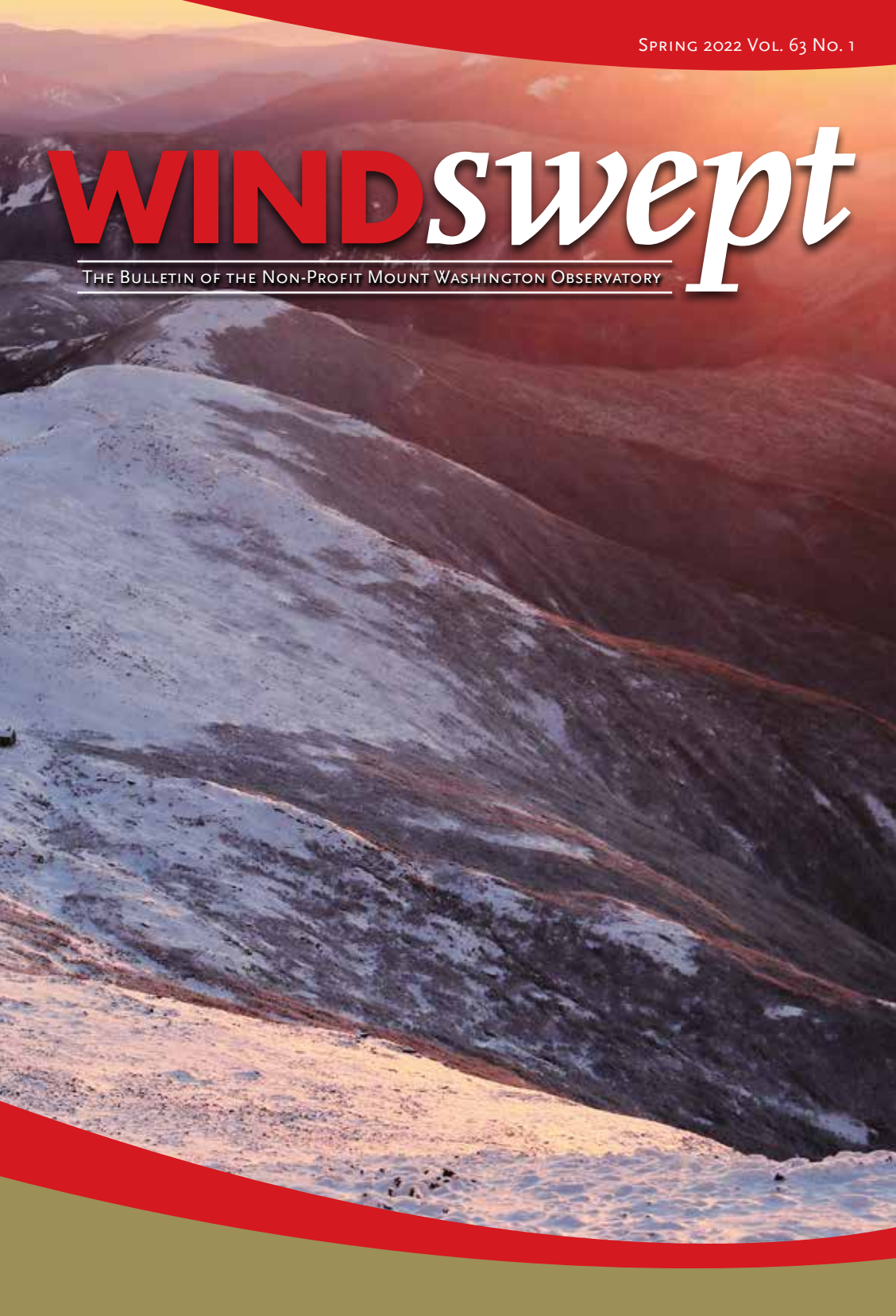
Spring 2022 Vol. 63 No. 1

WINDswept

The Bulletin of the Non-Profit Mount Washington Observatory



MWOBS

MOUNT WASHINGTON OBSERVATORY

SCIENCE IN THE MOUNTAINS™

A FREE VIRTUAL LECTURE SERIES

Each month, we host experts from across the fields of weather, climate, and beyond.

Join us via Zoom or Facebook/mwobs

Visit mountwashington.org/SITM for program updates and to register today.

Zoom calls have limited space available.
If you are unable to attend via Zoom, please go to
Facebook/mwobs for the live presentation.

MWOBS
MOUNT WASHINGTON OBSERVATORY

WINDswept

Table of Contents

FEATURES

NEWS

EDUCATION

WEATHER

DEPARTMENTS

Mount Washington Observatory™ is a private, nonprofit, member-supported institution with a mission to advance understanding of the natural systems that create Earth's weather and climate. It serves this mission by maintaining a weather station on the summit of Mount Washington, performing weather and climate research, conducting innovative science education programs, and interpreting the heritage of the Mount Washington region.

Membership in the Observatory is open to all. Members receive: Free tours of our famous mountaintop weather station in summer (updates to come in 2022); a one-year subscription to *Windswept™: The Bulletin of the Mount Washington Observatory*; meteorology and climate research news from the summit of Mount Washington, straight to your inbox; free admission to Extreme Mount Washington™ museum ; advanced notice of special events; a 15% discount on all purchases in our museum and online shop; and free admission to more than 300 science centers through the ASTC Passport Program (restrictions apply, please see the ASTC website for details).

Members will receive the three issues of *Windswept: The Bulletin of the Mount Washington Observatory*, for the year following the quarter in which they join. Please make checks payable to the Mount Washington Observatory and send to Mount Washington Observatory, PO Box 2310, North Conway, NH 03860-2310, or join at www.mountwashington.org.

Windswept: The Bulletin of the Mount Washington Observatory (ISSN 1098-7215, USPS 330-710) is published three times a year (spring, summer, fall/winter) by the Mount Washington Observatory. Single-copy price is $4.00, or $3.00 for members. Periodical postage paid at North Conway, NH, and additional mailing offices.
Editorial office to which all correspondence and address changes should be mailed is PO Box 2310, North Conway, NH 03860-2310 or submit via email to cbuterbaugh@mountwashington.org

Mount Washington Observatory
2779 White Mountain Highway | PO Box 2310
North Conway, NH 03860-2310
603-356-2137 | email@mountwashington.org | MountWashington.org

Administrative Offices
2779 White Mountain Highway
North Conway, NH 03860-2310
603-356-2137 phone

Summit Facility
Mount Washington
603-356-2137 phone

WINDswept

Editor: Charlie Buterbaugh
Graphic Design: Lori Dunn
Phone: 603-356-2137
Email: cbuterbaugh@mountwashington.org

Contributors:
Jackie Bellefontaine, Charlie Buterbaugh, Peter Crane
Cover Credit: Ryan Knapp. Sunset color on the southern Presidential Range in January.

Staff

Matthew Addison, *Weather Observer & Meteorologist*
Jackie Bellefontaine *Weather Observer & Education Specialist*
Jay Broccolo *Weather Observer & Meteorologist*
Charlie Buterbaugh *Director of Communications*
Dr. Peter Crane *Curator*
Linda & Hank Dresch *Volunteer Coordinators*
Donna Dunn *Interim Executive Director*
Stephen Durham, *Weather Observer & Education Specialist*
Greg Fitch *Transportation Coordinator*
Brian Fitzgerald *Director of Science & Education*
Stephanie Fitzgerald *Director of Development*
Keith Garrett *Director of Technology*
Craig Hill *Snowcat Operator*
Ryan Knapp *Weather Observer & Meteorologist*
Jon Powers *Snowcat Operator*
Sam Robinson *Weather Observer*
Rebecca Scholand *Director of Summit Operations*
Carrie Slife *Development Assistant*
Brenda Sullivan *Director of Finance & Administration*

Officers and Board of Trustees

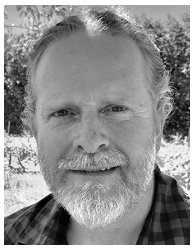
Chairman: Rob Kirsch *Concord, NH*
Vice Chairman: Bruce Soper *New London, NH*
Immediate Past Chair: Gary MacDonald *Conway, NH*
Treasurer: Beth Newhouse *Berlin, NH*
Secretary: Paul T. Fitzgerald *Laconia, NH*

Ed Bergeron *North Conway, NH*
Alexandra Breed *Gilford, NH*
Erica Broman *Longmeadow, MA*
Michelle Cruz *Conway, NH*
Ty Gagne *Hampton, NH*
John Gorman *Boston, MA*
Drew Landry *Keene, NH*
Michael Matty *South Hadley, MA*
Peter Middleton *Portsmouth, NH*
Ken Rancourt *Center Conway, NH*
Marsha Rich *Chichester, NH*
Mary Stampone *Dover, NH*
Karen Umberger *Kearsarge, NH*
Brian Underwood *Rye, NH*
Howie Weymss *Randolph, NH*

Life Trustees

Brian K. Fowler *Grantham, NH*
Guy Gosselin *Merrimack, NH*
Christopher Hawkins *Lancaster, NH*
Kenneth Jones *Amherst, NH*
Gail Langer *Harpswell, ME*
Gail Paine *Intervale, NH*
Leslie Schomaker *Jackson, NH*
Dr. Bryant F. Tolles, Jr. *Concord, NH*
Dr. Mark Van Baalen *Rockport, ME*

The Perspective Given by the Summit



Charlie Buterbaugh

BY **CHARLIE BUTERBAUGH**, EDITOR

Conversations at the Obs frequently delve into the interests of our supporters, the purpose of our work, and examples of our nonprofit's impact. The summit is a fitting place to gather perspective on these topics.

Last November, I spent a night at our weather station, visiting the crew with the assignment of shadowing one of our night observers. Staff Meteorologist Ryan Knapp was kind enough to let me follow him around, learn a bit about his nightly process, and write a story about the experience for this issue of *Windswept*.

After riding up the auto road in the MWOBS van, my day started with fairly clear skies opening to tremendous views of the slopes, ravines, and higher summits. On Mount Washington, everything is fascinating to those who don't experience it regularly. But around 9:00 that morning in the weather room, Observer Sam Robinson stepped away from his work to point out something noteworthy.

An asperitas cloud with a defined lower edge following exactly the curve of land was floating up from the Ammonoosuc Ravine. The shape of the mountain was mirrored perfectly in the cloud's lower outline as it ascended the western slope below the observatory, a beautiful example of Mount Washington influencing the lower atmosphere.

This calm scene contrasted sharply with our departure the following day. The summit was engulfed in a snow storm, and I witnessed the classic Mount Washington scenario of fog and blowing snow in the alpine tundra microclimate, only to find fair, no-worries-be-happy conditions below 4,000 feet.

Between my arrival and departure on the mountain, I learned numerous things. What struck me most was the relationship between weather, an ever-evolving dimension, and the unwavering consistency of observation science. In the face of cold fronts, warm fronts, pressure gradients, and other examples of weather's impermanence, the summit team observes and documents these conditions with exacting consistency, creating the data that become part of a permanent climate record. This consistent data set remains the key to helping our region understand an evolving environment and how the White Mountains are responding to regional climate trends.

The scientist brings order to an ever-changing world. A lot is riding on the quality and consistency of the observers' work in a very unpredictable place. There are some great passages about how wisdom gained on a summit changes us. As Rene Daumal wrote:

There is an art of conducting oneself
In the lower regions by the memory
Of what one saw higher up.
When one can no longer see,
One can at least still know.

Our Service to Science

Donna Dunn

BY **DONNA DUNN,**
INTERIM EXECUTIVE DIRECTOR

I've been thinking a lot about the word "service" lately. Customer service. Community service. Social service. Public service. One definition of service (that does not use the word "serve" in the definition) is "a helpful act."

It's led me to contemplate the service, or services, that Mount Washington Observatory provides.

The most obvious is our Higher Summits Forecast. Twice a day, our observers develop and update a 48-hour forecast used by outdoor recreationalists, search and rescue experts, the forest service, and others. The forecast is often picked up by other meteorologists and weather reporters.

Daily higher summit reports on North Conway's WMWV radio station are often how people discover this particular service. The forecast is posted on our website as a public safety service. It is transmitted to the AMC huts via radio so hikers enjoying a hut stay will know what to expect on the trails. The Mount Washington Avalanche Center uses our forecasts as well.

In this issue of *Windswept*, you'll read about the variety of ways we make our forecasts available to the public, including a new SMS or text messaging service, which gives immediate weather conditions direct to your cell phone and is highly accessible in the backcountry (see On Technology, p. 42). All methods of sharing our forecast help people plan and stay safe in the mountains.

Our regular synoptic observations are another key service, which we supply to the National Weather Service (NWS). The hourly weather observations are a snapshot in time, while the synoptic observations are a six-hour picture of the weather — more in-depth about maximum and minimum temperatures, precipitation, humidity, etc. This important information goes into the data and calculations that form the NWS weather models and shape meteorologists' forecasts throughout New England, which many rely on for planning purposes.

Our hourly weather record, kept for 90 years, serves researchers, climate scientists, meteorologists, data scientists, and others who are interested in examining the ups, downs, and variations over time of the weather on the summit of Mount Washington. Researchers access this information to examine climate trends at the higher

summits. Temperature trends over time have been a focus of recent research. New research will examine trends in wind and humidity over time, and perhaps provide information that will examine climate change trends beyond temperature. The MWOBS data set, unique in its comprehensive nature, helps scientists and researchers better understand and track the climatic changes at the higher summits.

Our museum, Extreme Mount Washington, in the Mount Washington State Park, serves to educate and inform a broad audience about weather on the summit. We share with the public the unique nature of the summit, the extremes of weather, and our history on Mount Washington. We help them begin to understand our work and the rich history of the Obs on the summit. We serve the public with an experience of mountain weather, no matter what is happening outside during their visit.

Mount Washington Observatory is in the business of science and research. We serve many audiences and provide different information and experiences. All of our services to our broad community are thanks to our members – the donors who make our work possible.

Looking south towards Crawford Notch on Jan. 14 after clouds cleared from the summit, with a strong ocean storm to our east/southeast spreading in high clouds overhead.

An Update on our Membership Model

BY **STEPHANIE FITZGERALD**

At the end of last year, we announced changes to ensure our membership model reflects our current programs and continues to strengthen our impact as a community.

In brief, these changes include:

- Changing the definition of "member" to anyone who makes a donation. Gifts are no longer split into general donations and membership dues. Any donation amount qualifies you and your household as a member. This improves our ability to steward and engage with all people who support our work.

- Discontinuing a dues structure with graduated tiers, a model that we had outgrown after closing the year-round Weather Discovery Center to re-focus on our core work.

- Evolving the benefits of membership towards content and resources that keep you connected with Mount Washington's weather and the unique work of our mountaintop weather station. Benefits now include a one-year subscription to *Windswept*, seasonal admission for your household into the Extreme Mount Washington summit museum, weather station tours (also seasonal), advanced notice of special events, and more. For a complete list of benefits and their details, head to mountwashington.org/membership.

- You also now have a new option of setting up a recurring monthly donation to sustain your membership throughout the year.

Most importantly, the changes are designed to streamline administrative tasks and strengthen the impact of your philanthropy. When you give a donation, it should go as far as possible toward supporting the continuation of our 90-year climate record, mountain forecasting services, and innovative educational programs.

We are asking for an annual donation of at least $60 per year, or $5 per month, to receive the benefits listed above, which we understand is an increase for many of our members. We have spoken to a few members about this change and want to verify that if you donate less than that per year, you are still considered a member with a membership card, member updates, and an invitation to our Annual Meeting each year. Any donation amount will continue your long-term membership with us. The increase helps us ensure a sustainable future for Mount Washington Observatory.

Regarding benefits, in the past, a membership provided the option of becoming a summit volunteer and travelling to our weather station to support our crew of observers during a week-long

shift, cooking meals and completing other helpful tasks. In the years preceding the pandemic, demand for this program had grown significantly, requiring considerable time from our staff to coordinate effectively.

The summit volunteer program is in the process of being redefined to make the best use of our volunteers' knowledge and talents in support of our operational needs. We also need to be mindful about the health and safety of our summit staff and partners who utilize the the NH State Park Sherman Adams building. As soon as the new program is ready, we will be contacting our members and past volunteers, and an application form will be available at mountwashington.org.

Finally, as part of changing our membership model, we will be opening access to much of our content, including weather observation cameras without the need to log in. All of our cameras will soon be available on our Weather Cams page at mountwashington.org, including two new live-streaming video cameras that are now accessible, showing Mount Washington from the east and a view looking south from our summit observation tower.

We're excited about the opportunity to serve a wider audience in response to high demand for our weather cams, a service maintained by MWOBS thanks to your support.

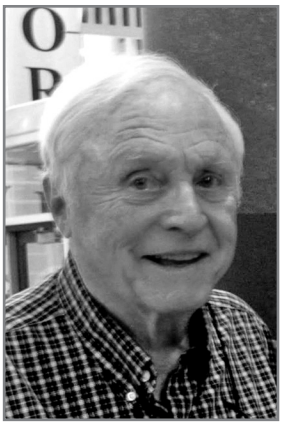
The Premium Content – Login page will be removed from our website in the near future. The current print edition of *Windswept* will continue to be mailed to you and published online. Archived editions will be accessible to anyone online, and we will continue publishing select stories on our Windswept Online page.

Over the next year, it's our priority to work with you, and our new database, to get everyone settled in this new model. We will continue sending annual renewal reminders and grandfather everyone's current benefits who joined or renewed last year through their current "expiration date." With any change, things can get missed, so please reach out to membership@mountwashington.org with your questions or concerns.

Thank you all so much for your amazing commitment to MWOBS' unique work. Your enthusiasm for weather, appreciation of science education, need for climate research, and appreciation of the extremes found only on Mount Washington encourage us as we continue our 90th year at the summit.

Charles Wilson Burnham
1933-2021

Charles Burnham, a life trustee at Mount Washington Observatory, passed away on Dec. 13, 2021.



Charles Wilson Burnham

Charlie became acquainted with MWOBS on his first ascent of Mount Washington in 1944. He joined the Board of Trustees in 1981, was a member of the Executive Committee from 1983 to 1994, and also served as vice president. He became a life trustee in 1996.

He is survived by his wife Mary Sue (Morgan) Burnham, who described Charlie as a map reader who hiked all 4,000-footers and could identify any White Mountain peak from various vantage points.

"We traveled the world and saw some fabulous sites, but Mount Washington was home," said Mary Sue, who lives in Durango, CO in addition to the family's summer home in Madison, NH, built in 1974.

Teaching was one of Charlie's greatest loves, whether in the classroom or on a snowy mountainside. He was beloved by his students for his knowledge and uncompromising attitude. Perfection was the goal in all that he did.

Born in 1933 in Detroit, MI to Charles Hubbard and Anne (Wilson) Burnham, he was raised in Winchester, MA. He attended MIT, as did his father and grandfather before him, graduating in 1954. Following two years of service in the USAF, he returned to MIT to earn a PhD in mineralogy and petrology in 1961.

Married in 1958, Charlie and Mary Sue had two sons, Jeffrey Wentworth, born in 1960, and David Wilson, born in 1963. Following graduate school, the family moved to Washington, D.C., where Charlie worked for the Geophysical Laboratory, an institution run by the Carnegie Foundation. In 1966, the family returned to the Boston area when he became associate professor of mineralogy at Harvard University in the Department of Earth and Planetary Sciences. He retired as a full professor in 1996.

Charlie died peacefully in Grand Junction, CO following a fall which occurred earlier in the year. In addition to Mary Sue, he is also survived by his son Jeffrey and wife Leiah, son David and wife Jenni, and grandchildren Ryan, Paige, Colby, Emily, Carter, and Oaklee.

There will be a memorial picnic held in the White Mountains during summer 2022.

My First Full Winter at the Top

TRANSLATED BY **STEPHEN DURHAM**

Meow from the top of New England! My weather observers were not kitten about the weather changing very quickly up here in the fall and winter. It is pretty clawsome watching all the ice and snow fall outside the weather room windows. I have been trying to stay pawsitive that we will see more snow to finish out the winter and spring.

Nimbus appearing worried about extreme cold temperatures this winter.

Another impressive observation I have made while here on the meowtain is the fur-ocious wind. When it gets really windy and cold, I enjoy a nap on the living room couch, where it's warmer and the wind is not so loud.

I am furever thankful for all the gifts Santa brought me and the weather observers. The toys and treats were pawsome! I am also very fur-tunate for the many people who contributed to the year-end campaign to support our not-fur-profit weather station.

This winter has been long and cold so far. I think I'm pretty lucky I don't have to be clawing away at work like the weather observers, who shovel snow and de-ice instruments in addition to their meteorology work. My favorite thing to do is when an observer gets up, I take over their seat. It's purr-fectly warm, and I try to take a nap to keep it warm for them until they return.

It is pretty quiet during the winter compared to the summer. I get to roam around the building like it's all mine. I am looking forward to warmer days again though, just so I can go outside to help with weather observations. Purr-haps spring and summer will arrive sooner in the coming months, be-claws I hope to see more visitors here at the summit again. Plus, I need to get outside to explore and enjoy the meow-nificant views!

FEATURE

The Microclimates of Mount Washington

BY **JACKIE BELLEFONTAINE**

Earth's global climate system is similar to a patchwork quilt, comprised of a variety of patterns all stitched together to form a cohesive unit.

Found across the earth, smaller-scale climates — known as macroclimates, mesoclimates, and microclimates — come together in a complex web forming our planet's global climate.

Microclimates, which are particularly interesting, can be defined as a set of climatic conditions that differentiate a localized area from the larger surrounding region. Such conditions include temperature, precipitation, humidity, wind, and solar radiation, among other variables.

Microclimates can span a spatial scale from the leaves on a tree to mountain slopes. The ecological community that has adapted to the environment further defines a microclimate; the community can also influence the microclimate through its own physical processes and structures. Microclimates are also interesting studies because of how they respond to larger-scale surrounding climates.

There are many components that influence microclimates, including the unique topography of mountainous terrain. Variations in topography can drive differences in temperature, precipitation, and exposure to solar radiation. Aspect, or slope orientation, determines how much solar radiation a given hillside receives. For example, south-facing slopes in the northern hemisphere receive more solar radiation than north-facing slopes. Additionally, east-facing slopes receive direct sun radiation in the morning hours, while west-facing slopes receive direct sun in the afternoon. Thus, eastern slopes are typically colder and drier while west-facing slopes are typically warmer and wetter.

In mountain climates, topographic elevation is another major influence driving orographic lift, which occurs when air is forced to rise and cool due to terrain features such as hills and mountains, resulting in cloud formation and precipitation, assuming cooling is sufficient. As a result, higher terrain typically experiences more cloudiness and precipitation than lower elevations. Orographic lifting can also cause rain shadows, which occur when the moist rising air begins to descend the leeward side of the mountain, warming and drying (see Figure 1).

In some regions, rain shadows can be quite dramatic, resulting in vastly different climates on adjacent mountainsides. Additionally, regarding elevation, a phenomenon known as the standard, or average, lapse rate affects temperatures experienced at different elevations. Simply stated, the standard lapse rate is the rate of change in temperature observed when moving vertically in the troposphere, where temperatures

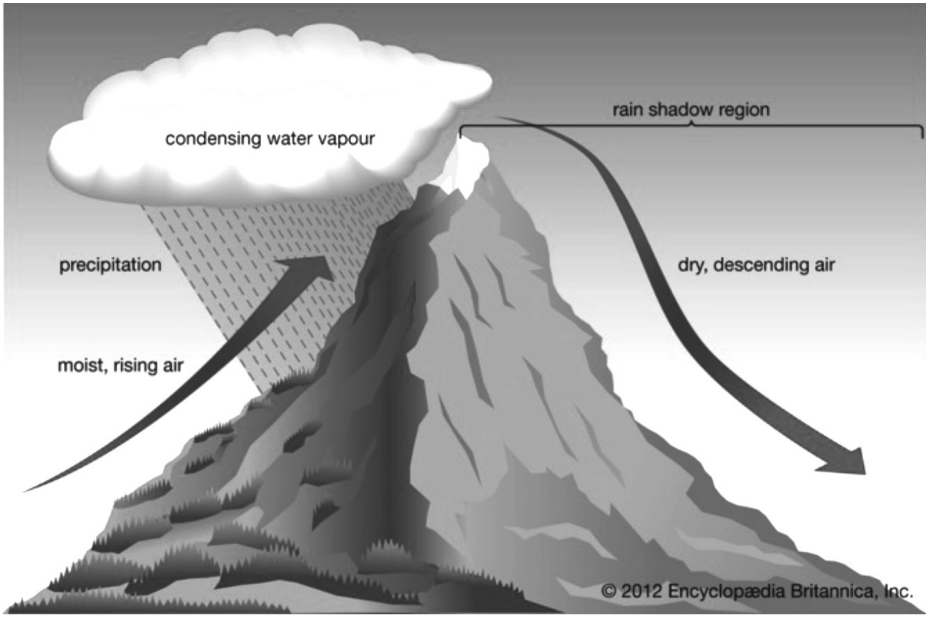


Figure 1. The process of orographic lift creating a rain shadow on the leeward mountainside (Encyclopedia Britannica graphic)

cool with increasing altitude. Therefore, higher elevations experience cooler temperatures on average. Coupled together, topography and altitude are major drivers of mountain microclimates. (Learn more about orographic lift and similar phenomena in Weather 101, p. 35).

Several microclimates can be found around Mount Washington, from the Horn, to Tuckerman Ravine, to the summit. These microclimates fall under three major climate zones, according to their elevations along a vertical transect from the base of the mountain to the summit.

These zones are defined using the Koppen Climate Classification System, also known as the Koppen-Geiger Climate Classification System, which categorizes the world's climate zones based on local vegetation. The system was first developed by German climatologist and botanist Wladimir Koppen in the 19th century after earlier biome research revealed how complex the relationship is between vegetation and climate.

Modified over time but still widely accepted by scientists, the Koppen system divides our global climate into five main zones based on major variables, typically temperature, that influence vegetation growth. These include Zone A (tropical), Zone B (arid), Zone C (temperate), Zone D (continental), and Zone E (polar). The zones are then subdivided based additional local factors related to annual temperature and precipitation. There are many subdivisions, from tropical rain forest climate to ice cap climate.

The Koppen subdivisions experienced during a traverse up Mount Washington are humid continental, subarctic, and alpine tundra climates (see Figure 2).

Humid continental climates are typically found between 30°N and 60°N in the northeastern and central regions of Asia, Europe, and North America. Features include large differences in seasonal temperatures, such as warm-to-hot, humid summers and cold-to-frigid winters. Precipitation in humid continental climate zones tends to be relatively well distributed throughout the year and is typically derived from frontal cyclones or convectional showers.

Figure 2. The three major Koppen climate zones found on Mount Washington. Brad Washburn photo.

A humid continental climate zone is found from the Mount Washington Valley to the base at about 1,600 feet, and up to about 2,500 feet in elevation. In line with the 1,900 Koppen classification, this zone encompassing the valley regions and lower elevations is characterized by a humid and warm season, absence of a dry season, and severe winter. Considered a transitional forest by ecologists, the northern hardwood forest found in this area are typical of a humid continental climate zone. Sugar maples, American beech, and yellow birch trees dominate. In addition, fauna such as black bears, moose, deer, and small species like gray fox and wood turtles do well in this environment.

Travelling farther up the transect from 2,500 feet to tree line is a subarctic climate zone, typically found in northern Canada and most of Alaska. Subarctic climate zones are characterized by severe winters, cool summers, and no dry season. What little precipitation that happens is mostly concentrated to winters. Boreal forests with fir and spruce trees and smaller animals, such as lynx and snowshoe hare, dominate the area.

Mount Washington's subarctic climate zone is unique due to orographic lifting that causes the mountain to receive more precipitation on average. The amount of precipitation received on Mount Washington also makes the next

climate zone up, the alpine tundra, even more unique.

Encompassing the zone above tree line, at approximately 4,400 feet and up, the alpine tundra is marked by harsh winters and mild summers. Mount Washington's alpine tundra is very similar to a polar tundra found in the Arctic. However, the high amount of precipitation received on the mountain changes the zone's classification.

On average, tundra climates receive just under 10 inches of precipitation annually. Mount Washington receives approximately 91 inches annually. In addition, our alpine tundra experiences some of the windiest conditions on Earth, contributing to the alpine zone's harsh tundra climate. Only hardy plant species such as sedge grass and small animals like pine martens (or a well outfitted Weather Observer!) can survive the alpine zone's adverse conditions.

Though there is still much to understand about how Mount Washington's alpine tundra will respond to a changing climate in the Northeast, Mount Washington Observatory has a unique vantage point to monitor any variations. The observatory has been collecting weather data since its establishment in 1932, all of which has contributed to a continuously growing climate record.

As currently observed and recorded, the summit is experiencing a slow, yet steady warming trend in contrast to lower elevations (see Figure 3). Although research on exact impacts of climate change on the alpine zone is not yet extensive, it can be assumed that the influences of a continuing warming trend could result in Mount Washington losing its unique alpine tundra climate classification.

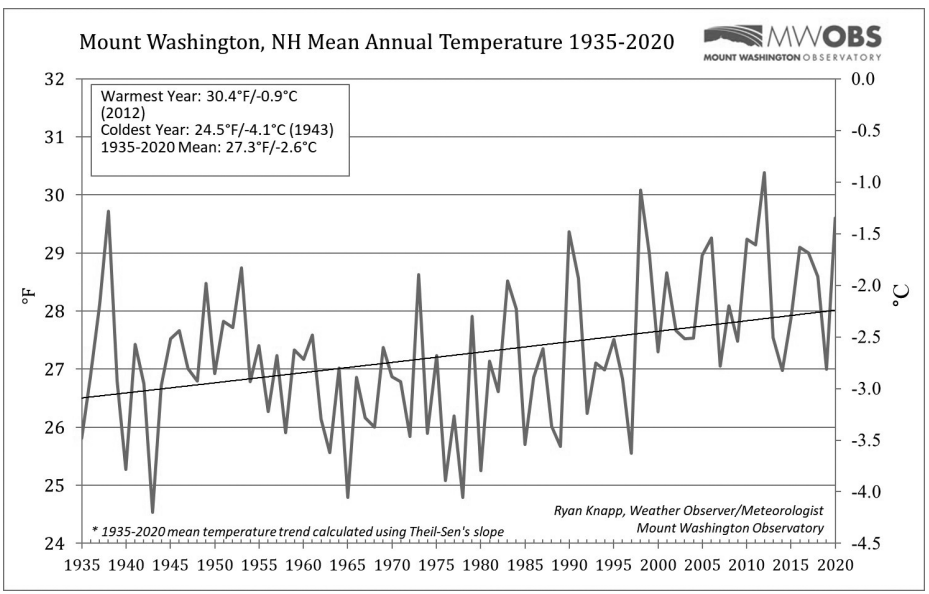


Figure 3. Mean Annual Temperature for Mount Washington spanning 1935-2020.

FEATURE

Mount Washington's Response to Climate Trends Now 'Statistically Significant,' Research Shows

BY **CHARLIE BUTERBAUGH**

Given the Northeast's quickly warming climate, a key question attracting the attention of scientists like Georgia Murray is, how are mountains responding?

Are summits of the White Mountains warming as quickly as lower elevations? Or are these peaks—with their diverse weather conditions, unique alpine environments, and immense appeal to outdoor enthusiasts—enjoying some degree of protection from climate change due to their height in Earth's atmosphere?

Getting to answers starts with long-term data. Unfortunately, as Murray and her colleagues point out in a recent study, the shortage of data collection at remote mountaintops hinders understanding of higher summit responses to human-caused carbon dioxide emissions during the last 170 years.

"Long-term and robust meteorological measurements in the Northeast mountains are sparse," writes Murray, a staff scientist at the Appalachian Mountain Club (AMC). "Fortunately, the summit of Mount Washington has one of the longest (since 1932) high-quality montane data sets in the world."

Mount Washington Observatory remains the only active meteorological station above 2,300 feet in the mountainous regions of New England that has both an extensive and continuous climate record.

"The quality of the data is exceptional. There is no other upper-elevation data set that can really compare," said Murray when we caught up with her recently.

A Sept. 2021 view of Mount Washington from the summit of Mount Monroe, with Lakes of the Clouds below the summit cone.

Georgia Murray sets up AMC's long-term cloud and rain monitoring site at Lakes of the Clouds Hut. AMC photo.

In their recent paper, "Climate Trends on the Highest Peak of the Northeast: Mount Washington, NH," lead author Murray and her colleagues build on previous studies of MWOBS' data set, which now spans nine decades. They incorporated new meteorological data collected over the last 15 years at the observatory's summit weather station (6,288 feet) and nearby Pinkham Notch (2,025 feet), a mid-elevation site where daily temperature and snow data have been collected since 1935.

"The comparison of these two sites provides a proxy for climate-change patterns across an elevational gradient in the northern Appalachian Mountains," Murray writes.

In other words, although the scarcity of data at higher summits in the Northern forest remains a challenge to understanding climate change on mountains, such understanding is possible only because of the continuous data collected by MWOBS and the cooperative station at Pinkham Notch, combined with research like that of Murray and her colleagues.

Until now, research showed that Mount Washington's summit had not yet tipped towards a significant warming trend, in stark contrast to sharp rates of change at lower elevations in the northeastern US, which is warming faster than other regions. As Murray points out, "80% of climate-model projections indicate that this region will cross the 2 °C [3.6 °F] warming threshold by 2040, a full 20 years ahead of the global temperature meeting this same marker," incorporating research by Karmalkar and Bradley (2017).

Scientists believe the summit continues to be buffered from the Northeast's exceptional rate of annual warming, but not to the extent previously shown. The recent data analyzed by Murray show that statistically significant warming is in fact taking place at both Mount Washington's summit and Pinkham Notch.

Climate change indicators from mountain sites reveal warming, even at New Hampshire's highest peak

Climate Indicator	Definition	Data Range 1935-2018 Pinkham Notch (2,032 Feet)	Summit (6,288 Feet)
Spring Temperature	Average spring temperature change	0.29 °F warmer/decade	0.25 °F warmer/decade
Summer Temperature	Average summer temperature change	0.20 ° F warmer/decade	Not significantly changing
Fall Temperature	Average summer temperature change	0.25 ° F warmer/decade	0.22 ° F warmer/decade
Winter Temperature	Average winter temperature change	0.40 ° F warmer/decade	Not significantly changing
Frost Day	Cold nights; Minimum daily temperature below 32 °F (0 °C)	-2.2 fewer days/decade	-1.8 fewer days/decade
Ice Day	Cold days; Maximum daily temperature below 32 °F (0 °C)	-2.7 fewer days/decade	-1.8 fewer days/decade
Thaw Day	Maximum daily temperature above 32 °F (0 °C)	+ 1.4 more days/decade	+1.7 more days/decade
End of Snow Season	End of continuous snow	1.7 days earlier/decade	Not significantly changing
Maximum snow depth (amount)	Maximum recorded snow depth for the season	11.5 less cm snow/decade	Not significantly changing
Total snowfall (amount)	Sum of all snowfall throughout the season	20.7 less cm snow/decade	Not significantly changing
Length of Growing Season	Length of period between last hard freeze (daily minimum< –4.4 °C) in the spring and first hard freeze in the fall	+3.9 more days/decade	+1.8 more days/decade

Murray et al. 2021 Climate Trends on the Highest Peak of the Northeast: Mount Washington, NH *Northeast Naturalist*

"Warming rates and significance at both Pinkham Notch and the Summit site increased with the additional 15 years added to the record since the previous analysis by Seidel et al. (2009). Summit annual temperatures are now increasing at a statistically significant rate, although still at a slower rate than Pinkham Notch," Murray writes. "The most recent 15 years have been the warmest period on record globally. This accelerated rate of warming regionally and in our study is consistent with the continued rise of greenhouse-gas emissions."

The new study also adds insights about climate indicators at Mount Washington and Pinkham Notch from the 1930s through 2018, including snow season start and end, frost days, ice days, thaw days, snow depth, snowmaking days before Christmas, and growing season start and end, similar to those developed by Contosta et al. (2019).

"We used the data but looked at it from a different lens," Murray said. "We looked at winter conditions and other indicators that people generally talk about, like snow arrival."

All monthly minimum and maximum temperature trends were warmer, though not all significantly so, at the summit and Pinkham Notch, except for maximum temperatures during October at Pinkham Notch and June at the summit.

"We definitely are seeing the signal of climate warming at these two sites,"

Murray said during her recent *Science in the Mountains*™ presentation.

The average annual temperature is warming 0.18 °F per decade at the summit and 0.25 °F at Pinkham Notch. Evidence of a changing winter season, while happening at both sites, is most dramatic at Pinkham Notch, where the average winter temperature is warming 0.40 °F per decade. This trend is consistent with what is being observed at lower elevations across the region.

On the summit, spring is warming fastest, at about 0.25 °F per decade on average.

Other climate indicators provide a sense of the condition of winter at higher elevations in the White Mountains. Mount Washington's summit is experiencing 1.8 fewer frost days (minimum daily temperature below 32 °F) per decade and 1.8 fewer ice days (maximum daily temperature below 32 °F) per decade. The length of the growing season on the summit is also increasing at 1.8 days per decade, potentially changing the life cycle of alpine plants and flowers.

"Even though the summit has some different warming trends statistically, I think it is starting to catch up. Because of those other indicators, we think the summit will soon be on its way to warmer winters and what we are seeing elsewhere," said Murray, who grew up in Freedom, NH and earned her master's degree from the University of New Hampshire with a focus on biogeochemical cycling. That means she studies how elements like carbon or sulfur move through Earth's atmosphere and biosphere and impact ecological systems.

A member of AMC's research department, Murray focuses on science and monitoring in the White Mountains, bringing a science-based perspective to conservation and policy work, such as greenhouse gas reduction programs to address climate change.

A core theme of Murray's career entails diving deep into data to emerge with knowledge that puts climate change in a relatable context. "Understanding the impacts of climate change is very much about how we make it relevant to us. What is it doing locally, and what is it doing globally? We know it is happening, but what is it doing in our back yard." Murray said.

On the other hand, she added, "we need to be careful about looking at local trends and not generalizing them globally but look at the whole system."

With the AMC, her key interest is how climate change is playing out in mountains. The organization and its hiking membership care deeply about alpine environments as a resource. Access to MWOBS's unique data set along with support from scientific staff at the observatory's summit weather station solves a critical challenge, providing researchers at AMC and other scientific organizations with the only source of continuous data for understanding how climate change impacts higher summits in the White Mountains.

To delve deeper into Murray's study, watch her recent *Science in the Mountains* presentation at mountwashington.org/sitm.

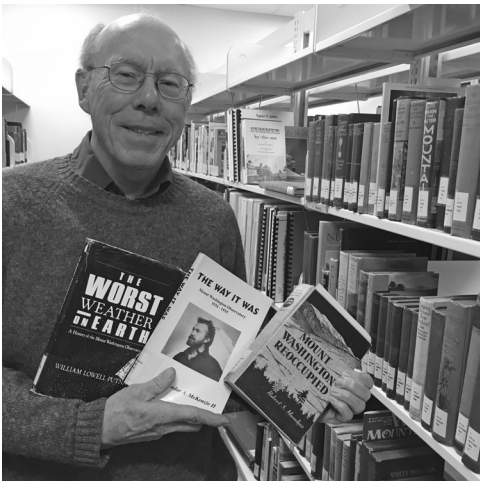
FEATURE

Observatory Library Reopens in New Quarters

BY **PETER CRANE**

The Mount Washington Observatory Gladys Brooks Memorial Library has reopened in its new location, on the second floor of MWOBS' administrative building on Main Street in North Conway.

The library was previously located in the basement level of the building. A review the building's use, space efficiency, and expenditures led MWOBS to vacate the lower two floors, making them available as rental space. The upper floor of the building, previously used solely as office space, has been renovated to allow both library and administrative offices.



Gladys Brooks Memorial Library Curator Dr. Peter Crane holds a few of his favorite books from the library's collection.

While the time between locations required books and other materials to be kept in storage, that storage remained relatively accessible, so that interlibrary loans and some other use of the materials could be continued during that period. With the return of the shelves to the library, and the books to the shelves, operations are again returning to normal for staff and visitors alike.

The library was named to honor Gladys Brooks, in recognition of the generous support received by MWOBS from the Gladys Brooks Foundation of Garden City, New York. The foundation honors the name and wishes of Gladys Brooks Thayer (1882-1976), whose life experiences encouraged her philanthropy, and her will created the Gladys Brooks Foundation, whose purpose is "to provide for the intellectual, moral, and physical welfare for the people of this country" by giving support for nonprofit libraries, educational institutions, hospitals, and clinics. The grants to MWOBS reflect the foundation trustees' interest in the observatory's work and their recognition of our role in the greater White Mountains community.

The collection began as the summit observers' library. It served two purposes: as a resource for training, research, and reference, and as a trove of recreational reading related to similar harsh environments, including other mountains and polar regions. The history and lore of the White Mountains was an integral part of the early library, in addition to meteorology. The creation of the observatory's Mount Washington Museum in 1973 put

a further spotlight on the organization as a curator of White Mountains material.

In 1982, a generous grant from the Gladys Brooks Foundation provided support for new library purchases and other educational activities. This grant and subsequent grants from the foundation attracted further gifts to MWOBS' collection, including papers of Cog Railway founder Sylvester Marsh in 1984 and the extensive Guy L. Shorey photographic collection in 1985, materials related to the Bradford Washburn map of the Presidential Range in 1989, the 1,500-item Walter Wright core White Mountains collection (also in 1989), the George McAvoy collection of materials from the Crawford House in 1990, and the Rudolf Honkala Polar collection.

Topic areas in the library include White Mountains art, travel essays and literature, town and regional histories, tourist guidebooks, recreational and outdoor guidebooks, plus basic regional reference books, as well as books which focus on relevant sciences such as meteorology, geology, and alpine ecology relating to the White Mountain region. There are more than 3,000 volumes in the collection, as well as periodicals and related published material.

In addition to books, the collection features postcards, stereographs, maps, engravings and other such illustrative material, newspaper clippings about significant persons, institutions, and events, plus photographs and ephemera. The library also serves as the permanent archive of the observatory, with some papers dating to the 1930s and earlier to MWOBS' predecessors in the late 1800s.

Most books are available to public library patrons throughout New Hampshire through the state's interlibrary loan program. Patrons of more than 65 libraries in the Granite State have taken advantage of this service to borrow books. Observatory members outside the state can also make arrangements to borrow books.

All told, the Gladys Brooks Memorial Library represents a significant research and public enrichment resource for the White Mountains region.

Hours are typically 10 a.m. to 4 p.m. Tuesdays and Thursdays, though those hours and days may vary depending on circumstances. Visits can also be arranged for mutually agreeable dates and times by appointment. It's best to call or email ahead of time at (603) 356-2137, ext. 203 or pcrane@mountwashington.org.

Crane and volunteer librarian Karen MacDonald examine a copy of the Bradford Washburn Mount Washington map, likely one of the last major maps of the area made without GPS technology.

FEATURE

A Night in the Life of a Weather Observer

BY **CHARLIE BUTERBAUGH**

Well over a mile above the valley of Mount Washington, in a weather station built into boulders deposited tens of thousands of years ago, a night observer keeps track of data through the night, maintaining one of North America's longest continuous alpine climate records.

He is mainly focused on the minutes, completing observations between 00:49 and 00:59 past every hour. Routine and process rule the night, but no two nights make the same weather. The consistency of process, timing, and location assure continuation of a 90-year data set. Weather presents a far less reliable dimension, especially on Mount Washington, where cycles are shaped by cold fronts, warm fronts, and extreme conditions that arrive as they please.

It's 5:30 p.m. on a mid-November Tuesday evening, and Staff Meteorologist Ryan Knapp seems accustomed to darkness, keeping the weather room dimly lit. He relieves the two day observers whose work started 12 hours ago. The transition between staff is critical. They compare notes about current conditions and forward-looking models.

"If you don't write something down, it could quickly become too little too late," says Knapp. "Weather systems could be arriving hours ahead of what the models are saying."

His running analysis combines real-time observations at the summit with data charts and weather maps displayed on multiple screens. Tonight, a low-pressure system approaching from the northwest pushes dry air like a bulldozer, creating pockets between moist layers.

The meteorologist checks data quality, verifying figures entered during the prior day to keep a clean baseline. In addition to the nightly checks, the team circles back to assure quality each morning, then again every five days, and once more at the end of the month.

"That's what goes into our 90-year record," says Knapp, referring to the monthly review.

Before the next ob, we head downstairs for dinner in the crew's living quarters. Seated at a long table, eating sautéed vegetables and pizzas charred by a commercial gas range, the three meteorologists and one intern debate whether the approaching cold front will bring freezing rain, sleet, or snow. Nimbus, the observatory's gray shorthair cat named after clouds that bring precipitation, makes his presence known.

After dinner, the crew scrubs and vacuums the entire quarters, including kitchen, pantry, bathroom, bunk rooms, and living room. They're tired but in high spirits. Snow is in the forecast. And their off week starts tomorrow after they welcome the alternating crew of observers and travel down the mountain, this time

Mount Washington Observatory Staff Meteorologist Ryan Knapp sets an anemometer on the observation tower.

of year by pickup truck on the auto road. If the snow is deep, they'll stop to put chains on the tires. In the back of their minds, they know the whole trip could be delayed by dense fog or high winds above tree line.

Knapp's short dinner break ends and he heads back up to the weather room. Except for my questions, he is alone once again for a nocturnal routine he has kept for 16 years.

Just after 7:45, he gears up briskly and ascends the observation tower, opens the door beneath an A-frame protecting against chunks of rime that fly when winds accelerate, and steps onto the vast observation deck, walking in darkness to the north end. He counts two layers of clouds below and three aloft.

The meteorologist heads to the designated spot for measuring ambient air temperature, turns his headlamp on, and spins the sling psychrometer, a low-tech instrument that's reliable in a variety of extreme conditions. This manual weather observation process has been happening the same way, every hour, since 1932. With side-by-side dry-bulb and wet-bulb thermometers, measurements are used to calculate dew point and relative humidity – the amount of water vapor in

Data is inputted after every hourly observation through the night.

the air.

During the next ob, he climbs three flights of stairs and ladders to the top of the observation tower, perched in darkness above anywhere attached to earth in the northeastern U.S. He checks the heated anemometers and, if needed, removes ice that accumulates fast as winds accelerate and temperatures plummet. Tonight, it's only hovering around freezing with winds gusting at 50 mph.

Heading inside, he closes the hatch at the top of the tower, quieting the west winds blowing out of the chasm of the Ammonoosuc Ravine against Mount Washington's windward flank, and again returns to the weather room to log data, check radar, and perform other tasks until he heads outside again regardless of the weather, repeating this routine through the night.

Asked if the work ever gets monotonous, he says no. The weather is ever-changing, and knowing his work continues the 90-year data set steels his sense of purpose.

"It's almost like having the mountain to myself," he says. "I only have to worry about the weather."

A playlist and mug of coffee also keep him going. He responds to a question on MWOBS' Facebook page about yesterday's photo of a cap cloud that formed over the summit. Knapp doubles as the observatory's photo administrator, and his summit photography has attracted a

colossal following (see front cover). He's known at the summit for rating sunrises on a scale of one to ten. A three on his scale is likely an eight or nine on ours.

But from now until early March, he'll go to sleep before sunrise, missing the morning blue hour.

It's approaching 1:00 a.m. and the meteorologist starts a synoptic observation, a six-hour detailed snapshot of conditions. He records maximum and minimum temperature, atmospheric pressure tendency, and precipitation types and totals. This all gets delivered to the National Weather Service. Being prompt matters. The synoptic data feeds weather models that Mount Washington's observers and many other meteorologists rely on for accurate forecasting.

The complexity of his work increases after the 1:00 synoptic. He starts to work on the daily mountain forecasts between 2:00 and 3:00, staying keenly aware of the observatory's backcountry audience. The Mount Washington and Higher Summits forecasts need to be posted on mountwashington.org before 5:00 a.m. The weather is always changing and the stakes are high. Search and rescue teams, climbing guides, and others rely on MWOBS' forecasting accuracy, helping them decide when to head out, how to modify plans, or sometimes postpone.

After a few hours of sleep in one of the cozy wood-paneled bunk rooms, I head back to the weather room and overhear Knapp recording his voice for the audio forecast. Falling snow is starting to accumulate at 5:15, when Weather Observer Sam Robinson arrives in the weather room to start his day. He fields a round of probing, collegial questions from Knapp about data points entered the previous day. It's all part of keeping the record straight.

Knapp and Robinson stay composed as ever. With winds on the increase and a snow storm in process, care will be needed on this shift change day as the next crew makes their way to the alpine zone for another challenging week at the weather station.

Knapp reads in an observatory bunk room after completing his nightly shift.

Programs Engage Students of All Ages, on Screen and in Person

BY **BRIAN FITZGERALD**

With the return of winter on the mountain, education-focused staff at Mount Washington Observatory have been busy producing content to connect with students of all ages. Virtual programming continues with our *Science in the Mountains* monthly lecture series and *Home of the World's Worst Weather ™ Live* weekly Virtual Classroom, while our *WeatherX* data literacy outreach includes teacher-led learning in classrooms as well as a virtual "Chat with a Scientist" component.

Science in the Mountains continues to be a fulfilling program, giving experts both internal and external to MWOBS the opportunity to speak in front of an engaged and thoughtful audience. Over 900 people joined the programs live on Zoom from September through January, with hundreds more viewing on Facebook Live or afterwards on our YouTube channel.

Highlights from the series included University of Maine Assistant Professor Aaron Putnam's global field work studying glacial history, Appalachian Mountain Club Staff Scientist Georgia Murray's overview of long-term Mount Washington summit and Pinkham Notch climate trends, and Appalachian State University Professor Baker Perry's expedition to install weather stations at the highest elevations of the Himalayas.

The tiny White Mountain Fritillary, a butterfly endemic to the Presidential Range of New Hampshire, was also given its day in the sun, as NH Fish & Game Biologist Heidi Holman spoke about research being gathered on the summit and analyzed in our laboratory space.

In case you missed any of the programs, recordings are available at mountwashington.org/sitm.

Weather Observer and Education Specialists Jackie Bellefontaine and Stephen Durham are continuing *Home of the World's Worst Weather Live* for a second full school year, starting last October. With an even broader reach this year, classrooms from across the region, including as far away as New Jersey and as close as northern New Hampshire, have joined the Virtual Classroom to learn from our experts about Earth's weather and climate.

Aligned with the Next Generation Science Standards, these programs have focused on helping middle school students connect concepts that they learn in the classroom with work conducted at MWOBS. Stephen's program about nor'easters and Jackie's program about the cryosphere are favorite staff picks. We hope you'll share the word about our free Virtual Classroom with teachers and others in your community, and if you'd like to brush up on your weather and climate knowledge, visit mountwashington.org/classroom to view all programs.

Our *WeatherX* curriculum development project, funded by the National Science Foundation, continues to support middle school students across the region, specifically in rural areas. The project team has been hard at work following teachers in New Hampshire and Maine as they test curriculum materials in the classroom.

Weather Observer and Education Specialist Stephen Durham leads a recent Virtual Classroom program focusing on how nor'easter storms develop.

Students have been excited to engage with extreme weather data as a means of learning data analysis and computational thinking skills, using the Common Online Data Analysis Platform (CODAP), an open-source data visualization tool, while also connecting with our weather observers during "Chat with a Scientist" sessions aimed at inspiring students to consider STEM careers. Stay tuned for more updates about *WeatherX*, now in its final year, as the team aims to wrap up project research and summary work by the end of 2022.

As always, if you or anyone you know wants to learn about our education programs, don't hesitate to email us at education@mountwashington.org.

Summer/Fall 2021 Weather Data

	AUG	SEPT	OCT	NOV
Temperature (°F)				
Average	53.2	43.1	38.4	18.4
Departure	+4.5	+/-0.0	+7.1	-2.4
Maximum	67	56	60	41
Date(s)	12th, 13th	18th	12th	8th, 18th
Minimum	37	26	14	-2
Date(s)	1st	29th	24th	23rd, 24th, 28th
Precipitation (inches)				
Monthly	5.74	10.47	12.60	6.75
Departure	-1.98	+2.81	+2.61	-1.34
24-hour Maximum	1.20	3.75	4.15	1.02
Date(s)	22nd/23rd	23rd/24th	30th/31st	15th/16th
Snowfall (inches)				
Monthly	0.0	1.9	10.7	49.1
Departure	-0.1	+0.7	-8.3	+13.5
24-hour Maximum	0.0	1.6	4.8	7.3
Date(s)	N/A	29th/30th	18th	15th/16th
Season Total	0.2	2.1	12.8	61.9
Departure	+0.1	+0.8	-7.5	+6.0
Wind (mph)				
Average	23.2	32.0	28.2	40.1
Departure	-1.3	+4.4	-7.3	+0.7
Peak Gust/Direction	82 W	93 W	92 E	107 NW
Date(s)	11th	12th	30th**	16th
Days 73+	1	9	9	18
Days 100+	0	0	0	3
Other				
% Sunshine	34	28	38	41
Clear Days	0	1	3	4
Partly Cloudy Days	3	3	3	3
Cloudy Days	28	26	25	23
Days with Fog	30	27	27	28
Days with Rain	18	21	16	4
Days with Snow	0	2	7	22

** Last of several occurrences

A Look Back as Late Summer Turned to Shoulder Season

BY **RYAN KNAPP**

August started the period off hot but dry, then seasonal temperatures and rain returned for September. Warmth returned for October and while the summit received plenty of precipitation, it was lacking with snowfall. Colder weather returned for November, bringing with it ample amounts of snow.

August 2021

A pair of lows passing on the 1st and 2nd provided fog and rain. High pressure to the south on the 3rd provided fair weather conditions that lingered until the 4th. A front from the south on the 5th provided summit fog and drizzle. High pressure on the 6th provided clearing but visibility was limited by haze. A cold front on the 7th provided rain and thunderstorms and elevated winds. A pair of lows on the 8th provided rain showers with a trailing cold front on the 9th providing some additional drizzle. High pressure on the 10th provided fair weather during the day then a weak low to the south provided fog and drizzle overnight followed by light rain on the 11th. A Bermuda High on the 12th and 13th provided hot and humid conditions with highs flirting with daily record highs. Relief came on the 14th when a cold front provided cooler/drier air and rain showers.

High pressure built on the 15th then remained through the 17th providing generally clear skies, mild temperatures, and dampened winds. Late on the 17th and then continuing through the 19th, the remnants of Tropical Storm Fred passed, providing tropical moisture that resulted in summit fog and over an inch of rain. Warm and humid weather lingered on the 20th with light rain showers and drizzle prior to clearing late in the day. Fog returned overnight and lingered into the 21st as a strong onshore flow pushed low-level moisture inland. On the 22nd and 23rd, the remnants of Hurricane Henri moved through providing fog and over an inch of rain. High pressure built on the 24th and lingered until early on the 27th. The ridge provided warm and muggy conditions along with intermittent fog and variable cloud cover. A cold front on the 27th allowed for cooler/drier conditions. A warm front on the 28th provided clouds, fog, and light rain. A weak ridge early on the 29th gave way to low pressure passing through Canada. A warm front on the 29th and then a cold front on the 30th provided light to heavy rain adding up to over and inch before things tapered. An upper-level trough on the 31st ended the month with summit fog.

September 2021

High pressure started the month, then the remnants of Hurricane Ida on the 2nd and 3rd delivered 1.77 inches of rain prior to tapering. A series of weak shortwaves passed overnight and into the 4th delivering fog, drizzle, and scattered rain showers. High pressure early on the 5th gave out to a warm front overnight and into the 6th. A weak cold front late on the 6th provided additional rain showers and increased winds as high pressure followed. The ridge would provide clearing late on the 7th but a warm front on the 8th would return fog and light rain. A cold front on the 8th/9th brought rain showers and cooler conditions. A coastal low on the 9th/10th would provide additional rainfall. High pressure built in for the 11th but high winds and summit fog would linger. A cold front passed on the 12th then high pressure provided generally fair weather conditions for the 13th/14th. A cold front the 15th provided light to moderate rain.

High pressure briefly returned on the 16th and 17th, then a coastal low moved through on the 18th. A broad area of high pressure built over the region on the 19th then lingered until the 21st. An upper level trough and a surface low from the west provided drizzle and rain showers for the 22nd and 23rd. A cold front on the 24th resulted in 3.42" of heavy rainfall. High pressure briefly provided fair weather on the 25th. A pair of fronts converged over the region on the 26th as low pressure passed to the south. Moisture wrapped northward late providing rain and drizzle on the 27th. High pressure crested on the 28th. A trough swung in for the 29th and 30th, providing cold and moist conditions that resulted in freezing drizzle, sleet, and snow.

October 2021

Icy conditions started the month off as a trough exited and high pressure built in. The ridge slid east and a weak warm front provided a wintry mix for the 2nd. An upper level trough provided drizzle and rain showers on the 3rd. A stalled front to our south provided drizzle on the 4th, then a low moved east along this front on the 5th providing light drizzle and showers prior to exiting. High pressure built late on the 5th providing undercast conditions prior to clearing out for the 6th and 7th. A backdoor cold front on the 8th ushered in cooler conditions as well as a return of undercast conditions that lingered into the 9th before mixing out as high pressure built over the region. The high remained over the region until the 13th providing fair weather conditions, relatively low winds, and warm temperatures with a new daily record high of 60F reached on the 12th. A weak front on the 14th returned summit fog and light drizzle. Low pressure from the Great Lakes moved northeast the 15th and 16th providing just over 2 inches of rainfall.

A cold front passed on the 16th and 17th, providing rain showers tapering to freezing drizzle as freezing temperatures returned. An upper level trough swung through on the 18th and 19th providing upslope snow that accumulated to 7.1 inches. High pressure built on the 20th, resulting in high winds that resulted in dense blowing snow. A warm front on the 21st caused a bit of melting as temperatures rose and some

light rain fell. A pair of cold fronts passed on the 22nd and 23rd providing light rain showers. High pressure built for the 23rd and lingered into the 24th. Low pressure on the 25th resulted in a wintry mix of freezing rain, sleet, and snow on the summit. A coastal low bombed out on the 26th and 27th providing high winds and 1.41 inches of rainfall. High pressure returned for the 28th/29th then another coastal low on the 30th and 31st provided a wintry mix that would turn to rain and dumping 5.01 inches of precipitation.

November 2021

A cold front on the 1st provided a wintry mix, triple-digit gusts, and cold air. A weak trough kept conditions cold and windy on the 2nd as light snow showers passed. A secondary trough passed on the 3rd providing light snow showers and colder air. High pressure built on the 4th but wouldn't provide clearing until the 5th. A weak low on the 5th returned fog and drizzle late but the ridge rebuilt on the 6th clearing summits and moderating temperatures. The ridge would then remain through the 9th. A low on the 10th provided just over five inches of snow, sleet, and snow pellets. High pressure returned on the 11th A low from the west on the 12th provided a wintry mix that turned to heavy rain by the evening resulting in a lot of melting. A weak low on the 13th provided 5 inches of snow and sleet. A weak cold front the 14th provided light snow showers. The 15th/16th saw low pressure from the Great Lakes passing delivering nearly a foot of new snow and high winds on its backside.

High pressure provided brief clearing on the 17th then a warm front returned fog and a wintry mix overnight. Warm air continued to move in on the 18th allowing for rain prior to a cold front passing the 18the and 19th returning light snow to the summits. Upslope snow lingered on the 19th and 20th then tapered as high pressure built over the region. The ridge exited on the 21st as low pressure from the west moved in. The low exited on the 22nd then a mid-level trough moved in for the 23rd and lingered until the 24th. High pressure returned for the 25th then exited as an upper-level trough and cold front moved in for the 26th with upslope snow lingering into the 27th. High pressure briefly returned on the 28th as a low passed to the south. A low from the west on the 29th and 30th provided light snow then a weak warm front would end the month with a few additional snow showers.

Interns Sam Gawel and Adam Muhith shovel snow outside the observation tower on Nov. 23.

2:33 PM Mon. August 2

"Until Next Time." This Wednesday marks the end of an amazing journey working for the Mount Washington Observatory as a summit Weather Observer and Education Specialist. Through the last year plus I have had the honor to be a part of an organization that means very much to me. I began as a summer intern in 2017 and fell in love with the uniqueness of the work that MWOBS was doing. I extended my stay on the summit as the fall intern and I knew upon leaving the internship that my eyes would always be peeled for a full-time position back on the summit. It took a few years of hard work and determination, but about a year ago, I landed my dream job as the Education Specialist who would also be immersed in the extremes that the highest peak in the Northeast had to offer. I have two very strong passions, the first being extreme weather and the second being education. I get so much joy and satisfaction sharing my excitement about the weather surrounding us. This position allowed me to explore both of those elements all in the same location. Leading Virtual Classroom programs from 6288' all while the extremes I was teaching about were simultaneously occurring out my window was the most perfect combination for me. I thank the observatory for allowing me to represent them through these programs.

—Nicole Tallman, Weather Observer/ Education Specialist

7:16 AM Wed. August 4

"The Next Chapter." It's hard to believe that today will be my last shift change as the Night Observer at Mount Washington Observatory. After an extraordinary 17 months of incredible weather and awe-inspiring views, this last week has been a relatively ordinary one. We've had days of fog, rain, and gusty winds with a few sunrises and sunsets sprinkled in. We even had a brief taste of winter, with temperatures falling to around freezing combined with sustained hurricane-force winds. I may be experiencing some of these things for the last time on the summit, but what's important to me is that I've lived all these experiences in the first place. After all, my last sunset on the summit isn't necessarily more special than my 100th and every one in between. I am simply grateful to have been here for them in the first place... I won't forget the nights watching and listening to thunderstorms roll in or the many dinner table conversations or the late mornings up in the weather room after shift. I won't forget the evening we all rushed outside to enjoy the double-rainbow at sunset, with undercast skies below. I won't forget the calm early mornings or the frantic late-night ice storms. I also won't forget how talented you all are at Wii Bowling... Everyone I've worked with at the observatory has had an impact on me in some way or another, and I am grateful for all of you.

—David Decou, Night Observer

Weather Observer Sam Robinson looks out at sunset from the observation tower on Oct. 8.

7:01 AM Wed. September 8

"Hello, Meteorological Autumn!" A big warm welcome to my favorite season, autumn! You may be thinking, "Wait? September only just started!" Well, September 1st marks the start of what is known as meteorological autumn, which differs from astronomical autumn. So, what's the difference? Earth's rotation around the sun forms the astronomical calendar, punctuated with significant points in rotation that define the changes between different seasons. These points are known as the equinoxes and solstices. Earth's tilt as well as the sun's alignment over the equator determine the two equinoxes and two solstices. The earth actually takes 365.24 days to travel around the sun, therefore an extra day is needed every four years, creating the Leap Year. Additionally, the elliptical shape of Earth's orbit around the sun can cause the lengths of the seasons to change as well. The variations in the durations and start of the seasons creates a challenge when trying to compare climatological statistics for a particular season across years. Thus, meteorological seasons came to be!

—Jackie Bellefontaine, Weather Observer/Education Specialist

3:25 PM Thu. October 14

"Founding Day!" Today we celebrate the founding of Mount Washington Observatory... Setting the stage on October 15, 1932, Bob Monahan, Sal Pagliuca, Alex MacKenzie, and Joe Dodge set up a permanent presence on the summit. Using funds obtained from a research grant and a few private donors, the Mount Washington Observatory was formally established, with a mission of advancing the understanding of weather, climate, and the mountain itself... Due to their steadfast dedication and the Observatory staff that followed, this mountaintop weather station remains a unique operation staffed 365 days a year and proudly maintains one of the longest running climate records in North America. Now 89 years rich in history we continue to gather, disseminate and analyze daily weather data; to contribute to the

critical, long-term weather and climate record essential to scientific understanding of weather and climate in a unique, extreme environment. Here's to approaching our 90th anniversary, and many more anniversaries to come!

—Mount Washington Observatory Staff, Weather Observers

4:46 AM Tue. October 26

"Bucket List Item Checked Off!" I'm not new to "extreme weather." However, the weather that Mount Washington offers is very different from the extreme weather I've experienced. Over the years, I've experienced "haboobs" (intense dust storms) in the Middle East, hurricanes across the U.S. Gulf Coast, massive ice storms in the Midwest, and severe thunderstorms and tornadoes in the south-central portions of the U.S. and in Africa. In my spare time, I enjoy chasing tornadoes and severe storms, as I enjoy taking weather photography (specifically of lightning). I've only been on the summit for five days now and have already experienced the thickest fog I've ever seen with sustained winds above hurricane force. Taking an observation with winds gusting to 81 mph is something I'll never forget (and is pretty awesome to experience). Additionally, I've had my first taste of winter as we received 3" of snow and even have quite a bit of glaze ice due to freezing rain. I know Mount Washington as Home of the World's Worst Weather has more to offer, and I can't wait to see what else is in store for me during my time here.

—Matthew Addison, Night Observer

6:34 PM Mon. November 8

"With Shoulder Season Comes Critical Transition in Operations." The dynamic nature of the weather on Mount Washington, with its quick and unexpected changes of conditions, make the task of planning and executing transportation difficult. With the Mt. Washington Auto Road now being closed for the season, our snowcat has been transported by flatbed up to Winter Cut-Off (about halfway up the road) where it will be staged until the road is snow covered top to bottom. The staging of the snowcat prevents the lower, bare sections of road from being damaged by the metal cleats and carbide studs on the tracks. Before snow limits our mode of transportation to the snow cat, we also utilize our 4wd van and pickup truck equipped with tire chains. All of us observers (and interns) are trained on installing the tire chains to make for a quick installation in inclement weather if need be. Sometimes, weather conditions will require the use of all the different modes of transportation in one trip: van without chains to almost tree line, then van with chains up to the snowcat, followed by the snowcat the remainder of the way. Thanks to a super generous donation, we also received a new pickup truck the beginning of this year, which is equipped with a V-plow. The relatively new design of the V-plow is much safer for us doing snow removal, as it forces the snow to both sides of the truck and cuts through the snow, as opposed to a traditional straight blade plow. A straight blade requires the plow to be angled to push the snow out of the way, which can dangerously force the truck sideways on the narrow summit road.

—Sam Robinson, Weather Observer/ Engineer

Adiabatic Processes in the White Mountains

BY **JAY BROCCOLO**

If you have ever observed clouds on one side of a mountain but not on the other, or wondered why there is fog around a summit yet the surrounding skies are cloudless, you have likely witnessed the results of an adiabatic process.

A multitude of weather phenomena occur throughout mountainous terrain, and the White Mountains are no exception. Orographic lift, the forced movement of an air mass from low to higher elevations as the air meets and ascends higher terrain, has a noticeable effect on the weather of mountain microclimates.

Lenticular cloud formation, down sloping leeward wind (sometimes referred to as foehn wind), heavy precipitation, and the rain shadow effect are all examples of weather phenomena that result from orographic lift. With orographic lift being responsible for the ascent of the air parcel, adiabatic heating, or cooling, causes the other weather phenomena to develop.

The word "adiabatic" stems from the Greek "adiabatos," which means impassable, and in thermodynamics, it describes a process that occurs in the absence of heat or mass transfer between the system and its surrounding environment. Concerning meteorology, the thermodynamic system would be the parcel of air that is ascending or descending into a different surrounding environment.

A simple example is a balloon. When let go from the ground, assuming the balloon is filled with a gas that is less dense than air, it will rise. While rising, the balloon expands as the volume of gas inside pushes outward against the boundary and increasingly toward the less dense surrounding environment.

Having said that, we know that no process is completely adiabatic. Processes in the atmosphere generally occur over varying timescales, some large, and heat dissipates out of systems through

Pileus clouds, or cap clouds, over mounts Clay and Jefferson result from orographic lift, an adiabatic process, as moist air is forced up the windward slopes.

boundaries and into surrounding environments. Air has low thermal conductivity, and parcels of air are quite large, so transfer of heat by conduction is small. Therefore, we assume that a system is adiabatic for mathematical theory purposes, but we approximate in weather prediction models.

An adiabatic process may seem similar to convection, but in reality, it is quite different. Convection is dependent on the varying lapse rates and the state of the atmosphere.

A lapse rate is the rate at which an atmospheric variable, in this case temperature, decreases with altitude. With a dry parcel of air, we assume the dry adiabatic lapse rate, which is 9.8° C/km or 5.4°F/1000ft. If the parcel of air is or becomes saturated, the wet or moist adiabatic lapse rate is assumed, which changes dependent on temperature unlike the dry adiabatic lapse rate, which is constant. Having said that, a representative value for a moist adiabatic lapse rate would be around 5°C/km or 2.7°F/1000ft. Lastly, the environmental lapse rate (the rate of temperature decrease with altitude at a specific location and time through a stationary atmosphere) is compared with the other two. As such, when the lapse rate is higher than the adiabatic lapse rate, convection will occur as the air parcel is less dense than the environment, and if the lapse rate is less than the adiabatic lapse rate, the air column is stable and convection will not occur.

When an air parcel is warm, it is inclined to expand, which lowers its density. This forces the air parcel to rise and carry internal energy upward, which is the process of convection.

The vertical convective motion ceases when the parcel of air has the same density as the environmental air at a given altitude. Convection and orographic lift are the methods that move the air parcel, and the adiabatic process is what happens to the parcel as it rises or sinks in the atmosphere.

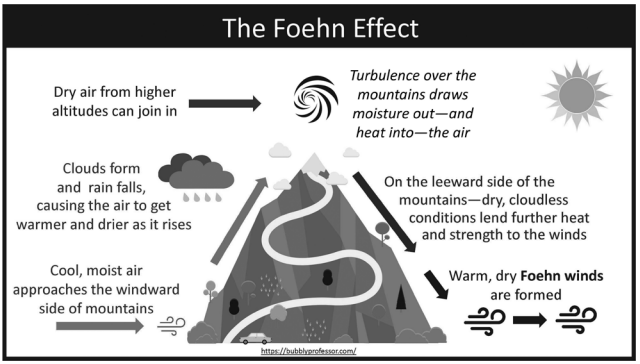
In the case of a rising parcel of air expanding, it pushes on the air around it, exerting a force known as thermodynamic work. An expansion or contraction of an air parcel without inward or outward heat transfer is an adiabatic process. Since the lifting and expanding parcel does not gain heat, it loses energy within the system (parcel of air), and so the temperature decreases and pressure drops. This is the process of adiabatic cooling, and it occurs with orographic lifting and lee waves, which can form some of our favorite clouds, such as lenticulars and pileus clouds.

Adiabatic cooling is also responsible for the potentially heavier precipitation on the windward mountainside. The drop in temperature and pressure helps to condensate any moisture, causing the cloud formation.

Adiabatic heating, the opposite, occurs when a parcel of air descends, and in the process both its temperature and pressure increase. The air parcel contracts and decreases in volume, boosting its internal energy to form a foehn wind, the warm, dry, downslope wind that occurs on the lee side of a mountain range.

When we combine adiabatic heating and cooling, we have the complete adiabatic process. With the condensation of moisture on the windward side

of the mountain range, the lee side is dry and results in a rain shadow effect. Overall, as a consequence of the different adiabatic lapse rates of moist and dry air, the air on the leeward slope becomes warmer than the air at the equivalent elevation on the windward slope.



This diagram of the foehn wind effect shows clouds dissolving on the leeside of a mountain, resulting from adiabatic processes and the atmosphere's interaction with land masses like Mount Washington.

How do meteorologists measure the change in the atmosphere vertically to assess adiabatic processes? The most common method is with radiosondes, which are attached to a weather balloon, lifting through the atmosphere to measure the environmental lapse rate, which is compared to the predicted adiabatic lapse rate to see whether air will rise or not.

The tool used to compare these lapse rates is called a thermodynamic diagram, more commonly known as a Skew-T or log-P plot in the U.S., and tephigram elsewhere. These plots have the dry and moist adiabatic lines for charting the temperature, wet-bulb temperature, and dew point. In fact, forecasters use Skew-T plots to judge the state of the atmosphere.

At Mount Washington Observatory™, not only do we use Skew-T plots and weather prediction models to forecast the weather, we also use our Mount Washington Regional Mesonet (MWRM), comprised of various weather instruments at different elevations along the Mount Washington Auto Road and other locations of the White Mountains.

With the MWRM data, we can see real-time temperature inversions that occur below summit level, which help us to forecast cloud levels, wind speeds, precipitation, and temperature. Our mesonet system could also help in depicting adiabatic processes within the Presidential Range, providing figures to explain the weather phenomena we see and experience.

One question often asked is, "Does Crawford Notch experience more precipitation than Pinkham Notch?" Some have stated lee side Crawford Notch does experience more snow, which would align with how adiabatic processes work. Having said that, we do not actually know. While our mesonet system is comprehensive, we require further data, specifically pressure data on the windward side of the Presidential Range. Having pressure data would add significant value to the MWRM, allowing researchers to better judge adiabatic processes in the White Mountains.

The next time you're in the mountains and see clouds that seem out of place or weird, there is a good chance it was created by adiabatic processes and the atmosphere's interaction with mountains.

Operating through Challenges and Triumphs

BY **REBECCA SCHOLAND**

It has been nearly two years of weathering the proverbial storm that is COVID-19 and unfortunately, the summit is still feeling the effects as we work to protect our arctic castle in the clouds. The observers and our interns have been resilient as ever, pressing forward through operational changes and adjusting along the way. We have said goodbye to staff and welcomed new teammates, adding pages to the observatory's historic presence on Mount Washington — all the while continuously observing and recording the weather in our nearly 90-year record.

In my last update I spoke of summer and fall interns joining us once again and new observers joining the team and studying for their METAR exam with the National Weather Service. We welcomed back fall intern Adam Muhith as well as new intern William Gabbert for our winter season on the summit. Observer Matthew Addison passed his METAR exam, officially rounding out our team of six certified observers.

Transportation up and down the mountain in late fall and early winter had its challenges. Pete Gagne moved on to a new adventure mid-fall, and Greg Fitch took over as transportation coordinator. Greg immediately hit the ground running as shoulder transportation season was already upon us. With the snow cat staged part of the way up the mountain,

we needed to utilize our 4WD truck and van with tire chains each week to move gear and personnel from the base up the mountain and transition into the snow cat for the remainder to the summit. This transitioning takes extra time and coordination each week as we conduct our shift changes. It was not until January that the snow coverage on the auto road allowed us to move our snow cat to the base.

Volunteers are still missed on the summit, but the observers have been honing their cooking skills and learning some new recipes along the way. After a two-year pause on the volunteer program, most of our observers haven't had the privilege of meeting so many of our biggest supporters through this program. We continue to work towards revamping the program to suit our new operations and needs and hope to see the program relaunch in 2022. We will be sure to keep everyone abreast of the news when the time comes.

Observer Matthew Addison passed his METAR exam, officially rounding out our team of six certified observers on the summit. To celebrate this accomplishment, all of the observers' certificates are now proudly hung in a new, more visible area of the weather room on the coveted "cloud paper."

Nimbus is also inching his way to his first anniversary on the summit as our new resident summit cat. He is a talkative fellow with a love of chasing mice out of our pantry. He is also a snuggly kitty when he is ready for a nap and often finds a soft warm spot to curl up.

His explorations of the New Hampshire State Park Sherman Adams building are also increasing. He finds himself more and more comfortable with his surroundings and how to navigate the large building.

As for my position as Director of Summit Operations, these past two years have been challenging. Coordinating and shifting operations around, frequently on a weekly basis, hasn't been easy. I have spent several shifts on the summit helping to cover and lend a hand with daily operations when someone has needed to stay home. Other valley staff and observers have also moved their schedules around to help at times. This flexibility, while difficult to manage at times, has allowed the summit to remain COVID-19 free. I am happy to report that the summit staff, by working together have kept it a safe place to work. That is something I am very proud of!

Building on Past Work to Shape our Future as a 'Scientific Partner of Choice'

BY **BRIAN FITZGERALD**

The Mount Washington Regional Mesonet is the focus of a technical overview manuscript nearing completion this spring, with staff members reporting the technical expertise needed to operate remote weather stations across challenging terrain and climate.

Like other departments at Mount Washington Observatory, research involves daily work connected to the past, present, and future. Tasks may involve drafting science communications to share the results of completed research, advancing current project work, or planning future investigations. Most days, work happens across all three timeframes as projects overlap.

Past work often remains in our daily thinking as we continue getting the word out about projects completed within the past year, such as our Climate Normals and Long-Term Visibility investigations. These projects eventually get communicated beyond the observatory walls through our website and social media pages, scientific journals and conferences, and educational programs such as our *Science in the Mountains* lecture series or Extreme Mount Washington summit museum.

In January, our staff and interns presented posters at the 2022 American Meteorological Society's Annual Meeting, detailing their Climate Normals and Long-Term Visibility projects.

In the here and now, work continues in earnest on three different MWOBS-driven projects. We are not able to publicly share information about one of the projects at the moment, though the wait will be worth it, I promise!

Present work includes completing the Next Generation Pitot Anemometer. Beginning in 2015, through a partnership with General Electric and UMass Lowell, MWOBS was able to produce the next "gold standard" pitot-static anemometer for use in some of the worst conditions on the planet.

After years of design, building, and testing work, this critical sensor is now in

the final stages of evaluation with the University of New Hampshire's John Olson Advanced Manufacturing Center, where preliminary wind tunnel testing results have been promising.

Stay tuned for a full summary report on this important project in the summer of 2022, by which time the Next Generation Pitot Anemometer will more than likely be the official wind speed measuring device for our summit weather station.

A technical overview manuscript focusing on our Mount Washington Regional Mesonet (MWRM) is nearing completion this spring, with several staff involved in reporting the technical expertise needed to operate remote weather stations across the challenging terrain and climate of the White Mountains of New Hampshire.

This project, while a present writing task, has provided a valuable opportunity to look back at the motivation for the network, the process of site selection and design, and the instrumentation that ultimately became necessary for the stations to record and transmit data accurately and consistently.

While regional and statewide mesonet systems — such as those in New York State, Kansas, and Oklahoma — at times operate in the face of similarly challenging weather conditions, few mountain networks of MWRM's scope exist in the U.S.

Beyond documenting and synthesizing the hard work already completed on the network, the ultimate goals of the technical overview paper are to share expertise with the mesonet community and motivate others to overcome network buildouts in challenging terrain and weather.

Finally, as we look forward, significant research opportunities are on the horizon. Collaborative research proposals are in the works with our network of partners, including the Appalachian Mountain Club, and conference abstracts are being submitted in the nearer term.

In the longer term, our research department is focused on fulfilling the first of four objectives established by the Observatory's new Strategic Plan: "MWOBS will be a scientific partner of choice in the areas of mountain meteorology, weather and climate." To achieve this objective, the Board of Trustees and Staff set forth an ambitious set of goals: 1) research planning, 2) building out research operational and infrastructure support, 3) strengthening and growing research and product testing relationships with external partners, and 4) committing to thoughtfully communicating the research work conducted at MWOBS through scientific conferences and papers, and through educational program pathways.

In this multi-year plan, MWOBS staff are already well on the way to supporting these goals, with planning in full swing following conversations with critical research partners and the completion of a research opportunities survey.

Stay tuned for more updates about our strategic research work, along with all projects past, present, and future. With high-quality climate data, talented staff, strong partnerships, and enthusiastic support from our members, the future is bright for research.

Weather Phone to be Retired as New Ways to Access Forecasts Flourish

BY **KEITH GARRETT**

My little brother and I wake up and look out the window. Eight inches of fresh snow! Last night, meteorologist Al Kaprielian had said it was going to snow overnight. Will it be a snow day? A warm spell the other day had melted the snow surface into a nice fast crust on the sledding hill out back. With ice hockey taking up our entire weekends, a mid-week snow day allowed us to sled, build snow forts in the snow banks, and generally wreak havoc across our neighborhood.

Was school cancelled? We had two ways to find out. Put on WMUR and watch the scrolling line at the bottom hoping to see 'Governor Wentworth Regional School District' flash by, or call the WASR weather phone.

To this day, I can still recall the phone number of the WASR weather phone, as well as their two primary sponsors – an art gallery and an auto dealership, and the voice of Alan Severy as he read the day's forecast. A few decades later, I even repaired the weather phone system a few times.

Sadly, the weather phone is no longer in service. Local analog telco lines in a hunt group were far too expensive at a business rate for the service to offset its costs. The Internet was disrupting radio, making it a challenge to continue especially for older AM stations like WASR.

With a variety of digital and audio options for accessing real-time, current summit conditions and Mount Washington forecasts now available, the days of our own weather phone are numbered. Our phone continues to receive calls every day, but only from about a dozen devotees who phone our summit staff for the update. It's how this small group chooses to keep in touch with the Observatory and mountain weather.

Changing technology, user habits, and workflows require us to evolve. Decisions sometimes don't come easily, and as we all know, it's not always sunny on Mount Washington. With our detailed forecasts available at mountwashington.org, historical weather and current forecasts accessible by voice and audio via Amazon Echo devices (Alexa), and our new text message service that sends current summit conditions and a synopsis of our forecast immediately to your mobile phone after you text "weather" or "forecast" to 603-356-2137, our weather phone will be discontinued in the near future.

Thanks to the wonders of technology, we will be reaching out to those who call us each day for the summit conditions and forecasts.

The new text messaging service was chosen for a variety of reasons. It is automated. The weather phone required a shorter, custom written forecast, and needed to be recorded every time it was changed.

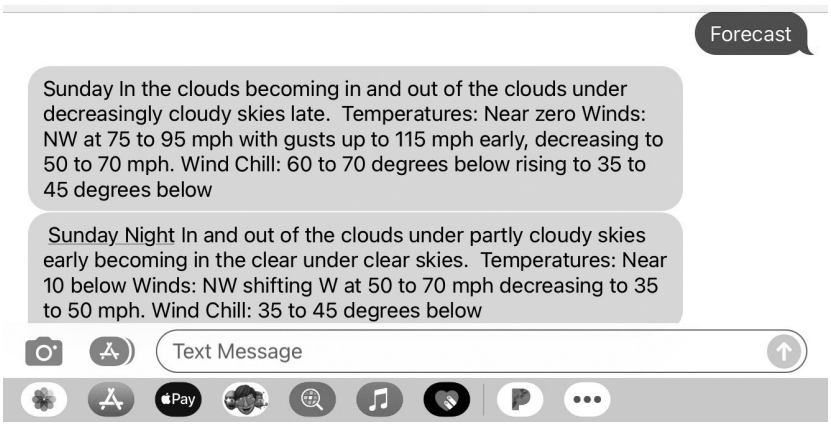
Most importantly, text messages work when voice and data cellular connections don't. There is very little, if any, cellular coverage across the White Mountains. The weather can change rapidly. In the backcountry, pulling up our website on a cell phone will rarely work when you need it to. Sending a text with just 'weather' or 'forecast' has a much better chance of making it through extremely low signal levels.

User adoption of both the Alexa skill and text service have both gone from a neat novelty feature to heavy usage in a relatively short time. A few days ago, nearly 1,500 people listened to our higher summits forecast on their Alexa device in one day. Hundreds look up what the weather was for a day they visited in the distant past. Our text service has skyrocketed in usage since its first deployment in mid-December of 2021. As of this writing, five weeks later, the texting service has processed over 35,000 messages, gaining traction among local and remote users far more quickly than we first imagined.

We know that a text messaging service lacks the same personal connection as the voice forecast recorded by an observer. Our online and radio voice forecasts aren't going anywhere.

If, like me, you need some consolation, read our text forecasts out loud, or in your head with the voice of Marty Engstrom or Al Kaprielian, or as I do with the voice of our Staff Meteorologist Ryan Knapp.

I would like to give a shout out to Engstrom and Kaprielian, who had a direct influence on why my brother Kevin is now working in weather at NOAA. I can still remember the first time Kaprielian used a technology based visual weather overlay on air, and his excitement, not that it was easy to tell it apart from his normal level of excitement.



Our new text message service sends current summit conditions and a synopsis of our forecast immediately to your mobile phone after you text "weather" or "forecast" to 603-356-2137.

The Benefit of Many Hands

BY **LINDA AND HANK DRESCH**

We have, fortunately and with great pleasure, been able to continue our regular monthly membership mailings. With the move back to the observatory's renovated offices in North Conway, the mailings are at 9:00 a.m. on the second Thursday of the month. As always, please look out for others' health and safety if you plan to attend.

Tending the grounds of the offices was our other major focus before winter. As usual, our stalwart gardeners Barbara Althen and Bill Ofsiany have done most of the work, with Peter Crane tending to the lawns on a regular basis.

Bill Ofsiany puts finishing touches on the Marty the Cat memorial stone.

In November, we held a dual membership mailing and grounds cleanup day, with some of us working inside, some outside, and some doing both. Joining the outside crew was a new member of our Valley Volunteers, Mark Bunker. If that name sounds familiar, Mark is the son of Bobbie and Briggs Bunker; it's good to have a Bunker on our roles once more.

Volunteers Marie Kaspar, Ava Honan, Bill Housum, Gary MacDonald, Linda Denis, Kim Henry, and Marietta Deegen prepare a large year-end membership mailing.

Two additions were also made to the gardens this year. One is the addition of spring bulbs donated by our volunteers, and the other is the installation of a memorial stone, coordinated by Rebecca Scholand, for Marty the "Summit Cat" adjacent to the flagpole.

The observatory is fortunate to have our dedicated volunteers ready to take on many tasks when requested. Over past few months, our volunteers have included:

Barbara Althen	Peter Fisk	Judy Meagher
Mark Bunker	Karen Franke	Gary MacDonald
Floyd Corson	Donna Gray	Bill Ofsiany
Peter Crane	Kim Henry	Jean Perry
Marietta Deegan	Ava Honan	Jane & Ken Rancourt
Linda Denis	Bill Housum	Julie Housum Stevens
Linda & Hank Dresch	Marie Kaspar	Jean Sweeney

Valley Volunteer Coordinators Linda and Hank Dresch can be reached at hankandlinda@mountwashington.org or by phone: 603-356-2137 ext. 208.

UPCOMING EVENTS

ANNUAL MEETING

The Mount Washington Observatory Annual Meeting is a recap of the prior year. It also gives a chance for observatory members and the public to meet the staff and trustees. This year, the meeting will be held on Saturday, June 25 at 11:00 a.m. at McAuliffe-Shepard Discovery Center in Concord, NH. Stay tuned for additional details.

SCIENCE IN THE MOUNTAINS

Measuring the wind speed at the summit of Mount Washington is no easy feat. It requires fully custom, heated anemometers to accurately measure super-hurricane-force winds while surviving brutal cold and severe icing conditions. Through a partnership with General Electric and UMass Lowell, an all-new pitot tube anemometer was designed, built, and tested to improve on previous designs used on the summit. On Tuesday, April 12 at 7pm, join Sam Robinson and Rebecca Scholand of MWOBS to learn about the history of measuring wind on the summit, why the new pitot design was warranted, and its journey to becoming an operational instrument Register today at **mountwashington.org/sitm.**

PROGRAM CONNECTS STUDENTS WITH WEATHER EXTREMES

Our education team has resumed free weekly distance learning programs to support STEM curricula throughout the nation. Students and weather enthusiasts can connect live to the Northeast's highest peak as MWO Weather Observer/Education Specialists present via Zoom and Facebook during brief sessions titled "Home of the World's Worst Weather Live." Programs are every Tuesday at 11:15 a.m. EDT. Targeted for grades 6-8 (but open to all), the programs expand on MWOBS' well-established distance learning, connecting students with the extreme weather and science taking place at the summit. Joining via Zoom allows participation in the Q&A. Register for programs today at **mountwashington.org/classroom.**

MEMBERSHIP MILESTONES

25 Years

Barbara B. Sweet
Robert D. Sgarzi
Nancy K. Spaulding
Jennifer Supple
Stephen Campbell
Leslie Schomaker
Robert A. Dunning
Paul M. Wexelblat
Joe Zabransky Jr.
Robert Healy
Ann Wilkins
Carl E. Hane
Jeffrey I. Schiller
Bernard Weichsel
Fran M. Trafidlo Jr.
L. Anthony Kingsley
Scott Taylor
Tom P. Gilmore
Adam Jared Apt
John Rhoads
Mark LePage
Francis S. Billak
Donald A. Bickford
Charlotte Dunning Burgess
Kenneth Kimball
Kenneth Stockwell
Jon Hill
Patricia V Dunn
Colin Robinson
Stephen Moore
Leonhard Wiegandt
Mike Tamulis
Chris Gordon
James Waterhouse
Harrison B. Bennett
Michael Pacitto

IN KIND DONORS & EVENT SPONSORS

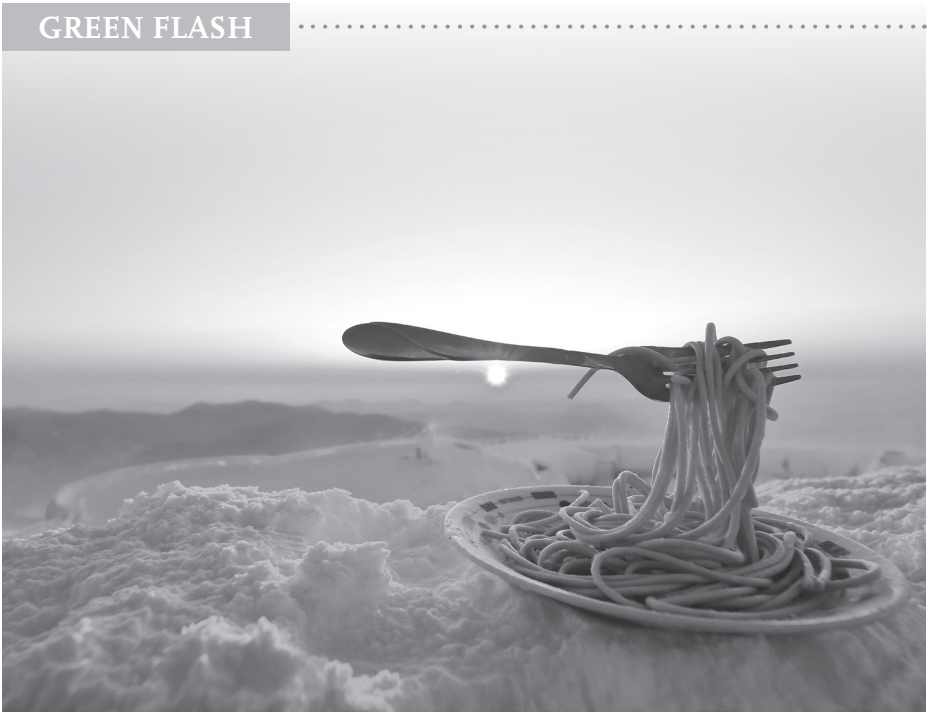
Appalachian Mountain Club
Attitash Mountain Service Co., Inc
Backpacker Magazine
Big Agnes
Big Dave's Bagels
Cascade Designs, Inc
Clif Bar, Inc
Cotopaxi
Cross New Hampshire Adventure Trail
David J. MacKenzie
David Raizen
Delta Dental
Eastern Mountain Sports
Far Bank
First Light
Flatbread Company
Garmin
Granite Outdoor Alliance
Great Glen Trails Outdoor Center
Honey Stinger
Hoo Rag
Hyperlite Mountain Gear
Jerry's Furniture
Kimberly's Gluten Free Kitchen, LLC
Lakes Region Coca Cola
Leave No Trace Center for Outdoor Ethics
Mark Badger
Martini Northern
Melcher & Prescott Insurance
Michael Zlogar
Mountain Center Physical Therapy
Mt Washington Radio
Mt. Washington Auto Road Co
Nikwax USA
Northway Bank
Oboz Footwear LLC
Petzl America
Science on the Fly
Settlers' Green Outlet Village
Shirley O'Malley
Ski The Whites
Smartwool
White Mountain Milers
White Mountain Oil & Propane

...Thank you

Tributes & Memorial Gifts

Joan Barnett ..... In Honor of Liz Barnett
Mary Ann Leekley ..... In Memory of William Bowden
Bruce C. & Marilyn Soper ..... In Memory of Charles Burnham
Chris Hawkins ..... In Memory of Charles Burnham
Gary L MacDonald ..... In Memory of Charles Burnham
Jack Middleton ..... In Memory of Charles Burnham
Mark Van Baalen ..... In Memory of Charles Burnham
Deirdre Byers ..... In Memory of James Byers
Glenn Richard ..... In Honor of James Colbath
Rachael P. Coshak ..... In Memory of Robert Crawford
Natalia Czar ..... In Memory of Jonathan Czar
Brenda Daly ..... In Memory of Pat Daly
Bridges Healthcare, Inc ..... In Memory of Pat Daly
Frank Cosenza ..... In Memory of Pat Daly
Frank Cosenza ..... In Memory of Pat Daly
Heather Labonte ..... In Memory of Pat Daly
Lisa B Palmucci ..... In Memory of Pat Daly
Ruth Kennedy ..... In Memory of James Durkee
Nancy L Eastham ..... In Memory of William Eastham
Kevin Fitzgerald ..... In Memory of Raymond Fitzgerald
Christopher Foster ..... In Memory of John Foster
Megan Hinckley ..... In Honor of Karen Franke
Pam Gravelle - Becker ..... In Memory of Paul Gravelle
Tracie Howell ..... In Honor of Britton Howell
Anonymous ..... In Memory of Charlie Humphreys
Barbara Erskine ..... In Memory of Charlie Humphreys
David Greer ..... In Memory of Charlie Humphreys
Frank Kaplan ..... In Memory of Charlie Humphreys
Jennifer Greer ..... In Memory of Charlie Humphreys
Jennifer Greer ..... In Memory of Charlie Humphreys
Jennifer Trachtman ..... In Memory of Charlie Humphreys
John H. Lyons ..... In Memory of Charlie Humphreys
Lidget LLP ..... In Memory of Charlie Humphreys
Lois McNamara ..... In Memory of Charlie Humphreys
Samuel Wagner ..... In Memory of Charlie Humphreys
The Fenner Family ..... In Memory of Charlie Humphreys
Deborah Kendall ..... In Memory of Clark Kendall
Joe Leanza ..... In Memory of Richard Kirsch
Michael John Knapp ..... In Honor of Ryan Knapp
Joseph Büch ..... In Memory of Robert & Anna May Büch
Mary E Burke ..... In Memory of Kevin McGrath
Christopher J. Daly ..... In Memory of Nicole Moore
Janice Newman ..... In Honor of Brian Newman
William D. DeCamp Jr. ..... In Honor of Edwin O'Malley
Erica Broman ..... In Memory of William L. Putnam
Patricia Coultas ..... In Memory of Lawrence Struck
Sharon Hewitt ..... In Memory of Bill Ware
Leo Willman III ..... In Memory of Leo Willman
Keith Fortier ..... In Honor of Gannon Winn
Fran Wray ..... In Memory of Fred Wray
Dennis Marrotte ..... In Honor of Nimbus the Summit Cat
Sharon Kate Hirsch ..... In Memory of Marty the Summit Cat

GREEN FLASH



Flash Frozen at -30 Fahrenheit

Weather Observer Ryan Knapp's whimsical photo of leftover spaghetti freezing mid-twirl put a fun twist on a -30 °F morning at the summit on Jan. 11, attracting the attention of PBS NewsHour, Good Morning America, and other media outlets.

CORPORATE SUPPORT

WINDswept

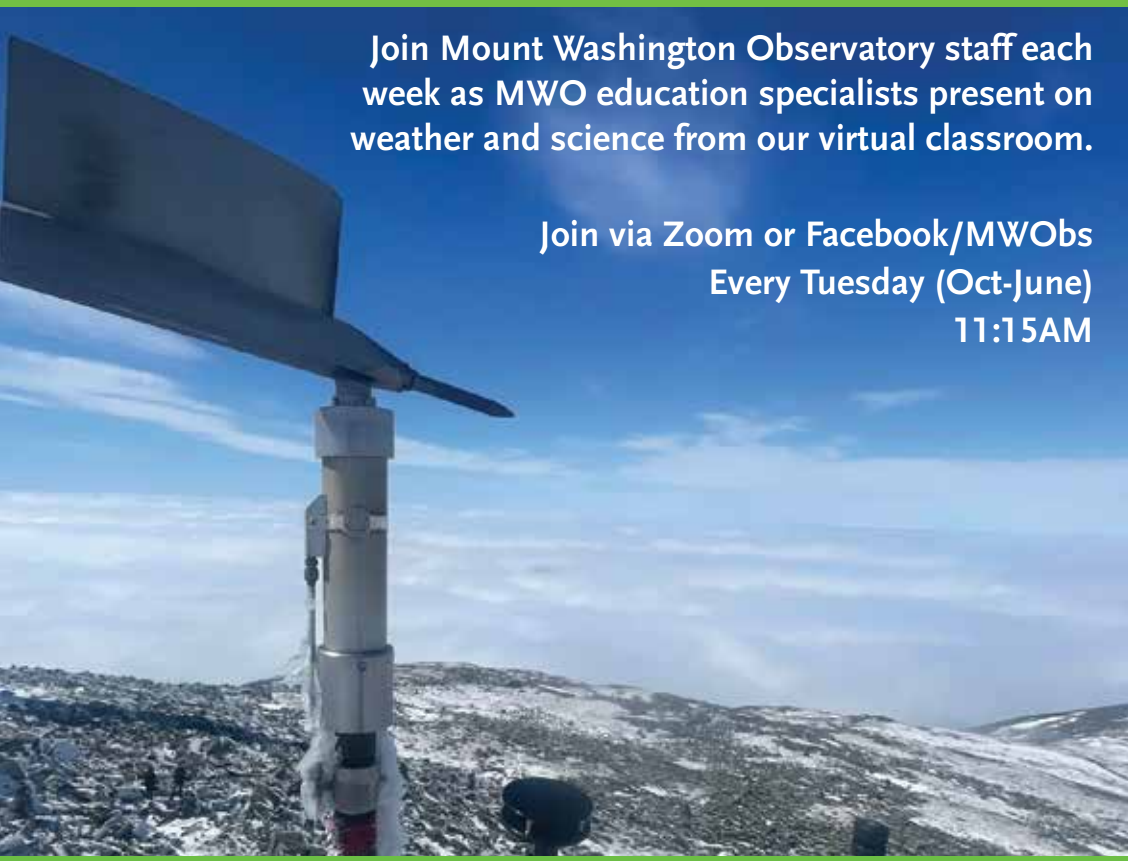
PO Box 2310
North Conway, NH 03860
Phone: 603-356-2137
www.MountWashington.org

NON-PROFIT
PRESORT AUTO
U.S. POSTAGE
PAID
N. CONWAY, NH
03860
PERMIT #160

MWOBS

MOUNT WASHINGTON OBSERVATORY

"HOME OF THE WORLD'S WORST WEATHER™ LIVE"



Join Mount Washington Observatory staff each week as MWO education specialists present on weather and science from our virtual classroom.

Join via Zoom or Facebook/MWObs
Every Tuesday (Oct-June)
11:15AM

Please share this information with your community's educators to raise awareness of this free offering in support of schools nationwide.

MOUNTWASHINGTON.ORG/CLASSROOM