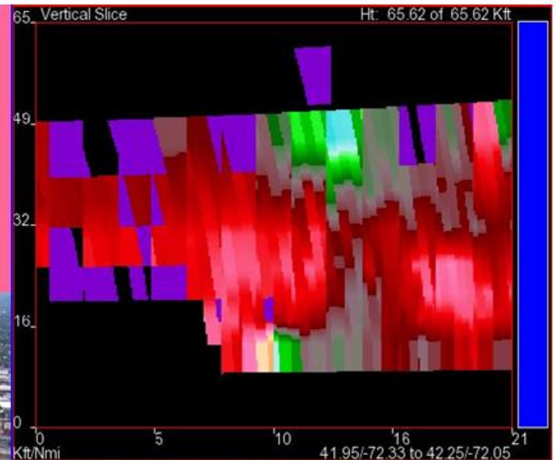
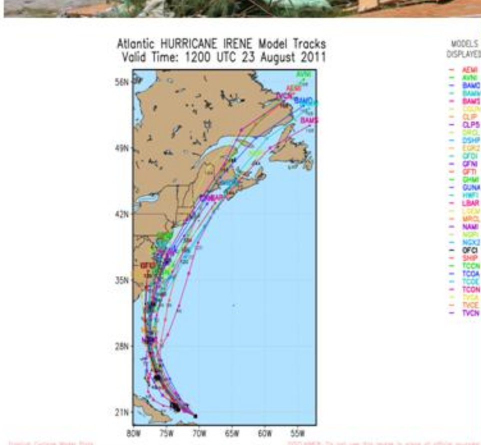
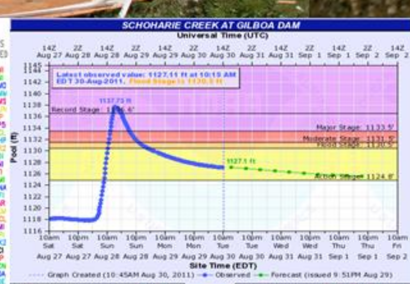
13th Northeast Regional Operational Workshop
November 2-3, 2011
Albany, New York







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Department of Atmospheric and Environmental Science

American Meteorological Society

Agenda
Northeast Regional Operational Workshop XIII
Albany, New York
Wednesday, November 2, 2011

8:00 am
Welcoming Remarks
Raymond G. O'Keefe, Meteorologist In Charge
Warren R. Snyder, Science & Operations Officer
National Weather Service, Albany, New York

Conference Chairs
Steve R. DiRienzo
Warning Coordination Meteorologist, National Weather Service, Albany, New York

Warren R. Snyder
Science & Operations Officer, National Weather Service, Albany, New York

Session A – Warm Season Topics / Convection

8:05 am
Verification of Thunderstorm Occurrence Using the National Lightning Detection Network
Kristen L. Corbosiero
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

8:30 am
A Multiscale Analysis of a Heavy Rainfall Event over Lake Michigan
Jason M. Cordeira
Department and Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

8:55 am
Identifying Key Features to Predict Significant Severe Weather Outbreaks in the Northeast United States
Neil A. Stuart
NOAA/NWS, Weather Forecast Office, Albany, New York

9:20 am
A Study on Convective Modes Associated with Tornadoes in Central New York and Northeast Pennsylvania
Timothy W. Humphrey
Department of Atmospheric and Environmental Sciences, University at Albany
State University of New York, Albany, New York

9:45 am
An Investigation of Null-event Severe Convective Watches in the WFO Baltimore/Washington Forecast Area
Matthew Kramar
NOAA/NWS, Weather Forecast Office, Sterling, Virginia

10:10 am
Break
Refreshments available for sale by the Capital Region Chapter of the AMS

10:40 am
The Massachusetts Tornado Outbreak of June 1, 2011
Joseph W. DelliCarpini
NOAA/NWS Weather Forecast Office, Taunton, Massachusetts

11:05 am
Challenges Associated with the Survey of the June 1, 2011 Massachusetts Tornadoes
Alan E. Dunham
NOAA/NWS Weather Forecast Office, Taunton Massachusetts

11:30 am
Applying Conceptual Models for Non-mesocylonic Tornadoes in Quasi-linear Convective Systems to National Weather Service Tornado Damage Surveys
Matthew Kramar
NOAA/NWS, Weather Forecast Office, Sterling, VA

11:55 pm
The Evolution of Quasi-Linear Convective Systems
Encountering the Northeastern U.S. Coastal Marine Environment
Kelly Lombardo
School of Marine and Atmospheric Sciences, Stony Brook University, State University of New York, Stony Brook, NewYork

12:20 pm
Lunch

Session B – Water (Hydrology, Flooding, and Tropical Storm Events)

2:00 pm
The April 28, 2011 Early-morning Tornado and Flash Flood Event in Central New York and Northeast Pennsylvania
Michael Evans
NOAA/ NWS Weather Forecast Office, Binghamton, New York

2:25 pm
Using Standardized Anomalies to Identify Significant Heavy Rain Events
Jason Krekeler
NOAA/NWS Weather Forecast office, State College, Pennsylvania

2:50 pm
An Examination of the 16-17 April 2011 Record Tidal Flooding on the Lower Delaware River
Dean Iovino
NOAA/NWS Weather Forecast Office, Mount Holly, New Jersey

3:15 pm
Flash Flood Composite Analysis in Vermont and Northern New York
John M. Goff and Gregory A. Hanson
NOAA/NWS, Weather Forecast Office,Burlington, Vermont

3:40 pm
Tropical Cyclone-frontal interactions and heavy rainfall: A comparison of Tropical Storms Lee and Eloise
Richard H. Grumm
NOAA/NWS,Weather Forecast Office, State College, Pennsylvania

4:05 pm
The Forecast Challenge of Tropical Storm Lee
Hugh W. Johnson
NOAA/NWS, Weather Forecast Office, Albany, New York

4:30 pm
Break
Refreshments available for sale by the Capital Region Chapter of the AMS

Session- C Keynote Presentation

Introduction – Steve R. DiRienzo

445 pm
A Historical Perspective of Flooding in the Mohawk Watershed related to Hurricane Irene and Tropical Storm Lee
Dr. John I. Garver
Department of Geology, Union College, Schenectady, New York

545 pm
Question & Answer Session

6:00 pm
Adjourn

Agenda
Northeast Regional Operational Workshop XIII
Albany, New York
Thursday, November 3, 2011

Session D – General Session
(Fire Weather, Cool Season, Meteorological Theory, Modeling, Operations)

8:30 am
Similar Day Ensemble Post-Processing as Applied to Wildfire Threat and High Ozone Days
Michael Erickson
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY

8:55 am
A Multiscale Perspective on the Intense Midwest Cyclone of 25-26 October 2010
Lance F Bosart
Department of Atmospheric and Environmental Sciences, University at Albany
State University of New York, Albany, New York

9:20 am
Field Observations and Modeling of the Microphysics for Winter Storms over Long Island, NY
David Stark
School of Marine and Atmospheric Sciences, Stony Brook University, State University of New York, Stony Brook, New York

9:45 am
Tracking Rossby Wave Packets in Global Analyses and Models
Matthew Souders
School of Marine and Atmospheric Sciences, Stony Brook University, State University of New York, Stony Brook, New York

10:10 am
Lower Stratospheric Fronts in Northwesterly and Southwesterly Flow and their Sensible Weather Implications
Andrea A. Lang
Department of Atmospheric and Environmental Sciences, University at Albany
State University of New York, Albany, New York

10:35 am
Break
Refreshments available for sale by the Capital Region Chapter of the AMS

11:00 am
Operational Utilization of WRF-ARW and the Model Evaluation Tools (MET) in Forecasting and Validation in Southeastern New York State as Applied to Hurricane Irene
James Cipriani
IBM Thomas J. Watson Research Center
Yorktown Heights, New York

11:25 am
Utilization of a High Resolution Weather and Impact Model to Predict Hurricane Irene
Brandon Hertell
Con Edison, New York, New York

11:50 am
Applications of Dual-Pol Radar Data into New England Weather Scenarios
Stephanie L. Dunten
NOAA/NWS Weather Forecast Office, Taunton, Massachusetts

12:15 pm
The Hydrometeorological Prediction Center (HPC) Winter Weather Desk: Verification, Changes, and Future Plans
Dan Peterson
NOAA/NWS, National Center for Environmental Prediction
Hydrometeorological Prediction Center
Suitland, Maryland

12:40 pm
Lunch

Session E – CSTAR & Related Topics

2:00 pm
Predictability of High Impact Weather during the Cool Season:
CSTAR Update and the Development of a New Ensemble Sensitivity Tool for the Forecaster
Brian A. Colle
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York

2:25 pm
The 4 September 2011 Tornado in Eastern New York: An Example for Updating Tornado Warning Strategies
Brian J. Frugis
NOAA/ NWS Weather Forecast Office, Albany, New York

2:50 pm
The 2011 "PRE-Season" In Review: A Look at Tropical Cyclones Irene, Katia, and Lee
Michael L. Jurewicz, Sr.
NOAA/NWS, Weather Forecast Office, Binghamton, New York

3:15 pm
A Multiscale Analysis of the Inland Reintensification of Tropical Cyclone Danny (1997) within an Equatorward Jet-Entrance Region
Matthew S. Potter
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

3:40 pm
Break
Refreshments available for sale by the Capital Region Chapter of the AMS

4:10 pm
Characteristics and Climatology of Appalachian Lee Troughs
Daniel B. Thompson
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

4:35 pm
Climatological Aspects of Freezing Rain in the Eastern United States
Christopher M. Castellano
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

5:00 pm
The June 1, 2011 Hail Monster Event across Eastern New York and Western New England
Thomas A. Wasula
NOAA/NWS, Weather Forecast Office, Albany, New York

5:25 pm
Wrap Up
Warren R. Snyder

5:35 pm
Adjourn

6:30pm
CSTAR Dinner at Buca di Beppo Italian Restaurant
44 Wolf Road, Colonie, New York

NROW XIV will be held October 31-November 2, 2012

Verification of Thunderstorm Occurrence Using the National Lightning Detection Network

Kristen L. Corbosiero
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

Since the summer of 1983, the University at Albany, State University of New York, has organized a daily thunderstorm probability forecast contest. The contest involves predicting the probability that thunder will be heard during a 24-h period at each of ten locations across the continental United States and the forecasts are verified by standard METAR reports. In recent years however, there have been several instances, particularly during overnight hours, in which a thunderstorm failed to be reported in the METAR observations despite its occurrence. During such instances, the forecast contest was verified by (i) contacting the attendant National Weather Service office directly, and/or (ii) examining Weather Surveillance Radar-1988 Doppler and National Lightning Detection Network (NLDN) data.

Given that the NLDN has continuous space and time coverage, an average detection efficiency in excess of 90% and mean location errors of ~500 m for cloud-to-ground (CG) lightning flashes, this presentation will examine the utility of using the NLDN to verify thunderstorm occurrence. In particular, a 16-year thunderstorm climatology (1995–2009) from Global Summary of the Day station observations will be compared to an NLDN lightning climatology at the ten stations currently used in the Albany Thunderstorm Contest and ten other first-order reporting stations distributed across a wide variety of climatological synoptic environments. Questions such as (i) how close to a station does CG lightning need to strike for a thunderstorm to be reported and does this distance vary by station, and (ii) are there detectable trends and interannual variability in thunderstorm occurrence will be addressed in this presentation.

A Multiscale Analysis of a Heavy Rainfall Event over Lake Michigan

Jason M. Cordeira[1] and Nicholas D. Metz[2]

[1]Department and Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York
[2]Department of Geoscience
Hobart and William Smith Colleges, Geneva, New York

This presentation is motivated by a heavy-rain producing convective event over Lake Michigan (LM) on 30 June and 1 July 2011 that contained limited predictability. The presentation focuses on i) the evolution of the antecedent large-scale flow for 20–30 June 2011, and ii) the initiation and development of convection between 1200 UTC 30 June and 1200 UTC 1 July 2011. The foci of this study are motivated by far-upstream precursors to heavy-rain producing convective events over the Great Lakes region and the possible influence of LM on heavy-rain producing convective events over the Great Lakes region.

The evolution of the antecedent large-scale flow is characterized by multiple tropical cyclone–jet stream interactions over the western North Pacific during 22–24 June 2011 that result in Rossby wave train amplification and dispersion across the North Pacific and North America. The Rossby wave train dispersion is associated with trough (ridge) development over western (central) North America on 28–30 June 2011. The resulting western Great Lakes environment featured conditions conducive to heavy rainfall and severe weather including reduced static stability associated with the eastward advection of an elevated mixed layer, increased lower-tropospheric moisture, increased shear associated with strong warm-air advection, and isentropic ascent coincident with a well-developed warm front.

Convection first initiates along the western shore of LM ahead of the surface warm front around 1800 UTC 30 June 2011 and develops into a lakeshore-parallel north–south-oriented band of convection. Analyses suggest that this convection may have been enhanced by the strong lake-induced thermal gradient between LM and Wisconsin leading to primarily elevated convection above the Lake Michigan marine layer. However, a WRF simulation of this convective event initialized with and without LM indicates that convection develops regardless of the presence of the lake and the associated lower-tropospheric thermal gradients. Thus, the lakeshore-parallel north–south-oriented band of convection likely develops in conjunction with the warm front of similar orientation.

Identifying Key Features to Predict Significant Severe Weather Outbreaks in the Northeast United States

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

On 1 June 2011, a significant severe weather event occurred in the northeastern U.S. with multiple reports of hail greater than 3 inches in diameter in New York and New England and an EF3 tornado in Massachusetts. This significant severe weather event had similar atmospheric characteristics to other historical significant severe weather events, defined by the Storm Prediction Center as hail greater than 2 inches in diameter, straight-line winds of ≥65Kt and/or tornadoes of EF2 magnitude or greater.

A previous study compared significant severe weather events with severe weather forecast busts (no tornadoes reported within the majority of a tornado watch or within a moderate risk region) in the Carolinas through the mid-Atlantic states, and identified atmospheric features that contributed to the occurrence of significant severe weather outbreaks in that region. That study researched 14 significant severe weather events from 1984 to 2002, and identified atmospheric characteristics that contributed to the development of the significant severe weather outbreak.

In this study, 20 significant severe weather events in the northeastern U.S. from 1953 to 2011 that produced F2/EF2 tornadoes were researched to determine if the atmospheric features in the Carolinas and mid-Atlantic events had similarities to the northeastern U.S. events. It was determined after researching these northeastern U.S. events, as well as selected forecast busts between 2003 and 2010, that the key atmospheric features supportive of significant severe weather in the Carolinas and mid-Atlantic were also valid for the northeastern U.S.

Atmospheric features that will be presented include 850 hPa winds, equivalent potential temperatures, 4-layer best lifted index and 850 hPa and 500 hPa heights and temperatures. It was determined that a progressive 850 hPa and 500 hPa vorticity center and 850 hPa equivalent potential temperature change of ≥25K in 12 hours over the region identified the strong low-level forcing that supported significant severe weather events. Other important features were surface based instability and an 850 hPa wind maximum ≥40Kt.

Future studies will include analyzing elevated mixed layers, values of Convective Available Potential Energy and deep layer shear.

A Study on Convective Modes Associated with Tornadoes in Central New York and Northeast Pennsylvania

Timothy W. Humphrey[1]
Michael 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

Between August 2000 and May 2011, WFO Binghamton's county warning area (CWA) experienced 52 tornadoes. This study examines the environments associated with these events, with a focus on how these environments vary by convective storm mode. The study began by identifying the most common convective storm modes associated with tornadoes within the CWA based on radar reflectivity. Supercells produced the majority of tornadoes and Quasi-Linear Convective Systems (QLCS) produced the second largest number of tornadoes. To gain a better understanding of the environments that favored different modes, synoptic and mesoscale environments were analyzed. Composite maps for each convective mode revealed several key differences in the synoptic-scale environments associated with supercells and QLCSs. Utilizing archived Rapid Update Cycle (RUC) model analyses, the study identified mesoscale parameters associated with each tornado. These parameters were grouped by convective mode to develop statistics on the mesoscale environments associated with each mode. Supercells were associated with moderate surface based instability and vertical wind shear, while QLCSs occurred in environments with low instability and high wind shear. Events with unverified tornado warnings (null events) were also analyzed to identify mesoscale environments where tornadoes may be less likely to form. Results showed that supercells in environments with weak 0-1 km bulk shear, as well as weak 0-3 km and 0-1 km storm-relative helicity, were more likely to produce null events.

The second half of this study involved analyzing radar data for different convective modes. Utilizing the Rotational Velocity (VR) - Shear tool in the **Advanced Weather Interactive Processing System (AWIPS),** rotational velocity and shear values were collected for tornadic and null events. GR2Analyst was also used to collect Normalized Rotation (NROT) data. Results showed that the characteristics of rotation prior to a tornado varied greatly based on the convective mode. These results were combined with environmental characteristics to create nomograms which are intended to aid forecasters with storm analysis and issuing tornado warnings.

An Investigation of Null-event Severe Convective Watches in the WFO Baltimore/Washington Forecast Area

[1]Lee Picard, [2]Matthew Kramar, [2]Gregory S. Schoor, [2]Steven Zubrick, [3]Andy Dean

[1]University of Miami, Coral Gables, Florida
[2]NOAA/NWS, Weather Forecast Office, Sterling, Virginia
[3]NOAA/NWS, Storm Prediction Center, Norman, Oklahoma

A few times each year, forecasters, both at the local National Weather Service (NWS) Weather Forecast Office (WFO) level and at the NWS Storm Prediction Center (SPC), anticipate the initiation of severe convective weather in the WFO Baltimore-Washington forecast area only to find that no, or very weak, convection occurs. In such cases, this consensus in the anticipation of severe weather leads to the issuance of convective watches that, in retrospect, prove unnecessary. Using synoptic compositing techniques, this study investigates synoptic scale patterns during these null-event severe weather watches in an attempt to distinguish their dynamic and thermodynamic environments from their more productive counterparts.

The Massachusetts Tornado Outbreak of June 1, 2011

Joseph W. DelliCarpini
NOAA/NWS Weather Forecast Office, Taunton, Massachusetts

The most significant tornado to impact Massachusetts in 16 years occurred on June 1, 2011. It traveled 39 miles from Westfield to Charlton Massachusetts and resulted in 3 fatalities and 72 injuries. At its peak, the tornado reached EF3 intensity and was up to one half mile in width. The tornado tracked through Springfield, MA, the fourth largest city in the WFO Taunton CWA, at the beginning of the evening rush hour. Many homes and commercial buildings were destroyed or sustained major damage. It was one of four tornadoes that formed in a rare environment for New England which featured high CAPE and high shear with the presence of an elevated mixed layer. Three other short track tornadoes were produced by another supercell that evening in Wilbraham (EF1), Brimfield (EF1), and Sturbridge (EF0). Many trees were downed or uprooted in these areas.

WFO Taunton received positive feedback from emergency managers and the media for performance during this event, including an editorial in the *Boston Globe*. Indeed, there were a number of best practices observed. However, the warning process also contained shortcomings that have been addressed in order to improve future performance. This included integration of near-storm environment information and radar analysis into the warning decision making process.

This presentation will focus on the evolution of the supercell that produced the EF3 tornado as it crossed southwest and south central Massachusetts, including an analysis of the synoptic and mesoscale environment as well as radar data. It will also include the perspective of forecasters at WFO Taunton, who incorporated multiple data sets into the warning decision making process.

Challenges Associated with the Survey of the June 1, 2011 Massachusetts Tornadoes

Alan E. Dunham
NOAA/NWS Weather Forecast Office, Taunton Massachusetts

A long-track tornado crossed southwest and south central Massachusetts on June 1, 2011. At its peak, the tornado reached EF3 intensity and was up to one half mile in width. Many homes and commercial buildings were destroyed or suffered major damage in West Springfield, Springfield, Wilbraham, Monson, and Brimfield. Countless trees were destroyed along the track of this tornado with near-complete deforestation in some areas.

Over the following days, two NWS Survey Teams from WFO Taunton assessed the damage between Westfield and Southbridge, Massachusetts. The teams faced many challenges which included extensive coordination with federal, state, and local entities, identification of damage degree indicators over a large area, and the intense public scrutiny associated with such a significant event. In addition, the teams had to take into account the sensitivity of the situation when dealing with those who had lost everything.

This presentation will address the challenges of conducting a major storm survey and also present actions that must be considered by the WFO before, during, and after its completion. Included will be what a survey team needs, both individually and as a team, to complete its mission.

Applying Conceptual Models for Non-mesocylonic Tornadoes in Quasi-linear Convective Systems to National Weather Service Tornado Damage Surveys

Matthew Kramar
NOAA/NWS, Weather Forecast Office, Sterling, VA

A large number of tornadoes each year in the forecast area of the National Weather Service Forecast Office (NWS WFO) in Sterling, VA (LWX) are non-mesocyclonic, embedded along the leading edge of quasi-linear convective systems (QLCSs). Detection of these often short-lived tornadoes has been challenging for three reasons: favorable environments for their formation were not anticipated adequately; their temporal duration often is smaller than the temporal resolution of the NWS WSR-88D radar scanning strategies; and the mechanisms by which these tornadoes are generated, until recently, was not very well-understood.

Since WFO LWX has the luxury of coverage by four Terminal Doppler Weather Radars (TDWRs), unprecedented multi-radar TDWR coverage of several recent QLCS tornado events was documented with one-minute temporal data resolution. These data and subsequent tornado damage surveys in the WFO LWX forecast area have revealed interesting conclusions about the nature and evolution of these small-scale vortices, and illuminate the need to ensure highly-detailed damage analysis in determining accurate tornado track information for such events.

The Evolution of Quasi-Linear Convective Systems Encountering the Northeastern U.S. Coastal Marine Environment

Kelly Lombardo and Brian A. Colle
School of Marine and Atmospheric Sciences, Stony Brook University, State University of New York, Stony Brook, NewYork

Though the evolution of quasi-linear convective systems (QLCSs) over central U.S. land areas has been well documented, there is considerably less known about the interaction of QLCSs with land-ocean boundaries. It is unknown why some systems quickly decay when encountering the coast while others maintain their intensity. This becomes particularly important in the coastal regions of the northeastern U.S. (i.e. New York City and Long Island) where millions of people live, since many of these QLCSs can produce damaging winds as well as flash flooding.

To better understand the different QLCS evolutions, we manually examined NOWrad radar reflectivity imagery from the 2002-2007 warm seasons (May-Aug) and identified 73 QLCS events that encountered the northeastern U.S. coast. We classified these events into 4 different categories based on their evolution upon encountering the coastline. There are 32 events that decay at the coastline, 18 events that slowly decay upon reaching the coast (i.e. show no signs of decay at coastal boundary but show signs of decay once over the water and within 100 km of the coast), 9 events that maintain their intensity and decay more than 100 km from the coast, and 6 events that organize along the coast. To investigate the different QLCS evolutions in the context of the surrounding ambient conditions, we created feature-based composites using North American Regional Reanalysis (NARR) data centered on the point at which the line crosses the coast at the closest 3-hr NARR time prior the crossing. For events that decay at the coast, the convective line is collocated with a surface pressure trough as well as a 1000 hPa thermal ridge, with MUCAPE values of ~1250 J kg^{-1}. The line forms within a 900-800 hPa frontogenesis maximum, between a region of warm air advection to the east and cold air advection to the west. A similar pattern exists for slowly decaying events, though the average MUCAPE is only ~750 J kg^{-1}, and the magnitudes of frontogenesis and temperature advection are greater than for decay events. For those events that survive over the Atlantic waters, the synoptic pattern is different. Upon reaching the coast, the convection is collocated with a 1000 hPa baroclinic zone, while the surface trough is ~250-300 km to the west. Surviving events form in a localized region of warm air advection, with little 900-800 hPa frontogenesis and MUCAPE of ~1000 J kg^{-1}.

To understand the differing processes between decaying and surviving QLCS events, 2 events will be contrasted: the 23 July 2002 decaying event and the 31 May 2002 surviving event. These cases form under similar synoptic conditions with one important difference; there is 900 hPa warm air advection ahead of the convection during the 31 May event, with cold air advection during the 23 July event, similar to the composites. Using Weather Research and Forecasting (WRF) simulations down to 2-km grid spacing with a 500 m nest, we will examine the role of the land-sea boundary in the evolution, including the source of air ingested into the storms as well as the role of the low-level temperature advection ahead of the system.

The April 28, 2011 Early-morning Tornado and Flash Flood Event in Central New York and Northeast Pennsylvania

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

A case study of a rare, early-morning tornado and flash flooding event in central New York and northeast Pennsylvania is shown. The tornadoes in central New York on the morning of 28 April, 2011, marked the final stages of a historical tornado outbreak that had its greatest impacts during the afternoon on 27 April, over the southeast United States. The event in central New York began shortly before 0600 UTC on the 28th, as a short line of thunderstorms spawned two tornadoes over the southern Finger Lakes area, ahead of a cold front moving east from Ohio to western Pennsylvania and New York. Shortly after the initial tornado touchdowns, the line broke up, and evolved into a series of supercells, which produced three more tornadoes. The event culminated as a second line of storms developed and moved east across the area. The primary impact of the second line was major flash flooding across northern Pennsylvania and southern New York, although another tornado was reported with the line in northeast Pennsylvania.

Storms on this day developed downstream from a deep trough of mid-tropospheric low pressure over the Ohio Valley, and a cold front moving east from Ohio to western New York and Pennsylvania. The focus for upward motion appeared to occur downstream of the surface cold front, juxtaposed with a cold front aloft and weak surface trough. Environmental instability was modest, however the low-level wind fields were very strong, with an 850 hPa southerly wind component of 4 to 5 standard deviations above normal and 0-1 km wind shear greater than 50 kt. High resolution model reflectivity is shown, and compared to observed radar reflectivity patterns. In general, a wide variety of reflectivity patterns were indicated by various models at various times, however all of the model runs appeared to develop some kind of linear feature prior to 12 UTC. Observed, radar-indicated normalized rotational values are shown from the GR2 analyst software for the tornadoes in this case. A wide variety of evolutions were indicated, ranging from rapid spin-up of rotation at all levels prior to tornado touchdown in some cases, a more gradual lowering of rotation from mid-levels to low-levels in another case, and relatively weak rotation in another case.

Using Standardized Anomalies to Identify Significant Heavy Rain Events

Jason Krekeler and Richard H. Grumm
NOAA/NWS Weather Forecast office, State College, Pennsylvania

Critical to identifying the potential for significant weather events is the ability to put the pattern into context. The standardized climate anomalies approach, outlined by Hart and Grumm (2001) and Grumm and Hart (2001) facilitates identifying patterns associated with significant events and may aid in putting the event into a meteorological and climatological context. The ultimate goal is to identify rainfall events which produce extreme rainfall.

Precipitable water anomalies on the order of 2 to 4 standard deviations above normal have been shown to be good predictors of heavy rainfall events in the United States. The combination of high precipitable water anomalies and positive v-wind anomalies (negative for southern hemisphere) are key ingredients in many synoptic scale heavy rainfall events (Grumm and Hart 2001; Graham and Grumm 2010 and Junker et al. 2009). Some of the more extreme rainfall events are often associated with low-level moisture flux anomalies on the order of 5 to 6 standard deviations above normal.

This paper will show the value of using standardized anomalies in identifying extreme rainfall events around the globe. Several significant, if not extreme, rainfall events from around the world are presented including historic rainfall and flooding in Pakistan during the summer of 2010 and 2011; the Australian floods of December 2010 and January 2011; the California floods of December 2010, and several record flood events over the United States during 2011. A forecast methodology is presented to increase forecaster confidence in predicting these extreme, high impact weather events.

An Examination of the 16-17 April 2011 Record Tidal Flooding on the Lower Delaware River

Lee Robertson and Dean Iovino
NOAA/NWS Weather Forecast Office, Mount Holly, New Jersey

Tidal flooding can have a significant impact on the highly populated coastal areas of New Jersey, Delaware and Maryland, as well as on the tidal portion of the Delaware River which bisects the Philadelphia metropolitan area.

On 16 April 2011, strong surface high pressure was located over Canada's Maritime Provinces and the adjacent waters of the western North Atlantic Ocean. Strong surface low pressure was located over the western part of the Great Lakes region with a trough extending to the southeastern states. The resulting persistent southeasterly fetch over the ocean waters off the Middle Atlantic region produced a tidal surge into the Delaware Bay and the lower part of the Delaware River on 16-17 April 2011. The surge caused major tidal flooding along the lower Delaware River with water levels similar to the record values that occurred during the Great Appalachian Storm of 25 November 1950.

The Numerical Weather Prediction (NWP) models handled the general evolution of the system well in the days leading up to the event. As early as the afternoon of 14 April 2011 it appeared as though moderate tidal flooding would occur on the lower portion of the Delaware River from the evening of 16 April 2011 through the early morning hours of 17 April 2011. However, the eventual magnitude of the tidal flooding was not fully captured by the Global Forecast System's (GFS) extra-tropical storm surge output, the Meteorological Development Laboratory's (MDL) extra-tropical water level forecasts or the Delaware Bay Operational Forecast System (DBOFS). Statistical algorithms developed at the National Weather Service Forecast Office (NWSFO) in Mount Holly, New Jersey also under-forecast the extent of the tidal flooding.

Comparison of the November 1950 and April 2011 events along the Delaware Bay and the lower Delaware River reveals some similarities in the surface weather pattern and the resulting wind direction. However, the Great Appalachian Storm brought significantly higher sustained wind speeds and gusts than the April 2011 system, along with a greater storm surge, lower surface pressures and almost twice as much rainfall at many locations. Although both events occurred during a full moon, the maximum astronomical tide levels for 16-17 April 2011 were about a foot higher than those for 25 November 1950. Historical research was completed to determine the extent of the flood damage along the lower Delaware River and its tributaries during the 1950 storm. Many of the same communities and neighborhoods were impacted by the tidal flooding caused by the April 2011 weather system.

Flash Flood Composite Analysis in Vermont and Northern New York

John M. Goff and Gregory A. Hanson
NOAA/NWS, Weather Forecast Office, Burlington, Vermont

A study of 51 flash flood cases in the National Weather Service Burlington VT's County Warning Area was conducted. Flash Flood cases were classified as stationary thunderstorms (Type A), classic training thunderstorms (Type B), and thunderstorms associated with meso-beta features (Type C). Composite analysis maps were generated using the NWS NCEP North American Regional Reanalysis (NARR) dataset, and composite soundings were generated using the RAOB program. The NARR composites showed flood producing storms developing in areas of moderately favorable upper level jet dynamics, weak mid-tropospheric ridging with an approaching short wave trough to the west, a weak surface trough in the vicinity, and a low level high moisture axis. Composite soundings revealed a tall narrow CAPE profile, deep warm coalescence layer, and a light veering wind profile through the boundary layer. Precipitable water, while high was not extremely anomalous; in most cases only 100% to 150% of normal. Type A and Type B soundings were similar, while Type C soundings tended to be cooler through the entire layer. Finally, the soundings were marked by a very low lifted condensation level, in many cases below 1,000 feet above ground level. By applying local forecast expertise in conjunction with the parameters identified in this study, it is hoped that skill in detecting the potential for flash flooding in the NWS Burlington, VT county warning area will increase.

Tropical Cyclone-frontal interactions and heavy rainfall: A comparison of Tropical Storms Lee and Eloise

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Slow moving tropical storm Lee brought heavy rains to the Gulf States before lumbering up the Appalachians toward a stalled frontal boundary. In the Mid-Atlantic region, the initial rain was focused along stalled east-west frontal boundary. The axis of the rain was oriented in a west-southwest to east-northeast direction across central Pennsylvania. As Lee approached the region, the orientation of the rain bands became more south-to-north, nearly orthogonal to the earlier rainfall axis. During this period of transition, the intensity of the rainfall increased and the heaviest rainfall rates were observed during the more north-to-south orientation of the rain bands.

The resulting multi-day rainfall event produced a broad area of rain in excess of 150 mm. Local rainfall maximums in excess of 300 mm were reported. The north-south axis of heavy rainfall affected most of the Susquehanna Valley. This combined with previous heavy rainfall over portions of the same area from tropical storm Irene 8 days earlier produced near historic flooding at many points in the Susquehanna River Valley. The rainfall produced the 4th highest ranked floods in the Mid-Atlantic region behind the flooding associated with tropical storm Agnes in June 1972, the snow melt and rain floods of January 1996, and the late winter floods of March 1936.

It is shown that both the synoptic pattern and rainfall pattern associated with tropical storm Lee were similar to the pattern observed during tropical storm Eloise. Similar to Lee, Eloise tracked northward from the Gulf of Mexico and into the Mid-Atlantic region from 23 to 25 September 1975. Eloise interacted with a stalled frontal system as well, and the rain transitioned from a Maddox frontal event to a Maddox synoptic event. The heavy rainfall associated with Eloise produced the 10th most significant flood in the Mid-Atlantic region.

A comparison of the patterns associated with tropical cyclones Lee and Eloise is presented. Subtle differences in the pattern and antecedent conditions are examined to explain the difference in the resulting flooding. The preliminary results imply that the conditions and patterns associated with both events could be applied to the forecast process to better anticipate extreme rainfall events during tropical cyclone-frontal interactions.

The Forecast Challenge of Tropical Storm Lee

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On 28 August 2011 Eastern New York and adjacent Western New England experienced one of the most destructive floods in history from Tropical Storm Irene. Overall, the track of Irene and precipitation amounts was well forecasted by the Hurricane Prediction Center, the Hydrological Prediction Center and the Albany Forecast office. Between the dates of 7 September and 9 September 2011, with little time for rivers to recover, the remnants of Tropical Storm Lee soaked the Albany forecast area with 12-25cm of heavy rain which resulted in additional flooding. The quantitative precipitation forecasts (QPF) associated with Lee was not forecasted well by the NAM 12, GFS40, ECMWF, and CMC thereby presenting an unusual challenge for the forecasters at the WFO Albany. This presentation will review how the operational weather forecast models handled the synoptic environment prior to and during Lee, including the many different forecast solutions. It will also examine the teleconnections at 500hPa that ultimately determined where the heaviest rains of Lee were focused. The presentation will then present possible "lessons" learned on how to deal with such a scenario in the future.

KEYNOTE Presentation

A Historical Perspective of Flooding in the Mohawk Watershed related to Hurricane Irene and Tropical Storm Lee

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The recent severe and catastrophic flooding driven by Hurricane Irene and Tropical Strom Lee will alter management strategies in the watershed. These floods have also changed the political and economic landscape related to development and infrastructure along the principle tributaries and on adjacent floodplains. Some of the primary challenges that have resulted from the Irene and Lee flooding including issues with the Gilboa Dam, the Erie Canal locks, and rebuilding on the floodplain. A key question is the historical context of these events, and how recent changes in precipitation patterns affect the overall response to rebuilding, reconstruction, and mitigation strategies. There is a relatively long record of flooding in the Mohawk watershed, and this record shows that flood levels during Hurricane Irene were high, but discharge or stage levels have been exceeded a number of times in the lower Mohawk. This is not the case with the Schoharie Creek, and the Irene event is now the flood of record and it was well above the last previous high water, which was the January 1996 breakup event. Because Irene flooding was so severe in the Schoharie watershed, an extraordinary amount of damage occurred in the lower Mohawk, and some of this damage resulted in Schoharie-derived debris and complications related to flow in the Erie Canal Lock system.

The long record of flooding on the Mohawk River is best gathered from historical archives that summarize events in the Schenectady area – one of the earliest and longest settled communities in the Mohawk watershed (and in New York State). Using these historical archives, we have attempted to reconstruct a chronology of ~350 years of flooding on the Mohawk River, but this chronology is weak until 1830. Floods on the Mohawk River include "free-water" events and "break-up" events. Break-up events are caused by rising temperatures, melting snow, and heavy rains in the winter or early spring, thus available water is in the form of both snow/ice melt and precipitation. Ice jams accompany break-up events in the majority of the large-scale flooding events (>15' stage elevation in Schenectady). Despite probable gaps in the historical record, the worst flooding occurred between 1869 to 1914, where stages >15' were reached eight times in 45 years. This period started with the great October flood of 1869, which was pronounced and major in the Schoharie Creek and at the time, the "greatest ever known" on the Mohawk River. Although the next two years had the highest annual precipitation ever recorded at Albany (>55'), annual precipitation decreased throughout this interval and the severity and frequency of major ice jams increased. This period concluded with the great flood of 1914, the most devastating event recorded on the lower Mohawk River when flood stage in Schenectady was 23.5' well higher than all others on record (including Irene in 2011, which was just over 17'). The long historical record shows that significant free water flood events are uncommon, and these events occur in late summer and early fall, during peak hurricane season and are associated with intense precipitation.

Flooding of Irene and Lee in 2011 will now be the model for these sorts of events, but events that were nearly as significant occurred in 1955, 1903, and in 1869. Of these free-water events, Irene ranks third, and Lee ranks fifth.

Similar Day Ensemble Post-Processing as Applied to Wildfire Threat and High Ozone Days

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As ensembles become more common in operations, methods are needed to correct for bias and underdispersion. A calibrated ensemble would be especially useful to populate the NWS Graphic Forecast Editor (GFE) during certain weather regimes. Removing biases can be complex, as these errors vary spatially, temporally, diurnally, and with the synoptic flow pattern. Unfortunately, removing ensemble bias and improving calibration for particular synoptic regimes remains largely unexplored. This talk will detail how bias correction and Bayesian Model Averaging (BMA) performs for 2-m temperature and 10-m wind speed on wildfire threat days and events with high ozone. Furthermore, the sensitivity of post-processing to the members selected and the potential atmospheric flow regimes on high fire threat days are explored.

The study combined the 13 member Stony Brook University (SBU, 12-km grid spacing) ensemble and the 21-member Short Range Ensemble Forecast (SREF, 32 – 45 km grid spacing) run at the National Centers for Environmental Prediction (NCEP) over the Northeast United States. Post-processing was completed on high fire threat and ozone days comparing the most recent consecutive days (sequential training) to the most recent similar days (conditional training). High fire threat days were selected for the 2007-2009 warm seasons (April to September) from the National Fire Danger Rating System, while high ozone days were obtained from AIRNow stations. The 2-m temperature was bias corrected with a running-mean bias technique, while a cumulative distribution function (CDF) bias correction was used for 10-m wind. BMA uses the 5 control members of the SREF and the 5 SBU members with the lowest mean absolute error for each PBL scheme (BEST10 ensemble). For the high fire threat days, potential synoptic regimes were found using EOF analysis on the North American Regional Reanalysis (NARR) 500-hPa data.

Conditional bias correction is better at removing model biases than the warm season average. As a result, conditional bias correction and BMA creates a more skillful ensemble than sequential bias correction with BMA. Additionally, there is a slight probabilistic benefit with combining the SBU and SREF compared to using each ensemble separately. BMA also generally performs better with the BEST10 ensemble compared to 10 randomly selected members. Finally, EOF's of 500 hPa NARR data reveal two modes associated with ridging in the Northeast that are correlated with temperature model biases on high fire threat days. This work can be extended to create automated gridded probabilistic forecasts operationally via analog post-processing.

A Multiscale Perspective on the Intense Midwest Cyclone of 25-26 October 2010

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Rapid cyclogenesis in the lee of the Rockies late on 25 October culminated in a large and intense cyclone over the Upper Midwest that achieved a measured minimum sea level pressure (SLP) of 955.2 hPa at Bigfork, Minnesota on 26 October and represented a new all-time minimum SLP value over the interior continental U.S. This intense cyclone produced a moderate severe weather outbreak along with sustained winds between 30–40 kt with higher gusts over a wide area of the Midwest. Extreme deepening occurred without appreciable low-level cold air and baroclinicity in conjunction with a strongly diffluent 90 m s^{-1} 250 hPa subtropical jet (STJ). This presentation will provide a multiscale overview of the antecedent conditions over the North Pacific that enabled this extreme weather event to occur and will also provide synoptic context for the event.

A merger of two very warm air masses in the upper-tropospheric air over the North Pacific Ocean preceded the intense North American cyclone. One warm air mass originated over the Sahara and moved eastward across the Middle East and Tibetan Plateau before reaching the subtropical western Pacific. Another warm air mass originated over the tropical western Pacific in an area of convectively enhanced outflow from TC Megi. Diabatically induced ridge building ahead of TC Megi resulted in downstream flow amplification and the development of a baroclinic trough over the Gulf of Alaska. The juxtaposition of this trough with these two warm air masses resulted in a strengthened meridional temperature gradient and a strong (250-hPa wind speeds >100 m s^{-1}) STJ over the eastern Pacific on 23–24 October. This STJ became strongly diffluent over the Rockies as the merged warm air mass moved inland over the southwestern U.S. on 24–25 October. Lee cyclogenesis east of the Rockies ahead of the STJ transitioned to dynamically driven strong cyclogenesis as the downstream half wavelength collapsed between the faster-moving upper-level trough and STJ, and the slower-moving downstream ridge in the diffluent flow. This cyclogenesis event will be compared and contrasted with the equally intense but more baroclinic "Cleveland Superbomb" of 25-26 January 1978 to help provide synoptic context to both events.

Field Observations and Modeling of the Microphysics for Winter Storms over Long Island, NY

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The precipitation type and intensity within Northeast U. S. winter storms is often highly variable. Mesoscale snow banding within these storms can lead to some of these precipitation variations, and there has been some recent work highlighting the dynamical evolution of these bands, such as within the comma head of the cyclone. However, the precipitation forecasts are also tied to the microphysics within the cloud, which can have large uncertainties within mesoscale models. There are few observations of the microphysics within East coast winter storms, which are needed to verify the models. The goal of this research is to determine the microphysical evolution and the factors that influence the microphysics during 13 storms over Long Island, NY during the 2009-2010 and 2010-2011 winter seasons. The microphysical observations will also be compared to the bulk microphysical schemes within the Weather Research and Forecasting (WRF) model. A vertically-pointing Ku-band radar was used to observe the vertical profile of reflectivity and Doppler velocity of the winter storms as they passed overhead. A PARSIVEL disdrometer was used to obtain particle sizes, fall speeds, and number concentration. A stereo microscope and camera were used to observe the snow crystal habit and degree of riming. Snow crystal identification followed Magono and Lee (1966). Snow depth and snow density were also measured. The winter storms varied from coastal low pressure systems with mesoscale snow bands in the comma head of the cyclone, coastal lows with no organized snow bands, warm advection events ahead of an approaching storm, and frontal passages. Overall, plate-like (22%), dendritic (21%), and side planes (18%) were the most common crystal habits on average. The riming of snow is common during these coastal events, with 62% of events having at least one period of moderate riming. The riming was largest: (1) near the strongest ascent core of a mesoscale snow band (eastern side or warm side of mid-level frontogenetical boundary), (2) when the seeder ice cloud aloft was removed by the dry intrusion, (3) small-scale convective cells, and (4) periods around freezing near the surface. During the heaviest riming periods, the snow-liquid ratios were 4:1 to 7:1, and ice fall speeds were 2-3 m s^{-1}. In contrast, there was little or no riming and snow ratios were 10:1 to 20:1 when the upward motion was generally weak during warm advection events. Rapid transitions of crystal habit, riming, and snow density were common within these storms. The habit variations were often associated with changes in the height of the maximum upward motion relative to the favored ice habit growth temperatures. Convective seeder cells aloft and changes in vertical motions and thermal profiles also led to some of these rapid transitions in microphysics. There are also large differences in the predicted microphysics and fallspeeds in the WRF microphysical schemes, which will be highlighted.

Magono, C., and C. Lee, 1966: Meteorological classification of natural snow crystals. *J. Fac. Sci. Hokkaido Univ. Ser. 7,* **2,** 321–335.

Tracking Rossby Wave Packets in Global Analyses and Models

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Rossby wave packets play an important role in model uncertainty and sensitivity in the medium (3-14 day) range and are frequently linked with high impact weather events. However, it is not well understood whether global NWP models can accurately reproduce wave packets, particularly in the medium range. In order to quantify errors in NWP wave packet prediction, an automated method for identifying and tracking wave packets is needed. This presentation will highlight two different tracking approaches and give verification statistics for each. A brief wave packet climatology will also be shown. Finally, in order to help forecasters become more familiar with wave packets as a part of our NOAA CSTAR, a new web page is being designed to show ensemble mean and spread for wave packet amplitude as well as wave packet tracks, model verification statistics and intensities.

Two different tracking techniques have been tested – TRACK, which identifies local maxima in wave packet amplitude and tracks them through time based on the statistical likelihood that they are related, and a hybrid technique, which combines feature selection with object orientation by attributing the entire wave packet object to the nearest local maximum and then requiring an overlap of 50% to continue tracking. These methods have been verified using NCAR Reanalysis 2.5 degree wind and height data at 300 hPa for five randomly selected cool season months. The verification of these approaches is based on two dynamical variables linked to wave packet propagation – ageostrophic geopotential flux divergence and local eddy kinetic energy. Our hybrid technique is more effective in complex flow regimes as seen in January, 2010 (TRACK missed 3 of the 15 packets in this month and produced 5 false alarms in a single month while the hybrid technique missed just one track and gave one false alarm). However, hybrid tracking was more likely to miss the beginning or end of a wave packet – life times for the hybrid technique averaged about four time steps shorter than TRACK for comparable events. TRACK is more likely to see an entire wave packet evolution, but also far more likely (17 false alarms to 5 for the hybrid method) to see tracks that lack dynamical support and should be excluded. Given this uncertainty, model verification may require an ensemble of both tracking techniques. This presentation will also highlight a real time ensemble wave packet web page (http://wavy.somas.stonybrook.edu/wavepackets), which includes packet track spaghetti plots, ensemble mean and spread for wave packet envelope amplitude and real-time model verification. We will also outline future plans for verification of forecast wave packets in The Integrated Grand Global Ensemble (TIGGE) archives and the potential for flow regime specific model performance analysis.

Lower Stratospheric Fronts in Northwesterly and Southwesterly Flow and their Sensible Weather Implications

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The structure, evolution, and dynamics of two lower stratospheric frontal zones, observed in association with upper-level jet front systems, are examined from a basic state variables perspective. The case studies highlight some substantial differences in lower stratospheric frontal development that occur in southwesterly and northwesterly flow. In the southwesterly flow case, the lower stratospheric front was aligned with an active surface cold front. A deep column of upward vertical motion resulted from the superposition of the lower tropospheric ascent associated with convection along the surface front and upper tropospheric-lower stratospheric (UTLS) ascent through the jet core forced by geostrophic warm air advection along the lower stratospheric cyclonic shear portion of the jet. The UTLS ascent, located on the cold edge of the lower stratospheric baroclinicity, served to intensify the lower stratospheric frontal zone via tilting during the intensification of the southwesterly flow jet.

In the northwesterly flow case, the lower stratospheric frontal intensity reached its peak prior to that of its upper tropospheric counterpart. At the time of peak intensity, geostrophic cold air advection characterized the lower stratospheric cyclonic shear, placing subsidence through the jet core within the UTLS. This subsidence subsequently weakened the lower stratospheric front while supporting upper tropospheric frontal development. The subsequent upper tropospheric front was a precursor for a major continental surface cyclogenesis event. The implications of these lower stratospheric frontal circulations on tropopause dynamics and downstream sensible weather are highlighted.

Operational Utilization of WRF-ARW and the Model Evaluation Tools (MET) in Forecasting and Validation in Southeastern New York State as Applied to Hurricane Irene

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On 27-28 August 2011, Hurricane Irene severely impacted northeastern portions of the United States, including New Jersey, Connecticut, Vermont, and New York, five days after being initially classified as a Category 1 Hurricane. Extensive damage from intense precipitation, strong winds, and flooding resulted in billions of dollars worth of damage to residential and commercial property, not to mention loss of life. IBM's "Deep Thunder" service currently provides operational forecasts twice daily for areas of southeastern New York State with 84-hour predictions at very high-resolution (2-km) utilizing the WRF-ARW community model. It exhibited proficient skill in forecasting regional as well as local scale impacts of Hurricane Irene days in advance as it weakened and made landfall as a tropical storm.

As is the case with any operational forecasts, verifying is essential in evaluating model "skill". Over the years, there have been many techniques developed for analyzing model performance in terms of verifying predicted/simulated precipitation. For our purposes, we will group these methods into two categories: (a) "traditional" approaches (Accuracy, Threat Score, etc.) based on site-specific observations and the more recent (b) spatial verification approaches (intensity-scale, object-based, etc.) that compare forecasts to gridded observations. For the former, we have been able to leverage data from a relatively dense mesonet. In contrast, the spatial methods have, in some instances, been able to reduce the "double penalty" associated with temporal and spatial phase errors that arise when using traditional approaches for high-resolution models. We will provide a brief overview of Deep Thunder and the forecasts that covered Hurricane Irene but will primarily focus on the verification of Deep Thunder's forecasts which captured the event, with the utilization of the "Model Evaluation Tools" (MET) suite, developed at the NCAR Developmental Testbed Center (DTC). This package of open source verification tools contains traditional approaches as well as spatial techniques, both of which were used to evaluate the Deep Thunder forecasts.

Utilization of a High Resolution Weather and Impact Model to Predict Hurricane Irene

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ConEdison has been working with the IBM Deep Thunder team to evaluate its high resolution WRF model within its service territory. The weather model provides a customized 2km resolution view of weather conditions across the ConEdison service territory. As discussed in last year's NROW presentation this weather model is coupled to an Overhead Electrical Impact model in the company's Westchester County territory. This probabilistic statistical model was developed by analyzing and incorporating significant historical weather event information and relating it to the number of ConEdison outage tickets or "jobs". The model attempts to predict the number of jobs that will be created based on the forecasted weather from Deep Thunder.

This presentation will take an overall look at the Deep Thunder weather forecasts leading up to Hurricane Irene and discuss how the impact model verified based on the actual number of jobs that were created in the Westchester County service area. Ongoing work and areas for improvement will also be discussed.

Applications of Dual-Pol Radar Data into New England Weather Scenarios

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Over the next couple of years, the WSR-88D network is scheduled for a major software and hardware upgrade to dual-polarization (dual pol) technology. This upgrade will provide the ability to collect data through both horizontal and vertical pulses, which allows forecasters to determine the size and shape of hydrometeors. To date, dual pol has been installed at several Weather Forecast Offices (WFOs) in the country, each located in a different climate regime. Forecasters at the new dual pol sites have been able to utilize the new dual pol products and apply them into their warning decision making process for flash flooding and severe weather. The upcoming winter will offer the opportunity to apply these new radar products to the challenges of winter weather forecasting, including precipitation type. WFO Taunton will receive its dual pol upgrade in January, 2012.

The presentation will focus on dual pol applications and lessons learned while using the dual pol products in warning decision making process, based largely upon experiences at WFO Wichita, KS. It will also discuss how to apply the new technology to the diverse weather of New England.

The Hydrometeorological Prediction Center (HPC) Winter Weather Desk: Verification, Changes, and Future Plans

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Verification of HPC's Winter Weather Desk (WWD) forecasts from the winter of 2010–2011 will be presented, including snowfall and low track forecasts. In the deterministic and probabilistic forecasts, a high bias was evident. Heavy snow events were forecast to occur more frequently than they were observed. Most human deterministic snowfall accumulation forecasts were able to improve upon the multi-model and ensemble consensus forecasts. Most human forecast modifications to the multi-model and ensemble probabilistic snowfall forecasts degraded the probabilistic forecast. The lowest position errors for the 48, 60, and 72 hour surface low forecasts were from a blend of the operational ECMWF and GFS forecasts. Changes to the suite of winter weather forecasts will be shown, including the availability of the UKMET model in the forecast snowfall accumulations blender. Snowfall and ice accumulation forecasts are now available in formats compatible for display in Geographic Information System (see http://www.hpc.ncep.noaa.gov/kml/about_winwx_kml.shtml
http://www.hpc.ncep.noaa.gov/kml/kmlproducts.php#winwx).
Finally, the experimental snowfall probability forecasts shown at http://www.hpc.ncep.noaa.gov/pwpf_24hr/wwd_24hr_probs_sn.php were produced for the 2010-11 season. These probabilities will be expanded to encompass 48 hour time periods to provide 'storm total' potential for events straddling two 24 hour periods.

The inaugural Winter Weather Experiment of the Hydrometeorological Testbed (HMT)-HPC was conducted January 10 - February 11, 2011, at HPC. The experiment explored the use of convection-allowing (~4-km resolution) models for improving near term forecasts of snow and freezing rain accumulations, and investigated different methods of quantifying and communicating the uncertainty associated with winter weather forecasts. The high resolution models did offer different forecasts than the global and regional scale models, adding to the suite of possible solutions. Although hourly 4 km data can allow a forecaster to visualize explicit prediction of mesoscale bands, the high-resolution guidance was only found useful in anticipating the placement and intensity of mesoscale snow bands when there was consensus amongst the guidance. The 2011-2012 HMT-HPC Winter Weather Testbed will examine the utility of a storm scale (4 km) ensemble from the Air Force Weather Agency and experimental National Centers for Environmental Prediction Short Range Ensemble Forecast output in providing improved probabilistic winter weather forecasts. Post processing and visualization of ensemble data, such as the use of clusters, will also be explored. Additionally, a review of the use of these probabilistic numerical model forecasts in assessing likely event impacts on the public will be conducted. The experiment will examine how humans can add value to probabilistic forecasts.

Predictability of High Impact Weather during the Cool Season: CSTAR Update and the Development of a New Ensemble Sensitivity Tool for the Forecaster

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Stony Brook University has been collaborating with several NWS offices and NCEP operational centers on a CSTAR project focusing on the predictability of high impact weather (http://dendrite.somas.stonybrook.edu/CSTAR/cstar.html). One of the goals is to provide forecasters with tools to better understand the origin of ensemble spread and errors in realtime. We have implemented an ensemble sensitivity analysis approach (Torn and Hakim 2008; 2009) that can highlight the upstream source regions where initial condition uncertainty leads to ensemble spread within a downstream boxed region (nor-easter cyclone along the East coast). Ensemble sensitivity is a correlation between a forecast metric at the final forecast time and any variable within the model state vector. We have extended the approach to medium range (4-7 days) ensemble forecasts and validated that it works in that time range. We have also modified the approach to develop forecast metrics more suitable to the forecaster. For example, an Empirical Orthogonal Function (EOF) analysis on the variance of ensemble sea-level pressure forecasts around a cyclone often reveals that the two EOF patterns that explain the most variance is the position and amplitude of the cyclone. One can calculate the upstream "sensitivity" associated with EOF1 (e.g. cyclone position error) by projecting this pattern onto the forecast of each ensemble member (members in the ensemble with anomalies relative to the mean that have pattern similar to the EOF pattern), which can then be correlated with pressure for each ensemble member at a particular forecast hour to get the sensitivity. The approach can also be run forward in time by first obtaining a ensemble mean error within a boxed region early in the forecast (e.g., 24-h 500 Z error), which is used to project on the forecast members one by one, and then do a regression based on the pattern of each ensemble member (similar to a weighted mean of members that have anomalies resembling the projected pattern) to get a downstream forecast sensitivity. The benefit of this ensemble sensitivity approach is that any relevant forecast metric can be used within a selected box (cyclone central pressure, EOFs, snow band position, precipitable water maximum, etc…), which makes it a very versatile tool for the forecaster.

The ensemble sensitivity approach has been applied to high impact weather events with large ensemble spread over the Northeast U.S., such as the 26-27 December 2010 NYC blizzard and hurricane Irene (26-28 August 2010). For the 26-27 December event, this talk will highlight some of the upstream sensitive regions that may have led to the dramatic shift in model cyclone tracks towards the coast between the 24th and 25th December model cycles. Also, the presentation will highlight efforts to make this ensemble sensitivity tool available in realtime to the forecaster. The idea is to let the forecaster select a region of interest and particular forecast metric, and then the tool will calculate the upstream sensitive regions. This will hopefully improve forecaster awareness of upstream error development and uncertainty.

The 4 September 2011 Tornado in Eastern New York: An Example for Updating Tornado Warning Strategies

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Despite not having the high frequency of occurrence experienced by other parts of the country, tornadoes occasionally affect portions of the Northeast. The latest climatology developed from the Collaborative Science, Technology, and Applied Research (CSTAR) IV program has shown that the Albany County Warning Area is affected, on average, by about 3 tornadoes per calendar year. Although radar advancements over the past ten years have dramatically increased the resolution of radar products, current tornado warning strategies are still based off of the original legacy version of the Weather Surveillance Radar 88 Doppler (WSR-88D) that was released during the mid-1990s.

One of the original tornado warning strategies developed was using the V-R shear relationship. A local COMET study (LaPenta et al. 2000) found that maximum gate-to-gate shear below 3 km was useful in identifying tornadic storms. A linear relationship was found between using gate-to-gate shear and the rotational velocity of the mesocyclone. Using this concept, nomograms for operational use were developed for local tornado warning guidance. However, because of the resolution of the original 4-bit radar products, this relationship was very sensitive to range from the radar. The warning meteorologist had to be sure to normalize the length of the diameter for measuring the shear value depending on the location of the storm in question. This could waste valuable lead time for tornado warnings.

On 4 September 2011, an EF1 tornado affected a 7 mile path across portions of the Mohawk Valley of eastern New York. While this tornado could have been predicted using the V-R shear relationship, this wouldn't be based off the highest resolution data possible. This study will illustrate the need for updated tornado warning strategies for the Albany CWA utilizing the high resolution 8 bit radar data currently available, which would avoid making large adjustments for range and can provide for longer lead times, potentially leading to a better protection for life and property.

The 2011 "PRE-Season" In Review: A Look at Tropical Cyclones Irene, Katia, and Lee

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Hurricane Irene and Tropical Storm Lee were the most high profile Atlantic Basin tropical systems to impact the United States in 2011. Hurricane Irene affected much of the Eastern seaboard, producing a wide swath of wind damage, heavy rainfall, and flooding from the Carolinas northward to New England. Tropical Storm Lee was remembered primarily for its excessive rainfall and flooding, which extended from the southern Appalachians northward to New York State.

With specific regard to Predecessor Rainfall Event (PRE) development, these two tropical cyclones were quite different. Although the direct impacts of Irene resulted in significant flooding over a fairly large area, PRE development was limited. Some of the mitigating synoptic factors for PRE formation will be discussed.

In the case of Lee, its plume of tropical moisture spread northward across the Eastern United States, while its remnant circulation slowly decayed on its track through the Tennessee and Ohio Valleys. Although heavy rainfall affected a fairly wide region during the period from 5-8 September, a catastrophic heavy rain/flood event took place over portions of Pennsylvania and New York State on 7-8 September.

Further detailed analyses of the 7-8 September event revealed a complicated synoptic pattern and moisture contributions from multiple sources, including distant Hurricane Katia. The role that Katia may have played will be closely examined.
Lastly, a comparison will be made with another historic heavy rainfall case (a PRE associated with tropical cyclones Ike and Lowell in 2008), in which two tropical air streams converged to help produce excessive rainfall amounts.

A Multiscale Analysis of the Inland Reintensification of Tropical Cyclone Danny (1997) within an Equatorward Jet-Entrance Region

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On 18 July 1997, Tropical Cyclone (TC) Danny made landfall in southeastern Louisiana as a very small and compact tropical cyclone. Danny reached a minimum central pressure of 984 hPa after it reemerged over water and subsequently made final landfall in southern Alabama, where excessive rains were reported, including nearly 960 mm over Dauphin Island. Danny weakened into a tropical depression as it slowly moved northward across Alabama, turned eastward into Georgia on 23 July, and accelerated northeastward across the Carolinas. On 24 July, Danny reintensified unexpectedly back to tropical storm strength over northeastern North Carolina as it interacted with a low-level baroclinic zone beneath an equatorward entrance region of an upper-level jet. Sustained winds around Danny increased from 20 knots to 40 knots and the central pressure decreased from 1012 hPa to 1000 hPa before it emerged over the Atlantic Ocean east of Virginia. This increase in sustained wind speed and decrease in central pressure while TC Danny was inland is the most extreme when compared to nine other TCs in a 61-year climatology (1950–2010) of inland reintensifying TCs over the eastern United States.

This presentation will document the results of a multiscale analysis of the inland reintensification of TC Danny with emphasis on synoptic and mesoscale processes. Datasets from the 0.5° Climate Forecast System Reanalysis (CFSR), analyzed surface maps, and surface observations are used to identify and document the synoptic background and underlying mesoscale features associated with the observed inland reintensification of TC Danny. WSR-88D radar datasets and satellite imagery are used to help identify structural changes in the convective and stratiform precipitation around TC Danny as it reintensified. A PV perspective is employed to facilitate the interpretation of the multiscale analysis.

Results suggest that the inland reintensification of TC Danny can be attributed to: (1) frontogenesis along the low-level baroclinic zone and associated tropospheric-deep ascent beneath the equatorward entrance region of the upper-level jet; (2) deep convection that provided a source of diabatic heating and reinforced the ascent near the storm center; (3) upper-tropospheric PV reduction north of the storm center that strengthened the meridional PV gradient and the associated jet; and (4) lower-tropospheric vorticity growth in an environment that favored enhanced ascent near the storm center. An analysis of the relative contributions of these processes to the inland reintensification of TC Danny is ongoing. For perspective purposes, we will also compare the inland redevelopment of TC Danny with the inland reorganization of the remnants of TC Camille (1969) and the associated devastating flooding across parts of Virginia and West Virginia. The flooding occurred as TC Camille approached the equatorward entrance region of a strong upper-level jet.

Characteristics and Climatology of Appalachian Lee Troughs

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Appalachian lee troughs (ALTs) can play an important role in the development of convective storms, some of which may become severe, in the region to the lee of the Appalachians. Accurately forecasting the location, mode, and severity of convection associated with ALTs is important due to the proximity of the convective initiation region to the densely populated Eastern Seaboard. Forecasting convection associated with ALTs can be challenging, especially in weak upper-level flow regimes that are characteristic of the region to the lee of the Appalachians during the summer months.

To investigate the structure of ALTs, 13 cases of ALT events associated with severe convection that affected the Sterling, VA (LWX), County Warning Area between May and September were analyzed using 0.5º resolution gridded data from the CFSR (Climate Forecast System Reanalysis). A climatology of ALTs in the lee of the Appalachians from the Carolinas northeastward to southern Pennsylvania, referred to as the "ALT Zone," was constructed based on criteria derived from the following low-level features that are common to the 13 cases: (1) a wind component orthogonal to and downslope of the mountain barrier, (2) a thickness ridge, (3) a thermal vorticity minimum, and (4) a geostrophic relative vorticity maximum. Horizontal maps of the thickness ridge and negative thermal vorticity, as well as vertical cross sections of geostrophic relative vorticity and potential temperature, suggest that ALTs are shallow, warm-core phenomena.

The purpose of this presentation is twofold. First, it will show the results of the ALT climatology by presenting a scheme for defining ALTs based on the magnitude of their surface pressure and low-level thermal anomalies. The ALTs defined by this scheme can be categorized based on their relationship to synoptic-scale cold fronts. Second, the presentation will examine the spatial and temporal distribution of severe local storm reports obtained from NCDC's *Storm Data* publication in the ALT Zone. Severe local storm reports in the ALT Zone have a distinct diurnal peak around 2200 UTC (1800 EDT) on days with and without ALTs, indicative of the importance of the diurnal heating cycle to severe local storm formation.

Climatological Aspects of Freezing Rain in the Eastern United States

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Ice storms are among the most hazardous, disruptive, and costly meteorological phenomena in the eastern U.S. The accretion of freezing rain during ice storms creates dangerous travel conditions, produces numerous power outages, and adversely impacts local and regional economies. Due to the combined influence of synoptic, mesoscale, and microphysical processes, freezing rain also presents a major forecast challenge. Empirical evidence suggests that operational models and forecasters often underestimate the extent and duration of freezing rain for scenarios involving frozen, mixed, and liquid precipitation types. In consideration of these societal impacts and forecasting issues, we have constructed a long-term (1975–2010) climatology of cool-season (Oct–Apr) freezing rain for NWS first-order stations within the eastern U.S. The results of this climatology will be applied toward: 1) determining the synoptic and mesoscale environments conducive to significant freezing rain events in the eastern U.S., and 2) developing methodologies to improve the operational forecasting of freezing rain.

The freezing rain climatology is constructed from NCDC's Integrated Surface Database and NCEP/NCAR reanalysis data. First, we calculate the monthly and seasonal frequencies of freezing rain using hourly surface observations from NWS first-order stations east of the Mississippi River (excluding those in Florida). This procedure allows us to evaluate the temporal and spatial variability of freezing rain, as well as define geographical regions where freezing rain is most prevalent. Next, we create synoptic composites to examine the dynamic and thermodynamic fields associated with significant freezing rain events in each region. Predominant features in these composites suggest how large-scale circulations, thermal boundaries, moisture transport, and the associated quasi-geostrophic (QG) forcing establish synoptic environments favorable for freezing rain. Although freezing rain typically occurs under preferred synoptic conditions, mesoscale processes such as cold-air damming, terrain–flow interactions, and frontogenesis ultimately determine the evolution and persistence of freezing rain events by modifying the dynamically and thermally forced synoptic-scale circulations and the associated QG forcing on regional and local scales. Therefore, a multiscale analysis is performed to identify important synoptic–mesoscale circulation linkages and differentiate among the physical mechanisms that modulate freezing rain in each geographical region. The anticipated findings will build upon existing conceptual models and provide operational forecasters with increased awareness of the synoptic and mesoscale processes that influence the initiation and evolution of freezing rain events in the eastern U.S.

The June 1, 2011 Hail Monster Event across Eastern New York and Western New England

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During the late morning and afternoon of 1 June 2011, most of upstate New York (NY) and New England was in a warm sector ahead of a strong cold front approaching from southeastern Canada, the eastern Great Lakes and the Ohio Valley. A humid and unstable air mass was over the Northeast. Surface dewpoints were in the 17-21°C range ahead of the boundary and 5-10°C in its wake by the late afternoon. A prefrontal surface trough was evident in the surface analysis in the early afternoon over eastern NY, which helped aid the strong to severe convection that developed. Convection rapidly developed ahead of the cold front and its associated prefrontal surface trough over eastern NY and western New England between 1500 UTC and 1800 UTC. The severe weather continued into New England through the early evening with large hail, damaging winds and tornadoes. The first of five baseball-size or larger (≥7.0 cm) hail reports occurred at 1700 UTC in Saratoga Springs, NY. Mammoth hail stones of 8 cm in diameter fell at Shaftsbury, VT, and of about 10 cm were measured in Windsor, MA located the Berkshires. The vast majority of the severe weather in the Albany forecast area was from large hail (≥ 2.5 cm) with nearly 3 dozen reports. There were about a dozen significant hail reports (≥ 5.0 cm) that occurred across eastern NY and New England from the entire event. A closed 500 hPa upper level low was approaching the Northeast from central Ontario. Mid and upper-level heights fell over NY and New England ahead of a short-wave trough quickly approaching from the Great Lakes Region. A strong mid-level jet streak of 50-75 knots moved into northern NY and New England, which helped enhance the convection with some upper level divergence over east-central NY and western New England. The thermodynamic environment was very volatile with an abundance of instability in place. A special 1600 UTC sounding at Albany revealed a surface-based convective available energy (SBCAPE) value of 3452 J kg^{-1}, a downdraft CAPE value of 1000 J kg^{-1}, wet-bulb zero height of 10.5 kft AGL, and mid-level lapse rates of 7.0°C km^{-1}. The 1600 UTC Local Area Prediction System (LAPS) analysis had SBCAPEs of 2000-5000 J kg^{-1} over eastern NY and western New England. The 1200 UTC KALB sounding had a well-defined elevated mixed layer approximately between 700 hPa to 500 hPa, which back trajectories showed originated from northern Mexico. The 0-6 km deep layer bulk shear increased in excess of 40 knots in the 1600 UTC KALB sounding with several supercells developing ahead of the cold front. The supercells became hail monsters with tall updrafts and massive elevated reflectivity cores associated with them.

This talk will take a multi-scale approach in analyzing the major severe event from the synoptic-scale to the storm-scale, in order to understand the convective environment that produced the anomalously large hail stones in the Northeast. 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 storm-scale analysis will utilize a variety of radar tools (Four-Dimensional Stormcell Investigator) and techniques.

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