20th Anniversary
Northeast Regional Operational Workshop (NROW) XX
November 6 — 7, 2019 | Albany, New York





Sponsored by:
National Weather Service
SUNY— University at Albany's Department of Atmospheric and Environmental Sciences
American Meteorological Society

Agenda
Northeast Regional Operational Workshop XX
Albany, New York
NanoFab South Conference Center, Room 103, 255 Fuller Road
Wednesday, November 6, 2019

8:50 am
Welcoming Remarks & Conference Logistics
Raymond G. O'Keefe, Meteorologist In Charge
Joseph P. Villani, NROW XX Steering Committee Chair
National Weather Service, Albany, New York

<u>Session A – Climatology/Observations/Tropical</u> (9:00 am to 10:20 am)

9:00 am
Understanding Frequent Lightning Environments over the NWS Albany, New York County Warning Area
Christina Speciale
NOAA/NWS Weather Forecast Office, Albany, New York
Brittany Connelly and Ian Anderson
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

9:20 am
New York State Mesonet: A Summary of Recent Updates, Case Studies, and Research Collaborations
Jerry Brotzge
New York State Mesonet, University at Albany, Albany, New York

9:40 am
The Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) Field Program
Brian A. Colle
School of Marine and Atmospheric Sciences
Stony Brook University, Stony Brook, New York

10:00 am
Forecast Parameters Favoring Systematic Large TC Track Errors in the EC and GEFS Ensembles
Nicholas Leonardo
School of Marine and Atmospheric Sciences
Stony Brook University, Stony Brook, New York

10:20 am to 10:40 am
Break: SUNY Albany AMS selling Refreshments (Conference Center Rotunda)

Session B – Numerical Weather Prediction and Applications

(10:40 am to 12:00 pm)

10:40 am
The Experimental High-Resolution SAR-FV3 Model with Local Forecast Examples
Michael Evans
NOAA/NWS Weather Forecast Office, Albany, New York

11:00 am
Evaluation and Verification of Boundary Layer Structure in Operational Models
Robert G. Fovell
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

11:20 am
Investigating the Uncertainties of Forecasting Northeast Cold Season Precipitation in Numerical Weather Prediction Models
Yanna Chen
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

11:40 am
The Influence of Turbulence Parameterizations on the 2 March 2018 Snowstorm
Matthew Vaughan
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

12:00 pm – 1:30 pm
Lunch

Session C – Research/CSTAR (1:30 pm to 2:50 pm)

1:30 pm
Simulating the Effects of Terrain-Induced Perturbations on Severe Convection Using an Idealized Valley
Brian Tang and William Flamholtz
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

1:50 pm
Single-Parameter Perturbations: Quantifying Microphysical Parameterization Uncertainty in Convection-Permitting Forecasts of the 10–12 December 2013 Lake-Effect Snow Event
W. Massey Bartolini
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York
2:10 pm

Advances in Our Understanding of Lake-Effect Systems from the Ontario Winter Lake-effect Systems Field and Research Program
Jim Steenburgh
University of Utah, Salt Lake City, Utah

2:30 pm
Mesoscale Gravity Waves as an Unclassified Type of Storm:
A Research to Operations Opportunity for Northeast U.S. Forecasters
Anton Seimon
Appalachian State University, Boone, North Carolina

2:50 pm to 3:10 pm
Break: SUNY Albany AMS selling Refreshments (Conference Center Rotunda)

<u>Session D – Severe Weather</u> (3:10 pm to 4:00 pm)

3:10 pm
A Machine Learning Approach to Severe Thunderstorm Downburst Prediction
Luke LeBel
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

3:30 pm
Correlating Trends in Flash Extent Density for Tornadic Supercell Development over the Northeastern United States
Michael L. Jurewicz, Sr.
NOAA/NWS, Weather Forecast Office, State College, Pennsylvania

3:50 pm to 4:00 pm
Break: SUNY Albany AMS selling Refreshments (Conference Center Rotunda)

<u>NROW XX Key Note Presentation #1</u> (4:00 pm to 5:00 pm)

A Probabilistic Foundation for Winter Decision Support Services
Dr. David Novak
NOAA/NWS/NCEP, Weather Prediction Center, College Park, Maryland

5:00 pm
Wrap up/Adjourn
Joseph P. Villani

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6:30–9:00 pm
CSTAR Dinner at Brown's Brewing Company (Trojan Room) for participants in UAlbany–NWS CSTAR VI & VII (417 River Street, Troy, New York, 518-273-2337)

Agenda
Northeast Regional Operational Workshop XX
Albany, New York
Nano South Conference Center, Room 103, 255 Fuller Road
Thursday, November 7, 2019

8:05 am
Opening Remarks
Raymond G. O'Keefe, Meteorologist In Charge
Joseph P. Villani, NROW XX Steering Committee Chair
National Weather Service, Albany, New York

NROW XX Key Note Presentation #2 (8:15 am to 9:15 am)

Celebrating 20 Years of NWS Winter Weather Program Advancements
Dr. Louis Uccellini
NOAA/NWS Headquarters Silver Spring, Maryland

Session E – Hydrology (9:20 am to 10:40 am)

9:20 am
Improving the Detection of Flash Floods in southern New England
Lindsay Lawrence
Hollings Scholar with NOAA/NWS Weather Forecast Office, Boston/Norton, Massachusetts

9:40 am
Meteorological Model Ensemble Forecast Service (MMEFS) vs. Meteorological Ensemble Forecast Processor (MEFP) Service during Spring 2019 High-Flow Events
Erick Boehmler
NOAA/NWS Northeast River Forecast Center, Boston/Norton, Massachusetts

10:00 am
A Comparison of New York State Mesonet Precipitation Data against Automated Surface Observing System (ASOS) Precipitation Data across New York State
Ronald S.W. Horwood
NOAA/NWS, Northeast River Forecast Center, Boston/Norton, Massachusetts

10:20 am
Improving Flash Flood Warning Services for Northern New England
Katy Hollinger
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

10:40 am to 11:00 am
Break: SUNY Albany AMS selling Refreshments (Conference Center Rotunda)

<u>Session F – High Impact Events/Messaging</u> (11:00 am to 12:20 pm)

11:00 am
The New York City Metro Area Transportation Apocalypse Event of 15 November 2018
Lance F. Bosart
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

11:20 am
Communicating Rip Current Risk with a Virtual Reality Video Game
Jase Bernhardt
Department of Geology, Environment and Sustainability
Hofstra University, Hempstead, New York

11:40 am
Aviation Impact-Based Decision Support Services – It's about more than just Thunderstorms
Scott Reynolds
NOAA/NWS Central Weather Service Unit, Nashua, New Hampshire

12:00 pm
The 1 December 2006 Anomalous Severe Weather Event across the Northeast
Thomas A. Wasula
NOAA/NWS Weather Forecast Office, Albany, New York

12:20 pm – 1:50 pm
Lunch

<u>Poster Session - NanoFab South Rotunda</u> (1:50 pm to 2:40 pm)

Recent Examples of Using Specific Differential Phase to Help Predict Severe Thunderstorm Wind Damage
Brian J. Frugis
NOAA/NWS Weather Forecast Office, Albany, New York

Tracking the Sherpa Fire Plume: How the Catalina Eddy Transports Pollutants in the L.A. Basin
Erin Leghart
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

Effects of Latent Heating on Frontogenetic Enhancement in Idealized Atmospheric Rivers
Justin Templer
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

Use of a GIS Application to evaluate the Accuracy of Forecaster and Model Predictions of Snowfall in eastern New York and western New England
Joseph P. Villani
NOAA/NWS Weather Forecast Office, Albany, New York

The Multi-Hazard Severe Event of 21 August 2019 across eastern New York and western New England
Thomas A. Wasula
NOAA/NWS Weather Forecast Office, Albany, New York

<u>Session G – Winter Weather</u> (2:40 pm to 4:00 pm)

2:40 pm
Forecast Considerations Involving Extreme Snow-to-Liquid Ratios
Peter C. Banacos
NOAA/NWS Weather Forecast Office, Burlington, Vermont

3:00 pm
Understanding the Interaction between Short-Wave Troughs and Lake-Effect Snow Events off Lake Ontario
Ian Beckley
Department of Geoscience, Hobart and Williams Smith Colleges, Geneva, New York

3:20 pm
Computing Snowfall Forecast Biases for Warning-Level Lake-Effect Snow Events Downwind of Lake Ontario
Jared Klein
NOAA/NWS Weather Forecast Office, Binghamton, New York

3:40 pm
New York State Mesonet Snow Network: Review of 2018-2019 Data and Plan for 2019-2020
Junhong (June) Wang
New York State Mesonet
University at Albany, State University of New York, Albany, New York

4:00 pm – Wrap Up/Adjourn
Joseph P. Villani

NROW XXI is scheduled for November 4–5, 2020

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

Christina Speciale[1], Brittany Connelly[2], and Ian Anderson[2]
[1]NOAA/NWS/WFO Albany, New York
[2]Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

Thunderstorms that produce frequent lightning present numerous hazards extending from property and tree damage to even loss of life. Over the ten year period from 2008 to 2017, lightning resulted in four fatalities within the National Weather Service (NWS) Albany, NY County Warning Area (ALY CWA). With increased emphasis on Impact-Based Decision Support Services where NWS forecasters assist emergency manager partners with public safety operations, it is becoming more crucial to anticipate convective environments that will support frequent lightning. Such reasons motivated this research which aims to develop a frequent lightning climatology over the ALY CWA. This research utilized the National Center for Environmental Information's National Lightning Detection Network archive of cloud-to-ground lightning strikes and investigated 60 cases which produced frequent lightning over the ALY CWA between 2008 and 2017. "Frequent lightning" was defined as a calendar day with 5000 lightning strikes or higher.

Undergraduate students from the State University of New York at Albany, NY assisted in analyzing archived data from the North American Mesoscale Model (NAM) using BUFKIT software for each of the 60 events. Values of various parameters from the model forecast profiles near the time of convective initiation were documented. Parameters that previous research has linked to frequent amounts of lightning were evaluated, including the amount and depth of instability, environmental lapse rates, shear and moisture. Key environmental temperature profile data were also recorded to analyze the potential for both liquid water and ice to coexist within towering cumulus clouds.

Preliminary results were mainly commensurate with our initial thoughts but we discovered a few interesting results. First, the normalized convective available potential energy (NCAPE) values typically exceeded 0.15 ms^{-2} with the more impressive lighting days in excess of 0.20 ms^{-2}. As expected, 700-500 hPa lapse rates ranged from 6.0 °C km^{-1} to 7.0 °C km^{-1} but the higher end lightning days featured even steeper lapse rates from 7.5 °C km^{-1} to 8 °C km^{-1}. Interestingly, the freezing heights ranged from 8 kft to 13 kft and the -20 °C heights remained mainly confined between 20 kft and 23 kft. Since frequent lightning typically occurs in moisture rich environments, we hypothesized that precipitable water values would fall on the higher end of the moisture spectrum but our findings presented an interesting result. Values mainly ranged from 1.00 to 1.75 inches and surprisingly rarely exceeded 2 inches. Another notable result was that effective shear values for frequent lightning days were rather low, generally only between 20 and 35 kts. The values of these and the other selected convective parameters will be presented in box and whisker plots to represent the climatology of frequent lightning environments within the ALY CWA. Our intent is that such a climatology will assist operational forecasters anticipate and communicate hazardous lightning situations to our deep core partners.

New York State Mesonet:
A Summary of Recent Updates, Case Studies, and Research Collaborations

Jerry Brotzge, Junhong Wang, Josephine Crouch, and Nick Bassill
New York State Mesonet, State University of New York at Albany, Albany, New York

The New York State Mesonet (NYSM; http://nysmesonet.org) is a high-quality network of 180 environmental monitoring stations (126 "standard" and 54 "specialty" sites) deployed statewide. A suite of environmental information, including temperature, moisture, precipitation, wind, pressure, solar radiation, snow depth, and soil temperature and moisture, is collected continuously every 5 minutes from every site; since the network's first stations were installed in fall 2015, over *one billion* observations have now been collected, quality controlled, and archived.

This presentation will highlight: (1) Recent changes to the NYSM system; (2) Various interesting measurements from weather events during the previous year; and (3) A summary of research collaborations resulting from the NYSM. One major change to the NYSM is the overhaul of the website. A few sensor quirks and updates will be discussed. Several weather events during 2018-2019 will be examined, highlighting the value of Mesonet data for monitoring these events. Finally, a list of ongoing research collaborations and data usage will be reviewed, showcasing weather's impacts across agriculture, energy, transportation, and health.

The Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) Field Program

Brian A. Colle[1], Pavlos Kollias[1], Mariko Oue[1], Michael French[1],
Nicholas Leonardo[1], Keenan Fryer[1], Jeff Waldstreicher[2], and
Lynn McMurdie[3]
[1]School of Marine and Atmospheric Sciences
Stony Brook University, Stony Brook, New York
[2]NOAA/NWS, Eastern Region Scientific Services Division, Bohemia, New York
[3]University of Washington, Seattle, Washington

There are many operational challenges with forecasting heavy snowfall within U.S. East Coast winter storms. The precipitation within these storms is frequently organized in multi-scale banded structures that are often poorly predicted given their transient behavior. There has been much research and operational attention to single-banded precipitation features associated with mid-level frontogenesis, but less attention on the genesis of multi-bands. There is also little understanding of the microphysical evolution with these bands. The NASA Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) Earth-Venture Suborbital-3 (EVS-3) field campaign will take place during the winters (mid-Jan through Feb) of 2020 – 2022 to sample a range of East Coast snowstorms using airborne remote sensing and in-situ instrumentation. The ER-2 aircraft will fly at high altitudes and carry a suite of remote sensing instruments including cloud and precipitation radars, lidar, and passive microwave radiometers to simulate satellite-borne instrumentation. The P-3 aircraft will fly within clouds and sample environmental and microphysical quantities using a turbulent air motion measurement system, microphysics probes, and a dropsonde system to sample vertical profiles of temperature, humidity and winds. These airborne measurements will be supplemented with ground-based measurements from rawinsondes launched from mobile sounding systems and at National Weather Service stations, ground-based and mobile radars on Long Island, and the New York State mesonet.

This talk will highlight the motivation for this project given recent snow banded verification and process study efforts. The talk will also highlight the Stony Brook Radar Observatory for IMPACTS, which features a dual-pol Ka-band scanning radar, vertically pointing w-band radar, microwave radiometer, two Microwave Rain Radars (MRR), Multi-Angle Snow Camera (MASC), scanning Doppler LIDAR, Parsivel mobile sounding system, and a state-of-the-art dual-pol phased-array X-band radar on a mobile truck. The information and real-time data is at: https://you.stonybrook.edu/radar/. Some results from winter storms during the past two years will be presented. The radar polarimetric and Doppler spectrum measurements identified aggregation and riming signatures in clouds accompanying the snowbands. The riming process was identified as a large amount of liquid water path (>200 g m^{-2}), turbulence signatures in Doppler velocity and spectrum width, and increases in particle fall speeds, consistent with rimed particles observed by the MASC. The riming signatures tended to be found in association with easterly to southerly winds at low levels. The aggregation signatures were identified as changes in polarimetric variables from a height with a temperature around -15°C toward the ground and slower fall speeds of ice particles. Large values of dual-wavelength ratio of S-band NEXRAD radar reflectivity to the Ka-band radar reflectivity were observed in a snowband, suggesting that the large snowflakes dominated, consistent with less rimed, large aggregates observed by the snow camera. These aggregation signatures tended to be observed with westerly to northerly winds.

Forecast Parameters Favoring Systematic Large TC Track Errors in the EC and GEFS Ensembles

Nicholas Leonardo and Brian A. Colle
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York

Our previous work verified the day 3-5 TC track forecasts of the ECMWF ensemble (EC; 51 members) and Global Ensemble Forecast System (GEFS; 21 members) for the 2008-2016 North Atlantic seasons. We found that the ECMWF has a negative along-track (slow) bias for cases undergoing extratropical transition, while the GEFS has a positive cross-track (right-of-track) bias for many cases. However, there are individual forecasts with track errors more than twice that of the sample climatology. Composites demonstrated that the largest slow biases tend to be associated with underamplified upper-level trough-ridge couplets, while the largest right-of-track biases are associated with the underprediction of an adjacent subtropical 700 hPa ridge. Better understanding the development of these common steering flow errors can help forecasters recognize situations when the model track guidance is prone to be significantly biased. That is, many of these cases develop from similar issues in the ensembles, which can be identified by analyzing trends in the ensemble guidance and ensemble sensitivity diagnostics of the TC track to certain meteorological fields early in the forecast.

Diagnostics for the largest slow bias cases in the EC reveal that the underamplification of the steering trough-ridge couplets is largely caused by the TC's divergent outflow being underpredicted, which is associated with insufficient near-TC convection and low-level moisture fluxes within the first 60 h of the forecast. Meanwhile, in the right-of-track cases, the local underprediction of the subtropical ridge is associated with the TC outer-core convection becoming too broad, which is caused by initial errors in the ambient moisture and stability. This error growth is further examined in 3 right-of-track cases with Weather Research Forecast model (WRF) simulations down to 4-km grid spacing, which show that the track forecasts do not significantly improve with increased horizontal resolution. Thus, forecasters should focus on the ensemble evolution of the initial near-TC fields (e.g., low-level moisture and wind) in forecasts with similar synoptic flow patterns.

The experimental high-resolution SAR-FV3 model with local forecast examples

Michael Evans[1] and Geoff Manikin[2]
[1]NOAA/NWS/WFO Albany, New York
[2]Environmental Modelling Center, College Park, Maryland

The Global Forecast System (GFS) upgraded to a new FV3-based dynamical core in 2019. This new dynamical core is expected to be the foundation for a more unified suite of operational numerical weather prediction (NWP) systems being developed at the National Center for Environmental Prediction. An example of newly-developed NWP based on the FV3 dynamical core is the high resolution (3 km) stand-alone regional model, (the SAR-FV3), which has been running in experimental mode since early in 2019. A subjective evaluation of this high resolution model has been performed by the Environmental Modelling Center's model evaluation group (MEG) since early 2019. The group that is testing this model includes several meteorologists who work at field offices within the National Weather Service.

This presentation will show some output from the SAR-FV3 for a small number of significant weather cases that have occurred over the northeast CONUS in 2019. Types of events include a rain vs. wet snow case from April, a case that featured an extremely intense low-level temperature gradient in April, and a moderately impactful severe weather event in August. Comparisons will be shown for these cases between the SAR-FV3 and forecasts from the 3 km NAM-nest. Initial findings indicate that the SAR-FV3 performed quite well, however challenges will probably remain related to forecasting the boundary layer and conditions associated with tight meteorological gradients. In addition, since the study began in April, more work is needed to evaluate the model's performance during winter events.

Evaluation and Verification of Boundary Layer Structure in Operational Models

Robert G. Fovell
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

NOAA's operational High Resolution Rapid Refresh (HRRR) model is run at convection-permitting (3 km) horizontal resolution and utilizes the Mellor–Yamada–Nakanishi–Niino level 2.5 (MYNN2) PBL scheme. This is a state-of-the-art treatment that has been substantially upgraded and expanded in recent years. HRRR forecasts of boundary layer wind, temperature, and specific humidity are being evaluated using 60 high-resolution radiosondes across the contiguous US (CONUS) that can provide roughly 5 m vertical resolution near the surface. Challenges in employing this underutilized resource have been mitigated or overcome and the spatially- and temporally-averaged composites are revealing shortcomings in the forecasts that can be addressed with further improvements to the scheme. Along with evaluation, some improvements will be proposed and tested.

Investigating the Uncertainties of Forecasting NE Cold Season Precipitation in Numerical Weather Prediction Models

Yanna Chen[1], Robert Fovell[1], Everette Joseph[2], and Michael Evans[3]
[1]Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York
[2]National Center for Atmospheric Research, Boulder, Colorado
[3]NOAA/NWS/WFO Albany, New York

A major winter storm on March 2, 2018, was a big forecast challenge with respect to predicting precipitation type for the northeast U.S including the Hudson Valley of eastern New York. Forecasts from the National Weather Service (NWS) blended the colder solution from the operational North American Mesoscale (NAM) model, and the warmer solution from the operational Global Forecast System (GFS) model, resulting in a mix of rain and snow in the Hudson Valley. However, the observations showed that the major precipitation type was snow even at the lower elevations in the mid and upper part of the Hudson Valley, and the snow depth forecast errors were around 8-12 inches near the Albany area.

The Weather Research and Forecasting (WRF) model was used to run nested simulations of this winter event at 25 km, 5 km and 1 km horizontal grid spacing. Experiments exploring sensitivity to model physics (including microphysics, cumulus, boundary layer, and radiation schemes) and domain configuration were made. The largest sensitivities with respect to snow depth were associated with cumulus and radiation schemes, and the vertical resolution in the middle troposphere was also found to be influential.

The WRF simulated results were compared with the NWS snowfall analysis observations from the Gridded Automated Zonal Precipitation and Complete Hi-res Output (GAZPACHO) using the point observations from public data statements (PNS) with an enhancement scheme that provides a more representative analysis for snowfall amounts in mountainous areas based on terrain slope. Additional measurements from the New York State Mesonet (NYSM) were added to the PNS and also used for the verification of surface temperature, snow depth and snow liquid water equivalent. These comparisons are providing clues regarding the causes of this dramatic forecast failure.

The Influence of Turbulence Parameterizations on the 2 March 2018 Snowstorm

Matthew Vaughan and Robert Fovell
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

Sub-grid scale turbulence in WRF is handled by planetary boundary layer (PBL) parameterizations. These schemes attempt to represent turbulent mixing processes occurring below the resolvable scale of the model grid, and act upon temperature, moisture, and momentum in order to produce a more realistic representation of the low-level atmospheric structure. In addition, more sophisticated schemes may alter cloud water and/or replicate the effects of radiationally driven cloud-top mixing. During a precipitation event, the modifications to temperature, moisture, and momentum fields by the PBL scheme may influence precipitation strength and, particularly in the cool-season, precipitation type. Given the diversity of PBL physics options available to the NWP community, we look to investigate the influence of various PBL schemes on a cool-season mixed-precipitation event.

This study uses the Weather Research and Forecasting model, run at convection-permitting resolution, to examine the effect of the PBL mixing on the extent and character of precipitation generated from the 2 March 2018 snowstorm impacting the northeastern US. Accumulated boundary layer tendencies of potential temperature, and moisture suggest the parameterized mixing applied by various PBL schemes can have a substantial impact on mesoscale precipitation location and type. In addition, PBL schemes with common lineages and theoretical underpinnings, such as the GFS and YSU schemes, can produce markedly different thermal profiles and precipitation types for the same initial conditions. This study explores why PBL schemes using similar theoretical assumptions produce differing thermal profiles and resulting precipitation fields.

Simulating the Effects of Terrain-Induced Perturbations on Severe Convection Using an Idealized Valley

William Flamholtz, Brian Tang, and Lance Bosart
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

Forecasting severe weather in regions of complex terrain is often difficult due to convective environment inhomogeneities induced by terrain. In the northeastern United States, one common inhomogeneity arises where terrain channeling of low-level flow occurs in valleys, where localized backed flow, and a subsequent increase of low-level wind shear and storm-relative helicity, may exist ahead of convection, thereby affecting the evolution of convection as it moves into valleys. Past research has shown that 0–1-km storm-relative helicity perturbations can exceed 40 m^2/s^2. Additionally, regions of upslope and downslope flow can modulate convective intensity as it moves across terrain. The goal of this research is to develop better understanding of specific mechanisms for how severe convection may be modulated by major N-S oriented valleys in the northeastern U.S., which can lead to an increased risk of severe weather hazards in valley locations.

This study uses idealized Weather Research and Forecasting (WRF) experiments to investigate how convective organization changes as simulated convection moves across an idealized valley with varying background low-level wind profiles. Several WRF simulations were conducted with an idealized valley with a width and depth motivated by the shape of the Hudson Valley. Additional simulations with only plateaus present were conducted as control comparisons for the valley simulations. Outside the valley (over the plateau), initial thermodynamic and wind profiles were used from HRRR analyses of past severe weather events in the northeastern U.S. Pressure perturbations were added to the model to induce a lee trough and terrain-channeling in the valley. Convection was initiated using a warm bubble over the plateau to the west of the valley, and the convection subsequently developed and moved over the valley.

We analyzed the evolution of the convection (e.g., maximum vertical velocity, low-level vorticity, updraft helicity) before, during, and after convection traverses across the valley. Preliminary analysis shows increases in 1-km vertical vorticity of ~0.008 s^{-1} in the upslope and downslope portions of the valley. Additionally, convective intensity is consistently higher in valley locations, where low-level storm-relative helicity is highest due to backed flow. Differences in organization are greatest in simulations with the highest directional shear in the 0–1-km layer.

Single-Parameter Perturbations: Quantifying Microphysical Parameterization Uncertainty in Convection-Permitting Forecasts of the 10–12 December 2013 Lake-Effect Snow Event

W. Massey Bartolini and Justin R. Minder
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

Lake-effect snow (LeS) presents a substantial forecast challenge for convection-permitting models, due in part to uncertainties in the parameterization of microphysical processes. Stochastic parameterization methods, where single-parameter values or process rates are perturbed using a Gaussian noise pattern that varies in time and space, are one approach to better represent physics uncertainties in the development of next-generation, convection-permitting ensembles. Here we focus on understanding microphysical uncertainties for a LeS event that occurred during 10–12 December 2013 during the Ontario Winter Lake-effect Systems (OWLeS) field campaign. Throughout this event, long-lake-axis-parallel snowbands persisted downwind of the eastern shore of Lake Ontario, leading to snowfall accumulations as high as 101.5 cm (liquid precipitation equivalent of 62.5 mm) on the Tug Hill Plateau.

We run nested simulations of the 10–12 December 2013 LeS event at 12-, 4-, and 1.33-km horizontal grid spacing using the Weather Research and Forecasting (WRF) model configured similarly to the operational High-Resolution Rapid Refresh model. All simulations use Thompson aerosol-aware microphysics, with sensitivity experiments conducted by varying fixed parameters within the scheme, such as snow mass-diameter (M-D), velocity-diameter (V-D), and particle size distribution (PSD) equation coefficients, collection efficiencies of cloud water by snow and graupel, and thresholds for ice nucleation.

Results from the WRF simulations are compared to detailed observations from OWLeS, including NEXRAD radar data, surface snowfall and crystal habit observations, and disdrometer data. Additionally, measurements from the University of Wyoming King Air (UWKA) aircraft, including in-situ flight-level thermodynamic and microphysical observations, are used to compare observed and modeled cloud structures. UWKA observations are also used to constrain the range of fixed parameter values in our sensitivity experiments.

We find substantial sensitivity of snowfall forecasts to parameter choices within the microphysical scheme. For instance, when varying the Thompson snow V-D and M-D equation coefficients to simulate different crystal habits based on V-D and habit observations from OWLeS, a large range of precipitation amounts is produced on the windward side of the Tug Hill Plateau. Between the two most extreme V-D and M-D experiments, representative of columnar and dendritic ice crystal habits, windward precipitation amounts vary by 15-30 mm, with the columnar experiment partially reducing a windward underforecast bias of 15-30 mm in a control simulation. In this manner, additional experiments are conducted to investigate the forecast sensitivity of snow and graupel amounts over the Tug Hill Plateau. These fixed-parameter experiments are a first step towards development of convection-permitting ensemble forecasts of LeS using stochastic physics.

Advances in Our Understanding of Lake-Effect Systems from the Ontario Winter Lake-effect Systems Field and Research Program

Jim Steenburgh[1], Leah Campbell[1], Peter Veals[1], Justin Minder[2], Ted Letcher[2], Phil Bergmaier[3], and Bart Geerts[3]
[1]University of Utah, Salt Lake City, Utah
[2]University at Albany, State University of New York, Albany, New York
[3]University of Wyoming, Laramie, Wyoming

The Ontario Winter Lake-effect Systems (OWLeS) field campaign collected comprehensive observations of lake-effect snowstorms generated by Lake Ontario from Dec 2013–Jan 2014. Observations of long-lake-axis-parallel (LLAP) lake-effect systems were made by fixed and mobile instrument platforms that included the University of Wyoming King Air Research Aircraft and a transect of profiling radars and snow measurement systems over the Tug Hill Plateau (hereafter Tug Hill). Research based on the data collected by these platforms, combined with real-data numerical simulations, illustrates the mechanisms responsible for LLAP-system initiation, intensification, and enhancement during OWLeS IOP2b, which produced 101.5 cm of snow in 24 hours on Tug Hill. A land-breeze front initiated along a bulge in the south shoreline between St. Catharines and Thirty Mile Point served as the locus for LLAP-system development. The LLAP system intensified over Lake Ontario where it featured a vigorous secondary circulation driven by solenoidal forcing and enhanced by latent-heat release in the updraft region. Further downstream, a second land-breeze front extended downstream from the southeast shoreline, cut obliquely across the LLAP system and contributed to snowfall enhancement over Tug Hill.

Multi-storm analysis of profiling radar data collected for OWLeS shows LLAP-systems typically undergo a convective-to-stratiform transition following landfall. This results in a decrease in convective vigor and echo top height, but more continuous snowfall, from the coast to Tug Hill. These findings contrast with contemporary conceptual models of lake-effect systems, which typically depict an increase in cloud depth and convective vigor over downstream topography. A multiyear analysis of data from the KTYX WSR-88D indicates that lake-effect enhancement over Tug Hill, as quantified by the ratio of upland-to-lowland liquid precipitation equivalent (LPE), is greatest during periods with strong incident flow, low CAPE, and non-banded lake-effect modes. Conversely, this enhancement is weakest, or there is a decrease in precipitation over Tug Hill, during periods with weaker incident flow, high CAPE, and banded lake-effect modes. Banded lake-effect modes produce large precipitation rates, but the ratio of upland-to-lowland LPE is near unity, indicating little increase over Tug Hill.

These results provide new insights into how coastline geometry, land-breeze fronts, and orographic processes modulate lake-effect systems east of Lake Ontario. In particular, we note that there can be strong variations in the distribution of precipitation from the coast to Tug Hill, that the mechanisms responsible for the Tug Hill maximum are not purely orographic, and that the view that lake-effect convection intensifies and deepens over downstream topography may be invalid or apply to a small subset of lake-effect periods.

Mesoscale Gravity Waves as an Unclassified Type of Storm: A Research to Operations Opportunity for Northeast USA Forecasters

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The hazardous weather associated with mesoscale large-amplitude inertia–gravity waves (MGWs) includes rapid fluctuations in surface pressure, precipitation rate and thunderstorm activity, along with surface winds that can reach 20–40 m s^{-1}. Their strong wind signatures constitute a storm by standard definition, yet MGWs remain unclassified as such. Along with their relative rarity (~1 event per year in the Northeast USA), the lack of formal designation contributes to MGWs remaining poorly understood by most meteorologists, and effectively unknown by the general public. Operational mesoscale forecast models have successfully predicted several recent events, and high-temporal resolution meteorological observation networks facilitate detection and monitoring. However, the uptake of such information by human forecasters is limited by insufficient MGW pattern recognition and knowledge. Substantial benefits could potentially be derived by 1) formally classifying MGWs as a storm type, 2) improving forecaster training, and 3) developing algorithms to detect characteristic MGW signals in operational mesoscale model output and observations.

We propose that a classification scheme be developed for MGWs based on physical characteristics derived from case studies of large-amplitude events (surface pressure change $\geq$5 hPa <30 min), and a methodology implemented for operational predictions and warnings. Automated detection of characteristic MGW patterns in forecast models and observations can inform forecaster-based subjective interpretation and warning issuance of potentially hazardous MGW events. Algorithms applied to forecast and observational estimates of pressure, wind, and vertical velocity can identify the potential for MGW generation and propagation. Probabilistic diagnostics generated from mesoscale ensemble simulations and graphical outputs could offer forecasters objective guidance identifying spatiotemporal MGW characteristics and potential hazards. Given the rarity of hazardous MGW events, such a system should operate unobtrusively and only activate for significant events. For cases where detection threshold values are exceeded, subjective forecaster interpretation should be applied in evaluation of model forecasts and real-time detection of candidate MGW disturbances. For the rare events where the MGW threat level is deemed significant, graphical products communicating the hazard in areas at risk could then be disseminated to media and the public.

Further research is still needed to advance the state of knowledge about cause and effect processes governing the occurrence and life cycles of large-amplitude MGWs. A critical science task remaining is to distinguish quantitatively the contributions of dry upper-level jet dynamics and moist convective dynamics to the formation, amplification, and evolution of large-amplitude MGWs.

A Probabilistic Foundation for Winter Decision Support Services

Dr. David Novak
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Winter weather events are costly and disruptive to the nation. This presentation will highlight recent advances in science and service to help mitigate winter weather impacts, with particular attention on using probabilistic information for decision support services. Rapid advances in observations, data assimilation and modeling have improved predictions such that some major snowstorms are being forecast a week in advance. However, the predictability of storms varies from event-to event and by scale. Further, specific impacts are more difficult to predict, given that impacts dependent on variables in addition to the weather (time of day, road treatment, social response, etc.). The variety of events, associated range of predictability, and resulting impacts call for using a probabilistic framework for decision making.

The National Weather Service winter weather program is guided by a vision of accurate, probabilistic, and impact-based forecasts. The program has embarked on several projects to accurately quantify and clearly communicate the risk of winter weather events, including use of convective-allowing ensemble data, provision of probabilistic snowfall graphics, and launch of impact-focused indices. These projects will be used to highlight the progress toward a probabilistic foundation for winter decision support services.

Improving the Detection of Flash Floods in Southern New England

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Over the past several years, detecting flash floods has become a greater challenge for forecasters at the Boston/Norton office of the National Weather Service, largely due to the rapid flux in urbanization and aging infrastructure. Flash floods that were once more common in rural areas around rivers and streams are now occurring more frequently in urban centers and other highly developed areas. Runoff during heavy rainfall events has fewer natural storage basins for drainage as a result of less vegetative cover from increased civic expansion in combination with the tendency of water to overwhelm storm drainage systems that rely heavily on infrastructure dating back to the early 1900s in several communities.

This study is an analysis of thirty-nine individual flash flood events in Southern New England from 2013-2018. The goal is to improve forecasters' abilities to better predict the development and impact of flash flood-producing storms given a variety of synoptic, mesoscale, and radar-based parameters. Additionally, a working "Flash Flood Playbook" was created based upon certain environmental criteria for several different synoptic and mesoscale patterns, in order to improve flash flood warning detection and lead time.

Meteorological Model Ensemble Forecast Service (MMEFS) vs. Meteorological Ensemble Forecast Processor (MEFP) Service During Spring 2019 High-Flow Events.

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Since 2017, NERFC has undertaken an effort to transition our ensemble river forecast products basis to the Hydrologic Ensemble Forecast Service (HEFS) software. During the development of the Meteorological Ensemble Forecast Processor (MEFP) component of the HEFS software, another software known as the Meteorological Model Ensemble Forecast Service (MMEFS) was in use. The MMEFS is capable of preparing GEFS forcings forecasts for the Community Hydrologic Prediction System (CHPS) rainfall – runoff models. Ensemble river forecasts resulting directly from the GEFS forcings were more applicable in the short-term than ensemble river forecasts from climatology. However, ensemble river forecasts were subject to bias in forcings of precipitation and temperature magnitudes and areal extent from the GEFS when downscaled to river basin areas. With the development of MEFP, and its application of the GEFS mean and distribution of GEFS forecast errors from observed forcing values historically, noticeably reduced bias in forcings ensembles and river flow forecasts were expected. Presentation of side-by-side comparisons of river ensemble forecasts driven by MMEFS and MEFP from high-runoff events in March and April of 2019 mostly support this expectation.

A Comparison of New York State Mesonet Precipitation Data Against Automated Surface Observing System (ASOS) Precipitation Data Across New York State

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The National Weather Service's (NWS) Northeast River Forecast Center (NERFC) produces over 200 daily forecasts of river stage and flow across New England and New York State. To produce accurate forecasts, real-time precipitation data is essential. Prior to implementation of the New York State Mesonet, the NERFC relied on Automated Surface Observing Systems (ASOS), satellite telemetered rain gauges from cooperating agencies such as the United States Geological Survey (USGS), the U.S. Forest Service and the New York City Department of Environmental Protection (NYCDEP). These precipitation sources along with 24-hourly NWS Cooperative Observer (COOP) observations, 24-hourly Community Collaborative Rain, Hail and Snow (CoCoRaHS) Network observations and WSR-88D radar estimates are combined to produce 6-hourly basin average melted equivalent precipitation estimates that are fed directly into the NERFC's hydrologic model as a forcing for river rises.

Despite the variety of precipitation datasets utilized above, significant limitations continued to hamper accurate real-time precipitation estimates across New York State. These limitations included: a lack of reporting locations in the Adirondack Mountains of northern New York State, automated rain gauge outages and inaccurate estimates of precipitation in freezing/frozen precipitation events.

With implementation of the New York State Mesonet, a new, high-density network of real-time precipitation data became available to the NERFC. All of the New York State Mesonet stations were added to the NERFC database in an effort to improve the accuracy of precipitation estimates across New York State. To this end, hourly New York State Mesonet precipitation observations for 13 sites across New York State were compared to nearby ASOS stations in an effort to validate the network.

Hourly precipitation data was collected from 15 January 2019 through 31 May 2019 to produce daily (12z –12z) precipitation values for both New York State Mesonet stations and ASOS stations. This time period ensured most of the precipitation events were synoptic in nature and both freezing/frozen events and pure rainfall events were sampled.

The results of this study show that the New York State Mesonet stations perform at least as well as if not better than ASOS stations during rainfall events and markedly better than most ASOS stations during freezing/frozen precipitation events. As a result, the New York State Mesonet precipitation data is now fully integrated into forecast operations at the NERFC.

Improving Flash Flood Warning Services for Northern New England

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Timely flash flood warnings are critical to the mission of the National Weather Service to protect lives and property. The current goal for flash flood warning lead time is 65 minutes. The goal of this project is to identify synoptic and mesoscale patterns that exist up to 24 hours prior to flash flood events in order to be better aware of flash flood potential before events occur. In this study, a climatology of flash flooding for Northern New England (defined as Maine, New Hampshire, and Vermont) was established from 2008-2018 using flash flood events from the Storm Events Database. Using Maddox et. al. (1979) as a reference, this study focuses specifically on 500 millibar trough/ridge patterns as well as the presence of a surface front and the vertical wind profile. While there is not a single definitive pattern responsible for flash flood events in northern New England, several "most likely" situations have been identified. Flash flooding was found to be more common in large trough patterns with weak to moderate vertical wind shear through the profile.

Unwarned events, as well as false alarm days, were also analyzed from a climatological perspective and for their synoptic characteristics. Identifying similar patterns in missed events, events that did not occur, and events that did occur within a warning will allow forecasters to better identify flash flood situations with more advanced notice leading to warnings that meet the NWS lead time expectations.

The New York City Metro Area Transportation Apocalypse Event of 15 November 2018

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A rather ordinary early season Nor'easter produced an epic transportation disaster in the New York City (NYC) metro area on the afternoon and evening of Thursday 15 November 2018 when the NYC metro area was nearly paralyzed by a 6" (15 cm) snowfall over a period of a few hours. The NYC media and the social media outlets had a field day hyping snow-induced transportation gridlock across the metro area while serving as "outrage outlets" for hundreds of thousands of aggrieved travelers who were frustrated at their inability to go from point A to point B. A critical question is how could a run-of-the-mill ordinary Nor'easter that was reasonably well-predicted and well-advertised by the available numerical guidance produce such a disproportionately high-impact disastrous transportation debacle? This presentation is motivated by the need to understand what happened, how it happened, and why it happened from both science and forecasting perspectives.

Observations from Central Park (KNYC) show that light snow (S-) began at 1836 UTC, transitioned to moderate snow (S) at 1859 UTC (23 min after snow began), and further transitioned to heavy snow (S+) by 1943 UTC (67 min after snow began). After the transition to S+, KNYC reported liquid water equivalents of 0.15", 0.25", 0.18" and 0.15" in the hours ending 2051, 2151, 2251, and 2351 UTC, respectively. These precipitation rates equated to snowfall rates of 1–3" h^{-1}, which were more than enough to disrupt transportation and produce widespread gridlock. This "transportation apocalypse" was compounded by a quasi-simultaneous mass exodus for home by millions of people when everyone panicked as snow began, rapidly intensified to S+, and accumulated on untreated roads. People were stuck in their cars, stuck cars made it impossible for road crews to treat and plow the roads, and massive gridlock ensued.

Confluent jet-entrance region dynamics contributed to an equatorward-directed surge of low-level cold Canadian air into the Northeast prior to the storm. This surge of cold Canadian air increased the baroclinicity across the Northeast and set the table for a subsequent warm-air advection-driven precipitation event. Heavy snow developed along a slow-moving east-west oriented axis of strong low-level frontogenesis beneath vigorous ascent aloft. Sensible and evaporative cooling from heavy snow established an isothermal (0°C) lapse rate in the planetary boundary layer (PBL) and delayed the changeover to mixed precipitation and rain. A critical forecast problem was determining the timing of this changeover, given the competing effects of sensible and evaporative cooling, adiabatic ascent, and horizontal temperature advection on the temperature tendency in the PBL. This talk will focus on the applicable meteorology, the governing dynamics, and relevant forecast issues.

Communicating Rip Current Risk with a Virtual Reality Video Game

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Rip currents are among the deadliest phenomena to influence beachgoers in the United States, yet few members of the public have an adequate understanding of their risk, nor the appropriate actions to take when caught in one. To improve public literacy, a virtual reality (VR) video game was created, in which participants were trained on how to swim in the ocean and wave for help, and then placed in a rip current without warning. The VR game and an associated survey was shared with Atlantic Ocean beachgoers on Long Island during summer 2019. The actions taken and binary outcome (escaped the rip current or drowned) were recorded for each participant. Those results were also compared to demographic data and factors such as swimming ability and frequency visiting ocean beaches. Moreover, a post-survey interview was conducted with each participant, in which they identified the least and most helpful aspects of the VR video game, and discussed its overall efficacy in enhancing rip current understanding. Preliminary analysis indicates that the deployment of VR in this manner can decrease rip current risk by demonstrating proper actions to take in a novel and memorable way. However, the interview data reveals a disconnect between an individual's knowledge of rip current risk and the mitigating actions taken during the simulation. Nevertheless, it is clear that VR and similar immersive technologies have the potential to enrich public outreach activity relating to atmospheric and oceanic hazards. Future work can capitalize on the data gathered in this study to develop even more nuanced and interactive simulations of such events.

Aviation Impact-Based Decision Support Services – It's About More Than Just Thunderstorms

Scott Reynolds
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When one thinks about the impacts of weather on aviation operations, the conversation usually starts (and ends) with thunderstorms. Thunderstorms do have a significant impact on the safe flow of air traffic about the National Airspace System (NAS). However, there are many more weather phenomena that play important roles in the safe movement of traffic around the NAS.

This presentation will highlight a number of the different weather-related impacts on the aviation community, with specific emphasis on the Northeast Corridor. Several recent case studies, including one that resulted in a National Transportation Safety Board (NTSB) investigation, will be presented to show ways that we can improve our forecasts, messaging, and ultimately, our service to our partners.

The 1 December 2006 Anomalous Severe Weather Event across the Northeast

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Severe thunderstorms across the Northeast are very unusual in the cool season. For example, Albany only averages about one thunderstorm day every decade in the month of December. Several Quasi-Linear Convective Systems (QLCS) occurred in Pennsylvania (PA) and west-central New York (NY) ahead of a vigorous cold front and its associated upper-level trough on 1 December 2006. These severe thunderstorms produced damaging winds in excess of 50 knots (58 mph), tornadoes up to F2 in intensity in northeast PA, and even a few large hail (greater than 1.9 cm) reports that occurred between 1700 UTC and 2200 UTC 1 December. These QLCSs eventually formed into an extensive squall line passing through eastern NY into New England with dozens of wind damage reports.

A backdoor cold front pushed south during the morning, spreading a shallow cold air mass through the Mohawk Valley and the Capital District with temperatures falling to around 5°C. The anomalously warm and humid air mass moved north of the Mohawk and Upper Hudson valleys in the late afternoon and early evening. On the south side of the boundary, air temperatures were in the 15-20°C range coupled with dewpoints around 15°C. The valleys were the last areas from which the shallow cold air (less than 0.5 km in depth) was scoured prior to the severe convection.

The synoptic and mesoscale environments were conducive for severe convection capable of tornadoes. Upstate NY and New England were located in the favorable left front quadrant of mid- and upper-level jet streaks with strong divergence aloft. At 1200 UTC, a low-level jet of 60 knots was heading northeast from the Mid Atlantic region, as the mid-level trough quickly accelerated northeast from the Tennessee and Ohio Valleys. The low-level jet advected higher amounts of theta-e in the boundary layer. The QLCSs' developed in a highly sheared environment (0-6 km bulk shear values in excess of 75 knots) with low to modest amounts of instability (Most Unstable Convective Available Potential Energy values in the 250-750 J kg^{-1} range). Helicity values in the 0-3 km layer were forecasted to be in excess of 500 m^2s^{-2}. Lifting condensation levels were low below 1 km (~3000 feet). Despite the potentially dangerous tornadic environment in place, no tornadoes occurred across eastern NY and New England.

This talk will take a multi-scale approach analyzing the event from the synoptic-scale to the storm scale to fully understand the environment that caused the anomalous December severe event. Special emphasis will be placed on a detailed radar analysis of the convection to draw some hypotheses why the tornadic signal waned northeast of PA in the early evening despite the favorable dynamics and thermodynamics. Observational data will extensively be used in the analysis including: surface and upper air observations, satellite imagery, and KENX WSR-88D data. Also, Vorticity Generation Parameter calculations from the NAM12 will be shown and discussed for the event.

Recent Examples of Using Specific Differential Phase to Help Predict Severe Thunderstorm Wind Damage

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Local research has shown the utility in using Specific Differential Phase (K_{DP}) during the severe thunderstorm warning process. By examining the values of K_{DP} within a vertical cross-sections of a possible severe thunderstorm, warning forecasters can potentially spot the pre-cursor to a wet microburst. High values of K_{DP} suspended aloft that crash towards the surface often cause a wet microburst when the precipitation loaded downdraft reaches the surface. This can be a useful tool in addition to the traditional warning method of focusing solely on radial velocity data, as Doppler radar radial velocity data may not always provide a clear picture on the scope of the storm due to inherent problems regarding the radar beam's height and angle. This local research has shown this signal to be especially true in storms that produce significant severe thunderstorm wind damage.

During the summer of 2019, numerous severe thunderstorms produced wind damage across the Albany New York County Warning Area. Between July 1st and August 31st, the Albany Weather Forecast Office issued 156 severe thunderstorm warnings and forecasters commonly examined K_{DP} columns aloft during the warning process. Several of these storms produce significant damage, resulting in extensive damage to trees and homes, as well as widespread media attention. Radar data from these storms will be presented to show how a signal for this damage can be seen within vertical cross-sections of K_{DP}. Utilizing K_{DP} can aid the severe thunderstorm warning process and can lead to longer lead times and more detailed warnings, as impact-based warnings require forecaster estimation of the damage potential and potential wind gusts speeds.

Tracking the Sherpa Fire Plume: How the Catalina Eddy Transports Pollutants in the LA Basin

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In June 2016, the Sherpa Fire blazed through Santa Barbara County, California, burning over 7,000 acres of land in both the Santa Barbara Region and Los Padres National Forest. The transport of emissions from the Sherpa Fire was influenced by the Catalina Eddy, a typical meteorological phenomenon observed off the coast of Southern California from late spring to early fall. On June 17, 2016, the NASA DC-8 conducted 11 missed approaches at airports throughout the Los Angeles basin as part of the KORUS-AQ campaign. The DC-8 sampled the Sherpa Fire plume at different altitudes during these missed approaches, providing an in-depth look at the spatiotemporal variability of the plume due to transport by the Catalina Eddy. This study aims to track the transport of the Sherpa Fire plume by analyzing vertical profiles of acetonitrile in the LA basin. Acetonitrile, which is an excellent tracer for incomplete biomass combustion, was found to be correlated with aerosol concentration in smoke-influenced air masses. Wind data collected from multiple Automated Surface Observing System (ASOS) stations were used to evaluate the influence that the Catalina Eddy had on the transport of the Sherpa Fire plume throughout the LA basin.

Effects of Latent Heating on Frontogenic Enhancement in Idealized Atmospheric Rivers

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Atmospheric Rivers (AR's) are described as long narrow channels of highly-concentrated water vapor residing in the lower troposphere. These systems are often responsible for large fractions of annual precipitation in the Western U.S. and can also be linked to numerous heavy rain events occurring across the East Coast as well (often having links to the tropics). Typically in AR cyclones, the most abundant precipitation rates reside within a narrow channel between the warm front and cold front, with the heaviest bands usually having links to frontogenic processes.

In this research, the intention is to analyze these frontogenetic processes and determine how latent heating (LH) plays a role in AR frontogenesis (FGEN) using the Weather Research and Forecasting (WRF) model. Two 240-hr simulations will be compared tracking the magnitude of the three main FGEN terms: diabatics, tilting and horizontal deformation. One simulation will mimic typical atmospheric conditions—with LH processes occurring, whereas the other will have the microphysical LH values set to zero. Comparing these two idealized baroclinic waves as they propagate should allow for a better understanding of how diabatics play a role in frontogenic processes. Furthermore, these results will illustrate how each of the FGEN terms are impacted by the presence of heat release as well as a few of the associated feedback mechanisms.

Since regions of FGEN are directly linked to areas of maximum vertical motion, determining the role of latent heating within AR systems can only yield beneficial results for forecasters. Furthermore, it should help provide insight into the dynamical and thermodynamic effects of latent heat release on the evolution of a mid-latitude cyclone as well.

Use of a GIS application to evaluate the accuracy of forecaster and model predictions of snowfall in eastern New York and western New England

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A collaborative project between the National Weather Service Forecast offices in Albany, New York and Knoxville, Tennessee has 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 analysis, or an analysis from the National Operational Hydrologic Remote Sensing Center (NOHRSC). This presentation will introduce the application, and summarize the results of associated projects that examine 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 two years of snowfall events from 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, and 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 analysis 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 Data Base, 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.

The Multi-Hazard Severe Event of the 21 August 2019 across eastern New York and western New England

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On 21 August 2019, a major severe weather event occurred across much of upstate New York (NY), and portions of western New England. Eastern NY and western New England had nearly three dozen severe reports of damaging winds in excess of 50 knots (58 mph), large hail (greater than 1.9 cm) and a couple of flash floods. Three tornadoes were also confirmed in the Albany forecast area; two EF0's (winds of 65 to 85 mph in Fulton and Saratoga Counties in New York) and an EF1 (winds of 86 to 110 mph in Windham County, Vermont (VT)). The damage from the brief tornado touchdowns in eastern NY was mainly to hardwood and softwood trees. The high end EF1 tornado (winds estimated up to 110 mph) in Windham County in southern VT not only produced significant tree damage but also damaged a home in the sparsely populated town.

Observational data, as well as short-range deterministic forecasts from the High-Resolution Rapid Refresh model suggested a highly impactful severe weather outbreak would likely occur. Much of the impacted area had just entered a warm sector with a warm front just north of the Mohawk Valley, Greater Capital Region, and southern VT. An approaching strong upper level short-wave and prefrontal trough would focus the strong to severe convection that afternoon. A moderate-to-abundant instability and high-shear pre-convective environment were in place before the severe weather. Surface based convective available potential energy values ranged from 1000 to 2500 J kg^{-1} with increasing effective bulk shear values of 30 to 45 kts. 0-1 km Storm-Relative Helicity values were in the 100-200 m^2 s^{-2} range. The effective bulk shear values in the 0-6 km layer suggested the possibility of mini-supercells with rotating updrafts capable of producing, damaging winds, large hail and tornadoes. Anomalous precipitable water values, intense rainfall rates, and the potential for convection repeatedly moving over the same areas hinted at an isolated flash flood or two, which did occur over Rensselaer County in the Capital Region including the city of Troy.

This poster 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})). A bow echo along the northern book end vortex of a line echo wave pattern will be analyzed where a lot of the wind damage and tornadoes occurred. Traditional base and derived WSR-88D radar products will also be shown in conjunction with the Dual-Pol data. The storm-scale analysis will focus on helpful forecast techniques, including applying results from a local rotational velocity (Vr)-shear study, to determine what caused the tornadoes and how the tornado warning process can be improved. Also, the role of collapsing K_{DP} columns with wet microbursts will be examined based on local and CSTAR research.

Forecast Considerations Involving Extreme Snow-to-Liquid Ratios

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A successful snowfall forecast relies on several correctly predicted components, including liquid equivalent precipitation amount, precipitation type, ground temperatures, and snow-to-liquid ratios (SLRs). In addition to its importance in correctly forecasting snow amount, SLR modulates the societal and economic impact of a snowfall event. Specifically, it is well documented that low SLRs (high snow density) result in greater road hazards, potential for power outages, and increased health risks associated with greater weight per unit volume. Conversely, high SLRs (low snow density) yield less adverse societal impact, and even offer benefits for recreational activities (e.g., “powder” snow for skiers). Thus, SLRs are an important forecast challenge, particularly at the extremes.

In this presentation, case examples are utilized to showcase factors contributing to periods of high (defined as ≥20:1) and low (defined as ≤10:1) SLRs across Vermont in comparison to climatology. In general, deep, saturated dendrite growth layers (-12^{o}C to -18^{o}C temperature range), strong upward vertical motion, and subfreezing surface temperatures favor high SLRs. Secondarily, light wind regimes minimize crystal fragmentation, which maintains higher SLRs. Meanwhile, non-dendritic crystal growth, and deep saturated isothermal layers near 0^{o}C favoring riming and aggregation, yield periods of low SLRs. Additionally, surface temperatures near 0^{o}C are needed for an increased risk of power outages, as increased adhesion of snow to objects and resultant snow loading contributes to downed trees and powerlines.

Current National Weather Service SLR forecasting practices using the Graphical Forecast Editor, Forecast Builder, and National Blend of Models - leveraging relationships between climatology, thermodynamic profiles, vertical motion, snow microphysics/crystal habits, and ground temperatures - will be described. Lastly, planned future work utilizing synoptic-scale and sounding composites will be briefly outlined.

Understanding the Interaction between Short-Wave Troughs and Lake-Effect Snow Events off Lake Ontario

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Shore-parallel lake-effect bands (SPBs) can cause inherent forecasting issues due to their associated snowfall rates and relatively small spatial coverage. These mesoscale precipitation events are known to interact with upper-tropospheric short-wave troughs which can cause changes in SPB structure and location. A ten cold-season (Oct–Mar) climatology of short-wave trough passages over Lake Ontario was compiled and utilized in the determination of concurrent lake-effect events. NOAA Nexrad imagery was used to analyze changes in lake-effect band intensity, inland extent, and band orientation during and after an upper-tropospheric trough passage. Roughly one in four cold-season short-wave trough passages concurred with ongoing lake-effect precipitation. SPB inland extent tended to increase when a trough was located over Lake Ontario, and the SPB precipitation region tended to shift southward during trough passage. Additionally, approximately half of SPBs took on the curvature of the 500mb height/wind field during short-wave trough passage. The frequency of concurrence between SPBs and trough passage demonstrates the need for the further investigation of the nature of their interaction.

Computing Snowfall Forecast Biases for Warning-Level Lake-Effect Snow Events Downwind of Lake Ontario

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Predicting storm total snowfall amounts for lake-effect snow (LES) events can be challenging to forecasters as seemingly subtle fluctuations in characteristics (e.g., location, intensity, and orientation) of these intense mesoscale snow bands have profound effects on observed snowfall amounts. This research investigated snowfall forecast biases of National Weather Service (NWS) forecasts for warning-level LES events occurring downwind of Lake Ontario in upstate New York.

A 36-case dataset of LES events from the 2015-2016 to 2018-2019 winter seasons that either had a Lake Effect Snow Warning in effect or warning-level snowfall was observed (a maximum snowfall report of at least seven inches was used as a proxy for warning criteria) was constructed using NWS Storm Data and a local text archive of NWS warnings. Gridded Automated Zonal Precipitation and Complete Hi-res Output (GAZPACHO), an NWS software application, was used to create gridded storm-total snowfall analysis and forecast (valid prior to the event onset) maps from NOHRSC v2 and NWS National Digital Forecast Database (NDFD) datasets, respectively, for all 36 events. After sorting these events by specific characteristics (e.g., shortwave trough passage, LES band type, inland extent), various snowfall forecast bias composite maps were produced using GIS.

Statistical analysis of these cases revealed characteristics in snowfall forecast biases for LES events downwind of Lake Ontario. The results of this study highlighted problematic areas in the higher terrain of New York (e.g., Tug Hill Plateau). The inland extent of warning-level snowfall amounts was often not forecasted far enough inland. Highlighting these biases can lead to improved forecasts, messaging and impact-based decision support services for LES events.

New York State Mesonet Snow Network: Review of 2018-2019 data and Plan for 2019-2020

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New York State provides ideal locations for all types of winter storms over complex terrain (blizzard, lake-effect snow storms, snow squall, ice storms …). The New York State Mesonet (NYSM) provides comprehensive snow measurements along with other surface and atmospheric measurements with unprecedented high spatial and temporal resolution. They include (a) accurate and continuous snow depth from an acoustic sensor at 126 sites; (b) snow water equivalent (SWE) measured by a downward-pointing gamma-ray device at 20 sites; (c) high quality precipitation data from a weighing gauge (with double alter shields to reduce under-catching) for all precipitation types (rain, snow and ice) at all 126 sites; (d) camera images every five minutes at 126 sites for snow conditions and a scale in the camera field of view to provide additional estimates of snow depth. This talk will focus on review of 2018-2019 winter data and plan for this winter. Total snow fall for 2018-2019 winter reviews coherent, interesting and surprise spatial features, such as maximum snow fall at Cold Brook. CS725 SWE Sensor was operational for the first time during last winter at 13 sites, and its data were compared with manual snow core measurements. The comparisons show general good agreements, but much larger CS725 values when the ground was thawed (with larger soil moisture). The latter is possibly due to the impact of soil moisture baseline used to account for gamma ray attenuation by soil moisture. Preliminary comparisons are done to compare CS725 SWE with NOAA SNODAS SWE products. We are also working on deriving SWE from the weighing gauge. For 2019-2020 winter, CS725 will be operational for all 20 snow sites. The soil moisture calibration for CS725 will be improved by using realistic and varied soil moisture. Manual snow core measurements will be standardized by following the strict guidelines and made more frequently. For this winter, NYSM is also coordinating with NOAA NOHRSC on their snow survey flights to fly over NYSM sites for SWE comparisons between ground-based (CS725) and aircraft-based Gamma ray measurements.

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