The 27 May 2014 Isolated Supercell across Addison and Rutland Counties of Vermont

1.) Introduction

On 27 May 2014, an isolated supercell developed across the higher terrain of the eastern Adirondack Mountains in northern New York and tracked southeast across the central Champlain Valley, before dissipating over southern Vermont. This single storm tracked along a sharp backdoor cold front, which separated warm moist tropical air with temperatures in the 80s to the south from cool moist maritime air with temperatures in the 50s to the north and east. In addition to the contrasting air masses, this boundary helped create favorable turning of the low level wind fields, which enhanced organized supercell thunderstorm development and low-level rotation.

This monster supercell produced a long 40 to 50 mile swath of large hail from Bridport to Shrewsbury, VT, along with several localized areas of damaging thunderstorm winds. A National Weather Service (NWS) damage survey team determines the wind damage was caused by straight-line winds. Click here for a complete summary of the public information statement. Numerous reports of golf ball (1.75") size hail were reported, along with a measured 74 mph wind gust 2 miles Northwest of Bridport, VT, and several areas of downed trees and power lines. Figure 1 below shows a map of the local storm reports received by the NWS office in Burlington, VT (BTV) during the event. Click here for a complete listing of all severe weather reports.

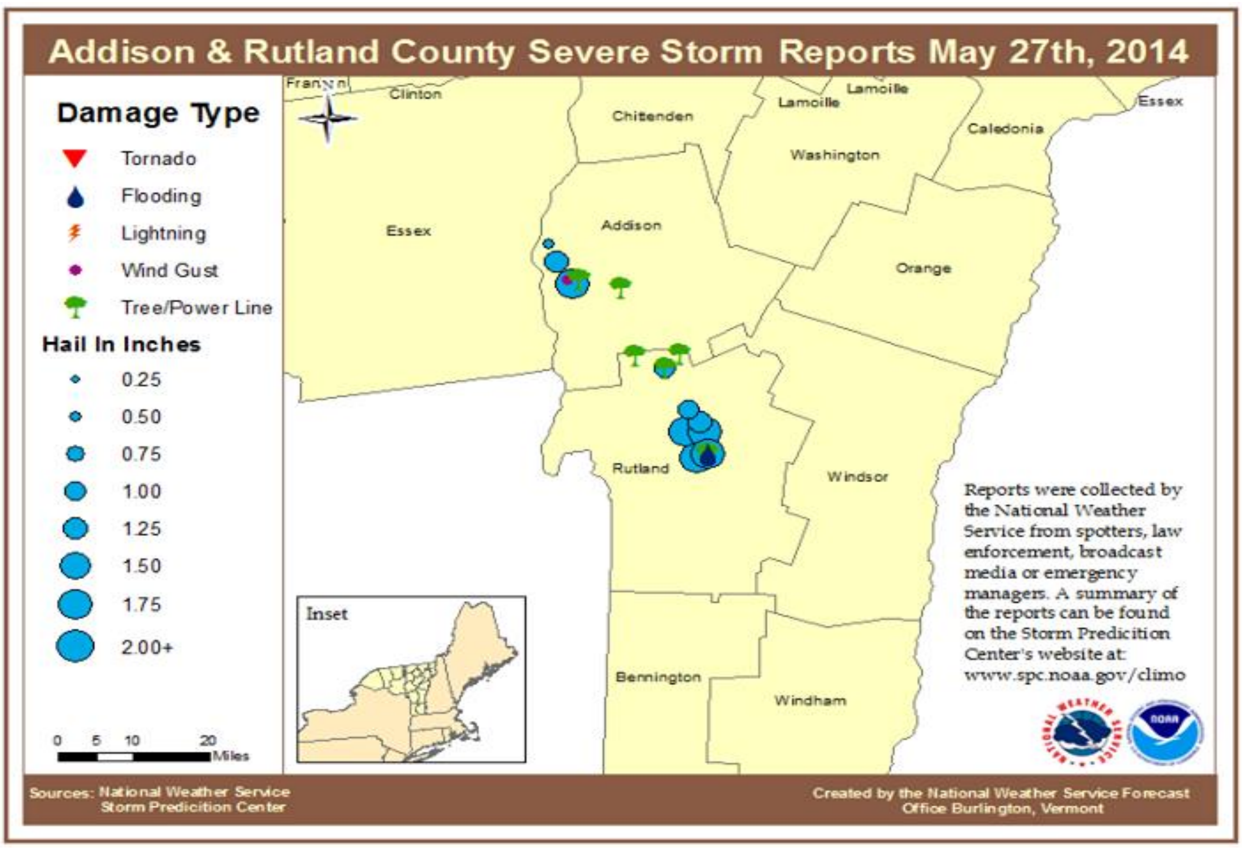

Figure 1: Map of Local Storm Reports on 27 May 2014. Green trees indicate trees or power lines down, light blue circles show location of large hail, and red dot is measured wind gust.

2.) Storm Prediction Center Outlook Information

In this section we will discuss the products issues by the Storm Prediction Center (SPC) leading up to and during the event, which will include the Day 1 Convective Outlooks and Mesoscale Discussions. Figure 2 below shows the SPC Day 1 categorical outlook (left image), Day 1 wind outlook (middle image), and Day 1 hail outlook (right image) on 27 May 2014 at 1630 UTC, which shows a small portion of the BTV CWA was in a slight risk for severe thunderstorms. From SPC, a slight risk 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. The probabilistic wind and hail forecast from SPC, showed a 15% chance of severe thunderstorm winds and 5% hail within 25 miles of a given point during the outlook period across central and eastern New York and extreme southwest Vermont. Click here for the 1630 UTC convective outlook text product from SPC on 27 May 2014.

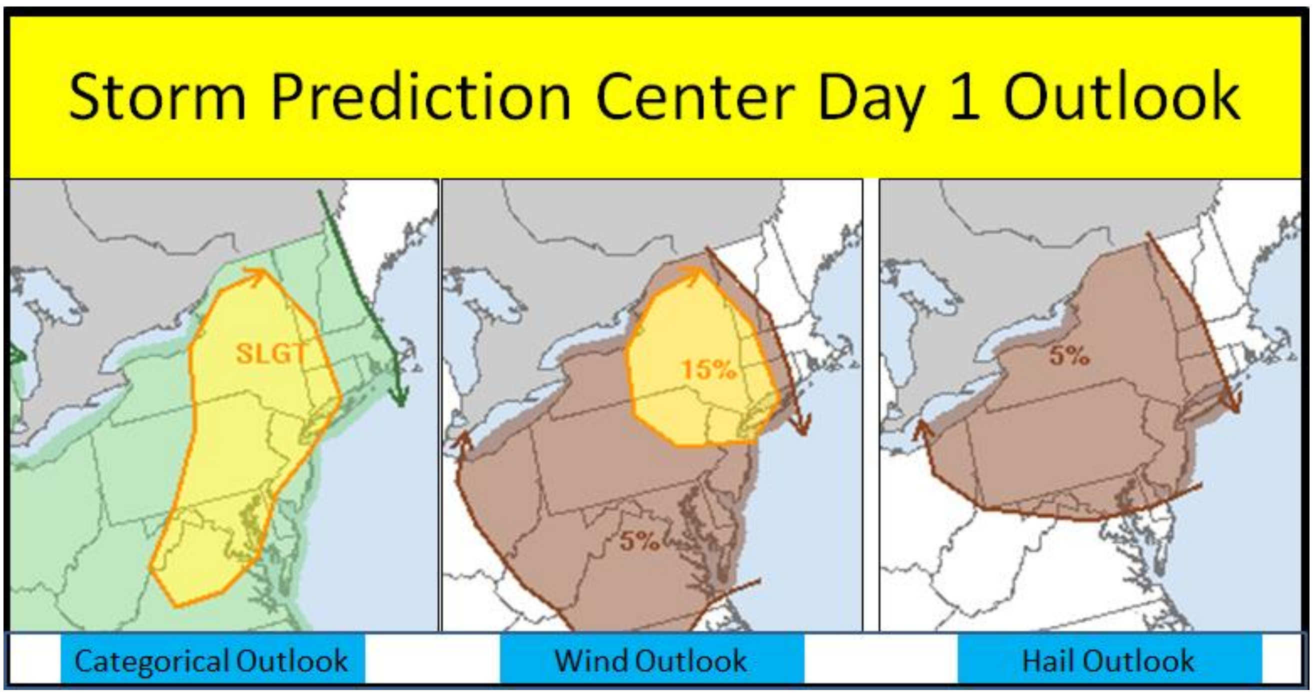

Figure 2: The Storm Prediction Center (SPC) Day categorical outlook (left), SPC Wind Outlook (middle), and SPC Hail Outlook (right) issued at 1630 UTC on 27 May 2014.

Figure 3 below shows SPC's mesoscale graphics issued prior to the severe weather event on 27 May 2014. The image below indicates a severe thunderstorm watch may be need shortly, but given the limited coverage of convection, no watch was issued for this event. The image below clearly shows the sharp instability gradient (red lines show mixed-layer CAPE) associated with the surface boundary across the southern portion of WFO BTV County Warning Area (CWA), along with weak surface low pressure (black lines indicate mean sea level pressure) developing across the Adirondack Mountains at 1800 UTC on 27 May 2014. The blue wind barbs in the image below show effective bulk shear parameters greater than 30 knots. Click here for the detailed mesoscale convective discussions #0727.

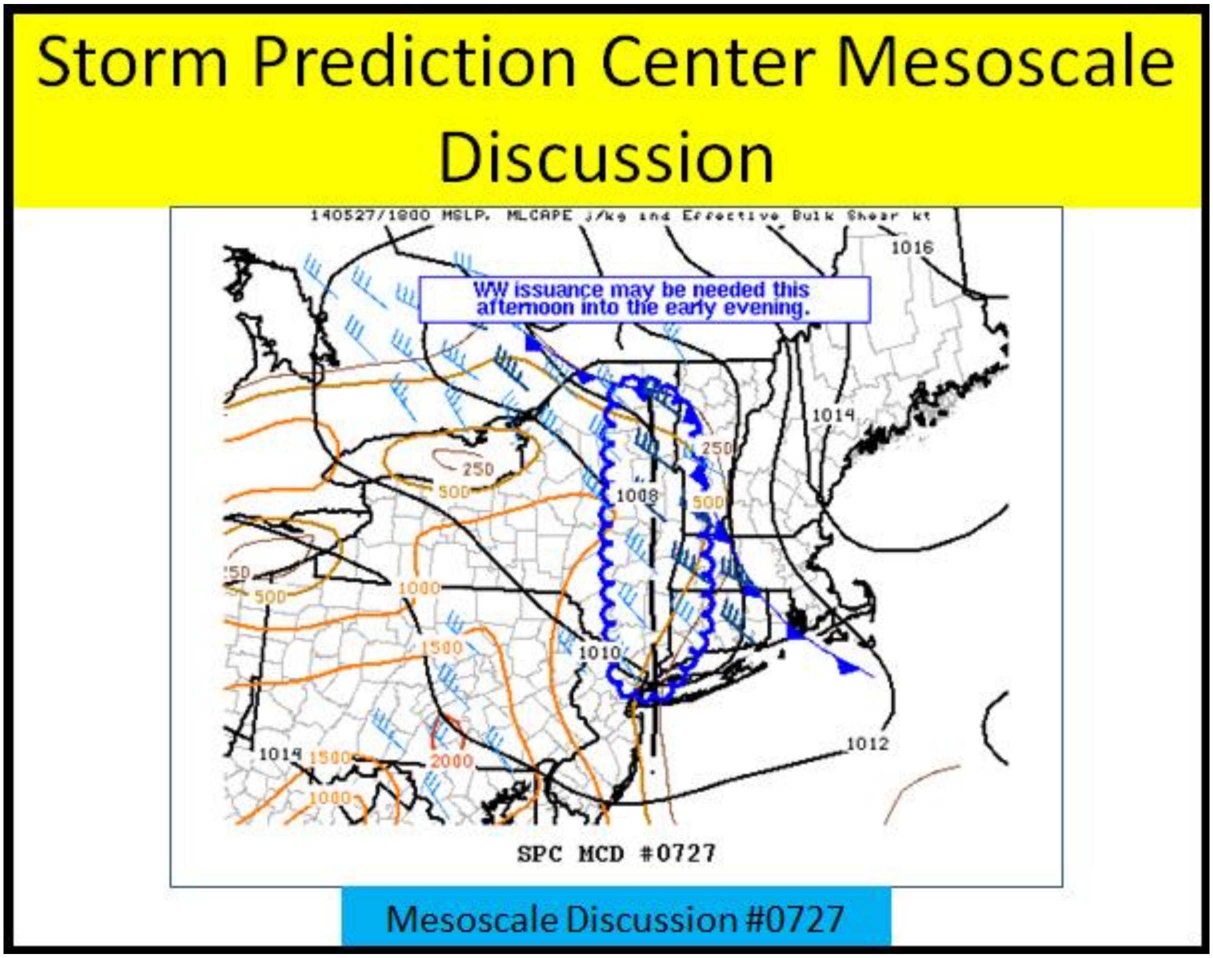

Figure 3: Storm Prediction Center Mesoscale Discussion #0727.

3.) Pre Storm Environment (Sounding, CAPE/Shear Parameters, and Surface Map)

In this section we will review the pre storm environment, including a model sounding, a surface analysis map, along with shear and instability parameters. It should be noted many of the large scale and local models struggled with the position of the cold front across our region and the associated placement and magnitude of instability. The result was that much greater instability developed across the eastern Adirondack Mountains and into southern Vermont than was suggested by some of the models, as surface temperatures warmed into the upper 70s and lower 80s.

Figure 4 below shows the BTV 4KM-WRF Bufkit sounding at Middlebury, VT at 2200 UTC on 27 May 2014. Based on observational data, the 1800 UTC run of the local BTV 4KM resolution model sounding at Middlebury, VT did the best at representing the pre-storm thermodynamic environment and associated wind fields. In addition, the close proximity of the sounding to the track of the supercell, provided forecasters with the best gage of the available CAPE and shear. This forecast sounding showed CAPE values of 1585 J/kg, and a lifted index of -5 Celsius. Meanwhile, the 0 to 6 km bulk shear was 50 knots with favorable directional and speed shear present. The combination of strong deep-layer shear and moderate instability helped to produce the persistent supercell thunderstorm. Also, precipitable water values of 1.42 inches suggested the potential for 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, suggest a greater potential for heavy rainfall, especially during the summertime.

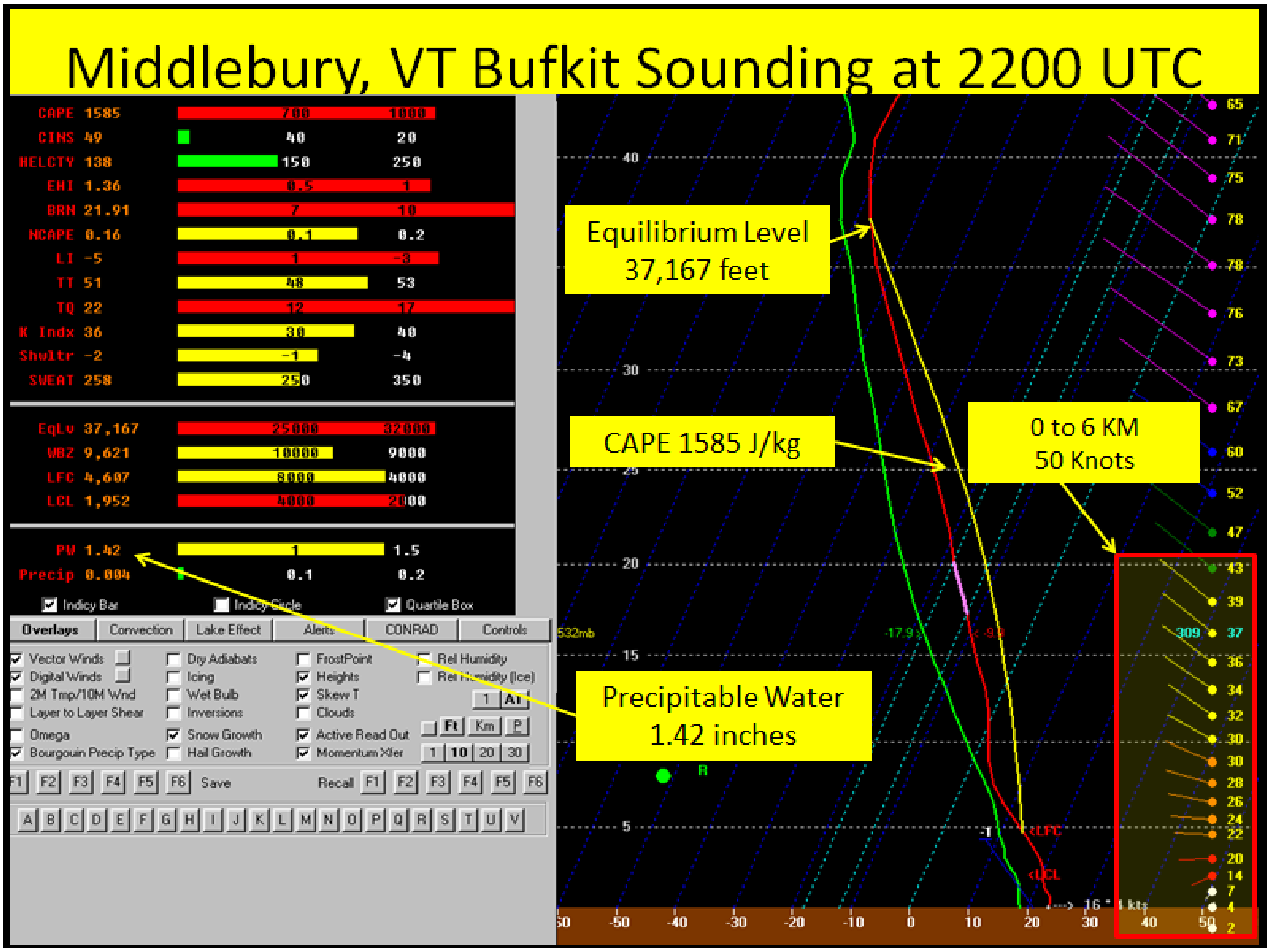

Figure 4: BTV 4KM WRF Bufkit Sounding at Middlebury, VT at 2200 UTC on 27 May 2014 (4 hour forecast based on 18 UTC run)

Figure 5 shows Rapid Refresh (RAP) analysis of CAPE and 0 to 6 km effective shear from SPC on 27 May 2014 at 1900 UTC. As a mid-level jet approached the region the deep layer shear increased to between 40 and 50 knots, while a sharp CAPE gradient developed across parts of our CWA. From SPC, the definition of effective bulk shear is “similar to the 0-6 km bulk shear, though it accounts for storm depth (effective inflow base to EL) and is designed to identify both surface-based and "elevated" supercell environments. Supercells become more probable as the effective bulk shear vector increases in magnitude through the range of 25-40 knots and greater”. The RAP most unstable CAPE showed a gradient of values between 1500 and 2000 J/kg across eastern New York, while values were less than 250 J/kg across central Vermont. Note, the best combination of deep layer shear and highest instability

(CAPE) was located across the eastern Adirondacks into parts of southern Vermont and closely matches the region of greatest concentration of wind damage and large hail.

The combination of moderate instability and effective shear values between 40 and 50 knots helped to produce this isolated supercell thunderstorm. The magnitude of the wind shear through a deep layer of the atmosphere is an important parameter to analyze in looking at the severe thunderstorm environment. Also, from Figure 5, you can see the Convective Inhibition (CIN; blue shaded areas) was nearly absent across western Vermont and northern New York as surface temperatures warmed into the upper 70s and lower 80s. At 19 UTC, CIN was only present over the cooler Atlantic Ocean waters and parts of southern New England.

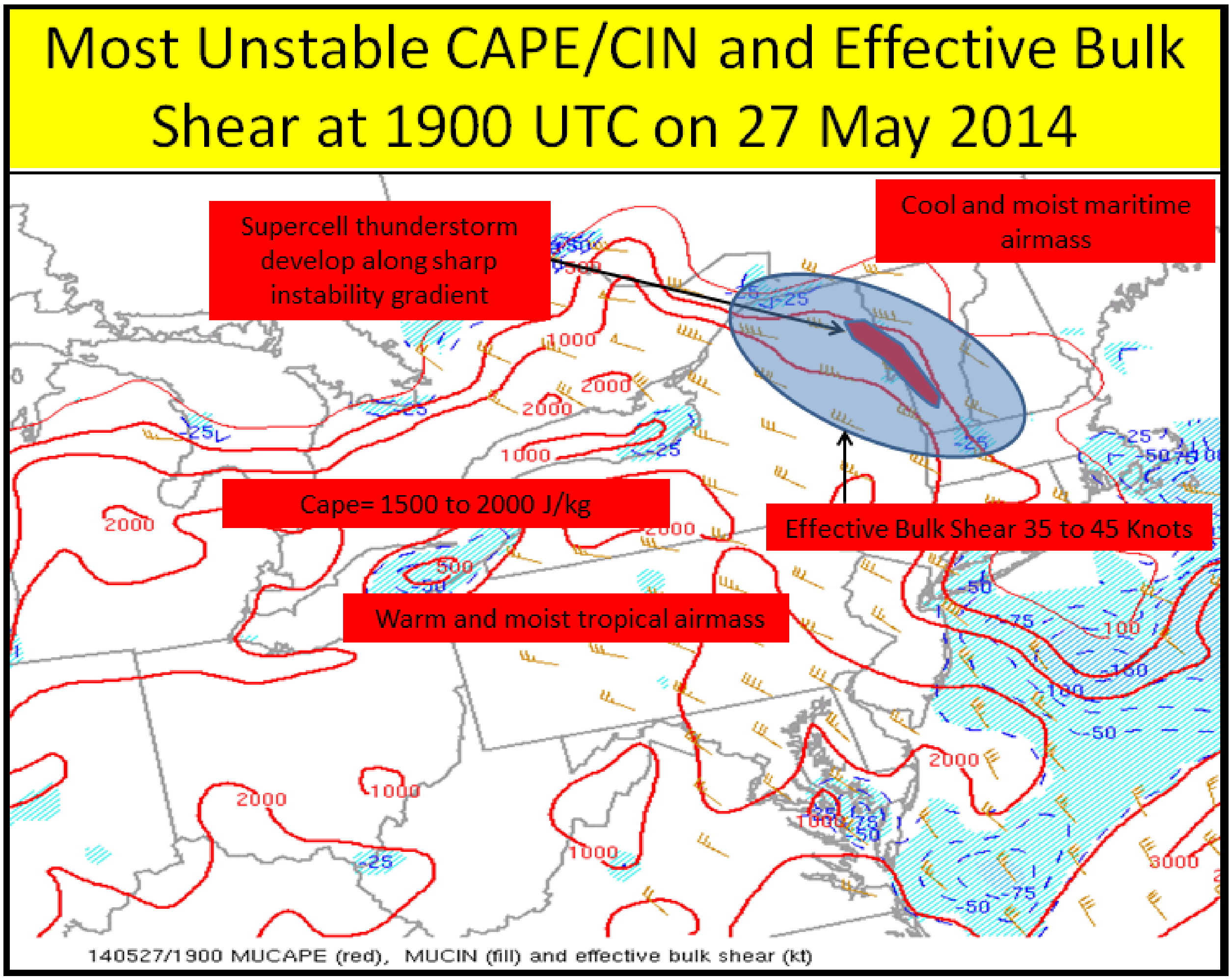

Figure 5: Storm Prediction Center (RAP) Rapid Refresh analysis of Most Unstable CAPE (red lines), Convective Inhibition (CIN) (light blue fill), and effect bulk shear > 25 knots (orange wind barbs) at 1900 UTC on 27 May 2014.

Figure 6 below shows the 1900 UTC surface map and associated analysis on 27 May 2014. This shows a sharp cold front with a well-defined wind shift from the southern Saint Lawrence Valley across the Adirondack Mountains into southern Vermont. This front separated temperatures in the upper 70s to lower 80s across eastern New York from the upper 40s to middle 50s over most of central and eastern New England associated with the maritime air mass which had pushed inland from the Gulf of Maine and Gulf of St. Lawrence. Glen Falls, New York reported a high temperature of 85 degrees on May 27th, prior to the arrival of the backdoor cold front (not shown). Surface dewpoints on the warm side of the boundary were in the upper 50s to lower 60s, before convection developed.

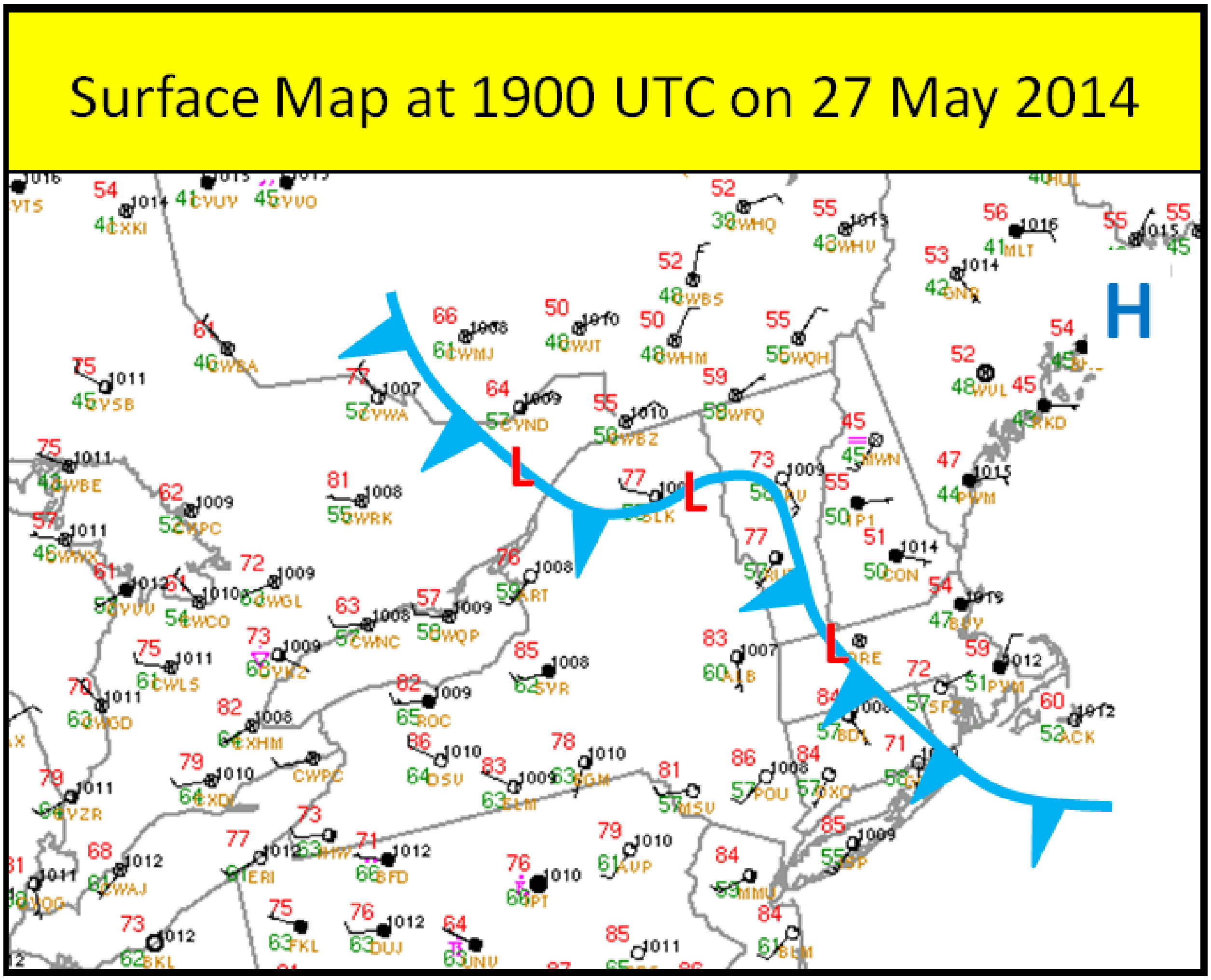

Figure 6: Surface Map at 1900 UTC on 27 May 2014 with surface plots and cold front (light blue line with triangles).

4.) Radar Overview

In this section we will investigate the radar data and storm structures of the supercell thunderstorm that produced a 40 to 50 mile swath of large hail and localized damaging winds across portion of the North Country on 27 May 2014. Figure 7 below shows the KCXX 0.5° base reflectivity loop from 1924 to 2104 UTC on 27 May 2014. This loop clearly shows an isolated supercell tracking southeast at 25 to 30 mph with a well-defined reflectivity core and hook echo structure on the southwest flank of the storm. This indicates a well-organized rotating supercell with 60 to 70 dBZ reflectivity representing large hail and very heavy rainfall.

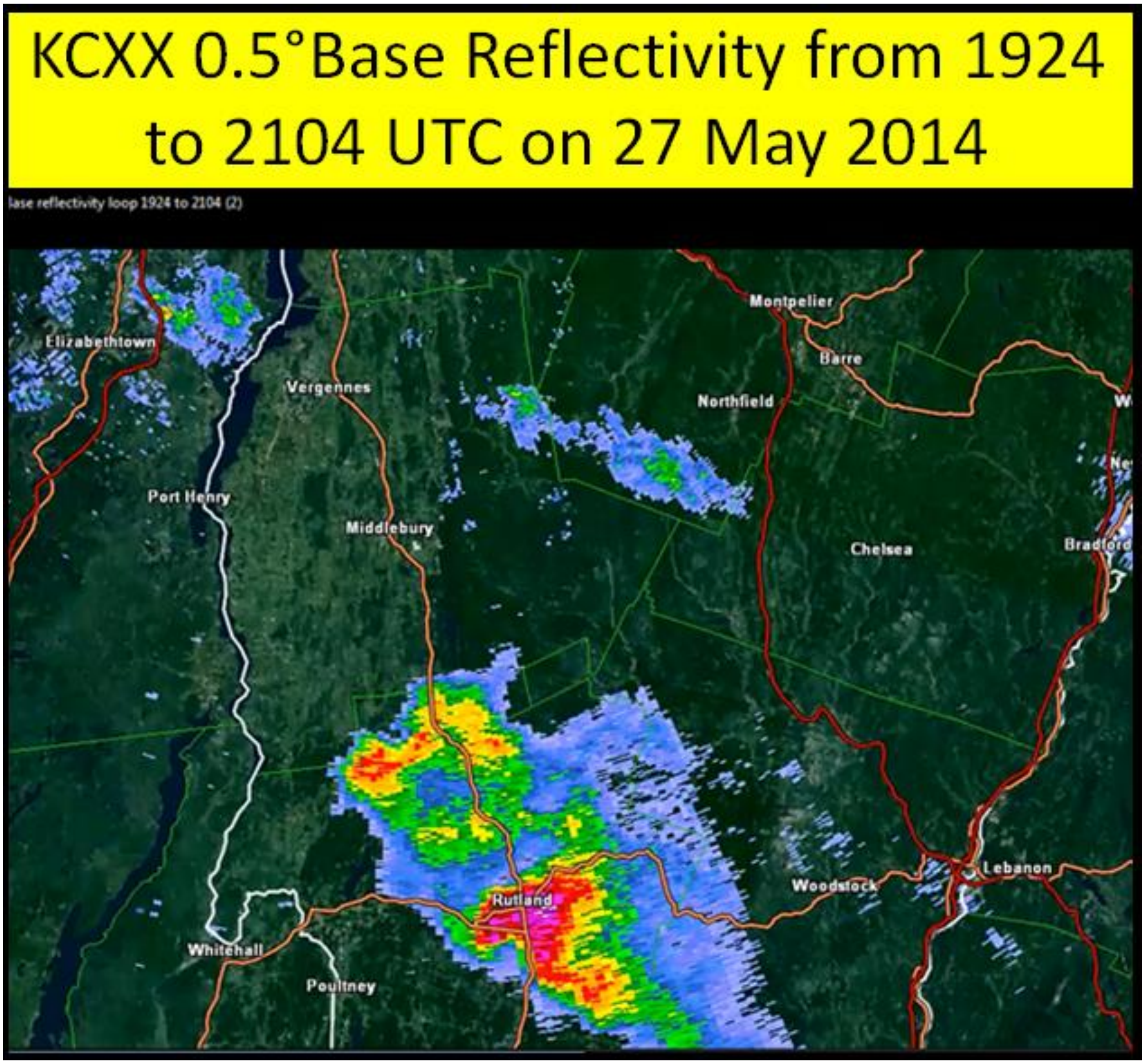

Figure 7: KCXX 0.5° base reflectivity loop from 1924 UTC to 2104 UTC on 27 May 2014. (Click image to view loop)

Figure 8 below shows KCXX 0.5° velocity (left) and reflectivity (right) at 1942 UTC near Bridport, VT on 27 May 2014. The velocity data show outbound winds (blowing away from the radar located in Colchester, VT) of 50 to 60 knots (yellow circle in the left image), which is likely associated with a descending rear flank downdraft. At this time, the storm inflow winds (winds blowing toward the radar) were generally less than 10 knots. The reflectivity structure (right image) showed a well-defined hook echo, with the outflow velocity closely associated with the southwest flank of the reflectivity hook. These outbound winds produced localized wind damage mainly across the slightly elevated terrain of southern Addison County near Bridport, Vermont. In addition, localized wind damage and large hail was observed under the storm core from several miles northwest of Bridport to West Shoreham to Rutland. This is depicted with the yellow circle in image below (right) highlighting the 60 to 70 dBZ (pink/purple) reflectivity core. The silo damage occurred several miles southwest of Bridport, VT, associated with the descending rear flank downdraft portion of the storm.

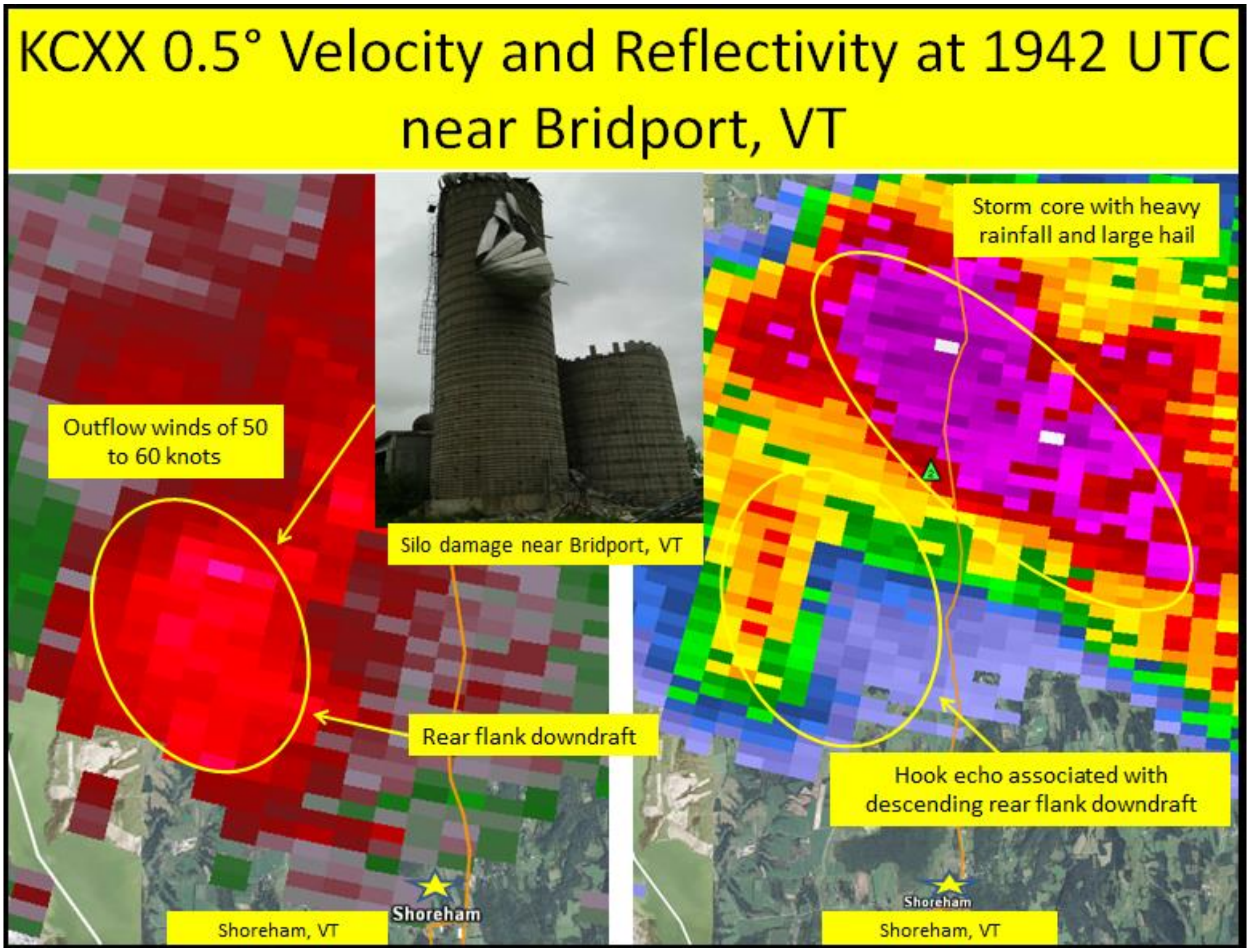

Figure 8: KCXX 0.5° velocity (left) and reflectivity (right) at 1942 UTC near Bridport, VT on 27 May 2014.

In the following image we associate reflectivity structure (left), with actual storm photograph (right) of supercell thunderstorm near West Shoreham, VT at 2024 UTC on 27 May 2014. In both the reflectivity cross section and storm photograph we are looking north into the storm with the east being to the right in the image below. The reflectivity cross section shows a well-defined storm reflectivity overhang and bounded weak echo region (BWER). Note how the strongest reflectivity core is elevated above an area where radar echoes are weak to non-existent. It is this region that is referred to as a BWER. Figure 9 shows a classic example of a BWER. Meteorologists can infer that the updraft is so strong that it is able to suspend rain and/or hail aloft, and not fall to the ground (hence, the lack of echo returns below the strong reflectivity core). Storms that have this particular signature are capable of producing severe weather.

Also, a strong southwest flank reflectivity core is present. This reflectivity core is associated with the descending rear flank downdraft and is shown nicely with lowering cloud structure photograph (lower right). Given the distance away and higher terrain, it looks like the cloud is touching the ground in the photograph below, but probably is several hundred feet above ground level. Also, note the cloud structure is not circular in shape, but instead has a boot like appearance on the east flank, indicating the potential for gusty downburst winds. The white areas in the photo background indicate the storm's core with very heavy rainfall and large hail.

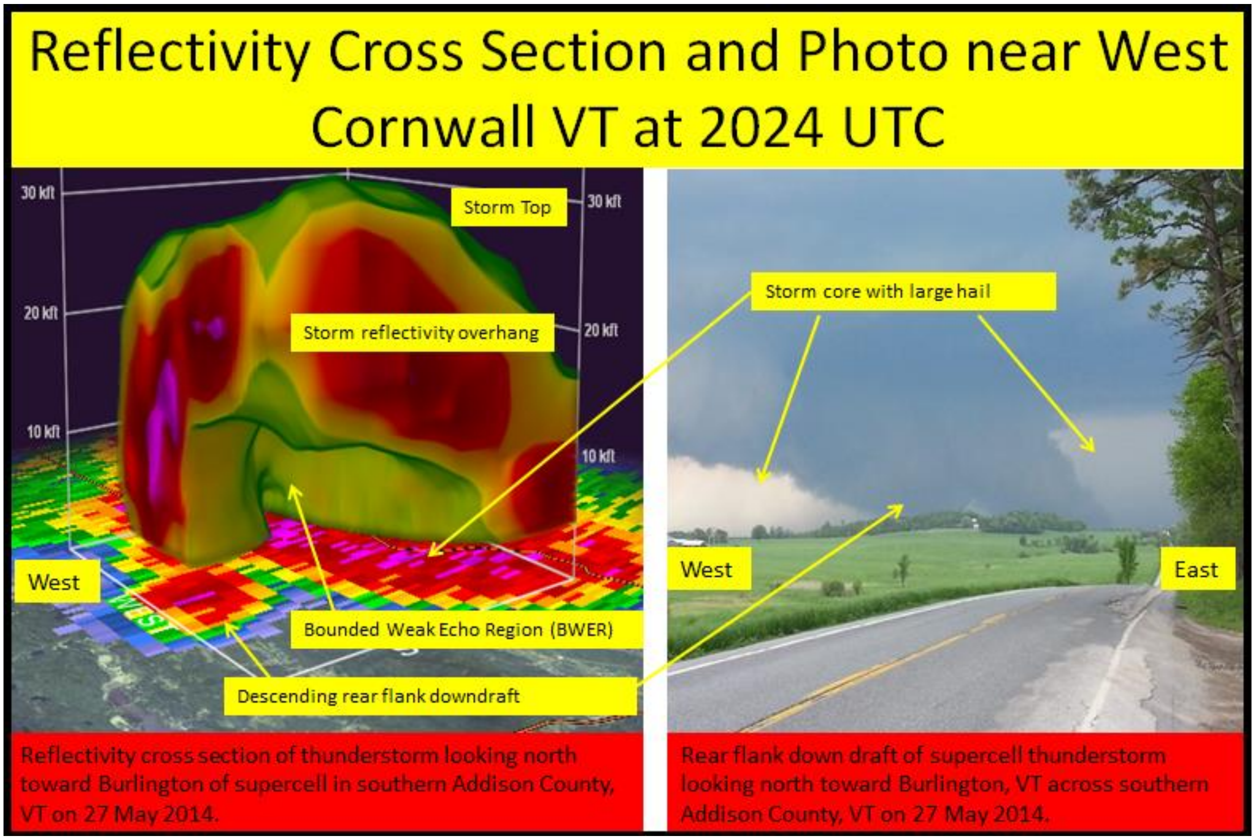

Figure 9: KCXX reflectivity cross section and storm photo near West Cornwall, VT at 2024 UTC on 27 May 2014.

Figure 10 below shows a KCXX reflectivity cross section of the golf ball (1.75") diameter hail producing supercell near Rutland, VT at 2040 UTC on 27 May 2014. This storm was 9 miles tall with storm top reflectivity over 48,000 feet above ground level (AGL). In addition, a solid 60 to 70 dBZ reflectivity core was present to 30,000 feet AGL, indicating a very warm and unstable air mass was being lifted into the storm's updraft. This is nicely associated with the reflectivity overhang in the image below and BWER, suggesting very strong storm relative inflow and a storm capable of producing severe weather. Soundings showed a very unstable profile with tall equilibrium levels to 37,000 feet and favorable shear for organized and persistent convection capable of producing severe hail.

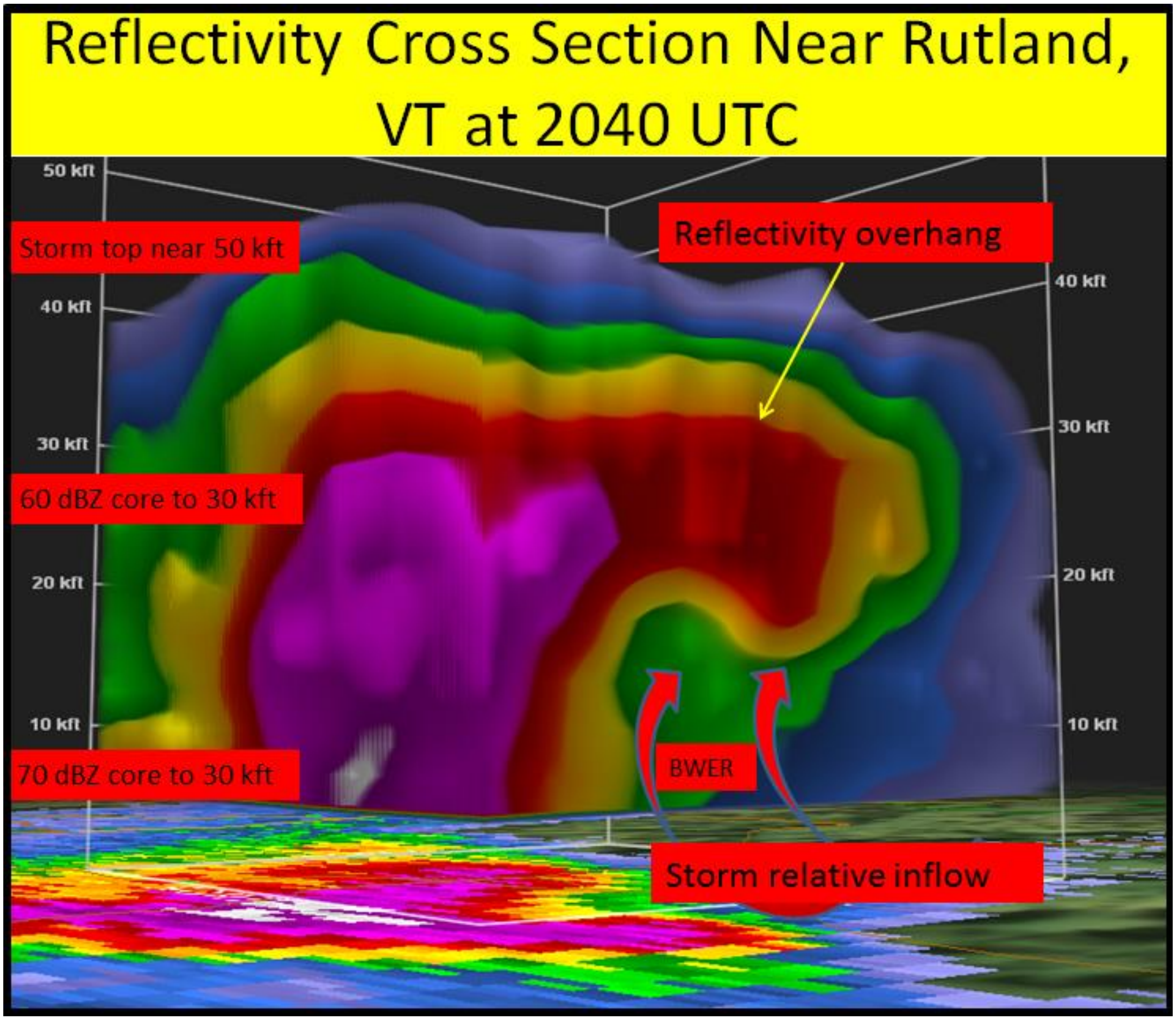

Figure 10: KCXX reflectivity cross section near Rutland, VT at 2040 UTC on 27 May 2014.

In figure 11 below we once again try to associate storm photograph (lower left) with storm reflectivity structure (lower right) as the supercell approached Rutland, VT at 2040 UTC on 27 May 2014. Once again the storm had a strong reflectivity overhang and a well-defined reflectivity core. This core was associated with > 60 dBZ to 30,000 feet above ground level, and helped produce the widespread golf ball (1.75") size hail in Proctor and Rutland, VT. The ragged nature of the cloud structure in the photograph, indicates strong winds and very turbulent air being lifted into the storm's updraft. It was noted just prior to the storm, the Automated Weather Observation Station (AWOS) at Rutland Regional Airport had southeast storm relative inflow winds sustained at 30 mph with gusts to 37 mph. This cloud photograph and reflectivity structure, both indicate a very potent thunderstorm capable of producing large hail and damaging winds. In this scenario, most the severe weather reports in Proctor and Rutland were from large hail, as the stable low levels prevented the stronger winds from mixing to the surface.

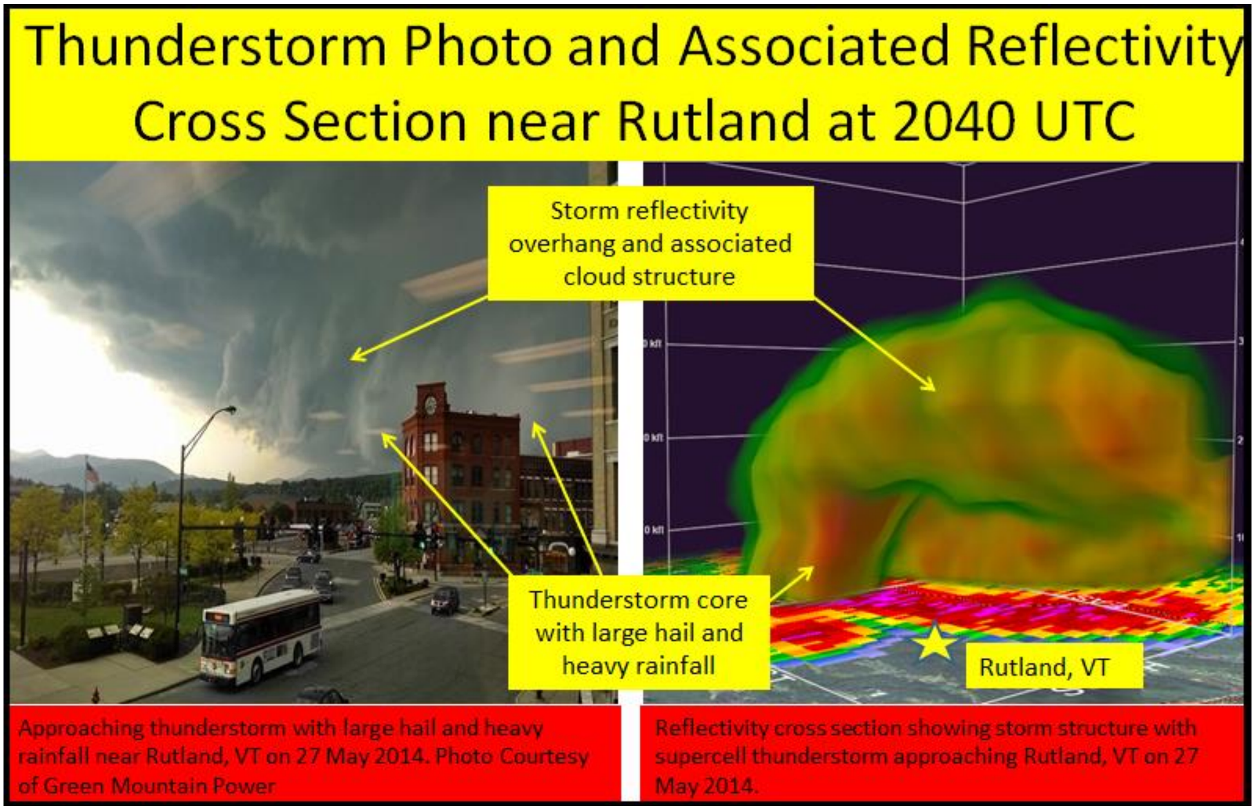

Figure 11: Photo of thunderstorm approaching Rutland, VT courtesy of Green Mountain Power (left) and associated KCXX storm reflectivity cross section (right) at 2040 UTC on 27 May 2014.

Figure 12 below shows Echo Top (lower left) and Vertical Integrated Liquid (VIL) (lower right) at 2040 UTC on 27 May 2014 near Rutland, VT. Echo top is a good indication of the storm top and the taller the storm the greater potential for severe winds or large hail. VIL is an estimate of the total mass of precipitation in the clouds. The measurement is obtained by observing the reflectivity of the vertical column 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 occurring, a result of a weakening of the storm's updraft and the storms inability to hold the copious amounts of moisture/hail within the storm's structure. This means greater potential for the storm to produce damaging winds as the downburst descends to the surface. Figure 12 shows VIL (gray and white color) values > 80 kg/m2 several miles northwest of Rutland. This indicates a very well developed updraft, which produced 1.75” diameter hail in Proctor and Rutland. This supercell storm continued to track southeast before weakening near Shrewsbury, VT during the early evening hours of May 27th.

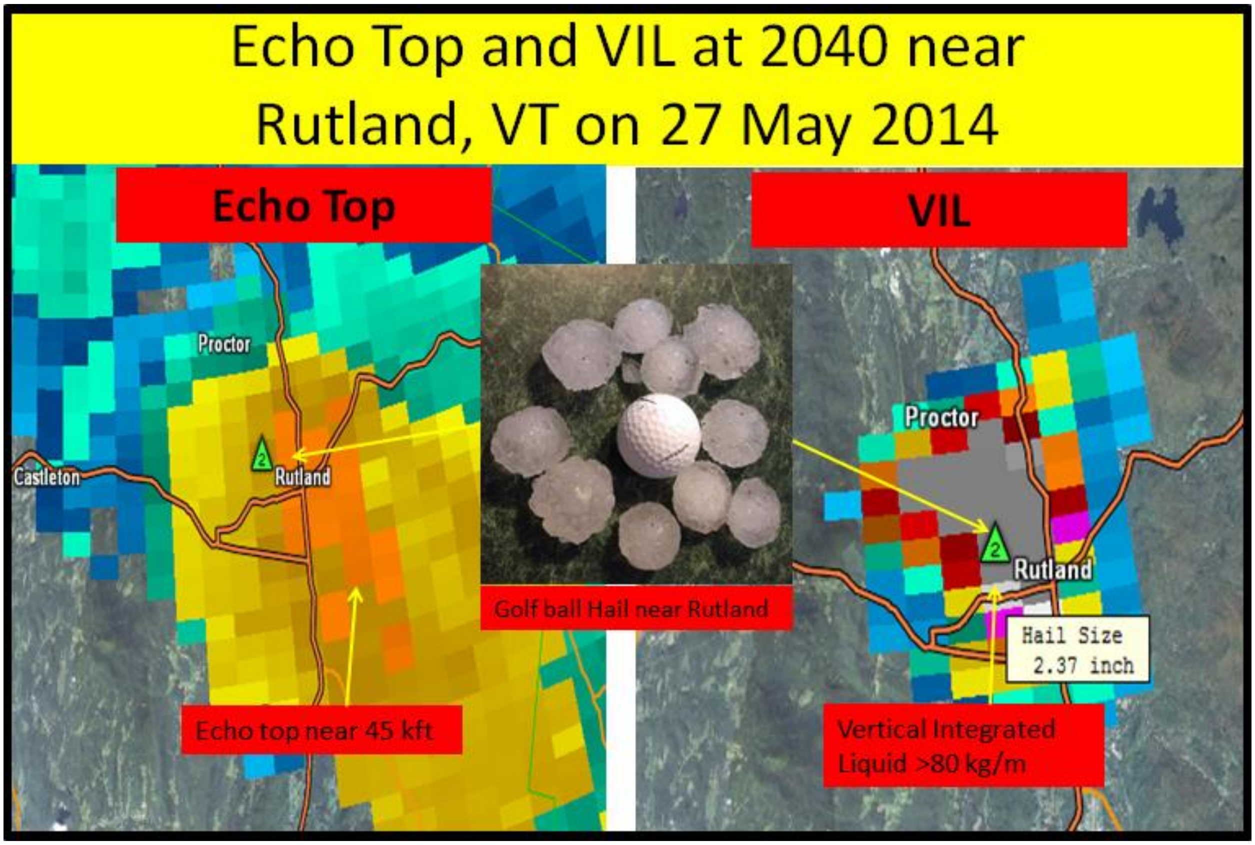

Figure 12: Echo Top (left) and Vertically Integrated Liquid (right) at 2040 UTC on 27 May 2014 near Rutland, VT.

5.) Conclusion and Summary

This was the first significant severe weather event of the 2014 season, which featured a long swath of large hail and localized wind damage associated with an isolated supercell thunderstorm. This was the only severe thunderstorm across the WFO BTV CWA on 27 May 2014. A 74 mph wind gust was measured northwest of Bridport, VT during the event, along with isolated areas of trees down and some structural damage to houses and farmsteads across southern Addison County. At the height of the storm, only 500 people were without power, indicating the main impact from the storm was very large hail. Many reports of hail up to golf ball size or 1.75" in diameter was observed. The image below shows areas of wind damage and the large swath of severe hail from near Bridport to Whiting to Proctor to Rutland. Finally, some brief heavy rainfall occurred with this supercell thunderstorm, with urban and poor drainage flooding being observed in the City of Rutland. Finally, Figure 14 shows some of the storm related structural and tree damage that occurred, along with several pictures of large hail. During the peak of the storm, hail was measured several inches deep in West Rutland.

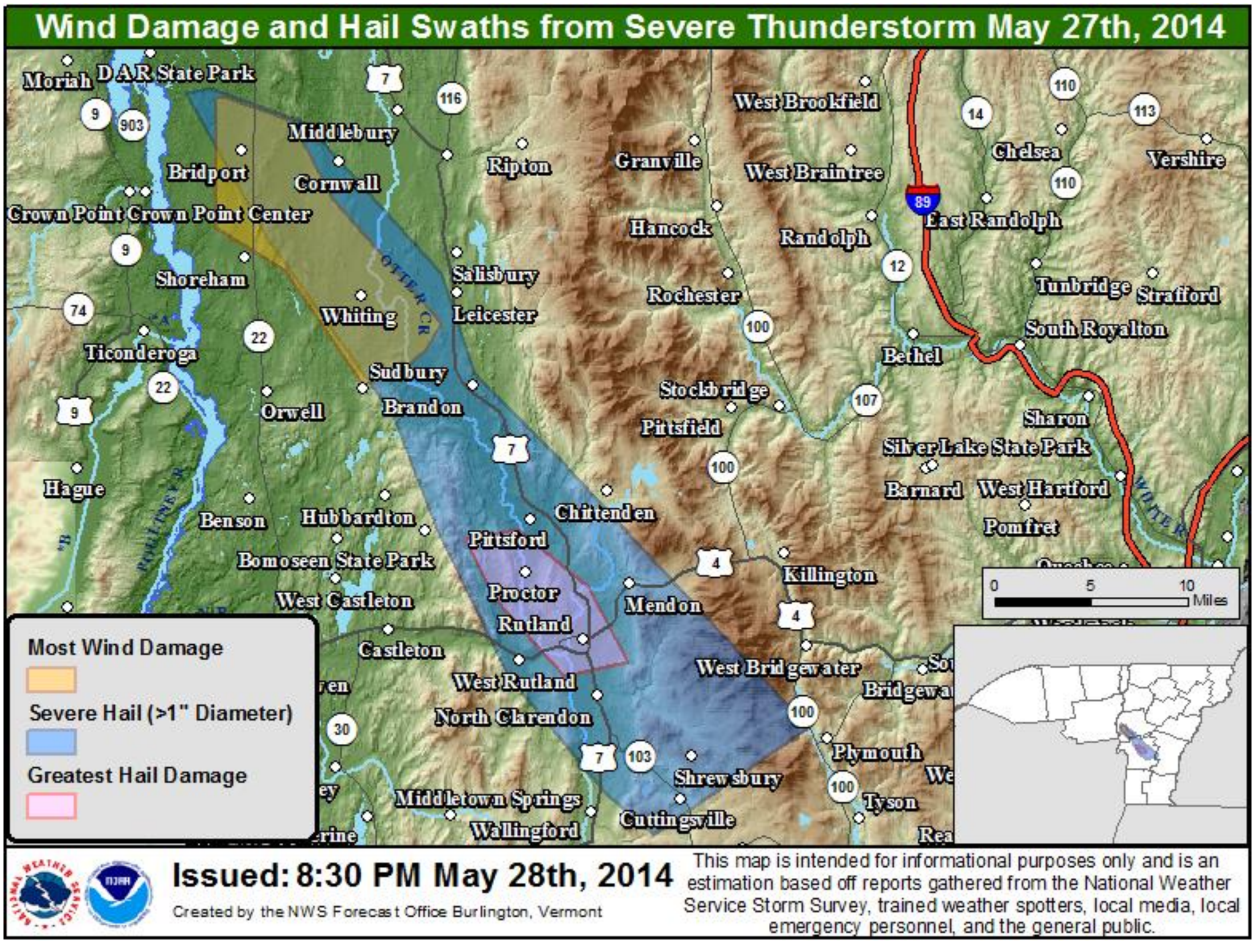

Figure 13: Wind and hail swaths from the supercell thunderstorm on 27 May 2014. Graphic courtesy of Mike Muccilli, WFO BTV.

Figure 14: Storm damage photos from 27 May 2014.