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25 Years of CSTAR - Operations and Research Collaborations Saves Lives

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The Fall of 2024 marks the 25th Anniversary of the establishment of the National Weather Service (NWS) Collaborative Science, Technology, and Applied Research (CSTAR) Program. The CSTAR Program has proven to be an extremely effective vehicle through which researchers and students collaborate with the operational meteorological community in applied research. These CSTAR projects aim to improve the accuracy and communication of forecasts and warnings of environmental hazards by applying scientific knowledge and information to operational products and services. The benefits of these Operations-to-Research-to-Operations (O2R2O) collaborative projects have never been more evident than during the recent Hurricane Helene.

Approximately 20 years ago, discussions between NWS operational staff and University at Albany researchers and students during NROW and CSTAR planning meetings revealed a recurring challenge: significant rainfall events were frequently observed well ahead of landfalling or near-coastal-tracking tropical cyclones (TCs). These discussions led to a subsequent CSTAR-funded project titled Predecessor Rain Events (commonly known as PREs) in Advance of Tropical Cyclones. The results of this project became the focus of Matthew Cote's M.S. thesis. The conceptual model developed through this collaborative project, and follow-on efforts led by Tom Galearneau, was recognized by forecasters in the Southern Appalachian region four days in advance of the landfall by Hurricane Helene along the Gulf Coast. The application of the PRE conceptual model enabled forecasters to effectively communicate to Emergency Management and other core partners the potential for what turned out to be a major rainfall event. This PRE event produced record two-day rainfall totals in Asheville, NC, during the 24 to 48 hours preceding the arrival of the rainfall directly associated with Hurricane Helene. The result was catastrophic flash flooding across the southern Appalachian region, the worst experienced since the Flood of 1916. The successful operational application of the PRE conceptual model, which originated from this CSTAR project, likely saved hundreds of lives across the region.

CSTAR at UAlbany: How Gene Auciello and Daniel Keyser Conspired to Create this Collaborative UAlbany-NWS Research Program that is Overseen by Professor Kristen Corbosiero

Lance F. Bosart
Department of Atmospheric and Environmental Sciences, University at Albany

When Gene Auciello was a meteorologist at WFO-Boston he took an interest in operationally oriented research projects. Gene's interest in operational research was sparked by frequent visits by MIT Professor Frederick Sanders to WFO-Boston at Logan Airport. Gene subsequently went to DC to work with then OM Director Ron Lavoie to colocate universities and NWS WFOs. After Gene assumed the Meteorologist-in-Charge position at WFO-ALY he began to work with Professors Daniel Keyser and Lance Bosart and their graduate students at UAlbany on collaborative operationally focused research projects. These collaborative operationally oriented research projects proliferated once the NWS formally created the CSTAR program. This short presentation will overview the ensuing success of CSTAR-supported collaborative operationally oriented research projects between UAlbany and WFO-ALY.

The UAlbany–NWS CSTAR Partnership 2014–2024: High-impact Weather in Complex Terrain

Kristen Corbosiero
Department of Atmospheric and Environmental Sciences, University at Albany

Motivated by high-impact, low-predictive skill weather events across the Northeast United States, Collaborative Science, Technology, and Applied Research (CSTAR) cooperative research grants V–VII (spanning 2014–2024) between the University at Albany (UAlbany) and National Weather Service (NWS) forecast centers and labs, investigated significant operational forecast problems identified by forecasters. These problems included the contributions of localized flow in complex terrain to: 1) the development of severe convection; 2) the type and intensity of winter frozen precipitation; and, 3) the areas of heavy precipitation and flooding associated with tropical moisture sources.

Collaborative research between UAlbany graduate students and faculty, and NWS forecasters, increased scientific understanding and improved forecasters' situational awareness of these high-impact weather events, and critical research findings were transitioned into operations. In this talk, the major scientific findings of these projects will be summarized, emphasizing the conceptual models that became an integral part of the research-to-operations success story of the UAlbany CSTAR program.

Stony Brook CSTAR Efforts: From Ensemble Tools to Stakeholder Communication

Brian Colle
Stony Brook University, New York

Recent strategic plans for the National Weather Service (NWS) have emphasized the goal of a “Weather-Ready Nation,” which will require users to better synthesize NWS forecasts to take preventative actions towards the protection of life and property. Ensemble weather prediction is an important component of this decision-making process; thus, operational ensemble systems need to be reliable and well calibrated, and forecasters require easy use of the data. Therefore, during the past decade the CSTAR projects at Stony Brook University have focused on how forecasters can better utilize ensembles in operations. This collaboration initially focused on the development on real-time web pages at the university for ensemble sensitivity, clustering using the GEFS, ECMWF, and CMC ensembles (100 members out several days), Rossby wave packets, and cyclone tracking. Some of the R2O successes is demonstrated by the implementation of the clustering tool within the IDSS (DESI) software, which is available at all forecast offices, and the ensemble sensitivity tool is now run operationally at the Weather Prediction Center (WPC). The first part of this presentation will overview some of these tools and the potential benefits to forecasters, students, and model validation.

Another challenge is how to get uncertainty and warning information the stakeholders, so that appropriate action can be taken. As tropical storm Ida (2021) illustrated in New York City (NYC) and other recent landfalling hurricanes over the Southeast U.S. (e.g., Helene 2024), there are large challenges in hazard communication. As a result, more recently the Stony Brook CSTAR efforts have focused more on this aspect of the problem with our current CSTAR project “Improving Communication With Highly Vulnerable Societal Groups (HVSGs) Through Partnerships, Audience Analysis, Crowd-Sourced Information, and Workshops.” This project is helping This project has conducted online and in person surveys to better understand risk perception with HVSGs and how they obtain hazardous weather information. Another goal is to help the NWS develop community partnerships through workshops and an expansion of the Weather Ready Nation (WRN) to include more community leaders in these NYC neighborhoods. The talk will summarize some of these efforts as well as future opportunities and challenges.

The UAlbany-NWS CSTAR Collaborative Partnership 2001-2024

Thomas A. Wasula[1], Neil A. Stuart[1], and Michael S. Evans[2]
NOAA/NWS/WFO, Albany, New York[1]
STM Weather Cropseyville, New York[2]

Motivated by forecast challenges including extreme, high-impact, low-predictive skill weather events across the Northeast United States, the University at Albany (UAlbany) and several National Weather Service Forecast Offices, led by the National Weather Service at Albany, have completed seven Collaborative Science, Technology, and Applied Research (CSTAR) grants between 2001-2024. These grants engaged operational research with the academic community with nearly three dozen projects completed. By establishing a strong, cooperative research relationship between students and faculty (i.e. Dr. Lance F. Bosart, Dr. Daniel Keyser, Dr. Kristen Corbosiero and others) at the University at Albany (UAlbany) and operational meteorologists at the NWS Forecast Office in Albany, New York, as well as other NWS forecast centers and NOAA labs, CSTAR has been instrumental in transitioning critical research findings pertaining to warm- and cool- season hazardous weather into operations.

This presentation will review significant CSTAR contributions from research to operations and operations to research with direct operational application, as well as the impacts of the UAlbany-NWS partnership on the operational weather forecasting community and beyond. Some conceptual models from the warm and cool season CSTAR projects will be reviewed briefly with illustrative applications from area forecast discussions pertaining to high impact events over the past few years.

Bios for our Past CSTAR Students

Heather Archambault:

Heather Archambault received a masters and PhD in Atmospheric Science from U Albany and was a NRC Postdoctoral Fellow at the Naval Postgraduate School. She worked at NOAA Research in program and scientific management for four years before joining Citadel, an investment fund, in 2018. Heather is currently a senior weather analyst at Citadel in Greenwich, CT. I was a CSTAR student between 2002 and 2005.

Tomer Burg:

Tomer received his B.S. and M.S. degrees from SUNY Albany, with a thesis on Northeast US winter cyclone track forecast biases, and Ph.D. from the University of Oklahoma, with a dissertation on tropopause polar vortices and their linkages to cold air outbreaks, Arctic cyclones, and polar lows. He is currently the Atmospheric River forecast testbed facilitator at the Weather Prediction Center. Tomer is a weather analysis and forecasting enthusiast with an interest in most weather phenomena, and on his spare time is a programmer and web developer.

Brian Filipiak:

Brian Filipiak is a PhD Student in the School of Civil and Environmental Engineering at the University of Connecticut. His research focus is on improving winter weather forecasts and their impact on power outage modeling; additionally, he is the lead forecaster for the University of Connecticut Outage Prediction Model, which serves companies across the northeast and mid-Atlantic United States. Brian is also a recent recipient of the NASA Future Investigator Fellowship, which will focus of refining snow microphysics relationships using NASA observations and applying them to develop physically based snow density forecasts. Previously, Brian received a master's degree in Atmospheric Science from SUNY-Albany, where his CSTAR research focused on combing a variety of data sources with machine learning to enhance the forecasting of precipitation type across New York.

David Novak:

David Novak is the Director of the Weather Prediction Center. In this capacity he is responsible for the overall provision of national forecasts of rain storms, winter storms, and extreme temperature events up to a week in advance. The Center is a catalyst for collaboration among NWS forecast offices, and is interwoven into the national emergency response framework - enabling national readiness for extreme weather events.

David grew up in Minnesota, where weather extremes sparked his love of weather. David graduated with an M.S. in Atmospheric Science from SUNY Albany in 2000 – and was among the first CSTAR class. Throughout his academic and professional career, David has championed collaborative research, bringing operational needs to the attention of the research community and integrating promising research into operations. Dr. Novak is deeply involved in the ongoing NWS transformation of operations to optimize use of Science and Technology to enable enhanced partner support.

Bios for our Past CSTAR Students

Dan Thompson:

After earning my undergraduate degree at the University of Wisconsin–Madison in 2008 and working two years in the private sector, I attended UAlbany and pursued my Master's degree in Atmospheric and Environmental Sciences from 2010–2012. My thesis as part of the CSTAR program was on Appalachian Lee Troughs and their association with severe convective storms, with academic advisors Dr. Lance Bosart and Dr. Dan Keyser, and NWS focal points Tom Wasula and Matt Kramar. Following graduation, I worked as a meteorologist at NWS Detroit and NWS Albany from 2013–2023, and I am currently the Science and Operations Officer at NWS Marquette, MI.

Matthew Vaughan:

Matt attended Embry-Riddle Aeronautical University and graduated in 2013. He began graduate school as a CSTAR student the same year working on low-predictive skill severe weather events in the Northeast U.S. He transitioned to modelling for his Ph.D work at UAlbany, graduating in 2021. Matt spent two years as an assistant professor at St. Cloud State University in Minnesota before joining the 16th Weather Squadron in 2023 as a meteorologist. In his current position, Matt is active in the R2O space, weaving the latest research into products tailored for the unique mission space of the DoD.

Alicia Wasula:

Alicia Wasula is the owner of STM Weather (formerly Shade Tree Meteorology), a forensic meteorology firm based in upstate New York. She received her BS, MS, and PhD degrees in Atmospheric Science from the University at Albany (1998, 2001, 2005). After teaching both general education and upper-level meteorology and related science courses for several years, Alicia moved into work in the private sector at Shade Tree Meteorology in 2013. In 2016, she purchased the company from her then-boss as he moved into retirement, and continues to operate the company, now STM Weather, today. Alicia's primary focus is on providing scientifically sound, clearly communicated weather information to her clients. Additionally, she is often engaged in outreach events in her community, presenting seminars on meteorology topics to gardening clubs, students, and others. She is the author of 'Gardening With Your Head in the Clouds: A Weather Primer for Gardeners'.

NWS Transformation Update

Ken Harding
Chief Operations Officer
NOAA/NWS Headquarters Silver Spring, Maryland

NWS Transform is an initiative aimed at modernizing the National Weather Service's capabilities in delivering accurate and timely weather information. By utilizing advanced technologies and data science, it enhances forecasting accuracy and community resilience against weather-related events. The initiative fosters collaboration with stakeholders and integrates diverse data sources to improve decision-making. Ultimately, NWS Transform strives to make critical weather information accessible and actionable, promoting proactive disaster preparedness and response across various communities.

The Evolution of Snow Squall Science and Forecasting

Peter C. Banacos[1], Michael Colbert[2], Michael L. Jurewicz, Sr.[2], Josh Weiss[3], Dana Tobin[3,4], Andrew Lyons[5], Greg DeVoir[2], and Ashley Novak[6]
NOAA/National Weather Service Burlington, VT[1]
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Cooperative Institute for Research in Environmental Sciences/Boulder, CO[4]
NOAA/National Weather Service/Storm Prediction Center/Norman, OK[5]
NOAA/National Weather Service Wilmington, OH[6]

The word "squall" is a nautical term of Scandinavian origin describing a sudden, violent gust of wind. With the advent of synoptic analysis and weather radar, terms such as "squall lines" and "snow squalls" were gradually introduced into the language of 20th century meteorology, having important implications for land- and air-based transportation. Snow squalls are a type of mesoscale convective system that can often produce a rapid onset of brief, heavy snow, and gusty winds. The associated whiteout conditions, falling temperatures, and potential flash freeze conditions on roadways make snow squalls a transportation hazard and a threat to life and property. For forecasters throughout the 20th century, societal mitigation of these threats was limited by: (1) a lack of forecast precision, (2) inadequate means of communicating the dangers to highway travelers (i.e., the absence of a short-fused, winter-specific warning), and (3) a relatively limited scientific understanding of snow squalls.

Efforts to define, understand, and anticipate snow squalls and their impacts have increased markedly since the 1990s, ultimately leading to the deployment of National Weather Service Snow Squall Warnings (SQWs) in the winter of 2018-2019. From a scientific standpoint, older empirical techniques and single case studies have been replaced by indices based on composite analysis, an increased understanding of snow squall dynamics, and high-resolution modeling, which allows these mesoscale features to be better anticipated and visualized by forecasters. This presentation will review the evolution of scientific understanding of snow squalls. The evolution includes forecast tools such as the WINDEX technique, the Snow Squall Parameter, real-time analysis of flash freeze potential, utilization of WSR-88D data for snow squall detection, and experimental products such as the hourly Winter Storm Severity Index (WSSI-H).

Decades of Snow Squall Research Leads to Successful Warnings at WFO Mount Holly

Michael Lee and Cameron Wunderlin
NOAA/NWS/WFO Philadelphia/Mount Holly, New Jersey

The Northeast is no stranger to snow squalls, and Weather Forecast Office Philadelphia/Mount Holly is no exception. In the 2023-2024 winter season, the Mount Holly County Warning Area experienced four snow squall events. During these events, two WFO Mount Holly meteorologists operated the snow squall warning desk for the first time. Despite lacking previous real-world experience, these forecasters were able to rely on decades of research, training, and best practices to deliver timely and successful snow squall warnings, helping to keep the public safe on the roads. In total, the office issued 39 Snow Squall Warnings this past winter across four events, with 34 of these warnings attributed to the efforts of the two meteorologists as they navigated the snow squall warning desk for the first time. This presentation will share the experience of the two meteorologists issuing snow squall warnings for the first time, the research and best practices that guided them, and the leadership opportunities this experience provided to them.

Applications of Winter Mesoanalysis: Lessons Learned From The February 16-17, 2024 Winter Storm

Paul Fitzsimmons, Alex Staarmann, and Michael Gorse
NOAA/NWS/WFO Philadelphia/Mount Holly, New Jersey

The Philadelphia/Mount Holly (PHI) Weather Forecast Office (WFO) serves over 12 million people, including the densely populated urban corridor from Philadelphia northeast through Trenton and then on through Middlesex County, NJ. On February 16-17, 2024, a fast-moving area of low pressure tracked east-northeast (ENE) from the Texas Panhandle across southern Delmarva, bringing a large swath of accumulating snow to the County Warning Area (CWA). Most of the region received 1 to 4 inches of snow as forecasted; however, there was a narrow band where 6-12+ inches fell, just south of the I-78 corridor, across portions of the PHI WFO area of responsibility.

This study examines the synoptic and mesoscale features behind the system's heavy snow band. Despite early winter hazard warnings, the heavy snow band deviated northward from the forecasted locations. As a result, many of the warned zones either failed to reach warning criteria or received very short lead-time warnings. The forcing for the event included a potent mid-level shortwave, a strong upper-level jet streak of 150+ knots, and a collocated zone of strong mid-level frontogenesis.

This study evaluates the PHI office performance for this event and discusses how lessons learned can be applied to similar future events. Partner feedback indicated they were unprepared for the higher snow amounts and would have planned differently had they known these higher amounts were possible. However, guidance and early evening mesoanalysis signals suggested the formation of a strongly forced snow band. Learning from this event may help forecasters recognize signals earlier, providing partners with more preparation time. Despite minimal impacts this time, the outcome could have been significantly different had the event occurred 12 hours earlier or later.

Evolving The Weather Prediction Center's Winter Weather Desk

Tony Fracasso, Alex Lamers, and Frank Pereira
NOAA/NWS/Weather Prediction Center College Park, Maryland

The Weather Prediction Center's (WPC) Winter Weather Desk (WWD) has been operational for two decades. Over time, it has significantly expanded its products and scope compared to other focus areas of WPC such as Quantitative Precipitation Forecasts (QPF), medium range, and surface analysis. A brief overview of the history of WWD will first be presented. In its current state, the WWD is participating in a coordinated winter watch experiment with 32 WFOs across the CONUS this winter in addition to providing internal (to the NWS) deterministic snow and ice grids as well as probabilistic winter precipitation forecasts (PWPF). Related winter impact products include the Winter Storm Severity Index (WSSI) and a probabilistic WSSI (WSSI-P) which are derived from the official NDFD and WPC Super Ensemble (WSE), respectively, aim to link the forecast and potential hazards.

Looking to the future, the WWD will likely evolve along with the NWS in general to focus more on the impacts of winter weather and less on the grid production. Options for a future WWD will be presented. Topics to be discussed are: 1) the role of the forecaster in the gridded dataset production as well as within the probabilistic space, 2) the role of a National Center and locally-issued watches, and 3) recent verification of a new approach to a forecaster-modified winter ensemble.

Snow-to-liquid Ratio Prediction over the Northeast United States Using Machine Learning

Michael Pletcher[1], Peter G. Veals[1], Randy J. Chase[2], Steve Hilberg[3], Noah Newman[3], Andrew A. Rosenow[4], and W. James Steenburgh[1]
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Cooperative Institute for Severe and High-Impact Weather Research and Operations Norman, Oklahoma[4]

Winter storms impact populated regions across the continental United States (CONUS), resulting in travel and economic disruptions, loss of life, and damage to property and infrastructure. Snow-to-liquid ratio (SLR), or the depth of liquid water equivalent that results from a specified depth of snowfall, is used operationally to forecast snowfall amount during winter storms. However, no clear prediction method for SLR has been established and some operational SLR prediction methods were developed for specific regions, resulting in inaccurate snowfall forecasts in some cases.

Using over 20 years of Community Collaborative Rain, Hail, and Snow Network (CoCoRAHS) manual snowfall observations and European Centre for Medium-Range Weather Forecasts Reanalysis v5 (ERA5) vertical profiles, we trained a CONUS deterministic prediction system for snow-to-liquid ratio (SLR). A random forest (RF) algorithm framework was developed for SLR predictions. The RF training and testing datasets were varied by region and snow climate which were developed using k-means clustering, gridded snowfall climatologies, and geographic boundaries. Quantitative snowfall forecasts (QSFs) were then produced by applying quantitative precipitation forecasts (QPFs) from NOAA's High-Resolution Rapid Refresh (HRRR) and Global Forecast System (GFS) to the predicted SLRs. SLR forecasts and QSFs were also derived from several operational SLR prediction methods and compared with results from the RF. Verification was performed using the National Operational Hydrologic Remote Sensing Center (NOHRSC) snow analysis and the RF testing datasets. Depending on region and storm regime, SLR and precipitation forecast errors were examined as a function of temperature, wind, moisture, and elevation to determine storm environments that may have contributed to poor or accurate snowfall forecasts. The resulting prediction and verification system provides a template for improved snowfall forecasts across the northeast U.S. and improves upon current operational SLR prediction methods.

The 16 July 2024 Significant Severe and Tornadic Event across New York and New England Part I: Synoptic and Mesoscale Overview

Thomas A. Wasula and Neil A. Stuart
NOAA/NWS/WFO Albany, New York

On 16 July 2024, a widespread severe weather event occurred across much of upstate New York (NY) and portions of New England. A Mesoscale Convective Vortex (MCV) produced widespread wind damage and several tornadoes across central and eastern NY into New England. Eleven tornadoes occurred with ten tornadoes in NY, which is an anomalously high amount, as about nine tornadoes occur annually in NY based on climatology data from 1980 to 2023. Over 200 severe reports were recorded, with the majority being damaging winds of 50 knots (58 mph) or greater, and a few large hail reports (1.9 cm in diameter or larger) across NY, Massachusetts, Vermont (VT), Maine, New Hampshire, and Connecticut. Damage surveys classified microbursts near Lake George and Stewart Creek in Warren County, NY and Rupert in southern VT, with estimated winds of 70 knots (80 mph) to 78 knots (90 mph). The widespread wind damage included numerous downed trees, several homes with roof damage, and some collapsed structures. The NY Mesonet sites in Edinburg (Saratoga County) and Glens Falls (Warren County) recorded gusts of 63 knots (73 mph) and 76 knots (87 mph), respectively.

This presentation focuses on a detailed synoptic and mesoscale analysis of the unprecedented severe weather event. An MCV approached upstate NY and New England from southeast Ontario in the late morning. The air mass became moderately unstable ahead of the MCV, with mixed-layer CAPE of 1000-2000 J kg^{-1} and effective bulk shear of 35-50 knots based on the HRRR data. The 0-3 km storm-relative helicity values increased to 150-250 m^2s^{-2} across central and eastern NY. A Mesoscale-Convective System (MCS) formed, with embedded meso-vortices and supercells between 1800 and 2300 UTC. The tornado threat was enhanced by the meso-vortices with strong low-level helicity ahead of the MCS. Finally, this study will discuss applications of recent warm-season severe Collaborative Science Technology and Applied Research (CSTAR) results, illustrating how this high-impact event could have been forecasted in advance based on the high shear and moderate to high CAPE pre-convective environment.

The 16 July 2024 Significant Severe and Tornadic Event across New York and New England Part II: Radar Analysis, Warnings and IDSS

Neil A. Stuart and Thomas A. Wasula
NOAA/NWS/WFO Albany, New York

On 16 July 2024, a widespread severe weather event occurred across much of upstate New York (NY) and portions of New England. A Mesoscale Convective Vortex (MCV) produced widespread wind damage and several tornadoes across central and eastern NY and into New England. Eleven tornadoes occurred, with ten in NY – an unusually high number, as NY averages about nine tornadoes per year based on a climatology from 1980 to 2023. Over 200 severe weather reports were documented, the majority involving damaging winds of 50 knots (58 mph) or greater, along with a few reports of large hail (1.9 cm in diameter or larger) across NY, Massachusetts, Vermont (VT), Maine, New Hampshire, and Connecticut. Damage surveys classified microbursts near Lake George and Stewart Creek in Warren County, NY, and Rupert in southern VT, with estimated winds of 70 knots (80 mph) to 78 knots (90 mph). The widespread wind damage included numerous downed trees, roof damage to several homes, and some collapsed structures. The NY Mesonet sites in Edinburg in Saratoga County and Glens Falls (Queensbury) recorded gusts of 63 knots (73 mph) and 76 knots (87 mph), respectively.

During this event, output from convection allowing mesoscale models (CAMS), neural network and machine learning applications were available in real-time to provide guidance on the near-term evolution of the severe weather potential. These sources of guidance, including the Colorado State University Machine Learning Probabilities, the Warn-on-Forecast System, and the National Centers for Atmospheric Research Neural Network, aided in enhanced predictions of convective characteristics, mesoscale analysis, and warning operations. Considerations for some of the warning decisions will be discussed based on CAM output, radar analyses, and real-time reports. Finally, examples of social media posts and IDSS will illustrate how the various severe weather threats were communicated.

A Probabilistic Look at Forecasting the June 2024 Northeast Heat Wave

Todd Foisy
NOAA/NWS/WFO Caribou, Maine

A Northeast U.S. heat wave around June 19, 2024, resulted in many daily record high temperatures and heat indices topping 105°F in some places. Excessive heat warnings were in place for much of New England, with some places under their first-ever excessive heat warning. However, in most areas, temperatures didn't quite reach the levels forecast from the National Blend of Models (NBM) and the National Weather Service in the mid-range. The NBM max temperature percentiles were especially too warm, in part due to the contribution of the ECMWF/EPS, which was too warm in this and other heat waves.

Fire Weather in New York and New England

Robert Fovell
Department of Atmospheric and Environmental Sciences, University at Albany

Although easily overlooked, the Northeastern United States has a fairly large number of wildfires as well as a distinct fire season. The US Forest Service fire incident database (Short 2022) contains almost 67,000 records for the period of 1992-2020 for upstate New York State (NYS) alone. About half of these fires occurred in the spring season, between April 1 and May 30, with about half of those incidents coinciding with forested areas. While fires tend to be small (only 3% exceeded 5 acres in reported size), interannual variability is large, with 2005 and 2008 being recent very active spring seasons (about 3000 incidents each) and 2011 having been relatively quiet (about 500 records).

When fires do occur, they generally appear across NYS, suggesting they are responding to mesoscale to synoptic scale weather conditions. These fires do not appear to be aggressively warned. Between 2007-2023, the National Weather Service in Albany (ALY) issued only 23 separate Red Flag Warnings or Fire Weather Watches. 61% of those were in the month of April, and only one was not during the spring season.

To enhance situational awareness of wildfire conditions for public utilities in the Northeast, we are evaluating existing fire weather indices -- including the Canadian Fire Weather Index, the Santa Ana Wildfire Threat index (SAWTi), the Hot-Dry-Windy metric, etc. -- and formulating a new measure tailored to conditions in the New York and New England areas. Fuels components are being obtained from several sources, including NCAR's fuel moisture analyses and NCEI's NDVI product. Weather components of these indices can be computed using operational forecasts on the short and medium range and also efficient artificial intelligence weather prediction models such as GraphCast. As described in Brewer, Fovell, and Capps (2024), we have developed a methodology for using the WRF model to downscale GraphCast forecasts, which can further enhance the value of these skillful but relatively coarse resolution (0.25 degree latitude-longitude) predictions.

New York State Mesonet-based Fire Danger Rating System

D. J. McGuinnes[1], Nathan Bain[1], June Wang[1], Scott Jackson[2], Bryan Gallagher[2], Abigail Komrac[2], and Delaney Martin[2]
New York State Mesonet, University at Albany[1]
New York State Department of Environmental Conservation[2]

The New York State Department of Environmental Conservation (DEC) Division of Forest Protection (DFP) and Division of Air Resources (DAR) and NYS Mesonet (NYSM) at University at Albany collaborated on a project entitled "New York State Mesonet-based Fire Danger Rating System". The outcome of the project includes (1) replacing the DFP's 12-station Remote Automatic Weather Stations (RAWS) network with 127 automated, on-line, state-of-the-art weather stations at the NYS Mesonet; (2) automatically ingesting the NYSM data into the national Weather Information Management System (WIMS) and publishing regional fire danger rating products; (3) developing an internal website to automatically display maps of NYSM data, WIMS outputs and Fire Danger Rating Area (FDRA) with functions allowing the DAR Meteorologists to manually change the FDRA and publish the final FDRA map to be included on the DEC website; (4) developing a public website to publish both current and historical FDRA maps and information. In this presentation, we will give an overview of the project and demonstrate how the websites work. We are also looking for collaborations with others on more fire weather related research and development by taking advantage of the products and tools from this project.

The Influence of Atmospheric Rivers on Northeast United States Extreme Precipitation

Evan Belkin[1,2], Ryan Torn[1], Kristen Corbosiero[1], and Jason M. Cordeira[3]
Department of Atmospheric and Environmental Sciences University at Albany[1]
NOAA/NWS/Northeast River Forecast Center Norton, Massachusetts[2]
Center for Western Weather and Water Extremes, Scripps Institution of Oceanography, University of California San Diego, La Jolla, California[3]

Numerous studies have shown that the frequency and intensity of extreme rainfall events have increased significantly across the eastern United States over the past several decades. These extreme rainfall events can be attributed to a variety of meteorological phenomena such as back-building and training convection, extratropical cyclones, and landfalling tropical cyclones (TCs). While all of these events feature the poleward advection of moisture, it is yet to be determined how much of this moisture advection is in the form of atmospheric rivers (ARs). Furthermore, while there has been extensive research to gain a better scientific understanding of the role of ARs in West Coast extreme rainfall events, this research has yet to be expanded to include the East Coast of the United States. The primary focus of this research will involve evaluating the influence of ARs on heavy precipitation events across the eastern United States. Recent extreme rainfall events will be sorted by season, weather system (e.g., convective, TC, extratropical cyclone, etc.) and whether an AR was present. In depth case studies for these extreme rainfall events will be conducted using ECMWF Reanalysis v5 and archived radar data to gain a greater understanding of the seasonality of East Coast extreme rainfall and the forcing mechanisms responsible for them. Greater knowledge of the characteristics and frequency of East Coast ARs and heavy precipitation events will enable research to improve their predictability.

Factors Contributing to Catastrophic Flash Flooding in Vermont's Northeast Kingdom on 30 July 2024

Peter Banacos, John M. Goff, and Robert D. Haynes
NOAA/NWS/WFO Burlington, Vermont

Flash flooding remains a vexing forecast and warning problem, especially in situations devoid of surface boundaries, which often serve to organize rainfall on the mesoscale. One such challenging heavy rainfall and flash flood event occurred during the pre-dawn hours of 30 July 2024 across northeastern Vermont. An unseasonably strong, closed upper-level low produced slow-moving thunderstorms across Caledonia, Orleans, and Essex counties, resulting in localized catastrophic flash flooding. Post-event flood surveys conducted by NWS Burlington revealed that Morgan, Lyndon, and St. Johnsbury were among the hardest-hit towns. Rainfall amounts were climatologically extreme for Vermont, exceeding 6 inches across portions of three counties. Rainfall of 8.08 inches and 8.04 inches were reported by the St. Johnsbury cooperative observer (SJBV1) and ASOS (K1V4), respectively, over a period of approximately 5 hours, including 2.34 inches at K1V4 between 07-08 UTC (3-4 AM EDT). The SJBV1 value represents a one-day record rainfall for any official observing site in Vermont outside of Mount Mansfield. The St. Johnsbury rainfall also exceeded the 1000-year average recurrence intervals predicted by NOAA Atlas 14 for durations of 2, 3, 6, and 12 hours.

Though not anticipated more than a few hours in advance, the quick shift in focus operationally by NWS BTV midnight shift meteorologists resulted in excellent flash flood and river flood warnings. Meteorologists correctly recognized that the hydrologic response to the developing convective rainfall would be enhanced by antecedent high soil moisture and the significant flooding that had occurred in the same region on 10-11 July 2024. Seven flash flood warnings were issued, verifying with a 100% probability of detection, a 0% flash alarm rate, and an average lead time of 89 minutes to the first report of flash flooding. Two of the flash flood warnings utilized the "catastrophic" impact-based warning tag and "Flash Flood Emergency" wording. Combined with a phone call to Vermont's Urban and Swift Water Rescue team leader, these operational actions were likely instrumental in precluding deaths or significant injuries despite the destruction of 42 homes, 16 bridges, and dozens of washed out roads.

This presentation will discuss the synoptic and mesoscale environment leading to the heavy rainfall, including possible mechanisms contributing to the observed quasi-stationary character of the flood-producing thunderstorm activity. Notably, on 30 July 2024, the multi-radar multi-sensor (MRMS) "radar only" quantitative precipitation estimates (QPE) were only about half of the gauge data and the dual-pol rainfall estimates from the WSR-88Ds at Burlington, VT (KCXX) and Gray, ME (KGYX). For warning operations, the low-latency and frequently updated QPE via the 2-min MRMS is frequently used by WFO meteorologists. An assessment of the MRMS "radar only" QPE shortcomings and possible algorithm corrections will be discussed.

Heavy Precipitation Object Tracking and Forecast Tools

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Flash flooding events are a leading contributor to damages to property and threats to life by weather phenomenon. Heavy precipitation events that cause flash flooding are difficult to forecast due to a number of factors that models struggle to capture consistently. The National Weather Service's Weather Prediction Center (WPC) forecasters generate many products to communicate the potential of flash flooding. To create these forecasts, the WPC uses a large amount of raw and post-processed model data. In an effort to assist in this process and to communicate model uncertainty efficiently, forecast tools have been created to track precipitation objects within the model and observation data. Three tools have been developed to analyze uncertainty and trend within convective allowing models using an ensemble-based approach. They employ NCAR's Model Evaluation Tools Model Object Diagnostic Evaluation Time-Domain to identify and track precipitation objects throughout the model forecast. These tools evaluate forecasted precipitation on the hourly and sub-hourly time scales. Uncertainty of the location of the precipitation objects is communicated through the use of object data from historically relevant events. Finally, to improve the weather enterprise's capability to utilize these tools, a new web page is under development. This innovative web page will include a more user-friendly & interactive interface to easily interrogate the precipitation object tracking tools.

Flood Inundation Mapping (FIM) & National Water Prediction Service (NWPS): Training & Outreach

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The National Weather Service (NWS) hydrologic services underwent two significant upgrades within the past year that enhanced the NWS's core mission. First, in 2023, the NWS embarked on a multifaceted effort to provide Flood Inundation Mapping (FIM) services. Then, in early 2024, the National Water Prediction Service (NWPS) website replaced the legacy Advanced Hydrologic Prediction Service (AHPS) website and introduced new capabilities for displaying and using hydrologic information.

These new services required the training of operational staff, as well as educational outreach to partners. For internal staff, online training modules were utilized to familiarize them with FIM and NWPS. Additionally, a handful of Subject Matter Experts (SMEs) were trained on FIM. This education provided them with the knowledge to offer one-on-one FIM training to operational staff. This training consisted of a simulated exercise designed to teach meteorologists about FIM and how it can be used for Impact-based Decision Support Services (IDSS).

For external partners, NWS State College, PA (CTP) executed an extensive outreach campaign, primarily aimed at the emergency management (EM) community. A tailored informational packet was provided, containing historical FIM data. The historical data gave officials an idea of what FIM products would look like in their respective areas. Emphasis was placed on the experimental nature of FIM services and datasets, with assurances that CTP would be available to assist EM personnel.

CTP continues to collaborate with and educate external partners, and we will be revisiting a number of counties throughout FY24 to show the utility of NWPS and reiterate the usefulness of FIM, and to encourage feedback. Internal staff training will continue as well, with a focus on integrating FIM products and services into operations. CTP SMEs are also working through initial coordination for tabletop exercises with county and state-level groups.

How National Weather Service Flood Inundation Mapping (FIM) Performed During the April 2024 Ohio Valley Floods

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The public release of the National Weather Service (NWS) forecast-based Flood Inundation Mapping (FIM) offers exciting new possibilities for enhancing communication about river flood hazards and forecasts. By visually representing flood threats on maps, forecasters and users gain real-time and projected flood insights to support life- and property-saving decisions.

NWS FIM Services were officially launched in the NWS Weather Forecast Office (WFO) Pittsburgh area in October 2023. WFO Pittsburgh was one of the initial offices to publicly disseminate FIM services. Leading up to and just after the release, there was little opportunity to test these services in real-time. However, that changed in April 2024 when the upper Ohio Valley experienced its first significant flood event with the FIM services publicly available. Late-winter dryness quickly gave way to early-April rain, resulting in impactful stream and river rises across the upper Ohio Valley, with crests exceeding levels not experienced in nearly 20 years. Numerous requests for hydrologic support were made to NWS Weather Forecast Office Pittsburgh (WFO PBZ). In collaboration with the Ohio River Forecast Center (RFC), FIM reviews were completed through various methods, fulfilling the needs of NWS Core Partners.

Since this was the initial test of NWS FIM in the Ohio Valley, which contains numerous flood control reservoirs and navigational structures, several logistical and data-quality concerns needed to be addressed collaboratively by WFO PBZ, the Ohio RFC, and the National Water Center (NWC). Real-time fixes were also performed by the NWC Geo-Intelligence Division (GID) to address calculation errors that produced over-inundation in the City of Pittsburgh. This presentation highlights how WFO PBZ and Ohio RFC incorporated this new dynamic service into NWS flood operations and lessons learned from the event.

A Summary National Precipitation Forecast Skill and the National Forecast Informed Reservoir Operations Expansion Pathfinder Effort

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Forecast Informed Reservoir Operations (FIRO) seeks to improve the efficiency and effectiveness of reservoir operations by leveraging reliable and skillful meteorological and hydrological forecasts to inform water management decisions. FIRO aims to provide increased operational flexibility to optimize competing resource objectives within a catchment area, its reservoir, and regions downstream. While there are many physical, hydrological, environmental, and engineering considerations that make FIRO potentially viable versus impractical at any given reservoir and dam, the potential success of FIRO relies at least in part on the skill of quantitative precipitation forecasts (QPF) from numerical weather prediction and/or operational forecast guidance.

This study demonstrates that western U.S. watersheds in California, Oregon, and Washington exhibit on average the highest QPF skill based on the critical success index for extreme watershed precipitation days (quantified by mean areal precipitation values above the top 1% of wet days locally). Watersheds in New England and the Mid-Atlantic exhibit similarly high QPF skill but reveal a more rapid decrease in skill as lead times increase. When watershed QPF skill is averaged across U.S. Army Corps of Engineers (USACE) sites by district, the Sacramento, San Francisco, Seattle, Charleston (South Carolina), Portland (Oregon), Los Angeles, Baltimore, and New England Districts round out the top eight locations. The results of this study motivate further national QPF skill analyses as part of the "FIRO Phase III: National Expansion Pathfinder" effort to develop and apply a FIRO screening process nationally across the USACE portfolio of dams.

Impact-Based Decision Support Services by NWS Baltimore/Washington Following the Collapse of the Francis Scott Key Bridge in Baltimore, Maryland

Kevin Rodriguez
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A disaster occurred in the early morning hours of March 26, 2024, when the M/V Dali container ship struck a support column of the Francis Scott Key (FSK) Bridge in Baltimore, Maryland, causing the bridge to collapse into the Patapsco River. In the hours after the bridge collapse, National Weather Service (NWS) Baltimore/Washington meteorologists provided initial Decision Support Services to local and state-level first responders on the scene. In the weeks and months that followed, detailed 24-hour spot forecasts, seven-day hazardous weather briefings, three-day wind forecasts, and daily 24-hour hazards and tide forecasts were provided to the Unified Command and other local, state, and federal partners involved in the recovery effort.

The weather support provided by NWS Baltimore/Washington was critical in enabling recovery personnel to work quickly and safely to reopen a crucial waterway, thereby maintaining the nation's economy. This presentation provides an overview of the nearly three months of Impact-Based Decision Support Services that NWS Baltimore/Washington meteorologists provided in response to the collapse of the FSK Bridge in Baltimore, Maryland.

Improving Operational Decision-Making with Insights from Weather Partners

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New York State Division of Homeland Security and Emergency Services

New York State Office of Emergency Management (OEM) serves as the operational arm of New York State's Disaster Preparedness Commission (DPC) and is responsible for directing state agency and assets in response to emergencies. Operational decision making, based on the best available information, is central to doing this effectively. While New York State's public safety agencies often have access to great information to inform these decisions, there are other organizations that are able to supply insights that can improve decision-making.

Through relationships with partners at the Federal level (the National Weather Service), and at the University of Albany (the Mesonet program, the New York State Weather Risk Communication Center, and the College of Emergency Preparedness, Homeland Security, and Cybersecurity), OEM has access to real-time data, expert insights, and additional information to provide them decision advantage. As a result of these partnerships, OEM has been able to establish thresholds that trigger specific actions for preparedness and response efforts.

From emerging weather data to information on effective alerting and risk communication, partner relationships will not eliminate uncertainty for emergency managers, but can certainly help reduce it and make it more manageable. With fewer and fewer "blue sky days," and more serial crises and overlapping disasters, the need to leverage the knowledge and insights of those outside our organization will become more and more important.

Clear Communication, Safer Communities: Refining Heat Messaging in the Northeast

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The National Weather Service (NWS) is instrumental in delivering timely and potentially life-saving heat information to the public. However, our previous research has highlighted a significant challenge: NWS heat messages frequently include meteorological jargon, such as "heat index." Although these terms may be clear to forecasters, they can leave the general public and those most vulnerable to heat struggling to fully grasp the message. Message understanding is essential for encouraging protective actions; people cannot act on information they do not fully understand. This means that without clear, plain language, the public may be less likely to take necessary heat precautions, putting lives at risk. In this presentation, we will share findings from focus groups conducted across geographically and demographically diverse urban areas in the U.S., with a particular emphasis on the Northeast. These focus groups were designed to explore participants' understanding and interpretation of key heat-related terms used in NWS heat communications. We will recommend alternative messaging and language to enhance the clarity of heat information from forecasters and heat risk communicators in the Northeast.

Challenges Communicating Severe Weather Risk in Spanish

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As the National Weather Service (NWS) continues to promote the translation of weather forecast, warning, and outreach products into languages other than English, it is imperative to understand how those new tools are working. Translating technical scientific jargon, or terms that may not naturally exist in other languages, can be quite challenging, so user feedback is necessary to help improve NWS products. Past findings have indicated, for instance, that the initial NWS Spanish term chosen for "rip current" was misleading to speakers of certain dialects. This presentation will provide further insights into this translation issue by discussing the results of two follow-up studies, one assessing the new translated terminology chosen by the NWS, and another evaluating the efficacy of a Spanish rip current virtual reality simulation as an outreach tool. Finally, initial work on a new project aiming to enhance Spanish snow squall risk communication will be covered. All these projects indicate that progress is being made in conveying hazardous weather information to Spanish speakers, but continued improvements are necessary.

Improving the Understanding of Risk Perception and Communication in the New York City Area Through Surveys, New Partnerships, and Workshops

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Recent flash and coastal flood events around New York City and Long Island have demonstrated the need for effective communication of the hazard down to the community level. In particular, it is not clear how vulnerable populations obtain warning information and what actions they take. Also, emergency managers and community leaders need better tools to help visualize the hazard. To investigate the usefulness of visualization, we ran a workshop utilizing the Reality Deck (RD) at Stony Brook University. The RD is a unique visualization facility consisting of a large room with hundreds of computer monitors on all four walls that allow for an immersive experience at high resolution. Groups of emergency managers, community leaders, NWS meteorologists, and scientists were shown a simulation of storm surge flooding from hurricane Sandy (2012) in Jamaica Bay, New York. Additionally, they were shown future projections of flooding, factoring in future sea level rise, and an immersive 3D bird's-eye view of a flooded community. We also had participants interact with the flood maps through Augmented Reality devices (iPads) to overlay demographic, infrastructure, and evacuation route data. Participants were asked about their perceptions of flood risk, intentions to take protective actions, and ratings of vulnerability. This presentation will show and discuss some preliminary results of the RD workshop. This presentation will also discuss the flood risk perceptions among low income populations in New York City, and how community organizations in these areas communicate weather information to these populations. Semi-structured interviews (N~26) were conducted with local community organizations in NYC to understand how and if they communicate weather information to residents. These interviews were complemented by a survey of low income residents in NYC using online and in-person. These results showed that community leaders and organizations are often conduits for weather information. As a result, we are in the process of growing the Weather Ready Nation (WRN) around NYC, including a partnership list for a workshop to discuss challenges in some of the communities.

Riding Through a Floodscape: Studying the Intersection of Buses and Rainfall in Queens

Nicholas Lucchetto, Jase Bernhardt, Ramiro Campos, and Tiffany Cousins
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New York City experiences many extreme flooding events. One of the worst occurred on September 29, 2023, when 9.8 inches of rain fell in a single day. For the low-elevation borough of Queens, where 52% of people rely on public transit, the burdens of flooding are worsened by sparse subways and stranded cars. Therefore, buses are a critical mobility and safety tool during a weather emergency in Queens. This study looks at how flooding affects New York City bus performance and infrastructure, by incorporating metrics like bus delay data, precipitation records, and 311 reports. This study at Hofstra University helps uncover how—and where—a multifaceted climate event affects the daily life of Queens residents and how NYC buses keep on rolling amid our climate crisis.

Characterizing the Impacts of 2024 Total Solar Eclipse Using New York State Mesonet Data

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On 8 April 2024, a rare total solar eclipse (TSE) passed over western New York State (NYS), the first since 1925 and the last one until 2079. The NYS Mesonet (NYSM) consisting of 126 weather stations with 55 on the totality path provides unprecedented surface, profile, and flux data and camera images during the TSE. Here we use NYSM observations to characterize the TSE's impacts at the surface, in the planetary boundary layer (PBL), and on surface fluxes and CO2 concentrations. The TSE-induced peak surface cooling occurs 17 minutes after the totality and is 2.81C on average with a maximum of 6.8C. It results in night-like surface inversion, calm winds, and reduced vertical motion and mixing, leading to the shallowing of the PBL and its moistening. Surface sensible, latent and ground heat fluxes all decrease whereas near-surface CO2 concentration rises as photosynthesis slows down.

Creating Convolutional Neural Networks to Monitor New York State Mesonet Daytime Precipitation from Camera Images

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We developed a low-cost air quality sensor package to measure PM2.5, CO, O3, NO2, and NO. The package easily integrates into existing NYS Mesonet (NYSM) sites which provide power, communications, automated remote data acquisition, and in situ high-quality meteorological data. Prior to deployment at NYSM field sites, the low-cost sensors were co-located with reference grade instruments at the NYS Department of Environmental Conservation Queens College II monitoring site. Data collected during the co-location period were used to develop calibration algorithms (i.e., multiple linear regression and/or machine learning) for the each low-cost pollutant sensor. Finding robust calibrations that work over long periods (> 1 year) was challenging due to low-cost sensor environmental sensitivity (e.g., temperature, humidity, other pollutants), degradation, and drift over time. During spring and summer 2023, 38 packages were deployed at NYSM sites in the NYC Metropolitan Area, such that most sites have been operational for over a year. Using the calibrated data from the 38 NYSM sites, we will present preliminary spatiotemporal trends of air pollution from May 2023 to September 2024.

Surface Energy Balance Across the 18-site New York State Mesonet Flux Network

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The New York State Mesonet (NYSM) Flux Network consists of 18 NYSM sites that have been enhanced to measure components of the surface energy budget each 30 minutes (incoming and outgoing longwave and shortwave radiation, ground heat flux, and eddy covariance latent and sensible heat fluxes). To date, the network has produced over 100 site-years of flux data. A NOAA Joint Technology Transfer Initiative (JTTI) collaborative project between UAlbany and NCAR aims to use the flux site data to evaluate high-resolution forecast model output. Whereas typical metrics include standard meteorological variables such as 2m temperature and humidity, this project is focused on process-associated variables (i.e., fluxes) and land-atmosphere coupling metrics such as the Bowen Ratio. To ensure the accuracy and consistency of the flux site data, quality assurance flags and scores were assigned to each measurement and used to filter data prior to further analyses. Once quality controlled, the flux data are integrated with NYSM standard site meteorological data to create comprehensive quality-controlled datasets, complete with various flags for user discretion. Additionally, the quality-controlled radiation components, turbulent fluxes, and ground heat flux from each site were examined to identify diurnal, seasonal, and interannual variability to monitor the accuracy and consistency since the network's inception. Energy budget closure was found to be on average between 60% and 70%, with the highest and lowest closure in the summer and winter months respectively. By demonstrating the network's ability to deliver reliable estimates of energy balance components, the NYSM observational flux data can be a robust tool for evaluating land surface models such as Noah MP and coupled model systems such as the United Forecast System (UFS).

A 200-year-old database for climate change study from archives of the New York Academy System, New York State's (and the World's) first mesonet, 1826-1872

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It may be a surprise to many that today's New York State Mesonet (NYSM) has a largely forgotten historical antecedent. The early mid-nineteenth century New York Academy System network recorded a trove of meteorological data beginning in 1826 and spanning decades before it was subsumed by the nascent national system it helped inspire. This network's parallels with the NYSM apparently have not previously been recognized. In its initial phase (1826-1850), the Academy System comprised over 65 sites at academic institutions extending over two-thirds of all New York State counties. In 1850 it aligned with the new Smithsonian meteorological network, subsequently expanding to hundreds of sites in almost all counties. The core of this second phase spanned late 1850-1863, though included select observations through 1872. Climatological observations followed prescribed protocols (expanded in the second phase) using standard instruments issued to each site, and included air temperature (3x daily), precipitation and wind direction, observer notes of basic sky conditions, and during the second phase, barometric readings. The Academy System included many locations in rural settings, thus offering consistency with most sites in the modern NYSM, and also provided direct linkage of climatological observations to vegetation phenology, which has already been intensively studied (Fuccillo Battle et al., 2022). In sum, the network's archive, the first period of which is now scanned and available for digitization, represents a statewide, first-in-the-world, mesoscale representation of climatological conditions that extend historical observations back in time prior to the major atmospheric effects of the Industrial Revolution. We propose a collaborative study with NYSM and interested researchers to mine the multi-decadal trove of historical Academies observations to enable a series of studies comparing the pre-Industrial past with contemporary conditions, as represented by the first decade of observations (2014-present) recorded by the NYSM. Upon completion of data digitization and quality control checks, a host of analyses could be performed. Some examples include: 1) preparation of analogous data series from paired-site contemporary NYSM observations, matching time of day and event-duration characteristics; 2) assessment of station temperature means and extremes, diurnal temperature range changes and growing season length; 3) evaluation of urban heat island evolution and magnitude by comparing urban and rural locations across two centuries, to contrast conditions over a 10-fold increase in state population since 1826 and corresponding urban expansion; 4) generation of historic and present-day probability distribution functions of precipitation at paired sites to examine intensity shifts under the current warming climate; 5) generation of gridded interpolation products for assimilation into historical reanalyses; and 6) reconstruction of historic Plant Hardiness Zones during one of the coldest periods of the late-Holocene for contrast with present conditions. In this presentation we will detail the Academy System's development and data resources, examine challenges and opportunities in data processing leveraging experience gained during the now-completed vegetation phenological study, and explore the potential utilization of the modern NYSM as a climate change detection tool if contrasted with the Academy System observational archive.

Exploring Autumnal Heatwaves in Buffalo, NY using NYS Mesonet Data

Hannah Attard and Shivani Sookhai
Daemen University

Heave waves, loosely defined as multiple days of abnormally hot temperatures, are a public health hazard, especially when they impact regions unaccustomed to extreme temperatures. The timing, frequency, and magnitude of heatwaves varies by region, thus heat waves must be analyzed by location.

In the last decade, the global average temperature has risen about 0.2℃. Residents of Buffalo, NY have noted that, along with summer seemingly being warmer, the Fall has had unusual outbreaks of warm temperatures. These anomalously warm temperatures in the Fall impact students and educators who are in buildings that lack air conditioning through health concerns and non-ideal teaching conditions. Based on these colloquial observations, the aim of this study is to determine if, when, and how often autumnal heat waves occur in Buffalo, NY.

To explore Autumnal heat waves in Buffalo, NY, NY State Mesonet data was utilized for the entire period of record, 2017-2024. Heatwaves are defined as the daily high temperature anomaly with respect to the climatological mean high temperature of at least 5℃ for 2 consecutive days. The analysis showed that every year since 2017 has had at least one heat wave, except for 2019. Details about these heat waves will be explored in the presentation.

Systematic evaluation of assimilating ground-based remote-sensing profiling observations of the New York State Mesonet for forecasting of convection initiation events in New York State

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The New York State Mesonet (NYSM) is a unique state-operated network in the United States, comprising 127 weather stations across New York State, with 17 stations equipped with advanced profiling systems. This network integrates surface data with kinematic profiles from Doppler Wind Lidars (DWLs) and thermodynamic profiles from Microwave Radiometers (MWRs). These comprehensive, continuous observations from the surface through the lower atmosphere below 2.5 km support various applications, including air quality monitoring, human health assessments, severe storm prediction, and renewable energy forecasting. While a previous study showed the positive impact of assimilating the wind profiles from NYSM DWLs on prediction skill for a single case, this study uses multiple high-impact thunderstorm cases to statistically assess the observational impact of NYSM data assimilation with ground-based remote sensing profiling observations.

In this study, we selected multiple convection initiation cases in New York State in 2024. We will assimilate the surface station data, thermodynamics and wind profiles from NYSM and evaluate their observational impacts on the prediction of convection and related hazards (e.g., strong gusts, hail) using the Data Assimilation Research Testbed (DART) and the Advanced Research version of the Weather Research and Forecasting model (WRF-ARW). In addition to exploring the statistical impact of assimilating NYSM observations using various metrics for predictions, we will analyze the effect of assimilating the MicroPulse Differential absorption lidar (MPD) collected with the NYSM during the April 2024 Eclipse field campaign. These preliminary analyses will assess the impact of assimilating surface and profiling observations currently available from the NYSM, as well as evaluate the impact of potential complementary observations to NYSM.

Leaning Into Partnerships for Future Snow Squall Innovations

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The Weather Channel, Inc.[4]

As we look to the future, it will be important to tap into other sectors of the weather enterprise to expand education efforts, increase public understanding, and improve visualization of snow squalls. We'll discuss several exciting projects that are underway.

Virtual reality (VR) simulations have shown promise in promoting hazardous weather awareness. A snow squall VR simulation immerses the participant in a squall, while vividly depicting what happens when proper caution is not taken: a terrifying, chain reaction collision. This approach is deemed necessary given the complexity of snow squall collisions and the urgency of conveying safety best practices.

Weather Channel Graphics: Recent partnerships between the NWS and Weather Channel have resulted in a significant expansion of snow squall content. Graphics and educational segments will be aired during snow squall events to increase awareness and preparedness. There are also plans to develop an Immersive Mixed Reality (IMR) segment to depict a snow squall pileup.

Hard-Stop Notifications: Smart phones provide GPS map services with traffic data in real time. Working with the NTSB, FHWA, and cell carriers, we seek to devise a program that monitors phones traveling at speeds of 45+ mph. If two or three phones come to a complete stop or rapidly decelerate, then the program provides alerts to upstream phones moving in the same direction, alerting them of a potential accident or traffic ahead. This would be integral to get approaching drivers to slow down.

Snow Squall Social Science Research: IPPRA annually fields a national survey measuring public understanding and risk perception of various winter weather hazards. In 2023, 58.8% of survey respondents rated their understanding of snow squall warnings as "poor" or "fair" (numerically, a one or two on a five-point scale where five is the highest). Evidence suggests more work needs to be done to increase public awareness and understanding of snow squall warnings.

Snowed Under by Jargon: Erie County Residents' Views on Cold Weather Terms

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Cold weather, whether moderate or extreme, can be deadly. Some researchers have found that it causes a mortality rate four times higher than extreme heat. In 2022, a "once-in-a-lifetime" blizzard struck Erie County during the Christmas holiday. Known as the Buffalo Blizzard, it was the most severe winter storm in western New York since the Blizzard of 1977 (NOAA). Its unprecedented intensity left officials unprepared. Despite travel bans from the City of Buffalo and Erie County, as well as advisories from the National Weather Service, some of the victims were outside their homes during the storm. It's difficult to fully grasp the impact of severe winter storms on communities accustomed to them—Erie County had already experienced 81.2 inches of snowfall just a month before the Buffalo Blizzard. Understanding what succeeded and failed in the communication surrounding this storm can help improve future winter weather messaging.

The Winter Storm Severity Index (WSSI) is a tool created by the National Weather Service (NWS) to give a broad overview of the potential impacts and severity of winter storms. It aims to capture the range and intensity of winter weather effects across different regions. The WSSI was developed based on impact-based warnings and input from professional stakeholders. However, since the WSSI is relatively new, it has not yet been tested with the public, and little research exists on how people understand winter weather terminology.

To explore this, we conducted 11 focus groups with Erie County residents, including both lifelong locals and those new to the area. Participants were shown tweets sent during the Buffalo Blizzard and asked questions about their understanding of winter weather jargon (such as snow bands, lake-effect snow, wind chill), their interpretation of various winter warnings and advisories, and their grasp of health risks (like hypothermia) and protective measures (like driving bans, travel restrictions, and states of emergency). We then qualitatively analyzed the data to see how participants explained the meaning of specific jargon.

Several key findings emerged: (A) Winter weather terms are generally understood through their impacts. When participants were unfamiliar with the exact definitions of certain phenomena, they conceptualized them based on the effects. This pattern was seen in both locals and transplants, though transplants did this more frequently. (B) Warning and advisory language can be confusing, especially regarding cold weather advisories and extreme cold warnings. (C) While the severity of driving bans and advisories is usually clear, the interchangeable use of terms like "travel ban" and "driving ban" in official messaging leads to confusion. Participants offered a wide range of interpretations when asked to differentiate between the two. These findings, among others, will help shape a statewide survey on how people mentally process winter storm jargon.

The 22-23 March 2024 Snow and Ice Storm across the NWS Albany County Warning Area

Lee Picard, Neil Stuart, and Thomas Wasula
NOAA/NWS/WFO Albany, New York

A significant winter storm impacted the NWS Albany forecast area, covering eastern New York and western New England, on 22-23 March 2024. The storm produced a wide range of precipitation, from 10 to 20 inches of heavy snow over the southern Adirondacks, Lake George-Saratoga Region, and southern Vermont, to nearly 3 inches of rain across the Mid-Hudson Valley and Litchfield Hills of Connecticut. A zone of mixed precipitation yielded 0.46 inches of flat ice accumulation during 10 hours of observed freezing rain at Albany International Airport, resulting in significant societal impacts across the Capital District and neighboring Schoharie Valley. Nearly 100,000 customers lost power, particularly in the immediate vicinity of the City of Albany in Albany and Rensselaer Counties, where 3 to 8 inches of snow fell atop 0.25 to 0.75 inches of flat ice accumulation, downing numerous large trees and power lines. Snowfall rates of 1 to 2 inches per hour in the mid to late afternoon caused perilous travel conditions, accidents, and road closures, including the heavily traveled New York State Route 7 in Troy. Additionally, minor flooding occurred on the Housatonic and Still Rivers in northwestern Connecticut.

Uncertainty in the distribution of precipitation types, along with coincident winter and hydrologic hazards, posed significant forecast and messaging challenges for NWS meteorologists. Numerical guidance struggled to correctly predict the location and substantial amounts of accumulating ice in the Albany area, with a persistent cooling trend on the day leading up to the event dramatically changing the distribution of freezing precipitation. Observations from regional ASOS, New York State Mesonet, WSR-88D radar, and spotter reports were essential for updating snow and ice accumulations and expanding Winter Storm Warnings to include the Capital District. A retrospective on the forecast process, including lessons learned in forecasting and messaging, as well as verification statistics, will be presented.

National Grid – Planning Preparation, and Response to Icing Events

Jonathan Pease
National Grid

National Grid New York will be discussing the strategies on how we plan, prepare, and respond to specific events such as the referenced ice storm of March 2024 and the intricacies that come with this type of event specifically. Discussion of the planning subjects from the requirements we have from our regulators of the New York State Public Service Commission to the more fluid decisions of what we can have as deciding factors for each event as it relates specifically to weather and location. Considerations of what impact specifically this event would have to the area surrounding areas of the service territory and the ability to scope the timing of the event impacts to determine the resources needed to bring in to be staged.

Weather events of this magnitude have lasting impacts to all the electric utilities for every jurisdiction of NY, which the lessons learned cascade through the future responses of National Grid. Permanent fixtures of changes get applied because of every utility's response. National Grid will provide perspective for some examples of these previously learned best practices which have been applied to our regular storm responses and how preparation to these large events have become more intuitive from the lessons as learned from the 2008 icing event. Presentation of some key weather details that National Grid seeks before a winter weather event, particularly freezing rain, to decide if extra staff is needed or if it needs to stage resources. Communications between all the weather partners that could strengthen the relationship of forecasts and the actual event impacts.

Evaluating Tools for Diagnosis and Nowcasting Precipitation Type and Freezing Rain: Results from the 3–4 February 2022 Winter Storm in the Hudson Valley

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Accurate prediction and diagnosis of winter precipitation type (p-type) and freezing rain accumulation is important for mitigating and responding to impacts on aviation, road transportation, power generation and distribution, winter recreation, ecology, and hydrology. Traditionally, airport station observations and manual observations from citizen scientists provide some of the primary datasets used in operational diagnosis of p-type and freezing rain for situational awareness and nowcasting. However, these datasets can have significant limitations in terms of spatial coverage, data quality, and/or latency. Recently developed and emerging tools may augment these traditional observations by providing complementary data and diagnostics that fill gaps and build confidence.

This study evaluates the utility of such tools in the context of a challenging to forecast and impactful winter mixed p-type event that affected the Hudson River Valley of New York State on 3–4 February 2022. Impacts from this event included prolonged power outages resulting from highly localized freezing rain accumulations of up to 0.75 inches (flat ice), which prompted the declaration of a state of emergency in Ulster County. The observations and diagnostic tools evaluated here include profiling radar and radiometer observations, diagnostic products from New York State Mesonet stations, gridded p-type and freezing rain analyses informed by NWP and NEXRAD radar observations (the Spectral Bin Classifier and the Freezing Rain Accumulation National Analysis), and a machine learning based p-type diagnostic. The strengths and weaknesses of each tool, synergies between them, and potential utility in forecasting operations will be discussed.

Climatology of Precipitation Features within the Cyclone Comma Head and Some Comparisons with WRF

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Snowbands and other organized precipitation structures are common features found in winter storms, and these features can lead to societal impacts. Past studies of the precipitation objects in the cyclone comma head have been limited to subjective (manual) analysis and case studies. We have conducted an automated climatology of precipitation structures within the comma head using over 20 years of composite radar data. This approach and results will also be useful for model validation of these structures, to improve forecasting of these events.

A new algorithm is used to identify precipitation structures in extratropical cyclones, building on work done by Ganetis et al. (2018). Composite radar over the Northeast U.S. and adjacent coastal waters from 1996-2023 is used to quantify the distribution of precipitation objects in terms of length, aspect ratio, and area in a cyclone relative framework. ERA-5 reanalysis is used to compute the thermodynamic and kinematic environment. Following, the WRF is run for 20 cases between 2018 and 2024, overlapping with the Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) campaign, to generate a model distribution of precipitation objects. Two IMPACTS cases from 2022 and 2023 will also be highlighted.

In the 1996-2023 climatology, there is a broad distribution of precipitation objects sizes, thus no clear separation between primary and multibands as defined in previous studies. Larger bands are coincident with mid-level frontogenesis and slantwise instability, while upright instability is more common in regions of more amorphous bands or cells. The frontogenesis signal is strongest for objects to the north of the cyclone center. Preliminary results also show that WRF lacks mid-sized precipitation features, and they are more amorphous than their MRMS counterparts. This is seen especially during the 23 January 2023 case, in which WRF was found to have a lower probability of objects 700-5000 km^2 in size.

Evaluation of WRF precipitation simulations for storm Ida over New York City Using NY/NJ Mesonet

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The objective of this research is to improve the forecasting of extreme rainfall events in urban areas by utilizing the Weather Research and Forecasting (WRF) model. We employed a three-tiered nested domain approach with spatial resolutions of 9 km, 3 km, and 1 km to downscale the ERA5 reanalysis output during Superstorm Ida over the New York City Metropolitan area. WRF was initialized using ERA5 forecasts from August 30 to September 1, 2021, at six-hour intervals, generating ten different simulations over a 120-hour forecast period.

After transitioning from a tropical system, Ida evolved into an extratropical system, influenced significantly by interactions with an Atlantic frontal system. These dynamics sustained Ida's convective potential, resulting in substantial precipitation events over the Northeastern US. Utilizing the WRF model, our goal is to reproduce the atmospheric conditions fostering this convective behavior from historical forecast data. To ensure a robust comparative analysis, historical station records were sourced from three weather station networks: the National Centers for Environmental Information (NCEI) of NOAA, Mesonet NY, and Mesonet NJ.

Seven statistical metrics were employed to critically assess the models' outputs against on-the-ground measurements. These metrics encompassed parameters such as the time and magnitude difference between precipitation peaks, and the Kling-Gupta Efficiency. To enhance the spatial validation of the WRF simulations, cumulative rainfall maps were juxtaposed against Multi-Radar/Multi-Sensor System (MRMS) data. Specifically, WRF showcased enhanced KGE values across varying simulations lead times.

After identifying the best schemes using ERA5, the model's performance deteriorated when it was initialized with GFS forecast data. This demonstrates a notable improvement in both the timing and intensity of precipitation, offering a more accurate representation of rainfall patterns and their magnitudes.

Overall, the research underscored WRF's potential to substantially augment early warning systems and drive regional flood models which makes it a candidate for an integration in the operational Stevens Flood Advisory System that uses meteorology from global models. This work sets a precedent for blending Mesonet observations from two distinct networks for a comprehensive assessment of weather forecast throughout the NYC metropolitan area, promising enhanced stakeholder engagement and enriched weather and climate communication. At present, this model is operating at an operational capacity, providing real-time forecasts for extreme rainfall events. Its integration into operational systems allows for continuous monitoring and timely predictions, ensuring that it can be leveraged for immediate decision-making and early warning applications in urban settings.

Improving the Quality of the NYS Mesonet Microwave Radiometer Data with a Novel Bias Correction Scheme

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Temperature retrievals from Microwave radiometers (MWR) suffer from systematic bias due to instrumental calibration issues and errors in the retrieval algorithm. In this study, we developed a novel bias correction (BC) scheme that can effectively correct the systematic cold bias in the temperature retrievals from the MWR; deployed as a part of the New York State Mesonet (NYSM) Profiler Network. This BC procedure uses the observed brightness temperature from the MWR as the main predictor to model the systematic bias in the temperature retrieval using multiple-linear regression. Because the brightness temperature channels contain information on the atmospheric conditions at different height levels, the BC scheme can adjust the predicted bias at each level based on the concurrent weather conditions.

Verification based on independent radiosonde soundings during the 2024 eclipse event at Belleville, New York shows that the BC scheme not only can effectively remove the cold biases present in the NYSM MWR temperature retrievals throughout the lower- and mid-troposphere, but also reduces the standard deviation of the temperature error by about 10-15%. Compared to uncorrected data, the bias-corrected temperature profile shows a clearer collapse of the planetary boundary layer during the eclipse totality and is more consistent with the lidar observations. The near-surface temperature data also better matches the surface station measurements. These results demonstrate the effectiveness of the bias correction scheme in correcting the systematic bias in the NYSM MWR temperature retrievals and improving the data quality.

The Southern Ontario Lidar (SOLID) Mesonet: Impacts on Aviation and Severe Weather Nowcasting

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There exists a demonstrated need for enhanced measurements of vertically-resolved meteorological parameters for nowcasting and to evaluate and enhance the performance of numerical weather prediction (NWP) systems. This is particularly true in urban areas where there exists a lack of upper air observations. To address this need, Environment and Climate Change Canada (ECCC) established the Southern Ontario Lidar (SOLID) Mesonet in and around Toronto. Seven Doppler lidars and one water vapour Differential Absorption Lidar (DIAL) provide real-time observations of aerosol backscatter, cloud base height, vertical wind and water vapour profiles, and the planetary boundary layer (PBL) height to aviation and operational weather forecasters. SOLID is designed to complement an adjacent profiling Mesonet, The New York State Mesonet. These two Mesonets are a primary source of upper air observations for the mixed rural / urban region they encompass, inhabited by 26+ million people.

As part of an ongoing impact analysis, this project will assess the potential of these profiling instruments to improve nowcasting and data assimilation efforts. A multi-year evaluation of Doppler wind lidars demonstrated excellent performance with small averaged differences (< 0.27 m/s) to co-located radiosondes. Several case studies demonstrate the impact of the Mesonet's observations, particularly for aviation nowcasting and severe weather (e.g., convective initiation). In one case, a passing cold front resulted in a sudden and extreme wind shift of ~180o within 10 min, affecting aviation operations at the Toronto Pearson Airport. It is envisioned that the improvement in knowledge of the state of the PBL will improve forecasters' situational awareness, provide near real-time analysis for automated nowcasting systems, and enable more in-depth verification of NWP forecasts.

Combining Low-Cost Air Quality Sensors with the New York State Mesonet for Fine-Scale Monitoring in New York City

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The New York State Mesonet (NYSM) standard sites capture images at a five-minute temporal frequency in 126 locations across New York State. The National Weather Service uses these cameras to monitor precipitation, especially in less populous areas. While these can be monitored via the camera viewer on the NYSM website, this requires human attention and many man hours to monitor. A Convolutional Neural Network (CNN) machine learning algorithm is used as an image classification tool to automatically monitor these stations to reduce human load. This project uses Explainable Artificial Intelligence (XAI) methods of labeling codebooks and inter-coder reliability to create datasets of labeled images for NYSM sites, which are co-located with ASOS sites. CNNs from multiple specific NYSM sites will be shown, as well as a generalized CNN for all labeled sites. Initial site-specific results, which train on one camera site and validate on a different camera site, have shown training accuracies above 90% but fail to generalize well through validation data on other camera sites. A generalized model is expected to perform with less accuracy, but future work about methods to improve generalizability will be discussed.

Improving Mesoscale Model Forecasts for Daily Weather Analysis in New York City

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Accurate and timely weather forecasts are essential for the efficient operation of complex urban environments like New York City (NYC). This study aims to evaluate the performance of mesoscale models in simulating and operationally predicting weather conditions within a major urban area, using NYC as the case study. The fully urbanized Weather Research and Forecasting (uWRF) model version 3.9, coupled with the Building Effect Parametrization and Building Energy Model (uWRF BEP+BEM) and the Mellor-Yamada-Janjic (MYJ) planetary boundary layer (PBL) scheme (hereafter referred to as uWRF), was used for this analysis over a seven-year period (2017-2024) at a spatial resolution of 1 km. For the operational forecast tool, the uWRF model has been upgraded to version 4.2, with BEP+BEM now coupled to the Mellor–Yamada–Nakanishi–Niino (MYNN-3) PBL scheme. The model provides both weather and energy demands simultaneously. The operational forecasts are executed once daily, initialized using the 00-UTC North American Mesoscale (NAM) forecast, and run for an 84-hour lead time, with each day simulated at least three times. Diagnostic weather variables and energy consumption data are generated at each time step, and verification of various weather parameters has been carried out.

This study presents a long-term assessment of forecast performance and zoom-in into two heat wave (HW) cases and two extreme precipitation (EXP) cases: (a) July 21, 2022 (HW) and (b) August 12, 2020 (EXP) using uWRF 3.9, and (c) July 16, 2024 (HW) and (d) August 6, 2024 (EXP) using uWRF 4.2. For both the HW and EXP cases, daily 2m temperature and daily precipitation forecasts from both models were compared with Mesonet data at the Manhattan station (73.97°W, 40.77°N). For the HW cases, total energy demand for New York City is compared against NY Independent System Operator (NYISO). Results indicate that the uWRF 4.2 model shows significant improvement in forecasting temperature, precipitation and energy over the city compared to uWRF 3.9 both for long range and extreme weather events. For heat wave events, the correlation between the model outputs and Mesonet data increased from 0.4 (uWRF 3.9) to 0.9 (uWRF 4.2), while the mean square error (MSE) decreased from 48.3°F to 13.2°F. However, for precipitation, the improvements were more modest. The correlation between the model outputs and Mesonet data increased from 0.45 (uWRF 3.9) to 0.58 (uWRF 4.2).

Innovative Geospatial Tools and Technologies To Empower NWS Service Equity Success

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The National Weather Service (NWS) is embarking on a dedicated effort to provide its preparedness efforts, data, forecasts, warnings, impact-based decision support services (IDSS), and other services in a more equitable manner. The overall goal is to ensure timely and actionable weather, water, and climate information is provided to all communities, with a specific focus on underserved and vulnerable populations (UVPs). Reorienting the agency to broaden its capacity to engage with all communities will require both operational changes and focused outreach and education efforts. Field offices are at the forefront of this change, as they most directly and frequently interact with local communities. Understanding the unique characteristics of the people they serve is one of the most important steps in connecting with their communities and building new relationships. However, easily-accessible datasets to assess community characteristics and robust methods to track community engagement are not widely available to NWS field office employees.

In response to these needs, the NWS Social Vulnerability Impact Assessment Tool (SVIAT) was developed and is being deployed across the agency. This web-based ArcGIS Online application serves as an interactive repository of various geospatial datasets and social vulnerability indices that empower NWS employees to learn more about the nuanced challenges their communities face. The goal of making this data available to field office personnel is to have more equity-informed outreach and education interactions, leading to new partnerships and increased trust within their communities. The SVIAT also features a reporting mechanism for these interactions, which improves on the legacy NWS Outreach and Education Event System (NOEES) by adding a geospatial component and other details to the engagement record. By seeing where interactions were performed in the past, field offices will be able to make concerted efforts in planning future outreach activities to ensure effective engagement with as many communities as possible. Finally, the tool will encourage investigation of the unique characteristics of local communities that are not captured by Census-derived vulnerability indices. In short, increased experience-based knowledge coupled with an improved understanding of the challenges communities face, will lead to informed future interactions resulting in more equitable, accessible, and actionable services from the NWS. The SVIAT will become operational in the NWS through 2025, afterwards it will be integrated into NWS Connect, the agency's interactive, growing toolset for IDSS and Community Engagement.

Language Program in the National Weather Service: How It Started and Where It Is Going

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The National Weather Service (NWS) continues to improve its products and services that help to fulfill its mission of "providing weather, water and climate data, forecasts, warnings, and impact-based decision support services for the protection of life and property and enhancement of the national economy." Starting at the San Juan forecast office and the National Hurricane Center, language translation of weather alerts and forecasts has been going on at on a limited basis for many years, with more local offices recently joining an experimental project. An internal NWS Assessment conducted in 2023 identified seven barriers to achieving Equitable Services for a Weather-Ready Nation, and one of these barriers was Language. It states that "most NWS operational services (forecasts and warnings), as well as education and outreach materials, are conveyed exclusively in English. This leaves non-English and English as a Second Language speakers unable or compromised in understanding and acting on the valuable weather information we provide."

In the summer of 2023, the NWS created a new position, the Language Program Lead, within the Office of Science and Technology Integration (OSTI), Social, Behavioral, and Economic Sciences (SBES) Program. This position seeks to increase the access, reach, and comprehension of the products and services provided by the NWS in languages other than English. This presentation will highlight the main efforts completed by the NWS as well as the potential future endeavors planned by the Language Program Lead and SBES Program to continue expanding language products and services to ensure equitable services for a Weather-Ready Nation. This presentation concludes with a proposed language strategy to establish best practices for the NWS.

Weather in More Languages: The NWS Translation Project at WFO New York, NY

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The New York, NY office of the National Weather Service (NWS) serves a diverse population of 19.4 million people, including almost 9 million people in New York City (NYC) alone. Within NYC, almost 200 different languages are spoken, and nearly 1.7 million people are considered to have Limited English Proficiency, meaning they speak or understand English less than well. This presents a significant challenge for effectively communicating life-saving weather information as NWS products are disseminated predominantly in English, with only limited translations available in Spanish. The need for additional translations was underscored in September 2021 when catastrophic flooding from the remnants of Hurricane Ida resulted in 13 fatalities in New York City; the majority of the victims were of Asian descent and either did not speak or had limited proficiency in both English and Spanish.

Since Spring 2023, NWS New York, NY has been a pilot office for the NWS Translation Project. This project aims to train an Artificial Intelligence (AI)-based language model to translate NWS text products, including watches and warnings, into multiple languages to help bridge language-based accessibility gaps in obtaining critical weather information. As a pilot office, NWS New York, NY is currently using this model to automatically translate products into Spanish, Simplified Chinese, and French. This presentation will provide a brief history of the NWS's translation efforts, outline the goals of the AI-based translation project, and discuss challenges encountered in providing these translations to the communities that need them most.

The Potential to Improve Efficiency in Operational Meteorology With Generative AI

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The National Weather Service Generative AI (GenAI) Team is a specialized subgroup of NWS Science and Operations Officers and Regional Meteorologists within the broader NOAA/NWS AI Strategy Group. The team is uniquely positioned to explore, document, and integrate generative AI technologies into operational meteorology, hydrology, and climate practices at local weather forecast offices and regional centers. By leveraging AI's potential, the SOO-DOH Generative AI Team aims to increase operational efficiency and improve the accuracy and timeliness of weather-related insights.

Key initiatives include creating AI-informed tools for operational meteorologists and enabling real-time translation of weather information, such as social media posts and formal weather briefings, into multiple languages to reach non-English speaking populations. Additionally, the team is developing recommendations on workforce training on AI and collaborating with other NOAA entities to ensure ethical and secure AI integration across NWS operations. This presentation will outline the team's activities to date and future initiatives.

Understanding Frequent Lightning Environments over the NWS Albany, NY County Warning Area

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Thunderstorms that produce excessive lightning are hazardous to the public, with impacts including: property damage, tree damage, and even loss of life. Emergency management partners responsible for public safety during large outdoor gatherings rely on NWS meteorologists to identify convective environments that support lightning and assess their level of confidence. If frequent lightning is expected, forecasters can include enhanced language in warning products while providing decision support to raise situation awareness and facilitate partner decision-making. This research expands upon an earlier study that analyzed the NCEI NLDN archive of cloud-to-ground lightning strikes from 2008 to 2017 to build a database of frequent lightning days. Environmental parameters, including instability, temperature, moisture, and shear, were assessed at convective initiation using RAP numerical weather model output via BUFKIT for each date. This initial study documented 60 “frequent lightning” cases, defined as a calendar day with 5,000 or more lightning strikes across the NWS Albany County Warning Area.

With the assistance from University at Albany student volunteers, 13 additional frequent lightning events from 2018 to 2023 were analyzed using the same methodology as the previous study. These results were then combined with the findings from the initial study to create a comprehensive climatology of all 73 frequent lightning events.

It was hypothesized that frequent lightning events would occur in moisture-rich environments and support very tall updrafts. However, 700-500 mb lapse rates only ranged from 5.8°C/km to 6.4°C/km, with the 90th percentile reaching as high as 7°C/km. Precipitable water values predominately ranged from 1.45 to 1.85 inches, with only a small subset exceeding 2 inches. Additionally, freezing heights ranged from 11 kft to 13 kft and -20°C heights were mainly confined between 22 kft and 24 kft. Another interesting result was that effective shear values remained rather low, generally between 22 and 36 knots, which typically favors pulse-type rather than organized convection. Finally, normalized CAPE values were found to be a key indicator of frequent lightning days, with values at or above 0.16 on nearly all frequent lightning days, while days with the highest lighting counts had values exceeding 0.20.

These results can help forecasters assess whether future convective environments may be capable of producing frequent lightning, thereby improving forecast confidence and messaging to partners.

Multiple Tropical Cyclone-Baroclinic Trough Interactions over the North Atlantic Ocean during September 2023

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This is a story about how relatively weak western North Atlantic tropical cyclones can result in extensive flooding from extremely heavy rainfall over parts of East Coast urban areas and adjacent Atlantic Canada and then move eastward across the North Atlantic Ocean and produce further damage from high winds and heavy rain over the United Kingdom. North Atlantic (NATL) Tropical Cyclones (TCs) Lee, Nigel, and Ophelia in September 2023 were all associated with significant weather impacts. TC Lee brought heavy rain to Nova Scotia, weakened after landfall, became associated with an inland coastal front, underwent extratropical transition (ET), and caused heavy rain and flooding in the UK on 19–20 September 2023. TC Nigel recurved poleward over the subtropical NATL, underwent ET over the central NATL, became a "bomb cyclone", and produced widespread high winds and heavy rains over parts of the UK as its remnants were ingested into a broad extratropical gyre cyclonic circulation.

TC Ophelia moved poleward along the US East Coast, weakened into a post-tropical cyclone (PTC) over eastern Virginia, stalled and subsequently dissipated. PTC Ophelia was associated with exceptionally heavy rains in the Middle Atlantic region. Two mesoscale frontal waves (MFWs) formed over the western NATL along a warm front that extended southeastward from PTC Ophelia. One of these MFWs moved eastward across the NATL, intensified into a "bomb cyclone" and brought hurricane force winds, heavy rains, and flooding to the UK where it was renamed "Storm Agnes". We will focus on how the interactions of TCs Lee, Nigel, and Ophelia with individual baroclinic upper-level troughs resulted in multiple "flavors" of ET over the NATL Ocean.

An Evaluation of Precipitation Estimates Associated with Ida in the Northern mid-Atlantic Region for a Forensic Case

Michael Evans
STM Weather Cropseyville, New York

Heavy rains associated with tropical cyclone Ida brought flooding to the northern mid-Atlantic region on September 1st, 2021. STM Weather has been contracted to evaluate meteorological conditions associated with the flooding and property damage in New Rochelle, New York, approximately 20 miles north of New York City. Included in our analysis is an evaluation of storm-total rainfall and rainfall rates that occurred during the storm. STM evaluated observed rainfall from numerous rain gages in close proximity to the incident site, along with rainfall estimates from the multi-radar-multi-sensor (MRMS) system. An analysis of rainfall from NOAA's National Water Center, which incorporates MRMS estimates along with human-based adjustments, was also evaluated. This presentation gives an overview of our analysis, and compares rainfall estimates from these various sources.

Hurricane Ida made landfall on the Gulf Coast and transitioned to an extra-tropical low-pressure system as it tracked northeast toward the mid-Atlantic region from August 30th to September 1st. The center of Ida tracked across central New Jersey to the southeast of New England, resulting in a band of extremely heavy rainfall across northern New Jersey and southeast New York, including the New Rochelle, New York area. Rain gages from ASOS, Cocorahs and New York State Mesonet networks located within this band indicated rainfall totals of 6 to 8 inches on September 1st through early on the 2nd. Rainfall within the heaviest rain band fell continuously for several hours during the afternoon through the evening on the 1st, with a period of extremely heavy rainfall occurring from approximately 8 PM through 10 PM. Comparisons between the rainfall measured by the rain gages and rainfall estimated by the MRMS system indicated that the rainfall was underestimated by the MRMS within this band. Radar estimates within this band appeared to be near or higher than gage measurements, but the MRMS system appeared to over-correct this bias, resulting in estimates that were too-low. In addition, there did not appear to be any improvement between initial MRMS estimates based on immediately available gages, and a second pass based on adding data from gages that became available later. Finally, estimates from the National Water Center were similar to the radar estimates, and were too-high.

Rainfall to the north of the heaviest rain band was continuous, but much lighter than the rainfall that occurred within the band on the 1st. For these locations, the MRMS and water center estimates were just slightly lower than the gage measurements. The MRMS system appeared to work as expected at these locations; the initial radar estimates were less than the gage measurements, but the gage-based corrections raised the estimates to values very close to the gage measurements.

Rainfall to the south of the heaviest rain band was more convective in nature than at locations farther to the north. At these locations, the MRMS and water center estimates both overestimated rainfall, based on comparisons with the gage measurements. The largest overestimates were made by the water center. Once again, the MRMS system appeared to work as expected at these locations; the radar estimates were higher than the gage measurements, but the MRMS system appeared to use gage data to adjust its estimates downward.

The Destructive Flooding Events of August 18-19th, 2024

Matthew Wunsch and David Radell
NOAA/NWS/WFO New York, New York

Forecasting and communicating the threat of impending meso- to storm-scale excessive rainfall events continues to be a top challenge for Weather Forecast Office (WFO) New York (OKX). These events, which occur over relatively short spatiotemporal timescales, can result in extensive impacts including loss of life. On August 18th and 19th, 2024, two significant Flash Flood Emergency-level events occurred within the WFO OKX County Warning Area over a 12 to 18 hour period; one in southwestern Connecticut and the other on Long Island in southeast New York. Both events had Annual Recurrence Intervals (ARIs) exceeding 1,000 years with localized precipitation amounts reaching 10-13 inches, resulting in catastrophic impacts across each area. This presentation reviews the synoptic, mesoscale, and storm-scale features that contributed to the development of these events. A timeline of forecasts, warnings, and Impact Based Decision Support Services (IDSS) from WFO New York, NY will be presented, along with an analysis of the radar operator's decision-making process during the event. Finally, the on-the-ground impacts, including two dam breaks, will be discussed.

Model Review of the Historic Flash Flood Events of August 18-19, 2024

David Stark and David Radell
NOAA/NWS/WFO New York, New York

Two significant flash flood events occurred during the day and evening of August 18-19, 2024, resulting in three fatalities in Connecticut. A stationary boundary with a series of weak low pressure systems moving northeast within a tropical air mass, generated excessive rainfall across the Tri-State area. Over a 12-18 hour period, two 1000-year precipitation events resulted in destructive flash flooding near Oxford, CT and Stony Brook, NY on Long Island. Localized total precipitation amounts of 10-13 inches were observed across these two areas, with precipitation rates exceeding 3-4 inches per hour.

Model guidance leading up to the events forecasted a widespread 1-4 inches of precipitation over the impacted areas, with some convective-allowing models indicating nearly 5 inches across southwest CT. However, these excessive rainfall amounts were either displaced out of the area or lost entirely in subsequent model runs. This presentation will discuss the operational model guidance used by the NWS New York forecast staff leading up to and during the events. In addition, an examination of NSSL's Warn-on-Forecast (WoFS) and NCEPs new Rapid Refresh Forecast System (RRFS) output, which were run retroactively for these events, will be examined.

Poster Abstracts

Relating CO_2 exchanges to time series at New York State Mesonet flux stations

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Surface layer concentrations of important scalars can yield information about surface exchanges. We estimate fluxes from previously overlooked details in the surface scalar time series, as a precursor to obtaining flux information from a network of only surface state observations using boundary layer budgeting (Fitzjarrald, 2004).

Ecosystem respiration continues regardless of wind speed. During low-turbulence conditions, the eddy covariance flux method is unsuitable. As nocturnal CO_2 emission converges into a layer [CO_2] builds up. $\partial C/\partial t = -\partial Fc/\partial z + Advhor + Advvert$. Focusing on undisturbed periods with little horizontal and vertical advection (Advhor + Advvert), and averaging to the level at which Fc --> 0, we define hc: $\partial Csfc/\partial t \approx Fc/hc$, with Csfc the surface observation. Previously, we found that, with concave terrain surroundings in the Hudson Valley, calm nocturnal conditions with intermittent turbulence predominate (Medeiros and Fitzjarrald, 2015).

The diurnal sequence of boundary layer structure on largely 'undisturbed' days unfolds: First, the surface stable layer fills in up to the time when the 2m-9m difference vanishes, followed by a period up to the point at which this layer becomes neutral. The second period often associates with a local Tdew maximum often coincident with a local [CO_2] maximum. During the early evening transition, as the stable layer reappears another 'jump' in Tdew, nearly coincident with a $\partial^2T/\partial t^2$ changing sign (Fitzjarrald and Lala, 1989; Acevedo and Fitzjarrald, 2002).

In the middle of the day, there is often a draw-down in [CO_2], regularly associated with carbon uptake, enhanced by an entrainment contribution in mid- to late afternoon—there is insufficient turbulent kinetic energy to effect entrainment at z_i .We seek to associate the $\partial[CO_2]/\partial t$ also with daytime CO_2 uptake. One recent example for two NYMN stations (Figure) shows how the eddy covariance flux can be linked to the CO_2 tendency both night and day.

Building on Freedman and Fitzjarrald (2001), we examine the diurnal patterns of temperature, specific humidity and [CO_2] from selected periods following frontal passage. We seek the preferred shape of these diurnal signals on undisturbed days and then associate features of the time series with the boundary layer state, using a variety of estimates for the boundary layer thickness, including New York State Mesonet (NYSM) lidar PBL and Automated Surface Observation System (ASOS) METAR cloud base estimates. The shape of selected scalars on undisturbed days is estimated by compositing, using an ARIMA moving average 'seasonal' decomposition, and, as time and understanding evolves, machine learning.

Developing a Socioeconomic-Aware Winter Storm Scale for Erie County, New York

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The operational Winter Storm Severity Index (WSSI), a scale that conveys forecasted impacts related to winter weather, encompasses weather conditions including but not limited to snow amount, blowing snow, and snow load. Climatology, land use, and urban-area designation are also considered. However, the WSSI does not directly include several non-weather factors, such as population and housing, road networks, and critical infrastructure. The deadly Buffalo, NY Christmas Blizzard of 2022 brought about the need for more effective preparedness and communication ahead of highly impactful winter weather events.

While the WSSI is an excellent tool to inform the community about important winter weather conditions, an improvement upon the WSSI that incorporates an area's geographic and socioeconomic details could increase the utility of the index. The operational WSSI provides a great starting point for such index due to its climatology-based output and assimilation of a wide scope of winter weather parameters.

Funded by Erie County, this project develops a Winter Storm Scale that integrates numerous geographic and socioeconomic inputs and returns a value pertinent to a location's risk for disruptions to life and property. The scale is calculated retroactively for a variety of events to assess its performance and establish benchmarks. This more comprehensive scale would give emergency management and county leaders a stronger ability to understand past storms and prepare for future storms.

Investigating River Ice Phenology and Climatology in the Northeast United States and the Link with Climate Oscillations

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The goal of this study is to conduct a comprehensive assessment of river ice phenology and climatology in Northeast United States, utilizing a combination of in situ observations and satellite imagery. Spatial and temporal patterns of ice formation, ice breakup, ice concentration, and breakup ice jams were analyzed. Investigation into how river ice phenology varied during the period 1985–2023 was performed using conventional trend analysis methods, alongside an examination of the teleconnections between ice phenology series and global climate oscillations. Complex spatiotemporal evolution of river ice across the Northeast United States was detailed, with notable influences of latitude on ice cover dynamics due to temperature variations from north to south highlighted. Leveraging 12 years of daily satellite observations, the necessity of integrating satellite imagery with in situ observations to develop a comprehensive river ice climatology was emphasized. Trend analysis revealed statistically insignificant delays in ice formation by an average of 0.45 days per year and a tendency for earlier breakup by 0.24 days per year. Trends in hydroclimatic variables, such as air temperature, snow cover, and rainfall, were discussed. Additionally, a considerable increase in mid-winter breakup ice jams frequency was revealed, with a significant change noted post-1992. The findings of this study pave the way for the development of regional river management strategies and adaptation to river ice-induced hazards.

Impact of LiDAR data assimilation on WRF-Chem ozone and wind profiles over NYC

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Complex interactions between atmospheric chemistry, topography, and emissions sources cause large spatiotemporal differences in ozone (O3) concentrations throughout New York State (NYS) and the New York City (NYC) metropolitan area. Accurately predicting and quantifying these spatiotemporal differences is paramount to implementing effective emission controls and economic policies. To address this need, a near-real-time version of the Weather Research and Forecasting model coupled with chemistry (WRF-Chem) is created for timely air quality forecasts, with the capability for retrospective runs as well. Local and regional transport, influenced by the wind, is important to effective O3 modeling in NYS. Small changes in wind speed and direction will impact the transport of an O3 plume, leading to inaccurate forecasts of pollutant peaks. The NYS Mesonet (NYSM) provides a unique set of observations across NYS and NYC, including surface stations, flux towers, and a profiler network. The NYSM profiler network includes a system of LiDARs, which measures the profile of wind speed and direction up to 7 km. Within WRF-Chem, it is possible to assimilate observational data into the model to constrain meteorological conditions. To test the impact of assimilating NYSM LiDAR data into WRF-Chem, a series of simulations are conducted — ones where LiDAR data assimilation is off, and ones where LiDAR data assimilation is turned on. The impact of the data assimilation is quantified in the WRF-Chem system by performing statistical analyses on the model output before and after assimilation. Additional analyses include time series analysis, Taylor diagrams, and vertical profiles at select sites across NYS. Preliminary results show modest improvements in the O3 time series across the state.

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