (Burlington), Vermont CWA (County Warning Area).

Synoptic Overview

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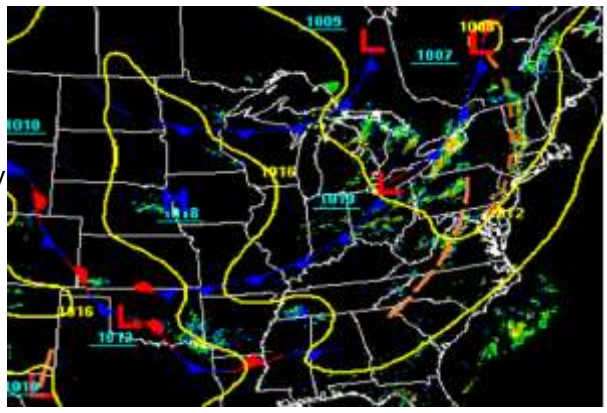

At 200 PM EDT August 21st, an area of surface low pressure was located over central Quebec, with a cold front extending southwestward from this feature into the central Great Lakes. A couple of surface troughs of low pressure that preceded the cold front are evident (indicated by dashed orange lines in Figure 1).

One of these surface troughs extended from the surface low southward along the eastern Champlain Valley and into the southern Hudson Valley of New York. This "pre-frontal trough" was instrumental in triggering the initial severe thunderstorms that affected central and eastern Vermont.

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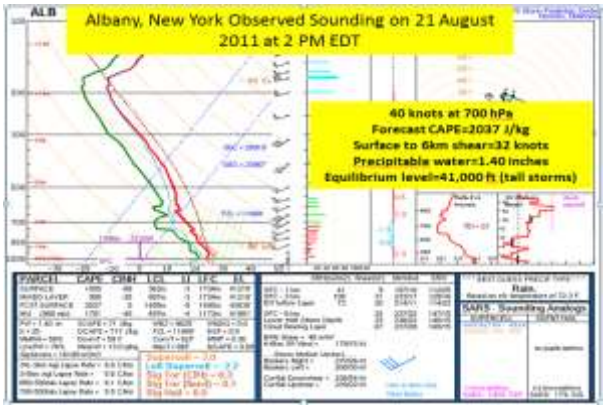

The 200 PM EDT 21 August 2011 rawinsonde observation at Albany, NY (Figure 2) shows moderate instability, and moderate deep-layer shear, due to the placement of the strong mid-level winds across the Ohio Valley into western New York. The combination of surface temperatures in the mid to upper 70s and dewpoints in the mid to upper 60s created forecasted surface-based convective available potential energy (CAPE) values of 2000 J/kg, with a lifted index (LI) of -4C (Celsius). CAPE values greater than 1500 J/kg, suggest a moderately unstable environment, favorable for thunderstorm development. The large CAPE profile and very high equilibrium levels indicated thunderstorm tops would extend to 35,000 to 45,000 feet into the atmosphere, and be capable of producing severe winds or large hail, along with very heavy rainfall. The equilibrium level is the level at which the rising parcel equals the actual air temperature at that given height, and results in the rising parcel now becoming stable; it no longer accelerates upward.

In addition, the Albany sounding showed surface to 6km shear of 32 knots. This shear was a result

of the approaching mid-level jet. Thunderstorms tend to become more organized and persistent as vertical shear increases. Supercells and organized convection, such as squall lines and bow echoes are commonly associated with vertical shear values of 30-40 knots and greater through this depth, which was present across our region due to the jet stream winds aloft. Finally, the 2 PM EDT Albany sounding showed precipitable water value of 1.40 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.

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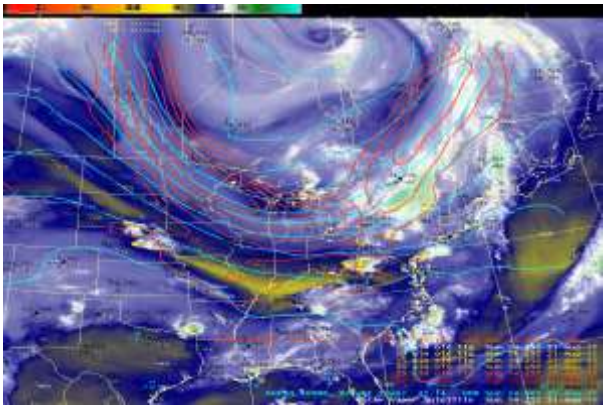

In addition, forcing associated with a potent upper-level trough over the northern Great Lakes and Ontario would increase across the North County. Figure 3 shows a water vapor satellite image loop from 1025 AM EDT to 715 PM EDT, which is a tool that meteorologists can use to track motions in the mid-levels of the atmosphere in near-real time. The first notable feature is the strong upper trough located near Hudson Bay, with embedded smaller "short-wave troughs" (indicated by smaller "kinks" in the light blue-colored 500 hPa height contour lines in Figure 3). More specifically, the "forcing" came from a zone of enhanced wind divergence in the middle and upper-levels of the atmosphere. Note that across New England, the blue 500 hPa height contours are spread apart. Wind directions tend to flow parallel to these height lines at mid and upper levels of the atmosphere; thus the wind is spreading out/diverging. In a process that is similar to spreading your hands forcefully straight in a pool of water (water from deeper in the pool must rise to replace the surface water that's being spread by your hands), air must rise from lower levels of the atmosphere to counteract the wind divergence above it. The combination of the increasing upper-level dynamics with the destabilizing atmosphere resulted in a second round of severe thunderstorms that developed around 4:30 PM EDT.

Severe Weather Timeline

The first batch of severe thunderstorms developed shortly after 1:00 PM EDT along a pre-frontal trough of low pressure in an air mass that would become moderately unstable with surface based CAPE (Convective Available Potential Energy) values between 1500 and 2000 J/kg. These initial storms primarily affected cities and towns in Windsor, Orleans, Orange and Essex Counties in Vermont. Severe weather associated with these first storms included reports of quarter-size hailstones in the towns of Bethel (Windsor County, VT), Greensboro (Orleans County, VT) and Morgan (Orleans Co., VT); with trees reported down in the towns of Randolph (Orange Co., VT) and in Chester (Windsor Co., VT). Numerous power outages took place, resulting from the localized strong to damaging winds and/or the frequent lightning associated with the thunderstorms. This initial activity would progress to the east into New Hampshire by middle of the afternoon.

The second round of thunderstorms developed along the Hudson and southwestern Champlain Valleys of New York and would spread into the Champlain Valley of Vermont and across south-central Vermont through the early evening. These storms produced large hail, high winds and very heavy rainfall rates, which combined with the slow-moving nature prompted flash flood warnings for parts of Essex County in New York and Addison County in Vermont. Significant flash flooding was reported in the town of Ticonderoga, NY, resulting in washouts of roads and ponding of water on an area country club. These thunderstorms would weaken as they moved northeastward towards Chittenden County.

At 6:00 PM another severe thunderstorm had developed in central Chittenden County close to North Underhill. This severe thunderstorm would eventually produce quarter-sized hailstones in North Underhill and again at Fletcher in Franklin County VT. However, the most significant severe thunderstorm would develop across Washington County in New York and move into southern

Rutland County by 6:15 PM. This particular thunderstorm had a previous history of producing wind damage in the Lake George area of New York. As it moved eastward into West Pawlet it continued to produce significant wind damage, with reports of numerous trees down along Button Falls Road, and golf ball size hail in South Wallingford before moving across Windsor County, Vermont and into New Hampshire.

Radar Review

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Figure 4 shows the northeast composite reflectivity loop from 136 PM EDT to 754 PM EDT on 21 August 2011, with severe thunderstorm warnings outlined in pink boxes and lightning plotted in white. From this loop you can clearly see several rounds of strong to severe thunderstorms which produced damaging winds, large hail, and localized flooding.

The heaviest concentration of showers and thunderstorms occurred across the eastern Adirondacks into central and southern Vermont. The brighter orange and red colors in the image suggest very heavy rainfall and potential for hail associated with the stronger thunderstorms.

Pawlet, VT Storm

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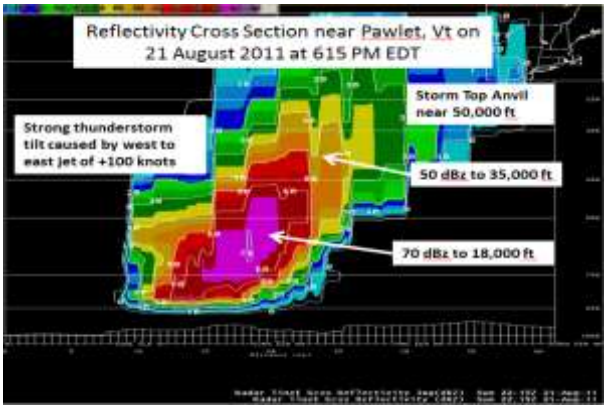

In the following section we will briefly discuss the individual severe thunderstorms which impacted central and southern Vermont, during the afternoon hours on 21 August 2011. The first storm we will investigate is the supercell near Pawlet, Vermont, which produced damaging winds and golf ball size hail. Figure 5 shows a reflectivity cross section near Pawlet, Vermont on 21 August 2011 at 615 PM EDT. This shows a very well developed storm reaching up to 50, 000 feet into the atmosphere and a very strong reflectivity core aloft. This 65 to 70 dBZ reflectivity core, suggested strong storm updraft, along with the potential for the storm to produce golf ball or larger hail, along with damaging thunderstorm wind gusts. Also, note the strong west (left) to east (right) tilt to the thunderstorm. exhibited, which indicated very strong mid to upper level winds aloft, pushing the storm eastward.

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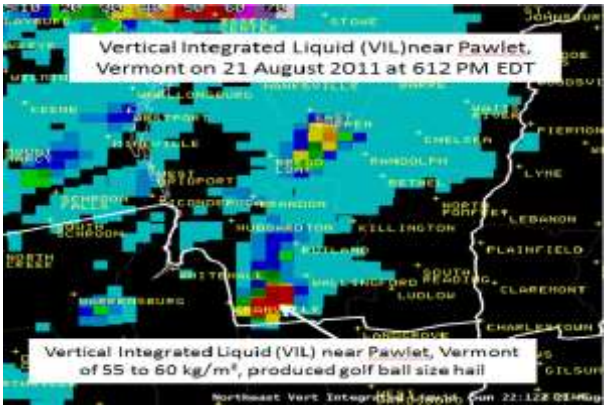

Figure 6 shows values of Vertically Integrated Liquid (VIL) measured from the Colchester, VT (KCXX) radar at 612 PM EDT on 21 August 2011. VIL is an estimate of the total mass of precipitation in the clouds. The measurement is obtained by observing the reflectivity of the air as obtained by radar. This measurement is usually used in determining the size of hail, the potential amount of rain under a thunderstorm, and the potential downdraft strength when combined with the height of the echo tops. When VIL values quickly fall, it may mean that a downburst is imminent, resulting in the weakening of the

storm's updraft and the storms inability to hold the copious amounts of moisture/hail within the storm's structure and a greater potential for the storm to produce damaging winds. Figure 6 shows VIL (pink/purple color) values between 55 and 60 kg/m2 near Pawlet, Vermont. This indicates a very well developed updraft, capable of producing large hail and damaging winds, especially when the storm collapses and weakens, which occurred between Granville, New York and South Wallingford, Vermont.

Breadloaf, VT Storm

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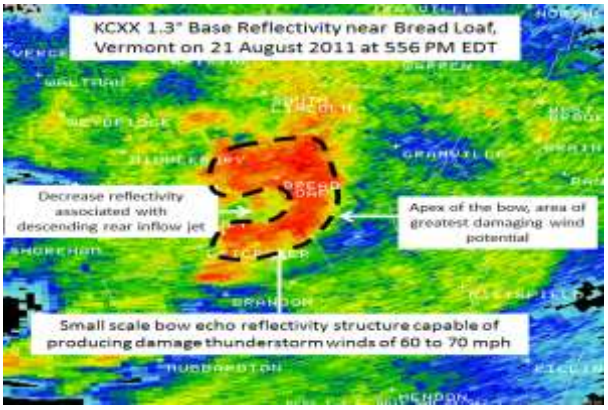

In addition, to the supercell thunderstorms which occurred across southern Rutland County near Pawlet on 21 August 2011, further north across central and northern Vermont, a bow-like line segment developed and created damaging straight-line winds from near Brandon to Brookfield, Vermont. Figure 7 is the KCXX 1.3° base reflectivity near Bread Loaf, Vermont at 556 PM on 21 August 2011, which clearly shows a bow like reflectivity structure. The weaker 20 to 30 dBZ returns (light green) suggests a descending rear flank downdraft jet is present and capable of producing damaging thunderstorm wind gusts of 50 to 60 mph, based on the velocity values.

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Figure 8 shows the KCXX 1.3° storm relative motion near Bread Loaf, Vermont on 21 August 2011 at 552 PM EDT. This image shows some broad cyclonic (counter-clockwise) circulation associated with this bow echo reflectivity structure. The storm locations across the higher terrain of central Vermont and the storm motion perpendicular to the radar beam resulted in very poor radar sampling, which greatly under-estimated the surface winds. This storm produced trees and power lines down from near Brandon to Brookfield VT on 21 August 2011. It should be noted that the strongest winds are typically found at the apex of the bow echo structure and in the comma-head portion of the storm.

Northeast VT Storm

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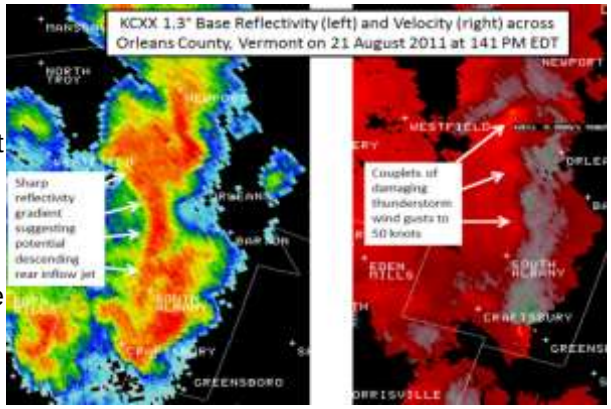

The final storms we will examine will be the broken line of strong to severe thunderstorms which produced isolated wind damage and one inch diameter hail across the Northeast Kingdom of Vermont. These fast moving storms traveled at 30 to 40 mph, and caused some isolated damage, due to gusty thunderstorm winds. Figure 9 shows the KCXX 1.3° base reflectivity (left) and velocity (right) across Orleans County, Vermont on 21 August 2011 at 141 PM EDT. The reflectivity image on the left clearly shows a sharp reflectivity gradient, suggesting potential descending rear inflow jet and damaging winds. Meanwhile, the velocity image on the left shows several enhanced couplets of winds greater than 50 knots and potential for damaging winds. These

small scale couplets indicate very localized and isolated areas of damaging winds.

Hydro Review

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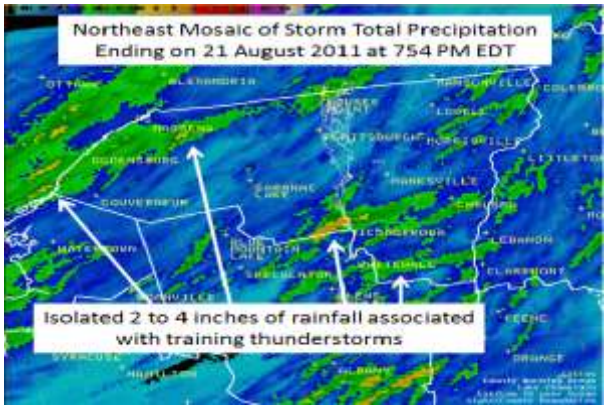

Many of the thunderstorms that impacted the region on August 21st were associated with heavy rainfall falling in a short period of time. Figure 10 shows a mosaic of Doppler Radar-derived Storm Total Precipitation for the North Country ending at 21 August 2011 at 754 PM EDT. It combines the Storm Total Precipitation product taken from several WSR-88D Doppler Radars and "combines" them together so that an entire Northeast regional Storm Total Precipitation can be displayed. Rainfall estimates ranged from 2 to 4 inches in localized areas of the St. Lawrence River Valley and in portions of central and southern Vermont. The heavy rainfall led to sharp river rises. The most notable rises from area hydrographs (not shown) were across Rutland and Windsor Counties. Additional showers and embedded thunderstorms (though non-severe) would move across the region after 9 PM, resulting in a "training" effect where precipitation tends to fall in the same area. Note the localized heavier amounts over southern Essex County in New York are consistent with the reports of flash flooding in the Ticonderoga, NY area.

Conclusion & Pictures

While the August 21st, 2011 Severe Weather Outbreak would be characterized as a moderate severe weather event, the significant flash flooding combined with several reports of severe weather made this a notable event, especially for the mid of August across the North Country. Below are several pictures taken from a NWS damage survey across southern Rutland County, Vermont.

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