ITHACATION

Cornell Chapter of the American Meteorological Society

Volume 25, Issue 1

Fall 2024

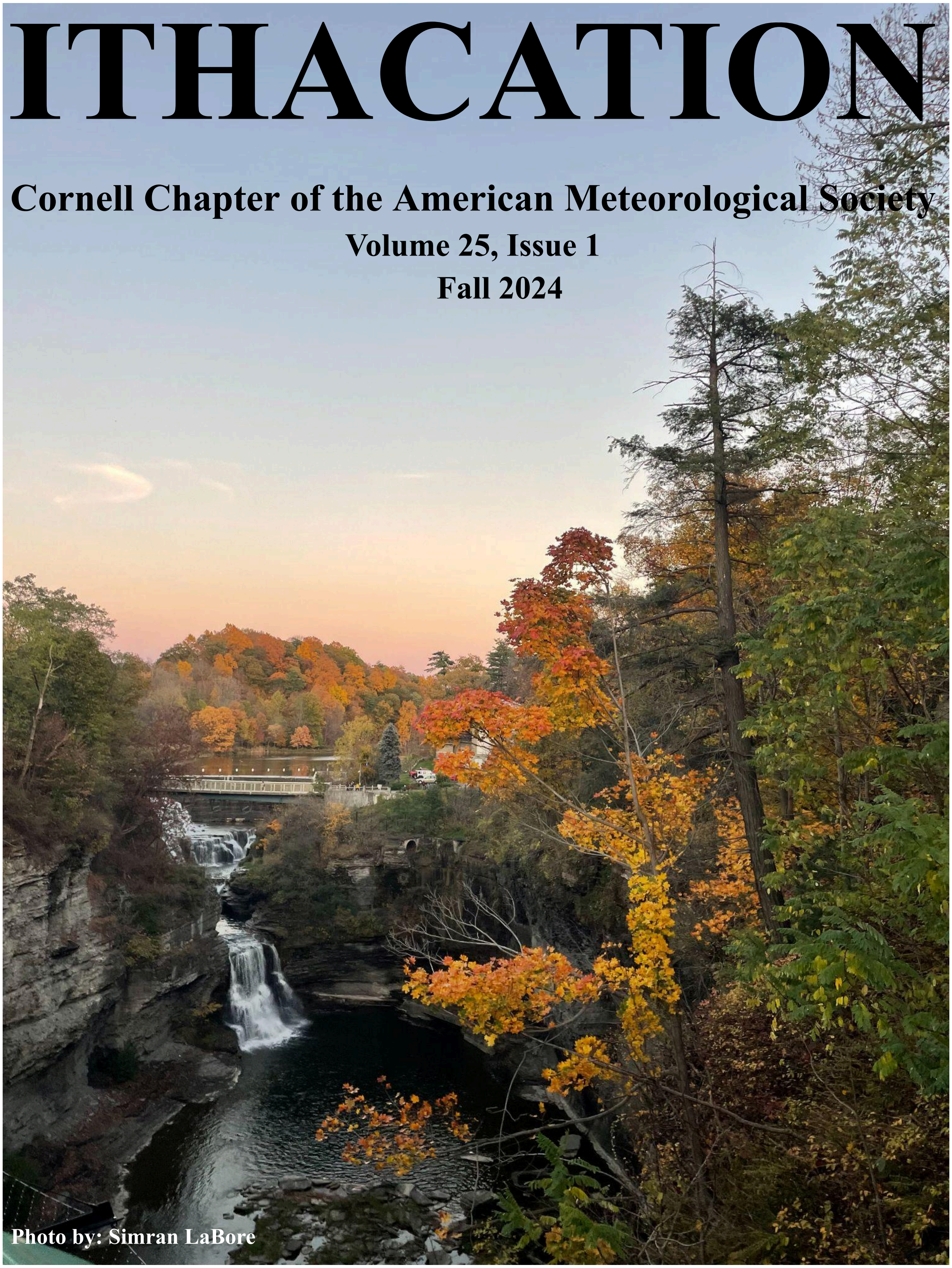


Photo by: Simran LaBore

From the Editor

It is my pleasure to introduce the latest edition of *Ithacation*, where members of the Cornell Chapter of the American Meteorological Society (CCAMS) share their insights and enthusiasm for the wonders of the field of Earth and Atmospheric Sciences.

This issue brings to light a variety of pressing topics and captivating stories, starting with Simran LaBore's deep dive into the fascinating electric skies of Catatumbo, an awe-inspiring phenomenon in Venezuela that turns night into day. Following closely is Jayden Vogler's thoughtful exploration of the flooding impacts of Hurricane Helene, emphasizing how this event could serve as a cautionary tale for Appalachia amidst growing concerns about climate change and infrastructure preparedness. Max Masleyev reflects on his summer internship experience, shedding light on the professional growth and learning opportunities available in atmospheric science.

Meanwhile, Packie Young and Jack Halberstadt recount their storm-chasing adventure in pursuit of the Greenfield Tornado of May 21, 2024, bringing readers into the heart of a truly thrilling experience. Rounding out this edition, Shawn Wallace takes us on a journey to witness the Northern Lights, adding a touch of wonder to our skies both near and far.

Whether you're a seasoned weather enthusiast or simply curious about the forces that shape our environment, this edition of *Ithacation* promises to engage, inform, and inspire. I am thrilled to bring these stories and studies to you, showcasing the hard work, passion, and creativity of Cornell's budding professionals. Enjoy!

Sincerely,
Lucy Alcoba [Editor-In-Chief]

In This Issue

Where Night is as Bright as Day: The Wonders of Catatumbo's Electric Sky

Simran LaBore '27

At the confluence of the Catatumbo River and Lake Maracaibo in northwestern Venezuela, a dramatic natural phenomenon unfolds—remarkably, it's not a rare spectacle. Catatumbo Lightning, "River of Fire," or "Relámpago del Catatumbo" as it is known by locals, is a seemingly never-ending lightning storm that occurs in the same region for approximately 300 nights out of the year, striking at an average of 28 bolts per minute for up to nine hours continuously. Evidence of this weather sensation dates back thousands of years, with a myriad of written and recorded accounts from sailors who used the lightning as a beacon. One story notes that in 1595, the storm's relentless flashes spoiled Sir Francis' Drake attack on the city of Maracaibo.

Today, the stormy region sustains nearly 20,000 fishermen, many of whom live in small, tin-roofed "palafitos," or overwater bungalows. Their livelihoods depend on the rich fish population, which is said to "bite best at dusk," during the Catatumbo Lightning. These residents succumb to lightning strikes 3 to 4 times more than the yearly averages recorded in the United States, and substantial research has and continues to be conducted to advance lightning detection and prediction in the area in order to minimize injury and death.. Lake Maracaibo is also recognized as one of the oldest lakes on Earth, and its rich geological history has made it one of the largest fossil fuel reserves in the world. Fueling stations in the middle of the lake, about a two-hour journey from the palafitos, force fishermen to venture into dangerous lightning storms to refuel their boats.

The reasoning behind the confounding lightning storms no longer remains a mystery; they are the product of a near perfect interplay of topography and wind patterns. The general formula for thunderstorms involves the key ingredients of unstable air and moisture. The latter is addressed by an endless supply of warm water provided by the inflowing Caribbean Sea, coupled with the tropical sun that extracts additional moisture from the lake. Mountain ridges encircle three sides of Lake Maracaibo, creating a narrow opening to the north that leads to the Gulf of Venezuela. At sunset, strong winds carry the warm air up the mountains to form cumulonimbus clouds. When water droplets of the warm humid air collide with ice crystals from the cold mountainous air, static charges build up, and it is the release of this buildup that generates the intense lightning storms.

But what makes Catatumbo Lightning so consistent? In 2015, a team of NOAA Researchers released dozens of weather balloons over the region. They discovered that just below the surface, at heights of no more than 1 kilometer (0.62 miles), a swift ribbon of air known as **the Maracaibo Basin Nocturnal Low-Level Jet** carries moisture from the Caribbean

Sea and Lake Maracaibo to the southern basin, where it interacts with the mountains. It is a North-South wind pattern created by the temperature differences between the basin and the sea. More specifically, it was the combination of Convective Available Potential Energy (CAPE) with the Jet that accounted for the phenomenon. “When winds transport this moisture toward the mountains, there’s nowhere for it to go except to rise rapidly,” said Ángel G. Muñoz, a physicist and researcher at the National Oceanic and Atmospheric Administration (NOAA). “The winds are key.”

The seasonal predictability of Catatumbo Lightning is backed by global-scale drivers such as El Ninõ, which provides insight into the extent of dryness for any given year. The storms are most active in the wetter months of September and October, and least active in the dry months of January and February. Therefore in El Niño years, the time and regional-extent of the lightning is greatly diminished, and in 2010, El Niño triggered a severe drought that forced the storm to pause for six weeks. Joaquín Díaz-Lobatón, a physicist and researcher at the Centro de Modelado Científico at Universidad del Zulia in Venezuela, crucially notes, providing warning several months in advance could help people take extra precautions, allowing fishermen to fish on milder nights and better plan their four-hour boat journeys, ultimately saving lives.

Helene’s Devastating Flooding: What It Means For the Future of Appalachia

Jayden Vogler ‘28

For three days, tropical moisture deluged the mountains of Western North Carolina as Hurricane Helene and its predecessor rain event (PRE) delivered a one-two punch. Helene made landfall as a rapidly-intensifying Category 4 storm in Florida on the evening of Friday, September 26, and tracked inland overnight. Rivers already swollen from the PRE spiked to major flood stage Friday morning. The French Broad River south of Asheville peaked over 10 feet above its record set in the Great Flood of 1916.

Sinkhole over a culvert in Edneyville, NC

By midday, nearly 20 inches of rain had fallen in the mountains, with orographic enhancement bringing several areas to 30 inches. The ensuing “thousand-year flood” was catastrophic. Debris flows rocketed down oversaturated mountain slopes. Water channeled into valley bottoms, turning creeks into raging rivers that carved away roads, buildings, and the land itself. When flood waters receded, hundreds of communities in and around Asheville opened their eyes to what some described as “biblical devastation”. The Swannanoa River washed out homes and roads in Black Mountain and submerged Asheville’s Biltmore Village in nearly 15 feet of water. The Broad River swept away much of Chimney Rock’s historic downtown and overtopped the Lake Lure Dam. The Pigeon River carved out multiple portions of Interstate 40 into Tennessee. As if the flooding was not enough, strong winds wiped out cell service towers and power lines.

Washed out road in Edneyville, NC

Over the following days and weeks, desperate civilians piled into long lines at gas stations, grocery stores, and relief shelters. Those trapped received aid by helicopter or mule, but many were not so lucky. In North Carolina alone, nearly 100 fatalities have been reported, and dozens remain missing.

After Helene, many residents voiced their surprise at how destructive the storm was. Many who live in Asheville take comfort in the mountains, perceiving themselves safe from the hurricanes and destructive storms of the Southern United States. Some have even labeled the city a “climate haven”.

But taking a quick look at the past decade or two reveals a very different story for the area. In 2004, back-to-back remnants from hurricanes Ivan and Frances delivered catastrophic flooding to areas east of Asheville, particularly the Swannanoa and Black Mountain communities. In 2021, Tropical Storm Fred dumped over 10 inches of rain in the Canton and Haywood County communities west of the city. In 2022, training thunderstorms on a stationary front caused widespread flooding in eastern Kentucky, killing 45. Further north in Vermont, a slow-moving cold front in July 2023 produced destructive flash flooding in mountainous portions of the state. This August, just two hours from Ithaca, flooding from the remnants of Hurricane Debby swept away homes and roads in Canisteo, NY.

Clearly, Appalachia is no stranger to significant flooding events, and thanks to our warming planet fueling storms with more moisture, it would be unreasonable to not expect this threat to increase. Mountainous regions are particularly susceptible to flooding, where water from hilltops funnels downward, putting homes and roads in valleys at risk. Appalachia's proximity to the Gulf of Mexico and Atlantic Ocean make it a sitting duck for storms that move through. While one would hope we never see an event of the magnitude of Helene again, we must be realistic.

More flooding is inevitable, and our infrastructure and disaster preparedness and response systems need improvements. As seen with Helene, many small mountain towns lack the capacity to respond to such events. People living in remote areas cannot communicate without cell service or escape without roads. Appalachia's median annual household income is $48,964, considerably less than the national median. Lack of money and resources to begin with make it incredibly challenging to coordinate rescue and relief efforts in times of disaster.

We need an extensive overhaul of how we prepare for and respond to events like Helene. Before the storm, meteorologists and public officials must communicate the threat, and authorities must connect with residents who need to evacuate. For remote areas, going door-to-door and activating sirens can convey the urgency to leave if flash flooding is expected. In the Chimney Rock and Bat Cave communities, homeowners during Helene described fast-rising water submerging their homes, forcing them to scramble up the walls of the gorge to safety. Evacuation routes, wilderness survival training, and flood insurance must be made available to the people of Appalachia. After the storm, FEMA must respond quicker to affected areas, especially already disadvantaged communities. Local relief efforts cannot carry the weight alone. Geologists and flood experts must communicate how to restructure roads in valleys and where to place buildings to minimize the risk of damage due to landslides and flooding.

Resilience is key. For all residents of Appalachia, Helene should serve as a stark warning. Keep listening to the stories of those who lived to tell the tale. Learn from past mistakes. Never forget Helene.

Exploring Eastern North Carolina with the Coastal Hazards, Equity, Economic Prosperity, and Resilience Hub (CHEER)

Max Masleyev '26

What is CHEER?

CHEER is a five-year, $16.5 million project funded by the National Science Foundation Coastlines and People program and is headquartered at the Disaster Research center in the University of Delaware. It is made up of an interdisciplinary team of graduate students and researchers from a variety of disciplines. This includes atmospheric scientists, environmental and structural engineers, economists, sociologists, and others who collectively address a range of issues surrounding natural disasters.

The Summer Scholars Program

For the past two summers, CHEER has hosted a summer program for undergraduate and graduate students to contribute to their innovative research. By conducting fieldwork, such field interviews, our task was to identify gaps in current literature and collective understanding by immersing ourselves in local perspectives and experiences. I was one of two atmospheric science undergraduates who worked alongside other students from environmental science, psychology, economics, and history backgrounds. Even though we came from different fields of study, we were united by a common goal to address the physical, emotional, and legislative issues surrounding natural disasters like hurricanes. Our case study area was in eastern North Carolina, which is a region that is notable for its encounters with hurricanes. This area is especially vulnerable due its many waterways within a vastly flat terrain, along with the iconic strip of barrier islands.

During the six week summer program, we traveled across 6 counties in the region to conduct field interviews with non-profit leaders, government officials, and others with experience and expertise in areas related to hurricane risks and community resilience. I was put on a research team with one other undergraduate student and a graduate mentor, where we focused on long-term pathways to housing recovery. As an atmospheric science major, I was somewhat out of my normal comfort zone, but nonetheless eager to learn about how to incorporate my own background into social and behavioral research. I learned that there were many connections to be made between people's stories about their damage and housing recovery from hurricanes and the science behind the weather phenomena themselves. At the end of the six week program, I presented my research findings to the fellow summer scholars, community stakeholders, and the CHEER team.

Impactful Hurricanes

First, let me go over some of the most impactful storms in the recent memory of North Carolina residents, which were repeatedly brought up during our interviews:

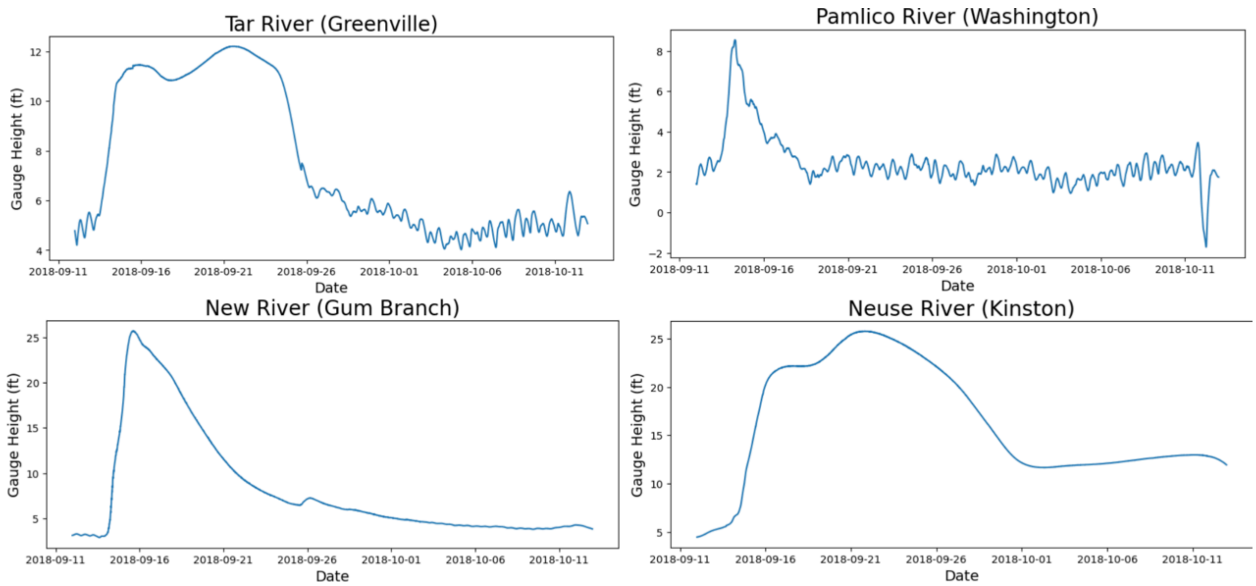
- Hurricane Florence hit the region in 2018 from September 14-18 as a category 1 hurricane. It was a large and slow moving storm that resulted in a wide-spread area of rain totals over 5 inches. The heaviest rain occurred in the south eastern part of the state, where totals reached multiple feet of rain. This same area also dealt with many confirmed tornadoes, which is an additional, unexpected threat from hurricanes that is often overlooked.

- Hurricane Matthew, just two years before Florence in 2016, also hit the region as a category 1 hurricane. Matthew traveled up the coast and brought its highest totals further inland. The compounding impacts from both hurricane Matthew and Florence pushed recovery times for many homeowners.

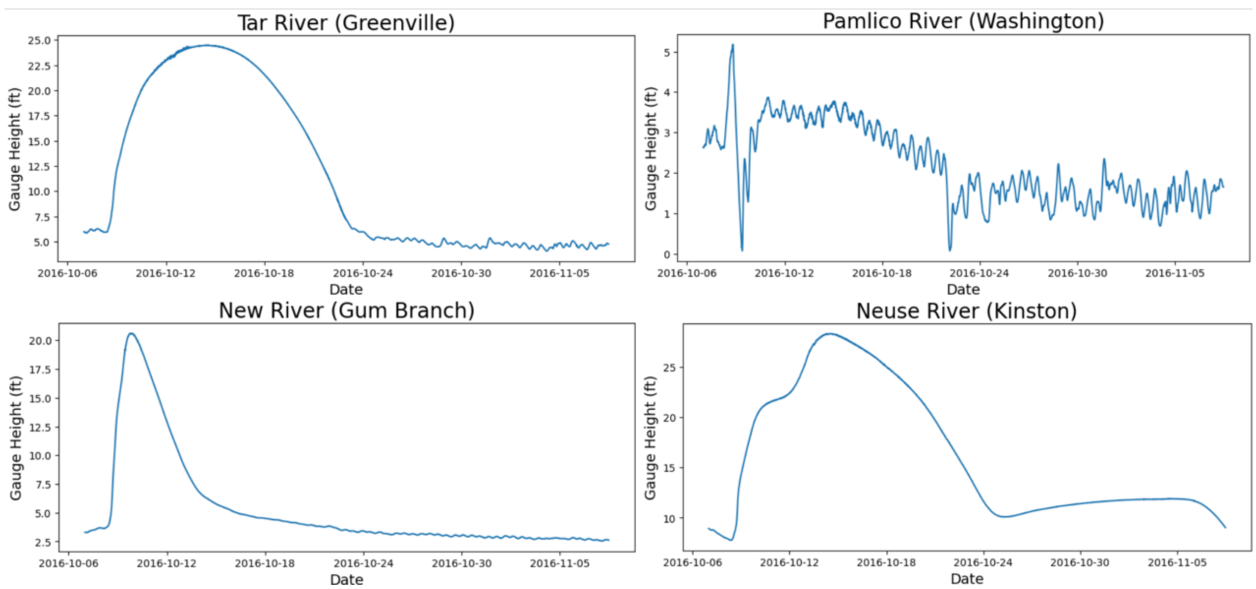
- Hurricane Floyd hit the region over 20 years ago, but remains prominent in North Carolina resident's memories. This hurricane was especially impactful for communities along the Tar river, such as Greenville, home to Eastern Carolina University where I stayed for the summer program. The aftermath of this hurricane was also when the federal "buyout" program first played a significant role in disaster recovery for this area.

Below are plots of the associated river floods from hurricanes Florence and Matthew across four different river stations. Although each station is characterized by different shapes and widths of the river, all the plots share patterns that are important to notice. All of these plots generally describe steep increases in gauge height (which measures the height above a certain reference point) followed by longer periods of receding water. In the Tar and Neuse rivers, these peaks can occur for over a week and have multiple maximums.

Hurricane Florence



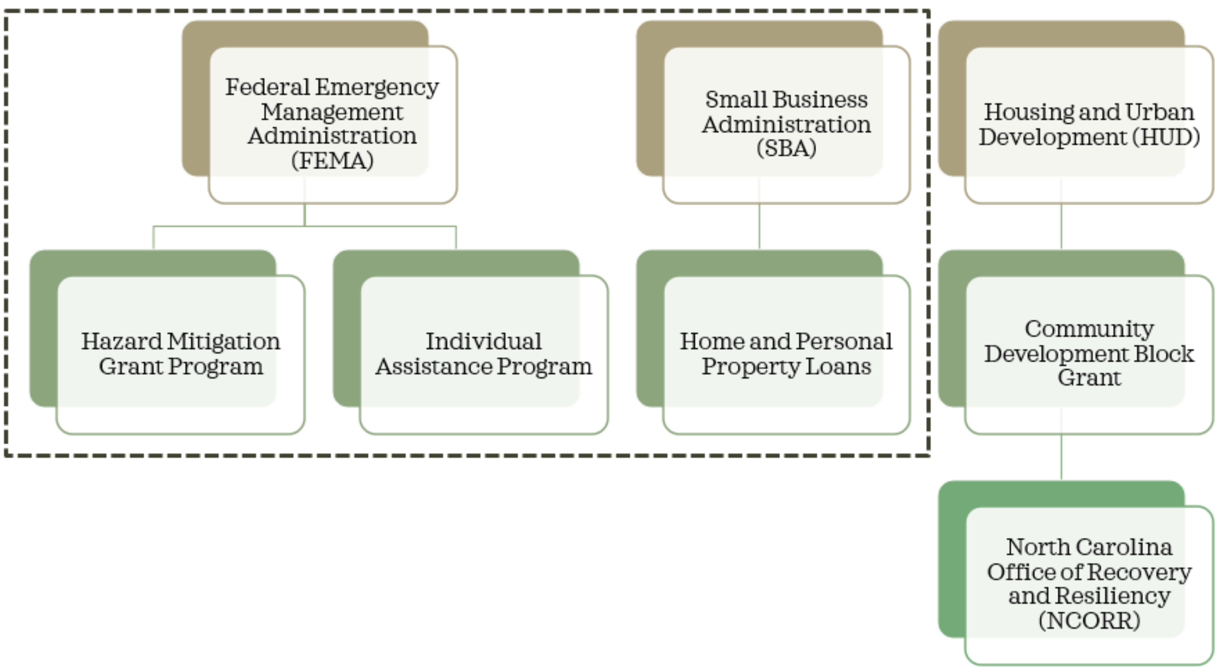
Hurricane Matthew



Pathways to Long term Housing Recovery for Homeowners

From our interviews and literature review, we identified 3 main categories for homeowners (as opposed to renters, other types of living situations) when recovering from a hurricane: **Repair, Buyout,** and **Elevation**. Each of these long term recovery pathways come with their own timelines, costs, and specific challenges, and homeowners choose a certain pathway based on a number of factors.

These differing recovery pathways relate to the concept of time compression in disaster recovery, where the management of long-term recovery involves combined forces of activities within a particular place (build environment) and specified periods of time (short-to long-term) (Holfmann 2022, Olshansky et a.l 2012). Time compression is also characterized by a large and immediate loss of capital services, as funding and resources are rapidly used up in recovery efforts. With varying sources of funding from local and federal programs, and different timelines across individual recovery efforts, the collective recovery process becomes drawn out as everyone scrambles for the limited resources available. This can exacerbate inequalities around homeowners' financial status, educational backgrounds around natural disaster recovery, and social networks of friends, family, or neighbors to help. However, there is also an eventual emergence of non-governmental organizations, such as non-profits and neighborhood groups, that fill in service gaps and alleviate some of these inequities.



Here is an overview of the federal and state organizations involved in funding for the three identified recovery pathways in North Carolina. First, the Federal Emergency Management Administration (FEMA) has its Hazard Mitigation Grant Program, which facilitates buyouts and elevations, and a separate individual assistance program that is generally for repairs. In addition, the Small Business Administration (SBA) has a home and personal property loans program that works together with FEMA through coordinated assistance and referral between the organizations. Independent of FEMA and the SBA, the department of Urban Development (HUD) has its Community Development Block Grant. This grant provides the funding for

NCORR, which is a state-level organization involved in more localized recovery efforts within the state of North Carolina.

Insights into the Long-Term Recovery Pathways

As I covered each of the recovery pathways, I addressed two research questions:

1) What are the motivations involved in pursuing specific pathways to homeowner's recovery?
2) What is the timeline to completion for each recovery pathway?

Motivating factors that led homeowners to choose <u>repair:</u>

- Minimal damage done to the property, specifically less than 50%. This means that the building does not have to go "rebuilding", in which it must meet updated building codes and design standards that may further increase costs.
- The property is located outside of a floodplain, meaning that it is generally not likely to be impacted by future flooding events
- The homeowner is insured and can receive a quicker and more reliable source of funding for repairs
- Their property has sentimental value that makes the cost of rebuilding worth it, such as a generational home that has been passed down within a family.
- A community aspect of having family, friends, or community/neighbor organizations in the area

To touch on that last point, here is a quote from our field interviews that highlights this:

> **"We use volunteer labor here instead of hiring contractors. That helps save a whole lot of money. <u>Last year we had more than 600 volunteers and it saved approximately $700,000 in labor from what we would pay a contractor.</u>"**
>
> - Craven County Non-Profit Leader

Generally, repair has the quickest timeline out of the three main recovery pathways. In addition to repair being a common option for homeowners facing less damage, the help of non-profit organizations and private insurance allow for quicker, local allocation of labor and resources. While repair may happen at a scale of different relates, full recovery can occur within monthly timescales.

Next is buyout, which is the process of moving a household or community out of a flood risk area (also known as "managed retreat"). The existing properties are torn down and eventually become city or town greenspace

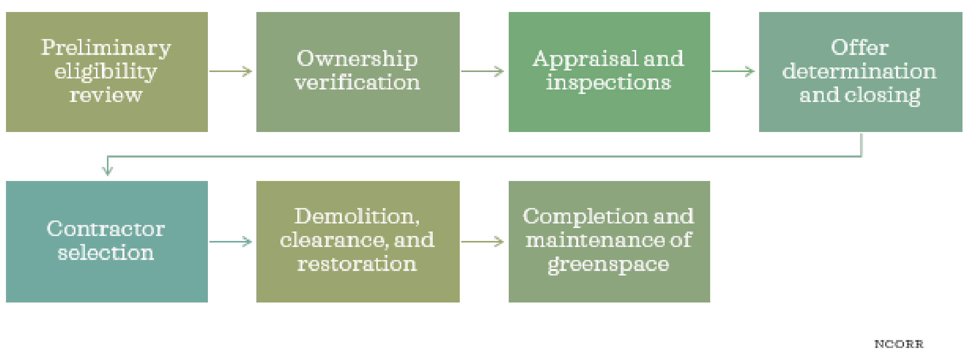
In the case of buyout, there are three requirements that must be met in order for a household to qualify:

1) The property is located in a floodplain
2) There is significant damage to the home (Greater than the previous stated 50% threshold)
3) There have been repeated losses from previous natural disaster events

In addition to these three requirements, other motivating factors include:

- The homeowners are younger and would have an easier to moving
- There is community pressure to participate in the buyout, with many neighbors choosing to participate in the buyout. This can leave empty neighborhoods with a weakened sense of community and quality of life.
- A strong incentive to move is offered in some communities through the State Aid for Repose Fund (SARF), which provides additional funding for homeowners to find a new home in the buyout process, but requires the home to be local to the town, city, or county. This keeps populations stable and allows for these communities to thrive again.

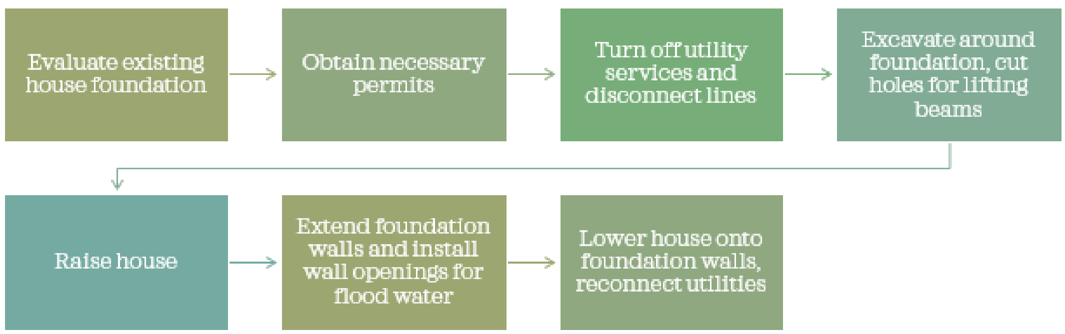
Unlike repairs, the buyout process occurs on a yearly time scale due to the many steps involved in this process, which often requires communication between federal, state, and city governments. This is an example of how time compression works to slow down recovery efforts, especially in complicated recovery pathways like buyouts. Here are the steps involved in a buyout:



"We submitted the paperwork for approval back in, of course, the end of 2018. We got approval back in 2020 telling us which lots and homes were eligible for it. A year and a half to two-year turnaround, which that did involve a leadership change"
– Pitt County Planner

The last pathway is the elevation of houses, which is an expensive and labor intensive process. Although elevation is often attributed to coastal homes, North Carolina has elevated houses that extend into far inland floodplains. The motivations specific to choosing this pathway include:

- Repetitive losses from previous storms (similar to buyouts)
- Access to wealth, flood insurance, or an agency that helps fund the high cost
- The home has a "historic" designation that requires it be maintained and preserved in the same area.



FEMA - Homeowner's Guide to Retrofitting

"It doesn't take them long to lift it, but it takes us a long time to get it prepped so they can lift it."

"So, my process can then take two to three weeks to get it ready for them to lift it. Their process was only three days. They could lift that house that high in three days."

"We had to clear out all of the old foundations and then we had to put all the new foundation block work and then they come and set the house back down. Then we go to put everything back together. So, it is a lot of stuff going on."

"You know, we had problems finding stuff, for one thing, electrical. Everybody was so booked up around us, you couldn't really find anybody to help"

- Craven County Contractor

Further Challenges

Buyout	Elevation
• Payment is based on a pre-market home value that is not reflective of the current housing market, due to the increase in home price over time due to inflation • Non-reusability of buyout property, since it may not have permanent structures, cost to maintain, and generally provide no source of revenue	• Large cost and risk to rebuild property in the same flood-prone areas • There may be additional costs and time spent, especially within vulnerable populations, such as disabled individuals who need an elevator installed to get to the first floor of their home.

While elevations also occur on yearly timescales, they may take even longer than buyouts due to the supplementary costs and time required.

Future Work

More investigation is necessary to identify details in the timelines for the recovery pathways. This can involve reaching out to individual homeowners to track the full recovery process, including their experience through finding a new home after payment from the buyout program. Much of the existing literature does not focus on this later aspect of the buyout process, and would provide a more complete and realistic picture of the buyout experience. In regards to repairs, identifying specific types of repairs and their associated timelines can also help.

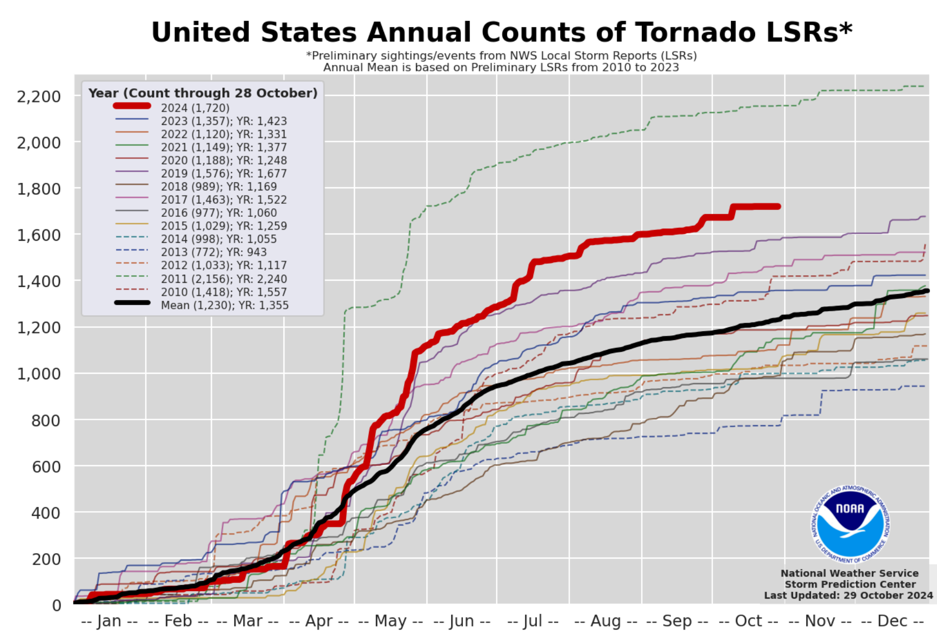
Related to the recovery process, there is also a question of whether a homeowner's circumstances immediately following a disaster have an impact on their long-term recovery. This includes the process of returning from evacuation, the type of access there is to resources, and the prior education of a homeowner on existing programs. Is there a way to quantify and correlate these factors at the beginning of the recovery to process the overall timeline of recovery?

Greenfield Tornado Chase

Packie Young '26 & Jack Halberstadt '26

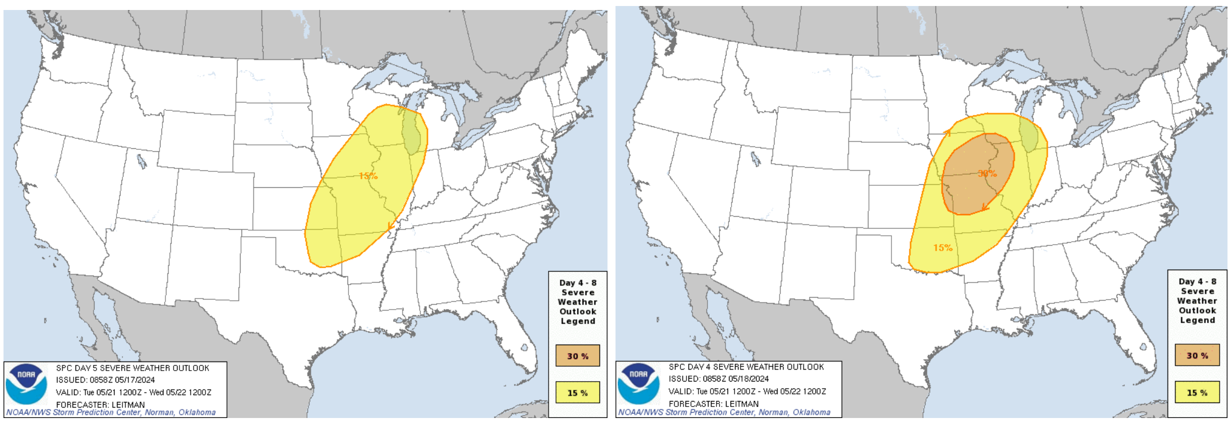
One random Saturday soon after the spring semester ended, the text came in. "Can I gauge your interest on something?" One quick call later, two college delinquents decided to take advantage of 2 days of free time and an exceptionally active Spring U.S. tornado season. The plan was simple. Chase a tornado. Little did we know what we would experience not 72 hours later…

2024 has been one of the wildest weather years in our young lives. What started with the warmest winter on record for the contiguous United States (CONUS) turned into one of the most active tornado seasons on record and nearly breaching hyperactivity in the Atlantic for the hurricane season with 5 hurricane landfalls in the U.S. so far making this hurricane season (so far) the second most costly of all time, surpassing the infamous 2005. But let's talk tornadoes. What began as a fairly average to even below average season skyrocketed in the month of May to the second most active in the past 15 years, just falling short of 2011 thus far. So many notable outbreaks occurred to produce the insanity that this year has been, but our adventure began on May 18, where we would end up chasing the infamous May 21 Greenfield tornado, the strongest tornado of the year so far.



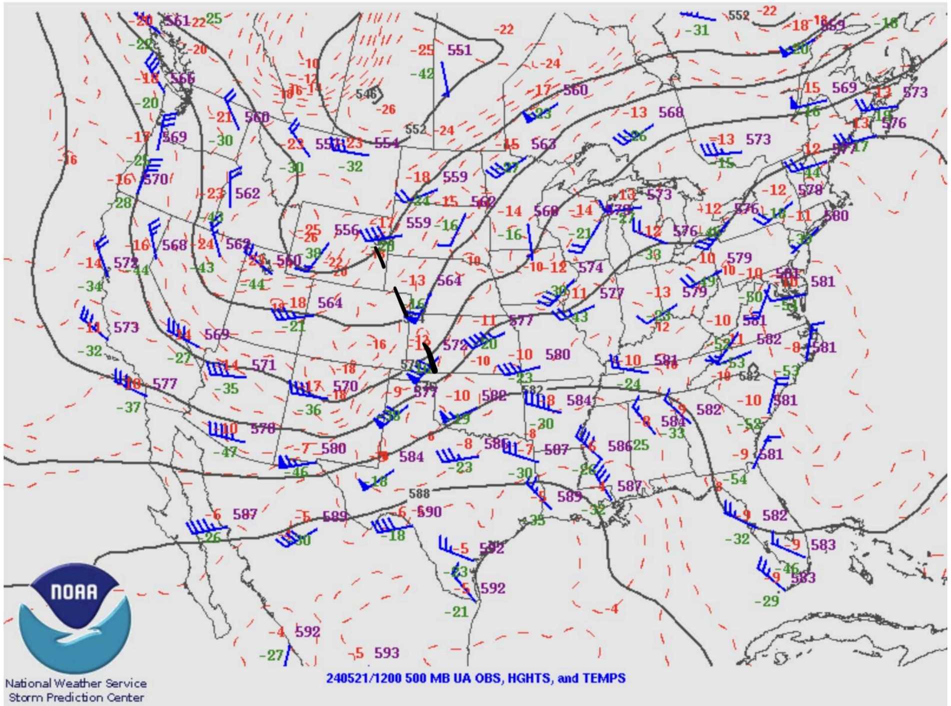
Tornado Local Storm Report Count through October 28 for this year (red) compared with the past 15 years.

As two weather weenies would, we both had been keeping up to date with the insanely tornadic spring and what the future was looking like. So naturally, we both saw the potential opportunity lining up on May 21. Forecast models were depicting a large and deep upper level trough to progress into the southwestern US with a large ridge building east. This reservoir of cold air associated with the trough next to the warmer air to the east helped to build instability in between, where severe weather could ensue. Some models were also hinting at a smaller shortwave trough moving into the Kansas-Missouri-Nebraska-Iowa border point, which would focus the best ascent into western Iowa. However, at the time, there was substantial difference in the timing of this shortwave, which could greatly shift the area of best tornado probabilities. The Storm Prediction Center (SPC) had noted the potential for a severe weather outbreak, issuing a day 5 15% (slight) risk for severe weather and a day 4 upgrade to a 30% (enhanced) risk for severe weather.



The day 5 and day 4 Storm Prediction Center risks for May 21 illustrating the increasing risk and slight eastward displacement.

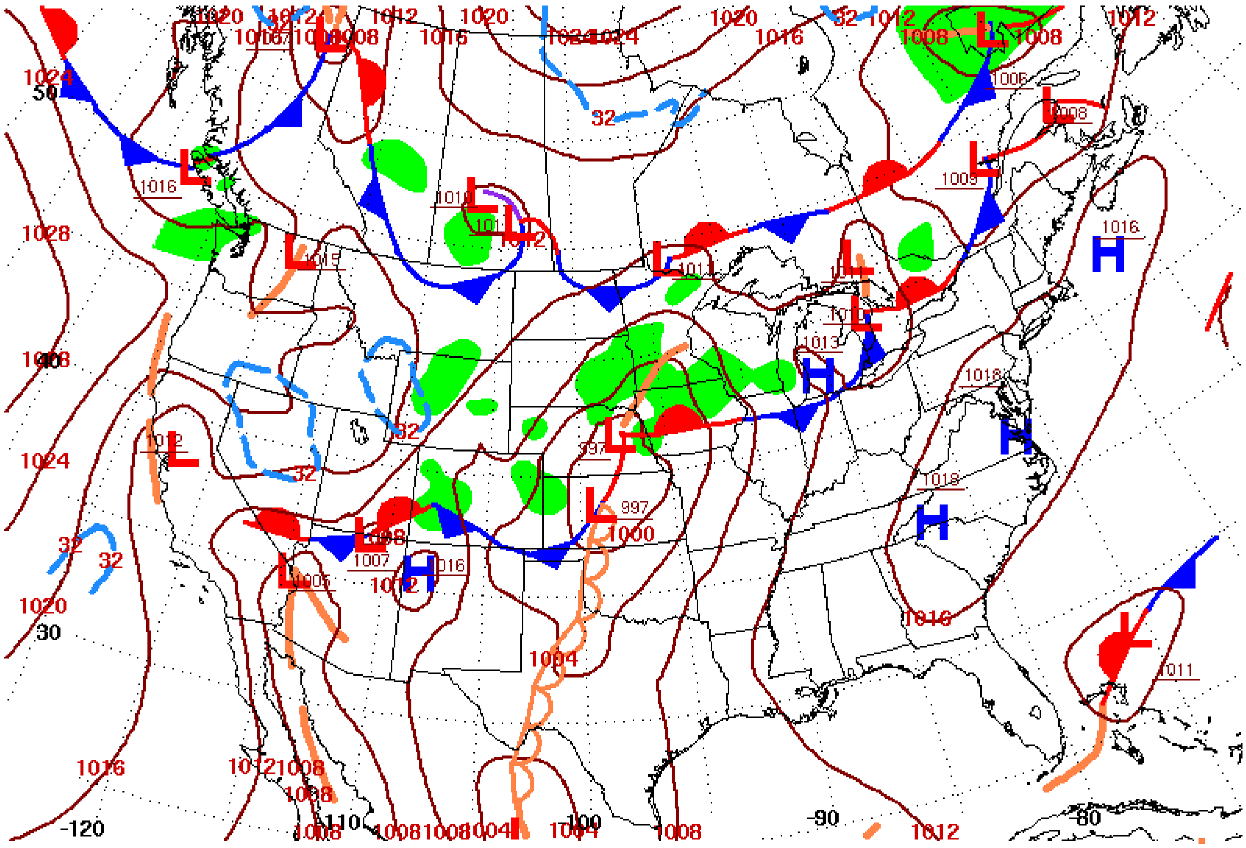
I am sure you can notice how the core of the risk seemed to focus on eastern Iowa and Northern Missouri. This all related to the timing of that shortwave trough, which was modeled as fairly progressive early on. More on this later.



The upper level pattern the morning of Greenfield. Black dashed line marks the shortwave trough.

As certainty in the event increased, the SPC slowly ramped up the wording and the threat level. By the day three outlook, the SPC had placed in their enhanced risk over a large section of the midwest, noting that *"Damaging gusts, large hail and a few tornadoes are possible through Monday night."* But why was this the event that looked so rewarding to chase? Why now?

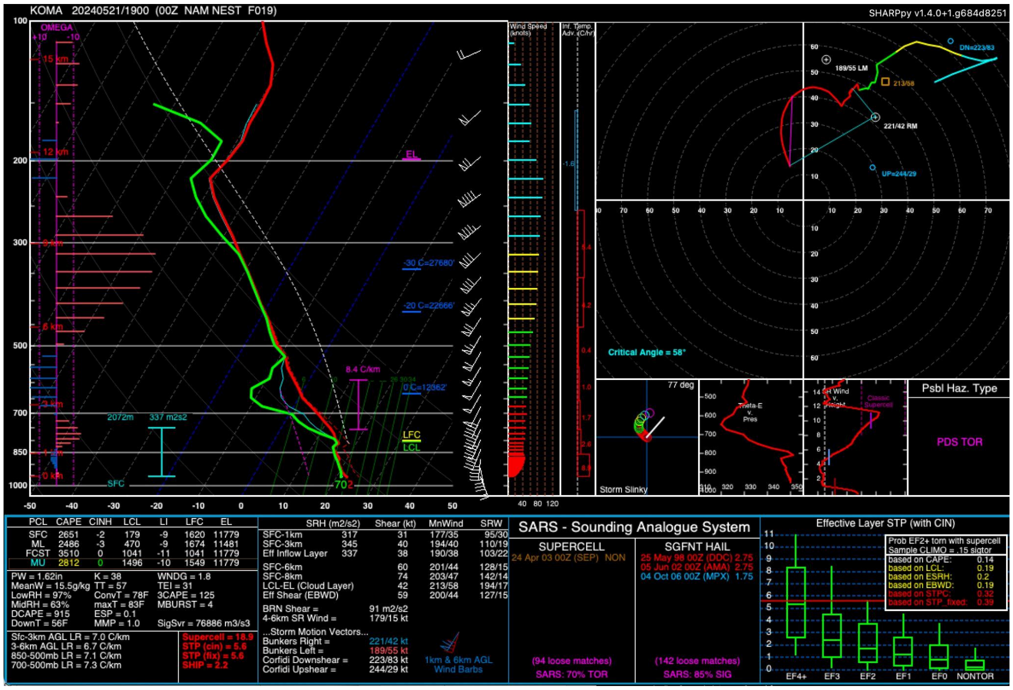
Well, we noticed that quite a few ingredients were coming together to produce prolific tornadoes on this day. As we mentioned before, the synoptics of the longwave trough, shortwave impulse, and the robust ridge over the southeast presented an environment very ideal for tornadogenesis. The broader scale troughing permitted surface cyclogenesis on the lee side of the Rocky Mountains in a very classic Great Plains low. This surface low pressure progressed quickly, moving into western Nebraska by the morning of the event.



Surface Weather Map at 7:00 A.M. E.S.T.

Surface map valid for the morning of Greenfield. Notice the low pressure placement in Nebraska and the northward-lifting warm front in Iowa.

With it though, even days before the event, rapid moisture advection from the Gulf of Mexico within the warm conveyor belt allowed for dewpoints in the mid 60s into Iowa and temperatures in the low 80s by mid afternoon. In addition, the strong southwesterly winds aloft combined with this moist advection at the surface from the south helped to curve and lengthen hodographs, or a polar coordinate graph of the vertical wind profile, and promote strong wind shear for severe storms and even rotating storms.



Forecast sounding for nearby Omaha, Nebraska valid 2pm central time roughly an hour before the Greenfield tornado occurred. Sounding shows an incredibly volatile atmosphere with strong low and mid level instability and intense vertical wind shear.

We knew this setup was a classic for high end tornado outbreaks, especially with that smaller shortwave trough moving in. The positioning of that shortwave trough was crucial for our final positioning, but the plans were set and we drove out from Philadelphia 12 hours to a cute town in the middle of Illinois called Ottawa. While out on our drive, the SPC had upgraded the risk to an uncommon Moderate level 4 out of 5 for significant damaging winds, so we knew that this was at least worth the drive. We even saw a few teaser storms for the next day on the drive in the Chicago metro which got us hyped for the next day. Although we knew how dangerous the next day could have been, nothing could have prepared us for what we would experience…

We woke up from our hotel in Ottawa, Illinois on the morning of May 21 to a major upgrade from the Storm Prediction Center (SPC). They had now forecasted a 15% hatched risk of tornadoes for the entirety of eastern Iowa. This magnitude of risk is rarely issued by the SPC, and signaled the chance for the most significant tornado outbreak of the year that day. After some discussion and lots of worry and excitement, we were out the door by 9am, with our initial target uncertain. We would either set up in eastern Iowa or we would make the trek out to southwest Iowa. This was a big decision, as eastern Iowa was only about 2 hours west while southwest Iowa was a much longer 5 hours (a distance we'd have to drive back later that day). Packie had a hunch that southwest Iowa would have the better chance for tornadoes. I was hesitant because that would require an additional 6 hours of driving that day on an already long

trip. But, it seemed as though this was the better choice and ultimately this is what I drove 12 hours out to the midwest to do, so I went with it, and we set out for southwest Iowa.
Walking outside to the car that morning already made the dangers of the day obvious. A ripping low level jet was already making conditions very windy and it felt like a tropical rainforest outside, with dew points soaring into the mid 70s, more typical of Miami, Florida than the midwest in May.

The drive was boring and straight for nearly 5 hours, directly west on I-80. The main change forecast-wise was that the SPC had issued a tornado watch for central Iowa with a rare PDS tag, indicating that *"Several tornadoes and a few intense tornadoes are likely"*. To our slight surprise, the skies were mostly cloudy for lots of the drive. Typically cloudy skies inhibit surface warming and instability, signaling a lowered risk of severe weather and tornadoes. However, right as we passed through Des Moines, the skies opened up and it became full sunshine. Temperatures quickly jumped into the 80s, and it became apparent to us that this would be a day for significant severe weather as skies remained mostly blue.

Our initial target was a town named Stuart, Iowa, about 20 miles north of Greenfield, where we met Packie's storm chasing friend Jacob to help guide us safely around any tornadoes. We arrived in Stuart as soon as thunderstorms began to develop about 30 miles west of us. Quickly the skies in the distance became ominous and winds increased. Then the inevitable finally happened, the first tornado warning of the day was issued on this line of storms as they were heading northeast towards our location at a whopping 65mph. This tornado warning was much further south than our location however, so we needed to travel that way in order to have a chance of seeing a tornado. Our initial target to watch the tornado was Greenfield, so we set out on the 25 minute drive south there.

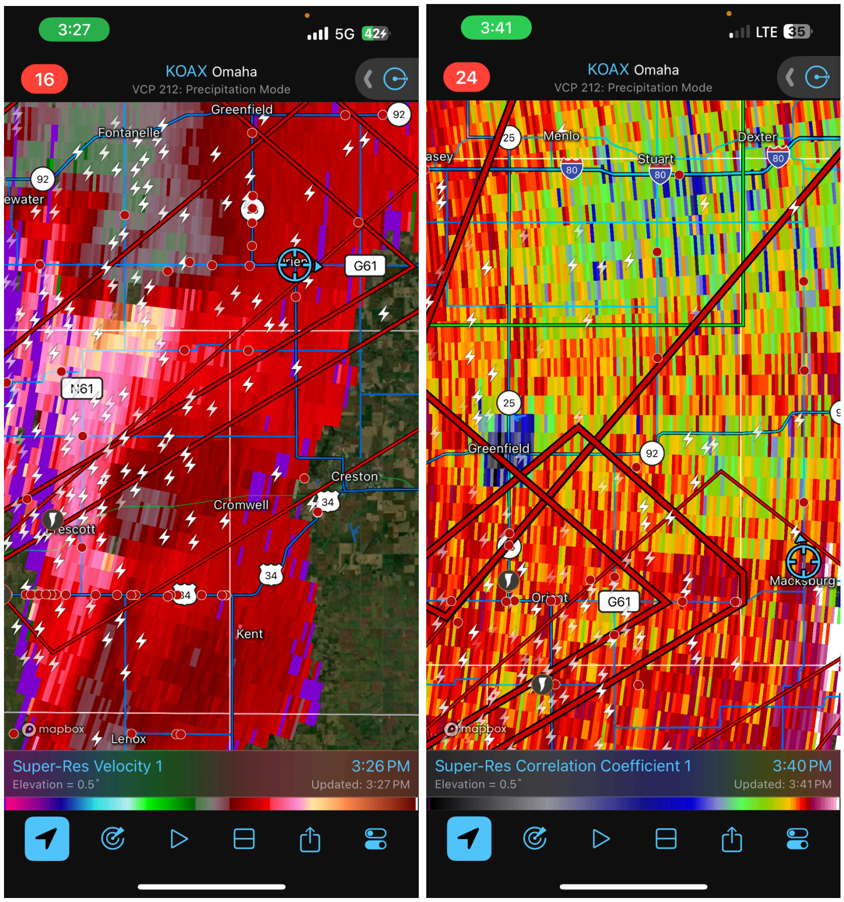
The sky continued to darken as we approached Greenfield, with the winds shaking our little Subaru Crosstrek as we drove closer to the storm. It was as we approached Greenfield that we received alarming news, there was a large and destructive tornado on the ground, and was headed in the general direction of Greenfield. We initially thought it would pass just south of downtown Greenfield, but we weren't quite sure. This meant our first make or break decision of the day was upon us. *Do we drive east out of Greenfield to stay out ahead of the tornado, or drop south and cross the tornado's path to potentially get a better chance of seeing it?* Ultimately we decided to continue straight south of Greenfield so we could safely cross the tornado's path and watch it pass north of us from a safe distance. The only memory we have of this stressful decision was the bustling intersection in downtown Greenfield where we had to make the decision, as the skies became pitch black and nerves of worry and excitement began to set in.

As we got out of downtown Greenfield and continued to drop south, our visibility got significantly better as man made obstructions vanished into endless farmlands. At first, all we saw in the direction of the tornado was rain curtains and dark clouds. However, as we crested the top of a hill continuing south, there it was. We clearly saw the stove-pipe like funnel from the cloud to the ground, as our phones were buzzing with a Particularly Dangerous Situation tornado warning, indicating a catastrophic threat to life and property. We were at awe, finally seeing our first ever tornado in person, a truly surreal experience for weather weenies like us. Due to the tornados' very fast speed, we were a safe 5-7 miles from the tornado when watching it, as well as well out of the way of its path. We were hesitant about getting out of the car to get pictures because it appeared as though we may have been in the path of multiple other potentially tornadic storms developing at the time.

So, we stayed in the car, racing south and eventually east as the road curved to the left. We vividly remember passing through the small town of Orient, only about 10-15 minutes south and east of Greenfield shortly after the road curved to the east. The sky was pitch black behind us and all of the local residents had their phones out taking videos of the storm. We felt the real sense of nerve as it seemed like more tornadoes were heading for this exact location. Fortunately, no other significant tornadoes formed outside of the earlier one we had seen in southwest Iowa that day, but unfortunately the prior tornado did not end without taking a toll on locals.

Our view of the Greenfield, Iowa tornado at 3:24 pm on May 21.

Right after we got out of Orient, we started receiving word that the destructive tornado that prompted the Particularly Dangerous Situation warning had made a direct hit on the town of Greenfield, the town we had just driven through 15 minutes prior. We were still full of adrenaline and couldn't believe what we were witnessing both on radar and through Twitter photos, but the sheer magnitude of the tornado began to set in.



Radar screenshots of our locations at 3:24 pm (left) and 3:40 pm (right). The left shows wind velocities and the right shows correlation coefficient. The tornado can clearly be seen with the bright orange and green colors right next to each other and a very low correlation coefficient directly over Greenfield, indicating lofted debris from the town.

The rest of the chase was relatively uneventful compared to our first 45 minutes or so. It involved racing north and east to try and keep up with the line of storms that had initially produced the Greenfield tornado to chase any other potentially tornadic storms. Outside of a brief rain wrapped tornado that was unchaseable, we did not see anything else significant that day. The day ended with an additional 3-hour drive back to our hotel and some Mexican food in a random small town in eastern Iowa.

Being in the town of Greenfield just 15 minutes prior to devastation really puts into perspective the catastrophe that results from these weather events, and only encourages us more to work harder to prepare properly and completely for every single potentially damaging weather event. Communication is key, and going on these types of storm chases helps us truly understand our impact.

*This article was written in memory of **Dean Wiggins**, **Pam Wiggins**, **Lee Williamson**, and **Michael Jensen**, all of whose lives were taken from the Greenfield tornado and whom we will never forget.*

A picture of us in front of a mesocyclone after our chase of the Greenfield tornado as storms began to wind down for the day.

Aurora Borealis Sparks the Sky Over Ithaca and Big Red

Shawn Wallace ‘27

Northern Lights over campus captured from the roof of Hollister Hall in the early morning on October 11th, 2024.

This year, people all across the world have been treated to amazing opportunities to see the Aurora Borealis, also known as the northern lights. October has been especially eventful, with two major events occurring within just a week's time, giving fantastic views to people across campus and surrounding areas who managed to notice.

A massive solar storm most recently impacted earth on the 10th and 11th. Excellent views of an ambient aurora and strong substorms were seen across the world and here in Ithaca from sundown until the early morning hours on the 11th before finally subsiding. Campus was buzzing with the news and eyes were trained to the sky, as it was hard to miss! For an aurora chaser like me, it was an unforgettable night.

Our sun has reached its maximum phase in its 11 year cycle, meaning that solar activity is expected to increase and peak within the next year. Once every eleven years, the magnetic poles on our sun swap places between the South and North poles, leading to periods of higher solar activity, also known as solar maximum. Solar minimum occurs at the end of a current solar cycle, as well as the start of the next, and is when the sun is least active. We define solar activity to be a period where the sun experiences a lot of sunspots, solar flares, CME's, and prominences all caused by changing magnetic fields on the sun. We also call this space weather.

But what does that all have to do with the northern lights we see on earth? When particles are expelled from the sun and directed at earth, either by solar wind or Coronal Mass Ejections, they collide with our magnetic field and atmosphere. Depending on the density and speed of these particles, they can either be directed to the poles or spread down to the lower latitudes, which is what happened most recently for us in Ithaca and the rest of New York on October 7th, 8th, 10th, and 11th.

When these particles collide with our atmosphere, they exchange energy with mostly nitrogen and oxygen, charging them and causing them to emit light. This light culminates in what we see on earth as the Aurora Borealis, with green and red being from oxygen in the upper atmosphere and purple and blues being from nitrogen.

In order to get the best show possible, earth needs to be targeted and impacted by a strong Coronal Mass Ejection (CME), which is plasma made up of electrons, protons, and heavy ions that are expelled from the surface of the sun and into the vacuum of space. If multiple CME's occur within a short period of time, they can also join forces in space to create a more long duration event here on earth, which is what happened during the infamous May 10th and 11th solar storm from this past spring.

Most CME's originate from solar flares, which NASA defines as an intense burst of radiation coming from the release of magnetic energy. There are two types of solar flares, impulsive and expulsive, the latter of which commonly produces CME's. We classify flares into C-class, M-Class, X-class, with X being the most powerful but least common. Any class of flare can produce a CME, although a higher class is most likely to expel the most material. Flares can also be short or long duration events and can switch from impulsive to expulsive and vice-versa.

These flares originate from sunspots, which are the visible components of active regions on the sun's surface. These intense and complex areas of changing and evolving magnetic fields are about 2,500 times stronger than the ones here on earth. When these magnetic fields continuously tangle, cross, and reorganize, which can eventually result in a release of energy in the form of a solar flare, and potentially a CME.

While space weather can be pretty cool at times, it poses significant threats to humans and our infrastructure. Astronauts and people flying at high altitudes can receive an increased amount of radiation, leading to possible health issues. Space weather also disrupts and can destroy satellites. It frequently causes radio blackouts and can affect the functionality of GPS. Our power systems are also especially vulnerable, as strong CME's that impact earth can cause voltage irregularities which can cause power outages. While we have not had any power outages in the last 20 years, Sweden experienced a blackout in 2003 from a strong solar storm and six million people were left without electricity for nine hours in Canada in 1989, also from a solar storm.

Can You Chase the Northern Lights?

Northern Lights captured from nearby Hector, NY, in Seneca County, during the late evening on October 10th, 2024.

While I have been chasing the Aurora Borealis for several years, I am by no means an expert. In fact, while we have been monitoring sunspots for hundreds of years, our first satellites which really helped us begin to study space weather were only sent to space in the mid-1990's, meaning that space weather is in reality a very new science. To this day, we only have a handful of satellites between us and our sun, which can only tell us so much. It is because of these reasons that forecasting space weather and chances for the northern lights can be extremely difficult.

Luckily, I was able to get in contact with Hunter Hurley, a professional photographer, aurora chaser, and severe storm chaser from Missouri. When I asked why he does what he does, he replied, "I chase the aurora because I'm fascinated by its beauty. Nothing gives you more emotion than being able to see and photograph the aurora. It's truly a life-changing experience". He also warned me about its difficulty, saying, "aurora forecasting is extremely tricky. Folks who aren't experienced using more advanced data will be greatly disappointed when the Space Weather Prediction Center 3-day KP forecast doesn't verify. It takes a keen eye to know exactly when the aurora and any Substorms may occur".

Knowing how and when to access data are the most important things to know for anyone who wants to chase. Preparation for a chase generally starts a day or two before the expected arrival of a CME that may impact earth. Chasers use a variety of satellite data and forecast sources leading up to an anticipated event, especially forecasts and data found on the Space Weather Prediction Center. Mainly, they are looking at data from the L1/ ACE satellite located ahead of the earth, which is used to create models, take pictures, and monitor conditions. Be forewarned, learning about space weather is not easy!

Physically chasing the Aurora Borealis is very much a "nowcasting" and in the moment experience. It is also significantly more difficult for the lower latitudes to see the aurora since particles are funneled towards the poles, making it impossible for lower latitudes to see much of anything without a strong CME. If you do attempt to chase in the northern hemisphere, find a dark area with little to no light pollution, the clearest skies you can, and views of the Northern horizon.

It is almost always best to chase just before and during a substorm. According to Hunter, "A substorm is a sudden/sharp release of energy from the tail of the magnetosphere into the high latitudes of the ionosphere. Substorm strength usually depends on the buildup of energy within the magnetosphere". Substorms increase activity and brightness, often allowing for the best viewing conditions at lower latitudes. Hunter also notes that if substorm conditions are just right, viewing the northern lights can be possible even with a weak CME impact or solar storm. The higher your latitude, the better the chance of seeing something. At higher latitudes, an ambient aurora is much more likely, meaning the lights will be able to be seen well without a substorm.

Solar storms are rated on what is known as the G-Scale, which ranges from 1-5 with 5 being the most rare and highest intensity. While forecasters rate storms using a variety of methods, it is mostly based on the following factors:

- <u>KP Index:</u> Variability in earth's magnetic field, rated from 0-9, with 9 being the highest. Relatively short term. Used to describe the strength for all of earth.
- <u>Disturbance Time Index (DST):</u> Measures the decrease in the horizontal component of the earth's magnetic field near the equator as the size of the magnetospheric ring current increases.
- <u>Solar Wind:</u> Speed and density of the particles coming at the earth from the sun. The faster and denser a storm is when it impacts the storm, the higher the level of impact.
- <u>Interplanetary Magnetic Field (IMF) and BZ:</u> BZ indicates the direction that the particles enter earth's atmosphere. A positive direction indicates particles entering the atmosphere from the southern hemisphere, meaning much less of a show in Northern latitudes, indicating that the southern lights will be stronger. The opposite is true for negative BZ values. In theory, the higher the value, the closer an aurora will appear towards the equator.

Since the average chaser is not a professional forecaster, it is best to keep an eye on solar wind characteristics and BZ components, which can be found on the SWPC website and SpaceWeatherLive.com, the two most highly regarded websites for new chasers. Hunter notes that substorms are what people should prioritize chasing rather than an ambient aurora, mainly for lower and mid-latitude locations, as "an Ambient aurora is much more rare than a substorm, and you usually need a prolonged and strong southward Bz component for ambient aurora to even show up (in lower latitudes)", noting "I've only been fortunate enough to experience ambient aurora 3 times, all which occurred during G4 (2) and G5 (1) events".

What are Quick and Easy Ways for Me to Find out About Northern Lights Chances and Information?

Views from the Robert Trent Jones Golf Course just outside of campus on October 8th, 2024.

Since the world of aurora chasing is confusing and requires many hours of research and patience, there are a couple of ways to make it easier. First, familiarize yourself with the two websites listed above. Both are excellent, accurate sources for space weather, especially real time observations. You can also access helpful information from the news or social media. Just be careful of who you choose to listen to. Hunter Hurley is a great source and can be found on Facebook and X @hunterhurleywx where he often posts helpful aurora chasing info as well as his photos, so go check him out!

Best of luck with the chase and hopefully we all get to see some more of mother nature's beauty over the course of the next year!

Works Cited

Aurora Forecast Iceland | Northern Lights Research Center, https://auroraforecast.is/. Accessed 30 October 2024.

"AER Dst Index." *Atmospheric and Environmental Research*, https://www.aer.com/science-research/space/space-weather/space-weather-index/. Accessed 30 October 2024.

"Kp Index." *Aurora Zone*, https://www.theaurorazone.com/nuts-about-kp/. Accessed 30 October 2024.

"NOAA Space Weather Scales | NOAA / NWS Space Weather Prediction Center." *Space Weather Prediction Center*, https://www.swpc.noaa.gov/noaa-scales-explanation. Accessed 30 October 2024.

"Sunspot regions | Solar activity | SpaceWeatherLive.com." *Space Weather Live*, https://www.spaceweatherlive.com/en/solar-activity/sunspot-regions.html. Accessed 30 October 2024.

"What Is an Aurora?" *NASA Space Place*, https://spaceplace.nasa.gov/aurora/en/. Accessed 30 October 2024.

Northern Lights On Campus!

During the month of October, 2024, Ithaca and Cornell University were treated to a breathtaking spectacle of the sky- an awe inspiring display of the Northern Lights. This rare and mesmerizing weather phenomenon made its way south, painting the night sky with vibrant shades of green, purple, and pink. As word spread, students, faculty, and locals gathered on campus, united in their excitement to witness this celestial event. It was a moment of collective wonder, where the magic of nature brought us all together to share in the beauty of the lights, reminding us of the incredible, unpredictable forces of our planet.

Below are several photos that were taken by CCAMS members from all around campus and Ithaca, NY!

Photos By: Jayden Vogler '28

Photo By: Max Masleyev ‘26

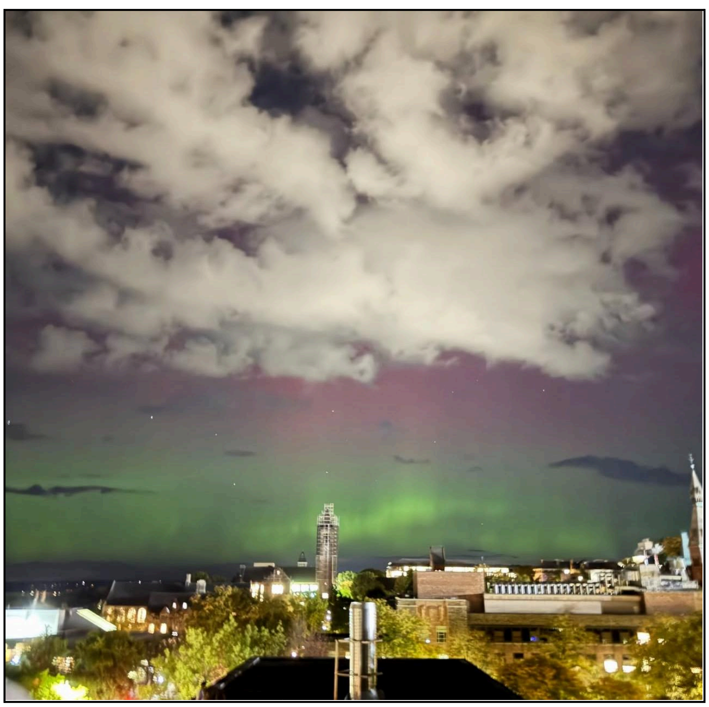


Photo By: Simran LaBore ‘27

Photo By: Avinash Aravind ‘27

CCAMS Fall 2024 Executive Board

Will Cano
President
Class of 2026

Dylan Wright
Vice President
Class of 2026

Melina Chapula
Treasurer
Class of 2026

Lucy Alcoba
Secretary
Class of 2027

Gabby Quaranta
Social Manager
Class of 2026

CCAMS Fall 2024 Officer Chairs

		
Avinash Aravind Forecast Chair Class of 2027	**Jayden Vogler** Merch Chair Class of 2028	**Simran LaBore** DEI Chair Class of 2027