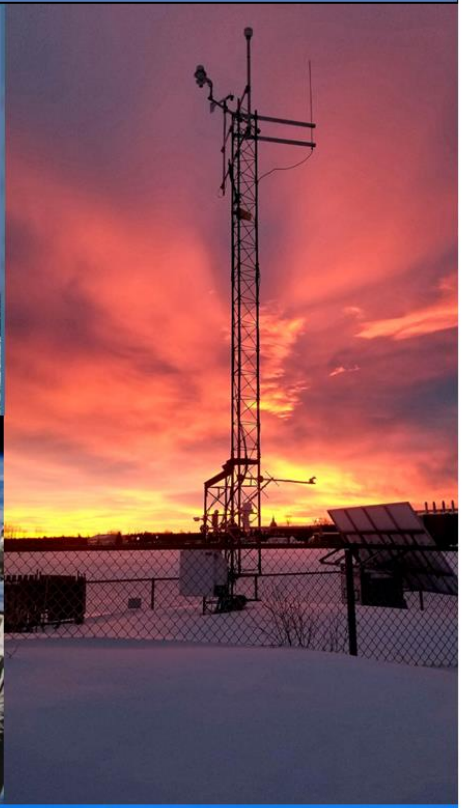
Northeast Regional Operational Workshop (NROW) XXII
November 9 - 10, 2021 | Albany, New York



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National Weather Service
SUNY— University at Albany's Department of Atmospheric and Environmental Sciences
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Agenda
Northeast Regional Operational Workshop XXII
Albany, New York
Virtual Meeting via GotoWebinar
Tuesday, November 9, 2021

8:50 am
Welcoming Remarks & Webinar Logistics
Stephen N. DiRienzo, Acting Meteorologist-in-Charge
Brian J. Frugis, NROW XXII Steering Committee Chair
National Weather Service, Albany, New York

Session A –Winter Weather I (9:00 am to 10:20 am)

9:00 am
Final Appraisal: Evaluating the accuracy of forecaster and model predictions of snowfall in eastern New York and western New England using a GIS application
Joseph P. Villani
NOAA/NWS Weather Forecast Office, Albany, New York

9:20 am
National Weather Service Effort to Improve Snow Squall Warnings and Associated Wireless Emergency Alerts
Michael Muccilli
NOAA/NWS Headquarters, Silver Spring, Maryland

9:40 am
High-Impact Model Biased Right of Track Winter Storms in the northeast United States
Michael Evans
NOAA/NWS Weather Forecast Office, Albany, New York

10:00 am
An overview of the upcoming 2022 Winter Precipitation Type Research Multiscale Experiment (WINTRE-MIX)
Justin Minder
University at Albany, State University of New York, Albany, New York

10:20 am to 10:40 am
Break

Session B – Winter Weather II (10:40 am to 11:20 am)

10:40 am
Weather Prediction Center Winter Weather Desk Updates
Bryan Jackson
NOAA/NWS Weather Prediction Center, College Park, Maryland

11:00 am
Forecast and Impact-Based Decision Support Services (IDSS) Challenges during the February 1-2, 2021 Nor'easter in Southern New England
Rodney Chai
NOAA/NWS Weather Forecast Office, Norton, Massachusetts

Session C – Modeling/NWP I (11:20 am to 12:20 pm)

11:20 am
Snow Multi-Bands in an Idealized Baroclinic Wave Simulation
Nicholas Leonardo
School of Marine and Atmospheric Science, Stony Brook University, Stony Brook, New York

11:40 am
Observed Evolution and WRF Uncertainties of an Amorphous Yet Intense Snow Band during IMPACTS on 7 February 2020
Phillip Yeh
School of Marine and Atmospheric Science, Stony Brook University, Stony Brook, New York

12:00 pm
Ensemble Clustering: Transition to Operations and Comparison of Clustering Approaches
Brian Colle
School of Marine and Atmospheric Science, Stony Brook University, Stony Brook, New York

12:20 pm – 1:40 pm
Lunch

Session D – Use of Observations & Remote Sensing I (1:40 pm to 3:20 pm)

1:40 pm
A COVID Conundrum: An Investigation into Enhanced Methyl Chloroform Measurements
Megan Schiede
University at Albany, State University of New York, Albany, New York

2:00 pm
Evaluating and Improving Snow Prediction in the National Water Model in New York State using New York State Mesonet Data
Sierra Liotta
University at Albany, State University of New York, Albany, New York

2:20 pm
New Winter Weather and Profiler Products from the NYS Mesonet
Jerry Brotzge
New York State Mesonet, University at Albany, State University of New York, Albany, New York

2:40 pm
Characteristics of Enhanced Spectrum Width Layers within Northeast United States Coastal Winter Storms
Erin Leghart
School of Marine and Atmospheric Science, Stony Brook University, Stony Brook, New York

3:00 pm – 3:20 pm
Break

Session E – Hydrology/Flood Messaging (3:20 pm to 4:00 pm)

3:20 pm
Evaluating Flash Flood Warning Communication Using an Immersive Simulation
Jase Bernhardt
Hofstra University, Hempstead, New York

3:40 pm
Findings and Recommendations from Two Tabletop Exercises in Support of the Implementation of Near Real-Time Forecast Flood Inundation Mapping Services in the Northeast U.S.
David R. Vallee
NWS/NOAA Northeast River Forecast Center, Norton, Massachusetts

4:00 pm
Wrap up/Adjourn
Brian J. Frugis

Northeast Regional Operational Workshop XXII
Albany, New York
Virtual Meeting via GotoWebinar
Wednesday, November 10, 2021

8:55 am
Opening Remarks
Brian J. Frugis, NROW XXII Steering Committee Chair
National Weather Service, Albany, New York

Session F – Use of Observations & Remote Sensing II (9:00 am to 9:40 am)

9:00 am
Relating Surface Wind Observations to the Local Environment Using Airborne Lidar
Alex Gallagher
University at Albany, State University of New York, Albany, New York

9:20 am
Representativeness of Coastal Stations for Verifying Open-Water 10 Meter Wind Forecasts
Nelson Shum
Meteorological Service of Canada, Toronto, Ontario

Session G – CSTAR Topics (9:40 am to 11:00 am)

9:40 am
CSTAR Update: Assessing Warm Season QPF in High Resolution Ensembles in New England
Rodney Chai
NOAA/NWS Weather Forecast Office, Norton, Massachusetts

10:00 am
Collaborations between the NWS and the University at Albany before and after our move to the ETEC
Michael Evans
NOAA/NWS Weather Forecast Office, Albany, New York
Ross Lazear
University at Albany, State University of New York, Albany, New York

10:20 am
Data Fusion: A Machine Learning Tool for Forecasting Winter Mixed Precipitation Events
Brian Filipiak
University at Albany, State University of New York, Albany, New York

10:40 am
A Mechanism for Upscale Growth of Convection in the Complex Terrain of the Northeast U.S.
Brennan Stutsrim
University at Albany, State University of New York, Albany, New York

11:00 am – 11:20 am
Break

Session H – Severe Weather I (11:20 am to 12:20 pm)

11:20 am
Review of the 2021 Tropical Remnant Tornadoes in Southern New England
Joseph W. Dellicarpini
NOAA/NWS Weather Forecast Office, Norton, Massachusetts

11:40 am
The Use of Radar-Based Techniques to Warn for Tornadoes in the Albany Warning Area
Hailey Culwell
Hollings Scholar Student, NOAA/NWS Weather Forecast Office, Albany, New York

12:00 pm
New Visualization Tools to Help Utilize ZDR/KDP Separation and Size Sorting Signals in the Tornado Warning Process
Michael L. Jurewicz, Sr.
NOAA/NWS Weather Forecast Office, State College, Pennsylvania

12:20 pm – 1:40 pm
Lunch

Session I – Severe Weather II (1:40 pm to 3:00 pm)

1:40 pm
Review of the July 21, 2021 “Non Event” in Southern New England
Joseph W. Dellicarpini
NOAA/NWS Weather Forecast Office, Norton, Massachusetts

2:00 pm
The 2 July 2020 Anomalous Severe Weather Event across eastern New York
Thomas A. Wasula
NOAA/NWS Weather Forecast Office, Albany, New York

2:20 pm
Analysis of WSR-88D SAILS Usage on Severe Weather Warning Performance
Joseph W. Dellicarpini
NOAA/NWS Weather Forecast Office, Norton, Massachusetts

2:40 pm – 3:00 pm
Break

NROW XXII Key Note Presentation (3:00 pm to 3:45 pm)

Introduction: Thomas A. Wasula

The Evolving Role of Humans in Weather Prediction and Communication
Neil A. Stuart, Lead Meteorologist
NOAA/National Weather Service, Albany, New York

3:45 pm – Wrap Up/Adjourn
Brian J. Frugis

NROW XXIII is scheduled for November 1–2, 2022

Final Appraisal: Evaluating the accuracy of forecaster and model predictions of snowfall in eastern New York and western New England using a GIS application

Joseph P. Villani[1], Michael S. Evans[1], Vasil T. Koleci[1], and Charles Gant[2]
[1]NOAA/NWS/WFO Albany, New York
[2]NOAA/NWS WFO Morristown, Tennessee

A collaborative project between the National Weather Service Forecast offices in Albany, New York and Morristown, Tennessee resulted in the development of a GIS-based application that produces high-resolution analyses of snowfall observations, and calculates errors and biases of corresponding gridded snowfall forecasts based on the analyses. Analyses are created from a blend of local WFO observations and the National Operational Hydrologic Remote Sensing Center (NOHRSC). This presentation summarizes the verification results combined from three winter seasons (2017-18, 2018-19 and 2019-20), examining topographical influences on patterns of observed snowfall and the accuracy and biases of various corresponding snowfall forecasts.

Patterns of observed snowfall and their relation to topography were examined by collecting data from three years of snowfall events across eastern New York and western New England. A detailed snowfall analysis was performed for each event. Composites of snowfall patterns were used to identify relationships between snowfall and various terrain features such as the Catskill and Green Mountains, and the Hudson and Mohawk Valleys. Orographic ratios were calculated for each event to quantify the impact of elevation on snowfall. Observations and short-range model forecasts of environmental characteristics such as wind, temperature and stability were utilized to determine how these factors affect the topography's impact on snowfall distribution.

Snowfall observations from our detailed analyses were compared to short-range forecasts of snow depth change from the 3 km NAM and HRRR, and snowfall from the National Weather Service's National Digital Forecast Database, to determine how well these forecasts account for terrain effects. Forecast errors were related to wind, temperature and stability to see whether these factors had an impact on the overall quality of the forecasts, as well as the forecasts ability to account for the effects of terrain. Results showed a consistent negative bias (forecast too low) for both the HRRR and 3km NAM, although placement and magnitude of forecast errors varied based on different environmental characteristics. NDFD forecasts displayed a mix of positive and negative bias, but with lower magnitudes compared to the high-resolution model guidance.

National Weather Service Effort to Improve Snow Squall Warnings and Associated Wireless Emergency Alerts

Michael Muccilli[1], Sarah Perfater[1], Stephen Baxter[1], Peter Banacos[2], Alex DeSmet[3], Alex Lukinbeal[4], Greg DeVoir[5], Richard Pollman[6], Megan Stackhouse[7], Rob Cox[8]
[1]NOAA/NWS Headquarters Silver Spring, Maryland
[2]NOAA/NWS WFO Burlington, Vermont
[3]NOAA/NWS WFO Salt Lake City, Utah
[4]NOAA/NWS WFO Missoula, Montana
[5]NOAA/NWS WFO State College, Pennsylvania
[6]NOAA/NWS WFO Detroit, Michigan
[7]NOAA/NWS WFO Grand Junction, Colorado
[8]NOAA/NWS WFO Cheyenne, Wyoming

Snow Squall Warnings (SQWs) remain a relatively new product to the National Weather Service (NWS), having been operationally implemented since Winter 2018-2019. The NWS continues to monitor feedback related to SQWs and the dissemination thereof to propose policy improvements, create and enhance training opportunities for forecasters, and to improve outreach, education, and communication of snow squall events with the public and core partners.

The dissemination of SQWs, especially when considering the use of Wireless Emergency Alerts (WEA), requires that forecasters consider anticipated societal impacts as a result of snow squalls in the warning decision making process, and this is explicitly noted in National Weather Service Instruction 10-513. Overuse of the WEA system for marginal events or during overnight hours is a major concern. Feedback received has shown that overuse of WEA may devalue the service and lead to users disabling the service altogether.

This talk will outline the two tracks the NWS is pursuing to not only mitigate these risks and to supply forecasters with the training necessary to make these judgments, but also to holistically improve the snow squall forecast, warning, and messaging process.

First, beginning no earlier than winter 2022-2023, the NWS will be appending Impact-Based Warning machine-readable tags to SQWs to characterize the snow squall impact ("Base", "Significant") and source information ("Radar Indicated", "Observed"). In turn, the characterization of the snow squall impact will allow the NWS to issue WEA for only those warnings with "Significant" tags, while still allowing for high-level dissemination of the warning information to the public and our partners. This is similar to the recently implemented changes to the Impact-Based Flash Flood Warning (FFW).

Second, a working group composed of NWS forecasters representing three regions of the United States that issue SQWs has developed multimedia training that covers best practices when it comes to forecasting, warning, and messaging snow squall events. This best practice information has been shared across the agency.

High-impact model biased right of track winter storms in the northeast United States

Michael Evans[1], Tomer Burg[2]

[1]NOAA/NWS/WFO Albany, New York

[2]University of Oklahoma, Norman, Oklahoma

Forecasters making predictions of snowfall and other storm-related impacts associated with winter storms along the northeast U.S. coast rely on accurate model forecasts of cyclone tracks. Over the past several years, several notable storms have occurred in this area that exhibited a right of track model forecast error, meaning that the model forecast cyclone track was to the right of what was observed. This error can contribute to heavy snow farther north and west than forecast, and the observed rain / snow line being north and west of the forecast. These recent storms have led many forecasters to believe that this right of track error is a consistent characteristic of model forecasts in this area, but recent research on forecasts from the Global Ensemble Forecast System (GEFS) showed no overall tendency for right of track errors vs. other types of error for a large dataset of storms. However, a review of high-impact winter storms along the northeast coast of the United States indicates that a significant subset of these storms is characterized by right of track model forecast errors, and an improved understanding of this bias would present forecasters with a target of opportunity to improve forecasts and IDSS messaging for winter storms.

This presentation will summarize results from a study of high-impact east coast storms characterized by a right of track error in the GEFS forecasts. A comparison of forecasts and observations will be presented for several cases, along with a summary of the impacts from these. A composite analysis from the North American Regional Reanalysis shows that these events are typically Miller A storms, characterized by the presence of a strong southern branch jet stream. It is hypothesized that reduced static stability and convection over the southeastern United States in advance of these storms may be one factor that leads to right of track errors. Finally, factors responsible for errors in model placement of heavy snowfall other than lower-tropospheric storm track will be discussed.

An overview of the upcoming 2022 Winter Precipitation Type Research Multiscale Experiment (WINTRE-MIX)

Justin Minder
Department of Atmospheric and Environmental Sciences, University at Albany, Albany, New York

During near-freezing surface conditions, diverse surface precipitation types (p-types) are possible, including rain, drizzle, freezing rain, freezing drizzle, wet snow, ice pellets, and snow. Such near-freezing precipitation affects wide swaths of the eastern United States and Canada, impacting aviation, road transportation, power generation and distribution, winter recreation, ecology, and hydrology. These events are shaped by diverse meteorological processes and are expected to change as the climate warms. Fundamental challenges remain in our ability to adequately observe, diagnose, simulate, and forecast them, especially when dealing with transitions between p-types and in regions of complex terrain.

To address these challenges, the Winter Precipitation Type Research Multiscale Experiment (WINTRE-MIX) will be conducted, with funding from the National Science Foundation. The overarching goal is to better understand how multi-scale processes influence the variability and predictability of p-type and amount under near-freezing surface conditions. The experiment will be conducted near the New York/Quebec boarder, a region that experiences plentiful near-freezing precipitation with interesting terrain influences. Field operations will be focused during 1 February – 15 March 2022.

The study will benefit from a strong backbone of existing state-of-the-art mesoscale observation networks, including the New York State Mesonet (NYSM). Additional sensors will be added to select NYSM stations to enhance observations including freezing rain sensors. WINTRE-MIX will supplement existing networks with additional observations from aircraft, mobile radars, and other surface-based instruments. Major facilities to be deployed are the National Research Council (NRC) Convair-580 research aircraft and three mobile Doppler on Wheels dual-polarization radars. WINTRE-MIX field activities will benefit from collaborative efforts by partners including: Canadian academic institutions (UQAM, McGill), Environment Climate Change Canada, the Federal Aviation Administration, the National Weather Service, and the private company Northview Weather. The comprehensive dataset generated will depict these events in unprecedented detail, as such events have not been the focus of a major field campaign in recent decades.

WINTRE-MIX research will contribute to improving forecasts of near-freezing precipitation through forecast model evaluation, model improvements, improvement of radar retrievals, and improvements to aviation icing diagnostics. The project will also work to improve communication between researchers, forecasters, and stakeholders through the facilitation of two workshops and engagement of citizen science observers.

Weather Prediction Center Winter Weather Desk Updates

Bryan Jackson

NOAA/NWS/Weather Prediction Center College Park, Maryland

The Weather Prediction Center (WPC) Winter Weather Desk (WWD) provides deterministic and probabilistic forecasts in support of National Weather Service (NWS) winter services. There are a few exciting updates to the WPC WWD product suite for the winter of 2021-2022. This proposed presentation would be on these changes, information about methods used by WPC to produce deterministic and probabilistic wintry precipitation accumulation forecasts, and WPC winter forecast verification from this past winter.

The Winter Storm Severity Index (WSSI), a scale for winter storm impacts, has been extended to Day 4 by utilizing data from the WPC Super Ensemble, the NBM, and NDFD data. This winter is the third season to employ the Advanced Weather Interactive Processing System (AWIPS) Graphical Forecast Editor (GFE), which is the software used by NWS field offices, for WPC winter forecast production. Forecast grids from both WFOs and WPC are now shared via Intersite Coordination (ISC), which will allow greater coordination opportunities between WFOs and WPC. Also, WPC deterministic and probabilistic snow accumulation forecast verification would also be shown.

Forecast and Impact-Based Decision Support Services (IDSS) Challenges during the February 1-2, 2021 Nor'easter in Southern New England

Rodney Chai
NOAA/NWS/WFO Boston/Norton, Massachusetts

Accurate forecasts of precipitation type and snowfall amount have been a recurring challenge in the coastal plain of southern New England which includes the high population centers of Boston, MA and Providence, RI. Forecast 'busts' (too little or too much snow) can have a significant impact on operating costs, not only for these larger cities and state Departments of Transportation, but also for local communities.

The February 1-2, 2021 Nor'easter was one of the most impactful winter storms for southern New England during the 2020-21 winter season. It was also one of the most challenging storms to forecast with a sharp snowfall gradient associated with the coastal front. Downtown Boston received 1.2 inches of snow while Bedford, MA, located about 17 miles to the west, received a whopping 18 inches of snow. This winter storm presented a significant forecast and communication challenge. The High Resolution Ensemble Forecast (HREF) was consistent in forecasting snowfall rates of 1-2 inches per hour coinciding with the evening rush hour near the coastal front. However, the HREF assumes a normal 10:1 snow to liquid ratio and does not take melting into account. To further complicate matters, there were locations that reported heavy snow but little accumulation due to a marginal near-surface thermal profile.

This presentation will describe the challenges associated with forecasting and messaging impacts associated with the coastal front in eastern Massachusetts for this winter storm. The importance of mesoscale analysis, including the integration of high-resolution data ensemble sets such as the HREF, will be stressed in order to show how NWS Boston meteorologists incorporated this information into the warning decision making process and IDSS briefings. This allowed core partners such as the Massachusetts Emergency Management Agency, MassPort (which operates Logan Airport), and others to make more informed decisions to deploy resources in advance of the storm.

Snow Multi-Bands in an Idealized Baroclinic Wave Simulation

Nicholas Leonardo and Brian A. Colle

School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York

The precipitation within the comma-head region of nor'easters often falls in one or more distinct bands, having significant localized impacts. Multi-banded events have been less extensively studied than single-banded events. Idealized simulations have been used to understand structures along the cold fronts of baroclinic waves, but not the banded features in the comma-head.

This study uses the idealized baroclinic wave configuration of the WRF-ARW (v3.4.1) model. Inner nests covering the comma-head region are added after 108 hours of simulation time, with horizontal grid spacings down to 800-m. Sensitivity experiments are run to test the phase space of environmental conditions theorized to promote multi-bands, adjusting the initial vertical thermal stability, the horizontal wind shear, or horizontal temperature gradient.

Multi-band structures develop northeast of the low pressure center between 120 h and 129 h simulation time. This activity evolves from cells that previously grew in 700-600-hPa conditional instability and ~900-hPa frontogenesis east of the low. These cells propagate northward with the mean flow, ascending to 600-500-hPa up the frontal zone. The bands weaken as they move north away from the instability, broadening in a southwest-northeast orientation with the mean flow deformation. The bands diminish by 138 h as the instability to the south is depleted. Thus, there may be a prior upstream evolution to multi-bands that is missed by instantaneous diagnostics.

In the sensitivity experiments, the multi-bands are reduced when the initial stability is increased by ~10%. Increasing the horizontal cyclonic shear delays the band development to 144 h, which corresponds to a delay in the instability generated via differential temperature advection around the low. Decreasing the horizontal temperature gradient by ~30% results in the low spinning-up ~2 days later, but band-like features still develop by 168 h.

Observed Evolution and WRF Uncertainties of an Amorphous yet Intense Snow Band during IMPACTS on 7 February 2020

Phillip Yeh[1], Brian A. Colle[1], Joseph Finlon[2], Lynn A. McMurdie[2], Victoria McDonald[2], and Andrew DeLaFrance[2]
[1] School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York
[2] Department of Atmospheric Sciences, University of Washington, Seattle, Washington

The Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) field campaign operated by NASA investigates the structure of mesoscale snow bands. Significant research has explored single (primary) bands in the cyclone comma head, but less is known about the broader spectrum of other snow band structures. This talk will discuss additional research on the 7 February 2020 event, which was associated with a surface cyclone that initiated along the Appalachian Mountains and deepened rapidly as it traversed across New Jersey and southern New England. Both the ER-2 and P-3 flew multiple West-East flight legs across New York State within the comma head of this cyclone, with three coordinated legs from 1500 UTC to 1600 UTC. A few areas of enhanced reflectivity developed after 1400 UTC in central New York and propagated eastward and became intense (5-8 cm snow rates), but the reflectivity structures never fully organized into a well-defined primary snowband. To investigate some of these features, the Weather Research and Forecasting (WRF) model version 4.0 was utilized to simulate this event, with a triple one-way nesting configuration (18-, 6-, and 2-km grid spacings). The effects of potential initial condition errors and model errors were explored by initializing the model with three different initial and boundary conditions (RAP analysis, GFS analysis, and ERA-5 analysis). The RAP analysis run was also initialized at two different times (1800 UTC 6 February and 0000 UTC 7 February 2020) and run with two different microphysics parameterizations (Thompson and P3).

Despite a strong jet, strong frontogenesis, low stability, and a rapidly deepening cyclone, this case failed to produce a coherent snow band for much of the time of interest. Additionally, there were no clear multi-band features. Notwithstanding, the storm produced significant snowfall (30-45 cm storm total) over a large portion of New York State. Preliminary results suggest while strong frontogenesis exists throughout the event, this forcing is spread out over a broad region along the sloping frontal zone instead of concentrated along a clear deformation axis at mid-levels. The riming and aggregation within the amorphous band likely enhanced the surface precipitation rates. The simulations were sensitive to both initialization time and microphysics scheme, which will be highlighted using comparisons with aircraft data. The Thompson WRF run produced the least riming and 20-40% less 6-h precipitation than the P3 scheme during the period of most intense snow rates, but even the P3 scheme somewhat underestimated the super-cooled water and riming during this event. However, the 0000 UTC 7 February simulations produced more riming and 33-50% more precipitation than the respective 1800 UTC simulations.

Ensemble Clustering: Transition to Operations and Comparison of Clustering Approaches

Brian A. Colle[1], Benjamin Kiel[1], Bill Lamberson[2] and James Nelson[3]
[1] School of Marine and Atmospheric Sciences, Stony Brook University Stony Brook, New York
[2] CU/CIRES University of Colorado Boulder, Colorado
[3] NOAA/NWS/WPC College Park, Maryland

Forecasters need more ways to interact with ensemble data than conventional mean, spread, and probabilistic products. There is an increasing need to incorporate information from the ensemble systems for impact decision support services (IDSS) within the NWS. During a previous CSTAR project, Stony Brook University (SBU) developed a clustering tool the GEFS, CMC, and EC ensembles, by first completing a principal component (PC) analysis on the sea level pressure spread for a region, and then a fuzzy clustering of the members in that PC1 and PC2 phase space. In a current JTTI project, Stony Brook University (SBU) in collaboration with WPC has implemented this ensemble clustering tool for days 3-7 and 8-10 for a few regions across CONUS, https://origin.wpc.ncep.noaa.gov/wpc_ensemble_clusters/day_3_7_slider/view.php and https://origin.wpc.ncep.noaa.gov/wpc_ensemble_clusters/day_8_10/view.php). The tool is now run operationally at WPC and evaluated by forecasters within the Extended-Range Forecast Experiment (ERFE). The first part of this presentation will show the operational efforts, examples, and feedback of the tool from testbed activities as well as other forecasters.

The presentation will then highlight research on the clustering approaches. The existing WPC clustering approach uses a K-means clustering of 500-hPa geopotential height, and then all the other fields are obtained from those same clusters. A different set of clusters is also created for each forecast lead time. At SBU, as part of a CSTAR and JTTI, we have been comparing different clustering methods for 180 United States East Coast winter storm events from 2007-2015 for lead times every 24 h from 24 h to 216 h. To obtain a cluster space, ensemble members were either simplified to multidimensional statistics (e.g., principal components, intensity minimum/maximum and location thereof), or grouped by direct input of the model ensembles into the cluster algorithm (Euclidean). Several cluster algorithms were tested using those three spaces, including k-means clustering, fuzzy c-means clustering, agglomerative hierarchical clustering (AHC), and self-organizing maps. To test the impact of using the mass field clusters for other variables, the same clusters generated from MSLP are applied to 12-h accumulated precipitation APCP, which is compared to generating 12-h APCP clusters directly. Lastly, clusters from a later forecast lead time are applied to an earlier lead time to compare with clusters made at that earlier lead time. It was found that clustering space is more important than the algorithm choice in ensemble member clustering. Using MSLP based clusters to obtain APCP scenarios increases the average cyclone displacement error by 10-15% for the scenario nearest to the analysis. Additionally, use of a later lead time to cluster an earlier lead time did not change the displacement or intensity errors of the scenario nearest analysis much. However, it is less likely that the largest cluster is also the cluster with lowest errors.

A COVID Conundrum: An Investigation into Enhanced Methyl Chloroform Measurements

Megan Schiede

Department of Atmospheric and Environmental Sciences, University at Albany,

Albany, New York

Methyl chloroform (CH_3CCl_3) was a commonly used solvent and degreasing agent prior to its classification as an ozone depleting substance, and subsequent prohibition by the Montreal Protocol in 1987. With an atmospheric lifetime of five to six years, temporal measurements of methyl chloroform illustrate the success of these restrictions as background values fell from approximately 130 ppt in the early 1990s to 1.5 ppt in 2020. The COVID-19 lockdowns brought about an ease in EPA restrictions, as well as a new opportunity for the NASA Student Airborne Research Program to extend whole air sampling across the United States. The results from this widespread sampling discovered enhanced concentrations of methyl chloroform near various highly populated coastal areas with the highest observed in Ithaca, NY at 16.4 ppt. Given the status of methyl chloroform as an ozone depleting substance, its use requires permission from the EPA implying its use should be easy to track. An investigation into past uses of methyl chloroform was conducted to determine if any plausible sources for these enhanced concentrations still currently exist. To confirm the validity of these sources, multiple NOAA HYSPLIT trajectories were run on the dates of enhanced observations. There are promising associations between the location of potential emission sources and enhanced methyl chloroform measurements. In order to further support these results additional whole air sampling must be conducted near sites of interest.

Evaluating and Improving Snow Prediction in the National Water Model in New York State using New York State Mesonet Data

[1]Sierra Liotta, [1]Justin R. Minder, [1]Patrick Naple and [2]Theodore W. Letcher
[1]Department of Atmospheric and Environmental Sciences, University at Albany, Albany, New York
[2]Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire

When snow melts, the water drains into nearby streams and rivers which can impact water supply and flood hazards. The National Water Model (NWM) provides high quality forecast data for streamflow in the continental United States using mathematical representations of hydrologic processes. The motivation of this research is to evaluate how the NWM simulates snow melt in New York State. Within the NWM, Noah-MP is the land surface model (LSM) used to simulate processes on land such as snow melt. There can be biases in these simulations due to errors in the LSM formulation and/or meteorological input. To evaluate the representation of snow melt in Noah-MP, we run point simulations at the New York State Mesonet (NYSM) sites and force Noah-MP with NYSM meteorological observations. This isolates the model parameterizations and allows us to manipulate the way the model handles various processes. We also explore which parameters impact snow melt in Noah-MP the most by conducting controlled sensitivity experiments where aspects of the model are altered in isolation and to highlight areas where improvement is needed.

The NYSM data were also used to evaluate the representation of snowmelt events in Noah-MP. This data includes measurements of snow depth, snow water equivalent (SWE, the depth of water produced if the snow was melted) and surface energy inputs/outputs (fluxes). We focus on the years of 2020 and 2021 because they have extensive high quality NYSM SWE measurements. We also focus on the month of March because this is when the majority of snow melt occurs during these years. Only a limited number of NYSM sites collect both flux and SWE data, so these sites are emphasized in our analysis. Flux data is important to studying snow because the energy input to and output from the snowpack cause variability in the snow melt. Additionally, SWE data is important because a change in snow depth does not necessarily mean the snow is melting. This can happen when snow settles, when water is retained within the snowpack, or when water is re-frozen within the snowpack.

Parameterizations in Noah-MP that have an impact on the snow accumulation and snow ablation period were identified and point simulations were run with alterations to these parameterizations. Altering the representation of precipitation phase in Noah-MP has proven to improve the snow accumulation when we use the HRRR based precipitation partitioning method in the model. Additionally, accelerating the rate in which the model ages snow improves the snow albedo and therefore the ablation period. Comparing the altered model’s predicted snow depth and SWE to the NYSM observed data reveals which changes improve the model outputs. When there are deviations in snow depth between the model and the observations, comparing deviations in the flux data can help us understand what is going wrong. We are using this analysis to optimize the most sensitive parameters in Noah-MP to reduce errors in the NWM predictions for the northeastern United States and therefore, improve streamflow forecasts for emergency and water resource management.

New Winter Weather and Profiler Products from the NYS Mesonet

J. Brotzge, J. Wang, N. Bain, B. Shrestha, and C. Thorncroft
New York State Mesonet, University at Albany, Albany, New York

The New York State Mesonet (NYSM; http://nysmesonet.org) is an operational network of 181 environmental monitoring stations deployed statewide. Originally funded by FEMA following Superstorm Sandy, the primary goal of the NYSM is to provide high quality weather data at high spatial and temporal scales to improve atmospheric monitoring and prediction, especially for extreme weather events. The Mesonet is comprised of four primary components: (i) A Standard Network of 126 weather stations; (ii) a Profiler Network of 17 enhanced sites with additional vertical sensing capacity; (iii) a Flux Network of 18 sites with energy budget sensors; and (iv) a Snow Network of 20 sites with additional snow measurement sensors. Data are collected in real-time every 5 minutes, with over one billion observations archived to date.

Recent funding opportunities have allowed for a more careful analysis and expansion of products from the Snow and Profiler Networks. A two-year grant from NOAA is providing funds to improve the accuracy and delivery of winter weather information from the NYSM. New products include: snowfall accumulation, Snow Water Equivalent (SWE), storm-estimated snow-to-liquid ratio (SLR), precipitation type, and a frozen soil flag. The National Mesonet Program is funding the expansion of products derived from the Profiler Network. These new products include: convective stability and shear indices, PBL height, and precipitation type, and sea breeze and low level jet identification flags for the Wantagh site location. This presentation will review these new winter weather and profiler products, how they will be disseminated, and how their impact will be assessed.

Characteristics of Enhanced Spectrum Width Layers within Northeast United States Coastal Winter Storms

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United States East Coast winter storms are often associated with heavy snowfall, strong winds, icing, and storm surge. There is a myriad of mesoscale structures within these storms, including snow bands, generating cells, gravity waves, and coastal fronts. Given their connection to storm impacts, these phenomena have been fairly well studied using conventional radars and models. Additional radars operating at higher temporal and spatial resolution help reveal more detailed structures within these storms. Beginning in 2017, the Stony Brook Radar Observatory (SBRO) at Stony Brook University on Long Island, NY has operated a suite of sophisticated remote sensing instruments ideally suited to study these complex winter storms. The Ka-Band Scanning Polarimetric Radar (KASPR) at the SBRO frequently observes transient horizontal layers of Doppler spectrum width (SW) in the PPI scans and vertical profiles during winter storms. The origin of these layers is unclear, but it is hypothesized the layers originate from turbulence within winter storms. They may also be indicators of microphysical processes such as riming, aggregation, and secondary ice production. Combined, the hypothesized origins make these SW layers an important feature for aviation forecasters as both shear and icing pose risks for aircraft. The goal of this presentation is to understand the frequency, altitude, thickness, and duration of these SW layers, and relate these to the environmental conditions within the storm.

The first objective is to classify SW layers into categories based on physical features, such as layer thickness, to investigate the processes responsible for layer formation. A 2D convolution-based feature recognition algorithm was applied to the vertically pointing KASPR scans to identify the layers in a time-height plot. Over 178 hours of KASPR vertical profiles and over 77 hours of KASPR PPI scans from 51 separate winter storms from 2017-2021 are utilized. Sounding data from the National Weather Service in Upton, NY (OKX) and from Stony Brook, NY provide insight into the relationships between SW layers and vertical layers of shear and stability. Polarimetric data from KASPR vertical profiles and dual-polarimetric data from KASPR PPI scans provide information about the microphysics in the SW layers.

Preliminary results reveal that the thickness of SW layers range from 15m to >1 km, yet ~70% of all SW layers are $<$ 100m thick. For layers identified in the vertical profiles, roughly 50% of all SW layers are observed in the vertical column for 30 seconds or less; however, the majority of layers that are $\geq$ 500m are observed for 90 seconds or longer. Mean doppler velocity (MDV) gradients observed inside of the SW layers are of higher magnitude than the MDV gradient observed in the surrounding environment. Across-layer MDV differences are found to increase as layer thickness increases, yet the relationship between across-layer reflectivity difference and layer thickness is not as prominent. Shearinduced turbulent layers are hypothesized to be one of the origins of the SW layers, as well as regions where there are local changes in the stability profile.

Evaluating Flash Flood Warning Communication Using an Immersive Simulation

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Despite great advances in forecast accuracy and warning lead time in recent years, effective communication of risk from weather hazards to impacted individuals remains a challenge. Flash flooding is particularly problematic, as the public may not take warnings as seriously as those for hazards they perceive to be more threatening, such as tornadoes and winter weather. Nevertheless, flooding is among the leading causes of weather-related fatalities annually in the US, with drivers particularly vulnerable. To better understand actions taken by motorists during a flood, a simulation was developed where participants drove a vehicle and encounter a flooded roadway. To provide context and a basis for evaluating warning efficacy, drivers in the simulation randomly received one of three text message alerts sent to their phone, visible from the driver's seat. One text message contained the standard Wireless Emergency Alerts (WEA) message sent during a flash flood warning. The second message also consisted of that text, along with a call to action— "Turn Around Don't Drown"— which is the centerpiece of a long-running National Weather Service flood safety campaign. The third message was the control, simply a breaking news alert not relevant to the context of flooding. Data was collected regarding whether participants stopped, turned around, or entered the flooded roadway.

Preliminary analysis indicates that participants receiving the warning message containing the call to action were significantly more likely to stop or turn around before entering the flood than those who received one of the other two alerts. Moreover, qualitative survey responses from participants further reinforced the utility of including the "Turn Around Don't Drown" call to action in the flood warning message, while also revealing that additional context, such as hyperlocal information on detours around the impassable roadway, would also be beneficial. The results of this work provide invaluable insights into how National Weather Service WEA messages are working along with suggestions for how they can be improved, though further work is needed to best understand how such changes could be effectively operationalized.

Findings and Recommendations from Two Tabletop Exercises in Support of the Implementation of Near Real-Time Forecast Flood Inundation Mapping Services in the Northeast U.S.

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The NOAA National Weather Service (NWS) has a mission to issue forecasts for the protection of lives and property and the enhancement of the national economy. Partners across the nation have expressed an urgent need for the provision of more detailed flood forecasts and the resulting inundation. In support of the 2018-19 Department of Commerce / National Oceanic and Atmospheric Administration Agency Priority Goal (APG) to mitigate flood impacts, the NWS's Office of Water Prediction demonstrated a novel approach to real-time flood inundation mapping capability, implemented as a service, over the state of Texas. This capability uses the Height Above Nearest Drainage (HAND) method to infer forecast stage given forecast streamflow, and forecast inundation extent given forecast stage.

Following the successful completion of the Texas Demonstration, a new 2020-21 Department of Commerce / National Oceanic and Atmospheric Administration APG was established. Its purpose was to improve flood related decision support services by expanding the demonstration of a new flood inundation mapping capability to at least an additional 10% of the U.S. continental population residing in flood-vulnerable freshwater basins. Additional coverage includes population served with National Water Model (NWM) hydrography downstream from a subset of NWS official forecast locations throughout the continental U.S., plus populations in the NWS Northeast River Forecast Center (NERFC) service area.

One of the major milestones of the 2020-2021 APG was to develop and conduct two tabletop exercises with core partners in the NERFC service area to demonstrate these new services and to have them apply these services in a simulated flood event. The NERFC developed and conducted tabletop exercises for; the state of Rhode Island based on the devastating floods of March 2010 which produced record river and small stream flooding, and New York State's Schoharie Valley based on the passage of Tropical Storm Irene in August of 2011 which produced catastrophic flooding in the valley.

This presentation will provide an overview of each tabletop exercise and will summarize the major findings and recommendations.

Relating Surface Wind Observations to the Local Environment Using Airborne Lidar

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Surface meteorological observations can be influenced by terrestrial features of varying size and proximity with respect to the measurement. Surface wind observations are particularly susceptible to blocking, attenuation, redirection, and channeling effects of roughness elements ranging from prominent mountains to small artificially built structures. In particular obstacles in the immediate area surrounding surface measurements can drastically alter the observed measurement from the larger flow and reducing the representative area of the observation. This can result in misleadingly biased forecasts if obstacles are sufficiently small and are unresolvable by numerical weather models. As such the World Meteorological Organization standards for surface wind measurements strive to site observations in clear open areas, but is not always tenable in the real world.

Thus, characterizing the local environment around surface observations is essential to understanding and mitigating the effect it has on final meteorological measurement. However, information about the area surrounding weather stations is sparse and lacking. Satellite photography lacks accurate measurements of size and height, while direct site surveys are rare and only provide information in the immediate area. Airborne lidar presents a unique opportunity to visualize a high resolution three dimensional environment around an observation site.

Here, we explore the connection between azimuthal patterns in observed surface winds and variation of surface features using data from two observing networks. The New York State Mesonet (NYSM) and ASOS are two networks present in New York State (NYS) that provide high quality but vastly different wind observations. NYSM contains 126 stations that are sited across NYS and aim to provide observations in previously sparse regions. Due to a number of limitations associated with New York geography these stations are not always located for ideal wind observations. Alternatively, ASOS stations are frequently sited at airports with long unobstructed fetches. For this study, airborne lidar scans surrounding each station were used to recreate and characterize its local environment and correlate terrain and obstacle obstruction angles relative to anemometer locations to observed wind quantities. Our analysis focuses on individual sites, network composites, and internetwork comparisons of neighboring stations from the two networks. Our results indicate strong relationships between the maximum obstruction angle and observed mean wind speed and gust factor (GF) in a given direction. Although individual stations demonstrated a large degree of variation in their correlations, network composites showed significant tendency for mean winds to decrease and GF to increase as features rise above the horizon relative to the observation. While we confirmed obstructions are far more prominent, in both frequency and angle amplitude, within 500m of NYSM stations than ASOS stations the two networks are remarkably similar in the their observed mean wind speed and GF for environments with similar degrees of obstruction. Additionally, we propose that GF may be used as a simple proxy for observation exposure in the absence of sufficient environmental data.

Representativeness of Coastal Stations for Verifying Open-Water 10 Meter Wind Forecasts

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When assessing the accuracy of open-water wind forecasts at 10 meters above mean sea level, observations from coastal stations and those located on small islands are often used to augment observations from marine buoys to verify the values predicted. The underlying assumption is that observations from land stations that are well-exposed to the marine environment behave very similarly to observations collected from marine buoys. To test the validity of this assumption, using the 10 meter ASCAT (scatterometer) wind fields as a reference, we examine the correlation between wind measurements from coastal stations and the ASCAT open-water wind measurements (in the vicinity of the stations). The same correlation is also made with measurements from marine buoys, and the results are compared. The study shows that despite the proximity to the marine environment of the coastal stations examined, their observed winds show very different characteristics than the winds observed by marine buoys. The results suggest a strong land influence on the coastal station wind measurements, despite the stations' surrounding environment being dominated by water, which has implications for how coastal stations should be treated when they are used to verify open-water wind forecasts. These findings also suggest a need for careful interpretation of coastal observations when they are used in the forecast process.

CSTAR Update: Assessing Warm Season QPF in High Resolution Ensembles in New England

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Quantitative precipitation forecasts (QPF) have long been difficult for numerical weather prediction to produce accurately. This is especially true in the warm season where weaker synoptic scale forcing and convective processes dominate. Frequently, the result is a modeled areal extent of high QPF that is too large, with an overestimation of the heavy rain and flooding threats.

In this project, we aim to address how forecasters can best identify situations when operational guidance will be more skillful regarding coverage, location, and maximum QPF. This project leverages convection allowing model (CAM) ensemble guidance during the 2015-2019 warm seasons, providing a probabilistic framework in addition to deterministic forecasts. Project goals include: identifying observed high QPF warm season events in the Northeast during this five-year period, categorizing events that featured strong or weak CAM ensemble QPF performance, and classifying synoptic and mesoscale patterns associated with the aforementioned categories. This information will be compiled into forecaster guides to improve situational awareness of patterns correlating to relatively high or low CAM ensemble QPF skill.

This talk will cover the following three components. First, we will review the five-year climatology of observed events, including updated information about synoptic patterns. Second, we compare and contrast the verification methods for the HREF/NCAR Ensemble. Third, we examine a couple of Flash Flood event case studies in Bar Harbor, Maine and Norwood, Massachusetts to highlight how to view the verification information in light of individual events. In addition, we examine case studies from recent tropical cyclones (TCs) to see how the Probability Matched Mean (PMM) field performs compared to a simpler mean value as well as compare the verification performance between TC and non-TC events.

Collaborations between the NWS and the University at Albany before and after our move to the ETEC

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The National Weather Service Forecast Office at Albany, NY and the University at Albany Department of Atmospheric Sciences (DAES) have a long history of working on collaborative projects that have benefited both the University and the National Weather Service (NWS). Examples of projects include NOAA-funded research grants via the Collaborative Science, Technology and Applied Research (CSTAR) program, which involve collaborative research between Master's degree students, their advisors and NWS meteorologists. Another successful endeavor has been the NWS student volunteer program which allows several students from the DAES each semester to work regularly scheduled shifts at the NWS, allowing them to gain experience in many facets of NWS operations. Finally, a NWS operations class has been organized where undergraduate students attend a weekly course focused on forecasting and warning activities and taught by NWS staff. These activities have benefitted the NWS by developing a pipeline of graduating students with useful skills for entry level meteorologists. Likewise, these activities have given students a broader and more complete learning experience, benefitting both students and the university.

The NWS and DAES have both moved into the Emergency Technology and Entrepreneurship Complex on the U Albany campus during the fall of 2021, with offices separated by just a short walk down the hall on the 4th floor. Due to this increased proximity, plans are in the works to enhance the already close relationship between the NWS and DAES. A case study program has been initiated this fall, with several undergraduate students working closely with NWS staff members on reviews of significant weather events that have affected the NWS Albany forecast area. Regularly scheduled map discussions are also being planned involving participation from both the NWS and DAES, along with event-driven discussions prior to expected significant weather events, and post-event reviews after major events. Labs in our NWS operations class will be enhanced by more easily incorporating both NWS and DAES resources. These activities will continue to benefit the NWS by keeping the NWS in touch with cutting-edge science ongoing within the DAES, and by continuing to promote a culture of science within the forecast office. The university will benefit by more directly observing the operational challenges faced by the NWS, which will help to direct their research efforts in ways that can provide maximum improvements in NWS forecasts and warnings.

Data Fusion: A Machine Learning Tool for Forecasting Winter Mixed Precipitation Events

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Operational forecasters face a plethora of challenges when making a forecast; they must consider a multitude of data sources ranging from radar and satellites, to surface and upper air observations, to numerical weather prediction output. Forecasts must be done in a limited window of time, which adds an additional layer of difficulty to the task. These challenges are exacerbated by winter mixed precipitation events where slight differences in thermodynamic profiles or changes in terrain create different precipitation types across small areas. In addition to being difficult to forecast, mixed precipitation events can have large-scale impacts on our society.

To aid forecasts being made for these events, the goal of this project is to take the multiple data sources used by forecasters and combine them together using machine learning to improve forecasting ability for mixed precipitation events. The anticipation is that by employing a machine learning framework, forecasters will have more time to spend analyzing the most difficult portions of the forecast.

In order to achieve these goals, Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) daily observations from trained reporters between January 2017 to September 2020 were used to identify precipitation events that included rain, snow, freezing rain, and sleet. The data associated with the timing of these mixed precipitation events were collected from the New York State Mesonet, National Weather Service upper air soundings, High-Resolution Rapid Refresh model (HRRR), and North American Mesoscale forecast model with a 4km resolution (NAM 4km).

A random forest machine learning algorithm was trained and tested on the identified cases from the CoCoRaHS reports. Once this algorithm was implemented, results showed that rain and snow can be accurately forecast with accuracy scores around 86% and 90% respectively; sleet and freezing rain can be forecast with moderate accuracy with accuracy scores around 51% and 66% respectively. It is worth noting that the accuracy score of some mixed precipitation occurring was on par with rain and snow at around 85%. The product created to run the nowcasts and forecasts will be tested in previous events as well as predicting new events. These results give a good indication that a product utilizing this method will provide accurate precipitation type forecasts to be employed in combination with analysis by an operational forecaster.

A Mechanism for Upscale Growth of Convection in the Complex Terrain of the Northeast U.S.

Brennan Stutsrim

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Upstate New York has a variety of complex terrain that can interact with the background flow to create mesoscale heterogeneities in the lower troposphere. The major valleys of Upstate New York, the Hudson and Mohawk Valleys, often have increased moisture content and stronger surface winds than the higher terrain surrounding them. These features can have a profound effect on the evolution of convective storms, especially in cases characterized by low-to-moderate shear, which tends to favor pulse-like or multicellular convection. Analysis of composite radar imagery has indicated that convective storms often change mode while descending from the Catskills Mountains into the Hudson Valley, coinciding with an increase severe weather reports. Some storms exhibited back building once reaching the Hudson Valley. Back building is when a convective line has new cells initiating adjacent to the mature cells such that the line propagates upstream with regards to the low-level flow. Back-building mesoscale convective systems (MCS) have been connected to an increased threat of heavy rainfall and flash flooding, especially in the Northeast.

A back-building mesoscale convective system (MCS) from 21 August 2019 was simulated using WRF-ARW to study the mesoscale interactions between the background flow, complex terrain features in and around the Hudson Valley, and the MCS's convective cold pool. During the three hours proceeding the MCS, southerly terrain-channeled flow created a favorable pre-convective environment in the Hudson Valley through a low-level maximum in water vapor flux. Discrete convection from the Catskill Mountains intensified once reaching the Hudson Valley, creating a cold pool with an outflow boundary oriented across the valley. The channeled flow increased the low-level convergence along the southern portion of the outflow boundary causing high equivalent potential temperature air from the lower Hudson Valley to be lifted, initiating new convective cells. The MCS propagated down the valley until the channeled flow was cut off by another convective line entering the lower Hudson Valley.

Decision trees were created to identify characteristics of the pre-convective environment that are conducive to back building in the Hudson Valley. Composite radar imagery was analyzed to identify cases with (n=15) and without (n=55) back building from June, July and August 2015-2020. HRRR 0-hour analyses, valid at 1800 UTC, were used to calculate area averaged variables in the Hudson Valley for each case and analyzed by the decision tree classifier. Variables related to surface-based instability, such as surface-based CAPE and lifted index, and low-level moisture content, such as 2-m AGL dew point depression, were chosen most often by the decision tree classifier. A high value of surface-based instability makes it more likely that a new updraft along the outflow boundary will grow into deep convection. A low 2-m dew point depression makes it more likely that a small vertical displacement of the surface parcel by the outflow boundary will result in saturation and positive buoyancy. Comparison of composite wind profiles from cases with and without back building revealed a difference in the wind speeds from 900 hPa to the tropopause. A mean tropospheric wind of 30 kt made it more likely that cells would move out of the Hudson Valley before forming a strong cold pool. A mean tropospheric wind of 20 kt resulted in slower cell motion, allowing stronger cold pools to form in the Hudson Valley and increasing the likelihood of back building.

Review of the 2021 Tropical Remnant Tornadoes in Southern New England

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Six weak (EF-0) tornadoes occurred in southern New England from August into early September, 2021 associated with the remnants of three tropical cyclones. The remnants of Tropical Storm Fred produced two tornadoes (Thompson, CT/Webster, MA and Clinton, MA); the remnants of Tropical Storm Henri produced three tornadoes (Marlborough, Bolton, and Stow, MA); and the remnants of Hurricane Ida produced one tornado (Dennis, MA). Tornadoes associated with tropical cyclone remnants are fairly rare in southern New England. Prior to these tornadoes, only one tornado (F1) was documented from the remnants of Tropical Storm Alison on June 17, 2001.

The tornadoes formed under a classic environment from decaying tropical cyclones: the presence of sufficient 0-3 km CAPE, strong low-level shear, deep tropical moisture resulting in low LCLs, and the presence of a surface boundary to enhance low level spin-up. This environment closely matched the tropical remnant classification (“Type D”) from a recent study of favorable tornado environments (O’Brien et al, 2017) in southern New England. These were the least common in the study which found that most tornadoes occurred with a closed 500 hPa low near southern Ontario (“Type A”) or a 500 hPa trough over the Great Lakes (“Type B”). The environment also showed similarities to those from other studies, most notably Schenkel et al (2020 and 2021). Radar signatures were subtle, yet NWS Boston meteorologists were able to integrate their knowledge of the near storm environment to successfully provide warnings with lead time for five of the six tornadoes.

This presentation will review the common synoptic and mesoscale environments that led to the formation of these six tornadoes. Radar imagery will also be shown to stress the importance of maintaining high situational awareness, including knowledge of the near storm environment, as part of the warning decision making process. A comparison with the only other tropical remnant tornado (Alison) will also be shown to discuss the improvements in technology and messaging.

The Use of Radar-Based Techniques to Warn for Tornadoes in the Albany Warning Area

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University of South Alabama
Michael Evans (Mentor)
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The northeast United States rarely sees tornadoes. However, the 2020 year produced many more tornadoes in New York than previously seen, and with current warning techniques, 50% of tornado warned storms were false alarms, and 43% of tornado events were unwarned. The goal of this project is to test and verify radar-based warning strategies for improved lead time and accuracy of tornado warnings, particularly for the Albany Weather Forecast Office (WFO) warning area. The mesoscale and radar environments of tornadic and non-tornadic cases of 2020 were analyzed, and the warning strategy point system put together by the Boston WFO was applied to the cases in the Albany WFO, and then the radar-based techniques of the Tornado Warning Improvement Project (TWIP) were also applied for quasi-linear convective system (QLCS) and supercellular tornadogenesis.

The warning strategy published by the Boston WFO showed great significance for warning for tornadoes during tornadic events, with 8 out of the 14 tornadic events examined having more than a 50% probability of tornadogenesis. The nontornadic events, however, also showed strong favorability for warning for tornadogenesis. While it proved useful for determining tornadic cases, there would be a high false alarm rate if relied upon solely for warning decisions. The TWIP supercellular and QLCS research showed similar results regarding the effectiveness of tornadic vs. nontornadic cases. The supercellular tornadogenesis research, in particular, would best be utilized if the parameters could be automated. More research could be done to discover a more streamlined tactic for warning accuracy and lead time for supercellular tornadogenesis.

New Visualization Tools to Help Utilize Z_{DR}/K_{DP} Separation and Size Sorting Signals in the Tornado Warning Process

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Previous work has shown promise in utilizing size sorting signals (separations between Z_{DR} areal maxima in the Z_{DR} arc region and K_{DP} areal maxima within the K_{DP} foot) to help discriminate between tornadic and non-tornadic supercells. In Loeffler et al. 2020, more than 100 supercell storms were investigated across geographically diverse regions of the United States to help demonstrate this potential capability. These research results and supporting theories will be briefly outlined for purposes of background review.

Supplemental placefiles have recently been added to the Gibson Ridge 2 software platform (GR2 Analyst), which allow users to view Level 2 radar data in both live, real-time and archived formats. These placefiles allow the user to employ tools which help to visualize and quantify Z_{DR} and K_{DP} separations (i.e. separation vector angles and physical separation distances) in potential tornado warning situations. Case studies of recent northeastern U.S. tornadic storms will be shown to demonstrate examples of how these tools could assist warning meteorologists.

Review of the July 21, 2021 “Non Event” in Southern New England

Joseph W. Dellicarpini
NOAA/NWS/WFO Boston/Norton, Massachusetts

Convective-allowing models (CAMs) highlighted the potential for convection throughout much of southern New England in the days leading up to July 21, 2021, with the possibility of severe weather in parts of Connecticut, Rhode Island, and southeast Massachusetts where a Severe Thunderstorm Watch was eventually issued. The expectation was for convection to initiate across Pennsylvania ahead of a negatively-tilted 500 hPa trough and surface cold front, then track into southern New England as moisture and instability were drawn northward.

In reality, the trough never gained negative tilt and remained neutral, causing the activity to head eastward and pass offshore well south of New England. Additionally, a weak surface trough not captured well by CAMs dropped south early in the day, and shifted surface winds to the west or northwest, thereby minimizing surface convergence and limiting the potential for convective development. A few thunderstorms did form later that evening as the cold front crossed the region.

This presentation will review synoptic and mesoanalysis data, forecasts from various CAMs, and radar and satellite imagery to step through the forecast and IDSS messaging process from the day before July 21 through the day of the anticipated event.

The 2 July 2020 Anomalous Severe Weather Event across eastern New York

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On 2 July 2020, a major severe weather event occurred across much of eastern New York (NY). Eastern NY had 30 severe reports of damaging winds in excess of 50 knots (58 mph), as a cluster of severe thunderstorms developed over the Lake George and Saratoga Region. The thunderstorms progressed southward in and along the Hudson River Valley and produced widespread damage throughout the Capital Region and Helderbergs in eastern NY. Any severe weather threat was expected to be isolated on this day with a "General Thunderstorm" forecast from the NOAA/NCEP Storm Prediction Center for the area.

Observational data, as well as short-range deterministic forecasts from the High-Resolution Rapid Refresh suggested some severe weather could occur despite northerly flow aloft and a mid and upper-level trough centered over eastern New England. A surface trough associated with the low would tap into a moderately unstable environment with surface based convective available potential energy values ranged from 1000 to 2000 J kg^{-1} with increasing effective bulk shear values of 25 to 35 kts. Downdraft CAPE values were in the 800-1200 J kg^{-1} range in the afternoon with steep low-level lapse rates of 8-9°C km^{-1}. The mid-level lapse rates were very weak at less than 6°C km^{-1}. The effective bulk shear values suggested that multi-cells forming into clusters or lines were possible with damaging winds the main threat.

This presentation will focus on a detailed mesoscale and radar analysis of the event, utilizing legacy and dual polarization data (differential reflectivity, correlation coefficient, and specific differential phase (K_{DP})). The storm-scale analysis will focus on the gust front and cold pools associated with the severe convection. Also, forecast techniques including the role of collapsing K_{DP} columns with wet microbursts will be examined based on local and CSTAR research in this low predictability high impact event.

Analysis of WSR-88D SAILS Usage on Severe Weather Warning Performance

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WFO Boston/Norton recently collaborated on an analysis conducted by MIT Lincoln Labs on the historical (2014–2020) statistical relationship between Supplemental Adaptive Intra-volume Low-level Scan (SAILS) usage on the Weather Surveillance Radar 1988-Doppler (WSR-88D) and National Weather Service (NWS) severe storm warning performance. SAILS provides additional base scans per volume in VCPs 12 and 212 and significantly reduces the time interval between low level scans. The radar operator may choose 1, 2, or 3 extra scans but there can be confusion as to which mode of SAILS might be most effective.

Results show meaningful improvement in severe thunderstorm (SVR), flash flood (FF), and tornado (TOR) warning performance associated with using SAILS versus not. Among the three possible SAILS operational modes of one (SAILSx1), two (SAILSx2), and three (SAILSx3) additional base scans per volume, SAILSx2 was determined to have better warning performance for SVR while SAILSx3 showed better warning performance for FFW and TOR compared to SAILSx1.

This presentation will provide a brief overview of SAILS and, through the results of the MIT Lincoln Labs study, will show the benefits of utilizing SAILSx2 and SAILSx3 in the warning decision making process. Two severe storm cases will be shown to reinforce the study's results, one that spawned a tornado and one that did not, where SAILS usage helped forecasters make the correct warning decision.

The Evolving Role of Humans in Weather Prediction and Communication

Neil A. Stuart
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A series of webinars and panel discussions were conducted on the topic of the evolving role of humans in weather prediction and communication, in recognition of the 100th anniversary of the founding of the AMS. One main theme that arose was the inevitability that new tools using artificial intelligence will improve data analysis, forecasting, and communication. We discussed what tools are being created, how they are being created, and how the tools will potentially affect various duties for forecasters in multiple sectors of the profession.

Even as artificial intelligence increases automation, we argue that humans will remain a vital part of the forecast process. Additionally, both university training and professional development must be revised to accommodate the evolving forecasting process, including addressing the need for computing and data skills (including artificial intelligence and visualization), probabilistic and ensemble forecasting, decision support, and communication skills. These changing skill sets necessitate that both the U.S. government's Meteorologist General Schedule-1340 requirements and the AMS standards for a bachelor's degree need to be revised.

Recommendations will be made for student and forecaster preparation and career planning, highlighting the need for students and forecasters to continue their education and learn new skills throughout their careers. Meteorologists, like all scientists, need to be flexible life-long learners and engaged in the changes to forecast technology in order to best serve the user community. Humans can maintain an essential role in weather prediction and communication some of those roles will be presented.

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Thank you to all attendees and presenters! We hope you all found NROW XXII to be an informative and interesting Workshop. We look to forward to next year's NROW XXIII at our brand new facility, the ETEC Building, tentatively scheduled for November 1-2, 2022!