Agenda
Northeast Regional Operational Workshop XVI
Albany, New York
Wednesday, November 4, 2015

8:30 am
Welcoming Remarks
Raymond G. O'Keefe, Meteorologist In Charge
Warren R. Snyder, Science & Operations Officer
National Weather Service, Albany, New York

<u>Session A – Cold Season Topics</u>

8:40 am
A Multi-scale Analysis of the 26-27 November 2014
Pre-Thanksgiving Snowstorm
Thomas A. Wasula
NOAA/NWS Weather Forecast Office, Albany, New York

9:01 am
Update to Gridded Snowfall Verification: Computing Seasonal Bias Maps
Joseph P. Villani
NOAA/NWS Weather Forecast Office, Albany, New York

9:22 am
Cool-season extreme precipitation events in the Central and
Eastern United States
Benjamin J. Moore
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

9:43 am
A Case Study of the 18 January 2015 High-Impact Light Freezing Rain Event
Across the Northern Mid-Atlantic Region
Heather Sheffield
NOAA/NWS Weather Forecast Office, Sterling, Virginia

10:04 am
The November 26, 2014 banded snowfall case in southern New York
Michael Evans
NOAA / NWS Weather Forecast Office, Binghamton, New York

10:25 am
Break

10:55 am
An analysis of Chesapeake Bay effect snow events from 1999 to 2013
David F. Hamrick
NOAA/NWS Weather Prediction Center, College Park, Maryland

11:16 am
Changes in the Winter Weather Desk Operations at the Weather Prediction Center (WPC), and New Experimental Forecasts
Dan Petersen
NOAA/NWS/NCEP Weather Prediction Center, College Park, Maryland

11:37 am
Applying Fuzzy Clustering Analysis to Assess Uncertainty and Ensemble System Performance for Cool Season High-Impact Weather
Brian A. Colle
School of Marine and Atmospheric Sciences, Stony Brook University,
Stony Brook, New York

11:58 am – Lunch

Session B –UAlbany/NWS CSTAR

1:30 pm
Updated Radar-Based Techniques for Tornado Warning Guidance in the Northeastern United States
Brian J. Frugis
NOAA/NWS Weather Forecast Office, Albany, New York

1:51 pm
Ensemble variability in rainfall forecasts of Hurricane Irene (2011)
Molly B. Smith
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

2:12 pm
A Multiscale Analysis of Major Transition Season Northeast Snowstorms
Rebecca B. Steeves
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

2:33 pm

A Composite Analysis of Northeast Severe Weather Events with Varying Spatial Impacts

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

2:54 pm

The 22 December 2013 Cold Air Damming Event across the Hudson River Valley in East-Central New York

Ian R. Lee
NOAA/NWS, Weather Forecast Office, Albany, New York

3:15 pm

Break

Session C – Heavy Rainfall and Hydrology

3:45 pm

Hydrologic Ensemble Forecast Service Revisited

Erick Boehmler
NOAA/NWS Northeast River Forecast Center, Taunton Massachusetts

4:06 pm

A multiscale analysis of three sequentially linked flood-producing heavy rainfall events during August 2014

Lance F Bosart
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

4:27 pm

An assessment of local forecaster's ability to anticipate flash flooding using the Hazardous Weather Outlook product at WFO Binghamton, New York

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

4:48pm

The Record South Carolina Rainfall Event of 3-5 October 2015:Estimating the Threat Using Average Recurrence Intervals

Charles Ross
NOAA/NWS Weather Forecast Office,State College, Pennsylvania

5:09 pm
The Record South Carolina Rainfall Event of 3-5 October 2015:
NCEP Forecast Suite Success story
John LaCorte
NOAA/NWS Weather Forecast Office, State College, Pennsylvania

5:30 pm
An Examination of “Parallel” and “Transition” Severe Weather/Flash Flood Events
Kyle Pallozzi
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

5:51pm
Wrap up
Warren Snyder

6:00pm - Adjourn

Agenda
Northeast Regional Operational Workshop XVI
Albany, New York
Thursday, November 5, 2015

Session D – Modeling/Ensembles/SUNY Stonybrook

8:00 am
Development of a Webpage to Diagnose Ensemble Cyclone Track Uncertainty with Additional Supporting Graphics
Michael Erickson
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York

8:21 am
Evaluation of WRF Simulated Multi-bands over the Northeast U.S. Using Varied Initial Conditions and Physics
Sara A. Ganetis
School of Marine and Atmospheric Sciences, Stony Brook University,
Stony Brook, New York

8:42 am
Exploring Multi-Model Ensemble Performance in Extratropical Cyclones over Eastern North America and the Western Atlantic Ocean
Nathan Korfe
School of Marine and Atmospheric Sciences, Stony Brook University,
Stony Brook, New York

9:03 am
Using Model Climatology to Develop a Confidence Metric for Operational Forecasting
Taylor Mandelbaum
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York

9:24 am
High Resolution Simulations of an Extreme Precipitation Event over Long Island on 13 August 2014
Nicholas Leonardo
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York

9:45 am
Variational Approach to Improve Computation of Sensible Heat Flux over Lake Superior
Zuohao Cao
Meteorological Research Division, Environment Canada, Toronto, Ontario, Canada

10:06 am
Break

10:35 am
Analysis of Two Missed Summer Severe Rainfall Forecasts
Zuohao Cao
Environment Canada, Toronto, Ontario, Canada

10:56 am
Utilization of Hyper-Local Weather Prediction to Increase Grid Resiliency and Accelerate Renewable Integration in Vermont
Rob D'Arienzo
Vermont Electric Power Company, Rutland, Vermont

Session E – General Session

11:17 am
An Integrated Modelling and Observing System for the Study of the Ecology of Lake George in the Jefferson Project
Anthony Praino
IBM Research, Yorktown, New York

11:38 am
Severe Turbulence Associated with a Meso-Low/Gravity Wave Across the New York Terminal Radar Approach Control
Gordon Strassberg
NOAA/NWS Center Weather Service Unit, Ronkonkoma, New York

Noon
Lunch

1:30 pm
A Comparison of LiDAR wind profiles with National Weather Service high-resolution rawinsonde observations
Jeffrey M. Freedman
Atmospheric Sciences Research Center, University at Albany, Albany New York

1:51 pm
The Provincetown IV Ferry Incident of August 13, 2014: Was a Rogue Wave to Blame?
Joseph W. DelliCarpini
NOAA/NWS Weather Forecast Office Taunton, Massachusetts

2:12 pm
The New York State Mesonet: Network Installation and Operations
J. Brotzge
Atmospheric Sciences Research Center, Albany, New York

Session F – Warm Season/Convection

2:33 pm
The August 4, 2015 Severe Weather Outbreak in Southern New England: Two Rare Significant Events Within 12 Hours
Hayden M. Frank
NOAA/NWS Weather Forecast Office, Taunton, Massachusetts

2:54 pm
Using Dual Polarization Radar to Determine Supercell and QLCS Characteristics Just Prior to Tornadogenesis and Tornado Dissipation
Michael L. Jurewicz Sr
NOAA/NWS Weather Forecast Office, Binghamton, New York

3:15 pm
Using Layered Precipitable Water and Other Satellite Derived Datasets to Anticipate High Impact Weather Events (Heavy Precipitation and Severe Weather Applications)
Michael L. Jurewicz Sr
NOAA/NWS Weather Forecast Office, Binghamton, New York

3:45 pm
Break

4:15 pm
Climatology of Polygon-Based Severe Thunderstorm Warnings for New England
Chris Kimble
NOAA/NWS Weather Forecast Office, Gray, Maine

4:36 pm
The July 19, 2015 “Non-Event” in Southern New England: What Happened?
Frank M. Nocera
NOAA/NWS Weather Foreacast Office, Taunton, Massachusetts

4:57 pm
Severe weather events in Southern Brazil and their similarity with events in the United States
Bruno Z. Ribeiro
National Institute for Space Research (INPE), São Paulo, SP, Brazil

5:17 pm
Analyzing the Roles of Low-Level Forcing and Instability in Significant Severe Weather Outbreaks in the Eastern United States.
Neil A. Stuart
NOAA/NWS Weather Forecast Office, Albany, New York

5:38 pm - Wrap Up
Warren R. Snyder

5:45 pm
Adjourn

7:00 pm
CSTAR Dinner at Buca di Beppo Italian Restaurant for Participants in UAlbany-NWS CSTAR V & Proposed VI.
44 Wolf Road, Colonie, New York

NROW XVII is scheduled November 2-3, 2016
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, Albany , New York

A Multi-scale Analysis of the 26-27 November 2014 Pre-Thanksgiving Snowstorm

Thomas A. Wasula, and Neil A. Stuart
NOAA/NWS Weather Forecast Office, Albany, New York

A late autumn snowstorm impacted the Northeastern U.S. right before Thanksgiving in 2014. The National Weather Service at Albany forecast area which includes east-central New York (NY), and western New England (southern Vermont, the Berkshires of western Massachusetts, and Litchfield County in northwestern Connecticut (CT)) received moderate to heavy amounts of snowfall. The snowfall ranged from 15 to 35 centimeters (cm) (5.9 to 13.8 inches) over a fairly large portion of the forecast area with some slightly higher and lower amounts. For example, Albany had its 5th greatest snowfall all-time in November (records back to 1884) with 26.4 cm (10.4 inches). One maxima of snowfall was over the southern Adirondacks, west-central Mohawk Valley and portions of the Lake George Region. Another maxima of higher snow totals was situated over the Berkshires, northern Litchfield Hills of CT, and the southern Green Mountains of western New England.

This talk will take a multi-scale approach analyzing the transitional season snowstorm from the synoptic scale to storm scale in order to understand the environment that produced the moderate to heavy snowfall across NY and New England. Observational data used in the analyses will include surface and upper air observations, satellite imagery, and Albany (KENX) WSR-88D 8-bit radar data. The role of upper and lower level jet streaks will also be investigated. Anomaly data will also be analyzed from the GEFS, SREF and NAEFS. Application of Collaborative Science, Technology, and Applied Research on mesoscale snowbands will also be shown in the presentation using various available deterministic model data.

UPDATE TO GRIDDED SNOWFALL VERIFCATION: COMPUTING SEASONAL BIAS MAPS

Joseph P. Villani, Vasil T. Koleci and Ian R. Lee
NOAA/NWS Weather Forecast Office, Albany, New York

A gridded snowfall verification method using Geographic Information Systems has been developed at NWS Albany, New York from 2013-2015. The verification is performed by calculating legacy National Weather Service (NWS) zone-averaged snowfall, but utilizes a gridded methodology for a more representative approach. A contoured snowfall analysis map is created using an interpolation scheme to obtain a graphical representation of observed snowfall across an area. Zonal statistics are then calculated using the observed snowfall analysis map, resulting in a more comprehensive mean snowfall for each forecast zone and more precise snowfall verification.

A method of creating error plots for gridded snowfall forecasts has been developed based on the gridded snowfall verification. Error plots for individual snowfall events are calculated by taking the difference between a NWS gridded snowfall forecast and an observed snowfall analysis. Forecast bias maps for snowfall can then be created by summing error plots of individual events using the raster calculator in ArcGIS. Seasonal snowfall bias maps for a number of events from the 2013-2014 and 2014-2015 winter seasons at NWS Albany have been compiled and are shown.

Cool-season extreme precipitation events in the Central and Eastern United States

Benjamin J. Moore, Daniel Keyser, and Lance F. Bosart
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

This study examines the climatological characteristics, dynamics, and medium-range (3–7 day) forecast skill associated with cool-season (September–May) extreme precipitation events (EPEs) over the central and eastern U.S. during 1979–2014. A climatology of "widespread" EPEs is constructed with a gridded gauge-based dataset for a domain covering the central and eastern U.S. by identifying days during which the 99th percentile of daily accumulated precipitation was exceeded at a minimum number of grid points. This minimum number of grid points was defined as the 95th percentile grid point count value for all days during the time period under consideration, thus selecting for events with large spatial coverage.

Composites of the EPEs in the climatology reveal a significant amplification of the tropopause-level flow across the North Pacific and North America during the ~5 days prior to the EPE. This flow amplification culminates in the formation of a high-amplitude trough–ridge pattern over the U.S., corresponding to surface cyclogenesis and anticyclogenesis and to strong water vapor flux and forcing for ascent in the precipitation region. Case studies of selected events suggest that Rossby wave breaking (RWB) may play a key dynamical role for the occurrence of EPEs. To examine the potential role of RWB, the EPE climatology is compared with a contemporaneous climatology of breaking Rossby waves, defined as potential vorticity (PV) streamers near the tropopause. From this comparison, it is found that ~78% of the EPEs were associated with a PV streamer. The PV streamers linked to EPEs are categorized as "anticyclonic," "cyclonic," or "neutral" based upon their predominant tilt. These categories contain ~60%, ~18%, and ~22% of the PV streamers linked to EPEs, respectively.

The anticyclonic and cyclonic categories are examined in a composite framework to illustrate two contrasting EPE scenarios. The anticyclonic category is associated with a highly meridional flow pattern over North America, featuring pronounced ridge amplification over western North America and the downstream development of an elongated positively tilted PV streamer that is flanked to the east by a northeast–southwest elongated front and a pronounced anticyclone. The EPE occurs in the presence of strong lower-tropospheric warm advection, frontogenesis, and water vapor flux established in conjunction with the development of a frontal wave cyclone downstream of the PV streamer. The cyclonic category, by contrast, is associated with a less-meridional flow pattern over North America, featuring a slow-moving negatively tilted PV streamer that amplifies over time, inducing strong surface cyclogenesis. The EPE occurs in the warm sector of the resulting cyclone in the presence of lower-tropospheric warm advection and along a corridor of strong lower-tropospheric water vapor flux. Numerical model forecasts from the NOAA global ensemble forecast system (GEFS) reforecast dataset are used to examine medium-range forecast skill and uncertainty associated with

EPEs in the climatology. Metrics of forecast skill and spread for accumulated precipitation and geopotential height are calculated for each EPE at 3–7-day lead time, and are compared between the anticyclonic and cyclonic categories. Illustrative case studies of EPEs associated with exceptionally low forecast skill are performed.

A Case Study of the 18 January 2015 High-Impact Light Freezing Rain Event
Across the Northern Mid-Atlantic Region

Heather Sheffield and Steven M. Zubrick
NOAA/NWS Weather Forecast Office, Sterling, Virginia

On the morning of Sunday, 18 January 2015, precipitation formed across the eastern Carolinas and subsequently moved into the northern Mid-Atlantic around 1200 UTC. Forecasters had anticipated most of this precipitation would fall as rain. However, just before precipitation onset, observed surface temperatures remained at or slightly below freezing across colder inland areas along and west of the I-95 corridor from Washington, D.C., northeast to Philadelphia and into New York City. At the time of precipitation onset around daybreak, precipitation fell as very light freezing rain across northeast Maryland, quickly producing icy roads and hazardous driving conditions. Observed precipitation amounts were generally a trace to less than 0.05 inches. Previous consensus of available deterministic and probabilistic model guidance was for most of the precipitation to fall as rain at onset. Chances were low for freezing rain, although at least a few model solutions showed a shallow near-surface sub-freezing layer at time of onset.

Based on model consensus and also upstream observations in Central Virginia and Southern Maryland, forecasters at WFO Sterling were anticipating surface temperatures across the WFO Sterling county warning area (CWA) to rise above freezing shortly after sunrise, and *before* precipitation onset. Thus, expectations were precipitation would fall as rain along and east of the I-95 corridor from the Washington DC metro into northeast Maryland, with perhaps patchy very light (trace) freezing rain possible west of the I-95 corridor. Pavement temperatures (from state-maintained sensor networks) were generally below freezing across northeast Maryland before 1200 UTC (before anticipated precipitation onset). Just after 1100 UTC, the area of precipitation expanded northwest earlier than anticipated. These factors combined to produce light freezing rain across northeast MD, which quickly produced icy roads. Ground (pavement) temperatures remained at or just below freezing through the mid-morning hours.

This event had virtually no lead time and thus no treatment resources available to treat icy roads. The light icy glaze led to hazardous road conditions, causing an adverse high impact on travel. Within the WFO Sterling CWA, icing conditions occurred generally just outside of the Baltimore, Maryland, metro area. There was one traffic-related fatality in northeast Maryland (Harford County), several other accidents with injuries, and numerous (non-injury) vehicle accidents, all attributed to icy roads. Route U.S. 40 at the Patapsco River was closed both ways for most of Sunday morning due to an accident involving 49 vehicles that produced 8 injuries.

This presentation will review the atmospheric and surface environment that led to this high-impact icing event and its forecast challenges. The study results revealed strong radiational cooling kept ground temperature from rising above freezing before precipitation began. In-situ, cold-air damming played a large role in keeping temperatures, especially road temperatures, at or below freezing in the northern Mid-

Atlantic. Timing from high-resolution convection-allowing models (CAMs) will be shown that highlights the challenges to anticipating the onset of light precipitation. The study also reinforces the importance of monitoring all available satellite, radar and high-density surface observations, particularly road pavement temperatures, to maintain a high level of situational awareness during potential freezing precipitation events.

The November 26, 2014 banded snowfall case in southern New York

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

A band of heavy snow developed over southern New York during the afternoon and early evening on November 26, 2014 as low pressure tracked northeast up the east coast. This presentation examines several interesting characteristics of this storm related to operational forecasting challenges.

A comparison between the flow pattern associated with this storm and a conceptual model for stationary snow bands is shown. It is demonstrated that the pattern associated with this storm matched the conceptual model for stationary snow bands, and a stationary snow band did develop.

Quantitative precipitation forecasts from the operational forecast models are shown for this case and compared to observations from Avoca, Pennsylvania, Binghamton, New York and Syracuse, New York. It is shown that forecasts trended upward as the event lead time decreased. It is also shown that the operational models correctly forecast the largest precipitation totals in northeast Pennsylvania, where the largest precipitation amounts were observed, with lower amounts farther north. However, despite the fact that the precipitation fell in the form of all snow across the entire area, the largest snowfall amounts were observed in southern New York, north of the largest observed precipitation totals. It is hypothesized that enhanced lift associated with frontogenesis may have resulted in a more favorable juxtaposition of vertical motion and temperature for the production of dendritic snow crystals in southern New York, resulting in higher snow to liquid ratios and largest snowfall totals in that area compared to areas farther to the north and south.

Finally, output from some high resolution modeling is examined for this case. Curiously, despite favorable signatures for banding seen in diagnostics from lower resolution models, reflectivity forecasts from some higher resolution runs did not appear to strongly highlight the potential for banding. This result implies that there is still a need for better understanding on the best methodologies for applying high resolution modelling to the forecast problem of snow banding.

An analysis of Chesapeake Bay effect snow events from 1999 to 2013

David F. Hamrick
NOAA/NWS Weather Prediction Center, College Park, Maryland

Lake effect snowfall is a common occurrence downstream from the Great Lakes during the cold season, but the same process can occur downwind of other bodies of water, including oceans, bays, sounds, and smaller lakes such as the Great Salt Lake in Utah and the Long Island Sound in New York. This provides an interesting local-scale forecasting challenge for snow when the atmospheric conditions are favorable for bay or ocean effect snow. In this study, four separate bay effect snow events from the Chesapeake Bay are analyzed over the Tidewater region of eastern Virginia.

Given the orientation of the Chesapeake Bay from north to south, bay effect snow events from this body of water are much less common than for the Great Lakes. Certain environmental factors must be in place to result in bay effect snow, including a temperature difference of about 15 degrees C from the bay surface to 850mb, minimal speed or directional shear, and a sustained wind direction from 340 to 10 degrees over at least several hours incorporating the greatest length of the Bay. Even with these conditions in place, development of bay effect snow bands is not guaranteed. For those events where it does occur, accumulating snow is mainly confined to the Norfolk and Virginia Beach areas, southern Eastern Shore of Virginia, and perhaps as far south as extreme northeast North Carolina.

This study will examine overall synoptic patterns, upper air data, surface observations, and radar and satellite imagery during the bay effect snow events. These parameters can be used as a guide to give forecasters clues to look for in the short-term forecast area, as well as pattern recognition.

Changes in the Winter Weather Desk Operations at the Weather Prediction Center (WPC), and New Experimental Forecasts

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

Changes to the 2015-16 WPC winter weather desk and product suite are discussed in this presentation, including changes in the snow/freezing rain probability forecasts, revision to the days 1-3 Winter Weather Watch Collaborator, the implementation of 24 hour a day, 7 day a week desk operations, and issuance of new experimental days 4-7 probabilistic winter weather forecasts. 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). The forecast models and ensembles used to derive the probability distribution will now include 26 Short Range Ensemble Forecast (SREF) system members (21 SREF members were used in the 2014-15 season). This increases the number of ensemble members to compute snow and freezing rain probabilities and percentiles to 63 for 2015-16. An announcement has been issued at http://www.nws.noaa.gov/os/notification/tin15-45pwpf.htm to indicate the forecasts will be issued on the Satellite Broadcast Network beginning November 16, 2015 for use by WFOs, the public, the media, etc.

To enhance collaboration, WPC introduced a Winter Weather Watch Collaboration Tool in 2014-15 to aid in making watch, warning, and advisory decisions at forecast offices. The graphics highlighted areas where there was greater than 50 percent chance of exceeding heavy snow and/or freezing rain watch issuance criteria. This year, per request from local forecast offices, a 30 percent contour will be added to these forecasts, so graphics will display both the 30 and 50 percent probability of exceedance. To increase winter weather decision support for the 2015-16 winter, the WPC acquired a new forecaster position to be able to provide collaboration services to forecast offices 24 hours a day, 7 days a week (up from 18 hours a day, 7 days a week during the 2014-15 winter season).

In 2014-15, WPC conducted testing of a Day 4-7 winter precipitation product, which forecast the probability of snow and/or icing exceeding 0.10 inches of liquid equivalent precipitation, with one forecast for each 24 hour period. The WPC Quantitative Precipitation Forecast (QPF) for the Day 4-7 period was used, as well as temperature profiles from ensemble members of the Global Ensemble Forecast System (GEFS), European Centre for Medium Range Weather Forecasts, and Canadian global forecasts. WPC has modified for the 2015-16 season, providing experimental Day 4-7 forecasts of the probability of 0.25” liquid equivalent precipitation in the form of snow and sleet at http://www.wpc.ncep.noaa.gov/wwd/internal/pwpf_d47/pwpf_medr.php for NWS Weather Forecast Offices (WFOs). This higher threshold is more representative of WFO watch/warning criteria, and freezing rain was removed to reduce potential confusion associated with the combination of three precipitation types on to a single forecast. On December 1, 2015, this product will be provided for external partners and customers, including the public.

Applying Fuzzy Clustering Analysis to Assess Uncertainty and Ensemble System Performance for Cool Season High-Impact Weather

Brian A. Colle, Minghua Zheng, and Edmund Chang
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York

Cool-season extratropical cyclones near the U.S. East Coast often have significant impacts for this populated region. For example, the January 2015 nor'easter caused thousands of flights cancellations, travel bans enacted in five states, and two related deaths. Hence it is crucial to forecast these high-impact weather (HIW) events as accurately as possible, including in the medium-range (3-7 days). Ensemble forecasting systems are applied in operations to show an envelope of likely solutions for HIW systems. However, it is generally accepted that ensemble outputs are underused in NWS operations partly due to the lack of verification to assess model biases and efficient tools to communicate forecast uncertainties. For our Stony Brook CSTAR project, we have applied a fuzzy clustering tool to diagnose the performance of different ensemble modeling systems (ECMWF, Canadian, and NCEP GEFS) in forecasting HIWs using multi-model ensembles.

To illustrate the application of the fuzzy clustering tool in verification and separation of scenarios, the late January 2015 blizzard is explored using the multi-model ensemble including 90-members from ECMWF, CMC, and NCEP ensemble datasets. Fuzzy clustering analysis based on the Principal Components of the two leading Empirical Orthogonal Function patterns of the 1- to 6-day ensemble forecasts are computed to group ensemble members into N (in our case 5) clusters. In actual operational application of the fuzzy clustering tool, the ensemble mean can be included as an additional member to objectively identify members that are closest to the mean. In summary, the clustering tool can efficiently separate different scenarios in a multi-model ensemble in targeted regional domains, provide forecasters an effective and objective method to compare forecast uncertainties among different operational models, and can be used as a tool to assess model performance.

We then examine 126 cool season HIW cases (2008–2015) using TIGGE ensemble data to statistically assess the performance of different modeling systems in capturing the scenario that includes the analysis. For these verification cases the analysis can be included as an additional ensemble member in the computation. The analysis falls into the ECMWF means' quadrants more often than the NCEP+CMC means for day 3 and day 6 forecast. However, it falls into the NCEP+CMC quadrants more often for the day 9 forecast.

Updated Radar-Based Techniques for Tornado Warning Guidance in the Northeastern United States

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

A recently updated Collaborative Science, Technology and Applied Research (CSTAR) study examined the V-R Shear Technique for tornado warning guidance to account for 8 bit, high resolution radar data. This technique, originally developed during a local Cooperative Program for Operational Meteorology, Education and Training (COMET) study in 2000, found that maximum gate-to-gate shear below 3 km was useful in identifying tornadic storms and that a linear relationship exists between the strength of the low level tornadic couplet and the mid-level mesocyclonic rotation (La Penta et al. 2000). The update to this original study found that while stronger tornadoes continue to show a signal using the V-R Shear Technique, weaker tornadoes didn't always show a signal using this method. Since the recent update only focused within and near the Albany, New York (NY) County Warning Area (CWA), additional tornadic events and null cases have been examined throughout the Northeastern United States to expand the dataset for areas with similar tornado climatology.

Recent examples studied include an EF3 tornado that impacted the Duanesburg and Delanson areas in eastern NY on 22 May 2014. While the Duanesburg-Delanson tornado showed a strong signal using the V-R Shear technique, other weaker tornadoes were difficult to detect using this method. Although the extent of the damage caused by weak tornadoes is similar to straight line wind damage from microbursts, better techniques are needed to detect these tornadoes. Other storm interrogation methods, such as looking at Normalized Rotation (NROT) in Gibson Ridge's GR2Analyst software, were examined to see if they help detect these weaker tornadoes. Although these weaker tornadoes are short-lived, recent radar advances, such as the Supplemental Adaptive Intra-Volume Low-Level Scan (SAILS) and Automated Volume Scan Evaluation and Termination (AVSET) could help detect these storms that previously may have gone undetected.

In addition, the implementation of impact-based warnings requires knowledge about the estimated strength of tornadoes once they form. While guidance for tornado strength has been developed using polarimetric radar products to detect the vertical extent of tornadic debris based off storms in the Plains and Southeast (Entremont and Lamb 2015), it has not been examined on a regional or local level in the Northeast. This study has extended this guidance to the Northeastern United States to be utilized operationally during the tornado warning process.

Ensemble variability in rainfall forecasts of Hurricane Irene (2011)

Molly B. Smith[1], Ryan D. Torn[1], Kristen L. Corbosiero[1], and Philip Pegion[2]

[1]Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York
[2]CIRES, Boulder, Colorado

Ensemble runs of weather models such as the Global Forecast System (GFS) are becoming an important component of a forecaster's toolbox. Ensembles aid in probabilistic weather forecasting, illustrating much more clearly the amount of uncertainty in a given forecast than deterministic models. This is especially apparent in precipitation forecasting, where slight perturbations in modeled atmospheric conditions can produce individual ensemble members with vastly different rainfall totals over a given area. This work aims to understand what modulates precipitation variability for heavy rainfall events associated with tropical moisture sources by using Hurricane Irene (2011) as a case study. To this end, the 0000 UTC 27 August GFS ensemble forecasts are examined to determine the amount of variability between the precipitation forecasts of the individual ensemble members, as well as the causes of the variability. The GFS ensemble members are then downscaled with WRF, to see what impact terrain and mesoscale processes have on storm rainfall totals. Initial analysis reveals that wetter GFS members produce more divergence aloft, possibly due to a greater amount of latent heat release within the Irene. This increase in outflow keeps a trough over the Great Lakes region farther to the west, which could provide a mechanism for steering Irene closer to the coast, allowing it to deliver more rain to the northeastern United States. In the WRF simulations, the wetter members feature a stronger cyclonic circulation, leading to increased confluence and thus frontogenesis over the Catskills. Our ultimate goal is to use this research to gain a broader understanding of precipitation variability and provide more decision support for forecasters.

A Multiscale Analysis of Major Transition Season Northeast Snowstorms

Rebecca B. Steeves, Andrea L. Lang, and Daniel Keyser
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

Major transition season Northeast snowstorms have the potential to cause widespread socioeconomic disruption in the form of transportation delays, infrastructure damage, and widespread power outages. Because heavy, wet snow tends to occur in transition season Northeast snowstorms, lesser accumulations can result in greater disruption than if the same accumulation occurred in winter season Northeast snowstorms. Motivated by the opportunity to improve scientific understanding and operational forecasting of major transition season Northeast snowstorms, we are conducting a multiscale analysis of this class of snowstorms that focuses on documenting: 1) the planetary-to-synoptic-scale flow patterns occurring prior to and during major transition season Northeast snowstorms, with emphasis on the role of tropical moisture transport occurring within atmospheric rivers in the formation and evolution of this class of snowstorms, and 2) the synoptic-to-mesoscale flow patterns in the extratropics occurring prior to and during major transition season Northeast snowstorms, with emphasis on the formation and maintenance of regions of lower-tropospheric cold air that coincide with areas of heavy snowfall.

An objectively developed list of major transition season Northeast snowstorms that occurred during fall and spring from 1983 through 2013 was constructed using National Climatic Data Center monthly Storm Data Publications. A fall event, 28–30 October 2011, and a spring event, 8–9 March 2005, were selected from this list of major transition season Northeast snowstorms to illustrate characteristic patterns of lower-tropospheric cold air that coincide with areas of heavy snowfall: a cold pool for the fall event and a baroclinic zone for the spring event. Case studies of these fall and spring events will be presented to illustrate planetary-to-mesoscale flow patterns occurring prior to and during major transition season Northeast snowstorms and to consider the hypothesis that atmospheric rivers play a key role in the formation and evolution of major transition season Northeast snowstorms. We will address this hypothesis by documenting tropical moisture transport along parcel trajectories to diagnose moisture sources for areas of maximum snowfall, as well as to diagnose the evolution of selected thermodynamic quantities and moisture variables along the trajectories. While addressing this hypothesis, we also will investigate the correspondence between vertically integrated water vapor transport and areas of heavy snowfall.

A Composite Analysis of Northeast Severe Weather Events with Varying Spatial Impacts

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

This study uses Storm Prediction Center (SPC) convective outlooks to compare kinematic and thermodynamic variables between severe weather events with large spatial impact and severe weather events with a smaller spatial impact. We use the 0600 UTC SPC outlook valid for the 24-hour period beginning at 1200 UTC to 1200 UTC the next day. Hail, wind, and tornado reports valid for the forecast period are projected on a 40 x 40 km grid across the northeastern U.S. to evaluate the areal impact of warm-season northeast severe weather events over a 33-year period from 1980–2012. Events in the dataset are categorized based on the areal coverage of severe reports and filtered to remove events lacking a 0600 UTC SPC slight risk outlook within the Northeast domain. Event-centered composites, using the point of maximum report density, are created to highlight differences in synoptic and local conditions between each event group. Composite results indicate low-level mean relative humidity, 850–500-hPa lapse rates, most-unstable convective available potential energy, and downdraft convective available potential energy are found to be statistically significant in discriminating events spanning a large area from those spanning a smaller area based on model reanalysis data.

The 22 December 2013 Cold Air Damming Event across the Hudson River Valley in East-Central New York

[1]Ian R. Lee and [2]David R. Fitzjarrald

[1]NOAA/NWS, Weather Forecast Office, Albany, New York
[2]SUNY Atmospheric Sciences Research Center, Albany, New York

A period of strong cold air damming (CAD) occurred across portions of the Hudson River Valley in east-central New York (NY) on 22 December 2013. This CAD event accompanied multiple waves of low pressure riding along a stationary boundary that produced significant icing across far upstate NY. A strong, anticyclonically-curved upper-level jet streak promoted a low-level northerly wind channeled along the valley axis below warmer southwesterly flow aloft. This cool and moist northerly wind was concentrated in the lowest 250 meters beneath a stable boundary layer capping inversion that inhibited turbulent mixing and momentum transfer. Temperature differences exceeding 15°C occurred among elevation-dependent observations spaced less than 10 kilometers apart. Dense fog and periods of freezing drizzle accompanied the low-level channeled flow, with clear conditions and overcast skies observed above the capping inversion.

A detailed examination of the boundary layer stability, moisture, and momentum profiles regarding fog formation and dissipation are assessed in relation to localized topographic influences and the synoptic flow pattern. Radiative cooling and turbulent mixing potential in relation to the Hudson River Valley boundary layer energy budget are explored. Richardson number estimates and a layer of shear instability associated with steep midlevel lapse rates aided by a dry, downslope wind off the eastern Catskill Mountains point to a potential role for breaking Kelvin-Helmholtz waves at and above the boundary layer capping inversion. These breaking waves are hypothesized to enhance mixing locally through periods of efficient entrainment processes between the top of the boundary layer and free atmosphere. Such sporadic mixing could help to explain periods of fog dissipation and sudden warming events near the surface.

Hydrologic Ensemble Forecast Service Revisited

Erick Boehmler
NOAA/NWS Northeast River Forecast Center, Taunton Massachusetts

Prior to 2012 the Office of Hydrologic Development contemplated the development of an ensemble forecast system that was expected to improve ensemble forecasts issued by the River Forecast Centers. The improved ensemble forecast system was introduced as the Hydrologic Ensemble Forecast Service (HEFS) at the time. Herein the HEFS is revisited and represented with respect to the "as built" version from what was contemplated. One of the four major components of the HEFS is the Meteorological Ensemble Forecast Processor (MEFP). The MEFP is a key component of HEFS through which meteorological (Met.) forcing variable ensembles for the Northeast River Forecast Center (NERFC) hydrologic models are generated from single-forecast-traces from multiple sources. MEFP algorithms generate bias corrected ensembles from the single-forecast-traces for the hydrologic models. Of the available sources, the GEFS, CFSv2, and climatology sources are utilized by the NERFC to provide 1-year ensemble flow forecasts in support of water resources management operations of the New York City Department of Environmental Protection to the city's water supply reservoirs and aqueducts. The MEFP component requires parametric data, which are estimated through a parameter estimation component of the HEFS, to model the uncertainties in the Met. forcing variables. Inclusion of the Weather Prediction Center forecasts, made available more recently in the parameter estimation component to MEFP, are being contemplated for use in the NERFC ensemble flow forecasts with HEFS. Through review of results from the Ensemble Verification Service component of HEFS, the integration of the Met. forcing variables from the operational Global Ensemble Forecast System source into HEFS are anticipated to provide a dominant improvement in skill in Met. and subsequent river flow ensemble forecasts through day-7 over those from the current, climatology based Ensemble Streamflow Prediction.

A multiscale analysis of three sequentially linked flood-producing heavy rainfall events during August 2014

Benjamin J. Moore, Philippe P. Papin, Nicholas P. Bassill, Josh J. Alland, Michael S. Fischer, Casey M. Peirano, Stephanie N. Stevenson, and Lance F Bosart
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

In this study, a multiscale diagnostic analysis of three sequentially linked flood-producing heavy rainfall events in eastern Michigan, Long Island, New York, and eastern Maine, respectively, during 11–14 August 2014 is performed. In addition, the Long Island event, during which a persistent "training" convective line produced ~345 mm of rain in less than 12 h at Islip, setting the all-time New York State 24-h precipitation record, is examined using an ensemble of convection-resolving Weather Research and Forecasting (WRF) model simulations. It is found that the three heavy rainfall events were preceded by the development of a Rossby wave train across the North Pacific and North America in response to a perturbation of the jet stream by a coherent tropopause disturbance over the western North Pacific. The Rossby wave train development culminated in strong cyclogenesis over the Gulf of Alaska, ridge amplification over western Canada, and the formation and amplification of an upper-level potential vorticity (PV) streamer (i.e., trough) over the eastern U.S. The PV streamer contributed to cyclogenesis and to the poleward transport of moist air over the Great Lakes during 11–12 August, supporting heavy convective rainfall (>100 mm) and flooding in the Detroit, Michigan, metropolitan area. During 12–13 August, continued amplification of the PV streamer was linked with the formation of a secondary low along the eastern U.S. coast and with the transport of an exceptionally moist air mass into the northeastern U.S. The secondary low tracked northeastward and interacted with a coastal front over New Jersey and Long Island, facilitating the development of the extreme-rain-producing convective line over Long Island. Thereafter, the low progressed into New England, producing heavy convective rainfall (>100 mm) and flooding across eastern Maine on 14 August. To diagnose the mesoscale processes associated with the heavy rainfall event over Long Island, the members of the WRF ensemble are ranked according to the correlation between the forecast and observed accumulated precipitation distributions in the vicinity of Long Island. A comparison of accurate and inaccurate members highlights the importance of strong frontogenesis driven by the interaction between a southeasterly low-level jet (LLJ) associated with the secondary coastal low and a coastal front over New Jersey and Long Island for forcing training convection across Long Island. Notable differences between the accurate and inaccurate members with regard to the mesoscale structure and evolution of the coastal low and the LLJ are evident, corresponding to less robust frontogenesis and less-organized, shorter-lived convection over Long Island in the inaccurate ensemble members.

An assessment of local forecaster's ability to anticipate flash flooding using the Hazardous Weather Outlook product at WFO Binghamton, New York

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

The Hazardous Weather Outlook (HWO) is an important tool for National Weather Service forecasters to communicate the potential magnitude and severity of upcoming significant weather events. The outlook is issued at least twice per day, and contains information on the potential for hazardous weather during the next seven days. As such, a review of the contents of the product can be used to evaluate forecaster's ability to anticipate hazardous weather. This presentation shows results from a study that examines the HWO issued at the National Weather Service Forecast Office in Binghamton, NY (WFO BGM), and compares the contents of the product to subsequent occurrences of warm-season flash flooding within the first 24 hours of the forecast.

HWO products issued during the early morning hours from WFO BGM were examined during the warm season (April – October) from 2011-2014. Contents of the product were compared to the occurrence of flash flooding in the first 24 hours of the forecast, to evaluate the forecaster's ability to anticipate flash flooding. In order to objectively evaluate the contents of the HWO forecasts, an assumption was made that forecasters were communicating a substantial probability for flash flooding when certain key words or phrases, such as "heavy downpours", "torrential rain", "flooding" or "flash flooding" were included in the product. A subsequent flash flooding event was defined anytime a report of flash flooding was received from the WFO BGM county warning area within 24 hours of the issuance of the HWO. A false alarm was defined any time flooding was mentioned in the HWO with no subsequent reports of flash flooding.
Preliminary results from the study indicated that forecasters at WFO BGM were able to anticipate flash flooding for 64 percent of the events in the study. A false alarm occurred 55 percent of the time when flooding potential was mentioned in the HWO. The greatest skill appeared to occur during the early fall, possibly due to the occurrence of flooding associated with tropical systems, while the least skill was demonstrated in August, when flooding may have been associated with isolated, weakly forced convection. Detected events ranged in magnitude from one flash flood report to 46, while missed events did not include the biggest cases, ranging in magnitude from one flash flood report to 16. Additional analysis indicated little difference in the magnitude of sounding-based parameters associated with detected events vs. missed events vs. false alarms. An analysis of composites of the large-scale flow pattern also indicated similar patterns for detected events vs. missed events vs. false alarms, with the main difference being that detected events were associated with the most pronounced features.

A brief comparison between two flash flood events occurring during the summer of 2015 is shown, to demonstrate the wide range of flow patterns that can occur with flash flooding in upstate New York. The results from this study highlight the difficulty associated with detecting environments favorable for flash flooding in our region.

The Record South Carolina Rainfall Event of 3-5 October 2015:Estimating the Threat Using Average Recurrence Intervals

Charles Ross and Richard H. Grumm
NOAA/NWS Weather Forecast Office, State College, Pennsylvania

Record setting rains affected South Carolina from 3 to 5 October 2015. The combination of an intense period of heavy rain on 4 October and a long duration rain event combined to produce rainfall totals between 10 and 24 inches and historic flooding across a large swath of South Carolina.

This presentation will demonstrate the value of average recurrence interval (ARI) data in real-time to anticipate flooding and the potential for high impact flooding. During the event ARI data for short time intervals; such as 1, 2 and 3 hour time periods; showed no significant signal. Longer duration accumulation intervals; such as 6, 12, 24 and 72 hours; indicated that the rainfall exceeded the 100 and 200 year ARI values. The storm accumulation period of approximately 72 hours exceeded the 1000 year ARI.

In addition to the real-time rainfall estimated ARI's, short term High Resolution Rapid Refresh data showing forecasts of 6-hour 100 year ARIs are presented. These data were available in real-time and showed successive forecasts and time periods where the 6-hour rainfall rates were between 100 and 200% of the 6-hour 100 year ARI.

This presentation will focus on the value of the ARI data in operational flood forecasting. Some of the limitations of using ARI data, and what does exceeding a 1000 year rain event mean will also be addressed.

The Record South Carolina Rainfall Event of 3-5 October 2015: NCEP Forecast Suite Success story

John LaCorte, Richard H. Grumm, Charles Ross
NOAA/NWS Weather Forecast Office, State College, Pennsylvania

Record setting rains affected South Carolina from 3 to 5 October 2015. The combination of an intense period of heavy rain on 4 October and a long duration of rain event combined to produce rainfall totals between 10 and 24 inches and historic flooding across a large swath of South Carolina.

This paper will document the success of the NCEP forecast suite in predicting the heavy rainfall which affected South Carolina. Long range forecasts from the NCEP Global Forecast System (GEFS) are presented showing forecasts from 30 September through 2 October. The GEFS forecast a high probability of over 4 and 6 inches rain over South Carolina in several 24 hour periods. Though these values are far lower than observed rainfall, these forecasts were in the tails of the GEFS quantitative precipitation forecast climatology implying that the GEFS was forecasting a record event relative to its internal climatology.

As the forecast horizon decreased, the NCEP GFS and SREF forecasts are presented. Similar the GEFS, the SREF showed a high probability of over 4 inches of quantitative precipitation over the same region. The 13km NCEP GFS is presented showing the quantitative precipitation and the ratio of the quantitative precipitation to the 24-hour 100 year ARI data. These forecasts consistently showed that the GFS was forecasting rainfall amounts of 125 to 200% of the 24-hour 100 year ARI values.

Short range High Resolution Rapid Refresh quantitative precipitation is shown relative to the 6-hour 100 year ARI data. These forecasts may have been valuable in defining areas of short-duration high intensity rainfall.

This paper will focus on the success of the NCEP guidance forecasting the heavy rain, the relatively predictable nature of this event with over 4 days of lead-time of the event, and the value of using climatological data in identifying potential high impact and record rain events.

An Examination of "Parallel" and "Transition" Severe Weather/Flash Flood Events

[1]Kyle Pallozzi, [1]Lance Bosart and [2]Steven Weiss

[1]Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York
[2]NOAA/NWS Storm Prediction Center, Norman, Oklahoma

Classical forms of severe weather such as tornadoes, damaging convective wind gusts, and large hail, as well as severe flooding events, all have large societal impacts. This societal impact is even further magnified when these hazards occur simultaneously in the same area. It is a major challenge for operational forecasters to not only accurately predict such events, but also to communicate all threats to the public in real time. This study attempts gain further insight with respect to combined severe weather/flash flooding events by further stratifying them into "parallel" and "transition" events. "Parallel" events are defined as cases where traditional forms of severe weather (tornadoes, damaging winds, large hail) are ongoing at the same time during which severe flooding is also occurring within a given area. "Transition" events are characterized by a shift in the main threat type with respect to time. Usually this shift is from classical forms of severe weather to flash flooding at a later time as initial discrete supercells grow upscale into mesoscale convective systems (MCSs) with training elements.

Combined severe weather/flash flooding cases were identified using severe weather and flash flood/flood reports from the NOAA Storm Data publication in conjunction with objectively established criteria. Once such cases were identified, they were then subjectively classified as either "parallel" or "transition" events using archived radar imagery, storm report plots and time series plots of severe weather and flash flood/flood reports. A 10 year climatology of these events within the United States is currently being constructed. Thus far, climatological results suggest that combined severe weather/flash flooding events are most common spatially speaking in the Mississippi and Ohio River Valleys. Within that region both "parallel" and "transition" events were common. In regions such as the Northeast and Deep South, "parallel" events were much more common compared to "transition" events. Given the focus of NROW, this presentation will place an emphasis on climatological results for the Northeast. The ability to diagnose and predict these high impact events is important from both the scientific and NWS hazardous weather service perspectives, and future work will include identifying similarities and differences in environmental and dynamical conditions that will facilitate the analysis of these two types of events.

Development of a Webpage to Diagnose Ensemble Cyclone Track Uncertainty with Additional Supporting Graphics

Michael Erickson[1], Brian A. Colle[1] and Brandon Hertell[2]

[1]*School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York*
[2]*The Consolidated Edison Company of New York, Inc., New York, New York*

As the number of available ensembles continues to grow, there is an increasing demand for intuitive and informative plots to help visualize the overwhelming plethora of ensemble model data. This talk is motivated by a project with Con Edison of New York, but it is also a goal of the Stony Brook Collaborative Science, Technology, and Applied Research (CSTAR) program. Towards this end, a work-in-progress operational cyclone track website has been developed using the Global Ensemble Forecast System (GEFS), Canadian Meteorological Center (CMC), Fleet Numerical Meteorology and Oceanography Center (FNMOC) and Short Range Ensemble Forecast System (SREF) ensembles. The goal of this website (http://smokey.somas.stonybrook.edu/cyclonetracks/) is to provide forecasters with a visual tool to evaluate the full ensemble spread of forecast tracks and to assess the ensemble's ability to highlight a variety of potential threats in the medium range. The website also includes ensemble spread and probability graphics for other model output variables such as 2-m temperature, 10-m wind speed and accumulated precipitation. This talk will provide an overview of the website and highlight some potential benefits for operational forecasters.

All cyclone tracking is performed on sea level pressure fields by the Environmental Modeling Center (EMC) using the National Center for Environmental Prediction (NCEP) tracking software. The result is one large text file of tracks encompassing all storms, forecast hours and members for each ensemble. Creating visuals from the entire suite of ensemble tracks would be confusing due to the vast number of cyclone tracks being plotted. Therefore a variety of visualization techniques are employed to separate the tracks of individual storms while emphasizing ensemble variability. Two techniques will be shown in real-time including 1) a "box-method" approach where only storms that pass within a pre-specified domain and time period are plotted and 2) a "moving-window" approach where tracks and ensemble probabilities within a 48 hour window of time are displayed. To compliment the ensemble track graphics, a few experimental non-track ensemble images will be presented. Furthermore, images from a few historical East Coast storm cases will be shown to illustrate the utility of the website during significant events. The potential benefit of the operational ensemble website will be addressed. Finally, potential future ideas for ensemble post-processing will be discussed.

Evaluation of WRF Simulated Multi-bands over the Northeast U.S. Using Varied Initial Conditions and Physics

SARA A. GANETIS AND BRIAN A. COLLE
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York

Mesoscale precipitation structures within Northeast U.S. winter storms result in heterogeneous spatial and temporal snowfall throughout the region during any one particular storm. There have been many studies of single-banded snowbands in the comma head, and several successful modeling studies of these bands, but fewer studies of multi-banded events. Multi-bands are defined as > 3 finescale (5–20 km width) bands with periodic spacing and similar spatial orientation, with intensities > 5 dBZ over the background reflectivity maintained for at least 1 h. While multi-bands have been observed to be more transient and shorter-lived structures than single bands, they are capable of producing similar snowfall rates and wind speeds. The Northeast U.S. blizzard of 26-27 December 2010, also known as the “Boxing Day Storm,” was an exemplary case of multi-banding. This presentation will illustrate some of the challenges in simulating these multi-bands for this case and a few others and the implications for operational forecasting. We hypothesize that multi-bands are more challenging than single bands for a mesoscale model to simulate since they are often generated in a weak area of deformation and frontogenetical forcing, may be linked to other mesoscale phenomena (e.g., gravity waves), require grid spacing likely less than 2-km, and form in an environment with weak instability that the model may not properly simulate more than 6-12 hours in advance.

The Weather Research and Forecasting (WRF) mesoscale model is used to test the sensitivity of the fine-scale precipitation structures within Northeast U.S. winter storms to horizontal grid spacing, initial and lateral boundary conditions (NARR, GFS, NAM, and RAP), and physics parameterization schemes including planetary boundary layer (PBL) and microphysical (MP). WRF temperature and moisture output is verified using radiosonde observations from Upton, NY (KOKX) and Chatham, MA (KCHH) and precipitation structures are verified using WSR-88D radars (KOKX, KDIX, KBOX). For the 26-27 December event, very few of all 24 ensemble members produced a realistic set of bands, while for other cases none of the members produced a band. The ability of the members to produce a band and the locations of the simulated bands are most directly tied to the initial and lateral boundary conditions used, while the magnitude and duration is most directly tied to the microphysical parameterization scheme used. The 1.33-km nest is able to reproduce realistic multi-bands for some of the members, so horizontal resolution < 1 km grid spacing is likely not the dominant factor for the WRF band errors. Rather, those members that are too stable or dry at low-to-mid-levels fail to produce bands. Those members that develop bands also have low-level potential vorticity maxima that exist before band development, which organize parallel to the shear vector and the weak deformation axis. This suggests that pre-existing convective cells (and associated PV anomalies) may be important. Future work will investigate the role of these PV structures and thermodynamics in a larger set of WRF simulations.

Exploring Multi-Model Ensemble Performance in Extratropical Cyclones over Eastern North America and the Western Atlantic Ocean

NATHAN KORFE AND BRIAN COLLE
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York

Forecasting extratropical cyclones in the medium to long range requires the use of ensembles. There has been very limited research related to the evaluation and verification of these cyclones in the various ensemble predication systems (EPS). More importantly, operational forecasters need more information on how the ensembles perform during significant cyclone events on a regional scale. The gridded archive within the Observing System Research and Predictability Experiment (THORPEX) Interactive Grand Global Ensemble (TIGGE) provides an opportunity to determine the cyclone performance in the global ensembles as well as explore some of the reasons for any systematic errors. This presentation will verify the track, intensity, and skill of winter season cyclones in these ensembles along the United States (U.S.) East Coast and Western Atlantic from 2007 to 2015.

The operational models evaluated include the 50-member European Centre for Medium-Range Weather Forecasts (ECMWF), the 20-member National Centers for Environmental Prediction (NCEP), and the 20-member Canadian Meteorological Centre (CMC). The ECMWF ERA-Interim Re-Analysis is used to verify cyclone properties for the October to March cool season from 2007-2015. The Hodges surface cyclone tracking scheme was used to track cyclones using 6-hourly MSLP from the analyses and ensemble members. The cyclone verification is binned into different groups according to forecast lead time, cyclone intensity, and magnitude of the cyclone errors for different lead times. Ensemble mean statistics will be presented such as the bias (mean error) and mean absolute error (MAE) for cyclone position and intensity. Additionally, cyclone tracks and statistics for larger error cases will be shown to identify the biases in each EPS during the short range (day 1-3) and medium range (day 4-6) for cyclones of varying intensities. The probabilistic skill is assessed using the Brier Skill Score, among other metrics; to show how representative the ensemble spread is relative to the uncertainty in the ensemble forecast.

There are systematic errors in these ensembles in the medium to long range, such as an underprediction of cyclone intensity over the North Atlantic and an overprediction of cyclone intensity in the eastern US. ECMWF ensemble mean displacement and intensity MAE for East Coast cyclones is the smallest of all EPSs, however the intensity biases are spatially similar to the NCEP ensemble mean. NCEP ensemble mean cyclone MAE on a year-to-year basis shows a slight improvement in the short range.

Using Model Climatology to Develop a Confidence Metric for Operational Forecasting

Taylor Mandelbaum[1], Brian A. Colle[1], and Trevor Alcott[2]

[1] School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York
[2] Earth Systems Research Laboratory, Boulder, Colorado

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 assess the ensemble spread relative to similarly anomalous events. We have attempted to take the M-Climate diagnostic a step further by assessing whether confidence in the developing anomaly is unusually high or low.

Our goal is to output an operational spread anomaly product that will complement the existing ESAT. In order to develop the product, we downloaded the GEFS Reforecast between 21 November 1985 and 10 March 2015. To test the efficacy of the project, we chose cases restricted to the winter (DJF) timeframe over the contiguous United States. In these cases, midlatitude synoptic cyclones are the most prevalent high impact events, especially for southern New York and New England. Our initial test variables include mean sea-level pressure (MSLP), surface temperature, and precipitable water. A future goal is to include other measures such as wind (magnitude and direction) and precipitation. The ensemble mean is used to determine standardized anomalies, at every point on the forecast grid, the current forecast for a given variable is compared to a 21-day M-Climate distribution centered about the day of interest. Reforecast cases at each point within one standard deviation of the current anomaly are used to compare the spread between the M-Climate days and the current forecast. Using this method, a spread anomaly can be calculated for each point on the domain. To improve sample size, we are testing the M-Climate spread anomaly calculated over a 3x3-degree grid centered about the original point. The resulting plot, together with the ensemble mean pressure contours of that forecast, displays a metric of quasi-confidence in the GEFS forecast. In this presentation, we will describe the procedure and highlight a few test cases of East Coast winter storms.

High Resolution Simulations of an Extreme Precipitation Event over Long Island on 13 August 2014

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

On 13 August 2014, the heavily-populated suburbs of Central Long Island were caught off guard by a historical flood. Within a 4 hour time period, almost 12” (~305 mm) of rainfall accumulated in an intense band over Suffolk County, with Islip MacArthur Airport receiving a record-breaking 24-h total of 13.57” (345 mm). While heavy rain was forecasted for the Northeast the day before, the amplitude of this event was severely underpredicted by all of the operational models. This study seeks to analyze the mesoscale evolution of this flooding event, and the key mechanisms behind it. Another objective is to determine whether a mesoscale model run at high resolution can realistically reproduce the development and intensity of the rainfall, and explore some of the sources of model uncertainty limiting its predictability. The Weather Research and Forecasting (WRF v3.5.1) model was used for these simulations down to 1-km grid spacing for an 18-h prediction starting at 0000 UTC 13 August 2014. Those WRF simulations initialized using the 0.5-degree Global Forecast System (GFS) analysis and 6-hourly forecast grids produced the most realistic predictions for this event. An ensemble of different model physics were also tested, but the control (best) run utilized the WSM6 microphysics, RRTM longwave radiation, Dudhia shortwave radiation, MYNN2.5 PBL, and KF cumulus schemes (for grid spacing > 5 km).

This realistic WRF member produced a narrow band of rainfall amounts in excess of 300 mm very close to the correct location. We will highlight some of the low-level forcing and vertical circulations associated with the rainfall in this successful run and compare them with observations. Both radar and surface observations, as well as 1-km WRF simulations, illustrate a weak meso-low near Long Island that enhanced the low-level convergence, upward motion, and rain rates over this region. The mean storm motion was parallel to the orientation of the front, resulting in cells “training” over the same location for a few hours. The importance of latent heating and cooling on this evolution explored using WRF runs in which these processes are turned off in the model. The role of a possible coastal front was also examined by rerunning the successful member after removing Long Island. Many WRF members using different initial conditions and physics underpredict the precipitation by a factor of two. We will show that the size of the nested domain has a significant impact on the evolution of the precipitation and the subsequent evolution of the intense precipitation band. A larger explicit precipitation domain (3-km domain) results in more spurious model convection forming to the south along the warm front during the first 6 hours of the simulation. This in turn perturbs (weakens) the low-level jet transporting moisture and instability to the location where cells initiate and grow over Long Island.

Variational Approach to Improve Computation of Sensible Heat Flux over Lake Superior

Zuohao Cao[1], Murray D. Mackay[1], Christopher Spence[2] and Vincent Fortin[3]

[1]Meteorological Research Division, Environment Canada, Toronto, Ontario, Canada
[2]National Hydrology Research Centre, Environment Canada, Saskatoon, Saskatchewan, Canada
[3]Meteorological Research Division, Environment Canada, Dorval, Quebec, Canada

The sensible heat flux is important for characterizing the energy transfer between the atmosphere and its underlying surfaces such as the Laurentian Great Lakes. Accurate representation of the flux and the interaction in this coupled system is therefore necessary to better predict hydro-meteorological variables.

The flux computation in current numerical weather prediction models suffers from substantial inaccuracies due to limitations of Monin-Obukhov Similarity Theory (MOST)-based algorithms used in the computation, especially over heterogeneous surfaces such as lakes. The variational method can overcome these drawbacks by making full use of the observed meteorological information over the underlying surface and the information provided by MOST. In this study, the variational method is employed for the first time to compute surface sensible heat fluxes over Lake Superior.

Direct eddy- covariance measurements of sensible heat fluxes over Lake Superior have become available only recently. The results show that the variational method yields very good agreements with the direct eddy- covariance measurements over Lake Superior. Also, it is exhibited that the variational method is much more accurate than the conventional flux-gradient method. It is anticipated that in the future the variational approach can be used to improve the GEM forecasting system.

Analysis of Two Missed Summer Severe Rainfall Forecasts

Zuohao Cao[1] *and Da-Lin Zhang*[2]

[1]*Environment Canada, Toronto, Ontario, Canada*
[2]*Department of Atmospheric and Oceanic Science, University of Maryland, College Park, Maryland*

Despite considerable progress in mesoscale numerical weather prediction (NWP), the ability to predict summer severe rainfall (SSR) in terms of amount, location, and timing remains very limited due to its association with convective or mesoscale phenomena. In this study, two missed SSR events that occurred in the highly populated Great Lakes regions are analyzed in the context of moisture availability, convective instability, and lifting mechanism in order to help identify the possible causes of these events, and improve our SSR forecasts/nowcasts.

Results reveal the following limitations of the Canadian regional NWP model in predicting SSR events: (1) the model predicted rainfall is phase-shifted to an undesired location that is likely caused by the model initial condition errors; (2) the model is unable to resolve the echo training process due to the weakness of the parameterized convection and/or coarse resolutions. These limitations are reflected by the ensuing model-predicted features: (1) vertical motion in the areas of SSR occurrence is unfavorable for triggering parameterized convection and grid-scale condensation; (2) convective available potential energy is lacking for initial model spin up and later for elevating latent heating to higher levels through parameterized convection, giving rise to less precipitation; and (3) the conversion of water vapor into cloud water at the high and middle levels is underpredicted. Recommendations for future improvements are discussed.

Utilization of Hyper-Local Weather Prediction to Increase Grid Resiliency and Accelerate Renewable Integration in Vermont

[1]Rob D'Arienzo and [2]Lloyd Treinish, [2]Anthony Praino, [2]James Cipriani

[1]Vermont Electric Power Company, Rutland, Vermont
[2]IBM Research, Yorktown Heights, NewYork

In recent decades, our climate has been changing such that extreme weather events of almost every type are increasing in both intensity and frequency. Such events impact all elements of our society but cause extensive damage to the infrastructure that undergirds our entire modern civilization: the power grid. For example over the past 2 years, Green Mountain Power, Vermont's largest distribution utility, spent approximately $63 million in storm costs alone. Damaged electrical systems paralyze health care and public safety, government and education, commerce and communication. Future changes in climate will only create more disruption, risk and economic losses across the entire United States. Thus improving our ability to understand and predict the weather is critical not just to ensure a reliable electric grid, but to our very ability to maintain a functioning society.

Vermont's complex terrain and vast local variability coupled with large gaps in observational data pose many challenges from a weather forecasting perspective. In a collaborative effort to increase the resiliency of Vermont's electrical grid, Vermont Electric Power Company (VELCO) and statewide partners developed the Vermont Weather Analytics Center (VTWAC) to increase grid reliability, lower weather event-related operational costs, and optimize utilization of renewable generation resources. VTWAC's longer term objective is to serve other societal sectors such as transportation, municipal governance, and environmental protection.

The weather prediction component is powered by IBM's Deep Thunder, an advanced NWP model that is based, in part, on a configuration of the Advanced Research core of the Weather Research and Forecasting (WRF-ARW) model. Deep Thunder runs two 48-hour forecasts daily at 1 km horizontal resolution and outputs variables at 10 minute intervals. Vertical resolution is also high with 51 vertical levels, ten to fifteen of which are typically below 160-m, in order to account for characteristics of the wind turbines. Deep Thunder uses RAP for background fields and NAM for lateral boundary conditions, as well as complex physics configurations to account for highly rural and urban environments. The installation of a statewide mesonet is also in progress which will aid in additional data assimilation, verification, and nowcasting capabilities.
An overview of the project will be presented which will highlight the coupled models that run off the foundational Deep Thunder predictive tool. Progress to date will be shared which will include some verification work on both warm and cool season events, as well as overall performance metrics across the model suite. Potential future work and applications of the operational weather model will also be discussed which include outage/impact prediction, road weather forecasting, recreational forecasting, and climate change research.

AN INTEGRATED MODELLING AND OBSERVING SYSTEM FOR THE STUDY OF ECOLOGY OF LAKE GEORGE IN THE JEFFERSON PROJECT

Anthony Praino, Lloyd Treinish, Harry Kolar, James Cipriani, Eli Dow, Michael Kelly, Frank Liu, Fearghal O'Donncha, Emanuele Ragnoli, Michael Passow, Lucas Villa Real, Campbell Watson
IBM Research, Yorktown, New York

We describe an integrated modeling and observing system that is being developed as part of the Jefferson project to study the ecology of Lake George in northeastern New York State. The Jefferson Project is collaboration between Rensselaer Polytechnic Institute, IBM and the FUND for Lake George. The focus of the project is to develop a detailed understanding of the overall ecology of Lake George, including the interactions of the physical, chemical and biological environment in and around the lake for the management of the numerous complex factors affecting the lake including: road salt, storm water runoff and invasive species. The lake is located in the southeast portion of the Adirondack State Park and is within the Albany WFO CWA. Lake George is a glacial, oligotrophic water body. It is unique among fresh water lakes because of its ecology, geographic orientation, historical importance and tourism driven economic impact. To enable a detailed understanding of the current ecological state of the lake as well as support an ongoing research and monitoring program we are developing an integrated modeling and observing system. The system is composed of several major components which include a coupled high performance computing modeling system to physically model atmospheric, hydrological and hydrodynamic aspects of the lake and surrounding region, a real time multi-sensor observing network composed of in situ sensors for atmospheric, stream and lake measurement, and an adaptive cyber infrastructure to control, coordinate, communicate, aggregate and deliver multiple data streams in real time. The modeling and observing systems will provide predictive and real-time analytics for research, operations and management as part of a lake monitoring and assessment program for the detection and response to adverse environmental and ecological effects. We present an overview of the project and details of the integrated modeling and observing system.

Severe Turbulence Associated with a Meso-Low/Gravity Wave Across the New York Terminal Radar Approach Control

Gordon Strassberg
NOAA/NWS Center Weather Service Unit, Ronkonkoma, New York

Early on the morning of 20 April 2015, an intense upper trough and stacked cyclone over the Great Lakes combined with strong, retreating surface high pressure over the Canadian Maritimes to produce a strong low-level jet (LLJ), coincident with the greatest surface pressure gradient between them. This jet, initially along the Mid-Atlantic coast at 1200 UTC, moved quickly north across the New York City/Long Island area by 1500 to 1600 UTC. The potential for severe turbulence due to the strengthening LLJ was highlighted early in the day by the Center Weather Service Unit (CWSU) via in-person and web briefings, along with Center Weather Advisories (CWAs).

Initially, few turbulence reports were received as winds increased, likely due to several shallow stable layers between the surface and 5000 feet, as is typical of strong cold-season systems. Between 1500 and 1600 UTC, however, numerous reports of severe turbulence were received from aircraft departing and arriving at the NY Terminal Radar Approach Control (TRACON) airports, coinciding with the west side of the LLJ as its core departed into southern New England. Surface observations indicated the presence of a weak meso-low that caused a small, but significant area of rapid surface wind shifts at Newark International Airport before it quickly weakened. Subsequent analysis of doppler radar data from KOKX and KDIX, as well as terminal doppler radar (TDWR) data from TEWR and TPHL, show the presence of possible gravity waves around this time as well.

The severe turbulence in this case led to many departure/arrival stops at the NY TRACON airports and caused aircraft to divert as well. This presentation will highlight the meteorological factors that caused this significant aviation weather event.

A comparison of LiDAR wind profiles with National Weather Service high-resolution rawinsonde observations

[1]*Jeffrey M. Freedman and* [2]*Raymond G. O'Keefe*

[1]*Atmospheric Sciences Research Center, University at Albany, Albany New York*
[2]*NOAA/NWS, Weather Service Forecast Office, Albany New York*

Continuous observations of the wind profile in the planetary boundary layer (PBL) are becoming a necessary component to support real-time observational analysis and operational forecasts for the public and private sectors. Such observations are critical in accurately assessing rapidly changing conditions in the PBL (where people tend to live) and are now necessary (if not mandatory) in supporting aviation, utility, air pollution monitoring, and renewable energy resource assessment and forecasting. The National Weather Service, however, has had limited access to such observations (e.g., NOAA's since discontinued Profiler Network), and no network of high resolution wind profilers has ever been deployed in the U.S., nor have such observations ever been incorporated into NOA A NWS operational forecasts (with the exception of a few field campaigns). Thus, operational forecasts have almost exclusively relied upon a network of rawinsonde sites that provide "snapshot" profiles of the PBL and the free atmosphere above—typically only twice a day. This observational "limitation", however, will be changing with the deployment of the first ever network of wind LiDARS (and microwave radiometers) as part of the New York State Mesonet.

Since 1997, the Albany National Weather Service Forecast Office (NWSFO) has launched twice-daily rawinsondes from the rooftop of the State University of New York's Center for Environmental (now Emerging) Sciences and Technology Management. In collaboration with the Albany National Weather Service Forecast Office, the UAlbany Atmospheric Sciences Research Center in June 2015, commenced a continuing inter-comparison study of wind profiles between a Leosphere Windcube 100S Doppler LiDAR and high-resolution rawinsonde observations. Here, we present preliminary results of the inter-comparison for the summer and fall transition seasons (June, July, August, and September) of 2015.

The Provincetown IV Ferry Incident of August 13, 2014: Was a Rogue Wave to Blame?

[1]*Joseph W. DelliCarpini and* [2]*Richard H. Bouchard*

[1]*NOAA/NWS Weather Forecast Office Taunton, Massachusetts*
[2]*NOAA/NWS National Data Buoy Center, Stennis Space Center, Mississippi*

On August 13, 2014, the passenger ferry *Provincetown IV* was en route from Provincetown to Boston when it encountered a large wave that smashed windows in the pilot house and temporarily disabled the engines, stranding the vessel about 5 miles off the coast of Scituate. Two injuries were reported on board. The rough seas were the result of an unusually strong low pressure system for mid-August, which tracked from the mid-Atlantic coast to the South Coast of New England and brought near gale force east to northeast winds.

At the time of the incident, significant wave heights as reported from the nearby NOAA Buoy 44013 (known as the Boston buoy) were 5 to 6 feet. A general rule-of-thumb would estimate maximum wave heights about twice as high, on the order of 10 to 12 feet. Initial eyewitness reports categorized these waves as rogue waves as high as 20 feet, which is the approximate height of the pilot house above the water line. Rogue waves are defined as waves that are more than twice the height of the significant wave height. So seemingly, the *Provincetown IV* incident met the criterion for rogue waves. The buoy indicated significant steepening of the waves during the incident and periods of reduced wind speeds that could have contributed to their generation.

This presentation will describe the meteorological conditions that led to this event. The wind and wave data from Buoy 44013 are reviewed for indications of conditions conducive to the formation of rogue waves. The question of whether or not this was a rogue wave, and can such waves be accurately forecast, will also be discussed.

The New York State Mesonet: Network Installation and Operations

J. Brotzge[1] , C. Thorncroft[2], and E. Joseph[1]

[1]Atmospheric Sciences Research Center, Albany, New York
[2] Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

The New York State (NYS) Mesonet Early Warning Weather Detection System is an advanced, statewide weather station network explicitly designed to enhance local data collection for improved weather monitoring and prediction. The Mesonetwork will consist of 125 surface weather stations with at least one station in every county and borough across the state.

Each of the Mesonet's 125 weather stations will measure surface temperature, relative humidity, wind speed and direction, precipitation, solar radiation, atmospheric pressure, photographic images and soil moisture and temperature at three depths (5, 25, and 50 cm). In addition, seventeen of the sites (known as "enhanced sites") will be outfitted with LiDARs and microwave radiometers providing wind, temperature, and moisture profiles in the vertical. Twenty of the sites will measure snow depth and snow water equivalent for hydrological applications, and seventeen of the sites will measure the surface energy budget, including radiation, sensible, latent and ground heat fluxes. All data will be collected every five minutes and then transmitted in real-time to a central location at the University at Albany, where the data will be quality controlled and archived, and then disseminated to a variety of users. Upon completion, real time data along with graphical products will be available to the public via a website (http://nysmesonet.org).

The first Mesonet site was installed at Schuylerville in August, with over a dozen sites to be installed by 31 December 2015. Site installations will continue through 2016, with the entire network expected to be completed by December 2016. This presentation will provide a general technical overview of the system, an update on network installation, and a quick look at data collected from the operational sites.

The August 4, 2015 Severe Weather Outbreak in Southern New England: Two Rare Significant Events Within 12 Hours

Hayden M. Frank
NOAA/NWS Weather Forecast Office, Taunton, Massachusetts

On Tuesday, August 4, 2015 two rare significant severe weather events affected southern New England. The first event occurred early in the morning across Rhode Island and southeast Massachusetts where widespread wind gusts of 60 to 80 mph downed trees and power lines. Rhode Island was especially hard hit. Major roadways and commuter rail lines in the Providence area were blocked by fallen trees, snarling the morning commute. Over 120,000 customers were left without power throughout the Ocean State, which was more than during Sandy. Ten minor injuries were reported at Burlingame Campground in Charlestown.

Another round of severe weather occurred during the afternoon, mainly along and north of the Massachusetts Turnpike, where there were many reports of golf ball sized hail. Hail as large as two inches in diameter was reported in downtown Boston, which was the largest on record in Suffolk County. Wind gusts of 50 to 60 mph caused some tree damage and isolated power outages, but not to the extent of what occurred earlier in the day.

This presentation will focus on the science behind these two events, including a review of the unusual environment that was in place that day across New England and the mechanisms that helped initiate thunderstorms. Radar data and mesoscale analyses will show the evolution of thunderstorm development during the morning and again that afternoon.

Using Dual Polarization Radar to Determine Supercell and QLCS Characteristics Just Prior to Tornadogenesis and Tornado Dissipation

[1]Michael L. Jurewicz Sr., [1]Michael Evans and [2]Christopher Gitro

[1]NOAA/NWS Weather Forecast Office, Binghamton, New York
[2]NOAA/NWS Weather Forecast Office, Kansas City/Pleasant Hill, Missouri

Research during the past several years has highlighted the importance of analyzing characteristics of the near-storm environment, when attempting to determine the severe and tornadic potential of convective storms. Highly precise and accurate measures of near-storm environmental characteristics are often lacking operationally, with forecasters typically forced to rely on lower-resolution datasets to infer storm-scale environmental characteristics, such as low-level shear, LCL heights, etc. However, recent observations associated with the implementation of dual polarization capabilities to the National Weather Service (NWS) Weather Surveillance Radar Doppler (WSR-88D) network, has indicated that this upgrade may allow meteorologists to more directly infer important storm-scale information, by identifying specific hydrometeor characteristics within different sectors of convective storms.

In this presentation, storms were investigated from four separate, tornadic cases over the Northeastern United States (two supercell events (29 May 2013 and 22 May 2014) and two quasi-linear convective system (QLCS) events (19 April 2013 and 8 July 2014)). Specific and consistent patterns in differential reflectivity (Zdr) and specific differential phase (Kdp) were noted in the inflow, rear-flank downdraft (RFD), and hook echo regions of the evaluated supercells, particularly just before both tornadogenesis and tornado dissipation times. An examination of the QLCS events indicated some similarities and some differences compared to evolutions seen with the supercells. Building upon previous research (Crowe et al. 2012, French et al. 2014, Kumjian 2011, and Markowski et al. 2002, among others), it will be demonstrated how Zdr and Kdp positioning and magnitude trends illuminated certain hydrometeor properties within different portions of these storms, and what clues these properties gave as to impending tornadogenesis, or tornado dissipation.

Using Layered Precipitable Water and Other Satellite Derived Datasets to Anticipate High Impact Weather Events (Heavy Precipitation and Severe Weather Applications)

[1]Michael L. Jurewicz Sr., [2]Christopher Gitro and [3]Sheldon J. Kusselson

[1]NOAA/NWS Weather Forecast Office, Binghamton, New York
[2]NOAA/NWS Weather Forecast Office, Kansas City/Pleasant Hill, Missouri
[3]NOAA/NESDIS/OSPO/SPSD/Satellite Analysis Branch, College Park, Maryland (Retired)

In anticipation of the first Geostationary Operational Environmental Satellite R series (GOES-R) launch, currently scheduled for October, 2016, the National Weather Service (NWS) seeks to provide forecaster training, prior to the platforms becoming operational. This initiative will be challenging, in that it will continue to be difficult to balance the training needs, priorities, and resources of satellite, dual-polarization radar, and numerical weather prediction topics. In light of several recent high impact weather events and findings from both National and Regional level service assessments, it remains clear that additional remote sensing products/techniques are needed to help anticipate and better forecast high impact weather events.

The purpose of this presentation is to highlight the use of new satellite datasets, which can assist in isolating locations favorable for excessive precipitation, as well as severe weather development. Brief case study examples will be shown, demonstrating the use of experimental CIRA SPoRT Layered Precipitable Water (LPW) data, which has the ability to track individual layers of moisture (or lack thereof). LPW data will also be compared with Total-column Blended Precipitable Water (TPW) data, in order to stress the benefits of using both datasets in tandem. Additionally, data from the experimental CIMSS NearCast model (theta-e and precipitable water difference fields) will be investigated, in order to show how the combination of real-time analyses from GOES sounder channels, along with numerical weather projections, can be assessed to pinpoint/track areas of deep moisture, dry layers, and regions of increasing convective instability. It is hoped that continued evaluation and documentation of key benefits from these new datasets, will increase visibility, and foster operational implementation of these products. Operational meteorologists will also benefit from exposure to these products, especially when even higher resolution datasets become available, with the launch of the GOES-R platforms.

Climatology of Polygon-Based Severe Thunderstorm Warnings for New England

Chris Kimble
NOAA/NWS Weather Forecast Office, Gray, Maine

In order to determine the climatological distribution of severe thunderstorms in New England, polygon warnings from 2008 through 2014 were gathered and analyzed. Using GIS software, plots showing the frequency of severe thunderstorm warnings were created. This gives a generalized view of the severe thunderstorm climatology in New England. These results also reveal several artifacts in severe thunderstorm warning frequency near County Warning Area boundaries. Reasons for these artifacts will be discussed as well as potential solutions.

The July 19, 2015 “Non-Event” in Southern New England: What Happened?

Frank M. Nocera
NOAA/NWS Weather Foreacast Office, Taunton, Massachusetts

Isolated severe thunderstorms were expected to occur across northern Massachusetts on July 19, 2015 due to the presence of high instability, favorable mid-level lapse rates, and moderate 0-6 km wind shear in place ahead of a weak surface trough. Forecasters at the National Weather Service in Taunton saw the potential for a “high end” severe weather event based upon the ingredients in place which included significant wind damage, large hail, and a tornado. This was communicated to federal, state, and local partners via email briefings as well as in statements, discussions, and social media.

Only one severe weather report of wind damage was reported that afternoon in northwest Massachusetts while the rest of southern New England did not even see any rain. Severe weather was focused to the west and north of the region, where hail as large as baseballs and significant wind damage occurred.

This presentation will review the synoptic and mesoscale environments that were in place that afternoon. Despite what seemed to be a favorable day for severe weather, the lack of low level forcing and upper level divergence was the probable cause for a lack of activity in southern New England. Other model fields will be shown that could have served as “red flags” against widespread activity. Recommendations will be discussed on how this information could have been better communicated to better convey the uncertainty that was associated with this case.

Severe weather events in Southern Brazil and their similarity with events in the United States

[1]Bruno Z. Ribeiro and [2]Lance F. Bosart

[1]National Institute for Space Research (INPE), São Paulo, SP, Brazil
[2]Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

The purpose of this presentation is to illustrate some severe weather patterns in southern Brazil and compare them with severe weather patterns in the United States. Due to similarities in the topography of North America and South America, including a north-south oriented mountain range on the western side of the continent and a source of warm, moist tropical air equatorward of subtropical and middle latitudes, the overall synoptic-scale characteristics of severe weather events over both continents are similar. However, local and regional differences between the two continents can be important in severe weather forecasting, as will be explored.

A case of severe squall line and an EF-3 tornado will be analyzed in a synoptic/mesoscale perspective. These cases are different in terms of synoptic setting. The squall line of 08 September 2015 occurred in a strongly forced environment, downstream of an upper-level trough. It was associated with a 60-kt northwesterly flow, 50 mm of precipitable water, 1500 J/kg of CAPE and occurred in the equatorial entrance region of a 120-kt jet streak. The tornado case of 20 April 2015, on the other hand, occurred on the anticyclonic side of an upper-level jet streak, with a precipitable water of more than 60 mm, but in the absence of large-scale forcing. These two cases elucidate the southern Brazil "cold season" and the "warm season" synoptic environments for severe weather, respectively, similar to that observed in the United States. Moreover, the tornado case was a particularly difficult forecast, since there was no inflow sounding available on that day. The thunderstorm occurred in a region of southern Brazil where there is no radar coverage, thus it was impossible to issue any tornado watch for the region. These and other issues of severe weather forecasting in southern Brazil will also be presented, enabling a comparison with the methodologies used by both countries to deal with severe weather events.

Analyzing the Roles of Low-Level Forcing and Instability in Significant Severe Weather Outbreaks in the Eastern United States.

Neil A. Stuart
NOAA/NWS Weather Forecast Office, Albany, New York

Significant severe weather outbreaks (winds ≥ 29 ms^{-1}, hail ≥ 2 inches in diameter and tornadoes rated ≥ EF2) are relatively rare but are considerably rarer east of the Appalachian Mountains compared to the central and southern U.S. The Appalachian Mountains can act as an obstacle, disrupting mesoscale features that initiate and maintain convection east of the mountains, resulting in challenges predicting the occurrence of significant severe weather in the eastern U.S.

This study will describe synoptic and mesoscale features as well as thermodynamic profiles of the atmosphere supportive of significant severe weather events in the eastern U.S. An analysis of forecast busts will illustrate the absence of atmospheric features and thermodynamic profiles that typically inhibit the development of severe weather, except for the case of isolated and unusual outlier events, which will also be presented.

It will be shown a 500 hPa vorticity maximum tracking east of the Appalachian Mountains in 24 hours, coincident with an 850 hPa wind core ≥ 18 ms^{-1}, an 850 hPa (Θ_e) gradient ≥ 25 K and 4-layer best Lifted Index exceeding -3 K was analyzed in nearly all 50 significant severe weather events identified in this study between 1953-2015 in the eastern U.S. Composites of 850 hPa winds and instability as well as analyses of elevated mixed layers will be presented. Hysplit analyses will show elevated mixed layers associated with regions of significant severe weather tracking from the Great Lakes and Ohio Valley into the eastern U.S. Gradients of 850 hPa (Θ_e) will also be shown that represent an important sharp low-level density discontinuity that can initiate, support and maintain convection.

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