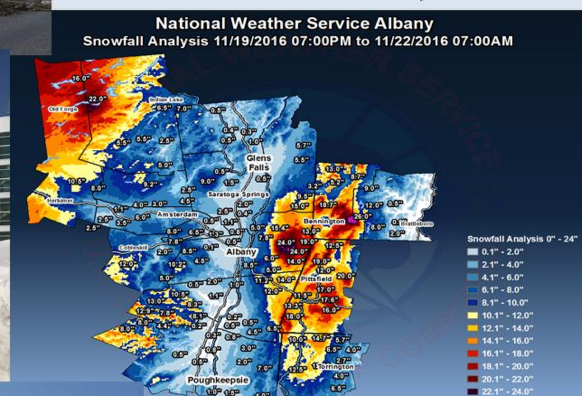
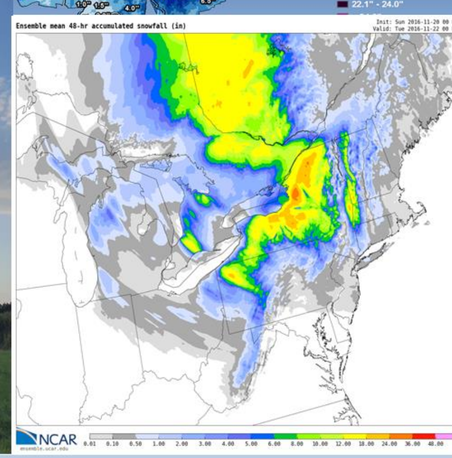
Northeast Regional Operational Workshop XVIII

November 1-2, 2017





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SUNY-University at Albany's Department of Atmospheric and Environmental Science

Agenda
Northeast Regional Operational Workshop XVIII
Albany, New York
Nano South Conference Center, Room 103, 255 Fuller Road
Wednesday, November 1, 2017

8:30 am
Welcoming Remarks & Conference Logistics
Raymond G. O'Keefe, Meteorologist In Charge
Thomas A. Wasula, NROW XVIII Steering Committee Chair
National Weather Service, Albany, New York

Session A – Extreme Weather Event(s)

8:45 am
Retrospective Analysis of the 1954-55 Hurricane Seasons and Impacts to the Northeast U.S.
Kevin S. Lipton
NOAA/NWS Weather Forecast Office, Albany, New York

9:05 am
A North Pacific Jet Phase Diagram Perspective on Extreme Weather Events During 2016–2017: General Characteristics
Andrew C. Winters
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

9:25 am
A North Pacific Jet Phase Diagram Perspective on Extreme Weather Events During 2016–2017: Illustrative Examples
Lance F. Bosart
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

9:45 am
Hurricane Harvey: The Name Says it All
Rich H. Grumm
NOAA/NWS Weather Forecast Office, State College, Pennsylvania

10:05 am
Morning Break
SUNY Albany AMS selling Refreshments in Nano South Conference Center Rotunda

Session B – Winter Weather Session I

10:30 am
The Major Lake-Enhanced Central New York Snowstorm of November 20-21, 2016
Part 1: Overview, Forecast Tools and Verification
Michael Evans
NOAA/NWS Weather Forecast Office, Albany, New York

10:50 am
The Major Lake-Enhanced Central New York Snowstorm of November 20-21, 2016 Part 2: Comparison with a Historical Analog and Assessing the Importance of Atlantic Inflow and Lake-to-Lake Connectivity
Michael L. Jurewicz Sr.
NOAA/NWS Weather Forecast Office, Binghamton, New York

11:10 am
Using GAZPACHO to Create Forecast Snowfall Bias/Error Maps Stratified by Flow Regime
Joseph P. Villani
NOAA/NWS Weather Forecast Office, Albany, New York

11:30 am
Applying Forecast Track Diagnostics in High-Impact Northeast Winter Storms: Climatology and Case Analysis
Tomer Burg
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

11:50 am
2017-18 Winter Weather Desk Operations at the Weather Prediction Center (WPC)
Dan Petersen
NOAA/NWS/NCEP Weather Prediction Center, College Park, Maryland

12:10 pm –1:40 pm
Lunch

Session C – Severe Weather

1:40 pm
A Rare February Severe Weather Event: The Goshen/Conway, MA EF-1 Tornado of 25 February 2017
Frank M. Nocera
NOAA / NWS Weather Forecast Office, Boston, Massachusetts

2:00 pm
Total Lightning and Uplsope Flow as Predictors of Severe Weather in the Northeast
Brian H. Tang
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

2:20 pm
The 24 July 2017 Overnight Tornadic Supercell in Eastern Maryland
Mitchell W. Gaines
NOAA/NWS, Weather Forecast Office, Mount Holly, New Jersey

2:40 pm
A Multi-Scale Analysis of the 18 May 2017 Severe Weather Event across Eastern New York and Western New England
Thomas A. Wasula
NOAA/NWS Weather Forecast Office, Albany, New York

3:00 pm
Break: SUNY Albany AMS selling Refreshments in Nano South Conference Center Rotunda

Session D – New York Mesonet and Applications

3:20 pm
An Update on the Installation and Operation of the New York State Mesonet
Jerry Brotzge
Atmospheric Science Research Center, Albany, NY

3:40 pm
Correcting Unfixable Error in Gust Forecasts Over New York Using a New Gust Parameterization: Network Average Gust Factor
Alex Gallagher
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

4:00 pm
An Analysis of a Possible New York State Dryline Utilizing the New York State Mesonet
Luke J. Lebel
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

NROW XVIII Key Note Presentation

4:20 pm
Progress in Forecasting Hazardous Convective Weather with the NCAR-WRF High-Resolution Ensemble
Morris Weisman
NCAR/MMM, Boulder, Colorado

5:10 pm
Wrap up
Thomas A. Wasula

5:15 pm
Adjourn

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

Agenda
Northeast Regional Operational Workshop XVIII
Albany, New York
Nano South Conference Center, Room 103, 255 Fuller Road
Thursday, November 2, 2017

8:15 am
Opening Remarks
Raymond G. O'Keefe, Meteorologist In Charge
Thomas A. Wasula, NROW XVIII Steering Committee Chair
National Weather Service, Albany, New York

Session E – Winter Weather Session II

8:20 am
The Value of Using Mesoscale Ensembles in Major Winter Storms
Rich H. Grumm
NOAA/NWS Weather Forecast Office, State College, Pennsylvania

8:40 am
The NWS Probabilistic Snowfall Forecast Experiment: 2016-17 Review and Future Plans
Jeff S. Waldstreicher
NOAA/NWS, Eastern Region Science Services Division, Bohemia, New York

9:00 am
Radar Signatures and Surface Observations During Multi-Vehicle Crashes in Snow
Dan B. Thompson
NOAA/NWS, Weather Forecast Office, Albany, New York

9:20 am
Implementation of NWS Snow Squall Warnings
Peter C. Banacos
NOAA/NWS, Weather Forecast Office, Burlington, Vermont

9:40 am
Communicating Uncertainty Using High Resolution Ensembles & Probabilistic Datasets for an Anomalous Early Season Snow Event in New England
Frank M. Nocera
NOAA / NWS Weather Forecast Office, Boston, Massachusetts

10:00 am
Break: SUNY Albany AMS selling Refreshments in Nano South Conference Center Rotunda

Session F – Ensembles/Modeling

10:20 am
Development of an Uncertainty Tool to Assess Model Forecast Parameters
Taylor Mandelbaum
School of Marine and Atmospheric Sciences
Stony Brook University, Stony Brook, New York

10:40 am
Predictability of Snow Multi-Bands Using a 40-Member WRF Ensemble
Ryan J. Connelly
School of Marine and Atmospheric Sciences
Stony Brook University, Stony Brook, New York

11:00 am
Convection-Permitting Ensemble Forecasts of the 10–12 December 2013 Lake-Effect Snow Event: Sensitivity to Initial and Boundary Conditions
W. Massey Bartolini
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

11:20 am
Convection-Permitting Ensemble Forecasts of the 10–12 December 2013 Lake-Effect Snow Event: Sensitivity to Microphysical and Surface-Layer Parameterizations
Justin R. Minder
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

11:40 am
Future NCEP Modeling Plans
Corey Guastini
NOAA/NWS/NCEP/Environmental Modeling Center, College Park, Maryland

Noon-130 pm
Lunch

Session G – Aviation/Verification/Climatologies

1:30 pm
Stratus Decks and Sea Breezes – DSS Challenges at KBOS
Scott Reynolds
NOAA/NWS Center Weather Service Unit, Nashua, New Hampshire

1:50 pm
An Analysis of Lead-Times for Northeast Tornado Warnings 2010-2016
Ethan C. Burwell
Earth & Atmospheric Environmental Sciences
Cornell University, Ithaca, New York

2:10 pm
A Dewpoint Climatology in the Capital District of New York
Cameron R. Paquette
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

2:30 pm
A Climatology of Inverted Troughs over the Gulf of Maine and New England
Joseph E. Cebulko
NOAA/NWS, Weather Forecast Office, Albany, New York

2:50 pm Break: SUNY Albany AMS selling Refreshments in Nano South Conference Center Rotunda

Session H – Heavy Precipitation/Flash Flooding/Tropical Systems

3:15 pm
Changes in Extreme Precipitation in the Northeast United States: 1979–2014
Macy E. Howarth
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

3:35 pm
Examination of the Flash Flood Vulnerability Index Using the October 20-21, 2016 Flash Flooding Event in Central Pennsylvania
Joseph Ceru
NOAA/NWS Weather Forecast Office, State College, Pennsylvania

3:55 pm
An Analysis of Large Track Error North Atlantic Tropical Cyclones
Nicholas Leonardo
School of Marine and Atmospheric Sciences
Stony Brook University, Stony Brook, New York

4:15 pm
Global Ensemble Forecasts of Hurricane Irma: Uncertainty Associated with United States Landfall
Rich H. Grumm
NOAA/NWS Weather Forecast Office, State College, Pennsylvania

4:35 – Wrap Up
Thomas A. Wasula

4:45 pm – Adjourn

NROW XIX is scheduled November 7–8, 2018

At the Nano South Conference Center, Room 103, 255 Fuller Road
On the Campus of the College of Nanoscale Science and Engineering
State University of New York Polytechnic Institute, Albany, New York

Retrospective Analysis of the 1954-55 Hurricane Seasons and Impacts to the Northeast U.S.

Kevin S. Lipton
NOAA/NWS Weather Forecast Office, Albany, New York

A total of 5 tropical cyclones directly impacted the northeast U.S. during the 1954-55 hurricane seasons, each producing significant wind and flood damage. Total U.S. deaths attributed to these storms were 359, with damage estimates of over $1.5B (unadjusted).

This presentation will examine the tracks, wind and rainfall distribution and impacts, and synoptic characteristics associated with each tropical cyclone during these seasons. In addition, a broader climatological analysis of each season will be presented, including tropospheric circulation patterns and anomalies, and western Atlantic Ocean Sea Surface Temperatures utilizing the NCEP/NCAR I Reanalysis and NOAA-CIRES 20th Century Reanalysis (V2 and V2c) datasets.

A North Pacific Jet Phase Diagram Perspective on Extreme Weather Events During 2016–2017: General Characteristics

Andrew C. Winters, Lance F. Bosart, and Daniel Keyser
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

Extreme weather events (EWEs) during a single season, such as those that occurred during February–March 2017 and are discussed by Bosart et al. (2017) in a subsequent presentation, can contribute disproportionately to temperature and precipitation anomaly statistics for that particular season. This disproportionate contribution suggests that (1) EWEs need to be considered in describing and understanding the dynamical and thermodynamic processes that operate at the weather–climate intersection, and (2) consideration of EWEs may improve operational probabilistic medium-range (8–10-day) temperature and precipitation forecasts. It is apparent that considerable variability characterizes the antecedent environments over the North Pacific prior to the development of EWEs over the continental U.S. This variability motivated the development of a North Pacific Jet (NPJ) phase diagram that was constructed employing the two leading EOFs of 250-hPa zonal wind during Sept.–May 1979–2014 in the CFSR. The projection of 250-hPa zonal wind anomalies at any one or multiple times onto the NPJ phase diagram provides an objective characterization of the state or evolution of the upper-tropospheric flow pattern over the North Pacific. Furthermore, the NPJ phase diagram offers the potential to increase confidence in medium-range temperature and precipitation forecasts over the continental U.S.

This presentation employs the GEFS Reforecast Version 2 dataset during Sept.–May 1985–2014 to construct a 30-year climatology of 9-day ensemble forecasts of the NPJ in the context of the NPJ phase diagram. Once constructed, NPJ phase diagram forecasts are classified based on the NPJ regime at the time of forecast initialization or at the time of forecast verification in order to examine the skill of forecasts initializing or verifying within the same NPJ regime. NPJ phase diagram forecasts are also stratified based on the magnitude of both the average 8–9-day GEFS ensemble mean error and the average GEFS ensemble member error within the NPJ phase diagram to determine the top 10% best and worst NPJ phase diagram forecasts. The best and worst forecasts are subsequently examined employing composite analyses to illuminate the types of synoptic patterns that are most frequently associated with the best and worst NPJ phase diagram forecasts, respectively. Predicated on the ability of the NPJ phase diagram to characterize the upper-tropospheric flow pattern over the North Pacific, a real time web interface for NPJ phase diagram products at NCEP-WPC has been developed and is illustrated.

A North Pacific Jet Phase Diagram Perspective on Extreme Weather Events during 2016–2017: Illustrative Examples

Lance F. Bosart, Andrew C. Winters, and Daniel Keyser
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

Extreme weather event (EWE) occurrences can contribute disproportionately to observed temperature and precipitation anomalies on subseasonal time scales and motivates us to better understand the dynamical and thermodynamical processes that govern EWE life cycles and their associated predictability. Research discussed by Winters et al. (2017) in the previous presentation suggested that correct forecasts of the North Pacific jet (NPJ) regime are necessary to produce successful operational probabilistic medium-range (8–10-day) temperature and precipitation forecasts, and that considerable variability characterizes the antecedent environments over the North Pacific prior to the development of EWEs over the CONUS. This variability motivated the development of a NPJ phase diagram to provide an objective tool to characterize the NPJ regime and the evolution of the upper-tropospheric flow pattern over the North Pacific prior to the development of EWEs.

The ability of the NPJ phase diagram to provide forecasters a "first alert" of the potential for EWE development will be demonstrated for two recent illustrative examples of high-impact weather events over the CONUS during February and March 2017. The first EWE occurred during a period of a significant NPJ retraction from 16–26 February 2017 and featured very heavy rains in California. This NPJ retraction was accompanied by a regime change from a strong zonally oriented NPJ to a Rex block situated over the Gulf of Alaska that also resulted in significant cooling over the western CONUS and impressive warming over the central and eastern CONUS. The second EWE occurred during a period of NPJ extension and equatorward shift in the presence of a persistent Rex block from 28 February to 16 March 2017. This NPJ extension and equatorward shift culminated in the formation of a deep trough over the eastern CONUS that resulted in the occurrence of the "Pi day" snowstorm over the Northeast. These illustrative EWEs occurred on a variety of temporal and spatial scales and featured a variety of relatively short predictability horizons. Application of the NPJ phase diagram methodology to these EWEs will be used to illustrate the sensitivity of EWE predictability horizons to upstream disturbances and jet stream configurations.

Hurricane Harvey: The Name Says it All

Richard H. Grumm[1] and Brian Miretzky[2]
[1]NOAA/NWS Weather Forecast Office, State College, Pennsylvania
[2]NOAA/NWS Eastern Region, Bohemia, New York

Hurricane Harvey came ashore near Rockport, Texas (TX) around 0300 UTC 26 August 2017 as a category 4 storm. Winds in Rockport reached 130 mph. Most of the wind damage was focused close to the storm center. As the storm moved inland and then re-entered the Gulf of Mexico the extreme rainfall associated with the storm system became the most critical issue.

The rainfall associated with Harvey exceeded 1000 mm (50 inches) with a large swath of eastern TX receiving over 300 mm of rainfall. The extremely heavy rainfall resulted in record flooding over most of northeastern TX and the Houston metropolitan area. The damage to infrastructure and flooded automobiles will likely make Harvey one of, if not the most costly weather disasters in United States.

This paper will document the rainfall associated with Harvey and show forecasts of the rainfall. It will be shown that the NCEP GEFS produced extreme rainfall amounts. Operational GEFS forecasts of QPF verse the internal model QPF climatology (M-Climate) showed that the GEFS consistently forecast record rainfall within the modelling system for several days prior to the flooding and at nearly all 6, 12, 24, 36, 48, and 72 hour forecasts lengths. This historic rainfall event demonstrates the need for model climatology to gage both the meteorological and climatological significance of an event.

Despite the success of these forecasts, there was considerable uncertainty as to where the heaviest rain would fall. Predictability diagrams are used to show how well the GEFS forecast the event but also how some of the details were harder to predict.

A brief summary of high resolution ensemble data is used to show how valuable these data are in refining the threat for extreme rainfall and show where extreme rainfall is most likely to occur. These high resolution tools show great potential to improve short range DSS activities.

The Major Lake-Enhanced Central New York Snowstorm of November 20-21, 2016
Part 1: Overview, Forecast Tools and Verification

Michael Evans
NOAA/NWS Weather Forecast Office, Binghamton, New York

A very unusual lake-enhanced snow event occurred across central New York and extreme northern Pennsylvania on November 20-21, 2016. This presentation gives an overview of the event and illustrates the output from some tools available to forecasters to forecast the event. Verification of National Weather Service snowfall forecasts is shown using a new tool developed at the National Weather Service forecast office in Albany.

This event was unusual primarily due to the very large snowfall amounts observed across a widespread area of central New York. For example, snow amounts in the Syracuse area were as much as 90 cm (36 in) over 36 hours. Heavy snow also extended well south of the traditional lake effect snow belts near Lake Ontario, with as much as 70 cm (27 in) of snow reported as far south as Binghamton, New York just north of the New York / Pennsylvania border.

The storm was associated with a very slow-moving closed-contoured mid-tropospheric cyclone over northern New England and the Canadian Maritimes. Satellite imagery indicated a mid-level moist plume from the central Atlantic curving northwestward around the northern and western flank of the mid-tropospheric cyclone across New York. A trajectory analysis showed a persistent flow from Georgian Bay southeastward across western Lake Ontario and the twin tiers of northern Pennsylvania and southern New York, and operational model forecast soundings for central New York indicated a deep, moist lower-tropospheric flow from approximately 310 degrees. Forecaster experience and historical analogs indicate that this pattern has historically been associated with significant lake-effect snow across central New York. High resolution models also provided some signals for the potential of significant lake effect snow across central New York including the southern tier.

Output from a gridded snowfall forecast verification program developed at the National Weather Service at Albany is shown for the case. It is shown that snowfall amounts for the storm were significantly under-forecast, however forecasts improved as the event drew near.

The Major Lake-Enhanced Central New York Snowstorm of November 20-21, 2016
Part 2: Comparison with a Historical Analog and Assessing the Importance of Atlantic Inflow and Lake-to-Lake Connectivity

Michael L. Jurewicz, Sr.
NOAA/NWS Weather Forecast Office, Binghamton, New York

An intense lake-effect snow event on November 20-21, 2016 produced 20-40” (50-100 cm) over sections of central New York within a 24-36 hour period. Heavy snowfall totals extended unusually far inland from the Lake Ontario shoreline, actually reaching into far northern Pennsylvania. This event will be compared to another event that occurred in early December, 2010, when snowfall totals of 40-60” (100-150 cm) were observed over portions of central New York (centered near Syracuse, NY) during an extended period of lake-effect snow. Interestingly, similarly heavy totals were also measured well upstream over southern Ontario. In fact, London, Ontario recorded an impressive 47.2” (120 cm) in a single day, easily establishing their 24 hour snowfall record.

Synoptic and mesoscale aspects of each case will be compared and contrasted. Key aspects that will be investigated include a long fetch of Atlantic moisture which wrapped around the main vertically stacked cyclone in each case, as well as influences from upstream Great Lakes (most notably Lake Huron (including Georgian Bay) and northern Lake Michigan). Additionally, surface, 850 hPa, 700 hPa, and 500 hPa data will be compared against composite plots of past lake-effect snow events that featured lengthy inland extent.

Using GAZPACHO to Create Forecast Snowfall Bias/Error Maps Stratified by Flow Regime

Joseph P. Villani[1] and Michael Main[2]
[1]NOAA/NWS Weather Forecast Office, Albany, New York
[2]Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

The GAZPACHO (Gridded Automated Zonal Precipitation and Complete Hi-Res Output) verification program was used to create maps of observed snowfall, zone-average snowfall and forecast error maps for 56 snowfall events in the National Weather Service Albany, NY County Warning Area (ALY CWA) (eastern New York and western New England) from the 2013-2017 winter seasons. The criteria for an event was when at least advisory level snow fell or advisory level snow was forecast (around 4 inches or greater somewhere in the ALY CWA).

Flow regime stratification was done by first creating categories based on wind direction and speed. The wind direction was broken into four quadrants, corresponding to 0-90°, 90-180°, 180-270°, and 270-360°. The three wind speed categories chosen were 0-19 kt, 20-39 kt, and 40 kt or greater. Twelve categories were defined based on the various direction and speed combinations. Winds at 925 and 850 mb were then investigated using Albany, NY (ALY) observed sounding data for each snowfall event. The wind direction and speed (at 0000 or 1200 UTC) closest to the midpoint time of each event was used.

Events were then stratified into each wind category based on the ALY 925 and 850 mb wind data. Forecast bias and mean absolute error (MAE) maps were computed for each of the twelve wind categories from the 56 total snowfall events. Since there were 12 wind categories and 55 total snowfall events, some of the categories only contained a few events. However, there were several wind categories with five or more events.

Results from a few of the wind categories using 925 mb winds will be presented, with some discernible patterns noted in the forecast bias and MAE maps. It is hypothesized that some of the larger forecast biases can be attributed to terrain influences based on the over/under forecast of snowfall in favored upslope/downslope areas in the ALY CWA.

Applying Forecast Track Diagnostics in High-Impact Northeast Winter Storms: Climatology and Case Analysis

Tomer Burg, Andrea L. Lang, Kristen L. Corbosiero, and Ryan D. Torn
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

A conventional forecasting notion is that as lead time decreases, numerical weather prediction models exhibit a westward trend in the forecast position of low-pressure systems along the East Coast of the U.S. This westward trend, which may turn seemingly weak ocean cyclones into high-impact weather events for the Northeast U.S., is sometimes attributed to the representation of latent heat release in the NWP models downstream of the trough associated with the incipient cyclone. Specifically, it is commonly believed that the underrepresentation of latent heating at longer lead times prevents a NWP forecast from properly depicting the negative tilt of the trough, and the reduction of the half wavelength between the cyclone and downstream ridge, that is commonly observed.

A climatology of ensemble forecasts of high-impact Northeast winter storms initialized at short to medium-range lead times was constructed using the Global Ensemble Forecast System (GEFS) Reforecast version 2. The climatology utilizes cyclone forecast position ellipses following the methodology of Hamill et al. (2011) to quantify the nature of the cyclone position uncertainty at various forecast lead times by examining the position ellipse axes, representing the directions of greatest and smallest cyclone position uncertainty. To demonstrate this methodology, the European Centre for Medium-Range Forecasts (ECMWF) 51-member operational ensemble forecasts of the northeast winter storm of 13–15 March 2017 is used as a representative case study. The case analysis will highlight the cyclone track uncertainty by examining the role of the physical and dynamical processes linked to latent heat release in ensemble members grouped by location in the position ellipse. The results of the case study are presented in the context of results from the climatological analysis of trends in the position error of northeast winter storm forecasts. The application of these results from the GEFS reforecast analysis will then be applied to the operational ECMWF ensemble forecasts available during the event.

2017-18 Winter Weather Desk Operations at the Weather Prediction Center (WPC)

Dan Petersen
NOAA/NWS/NCEP/Weather Prediction Center, College Park, Maryland

WPC winter weather desk operations and forecast products are discussed in this presentation, including changes to winter weather probability forecasts, new issuances of the days 1-3 Winter Weather Watch Collaborator, and shift deadline changes.

The WPC produces 12 and 24 hour probabilistic winter weather forecasts for snow and ice accumulation across the 48 contiguous states (http://www.wpc.ncep.noaa.gov/pwpf/ about_pwpf _productsbody.html). For 2017-18, to better resolve winter precipitation in complex terrain, WPC will perform QPF and precipitation type calculations at 5 km grid resolution instead of the 20 km grid resolution used over the past several seasons. To further improve precipitation type forecasts, a new snow level computation will be implemented where the 0.5°C wet bulb temperature intersects the 5 km resolution terrain as depicted in the Unrestricted Mesoscale Analysis (URMA). Examples using this precipitation type methodology will be shown.

The ensemble suite underlying WPC's probabilistic winter precipitation forecasts (PWPF) will be modified for the 2017-18 season with the reduction of ECMWF and SREF ARW ensemble members. In addition, WPC will incorporate additional high resolution window (WRF ARW/NMMB) model runs after the Environmental Modeling Center's next scheduled implementation in November, 2017. Including earlier arrival of NWP in PWPF will result in a total of 4 additional high resolution WRF members per cycle (6 versus the previous 2).

WPC's Winter Weather Watch Collaborator output has been generated over the last three winters to forecast the probability of meeting or exceeding winter storm warning criteria for heavy snow and/or freezing rain. For 2017-18, PWPF produced at 0830Z and 2030Z will updated at 1400Z and 0200Z using later arriving NWP guidance mentioned above. Corresponding exceedance probabilities, percentile accumulations, and watch collaborator output will subsequently be updated and made available to field offices. Eastern Region has requested earlier collaboration prior to final WPC forecast generation in order to discuss the meteorological weather situation and address model and probability trends. The new collaboration window will cover 1430-15Z.

WPC also generates probability forecasts of snow/sleet exceeding 0.25 inches (~6 mm) water equivalent over a 24-hour (12Z-12Z) for days 4, 5, 6, and 7. These forecasts were included in the NWS National Digital Forecast Database (NDFD) as an experimental element last winter and will become operational for the 2017-18 season. The outlook is prepared twice daily by WPC medium range forecasters and is available on the web at: http://origin.wpc.ncep.noaa.gov/wwd/ pwpf_d47/pwpf_medr.php.

A Rare February Severe Weather Event:
The Goshen/Conway, MA EF-1 Tornado of 25 February 2017

Joseph W. DelliCarpini, Frank M. Nocera, and Kevin J. Cadima
NOAA/NWS Weather Forecast Office, Boston, Massachusetts

On 25 February 2017 a tornado rated EF-1 on the Enhanced Fujita Scale struck Goshen and Conway Massachusetts. This was a highly unusual occurrence and was the first February tornado recorded in Massachusetts since records began in 1950. Based upon the damage survey, the tornado briefly touched down in Goshen where it produced minor damage, then lifted for several miles before touching down and cutting a 5-mile path through the town of Conway, where more significant damage occurred. No injuries or fatalities were reported.

The tornado formed near a surface boundary in a classic high shear, low CAPE environment but one that was extremely rare in February. A cold front provided strong forcing and compensated for the lack of instability, while a strong low level jet transported anomalously warm and moist air into the region. More than 130 reports of severe weather occurred from Virginia to New England, including 4 tornadoes.

This presentation will review the synoptic and mesoscale environments present that day, which has been shown to be favorable for tornadoes in New England. Radar data will also be analyzed to show the evolution of tornado development as convection entered western Massachusetts. Finally, although a Severe Thunderstorm Warning was in effect, guidelines to issue Tornado Warnings in these situations will be discussed.

Total Lightning and Upslope Flow as Predictors of Severe Weather in the Northeast

Brian H. Tang, Pamela Eck, and Lance F. Bosart
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

While radar data is the chief tool used to nowcast severe weather, new tools have emerged in recent times, such as the High-Resolution Rapid Refresh model and total lightning from both land-based and space-based lightning detection instruments. Our goal is to investigate ways to use these new sources of data to better predict severe weather in the Northeast, where the interaction of convection with complex terrain may play a substantial role in modulating severe weather.

This study explores using a combination of predictors following each storm, such as total lightning flash rate, the change in total lightning flash rate, upslope flow, radar reflectivity, and echo-top height in order to comprehensively produce an algorithm to forecast severe weather. In order to deal with the disparity of types of data, we use a random forest, a machine-learning algorithm consisting of a multitude of decision trees, to predict whether a particular storm will become severe or non-severe using the aforementioned predictors. The random forest, tested on eight severe weather days during July 2015 encompassing 57 individual storms, yielded a probability of detection of 82% and a false alarm rate of 23% for severe weather, indicating the algorithm has potential to be useful for predicting severe weather. The algorithm also indicates that upslope flow, the total lightning flash rate, and the change in total lightning flash rate are the three most important variables in the algorithm.

The 24 July 2017 Overnight Tornadic Supercell in Eastern Maryland

Mitchell W. Gaines and Jared R. Klein
NOAA/NWS Weather Forecast Office, Mount Holly, New Jersey

An EF-2 tornado impacted the eastern shore of Maryland during the overnight on 24 July 2017. A waterspout formed over the Chesapeake Bay just south of the Chesapeake Bay Bridge before moving ashore near the Bay City area of Kent Island, Maryland around 1:23 AM. The tornado then tracked northeastward across Stevensville, Maryland before dissipating around 1:27 AM. A storm survey conducted by the Mount Holly, NJ National Weather Service Forecast Office (WFO PHI) uncovered a path of damage that was nearly two miles long and 150 yards wide. The overnight timing of the tornado was extremely rare for this geographic region, especially considering a tornado of this magnitude.

Like many tornadic events in the mid-Atlantic and Northeast regions, this tornado spun up quickly and lasted for only a few minutes, posing a challenge for NWS radar meteorologists to provide sufficient warning lead time for residents to take appropriate action prior to impact. The late night occurrence of the tornadic event, the simultaneous hazard of flash flooding from organized heavy rainfall, and the long duration of the severe weather event added to the complexity of the warning environment.

This presentation will provide an overview of the radar data from nearby Dover, DE (KDOX) WSR-88D and Baltimore-Washington International Airport (TBWI) Terminal Doppler Radar to show the mesocyclonic storm structure of the tornadic storm. An examination of the meteorological pattern for this event will assist in identifying several mesoscale factors that may have contributed locally to tornadogenesis over the warm, moist waters of the Chesapeake Bay. Also discussed are the methodologies used in the storm survey and the unique challenges related to the building code that the survey team had to work through to determine the EF-scale rating. Several weeks following the event, WFO PHI had an extraordinary opportunity to talk with the community that was affected by the storm at a local town hall meeting. Interactions from this meeting provided valuable insight from a social science perspective.

A Multi-Scale Analysis of the 18 May 2017 Severe Weather Event across Eastern New York and Western New England

Thomas A. Wasula and Brian J. Frugis
NOAA/NWS Weather Forecast Office, Albany, New York

On 18 May 2017, a fairly widespread severe weather event occurred across much of eastern New York (NY), and portions of New England. The Mohawk Valley, and the Capital Region in NY, as well as the north of the Berkshires of Massachusetts into the Adirondacks, Upper Hudson Valley, and Vermont had over 40 severe reports with the majority being damaging winds 50 knots or greater and a half dozen of large hail (1.9 cm in diameter or larger). Most notably, a macroburst with extensive straight-line damage occurred in portions of southeast Warren and northern Washington Counties in the late afternoon into the early evening. The widespread wind damage included several downed trees, destruction of a barn, and damage to roofs of a few more buildings especially from Queensbury in Warren County, to Kingsbury in Washington County. The NY Mesonet site in Glens Falls recorded a gust to 59 knots (68 mph), and winds were estimated from the damage to be as high as 78 knots (90 mph) just north of the location towards Queensbury.

The air mass was anomalously hot ahead a cold front and its associated prefrontal surface trough and lake breeze boundary that afternoon. Max temps were in the 32-35°C range across portions of eastern NY and western New England with several maximum temperatures tied or broken. The 1200 UTC 18 May 2017 North American Ensemble Forecast System showed standardized low and mid-level height anomalies 1 to 2 standard deviations above normal, as well as 850 hPa standardized temperature anomalies 1 to 3 standard deviations above normal. During the afternoon, the mesoscale and pre-convective environment became more unstable ahead of the approaching boundaries, as indicated by the Rapid Refresh data with surface based convective available potential energy (CAPE) values in the 1000-2000 J kg^{-1} range with steepening low and mid-level lapse rates. The 1800 UTC 18 May 2017 KALY sounding exhibited an inverted-V signature with an extremely high Downdraft CAPE value of 1501 J kg^{-1} and 0-6 km shear of 40 knots. Some supercells were possible initially before evolving into a squall line due to the fairly unidirectional flow in the low to mid-levels of the troposphere with damaging winds becoming the main threat.

This talk will focus on a detailed mesoscale and radar analysis of the event. Some NY Mesonet data will be shown in the case analysis. Traditional base and derived WSR-88D radar products will also be shown in conjunction with Dual-Pol data. The storm-scale analysis will focus on forecast techniques utilized by the WFO ALY during the event found to be useful. These included applying results from a local 1-inch hail study and preliminary results on an extreme damaging wind study potentially using differential reflectivity arches and specific differential phase spikes to determine what caused the large hail and damaging wind reports. Finally, a brief review of the performance of the High Resolution Ensemble Forecast (HREF) output (versions 1 and experimental version 2) will be shown for the event in the Albany forecast area.

An Update on the Installation and Operation of the New York State Mesonet

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The New York State (NYS) Mesonet Early Warning Weather Detection System is a new advanced meteorological network that provides unprecedented weather information across the state. Designed primarily to facilitate emergency management, this network is the first of its kind in New York and will consist of 126 surface weather stations with at least one site located in every county and borough across the state. This weather detection system provides federal, state, and local communities with access to high-resolution, real-time data, and more robust predictive models. Funded by FEMA, the network is designed, implemented, and operated by scientists at the University at Albany with support from the New York State Department of Homeland Security and Emergency Services.

Each of the Mesonet's 126 weather stations measures surface temperature, relative humidity, wind speed and direction, precipitation, solar radiation, atmospheric pressure, snow depth, and soil moisture and temperature at three depths. In addition, 17 of the sites are outfitted with LiDARs, microwave profilers, and sun photometers providing wind, temperature, and moisture profiles in the vertical. Another 17 sites measure the surface energy budget, and another 20 sites measure snow water equivalent for hydrological applications. All data are transmitted in real-time to the University at Albany, where data are quality controlled and archived, and then disseminated to a variety of users. Real-time data along with graphical products are available to the public via website at http://nysmesonet.org.

This presentation will provide an update on site installations, network reliability, data quality, and new product development. Sample data will be reviewed, and the status of the enhanced, flux, and snow sites will be discussed in detail.

Correcting Unfixable Error in Gust Forecasts over New York Using a New Gust Parameterization: Network Average Gust Factor

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The Northeast and particularly New York State (NYS) are regions that have a wide diversity of topography and land cover types. Because of this siting largely exposed stations for meteorological observations (especially winds) is not always possible as obstructions are numerous and widely varied in nature. These obstructions have the potential to introduce systematic unfixable bias when comparing numerical model output to observations since weather models cannot resolve these misoscale and mososcale features. Fovell and Cao (2014) developed a simple gust parameterization that has the potential to correct these biases in sustained wind speed and gust forecasts. Because gusts are less likely to be influenced by potential obstructions the ratio of the gust to the sustained wind speed, known as the gust factor (GF), contains information on station exposure. It was found that station GF is related to these unfixable biases and locations near the network average GF had little systematic bias. By multiplying forecasted sustained wind speeds across the board with the network average GF systematic biases were eliminated.

This gust parameterization is tested over NYS using data from the NYS Mesonet and the Big Weather Web (BWW) physics ensemble produced by SUNY Albany, for July 2016. The BWW provides numerical model output from several physics configurations allowing the choosing of the optimal setup to reduce physics based bias and evaluate potential systematic biases from unseen obstructions. The NYS Mesonet data allows for calculation of both station and network average GFs and verification of the BWW simulations. The NYS Mesonet also provides the opportunity to test this gust parameterization against observations from both propeller and sonic anemometers.

An Analysis of a Possible New York State Dryline Utilizing the New York State Mesonet

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The New York State Mesonet (NYSM) consists of 126 standard surface stations that record atmospheric and soil data as well as camera images every five minutes. An additional 54 specialty sites collect observations of vertical profiler data, radiation, surface energy flux, and snow water equivalent. With at least one site deployed in every county and borough across the state and with an average spacing of 25 km, the NYSM allows for detailed mesoscale analyses of major weather events across New York State.

This review examines one unique case that exemplifies the value of the NYSM to aid with real-time storm-scale analysis. The case investigated in this study involves a boundary that intersected western New York between 29 and 31 May 2017. Operationally, this boundary was classified initially as a weakening occluded front that was reinforced periodically by cold fronts. Mesoscale observations from the NYSM, however, suggest that this boundary exhibited characteristics more similar to a dryline. The boundary was characterized by a strong dew point gradient (up to 8ºC) and a pronounced wind shift. Moreover, NYSM observations indicate that the boundary strengthened during the day and weakened overnight, similar to observed dryline behavior. Finally, observations from a NYSM profiler station in the vicinity of the boundary suggest that the boundary tilted eastward with height, again consistent with dryline structure.

The storm-scale evolution of this boundary is especially important because of its role in modulating severe weather. On 30 May, several rounds of thunderstorms occurred in the vicinity of the boundary, a few of which produced a small number of severe weather reports. On 31 May, however, severe weather was much more widespread, particularly in the Capital Region. NYSM observations point towards a direct link between the severe weather and a mesoscale moisture gradient. Careful monitoring of this boundary pinpointed when and where severe weather was most likely to occur.

Progress in Forecasting Hazardous Convective Weather with the NCAR-WRF High-Resolution Ensemble

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Over the past three years, NCAR/MMM has offered access to 48h forecasts from an experimental 10 member convective allowing (3 km) ensemble based on the WRF-ARW model, using the Data Assimilation Research Testbed (DART) ensemble Kalman filter approach to produce perturbations for the model initial state. The hope was to gain feedback from both the forecast and research communities on the potential value of such a high-resolution forecast tool, as well as to help refine and improve the presentation of the new ensemble probabilistic guidance for such forecast applications. In this talk, I will review examples of the unique capabilities offered by this system for forecasting convective hazards, including tornadic supercells, derechoes, and flash flooding, and will also review some of the forecast limitations that have been noted over the course of this experiment. I will also discuss the research opportunities that are available to those interested in further exploring this experimental forecast database.

The Value of Using Mesoscale Ensembles in Major Winter Storms

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A rapidly developing cyclone brought heavy snow from Pennsylvania into New England on 14 March 2017. A wide area from northeastern Pennsylvania into central New York received from 20 to 40 inches of snow. Initial forecasts implied that the heavy snow would affect most of the major cities along the East Coast from Boston to Washington, DC. However as forecast length decreased, the confidence in snowfall along the coastal plain began to decrease in the numerical guidance.

Forecasts for heavy snow and blizzard conditions were conveyed to the public 2-2.5 days before the event began. But as the forecast length decreased, the location of the heavy snowfall and the potential areas for blizzard conditions changed. As the event fell into the forecast range of shorter range ensemble forecast systems confidence in the areas to received heavy snow and blizzard conditions shifted.

The mesoscale nature of regions of extremely heavy snowfall and regions in which blizzard conditions occur require shorter predictability horizons to issue high confidence forecasts of these conditions. This requires the use of high resolution ensemble forecast systems to make improved forecasts.

In this talk, the NCAR 3km ensemble and the NCEP HREF version II are used to show how high resolution mesoscale guidance may have improved the issuance of specific warnings for areas of heavy snow and blizzard conditions. It will be shown that the higher resolution guidance identified the potential for rain and ice pellets along the coastal plane and limited the region susceptible to blizzard conditions. These data suggest forecasting blizzard warnings may be as challenging as forecasting convection and should be issued at relatively short lead-times.

The NWS Probabilistic Snowfall Forecast Experiment: 2016-17 Review and Future Plans

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Starting as pilot efforts at WFOs Sterling VA and Taunton MA during the winter of 2013-14, the NWS probabilistic snowfall experiment has grown to involve more than 60 NWS forecast offices across all parts of the CONUS during the winter of 2016-17, with additional expansion planned for 2017-18. The forecast methodology has evolved considerably during the last several winters. The approach utilizes NCEP's Weather Prediction Center's (WPC) probabilistic snowfall percentile accumulation values, generated from an ensemble of NWP snowfall forecasts, to create a cumulative probability distribution function with the official NWS WFO snowfall forecast as the mode of the distribution. Tenth and 90th percentile graphics, exceedance probabilities, and categorical range probabilities for a variety of thresholds are output and made available to end users for decision making. The 10th and 90th percentile values are communicated as higher and lower end scenarios, while the official (e.g., NDFD) NWS WFO snowfall is communicated as the expected (e.g., most likely snowfall amount set as the mode of the distribution).

Through forecaster and user feedback, including a formal social science study this past winter, much has been learned about how to effectively create, display, and communicate probabilistic snowfall information. This presentation will discuss how the methodology, graphics and web page presentation, and decision support messaging of the snowfall probability has evolved during the last several winter seasons. Emphasis will be on the impact of the changes made for the 2016-17 winter season and the resulting user feedback. Some 2016-17 season verification results will also be presented. Plans for probabilistic snowfall and ice accumulation forecasts for the 2017-18 winter season will also be discussed.

Radar Signatures and Surface Observations During Multi-Vehicle Crashes in Snow

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Multi-vehicle crashes (commonly called "pile-ups") continue to plague the U.S./Canadian Great Lakes region and portions of the Upper Midwest and Northeast during the cold season. Pile-ups result in huge economic and safety impacts, including extended freeway closures, road repair, emergency medical services deployment, property damage, injuries, and fatalities. Experience suggests many cold season pile-ups occur during rapidly fluctuating atmospheric conditions (e.g., a sharp increase in precipitation rate and wind speed leading to decreasing visibility and temperatures and road surfaces becoming slippery). Events that fit these characteristics are typically called "snow squalls" or "snow bursts" and are associated with shallow but vigorous convection rooted in the boundary layer. Recent research has examined case studies (e.g., Pettegrew 2009, Milrad et al. 2011) and constructed a climatology (Banacos et al. 2014) of snow squalls. Despite the impacts associated with them, many snow squalls are transient and do not produce snowfall amounts that are sufficient to trigger a Winter Weather Advisory or Winter Storm Warning. These events have been referred to as "High-Impact, Sub-Advisory" (HISA; Devoir 2004, Devoir and Ondrejik 2008).

The present study differs from past work by compiling a list of pile-ups occurring during snowfall and investigating the radar signatures and surface observations in their vicinity. The list was compiled using an internet search and attributes of the pile-ups were documented from news reports. The radar signatures associated with each event were manually classified as convective, stratiform, or hybrid, and a dominant forcing mechanism for the snowfall was determined. Meteograms from a representative observation location were constructed in order to determine the weather conditions prior to and during the pile-up. In addition, the presence or absence of an NWS-issued product at the time of the pile-up was documented.

A clear diurnal distribution in pile-ups was found, with over 80% of events occurring between 900 and 1600 local time. Also, nearly 85% of the events were categorized as convective or hybrid. These results suggest a dependence on diurnal processes to invigorate convection, as well as an ideal traffic rate for pile-ups to occur. They also suggest that the vast majority of these events occur with narrow-banded or cellular radar signatures with large horizontal gradients of radar reflectivity, snowfall intensity, and visibility. Additionally, nearly half of the events that occurred in the U.S. were HISA events. This subset of events resulted in an average of 52 vehicles involved and 16 injuries per event, and a total of 20 fatalities. These results quantify the impact of HISA events and echo prior work that identified a gap in the NWS watch-warning-advisory paradigm. The NWS is addressing this gap by testing a Snow Squall Warning product at eight Weather Forecast Offices for the winter of 2017-18.

Implementation of NWS Snow Squall Warnings

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A top priority of National Weather Service (NWS) Forecast Offices (WFOs) is to protect life and property via issuance of short-fused warnings as severe weather become imminent. Heretofore, a gap has existed in the NWS product suite with respect to highlighting snow squalls, with inconsistent use of special weather statements (SPS) and varying degrees of forecaster awareness of the transportation hazards posed by snow squalls. Development of a baseline NWS snow squall warning and forecaster training is aimed at filling this need.

Snow squalls are mesoscale convective systems producing short-lived heavy snowfall, strong surface winds, and low visibility conditions. Unlike lake effect snow, snow squalls along arctic fronts exhibit a rapid forward motion perpendicular to the long axis of the band, limiting heavy snowfall duration to 15-30 minutes in most cases. However, the rapid onset of near-zero visibility and icy roads can result in potentially deadly driving conditions despite small snow accumulations (often < 1 in or 2.5 cm). The hazard posed by snow squalls is especially great where high speed travel occurs, including interstates and state highways.

For winter 2017-2018, an experimental snow squall warning program is planned at eight WFOs to better highlight the threat to the traveling public, with the goal of reducing travel speeds and mitigating accidents and highway pileups. There will be elements of forecaster judgment in the warning product. For instance, “flash freeze” situations - with temperatures falling below freezing as the squall passes - often results in increased accident rates as wet roads become icy. Likewise, higher traffic volumes during daylight and rush hour periods also result in greater transportation hazards.

This presentation will discuss the new NWS snow squall warning and strategies to identify snow squall environments before they develop. A case study from 14 February 2015 will be shown to detail the environmental and sensible weather conditions accompanying linearly organized snow squalls.

Communicating Uncertainty Using High Resolution Ensembles & Probabilistic Datasets for an Anomalous Early Season Snow Event in New England

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An anomalous early season snow event impacted southern New England during the afternoon and evening hours of 27 October 2016. Snowfall amounts of up to 6 inches were reported across the high terrain (above 1500 ft) of western Massachusetts with accumulating snow observed all the way down to the valley floor of the Connecticut River Valley, including the highly populated city of Springfield, MA. Given trees were still partially leaved the weight of the heavy snow resulted in localized areas of down tree limbs and isolated power outages.

Unlike snowstorms in the middle of the winter season (December, January & February), this storm presented uncertainty with snowfall amounts given the lack of cold air resulting in concerns regarding precipitation type and intensity, duration of snow and accumulations on paved vs. unpaved surfaces given the time of year. High resolution ensembles and associated impact graphics along with operational model guidance showed the potential for an anomalous early season snow event in the days leading up to 27 October 2016.

As part of its Decision Support Services program, the National Weather Service (NWS) in Boston provided email briefings to its core partners and social media posts to the general public in the days leading up to this snow event. However, there were challenges in communicating the uncertainty in the forecast even 6-12 hours before the snow began.

This presentation will focus on the science behind this anomalous event including a review of how high resolution ensembles and associated impact graphics increased forecaster confidence on a reasonable "worst" case scenario becoming more likely. In particular the use of experimental probabilistic snowfall forecasts will be discussed.

Development of an Uncertainty Tool to Assess Model Forecast Parameters

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Probabilistic forecasting is an important tool for both public and private sectors. The use of ensemble models increases the awareness of uncertainty and errors in the output of a model. Although the use of ensembles has increased, there exist many opportunities for better visualization of ensemble model output, which is a major objective of the Stony Brook University CSTAR project. The Ensemble Situational Awareness Table (ESAT), managed by the National Weather Service and Weather Prediction Center, compares forecasts from the North American Ensemble Forecast System (NAEFS) and Global Ensemble Forecast System (GEFS) to reanalysis (R-Climate) and model reforecast (M-Climate) climatologies. Standardized anomalies, percentiles and return intervals are calculated to assist in identifying potentially significant weather events. While M-Climate output from the GEFS reforecast can place the current ensemble mean forecast in context, it does not yet assess the ensemble spread relative to similarly anomalous events. We have attempted to take the M-Climate diagnostic a step further by assessing whether forecast uncertainty is greater or less than normal, given standardized anomalies based on the distribution of spread. We have also begun verification of the operational spread/error relationship to assess the efficacy of utilizing both spread and standardized anomalies of spread to communicate uncertainty.

Our goal is to output and verify an operational spread anomaly product that will complement the existing ESAT. The tool is constructed by utilizing the GEFS Reforecast between 21 November 1985 and 10 March 2017. Cases restricted to the winter (DJF) timeframe over the contiguous United States were chosen for this project. Mid-latitude synoptic cyclones are the most prevalent high impact events, especially for southern New York and New England. Initial test variables include mean sea-level pressure (MSLP), surface temperature, and precipitable water but MSLP will be focused on in this presentation. The ensemble mean is used to determine standardized anomalies at every point on the forecast grid by subtracting the value from the seasonal M-Climate distribution then standardizing based on the grid point standard deviation. Reforecast cases at each point within a threshold of comparable standardized anomalies to the forecast are utilized to construct a new M-Climate. Using this method, a spread anomaly can be calculated for each point on the domain. The resulting plot, together with the ensemble mean pressure contours of that forecast, displays a metric of quasi-confidence in the GEFS forecast. The spread/error verification of DJF storms utilizes a 2007-2014 climatology of verified east coast cyclones. By analyzing the ensemble spread for both all members of the GEFS (for this presentation, focusing on forecast hour 96) as well as only members with a verified cyclone against the mean error of the MSLP field, a simple view of the magnitude and colocation of the spread and error can be assessed. In this presentation, we will describe the procedure, highlight a few test cases of East Coast winter storms, and present some preliminary results on spread/error analysis of the winter storm climatology.

Predictability of Snow Multi-Bands Using a 40-Member WRF Ensemble

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Northeast U.S. winter storms can exhibit several different precipitation structures within the cyclone comma head: (1) a relatively large primary band, (2) multi-bands (no primary band), (3) both single and multi-bands, (4) cellular convection, and (5) stratiform only (no bands). It has been shown that mesoscale models when run at high resolution (< 5-km grid spacing) can realistically simulate primary bands. However, an evaluation for multi-bands is lacking.
This study determines the ability of the Weather Research and Forecasting (WRF) model to resolve multi-bands using an ensemble that combines multiple generation techniques. WRF was nested down to 2-km grid spacing within two outer (18 and 6 km) domains and using 45 vertical levels. The control run uses the same physics schemes as the operational HRRR: Thompson microphysics, MYNN2 planetary boundary layer, and the Grell-Freitas cumulus (in the 18-km domain only). Initial (ICs) and lateral boundary conditions (BCs) are provided by the GFS Ensemble Reforecast (GEFSR). The 40-member ensemble is then generated by combing:

- ICs/BCs diversified by initializing with GEFSR members 1 through 5,
- the YSU PBL and Morrison microphysical schemes, replacing the HRRR schemes
- by applying the stochastic kinetic energy backscatter scheme (SKEBS) and stochastic perturbation to physical tendencies scheme (SPPT)

GEFSR ICs are initialized by the Earth Systems Research Laboratory (ESRL) at 00 UTC only; therefore, the three winter storm cases that were selected for this study were ones that exhibited multi-band snow occurring in the time window of 12 UTC to 06 UTC the following day (forecast hours 12-30). The cases are 10 Dec 2013, 26-27 Nov 2014, and 07-08 Jan 2017.
The Method for Object-Based Diagnostic Evaluation (MODE) tool from NCAR is used for verification by operating on both WRF's simulated reflectivity field and on radar reflectivity from the WSR-88D radar network at one site for each case. Multi-bands are defined according to Novak (2004) as MODE-identified objects 5-20 km in width and with a >2:1 aspect ratio. The Rapid Refresh (RAP) analysis was used as the verifying dataset for meteorological variables.

Preliminary results suggest that the WRF exhibits minimal success at predicting the presence of multi-bands, with a probability of detection (POD) between 0.4 and 0.6 and false alarm ratio (FAR) between 0.3 and 0.5 for each case. The correct simulation of precipitation structure is most sensitive to errors in stability in the 800-700 hPa layer. A signal, though less significant, also exists for relative humidity and moist potential vorticity (MPV) in the 700-600 hPa layer, suggesting resolution of multi-bands may depend on gravity waves ducting through a stable layer concurrent with a significant reduction in stability directly above that layer. There is no sensitivity to errors in frontogenesis magnitude at any level between 900 and 600 hPa.

Convection-Permitting Ensemble Forecasts of the 10–12 December 2013 Lake-Effect Snow Event: Sensitivity to Initial and Boundary Conditions

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Lake-effect snow (LeS) is a high-impact weather phenomenon that is difficult to forecast, due in part to sensitivities of numerical simulations of LeS to uncertainties in the synoptic and mesoscale initial conditions/boundary conditions (ICs/BCs) that influence the position, intensity, structure, and evolution of individual LeS bands. High-resolution, convection-permitting ensemble forecast systems can be used to characterize these IC/BC influences on the forecast. To this end, we focus on one such storm that occurred during 10–12 December 2013 during the Ontario Winter Lake-effect Systems (OWLeS) field campaign. Throughout this event, long-lake-axis-parallel snow bands 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.

To explore the effects of IC/BC uncertainty on this event, we run limited-area, 20-member Weather Research and Forecasting (WRF) ensemble simulations. The convection-permitting ensembles, at 1.33-km horizontal grid spacing, are initialized at each of three different lead times. One subset of the WRF ensembles is initialized from Global Ensemble Forecast System (GEFS) ICs while the other subset uses ICs from the NCAR Data Assimilation Research Testbed system, the same continuously cycled, ensemble Kalman filter data assimilation used in the NCAR ensemble. All of the ensembles use BCs generated by the GEFS.

From these ensembles, we quantify the extent, orientation, and intensity of LeS and assess the precipitation forecast uncertainty as a function of lead time and IC source. These WRF forecasts are evaluated against OWLeS snowfall and radar observations to understand how the ensemble distributions of snow band morphologies and snowfall amounts compare to the observations. We are working to quantify how uncertainties in LeS are modulated by uncertainties in synoptic and mesoscale features such as short-wave troughs and lake-breeze fronts, which may act to constrain the predictability of these high-impact LeS events.

Convection-Permitting Ensemble Forecasts of the 10–12 December 2013 Lake-Effect Snow Event: Sensitivity to Microphysical and Surface-Layer Parameterizations

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Lake-effect snow (LeS) presents a substantial forecast challenge for convection-allowing models, due in part to uncertainties in how best to parameterize microphysical and boundary-layer processes. Here we focus on understanding these uncertainties for a LeS event that occurred during 10–12 December 2013 as part of the Ontario Winter Lake-effect Systems (OWLeS) field campaign. Throughout this event, long-lake-axis-parallel snow bands 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 this event at 12-, 4-, and 1.33-km horizontal grid spacing using the Weather Research and Forecasting (WRF) model, configured in the same manner as the High-Resolution Rapid Refresh model. Sensitivity experiments are conducted by simulating the event multiple times with different microphysical and planetary boundary layer/surface layer (PBL/SL) schemes. LeS band intensity and morphology are the primary differences between microphysics and PBL/SL experiments, with relatively smaller changes in band position. Maximum storm-total liquid precipitation equivalent amounts among microphysics ensemble members have a range of at least 30–60 mm, while surface-layer sensitivity experiments have a range of at least 40–80 mm. Results from the WRF simulations are compared to detailed observations from OWLeS, such as scanning and profiling radar data, surface snowfall and crystal habit observations, and aircraft measurements. These comparisons are used to determine which microphysics and PBL/SL schemes provide the most realistic representation of the parameterized processes and LeS forecasts.

Future NCEP Modeling Plans

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The future of NCEP modeling centers on the Finite-Volume Dynamical Core on the Cubed-Sphere (FV3). NCEP's goal over the next few years is to reduce the current complexity of the NCEP modeling suite by unifying around the FV3. Unification will begin with NCEP's global models—no more operational implementations or upgrades will be done with the Global Spectral Model that powers the GFS and GEFS. Next, regional and convection-allowing models will switch to using the FV3. Development has stopped on the NMMB core used by the NAM, NAM nest, hi-res window NMMB, and half the members of the SREF with those resources now devoted to FV3 development. While FV3 unification is a goal for the next few years, an immediate goal is the operationalization of a convection-allowing ensemble. To accomplish this goal, a poor-man's ensemble that mimics the Storm-Scale Ensemble of Opportunity (SSEO) aggregated by SPC will become operational in fall 2017. This operational convection-allowing ensemble will be known as the High-Resolution Ensemble Forecast system (HREF). A long-term goal is to replace the multi-core configuration of the HREF with an ensemble that uses a single core and techniques such as stochastic physics to achieve spread, but the 2017 HREF configuration will serve as a baseline that future ensembles must outperform.

Timelines of planned NCEP model implementations and a migration to the FV3 will be presented. In addition, examples of the utility of the HREF in forecasting will be presented with a focus on weather in the Northeast.

Stratus Decks and Sea Breezes – DSS Challenges at KBOS

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Boston's Logan International Airport (KBOS) can be one of the most challenging airports to forecast for. Winter storms, severe weather, fog, low clouds, wind – they all can have a very big impact on airport arrival and departure operations, individually and collectively. Combine that with 6 operational runways, all with specific operational requirements, and the fact that KBOS is the 18th busiest airport in the US, and you have the recipe for one of the most challenging airports to forecast for east of the Mississippi River.

On Saturday 19 August 2017, a slow moving cold front was forecast to work its way across New England during the day and evening. Early morning showers and IFR ceilings were forecast to give way to improving conditions and a potential sea breeze later in the day. A combination of a late morning sea breeze (well forecast) and afternoon stratus and fog intrusions (not so well forecast) caused multiple impacts to the arrival and departure operations at KBOS during the afternoon and evening hours.

This event will be discussed to show how an elevated level of situational awareness can help mitigate impacts from short-fused forecast "dilemmas", and how we can better anticipate and mitigate impacts from such events.

An Analysis of Lead-times for Northeast Tornado Warnings 2010-2016

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New York's first tornado of the year touched down on May 31, 2017. The storm moved through the town of Wappingers in Dutchess County as an EF1 with 100 mph winds. While no deaths or injuries were attributed to this storm, the tornado is notable for its unrealized potential-impacts. Forming on a school day, the tornado touched down one-quarter mile from Vassar Road Elementary School, and less than half a mile from Kinry Road Elementary School. The two schools serve approximately 700 kindergarten through fifth grade students in the Wappingers School district. With the tornado forming at 6:58PM, it is likely that both elementary schools were largely empty, however, that was not the case three miles down the road at Roy C. Ketcham High School where their annual spring chorus concert began at 7:00PM. The initial tornado warning was issued at 7:14PM.

It was from the lack of advanced notice during the Wappingers Tornado that this analysis was inspired. Timely warnings are the primary means of notifying people of imminent danger; without them, populations such as those in Wappingers, are left vulnerable. The purpose of this work was to examine factors that characterize Northeast tornados with positive warning lead-times (i.e. warnings issued prior to tornado formation), negative warning lead-times (i.e. warnings issued after tornado formation), and those that received no warning. The project closely follows the analytical framework set forth in Brotzge and Erickson (2008), evaluating factors such as storm order per day and radar morphology. The geographical focus area was confined to tornadoes occurring in states north and east of the Potomac River over a period encompassing the years 2010 through 2016. By analyzing situational characteristics of positive, negative, and absent lead-times, it is hoped that greater operational awareness can be obtained and contribute to increased tornado warning lead-times.

A Dewpoint Climatology in the Capital District of New York

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Dewpoint temperature is the temperature to which a given air parcels must be cooled at constant pressure and constant water vapor content in order for saturation to occur, as defined by the American Meteorological Society. Local and regional variations in boundary layer moisture are important in forecasting convection, wet-bulbing during precipitation events, and calculating heat indices, for example. The purpose of this project was to develop a climatology for dewpoint around the Albany, New York area to evaluate some challenges in forecasting. Three cities within the Albany County Warning Area (CWA) were chosen: Albany, Glens Falls, and Poughkeepsie. Yearly, monthly, and seasonal averages were calculated, and unusually high and low dewpoint events were also noted. Data was taken from the archive provided by NOAA's National Centers for Environmental Information (NCEI) (formally known as National Climate Data Center (NCDC)), and all data was formatted and calculated in Microsoft Excel. Plans for future work include correlating ENSO events to dewpoint data obtained in this study.

A Climatology of Inverted Troughs over the Gulf of Maine and New England

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Inverted troughs (ITs) over the Gulf of Maine are cool season phenomena that are responsible for unexpected high-intensity snowfall over New England. An IT is a north and westward extension of relatively low atmospheric pressure that contains an easterly component of wind and cyclonic relative vorticity. These ITs have the ability to focus moisture into a low-tropospheric convergence zone, lift the air parcel into an unstable atmosphere, and produce high-intensity banded precipitation over a given region. This study creates an inceptive 25-year cool season (September–May) climatology of ITs over the Gulf of Maine from 1989 to 2013. The dynamical characteristics of the IT-influenced precipitation events are investigated via composite analyses of various dynamics parameters at the time of IT maximum amplification.

The temporal climatology suggests that IT manifestation is most common during relatively cool months of the year (i.e., December through April). A k-means clustering test indicated that there is no obvious clustering of IT location based on surface cyclone location alone, but when the orientation of the IT axis is considered as well, there appears to be two possible clusters: (1) cyclones with ~NW-to-SE ITs, and (2) cyclones with ~W-to-E ITs.

Composite results suggest that (1) north and westward extensions of quasi-geostrophic forcing for upward vertical motion removed from the sea-level pressure minimum of a parent-low pressure system can result in the genesis of ITs, and (2) IT axes serve as low-tropospheric convergence zones and loci of frontogenesis resulting in characteristics of frontal boundaries. It is hypothesized that mesoscale responses to the synoptic-scale forcing are responsible for the enhanced regions of precipitation located within the bounds of the IT. A robust mesoscale analysis is not detailed in this presentation but will be the focus of future work. Operational forecasting techniques based upon the results of this study are proposed in order to improve the forecasts of IT-influenced precipitation.

Changes in Extreme Precipitation in the Northeast United States: 1979–2014

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Extreme precipitation can have significant impacts on infrastructure and property, human health, and local economies. This study examines recent changes in extreme precipitation in the Northeast United States, which here includes the states of Maine, New Hampshire, Vermont, New York, Massachusetts, Connecticut, Rhode Island, Pennsylvania, and New Jersey. From the United States Historical Climatology Network, daily station data at 58 stations missing less than 5% of days for the years 1979–2014 was used to analyze both total and extreme precipitation, with the latter defined as the top 1% of days with precipitation.

Results indicated both seasonal and spatial variability in extreme precipitation in the Northeast. The threshold for the top 1% of precipitation increased from 41.4 mm in the winter, to 58.9 mm in the fall season. The coastal areas had more intense extreme events (55–75 mm) that occurred less frequently (36–54 events between 1979–2014) than that of inland stations, which had less intense (38–55mm) but more frequent extreme precipitation events (55–75 events between 1979–2014). A statistically significant increasing trend of average and extreme precipitation was found in both precipitation amount (0.28 mm decade^{-1} and 2.78 mm decade^{-1}, respectively) and frequency (6.94 average events decade^{-1} and 4.44 extreme events decade^{-1}, respectively), especially during the summer and fall seasons. Further investigation into the causes of the observed increase in the frequency and intensity of extreme events, particularly into changes in the types of weather that lead to these events, will be completed.

Examination of the Flash Flood Vulnerability Index Using the October 20-21, 2016 Flash Flooding Event in Central Pennsylvania

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The Flash Flood Potential Vulnerability Index (FFVI) is a method based on the Flash Flood Potential Index. The Flash Flood Potential Index (FFPI) is a method of ranking watersheds by their relative runoff potential. The FFPI was developed at the National Weather Service Colorado Basin River Forecast Center in 2003.

The original FFPI methodology averaged together indices mapped to four different physical characteristics that are related to flash flood potential: land surface slope, land use, soil type, and vegetation cover. The FFVI integrated population vulnerability into the index. This index included the social vulnerability index with the added component of the population density.

This presentation will provide an overview and an application of the Flash Flood Vulnerability Index. The record flooding of 20-21 October 2016 in Milesburg, PA is used to illustrate the use of the Flash Flood Potential Vulnerability Index. There was a weak correlation between the FFVI and the areas affect by flash floods. The results show that there was a correlation between population and reports of flash flooding. In the more rural areas there was considerable damage but initially there were few reports of damage. In areas with higher population densities there were more reports though there was generally less significant damage.

The obvious conclusion is that where the most rain occurs is likely close to where the greatest impact may be. In rural areas this impact may occur with few reports of significant impact verse a more populated area. This may make low population density areas more vulnerable.

An Analysis of Large Track Error North Atlantic Tropical Cyclones

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On average, medium-range (day 3-5) model track forecasts of North Atlantic tropical cyclones (TC's) have improved throughout the decades. However, even the most reliable models have struggled to forecast specific TC's (i.e. Joaquin (2015)), resulting in track errors more than twice as large as climatology. These cases raise questions regarding whether their tracks are associated with common steering patterns that are inherently unpredictable or prone to systematic model biases. If there are common patterns, how sensitive are TC tracks to them and how early can their significance be traced back in the forecast?

This study verifies the 2008-2015 TC track forecasts of global ensembles, focusing on the ECMWF (51 members) and GEFS (21 members) for the North Atlantic. The NHC's best-track data is used as the verifying analysis. The largest ensemble mean along- and cross-track errors from each day 3-5 forecast are analyzed. The forecasts are defined as "north" ("south") cases if the verifying best-track (never) crosses north of 30N, thereby separating TC's potentially undergoing extratropical transition (ET) at higher latitudes. For north and south cases separately, the top 20% most negative and most positive of these along- (cross-track) errors are considered "slow" and "fast" ("left" and "right"), respectively. The model fields of each case are analyzed with standardized differences of the 10 "slowest" ("left-most") ensemble members and the 10 "fastest" ("right-most") ensemble members. In addition, the role of ET on the tracks of north TC by using the cyclone phase space (CPS) diagnostic. Model fields are also evaluated against the CFSR reanalysis.

The along-track biases of the ECMWF and GEFS are significantly more negative for north TC's. Meanwhile, the GEFS has a more right-of-track bias for south TC's. For north TC's forecasted by the ECMWF, the slow cases on average are associated with inherently stronger TC's than the fast, but the intensity errors of slow and fast cases are comparable. From the CPS diagnostic of the slow north cases, the 10 slowest members tend to undergo ET later than the 10 fastest members 36 hours prior to the large mean track error. However, the along-track errors of the two sets of members tend to significantly drift apart 60 hours prior to large error, suggesting that the cause of the error had already affected the TC. From vortex-relative composites, the slow north cases are associated with more amplified flow patterns than the fast north cases. Composited standardized differences imply that the slow north cases are under-amplifying upstream troughs and downstream ridges. This under-amplification is driven by an under-prediction of the divergent outflow of the TC and its interaction with ambient PV gradients.

Global Ensemble Forecasts of Hurricane Irma: Uncertainty Associated with United States Landfall

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Hurricane Irma made landfall on the Cudjoe Key, Florida (FL) as a category 4 hurricane. The massive storm produced extensive damage in the FL Keys due to the combined effects of winds, waves, storm surge, and heavy rainfall. The storm made a second landfall on Marco Island, FL, Sunday 10 September 2017.

The storm was relatively well predicted early on by the European Center, National Centers for Environmental Predictions, and the United Kingdom Meteorological Office global forecast systems. All of the systems forecast the storm to develop and move steadily to the west into the Leeward Islands and the Caribbean then miss Puerto Rico, before moving along the north coast of Cuba.

Longer range forecasts initially forecast the storm to make a sharp north turn. Forecasts from 3 September for example, had the storm move northward just east of the FL with some potential tracks along the coast. Successive forecasts progressively shifted the storm track to the west. It will be shown that the EC ensemble forecast system had about 1 day of additional lead-time correctly tracking Irma over the FL Keys and into the West Coast of FL. The GEFS and UKMO systems showed a similar track with slightly shorter lead times.

The potential threat to the Caribbean and eventually FL with such long lead-times was impressive. Despite these successful forecasts, decisions related to what areas to evacuate were difficult due to the uncertainty of the storm track. Earlier forecasts suggested landfall on the United States as far north as South Carolina while shorter range forecasts placed the landfall farther south and west with time. This raises interesting questions related to when and where to consider evacuation.

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