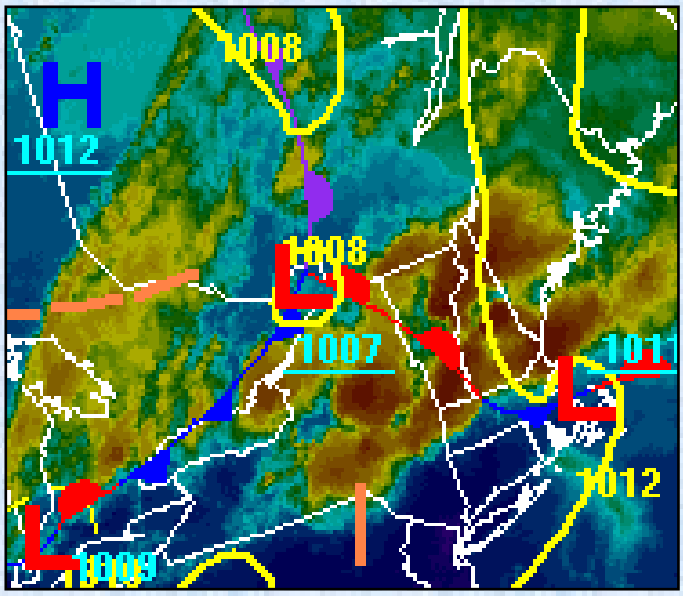
by John Goff and Jessica Neiles

GENERAL SUMMARY



Beginning on the morning of Monday July 9, 2007 residents began hearing the first reports of severe weather across Essex and Franklin counties. No one knew that this was to be the beginning of one of the more active three day stretches of severe weather across Vermont and northern New York in several years. From large and destructive hail from severe thunderstorms on July 9-10, to devastating flash flooding on July 11, millions of dollars in damage occurred as a direct result of the weather. The unusual set-up focused along a nearly stationary surface frontal boundary draped across the northern New York into Vermont, separating hot and humid air to the immediate southwest from cooler air to the northeast. With a fairly non-descript pattern aloft, this boundary provided the needed mechanisms for lift to spark a variety of severe weather across the area, described in detail below.

DAY 1: MONDAY JULY 9, 2007

Early Monday morning a warm front slowly approached the Burlington forecast area from the west. By 7am the front was situated N-S across Central New York (see Figure 1). This front would provide the focus for numerous thunderstorms, quite a few of which exceeded severe thresholds. The first severe thunderstorm warning of the day was issued just after 10am, and the last just before 10pm, with a total of 24 warnings issued for the day. Analysis of the afternoon forecast sounding at Burlington, VT suggested an increased potential for strong to severe thunderstorms across the area, with excessive CAPE values greater than 3000 J/kg, and impressive shear profiles.

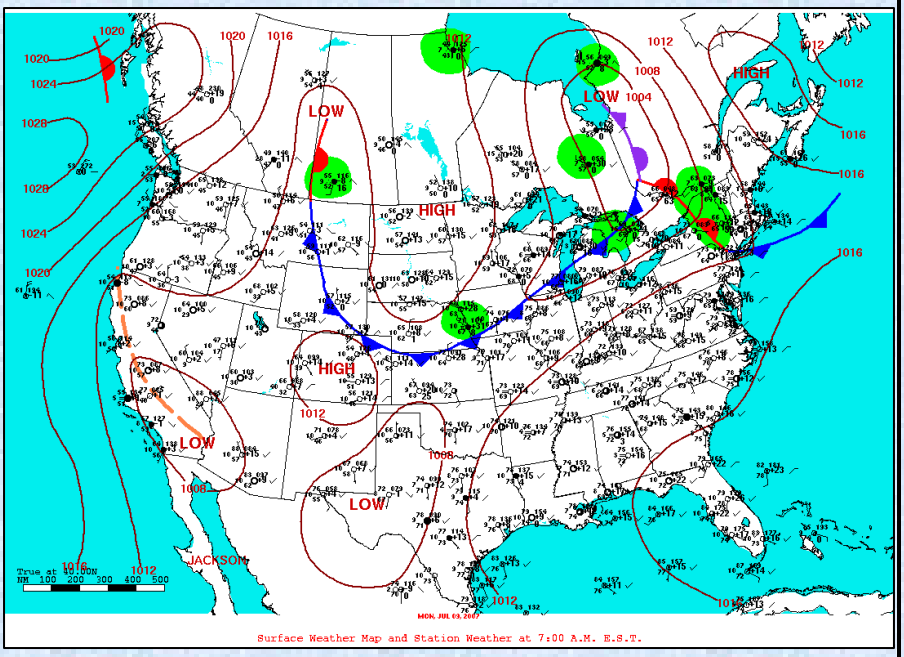


Figure 1: Surface weather map on the morning of 07/09/2007

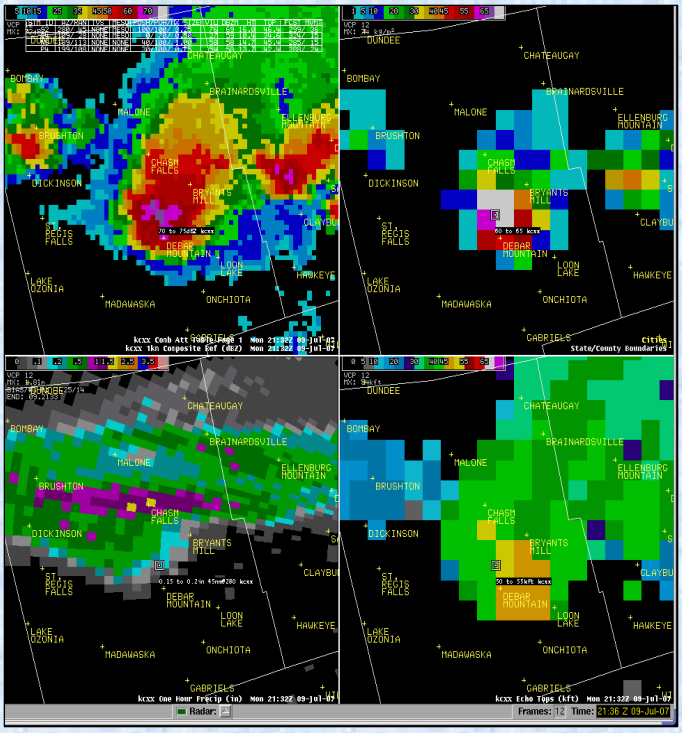


Figure 2: Analysis of Duane Center storm showing (clockwise from top left) Composite Reflectivity, VIL, One Hour Precipitation, and Echo Tops.

At 4:47pm forecasters at the Burlington forecast office issued their sixth severe thunderstorm warning of the day for Franklin and St. Lawrence counties in NY. This storm was part of a larger cluster of storms that proved to be the most severe of the day as they carved a path across northern New York southeastward into northwestern and central Vermont. As the storm initially approached Duane Center, NY around 5:30pm, it possessed an echo (storm) top over 50,000 ft and a Vertically Integrated Liquid (VIL) content greater than 75 kg/m^2 (see Figure 2). A high VIL number often implies the presence of a large hail core in a given storm. Cross-sectional radar imagery of the storm is also shown (see Figure 4 on the following page), revealing the pronounced high reflectivity core aloft, and indicating the presence of large hail. In the image sequence, you can see the hail core dropping inside the storm on its way to the ground. Quarter size hail was reported by law enforcement around 5:30pm in Duane Center, NY.

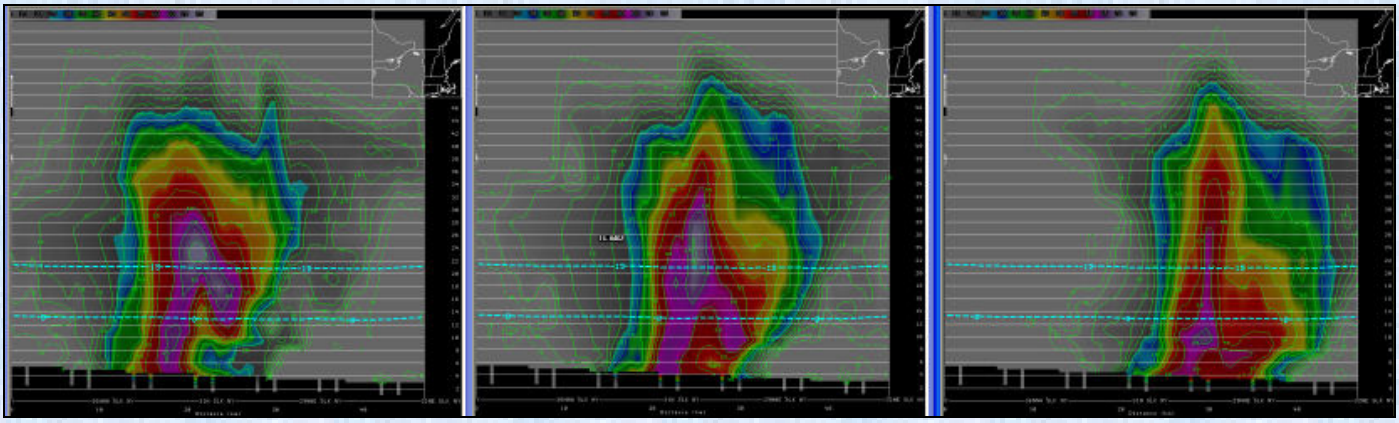


Figure 3: Radar cross-section analysis of Duane Center, NY severe thunderstorm near peak intensity, showing pronounced descending hail core.

As the storm cluster continued to progress southeast, it crossed into northwestern Vermont producing large hail and damaging winds across Chittenden County from South Burlington to Richmond. Low level velocity signatures off KCXX radar showed the severe gust front winds as they pushed across Colchester, VT just south of Mallets Bay (see Figure 4). As the storm continued to push southeast, forecasters issued their eleventh severe thunderstorm warning of the day for Washington County, VT at 638 pm. This storm approached the Duxbury area around 6:45pm and had an echo top over 56,000 ft and a VIL content greater than 70 kg/m^2. Similar to the Duane Center storm, it also had a high reflectivity core aloft (60 dBZ to 38,000 feet!) Hail the size of golf balls and larger was reported in Duxbury

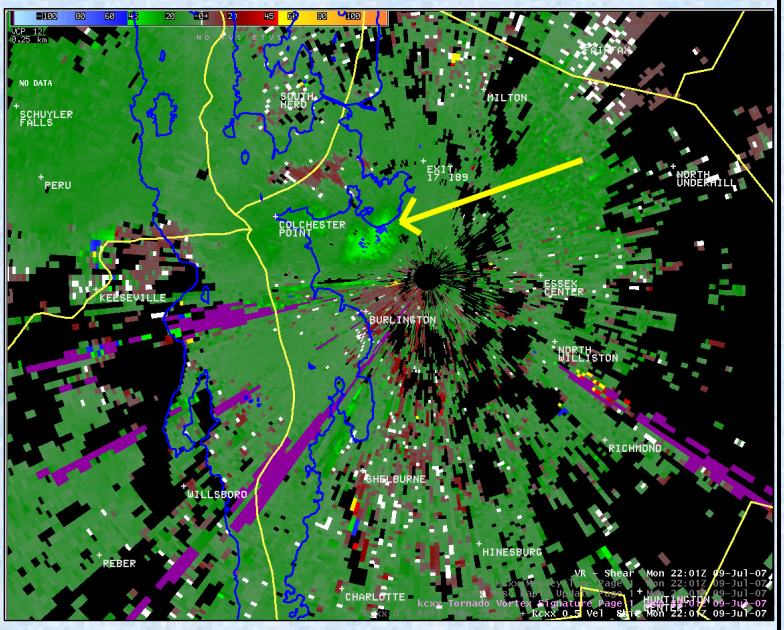


Figure 4: Low level velocity signature from KCXX radar, showing inbound values in excess of 50 knots (arrow) just south of Mallets Bay in Colchester, VT.

Hail the size of golf balls and larger was reported in Duxbury around 7:00pm as the hail core descended to the surface. At right is an image of that hail, truly impressive by any standards.

Image 1: Picture of Duxbury hail stones that fell on the evening of July 10.

DAY 2: TUESDAY JULY 10, 2007

After such widespread severe weather the previous afternoon and evening, it was hard to imagine that a repeat performance could occur again on the following day, but indeed Mother Nature had a few more tricks up her sleeve. Once again, the nearly stationary frontal boundary was to prove the primary culprit. During the morning hours, analysis indicated the frontal position extending from northern Massachusetts westward across south central Vermont into the eastern Great Lakes (see Figure 5). While boundary layer winds were relatively light, copious amounts of low to mid level moisture were present across Vermont and northern New York.

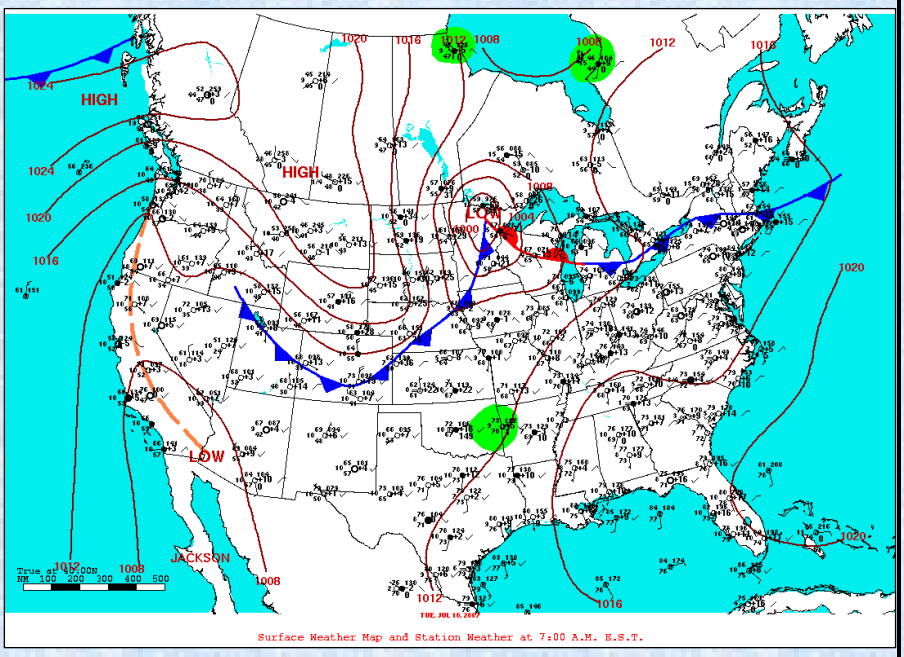


Figure 5: Surface weather map on the morning of 07/10/2007

With anticipated heating during the daylight hours, enhanced low level instability was anticipated. This factor, combined with an approaching weak shortwave at 700 millibars and residual innocuous boundaries left over from convection the prior evening lead to increased confidence that another active weather day was likely on tap. Indeed, as the first storms began to erupt across Essex County, NY during the early afternoon hours, Severe Thunderstorm Watch #505 was issued. As the day progressed, thunderstorms continued to grow in coverage and intensity, with some thirteen individual storms reaching severe limits. While the overall intensity of the storms was not as great as those experienced on Monday the 9th, a few were quite noteworthy. Of particular interest was the severe storm which tracked across the towns of East Charleston and Morgan, VT during the late afternoon hours. This was clearly the strongest storm of the day, and despite significant loss of low level radar data due to beam blockage, a pronounced deep high-reflectivity core (greater than 60 dBZ) above 25,000 feet was quite evident in cross-sectional imagery (see Figure 6). This marked signature on radar is often a strong indicator intense updraft strength and hail within any given thunderstorm, with the rough rule of thumb being "the stronger and higher the reflectivity core, the stronger the updraft, and greater potential of severe hail", severe hail being defined as stones with a diameter equal to or greater than 3/4 inch (penny size).

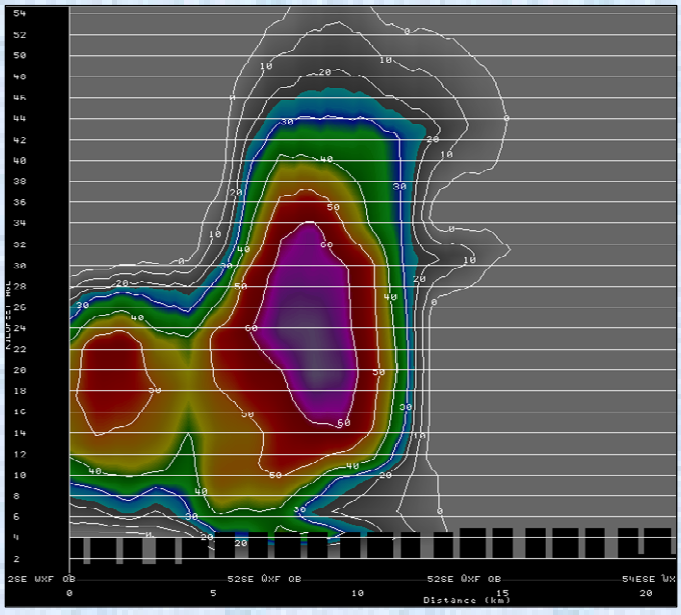


Figure 6: Radar cross-section of Morgan, VT storm near peak intensity.

This storm certainly met those criteria and a Severe Thunderstorm Warning was promptly issued for Orleans County at 500 pm local time. With such an impressive radar signature, meteorologists at the NWS in

Burlington knew it only a matter of time before the storm's core would descend, along with microburst and/or strong to severe straight-line winds and hail. Unfortunately, this began to happen almost immediately after crossing the Caledonia/Orleans county line. As this began to occur, an updated Severe Weather Statement regarding the storm and the status of the warning was issued at 547 pm, highlighting the potential for golf ball sized hail and destructive winds in excess of 70mph. The image collage below (Figure 7) shows this "core drop" in classic detail. Note the high-reflectivity core descending in elevation from left to right across the top row of radar cross-section images during the 536 pm to 553 pm time frame. These correspond to the composite radar reflectivity images in the panes immediately below, thus showing the track and location of this event quite nicely. Again, the lowest elevations of the storm were blocked quite heavily from the radar's field of view due to the intervening mountains. Thus the appearance of the core weakening as it descended is an artifact of this sampling error.

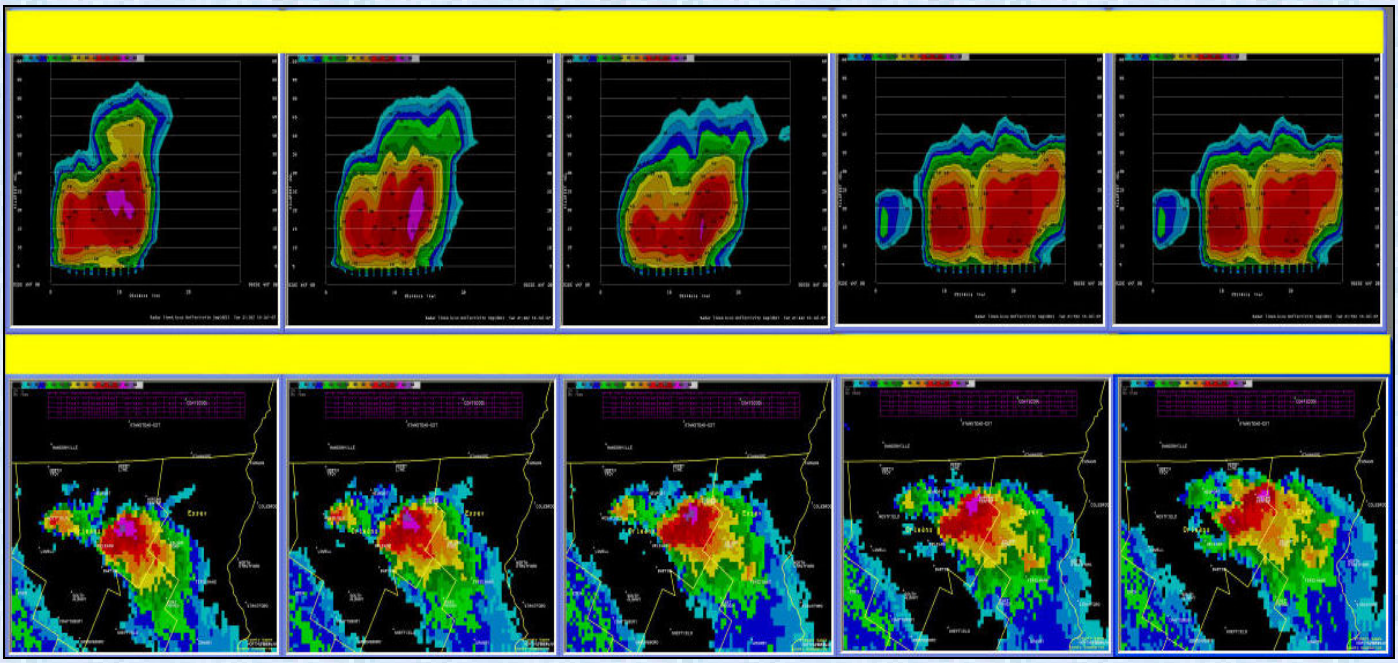


Figure 7: Collage cross-section radar imagery of Orleans County severe thunderstorm, showing reflectivity core drop and corresponding composite reflectivity imagery during the same time.

Image 2: One of many trees toppled in the Morgan, VT area on the afternoon of July 10, 2007. (Photo credit: Jennifer Williams, Morgan, VT).

DAY 3: WEDNESDAY JULY 11, 2007

By the early afternoon hours of July 11th, the realization that yet another day of potentially active day was on tap for much of Vermont and northern New York. The synoptic set-up was beginning to evolve into a different scenario, as the old stationary front responsible for severe weather the prior two days had lifted northeast of the area as a warm front, and a cold front across the eastern Great Lakes began to advance eastward towards the region (Figure 8). Initially, the thought was another round of possibly severe weather may occur along and ahead of this latter front. However, it became quickly apparent that another inherently and potentially dangerous phenomena was beginning, that of training thunderstorms with torrential rainfall.

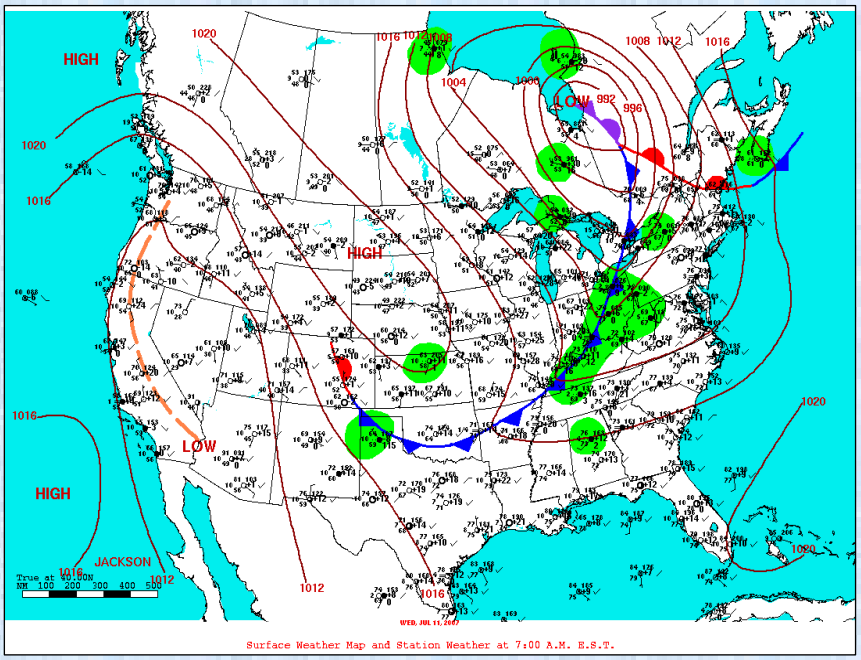


Figure 8: Surface weather map on the morning of 07/1//2007

The unfortunate reality that day was that the most reliable models did not strongly suggest this possibility across Vermont. However, the expertise of forecasters recognized the evolving scenario, and as the first training cells began to develop across south central Vermont, a Flash Flood Watch was issued for the entire forecast area around 1 pm local time. A closer look at the synoptic set-up revealed classic surface to mid-level airmass convergence along and just east of the Green Mountains, as south-southeasterly flow off the Atlantic abutted against southwesterly flow ahead of the surface front. With ample low level instability and moisture in place, this convergence allowed air to be lifted quickly along and just east of the Green Mountain spine, and thunderstorms rapidly developed. Typically this scenario is fairly benign, with initial storm development along the convergent axis, though with some forward movement as the axis drifts eastward with time. However, on July 11 this axis remained stationary for nearly 6 hours as the surface front to the west slowly approached. With southwesterly flow at upper levels atop the low to mid-level convergent zone, the perfect evacuation channel aloft was generated and training thunderstorms developed. The graphic at left (Figure 9) shows this convergence zone quite nicely.

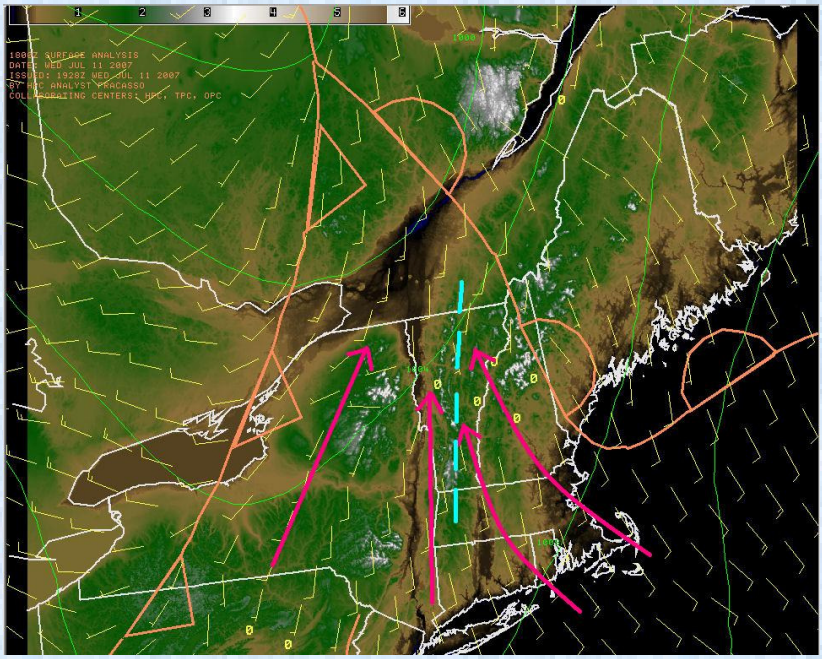


Figure 9: Surface mean sea level pressure (green lines) and surface fronts/wind barbs at 3 pm local time on 07/11/2007. Also shown are low to mid-level convergent

streamlines (pink) and axis of convergence (light blue).

As thunderstorms began to train along the eastern slopes of the Green Mountains, Flash Flood Warnings were initially issued for Windsor, Caledonia and Washington Counties. Early radar signatures indicated that the northwestern portions of Windsor County were experiencing the most excessive rainfall, and forecasters quickly realized a potentially dangerous situation was developing in the Stockbridge/Gaysville area where many smaller streams feed into the headwaters of the White River. The graphic below (Figure 10) shows the one hour precipitation estimates over this area from the KCXX (Burlington, VT) radar at the height of the event around 2 pm. As you can see, rainfall amounts in excess of 3 inches had occurred in this area during this time, with more to come, certainly cause for concern. Later in the afternoon it became apparent that serious flash flooding had indeed occurred in the Stockbridge and Gaysville area, with several roads washed out and at least one bridge completely washed away. As the afternoon progressed, training thunderstorms continued to develop northward, affecting much of western Orange, and eastern Washington, Lamoille and Orleans counties. The heavy rains resulted in severe flooding across the area as streams and small rivers quickly became swollen. Forecasters noted the very rapid rise on a number of these small waterways was about as rapid as ever observed.

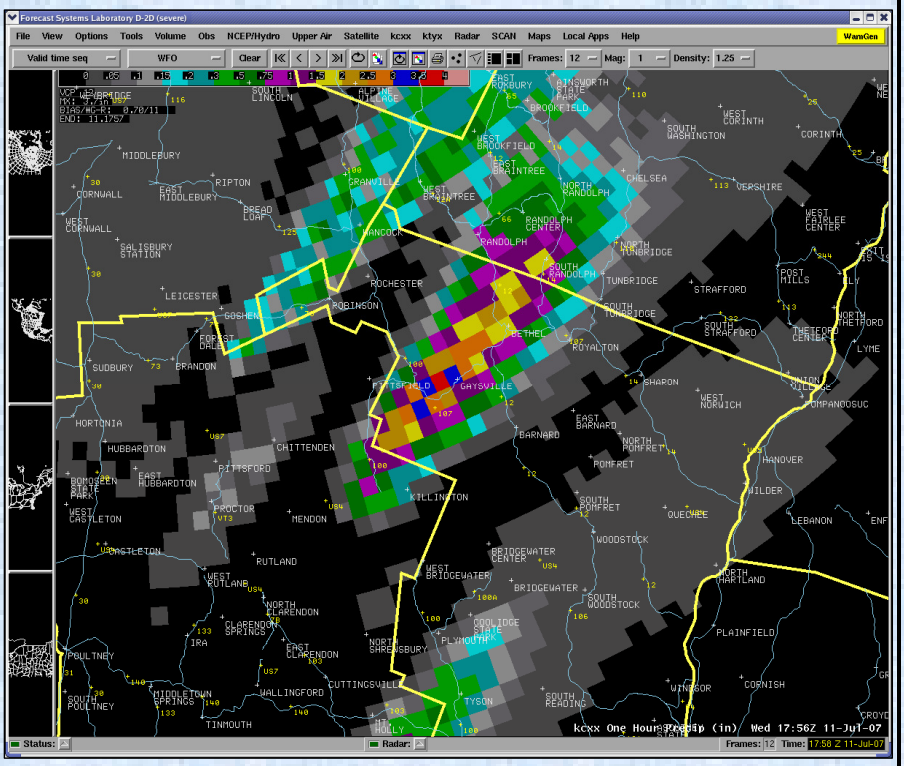


Figure 10: One hour precipitation estimates from KCXX radar, indicating totals in excess of 3 inches in portions of northwestern Windsor County near the towns of Stockbridge and Gaysville.

For example, the Ayers Brook in Randolph, recorded a peak water level of 9.55 ft, good for 3rd place on their crest history, ranking behind only the 1927 flood and an event in June 1998. Numerous roads were reported to be flooded and damaged. Particularly hard hit was the city of Barre where a local state of emergency was declared when the main part of town became submerged under several feet of water. In nearby Williamstown, over 100 people were evacuated from their homes. There were also worries over the potential failure of a couple of earthen dams in the area. Burlington forecasters coordinated with the Northeast River Forecast Center in Taunton, MA to run special river forecasts. The Burlington office was also a primary participant in two conference calls run by the Vermont Emergency Management during the evening. Initial estimates from the Vermont Emergency Management are that damage costs will be well into the hundreds of thousands of dollars, but that only includes infrastructure such as roads, bridges and culverts. Damages to homes and businesses will total even more. As of this writing, the Federal Emergency Management Agency has declared surveyed the hardest hit areas, and declared them eligible for federal disaster assistance. The images on the following pages show the radar imagery during the early stages of the event, and some of the damage experienced in the Barre, VT area.

As the week wore on, the threat of severe weather ended across the area, bringing a collective sigh of relief from forecasters and residents alike across the North Country. Certainly the three day period of July 9-11, 2007 will be remembered as one of the more noteworthy severe weather episodes in the past 10 years.

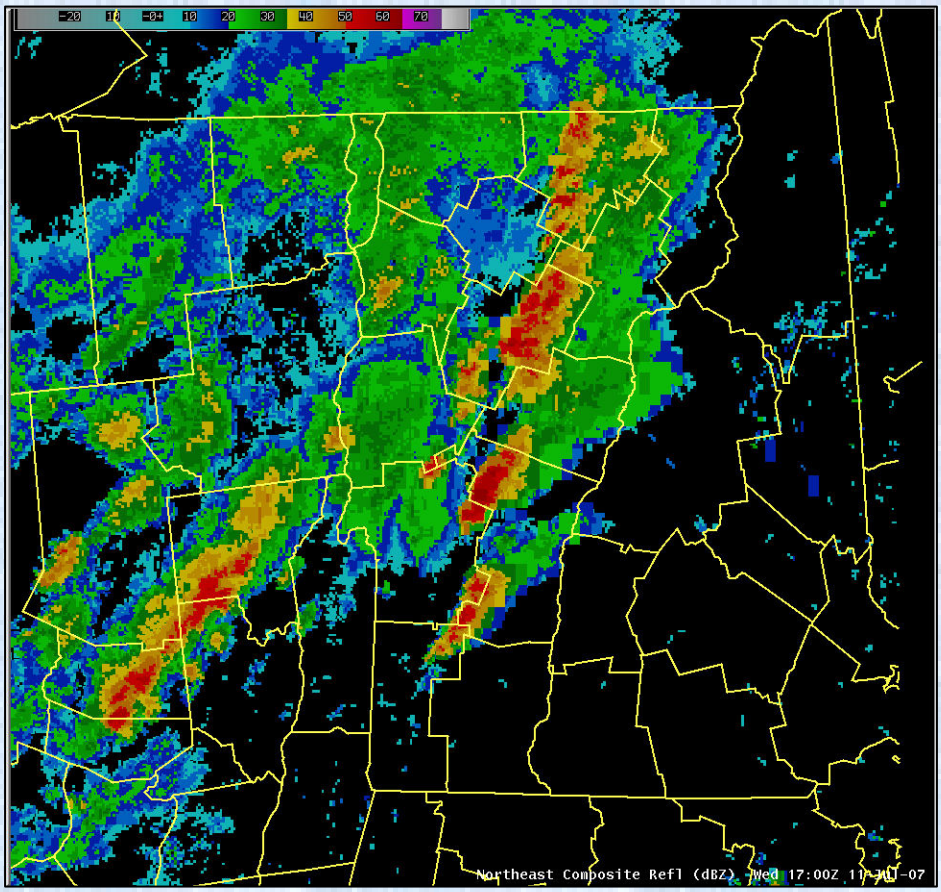


Figure 11: Regional multi-radar composite imagery during initial stages of event at 1 pm local time.

Image 3: Picture showing one of the hardest hit areas in East Barre after the devastating flash

floods of July 11, 2007 (photo credit Gerry Macke/NWS Burlington, VT).