The Four Seasons

National Weather Service Burlington, VT

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Letter from the Editors

Welcome to the fall 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 the record breaking heat this past summer. We also look at the busy summer our forecasters had, from providing weather support for wildfires out west, visiting the NERFC, completing an intensive Leadership program, and installing a new weather station in central Vermont. You'll also get to "meet a forecaster" as well as help us say goodbye to our Meteorologist-in-Charge. We hope you enjoy the newsletter and thank you for reading!

The Record Breaking Heat of Summer, 2018
-Robert Haynes and Rebecca Duell

The meteorological summer (defined as the months June, July, and August) of 2018 was the 2nd hottest in Burlington's period of record–second only to 1949 by a tenth of a degree. Most of June was near to below average, but towards late June, a strong ridge of high pressure developed along the eastern United States causing a prolonged, dangerous heat wave across New England. This feature persisted for the remainder of the summer, leading to a constant stream of warm, muggy air from the Gulf of Mexico. A wide array of heat-related records were broken this summer as a result of this weather pattern (Table 1).

Record Broken	New Record as of 2018
Highest low T at BTV	80° (July 2nd)
All-time warmest mean monthly low T at BTV	76.0° (July)
All-time warmest mean monthly max T at BTV	87.4° (July)
Warmest August mean monthly T at BTV	74.5°
Warmest August mean monthly low T at BTV	64.9°
Consecutive days ≥ 80°F at BTV	29 Days
Warmest August monthly low T at Montpelier	58.3°
All-time max T tied at Mt. Mansfield	84°

Table 1. Some of the records broken this past summer.

While the number of daily record highs tied or broken were not overly abundant, the persistence and lack of relief resulted in several longer running temperature records to be broken. The heat wave, defined as three or more consecutive days at or above 90°F, from June 30th to July 5th, was the 2nd longest heatwave in Burlington's records. July 2018 was the hottest month experienced on record for the Burlington area, and August 2018 bested its monthly mean record as well. Additionally, the consecutive number of days at or above 80°F was the most in Burlington's period of record at 29 days (Figure 1, consecutive days highlighted in yellow). High dewpoint temperatures contributed to low temperatures well above seasonal norms. On July 2, temperatures at Burlington failed to fall below 80°F for the first time in our period of record. The muggy air mass also facilitated issuance of the first excessive heat warnings from our office for the St. Lawrence and Champlain Valleys, where heat indices exceeded 105°F for at least 2 consecutive hours or longer. Table 1 (previous page) is a sampling of some of the most impressive heat records broken this year.

Sun	Mon	Tue	Wed	Thu	Fri	Sat
June	25 72°	26 78°	27 79°	28 75°	29 88°	30 93°
July 1 96°	2 97°	3 93°	4 95°	5 95°	6 83°	7 81°
8 87°	9 92°	10 89°	11 79°	12 84°	13 86°	14 83°
15 90°	16 96°	17 87°	18 78°	19 85°	20 91°	21 89°
22 83°	23 85°	24 92°	25 85°	26 83°	27 89°	28 83°
29 82°	30 85°	31 87°	Aug 1 84°	2 86°	3 81°	4 88°
5 91°	6 95°	7 85°	8 87°	9 88°	10 80°	11 83°
12 84°	13 85°	14 86°	15 88°	16 80°	17 78°	18 72°

Figure 1. Observed high temperatures at Burlington International Airport from June 25th through August 18th. During the period from June 29th to August 16th, the temperature reached or exceeded 80 degrees for 47 of 49 days.
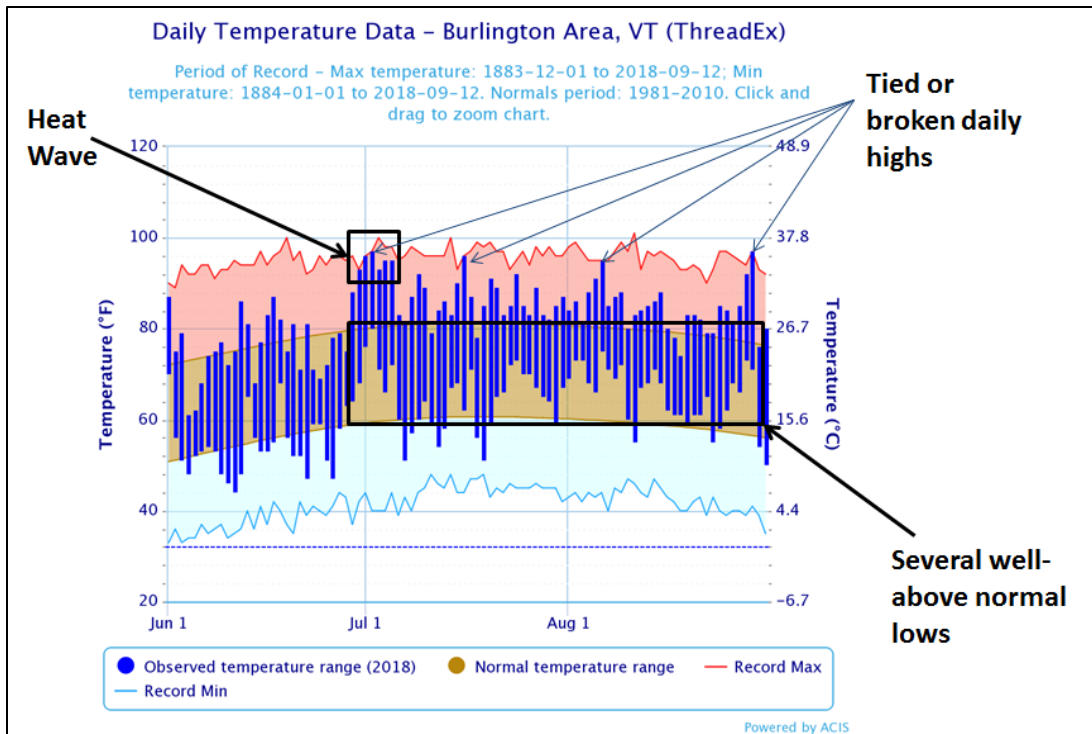

Figure 2. Observed Daily Temperature Data from Burlington.

So *why* was this summer so hot and muggy?

During a typical summer, high pressure builds over the western Atlantic Ocean. This high pressure is a semi-permanent feature of the summer months often centered near Bermuda, giving it its colloquial name the "Bermuda High". Clockwise flow around high pressure, allows the Bermuda High to steer warm, moist air from the tropics towards the southeastern United States, and then northeast off the Mid-Atlantic coast (Figure 3). This is why the southeastern US gets so hot and sticky in the late summer months. Depending on the high's strength and location, this tropical air mass can make it into New England. When this happens it brings us our most humid days of the summer, however these stretches are usually short-lived.

Figure 3.Typical summer pattern and location of the Bermuda High

So what happened this year?   The Bermuda high was abnormally strong, and extended further northwest than a typical year (Figure 4). Instead of the tropical air being steered off-shore before reaching the northeast, the tropical air was able to work its way up the entire east Coast persisting further north than normal throughout the summer.

For further explanation on the reasons behind this summer's record heat, we can look aloft at the upper levels of the atmosphere. The most notable feature in the upper levels was an anomalously strong ridge of high pressure over the eastern US. This upper-level ridge essentially blocked cooler, drier Canadian air from moving into the northeastern US, and

Figure 4. 2018 Summer pattern. Note the atypical northwestward extent of the Bermuda High.

kept our atmosphere more stable—limiting chances for cooling showers and storms. Comparing 2018 to 1949 (Burlington's warmest summer on record) using NCEP/NCAR reanalysis of 500mb heights, some other notable features stand out (Figure 5). Another strong ridge of high pressure is noted in the northeastern Pacific. Between the two highs is an upper trough, which promoted moist, southwest flow into New England.
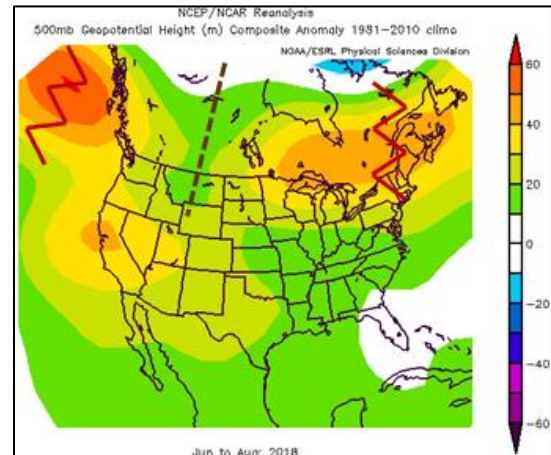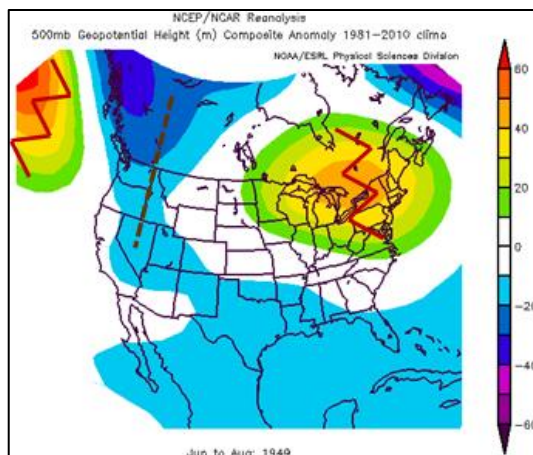

Figure 5. Comparison of 500mb Geopotential Height anomalies in the record breaking summer of 1949 (left) and 2018 (right). Both summers featured an anomalously strong ridge of high pressure (denoted with a zig-zag line) over the northeastern US, a ridge over the northeastern Pacific, and a trough (denoted with a dashed line) in between the two ridges over the Intermountain West. Image provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/

What about this winter? ?

So the big question as we get ready to dust off our skis and break out the winter parkas is what will this winter be like??? Does the record heat of the summer mean that winter will also be warm? Not necessarily. We looked back at winter temperatures statistics following the top 25 warmest summers, and found much variation in winter temperatures following our warmest summers. On average, mean winter temperatures following the 25 warmest summers at Burlington have been 1.6°F above normal. But that's just an average, and there have been some winters after warm summers that have averaged below normal.

One way that forecasters predict long-term trends in temperatures and precipitation is to look at atmospheric teleconnections. NOAA's Climate Prediction Center has forecasted a 65 to 70% chance of an El Niño onset during the winter of 2018-2019. But what does this mean for New England? It turns out that there isn't a very strong correlation between El Niño conditions and winter weather anomalies over the Northeast. We looked back at recent El Niño years and compared Burlington's winter temperatures, and found El Niños

winters to be about one degree on average warmer than normal for us in the North Country. But just as was the case following our warmest summers, this just an average, and there have been quite a few El Niño years where Burlington has recorded a colder than average winter. Overall, El Niño is a much better predictor for winter weather patterns in the southern and western US than the northeastern US. A far more useful teleconnection to predict our upcoming temperatures in the northeast US
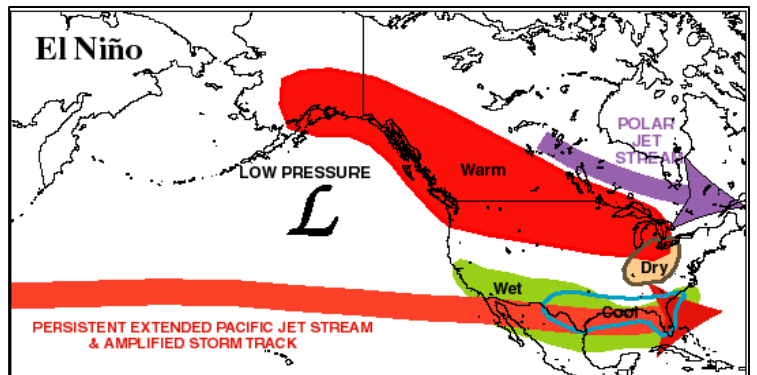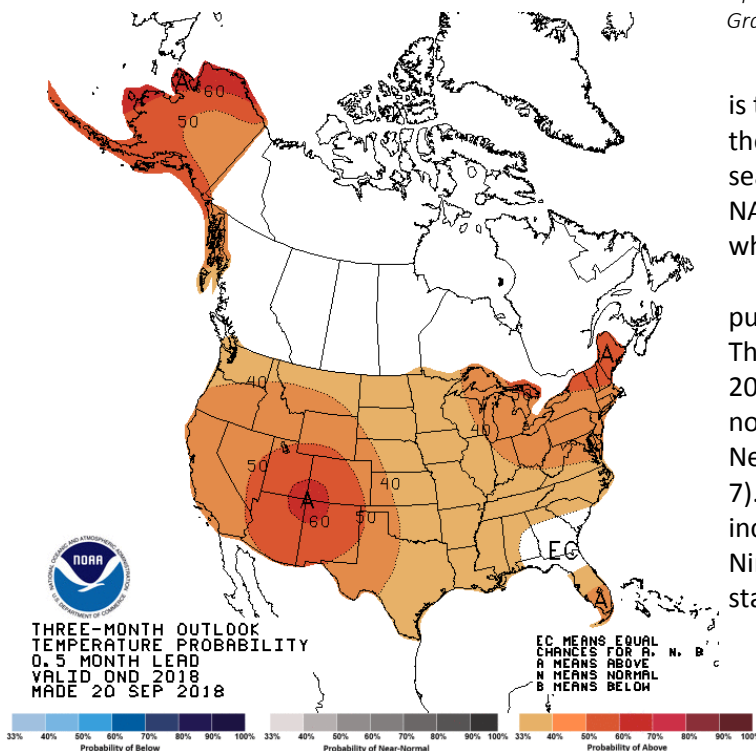

Figure 6. Typical January – March weather anomalies and atmospheric circulation during moderate to strong El Niño. Graphic courtesy of the Climate Prediction Center www.cpc.ncep.noaa.gov

is the North Atlantic Oscillation (NAO). However, the NAO can shift phases multiple times in a season, so it's too early now to see what the NAO has to say for our upcoming winter as a whole.

NOAA's Climate Prediction Center (CPC) puts out three-month outlooks for temperature. The three month outlook, made on September 20, gives a 50% to 60% probability of above normal temperatures for Vermont and Northern New York for October through December (Figure 7). This outlook takes many factors into account, including the forecast development of a weak El Niño, long-range weather model forecasts, statistical trends, and decadal trends.

Figure 7. (left) Three-Month Temperature Outlook Issued 20 Sept. 2018, Valid Oct.-Dec 2018. Graphic courtesy of the Climate Prediction Center www.cpc.ncep.noaa.gov

Providing Decision Support Services on Large Western United States Wildfires
By Brooke Taber

In the United States this year there has been almost 45,000 wildfires burning nearly 7 million acres of land. Similar to the previous couple of years this reflects an above average season, with many of the fires occurring across the western United States, due to above normal temperatures, reduced snow pack, and below normal precipitation. Figure 1 shows location of large wildfires across the western United States.

This past summer I had the opportunity as an Incident Meteorologist (IMET) to provide on-site decision support services to several large wildfires in western Colorado. National Weather Service IMETs are key members of the incident command team, which continuously provide on-site meteorological support for keeping both fire fighters and the general public safe. This support includes site specific weather briefings and forecast information, along with a continuous weather watch for changing or threatening weather, which could have significant impacts on fire behavior and crew
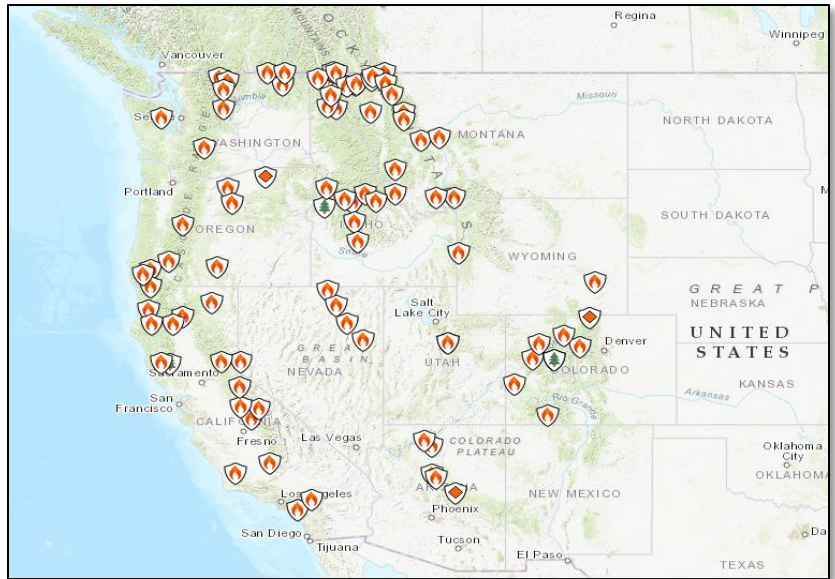

Figure 1: Locations of fires across the western US in late August

safety. We are especially concerned with temperatures, relative humidity, wind speed and direction, along with chances of precipitation and thunderstorms. We provide numerous weather briefings to fire planners and operations for developing strategies to quickly and effectively suppress the fire, utilizing both by air and ground resources.

Figure 2: Pictures of fire activity and retardant drop from aircraft on Lake Christine Fire in Colorado. Pictures courtesy of Rocky Mountain Incident Management Team Black.

My IMET deployment included working for two different Rocky Mountain Incident Management Teams. This included providing decision support services for the Lake Christine Fire near Aspen, Colorado, then transferring after seven days to Cache Creek Fire near Rifle. The Lake Christine Fire was on the White River National Forest and grew to 12,000 acres during my deployment. We experienced several rounds of isolated thunderstorms, which produced spotty rainfall on the fire, along with localized gusty outflow winds up to 55 mph.

These winds created localized extreme fire behavior with torching trees and spot fires, making it very difficult given the conditions to control the fire for fire fighters. In addition, several days of high instability with warm and dry conditions produced large dust devils near the burn scars. As the IMET, I briefed crews daily on the thunderstorm potential and associated hazards, along with provided them with numerous radio updates of when and where thunderstorms would impact different divisions on the fire. Figure 3 (right) shows several pictures of the weather I observed while deployed on the Lake Christine Fire.

Figure 3: Weather impacts on Lake Christine Fire dust devil (left), debris flow from heavy rainfall (middle), and approaching thunderstorm (right). Photos courtesy of Brooke Taber.

The combination of rainfall from thunderstorms, higher relative humidity values and cooler temperatures, resulted in crews making steady progress in containment lines by August 1st on the Lake Christine Fire. Given nearly 90% containment a transfer of command occurred to the local forest service unit and my services were no longer needed, therefore I was able to relocate to the Cache Creek Fire. This fire was located 8 miles southwest of Rifle, Colorado and was started by lightning. When I first arrived the fire was only 100 acres, but quickly grew to over 1000 acres due to the combination of hot, dry, and breezy conditions. In addition, poor relative humidity recoveries occurred at night, along with breezy downslope winds, resulting in active fire behavior. While on the Cache Creek Fire we experienced several rounds of thunderstorms, which produced gusty and erratic outflow winds, along with active fire behavior, but little rainfall. This created daily challenges for the fire crews with limited containment during my time providing weather support. Figure 4 shows a large smoke column, main street at our incident command post (ICP), and several spot fires from the Cache Creek fire. The ICP main street is where tents and trailers are located to provide supplies, communications, shelter for meetings, and overall work space for personnel supporting the fire crews.

Figure 4: Large smoke column (left), main street from our incident command post (upper right), and spot fires (lower right) from the Cache Creek Fire.

Both the Lake Christine and Cache Creek fires had some busy weather days, which resulted in active fire behavior and challenging conditions for crews building containment lines. As a result of hand crews, relentless aircraft dropping water, and timely burn out operations in the cities of El Jebel and Basalt, Colorado, over a billion dollars of infrastructure and homes were saved. I enjoyed providing daily weather briefings to the crews on critical weather conditions impacting the fire, while sharing this information to the general public during community meetings. I had a positive experience working with both incident management teams, while on the Lake Christine and Cache Creek fires.

Spotlight on... The Northeast River Forecast Center
- Rebecca Duell and Andrea LaRocca

Weather forecasts are important to many different users and partners across New England, but equally as important are the forecast responses of local waterways, including the St. Lawrence River, Lake Champlain and other main stem rivers across northern New York and Vermont. In conjunction with National Weather Service (NWS) offices, River Forecast Centers (RFCs) collaborate with federal, state and local agencies to provide accurate forecasts for rivers, streams, lakes and main tributaries into these bodies of water. These agencies are located regionally across the country. Our local RFC is co-located with the NWS Norton/Boston Forecast office in Norton, MA. The Northeast RFC (NERFC) forecasts for basins extending from Lake Ontario, east through the entirety of New England, including much of New York (Figure 1).

This fall, NWS Burlington sent four meteorologists to the NERFC for three days each to learn more about RFC operations and products. Each forecaster from Burlington was able to spend a day shadowing a Hydrometeorological Analysis and Support (HAS) forecaster, and a day shadowing a Hydrologist. HAS forecasters are responsible for quality controlling precipitation data, creating Quantitative Precipitation Forecasts (QPF) for the region, and providing support and hydrologic advice to WFO forecasters as needed. Hydrologists are responsible for taking the precipitation forecasts created by the HAS and using different hydrologic models to create short-, medium-, and long-term streamflow forecasts, graphically depicted in hydrographs such as the one seen in Figure 2.
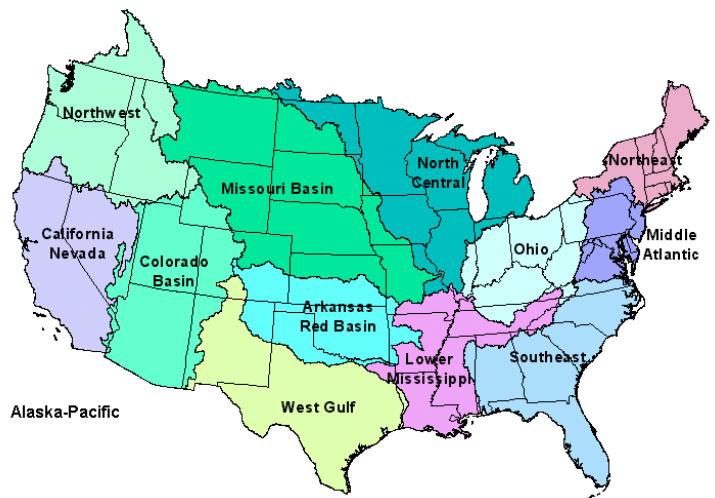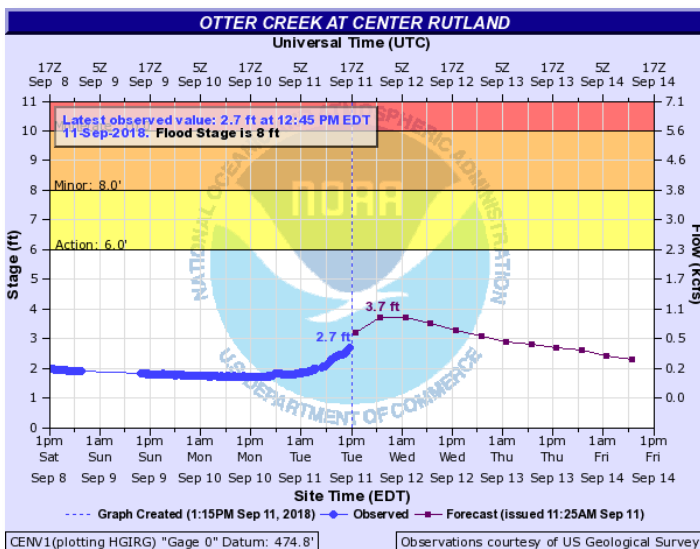

Figure 1: Areas of responsibility for the nation's 13 River Forecast Centers

Each hydrologist at the NERFC also serves as a focal point for an area of the northeastern US, and Burlington forecasters were able to gain important local knowledge on the Lake Champlain area by sitting with the Lake Champlain Focal Point.

Figure 2: Example hydrograph created by the NERFC for one of our river forecast points, Otter Creek at Center Rutland. Time progresses from left to right on the x-axis, and river stage (ft) is on the y-axis. The blue line is observed values, and the purple line is forecast values from the NERFC. River flood stages ('Major', 'Minor', and 'Action') are color coded for reference.

There are many exciting projects going on at the NERFC both on a national and local level to improve water forecasting. One of the biggest national projects that the nation's RFCs are assisting with is the testing and development of a new cutting-edge hydrologic model, the **National Water Model (NWM)**. The project, led by the Office of Water Prediction's National Water Center (based in Tuscaloosa, Alabama), is a collaboration between a number of academic and federal research partners that will revolutionize water forecasting in the US.

The NWM simulates observed and forecast streamflow over the entire USA, and will offer tremendous benefits in the form of water resource management, natural hazard preparedness, and the protection of life and property. For more information on the National Water Model, click on this link:

http://water.noaa.gov/about/nwm

Transforming NOAA Water Prediction

TODAY	THE FUTURE
Approximately 4000 forecast locations at points	Approximately 2,700,000 forecast stream reaches
Forecast river flow/stage	Forecast all hydrologic parameters which define the water budget
Driven by large catchment "lumped" modeling	Driven by high resolution Earth System modeling
Average basin size greater than 420 square miles	Average basin size ~1 square mile
Impact-based forecasts at selected points	Predictions linked with detailed local infrastructure data to communicate street level impacts
13 River Forecast Centers developing separate versions of the same regional model	NOAA, academia, and federal partners developing/evolving same national, community-based model

For the hydrology community, the implementation of the NWM and the leap ahead capability it provides parallels the implementation of mesoscale atmospheric models in the 1970s (i.e., model resolution substantially greater than available observational network)

*Figure 3: Comparison of NOAA water prediction capabilities prior to and after the start of the **National Water Model**.*
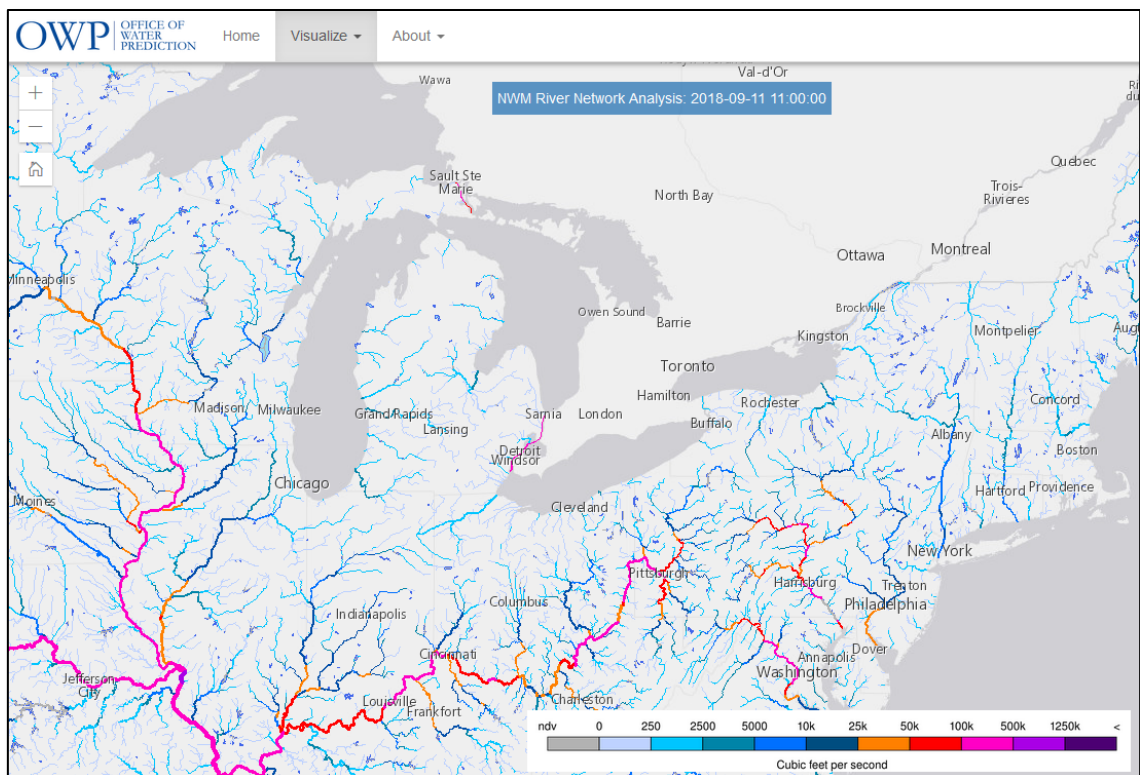

Figure 4: Example of visualized output from the National Water Model, with streamflow for different waterways depicted in cubic feet per second.

In addition to national projects, the NERFC is also working on a number of local projects in a continuous effort to improve water forecasting in the northeastern US. Current projects being worked on at the NERFC include beta-testing a new wave model that would better incorporate forecast winds into Lake Champlain wave forecasts. Local forecasters at Burlington and the NERFC know that strong southerly winds lead to higher water levels and bigger waves in the northern portions of the Lake, but current models can struggle to handle local effects like these. The new model being created and tested would increase the accuracy of lake forecasts by better accounting for the effects of wind.

Overall, visiting the NERFC was a valuable learning opportunity for forecasters new to the New England area. With flooding posing such a threat to the North Country, acquiring a solid understanding of all the resources available to support hydrologic forecasts in the region can provide critical lead time and the most accurate forecasts during hazardous flooding events. We here at NWS Burlington would like to extend a sincere thank you to the Northeast River Forecast Center for all that they do for us, and for hosting us on our familiarization trips.

*Figure 5: NERFC Hydrologist **Tracy McCormick** (left) trains NWS Burlington meteorologists **Matthew Clay** (middle) and **Rebecca Duell** (right).*

Meet a Forecaster:
Maureen Hastings

How and when did you become interested in meteorology?

I grew up in eastern Kansas, so weather–particularly severe weather–has always played a big part in my life. My dad was always keyed into what the weather was doing, so it was natural for me to do the same, but it wasn't until a tornado hit my town in November 1989 that I really started paying attention. The storm and its impacts intrigued me and I started reading everything I could about weather. I attended several storm spotter seminars hosted by WFO Topeka, and that's all it took for me to realize that I wanted to follow in the footsteps of those people I saw onstage.

What has your NWS path looked like?

I was a student volunteer at NWS Norman for a year while in school at the University of Oklahoma and for a short time after graduation. My first paid job with the NWS was here at WFO Burlington, starting in September 2003. After 7 years in Burlington, I moved to the Caribou NWS office to become a journeyman forecaster and the hydrology program manager. Six years later, I missed Burlington so much I opted to move back as a journeyman forecaster.

What part(s) of returning to Vermont are you most excited about?

Vermont is the perfect mix of country and small-city living. I crave the peace and quiet of nature, but don't want to be too far from stores, restaurants, and other services. Here in Vermont, I can live in the country and be just a short drive to outdoor activities while staying relatively close to the amenities of a good-sized community; this was something that was harder to do in far northern Maine, which is far more isolated and rural.

*Ice on the St. John River, in northern Maine. Picture taken by **Maureen Hastings** while monitoring ice jams from a helicopter with the Maine Forest Service.*

What will you miss the most about living/working in Caribou?

Definitely the people. Aroostook County natives are some of the friendliest, most helpful people around, and I made some great friends while I was there. I will miss the stark remote beauty as well; some of my fondest memories are of long days spent driving around the countryside performing snow and river ice surveys.

Any specific examples of things you learned while working in Caribou that you want to bring back to Burlington?

I think the biggest thing I can bring back to Burlington is everything I learned about river ice and ice jams. As NWS Caribou's hydrology program manager, I worked closely with local, state, and federal officials each year both before and after ice out. I gained a lot of knowledge, not only about the physical processes involving river ice and break up, but also in how best to serve NWS partners during this highly critical season.

Any crazy stories about working in rural northern Maine?

It's not so much that I saw anything truly crazy but more what simply became the norm while working and living in Aroostook County. Putting in 10-12 hour days to perform outreach and meet with partners (4 hours one-way to drive to the Maine coast), driving for hours in the North Woods and encountering no one but the occasional logging truck, regularly seeing moose while out and about (even right in the office's front drive), experiencing bitterly cold temperatures (-40°F was the coldest); all these things simply became routine.

What's your favorite part of working for the NWS? Most challenging?

One of the things I love most about working for the NWS is the challenge; the weather is always changing and I enjoy trying to get the forecast just right. I also really enjoy working closely with our partners and ensuring they have the information they need to keep the public safe. The most challenging is probably the rotating shifts; it's hard on the system to constantly switch from days to evenings to midnights.

What do you like to do in your free time?

I enjoy activities such as hiking, snowshoeing, kayaking, reading, going to the movies, and visiting local museums.

Welcome back, Maureen!

Lake Eden: The Newest NWS Observing Site
-Marlon Verasamy

Here at NWS Burlington, we're always looking for new ways and locations to get real time weather data to help us provide forecasts across Vermont and Northern New York. This summer we added a new location that not only provides another piece of real time data in Lamoille County, but also help teach young people about the basics of weather observations. The Mount Norris Boy Scout Camp at Lake Eden in Eden Vt has become the location of the newest automated weather station site this past July.

This station will not only provide valuable data near a known flood prone area but also allows for an educational source for the hundreds of scouts that spend time each summer and parts of the winter at the scout camp. Informational plaques that will be added to the system later this year will allow scouts to access information that can assist them in achieving their weather merit badge. To see the latest observation from Lake Eden, follow this link: Mt. Norris Reservation at Lake Eden (LEDV1)

Eastern Region Leadership Development Program

- Jessica Neiles and Robert Deal

Recently, NWS Burlington was able to send two employees to our National Headquarters in Silver Spring, Maryland, to graduate from the Eastern Region Leadership Development Program (ERLDP). Twenty seven NWS employees along with the seven facilitators spent four days together listening to guest speakers, learning about each other, challenges in the NWS, and learning about how they can embrace the evolution of the NWS.

*Figure 1: Graduates of the 2018 ERLDP, including NWS Burlington employees **Jessica Neiles** and **Robert Deal***
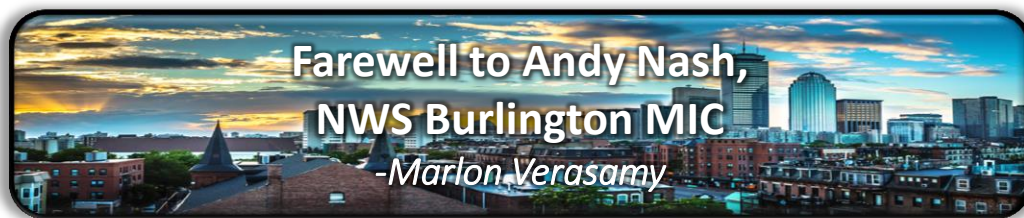
The graduation week of ERLDP is the culmination of a two year development program. At the beginning of the program, students go through a leadership assessment where they can identify areas that need development. From there students work one-on-one with a mentor who helps guide them through the process of self-exploration, awareness, and project work. Along the way, students participate in guided conference calls with each other that are focused on People and Relationships, Teams, Communications, and Leadership, sharing experiences about each topic.

The guest speakers at graduation included Harvey Coleman, Richard "Dick" Brundage, and a panel of NWS senior leadership. Harvey Coleman spoke about how people can "Empower Yourself! The Organizational Game Revealed". This talk explained the idea that there's a hierarchy in both business and society that develops as a result of choices that we make. One important take away was that "the game" is all about people, and the relationships that get developed. The second guest speaker was Richard "Dick" Brundage. He spoke about the idea of Crisis Communication and how speaking from the heart, not the head, is important because it shows that there really is care and empathy in tough situations. Students learned about media cadence and how to build effective communication.

The final portion of the week was dedicated to the students. All students gave presentations without PowerPoint or visual aids and were asked to speak from the heart about the program. It was a unique part of the graduation experience where students get to demonstrate how the program changed them and how the program and mentors helped student believe in themselves more. It was certainly the highlight of the event for the students to learn more and appreciate each other's stories.

The two recent graduates join a long list of NWS Burlington employees (current and previous) who have either graduated from the program or are mentors in the program. This was the final graduating class of ERLDP. The program now includes the National Center for Environmental Prediction and so the name of the program "Eastern Region Leadership Development Program", no longer fits. The new title for the program will be called "CLASS" which stands for "Cultivating Leaders to Advance Science and Service."

Farewell to Andy Nash, NWS Burlington MIC
-Marlon Verasamy

We close the newsletter with a fond farewell to our Meteorologist in Charge, Andy Nash as he leaves NWS Burlington after 11 years to become the Meteorologist in Charge for NWS Boston/Norton.

Andy grew up in Connecticut, being fascinated by all things weather for as early as he can remember, and knowing that he wanted to ultimately become a meteorologist. He went to the University of Hawaii where he earned his Bachelor's and Master's degrees in Meteorology. After graduating in 1992, he started his career with the National Weather Service. His first position was a Meteorologist Intern in Montgomery, Alabama. In 1994 he was promoted to General Forecaster at the office in Tampa Bay Area/Ruskin, Florida, before moving on in late 1998 to the office in Taunton (now Norton) Massachusetts. The following year he transitioned to NWS Eastern Region Headquarters on Long Island to become the Regional Program Manager for Aviation and Severe Weather services. In 2002 he return to Hawaii to become the Science and Operations Officer (SOO) at the Honolulu Forecast Office and Central Pacific Hurricane Center, eventually becoming the Director of Operations/Deputy Director in Honolulu. Finally, in 2007 Andy was selected to be the Meteorologist-in-Charge of the office here in Burlington.

Over the years, Andy has not only hired most of the current members of the office here in Burlington, but has allowed all of us here to grow and excel professionally, allowing NWS Burlington to continue to find new and innovative ways to provide the best weather forecast for the members of our Vermont and northern New York communities. We wish Andy and his family all the best on their new adventure and thank him for all that he has done for NWS Burlington.

The Four Seasons
Volume V, Issue II

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Marlon Verasamy, Observing Program Leader
Andrea LaRocca, Meteorologist

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!

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