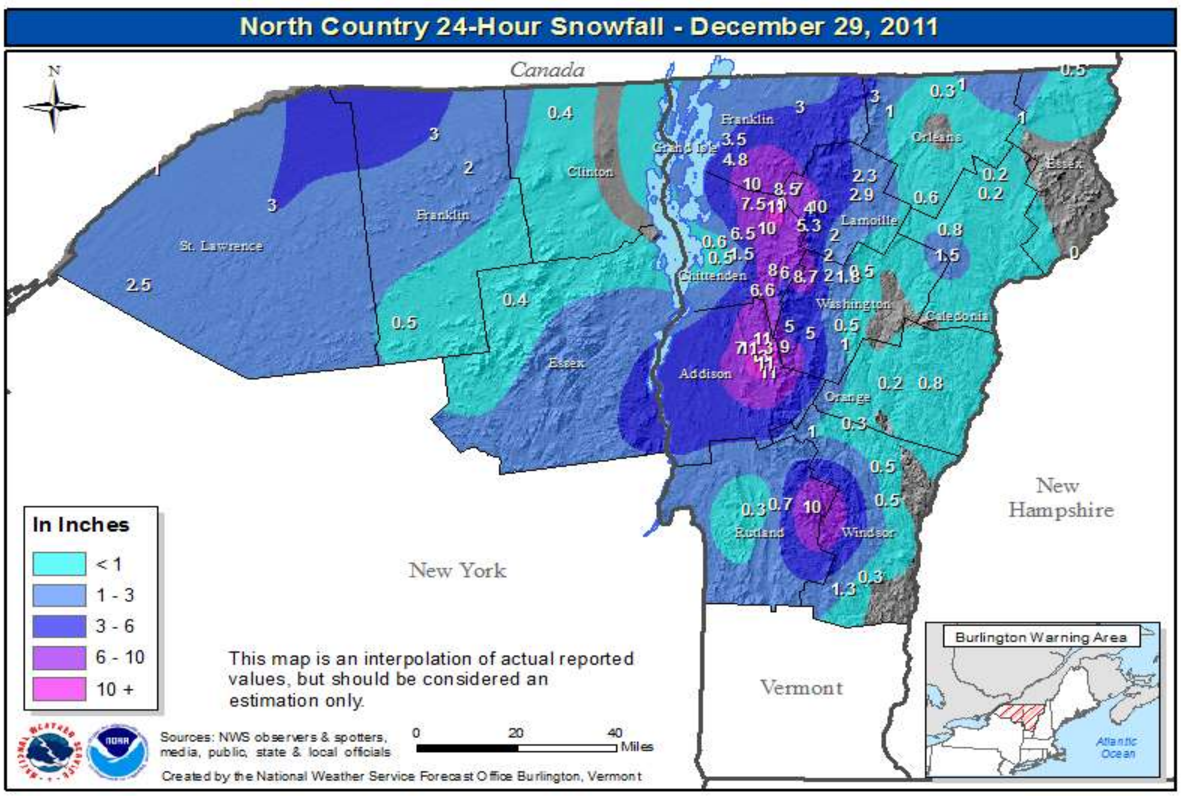
The Localized Upslope Snow Event on 28 December 2011

Introduction

On 28 December 2011 an arctic front moved across the North County and produced localized heavy snowfall across the western slopes of the Green Mountains. This arctic front was accompanied by gusty northwest winds and rapidly falling temperatures, which created extremely hazardous driving conditions across northern New York and most of Vermont during the afternoon and evening hours. Numerous car accidents were reported on area roadways, with a section of Interstate 89 being closed for several hours. Temperatures ahead of the arctic front were well into the 30s to near 40 degrees initially, so when the rain and snow showers fell, they melted on contact with the road surfaces. However, temperatures fell at a rate of 7 degrees per hour behind the front during the afternoon hours, creating a "flash freeze" and extremely slippery driving conditions. As winds shifted to the northwest, an upslope snow event developed along the western slopes of the Green Mountains in Vermont and parts of the northern Adirondack Mountains in New York. A wide range in snowfall totals were reported across Weather Forecast Office Burlington, Vermont's (WFO BTV) area with just a dusting across the immediate Champlain Valley to over a foot near Lincoln, Vermont in Addison County. In addition, 1 to 4 inch amounts were common across the northern Adirondack Mountains in New York. Click here for a complete listing of snowfall total across WFO BTV county warning area. Figure 1 below shows the 24 hour snowfall accumulations across the North Country ending at 7 AM on 29 December 2011.

Click to enlarge



Synoptic Pattern (Large Scale)

Click to enlarge

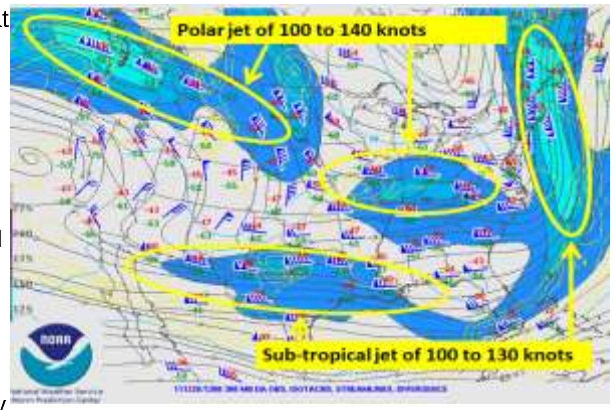


Figure 2a shows that a complex upper level pattern at 300 hPa, associated with a split flow between the northern and southern stream jets, occurred during this event. Initially, a large plume of sub-tropical moisture moved from the Gulf of Mexico into the northeast United States associated with the southern stream, during the evening hours on December 27th.

This strong upper level jet of 100 to 130 knots helped to promote significant lift across our region, aiding in the development of widespread precipitation on the warm side of the system. Also, seen in figure 2a, potent energy in the northern jet stream and the associated arctic front quickly moved in behind the area of low pressure, causing temperatures to quickly drop, along with scattered snow showers.

Click to enlarge

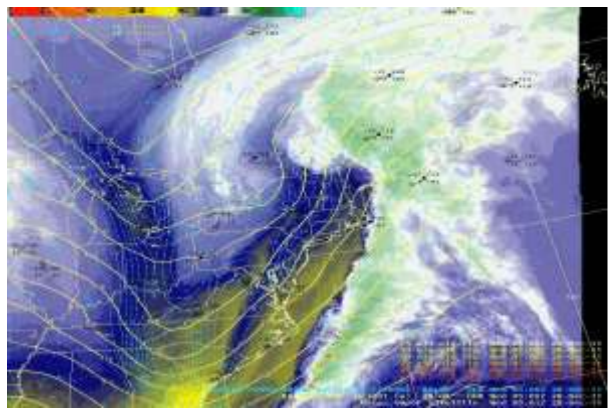


Figure 2b shows a water vapor loop on 28 December 2011 from 0501 UTC (1201 AM EST) to 2301 UTC (601 PM EST) with RUC 400 hPa height (yellow), 700 hPa to 300 hPa vorticity (light blue), and 400 hPa upper air (plotted black). The brighter greens show the sub-tropical moisture plume associated with the southern stream jet.

Meanwhile, a secondary area of enhanced mid-level moisture and associated vorticity rotated across our northern areas during the afternoon hours on December 28th. This moisture and lift aided in the development of more snow during the evening commute on the 28th.

Click to enlarge

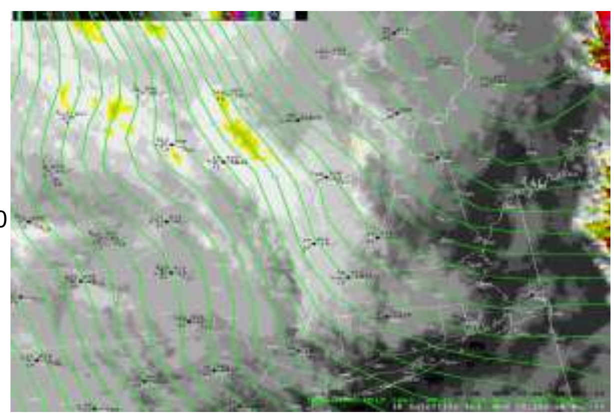


Figure 3 shows the infrared satellite loop from 1515 UTC (10:15 AM EST) to 2345 UTC (6:45PM), along with MSAS mean sea level pressure (green lines). Note the enhanced area of cloud cover (brighter yellow) just west of the Green Mountains and over the Champlain Valley on the 28th of December.

This enhanced area was caused by the secondary 500 hPa vorticity maximum mentioned above, which produced additional atmospheric lift combined with leftover moisture behind the arctic front. This energy and moisture aloft combined with favorable conditions in the low levels, produced ideal conditions for a localized snow event across portions of the Green Mountains.

Click to enlarge

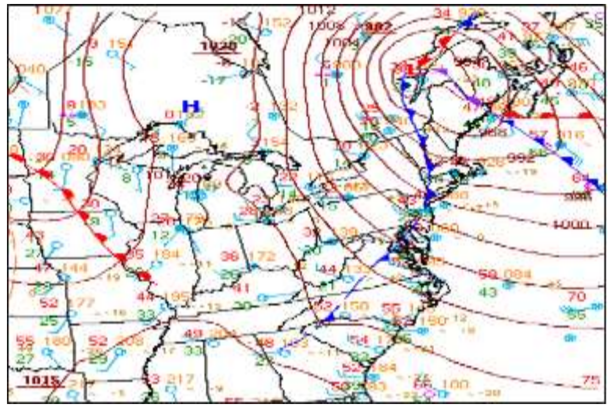
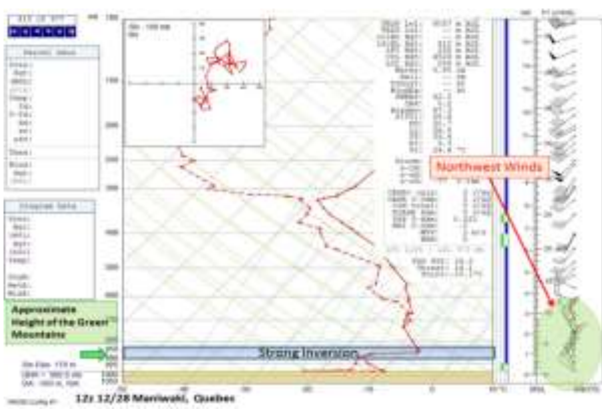


Figure 4 is a surface analysis performed at 1800 UTC (1 PM EST) which clearly shows the passage of the arctic cold front located across eastern Vermont, with surface low pressure over northern Maine.

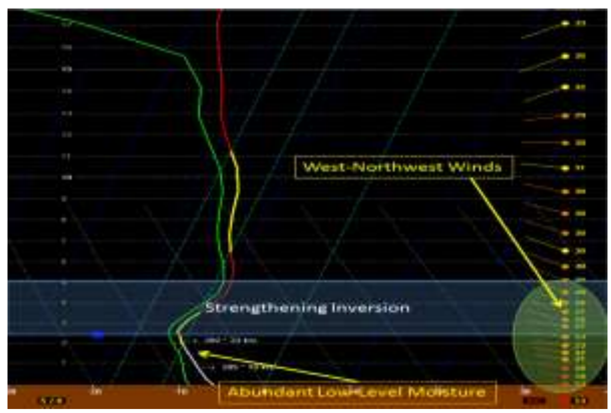
The counter-clockwise circulation around low pressure helped to push very cold air across our region, on gusty northwest winds of 15 to 30 mph. The combination of building high pressure and departing low pressure created a strong pressure gradient over the North Country, resulting in gusty west to northwest winds and bitterly cold wind chill values.

Mesoscale Setup (Small Scale)

One of the main pieces of information needed to understand this event as well as other similar localized events is knowledge of the terrain of Vermont. The Green Mountains, with peaks as high as 4395 feet (Mount Mansfield) run primarily north to south through the central portion of the state. These features greatly affect the weather within the state, and especially on days like December 28th. After the passage of the cold front, cold west to northwest winds rushed into the region rapidly cooling off the low levels of the atmosphere and creating an inversion layer in the atmosphere between about 2500 feet and 5000 feet above mean sea level (colder air below with increasing warmth through the layer). Inversion layers are very stable portions of the atmosphere that limit the amount of vertical motion through the layer. The inversion can be seen in Figure 5A showing an upper air sounding taken at 1200 UTC (7:00 AM EST) in Maniwaki, Quebec before the cold air rushed into Vermont. Figure 5B also shows the inversion in a morning forecast sounding for Burlington, VT for later that afternoon.



Click to enlarge



Click to enlarge

Click to enlarge

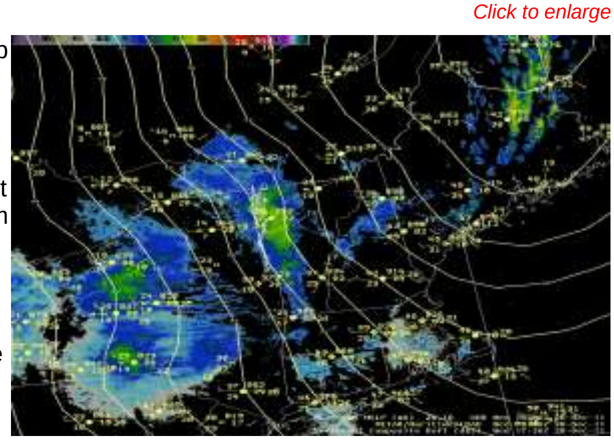


Figure 6 shows a radar mosaic composite reflectivity loop from 1736 UTC (1236 PM EST) to 2354 UTC (654 PM EST) on 28 December 2011. The combination of brisk west to northwest winds of 15 to 30 mph pushing up against the higher terrain of the Green Mountains, and strong low level cold air advection, helped to squeeze out additional moisture to produce localized heavy snow from Jay Peak to North Underhill to Killington.

The radar loop shows the stronger reflectivity (brighter yellows/oranges) representing higher snowfall rates across the eastern portion of the Champlain Valley to the western slopes of the Green Mountains. The image also shows very limited activity east of the Green Mountains, due to the low level blocking signature associated with the developing temperature inversion, which prevented the snow from spreading into central and eastern Vermont.

Click to enlarge

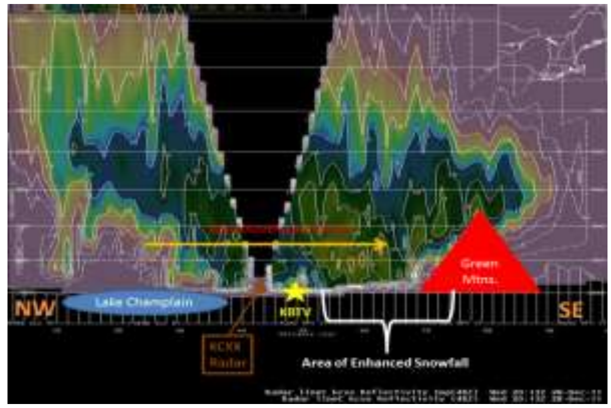
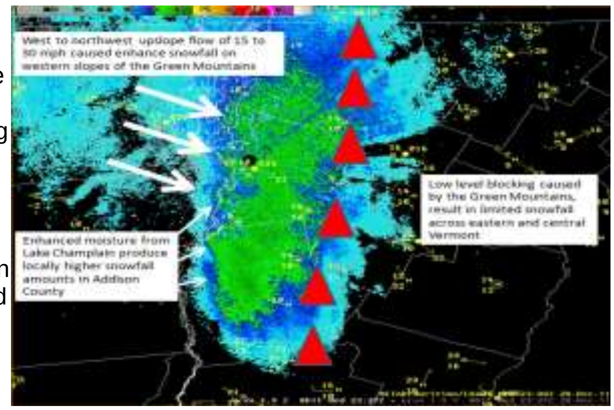


Figure 7 is a northwest-southeast oriented cross-section of radar reflectivity from the Colchester radar. It depicts the west-northwest winds and stronger/higher radar reflectivity values (yellow/orange colors) just west of the spine of the Green Mountains with a dramatic cutoff to the east.

During the overnight hours, drier air worked into the region, ending the snow. Please note in the image the black area above the KCXX radar is the cone of silence, where the beam is unable to detect precipitation due to the lack of scans above 19.6 degrees.

Click to enlarge



On an even smaller scale, within the band there was an area of higher radar reflectivity returns and heavy snow over portions of Addison County. This is believed to have been caused by additional moisture and instability in the lowest levels of the atmosphere added by cold air moving over Lake Champlain. Figure 8 shows the KCXX 1.5° reflectivity on 28 December 2011 at 2327 UTC (627 PM EST), along with surface observations (plotted yellow). The image below shows narrow bands of enhanced lake effect snow streamers, especially across parts of Addison County. This additional moisture and instability, was lifted by the western slopes of the Green Mountains, to produce over 12 inches of snow at Lincoln, Vermont in eastern Addison County. Furthermore, the radar and surface observations show very little snow making it into central and eastern Vermont, caused by the orographic blocking signature. Also, from the image you can see plenty of radar activity near Burlington, Vermont, but strong west to northwest winds pushed heavier snow against the Green Mountains, and resulted in very limited snowfall amounts across the immediate Champlain Valley. A very sharp snowfall gradient was observed from only a dusting at Burlington to 6 inches in Essex Junction, to 11 inches in North Underhill, Vermont.

Conclusion

On 28 December 2011 a localized heavy snow event occurred along and just to the west of the Green Mountains. A sharp cold frontal passage, increasing west-northwest winds, and plenty of lingering low-level moisture were the main contributors to the event. Snow showers developed as colder air pushed eastward into Vermont and organized into a band of heavy snow situated just over and just west of the Green Mountains as the cold frontal inversion strengthened, blocking the westerly flow and trapping moisture and snow along the mountains. Area roadways quickly became icy and snow covered, resulting in many car accidents and even the closure of I-89. Figure 9 below shows the back-up of traffic on I-89 due to the closure. By the time all was said and done, snowfall amounts ranged from a half inch or less near Burlington to as much as 8-13" in the hardest hit locations just west of the spine of the Green Mountains.

Click to enlarge