Agenda
Northeast Regional Operational Workshop XIV
Albany, New York
Wednesday, October 31, 2012

9:15 am
Welcoming Remarks
Raymond G. O'Keefe, Meteorologist In Charge
Warren R. Snyder, Science & Operations Officer
National Weather Service, Albany, New York

Session A – Cold Season Topics

9:30 am
Large-scale Precursors to Major Lake-Effect Snow Storms Lee of Lake Erie
Hannah E. Attard
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

10:00 am
2-3 January 2010 Northeast Winter Storm: A Case Study
Adrian N. Mitchell
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

10:30 am
Mechanisms for Transient and Long-Duration Mesoscale Snowbands in Northeast U.S. Winter Storms
Jaymes S. Kenyon
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

11:00am
Methodology for Developing a Heavy Wet Snow Scale for a Utility Company
Brandon Hertell
Consolidated Edison Company of New York, Inc, New York, New York.

11:30 am
The Prediction of Onset and Duration of Freezing Rain in the Saint-Lawrence River Valley
Sophie Splawinski
McGill University, Montreal, Quebec, Canada

12:00 pm
Precipitation Modulation by the Saint Lawrence River Valley in Association with Transitioning Tropical Cyclones
Shawn M. Milrad
Department of Atmospheric and Oceanic Sciences
McGill University, Montreal, Quebec, Canada

12:30 pm
Synoptic and Mesoscale Aspects of Ice Storms in the Northeastern United States
Christopher M. Castellano
Northeast Regional Climate Center
Cornell University, Ithaca, New York

1:00 pm - Lunch

Session B – Modeling

2:30 pm
Hindcast Analysis of the June 2012 Derecho and Its Impact on the Baltimore-Washington Metropolitan Area using High-resolution WRF-ARW
J.P. Cipriani
IBM Thomas J. Watson Research Center, Yorktown Heights, New York

3:00 pm
Implementation and Operation of Mesoscale Numerical Weather Prediction Modeling Systems for Business Applications
Anthony P. Praino
IBM Thomas J. Watson Research Center
Yorktown Heights, New York

3:30 pm
Break

3:45 pm
Predictability of High Impact Weather During the Cool Season Over the Eastern United States (via GoTo Meeting)
Jeff Tongue
NOAA/NWS Weather Forecast Office, New York, New York

4:15 pm
On the Use of High Resolution Models (via GoTo Meeting)
Richard H. Grumm
NOAA, NWS Weather Forecast Office, State College, Pennsylvania

4:45 pm - Adjourn

Agenda
Northeast Regional Operational Workshop XIII
Albany, New York
Thursday, November 1, 2012

Session C – General Session

9:30 am
The Tropical Storm Irene "Mega Flood" in The Catskills. -Why it Was Not an Unprecedented Event and Why Cataloging Past Events Will Help us Attain a Weather Ready Nation.
Stephen N. DiRienzo
NOAA/NWS Weather Forecast Office, Albany, New York

10:00 am
Increasing Your Social Reach on Facebook
Erik Heden
NOAA/NWS, Weather Forecast Office, Binghamton, New York

10:30 am
Operational Changes and Future Plans at the Hydrometeorological Prediction Center (HPC)
Dan Petersen
NOAA/NWS, Heavy Precipitation Center, National Centers for Environmental Prediction, College Park, Maryland

11:00 am
An Overview of the Northeast River Forecast Center Implementation of the Hydrologic Ensemble Forecast Service (HEFS) and related activities supporting the New York City Department of Environmental Protection (NYCDEP) Operational Support Tool (OST)
David R. Vallee
NOAA/NWS Northeast River Forecast Center, Taunton, MA

11:30 am
Lunch

Session D – Warm Season Topics/ Convection

1:00 pm
The 26 July, 2012 Twin Tier Severe Weather and Tornado Outbreak
Part I: Environmental characteristics
Michael Evans
NOAA/NWS Weather Forecast Office Binghamton, New York

1:30 pm
The 26 July, 2012 Twin Tier Severe Weather and Tornado Outbreak
Part II: Radar Analysis
Michael Evans
NOAA/NWS Weather Forecast Office, Binghamton, New York

2:00 pm
Environmental Characteristics of Recent Tornadic Versus Non-Tornadic Events
Michael L. Jurewicz, Sr.
NOAA/NWS, Weather Forecast Office, Binghamton, New York

2:30 pm
A Storm-Scale Analysis of the 29 May 2012 Null Tornado Watch Across Eastern New York and Western New England
Thomas A. Wasula
NOAA/NWS Weather Forecast Office, Albany, New York

3:00 pm
Meteorological Factors that Resulted in Extreme Rainfall During Tropical Storm Irene
Joseph P. Villani
NOAA/NWS Weather Forecast Office, Albany, New York

3:30 pm
Break

4:00pm
The Hydrology of Tropical Storm Irene
Britt E. Westergard
NOAA/NWS Weather Forecast Office, Albany, New York

4:30 pm
Case Studies of Central American Gyres
Philippe P. Papin
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

5:00 pm
Upper-Level Precursors Associated with Subtropical Cyclone Formation in the North Atlantic Basin
Alicia M. Bentley
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

5:30 pm
Tropical Cyclones and Heavy Eastern U.S. Rainfall
Lance F. Bosart
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

6:00 pm
Wrap Up
Warren R. Snyder

6:10 pm
Adjourn

7:00 pm
CSTAR Dinner at Buca di Beppo Italian Restaurant
44 Wolf Road, Colonie, New York

NROW XV will be held November 6-7, 2013

Large-scale Precursors to Major Lake-Effect Snow Storms Lee of Lake Erie

Hannah E. Attard
Ross A. Lazear

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

While lake-effect snowstorms have most commonly been researched at the mesoscale and synoptic scale, this study focuses on the Northern Hemisphere large-scale pattern observed in the days prior to major lake-effect snow events. The initial case list for the study was obtained from the National Weather Service (NWS) at Buffalo's Lake Effect webpage, where NWS forecasters record and name major lake-effect events occurring in their County Warning Area. This list, encompassing 1998 to 2010, was narrowed down to cases that lasted at least 24 hours, produced at least 12 inches of snow, and had no synoptic-scale forcing. Because we are interested in large-scale patterns that lead to the onset of major lake-effect events, any case that occurred within seven days of the previous case was discounted, resulting in a final list of 31 cases. To ensure statistical significance of our results, more cases will be added for a future study.

The 31 cases were then stratified into different categories including events that: occurred from January through April; occurred from October through December; lasted for 24-42 hours; lasted for more than 42 hours; were considered shore-parallel; and were considered wind-parallel. These categories were established in order to identify specific large-scale patterns leading up to different types of lake effect events. Climate Forecast System Reanalysis data was used to composite each category of lake-effect events from event onset to 14 days prior to onset. Standardized anomalies were computed using NCEP/NCAR reanalysis data; results from these composite analyses are shown. Additionally, the state of the Arctic Oscillation, the Pacific North American pattern, and the Madden-Julian Oscillation were analyzed for the days leading up to and during the major lake-effect events.

2-3 January 2010 Northeast Winter Storm: A Case Study

Adrian N. Mitchell, Kristen L. Corbosiero, and Lance F. Bosart

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

The snow storm of 2-3 January 2010 affected parts of the Northeast with significant snowfall and strong winds. Record single storm snowfall totals as high as 84 cm were reported in Burlington, Vermont with winds of 20-25 m/s from Maine to New York. Despite uniform precipitation type, total snowfall varied significantly over a small spatial scale, highlighting the importance of orography and other mesoscale processes. This presentation will analyze the significant large scale features that led to the unusual track of this cyclone as well as the small scale forcing mechanisms responsible for producing a record setting snowfall in Burlington, VT.

Analysis of the event found that strong upper level blocking in the North Atlantic Ocean, coincident with an extremely negative phase of the Arctic Oscillation, was responsible for the development of a large cutoff low over the northeast United States on 2-3 January. Intense cyclogenesis took place off the New England coast as a slow moving surface low pressure system retrograded southwestward into the Gulf of Maine. Snowfall over northern New England was enhanced in the equatorward exit region of an anomalous easterly jet streak over southern Quebec, as well as through upslope flow along a cold wedge of air banked up against the western spine of the Green Mountains.

Mechanisms for Transient and Long-Duration Mesoscale Snowbands in Northeast U.S. Winter Storms

Jaymes S. Kenyon[1], Daniel Keyser[1], Lance F. Bosart[1], and
Michael S. Evans[2]

[1]Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York
[2]NOAA/NWS, Weather Forecast Office, Binghamton, New York

The distribution of snowfall accumulation attending winter storms is a product of both precipitation intensity and duration. Many heavy snowfall events are associated with distinct mesoscale snowbands, which strongly modulate snowfall accumulation. Mesoscale snowbands are known to be favored within environments characterized by frontogenetical forcing in the presence of weak moist symmetric or gravitational stabilities. Although the development of mesoscale snowbands can often be successfully anticipated at 24−36 h forecast ranges, anticipating band duration at a fixed location remains a forecasting problem. However, given that snowband duration is closely related to attributes of snowband motion, improved understanding of band motion presents an opportunity to improve snowfall accumulation forecasts. This study investigates synoptic and mesoscale features associated with transient and long-duration (i.e., locally persistent) snowbands. A new snowband classification scheme is proposed, wherein long-duration snowbands are classified according to specific modes of band motion: lengthwise translation and pivoting. Lengthwise translation occurs when the cross-axis component of band motion is approximately zero, thereby favoring heavy snow accumulation along a narrow, along-axis corridor. Pivoting occurs when a snowband rotates cyclonically over a limited region, yielding a quasi-stationary band in that region. Using archived WSR-88D data, 71 heavy snow cases in the Northeast U.S. (spanning the years 2005−2010) are being classified according to this scheme, from which a limited snowband motion climatology will be constructed. Gridded data from the 0.5° resolution NCEP Climate Forecast System Reanalysis are used to identify synoptic and mesoscale features associated with these cases. Preliminary results suggest that lower-tropospheric temperature advection and confluent versus diffluent flow in the near-band environment are useful in distinguishing between environments favoring transient, lengthwise-translating, or pivoting snowband modes. In turn, these respective modes of snowband motion are associated with characteristic vertical wind shear profiles. Partitioning of the *Q*-vector into along- and cross-isentrope components also suggests that snowband pivoting is associated with substantial rotational frontogenesis, which is largely absent with lengthwise translation. Three cases that typify these respective snowband modes and their attendant synoptic and mesoscale environments will be presented.

Methodology for Developing a Heavy Wet Snow Scale for a Utility Company

Brandon Hertell
Consolidated Edison Company of New York, Inc, New York, New York.

Freezing rain has typically been the winter weather type that utility companies with an overhead electric infrastructure fear the most. However in recent years the Consolidated Edison Company of New York (Con Edison) has dealt with two major Northeast snow storms that have caused significant customer outages due to the density of the snow that fell. Neither storm had freezing rain, rather it was the weight of the snow accumulating on branches and power lines that caused power failures.

By February 25, 2010 1-3' of heavy wet snow had fallen across the Con Edison service territory. The greatest snow accumulations were in the company's northwestern territories outside of the NYC metropolitan area. Due to the complex nature of this storm and its multiple phases, in some places it had been snowing for almost 48 hours straight. This was the first snow only storm to cause significant customer outages in over 10 years. At the peak, 62,500 customers were without power.

Again on October 29, 2011 an unprecedented and unseasonable Nor'Easter left millions without power across the Northeast. Snow fall records in many cities across the Northeast were shattered thanks to this storm. At the peak Con Edison had 130,000 customers without power, the 3rd most impactful storm in the company's history.

While the company was prepared in advance both storms, forecasting the density of snow, and tracking the real time rain/snow line can be difficult for forecasters to pin down in advance. To be better prepared for the next heavy wet snow event Con Edison meteorologists developed new snow triggers to clearly communicate the potential impact from the next snow storm. This talk will provide an overview of each storm and provide some theories as to how the storm environment caused the snow to be so destructive. It will also describe the methodologies used to revise the company's storm preparedness matrix for heavy wet snow.

The Prediction of Onset and Duration of Freezing Rain in the Saint-Lawrence River Valley

Sophie Splawinski[1]*, John R. Gyakum, Eyad H. Atallah*
McGill University, Montreal, Quebec, Canada

Introduction: Freezing rain (FZRA), a hazardous meteorological phenomenon, poses a significant threat to the general public and can severely damage societal infrastructure. The phenomenon is well known throughout the St-Lawrence River Valley (SLRV), which is known to have one of the highest frequencies of FZRA in the world due to its orography and spatial orientation. Our focus is to provide meteorologists with the means to better predict both the onset and duration of FZRA at Montreal (CYUL) and Quebec City (CYQB) in a two-stage process utilizing regression and pressure gradient analyses, respectively. **Methods:** Analysis of a 30-year period, from 1979 through 2008, was conducted. We defined a severe FZRA event as one lasting at least six hours, with at most four consecutive hourly non-FZRA reports, and found 47 cases at CYQB and 46 cases at CYUL. Furthermore, it was necessary to incorporate null cases in our regression analysis. We defined a severe null case as one where precipitation occurred in conjunction with a northeasterly wind for at least six hours, with at most four consecutive hourly non-precipitation and/or non-northeasterly wind reports. Northeasterly wind directions were defined in a 50 degree bin encompassing the orientation of the valley at each city, 40-90 degrees at CYQB, 20-70 degrees at CYUL. For our regression analysis, we first recorded surface temperatures and warmest upper-level temperatures at the onset of severe FZRA events, the mean upper-level pressure being at 850hPa. Similarly, we then recorded onset surface and 850hPa temperatures for all null cases. For our pressure gradient analysis, we utilized a 100km diameter along the axis of the SLRV to calculate the gradient. **Results:** Our regression analysis provides meteorologists with the POFR (probability of freezing rain): the ability to input model forecasted temperatures at two pressure levels and determine the probability of the onset of FZRA based on a 30-year climatology of northeasterly related precipitation. Furthermore, the pressure gradient analysis provides meteorologists with the CPOFR (conditional probability of freezing rain): the ability to analyze the probability of freezing rain duration based on a 30-year climatology. **Discussion:** Utilizing these methods could provide meteorologists with the opportunity to produce more highly accurate forecasts of both the onset and duration of freezing rain events. These methods are also applicable to any region of similar orographic influences and/or mechanisms for the formation of atmospheric conditions conducive to freezing rain.

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[1] Lead Author

Precipitation Modulation by the Saint Lawrence River Valley in Association with Transitioning Tropical Cyclones

Shawn M. Milrad, Eyad H. Atallah and John R. Gyakum
Department of Atmospheric and Oceanic Sciences
McGill University, Montreal, Quebec, Canada

The St. Lawrence River Valley (SLRV) is an important orographic feature in eastern Canada that affects surface wind patterns and contributes to locally higher amounts of precipitation. The SLRV's impact on precipitation distributions associated with transitioning, or transitioned, tropical cyclones approaching the region is assessed. Such cases can result in heavy precipitation during the warm season, as during the transition of Hurricane Ike (2008).

Thirty-eight tropical cyclones tracked within 500 km of the SLRV from 1979-2011. Utilizing the National Centers for Environmental Prediction (NCEP) North American Regional Reanalysis (NARR), 19 of the 38 cases (Group A) had large values of ageostrophic frontogenesis within and parallel to the SLRV, in a region of northeasterly surface winds associated with pressure-driven wind channeling. Using composite and case analyses, we find that the heaviest precipitation is often located within the SLRV, regardless of the location of large-scale forcing for ascent, and is concomitant with ageostrophic frontogenesis.

The suggested physical pathway for precipitation modulation in the SLRV is as follows: Valley-induced near-surface ageostrophic frontogenesis is due to pressure-driven wind channeling as a result of the along-valley pressure gradient (typically exceeding 0.4 hPa $(100\ km)^{-1}$) established by the approaching cyclone. Near-surface cold-air advection, resulting from northeasterly pressure-driven channeling, produces a temperature inversion, similar to what is observed in cool-season wind channeling cases. The ageostrophic frontogenesis, acting as a mesoscale ascent-focusing mechanism, helps air parcels to rise above the temperature inversion into a conditionally unstable atmosphere, resulting in enhanced precipitation focused along the SLRV.

Synoptic and Mesoscale Aspects of Ice Storms in the Northeastern United States

Christopher M. Castellano[1], Lance F. Bosart[2], Daniel Keyser[2], John Quinlan[3], and Kevin Lipton[3]
Northeast Regional Climate Center
Cornell University, Ithaca, New York[1]
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York[2]

NOAA/NWS Weather Forecast Office, Albany, New York[3]

Ice storms are among the most hazardous, disruptive, and costly meteorological phenomena in the United States. The accretion of freezing rain during ice storms endangers human lives, undermines public infrastructure, and adversely impacts local and regional economies. Previous studies have demonstrated that the northeastern U.S. is especially susceptible to damaging ice storms. Furthermore, ice storms present a major operational forecast challenge due to the combined influence of synoptic, mesoscale, and microphysical processes on precipitation type. In consideration of these societal impacts and forecast issues, we constructed a 17-cool-season climatology (Oct 1993–April 2010) of ice storms in the northeastern U.S. and performed a composite analysis to: 1) identify antecedent environments conducive to ice storms, and 2) examine dynamical processes that influence the evolution of these ice storms.

Using the National Climatic Data Center's *Storm Events Database,* we established a history of ice storms affecting 14 National Weather Service county warning areas (CWAs) within the domain of the Northeast Regional Climate Center. First, we analyzed the temporal and spatial variability of ice storms during the 1993–2010 period. Next, we partitioned individual ice storms by five characteristic synoptic-scale weather patterns and created composites for the two most common event types impacting the Albany, NY, CWA (Type G and Type B). Synoptic composite maps (based on 2.5° NCEP/NCAR reanalysis data) illustrate how the evolution of the large-scale circulation and associated quasi-geostrophic (QG) forcing, thermal boundaries, and moisture transport establish synoptic environments favorable for freezing rain. Moreover, the recognition of key synoptic ingredients 24–48 h in advance is crucial to provide ample warning and ensure adequate preparation for an impending ice storm.

Although freezing rain typically occurs under preferred synoptic conditions, mesoscale processes ultimately determine the persistence of freezing rain by modifying the dynamically and thermally forced synoptic-scale circulations and the associated QG forcing on regional and local scales. Therefore, we also generated composite cross sections from 0.5° Climate Forecast System Reanalysis (CFSR) data to highlight important synoptic–mesoscale linkages. Our results suggest that ice storms in the northeastern U.S. commonly occur near the equatorward entrance region of an upper-level jet, and on the poleward side of a surface warm front. Moreover, low- to midlevel geostrophic warm advection and moisture transport, in conjunction with near-surface ageostrophic cold advection, helps maintain a thermodynamic profile conducive to freezing rain.

Hindcast Analysis of the June 2012 Derecho and Its Impact on the Baltimore-Washington Metropolitan Area using High-resolution WRF-ARW

J.P. Cipriani, L. A. Treinish, and A. P. Praino
IBM Thomas J. Watson Research Center, Yorktown Heights, New York

On 29 June, during the 2012 summer heat wave, a long-lived derecho formed and propagated from the Midwestern U.S., across the Appalachian Mountains, and into the Mid-Atlantic U.S. in a span of eighteen hours. At approximately 10:00 EDT, a thunderstorm cell in central Iowa moved into Illinois, at which point it intensified into a mesoscale convective system (MCS). The extremely high temperatures in the lower planetary boundary layer added to the convective available potential energy (CAPE) at the surface, which exceeded 5000 J/kg. The heat wave contributed to the further intensification as the MCS made its way into the Chicago area. By the time the storm reached Indiana, it had made its transition into a derecho, which continued to follow a stationary front and displayed bow-echo characteristics and generated wind gusts exceeding 90 mph.

As the derecho propagated, it produced a leading-edge gust front, which was associated with multiple downbursts and surface divergence. At 18:30 EDT, thought to dissipate due to the complex terrain and forthcoming loss of heat fluxes due to diurnal heating, the storm system crossed the Appalachians, weakened slightly, and then came into contact with another unstable air mass, resulting in a re-intensification. At this point, the NOAA Storm Prediction Center (SPC) issued a severe thunderstorm watch for Washington, D.C., and by 21:00 EDT a moderate derecho risk was extended into the Mid-Atlantic States. The storm passed through the Baltimore-Washington metropolitan area at approximately 22:00 EDT and across the Chesapeake Bay and out to sea around 02:00 EDT on 30 June. The overall damage was extensive and widespread: 22 deaths across seven states and 3.7 million people left without power, with one million in Virginia and one million in Maryland and Washington, DC.

IBM Research developed and operates a high spatial and temporal resolution weather forecasting capability known as *Deep Thunder*, which can be utilized to predict the business impact of severe weather events in order to optimize resources and mitigate negative effects. *Deep Thunder* was deployed for the Baltimore-Washington area in an attempt to capture the 29 June 2012 derecho via hindcast analysis. For this purpose, the Advanced Research Weather (ARW) core of the Weather Research and Forecasting (WRF) model (version 3.3.1) was used to produce several 84-hour forecasts prior to the event, with output every ten minutes. The domain was based on the current operational *Deep Thunder* configuration for the New York metropolitan area but was fine-tuned for the characteristics of the Baltimore-Washington region, which resulted in the use of more sophisticated cumulus and microphysics schemes. The model consisted of three, two-way feedback nests at 15.75-, 5.25-, and 1.75-km horizontal resolution, each with forty-two vertical levels. Background fields were derived from 12-km output from the regional

NOAA/NCEP North American Model (NAM), along with NASA 1-km sea surface temperatures to account for the Chesapeake Bay influence along the Atlantic Coast. The grid mesh sizes were the following: 76x76 (at 15.75-km), 154x154 (at 5.25-km), and 178x178 (at 1.75-km). Because of the complex topography of the Appalachians, 90-m terrain data were ingested for the outer two domains, while 30-m terrain data were used for the innermost domain, with both sets available from the Shuttle Radar Topography Mission (SRTM) archive.

A three-dimensional variational data assimilation technique was also employed to perturb the initial conditions for each domain via the ingestion of surface observations from the dense mesonet (WeatherBug) operated by EarthNetworks. Near-real time surface measurements are available every five minutes. For the assimilation, WRFDA, version 3.3.1, was utilized and able to process temperature (K), dew point (calculated, K), pressure (Pa), and horizontal wind components (m/s). The total number of stations in each domain were: 3900 (outermost), 2849 (intermediate), and 1053 (innermost).

We will primarily focus on one of the hindcasts, initialized at 00 UTC on 29 June 2012, which would have provided an 18-hour lead time for the event's impact in the Baltimore Washington metropolitan areas. The model was able to effectively capture characteristics of the bow-echo structure, multiple downbursts and low-level divergence, resulting in the propagating gust front, and associated surface wind gusts. Mid-level analysis revealed the presence of graupel and ice, as well as the release of latent heat, both of which likely contributed to the simulated downbursts. We will discuss the research objectives and challenges, model results and comparisons with observations, and potential future work.

Implementation and Operation of Mesoscale Numerical Weather Prediction Modeling Systems for Business Applications

Anthony P. Praino, Lloyd A. Treinish, James Cipriani
IBM Thomas J. Watson Research Center
Yorktown Heights, New York

For many business applications there is significant sensitivity to local weather conditions, especially with regard to planning, operations and decision making. The availability of highly localized weather model-based predictions has demonstrated the ability to improve the response to, and mitigate the impact of environmental conditions on businesses and municipalities. To enable the creation of integrated solutions focused on the forecasts of such weather impacts, IBM Research has an on-going project, dubbed "Deep Thunder".

A key part of the Deep Thunder project is the development, implementation and operation of high performance computing (HPC) systems which provide the information technology infrastructure to enable timely generation and delivery of high-resolution numerical weather prediction forecast products coupled with customized visualizations and business analytics.

The current systems support the development and production of forecast products based upon the WRF-ARW community model driving visualization and analytics with throughput sufficient for operational use. These systems run on a variety of computing platforms and technologies focused on providing integrated, optimized customer solutions updated several times per day, with forecast periods of one to three days. We will discuss some of the current as well as future products and systems as well architectural and operational aspects of the Deep Thunder infrastructure that are part of the global operation supporting IBM's smarter planet initiative.

Predictability of High Impact Weather during the Cool Season over the Eastern U.S. An NWS CSTAR Project -Need for Visualization and Communication Tools

Jeffrey Tongue
NOAA/NWS Weather Forecast Office, New York, New York

(REMOTE PRESENTATION)

Extratropical storms have major societal impacts on the northeastern U.S., particularly during the cooler months. These impacts can include flooding, heavy snow, high winds and coastal flooding. While meteorologists have studied these storms in great detail and vast improvements in forecast skill have occurred in recent years, predictability of mesoscale phenomenon within extratropical storms remains a major challenge. Stony Brook University and several National Weather Service (NWS) Weather Forecast Offices (WFO) were awarded a Collaborative Science, Technology, and Applied Research (CSTAR) project (http://dendrite.somas.stonybrook.edu/CSTAR/cstar.html) that began in May 2010 to help address this operational forecast challenge. One result is the need for meteorological tools to allow forecasters to quickly and easily examine and assimilate data from ensemble forecast systems (EFS).

Forecasters continue a strong reliance on deterministic models. There are many reasons for this reliance, but one is the lack of visualization tools for meteorologist to assimilate vast amounts of data from EFS's in a fast and effective manner. For the past two years, the CSTAR group has been utilizing portions of the Advanced Linux Prototype System (ALPS) developed by Global Systems Division (GSD) of the Earth System Research Laboratory in 2004. ALPS simply modified NWS Advanced Weather Interactive Processing System (AWIPS) software that includes statistical analysis tools. These tools applied to individual members of an EFS allows forecasters to acquire a new sense of EFS predictability and allow for an understanding of uncertainty that can be communicated to users.

This presentation will demonstrate the ALPS concept utilizing NCEP's short range and global EFS's using data from a recent cyclone.

On the Use of High Resolution Models

(REMOTE PRESENTATION)

Richard H. Grumm
NOAA, NWS Weather Forecast Office, State College, Pennsylvania

The "*warn-on-forecast*" concept is an emergent vision of the weather forecasting community and is a goal of the National Weather Service. For convective scale and other mesoscale phenomena, the current warning philosophy is biased toward observations with a large emphasis on radar, satellite, and during more convective scale events, spotter information. The spotter information covers the range from temperature, winds, rainfall data, to cloud and storm damage characterization.

The reliance on near real-time observations severely limits the lead-time of warnings for mesoscale weather events from snowbands to supercells. The basic concepts for forecasting near-term weather or NOWCASTING date back over 50 with radar being the dominant tool until satellites became more readily available. High speed computers, mesoscale data networks, and asynchronous data flow have made the high resolution models critical players in the evolution of NOWCASTING.

This paper is focused on when and how to use high resolution models. These models can be quite seductive in terms of both the appearance and timing of key features. However they are subject to considerable run-to-run variation in terms of timing, intensity, and character of mesoscale features. The lack of true storm scale ensembles produces some issue related to dealing with uncertainty at forecast ranges of 0-9 hours.

This paper presents examples from the 3km HRRR and 4km NAM of several recent events mesoscale weather events. These high resolution systems, when used in conjunction with the SREF can be of considerable value in determining the potential mode of convection; areas of heavy precipitation; and areas affected by severe weather. However, these systems can produce potentially visually interesting yet inaccurate scenarios. Effectively using these data can improve short range forecast and a forecast strategy is presented. These concepts may better prepare forecasters to leverage storm-scale ensembles which will play an even more significant role in NOWCASTING within the next 5-10 years.

The Tropical Storm Irene "Mega Flood" in The Catskills. -Why it Was Not an Unprecedented Event and Why Cataloging Past Events Will Help us Attain a Weather Ready Nation.

Stephen N. DiRienzo
NOAA/NWS Weather Forecast Office, Albany, New York

To counter the threat posed by extreme weather, the NWS must communicate its forecasts and warnings quickly and effectively before, during, and after a high-impact weather, water or climate event. To do this, forecasters have to first recognize the scale of the event. Forecasters must then provide probabilistic, threat-based impacts to the public, emergency responders and emergency managers.

Much work has been done on using meteorological field anomalies to help recognize a potential high-impact event. However what happens when an event is so large, it dwarfs previous events in scale? Is there a method that forecasters can use to help determine that an extreme event is a credible threat? This work makes the case for historical research, into past weather, water and climate events in, and near a NWS county warning area, as a method for scaling events and determining credible threats.

Tropical Storm Irene produced devastating flooding in the Catskill Mountains of New York in August of 2011. On the Schoharie Creek at Prattsville, river flows peaked more than twice as high as any previous flood at that site. Although this magnitude of flooding was unprecedented at the Prattsville gauge, it was not an unprecedented event in the NWS Albany county warning area, or neighboring forecast areas.

Research was conducted to find additional extreme flood events at USGS river gauge sites in and near the NWS Albany county warning area. It will be shown that at least four such events have been documented by the USGS since 1865. A comparison of events will be shown by looking at the antecedent conditions, precipitation, river flows and destruction at various locations. It is hoped that by cataloging such events, forecasters will be able to compare these past events to future events and provide threat-based impacts. It is also believed that similar cataloging of other meteorological events such as ice storms, snow storms, heat waves etc. will aid forecasters in making more accurate forecasts and communicating forecasts and warnings quickly and effectively.

Increasing Your Social Reach on Facebook

Erik Heden
NOAA/NWS, Weather Forecast Office, Binghamton, New York

In the spring of 2010, the National Weather Service began to explore the application of Facebook as a tool to expand the reach of NWS information at field offices and national centers. Based on positive results from this exploration, Facebook was expanded to all of the National Weather Service offices in the summer of 2011. Facebook as a tool can be very effective at educating users, disseminating our message, and allowing us to reach a wider audience. Facebook can also provide an important source of incoming information during significant weather events. Our experiences have shown that in order to gain the greatest possible benefits from Facebook, posts need to be appropriate for a wide range of social media users, and not just a regurgitation of information that could be obtained from local web pages. This presentation will review the implementation of Facebook at the National Weather Service office in Binghamton, NY, including results and best practices that have been learned over the last year.

Experiences from the last year indicate that posting during more favorable times of day, such as the early evening, increases the visibility of your post. Asking questions to elicit feedback can be especially useful when trying to fill in data gaps when you may be missing "ground truth". It is crucial to include graphics with as many posts as possible while being cognizant of your audience by adding cities and landmarks, to make this information easy to read and understand. If you want a message to reach the widest audience, ask for help by "sharing" your graphic. By implementing the social aspect of Facebook, you have a greater chance of success in communicating with and expanding your audience and in return, meeting a core mission goal of protecting life and property. By executing these learned best practices, as of October 2012 the Facebook page of WFO Binghamton has become the most "liked" page in the Eastern Region of the National Weather Service, despite having a smaller population.

Operational Changes and Future Plans at the Hydrometeorological Prediction Center (HPC)

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The HPC product suite is constantly evolving in response to new customer needs. Recent changes at HPC, as well as changes upcoming in the near future, are discussed in this presentation. These activities include changes to the HPC winter weather product suite, the Winter Weather Experiment (WWE), a new heavy rain and flash flooding forecast desk (MetWatch), and expanded Medium Range and QPF products.

48-hour snowfall and ice accumulation probability forecasts are now operational. These probabilities were expanded to encompass 48 hour time periods to provide ‘storm total’ potential for events straddling two 24 hour periods. Additionally, the HPC web page will now have an archive of winter weather probabilistic snow and ice accumulation forecasts, as well as surface low track forecasts.

The Hydrometeorological Testbed (HMT)-HPC will again host the WWE in early 2013 at HPC. The experiment allows forecasters to test and evaluate experimental models, experimental ensembles, new post-processing techniques, etc. to assess their impact on winter weather forecast skill. For example, this year forecasters will evaluate a new procedure that calculates changes of snow cover following melting due to ground warmth.

HPC has completed a prototype evaluation for the new MetWatch forecast desk that produces a short term (1-6 hr) mesoscale heavy rain discussion and graphic. This desk was motivated by the request for increased flash flood and heavy rain support. An experimental and eventual operational implementation of the precipitation discussion and graphic are expected in 2013.

Several major changes to HPC product issuances will occur soon. First, a new night time forecast package will be added to the suite of medium range (days 3 – 7) grids produced at the HPC. This change will aid the local offices that provide medium range forecasts twice daily. Also, beginning this winter, HPC will produce operational 6 – 7 day QPFs twice daily. These changes will allow some HPC QPF products to be produced earlier; timing details are discussed in the presentation.

An Overview of the Northeast River Forecast Center Implementation of the Hydrologic Ensemble Forecast Service (HEFS) and related activities supporting the New York City Department of Environmental Protection (NYCDEP) Operational Support Tool (OST)

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The Northeast River Forecast Center (NERFC) is one of five river centers in the nation that are leading the testing and implementation of the Hydrologic Ensemble Forecast Service (HEFS). When completed, this new service will provide an integrated suite of short- to long-range hydrologic ensemble forecasts. As part the testing and implementation, the NERFC has engaged in additional activities to support an Operational Support Tool (OST) which is being developed by the New York City Department of Environmental Protection (NYCDEP). The OST will leverage the services delivered by HEFS to improve the NYCDEP management of the New York City Water Supply system of reservoirs, which provides drinking water to approximately nine million people in and around the New York City region. This presentation will describe the activities conducted by NERFC to implement HEFS as well as several additional activities in support of the NYDEP OST development.

The 26 July, 2012 Twin Tier Severe Weather and Tornado Outbreak Part I: Environmental characteristics

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Environmental characteristics associated with a major severe weather outbreak on 26 July 2012 over southern New York and northern Pennsylvania are examined. The large-scale pattern on 26 July featured zonal mid-level flow and large deep-layer shear across the northern mid Atlantic area, with New York and Pennsylvania on the southern edge of the strongest westerly flow aloft. A large instability gradient was located across the region, with very unstable air and an elevated mixed layer over Pennsylvania, and a more stable air mass with low lifted condensation levels to the north across central New York. At the surface, a weak, disorganized area of low pressure was located over Lake Ontario, with a surface trough extending to the south and moving eastward across central New York and Pennsylvania. High resolution model forecasts run early on the 26th were inconclusive on the preferred convective mode, indicating the development of either broken lines or clusters of storms during the afternoon.

A short study comparing environmental features on the 26th, to factors associated with other recent, high-impact warm-season convective lines, is shown. Results indicate many similarities between the environment on the 26th, and the environment associated with the other events, including a west-southwest flow aloft with modest height falls, and surface low pressure located over the Great Lakes. Large convective available potential energy downstream from the line was present for all of these events, along with strong shear, primarily in the lowest 3 km of the atmosphere. The tendency for strong, convective winds to occur with these systems can be explained by comparing the results of this study to a conceptual model for convective lines with well-developed rear-inflow jets.

The 26 July, 2012 Twin Tier Severe Weather and Tornado Outbreak Part II: Radar Analysis

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A major severe weather outbreak struck the southern tier of New York and the northern tier of Pennsylvania on 26 July, 2012. Seven tornadoes were confirmed in the Binghamton, New York county warning area, which includes central New York and northeast Pennsylvania. In this presentation, the structure of the storm associated with several of these tornadoes is shown, by examining data from the Binghamton, New York WSR-88D radar. A broken line of convective storms initially developed over western New York and northwest Pennsylvania during the early afternoon on the 26th. A supercell storm developed along the northern end of the line over south central New York around 1900 UTC and moved east, producing 4 EF-1 tornadoes just north of the New York-Pennsylvania border between 1930-2015 UTC. Three of these tornadoes had track-lengths in excess of 2 miles, with one exhibiting a length of 14 miles. One tornado tracked across downtown Elmira, New York, producing extensive damage. In addition to the tornadoes, damaging straight-line winds occurred across a wide area. An examination of the evolution of the reflectivity pattern associated with the supercell indicated that it remained loosely attached to the northern end of the convective line throughout its lifecycle. The storm produced tornadoes as a very pronounced inflow notch developed on its northeast side. Velocity data from the Binghamton WSR-88D indicated the development of a rotational couplet near the inflow notch during the early stages of the storm's life-cycle, and juxtaposed with the first tornado occurrence. A second velocity couplet subsequently developed south of the initial couplet and was associated with the 3rd and 4th tornadoes, including the tornado that tracked across Elmira. Rotational velocity values associated with these couplets were rather modest, averaging around 25 kts across a distance of 1.5 nm throughout the period when the storm was producing tornadoes. During the early stages of the storm's lifecycle, rotation appeared to develop and strengthen simultaneously at lower-to-mid levels, as opposed to the more classic scenario where rotation develops at mid-levels then "spins-down" to the surface. Maxima of spectrum width were identified and associated with each tornado, with values generally trending upward, to near or above 20 kts around the time of tornado touchdown. Finally, an examination of some of the newer dual-polarization-based products around the time of the Elmira tornado indicated the development of a Z_{dr} arc near the inflow region of the storm, and a separation between maxima of Z_{dr} and K_{dp}. Recent research has indicated that both of these signatures may be an indication of a local enhancement of storm relative helicity in the vicinity of the storm, which may lead to an increased likelihood of tornado development.

Environmental Characteristics of Recent Tornadic Versus Non-Tornadic Events

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Two severe weather events, which occurred in the Northeastern United States during the summer of 2012, will be examined. On July 26, a major severe weather outbreak took place across portions of New York State and Pennsylvania. This event featured intense linear development ahead of a surface cold front, which ultimately produced several long-lived supercells, and seven confirmed tornadoes. On August 14, a broken line of thunderstorms, some strong to severe, also formed in advance of a progressive cold front. Despite the issuance of tornado warnings this day, based on radar signatures, no tornadoes were sighted or confirmed.

On the synoptic-scale, although there were some similarities in environmental conditions between the two cases (namely with regards to stability and low-level moisture), there were also important differences (namely with regards to shear profiles). Direct radar comparisons are made between one of the tornadic cells on July 26 and one of the non-tornadic cells on August 14. These individual storms were at a comparable radar range (both 30 to 40 nautical miles from the Binghamton, NY (KBGM) WSR-88D). On the storm-scale, these cells exhibited very similar characteristics. Each storm showed signs of increased organization, featuring implied updraft strength, and intensifying low-level rotation with time. However, only the supercell from July 26 produced a tornado.

The similarities and differences in the synoptic and storm-scale environments will be looked at in greater detail. In addition, some results of recent research comparing tornadic and non-tornadic supercell environments will be examined.

A Storm-Scale Analysis of the 29 May 2012 Null Tornado Watch Across Eastern New York and Western New England

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On 29 May 2012, a widespread severe weather event occurred across much of upstate New York (NY), Pennsylvania (PA) and portions of New England. The NWS/Storm Prediction Center posted a moderate risk early that afternoon for much of central and eastern NY, northeast PA, and extreme western New England. A tornado watch was issued shortly thereafter for much of eastern NY, Vermont, and western Massachusetts. The Northeast United States had over 100 severe reports of damaging winds in excess of 50 knots (58 mph), and large hail (greater than 1.9 cm). There was also only one weak confirmed EF0 tornado in the Northeast Kingdom of VT. The vast majority of the severe reports were large hail (30 reports greater than 2.5 cm) with 4 significant hail stone reports exceeding 5.0 cm in diameter in the Albany forecast area. The severe convection was focused ahead of a surface cold front and a potent short wave trough approaching from the Great Lakes Region. The surface cold front interacted with a volatile thermodynamic environment.

Observational data, as well as short range deterministic Rapid Refresh data suggested a major severe weather outbreak would occur. A cyclonically curved upper-level jet was located well upstream of NY over the Great Lakes Region with a plume of divergence migrating into the Northeast during the afternoon. The 29 May 2012 1700 UTC KALB "special" sounding was very unstable with a pronounced Elevated Mixed Layer (EML). Surface based convective available potential energy values exceeded 3500 J kg^{-1} with steepening mid-level lapse rates to around 7ºC km^{-1} (presence of the EML), coupled with wet bulb zero heights falling to 10-12 kft AGL. Surface dewpoints exceeded 20ºC over a large portion of eastern NY and western New England. Downdraft convective available potential energy values also exceeded 1000 J kg^{-1}. The effective bulk shear values in the 0-6 km layer were in the 40-50 kt range for a large portion of the Tornado Watch box, suggesting the possibility of supercells with rotating updrafts capable of producing extremely large hail and tornadoes.

This talk will focus on a detailed radar analysis of the event, utilizing the new dual polarization data (differential reflectivity, correlation coefficient, and specific differential phase). Traditional base and derived WSR-88D radar products will also be shown in conjunction with the Dual-Pol data. Some tools included in the analysis will be the Four -Dimensional Stormcell Investigator and GR2Analyst software. The storm-scale analysis will focus on helpful forecast techniques, including applying results from a local 1-inch hail study, to determine what produced the copious severe "large" hail reports and contributed to the paucity of tornadoes.

Meteorological Factors that Resulted in Extreme Rainfall During Tropical Storm Irene

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On 28 August 2011, Tropical Storm Irene produced extremely heavy rainfall across eastern New York and western New England, which resulted in record flooding along several rivers. The heavy rainfall and record flooding were especially prevalent across the eastern Catskill River basins, including the Schoharie Creek, which fed downstream into the Mohawk River. A maximum area of 30 cm to 45 cm (approximately 12 to 18 inches) of rain fell across the elevated terrain of Greene County, which was followed by extreme runoff into the Schoharie Creek basin. This area received much more rain than the rest of the Albany Forecast Area. This presentation will primarily discuss the meteorological factors that contributed to the extreme rainfall in the eastern Catskills.

There were several key factors that enhanced rainfall amounts in the eastern Catskills, primarily in Greene County. One factor in particular likely contributed significantly to the extreme rainfall maximum. Low-level north-northeast winds with speeds of around 25 m/sec (anomalies of +5 to +6 standard deviations above normal) were oriented perpendicular to the northeast portion of the Catskills in central Greene County. It is hypothesized that upslope enhancement was particularly significant in this area due to the strong low level winds oriented perpendicular to the escarpment. Also, the steepness of the escarpment has a dramatic elevation rise of over 900 meters (approximately 3000 feet) in a short distance. The areas which received over 30 cm of rain were directly downstream of where this upslope enhancement likely occurred.

It is also hypothesized that steeply-sloped frontogenesis played a significant role in contributing to the extreme rainfall. The magnitude and depth of the frontogenesis noted during Irene is not typical of most tropical cyclones, implying extra-tropical transition was occurring as Irene approached southern New England. A cross-section of the frontogenesis fields will be shown, which implies the presence of strong upward vertical motion. Vigorous ascent of air parcels in a moist tropical environment was an important contributor to the copious rainfall amounts.

Antecedent conditions played a significant role in the magnitude of flooding. Rainfall for August 2011 was above normal prior to Irene, with ground water tables already running high. This was in contrast to when Tropical Storm Floyd impacted the area with heavy rainfall on 16-17 September 1999. Dry conditions were in place prior to Floyd, with some areas approaching drought status. Flooding was not nearly as severe for Floyd compared to Irene. Also, rainfall during Floyd lasted 18 to 19 hours, while Irene's duration was only 12 to 13 hours. Thus, the rainfall rates were around 40% higher during Irene, which also contributed to severe flash flooding.

The Hydrology of Tropical Storm Irene

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Tropical Storm Irene produced extremely heavy rainfall across eastern New York (NY) and western New England from 27-28 August 2011. A maximum area of storm total precipitation of 12 to 18 inches (30 to 46 cm) fell across the elevated terrain of the Catskills in Greene County. A secondary maximum of 6 to 8 inches (15 to 20 cm) fell across south-central Vermont and northwestern Massachusetts, with widespread rainfall amounts in excess of 4 inches (10 cm). A New York State 24-hour rainfall record was set at a National Weather Service (NWS) rain gage in Tannersville, NY. Record flooding occurred at thirteen forecast points in the NWS-Albany Hydrologic Service Area, including ten points throughout the Hudson-Mohawk River basin as well as points in the Connecticut River and Lake Champlain drainages. Thirty five of NWS Albany's river forecast points experienced flooding as a result of the excessive runoff. The path of Tropical Storm Irene also caused storm surge up the Hudson River at Poughkeepsie and Albany. This presentation will review both the hydrologic effects and impacts of this event and the operational challenges of forecasting widespread rapid rises to record flooding.

Case Studies of Central American Gyres

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Monsoon gyres, commonly found over the western Pacific Ocean, are characterized by broad low-level (850 hPa) cyclonic circulations that occur at a variety of spatial scales ranging from 1500-3000 km. Low-level cyclonic gyre circulations, while less frequent and occupying a smaller scale, have also been observed over Central America (CA) during the tropical cyclone (TC) season. A noteworthy CA gyre observed during the 2010 PREDICT field project served as a "collector" of TC Matthew and a source for TC Nicole. The remnants of TC Nicole moved quickly up the eastern US seaboard leading to substantial flooding from North Carolina to Maine. Another CA gyre circulation developed in October 2011. Devastating flooding occurred in Guatemala and El Salvador when TD 12-E, embedded in a gyre circulation, made landfall on the Pacific coast of Central America. These gyre occurrences, their apparent links to TC activity, and their association with high-impact weather motivate this presentation.

A preliminary climatological study of CA gyres suggests that their spatial scales vary between 1000-2000 km. These gyres also tend to be co-located with reservoirs of deep moisture characterized by high precipitable water values (>50 mm) and embedded deep convection on their southern and eastern sides. Catastrophic flooding can occur in this corridor when the cyclonic flow interacts with the topography of CA producing upslope precipitation. CA gyres in their latter lifecycle can also interact with mid-latitude disturbances, providing an influx of deep tropical moisture that can impact areas well outside of the tropics (e.g. northeastern US).

A CA gyre climatology including gyre frequency over the TC season and individual gyre duration is currently being constructed. For this presentation, several CA gyre case studies will be selected to highlight genesis pathways, evolution, and societal impact of these disturbances using the 1980-2010 Climate Forecast System Reanalysis. This includes the role that intraseasonal and interannual circulations such as the Madden-Julian Oscillation and El Nino-Southern Oscillation might play in gyre development. TC occurrences within gyre circulations will also be examined further, focusing on their role as gyre catalysts.

Upper-Level Precursors Associated with Subtropical Cyclone Formation in the North Atlantic Basin

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Oceanic cyclones exhibiting properties of both tropical and extratropical systems have been categorized as subtropical cyclones (STCs) since the early 1950s. The development of STCs, sometimes called hybrid cyclones in the current literature, requires the existence of a baroclinically unstable environment, quasigeostrophic forcing for ascent, and the production of lower-to-midtropospheric potential vorticity (PV) by diabatic heating. Previous studies have established that STC formation is associated with weak low-level baroclinicity, significant lower-to-midtropospheric PV, and relatively cold upper-tropospheric air accompanying intrusions of midlatitude PV streamers into the subtropics. The hybrid nature of STCs makes them likely candidates to become tropical cyclones (TCs) via the tropical transition process.

The opportunity to investigate the relationship between STCs, TC formation, and high-impact weather events motivates this presentation. We will use the NCEP Climate Forecast System Reanalysis 0.5° gridded dataset to construct a North Atlantic STC climatology for 1979–2010. The STCs included in the climatology are defined as a subset of North Atlantic cyclones in which: 1) the ratio of PV associated with low-level baroclinicity to PV associated with midlevel latent heat release is small, and 2) tropospheric-deep wind shear values exceed 12.5 m s^{-1} during the initial development of each cyclone. Intraseasonal and interannual variability in STC frequency, track, and intensity will be documented for this climatology. Synoptic-scale anticyclonic wave breaking (AWB) events in the midlatitudes inject relatively cold upper-tropospheric air into the subtropics in association with PV streamers. Such intrusions of relatively cold upper-tropospheric air can help to destabilize the subtropical troposphere and facilitate the development of the deep convection that can serve as a catalyst for STC formation. A synoptic overview of STC Sean (2011) will be presented as an illustrative case of STC formation and a noteworthy example of an STC that indirectly contributed to an early season snowfall in the northeastern United States. Sean formed beneath the fractured equatorward end of an elongated PV streamer on the equatorward side of a fold-over ridge produced by an antecedent AWB event. The ratio of PV associated with low-level baroclinicity to PV associated with midlevel latent heat release and the tropospheric-deep wind shear, both calculated over the life cycle of STC Sean, will be presented as a "proof of concept" of the methodology being implemented to construct the North Atlantic STC climatology and diagnose the structure and evolution of this category of cyclones.

Tropical Cyclones and Heavy Eastern U.S. Rainfall

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Three recent tropical cyclone (TC)-related extreme weather events (EWEs) noteworthy for producing heavy rain and flooding in the northeastern U.S. will be used to illustrate characteristic upper-level flow patterns and tropical moisture corridor configurations associated with these EWEs. The three TC-related EWEs include: 1) Matthew and Nicole in late September 2010, 2) Irene in late August 2011, and 3) Lee, Nate, and Katia in early September 2011. Between late summer and mid-autumn, broad low-level cyclonic circulations with spatial scales of 1000-2000 km can develop over Central America on time scales of 1-2 days and persist for 3-5 days. These broad cyclonic circulation regions, which hereafter we will call gyres, can absorb westward-moving tropical cyclones (TCs) from the east (e.g., TC Matthew), can disgorge cyclonic circulations to the northeast that later develop into TCs (e.g., TC Nicole), and can provide a supportive background cyclonic vorticity environment for weak TC development (e.g., TC Nate) when weak low-level vorticity bands along remnant southward-moving cold fronts in the wake of a predecessor TC (e.g., TC Lee) reach the southern Gulf of Mexico and Central America.

A distinguishing feature of a Central American gyre is that it can be directly associated with exceptionally heavy rainfall and damaging regional flooding, such as occurred in conjunction with the landfall of TC Nate. Similarly, a deep poleward tropical moisture transport from a Central American gyre in response to amplified mid-latitude flow can lead to flooding rains in mid-latitudes such as occurred along the Atlantic coast in conjunction with TCs Nicole and Lee in September 2010 and 2011, respectively. The primary focus of this presentation will be on the large-scale flow contribution to the formation of a well-defined Central American gyre in late September 2010 during the PREDICT field experiment and the subsequent impact of the gyre circulation on the mid-latitude flow and weather over eastern North America. Gyre formation allowed cyclonic vorticity and tropical moisture to become concentrated over Central America. Gyre-TC interactions and gyre-induced poleward tropical moisture surges will be discussed in conjunction with the "birth" of TC Nicole and subsequent very heavy rains along the U.S. East Coast.

A secondary focus of this presentation will be on comparing and contrasting the 1) gyre- and TC Nicole-related heavy rain event of early September 2010 with the non gyre-related heavy rain and flooding spawned by recurving TC Irene, and 2) the quasi gyre-related heavy rain and flooding associated with the complex interactions of TCs Lee, Katia, and Nate. TC Irene followed a "perfect track" for significant inland flooding as the storm interacted with a weak baroclinic trough to the west and the equatorward entrance region of a strengthening 250-hPa jet to the northeast. The complex interactions of TCs Lee, Nate, and Katia enabled a sustained poleward flow of deep tropical moisture to persist along the Atlantic coast in the vicinity of a weak frontal zone.

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