The Significant Severe Outbreak on June 10, 2008

On June 10, 2008 a significant severe weather outbreak occurred across northern New York as well as central and northern Vermont. This outbreak featured two major rounds of severe weather, which produced over 50 severe weather reports across the Weather Forecast Office (WFO) Burlington (BTV) forecast area. The maps below shows the Storm Prediction Center (SPC) outlook for severe weather, along with the highlighted potential for damaging winds. SPC placed the WFO BTV forecast area in moderate risk for severe thunderstorms, which indicated the potential for a significant severe weather outbreak.

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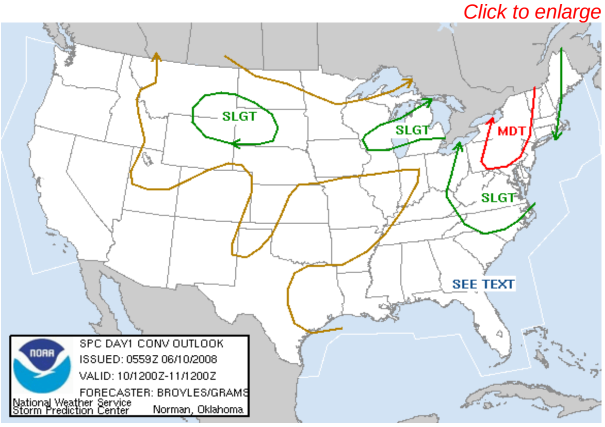

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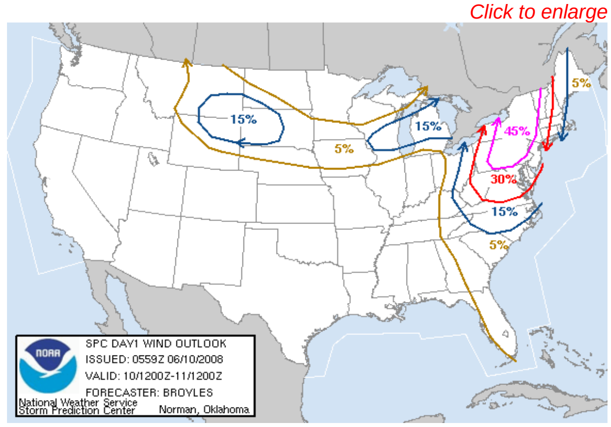

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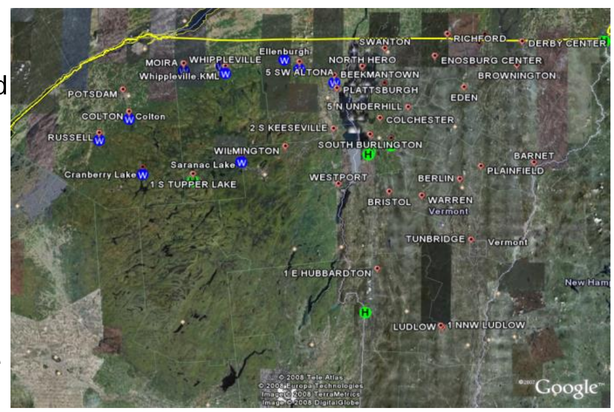

The severe weather reports included numerous trees and power lines being knocked down, from damaging thunderstorm winds up to 80 mph, along with up to golf ball size hail. The widespread severe thunderstorms produced over 50,000 power outages across northern New York and Vermont during the event. Click here to view the local storm report from the National Weather Service Office in Burlington, Vermont. Meanwhile, the image to the right shows a plot of all the severe weather reports across our forecast area. Remember, National Weather Service severe weather criteria is three quarter inch hail or larger (indicated by the green circles), thunderstorm wind gusts 58 mph or higher which may cause tree or property damage (indicated by the blue circles), and tornadoes of any intensity.

The large scale pattern on June 10th featured a departing mid/upper level ridge along the eastern seaboard, which provided our region with surface temperatures well into the 80s and lower 90s, along with very high humidity levels. On June 10th Burlington reached a high temperature of 93 degrees, before the thunderstorms arrived. Meanwhile, several potent disturbances in the fast jet stream winds aloft helped to enhance a mid/upper level trough across the central Great Lakes. This energy and associated cold pocket of air at 30,000 to 35,000 feet above the surface interacted with a very moist and unstable air mass at the surface to produce several rounds of significant severe weather across the WFO BTV county warning area (CWA).

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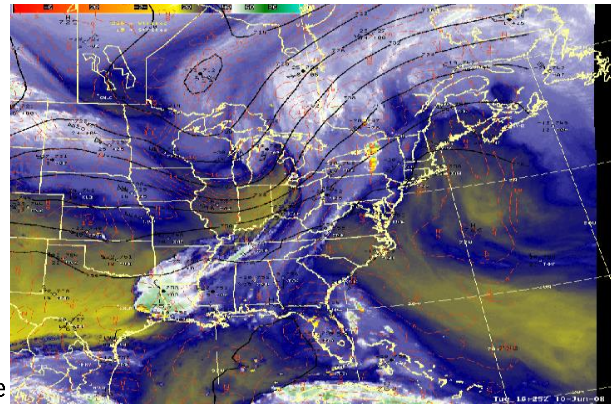

The first round of severe thunderstorms occurred between noon and 4 PM and was associated with a weak pre frontal surface trough and embedded disturbance aloft. The second round of storms occurred between 6 PM and 10 PM, which featured a sharp cold front, along with another potent disturbance in the winds aloft. This setup of two rounds of significant severe weather is unusual across our forecast area, due to the fact many times the rain-cooled air associated with the first round stabilizes the atmosphere and limits the overall severe weather threat associated with the second round of storms. Figure 4 shows a water vapor loop, along with lightning activity (indicated in red/white), and movement of several disturbances aloft (shown in red) from 1225 PM through 700 PM on June 10th. The image shows two distinct rounds of storms across our county warning area, which is shown by the lightning activity. In addition, note the significant drying/subsidence aloft across the Ohio Valley and eastern Great Lakes associated with potent short wave energy and digging mid/upper level trough.

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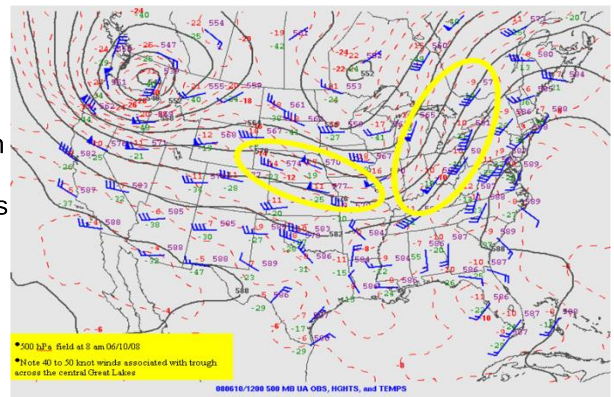

Figure 5 shows the upper air analysis at 500hPa (near 20,000 feet) on June 10th at 8 AM. Note the digging trough across the central and western Great Lakes, along with several embedded jet couplets. As the trough moved into our region, these jet couplets helped to enhance lift for thunderstorms and created an environment favorable for severe thunderstorm winds. Finally, the red dash lines show temperatures at 500hPa with -9C across our region and near -20c associated with the trough across the northern Great Lakes. This cooler air aloft helped to enhance thunderstorm development for the second round of convection across our forecast area and provided favorable conditions aloft for large hail. For example, golf ball size hail was observed at Tupper Lake, NY associated with the second round of storms. Meanwhile, the upper air analysis at 250 hPa (not shown) revealed a developing 100 knot jet approaching our western forecast area by 8 PM on June 10th.

Pre Storm Thermodynamic Environment

The pre storm thermodynamic environment featured a very warm air mass in place with surface temperatures well into the 80s and lower 90s. In addition, to the warm surface temperatures, plenty of low level moisture was available with dewpoints in the 60s to lower 70s ahead of the approaching cold front. These temperatures combined with plenty of moisture contributed to a very unstable atmosphere (with respect to vertical air motion), which produced robust updrafts and towering cumulus clouds.

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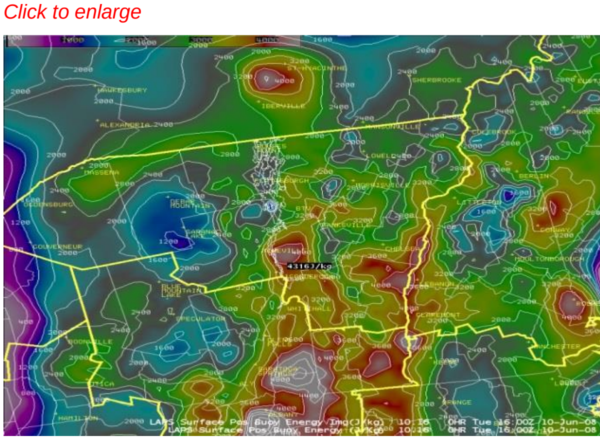

Figure 6 shows a noon time analysis of surface based Convective Available Potential Energy (CAPE). CAPE is effectively the positive buoyancy of an air parcel and is an indicator of atmospheric instability. Note the surface based CAPE axis of 2500 to 3500 j/kg across the central and southern Champlain Valley, along with another axis across the Saint Lawrence Valley.

This diagnostic helps forecasters identify areas of maximum instability and the potential for severe thunderstorms, if vertical wind shear and a lifting mechanism are also present. Furthermore, CAPE values ranged between 3000 and 4000 j/kg across the Connecticut River Valley. Many times the warmest temperatures and highest CAPE values are located in the valleys, where the atmosphere is the most unstable.

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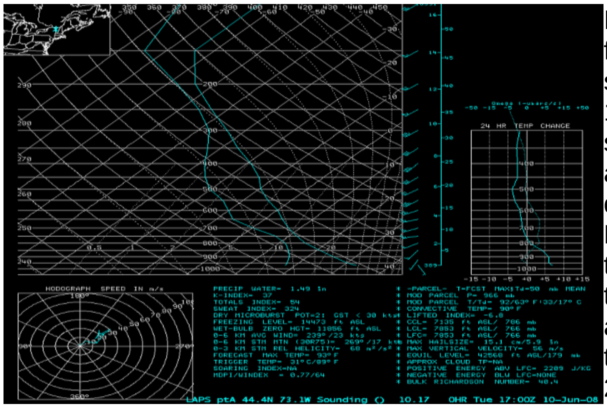

In addition to plenty of low level instability, the atmosphere featured strong winds from 4,000 feet to 30,000 feet above the surface. These winds included speeds of 30 to 40 knots at 10,000 feet and between 40 and 50 knots at 30,000 feet. These strong winds and the amount of available CAPE in the atmosphere, were excellent indicators for thunderstorm development, with the primary threat being severe winds. Furthermore, forecast soundings at Burlington showed some turning of the low level wind field, which helped to enhance the 0 to 1 KM shear values. From figure 7, which is a vertical sounding at Burlington Vermont at 1 PM, notice the southeast winds of 5 to 15 knots near the surface, shifting to the southwest between 2000 and 4000 feet. Also, note the CAPE value of 2200 J/kg and precipitable water value near 1.50 inches. These values suggested the potential for strong to severe thunderstorms capable of producing damaging winds and very heavy rainfall. However, with the freezing level around 14,000 feet, the potential of severe hail would be limited to the strongest storms, with the greatest vertical development, due to the extremely high freezing level

Radar Analysis

The June 10th severe weather outbreak featured two distinct rounds of convection across the WFO BTV forecast area. The first round of convection developed around noon over eastern Lake Ontario and moved into the northern Adirondack Mountains and the Champlain Valley by 2 PM, and then across central and eastern Vermont by 4 PM. The first line of convection produced numerous trees down across St Lawrence County and northern New York, along with damaging winds between Shelburne and Williston, Vermont. An Automated Weather Observing Station (AWOS) at Potsdam measured a 58 mph wind gust, while winds were estimated at 70 mph at North Hero, associated with the first line of convection. In addition to the damaging thunderstorm wind gusts, one inch diameter hail was observed at Shelburne, Vermont at 225 PM.

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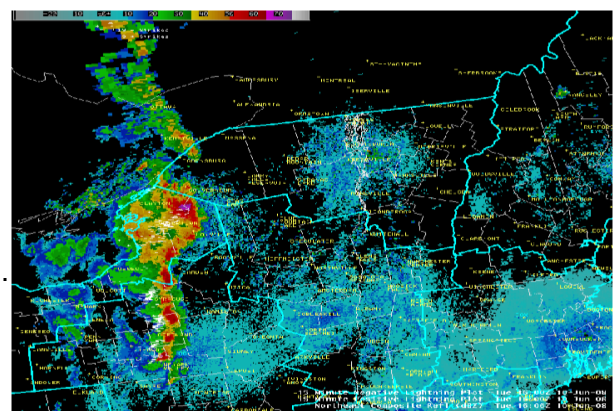

Figure 8 below shows a composite reflectivity radar loop from Noon through 4 PM, along with lightning activity in white. First, note the very strong storm with (65 to 70 DBZ) the purple reflectivity returns across St Lawrence County, and northern New York along with the associated cloud-to-ground lightning strikes.

Then notice the line redeveloping across the Champlain Valley around 2 PM with more purple returns in the reflectivity structure.

Given the large scope of severe weather and numerous reports of damaging winds associated with the first line of convection, we will closely investigate the bow echo which occurred over northern New York, and the storm which tracked from Shelburne to Williston, Vermont.

The first significant line segment with an embedded bow echo tracked across southern St Lawrence County and into the western Adirondack Mountains in northern New York between noon and 1:30 PM. This storm produced widespread wind damage with numerous trees and power lines being knocked down between 12:30 PM and 1:30 PM on June 10th. At 1:19 PM a measured thunderstorm wind gust to 59 mph was observed at Malone, New York.

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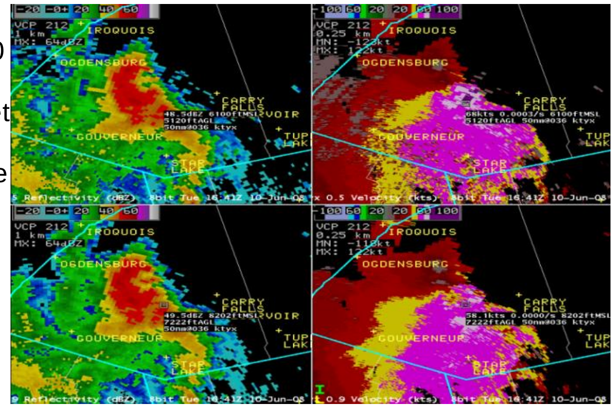

Figure 9 shows the 0.5 and 0.9 elevation slices from the KTYX radar at 12:41 PM. Due to the location of the cells being 40 to 50 nm away from the KTYX radar site and the radar located on top of the Tug Hill Plateau, we can only view the storms at 5,100 feet above the ground and higher at the lowest elevation slice. The radar reflectivity (images on the left below) shows a little bow like structure, but given the elevation, the structure is not all that impressive. Meanwhile, the velocity (image on the right side below) shows outbound velocities of 60 to 70 knots at 5,100 feet above the ground across central St Lawrence County. The highest velocities were located at the leading edge of the strongest reflectivity core and were associated with the rain-cooled outflow air moving away from the radar site and outward from the thunderstorm.

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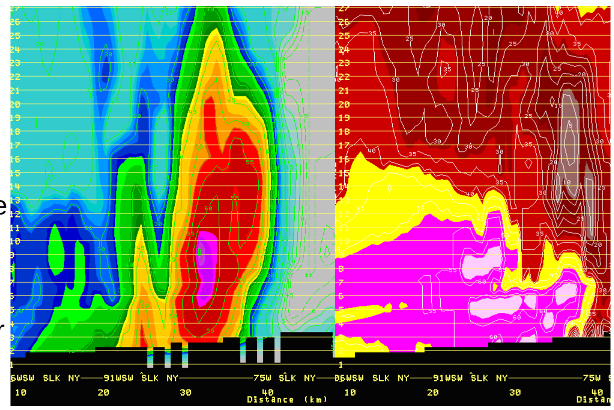

Figure 10 shows a reflectivity and velocity cross section taken from the KTYX radar at 12:23 PM, as the storms were entering southern St. Lawrence County. This particular storm featured a 60 to 65 DBZ core to 13,000 feet, along with outbound velocities of greater than 60 knots. This is indicated by the white color in the image below on the right. In addition, the outbound flow between 4,000 and 7,000 feet, along with the steep leading edge of the reflectivity gradient, may suggest the development of a shelf cloud. A shelf cloud develops by cool air sinking air from a storm′s downdraft and spreads out across the surface with the leading edge called a gust front. This outflow undercuts warm air being drawn into the storm's updraft. As the cool air lifts the warm moist air, water condenses creating a shelve cloud. Severe thunderstorm winds are usually located just along or behind the shelve cloud feature. Finally, some broad 25 to 30 knot inbound and outbound rotation was observed from 5,000 to 7,000 in the comma head portions of this storm, but due to poor radar sampling this image will not be displayed.

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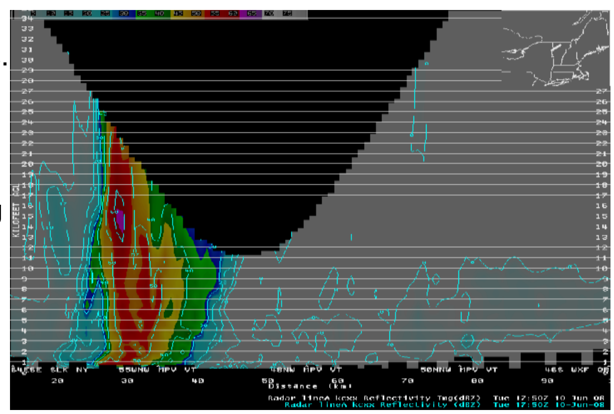

The Shelburne to Williston, Vermont storm produced 1 inch diameter hail near Shelburne, causing damage to roofs and cars. This cell also produced severe winds, which knocked down numerous trees and power lines near Williston. Figure 11 shows a reflectivity cross section loop of the storm, which tracked from Shelburne to Williston. Note the white 70 to 75 DBZ reflectivity core at 18,000 to 23,000 feet above the ground. This very strong reflectivity core aloft is produced by extreme unstable air being advected into the storms updraft. This very strong reflectivity core aloft, probably contained large hail and very heavy rainfall. Furthermore, when the core collapsed, the strong winds aloft were transported to the earth′s surface. Notice at the beginning of the loop, the very strong reflectivity returns of 60 to 70 DBZ at 15,000 feet above the surface, but as the loop moves through time, the stronger reflectivity returns descend toward the surface. This is associated with the storm collapsing, because the updraft (air rising) can not hold the hail and heavy rainfall aloft any more, which results in very heavy rain, damaging winds, and large hail reaching the surface. Sometimes, if the atmosphere is extremely unstable, like on June 10th, thunderstorms can go through several updraft and downdraft cycles.

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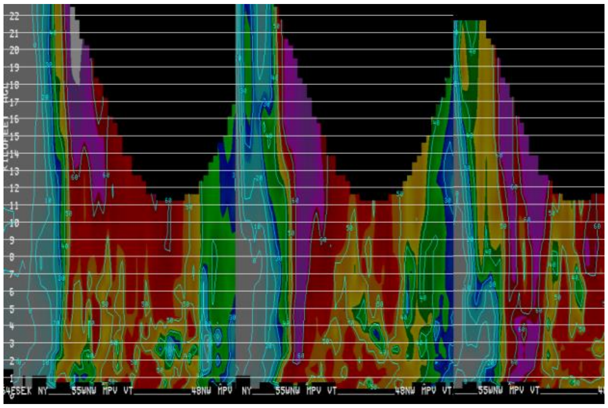

The radar reflectivity cross section above (figure 12) shows the collapsing thunderstorm near Williston, Vermont. Notice the image on the left at 2:26 PM and the 70 to 75 DBZ between 18000 and 22000 feet above the surface. The middle image (taken at 2:32 PM) shows the descending 60 to 65 DBZ reflectivity core toward the surface. This was very close to the time when strong damaging winds were occurring in the Williston area. Finally, the last image on the right (taken at 2:36 PM) shows the very strong descending reflectivity core to the surface, which produced severe thunderstorm winds, heavy rain, and hail. In addition, due to the proximity of the storm to the KCXX radar, some data were unavailable due to the cone of silence. This is caused by the radar only being able to tilt 19.5 degrees above the surface, therefore reflectivity returns at high altitudes close to the radar are not detected. This results in warning meteorologists having to use surrounding radars at greater distances to investigate storms in the cone of silence.

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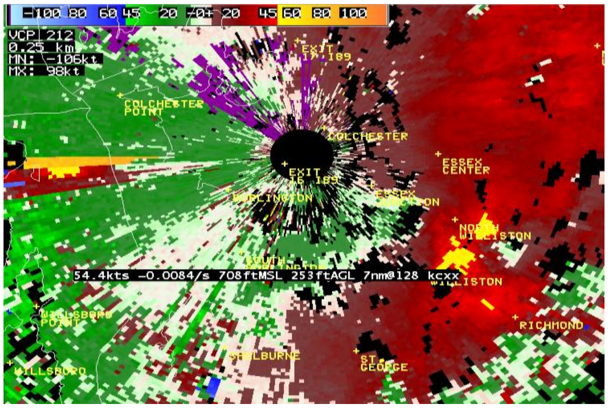

Figure 13 shows a velocity image at 2:36 PM of the storm near Williston, Vermont. The yellow area on the image below indicates outbound winds greater than 50 knots moving away from the radar (toward the Green Mountains to the east).

These very strong thunderstorm winds were produced by the storm collapsing and pulling down the stronger jet stream winds aloft toward the surface. These winds produced widespread tree damage in and around the town of Williston.

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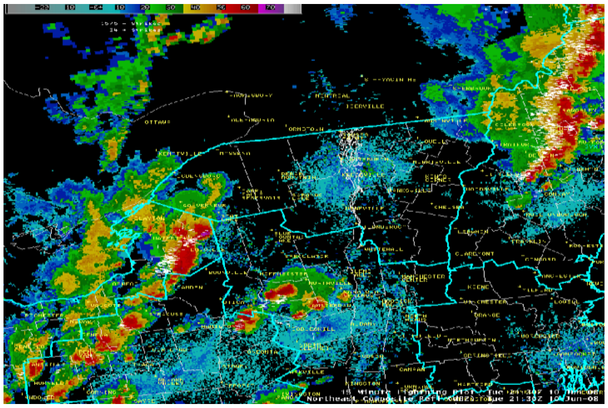

The second line of damaging thunderstorm winds and up to golf ball sized hail occurred between 6:30 and 10:00 PM. We will first investigate the storm, which tracked across northern New York between 6:30 and 7:00 PM and produced golf ball size hail near Tupper Lake, New York and widespread tree damage. Next, we will examine the storm which impacted the Champlain Valley around 7:30 PM and created a very dramatic shelf cloud structure. Figure 14 is a composite reflectivity loop with lightning from 530 PM to 10:00 PM. Note the several embedded lines of strong to severe thunderstorms that develop across our forecast area ahead of the approaching cold front. In addition, note all the lightning activity associated with these thunderstorms.

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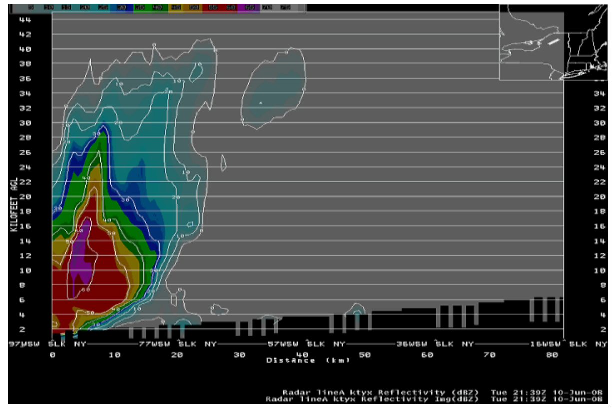
The next image (figure 15) is a reflectivity cross section taken near Tupper Lake, New York between 5:48 PM and 6:19 PM. The image below shows an extremely strong (70 to 75 DBZ) reflectivity core aloft, along with a forward tilt to the vertical reflectivity structure. The strong reflectivity core aloft, indicated large hail, while the forward tilt suggested strong deep layer winds were impacting the storm, which can enhance the potential for severe thunderstorm winds, if transported to the surface in a downdraft. Furthermore, at the beginning of the loop, note the strong 60 to 65 dBZ reflectivity core aloft, associated with the storm updraft. Meanwhile, toward the end of the reflectivity loop you can notice a bow echo structure in the vertical, as a descending rear inflow jet develops.



At 7:33pm, the line segment with several embedded bow like structures was approaching the Champlain Valley. In addition, note the comma head structure to the reflectivity gradient between Plattsburgh and Dannemora, NY. The apex of the bow echo structure, which is located just east of Colchester Point at 7:30 PM tracked northeast toward Milton, Vermont. This produced numerous trees down and a very interesting cloud structure near the City of Burlington. Figure 16 below shows the velocity and reflectivity structure associated with the storm approaching Burlington, VT. The velocity data located on the upper right clearly shows all inbound winds of 40 to 50 knots coming toward the KCXX radar, which is shown in the blue color. In addition, the radar shows no outbound velocity couplet, which would have suggested potential rotation in the storm. Meanwhile, the 0.5 degree reflectivity (upper left) shows a bow like structure to the reflectivity gradient. This low level reflectivity gradient structure supports the potential for straight line wind damage.

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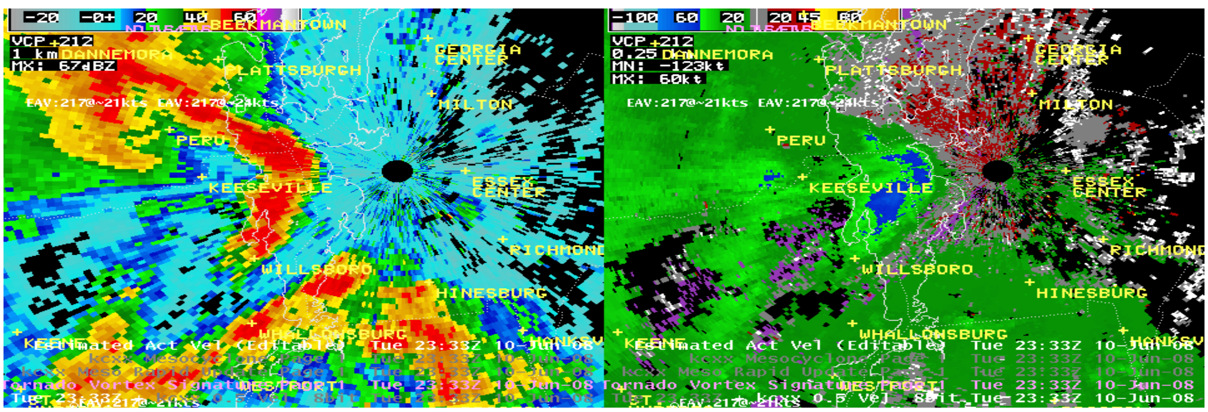

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Furthermore, Figure 17 shows the shelf cloud, which occurred with this velocity and reflectivity structure across Burlington and the Champlain Valley on June 10th around 7:35 PM. Note winds in the picture are blowing from west to east, based on the trees, which is the same direction the clouds are moving. The wind direction and cloud movement is toward the radar, because the picture is taken from Overlook Park in South Burlington, Vermont looking north toward the City of Burlington. The low hanging shelf cloud is developed by cool outflow air undercutting warm moist air being drawn into the storm's updraft. As the cool air lifts the warm moist air, (because cold air is more dense and tends to be near the surface), water condenses, creating a shelf cloud like that shown in Figure 17. We received numerous photos of this low hanging cloud structure, but no picture showed any vertical column with rotation. These pictures combined with very good radar sampling, confined no tornados developed across Burlington on June 10th.

Summary & Photos

This severe weather event on 10 June 2008 produced over 50 reports of severe weather, along with widespread power outages across northern New York as well as central and northern Vermont. In addition, damaging hail up to golf ball size and thunderstorm wind gusts to 60 mph occurred with this significant severe weather outbreak. The pictures below were taken by Brooke Taber and Scott Whittier of WFO BTV. The pictures were taken of damage in the Williston and South Burlington areas of the Champlain Valley.

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