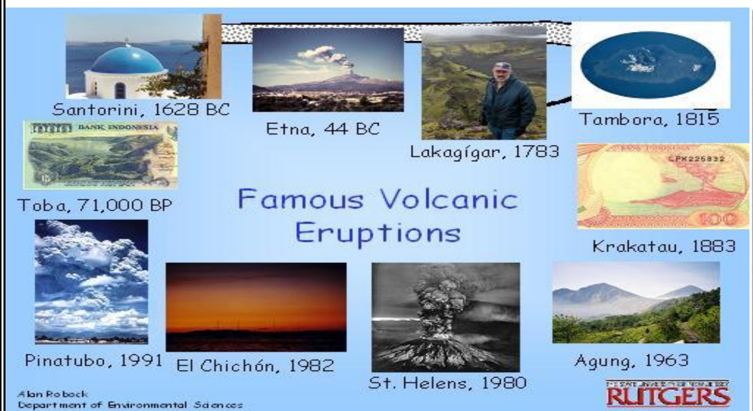
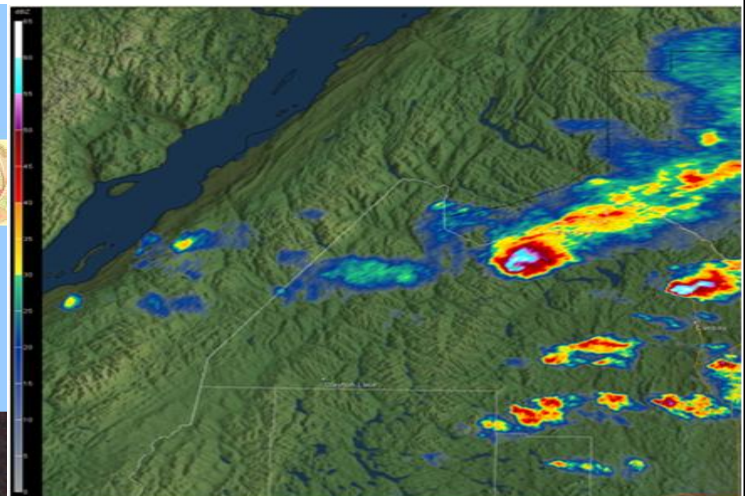
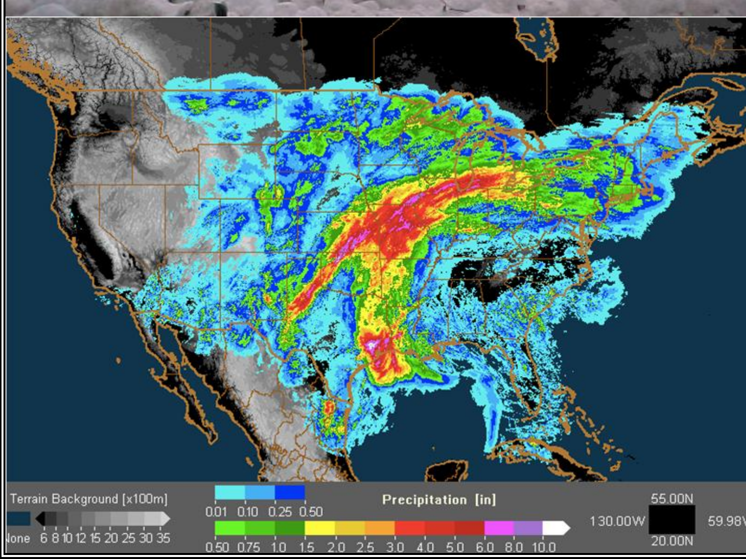
11th Northeast Regional Operational Workshop
November 4 & 5, 2009
Albany, New York







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Department of Atmosheric and Environmental Sciences, UAlbany

American Meteorological Society

Agenda
Northeast Regional Operational Workshop XI
Albany, New York
Wednesday, November 4, 2009

7:50 am
Welcoming Remarks
Eugene P. Auciello, Meteorologist In Charge
Warren R. Snyder, Science & Operations Officer
National Weather Service, Albany, New York

Conference Chairs
Steve R. DiRienzo
Senior Service Hydrologist, National Weather Service, Albany, New York

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

Session A – Warm Season Topics / Convection

8:00 am
Southerly or "Reverse Mohawk-Hudson Convergence Cases"
Hugh W. Johnson and Kim Sutkevich
NOAA/NWS Weather Forecast Office Albany, New York

8:15 am
Preparing for a Change in Severe Hail Warning Criteria in 2010
Brian J. Frugis
NOAA/NWS Weather Forecast Office Albany, New York

8:30 am
Issues Associated with Transitioning to a New Severe Hail Criteria
Matthew Steinbugl
NOAA/NWS Weather Forecast Office, State College, Pennsylvania

8:50 am
Predicting Severe Hail in the WFO LWX County Warning Area: Toward Increased Accuracy in Hail Size Forecasts
Matthew R. Kramar
NOAA/NWS Weather Forecast Office, Sterling, Virginia

9:10 am
The Impact of the St. Lawrence Valley on the Precipitation Distribution of Hurricanes Katrina and Rita (2005)
Eyad Atallah
McGill University, Montreal, Quebec, Canada

9:30 am
Reanalysis of Southern New England Tornadoes to Improve Warning Verification
Joseph W. DelliCarpini
NOAA/NWS Weather Forecast Office, Taunton, Massachusetts

9:50 am
Evaluation and Response to the Northern and Downeast Maine Tornado Events of 2009
Todd Lericos
NOAA/NWS Weather Forecast Office, Caribou, Maine

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

Session B – Cool Season Topics /Winter Weather

10:30 am
HPC Winter Weather Desk Operations and Upcoming NCEP Model Changes
Dan Petersen
NOAA/NWS Hydrometeorological Prediction Center, Camp Springs, Maryland

10:50 am
Far Upstream Precursors of Early-Season Cold-Air Outbreaks over the Northeast United States
Jason M. Cordeira
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, NY

11:10 am
Improving Forecasts for High Impact Sub-Advisory Snow Squalls
David Nicosia
NOAA/NWS Weather Forecast Office, Binghamton, New York

11:30 am
Planetary and Synoptic Analysis of Freezing Rain Events in Montreal, Quebec
Gina M. Ressler
Department of Atmospheric and Oceanic Sciences, McGill University, Montreal, Quebec, Canada

11:50 pm
Use of a Historical Analog-Based Winter Storm Guidance Package for Forecasting a Central New York Snow Event
Michael Evans
NOAA/NWS Weather Forecast Office, Binghamton, New York

12:10 pm
Lunch

Session- C Keynote Presentation
Introduction – Warren R. Snyder

1:30 pm
Volcanic Eruptions and Climate: Comparing Climatic Response to Low and High Latitude Volcanic Eruptions, and Are They a Good Analog for Geoengineering?
Alan Robock
Department of Environmental Sciences, Rutgers University, New Brunswick, New Jersey

3:00 pm
Question & Answer Session

3:15 pm
Break
Refreshments available for sale by the Capital Region Chapter of the AMS

Session D – Hydrology and Heavy Rain Events

3:30 pm
Application of Forecast Verification Science to Operational River Forecasting in the National Weather Service
Julie Demargne
NOAA/NWS Office of Hydrologic Development, Silver Spring, Maryland

4:00 pm
Ice Jams on the Lower Mohawk River
John I. Garver
Geology Department, Union College, Schenectady, New York

4:20 pm
Simulating River Ice Thickness to Provide Advance Notification of Breakup Ice Jam Potential to Emergency Managers
Stephen N. DiRienzo
NOAA/NWS Weather Forecast Office, Albany, New York

4:40 pm
Ice Jam History, Ice Jam Mitigation Training and Ice Mitigation Efforts in WFO Albany's Hydrologic Service Area (HSA)
John S. Quinlan
NOAA/NWS Weather Forecast Office, Albany, New York

4:55 pm
Implementation of the Community Hydrologic Prediction System at the Northeast River Forecast Center
David R. Vallee
NOAA/NWS Northeast River Forecast Center, Taunton, Massachusetts

5:20 pm
A Review of the Precipitation Distribution Associated with the TROWAL and its Application to a New England QPF Event.
Frank M. Nocera
NOAA/NWS Weather Forecast Office, Taunton, Massachusetts

5:40 pm
An Overview of an Unprecedented Flash Flood Event in Western New York
David Zaff
NOAA/NWS Weather Forecast Office, Buffalo, New York

6:00 pm
Adjourn

Agenda
Northeast Regional Operational Workshop XI
Albany, New York
Thursday, November 5, 2009

Session E – General Session

8:00 am
The Influence of Upper-Level Sub-Synoptic Scale Potential Vorticity Disturbances on Severe Weather in the Southwestern United States
Scott Sukup and Tim Melino
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

8:20 am
The Impact of Recurving Western North Pacific Typhoons on the Large-Scale Flow Pattern over North America
Heather M. Archambault
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

8:40 am
Decision Support Services for High Profile Events
Brandon Smith
NOAA/NWS Weather Forecast Office, Upton, New York

Session F – Modeling and Ensemble Forecasting

9:00 am
1. **Lessons in Predictability: The Post Groundhog Day 2009 Storm**
2. **Lessons in Predictability: Part 2 - The March 2009 "Megastorm"**

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

9:30 am
Towards an Ensemble Forecast Air Quality System for New York State
Michael Erickson
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York

9:50 am
Meteorological Evolution and Model Performance for Fire Threat Days Over the Northeast U.S.
Joseph Pollina
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York
NOAA/NWS Weather Forecast Office, Upton, New York

10:10 am
Evaluation of a Multi-Model Storm Surge Ensemble for the New York Metropolitan Region
Brian A. Colle
School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York

10:30 am
Developing Better Forecasts:
An Analysis of Two Storms During Summer 2009 Using the High Resolution WRF Model and Observations on July 7 and August 18
E. Novakovskaia
IBM, Yorktown Heights, NY

10:50 am
Break
Refreshments available for sale by the Capital Region Chapter of the AMS

Session G – CSTAR & Related Topics

11:10 am
A Climatology of Convective Types over the Northeast U.S: Ambient Conditions and the Role of the Appalachian Lee on Initiation
Kelly Lombardo
School of Marine and Atmospheric Sciences, Stony Brook University, State University of New York, Stony Brook, New York

11:30 am
Wind Channeling in the St. Lawrence River Valley: Synoptic Patterns, Local Conditions, and Operational Forecasts
Alissa Razy
Department of Atmospheric & Oceanic Sciences, McGill University, Montreal, Quebec, Canada

11:50 am
Lunch

1:00 pm
Northeast Convective Flash Floods: Helping Forecasters Stay Ahead of Rising Water
Joseph P. Villani
NOAA/NWS Weather Forecast Office, Albany, NY

1:20 pm
The Northeast Convective Flash Flood Project:
July 29th 2009 Flash Flood Case Study
Derek V. Mallia
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

1:40 pm
An Examination of the March 1-2, 2009 East Coast Gravity-Wave Using High-Resolution Operational Data Sets
Alan M. Cope
NOAA/NWS Weather Forecast Office, Mount Holly, New Jersey

2:00 pm
An Application of a Cutoff Low Forecaster Pattern Recognition Model to the 30 June - 2 July 2009 Significant Event for the Northeast
Thomas A. Wasula
NOAA/NWS Weather Forecast Office, Albany, New York

2:20 pm
Analysis of Precipitation Distributions Associated with Two Cool-Season Cutoff Cyclones
Melissa Payer
Department of Atmospheric and Environmental Sciences
University at Albany, SUNY, Albany, New York

2:40 pm
Break

3:00 pm
Cool-Season High Wind Events in the Northeast
Jonas V. Asuma
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

3:20 pm
Synoptic Environments Associated with Predecessor Rain Events in Advance of Landfalling Tropical Cyclones
Benjamin J. Moore
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

3:40 pm
A Comparison of Predecessor Rainfall Event Development with Tropical Cyclones Danny and Bill from the 2009 Season
Michael L. Jurewicz, Sr.
NOAA/NWS Weather Foreacst Office, Binghamton, NY

4:00 pm
Predecessor Rain Events Ahead of TC Ike and TC Lowell on 11–14 September 2008
Lance F. Bosart
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

4:20 pm
Adjourn

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

NROW XII will be held November 3-4, 2010

Southerly or “Reverse” Mohawk Hudson Convergence Cases”

Hugh Johnson and Kim Sutkevich
NOAA/NWS Weather Forecast Office Albany, New York

The Hudson Valley extends from south to north, spanning over 200 miles from north of New York City, to south of Burlington, VT. Research has been completed that indicates the surface wind is influenced by the Hudson valley, often flowing north through it, even when the mean gradient wind would indicate a westerly flow and in fact does blow from the west in the Mohawk Valley. During a departing coastal storm, this phenomenon, the persistent northerly flow in the Hudson Valley, coupled with a westerly wind in the Mohawk Valley, is termed Mohawk Hudson Convergence (MHC). MHC can produce lingering light precipitation.

In a situation where a southwest gradient sets up ahead of a cold or warm front, the surface wind in the Hudson Valley usually remains South or even Southeast while the wind turns southwest in the terrain to the west of the Hudson Valley. This difference in wind direction could lead to low level convergence as well as a difference in the dewpoint. The dewpoints are higher in the Hudson Valley and produce a “discontinuity” line. These are called southerly or “reverse” Mohawk-Hudson cases.

Assuming the air mass is unstable enough for convection; both the aforementioned features could trigger convection or enhance developing convection as it moves into the Hudson Valley. We will take a look at various cases and attempt to produce some sort of flow chart that can at least help forecasters to identify when Southerly Mohawk cases can occur.

Preparing for a Change in Severe Hail Warning Criteria in 2010

Brian J. Frugis
NOAA/NWS Weather Forecast Office Albany, New York

The National Weather Service (NWS) Eastern Region (ER) will be changing the criteria for severe hail from 0.75" (1.9 cm) to 1.00" (2.5 cm) on 1 January 2010. Many techniques have been developed for forecasting severe hail, such as the Vertically Integrated Liquid (VIL) of the Day method, but these are based on 0.75" severe hail criteria. Previous studies have also been based on combined hail and severe wind reports. In anticipation of this change, new warning guidelines and techniques will be needed for accurately predicting severe hail.

Two major cases of severe hail occurred across the Albany County Warning Area (CWA) during the Summer of 2009. The combination of the 15 June 2009 and 16 July 2009 severe weather events yielded over 70 storm reports of severe hail. Out of these 70 reports, about half (37) would be considered severe under the new 1.00" criteria. Since these reports contained a wide variety of hail sizes, several parameters commonly looked at during warning decisions were examined for each of these severe hail reports. These parameters include VIL, the height of the storm Echo Top (ET), VIL Density, and the ETs of the 50 dBZ, 55 dBZ, 60 dBZ, and 65 dBZ levels. Each of these parameters were compared to find the average difference between the severe and non-severe hail reports. Radar data from the KENX WSR-88D located in Berne, New York (NY) was primarily used for this study. However, additional radar data from the KTYX WSR-88D in Montague, NY and the KBGM WSR-88D located in Binghamton, NY was also used for this study, mainly when thunderstorms were located too close to the KENX cone of silence to reveal more accurate data.

The initial study revealed some interesting statistics regarding the comparison of the old and new severe hail criteria. Thunderstorms producing hail reaching 1.00" in diameter was shown to, on average, have a 50 dBZ echo top 2.2 kft AGL (671 m) taller than a storm producing hail of 0.75" in diameter. The VIL was also shown on average to be 5 kg/m^2 higher as well, although VIL has a limited value since it's air mass dependent. Additional studies will have to be done to include more hail reports from previous years to see if the results reached in this study will be useful for operational storm interrogation.

Issues Associated with Transitioning to a New Severe Hail Criteria

Matthew Steinbugl, Richard Grumm and John La Corte
NOAA/NWS Weather Forecast Office, State College, Pennsylvania

The current NWS severe weather product specification states in part, that severe thunderstorm warnings should be issued when there is radar indication and/or reliable spotter reports of hail three-quarter (¾) inch (penny) in diameter or larger. A survey of the emergency management community and media partners within Eastern Region (ER) was conducted to determine whether they would support a change in the current hail criteria from ¾ to 1 inch. The impetus behind the proposed change is focused on an effort to better represent hail sizes which produce damage and reducing user complacency to numerous severe thunderstorm warnings for ¾ inch hail. Despite mixed results and strong opinions on both sides of the issue, an overall assessment of the survey responses supported a change in hail criteria which will be implemented 1 January 2010.

It is important to note that this change will have implications on Regional severe thunderstorm warning performance, with potential significant impacts associated with false alarm rates (FAR). An analysis of the last two years of verification shows the change could potentially increase regional FAR by as much as 30 percent. In addition to the expected increase in FAR, local hail climatology distributions in Central Pennsylvania indicate that the majority of severe hail reported, over 50% of the time, is less than an inch diameter. Based on the new criteria, it will be important to distinguish between non-severe and severe hail storms.

Ultimately, the main challenge facing ER forecasters will be training. Various techniques have been developed in attempt to detect thunderstorms capable of producing severe-sized hail. But, these techniques were associated with the ¾ inch hail criteria. This suggests that a re-evaluation of the methods used for identifying severe-sized hail is necessary. In this study, radar data were analyzed for select severe thunderstorm events that produced hail greater than or equal to one inch in diameter in Pennsylvania during the 2008-2009 convective seasons. Standardized climatological anomalies of mid-level lapse rates were also computed to highlight areas where large hail, *1 inch or more in diameter*, may occur. The ultimate goal is to develop a warning criterion in an effort to minimize false alarms while continuing to extend and improve detection and lead time.

Predicting Severe Hail in the WFO LWX County Warning Area: Toward Increased Accuracy in Hail Size Forecasts

Jeff Waters
Pennsylvania State University, State College, Pennsylvania

Matthew R. Kramar
NOAA/NWS Weather Forecast Office, Sterling, Virginia

One of the challenges in National Weather Service (NWS) warning operations is differentiating radar reflectivity signatures for hail from those of very heavy rain, and subsequently identifying maximum expected hail size from reflectivity patterns. This issue becomes even more complicated when storms are located over sparsely populated areas, which makes real-time confirmation of conditions nearly impossible.

Studies to address this challenge have already been conducted for the Northern Plains (Donavon and Jungbluth 2007) and Southern High Plains (Porter et al. 2005). Atmospheric freezing levels and storm reflectivity core heights (greater than or equal to 50dBZ) as determined from WSR-88D data were correlated in consideration of reported hail size with subsequent operational success.

The present study seeks to establish such a statistical database of severe hail events for the Mid-Atlantic region. Using methods developed by Donavon and Jungbluth (2007), rawinsonde observations (RAOB) soundings from Sterling, VA (IAD) and surrounding NWS Weather Forecast Offices (WFOs), reflectivity data from nearby WSR-88D radars, and Storm Data reports from WFO Sterling (LWX) were used to establish comparable seasonal statistics for anticipated hail size for Mid-Atlantic region thunderstorms. Results from this study are expected to better enable warning meteorologists to anticipate hail-size diameter and aid in warning decision-making with greater confidence (especially in light of potential changes to severe thunderstorm hail diameter criterion), thereby increasing average warning lead time.

The Impact of the St. Lawrence Valley on the Precipitation Distribution of Hurricanes Katrina and Rita (2005)

Eyad Atallah and John Gyakum
McGill University, Montreal, Quebec, Canada

The Atlantic Basin hurricane season of 2005 was extraordinary considering the fact that there were twenty-seven named tropical cyclones given that the climatological mean is thirteen. Of those twenty-seven, two storms (Katrina and Rita) directly impacted the St. Lawrence Valley as they underwent extratropical transition (ET), resulting in significant flooding across many area located near the Valley. In fact over 50% of the seasonal rainfall in the fall of 2005 in the St. Lawrence Valley can be directly attributed to the aforementioned storms. However, what makes these cases particularly interesting is the fact that precipitation amounts in close proximity of the Valley were generally 25-50% greater than precipitation amounts either north or south of the Valley. Consequently, this study will try to assess the dynamic and thermodynamic factors which account for the increased precipitation values immediately along the valley.

Recent work by Carrera and Gyakum 2009 has established the preference of along Valley winds (northeasterly and southwesterly) for numerous Valley stations. In the case of synoptic-scale low pressure systems appoaching the region from the southwest, the surface wind in the Valley is often from the northeast, as a result of pressure driven channeling. This pressure driven channeling results in enhanced frontogenesis along the St. Lawrence Valley, as relatively cool-dry air is advected by the northeasterlies into along Valley locations, while to the south of the Valley, surface southeasterlies advect warm moist air northward. Preliminary results indicate that during the ET's of Katrina and Rita the enhanced forcing for ascent from fontogenesis was fairly shallow in nature as it is driven by a shallow topographical feature. However, while the forcing was relatively shallow, the thermodynamic structure of the atmosphere (moist neutral to convectively unstable) facilitated enhanced vertical ascent throughout a deep layer in the troposphere. Consequently, the resulting precipitation distribution was strongly impacted, with upwards of 50% more rain falling in the immediate vicinity of the Valley.

Observational study of wind channeling within the St. Lawrence River Valley Marco L. Carrera, John R. Gyakum, Charles A. Lin *Journal of Applied Meteorology and Climatology.* 2009 early online release, posted June 2009

Reanalysis of Southern New England Tornadoes to Improve Warning Verification

Daniel M. Brook*
Lyndon State College, Lyndonville, Vermont

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

Warning verification statistics from the NOAA/National Weather Service Weather Forecast Office (WFO) in Taunton, MA showed a clear need to better understand the synoptic and mesoscale conditions associated with southern New England tornadoes.

Since the installation of the WSR-88D in 1993, fourteen tornadoes were identified and classified into five different categories based upon their associated environments. Tornadoes have occurred in varying types of storm environments including supercells, squall lines, pulse convection, and cold pool vortices. Most events in the study required high shear, deep moisture at low levels, and were enhanced by terrain boundaries. A low level coastal jet was found to form when stronger tornadoes occurred during certain synoptic conditions. Reflectivity and velocity data were analyzed for selected cases, in order to look for clues which would assist operational forecasters in their warning decision making process. Many of these signatures were subtle and only present for one or two volume scans.

Results from this study were implemented into operations at WFO Taunton during the 2008 convective season. On July 23, 2008, an EF1 tornado produced damage in Warren, Rhode Island and Swansea, Massachusetts. Utilizing the research from this study, WFO Taunton forecasters were aware of the tornadic potential that day, and subsequently issued a Tornado Warning for the storm, which was the first warning to be verified by a tornado in the County Warning Area since 1997.

This presentation will show the results of this study, including the five different categories which are favorable for tornado formation in southern New England, as well as radar analysis of selected events.

* Present affiliation: Meridian Environmental Technology, Grand Forks, ND

Evaluation and Response to the Northern and Downeast Maine Tornado Events of 2009

Todd Lericos and Hendricus Lulofs
NOAA/NWS Weather Forecast Office, Caribou, Maine

During the summer season of 2009, National Weather Service Office (NWS) in Caribou, Maine experienced an above normal number of confirmed tornado events within its county warning area (CWA). The first confirmed tornado of the season was a missed event that was later confirmed to be produced by a low-topped (or mini) supercell. Further, investigations led to the discovery of deficiencies in the environmental assessment of low-topped tornado producing storms that characterized this event. An evaluation of radar techniques used during the event also indicated insufficient velocity color scales detect early tornado genesis rotation.

A rapid response to these findings led to the development of training material to highlight the discovered deficiencies. A thorough review of current research on low-topped convection was presented to NWS Caribou staff. In addition, recommendations on AWIPS procedures and Radar color scales also were presented. The results of these training initiatives led to the proper detection of the next three events that occurred. A 92% detection rate, no false alarms and a 14 min average lead time resulted.

Although these training initiatives on low-topped convection had a positive impact, a number of hypotheses have emerged from the study of these events. First, a qualitative assessment would seem to indicate that the environmental assessment of low-topped convection may be a larger concern for northern tier NWS offices than previously thought. Second, qualitative assessment of numerous convective events indicates that summer convection seems to have a propensity to increase low level mesocyclogenesis as it moves from higher terrain in western Maine into the St. John Valley in eastern Maine and western New Brunswick. Lastly, severe weather climatologies for northern and downeast Maine may not be representative of the actual occurrence of severe weather due to population and radar sample characteristics. Each of these hypotheses merit further study.

HPC Winter Weather Desk Operations and Upcoming NCEP Model Changes

Dan Petersen
NOAA/NWS Hydrometeorological Prediction Center, Camp Springs, Maryland

An overview of HPC's Winter Weather Desk (WWD) and associated operational changes for the upcoming season will be presented. Particular focus will be placed on the advent of gridded snowfall, ice accumulation, and snow ratio guidance for NWS Weather Forecast Offices. Verification of the WWD snowfall, freezing rain, and low track forecasts for the 2008–2009 seasons will also be presented. Several NCEP modeling systems will be undergoing changes during the upcoming winter season, including the NCEP Short Range Ensemble Forecast System (SREF), Global Forecast System (GFS), and the NCEP Global Ensemble Forecasts System (GEFS). An overview of these changes will be presented, with a focus on the SREF changes and associated temperature and precipitation skill improvements. Proposed SREF changes over the next several years will also be highlighted.

Far Upstream Precursors of Early-Season Cold-Air Outbreaks over the Northeast United States

Jason M. Cordeira, Lance F. Bosart, and Daniel Keyser
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, NY

Cold-air outbreaks (CAOs) between September and November over the Northeast U.S. are known to influence the end of the growing season, the development of early-season lake-effect snow and rain events downwind of the Great Lakes, precipitation type during Nor'easters along the U.S. East Coast, and futures markets for the purchase and sale of home heating fuels. The high-impact nature of CAOs over the Northeast U.S. motivated a climatology of their occurrence and an investigation of common upstream precursors to their development.

Early-season CAOs were identified by first generating a climatology of 850-hPa temperatures and temperature anomalies from archived Albany, NY radiosonde data and the 2.5° NCEP–NCAR reanalysis between 1979–2008. The early-season CAO climatology focused on the coldest 2.5% of the standardized 850-hPa temperature anomaly distribution.

A composite analysis of early-season CAOs suggests that these events are driven, in part, by modifications to the upstream flow by synoptic-scale transients over the North Pacific. In particular, CAOs are often preceded by the strengthening and zonal elongation of the North Pacific jet stream (NPJ) in association with potentially warm upper-level outflow in the equatorward jet-entrance region from westward-moving tropical cyclones. Modifications to the upper-level flow over the North Pacific result in persistent cyclone activity on the cyclonic shear-side of the NPJ and the development of anomalous upper-level geopotential heights over the Gulf of Alaska and northwest Canada. As a result, cold air located over northern Canada is displaced into the Northeast U.S.

Improving Forecasts for High Impact Sub-Advisory Snow Squalls

David Nicosia
NOAA/NWS Weather Forecast Office, Binghamton, New York

Greg DeVoir, Richard Grumm & James Dickey
NOAA/NWS Weather Forecast Office, State College, Pennsylvania

Snow squalls, with high winds, rapid snow accumulation, and sudden reduction in visibility, are a major killer in the state of Pennsylvania. Over the past 10 years, snow squalls ranked third among storm-related hazards just behind floods and high winds in Pennsylvania. In fact, more people have been killed in Pennsylvania by snow squalls than from large scale winter storms, lightning and tornadoes in the last 10 years. Pennsylvania has the fourth highest interstate mileage in the nation and hosts major transportation arteries from New York City, New England and Philadelphia. Hence, the Pennsylvania interstate system is particularly vulnerable to adverse weather conditions.

Despite the dangers, snow squalls do not produce enough snowfall to meet National Weather Service (NWS) winter weather advisory, or winter storm warning criteria due to their brief nature. Many times only an inch or two of snow falls which is well below warning and advisory thresholds. The purpose of this study is to explore ways to expand forecasting and detection of high impact sub-advisory (HISA) snow squalls. This study examines the predictability of two deadly HISA snow squall events in Pennsylvania.

Both cases exhibited a sharp strongly forced arctic front that was accompanied by strong cold air advection (CAA) between 850 and 500 hPa. The effect of this CAA was to steepen lapse rates from the surface through 600 hPa and provide a thermodynamic environment which supported convective available potential energy (CAPE). The CAPE was realized as the front swept east resulting in winter-time low-topped convection with strong winds, heavy snow and white-out conditions. The wind shear was strong and unidirectional for both cases. This suggested a linear mode of convection, and indeed, there were two lines of convective snow squalls.

It is clear from these two cases that the conditions that favor the formation of HISA snow squalls can be anticipated by forecasters in advance from model data to raise situational awareness. Additionally, the WSR-88D Doppler radar network can detect intense HISA snow squalls allowing forecasters to track and time their arrival. Precursor boundary layer conditions are also important as surface temperatures were above freezing before the front and snow squalls passed through. A sharp drop in temperature below freezing combined with heavy snow to creating treacherous road conditions. The heavy snow, high winds, and blowing snow created white-out conditions to further add to the danger. Road sensor networks, web cams, and timely spotter reports are important for forecast success of such events. Hence, forecasters may have to look beyond traditional meteorological data sources to effectively detect and warn on such events.

Since the NWS currently does not have a warning that addresses this deadly hazard, this study discusses possible methods for getting an effective message out to the emergency management community, departments of transportation, the media and public at large. Understanding travel patterns, rush hour times, holiday travel also may be an important element in effectively warning for such events.

Planetary and Synoptic Analysis of Freezing Rain Events in Montreal, Quebec

Gina M. Ressler, Eyad H. Atallah, and John R. Gyakum
Department of Atmospheric and Oceanic Sciences, McGill University

Freezing rain is a major environmental hazard that affects many parts of Canada and the United States. It is especially common along the St. Lawrence river valley, where orographic pressure-driven channeling becomes important. For large cities like Montreal, severe freezing rain events can have a devastating effect on property and transportation, leaving many people without electricity, and posing a significant risk to human health. To date, much of the research in this area has focused on analyzing the climatology of freezing rain, carrying out individual case studies, or using statistical models to improve prediction of freezing precipitation. Very few studies have conducted a thorough synoptic analysis of freezing rain events, fewer still in Quebec. Therefore, the goal of this project is to characterize the relevant planetary and synoptic features of a Montreal freezing rain event, in hopes to better understand event causation, duration, and severity.

Environment Canada hourly surface observations at Montreal, Quebec (YUL) for the period 1979-2008 are utilized to construct a complete list of freezing rain occurrences. It is found that Montreal experiences over 28 hours of freezing rain per season, from November to April. From these data, 163 synoptically independent events are defined, and 46 of them are categorized as severe. Severe events are defined as having 6 or more hours of freezing rain observations per event.

Using data from the North American Regional Reanalysis (NARR), the 500hPa height and absolute vorticity fields for each severe event are analyzed. Based on the location of the 500hPa trough axis, the events are partitioned into three groups: western, central, and eastern cases. Composite dynamical structures are then presented for all three groups, and a comparison of average duration and severity is made. Preliminary results indicate that, although the "western trough" group contains the lowest number of cases, they are, on average, longer-lived and more severe. The initial results from the composite maps indicate that a surface cyclone-anticyclone dipole is the dominating feature, but several important physical differences exist between the groups.

Use of a Historical Analog-Based Winter Storm Guidance Package for Forecasting a Central New York Snow Event

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

This presentation illustrates the use of a web-based winter storm guidance package, developed by Saint Louis University, for a snow event that occurred over central New York on December 31, 2008. The system works by ingesting current forecasts from numerical forecast models and running algorithms that search a large database of historical winter storms to determine the best historical analogs to the current forecast. The determination of the best historical analogs is based on the forecast evolution and spatial distribution of several parameters that have been found to be important for forecasting snowfall, such as the surface pressure pattern, the 300, 500 and 850 hPa height pattern, the 850 hPa temperature, 700 hPa frontogenesis, etc. The system provides forecasters with a large suite of information on the characteristics and impacts associated with the best historical analogs, including snowfall maps from the individual analog storms, mean snowfall maps associated with the 15 top analog storms, and probabilistic snowfall information.

The use of this system will be demonstrated by examining data from an event that brought significant snow to portions of central New York on December 31, 2008. Low pressure tracked east from the Ohio Valley to the mid-Atlantic coast on the 31st, producing a band of 15 to 25 cm (6 to 10 inches) of snow across the area from the northern Finger Lakes eastward to the Mohawk Valley in central New York. Examination of maps from the top historical analogs returned by the system, indicated that two historical events appeared to be particularly good analogs to the GFS forecast of the event in question. Snowfall maps from these two events indicated that both events were associated with a band of 15 to 20 cm (6 to 8 inches) across central New York. Probabilistic maps based on the top 15 analogs also indicated that the highest probability of significant snowfall for the event would be in a band across central New York.

Case studies of this and other storms during the 2008-2009 winter season indicated that the historical analog winter storm guidance was useful for forecasting snowfall amounts and locations associated with upcoming storms. The recommended practice for usage of the guidance is to combine examination of output from the individual best historical analogs, with examination of the probabilistic data, to provide forecasters with a historical context for what impacts similar storms have had, as well as a “sanity” check on quantitative precipitation forecasts and implied snowfall forecasts from operational models. As is the case for any guidance that relies on accurate model forecasts, the best results from the system will usually come when the data is examined at short forecast lead times.

Volcanic Eruptions and Climate: Comparing Climatic Response to Low and High Latitude Volcanic Eruptions,and Are They a Good Analog for Geoengineering?

Alan Robock
Department of Environmental Sciences, Rutgers University, New Brunswick, New Jersey

Large volcanic eruptions inject sulfur gases into the stratosphere, which convert to sulfate aerosols with an e-folding residence time of about one year. The radiative and chemical effects of this aerosol cloud produce responses in the climate system. Using examples from major eruptions of the past and results from experiments with numerical models of the climate system, this talk illustrates the major impacts. Volcanic eruptions produce global cooling, and are an important natural cause of interdecadal and interannual climate change.

One of the most interesting volcanic effects is the "winter warming" of Northern Hemisphere continents following major tropical eruptions. During the winter in the Northern Hemisphere following every large tropical eruption of the past century, surface air temperatures over North America, Europe, and East Asia were warmer than normal, while they were colder over Greenland and the Middle East. This pattern and the coincident atmospheric circulation correspond to the positive phase of the Arctic Oscillation. High latitude eruptions in the Northern Hemisphere, while also producing global cooling, do not have the same impact on atmospheric dynamics. They weaken the Indian and African summer monsoon, and the effects can be seen in past records of flow in the Nile and Niger Rivers. In fact we can use records of the Nile River flow to provide an improved date for the Eldgjá eruption in Iceland, which we now date at 939 A.D. Very large, but rare, eruptions, such as that of Toba 74,000 years ago, may have caused very large climate changes. Such an eruption today, however, could not produce an ice age.

In response to the global warming problem, there has been a recent renewed interest in geoengineering "solutions" involving "solar radiation management" by injecting particles into the stratosphere, brightening clouds, or blocking sunlight with satellites between the Sun and Earth. While volcanic eruptions have been suggested as innocuous examples of stratospheric aerosols cooling the planet, the volcano analog actually argues against geoengineering because of ozone depletion and regional hydrologic responses.

I will describe different proposed geoengineering designs, and then show climate model calculations that evaluate both their efficacy and their possible adverse consequences. No such systems to conduct geoengineering now exist, but a comparison of different proposed stratospheric injection schemes, airplanes, balloons, and artillery, shows that using airplanes would not be expensive.

If there were a way to continuously inject SO_2 into the lower stratosphere, it would produce global cooling, stopping melting of the ice caps, and increasing the uptake of CO_2 by plants. But there are 17 reasons why geoengineering may be a bad idea. These include disruption of the Asian and African summer monsoons, reducing precipitation to the food supply for billions of people; ozone depletion; no more blue skies; reduction of solar power; and rapid global warming if it stops. Furthermore, the prospect of it working would reduce the current drive toward reducing greenhouse gas emissions, there are concerns about commercial or military control, and it would ruin terrestrial astronomy. Global efforts to reduce anthropogenic emissions and to adapt to climate change are a much better way to channel our resources to address anthropogenic global warming.

Application of Forecast Verification Science to Operational River Forecasting in the National Weather Service

Julie Demargne[1,2], James Brown[1,2], Yuqiong Liu[1,3], Dong-Jun Seo[1,2]

[1]NOAA/NWS Office of Hydrologic Development, Silver Spring, Maryland

[2]University Corporation for Atmospheric Research, Boulder, Colorado

[3]Riverside Technology, Inc., Fort Collins, Colorado

Progress has been made in the NOAA's National Weather Service Hydrologic Services Program towards systematically verifying hydrometeorological and hydrologic forecasts and effectively communicating verification information to all users. The NWS produces hydrologic forecasts across time scales from hours to months to support a wide variety of applications, such as public safety during flooding and economic well-being for large-scale water management. These forecasts are subject to various sources and types of error and uncertainty. Thus, forecast verification is essential to monitor forecast quality over time, analyze the different sources of error and uncertainty across the entire river forecasting process, and to compare the quality of forecasts from different forecasting methodologies. Ultimately forecast verification is considered successful when its results are used by forecasters and developers to guide improvements of the forecasting system and by users to maximize the utility of forecast information in their risk-based decisions. NWS researchers and forecasters are working together to develop meaningful verification products to effectively help forecasters and external users in their decision making. These products include diagnostic verification information, which aims to identify forecasting errors under a range of observed and forecast conditions, and real-time verification information, which focuses on the forecasting errors in a specific, real-time, forecast given similar forecasts from the past (historic analogs). In this presentation, we discuss progress and challenges in hydrologic verification science and proposed hydrologic verification standards to support the needs of all forecast users.

Ice Jams on the Lower Mohawk River

John I. Garver
Geology Department, Union College, Schenectady, New York

Ice jams are common on the lower Mohawk River largely because of the unique geologic setting of this reach of the river. Ice jams occur when the frozen river breaks up during events that result in rapid increase in discharge, and ice jams occur on the rising limb of the hydrograph, when the floodwaters are building. When flow starts to rise it is not uncommon for unimpeded ice runs to develop, but invariably the ice gets blocked by constrictions especially where the flood plain is reduced in size. The lower part of the Mohawk River has chronic ice jam problems and the historic record indicates that the section between the Stockade and the Rexford Knolls is the most jam-prone in the entire watershed. Ice jams that build to sufficient thickness to dam the river result in spectacular rapid rates of water rise behind the dam; water level differentials between 15 and 25 feet are not uncommon.

One of the worst ice jams in history of Schenectady occurred on 13 February 1886 when a spectacular ice gorge formed and lodged in and around the islands near Schenectady. When the water receded, the remaining ice pile was 30 to 40 feet high. The January 1996 flood is the worst recent flood and it is fairly well documented. We measured the elevation of ice scars on trees lining the river banks to reconstruct ice elevations and infer jam points. The highest ice-scar elevations occur between Lock 8 and the Stockade in Schenectady, and two possible jam points are inferred from the data based on abrupt downstream elevation changes of the highest ice damage on bank-lining trees. The 15 March 2007 flooding in the Stockade was entirely related to ice jamming downstream from the city of Schenectady. During this event, discharge in the Schenectady reach of the Mohawk River never surpassed 45-50 k cfs, which makes this an insignificant event with respect to expected high water. However, the formation of the ice jam and the resulting backup of water was responsible for the inundation that occurred in the Stockade. This reinforces earlier findings that the key component in these events is the evolution of stage elevation, which is not directly related to discharge. The ice out event that occurred between 8 Mar and 10 March 2009 resulted in bank full conditions, and an ice jam occurred. During this event, we collected data on the elevation of the river using two strategically placed pressure transducers during ice out which provides unique insight into how ice movement progresses. During this event, a 1.69 m rise occurred in 200 minutes (3.3 hr) or a rise of about 0.5 m per hour.

It is typical for ice jams to form on the Mohawk between the Old Burr Bridge abutments and the Rexford Knolls - the most common jam points on this entire stretch of the Mohawk. Our analysis of the historical records suggests that the Rexford knolls, a bedrock-incised part of the Mohawk channel, is a distinct and chronic jam point for ice floes.

Simulating River Ice Thickness to Provide Advance Notification of Breakup Ice Jam Potential to Emergency Managers

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

Previous studies by the Weather Forecast Office (WFO) in Albany, NY have resulted in a method to simulate river ice thickness throughout the winter. This method makes use of an equation to estimate river ice thickness found in the U.S. Army Corps of Engineers Engineer Manual 1110-2-1612. The Albany WFO was able to use river ice simulations to accurately predict the threat of significant ice jam potential during the late winter/spring of 2006-2007, despite a very late start for river ice formation. This threat was communicated to the emergency management community via seminars at local emergency management offices and fire houses. However, the emergency management community and public needs for flood services were not completely met, as we could not accurately predict the extent of flooding due to ice jams. A study from a severe ice jam flood along the Mohawk River in Schenectady, NY will be used to illustrate our methods and the shortcomings in ice jam flood prediction.

Ice Jam History, Ice Jam Mitigation Training and Ice Mitigation Efforts in WFO Albany's Hydrologic Service Area (HSA)

John S. Quinlan
NOAA/NWS, Weather Forecast Office, Albany, New York

Ice jams are a frequent occurrence in the Northeast United States and most often occur during the second half of the winter season. New York State ranks second in the nation in the total number of ice jams with only the state of Montana recording more since 1780. While freeze-up jams normally cause nuisance flooding early in the winter season, it is the break-up jams which usually occur in January, February and March that result in most of the ice jam flood events.

The National Weather Service in Albany, NY has maintained an ice jam reference for many years listing the major trouble spots on streams and rivers in eastern New York and western New England. During the last 10 years a concerted effort has been made to train emergency managers, highway departments and first responders on the favorable locations for ice jams to occur, when ice jams are expected to occur, and mitigation techniques to diminish the impact of the ice jams.

This presentation will include a history of ice jams in the Mohawk, Hudson and Housatonic River Basins, discuss the Ice Jam Training and Mitigation workshops that have been conducted in recent years, and highlight successful Ice Jam Mitigation techniques that have been used in Herkimer County.

Implementation of the Community Hydrologic Prediction System at the Northeast River Forecast Center

David R. Vallee
NOAA/NWS Northeast River Forecast Center, Taunton, Massachusetts

The Northeast River Forecast Center (NERFC) is one of thirteen national river forecast centers (RFC) which provide water resource forecast services, built upon the National Weather Service River Forecast System (NWSRFS). NWSRFS has been utilized for nearly three decades, but as demands increase for new and more complex water resource services, NWSRFS will be unable to meet these new requirements. As a result, NERFC along with three other RFCs, are leading the implementation of the Community Hydrologic Prediction System (CHPS) which will replace NWSRFS during the next two years. CHPS provides a modern service oriented architecture, which allows for a more modular software infrastructure. This design should permit easier introduction of new science into the forecasting system. This presentation will discuss the implementation of CHPS at NERFC, the national implementation plan for all thirteen River Forecast Centers, and will address opportunities which will exist for collaboration with our partners once CHPS is fully implemented.

A Review of the Precipitation Distribution Associated with the TROWAL and its Application to a New England QPF Event.

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

Precipitation distribution associated with a TROWAL is typically poorly modeled by NWP and usually is accompanied by significant precipitation. However knowledge of the structure and conceptual model of the TROWAL provides forecasters an opportunity to improve upon model QPF. In addition, applying these techniques to satellite and radar imagery can assist with enhanced short term forecasting operations. A family of new AWIPS procedures has recently become available to field offices to help forecasters diagnose the TROWAL and its associated forcing, stability and QPF distribution.

These new procedures will be demonstrated and applied to a recent TROWAL event in Southern New England, which featured a widespread modest to heavy rainfall event that was poorly modeled by most operational NWP. Unexpected pockets of one to two inches of rainfall occurred across Eastern Connecticut, Rhode Island and Southeast Massachusetts on 6 and 7 November 2008. However, through application of the conceptual model of the TROWAL and utilization of the new AWIPS diagnostic procedures, some additional insight was provided to forecasters during the event. Specifically, details on the location and magnitude of the heaviest precipitation axis along with an understanding of why one of the NWP models was generating heavy QPF across the area of interest were realized.

An Overview of an Unprecedented Flash Flood Event in Western New York

David Zaff and Tom Niziol
NOAA/NWS Weather Forecast Office, Buffalo, New York

On the evening of Sunday, 9 August 2009, a catastrophic flash flood occurred over portions of Western NY. Although numerous locations sustained damage from this event, the village of Silver Creek along the Lake Erie shoreline, and nearby Gowanda were particularly hard hit by high waters.

This event came on the heels of an unusual summer that featured generally cool and wet weather across the Northeast U.S. for June and July with a corresponding slow start to the severe weather season. However, by the end of July, the National Weather Service in Buffalo, NY (NWS BUF) recorded four tornadoes in one weekend as the synoptic pattern evolved from a persistent upper level trough in the Northeast to an upper level ridge. The term “ring of fire” is often used to describe the eventual pattern that developed, with convection making a clockwise ring around the ridge from the Gulf Coast northward toward the plains states and eventually east and southeast toward the eastern Great Lakes region.

By 9 August, increasingly warm and humid air had moved in. Summer had finally arrived with surface temperatures pushing 25˚C and dewpoints approaching 20˚C. That afternoon, a derecho moved across Western NY with numerous reports of wind damage, drenching rains, and yet another tornado embedded in the line of convection. Many areas received a solid inch of rain or more as this first line moved through, saturating the ground and increasing stream levels. Eight hours later, a second round of severe weather moved into the region. Initially, the event had similar characteristics to the severe weather that moved through earlier in the day, and numerous severe weather warnings were issued for damaging winds. As the line moved south-southeast toward southern Erie County, another east-west oriented line of storms developed further to the south over Lake Erie, and began moving east toward the same location.

The interaction of the two lines produced prolific rainfall rates. One spotter reported an astonishing 15.19 cm of rain between 1030 PM EDT and midnight. The resulting deluge turned nearly every stream into a raging river, causing catastrophic damage overnight. In Silver Creek, an entire mobile home community was destroyed. In Gowanda, two men lost their lives as a result of the disaster. It is estimated that nearly 30 percent of the homes in Gowanda were damaged. Roughly 80 percent of the roads in village will need to be rebuilt.

This presentation will look further into the meteorology behind this event, and how topography played a role. Emphasis will be placed on how a severe weather can quickly turn into a flash flood event.

The Influence of Upper-Level Sub-Synoptic Scale Potential Vorticity Disturbances on Severe Weather in the Southwestern United States

Scott Sukup, Tim Melino, Lance F. Bosart and Jamie Matusiak
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York, Albany, New York

Steven J. Weiss, Jonathan Racy, Russell Schneider and David Bright
NOAA.NWS Storm Prediction Center, Norman, Oklahoma

Erik Pytlak
NOAA/NWS Weather Forecast Office, Tucson, Arizona

During the North American monsoon (NAM) season, the southwestern United States (US), experiences episodes of severe weather and flash flooding produced by mesoscale convective systems (MCSs). MCS-related severe weather and flash flooding during the NAM typically impacts Arizona, New Mexico, southern Nevada, Southern Utah, and parts of inland southern California from early July to late September. These severe weather and flash flooding events can be difficult to forecast because they often occur in regions of weak dynamical forcing over complex terrain.

The large-scale flow pattern during the NAM typically consists of a subtropical continental anticyclone situated to the east of Arizona and New Mexico. Small variations in the position of this anticyclone govern the pathways for westward and eastward-moving sub-synoptic scale upper-level potential vorticity disturbances (PVDs). These PVDs typically originate via fracture in the subtropics from the equatorward ends of potential vorticity (PV) tails. Identifying and tracking PVDs in observations and models may prove to be a useful forecasting tool for predicting severe weather throughout the Southwest.

The purpose of this presentation is to present a severe weather and PVD climatology for the southwestern US and demonstrate that sub-synoptic scale upper-level PVDs can play an important role in organizing and maintaining MCSs and severe weather in this region. A case study from 28-29 July 2006 will be used to illustrate the influence these PVDs can have on severe weather and MCS development in the Southwest.

The Impact of Recurving Western North Pacific Typhoons on the Large-Scale Flow Pattern over North America

Heather M. Archambault, Daniel Keyser, Lance F. Bosart
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

Typhoons that recurve into the extratropical western North Pacific (WNP) can initiate or amplify Rossby wave trains that subsequently propagate along the North Pacific jet stream. Such Rossby wave trains may produce high-impact weather events and induce large-scale flow anomalies over North America that can influence the sign and magnitude of regional precipitation and temperature anomalies on intraseasonal time scales. Since the downstream flow response to recurving typhoons exhibits considerable case-to-case variability, understanding when recurving typhoons are more likely to initiate or amplify Rossby wave trains that may impact North America is a critical forecast problem.

The downstream extratropical flow response to recurving WNP typhoons is investigated through a typhoon-relative compositing study performed using Japan Meteorological Agency best-track and 2.5° NCEP–NCAR reanalysis data. Preliminary results suggest that WNP typhoons that recurve at relatively low latitudes (i.e., equatorward of 25°N) are associated with more coherent Rossby wave trains than those that recurve at higher latitudes. Such low-latitude typhoon recurvatures tend to occur in spring and late fall when the North Pacific jet stream is relatively strong and displaced equatorward, and are characterized by cyclonic, rather than anticyclonic, wave breaking activity over the North Pacific.

Decision Support Services for High Profile Events

Brandon Smith
NOAA/NWS Weather Forecast Office, Upton, New York

The National Weather Service Weather Forecast Office, New York, NY (OKX) serves one of the Nation's most densely populated areas. The New York City Metropolitan area also includes the Nation's most congested airspace and as well as a very busy maritime sector. With complex and diverse weather, it is no surprise that OKX requires a vibrant Decision Support Services Program (DSSP) capable of supporting high profile events.

The NWS provides a full spectrum of hydrometeorological information to emergency managers, law enforcement, and public officials to support their decision-making with the focus of protecting lives and property. The delivery of these services ranges from phone and internet briefings to full on-site support.

This presentation provides an overview of the DSSP at OKX and includes an explanation of specific types of services provided by the office. Specific examples presented will include the following recent high profile events:

- The Fall of 2008 Presidential Debates.
- The support of the New York City Office of Emergency Management during the Macy's Thanksgiving Day Parade, which attracts over 3 million spectators.
- Decision Support Services to the Federal Aviation Administration's New York Terminal Radar Approach Control Facility.

Lessons in Predictability: The Post Groundhog Day 2009 Storm

Neil A. Stuart[1,] Richard H. Grumm[2], and Michael J. Bodner[3]

[1]NOAA/NWS Weather Forecast Office, Albany, New York
[2]NOAA/NWS Weather Forecast Office, State College, Pennsylvania
[3]NOAA/National Centers for Environmental Prediction, Camp Springs, Maryland

In late January 2009, forecasts from deterministic models indicated the potential for a significant storm in the eastern United States on or about 3 February 2009. Forecasts from the European Center for Medium Range Predictions, the United Kingdom Meteorological Office, the National Centers for Environmental Predictions, and the Meteorological Services of Canada, deterministic models all showed a significant storm in the eastern United States from forecasts initialized at 1200 UTC 29 January.

There was considerable uncertainty with each center's track and the intensity of the storm, relative to the each other. All of these forecasts tracked the cyclone inland, with rain and potentially heavy rainfall a forecast concern in the coastal plain. To the west, snow and potentially heavy snow was a possible forecast with this storm.

Successive forecasts from most models of each center quickly backed off the from the significant storm scenario. Despite of this trend, forecasts of a potent high impact storm with heavy snow, heavy rain, and flooding had been made and presented in the media from various forecast entities.

The specific forecasts from each model showed a deep cyclone and a significant amount of precipitation. From a meteorological perspective, these forecasts provided the illusion of a significant event, and reinforced meteorological preconceptions. The individual forecasts did not convey the inherit uncertainty in the forecast. One of the significant limitations of single model solution is the illusion of certainty in what often is a highly uncertain situation.

This presentation will show forecasts associated with this storm from each centers' model. It will be shown that a "poor man's" ensemble approach and traditional ensemble forecast system output indicated the high degree of uncertainty associated with this event. This is an excellent case to demonstrate why forecasters should embrace and understand meteorological <u>and</u> uncertainty information.

Lessons in predictability: Part 2 - The March 2009 “Megastorm”

Michael J. Bodner[1] , Richard H. Grumm[2] and Neil A. Stuart[3]

[1]NOAA/NWS National Centers for Environmental Prediction, Camp Springs, Maryland
[2]NOAA/NWS Weather Forecast Office, State College, Pennsylvania
[3]NOAA/NWS Weather Forecast Office Albany, New York

On 3 March 2009, a winter storm brought heavy snow to the heavily populated corridor of the eastern United States, from Charlotte, North Carolina to Boston, Massachusetts. This storm was relatively well predicted by the forecasts from the European Center for Medium Range Predictions, the United Kingdom Meteorological Office, the National Centers for Environmental Predictions (NCEP), and the Meteorological Services Canada deterministic models. All of these models showed the potential for a significant winter storm in the medium range (days 4-7) time frame.

In addition to deterministic predictions for the storm from each center, the NCEP ensemble forecast system (GEFS) also forecasted a potentially significant snow storm. Moreover, the ensemble data also indicated considerable uncertainty with respect to storm track and the amount of potential snowfall among the various members. Despite this uncertainty of the storm projection, this storm was portrayed by some as a high impact storm and was labeled the “Megastorm” of 2009. Despite the highlighting name and the area affected and observed snowfall resulted in a low impact rating of “1” on the Northeast Snowfall Impact Scale (NESIS).

The presentation will present the forecast data used by the Hydrometeorological Prediction Center (HPC) medium range desk (days 4-7), and winter weather desk (days 1-3) for the 3 March 2009 event. The focus will be on the uncertainty information, which could have reduced any premature classification of this event, and at the same time, enhanced forecaster confidence.

Towards an Ensemble Forecast Air Quality System for New York State

Michael Erickson[1], Brian A. Colle[1], Christian Hogrefe[2,3], Prakash Doraiswamy[3], Kenneth Demerjian[3], Winston Hao[2], Mark Beauharnois[3], Jia-Yeong Ku[2], and Gopal Sistla[2]

[1] School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, NY
[2] New York State Department of Environmental Conservation, Albany, NY
[3] Atmospheric Sciences Research Center, State University of New York at Albany
Albany, New York

Air quality forecasts are important for public health and safety. The goal of this project is to develop a multi-model ensemble air quality forecast system for New York State. The ensemble is a collaborative effort between the New York State Department of Environmental Conservation (NYSDEC), SUNY Albany/ASRC (Atmospheric Sciences Research Center) and Stony Brook University (SBU), with support from NYSERDA (New York State Energy Research and Development Authority) and NYSDEC. To capture the uncertainty in air quality forecasts, the ensemble consists of a variety of atmospheric models (MM5, WRF-ARW, WRF-NMM) using varied initial conditions (GFS, NOGAPS, CMC, and NAM) and physics (convective parameterization, boundary layer, and microphysics) as well as different air quality models (CMAQ, CAMx) and pollutant emission inventories (EPA, NYSDEC). Daily forecasts can be found at http://asrc.albany.edu/research/aqf/aqvis. This talk will present some preliminary results of the air quality forecast ensemble. Results for the air quality model are verified against observations from the AIRNOW database and STN monitors. The SBU ensemble is verified against ASOS surface observations in New York State.

Preliminary modeling results for ozone and particulate matter (PM2.5) for the 2008 and 2009 warm and cool seasons are presented. The air quality model predictions track observations reasonably well for all regions in New York; however, systematic biases and underdispersion are common in the ensemble for both PM2.5 and ozone. Summer ozone is typically overpredicted by most members. It is hypothesized that the ozone overprediction during the summer of 2009 was enhanced in part by a decrease in pollutant emissions relative to the inventories available. Winter particulate matter is underpredicted for all regions in New York, except in the New York City area where overprediction is noted. The SBU ensemble is underdispersed and has systematic biases in temperature and wind speed that may be impacting the air dispersion results. Typically, the model underpredicts (overpredicts) summer temperature (wind speed), with the greatest bias occurring in the evening (morning). A post processing technique known as Bayesian Model Averaging (BMA), which weights members based on past performance while quantifying forecast uncertainty, is shown to remove the SBU ensemble underdispersion and biases. An example of BMA will be provided for the SBU ensemble, and future applications of BMA in the air quality ensemble will be discussed.

Meteorological Evolution and Model Performance for Fire Threat Days Over the Northeast U.S.

Joseph Pollina[1,2], Brian A. Colle[1], and Joseph Charney[3]
[1] School of Marine and Atmospheric Sciences, Stony Brook University, Stony Brook, New York
[2] NOAA/NWS Weather Forecast Office, Upton, New York
[3] USDA Forest Service, East Lansing, Michigan

Large wildfires are not as common over the Northeast U.S. as the western states, but they can still have a substantial impact given the large population over the Northeast. For example, the "Sunrise Fire" in the Pine Barrens region of eastern Long Island in August 1995 burned 7,000 acres, which destroyed or damaged several homes and businesses as well as 5 fire trucks. Few studies have focused on fire weather forecasting over the Northeast U.S., and there have been no formal studies of the synoptic climatology favoring Northeast fire events.

This presentation will first summarize those areas over the Northeast that have had large (> 100 acre) wildfires, such as the Pine Barrens in southern New Jersey, the lower Hudson Valley, and inland Massachusetts. Next, the common meteorological evolutions are described for 97 fire threat days from 1998 to September 2009, in which the National Fire Danger Rating System (NFDRS) had a fire danger that was "high, very high, or extreme." This was obtained using http://www.wfas.net/component/option,com_wrapper/Itemid,92/ from the Wildland Fire Assessment System (WFAS). Following a similar study over West Virginia, a classification scheme was implemented for the Northeast U.S. that describes the favored positions of the surface cyclones and anticyclones for these fire days The North American Regional Reanalysis (NARR) was used to composite the high fire threat days.

About 52% of the fire threat days occur in April (~11% in May), while there are no events during the summer. The early spring maximum is likely from the dry continental air that advects across the Northeast from Canada as well as the pre-existing surface fuels during this pre-green up period. For high fire threat days, the most common (~39%) synoptic evolution is the "pre-high," which involves a high building in from the Great Lakes and southern Canada. During these periods there is dry northwesterly flow over the Northeast, which will be shown to subside from the mid-troposphere to the boundary layer for some of these events. Additional low-level drying occurs as the air descends into the lee of the Appalachians.

The surface temperatures and winds in the Stony Brook and NCEP SREF ensembles were also verified for the fire threat days for using all NWS stations over the Northeast U.S. Both ensemble systems have a 1 to 3°C cool bias for these fire events during the day, which is 30-50% larger than all the warm season average bias. As a result, a standard bias correction using the previous 1-2 weeks does not remove most of the bias. Rather, a bias correction using the previous 5 fire weather events is shown to be far superior for surface temperatures and winds.

Evaluation of a Multi-Model Storm Surge Ensemble for the New York Metropolitan Region

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

Storm surge is a major hazard for many coastal areas, and it is often difficult to forecast given the limited numerical guidance available and the complex bathymetry near the coast. There has been limited evaluation of operational storm surge models. Furthermore, there have been no formal ensemble efforts utilizing multiple atmospheric and storm surge models. For this study, three real-time storm surge forecasting systems (8 member Stony Brook ensemble, Stevens Institute of Technology, and NOAA-extratropical surge model) were verified deterministically and probabilistically for 75 available days during the 2007-2008 and 2008-2009 cool seasons for 5 stations around the New York City/Long Island region. Some of the days with a common bias were composited using the North American Regional Reanalysis (NARR).

Stevens (SIT) has the lowest root mean square errors (RMSEs) on average, while the NOAA-ET has the largest RMSEs later in the forecast (36-48 h) as a result of relatively large negative bias. The Stony Brook storm surge (SBSS) ensemble also has a slight negative surge bias, which is not related to a bias in surface wind forcing. The negative bias for NOAA-ET and SBSS, which occurs primarily for coastal storm events, may be from running two-dimensionally and neglecting wave impacts. The SBSS ensemble is clustered together for deterministic errors, since many of the atmospheric members have a similar wind accuracy on average. Construction of the multi-model surge ensemble (ALL) using all models (8 SBSS members, SIT, NOAA-ET) improves upon the SBSS ensemble mean. A bias correction applied to the ALL ensemble (BC-ALL) also helps improve the accuracy, but the ME is slightly positive over all forecast hours.

Probabilistically, the SBSS and ALL ensembles are underdispersed and become slightly more dispersed after applying a bias correction. The inclusion of model members using different ocean models improves the Brier skill score (BSS) for positive surge thresholds. A three member ensemble (ENS-3 = SBSS control member, SIT, NOAA-ET) has a larger BSS (skill) than the SBSS and ALL ensemble; thus, illustrating the benefit of a multi-model storm surge ensemble. The bias corrected ALL and ENS-3 ensembles have a better BSS than their raw ensembles. Reliability diagrams for surge events > 0.3 m shows that the SBSS and ALL ensembles are underconfident for forecast probabilities less than 80%, so more work is needed to improve these storm surge models in these complex coastal environments. Overall, the added skill of using multiple surge models suggests that various groups (NOAA and universities) should all help provide operational model guidance rather than forecasters just utilizing any one storm surge system.

Developing Better Forecasts: An Analysis of Two Storms During Summer 2009 Using the High Resolution WRF Model and Observations on July 7 and August 18

E. Novakovskaia
IBM, Yorktown Heights, NY

B. Hertell
Consolidated Edison, New York, NY

In recent years, there have been a number of severe summer weather events causing a very localized and significant impact within the greater New York City metropolitan area and in Westchester County, NY. During the last summer season, the NWS Forecast Office in Upton, NY added the storms on July 7, 2009 and August 18, 2009 to their list of high-impact weather events for the region. These storms took place in densely populated urban areas and resulted in losses and damages to residential, commercial, and public infrastructure. They also disrupted vital operations including services of local utility companies.

A detailed analysis of such events is important both for understanding of the complex atmospheric dynamics and for decision making, emergency response and preparedness, and planning for storm recovery actions. Typical near-surface observing networks do not provide complete information on the multi-faceted aspects of severe weather events that is needed for allocation of resources with sufficient lead time. The availability of highly localized numerical weather predictions is especially critical for storm analysis. To support decision making for many weather-sensitive operations such as emergency management by municipal and state government agencies and private transportation and utility companies, an operational mesoscale prediction system, called "*Deep Thunder*", has been developed at the IBM Thomas J. Watson Research Center. It is implemented and applied to business problems in a number of metropolitan areas in the US, including New York City.

In this presentation we examine the weather factors surrounding the two storm events: the thunderstorm microburst on July 7, 2009 in southern Westchester County, NY and the straight-line wind event on August 18, 2009 in the Bronx and Central Park. We discuss the operational high-resolution WRF model "*Deep Thunder*" forecasts at 2 km horizontal resolution, available sounding data, as well as surface observations from the network of WeatherBug stations operated by AWS Convergence Technologies. To assess the uncertainties in high-resolution mesoscale forecasts, we utilize ensemble-based probabilistic predictions suitable for risk analysis, and examine the most extreme and damaging scenarios. Multiple forecast realizations in the ensemble are created using a variety of physical process schemes within the WRF-ARW model and the same initial and boundary conditions. Our analysis indicates that for highly localized severe weather events the numerical simulations and especially ensemble-based forecasting systems bring additional value for timely optimization of business operations, allocation of resources, their routing and deployment scheduling.

A Climatology of Convective Types over the Northeast U.S: Ambient Conditions and the Role of the Appalachian Lee on Initiation

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

Convection over the Northeast is modified by the Appalachian terrain and cool Atlantic coastal waters. The impacts of the terrain and marine air on the evolution of the organizational structures of convection have not been quantified over the Northeast. This presentation will highlight the modification of convective structures (initiations and evolutions), focusing on the ambient conditions that support these structures. Particular attention is placed on the Appalachian lee (e.g., PA and NJ) in the initiation of convection, since this is a region of enhanced convective activity.

Different convective structures over the Northeast were identified for two warm seasons (2007 and a random warm season from 2002-2006). This involved manually examining 15-minute 2-km NOWrad radar imagery and classifying the convection into three types of cellular convection (individual cells, clusters of cells, and broken lines), five types of quasi-linear systems (bow echoes, squall lines with trailing stratiform rain, lines with leading stratiform rain, lines with parallel stratiform rain, and lines with no stratiform rain), and nonlinear systems. The spatial initiation of each convective element was documented according to 4 geographically determined domains (upslope, high terrain, coastal plain, coastal ocean) and the time of initiation was recorded. To understand the ambient conditions that support these structures, 29 days were selected in which there was a clear dominant structure (cellular, linear, nonlinear). The ambient thermodynamic conditions and dynamical forcing for each event were calculated. To determine the role of the Appalachian lee on convective initiation, 69 events were selected in which convection developed exclusively within the Appalachian lee. These events were classified according to 4 synoptic surface regimes: lee troughs, propagating troughs/fronts, onshore flow, uniform wind. Using NARR composites, the ambient conditions responsible for convective initiation in each of the 4 regimes were examined.

Cellular convection over the Northeast initiates over the high terrain during the early afternoon, but over the coastal plain there is favored genesis from the early afternoon into the evening. Days favoring cellular convection have surface based CAPE values from 1000 to 2500 J kg^{-1}, but little low- to mid-level forcing. Linear days have similar CAPE, but slightly higher precipitable water values compared to cellular days (41 mm vs. 36 mm respectively). Linear systems form under moderate forcing (i.e. 850 hPa warm air advection, 500 hPa positive vorticity advection, 950 hPa frontogenesis). Nonlinear days have little or no surface based CAPE, a weak dependence on moisture (precipitable water values from 16 to 50 mm), and the strongest synoptic forcing of the 3 categories. Convection forming within Appalachian lee initiates primarily between 1500-1800 UTC. About 40% of these events occurred with a propagating trough or front, as instability develops in the lee. About 20% were associated with stationary lee troughs, 25% with onshore flow (including sea breezes), and 12% with no surface wind boundaries.

Wind Channeling in the St. Lawrence River Valley: Synoptic Patterns, Local Conditions, and Operational Forecasts

Alissa Razy, Eyad Atallah, John Gyakum
Department of Atmospheric & Oceanic Sciences, McGill University, Montreal, Quebec, Canada

Winds blowing in the St. Lawrence River Valley (SLRV) are prone to channeling along the valley axis, which is generally oriented northeast/southwest. Channeling refers to processes that force the wind to blow along a valley's axis, regardless of the wind direction above ridge height (Kossmann and Sturman 2003). The island of Montreal, the most populated city in the SLRV, sits in a slightly bent section of the valley that runs northeast/west-southwest. To better understand channeling effects, surface data from Trudeau Airport in Montreal (YUL) of observed winds is being studied in conjunction with data derived using the North American Regional Reanalysis produced by the National Center for Environmental Prediction.

Carrera et al. (2009) present preliminary conclusions concerning the physical processes associated with winds channeled in the SLRV, but note that further investigation is required. In particular, there is a need to classify conditions that lead to various situations of channeled winds (or lack thereof) in order to improve accurate forecasting of potentially damaging weather events (e.g. freezing rain, wind forecasting for aviation purposes, improved precipitation prediction including mesoscale banded precipitation forecasting). Accordingly, the work presented here builds on the work of Carrera et al. (2009) by identifying characteristic patterns at the local, mesoscale and synoptic scales that accompany various wind regimes. Specifically, we will be examining weather conditions at these scales for given pairings of ranges of geostrophic wind directions (based on mean sea-level pressure) with resulting clusters of observed wind directions.

Interestingly, despite the prevalence of clear channeling effects in the SLRV, there are also periods of sustained cross-valley winds (e.g. southeasterly winds). The preliminary work presented here indicates that the same synoptic systems will generate different local wind regimes – both channeled and cross-valley winds. The direction of sustained local flow depends on the nature of the pressure and temperature gradients at the SLRV, and on the atmospheric stability. Taking into account all these factors provides insight that can help improve operational wind forecasts.

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Northeast Convective Flash Floods: Helping Forecasters Stay Ahead of Rising Water

Joseph P. Villani
NOAA/NWS Weather Forecast Office, Albany, NY

Derek V. Mallia
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

Flash flooding (FF) is a common occurrence in the Northeast during the late spring and summer months. Days when FF associated with deep, moist convection occurs can be difficult to forecast, especially when determining whether the outcome will be widespread or isolated FF. There are many factors that contribute to FF, with both hydrologic and meteorological components. The main goal of this research is to better anticipate the meteorological environments that produce FF, especially during the watch phase of an event (typically 12-24 hours preceding FF). Another objective is to identify factors that may help forecasters distinguish days with widespread FF as opposed to isolated FF.

Twenty FF events within the Albany County Warning Area (CWA) during the warm seasons (May-September) of 2005-2009 were investigated. FF events associated with tropical systems were not included in this study. Events were classified by the dominant synoptic scale feature in place when FF occurred. Also, various sounding-derived parameters were compiled and will be shown for each event. Composites for select synoptic scale features were plotted and stratified by days with widespread FF vs. days with isolated FF.

Results indicated little difference for most parameters comparing days with widespread FF vs. isolated FF. The maximum 0-3 km winds were somewhat stronger for widespread events (average of 21 kts for widespread compared to 17 kts for isolated), but little else yielded concrete results. However, notable signatures were evident in some composite plots of synoptic scale features, including 250 hPa zonal mean wind, 500 hPa geopotential height anomaly, and 850 hPa meridional wind anomaly. These signatures will be shown in the presentation.

Initial results have shown a strong relationship between cut-off lows and widespread FF. Also, based on observed sounding data preceding FF, most events exhibited a veering wind profile in the lowest 3 km and unidirectional flow in the 3-6 km layer. Other findings will be presented as well, including observations from storm-scale analyses of all 20 FF events.

The Northeast Convective Flash Flood Project: July 29th 2009 Flash Flood Case Study

Derek V. Mallia
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

Joseph P. Villani
NOAA/NWS Weather Forecast Office, Albany, New York

The July 29th 2009 Flash Flood event was one of most significant single day flash floods to affect the Albany County Warning Area (CWA) this decade. Five counties across the CWA had rainfall totals exceeding 3 inches in 7 hours. The flash flooding transformed many small creeks into raging rivers that closed or washed out several roads and threatened the lives of local residents who were forced to evacuate their homes. The counties hit hardest by the flash floods were Saratoga, Columbia, Rensselaer, Berkshire, and Greene County.

The mesoscale and synoptic features that played a role in the July 29th flash flood event were the divergence associated with right entrance region of the 250hPa jet, 500hPa shortwave trough and cyclonic vorticity advection, and 850hPa theta-E advection. These features were analyzed using the Rapid Update Cycle (RUC), Geostationary Operation Environmental Satellite (GOES), and the KENX Albany radar using the Advanced Weather Information Processing System (AWIPS) and Four Dimensional Storm Investigator (FSI).

Key features from this event were compared with the other events researched in the Northeast Convective Flash Flood Project. The July 29th atmospheric parameters were also compared with composites of all warm season flash flood cases between 2005 and 2009, along with composites of widespread cases and isolated cases. Conclusions have been made regarding the ability to predict widespread flash flood or isolated flash flood based on the parameters investigated in this project, and will be shown in the presentation.

An Examination of the March 1-2, 2009 East Coast Gravity-Wave Using High-Resolution Operational Data Sets

Alan M. Cope
NOAA/NWS Weather Forecast Office, Mount Holly, New Jersey

The East Coast winter storm of March 1-2, 2009 was accompanied by a large-amplitude inertia gravity wave which developed near the Virginia-North Carolina border during the evening of March 1 and moved northeast to southern New England by the morning of March 2. This gravity wave was typical of other such events discussed in the literature, in that it formed in a cool stable ducting layer beneath an inversion, pole-ward of a modest (~1002 hPa) surface low and associated frontal boundary, and also beneath an advancing upper-level jet streak and an area of upper-level divergence near the inflection point in the 300 hPa height field. The wave propagated northeast at an average speed of around 35 kt (18 m/s), and was associated with surface pressure falls up to 8 hPa in less than 30 minutes. Surface wind gusts of 45-55 kt (23-28 m/s) combined with very heavy snow produced numerous reports of downed trees and power lines, causing loss of electric power to about 60,000 customers in NJ and Delmarva early on the morning of March 2.

The gravity wave passed over several of the National Weather Service's WSR-88D radars, in particular KDOX (Dover, DE), from which high-resolution reflectivity and velocity data were obtained. The wave's radar reflectivity signature included a narrow line of enhanced echoes (up to about 50 dBZ) centered at 4-5 kft (1.2-1.5 km) AGL, but reaching no higher than about 7 kft (~2 km) AGL. The radar velocity signature appeared first as a maximum of outbound (NE) winds approaching from the southwest prior to local wave passage, then as a maximum of inbound (NE) winds receding to the northeast following the passage. Vertical cross sections of velocity showed a maximum of at least 65 kt (33 m/s) at around 1.5 kft (0.5 km) above the surface.

Another interesting aspect was the presence of a distinct forecast signal in the NCEP operational model runs prior to the event, particularly in the 12-km NAM-WRF. Although details of the gravity wave's timing, location and structure were not precisely forecast, a definite signal was present in the forecast MSLP pattern as well as the pressure-change fields. Operational NWS forecasters on duty were able to recognize the event as it occurred and mentioned it in several statements and forecast discussions.

The conference presentation will show more details of the gravity wave signatures in the pressure, wind and precipitation fields using high-resolution radar imagery, satellite imagery, 1-min ASOS observations, and other relevant data. Also, the large-scale environment in which the gravity wave occurred will be further examined, along with the operational mesoscale model forecasts.

An Application of a Cutoff Low Forecaster Pattern Recognition Model to the 30 June - 2 July 2009 Significant Event for the Northeast

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

Matthew A. Scalora, Lance F. Bosart, and Daniel Keyser
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

Cutoff lows remain a challenge to operational forecasters. Predicting the potential for severe weather, flooding, heavy precipitation, or non-impact sensible weather relies heavily on the track of a cutoff low, shear and instability profiles down stream, and various synoptic and mesoscale meteorological parameters. The Collaborative Science Technology and Applied Research (CSTAR) program has studied warm season cutoff lows impacting the Northeast for nearly a decade. Most recently, results have yielded an expanded precipitation climatology with cutoffs in the months of May to September across the Northeast, as well as five key patterns of cutoffs based on the tilt of the longwave 500 hPa trough. These five distinct patterns examine lower-, middle-, and upper-level synoptic and mesoscale features such as temperature and moisture profiles, low-level jets and mid- and upper-jet streaks associated with the cutoff and the sensible or extreme weather it produces.

A Great Lakes cutoff low impacted the Northeast from 29 June to 2 July 2009. On the 30 June the cutoff resembled a neutral tilt “Type A” pattern developed in CSTAR. Over 40 severe weather reports of damaging winds in excess of 50 knots (58 mph), and large hail (greater than 1.9 cm) occurred from Pennsylvania and New Jersey northeast into New York and New England. The majority of the severe reports were large hail. The severe convection was focused ahead of a surface trough and a potent short wave trough rotating around a strong 500 hPa cutoff low, meandering eastward across Michigan. Strong differential cyclonic vorticity with a potent upper level jet streak helped initiate the severe convection with steepening mid-level lapse rates, lowering wet bulb zero heights, appreciable instability (surface based convective available energy of 1000-2000 J kg^{-1}), and low level moisture (precipitable water values of 2.5-4.0 cm) in place.

The following day less severe weather occurred (less than a dozen reports) across NY and New England with the cutoff, but significant flash flooding occurred across east central NY. Plenty of heating coupled with anomalously high precipitable water values (one to three standard deviations above normal), and channeled deep tropospheric southerly flow produced training flash flooding thunderstorms with hourly rainfall rates exceeding 5 cm. Again, an application of the CSTAR neutral tilt “Type A” pattern fit the scenario for the flash flood and minor severe event.

This talk will take a multi-scale approach utilizing the cutoff low pattern recognition schematic or model for the event from the synoptic-scale to the mesoscale, in order to understand the convective environments that produced the severe weather and flash flooding. There will be a heavy emphasis on the utilization of observational data to find clues that led to the active weather with the Great Lakes warm season cutoff low.

Analysis of Precipitation Distributions Associated with Two Cool-Season Cutoff Cyclones

Melissa Payer, Lance F. Bosart, and Daniel Keyser
Department of Atmospheric and Environmental Sciences
University at Albany, SUNY, Albany, New York

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

Forecasting precipitation distributions associated with 500 hPa cool-season cutoff cyclones can be a challenge in the Northeast. Current numerical weather prediction models often have difficulty predicting the track, intensity, and location of cutoffs in the region, given that cutoff cyclones are generally slow moving and interact with the complex topography in the Northeast. This presentation will focus on two case studies of cutoffs where precipitation distributions proved to be difficult to forecast: 8–9 March 2008 and 2–3 February 2009.

Cutoffs were identified using four-times daily 1.0° GFS analyses for the five cool seasons (1 October–30 April) from 2004/05 through 2008/09. A cutoff cyclone was defined as a 30-m geopotential height rise in all directions at 500 hPa for at least three consecutive analyses (i.e., over a 12-h period). Precipitation distributions were determined using 6-h National Precipitation Verification Unit Quantitative Precipitation Estimates. A cutoff was associated with heavy precipitation if at least 25 mm of precipitation fell over the Northeast in a 24-h period from 1200 UTC to 1200 UTC. Standardized anomalies of fields such as precipitable water, 850 hPa winds, and 500 hPa geopotential heights were created with respect to climatologies generated from 2.5° NCEP–NCAR reanalysis data.

Numerical models showed considerable variability in forecasting the 8–9 March 2008 cutoff 3–8 days prior to the event with uncertainty in the timing, track, and intensity of the surface cyclone. Numerical model forecasts confined the heavy precipitation (>25 mm) to coastal regions; however widespread heavy precipitation was observed throughout much of the Northeast. The heavy precipitation was collocated with strong cyclonic vorticity advection associated with an elongated lobe of cyclonic absolute vorticity east of the cutoff. Advection of Atlantic moisture by the low-level jet contributed to +2 to +5 standard deviation (SD) precipitation anomalies for this event.

The 2–3 February 2009 cutoff was considered a forecast bust for the Northeast. Heavy precipitation (>25 mm) was forecast to occur with this event; however most locations received less than 5 mm. Numerical models exhibited large disagreement in the speed and track of the cutoff, which directly impacted forecasts of precipitation type and amount. Several factors were unfavorable for heavy precipitation in the region, including upper-level forcing for ascent associated with a 250 hPa jet, as well as the development of surface thermal boundaries, both of which were located off the coast. Standardized anomalies of precipitable water were small, between +0.5 and +1 SD, at locations along the coast where the highest amount of precipitation (~10 mm) was observed.

Cool-Season High Wind Events in the Northeast

Jonas V. Asuma, Lance F. Bosart, Daniel Keyser
Department of Atmospheric and Environmental Sciences
University at Albany, State University of New York,Albany, New York

John S. Quinlan, Thomas A. Wasula, Hugh W. Johnson, Kevin S. Lipton
NOAA/NWS Weather Forecast Office, Albany, New York

Forecasting high winds events, especially those with a convective component, during the cool season (defined here as October through April) can be challenging for NWS forecasters in the Northeast. On average, the Northeast experiences approximately 23 high wind events per cool season, 13 of which have a convective component. The purpose of this presentation is to provide insight into the frequency of cool-season high wind events in the Northeast and to determine the mean synoptic environment of the event types.

High wind reports in the Northeast from 15 October 1993 through 31 December 2008 were extracted from the NCDC storm report database and stratified into three categories of events: hybrid (contains both gradient and thunderstorm wind reports), pure gradient (contains only gradient wind reports), and pure convective (contains only thunderstorm wind reports). A total of 358 high wind events were identified of which 158, 156, and 44 were in the hybrid, pure gradient, and pure convective categories, respectively.

For each event type, composite averages of mean sea level pressure, geopotential height, temperature, precipitable water, and wind were calculated from the NCEP–NCAR reanalysis. These composite analyses were centered on the location of the initial storm report in the Northeast. On average, the locations of the hybrid and pure convective composite cyclone are to the north of the initial storm report, whereas the location of the pure gradient composite cyclone is to the east of the initial storm report. Relative to the pure gradient composite, low-level winds tend to be more southerly near the location of the initial storm report in the hybrid and pure convective composites, leading to more moist profiles. Pure convective events tend to have the most moisture, whereas pure gradient events tend to have the least. Likewise, lifted index profiles show that pure convective events tend to be the least stable, whereas pure gradient events tend to be the most stable. Relative to the pure convective composite, both hybrid and pure gradient composites exhibit more amplified upper-level wave patterns.

Synoptic Environments Associated with Predecessor Rain Events in Advance of Landfalling Tropical Cyclones

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

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

Predecessor rain events (PREs) are distinct mesoscale regions of heavy rainfall that develop approximately 1000 km poleward and in advance of landfalling and recurving tropical cyclones (TCs) and approximately 24–36 h before the passage of the main rain shield of the TC. PREs develop as a continuous poleward stream of deep, tropical moisture emanating from the TC encounters a region of atmospheric lifting to produce heavy, prolonged rainfall. PREs present a forecast challenge because they have the potential to cause significant inland flooding, given that they are characterized by large rainfall totals (>100 mm in 24 h).

While most PREs exhibit similar synoptic-scale characteristics (e.g., anomalously high precipitable water values, formation in an equatorward jet entrance region), these events can vary considerably with respect to their location relative to the parent TC. Additionally there is considerable variability in the structure, intensity, and longevity of PREs. This physical and spatial variability is largely dependent on different synoptic-scale flow patterns in which PRE-producing TCs are embedded. To investigate their preferential synoptic environments, PREs occurring during 1988–2008 are categorized based on whether the parent TC had yet recurved at the time of PRE initiation. PREs are classified as either pre-recurvature (the TC had not yet recurved at the time of PRE initiation) or post-recurvature (the TC had already recurved at the time of PRE initiation). TC-relative composite analyses, conducted using the 2.5° NCEP–NCAR reanalysis, suggest coherent synoptic-scale environments for each category. While composites for pre-recurvature and post-recurvature PREs indicate the importance of an upper-level jet, thermal advection, and low-/mid-level frontogenesis, the location, orientation, and magnitude of these key features differ markedly between the two categories. Our results are suggestive of two distinct flow patterns favoring PRE development.

The purpose of this presentation is to document key synoptic-scale features in the environments of PREs occurring before and after the parent TC recurves in order to establish distinctive scenarios favorable for the PRE development. This objective will be accomplished by: (1) identifying, through composite analysis, key physical and dynamical mechanisms characterizing each PRE category, and (2) illustrating these mechanisms through brief case analyses of PREs associated with TC Frances (2004) and TC Rita (2005).

A Comparison of Predecessor Rainfall Event Development with Tropical Cyclones Danny and Bill from the 2009 Season

Michael L. Jurewicz, Sr.NOAA/NWS, Weather Foreacst Office, Binghamton, NY

Predecessor Rainfall Events (PREs) are phenomena which feature areas of heavy rainfall (at least 4 inches (100 mm)) that form well in advance of Tropical Cyclones (TCs). Although PRE existence is tied to that of the TC, they remain distinct from the TC's main precipitation shield. Mean separation distances between PRE centroids and the circulation centers of TC are around 1000 km. On average, it takes about 36 hours for a TC to reach the latitude of where the PRE occurs.

Although 2009 was a below average year for TC development in the Atlantic Basin, two TCs (Danny and Bill) tracked close enough to the United States in a favorable large-scale pattern, so that PREs were observed.

On Aug. 15, Tropical Storm Bill formed in the central Atlantic. By Aug. 21, Bill intensified into a major hurricane, well east of the Carolinas, before eventually weakening and recurving into the westerlies, offshore from New England and the Canadian Maritime provinces. While Bill was tracking northward on Aug. 22, approximately 800 km southeast of Cape Cod, bands of heavy rainfall developed over portions of eastern New York and New England. One particular band dropped up to 5 inches (125 mm) of rain on southern New Hampshire during the afternoon and evening of Aug. 22, resulting in flash flooding.

On Aug. 26, Tropical Storm Danny formed just east of the Bahamas. Danny also tracked northward offshore of the U.S. East Coast, before ultimately weakening as it turned into the westerlies, well east of the Mid-Atlantic region. During the overnight and early morning hours of Aug. 29, while Danny was well off the coast of South Carolina, bands of very heavy rainfall appeared to impact an area just east of the New Jersey shoreline. Radar estimates indicate that 8 to 10 inches (200-250 mm) of rain were produced by these bands.

In both aforementioned instances of heavy rainfall, downstream ridge amplification and associated upper-tropospheric jet modification, as well as significant deep-layered moisture contributions from the vicinity of each TC suggested that PRE dynamics were at play. In advance of Danny, this presentation will also theorize as to why PREs were not more prevalent across much of the Mid-Atlantic and Northeastern states.

Predecessor Rain Events Ahead of TC Ike and TC Lowell on 11–14 September 2008

Lance F. Bosart, Thomas J. Galarneau, Jr., Jason M. Cordeira, and Benjamin J. Moore
Department of Atmospheric and Environmental Sciences, University at Albany, State University of New York, Albany, New York

All-time record 24-h rainfall totals were recorded at Lubbock, Texas, Wichita, Kansas, and Chicago, Illinois, between 11–14 September 2008 in conjunction with multiple predecessor rain events (PREs). These multiple PREs fed off of middle- and upper-level moisture transported northeastward ahead of eastern North Pacific tropical cyclone (TC) Lowell, lower-level return-flow moisture transported northwestwards up the Rio Grande River Valley in conjunction with a retreating weak frontal boundary along the coast of the northern Gulf of Mexico, and tropospheric-deep moisture transported northwestward and northward ahead of TC Ike in the Gulf of Mexico. The associated trifecta of moisture flux sources enabled tropical moisture flux convergence to be concentrated along a band that stretched from the Big Bend region of Texas northeastward to the western lower Great Lakes between 11–14 Sep.

The multiple PREs that formed along the aforementioned band of moisture flux convergence resulted in widespread flooding, and are the focus of this presentation. Diagnostic quantities were computed using the 0.5° NCEP GFS gridded analyses to help elucidate the physical processes important in organizing the multiple PREs. The results of the diagnostic calculations suggest that: 1) the return flow of tropical moisture up the Rio Grande River Valley, in conjunction with deep warm-air advection beneath the equatorward entrance region of a weak subtropical jet, helped to trigger initial PRE development over Texas, 2) the arrival of tropical moisture from TC Lowell contributed to new PRE development over Kansas and Missouri in conjunction with low- and mid-level frontogenesis in an environment supportive of training echoes, and 3) the ingestion of deep tropical moisture from TC Ike and continued frontogenetical forcing for ascent along an intensifying frontal boundary over Kansas, Missouri, Iowa, and Illinois beneath the equatorward entrance region of a diabatically enhanced jet culminated in a major PRE in the vicinity of the western lower Great Lakes.

Acknowledgements

Eugene P. Auciello
For Inspiring the Creation of the Northeast Regional Operational Workshop in 1999
For a decade of support of NROW
His dedication and support to collaborative operational research between the National Weather Service and Universities

Department of Atmospheric and Environmental Sciences
University at Albany
National Weather Service Albany
Conference Facilities at Alumni House

Peggy Kelly
Hotel & Travel Coordination

Alan Robock, Todd Lerichos, Chris Bouck, Lance Bosart, Robert Kilpatrick
Northeast Regional Operational Workshop Preprint Cover Images
(Clockwise from upper left)

Warren R. Snyder
Northeast Regional Operational Workshop Coordinator
Northeast Regional Operational Workshop Preprints
Northeast Regional Operational Workshop Preprint Cover Design

Capital Region of New York Chapter of American Meteorological Society
Snacks & Refreshments

Vasil Koleci & Ingrid Amberger
Web Team