The Four Seasons

National Weather Service Burlington, VT

VOLUME VI, ISSUE III

FALL 2020

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Letter from the Editors

Welcome to the Fall 2020 edition of The Four Seasons, a quarterly newsletter issued by the National Weather Service in Burlington, VT. In this edition we'll take a look back at this year's record-breaking summer as well as examine some of the local impacts from Tropical Storm Isaias. We'll also learn about Mountain Lee Wave Clouds that are common to our area. Then we'll introduce you to our BTV winter weather page (if you aren't already using it!) so you can get more in-depth information this winter on our winter forecasts. Finally, we'll take a look at some exciting promotions that have happened in our office over the summer. Thanks for reading and we hope you enjoy the newsletter.

Tropical Storm Isaias Recap

-Seth Kutikoff

Antecedent Conditions

Based on evaporative demand and rainfall deficits, drought conditions were significant at the start of August (Figure 1). However, across far northern Clinton County, extending eastward into Vermont, a dent into drought intensity had been made in recent days due to fairly prolific showers and thunderstorms. Additionally, over an inch of rainfall had been observed early on August 2 in a narrow swath from Essex County, NY, into northern VT.

While uneven in distribution, the rainfall from Isaias impacted soil moisture with values approaching normal levels and also provided sufficient rainfall to bring streamflows back towards normal levels in most cases. Altogether, the data suggested that if flash flooding was to occur, it would be most likely in northeastern NY and northern VT.

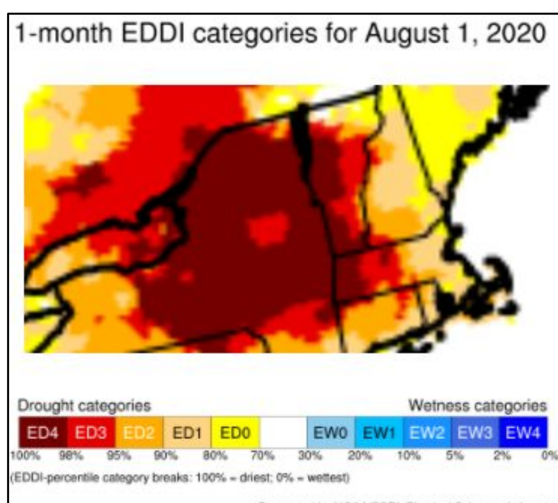

Figure 1 (right). Evaporative Demand Drought Index indicated among the driest conditions on record.

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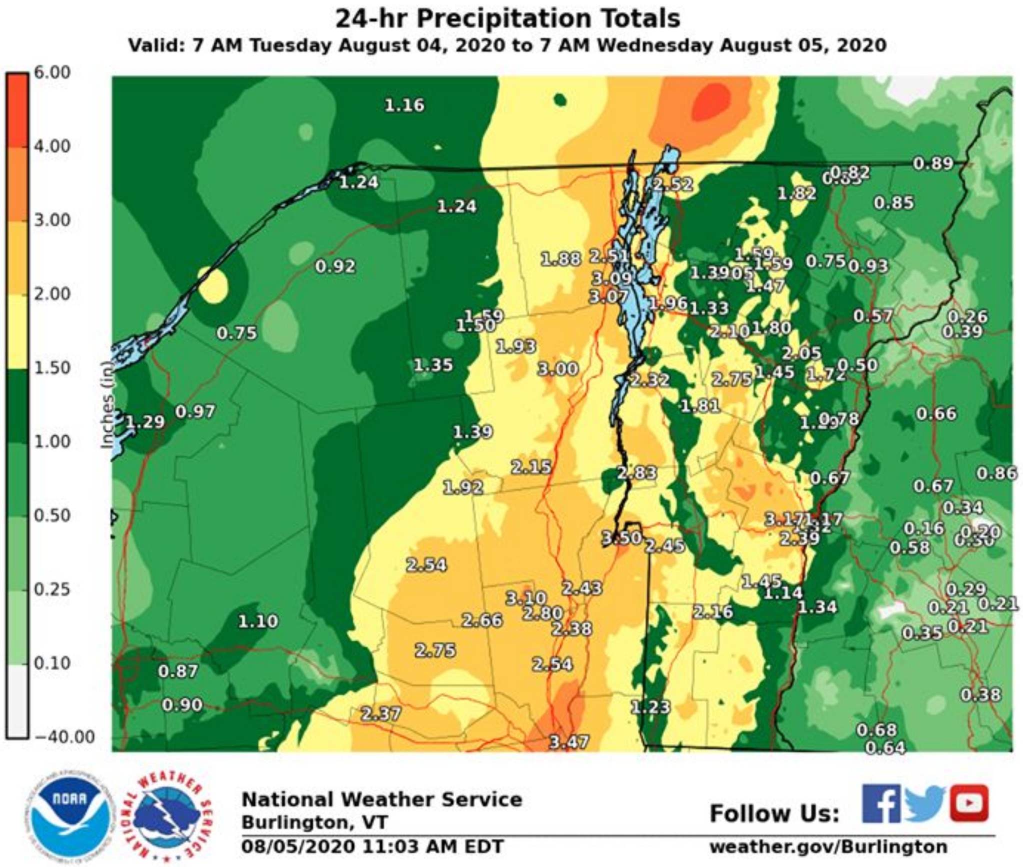

Rainfall

Tropical Storm Isaias produced heavy rain up to 0.75" per hour for 2 to 4 hours, helping storm totals reach 2 to 3 inches mainly in northeastern NY and the Champlain Valley, with isolated areas receiving greater than 3 inches (Figure 2). This beneficial rainfall was also enough for daily records to fall at Burlington and Plattsburgh, with each location receiving approximately 2.5" storm total rainfall over roughly 16 hours, including 0.86" and 1.34", respectively, between 7 and 9 PM when the core of Isaias moved through. A flood warning was issued for the East Branch of the Ausable River at Ausable Forks where minor flooding occurred for a couple of hours, but no other flooding was reported due to dry soils and rainfall rates never exceeding 1" per hour.

Winds

Damaging wind gusts mainly in the 35 to 45 mph range combined with wet conditions caused some fallen trees and power outages in northeastern NY, the Champlain Valley, and along and just east of the Green Mountains. Likely due to relatively stable air in our region, severe winds observed in southern New England didn't realize themselves in the North Country. Even though the center of Isaias passed 5 miles NNW of Rutland at 8 PM with maximum sustained winds of 50 mph, and likely passed between Montpelier and Burlington on its way to Quebec, only modest maximum wind gusts (Fig. 3, Page 3) occurred producing isolated power outages. Green Mountain Power reported that one of the areas that was hit hardest was along in eastern Vermont through the Upper Valley area north of White River Junction.

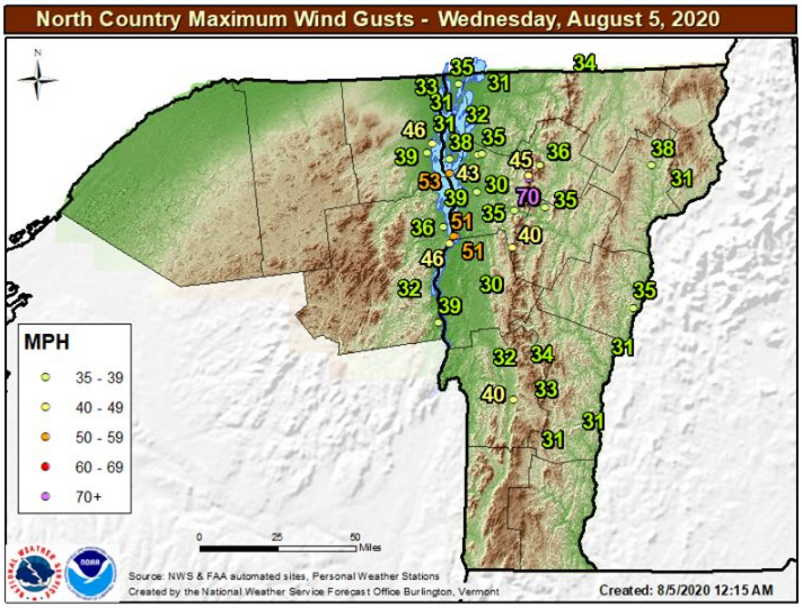

Figure 3 (above). Maximum wind gust map generated from the public information statement containing quality controlled reports.

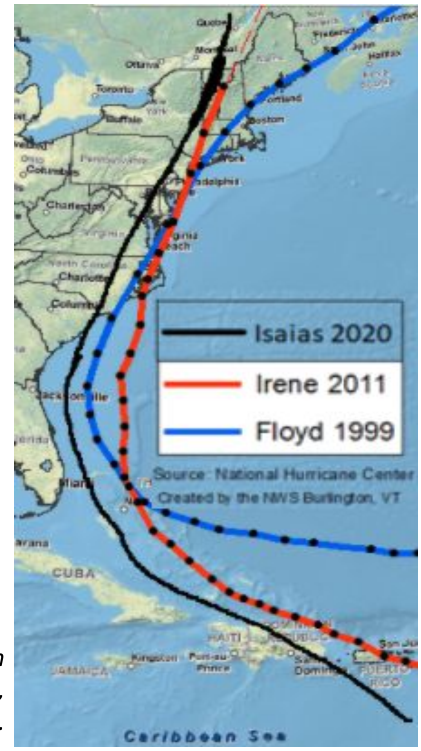

Figure 4 (Right). Storm tracks of Isaias, Irene, and Floyd.

Comparison to Irene and Floyd

With a weak Category 1 landfall over the eastern Carolinas and track north-northeastward into New England, the storm track resembles a blend of Irene and Floyd (Figure 4). Since stronger winds are east of the center, the inland track of Isaias produced damaging wind over the high population areas of the mid-Atlantic and southern New England. It had very fast storm motion, building to 40 mph by 2 PM when it was west of NYC. At the same latitude, Irene was moving 26 mph with the same max sustained winds of 65 mph. However, Irene's central minimum pressure was 29 mb lower. Coincidentally, both storms were in Vermont at the same time of day, 8 PM. When Irene was 20 miles south of St. Johnsbury, it was still moving at 26 mph with a minimum pressure of 978 mb. Isaias was 5 miles north-northwest of Rutland moving 40 mph with a minimum pressure of 997 mb. A comparison of three storms at a comparable location near New York City is shown in table 1.

	Isaias	**Irene**	**Floyd**
Time	2 PM TUE AUG 04 2020	9 AM SUN AUG 28 2011	8 PM EDT THU SEP 16 1999
Location	ABOUT 65 MI W OF NEW YORK CITY	ABOUT 0 MI N OF NEW YORK CITY	ABOUT 25 MI ESE OF NEW YORK CITY
Movement (MPH)	NNE AT 40	NNE AT 26	NNE AT 30
Maximum sustained winds (MPH)	65	65	65
Minimum central pressure (mb)	994	965	974

Table 1. Comparison of Isaias to Floyd and Irene when the center of each storm was passing by New York City and was already impacting the North Country.

Adirondack and Green Mountain Lee Wave Clouds

-Pete Banacos

"Never be too quick to clear us out behind a cold front".

So goes the oft stated first piece of forecasting advice across Vermont and northern New York that echoes back across decades. Indeed, post-frontal stratus can linger, sometimes for days across the North Country. There are two key reasons for this:

1. When unfrozen, the Great Lakes serve as a moisture source in post-frontal west to northwest flow. Cool air passing over relatively warm water - especially in the fall - results in vertical fluxes of heat and moisture from the lakes, and is favorable for downstream cloudiness. Those trajectories often point toward northern New York, where the Adirondacks serve as a source of orographic lift and additional cloud formation.

2. The vertical profile of temperature and moisture behind the surface cold front typically includes a frontal inversion. An inversion - where temperatures rise with height - is a very stable layer of air, which is resistant to vertical mixing. This helps "trap" existing moisture and low clouds. Subsidence can further strengthen these stable layers as high pressure builds in. Subsidence will eventually bring about sufficient drying to thin out and dissipate the stratus layer. However, that drying process sometimes takes a day or more.

These factors come together most dramatically in late fall, when temperature differences and vertical moisture fluxes over the Great Lakes are highest. Also, the low sun angle makes it particularly difficult to mix out the frontal inversion. November is the cloudiest month on average at Burlington, Vermont (Figure 1), and generally across the North Country.

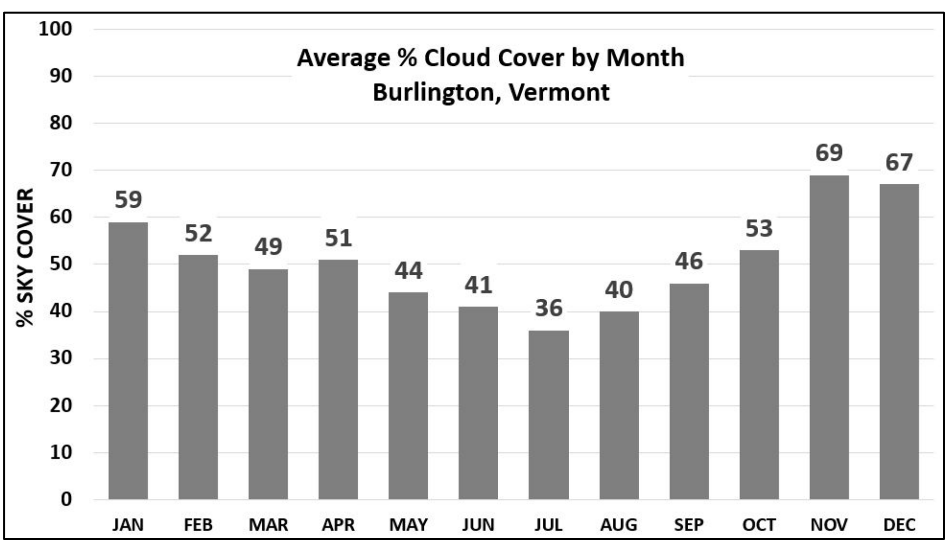

Figure 1. The monthly march of average cloud cover (in percent) at Burlington, Vermont based on daylight periods, 1961-1990. Average cloud cover reaches a peak in November (69 percent) and a minimum in July (36 percent).

With stratus trapped in or below the post-frontal stable layer, we often see a wavy appearance in the cloud structure in the lee of the mountains from a satellite perspective (Figure 2). The sequence for wave cloud formation is depicted in Figure 3. As the wind approaches the mountains, the air can flow around or up and over the barrier. For air forced upward, the stable layer will cause this displaced air to subsequently trend back downward once past the mountains. This stability

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sets up an oscillation, a series of upward and downward motions creating the observed wave pattern. We can "see" the waves because the rising air cools and, if the layer is sufficiently moist, condensation and cloud formation will be enhanced in areas of upward motion. The opposite is true in areas of downward motion. The wave pattern can be seen within the top of the stratus layer, or as a series of cloudy and cloud-free areas, depending on moisture availability. These oscillations eventually dampen as the air settles back near its original height. As a result, the waves are most pronounced immediately downwind of the mountains, and tend to decrease in magnitude further downwind; a feature also evident in Figure 2.

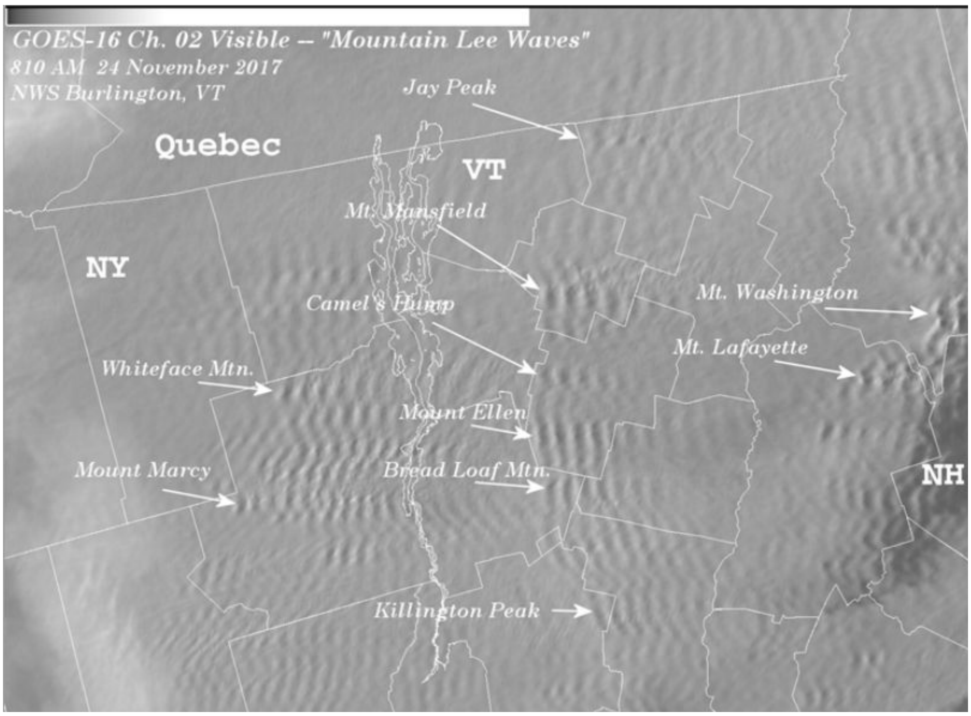

Figure 2 (left). GOES-16 visible (channel 2) satellite image from 810 AM EST on 24 November 2017. Locations of prominent mountain peaks are annotated. Wind flow at 4000 feet was westerly. Note presence of mountain lee waves within the stratus layer downwind of the mountains, and smoother appearance of stratus upwind of the mountains. In New Hampshire, the mountain lee waves produce a series of cloudy and cloud-free areas east of the taller White Mountains near the Presidential Range.

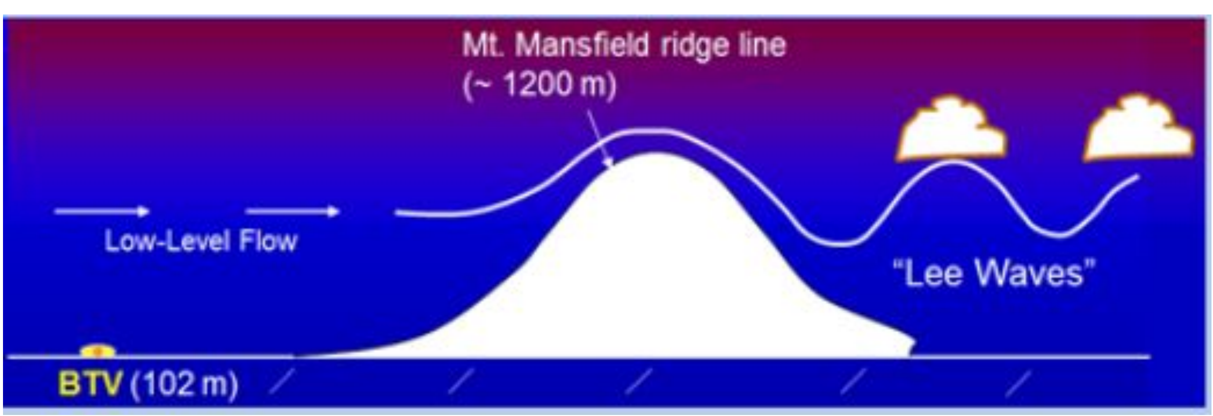

Figure 3. Schematic showing low-level westerly flow from the Champlain Valley forced up and over the Green Mountain ridge line. If the atmosphere is moist and stable in vicinity of mountain top level (around 1200m or 4000ft), an induced downwind oscillation forms wave clouds in the lee of the mountains. The lee waves appear as transverse waves in the downwind cloud pattern, as evident in Figure 1.

You may hear different terminologies applied to this phenomenon in our forecast discussions. *Mountain waves*, because it is the mountains that excite the wave. *Lee waves*, because they form downwind of the mountains. *Standing waves*, because they are virtually stationary with respect to the earth's surface. Or *Transverse waves*, because the long axis of the wave is perpendicular to the wind direction.

No matter the terminology, you now know the reasons for these wave clouds and how the combination of wind, moisture, stability, and topographic factors act favorably in wave cloud production across the North Country.

Interested in viewing GOES satellite imagery in real time? Visit the NOAA GOES image viewer at: https://www.star.nesdis.noaa.gov/GOES/index.php

The BTV Winter Page

-Rebecca Duell

Did you know that you can access a range of winter forecasts online, anytime, on our Winter Weather Page? Head to www.weather.gov/btv/winter to check it out. The page contains all kinds of information and graphics of our forecasts for winter precipitation.

You can find our official snowfall or ice forecasts on the page, as well as "probabilistic" precipitation forecasts to better communicate forecast uncertainties during winter events. Probabilistic forecasts are simply the the percentiles (ie. 10%) or probabilities (i.e. 1 in 10 chance) of exceeding certain precipitation thresholds. On the webpage, this is presented as two additional graphics in addition to our official forecast - A high end amount graphic (1 in 10 chance of higher snowfall) and a low end amount graphic (9 in 10 chance of higher snowfall). In addition, you can find a table showing probabilities of various snowfall thresholds for different cities in our forecast area.

Snowfall Totals by Location

Experimental - Leave feedback

11/09/2017 0700PM to 11/10/2017 0700AM

What's this?

County:

	Snow Amount Potential			Chance of Seeing More Snow Than							
Location	Low End Snowfall	Expected Snowfall	High End Snowfall	>=0.1"	>=1"	>=2"	>=4"	>=6"	>=8"	>=12"	>=18"
Barre, VT	0	<1	<1	71%	0%	0%	0%	0%	0%	0%	0%
Burlington, VT	0	<1	<1	47%	0%	0%	0%	0%	0%	0%	0%
Island Pond, VT	<1	1	1	80%	27%	0%	0%	0%	0%	0%	0%
Malone, NY	<1	1	2	85%	46%	1%	0%	0%	0%	0%	0%
Massena, NY	<1	1	2	85%	43%	4%	0%	0%	0%	0%	0%
Middlebury, VT	0	<1	<1	63%	0%	0%	0%	0%	0%	0%	0%
Newport, VT	<1	2	2	85%	45%	0%	0%	0%	0%	0%	0%
Plattsburgh, NY	0	<1	<1	60%	0%	0%	0%	0%	0%	0%	0%
Potsdam, NY	<1	1	2	87%	51%	0%	0%	0%	0%	0%	0%

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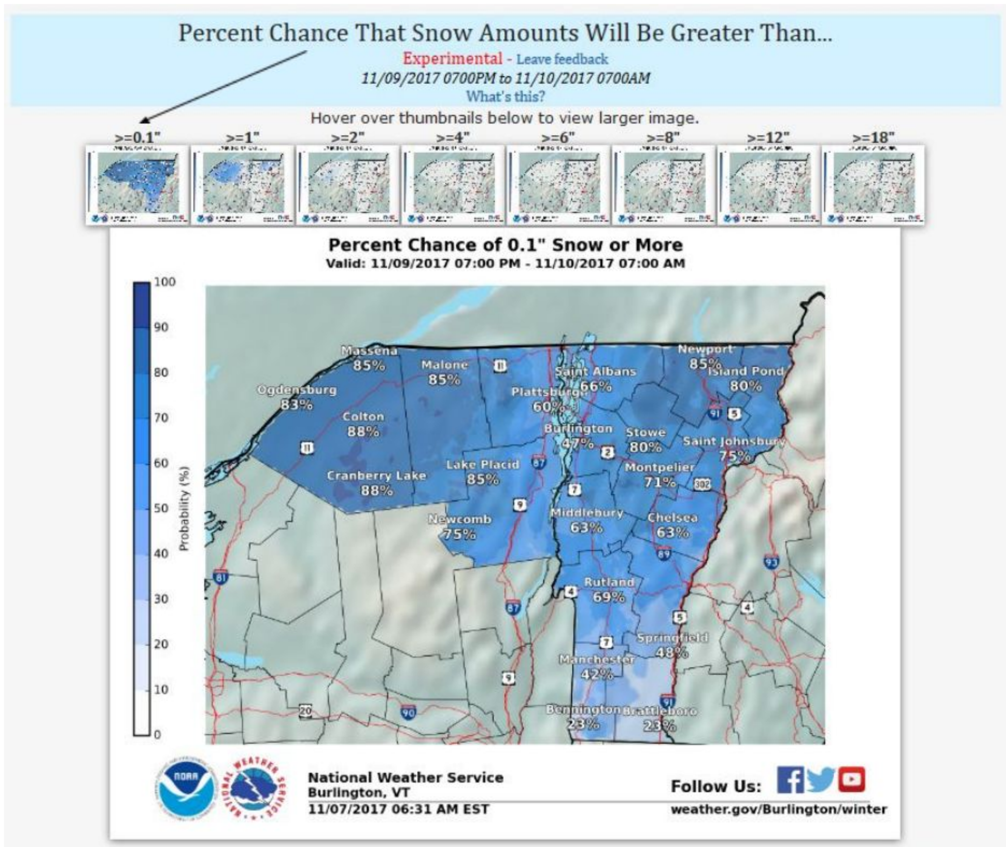
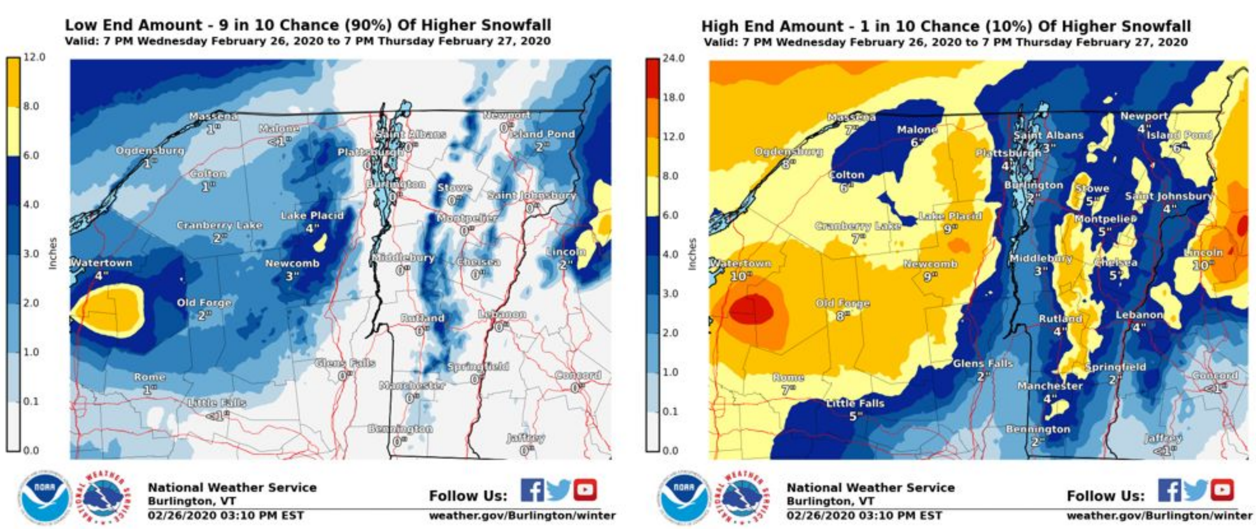


Figure 1. Example of Percent Chance Snowfall Graphics available on the BTV winter page



Possible low-end snowfall (90% chance)

Possible high-end Snowfall (only 10% chance)

Figure 2. Example of probabilistic snowfall graphics available on the BTV winter page.

The Summer of 2020 - Hottest Summer on Record, Drought and TWO Tropical Storms

-Scott Whittier

Remember early May, when temperatures were only in the 30s and we saw *snow* and were wondering if summer temperatures were EVER going to come? Well, "be careful what you wish for" as Meteorological Summer (June, July, August) was the hottest summer on record in the Champlain Valley (since 1892) and included the hottest month (July) ever recorded.

Rank	Year	Mean Avg Temperature
1	2020	72.3
2	1949	72.2
3	2018	72.1
4	2005	71.5
5	2016	71.4
-	1995	71.4

Figure 1. Top 5 warmest Average Mean Temperatures for June, July, and August

A normal summer season in the Champlain Valley witnesses seven days of 90 degree heat or warmer. This year we witnessed 18 days (5th all-time). A heat wave is defined by 3 consecutive days with temperatures at or above 90 degrees and BTV witnessed 3 of them, including a 6 day stretch from June 18-June 23, tied for the 2nd longest on record. Some of you may think it was hotter, while the number of days with temperatures of 85 degrees or higher were 44 days, 2nd All-Time (49 days in 1949) and a new record for the number of 80 degree or warmer days was set. Note, that 4 of the last 5 years are on the Top 6 list. What about elsewhere across Vermont and northern New York this summer? Looking at the climate records, St. Johnsbury was 4th, Montpelier was 9th and Massena, NY ranked 10th warmest.

Rank	Year	Number of Days Max Temperature >= 80
1	2020	69
2	1949	68
3	2018	65
4	1995	63
-	1973	63
6	2019	62
-	2016	62
8	2012	61
-	2005	61
-	1975	61

Figure 2. Top 10 years with the number of days with a max temperature greater than or equal to 80 degrees F.

We often get asked are summers (and the overall climate) getting warmer? Just looking back at the last 10 summers (2011-2020) for Burlington, the average summer temperature has increased about 2 degrees. In addition, only 1 month of the 30 meteorological summer months in these 10 years averaged below normal (June 2015 by 1 degree).

Drought

Winter 2019-20 brought near or slightly below normal precipitation across the region, including snowfall, with Spring 2020 (March, April, May) seeing an increase in precipitation deficits as April and May came along. During April and May alone precipitation deficits of 2 to 4 inches (40-70 percent of normal) occurred with the greatest shortfalls across St. Lawrence County, NY, and the Connecticut River Valley. June's weather of warm/hot temperatures, plenty of sunshine and near record dryness led to lots of evaporation and accelerated the formation of drought conditions across the region. June brought only 33 to 60 percent of

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normal precipitation to the North Country, including the 2nd driest June on record at Massena, NY, and St. Johnsbury, VT, with only 0.77 and 1.20 inches of rainfall respectively.

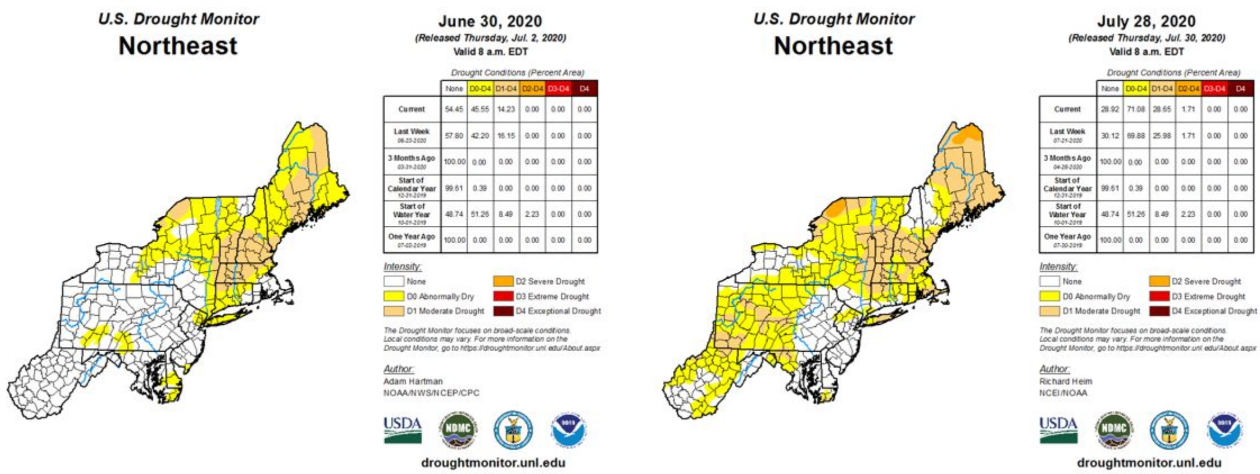
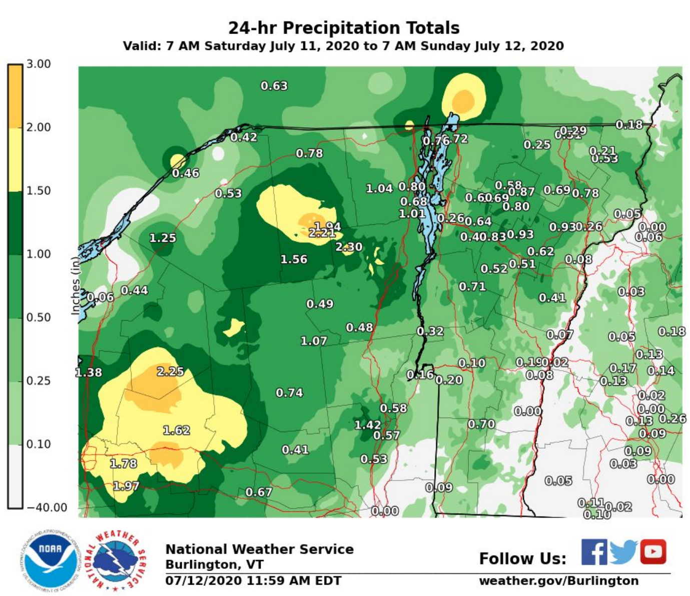


Figure 3. US Drought Monitor for June 30, 2020 (left) and July 28, 2020 (right)

In July, there was still only scattered thunderstorm activity across the region. The close passage of the remnants of [Tropical Storm Fay](#) (July 11th) brought a measly 0.5 to 1 inch to portions of northern VT and 0.5 to 1.5 inches to northern NY. It was not enough, as the combination of only 60-90 percent of normal rainfall and the hottest month on record in the Champlain Valley, accounted for an expansion of drought conditions across the region.

In August, it was a tale of the "haves and have nots" as more frequent rainfall events along the Canadian border in northern New York and the track of [Tropical Storm Isaias](#) across the Champlain Valley and northern New York brought some welcomed relief. Yet, it stayed much drier than normal in eastern VT and throughout much of eastern New England. Therefore, there was some lessening of drought conditions in northern NY but continued expansion in eastern VT and much of New England by [September 1st](#).



On a final note, many waterways (rivers and lakes) have seen well below normal levels for this summer into the fall and this included Lake Champlain. Figure 5 (next page) shows that the lake level by early July was comparable to a normal lake level after Labor Day and that lake levels by the end of the month were near the levels normally experienced at the lake climatological low point in October.

Figure 4 (left): 24 Hour Precipitation Totals for July 11th, 2020 (Tropical Storm Fay)

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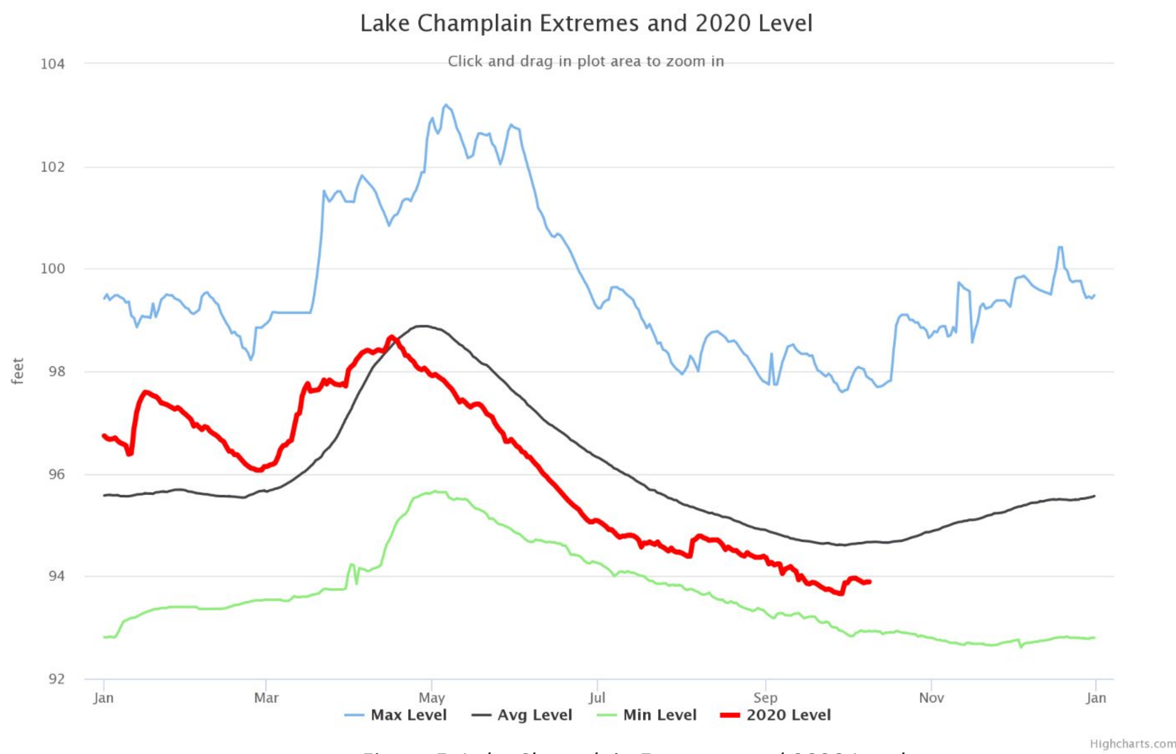

Figure 5. Lake Champlain Extremes and 2020 Level

Changes At BTV - Congrats Pete and Jessica!

Pete Banacos has become the new Science and Operations Officer (SOO) of the National Weather Service in Burlington. Prior to becoming SOO, Pete served as a Lead Forecaster in Burlington since November 2005. Pete began his NWS career at WFO Upton/New York City and then worked at the Storm Prediction Center in Norman, Oklahoma. He earned a B.S. in Meteorology and minor in Mathematics from Lyndon State College (now Northern Vermont University) and a M.S. in Meteorology from the University of Oklahoma. Pete also serves as an Associate Editor for the American Meteorological Society's *Monthly Weather Review*.

Jessica Neiles has been promoted to Lead Meteorologist at the National Weather Service in Burlington. Jessica began her NWS career as a meteorologist in the Weather Forecast Office in Wilmington, North Carolina in 2004. She joined us here in Burlington as a forecaster in 2007. Jessica earned a B.S. in Atmospheric Science with minors in Physics and Mathematics from University at Albany - State University of New York in 2003. She is also from Albany, NY. Outside of work, Jessica enjoys spending time with her husband and two children, and appreciating all of the wonderful things that Vermont has to offer.

The Four Seasons

Volume VI, Issue III

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We Need Your Storm Reports!

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!

For reports, please call:
(802) 863-4279
Or visit:
http://www.weather.gov/btv/stormreport

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