Multifaceted General Overview of the East Central Florida Tornado Outbreak of 22-23 February 1998

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1. Introduction

During the late night and early morning hours of 22-23 February 1998 (Sunday-Monday), the most devastating tornado outbreak ever to occur in the state of Florida, in terms of both loss of life and property damage, occurred within the National Weather Service Office in Melbourne's (NWS MLB) county warning area. Forty-two people died as a result of the tornadoes and more than 260 others were injured. While outbreaks of strong and violent tornadoes have been documented on occasion in central Florida over the past 100 years, the high death toll was unprecedented. In addition, over 3,000 structures were damaged, while more than 700 were completely destroyed. A total of seven confirmed tornadoes occurred during the night (Fig. 1) approximately between 11 pm and 230 am. Four of these (South Daytona, Winter Garden, Sanford, and Kissimmee) produced long damage tracks of 8, 18, 14, and 38 statute miles respectively, resulting in the majority of damage and all fatalities.

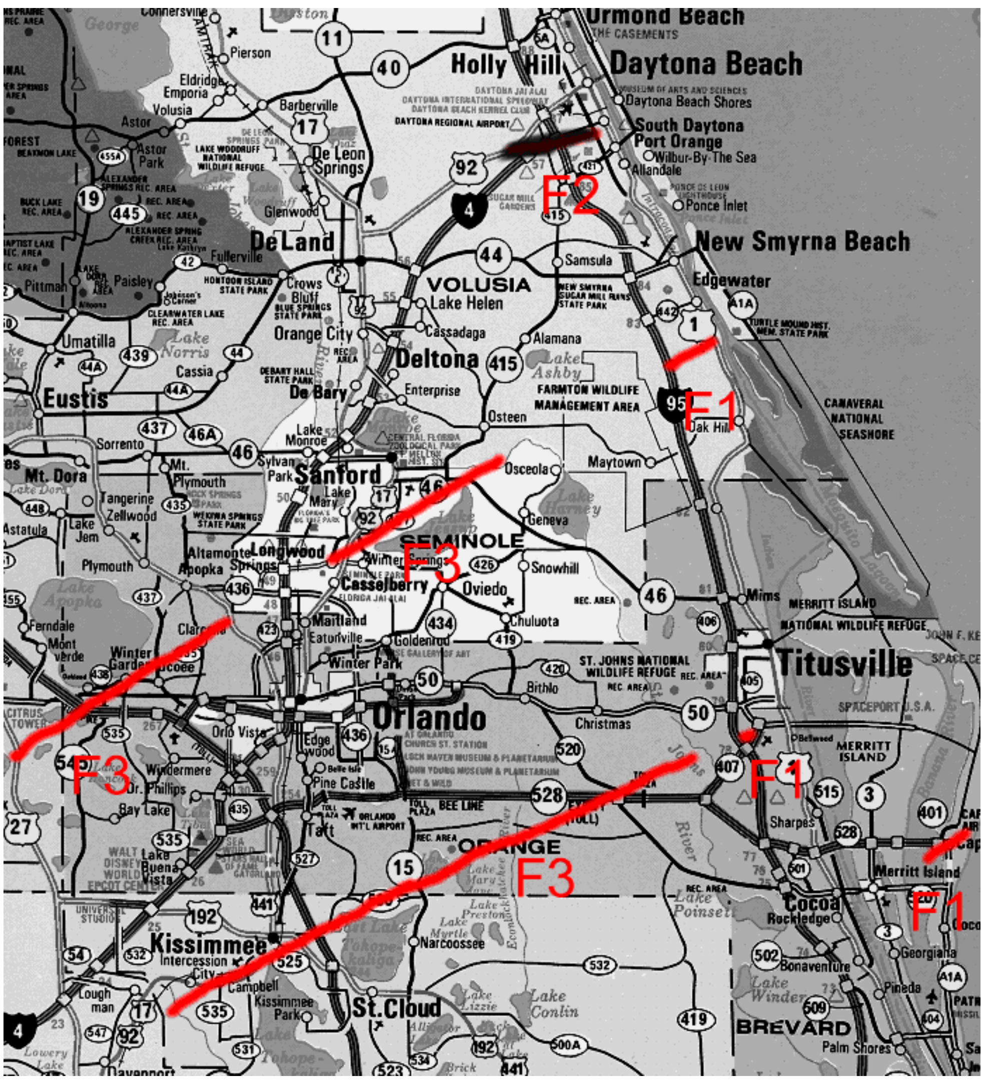

Figure 1. The respective damage paths of the seven tornadoes which occurred during the 22-23 February 1998 tornado outbreak over east central Florida.

Official Service Assessment has estimated three of these tornadoes to have reached F-3 intensity on the Fujita scale with estimated wind speeds around 200 mph (NOAA NWS, 1998). Before sunrise that morning, it was evident that this event was of historical significance (Fig. 2).

PUBLIC INFORMATION STATEMENT
NATIONAL WEATHER SERVICE MELBOURNE FL
600 AM EST MON FEB 23 1998

...EAST CENTRAL FLORIDA TORNADO OUTBREAK POSSIBLY THE MOST DEVASTATING IN THE HISTORY OF FLORIDA...

PRELIMINARY REPORTS OF OVER 20 FATALITIES OBTAINED FROM NEWS REPORTS IN THE AFTERMATH OF THE TORNADO OUTBREAK THAT STRUCK EAST CENTRAL FLORIDA LATE SUNDAY NIGHT AND EARLY THIS MORNING INDICATE IT MAY BE THE DEADLIEST IN FLORIDA HISTORY. THE ONLY COMPARABLE OUTBREAKS ARE THE TORNADO OUTBREAK OF MARCH 31ST 1962 THAT KILLED 17 PEOPLE IN SANTA ROSA COUNTY AND THE TORNADO OUTBREAK OF APRIL 4TH 1966 THAT KILLED 11 PEOPLE IN HILLSBOROUGH AND POLK COUNTIES.

Figure 2. The Public Information Statement issued by the National Weather Service in Melbourne emphasizing the magnitude of the tornado event.

This ***poster*** will present aspects of the outbreak, beginning with a review of previous local research concerning favorable outbreak conditions and the link between El Nino and extreme Florida tornado outbreaks. These studies were used well ahead of the event to inform the public and emergency management community of the greater than normal threat for significant winter and spring tornado outbreaks, and to posture the local NWS for such occurrences.

The NWS MLB also had real-time access to a multitude of data including experimental radar and lightning workstations throughout the event, enabling a more thorough assessment of individual tornadic supercells. Radar reflectivity and velocity images during various stages of maturity of each associated storm will be illustrated and compared to concurrent damage photos on the actual poster. Trends of mesocyclone and tornado vortex parameters will be presented in relationship to tornado occurrence and parent circulation occlusion cycles The utility of the National Severe Storms Laboratory (NSSL) Warning Decision Support System (WDSS) algorithms will be discussed, specifically the Tornado Detection Algorithm (TDA), which will be available on the official operational system during later this year. Unique Total Lightning Information (TLI) signatures will address the horizontal, vertical, and temporal nature of the electrical discharges associated with the tornado-producing cells.

2. Past Research

Recently, local research has better defined the character and climatology of peninsular Florida tornado outbreaks and their variability (Hagemeyer, 1997). Comparisons and brief case studies of outbreak-types were previously investigated with the intention of providing comprehensive understanding and improvements in forecasting such outbreaks. Additional local research also explored the potential for significant tornado occurrences in Florida during strong El Nino events (Hagemeyer, 1998). It was concluded that during strong El Nino events, the mean position of the southern branch of the winter/spring jet stream is centered much farther south than normal over the Gulf of Mexico and Florida peninsula, and is stronger than normal. This tends to bring greater vertical shear over central Florida and increases the chance that a dynamic environment favorable for significant tornado occurrence will exist over the area. During December 1997, the state of Florida (emergency management) was apprised of this finding in preparation of the 1997-98 winter/spring season with respect to heightening severe weather awareness.

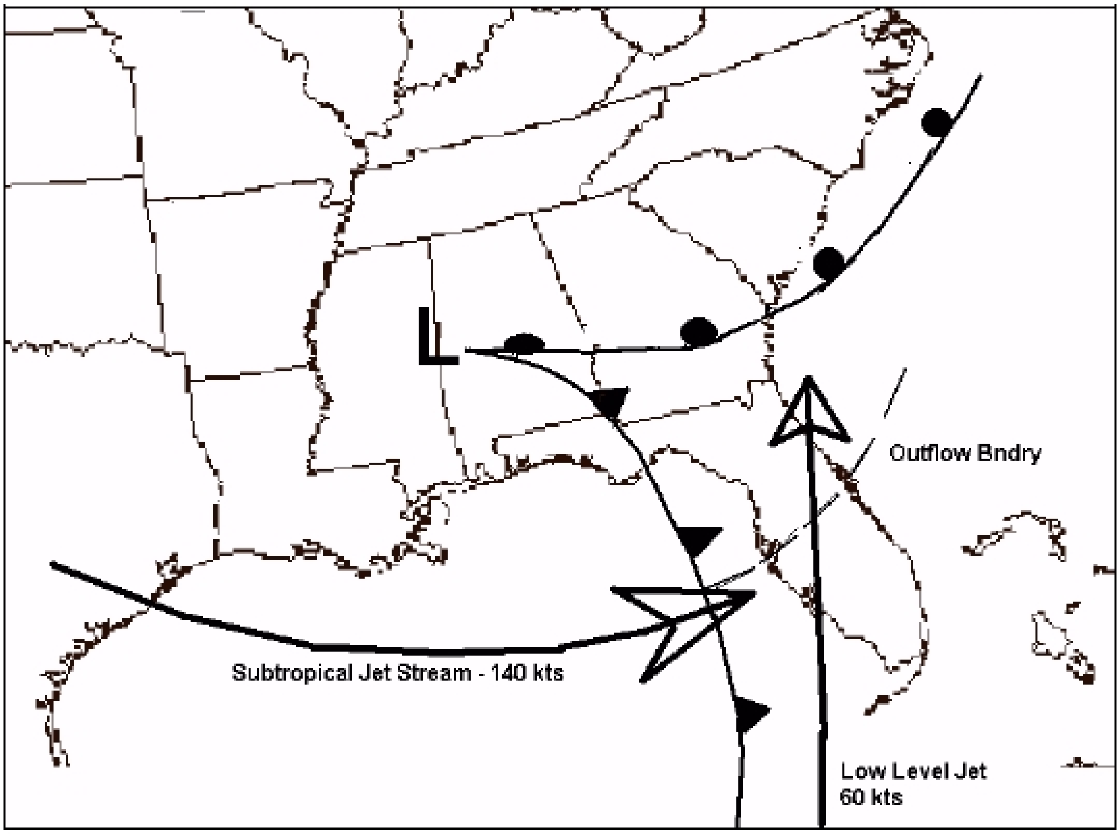

Figure 3. Synoptic situation, 7p.m. EST, February 22, 1998. Depiction taken from the NOAA NWS Service Assessment Report.

During the evening of February 22, the synoptic situation (Fig. 3) supported the potential for a severe weather outbreak over Florida and was remarkably similar to the mean pattern as conceptualized by Hagemeyer. A strong upper trough associated with a 140 kt jet streak was approaching the peninsula from the west. A surface low was located over Alabama, trailing a cold front over the eastern Gulf of Mexico with the warm front located north of the area. This left the peninsula in the warm and unstable sector in the presence of a developing nocturnal low-level jet with wind speeds greater than 50 knots just above the surface.

3. Anticipation of Tornado

With recently gained insights relating to Florida tornado outbreaks fresh in the minds of MLB forecasters, the annual training session (local) was conducted in December 1997 instead of early February. The training was centered around radar analysis techniques for the detection and manual assessment of mesocyclones and tornadic mesocyclones. Many of the techniques which have been taught and endorsed by the Operational Support Facility (OSF) were emphasized, but accented with local research results and experience. Training examples were confined to WSR-88D KMLB data. An internal intranet web site (Fig. 4) was prepared which made it possible to exploit the "Tornado Warning Guidance" document comprised of preliminary results of the National Severe Storms Laboratory (NSSL) from project *VORTEX*. The document was modified to better apply to the east central Florida environment. The emphasis was placed on the higher probability of occurrence situations of radar observed supercells with respect to low-level radial convergence, boundaries, magnitude of

TORNADO WARNING GUIDANCE

Origin & Application: The following "Operational Resource" is taken from the document TORNADO WARNING GUIDANCE which was distributed by the OSF (1997). It is based on the preliminary results of NSSL from Project VORTEX. This particular resource concentrates on tornadoes associated with mesocyclones (supercells). Tornadoes associated with non-supercells and tropical cyclones are not specifically addressed within this document.

This document was modified by the SOO/MLB to better apply to the east central Florida environment.

Number 1: ***Low-Level Radial Convergence***
Number 2: ***Cold Air & Boundaries***
Number 3: ***Changes in Near-storm Environment***
Number 4: ***Lag Time***
Number 5: ***Not All Tornadoes Form the Same Way***
Number 6: ***Absence of Classic Radar Signatures***
Number 7: ***Assumed Motion of the Tornado***
Number 8: ***Use All Information - Storm Spotters***
Number 9: ***Lack of Damage Reports***
Number 10: ***Storm History***
Number 11: ***Broader Areas of Cyclonic Circulation***
Number 12: ***Maximum Rotational Velocity***
Number 13: ***Low-Level Shear***
Number 14: ***Mesocyclone Strength Nomograms***
Number 15: ***Radar Observance of TVS***

Figure 4. Example of intranet web page developed at NWS MLB available as a training resource or operational guide. Examples are particular to the east central Florida environment and the WSR-88D KMLB radar.

rotational velocity, and low-level shear of the core mesocyclone. This "living document" remained available as a training resource and operational guide and was placed on the forecast floor. Forecasters were acute to looking for concentrated mid-level mesocyclone cores and assessing the magnitude of low-level rotational velocity and low-level shear. During the outbreak many of the storms possessed rotational velocities in excess of 45 kts (Fig. 5) and low-level shears greater than 0.015 s-1.

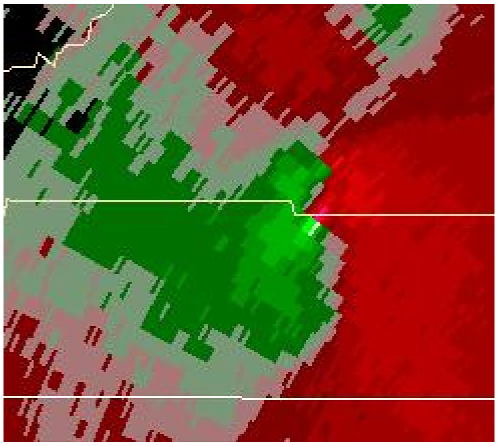

Figure 5. Storm relative velocity depiction at 0.5 degrees elevation of the mesocyclone and associated TVS with the Kissimmee storm after it crossed into Orange County. Rotational velocities were in well excess of 45 kts and low-level shear much greater than 0.015 s-1.

As the event began, numerous developing supercells were embedded within an approaching (broken) squall line which was moving into a higher theta-e environment. Storms which seemed to rapidly organize were slightly out front of the others with unobstructed inflow. New storms formed on the southwest end of the line and rapidly moved northeast at 50 kts. The first tornado (F2) occurred in south Daytona Beach around 1055 pm and was associated with a long-track mesocyclone which was first detected in Sumter County over one hour earlier. This tornado resulted in 1 fatality and 3 injuries. The second tornado (F3) formed over south Lake County and quickly moved into west Orange County through the town of Winter Garden around 1150 pm where there were 3 fatalities and 70 injuries. This cyclic storm later achieved tornado two more times moving through the town of Sanford at 1215 am (F3) killing 13 and injuring 36 and then over east Volusia County (F2) with no deaths or injuries. The Kissimmee tornado (F3) occurred around 1250 am and had the longest track. This tornado killed 25 people and injured more than 150 where numerous casualties occurred in the Ponderosa RV park in Kissimmee. This storm also recycled to produce and F1 tornado in north Brevard County around 138 am but with no casualties. Later, a brief F1 touched down again in north Brevard County near Port Canaveral at 230 am and also resulted in no casualties. The poster will show the individual tornadic supercells and the respective radar parameter trends.

4. Experimental Data

There was considerable experimental data available during the event. The WDSS workstation was available most of the time and provided value-added information to warning forecasters. The NSSL tornado algorithm performed very well (Fig. 6) scoring a probability of detection near 100 percent.

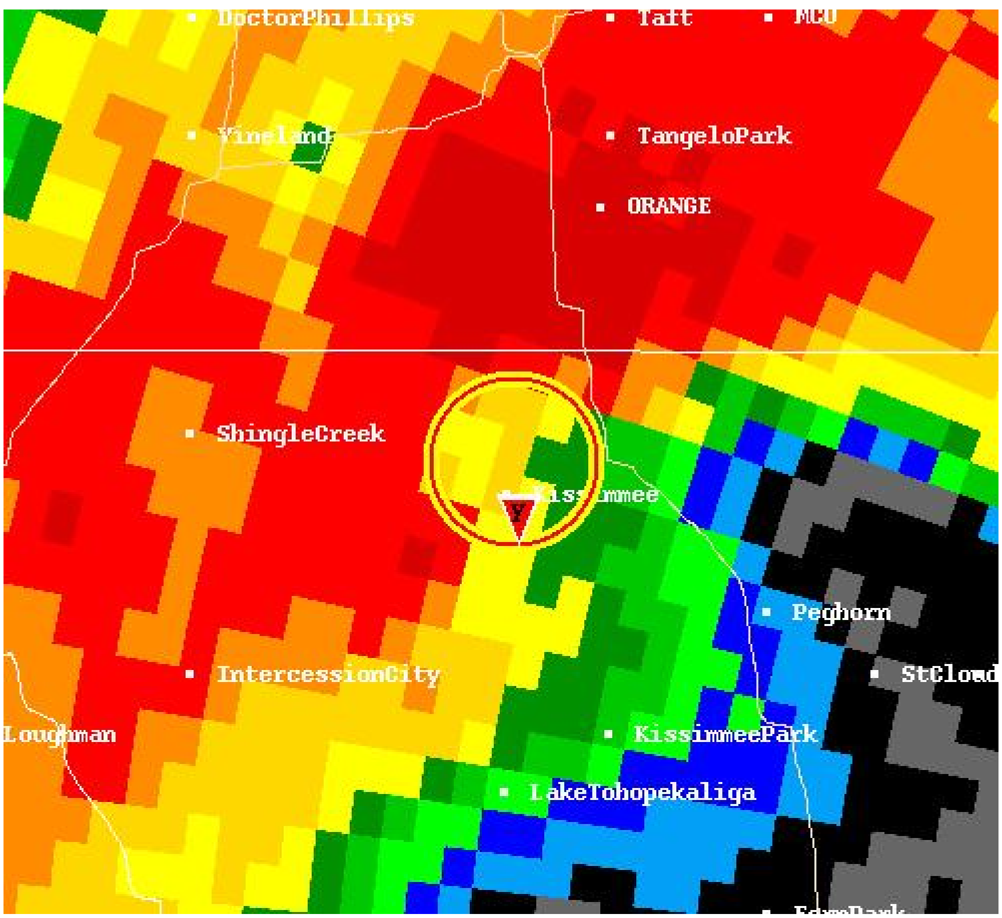

Figure 6. Example of the success of the new NSSL tornado detection algorithm on the WDSS.

At this time the false alarm ratio had not been calculated. However, when compared to the current tornado algorithm available on the operational system, it was far superior since the current algorithm only produced one tornado detection on one scan. Also available during the event was an experimental lightning workstation which overlays total lighting information with radar information (Fig. 7). Several of the tornadic storms were found to have flash rates as high as 400 fpm with rapid rate increases. Also, signals were present that may lead to rapid rate decreases which could identify the collapse of the updraft and bounded weak echo region.

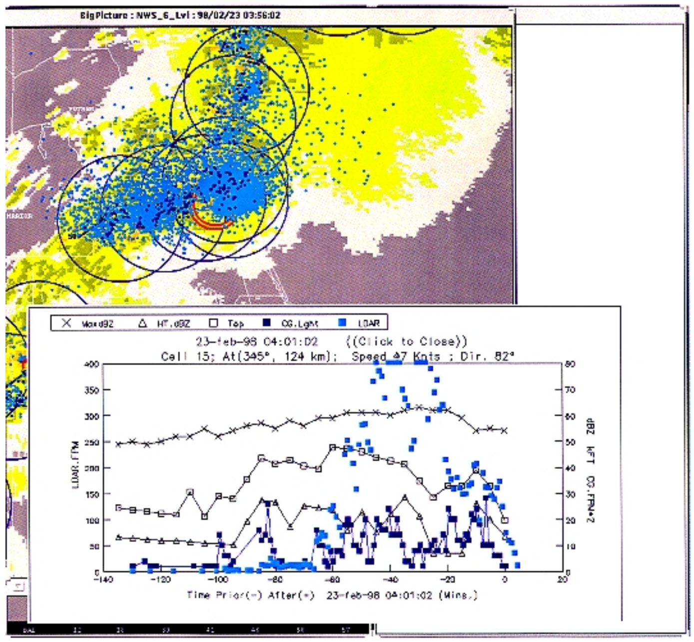

Figure 7. Example of the LISDAD workstation output for the Daytona Beach tornado. Please refer to other papers in this volume which fully describe this work.

5. Summary & Conclusions

Greater detail and examination of this event will be available on the actual poster. Also, check out our web site at ***http://sunmlb.nws.fit.edu***.

Thursday, 22 October 1998

8:00 AM *Internet Map Briefing*

SESSION X - SEVERE STORMS

Session Chair: Rodger A. Brown, NOAA/National Severe Storms Laboratory, Norman OK

8:15 AM What is the Typical Structure of the Mesocyclone, A Rotating Updraft or a Baroclinic System?: Leslie R. Lemon: Lockheed Martin Ocean, Radar & Sensor Systems, Independence MO

8:30 AM Mesoscale Boundaries and the May 27, 1997 Tornadic Storm as Seen in AWOS and ASOS Data: Lon Curtis, KWTX-TV, Waco TX

8:45 AM The Merits of Storm Relative Layer Calculations in Determining Near-storm Environment Parameters: Gregory J. Stumpf: NOAA/NSSL and Cooperative Institute for Mesoscale Meteorological Studies, Norman OK; and Richard L. Thompson, NWS/Storm Prediction Center, Norman OK

9:00 AM A New Look at the Super Outbreak of April 3-4, 1974: Dan McCarthy, NWS/Storm Prediction Center, Norman OK, Jack Kain, NOAA/National Severe Storms Laboratory/Cooperative Institute for Mesoscale Meteorological Studies, Norman OK, and Mike Baldwin: General Sciences Corp., Norman OK

9:15 AM A Multifaceted Review of the East Central Florida Tornado Outbreak of 22-23 February 1998: David W. Sharp, Scott M. Spratt, Anthony Cristaldi, and Bartlett C. Hagemeyer, NWS Forecast Office, Melbourne FL

9:30 AM The Impact of Regional Evapotranspiration on Thunderstorms on the Canadian Prairies: James Cummine and R.L. Raddatz: Prairie and Northern Region Environment Canada, Winnipeg, Manitoba

9:45 AM A Comparison of Meteorological Conditions Associated with Strong and Violent Tornado Episodes Involving the Occurrence and Non-Occurrence of Large Hail: Paul R. Janish, John A. Hart, and Robert H. Johns: NWS/Storm Prediction Center, Norman OK

10:00 AM *Coffee Break*

SESSION XI - RADAR METEOROLOGY *(PART 2)*

Session Chair: Leslie R. Lemon: Lockheed Martin Ocean, Radar & Sensor Systems, Independence MO

10:30 AM The Alabama Killer Supercell of 8 April 1998: Kevin J. Pence, Christopher A. Liscinsky, and Ronald A. Murphy: NWS, Birmingham AL

10:45 AM Tornadogenesis Associated with the 1 July 1997 Derecho - A Radar Perspective: Gregory A. Tipton, NWS Wilmington OH; and Eric D. Howieson, NWS, Tulsa, OK

11:00 AM Performance of the WSR-88D Build 10 Tornado Detection Algorithm: Adaptable Parameter Sensitivity Studies: Robert R. Lee, NWS WSR-88D Operational Support Facility, Norman OK

11:15 AM Improved WSR-88D Detection of Mesocyclone and Tornadic Vortex Signatures: Rodger A. Brown and Vincent T. Wood, NOAA/National Severe Storms Laboratory, Norman OK

11:30 AM "Rapid Update" of Radar-Derived Severe Weather Algorithms: Amy Lee Wyatt, E. DeWayne Mitchell, Gregory J. Stumpf, Arthur Witt, and Michael Lehmann, National Severe Storms Laboratory/Cooperative Institute for Mesoscale Meteorological Studies, Norman OK

11:45 AM Evaluation of a Modified WSR-88D Volume Coverage Pattern for Use in Severe Weather Situations: Janelle M. Janish, Rodger A. Brown, and Vincent T. Wood, Cooperative Institute for Mesoscale Meteorological Studies/National Severe Storms Laboratory, Norman OK

12:00 PM *Lunch*

SESSION XII - TRAINING, EDUCATION, AND RESEARCH *(PART 2)*

Session Chair: Gail Hartfield: NWS Forecast Office, Raleigh NC

1:30 PM AWIPS Centralized User Training: Operations and System Management: Christy Roach and Corey Lefkov, Litton PRC Inc., McLean VA

1:45 PM AWIPS On-Site User Training: Christy Roach and Matt Kensey, Litton PRC Inc., McLean VA

2:00 PM Development of a Prototype AWIPS Operational Data Repository System: Joan M. Brundage, Leslie A. Ewy, Glen F. Pankow, Amenda B. Stanley, and Susan M. Williams, NOAA Forecast Systems Laboratory, Boulder CO

2:15 PM Meted: A New Website for Meteorology Education and Training: Timothy Spangler, Joseph Lamos, Julee Syverson, Dennis Ward, Susan Jesuroga, and Greg Byrd, UCAR/COMET, Boulder CO

2:30 PM Coach: Design and Implementation of an Operational Performance Support System at the Tulsa NWS Forecast Office: Steve E. Nelson and Lans P. Rothfusz (NWA Secretary), NWS, Tulsa OK; Christopher Jacobson, NWS Corpus Christi TX, and J.T. Johnson, NOAA/National Severe Storms Laboratory, Norman OK

2:45 PM Warning Coach: Design of a Storm-Scale Operational Support System: R. Jason Lynn and J.T. Johnson, NOAA/National Severe Storms Laboratory/Cooperative Institute for Mesoscale Meteorological Studies, Norman OK

3:00 PM *Coffee Break*

SESSION XIII - QUANTITATIVE PRECIPITATION FORECASTING/HEAVY RAINFALL

Session Chair: Rod Scofield: NOAA/NESDIS, Camp Springs MD

3:30 PM Interactive Software for Probabilistic Quantitative Precipitation Forecasting: Theresa Rossi, NWS Forecast Office, Pittsburgh PA, and a past-president of the NWA; and Roman Krzysztofowicz, University of Virginia, Charlottesville VA

3:45 PM Results From the First Quantitative Precipitation Estimation (QPE) Workshop: James Gurka, Dr. Thomas Graziano, and Dr. Stephan Smith: NOAA/NWS/Office of Meteorology, Silver Spring MD

4:00 PM An Analysis of a "Synoptic Type" Heavy Rainfall Event: Influence of the Right Entrance Region of an Upper Level Jet Streak: James T. Moore, Stephen R. Considine, Patrick S. Market, and Scott Watson, St. Louis University, St. Louis MO

4:15 PM Significant Rainfall Climatology for Missouri and Southern Illinois: Steven R. Considine and James T. Moore, St. Louis University, St. Louis MO.

4:30 PM WSR-88D Precipitation Estimates Using the Tropical Z-R Relationship During Six Heavy Rainfall Events Across Southeast Texas and Southern Louisiana: Robert Darby, NWS, Lake Charles LA