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# WINDswept

The Bulletin of the Non-Profit Mount Washington Observatory

2022 YEAR-END CAMPAIGN

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# WINDswept

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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 who donate at least $60/year or $5/month receive: Tours of our famous mountaintop weather station (generally mid-May through mid-October); 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* 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 mountwashington.org.

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# *Overcoming Extremes to Ask the Unanswered Questions*

*Charlie Buterbaugh*

BY **CHARLIE BUTERBAUGH**, EDITOR

This edition of *Windswept* aims to capture some of the Observatory's rich history. As Peter Crane conveys in his article (p. 19), what started in October 1932 as a one-year experiment in atmospheric science has continued for almost a century.

Although our founders couldn't predict the longevity of their project, they understood Mount Washington's importance to the study of mountain meteorology. So they resolved to establish the mountaintop station, one of the first of its kind in the world.

Their early innovations in measuring wind speed, in the face of extreme weather on the exposed summit, set the stage for measuring a world record-setting 231 mph wind gust on the afternoon of April 12, 1934. The measurement was extensively verified, setting the standard of data quality throughout our history.

Sustaining a home for mountain meteorology and climate science on the summit for 90 years has given researchers one of the most valuable data sets for studying high-terrain weather and climate, as well as extensive knowledge and best practices for instrument design and data quality.

The Observatory's experience of seeing just about everything Mother Nature can throw at a weather station has opened many doors. It's the reason climate scientists Baker Perry and Tom Matthews formed a partnership with our team to test instruments and tripods planned for installation on Mount Everest.

In June 2021, they asked our Director of Technology Keith Garrett to design and build a custom pitot static tube anemometer – pairing it with a data logger for remote deployment at the planet's outer edge, atop Everest.

Two of these new wind sensors were successfully installed in May at 25,938 and 28,904 feet in elevation, helping scientists understand snow and ice loss in the Himalayas, which act as water towers to over a billion people downstream. See story on p. 33.

The need to understand weather and climate trends where the land surface meets the atmosphere continues to drive our work. Studying our weather remains vital to understanding Earth's climate, locally and globally.

*Continued on page 6*

# *Envisioning 90 More Years Leading Scientific Research and Learning on Climate and Weather*

*Drew Bush*

BY **DREW BUSH,**
EXECUTIVE DIRECTOR

Ninety years. Just a few weeks ago, from the perspective of those of you reading this column, we celebrated this historic milestone on the summit of Mount Washington with an open house at our weather station. We owe a huge thanks to our staff and volunteers for making this possible.

Each year, we mark our Founders Day on Oct. 15. This year, I have had the privilege to witness the planning and execution of this event for the first time as Mount Washington Observatory's newest staff member. I look forward to many more years marking this event as we work together to chart a course that sustains this amazing organization for another 90 years.

Although I have only been with the Observatory for a few months, I am quickly becoming familiar with the important legacy for which we are all responsible. The data contained in our weather record has its origins in the late 1800s and not only contributes to forecasts that keep people across our region safe, but also provides an important tool for those working to understand how weather and climate operate and, in the future, may change.

While the Observatory provides an important home for research into these topics, our mission also means we must work to educate our society's children, adults, families, and leaders about the human relationship to climate and weather. Extreme weather events, like those we experience atop the Rockpile, are becoming more common as our climate changes. Scientific research globally indicates this will only continue. Our communities require sound science and an educated public to better prepare for and manage these events in a manner that protects people and their livelihoods.

Like you, I find it easy to revel in the grandeur of the weather we experience each day. I too sometimes forget that weather affects all that people do, indelibly shaping the evolution of human civilization. In my new role, I plan to bring this focus to all of our efforts in attracting cutting-edge research, developing educational programs that tie weather to human experience, and enlarging the way in which we communicate to reach new audiences. Achieving these goals means bringing more diversity to the Observatory, engaging additional partners, and increasing our financial support.

I am fortunate to have the benefit of a talented staff, volunteer group, and

Board of Trustees in this work. Their efforts mean we are already poised to launch a new website in the near future, build new partnerships, launch research projects that will engage many new undergraduate and graduate students, and open many new educational programs – including wintertime educational trips to the summit and virtual lessons that bring our science into middle school classrooms.

We have even worked with partners at the Appalachian Mountain Club and Hubbard Brook Ecosystem Study to install new panels in our Extreme Mount Washington summit museum, which display data and summaries of climate trends in the White Mountains, and we have started a project with Mount Washington State Park to create a new interpretive exhibit in the Sherman Adams summit building to inform visitors about the history of the mountain and the Observatory's scientific role.

Our work has only begun. As I have written, there is so much more to do to fulfill our mission. We hope you will consider joining us for one of our programs, whether you live near or far. As you do so, please know that while we receive supplemental funding from NOAA/National Weather Service in exchange for our data, we rely substantially on our members for support. Our year-end campaign will be headed your way soon. Please consider a generous gift that will sustain our next 90 years.

*In My View continued from page 4*

Every year of data that our observers collect on Mount Washington and share with the world offers another valuable opportunity to look at broader trends. What's happening at the upper layers of the atmosphere ultimately has impact on what is experienced down below.

Our quest continues today as we overcome extremes to ask the unanswered questions, at a place unlike any other, where the weather meets Mount Washington.

# *Feline Fine in the Alpine Sunshine*

TRANSLATED BY **FRANCIS TARASIEWICZ**

Meow from high up in the catmosphere. I have many tails to share as this pawsome summer and fall wind down on the meowtain! Furst, I noticed many brand mew observers on the summit. This means lots of purr-fectly warm seats to steal while they go out to take observations.

*Nimbus explores the kitty-sized caves around the summit.*

Recently, the humans up here have let me-owt to explore the summit. I use these oppawtunities to explore the many caves between the rocks. These caves are litter-ally the perfect size for me! I purrsonally love the feeling of the rocks and moss on my fur. When I'm not in the rocks, I'm on the rocks feline fine in the alpine sunshine.

Inside the Observatory, I am helping to maintain claw and order with the summit mice that sneak into the humans' area. I've definitely purrfected my hunting skills and as a result, the mouse situation is so fur so good.

I've also had a chance to get in a lot of sun-filled kitty naptime. Sometimes, I find a human's chair and sleep in it fur hours! I'll only sometimes open my eyes when the observer opens the big loud metal door underneath the meower... I mean... tower (sorry, I'm writing this at noon which is way past my bedtime).

The other night, after I had my cat-puccino and was working through some zoomies, I heard a large banging from above. What was this noise that was stressing meowt? At furst, I thought it might be thunder (pawsitively the worst noise evfur), but this one continued again and again. To my su-purr-ise, the night observer, Alexis, came back covered in ice! I think this brave human was knocking the ice off the instruments. I guess this means I can't pawcrastinate on growing my winter coat meowch longer.

What was that? Could it be my treat drawer!? These new observers sure are generous. My apawologies but meow for now!

# *Observatory Welcomes New Executive Director*

Mount Washington Observatory began a new chapter in September when the Board of Trustees unanimously selected Dr. Drew Fulton Bush as the organization's new executive director.

Trustees Chair Robert C. Kirsch called Bush a passionate and visionary leader who will bring a distinctive strategy for the future while building upon the Observatory's 90-year legacy in mountain meteorology and climate science.

"Drew has a remarkably well-rounded weather and climate science, education, fundraising, and leadership background and will advance the Observatory's strategic vision as the go-to organization for mountain-based atmospheric and climate research," said Kirsch. "He has an empathetic and open way that will be positively received by our membership, board, and staff, leading to easier, broader, and more rapid advancements for our organization."

Throughout his career, Bush has made significant contributions working as a nonprofit leader, researcher, and educator. Most recently, he directed research in McGill University's Department of Geography, led communications and development as the Assistant Director at the Old Stone House Museum & Historic Village, and served as the Director of Programs at the Fairbanks Museum & Planetarium, leading educational and public programs. His research has examined the human relationship to climate and weather as well as the means to improve public knowledge of these topics and participation in policymaking on them.

*Drew Bush, left, made several overnight summit visits during his first month at the Observatory to get better acquainted with our mountain staff. He is shown above with Director of Weather Operations Jay Broccolo.*

Bush received his Ph.D. from McGill University's Department of Geography and Bieler School of Environment, a

Master of Environmental Management from Duke University, and a B.A. from Colby College. Prior to starting his new role at the Observatory on Sept. 26, he and his wife Sara Lewis, and their daughter Eleanor, moved from Lyndonville in Vermont's Northeast Kingdom to the Mount Washington Valley, where Lewis has joined Josiah Bartlett Elementary School as a music teacher.

"Donna Dunn, whose role as our Interim Executive Director concludes with the hiring of Dr. Drew Fulton Bush, has been instrumental over the last two and a half years in leading Mount Washington Observatory through a period of extraordinary challenge and change," said Gary MacDonald, Immediate Past Chair of the Board of Trustees. "As we celebrate 90 years of weather observing and research in October, we will look back at the last few years as a time when critical structures were put in place for a successful future."

Learn more about Bush in the Q&A feature story on p. 16.

## *New Trustees Elected*

Mount Washington Observatory's Annual Meeting was held Sat., June 25 at McAuliffe-Shepard Discovery Center in Concord, NH.

Board of Trustees Chair Robert C. Kirsch addressed members in attendance, followed by former Interim Executive Director Donna Dunn providing an update on Observatory news.

Four retiring trustees were recognized for their many years of dedicated service: Alexandra T. Breed, 31 years of service; Jack Middleton, 65 years of service; Brian C. Underwood, 28 years of service; and Howie Wemyss, 17 years of service.

Before the Annual Meeting, trustees held their regular meeting, during which four new trustees were unanimously elected based on the Governance Committee's recommendation. The new trustees are Lourdes B. Avilés, Ph.D.; Teresa S. Bowers, Ph.D.; Jonathan Haynes; and Jeannie Oliver.

In other board action, Middleton was appointed as a Life Trustee and Kirsch was appointed the Observatory's representative on the Mount Washington Commission, succeeding Middleton, who has served on the commission since 1968.

*Lourdes B. Avilés*

*Teresa S. Bowers*

*Jonathan Haynes*

*Jeannie Oliver*

# *Broccolo Promoted to Director of Weather Operations*


*Jay Broccolo*

Jay Broccolo, who joined the Observatory in March 2019 as a weather observer and meteorologist, began his new role as director of weather operations on July 1. The new role encompasses leading our team of weather observers while overseeing Observatory research and the Mount Washington Regional Mesonet.

Raised in Westerly, RI, Broccolo grew up along the southern coastline of Rhode Island, experiencing all sorts of extreme weather, from hurricanes to nor'easters. An Eagle Scout, he earned his B.S. in geology and geological oceanography at the University of Rhode Island and a Master of Research in climate and atmospheric science from the University of Leeds.

Learn more about Broccolo in his Summit Operations column on p. 51.

# *22nd Annual Seek the Peak Raises Critical Funds*

On July 15 and 16, outdoor enthusiasts from around the country gathered to support the Observatory at the 22nd annual Seek the Peak. During the Adventure Expo, participants, sponsors, staff, and volunteers came together to celebrate at the base of Mount Washington, having successfully raised $175,000 to support our work.

The event kicked off Friday evening under clear skies at Tuckerman Brewing Co., where fundraisers enjoyed live music and caught up with Observatory staff and fellow participants. Backpacker Magazine's Get Out More Tour was on hand to raffle off the first of the weekend's amazing gear giveaways.

Expo doors opened at Great Glen Trails on Saturday with outdoor gear companies, local nonprofit groups, and food trucks assembled under colorful tents to create the Vendor Village. Roy Prescott from WMWV spun tunes throughout the day, and Bear Mountain Band provided live Bluegrass. Participants who selected running as their challenge participated in Seek the Peak trail races, put on by White Mountain Endurance. At the summit, participants enjoyed tours of the weather station, with mild temperatures and good visibility on the instrument tower.

The final hour of the Expo included recognition of 2022 top fundraisers and the much anticipated gear giveaway. This year, the top fundraiser was Christopher Nichols, with Brad Griswold taking runner-up. The Nichols Clan was the Top Fundraising Team, winning an overnight trip to the summit this fall. Dozens of prizes – including backpacks, tents, trekking poles, and other amazing outdoor gear – were raffled off. Anyone who raised $300 or more was eligible to win.

A special tribute was paid to long-time supporter and volunteer Pat Daly, who recently passed away. Those moments of remembrance served to punctuate how important members are to the Obs, whose community is vital to sustaining the summit weather station. Seek the Peak 2023 takes place July 14-15.

# *New Trail Signs Meant to Improve Weather Safety in the White Mountains*

A project led by Life Trustee Jack Middleton to design and print over 100 warning signs for display at White Mountain trailheads was recently completed.

The bright yellow signs, printed on 1/8" sturdy metal, warn of potentially dangerous weather at higher elevations, while informing hikers that a quick text to 603-356-2137 will generate an automated reply with the current summit conditions and Observatory forecast.

With a QR code that generates an automated text when scanned, the signs are meant to increase awareness and access to weather information in the backcountry, where WiFi signals are often not available.

"What inspired this are the news reports on a frequent basis of people being injured on mountains at higher elevations, often with injuries that can be life-threatening," said Middleton. He also credited author Ty Gagne's books about decision-making and risk in mountaineering as inspiration.

White Mountain National Forest, New Hampshire State Parks, Appalachian Mountain Club, and Randolph Mountain Club are all assisting with hanging the signs at trail heads leading to higher elevations in the Presidential Range and Franconia Notch.


*Life Trustee Jack Middleton holds one of the signs warning of high-elevation weather.*

# *NH Legislators Visit Weather Station*

Observatory trustees and staff hosted NH state representatives from Carroll and Coös counties, together with Mount Washington summit partners, for evening tours of our mountaintop weather station on Aug. 19 and 20, with the aim of raising awareness about our work in New Hampshire.


*Attending Aug. 19, left to right, are State Representative Karen Umberger (also an Observatory trustee), State Representative Mark McConkey, Carol McConkey, State Representative Jonathan H. Smith, Christina Smith, Observatory volunteer Karen MacDonald, State Representative Larry Laflamme, and Cam Spence with her husband, State Representative Jerry Knirk. State Representative Robert Theberge, not shown, also attended.*

*Attending Aug. 20, left to right, are Observatory Board of Trustees Chair Robert C. Kirsch, Howie Wemyss of the Mount Washington Auto Road, State Representative Edith Tucker, State Representative Karen Umberger, Trustee Gary MacDonald, State Representative Chris McAleer, Earl Duval of the Mount Washington Cog Railway, Observatory Director of Weather Operations Jay Broccolo (in back), Laurie McAleer, Mount Washington Cog Railway Owner and President Wayne Presby, State Representative Anita Burroughs, Sue Wemyss, State Representative Stephen Woodcock, Denise Woodcock, Mount Washington State Park Manager Patrick Hummel (in back), Jon Burroughs, State Representative Arnold Davis, Debi Davis, Trustee Beth Newhouse, State Representative Troy Merner, and Janet Merner.*

# *A Bold Rescue Attempt, in Vain*

Harsh weather in the Presidential Range on Sat., June 18 resulted in the death by hypothermia of Xi Chen, 53, of Andover, MA.

Chen was reportedly hiking a Presidential Traverse, traveling the range from Randolph to Crawford Notch, but the weather on that day was not all conducive to such an endeavor. Saturday's forecast, as issued by the Observatory on Friday morning, called for the summits to be in the clouds with a chance of rain and snow showers, with temperatures falling into the 20s °F, and winds of 55 to 75 miles per hour increasing to 60 to 80 miles per hour with gusts to 100.

There were minor variations in the updated forecasts on Friday afternoon, June 17, and Saturday morning, but the picture remained much the same. On Saturday, conditions on Mount Washington's summit, which remained in the clouds, included very low visibility, riming, glazing, freezing drizzle and freezing rain, and a bit over an inch of snow fell. The temperature was mostly between 29 and 32 °F, and winds averaged nearly 60 mph with a peak gust of 86 mph.

Conditions were more winter-like than what might befit the weekend before summer solstice, but such turns in the weather are common on Mount Washington.

Not much detail regarding Chen's hike is available, but it was at 6:30 that Saturday evening when the New Hampshire Fish and Game Department received a call from Chen's spouse, relating that she had received text messages from him and that he was in serious distress, cold and wet, on the Gulfside Trail on Mount Clay, about a mile north of the summit of Mount Washington.

Given the dire report, Fish and Game initiated a rescue response involving their conservation officers and members of the Mountain Rescue Service. Rescuers were brought to the summit via the Mount Washington Auto Road. Mount Washington State Park personnel assisted with this effort, which required chains to be used for safe passage on the icy upper reaches of the road. The rescuers braved the very difficult weather conditions, rough and snowy trail, and darkness, and located Chen at about 10:30 that night. At that time, Chen was unresponsive but showed signs of life, and he was transported via litter to the summit, down the road to a waiting ambulance, and brought to Androscoggin Valley Hospital in Berlin. In spite of several hours of medical intervention, Chen succumbed to hypothermia.

Our condolences go out to Mr. Chen's family. While it is hard to think that any good can come out of such a loss, we can only hope that it will be a clear reminder to the hiking public that Mount Washington's weather – even in June – can be brutally unforgiving. Proper clothing, equipment, fitness, knowledge, and most of all, judgement, are needed to keep a mountain excursion safe. Some mountain adventures are best postponed to a better day.

*Continued on page 18*

# *Sam Gawel, Fall 2021 Intern, Dies at Age 21*

Observatory staff were deeply saddened to hear of the untimely passing of Samuel Ethan Gawel, a senior at Dartmouth College who spent his fall 2021 semester interning with our summit team.

His mother Leah Gawel, speaking at a memorial service on Sept. 23 at the Dartmouth Outdoor Club, confirmed that Sam died of suicide.

The obituary in the Caledonian Record stated, "Sam was adored by his parents, Randy & Leah, his sister, Sophia, his puppies, Charlie and Walter, and his extended family and friends."

*Sam Gawel stands on the observation deck at sunset on Sept. 14, 2021, during his fall internship.*

Sam was a double major in earth sciences and anthropology. Born and raised in Detroit, he considered the White Mountains a second home, with many family members living here or coming from the area. In summer 2021, his immediate family moved to Piermont, NH, "and we couldn't be happier for it," Sam wrote in an Observer Comment blog dated Sept. 14, 2021 at mountwashington.org.

"He was an outdoor enthusiast whose passions included meteorology and snow sciences. His favorite past times were hiking with inadequate supplies, spending time with family and friends, traveling with no plan, cooking exotic foods that produced endless kitchen messes, listening to eclectic music, watching movies, and memorizing encyclopedic facts. Sam was best known for being everyone's 'best friend' and for his patience, kindness, and empathy," his obituary stated.

Leah contacted the Observatory shortly following her son's passing to convey the positive impact his summit internship made on him.

In December 2021, Sam published his second Observer Comment blog, noting, "it hurts to acknowledge these next few days are my last on the summit. I have been working here since September, and these months have proved to be some of the most formidable of my life."

He wrote that the experience shaped the long-term vision of his future, adding that his internship inspired him to pursue graduate education in meteorology.

Observatory trustees and staff offer our deepest sympathy to Sam's family and friends and our sincere gratitude for the abundance of donations received in tribute to Sam. Some of the tributes are listed on p. 59. A plaque in Sam's memory is being planned for permanent display at the weather station.

# *Q&A with New Executive Director Drew Bush*

Dr. Drew Fulton Bush started his role as Mount Washington Observatory's executive director on Sept. 26. Shortly thereafter (less than a week), Observatory staff submitted questions to gather their new leader's perspective on weather, climate, Mount Washington, and the organization's work. Following are his answers.

*Drew Bush*

## What's a weather memory that stands out in your mind?

I have experienced quite a few squalls, snowstorms, and other weather events while backpacking, kayaking, and partaking in various outdoor passions. One that stands out in my memory was a microburst that hit the Isles of Shoals, NH in 2001.

At the time, I was attending Colby College and working as the supervisor of Star Island's paint crew. It had been a peaceful summer day right up until we noticed menacing, dark clouds moving rapidly across the ocean. Within minutes, wind speeds picked up dramatically and became so intense that a riding lawn mower, garden implements, and other construction materials and debris were hurled through the air, some impaling buildings or smashing windows. The windward corner of the historic Oceanic Hotel's front porch was ripped loose, and a gazebo on the front lawn rose up into the air and got dismantled. No one was seriously hurt, a testament to the quick response of the staff. It was all over in under 10 minutes.

**When was your first visit to Mount Washington, and what were some of your first impressions of this iconic place?**

When I was 7, I began my first hikes in the White Mountains with my dad and brother. One of our first trips included hiking all of the Appalachian Mountain Club's huts in the Presidential Range. I can think of no other experience like poking your head above tree line in the White Mountains for the first time. For many years, I told anyone who would listen that the Lakes of the Clouds hut was my very favorite. Those early experiences among the high peaks fired my imagination. They have been formative in everything that I still do today.

**Do you have a favorite meteorological phenomenon?**

I love all types of weather. I have laughed about phones freezing to my face while walking home from McGill University as a doctoral student in Montreal and been drenched in my kayak while sheltering from storms on the Maine Island Trail. My favorite recent memory must be experiencing snowflakes in July while hiking in the mountains of British Columbia.

**What about Mount Washington Observatory made you want to get involved with the organization?**

Everything. Our curator, Dr. Peter Crane, recently lent me William Putnam's book, "The Worst Weather On Earth." From its first lines noting the unique nature of Mount Washington and the "sheer, sustained, uncomfortable conditions" found on it, I couldn't put the book down. I share the passion and drive of the early founders of the Observatory, not only to record invaluable climate and weather data but also to persevere in this mission no matter the obstacles. I have spent more than a decade studying and working on the human relationship to climate and weather – and I only hope that I can contribute to sustaining this amazing organization for another 90 years.

**What role do you see the Observatory playing in helping the public and the scientific community better understand our weather and climate?**

The Observatory provides a unique place for research and education, both because of the history of its meteorological record (there are only a handful like it in North America) and due to the extreme weather Mount Washington experiences. Both of these strengths have become increasingly important as our world's climate changes and crisis managers grapple with new and changing weather events. I believe we can lead our region and country in research and learning that informs public dialogue on these topics and helps to make people and their livelihoods safer, wherever one lives.

**The Observatory is focused on the natural world, but it accomplishes its important work through people: the staff, the many volunteers including our trustees, and our members. What in your background has given you the skills to lead this**

**community in accomplishing the Observatory's mission?**

I lead with empathy. I have always been very aware of those around me and, I think, capable of trying to put myself in their shoes. Perhaps without meaning to, I have taken this strategy to nearly every leadership role I have undertaken and used it, along with setting high expectations, to attract and retain close-knit communities of talented people. I believe the Observatory already starts strong from this perspective, but I look forward to driving the mission forward using this approach.

**What experience, in your personal or professional life, will prove must helpful to you in your position as executive director?**

I hope much of my background will prove useful. Of course, I aim to lend my research and educational experience to help grow both of these departments at the Observatory. I also believe my decades of work with nonprofits and volunteer boards will help the organization improve the efficiency of how it operates, communicates about its work, and sustains itself financially.

**If you could sit down with Joe Dodge and Bob Monahan, what are a couple of questions you would ask them?**

What was it like to establish this organization? How did you feel those first few years as you encountered obstacle after obstacle? What motivated you? What pitfalls should a leader of this organization avoid?

**What weather conditions do you look forward to experiencing on the summit?**

Until recently, I had never driven the Mount Washington Auto Road. My experiences had always involved hiking to the summit. I look forward to my first trips in winter in the Observatory's snowcat. I would love to experience winter on Mount Washington and winds in excess of 100 mph – from within the safe confines of the weather station, of course.

**What are your hobbies?**

Given the opportunity, I love just about any kind of outdoor activity. Kayaking, sailing, backpacking, and gardening are my particular favorites. Indoors, I love cooking and reading.

*A Bold Rescue Attempt, in Vain continued from page 13*

**Other Mountain Tragedies**

Two other hikers lost their lives on Mount Washington this summer. On Sat., July 30, John R. Quick Jr., 65, of St. Peters, MO, fell prey to apparently undiagnosed cardiovascular disease. He had ascended via the Ammonoosuc Ravine Trail and was starting down the Jewell Trail when he was stricken. In spite of valiant efforts of passersby to revive him, and subsequent efforts of rescue personnel, he did not survive.

On Thurs., Aug. 25, Yanick Belanger, 46, of Mont-Saint-Hilaire, Quebec, died of an apparent heart attack just below the summit after ascending via the Ammonoosuc Ravine Trail. Mount Washington State Park staff and others attempted to revive him, but to no avail.

# *What Started as an Experiment Endures for 90 Years... and Counting*

BY **PETER CRANE**

It was in October 1932 when a new White Mountains institution was established. However, its founders didn't know it would last decades, let alone into the next century.

Mount Washington Observatory was seen as a short-term project with an important but time-limited mission.

*The team that made up the first Observatory crew numbered four: Alex McKenzie, left, Bob Monahan, Joe Dodge, and Sal Pagliuca.*

The timing of the enterprise was especially important since it served as a contributor to a worldwide scientific exercise, the International Polar Year (IPY), devoted to the study of high latitudes and altitudes. There was a keen interest in learning how weather systems interacted with high terrain, and a recognition that full-time mountain stations gave detailed information that aircraft or balloons could only briefly sample.

Mount Washington's was the only mountain station in North America to partner in the IPY. To add to the value of the summit observations, parallel, comparative observations were made at Pinkham Notch by Observatory cofounder Joe Dodge and at the Mount Washington Cog Railway's Base Station by caretaker Charles Buckner.

The team that made up the first Observatory crew numbered four: Dodge, Bob Monahan, Alex McKenzie, and Sal Pagliuca. Dodge was best known as Huts Manager for the AMC. Monahan, a Dartmouth graduate, received a Master's in forestry from Yale. He and Dodge were the principal organizers of the enterprise.

The spirit of mountain adventure was an important impetus for their daring


*In 1937, Henry Teague of the Mount Washington Railway Company erected a sturdy building on the summit which was rented to the Observatory. Its frame was made of 9" x 10" railroad timbers. The building would serve as the home of the Observatory until 1980.*

project. The challenge of spending an extended period atop the Northeast's highest peak, and doing valuable work there, was undeniably attractive. And like their predecessors, Dodge, Monahan, and their colleagues were intrigued by the severity of Mount Washington's weather and wished to be immersed in it, to document it, and to learn more about it for the cause of science.

They benefitted from the enthusiasm of Dr. Charles F. Brooks, director of Blue Hill Observatory, which supplied weather instruments and training. The tools for investigating alpine weather were evolving with the field of meteorological science. Using sounding balloons added a new significance to observations from the mountaintop. In the 20th century's first decades, new technologies including powered aviation and radio made understanding of weather more com-

*Early weather observers launch a weather balloon from the summit.*

*Alex McKenzie, left, and Joe Dodge conduct radio communications, a critical element of the Observatory's early mission.*

pelling and provided new opportunities for its study.

As with earlier summit occupations, having sufficient funds for the unavoidable expenses of a mountaintop operation was a serious need. The Depression years did not make fundraising an easy task. No government funds were available. But after Dodge gave a presentation on the plans to the New Hampshire Academy of Science, the Academy made a generous contribution, which allowed even this challenge to be surmounted.

One of the Academy's members, Henry S. Shaw, was also intrigued by the occupation of the summit, especially for radio research, and became an important donor in the earliest years.

The Observatory, like the IPY, was intended to be a short-term enterprise.

*Mountain staff are shown mid-20th century navigating winter conditions during shift change on the Mount Washington Auto Road.*

But, unlike the IPY, the Observatory continued.

Weather observations continued on a daily basis, research projects filled the hours of the staff, and regular communications with the public helped foster better understanding and respect for the sometimes harsh but also fragile alpine environment.

"After one winter, there was no good reason to stop; and there was excellent reason for continuing, for the data obtained were proving of value in forecasting," wrote Brooks.

*The "Heated No. 2" anemometer became the main wind sensor on the summit in 1933. It is most famous for recording The Big Wind of 231 mph on April 12, 1934, which still stands as the fastest surface wind speed ever observed by a human.*

As might be expected, the 1934 World Record Wind clocked by Observatory staff only added to public interest in their work, and to the determination to continue it.

All of that started, remarkably, 90 years ago. Many things have changed on Mount Washington since Oct. 15, 1932. Buildings have changed – including those that have housed the Observatory – and patterns of summit use have changed.

The challenges of maintaining a remote weather and research station in a remarkably harsh location are certainly still with us. Those include the logistical challenges related to transportation and other mountain operations, the need to raise funds to support the Observatory activities, and the work required to recruit, train, and retain talented staff.

Just as in the early days of the Observatory, the kindness and generosity of many supporters, including private companies on and private individuals off the mountain, allow the nonprofit organization to continue its important work.

Today's Mount Washington weather observers write mountain forecasts, maintain the 90-year data set, and research the atmosphere, helping scientific, aviation, and outdoor lifestyle communities understand the unique relationship between weather and high terrain in the White Mountains. For nine decades, the Observatory has maintained one of North America's longest running alpine climate records.

The quest continues today as the Observatory overcomes extremes where the weather meets Mount Washington.

# *From the Pages of the News Bulletin and Windswept*

BY **PETER CRANE**

While the first full day of crew members recording observations on Mount Washington's summit happened on Oct. 15, 1932, the first issue of the Observatory's *News Bulletin* was not published until November 1937.

By that time, membership was already established, with 305 members supporting the work of this fledgling institution. Thus, information about the founding of the Observatory, and such early events as the world record wind of April 1934, are mentioned only in retrospect in the *News Bulletin*.


The first issue described the "New Building" at length. Up to 1937, the Observatory had borrowed space in the Stage Office of the Mount Washington Summit Road Company and the Camden Cottage associated with the Summit House. In 1937, Henry Teague of the Mount Washington Railway Company erected a sturdy building on the summit which was rented to the Observatory. Its frame was made of 9" x 10" railroad timbers. Of its robust attachment to the summit rocks, the *News Bulletin* noted, "It is obvious that if the building is to blow away it will have to go as a unit and take a chunk of the top of the mountain with it." That building would serve as the home of the Observatory until 1980.

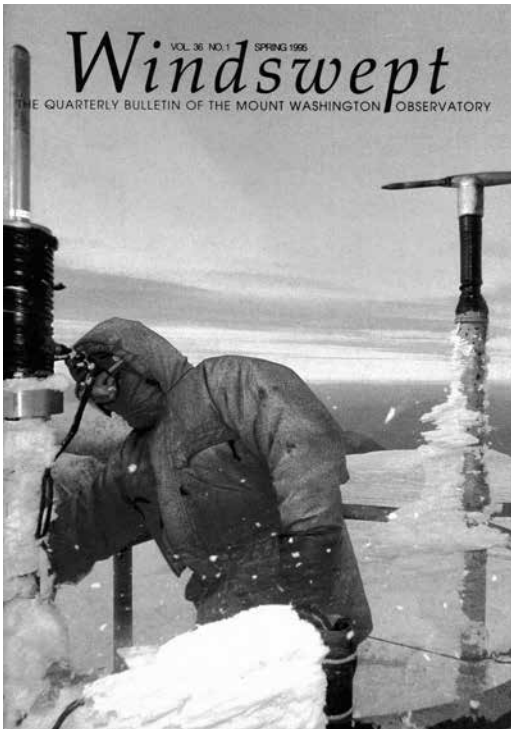
Other articles in that first issue highlighted the Observatory's lease, discussed current Observatory personnel, mentioned the Yankee Network and its work, mentioned the use of weather

balloons, and included material on the mountain's weather, geology, radio experimentation, and rime ice.


Editions of the 1930s were somewhat Spartan affairs, printed on plain paper, sometimes with photos, sometimes not. Glossy paper, and larger photos, debuted in 1940, with issue number 10 in January of 1942, noting "Changing Times on the Mountain." That article included notes on a newly built instrument tower and staff turnover, not unexpected for an unusual, remote, and challenging position.

But greater changes occurred shortly after December 7, 1941, with the April 1943 issue headline, "The Observatory During Wartime." Author of the accompanying article, Victor Clark, a young observer who would soon be joining the Army, noted, "The important nature of Observatory activities immediately became apparent when war was declared... At once, orders were received from the Weather Bureau forbidding the transmission of weather data except when hidden in a secret government cipher, and any mention of current weather over the radio, except in code, was strictly prohibited." Clark added, "As might be expected, the turnover of personnel has been greatly accelerated."

The 10th anniversary of the News Bulletin, issued in September 1943, offered an historical perspective on the first decade of the organization, information on current observational procedures, and an extensive review of the mountain's weather data. A special feature was "Observatory Roll Call," with names, addresses, and brief notes from all who had worked at the Obs during its first 10 years. Many were working




directly or indirectly in the war effort.

Not all of the news carried in the Observatory's member magazine has been cheery and bright. Issue 13 in November 1944 included notice of the death of original observer Sal Pagliuca, who died stateside in the service of his country. The June 1959 issue included a memorial to Dr. Charles F. Brooks, who had been president of the Observatory and essential in establishing its sound scientific footing during the Observatory's early years. Other passings have also been noted through the years.

Sometimes the articles in the publication have been unusually candid. In February 1950, cash flow challenges were mentioned, with the admission that "some of the officers kick in with loans to the Observatory in order to meet the current payroll."

In June 1952, Brooks, on the occasion of the 20th anniversary of the organization, noted, "There have been many crises, resulting from inadequate funds from private sources, from uncertainties in Weather Bureau appropriations, from delayed renewals of other Government contracts, and from miscellaneous causes. It is truly amazing that none of these has closed the Observatory." (We are happy to say that even with occasional fiscal challenges, we have made it another 70 years since that statement!).

1960 marked a real turning-point for the Observatory's member publication. Up to that time, the *News Bulletin* had appeared irregularly. Some issues were rather slim, others lengthy with many articles. No issue appeared in 1951, prompting an apology from the officers and trustees to the members.

Starting in 1960, the *News Bulletin* assumed a regular publication schedule of four issues each year. In lieu of the former 8 ½ x 11" format, the new format was 6 x 9". The issues typically featured a full-cover photo (though sometimes other artwork), and were color coded according to the season: sepia for autumn, blue for winter, green for spring, and yellow for summer. The editor was Alan A. Smith, who would serve in that capacity into 1965, and later served as Observatory president.

The June 1971 issue was noteworthy for at least two items. The cover sported an architect's rendering of what would be

the Sherman Adams Building, though that structure would not be built until 1978-1980, and Guy Gosselin, then chief observer, had a thoughtful article on the Observatory's mission, including the passage, "There was a time when we were planning a museum to which we might charge admission. It appears that this idea is now out of the question, but it was a good one nonetheless." Good enough that the March 1973 issue noted that starting "In 1973, the public will be served by a new Museum at the Summit of Mount Washington, operated by the Observatory."

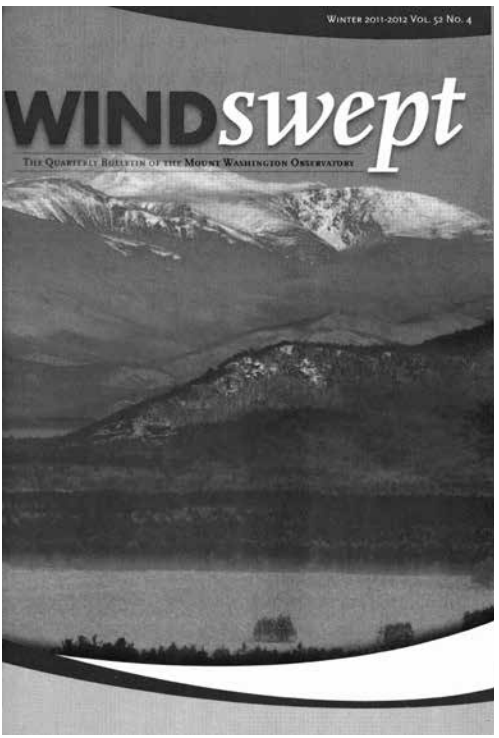
The museum was located in leased space in WMTW's Yankee Building, and helped inform visitors through 1980; a new museum was opened in the Sherman Adams Building in 1981.

The founding of the summit museum was a natural outgrowth of the display room that had been in the Observatory since the early 1940s. It served two important functions: educating and informing visitors about the mountain – its history, weather, natural history, and geology – and about the Observatory, and generating income through admission and sales to augment other sources of revenue.

The museum demonstrated the entrepreneurial spirit that the Obs, and members of the summit crew, were so imbued with, and also showcased their many talents – documentary research, carpentry, photography, and more – which allowed the museum to be built with remarkable economy.

Issues of the *News Bulletin* through the 1970s track the progress, planning, and fundraising for the Sherman Adams Building, which would serve as Mount Washington State Park's headquarters and visitor center and would also become the new home for the Observatory and its museum.

In December 1980, the *News Bulletin* carried exciting news of the move from "the old house," which had served as home to the Observatory since 1937, to the brand new Sherman Adams Building. August 1 was the big day. The barometer was carefully removed, and then Observer "Rob Kirsch, displaying a sharp historical sense, managed to do the last observation in the old building and the first in the new." Kirsch currently serves as the Observatory's board of trustees chair.



Observatory news took place in the valley, too. The Spring 1991 issue noted the establishment of the first official Obs valley facility in North Conway, after years of using locations such as the Appalachian Mountain Club in Pinkham Notch, Joe Dodge's house on West Side Road in Conway, and Guy Gosselin's house in Gorham as offices for the organization. A few years later, the Observatory's office and Weather Discovery Center moved to a nearby location in North Conway in 2004 (where the administrative offices are now located).

The Winter 1992 issue included an article about a new educational program of the Observatory: EduTrips. The overnight trips provided a way for members to experience the mountain in winter, to learn about various topics such as photography, mountain meteorology glacial geology, and more. EduTrips continue to this day.

The publication's format remained in place (with one change – the dropping of "News" from News Bulletin in 1993) until Spring 1995, when a major change took place. Peggy Dillon, former summit observer and new editor of the Bulletin, really shook things up overseeing a change in the publication's name to "*Windswept*," an appropriate and evocative title suggested by then Board President Brian Fowler, and transformed the magazine by adding color to the cover.

Inside, too, our member magazine sported a new look, from different typefaces to more standardized departments. While stylistic elements have changed since then, including a new look to the cover introduced in 2007, the template set in 1995 remains at the heart of *Windswept* today.

In 2001, the spring issue of *Windswept* mentioned a new event on the mountain, sponsored by the Observatory. "Seek the Peak" was dubbed "The First Annual Mount Washington Observatory Hike-a-Thon" and was held in late July. While this fundraising event has changed in various ways over the last two decades, it remains a staple of the Observatory calendar.

In 2014, *Windswept* carried the exciting news about the opening of "Extreme Mount Washington," a new museum experience for summit visitors.

Yet another change occurred in 2016. For many years, *Windswept* had been the quarterly bulletin of the Mount Washington Observatory. But financial challenges besetting all facets of publishing, and the rise of digital media, led to the quarterly becoming a triannual publication, with issues in spring, summer, and fall/winter.

In fall 2021, 450 Observatory members responded to a *Windswept* survey, which asked readers to select their three favorite story topics. The top responses were: history of Mount Washington and the Observatory (selected by 74.5% of respondents), weather/meteorology (74%), summit operations and observer life (72%), and climate science and research (51%). 90% of respondents said they prefer to read *Windswept* in print.

As we move forward, our readers will continue to be our guide.

# *Pilots Rely on Observatory for Conditions at Altitude*

BY **ALEXANDRA BRANTON**

*A glider flying near Mount Washington. Photo by Peter Stauble of Franconia Soaring.*

In addition to hikers and climbers, the local general aviation community relies on Observatory forecasts and weather data to stay informed about conditions in the White Mountains.

General aviation includes any aeronautical activity that is not related to commercial or military operations. Some of the most popular general aviation activities are personal, recreational, and sightseeing flights, and glider operations.

Each of these activities operates at relatively low altitudes, where the mountains can have a significant effect on the free atmosphere. Local aviator and Aviation Academy President Ed Bergeron says his preferred altitude is 3,000 to 4,000 feet, depending on winds and other conditions.

Our location at 6,288 feet makes the Observatory a great resource to Bergeron and other pilots wanting to know what the conditions are like at altitude. Another benefit of our higher elevation relative to the surface is the unique ability to supplement pilot reports (PIREPs), which Bergeron says are lacking in this area.

Using PIREPs, pilots communicate

**KMWN 121847Z 13001KT 1/16SM -SHRA FG VV000 11/11 RMK SHRAB45**

| | |
|---|---|
| **Temperature:** | 11.0°C ( 52°F) |
| **Dewpoint:** | 11.0°C ( 52°F) [RH = 100%] |
| **Winds:** | from the SE (130 degrees) at 1 MPH (1 knots; 0.5 m/s) |
| **Visibility:** | 0.06 sm ( 0.10 km) |
| **Ceiling:** | indefinite ceiling with vertical visibility of 0 feet AGL |
| **Clouds:** | obscured sky |
| **Weather:** | -SHRA FG (light rain showers, fog) |

*An example of a METAR, retrieved from AWC, disseminated by Mount Washington Observatory on Sept. 12, 2022. The decoded version is shown below the raw.*

potentially hazardous weather phenomena that they experience in flight. Once a pilot submits a PIREP, it is available to everyone and can assist others in developing safer flight plans.


*This Observatory weather camera view from Wildcat Mountain provides an example of mountain obscuration.*

The Observatory keeps pilots informed through the dissemination of standardized aviation weather reports called METARs. Weather observers take hourly observations year-round and publish them in METAR format. The data in a METAR include date and time of report, wind speed and direction, visibility, present weather, sky condition, temperature, dew point, pressure, and remarks (additional important information).

There are many reasons why this information is useful to aviators, especially in airspace over complex terrain such as the White Mountains.

Jim David of Franconia Soaring says he uses the Observatory's current observations every day he flies. He and others in the soaring club participate in glider activities, a sport that is highly reliant on wind. Mount Washington is famous for its extreme wind, and David notes, "sometimes the wind is blowing (from) 270 degrees at 60 miles per hour" at the summit "with nothing on the ground in Franconia."

Highly variable winds like this can cause local areas of wind shear, which includes sudden changes in wind speed and/or direction. As a pilot enters an area of wind shear, this can affect aircraft attitude, the orientation of an aircraft with respect to the horizon, and airspeed.

If the attitude or airspeed suddenly changes too much, this can cause an aircraft to stall and no longer generate lift.

Gustiness is another characteristic of wind reported in a METAR. While the Observatory does not report on turbulence, gustiness can be a good indication of rough air in an area. Similar to wind shear, wind gusts can also have effects on the nose-up/nose-down pitch of an aircraft in extreme cases.

Following the wind group data in a METAR are the visibility, present weather, and sky condition. These groups contain information about cloud heights and weather phenomena such as fog or thunderstorms. Although they are separate groups, the three go hand-in-hand to paint an accurate picture of what is going on at a weather station.

Most importantly, these groups dictate what ratings a pilot must hold in order to fly that day. For example, pilots who do not hold an instrument rating can only fly in Class E airspace – where most general aviation activity takes place – when visibility is at least three statute miles and a distance of at least 500 feet is possible

between the aircraft and all clouds.

Days like these are rare in the White Mountains, and the Observatory is critical in making pilots aware of the conditions.

The visibility, present weather, and sky condition groups are also beneficial when identifying possible areas of mountain obscuration, when clouds obscure higher summits because they are present at the same elevation. For example, when the Observatory reports 1/16 of a mile in visibility, fog for present weather, and a sky condition of vertical visibility zero, aviators would not be able to see the mountain tops in the area.

Mountain obscurations can be extremely hazardous when combined with other conditions that make flying at a constant altitude difficult. This is especially hazardous to pilots who are unfamiliar with the terrain and might fly at a lower, unsafe altitude.

Thunderstorms can have several impacts on aviation and are also reported in these groups. Because Mount Washington is at such a high elevation compared to the rest of the area, thunderstorms can be observed and identified anywhere from the summit within a 130-mile radius (assuming maximum visibility). Knowing the location and direction in which thunderstorms are moving is important to pilots because of the several hazards a thunderstorm can produce. Hazards to aviation include lightning, wind shear, turbulence, and hail.

The temperature and dew point data included in a METAR are of high interest to pilots. Freezing temperatures and high humidity, which occur when the temperature and dew point are close in value, can cause ice to form on aircraft. This can have aerodynamic implications that negatively affect flight. For example, if ice forms on aircraft wings, airflow is disrupted and the generation of lift is not as strong. Another consequence is the increase in weight and drag when ice forms on the fuselage.

On the other end of the spectrum, warm temperatures with high humidity can have profound effects on aircraft performance. In these conditions, engines become less efficient and require more fuel to travel shorter distances.

The remarks section is the last part of a METAR. This is where a weather observer codes any other noteworthy information. For example, lenticular and rotor clouds are good indicators of turbulence in the area and are coded here.

There are many other ways for aviators to get important meteorological information from the Observatory. Resources include hourly METAR, the Mount Washington Regional Mesonet, and the Higher Summits Forecast. Pilots can access this information via mountwashington.org, the Aviation Weather Center at aviationweather.gov, and the Federal Aviation Administration weather briefing phone number, 1-800-WX-BRIEF.

# *The Mountain, the Professor, and the Circumhorizon Arc*

BY **LOURDES B. AVILÉS**

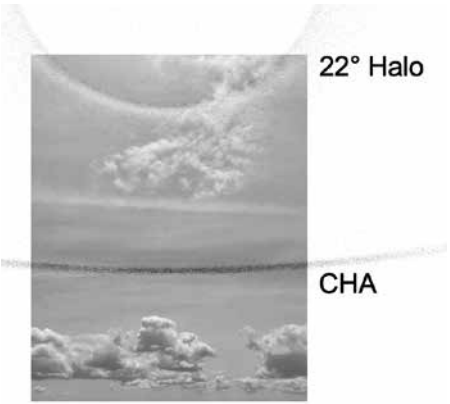
The Home of the World's Worst Weather is also an excellent location to observe a variety of atmospheric optical effects. The summit of Mount Washington provides one of the best vantage points in New England to see, for example, the northern lights when they sporadically appear at these latitudes.

Fogbows, glories, and the specter of the Brocken are some of the most common and noticeable to casual observers. Once in a while, rainbows and ice halos can also make an appearance on the summit.

For many years, I have been paying attention to the views in the sky. As a professor of meteorology and physics at Plymouth State University, I relish the times when I get to teach about atmospheric optical effects in my courses. Friends, colleagues, and students know to send me pictures of their sightings or alert me to go outside to see anything from a beautiful rainbow to rare complex ice halo displays.

During the last few years, I have been writing a textbook about the science and history of atmospheric optics to be published by the American Geophysical Union, and as I have learned more and more about these topics, my increased appreciation has led to a significantly longer bucket list of effects that I want to observe.

The elusive circumhorizon arc (CHA), sometimes very colorful, sometimes offering perplexingly strange sights, is one of these effects that I have been hoping to spot in the last couple of years. Just like a simple 22° halo that many of us might have seen around the sun or the moon many times, the CHA is produced by small ice crystals suspended in the atmosphere (in clouds or just floating in the air) as they refract (bend) sunlight toward our eyes.




*The dark line on this photo indicates where a colorful but faint rainbow-like circumhorizon arc (CHA) appeared on July 16 above Mount Washington's summit.*

As its name suggests, the CHA parallels the horizon, and it is more than twice as far below the sun as the 22° halo would be, at approximately 45 to 50 degrees below. Additionally, the sun must be at least 58° above the horizon for the geometry – of the paths that the light rays take through the ice crystals and toward our eyes – to work out just right.

This means that for our New Hampshire

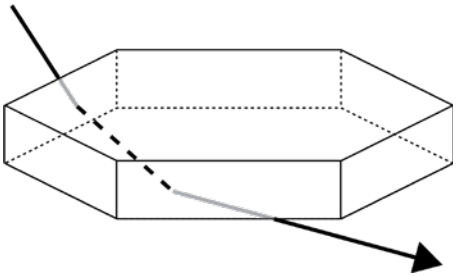
latitudes, the CHA can only be a summer treat. The ice crystals normally involved in its formation are flat hexagonal plates, with the light entering on one of the sides and coming out the bottom of the horizontally oriented crystals.

As we all know from middle school science, visible light is made of all colors of the spectrum, each of which refracts slightly differently when light moves from one to another transparent medium (in this case from air to ice and back out to air). This slight difference in the angle of refraction causes the white sunlight to separate into all the colors, which can be quite striking in a CHA.

The order is the same as in a rainbow, with red on top and violet at the bottom. The needed ice crystals are usually provided by thin and wispy cirrus clouds that can come in a variety of configurations. To see a full arc, plate-filled cirrus must be covering a large portion of the horizon under the sun. Patches and different cloud shapes can, on the other hand, cause the appearance of the CHA to vary significantly.

Sometimes, a small portion of the arc is visible as an otherwise unexplainable colorful patch in the sky, or it might take more interesting shapes (but always with the colors arranged in the same order). CHAs are sometimes called fire rainbows, since the cirrus wisps that provide the plate crystals might resemble a row of burning flames. Odd shapes like winged angels can also give the sight a divine appearance.

The Seek the Peak event this past July provided the awaited opportunity. My companion and I decided to head up to Mount Washington's summit before the festivities at the base started and enjoy a tour of the Observatory, during which we of course took the pleasure of climbing the steep red ladder up to the observation tower.



*Light goes into one of the short vertical sides and out of the bottom of the horizontally oriented, plate-like hexagonal crystals in order to form a circumhorizon arc*

Once there, we marveled at the beautiful sights like we have done many times in the past, and I took a couple of pictures of a 22° halo, on which I had been keeping an eye during our long drive from home.

Just as we were about to leave, there it was, a CHA! It was not one of those showy ones that immediately catches your eye; it was relatively faint but appropriately colorful, and more importantly, it was my first CHA since I knew exactly what I was observing.

The sky was hazy with a relatively thick patch of cirrus and the sun was very bright, so we were not staring in that direction while on the tower. The unexpected CHA sighting delayed our climb back down as I took as many pictures as I could before it faded even more. Back at home, I saw that some of the first 22° halo pictures I took on the tower had the CHA in them. The thing had been there the entire time and I had not noticed it until the very end, almost missing it.

*Lourdes B. Avilés became a Mount Washington Observatory trustee in June 2022.*

# *Observatory Builds New Wind Sensors for Frontier Science on Everest*

BY **CHARLIE BUTERBAUGH**

**SPECIFICATIONS:** Custom Pitot Static Tube Anemometer

**MASS:** 2.5kg

**SENSOR TYPE:** Omega 0-30 inches of water column wet/wet differential pressure transducer

**SENSOR OPERATING TEMPERATURE RANGE:** -45c to 121c

**ROUGH SENSOR ACCURACY:** 1% full scale at -17c to 85c, ~2% outside of calibrated range

**SPEED CAPABILITIES:** ~180 m/s - ~400mph dependent upon station pressure, temperature, and relative humidity. Lower bound of ~10 m/s.

**PRIMARY MATERIALS:** Custom stainless steel pitot tube assembly from Aeroprobe Corporation, anodized aluminum enclosure.

**Estimated wind direction angle for optimal readings +/- ~20 degrees**


*The expedition team constructs the weather station at Bishop Rock during the May 2022 expedition of Mount Everest, supported by National Geographic and Rolex through their Perpetual Planet Expeditions. Credit: Arbindra Khadka/National Geographic.*

In May, climate scientists and a cadre of highly specialized Sherpas ventured to Mount Everest to install new automated weather stations at the planet's outer edge. Their packs held tripods and a load of tech. In the mix were two lightweight wind sensors custom-designed by Mount Washington Observatory.

Expedition leaders Baker Perry and Tom Matthews share a fascination with places where weather dictates everything. This climb continued their quest to measure how snow and ice are responding to the behavior of upper-atmosphere winds, including the jet stream as it meets the Himalayas.

"We need reliable measurements of wind speed and direction," said Perry, a professor of geography at Appalachian State University and National Geographic Explorer. "With the combination of low relative humidity in winter and exceptionally high wind speeds, there is an enormous amount of snow and ice that sublimate directly into water vapor, into the atmosphere."

The glacierized area of High Mountain Asia holds vast quantities of snow and ice, and the Himalayas act as water towers to over a billion people downstream.

Conditions at such elevated terrain make climbing exceptionally difficult. Installing weather stations in sub-freezing temperatures adds another level of complexity.

Perry described it plainly: "Once you get above 23-24,000 feet, there's not a whole lot of fun, there is a lot of suffering."

With the windchill dipping below -40 °F, on May 9 the climbing team led by Tenzing Gyalzen Sherpa overcame the enormous physical and mental challenges of taking field work to such an extreme, successfully installing new sensors at South Col (elevation: 25,938 feet) and an entirely new station at the Bishop Rock (elevation: 28,904 feet), just below Everest's summit.

It wasn't their first time on Everest. Perry and Matthews co-led a previous Everest Expedition in 2019, installing stations in the Khumbu region and collecting samples of snow, ice, and soil from extreme elevations. Both projects were supported by National Geographic and Rolex through their Perpetual Planet Expeditions, a partnership harnessing scientific expertise and cutting-edge technology to reveal new insights about the impacts of climate change on the systems that are vital to life on Earth.

A key part of preparing for the 2019 and 2022 expeditions involved pretesting weather station equipment on Mount Washington, NH, against its reliably extreme weather. A subarctic environment on par with Antarctica and the polar regions, nowhere else in the contiguous United States is able to offer such readily accessible and consistently extreme conditions.

In January 2020, Perry and Matthews, a professor of environmental geography at King's College London and fellow National Geographic Explorer, presented on their first Everest Expedition at the American Meteorological Society's (AMS) annual meeting. Afterwards, they met with Observatory Director of Technology Keith Garrett about the operational challenges of the stations they installed in 2019, which at the time had just stopped transmitting data.

The conversation turned to the future of measuring wind in the Himalayas' high altitudes. They considered the feasibility of installing an Observatory-built pitot static tube anemometer on Everest.

Pitot anemometers, typically used as air-speed sensing instruments on aircraft, have been custom-developed by the Observatory for measuring wind on Mount Washington for decades. A commercial, off-the-shelf alternative that is robust enough to handle the summit's extreme cold and icing while producing accurate wind speed measurements does not exist.

According to Perry, "the Observatory probably has more experience than anybody around the world at measuring the weather in an extreme location, and in particular measuring the wind and developing innovative sensors and technology to maintain high-quality wind

observations."

*Baker Perry leads installation of a weather station in winter 2018 at 4,000 feet in elevation on Mount Washington, in preparation for the 2019 expedition to install multiple stations on Mount Everest.*

After the 2020 conversation at AMS, Garrett was uncertain. "Automated weather stations in extreme conditions are hard. Many of our stations (on Mount Washington) require multiple visits per year for repairs. We have the luxury of relatively easy access and normal oxygen levels in which to work on them," he said.

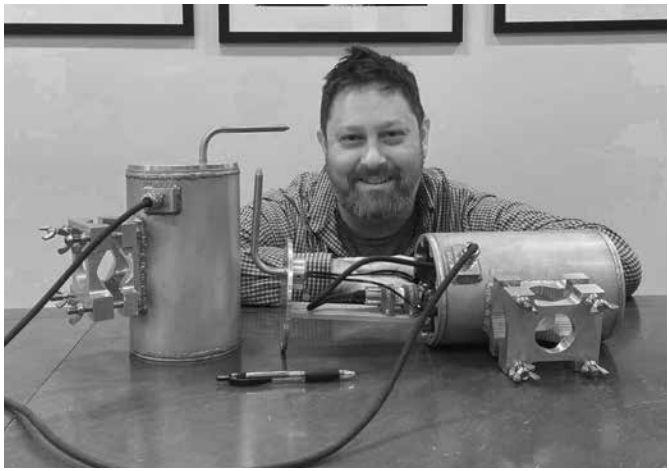
In addition to Mount Washington's summit, the Observatory manages the Mount Washington Regional Mesonet, 18 remote weather stations that measure temperature, relative humidity, and other variables.

At the Observatory's summit weather station, staffed and operated 24/7, 365 days a year, instrumentation requires hourly de-icing and maintenance in winter. More extreme events require deicing the pitot system as frequently as every 15 minutes to keep the data flowing.

By sharp contrast, the automated stations on Everest are at the complete mercy of the weather. Seven months after the Balcony station (elevation: 27,657 feet) was installed in 2019, nearly all of the sensors were destroyed and it went offline. Both wind sensors at the South Col (26,066 feet) were also destroyed about the same time, but not before logging a 150 mph wind gust with temperatures of -40 °F, leaving little doubt as to what happened at the Balcony. Remarkably, the remaining sensors and the station at the South Col survived two full years and even partial burial by monsoon snowfall.

Valuable data and insights had been collected, showing substantial loss of snow and ice even at extremely low temperatures.

"We have observational records from ice cores showing that the top of the core is nearly 2,000 years old, suggesting that the more recent ice may have ablated (been lost) relatively recently. The weather station data allowed us to hypothesize that this ice is missing because of melt and the increase in sublimation that has occurred as temperatures rise a little bit. And if the wind speed increases, that can raise the sublimation rate," Perry said. "There is a fascinating combination of extreme sunshine, wind, humidity, and temperature that we now know is making the highest elevation of the planet more susceptible to loss of snow and ice."



*Mount Washington Observatory Director of Technology Keith Garrett is shown in North Conway, NH with the two pitot static tube anemometers custom-built for installation in May 2022 on Mount Everest.*

In a May 2021 article in the *Bulletin of the American Meteorological Society,* first authors Perry and Matthews argue for the importance of measuring wind, relative humidity, and other variables in addition to temperature, since loss of snow and ice occurs on Everest "despite persistently below-freezing air temperatures."

To continue collecting data from the highest mountains in the world, which Perry calls "a critical yet under-monitored cog in the Earth's climate system," he and Matthews contacted the Observatory in June 2021 with their request for two custom-designed, portable, low-power, lightweight, durable pitot static tube anemometers – needed in a very limited amount of time.

They planned to install the sensors on Everest the following May during the pre-monsoon climbing season, on new weather stations that would also have satellite communication devices, air temperature and relative humidity sensors, solar panels, data loggers, and other equipment.

Garrett got to work. The next few months were spent discussing instrument needs and specifications, considering pros and cons of different aspects, and building a proof of concept. Decisions needed to be made in several important areas, including wind direction and instrument heating capabilities.

The Observatory uses a separate vane to track wind direction. A pitot anemometer with both wind speed and direction tracking would require 360-degree rotation while transmitting power and signal to and from the transducer, which converts pressure to speed data. That dual-function setup has been fraught with power issues and other complications in Mount Washington's full conditions.

Wind direction was removed from the Everest pitot design given the short time window to source design drawings and parts, the need to reduce instrument complexity, weight, and points of failure, and the team's primary goal to measure winds from the west. A separate wind vane on the new Everest station tripods would suffice.

Heating the instruments to mitigate icing would also mean additional equipment and weight in the expedition team's packs. Further, heating the instrument can lead to clogging. As the

heating mechanism melts rime ice, the liquid water refreezes almost immediately, often turning to solid ice inside the anemometer as experienced on Mount Washington. This creates a serious issue when no one is there to address it.

With no heat, the instruments are expected to freeze over during the monsoon months of June through September, potentially for long periods of time. Nonetheless, the team removed heating from the design with the expectation that the anemometers can survive icing and recover when the ice buildup sublimates.

During periods when the units freeze, the instruments can still provide useful data. Tracking the freeze, thaw, and operational cycles in conjunction with the other wind monitors, solar radiation, and temperature/relative humidity sensors on the stations can factor into the team's research.

The nature of this frontier science involves many unknowns. After installing the new weather stations on Everest, Perry and Matthews have no eyes on the instruments to know what's happening, and the time horizons for going back are long.

But the data being collected on Everest help fill big gaps in what is understood about the outer margins of the planet, where the land surface meets the upper atmosphere.

"Mountains totally perturb the atmosphere. What we think we understand, we don't necessarily. That's what we're learning from Everest," Perry said. "There are a lot more higher elevations around the planet where snow and ice are so important to sustaining communities downstream. Satellites do not necessarily capture what's going on."

According to Perry, if the Everest expeditions can improve understanding of the processes driving the change, and ultimately improve projections of water availability and climate trends, that's a real plus for planning climate adaptations and risk management.

Since completing the installations in May 2022, both the Bishop Rock and South Col stations have provided valuable data but have gone offline intermittently, presumably due to snow and rime ice buildup on the solar panels and/or satellite antennae (the South Col station was offline for nearly two months previously during the monsoon in 2020 but resumed transmissions in October).

As of this writing, the new pitot anemometer at the South Col is online and being tested with wind speeds in recent weeks nearing 100 mph. The team is cautiously optimistic that transmissions from Bishop Rock will stabilize as winds pick up and relative humidity drops.

With 90 years of experience measuring extreme weather, the Observatory specializes in instrumentation that can withstand the world's harshest weather conditions, with Mount Washington serving as an ideal testing ground.

"Mountains make their own weather," said Perry, who has climbed Mount Washington many times. "What happens at 6,000 feet in the free atmosphere is a lot different from what is happening on Mount Washington. That's why it's so important that we have the technology and tools to observe the weather in these places."

# *After Busy Summer of Tours, Winter Trips are Set to Relaunch*

BY **BRIAN FITZGERALD**

Summer is an abbreviated yet intensely busy period on the Rockpile, when travel by road, railway, and trail all offer access to New England's highest peak.

Visitors to Mount Washington State Park are able to enjoy the Sherman Adams Visitor Center, which houses the Observatory's weather station and *Extreme Mount Washington* summit museum. Summer 2022 saw many groups visit both Obs facilities, with a notable return of weather station tours for our members. Tours were paused at the pandemic's onset.

From May through October, over 120 groups registered for tours of the weather station, in addition to the 50 tours offered during Seek the Peak on July 16 and 17. For members both new and longstanding, the opportunity to visit the historic weather station was a big step toward a post-pandemic sense of "normalcy."

If you visited the summit museum this summer, chances are you saw some brand new faces and exhibits in the retail and exhibit spaces. Subtle, yet important, new exhibits in the museum include information about climate change in the White Mountains and a rotating slideshow of current Observatory research.

This summer saw a re-launch of the summit volunteer program with an emphasis on museum support. Our docent volunteer program ran May through October in conjunction with the operating schedule of the museum, with pairs of volunteers joining our weather station staff for full Wednesday-to-Wednesday shifts.

Volunteers welcomed visitors to the museum space, provided information and brief table-talks, and helped attendants at the retail register. Overall, 17 pairs of volunteers gave a week of their time and over 600 hours in support of the Observatory. We are so grateful for our awesome volunteers!

*Science in the Mountains* continued in earnest this past summer with great participation from viewers on Zoom, Facebook, and YouTube. Speakers from both the Observatory and outside the organization presented on topics such as the creation of the US National Climate Assessment, forecasting hurricanes, current Observatory research, and climate change in the Gulf of Maine.

Summer interns Naomi Lubkin and Henry Moskovitz presented recently launched research projects to an audience of over 200 live attendees. Lubkin's discussion of a new investigation of long-term wind and relative humidity records from the summit showed potential implication for icing events that impact tree line in the White Mountains. Near-surface lapse rates and the importance of understanding aspects like temperature changes along mountain slopes like Mount Washington, contrast with the free atmosphere, were covered by Moskovitz.

With a new school year in session, several new and returning programs have launched for students of all ages. For middle school students, the free Virtual Classroom series featuring topics in weather, climate, and climate change has returned with expanded ways for students to connect with Observatory scientists. More information is available at mountwashington.org/classroom.


*Director of Education Brian Fitzgerald gives a weather station tour during Seek the Peak weekend.*

The National Science Foundation-funded *WeatherX* curriculum development project is delivering more resources to the K-12 space, with finalized curriculum materials set to be released at no cost to educators. Particularly for middle school educators, these materials add innovative ways to teach data literacy skills to students through the exploration of extreme weather data from Mount Washington Observatory and NOAA weather stations near your own community. Stay tuned for our materials release!

With an eye toward winter, we look forward to the much-anticipated return of *Arctic Wednesdays*, a professional development program for teachers that, prior to the pandemic, saw nearly four-dozen teachers participate since 2017. Open to a limited number of groups through an application process, this program challenges K-12 teachers to find meaningful ways to integrate a Wednesday shift change trip to the summit weather station.

Since the program's inception, teachers from a variety of schools, grades, and backgrounds have conducted human health studies, tested student engineered instruments, and collected weather comparison data during trips to the summit. If you know a teacher who might benefit from such an experience, be sure to spread the word about the *Arctic Wednesdays* program.

Last but not least, the ever-popular *Overnight Edutrip* program is set to return in winter 2023. Program topics, instructors, dates, and pricing are available at mountwashington.org under Visit Us.

The *Overnight Edutrip* program includes a one-night stay and provides one of the best ways to truly get to know the summit of Mount Washington in winter, along with a first-hand look at the dedication and skill of Observatory staff who work hard throughout the year to support the mission to advance understanding of our weather and climate.

As always, if you have any comments, questions, or suggestions, feel free to reach our education team by emailing education@mountwashingon.org. Happy learning!

# *Spring/Summer 2022 Weather Data*

| | APRIL | MAY | JUNE | JULY |
|---|---|---|---|---|
| **Temperature (°F)** | | | | |
| Average | 23.2 | 40.4 | 43.4 | 50.0 |
| Departure | -0.5 | +4.1 | -2.1 | +0.1 |
| Maximum | 52 | 63 | 65 | 63 |
| Date(s) | 25th | 22nd | 26th | 17th, 23rd, 24th |
| Minimum | 5 | 20 | 26 | 37 |
| Date(s) | 29th | 18th | 19th | 9th |
| **Precipitation (inches)** | | | | |
| Monthly | 7.40 | 4.87 | 6.50 | 7.26 |
| Departure | +0.09 | -2.81 | -2.09 | -1.67 |
| 24-hour Maximum | 1.21 | 1.63 | 1.26 | 2.54 |
| Date(s) | 19th | 16th/17th | 9th/10th | 18th/19th |
| **Snowfall (inches)** | | | | |
| Monthly | 45.9 | 2.3 | 1.9 | 0.0 |
| Departure | +12.8 | -10.6 | +0.6 | ± 0.0 |
| 24-hour Maximum | 9.7 | 1.7 | 1.3 | 0.0 |
| Date(s) | 27th | 17th/18th | 18th | N/A |
| Season Total | 255.8 | 258.1 | 260.0 | 0.0 |
| Departure | -11.8 | -22.4 | -21.8 | ± 0.0 |
| **Wind (mph)** | | | | |
| Average | 39.7 | 28.1 | 29.6 | 32.7 |
| Departure | +4.1 | -1.5 | +2.8 | +7.2 |
| Peak Gust/Direction | 142 SE | 112 NW | 96 NW | 91 NW |
| Date(s) | 19th | 18th | 19th | 19th |
| Days 73+ | 20 | 6 | 7 | 9 |
| Days 100+ | 4 | 2 | 0 | 0 |
| **Other** | | | | |
| % Sunshine | 36 | 59 | 35 | 45 |
| Clear Days | 0 | 2 | 0 | 0 |
| Partly Cloudy Days | 3 | 5 | 4 | 6 |
| Cloudy Days | 27 | 24 | 26 | 25 |
| Days with Fog | 28 | 20 | 29 | 28 |
| Days with Rain | 10 | 16 | 19 | 16 |
| Days with Snow | 24 | 4 | 4 | 0 |

# *Snow and Cold Extend into Mid-Summer*

BY **RYAN KNAPP**

Winter conditions of snow, cold, and winds transitioned into the more typical summer pattern of rain, warm, and thunderstorms. While there was plenty of warmth in the mix, winter didn't fully want to release its grip as June saw late-season snowfall, and July started with several lows dipping into the 30s.

## April 2022

The month started with a wintry mix as low pressure passed. As high pressure briefly built overnight, winds climbed peaking at 125 mph on the 2nd. Upslope flow provided snow showers on the 2nd. Low pressure on the 3rd/4th provided additional snowfall. High pressure returned for the 5th/6th providing fair weather conditions and milder temperatures. An upper-level low passed overhead on the 7th providing a wintry mix of snow/sleet/freezing rain. The wintry mix lingered into the 8th as a coastal low moved north. Another low from the west on the 9th/10th delivered 8.3 inches of new snow with an additional 0.5 inches of snowfall falling on the 11th prior to tapering as high pressure briefly crested overhead. Low pressure on the 12th provided a wintry mix prior to high pressure returning late overnight. A warm front swung north and stalled along the international border on the 13th/14th providing a wintry mix that turned to rain and provided isolated thunderstorms. Low pressure tracked east along the front eventually dragging a cold front across the region late on the 14th and into the 15th transitioning precipitation back to light snowfall prior to tapering.

A broad area of low pressure lingered over the Canadian Maritimes providing continued snowfall for the 16th/17th which amounted to 7.9" of new snow. High pressure briefly crested on the 18th then a warm front swung north overnight and into the 19th. Precipitation started as snow but transitioned to rain during the day. As the low passed, winds boosted to 142 mph and cold air returned allowing for snow to return overnight. Snow tapered on the 20th as high pressure built back late. Fair conditions early on the 21st eroded to fog and snow/sleet as a warm front passed. A cold front on the 22nd provided additional snowfall then tapered as high pressure built for the 23rd. High pressure remained for the 24th/25th allowing for fair weather conditions and temperatures rising to 52F. A trough passed on the 26th dragging a cold front through resulting in light rain transitioning to light snow. A broad low strengthened as it moved into the Gulf of Maine on the 27th delivering 9.7 inches of snow. The low became qua-

si-stationary for the 28th then slowly exited on the 29th/30th, which resulted in light snowfall and stiff winds. High pressure built late on the 30th ending the month with improving conditions.

## May 2022

High pressure provided fair weather on the 1st followed by low pressure for the 2nd which provided a wintry mix that transitioned into rain by the 3rd. A weak trough continued light rain showers overnight and into the 4th with low pressure passing later that day providing additional rain that tapered to drizzle early on the 5th. High pressure then built over the region and remained overhead through the 13th providing fair weather conditions for the summits. As the ridge shifted offshore, temperatures rose and new daily record highs were set on the 12th, 13th, and 14th. A cut-off low late on the 13th eventually returned clouds and summit fog then rain and thunderstorms moved in on the 14th. Rain an drizzle continued on the 15th as a weak cold front passed.

Another low passed on the 16th providing thunderstorms and over an inch of rain. A cold front on the 17th transitioned precipitation back to snow with over an inch accumulating. A secondary cold front continued snow overnight and as the low departed, winds peaked at 112 mph. High pressure crested on the 18th then a trough moved in from the west on the 19th providing a wintry mix. Rain tapered early on the 20th then high pressure provided clearing until the 21st. A cold front on the 21st provided rain and thunderstorms. Another cold front on the 22nd provided rain showers and thunderstorms and a significant drop in temperatures going from 63F to 38F by midnight. Temperatures continued to drop on the 23rd but precipitation tapered prior to any snowfall. High pressure provided clearing on the 23rd then remained in place until the 25th providing fair weather skies with just a few periods of fog working in periodically. Low pressure returned on the 27th/28th providing thunderstorms and rain showers. High pressure returned on the 29th/30th then a weak cold front on the 31st provided fog, drizzle, and light rain showers.

## June 2022

A series of weak disturbances from the west provided fog, drizzle, and rain showers for the 1st/2nd. Low pressure on the 3rd/4th provided continued fog/rain prior to high pressure providing clearing late on the 4th. Additional showers lingered into the 5th prior to tapering and a clearing pattern setting up with high pressure for the 6th/7th. Low pressure provided rain late on the 7th and into the 8th. A weak ridge provided a quick break prior to another low on the 9th. An upper-level low over Hudson Bay rotated in a few additional weak disturbances for the 10th/11th. Low pressure passed with light rain showers on the 12th. An upper-level trough provided continued fog on the 13th and some added drizzle on the 14th. High pressure provided fair weather for the 15th.

A trough and associated cold front on the 16th/17th provided rain showers and thunderstorms. Cold air following the cold front provided a return of winter weather with high winds, freezing temperatures, and nearly 2 inches of snowfall for the 18th/19th. High

pressure returned on the 20th and remained through the 22nd providing improved summer-like weather which quickly melted off the snow/ice. A surface low on the 23rd/24th provided fog and light rain/drizzle. High pressure returned with fair weather conditions for the 25th/26th. A cold front provided drizzle/rain for the 27th/28th. Clearing from high pressure returned late on the 28th and early on the 29th. A cold front on the 29th returned fog and rain then high pressure cleared summits for the 30th.

## July 2022

A warm front passed early on the 1st followed by a cold front for late on the 1st into the 2nd providing thunderstorms and rain showers. High pressure built behind the front for the 3rd/4th. Low pressure from the west on the 5th provided light rainfall. A cold front on the 6th provided additional rain and cooler temperatures. High pressure returned on the 7th but low-level moisture resulted in clouds/fog that lingered into the 8th. The 9th saw fair weather conditions return which would then linger through the 11th. A low from the west on the 12th provided thunderstorms and rain then rain/drizzle lingered into the 13th/14th as the low exited. High pressure provided clearing late on the 14th then fair weather conditions lingered through the 17th.

Low pressure tracked up the St Lawrence River on the 18th/19th providing 2.78" of rainfall. High pressure crested on the 20th but fog and high winds lingered. A cold front on the 21st provided thunderstorms and rain showers. Surface high pressure built on the 22nd through the 24th providing warm summer weather but a lingering upper level trough provided variable amounts of fog/clouds along with isolated showers and thunderstorms. A cold front on the 25th provided thunderstorms and steadier rainfall which tapered early on the 26th as high pressure built back in. High pressure provided fair weather on the 27th. The 28th saw a warm front pass with light rain followed by a cold front on the 29th which provided isolated thunderstorms and rain showers. A trailing trough provided fog on the 30th but high pressure on the 31st ended the month with fair weather skies and summer warmth.

*This photo by Weather Observer & Meteorologist Ryan Knapp shows the moon over the Franconia Ridge in August.*

COMPILED BY **SAM ROBINSON**

## 12:03 p.m., Tues., April 12

"A Look Back at Measuring the Extreme Winds on Mount Washington." Beginning back in the late 1800s, the Blue Hill Observatory originally loaned some cup anemometers to Mount Washington Observatory beginning a record of wind speeds. However, these anemometers were non-heated, preventing a continuous record in the wintertime icing conditions. Attempts to overcome extreme icing to record wind continuously led to the development of a heated anemometer, aptly named the Heated No. 1. Implemented on Nov. 9, 1932, Heated No. 1 was able to take measurements when winds were between 11-120 mph in icing conditions. After it went up, efforts to improve Heated No. 1 resulted in the Heated No. 2 becoming an operational instrument. Heated No. 2 became the main instrument on the summit in 1933 and is most famous for recording The Big Wind of 231 mph on April 12, 1934, which still stands as the fastest surface wind speed ever observed by a human. Measured in extremely challenging icing conditions, the measurement was extensively verified, setting the standard of data quality for weather observers throughout our history. The Heated No. 2 is currently on display in the Extreme Mount Washington museum on the summit.

**— Adam Muhith, Summit Intern**

## 8:24 a.m., Tues., May 10

"Spring Weather Means it's Time to Fly (or Hike)!" As winter starts to lose its tight grip on the higher summits this spring, the Home of the World's Worst Weather has begun to show a bit of forgiveness. Overall, winds have relaxed a bit, temperatures have become less bone-chilling, and the snow and ice are beginning to disappear. This seasonal improvement in weather tends to lead to increased recreational activity around the mountains but also more favorable conditions for aviation activities. Over the past few weeks, we have witnessed multiple training exercises from both American and Canadian search and rescue helicopters due to the unique terrain of the White Mountains and the availability of the helicopter land-

*A Royal Canadian Airforce's large, bright yellow "Cormorant" was in our region in April for training.*

ing pad located just off the summit cone... One of the more notable helicopter landings I've experienced so far this year has been the Royal Canadian Airforce, specifically the 413 Transport and Rescue Squadron from Nova Scotia. This is the first time I have seen them in our area, as they normally stay in, well, Canada! The White Mountains provide a great environment for the squadron to train due to similarities with the terrain they service in Canada and relatively nearby airports (and heli-pads). This simplifies training exercise coordination, makes it easier for the helicopter to stay fueled up, and provides rest time for the crew when needed. The large, bright yellow "Cormorant" was in our region this past week for training, a first since 2019 due to the pandemic according reporting by the "Conway Daily Sun."

**— Sam Robinson, Weather Observer & Engineer**

## 6:55 p.m., Tues., May 17

"Research to Look at Near-Surface Lapse Rates: the Amount of Temperature Change with Elevation." We recently completed a technical overview of the Mount Washington Regional Mesonet (MWRM) for submission to a scientific journal. The paper coalesces the history, metadata, instrumentation, functions, and uses of the MWRM, our network of remote weather stations at varying elevations. The overview, which explains the value of a mesonet in the White Mountains along with the unique challenges presented by the terrain and harsh weather, is beneficial not only for our work but for other organizations that operate a series of automated weather stations in close enough proximity to measure, record, track, and communicate mesoscale meteorological phenomena. By mesoscale, I am referring to an area larger than microscale, like a town or city's environment, but smaller than synoptic scale, a large country or continent. Mesoscale, typically between tens of kilometers to several hundreds of kilometers, essentially refers to an area large enough to encapsulate storm-scale systems, like cyclones, extra-tropical cyclones, frontal systems, and squall lines. Organizing all of this information will make it much easier for our weather observers and the scientific community to access this information as well as assist other mesonet system administrators to overcome some of their own unique challenges, establish a new mesonet, add further stations to one in existence, or maybe spark some new ideas and technology solutions. As we move into the summer, our intern program is back in full force and focused on research and weather operations. One of the research projects that will occur throughout 2022 and bring us into 2023 is the establishment of near-surface lapse rates on the windward and leeward flanks of Mount Washington. Intern Henry Moskovitz will be starting this project with a literature review, initial collection of data, and establishment of methods of analysis. He will be fortunate to get a first look at the summer seasonal lapse rates and see how they compare to what is generally known. The project will make use of our MWRM, provide undergraduate research experience, produce research that will add to the scientific community, improve our forecasting toolkit to better prepare the recreational

*Rain showers approach from the northwest on June 11. Since temperature is so fundamental to forecasting precipitation and other weather conditions, we are very interested in understanding more about Near-Surface Lapse Rates and the distribution of temperature across mountains.*

and business community, and improve our understanding of climate change and its effects on the alpine zone.

**— Jay Broccolo, Weather Observer & Meteorologist**
*(now Director of Weather Operations)*

## 1:43 p.m., Mon., Jun 20

"From the High Arctic to Mount Washington's Alpine Tundra." Transitioning from working in the high Arctic to the top of Mount Washington has had its fair share of similarities... During both my undergrad and graduate degree programs, I was able to live and work in the Arctic, and I have noticed some stark similarities between living on the top of Mount Washington and the top of the world. The lack of trees and other tall vegetation here in the high alpine regions of the White Mountains reminds me of the Arctic tundra. While the weather can change just as fast at 70+ degrees north, the winds generally are not as high on a daily basis. Additionally, much like in the Arctic, on the summit when you get nice weather and sunny skies, you take advantage of them

because they are few and far between. My first shift on the summit was a treat because we had several nice days allowing for an evening hike after dinner... The highlights of the evening include sitting down for a family-style dinner and hearing about each person's day before taking time to study the METAR booklet or challenging the NH State Parks staff to a round of Mario Kart.

**— Hayden Pearson, Weather Observer & Research Specialist**

## 5:27 p.m., Mon., June 27

"Saying Farewell to the 'Home of the World's Worst Weather'." In January 2021, I started an incredible adventure here at Mount Washington Observatory as an intern, followed by joining our summit staff that following March as a weather observer and education specialist. Over my time here, I have grown in many ways and have found a home on the summit. I'm so fortunate for my experiences and the amazing people who make up the summit — my fellow observers who are truly incredible individuals, the fabulous volunteers, our enthusiastic interns, the awesome NH State Parks crew, and the Observatory's dedicated staff down in the valley. Thank you all for making my time here truly something special. I will miss the extreme weather, the challenges and the learning experiences of this unique place, but I will miss the people most! I can't wait to see what the future holds for all of you incredible people. Until next time! With all my heart,

**— Jackie Bellefontaine, Weather Observer & Education Specialist**

## 12:34 p.m., Tues., July 26

"Dear Self, Mount Washington has A Lot to Teach You." I just started working at the Observatory at the beginning of June, as the night observer, so I had not seen snow on Mount Washington yet. Temperatures dropped well below freezing and winds were gusting over 90 mph by the time the night shift started on June 19. With sub-zero temperatures and high wind speeds, it is critical that observers wear the right gear to go outside. I needed to make sure I wore several warm layers, a waterproof jacket, winter hiking boots, gloves, and ski goggles when I went outside that night to make weather observations... Choosing a heavy mallet as my weapon of choice to break up the rime ice forming on the weather instruments, I remember that sound of the wind that struck me first as I stepped onto the observation tower. The winds were so ferocious that it sounded like a freight train outside. It was exhilarating just using brute force to break up the rime ice, but I learned quickly to be cautious of where and how I stood while de-icing. If I was not careful, one smack of the mallet and the hurricane-force winds could send large chunks of rime ice flying into the air right back at me.

**— Alexis George, Weather Observer & Meteorologist**

# *The Conditions that Create Rime Ice*

BY **HAYDEN PEARSON**

As winter weather becomes more prevalent in the White Mountains, we begin paying closer attention to events that could cause icing on Mount Washington's summit. Such events require taking down the unheated RM Young anemometer and continuous deicing with rubber mallets, among other measures to protect instruments. While visually stunning, the beautiful white ice known as rime can damage wind sensors and other instruments, which is why our weather observers monitor icing events closely.

How and why does this ice form on the summit?

There are two types of rime ice. The speed of the wind determines what type is formed. Soft rime is not as thick and appears very fragile or sugary. This usually forms during calm winds and can be confused with hoar frost. Unlike rime ice, hoar frost is formed when

*Hard rime ice, with a beautiful feather-like appearance, accumulates in September on the summit observation deck visitor binoculars.*

moisture in the air skips becoming a droplet and directly crystalizes.

*Early development of hard rime ice forming on the instrument tower in June.*

Hard rime ice is what is most commonly associated with the summit and is often very dense. Hard rime occurs in high wind speeds and gains its milky white appearance from air that becomes trapped in the ice when it forms. Both forms of rime ice are semi-porous and, due to the crystalline structure, brittle. While rime ice doesn't just form at high elevations, it does need specific conditions to occur.

Excess moisture suspended in the atmosphere, usually in the form of fog, and temperatures below freezing to allow super-cooling of the suspended water droplets, are the most common conditions needed for rime ice to form, allowing the individual water molecules to initiate crystal formation once they come into contact with an object.

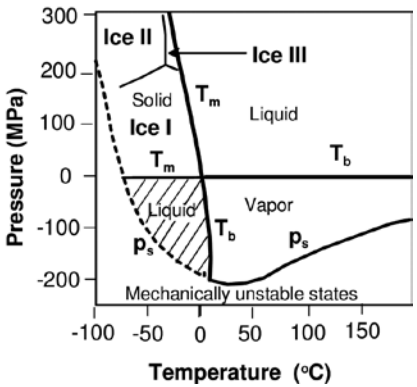
Since the summit of Mount Washington is in the fog 60% of the year, there is no dearth of suspended water.

What does it mean for suspended water particles to become super-cooled? While the freezing point of water is typically 32 °F or 0 °C, liquid water can exist well below these temperatures given the right conditions. Changing the pressure surrounding a liquid can alter the boiling and freezing points. This is what happens when using a backpacking stove to boil water at elevation compared to at sea level. It will take longer to cook the food at elevation because the decrease in atmospheric pressure has actually lowered the water boiling point.

Decreasing atmospheric pressure also decreases the freezing point of water. Liquid water in clouds has been found to be as cold as -40 °F (-40 °C), while lab settings have found water to remain in liquid form as low as -55 °F (-48 °C), below which point no liquid water was able to be detected (Moore et al 2011).

In order for ice crystals to form, there

needs to be some sort of surface or movement that creates ice nuclei. This is essentially the stable foundation that enables the ice crystal to grow.




*The phase diagram of super-cooled and superheated bulk water at negative pressures. T b represents the boiling curve, T m the freezing curve, and P s is the limit of stability. Pressure at sea level is equal to 0.1 MPa.*

When the wind blows the super-cooled water droplets into our instruments on the observation tower, a trail sign, exposed rock, or any other physical surface that is at or below freezing, this allows the ice crystals to nucleate, crystallizing upon impact. For this reason, rime forms in the direction of the wind, and over time can form into the picturesque columns that we frequently see in the winter.

*References*

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# *Striving to Build on Our Predecessors' Accomplishments*

BY **JAY BROCCOLO**

The past three years have been quite the doozy and full of transition. The summer has passed and the summit is readying for winter. Every year, twice a year, during autumn and spring, I am reminded of how life continues, regardless of what is happening around us.

This year, during autumn, the leaves seem to be changing color earlier than normal, possibly because of the recent dry conditions. Nonetheless, the trees are also prepping for winter regardless of what summer conditions brought. The reason I discuss the trees and falling leaves is because they represent change, which can be hard. But it is necessary and sets us up for the future.

*Director of Weather Operations Jay Broccolo, standing, works on a monthly data quality check with Weather Observer & Research Specialist Hayden Pearson.*

As I transition from Weather Observer to Director of Weather Operations, I think of all the experiences, change, and effort that came before me. I am fortunate to have worked with and been led by many, on and off the summit. Before I mention a few individuals and teams that prepared me for this new position, I want to share some "summit happenings" from the summer season.

First off, the COVID era of the Observatory is coming to end. This means a number of returns for the summit; arguably our favorite one is the return of summit volunteers. I almost forgot what it was like to have their valuable support! For most of the observers, volunteers are an entirely new feature of life on the summit. This past summer saw many new faces, which we hope to see again and become part of the crew.

We also look forward to the return of our winter volunteers. Our volunteer program is a true staple of the Observatory, with many returning to the summit throughout decades. From my own experience, our returning winter volunteers are part of the Obs family. I have often learned from their life experiences, and I consider many of

them life coaches.

I am excited for our newer observers (Alexandra Branton, Alexis George, Hayden Pearson, and Francis Tarasiewicz) to experience the wisdom that our volunteer family has to offer.

The summit museum and weather station tours were back in full swing over the summer, and this year is the first in a long time that we have had docents collaborating with museum attendees, helping to educate the public about our work in addition to their tasks of meal prep, housekeeping, and of course enjoying the mountain. This has also opened up the ability for our interns to focus more on science and research.

We've continued upgrading the summit computers to excel in handling the graphical outputs that we use to forecast, conduct research, and educate the public. The weather wall, where we have several instrument readings and outreach equipment displayed, had some new monitors added with newer tech. We can now display our real-time wind and temperature data flow while watching the radar and satellite stream, without having to continuously swap between screens.

We've also had the inside of the weather tower repainted. Greg Fitch, our facilities guru, has put in a lot of work on the summit, catching up on maintenance tasks and teaming with myself, Director of Technology Keith Garrett, and the observers to go through the summit and clear out our older tech.

We've made significant progress and opened up some of the spaces for better and more efficient use, which brings me to my final point, my goals as Director of Weather Operations.

My plan is to build comradery while increasing cohesion between summit, research, and mesonet operations. There is a great deal of overlap between these three Observatory functions, and my goal is to tap into the overlap to streamline tasks and projects.

As a weather observer myself for almost four years, I was fortunate to have Rebecca Scholand as our Summit Operations Director. Scholand put in much of the work that led to the formation of this new role and my stepping into it. I learned a great deal from her, and I strive to build on her success. Her tenure brought a renewed sense of teamwork to the summit, and her decision to leave was acutely felt.

Before I started my new role, Director of Education Brian Fitzgerald took the reins and wore two hats (really three or four). His dedication is inspiring, and he has been extremely helpful in my transition.

I would also like to share my profound appreciation for our former Interim Executive Director Donna Dunn. Her determination and skillset not only got us through COVID, but brought us out on the other side standing taller. Her efforts prepared us and set us up for a new season of the Observatory, and it is certainly looking very bright.

Lastly, all the past and current observers I have had the pleasure of working with have brought different skill sets to the summit team. I have learned a great deal from them all and continue to do so today. My goal is to be a coach and a leader to the observers while leveraging my own background, skillset, and interpersonal skills to build upon all the previous accomplishments that came before me.

# *Gaining Insights on Relationships Between Weather and Mountains*

BY **JAY BROCCOLO**

Research at the Observatory is taking shape and growing. A lot is happening to set the stage for collaborations that can propel us into the future.

Summit interns Henry Moskovitz and Naomi Lubkin (working in collaboration with Appalachian Mountain Club intern Larz von Huene) shared the results of their summer research projects during the August edition of *Science in the Mountains*.

Moskovitz's investigation delved into near-surface lapse rates (NSLR) on Mount Washington, or the rate of temperature change along sloping terrain. Global averages have been established for lapse rates in the free atmosphere. However, these are often not representative of NSLR and can introduce forecasting errors, especially in regions with complex terrain.

Since temperature is so fundamental to forecasting precipitation and other weather conditions, we are very interested in understanding more about the distribution of temperature across mountains.

Our Fall intern Jackson Hawkins has undertaken the data analysis and methods portion of this project and is finding initial differences in seasonal NSLRs, with the spring season appearing to have the steepest rates. Conceptually, a steeper lapse rate during meteorological spring (March, April and May) makes sense. March and April tend to be the windiest months of the year. More is to come with further statistical results during winter, and we look forward to presenting initial results at the American Meteorological Society's 2023 Annual Meeting in Denver.

Lubkin and von Huene's research asked this question: What are the long-term wind speed and moisture trends on Mount Washington, and how are they affecting tree line, the boundary between the Boreal forests and alpine zone?

High wind speeds, freezing fog, and other conditions work together to cause limb damage and prevent growth on trees, resulting in an environment that is predominantly populated by small alpine vegetation. Lubkin and von Huene hypothesize that wind speeds will continue to decline slightly, relative humidity will continue to remain mostly unchanged, and as a result, damaging winds will, if anything, slightly decrease. If this is true, they expect an upwards shift in the tree line due to a decrease in damaging events.

Lubkin and van Huene established "event" parameters to analyze the event distribution through the years. Events were categorized into three wind speed thresholds consisting of 25, 60, and 100

*Observatory summer intern Naomi Lubkin, left, and Appalachian Mountain Club intern Larz von Huene researched wind speed and moisture on Mount Washington to better understand how long-term trends are affecting tree line, the boundary between the Boreal forests and alpine zone.*

mph while in the fog and below freezing. They then analyzed the number of events through the dataset, which they had to homogenize due to the different locations of measurement points, to see if the frequency of events is changing or not. We will investigate this further to see if there is any statistical significance.

The Observatory is also working with the Northeast Alpine Summits Monitoring Group, which includes the University of Vermont's Mt. Mansfield Science and Stewardship Center, Sleepers River Watershed (USGS), the Atmospheric Sciences Research Center at Whiteface Mountain Field Station (SUNY Albany), and our organization.

Our goal is to establish a regional network of monitoring sites and congregate resources and skills to better depict the environment in the Northeast. Essentially, the project involves pulling together each organization's mesonet systems, including our network of 18 remote stations in and around the White Mountains that continuously collect weather data (the Mount Washington Regional Mesonet), and discovering how we can grow and improve our monitoring networks while enhancing communication of the data to the general public.

The Observatory is also expanding research capabilities by forming new relationships with key scientific organizations, which will provide better access to national funding, support our in-house data management, make our data set 'shovel ready' for research, and improve on our own ability to display our mesonet data.

These are just a few of the exciting projects coming to fruition. There are certainly more in the works.

# *A Western Flank for the Mount Washington Regional Mesonet*

BY **KEITH GARRETT**

Over the last few years, the Observatory's mesonet stations at the base of the Mount Washington Cog Railway and at the railway's Halfway House (elev. 4,500 feet) were removed or disabled. Our station at the base needed to be removed due to the construction of the railway's new maintenance and assembly facility, which was built on top of where the station used to sit.

Due to radio failures and upgrades across other mesonet stations, as well as equipment failures, our ability to acquire data from the 4,500 station was lost. The aim is to resolve both of these issues.

A recent visit to the 4,500 station showed that it was in extremely poor shape. The solar charge controller had crashed, and while the station was getting plenty of sunlight, the batteries had lost all charge.

Each battery was at about 6.3 volts out of 12. Due to the age of the batteries, as well as over-discharging them, likely all of the six batteries will need to be replaced. Currently, these batteries cost around $900 each.

Another issue discovered during this visit relates to power regulation. While the solar array/battery bank operated at 24vdc, only the communications radio required that voltage, and a step-down transformer was used for 12vdc output for the rest of the equipment and sensors. The voltage input side of the transformer was just 24vdc. During full sun, the array puts off 36vdc, and these higher voltages were fed to the equipment if the charge controller detected no load.

*The Mount Washington Cog Railway's Half-Way House.*

During the site visit, with the datalogger powered up, but no radio, the charge controller was not detecting enough of a current draw to switch from 36vdc output to 24vdc. We think this voltage change was responsible for destroying the 24v communications radio previously installed at the station.

New power regulators have been received. These new regulators take 9-36vdc input, and output both 12vdc for the data acquisition system and sen-

*The railway's base station is shown from a distance.*

sors, as well as 24vdc for the replacement radio. The next site visit will involve installing these as well as testing the new communications link to Bretton Woods.

Batteries were left in a charging state, with no load attached, and hopefully a few of them can be salvaged.

A new mesonet station for the railway base is also under construction. Areas on or near the base station were not considered for siting reasons. Roof pitches accelerate winds, black shingles bias temperatures, and many areas do not have 360-degree exposure.

A three-meter tripod station will be installed next to Peppersass Pond, located roughly central to the base area. The location offers views of Bretton Woods, required for radio communications, and is open to direct sunlight. A low shrub-line exists about 50 meters to the west, which can be cleaned up. Air temperature and relative humidity readings will be taken at two meters, with wind speed at three meters, consistent with most stations.

This station will also be solar-powered and communicate with the Observatory as power is sufficient. We are hoping to add a suite of other sensors to the railway base and 4500 stations, including station pressure and particulate/$CO_2$ sensors, ground temperature, and soil moisture, but only after testing operations for the winter. An atmospheric lidar would be a great addition if funding can be raised.

Future plans under consideration include expanding our mesonet to complete a vertical profile on the western side of Mount Washington. This would give our scientists a powerful data set for determining effects of air mass movements across the White Mountains. We are still in the planning phase, determining locations, exposure, power budgets, sensors, and costs.

As we plan and install the railway base and 4,500 stations, and anticipate others on Mount Washington's western flank, we must ask ourselves, what will scientists 30 years from now want and need from the data to improve their understanding of how mountains influence weather?

# *Volunteers Deliver Critical Support for Seek the Peak*

BY **LINDA AND HANK DRESCH**

Meteorological winter is here. As we look back at summer, the Seek the Peak fundraiser was a success thanks to Stephanie Fitzgerald and Carrie Slife's careful planning. Even the weather cooperated with a warm, slightly overcast, but pleasant day.

The help of our Valley Volunteers plus many others was greatly appreciated! We were also pleased to have many Observatory trustees lending a hand.

August's membership mailing was the largest for the year as it included thank you letters to everyone who supported Seek the Peak. Over 1,500 letters were assembled that day, with only four of our volunteers available. Fortunately, our nonagenarian Bill Housum was there, as usual, unfazed by the task.

These mailings take place at 9:00 a.m. on the second Thursday of every month, and we are always pleased to have folks join us.

The gardens around the Observatory's North Conway offices had a spectacular start this year, thanks almost exclusively to Barbara Althen and Bill Ofsinay's dedication and expertise. However, a major setback occurred in July when Barbara needed surgery followed by an extended recuperation period to address a past leg fracture.

*Valley Volunteers helping staff prepare for the 22nd annual Seek the Peak (and sporting their favorite Seek the Peak T-shirts), include Marie Kaspar, kneeling at left, Linda Dresch, Joan Kurtz, Hank Dresch, standing at left, Kim Henry, Jean Sweeny, Linda Denis, Sandy Kurtz, Bill Ofsiany, Barbara Althen, Karen Franke, Bill Housum, and Gary MacDonald.*

A core group of our volunteers assumed responsibility for the majority of the grunt work. We now anxiously await Barbara and Bill's return. The volunteer gardeners who filled the gap include Karen MacDonald, Donna Gray, Linda Denis, Peter Crane, and Linda & Hank Dresch.

We offer our very sincere thanks to the dedicated volunteers who have been able to help us over this past period.

These folks include:

| | |
|---|---|
| Barbara Althen | Ava Honan |
| Kathy & Ed Boyle | Bill Housum |
| Floyd Corson | Marie Kaspar |
| Peter Crane | Joan & Sandy Kurtz |
| Linda Denis | Judy Meagher |
| Linda & Hank Dresch | Bill Ofsiany |
| Peter Fisk | Jean Perry |
| Karen Franke | Jane & Ken Rancourt |
| Kim Henry | Jean Sweeney |

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*...Thank you*

## MEMBERSHIP MILESTONES

# *Celebrating 50 Years of Membership*

*Guy Gosselin*

Guy Gosselin of Berlin, NH joined Mount Washington Observatory's staff in January 1961, became chief observer not long after his start at the weather station, and was appointed director of the Observatory in 1971. While he's been a part of the organization's community for longer than 50 years, his official membership began in 1971, and we thought this was an appropriate time to celebrate his anniversary.

In addition to leading Observatory staff, Gosselin helped build educational programming with development of the first summit museum and EduTrips, and he was editor of the *News Bulletin* in the late 1980s and early '90s.

We cannot thank him enough for well over 50 years of service, support, knowledge, and insight.

# *Memorial Gifts in Memory of Samuel Ethan Gawel*

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Callie Pecunies as part of the WMS Alumni Group
Dartmouth Club of Detroit; Richard Paul
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Brian & Heather Morse ..... In Memory of Aurelie Druckenmiller
John Humphreys ..... In Memory of Charlie Humphreys
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John Schiffman ..... In Honor of Jack Middleton
Beverly Buettgens ..... In Honor of George Albion Moberger
Denise Kresco ..... In Honor of George Albion Moberger

## GREEN FLASH

# *Mama Bear above Tree Line*

*A mother Black Bear traverses the south side of Mount Washington at sunset on Aug. 29, heading towards the mountain's eastern slope with her two cubs (not visible in image). A video posted on our Facebook page shows the bears moving with ease over the boulders.*

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