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Partners or Cooperative Project: COMET Outreach Project

Project Title: Enhanced Observations to Improve the Forecasting and Warning of Damaging Freezing Precipitation Events in Western North Carolina

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Section 1: Summary of Project Objectives

The primary COMET Outreach Partner Project (Sounding-based Experiment on Mixed Precipitation Events, SEMPE) objective was to take observations of vertical profiles of temperature, moisture, and wind during synoptic events that were favorable for mixed precipitation (any combination of snow, sleet, and freezing rain) in order to provide more information about the nature and evolution of the cold air damming that leads to significant freezing precipitation accumulations near the mountains of western North Carolina.

The observational study focused on the evolution of the vertical profile of temperature, moisture, and wind for a single location south or east of Asheville, North Carolina during several potential mixed precipitation events spanning from December 2006 through April 2007. The study addressed two of the highest priority items for research as listed by the NWS Office of Science and Technology (http://www.comet.ucar.edu/outreach/part.htm):

- The effect of topography and other surface forcing on local weather regimes
- Locally hazardous weather, especially severe convection, winter weather, and phenomena that affect aviation

Along with addressing two NWS priority items, the study also served to improve the quality of education for the undergraduate students enrolled at the University of North Carolina Asheville (UNCA) through the increased awareness of the NWS operational problems and needs and through the direct involvement of research in conducting the soundings and in analyzing the event case studies.

The collection of observations over western North Carolina for research and real-time operational purposes presented an excellent opportunity for model validation of the operational NAM and of local workstation mesoscale models (e.g., WRF). The high

temporal resolution of the soundings has provided a good data set to compare against the model output, including the BUFR soundings.

Section 2: Project Accomplishments and Findings

Table 1: SEMPE Intensive Observation Periods (IOPs) during the 2006, 2007 cool season.

IOP	Date (2007)	Purpose	Soundings (UTC)
1	9 Jan	NW flow snowfall	1810
2	18 Jan	Mixed precipitation	1018, 1155, 1424
3	21 Jan	Mixed precipitation	1352, 1555, 1801, 2045
4	1 Feb	Mixed precipitation	1102, 1301, 1507, 1701, 1846
5	4 Apr	Mntn squall line	0536, 0723, 0843
6	15 Apr	Strong winter storm	1647, 1851, 2059, 2308
7	16 Apr	Strong winter storm	0056, 0249, 0455
8	17 Apr	PBL study	1440, 1558, 1752, 2001
9	20 Apr	PBL study	1355, 1552, 1803, 2006

The final listing of the $SEMPE_{0607}$ IOPs is provided in Table 1 and illustrates the unique challenge facing the PIs during the past cool season. Three of the nine IOPs sampled the target synoptic event (mixed precipitation storms), primarily a consequence of a warmer-than-normal winter for the southeastern United States. As the original experiment deadline approached (28 Feb 2007), it was apparent that the actual number of planned IOPs would fall far short of the goal (seven) if the original target synoptic event was strictly followed. In consideration of opportunities that often occurred for the southeastern U.S. in March and April, the decision was made to extend $SEMPE_{0607}$ until 30 April 2007. The extension of the experiment allowed the sampling of the downstream side of a decaying squall line as it moved across the southern Appalachian Mountains, sampling of a winter storm that had strong winds and caused significant damage in the Asheville region, and sampling of the evolution of the planetary boundary layer under nearly clear sky conditions in collaboration with a fire weather study guided by Dr. Brian Etherton at the University of North Carolina Charlotte along with Larry Lee and Mike Cammarata of the NWS.

One of the student researchers supported by the COMET Outreach Partner Project has been able to analyze in depth the 1 February 2007 (IOP-4) SEMPE case study. Comparisons were made between the SEMPE vertical profile observations and forecasts from the GFS, NAM, and RUC simulations within the 24-h period preceding the event. Results from the study have been communicated via a seminar at the Greenville-Spartanburg NWS office in July 2007 and during a presentation at the 12th AMS Conference on Mesoscale Meteorology in August 2007 (Miller and McCall 2007). Work will continue on this case study through the Undergraduate Research Program at UNCA and future findings will be communicated at a seminar at UNCA in October 2007, at the National Conference on Undergraduate Research in the spring 2008, and in an article to be submitted to an AMS journal.

A presentation was made describing the status of the SEMPE program on March 21, 2007 at the 13th Annual Mini-Technical Conference in Columbia, SC which publicized the availability of data from the experiment to personnel from surrounding NWS offices along with researchers at the Savannah River National Laboratory and with researchers at universities located in the North and South Carolina region.

Section 3: Benefits and Lessons Learned: Operational Partner Perspective

In spite of the mild winter weather, the IOPs produced useful data for operations and interesting data for research. For example, an IOP was declared on 18 January 2007 when a weak low pressure system moved across the southeastern states while cold air damming existed in the Carolinas and Virginia. The real time upper air data from the serial SEMPE radiosonde releases were used by the forecasters at WFO Greenville-Spartanburg (GSP) to monitor the progress of lower tropospheric warming that was forecast by the operational models. The ability to validate the numerical models in this particular case was important because temperatures in the vicinity of 850 mb were forecast to gradually increase causing the light precipitation to transition from snow to mixed precipitation to rain. Examination of the SEMPE data from this IOP will result in an informative case study that provides forecasters with insight into the infiltration of cold air through the Swannanoa Valley into the Asheville area during cold air damming events.

Preliminary results from examination of the 1 February 2007 event (IOP-4) have provided forecasters with an initial look at factors that are likely to explain why the numerical model guidance overestimated precipitation amounts in the mountain valley where Asheville is located. Similar occurrences have been noted in the past when accumulations of ice and snow in close proximity to the city have been much less than numerical guidance indicated. Forecasters at WFO Greenville-Spartanburg have now been introduced to the "bowl" hypothesis which states that under certain circumstances cold air pooling in the valley can inhibit moistening of the near surface air as precipitation spreads across the mountains.

The IOPs provided forecasters with real-time upper air data in the Asheville area for the first time since the modernization of the National Weather Service was completed. This information was used operationally during each IOP to compare the actual temperature, moisture, and wind profiles with the corresponding numerical model output. The closest upper air station (Greensboro, NC) is somewhat distant from the mountains so the SEMPE soundings furnished a detailed look at the character of the atmosphere in the Swannanoa Valley. An understanding of flow through the Swannanoa Valley is important because it is one of the key avenues through which cold air enters the Asheville area during cold air damming events. In the 18 January 2007 example cited above, forecasters at WFO GSP were able to validate the model forecasts of warming just above the valley floor that subsequently reduced the threat of freezing and frozen precipitation.

The active collaboration between the NWS and UNCA has promoted interest among UNCA students in seeking volunteer opportunities at WFO GSP. During the summer of 2007, three students from UNCA occupied summer volunteer positions.

Section 4: Benefits and Lessons Learned: University Partner Perspective

The primary beneficiaries of the SEMPE program have been the research students directly involved in making the weather balloon launches, collecting the data, and posting the data. The students have had a unique opportunity to understand the logistical, scientific, and operational challenges in making weather observations in adverse conditions. They have seen firsthand how observations can be impacted by systematic and random errors and how this error can inhibit the interpretation of

atmospheric structures. Finally, the students have gained an appreciation of operational forecasting challenges impacting Western North Carolina and the difficulty in understanding how the weather is evolving when so much of the atmosphere is unobserved. Much more will be learned as the data analysis phase continues over the current academic year.

The primary challenges during the experiment were (1) the lack of cooperation from Mother Nature, (2) difficulties in retrieving winds using the LORAN-C method, and (3) determining a reliable method to plot and post the data using the internal networks of two different universities.

The first challenge was avoided by sampling other types of weather events as described in Section 2 above. The second challenge was overcome by placing each sonde on a ladder with the LORAN antenna wire stretched out along the ladder well before launch time. This enabled the local LORAN station chain to get a "lock" on the sonde signal and winds were then capable of being retrieved from the surface up to very high altitudes. The third challenge was overcome using software on the SEMPE laptop to create the plots (one of the students modified a MATLAB program to create Skew T plots posted on the SEMPE web page http://www.unca.edu/weather/) and using secure shell FTP software (SFTP) to transfer the plot and modified SEMPE web page from behind the firewall at Warren Wilson College to the UNCA-based SEMPE web page.

Section 5: Publications and Presentations

Moore, P. D. and L. G. Lee, 2006: Typical cold air damming scenarios for western North Carolina. Seminar at UNCA, Asheville, North Carolina, October.

Miller, D. K., 2007: Status report on the Sounding-based Experiment on Mixed Precipitation Events (SEMPE) 2006-2007. 13th Annual Mini-Technical Conference, Columbia, South Carolina, March.

Miller, D. K. and C. J. McCall, 2007: Impact of the Southern Appalachian Mountains on the SEMPE IOP-4 event. Seminar at the GSP NWSFO, Greer, South Carolina, July.

Miller, D. K. and C. J. McCall, 2007: Impact of the Southern Appalachian Mountains on the SEMPE IOP-4 event. 12th Conference on Mesoscale Processes, American Meteorological Society, Waterville Valley, New Hampshire, August.

Section 6: Summary of University/Operational Partner Interactions and Roles

The steps in having a successful SEMPE program required a planning meeting between researchers at UNCA and GSP personnel in August 2006 at the UNCA campus, a seminar about cold air damming given by GSP personnel at the UNCA campus in October 2006, and a training exercise in November 2006 to familiarize the five SEMPE research students with the proper procedures for conducting a weather balloon launch.

Over the course of the SEMPE program (1 December 2006 start date), the PIs (Lee and Miller) conducted conference calls when conditions seemed favorable for the potential occurrence of a mixed precipitation event. Once a decision had been made to conduct an IOP, the SEMPE research students, area researchers, and area NWS forecasters were notified via email of the pending availability of data associated with the SEMPE weather balloon launches.

Once a SEMPE IOP was underway, weather balloon data were shared directly with forecasters at GSP via email to the lead forecaster and also were made available to the general public via the posting of data to the SEMPE data web page (http://www.unca.edu/weather/). The local airport control tower (AVL) was notified via a phone call before each balloon launch. Communication between forecasters at GSP and SEMPE research students was maintained via email to determine if conditions warranted additional balloon launches. Once a consensus was reached that a particular weather event had ended, the determination was made to end the corresponding IOP.

The following responsibilities were defined in the proposal stage and were mostly executed during the SEMPE field phase:

UNCA tasks during the field program:

- establish data feed from Perry Farm instruments to UNCA (*not* completed)
- weekly conference calls with GSP forecasters (completed)
- deploy soundings during IOPs (completed)
- upload text sounding files to UNCA-ATMS web page (completed)

WFO GSP tasks during the field program:

- watch for favorable mixed precipitation conditions 48-h in advance of event (completed)
- weekly conference calls with UNCA researchers (completed)
- provide weather guidance to UNCA sounding team during IOPs and modify observing plan, if necessary (completed)
- download text sounding files from UNCA-ATMS web page (completed)
- update weather forecasts and discussion, if necessary (completed)

and the partners have been successful in accomplishing these goals, with the exception of getting a real-time data feed from the Perry Farm instruments to UNCA. We have access to this data in research mode (non real-time) through our collaboration with Dr. Sandra Yuter at NC State University and Dr. Baker Perry at Appalachian State University.

Section 7: Acknowledgements

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