



The Four Seasons



National Weather Service Burlington, VT

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WINTER 2016-17

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Letter from the Editors

Welcome to the Winter edition of *The Four Seasons*, a quarterly newsletter issued by the National Weather Service in Burlington, VT. In this edition we review a noteworthy early season snowstorm that occurred this past October and the 2007 Valentine's Day snowstorm. We discuss the drought that has been affecting the North Country then look at some winter climate statistics as well as the outlook for the 2016-2017 winter season. We delve into several new features available on our webpage. Closing out the newsletter are a few articles of recent activities our staff has had inside and outside of the office. Thanks for reading, we hope you enjoy the newsletter and Happy Holidays!

10 Year Anniversary: The Valentine's Day 2007 Snowstorm

-Peter Banacos

One of the most significant snowstorms in North Country weather history occurred ten winters ago, affecting Vermont and northern New York on Wednesday, 14 February 2007. Widespread 20 to 30 inch snow amounts were received from the Adirondacks eastward across much of central and northern Vermont, with isolated amounts near 3 feet (Figure 1, on next page). The storm set a new 24-hour snowfall record in Burlington, Vermont at 25.3 inches, exceeding the previous mark of 23.1 inches set on 14 January 1934 (a record that still stands as of this writing). The Burlington storm total snowfall of 25.7 inches for the Valentine's Day 2007 event remains the fourth largest 3-day snow total on record (Table 1). The Public Information Statement containing these snowfall amounts can be found [here](#).

Table 1.
Largest Snowfall Totals over 3 days in Burlington, VT History
(Records began in 1883)

Rank	Date	Snowfall (Inches)
1	January 1-3, 2010	37.6"
2	December 26-28, 1969	29.7"
3	March 6-8, 2011	25.8"
4	February 14-16, 2007	25.7"
5	January 13-15, 1934	24.8"



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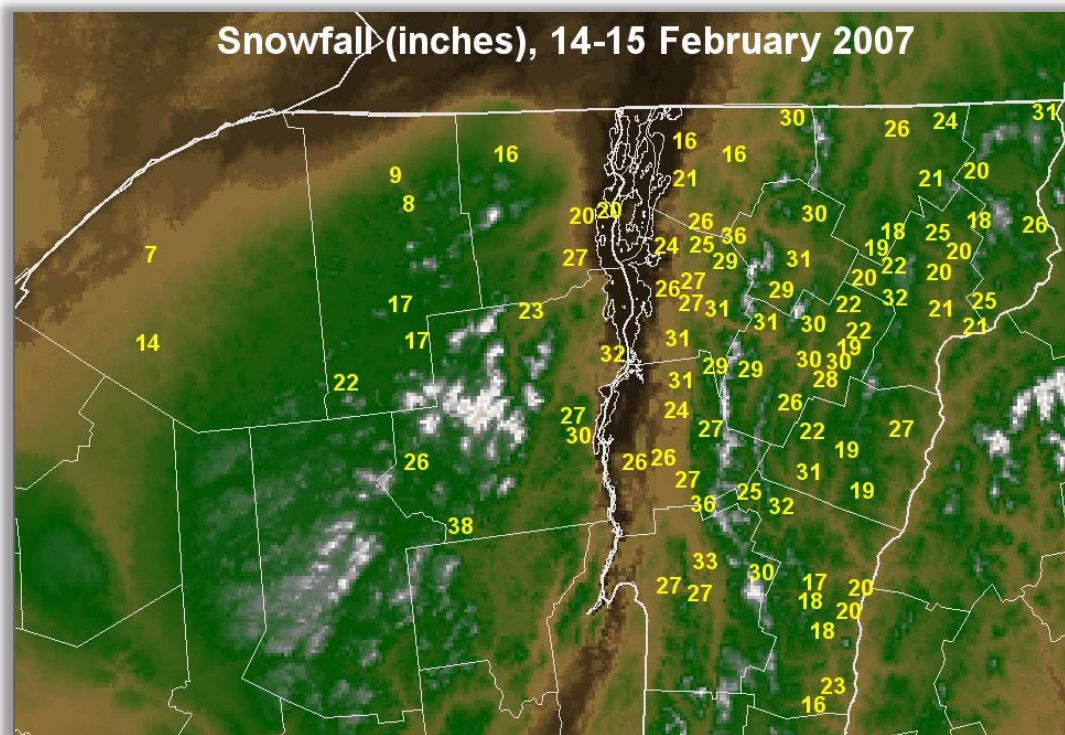


Figure 1. Snowfall totals (in inches) across the WFO Burlington forecast area on 14-15 February 2007. ◆

An Analysis of the 22-23 October 2016 Early Season Snow Event -Brooke Taber

A long duration precipitation event associated with a complex area of low pressure impacted the North County starting late on October 21st and continued into the early morning hours on the 23rd. Widespread precipitation amounts ranged from 1 to 3 inches across the area, with a new daily rainfall record of 1.04 inches being set at Burlington, Vermont on October 22nd. The forecast challenge was determining how quickly the rain would change to snow and the associated snow levels, followed by the potential impacts of a heavy wet snow. Temperatures were well into the 60s and 70s on Friday October 21st, but quickly dropped 15 to 25 degrees as a sharp cold front crossed the region during the afternoon hours. Figure 1 shows the sharp contrast between mid-70s temperatures across the central Champlain Valley and upper 40s over the western Adirondacks for highs on Friday, October 21st.

As cold air filtered on the backside of low pressure located over the Gulf of Maine, rain changed to snow across the northern Adirondacks in New York by mid-afternoon on the 22nd above 2000 feet and by early evening across the central and northern Green Mountains of Vermont. By early morning on October 23rd snow levels had dropped to around 1000 feet causing minor travel troubles and up to 10,000 customers to lose power across the region. Total snow accumulations ranged from nothing in the valleys below 1000 feet, but up to 9 inches atop Mt. Mansfield and widespread 3 to 6 inches over the northern Adirondacks and northern Green Mountains of Vermont. Figure 2 shows the areal distribution of storm total snowfall associated with this early season heavy wet snowfall.

Several rounds of moderate to heavy rainfall were associated with this complex area of low pressure. Initially, the heavy rain occurred across the Saint Lawrence Valley and parts of eastern Vermont, but shifted

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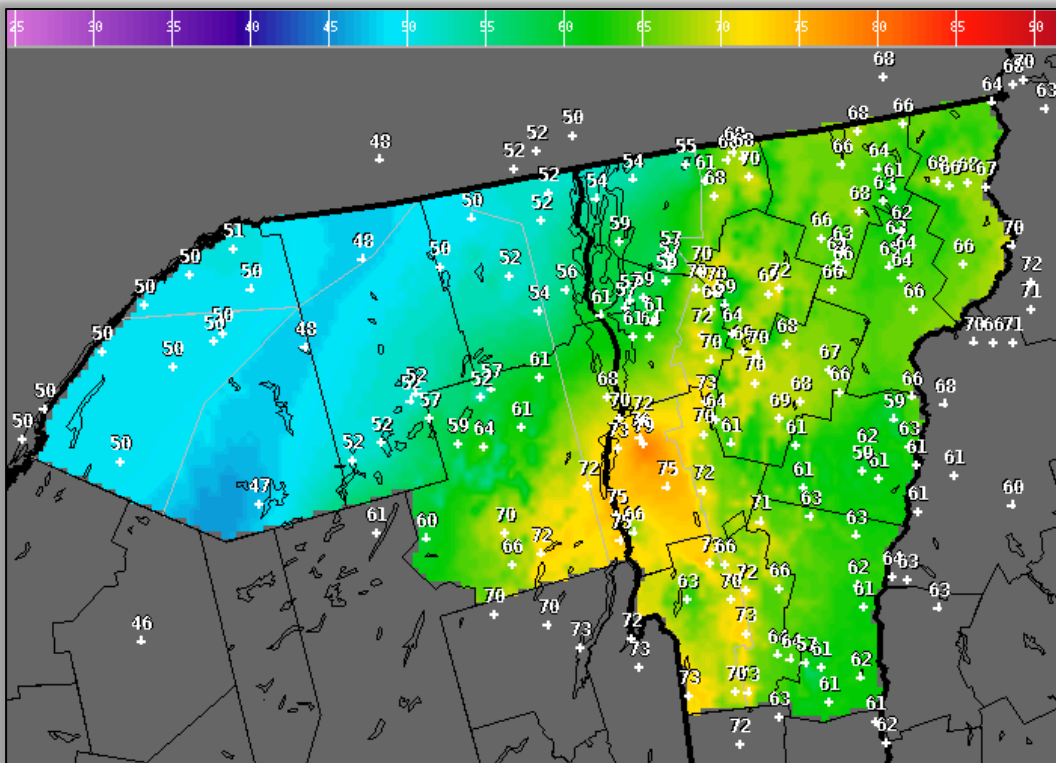


Figure 1: 24 hour high temperature (°F) ending 7 AM EDT on 22 October 2016.

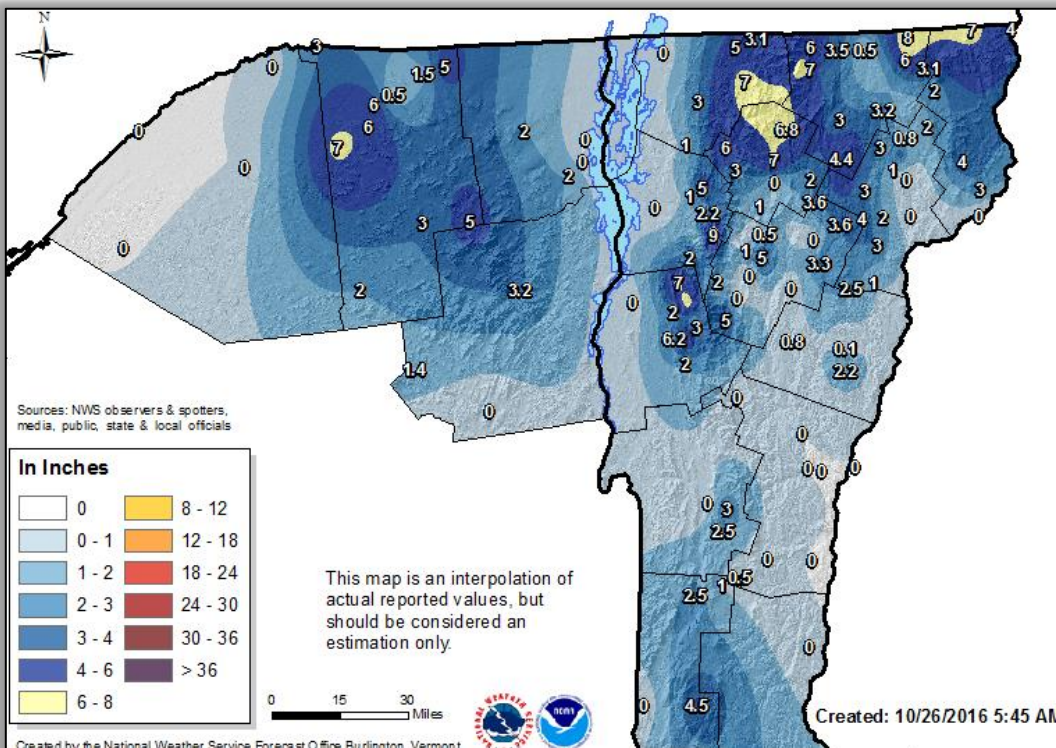


Figure 2: North Country storm total snowfall ending 23 October 2016.

into northern and central Vermont by the 22nd and became terrain focused over the mountains by early morning on October 23rd. Figure 3 shows the 24 hour precipitation ending at 7 AM on 22 October 2016, indicating an axis of 1.0 to 1.5 inches of rain across the Saint Lawrence Valley and another ribbon of heavy rainfall over eastern Vermont.

Figure 4 shows the evolution of elongated surface low pressure across the Ohio Valley/northern New York on 21 October 2016 at 8 AM (left image). This 1004mb low pressure system redevelops along the southern New England coast on the 22nd and intensifies into a 979 mb cyclone over northern Maine by early morning on October 23rd. A 25mb drop in pressure occurred in a little over 24 hours associated with rapid

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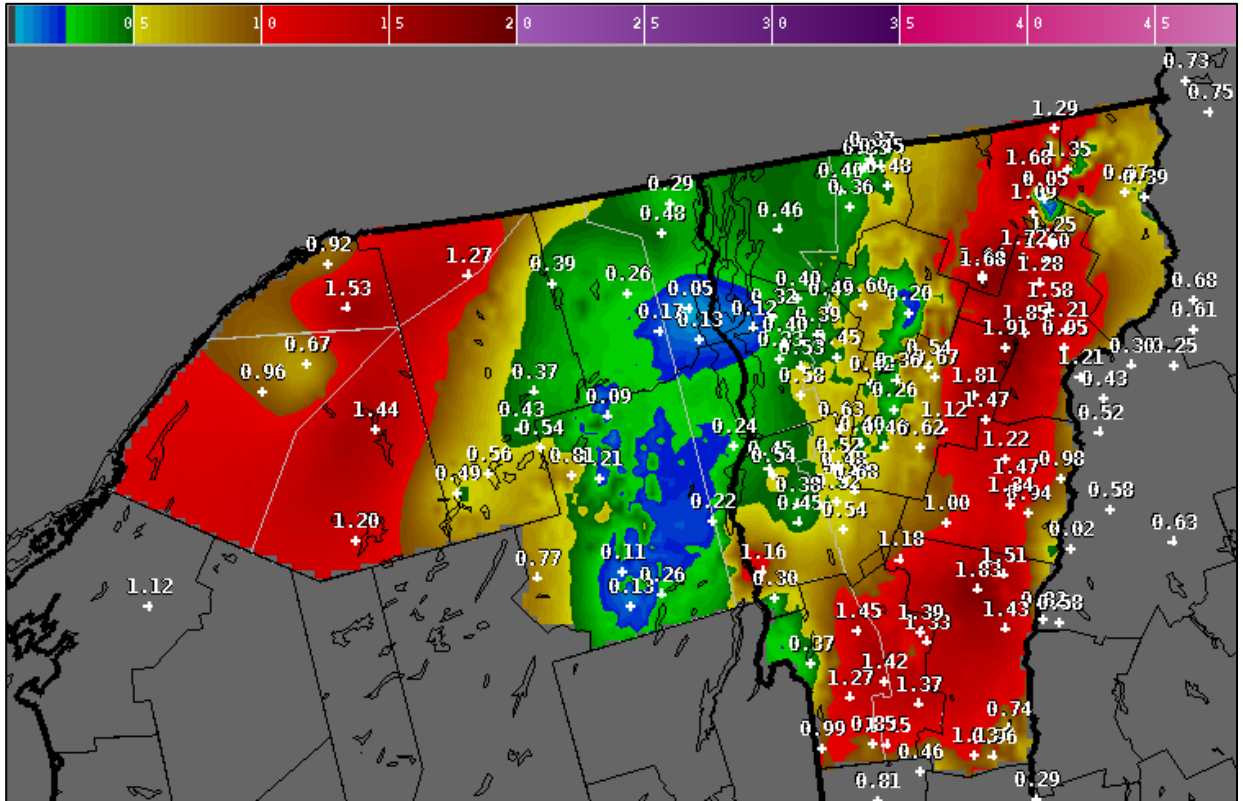


Figure 3: 24 hour precipitation (inches) ending 7 AM EDT 22 October 2016.

deepening of this system, which helped to capture cold enough air to support snow above 1000 feet overnight on the 22nd into the early morning hours on the 23rd. In addition, to the heavy wet snow, gusty northwest winds developed with Burlington, Airport gusting to 36 mph. These winds combined with the heavy wet snow caused up to 10,000 customers to lose power during the storm. The good news was temperatures climbed back into the 40s the next day and most of the snow was history. However, another heavy wet snow elevation dependent event occurred on 27-28 October 2016 causing up to 25,000 people to lose power across parts of central, eastern, and northern Vermont, as well as parts of the northern Adirondacks. This storm produced a widespread 3 to 6 inches above 1000 feet, with isolated amounts up to 10 inches near Killington, Vermont.

These two early season heavy wet snow events produced moderate impacts across the higher elevations with slippery travel and power outages. However, both events helped to provide relief from the moderate to

severe drought across the region, while increasing water levels on Lake Champlain and local streams and rivers. ♦

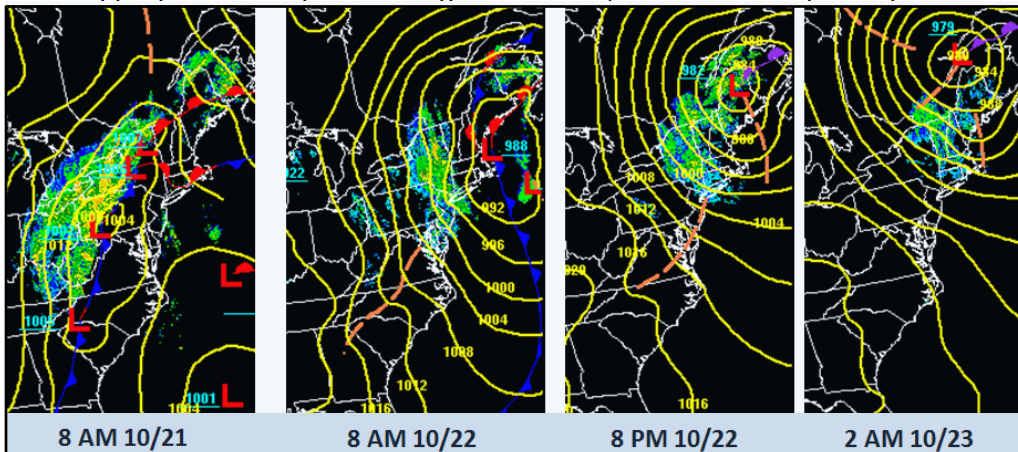


Figure 4: Surface low pressure evolution from 8 AM on 21 October 2016 to 2 AM on 23 October 2016.

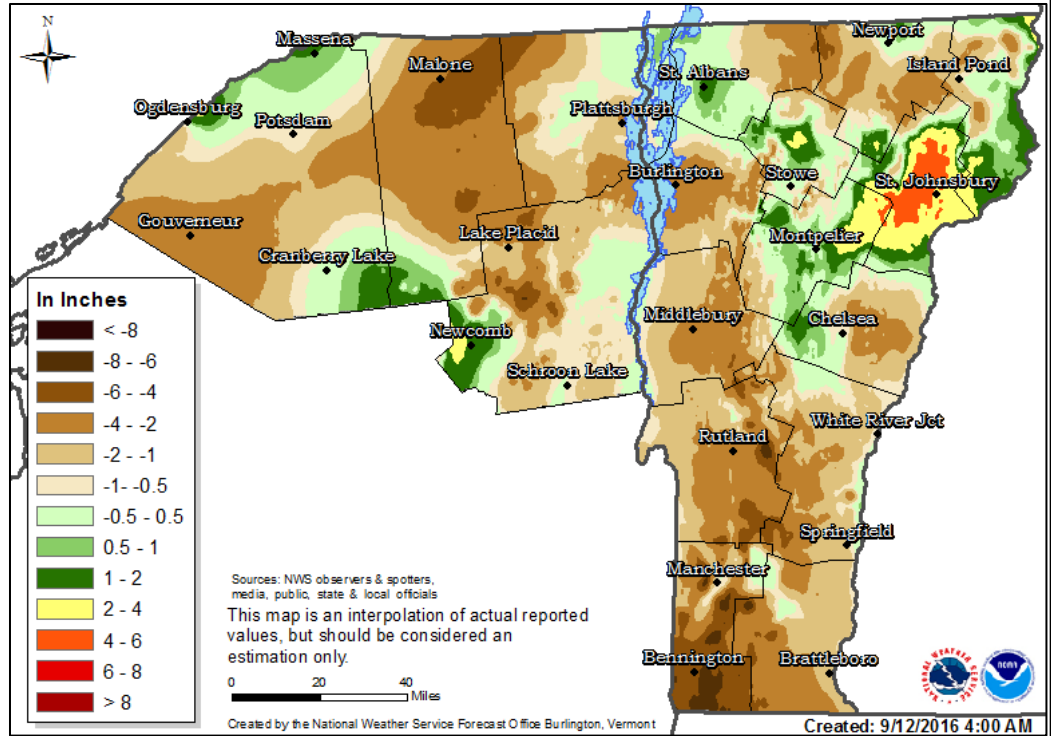
Drought in the North Country

-Greg Hanson

The overall climate in northern New York and North and Central Vermont can swing between wet and dry periods, and this summer and fall leaned toward the dry side. Precipitation across the region trended below normal for much of the region, with departures increasing in late summer and early fall. Figure 1 shows summertime rainfall departures from normal for June through August, with only portions of the Northeast Kingdom of Vermont showing areas well above normal.

The below normal precipitation culminated in a drought designation for the region by the US Drought Monitor (<http://droughtmonitor.unl.edu>). The Drought Monitor assigns an intensity level depending on

drought indicators such as precipitation, soil moisture, streamflow, as well as local drought effects. At the peak of the driest period a broad swath of D2, Severe Drought, from northern New York to southeast Vermont. Other areas of the northeast were even drier, with D3 Extreme Drought designations given to western New York and southeast New England.



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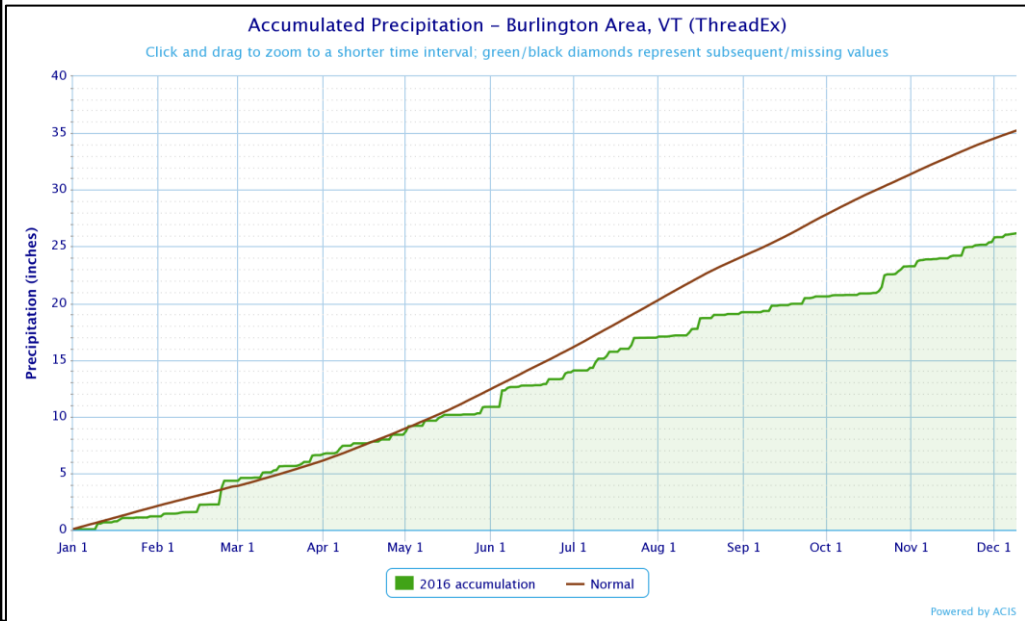
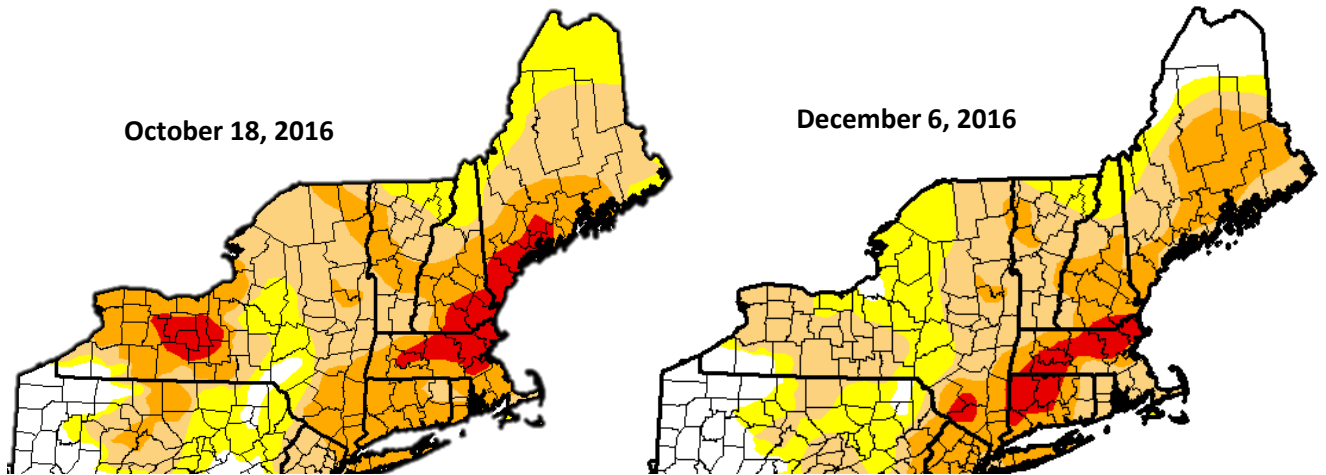


Figure 1. Precipitation Departure From Normal, June-August 2016

Figure 2. Accumulated Precipitation for 2016 through early December 2016

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By early December, precipitation returned, shrinking the area of Severe Drought. The areas of Extreme Drought also decreased in coverage as early winter progressed.



Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

U.S. Drought Monitor Northeast



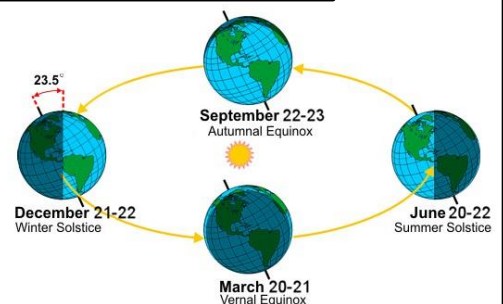
Drought can be described within several types in order to give some context of its impacts. A Meteorological Drought is usually defined by quantifying the lack of precipitation by some amount below normal. A Hydrological Drought goes a bit further, and relates the lack of precipitation to a change in river flows and groundwater levels. Hydrologic

drought can have impacts on community water supplies, river flows available for power generation, and impacts on aquatic species. There were reports of water supplies from shallow wells and springs going dry and well drillers and water haulers being very busy through late summer and early fall. Agricultural Drought becomes apparent during the growing season when the lack of precipitation affects crops and pastures. This year in some areas farmers had to irrigate more, and pasture grasses were stressed. Farm ponds and wells became stressed from increased demand.

What does the future hold? The North Country tends to see some recovery in ground water and soil moisture through fall as temperatures cool, plants die off, and evaporation slows. In the near term the weather patterns have become more active, with more frequent precipitation events at least through the first of the year. For the rest of the winter our wintertime snowpack provides a storage of water for spring runoff. ♦



Astronomical winter begins with the Winter solstice that occurs at 5:44 am EST on December 21st when the northern hemisphere is tilted away from the sun (see image to the right). Astronomical winter lasts until the Vernal, or Spring, equinox which will occur on March 20, 2017 at 6:29 am EDT (<http://www.weather.gov/cle/Seasons>). However, in the weather community, we use meteorological winter (December through February) which began on December 1st, this helps with keeping a



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consistent data set for climate seasonal records.

Table 1 shows Burlington, Vermont's most recent 30-Year Climate Normals (1981-2010): Mean Max (High) Temperature, Mean Min (Low) Temperature and Mean Average Temperature by month with the winter months of December, January and February highlighted. For Burlington, Vermont, the average or mean monthly max temperature during meteorological winter generally ranges from the mid 20s to mid 30s, while the mean monthly min temperature ranges from 10 to about 20 degrees Fahrenheit.

Month	Mean Max Temperature Normal (°F)	Mean Min Temperature Normal (°F)	Mean Avg Temperature Normal (°F)
January	27.2	10.2	18.7
February	30.6	12.5	21.5
March	40.0	22.0	31.0
April	54.7	34.8	44.8
May	67.2	45.4	56.3
June	76.3	55.3	65.8
July	80.9	60.3	70.6
August	79.0	58.5	68.8
September	70.4	50.7	60.5
October	57.2	39.1	48.1
November	45.5	30.9	38.2
December	33.2	18.5	25.8

Table 1. Climate Normal Temperatures for Burlington, VT

Figure 1 shows the yearly climate normal for snowfall at Burlington (81.8 inches) distributed by month and the map (figure 2) on the following page shows the climate normal for annual snowfall across the North Country. Note on figure 1 that the peak of snowfall usually occurs in January for Burlington. As of December 15, 2016, Burlington had 12.7 inches of snowfall since July 1, which is only 0.3 inches below normal.

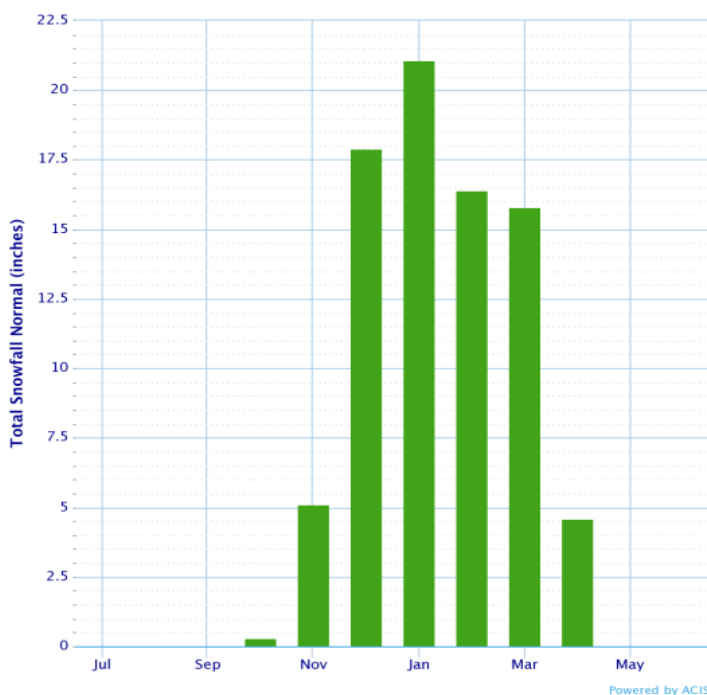


Figure 1. Monthly Climate Normals for snowfall at Burlington, VT

Looking Back at Last Winter

Meteorological winter 2015-16 at Burlington, VT and much of the North Country was the warmest on record. The mean average temperature for the winter was 30.1 degrees, breaking the old record of 28.7 degrees set in the winter of 2001-02, and leap-frogging past the normal mean temperature of 22.0 degrees, a departure of +8.1 degrees. You may recall the

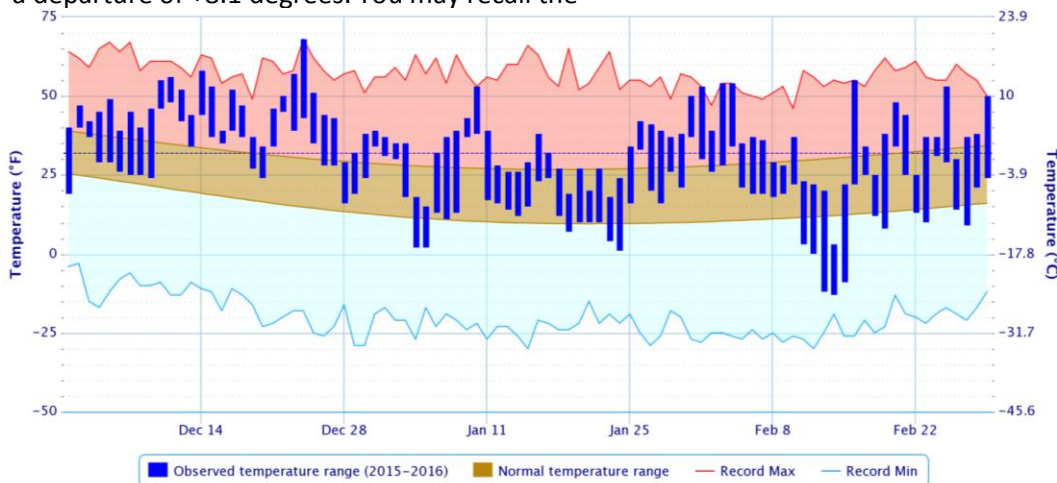


Figure 3. Graph of observed temperatures compared to normal for Burlington, VT December 2015 through February 2016

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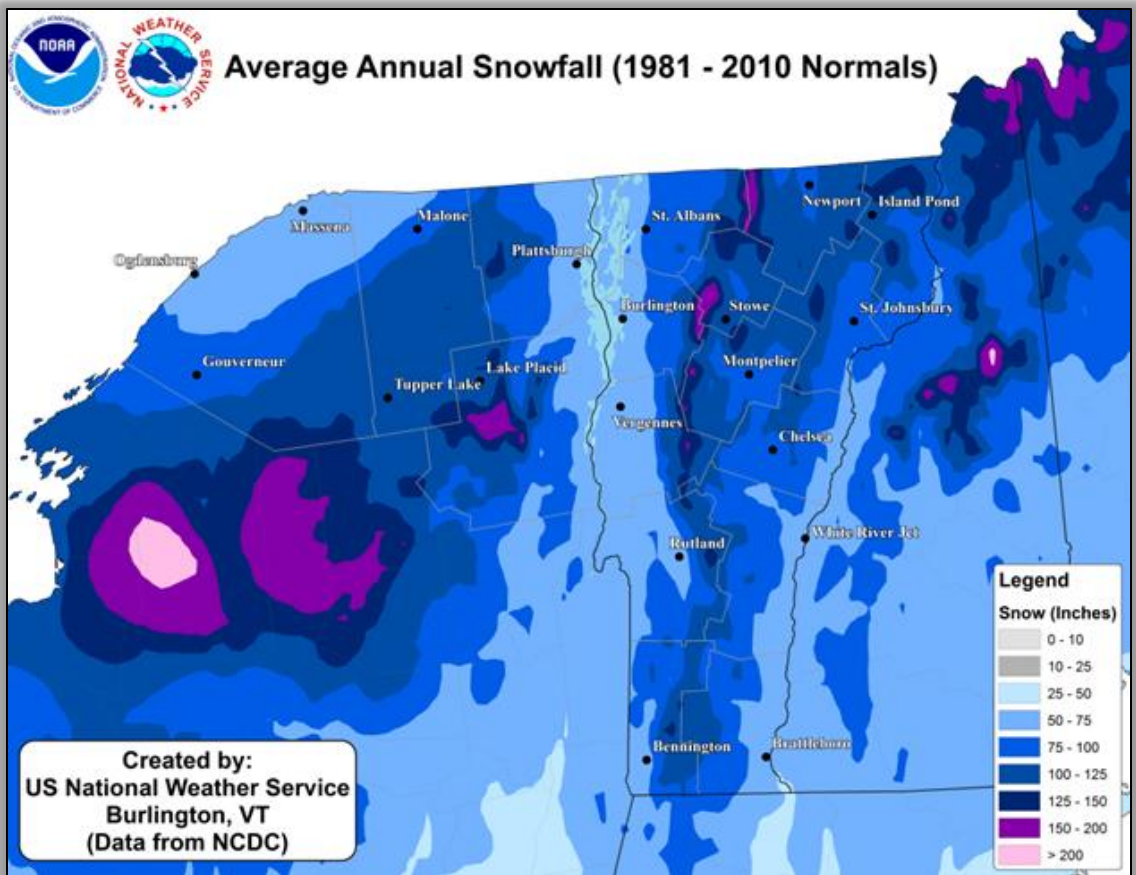


Figure 2. Map of Climate Normals for snowfall

record warm temperatures that occurred on Christmas eve. At Burlington, a new record max temperature was reached at 68 degrees for December 24th. December was the warmest on record with a mean average temperature of 39.2 degrees, beating the old record of 32.6 degrees set in 2006, while the climatological normal is 25.8 degrees.

We still did experience some winter cold, in fact the days surrounding Valentine’s day witnessed wind chills of 30 to 50 degrees below zero - some of the coldest wind chills in years. You can see the warmer than normal trend on Figure 3, on the next page – along with the cold snap that occurred in February, falling into the light blue shaded area for below normal temperatures.

Figure 4 shows an overall trend of warmer winters (red line), especially since the 1990s. In fact, five of the top ten warmest winters have occurred since the 1996-97 winter season.

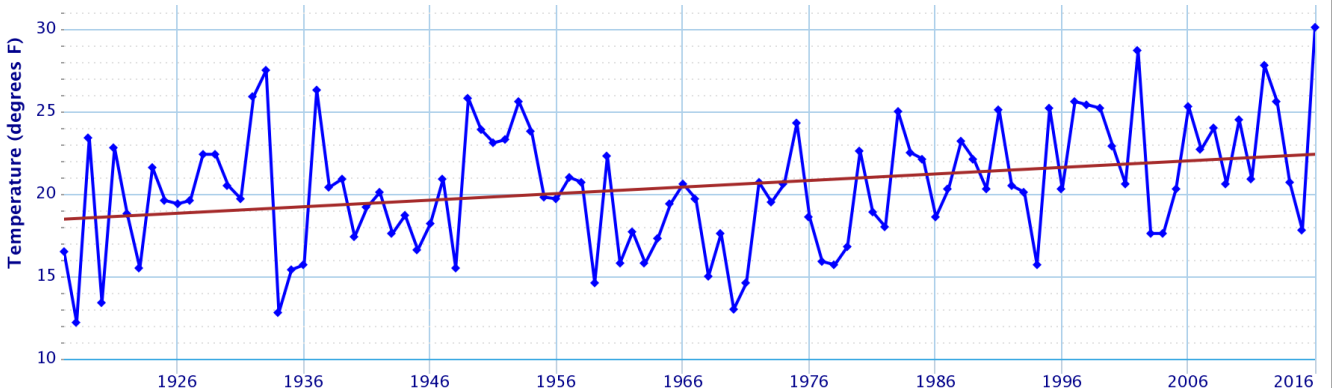


Figure 4. Mean Average Temperature during meteorological winter since 1917 for Burlington, VT

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What about snowfall or lack thereof for the 2015-16 snow season? First, we normally reference snowfall to the “snow season” (July 1st through June 30th). Vermont and Northern New York witnessed one of the least snowiest seasons in modern times. In fact, the NWS office at Burlington witnessed the 3rd least snowfall since records began in 1894 and the least snowiest since measurements have been taken at the airport in 1948. The red line on figure 5 delineates the change in measurement locations.

Total Snowfall Jul 1 to Jun 30 – Burlington Area, VT (ThreadEx)

Use navigation tools above and below chart to change displayed range

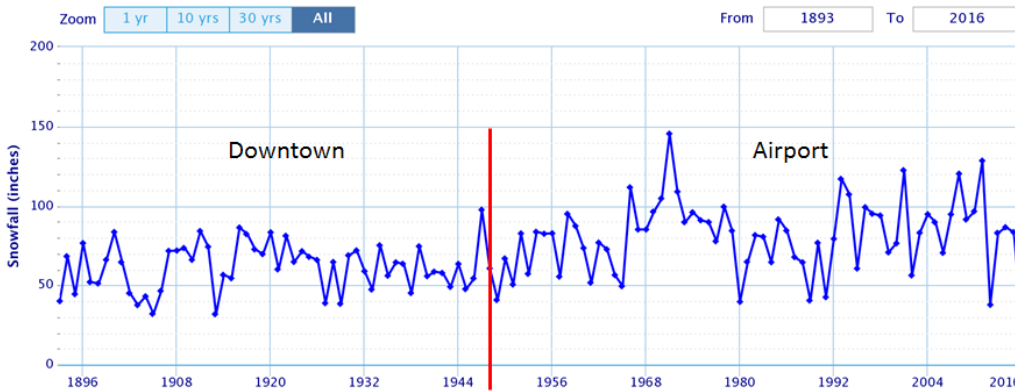
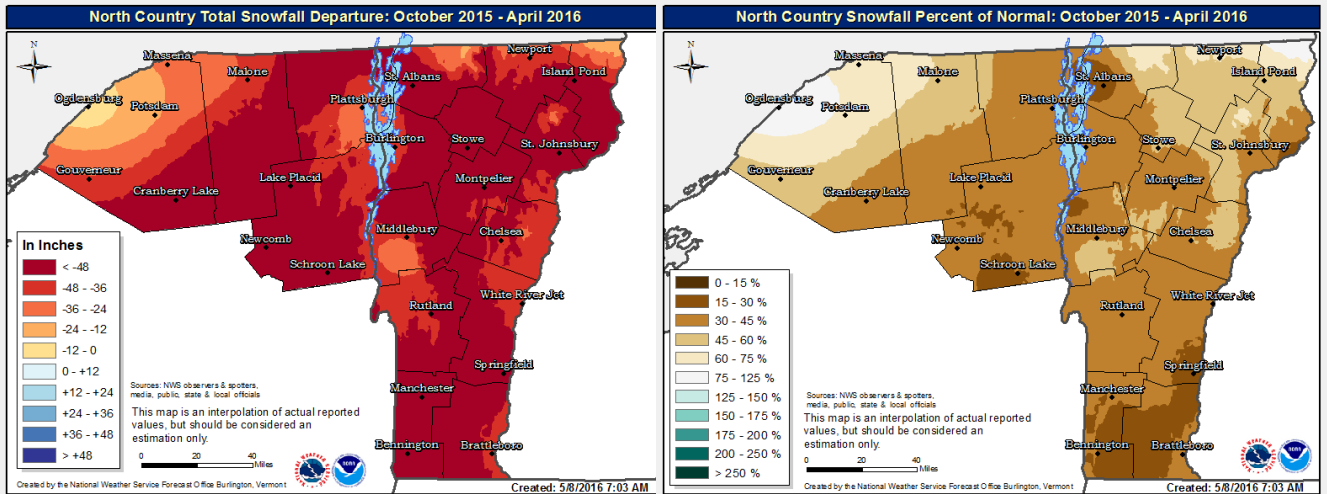


Figure 5. Snowfall totals for Burlington, VT

Much of the region witnessed snowfall 2 to 4 feet below normal with some mountains across the area experiencing deficits of 5 feet or more, which is approximately 35 to 50 percent of normal snowfall, as depicted in Figures 6 and 7.



Figures 6 & 7. Departure from normal snowfall in inches and percentage of normal for Oct 2015-April 2016

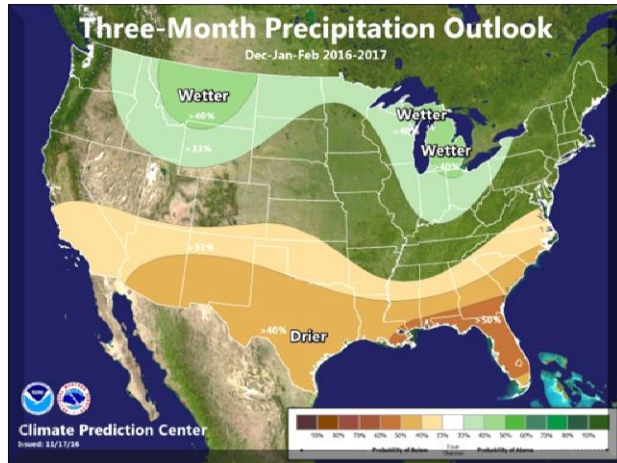
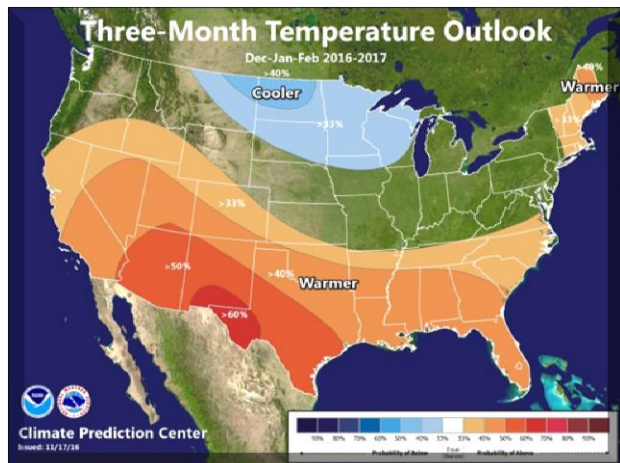
What was the main cause for this winter’s record warmth? Although there are other meteorological variables that can impact the daily weather across the North Country, the main variable for the 2015-16 winter season was the strong [El-Nino conditions](#) that occurred over the equatorial regions of the central and eastern Pacific ocean that influenced the jet stream and steering patterns across North America.

Looking ahead to what winter 2016-17 holds for the North Country, we see last winter’s strong El-Nino has been replaced by a developing La-Nina pattern. These equatorial-oceanic features of the Pacific have limited direct impacts in the northeast United States with seasonal forecasting being of low confidence. The specialist at NOAA’s Climate Prediction Center has predicted that there is a slight warm bias possibility and no real indicator on precipitation trends.

Lastly, looking at past climatology and statistics, back to back record warmth and least snowiest winters is highly unlikely, but that doesn’t mean the pendulum will swing to be coldest and snowiest either. Therefore, our best advice is to prepare for the season and act accordingly when dangerous winter conditions

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present itself. Stay safe, stay warm and from all of us at NWS Burlington...Have a Safe and Joyous Holiday season and 2017. ♦



Winter Weather Workshop Highlights

-Brooke Taber

On 8 December 2016 Weather Forecast Office (WFO), Burlington, Vermont held their annual Winter Weather Workshop. This workshop brought partners from outside our organization together, such as local media and a meteorology professor from Lyndon State, to discuss winter forecasting challenges and how to better service customers across the North Country. We examined internal tools for enhancing our freezing rain accumulation maps, along with reviewing the 24-25 February 2016 Saint Lawrence Valley and Eastern Vermont Ice Storm. In addition, we learned about power outage predictions in snow and ice storms, along with winter weather applications of dual pol radar data for determining precipitation type. The afternoon session featured an interesting discussion on how to better handle freezing rain events and communicating the potential impacts during criteria commuting times. We were provided an update on an experimental Winter Storm Severity Index and Probabilistic Snow, which is available on our web site under the winter

weather menu. Overall the Winter Weather Workshop was well attended by the WFO BTV staff, with a delicious potluck lunch, and beneficial discussions on how to better service the public through the products and services the National Weather Service provides. Figure 1 below shows the WFO BTV staff listening to a presentation during our Winter Weather Workshop. ♦



Two Experimental Winter Storm Forecasting Products Available This Winter

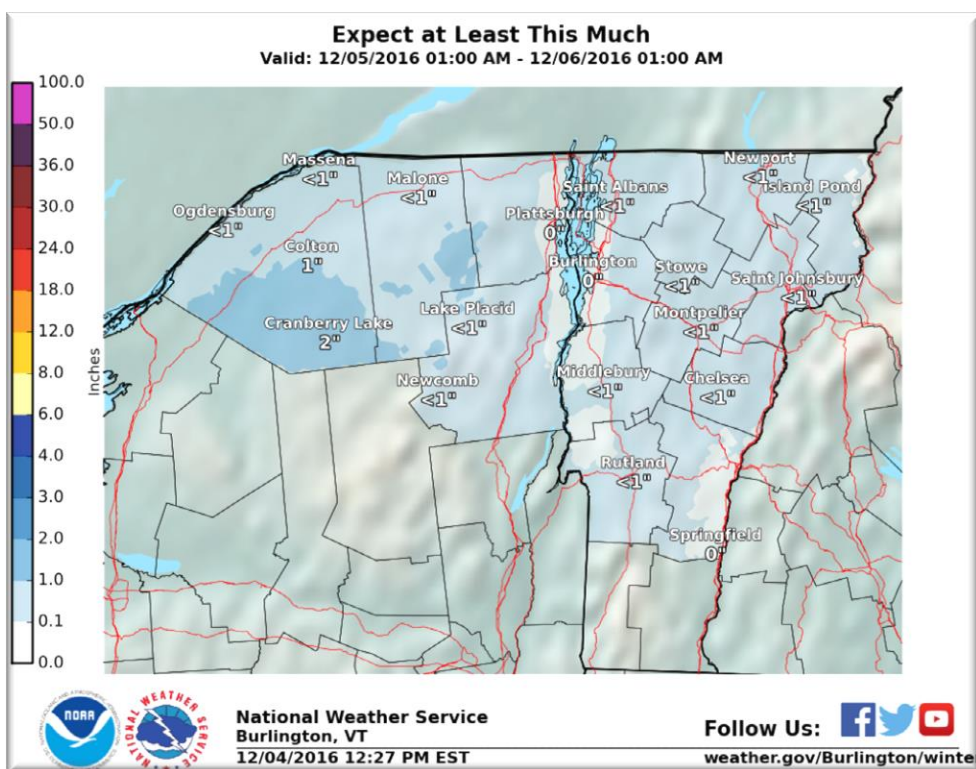
-Andy Nash

For many decades, the National Weather Service has provided the public and other users primarily a single snowfall accumulation range for any specific area as part of the forecasts and warnings relating to winter storms. However, the needs of today's society have grown beyond just needing a basic snowfall forecast. Many decision makers now require more detailed information, such as how "wet" the snow will be or what the chance that 4 inches versus 10 inches of snow could occur. To meet those evolving information needs, we are producing two experimental products this winter and making available on our website.

The first product is called Probabilistic Snowfall and can be accessed at <http://www.weather.gov/btv/winter>. The second experimental product is called the Winter Storm Severity Index, and that is available at <http://www.weather.gov/btv/winterseverity>. Both of these experimental product webpages have links to surveys, and we encourage you to provide your input on the usefulness and understandability of each product.

Probabilistic Snow

The purpose of the probabilistic snowfall product is to provide users information about the range of snowfall possibilities in order to better communicate the inherent uncertainties within every forecast. The various probabilities are produced by combining the official forecast of "most likely" snowfall amounts produced by the forecasters here at NWS Burlington, with the output of 70 different computer models. The models help to provide the range of possibilities of expected snowfall. This probability



range is then provided via a series of maps and tables on the webpage.

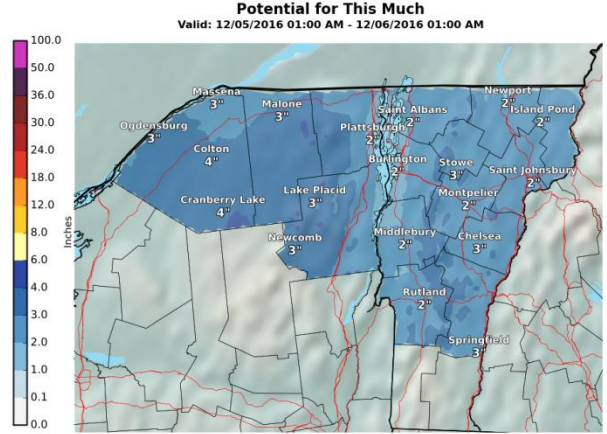
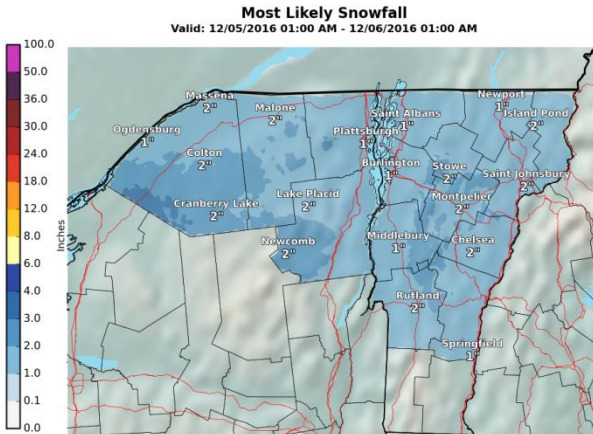
Figure 1.

- The first map on the page is labelled "Expect at Least This Much" (Figure 1). Technically the amounts indicated on the map represent the values in which there is a 90% chance of exceeding or put another way, only a 10% chance of having less snow actually occur.
- The second map on the page is labelled "Most Likely Snowfall" (Figure 2). This represents the official forecast as produced by the on-duty meteorologists here, and the snowfall amount that has the highest probability of occurring.
- The third map on the page is labelled "Potential for This Much" (Figure 3). This map depicts the values in which there is only a 10% chance of exceeding, or 90% chance of being less than that amount.

In this particular case, the minimum amount expected in Stowe is less than 1", while the expected maximum potential is 3" and our official forecast for the most likely result is 2". The range of less than 1" to

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3" is not very large, thus it can be inferred that there is a very high confidence in the official forecast for 2". Quite often with major winter storms, we have considerable uncertainty regarding the exact track and intensity or even where the zone between a rain and snow will occur. In these types of situations, the ranges between the low and high potential amounts could be extreme. So if the "expect at least this much" was 1" and the "potential for this much" was 12" and the official forecast was 2", it can be inferred that our confidence in the forecast for 2" is not as high.



National Weather Service
Burlington, VT
12/04/2016 12:26 PM EST

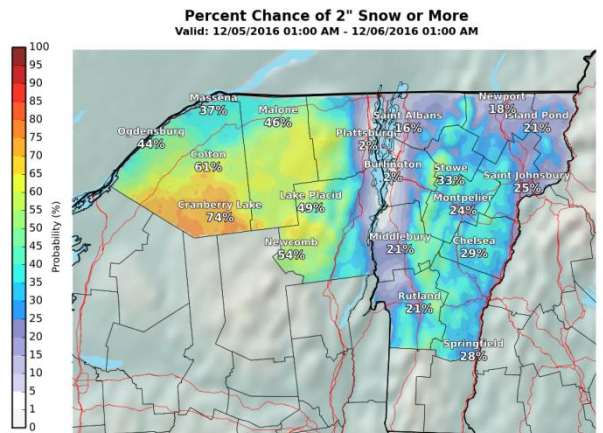
Follow Us:
weather.gov/Burlington/winter



National Weather Service
Burlington, VT
12/04/2016 12:27 PM EST

Follow Us:
weather.gov/Burlington/winter

The next section of the webpage provides information that more clearly outlines what the various chances are for specific snowfall amounts to occur. This is done through a series of maps and a table. The maps show probabilities of exceeding certain snowfall totals. Figure 4 shows the probability of locations receiving at least 2" of snow. The chances range from very low (2% in Burlington) to very high across northern New York (74% chance in Cranberry Lake). Immediately below these maps is a table that provides the information in a table. Figure 5 shows an example. The first few columns provide the "expect at least this much", "most likely" and "potential for this much" information. The remaining columns specify the chance of snow accumulations falling within specific ranges. In this example, for Newport VT the single highest probability within any range is 38% for 4-6", which matches the most likely forecast of 6". There is still a 3% chance of snowfall reaching the 8-12" range and a 27% chance of less than 4" (calculated by adding the individual probabilities of 1%, 2%, 4%, 20%) for the corresponding columns.



Chance of Snow Accumulation

Experimental - Leave feedback

12/16/2016 0600AM to 12/17/2016 0600PM

What's this?

County:

Location	At least	Likely	Potential for	0"	0.1-1"	1-2"	2-4"	4-6"	6-8"	8-12"	12-18"	>18"
Barre, VT	3	5	6	0%	2%	4%	32%	53%	9%	0%	0%	0%
Burlington, VT	4	8	8	1%	2%	3%	15%	31%	42%	6%	0%	0%
Island Pond, VT	3	5	6	0%	1%	4%	38%	54%	3%	0%	0%	0%
Malone, NY	3	7	7	3%	3%	5%	20%	33%	34%	2%	0%	0%
Massena, NY	4	7	8	0%	1%	2%	13%	34%	44%	6%	0%	0%
Middlebury, VT	3	7	7	3%	3%	5%	20%	34%	34%	1%	0%	0%
Newport, VT	3	6	7	1%	2%	4%	20%	38%	32%	3%	0%	0%
Plattsburgh, NY	4	7	8	1%	1%	3%	15%	32%	43%	5%	0%	0%

Clockwise from top left: Figures 2, 3, 4 and Figure 5 (right).

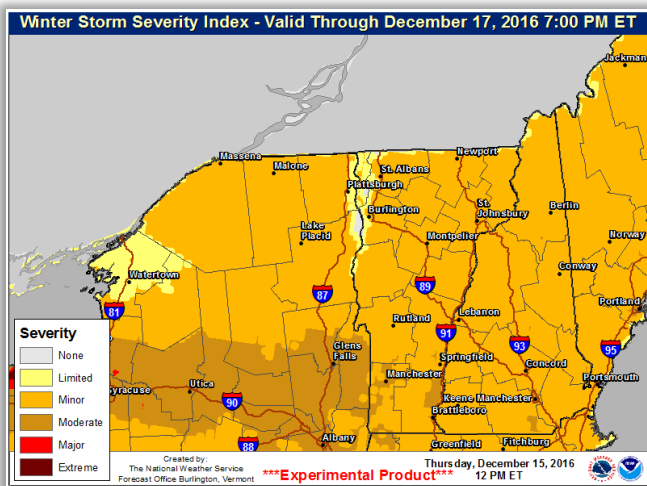
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Winter Storm Severity Index

The purpose of the Winter Storm Severity Index is to enhance the communication to decision makers and the general public concerning the expected severity and potential level of societal impacts due to the various aspects beyond just snowfall that winter storms bring.

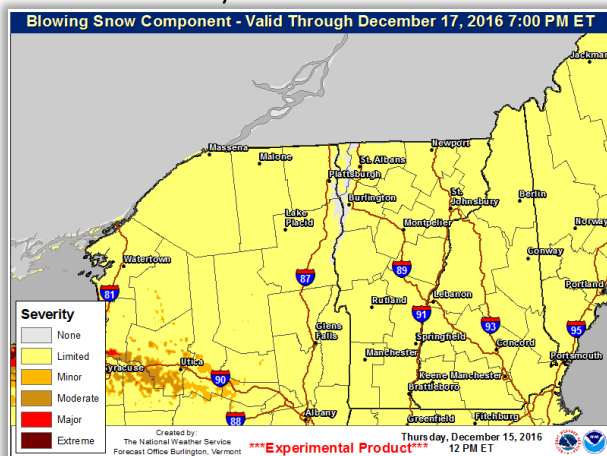
The index uses NWS forecast data and non-meteorological datasets to derive projections of the overall severity on a 5-level scale of different potential components commonly associated with winter weather. Those components are: snowfall amount, rate of accumulation, loading of snow on trees or powerlines, blowing/drifting snow, ice accumulation, flash freeze and ground blizzards. Some components take into account whether the landscape is open fields or forested areas or urban areas. For example, open fields will experience more severe conditions during a snowstorm with strong winds due to more blowing/drifting snow, while urban and forested areas will have more impacts during a heavy wet snow event. The normal snowfall patterns across the country are also taken into account, so 2" of snow in Atlanta will show up as a major event, while 2" in Burlington would be in the lowest level (limited) category.

After the severity for each component is calculated, it is combined into the final Winter Storm Severity Index. The webpage provides users the ability to view the final Severity Index values in map form, as well as view the individual components. Having the product in the form of a map allows users to better understand and see the spatial variability in the overall severity of a storm, well beyond just referring to a map where Winter Storm Advisories or Warnings are displayed to only the level of a county. The component maps allow users to better understand why a particular location of interest is depicted in a certain category. For example, perhaps all of Northern New York and Vermont is expected to have a moderate level severity event. However, the reason is blowing snow in northern New York, snow loading in northern Vermont and ice accumulation in southern Vermont. The kinds of decisions that people will have to make will vary greatly between the areas, even though the storm will be roughly the same severity.



due to another aspect of the expected event. In this case, but not shown, it was due to the total snow expected. The specific definitions of each of the severity levels can be found on the webpage. The different levels are described in general terms with regard to overall impact to society, but the Winter Storm Severity Index is not an attempt to predict any specific impacts (eg: school closures, power outages). ◆

Figure 6 (left) provides an example of the Winter Storm Severity Index. In this case, most of Vermont and northern New York are expected to see a minor winter storm event. However, a few locations in far southern Vermont extending into central New York are facing a moderate severity event. Breaking it down a little more, figure 7 (below) shows the severity due to blowing snow. There are areas of moderate severity across central New York, but not for southern Vermont, so that means the reason for the moderate severity in southern Vermont has to be



In My Comfort Zone

-Conor Lahiff

My name is Conor, and I'm a self-proclaimed "weather weenie". Weather is my job, but like many other meteorologists out there, I have another passion and mine is snowboarding. When the days start getting shorter, and

the nights colder, my thoughts drift towards the mountains and my dreams of powder. Long before I started down the path towards my current career, snowboarding was a big part of my life, so much so that I began competing in the United States of America Snowboard and Freeski Association (USASA) tour for amateurs. As a college student competing in the Northern Vermont Series, I made it all the way to the national championships in 1999 for slopestyle and boardercross.

Fast forward a few years, I finished college, married my wife, had 2 kids - you see where this is going. Snowboarding, at least competitively, took a back seat. That is until two years ago when my (now) 12-year-old son decided he wanted to take his snowboard life to the next level. So he dabbled a little bit in competitions during the 2014-2015 season, both in freestyle and racing, and actually qualified for nationals in giant slalom! A great accomplishment for sure, but for only 1 event we decided the cost to go to nationals was too high. Setting our sights on the following year, he made it a goal to make it back to nationals, and to help him accomplish that goal, I made a



leap way outside of my comfort zone at the age of 38, to join him in competition. Removed from the competition scene for quite some time, it had been several years since I had really tried anything in the terrain park, especially these new rails and boxes which didn't exist when I last competed! Challenging each other, my son and I trained hard, competed harder, and -- despite a record breaking warm winter -- we amazingly both qualified for nationals in slalom, giant slalom, boardercross, and slopestyle!

Nationals were held in the first week of April at Cooper Mountain in Colorado, and all I can I say is what an experience! After a lackluster winter back home with very little snow, we were amazed at the coverage Colorado had, even so late in the season. Upon arrival, we had only 1 day to acclimatize to life at 10,000 feet before the competition began, which if you've ever been at that altitude or higher you know how hard it is to get used to. Needless to say, by the end of our first day on the mountain, we were exhausted! Four days of events followed, most of which were sunny and warm, but we were treated to one amazing powder day at the end of the week. The field of competition was fierce, well, mainly for my son. His division included over sixty 11-12-year-olds, while my old man division only averaged about seven competitors per event! Both of us did not fare well in boardercross, but I was very proud of my son placing right in the middle of the field for all the other disciplines. As for me, I was pretty proud of myself as well, grabbing bronze in both slalom and giant slalom, and silver in slopestyle!

So here we are in December again. The days are getting shorter, and the snow is falling across the North Country. We're planning to compete again this year and hope to make it back to Colorado for the 2017 championships. We've already been up to the mountain a few times this season, and can't wait for the next big storm to hit! ♦





The Four Seasons

Volume I, Issue I



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Please report snowfall, flooding, damaging winds, hail, and tornadoes. When doing so, please try, to the best of your ability, to measure snowfall, estimate hail size, and be specific as to what damage occurred and when. We also love pictures!

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