10.10 AN OVERVIEW OF SURFACE TRANSPORTATION WEATHER RESEARCH CONDUCTED THROUGH THE COOPERATIVE PROGRAM FOR OPERATIONAL METEOROLOGY, EDUCATION AND TRAINING (COMET)

Paul Pisano*
Federal Highway Administration, Road Weather Management Program, Washington, DC

Dr. Tim Spangler
Cooperative Program for Operational Meteorology, Education and Training, Boulder, CO

Dawn Hardesty
Mitretek Systems, Inc., Center for Information & Telecommunications Technology, Washington, DC

1. INTRODUCTION

State Departments of Transportation (DOTs) operate over 1,300 fixed Environmental Sensor Stations (ESS) that provide information to support surface transportation decisions. Fixed and mobile ESS observations include parameters such as road temperature, road surface conditions, driving visibility, and chemical concentrations that depress road freezing points. In addition, fixed ESS sites typically measure winds, temperature, pressure, precipitation amounts, and humidity, which can be valuable supplemental observations for weather forecasting.

In 2001, the National Weather Service (NWS) and the Federal Highway Administration (FHWA) began a joint research effort to evaluate how ESS data can best be used for both road condition forecasting and broader weather forecasting. One of the goals of the project is to promote sharing and using ESS observations and advanced meteorological modeling techniques to improve road condition forecasting for road maintenance, operations, and travel decisions. Project goals also include enhancing the NWS forecasting capabilities by setting up and analyzing high-resolution mesoscale and regional scale simulations.

In order to accomplish goals, the project has established cooperative working relations between state DOTs, the university community, and local NWS Weather Forecast Offices (WFOs). Working through the Outreach Program of the Cooperative Program for Operational Meteorology, Education and Training (COMET), a request for proposals was issued and five universities received FHWA funding for two-year projects to work on a variety of research subjects. This paper will describe the five research projects and their results to date, one year into the two-year efforts. The five projects selected are located in Iowa, Nevada, New York, Pennsylvania, and Utah.

2. PROJECT OVERVIEWS

2.1 Improved Frost Forecasting Through Coupled Artificial Neural Network Time Series Prediction Techniques and a Frost Decomposition Model

* *Corresponding author address:* Paul Pisano, Road Weather Management Program, 400 7th Street, S.W. Washington, DC 20590; paul.pisano@fhwa.dot.gov

At Iowa State University, several research efforts have been taking place using Road Weather Information System (RWIS) data from sensors deployed along roads. In the late 1990's, RWIS data from five sites over three winter seasons were used to test a frost deposition model (Knollhoff 2000). The model was shown to possess useful skill when values of air temperature, dew point, wind speed, and road surface temperature from archived RWIS observations were used as inputs (perfect forecast), with verification using yes/no frost observations collected by the Iowa Department of Transportation maintenance garages. During the winter of 2001-02, the frost model was tested for Ames, Iowa using RWIS observations, contracted agency forecasts, and Mesoscale Model 5 (MM5) model predictions as inputs. The RWIS observations were from a site approximately 10 km away from the bridge where verification was performed. Reasonably successful forecasts were obtained using the RWIS data, although some false alarms and missed events were noted, possibly due to small-scale variability in the atmospheric parameters (conditions differed at the bridge from those valid at the RWIS site), and the presence of residual anti-icing chemicals on one or two occasions. Forecasts from the contracted agency were found to have the least skill, with raw MM5 output yielding surprisingly good forecasts. At the present time, work is ongoing to train a neural network system to predict the parameters needed for input in the frost deposition model. The neural network is being trained on three years of Nested Grid Model – Model Output Statistics (NGM-MOS) forecasts and 111 parameters from the RWIS instruments for four sites across Iowa: Waterloo, Des Moines, Mason City and Ottumwa. Two-meter temperature and dew point, five m wind speed, and road surface temperature will be predicted every 20 minutes over the period 1800 LST to 0900 LST using separate neural network models. It is anticipated that the neural network will help establish relationships between predicted NGM-MOS parameters and RWIS observations, yielding improved forecasts over those obtained using MOS output alone, or raw MM5 output.

In addition to the use of RWIS information in the creation of a time-series predictive system coupled with the frost deposition model, work has been ongoing to compare the representativeness and accuracy of the

RWIS measurements with those from automated surface observing systems (ASOS) and automated weather observing systems (AWOS) stations in Iowa. These efforts have been assisted in this regard by the establishment of the Iowa Environmental Mesonet (IEM) project. RWIS observations are being merged with ASOS and AWOS reports and presented in real time via web pages supported by the IEM group (see http://mesonet.agron.iastate.edu).

Real-time comparisons of the data types are also being performed, and some long-term statistics have been computed. In general, it seems the RWIS data tends to have slightly higher dew point readings in the overnight hours as compared with ASOS data, whereas the reverse is true during the daytime hours. A detailed comparison of RWIS and ASOS temperatures from January 1 through September 10, 2002, at three sites where the instruments were in close proximity (within 15 km) suggests that the lack of aspirated thermometers in RWIS sensors results in a noticeable high bias in temperature readings during periods of light winds. When winds are around three knots or less, RWIS temperatures average one to three degrees F warmer than ASOS readings. Because lighter winds typically occur from early evening until around sunrise the following morning, the temperature differences are generally restricted to this period. The high bias in RWIS temperatures and dew points at night may adversely affect frost models that make use of this information.

2.2 Development of an Interactive Mesonet for PENNDOT

Under the cooperative agreement sponsored by COMET and FHWA, the State Climate Office at Penn State University along with the NWS Office in State College (CTP) have collected data from the Pennsylvania Department of Transportation's (PennDOT) RWIS network since May 2001. In all, over 80 sites (see figure 1) have reported with a frequency as often as every 30 minutes. The RWIS sensors are strategically located to assist PennDOT in their Total Storm Management Program. Each of PennDOT's 11 districts uses the data to plan their response to hazardous winter weather.

The agreement focused on several aspects of developing a working partnership between the three groups. Initially, the climate office developed a storage and retrieval system for all RWIS data as well as a quality control routine. During this time, the NWS tested the incorporation of RWIS data into their Advanced Weather Interactive Processing System (AWIPS) for enhancement of winter weather warnings. PennDOT was given feedback on the quality and frequency of the atmospheric portion of RWIS data to insure the best reports. Together the partners conducted an intensive winter weather training session in October 2002 with virtually all DOT districts participating to raise their awareness of data and forecast information availability to the DOT road crew managers. The final phase involves the completion of the data interface, the determination of microclimate regimes, and their effects on local forecasts and assistance in placement and upgrades to the current RWIS network.

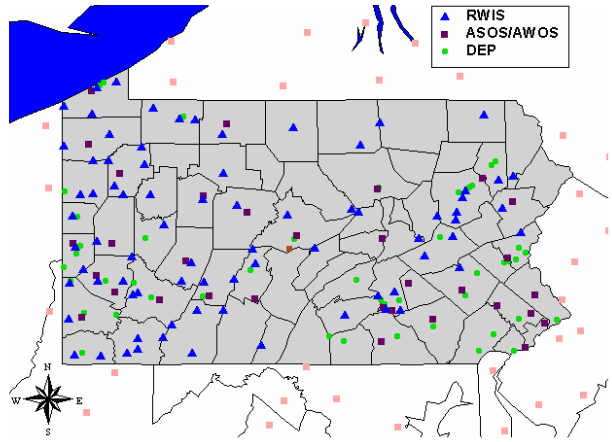

Figure 1. Locations of RWIS, ASOS/AWOS and DEP stations

2.3 Use of Road/Weather Information System in the Improvement of Nevada Department of Transportation Operations and National Weather Service Forecasts in the Complex Terrain of Western Nevada

The main goal of the project is to improve mesoscale forecasts of weather phenomena as well as pavement temperature in complex terrain by using real-time data and mesoscale models. The specific objective of this project was to investigate the use of data from the Nevada Department of Transportation (NDOT) operational network to improve MM5 forecasts of meteorological fields in the complex terrain of northern Nevada. The study focused on analysis and modeling of an intense snowstorm that occurred in California and Nevada from March 7 - 9, 2002. This case has been simulated with the Desert Research Institute (DRI) operational version of MM5 with two model grids. The coarse grid has an 18 km horizontal resolution and covers the entire western US, while the nested grid has a 6 km resolution and covers all of Nevada and part of California. The simulation used the global data network for initial conditions and Eta model results for boundary conditions. This simulation represents a baseline model run. In order to improve the model results, data from the NDOT stations has been assimilated into MM5 using a Four Dimensional Data Assimilation (FDDA) technique. Prior to use, the data were examined for quality and consistency. During the same period, an intense field program took place in the Reno and Washoe basins. The program was conducted by the National Center for Atmospheric Research, Boulder, CO and the DRI and included surface and upper-air (wind profiler and acoustic sounder) measurements. The data from the NDOT stations agree quite well with the data from the special program stations and to lesser extent with the nearest NWS data. In order to develop an optimum setup for the FDDA, a number of sensitivity tests have been conducted with respect to varying assimilation control parameters such as the nudging coefficient and radius of influence as well as optimization of the number and selection of the NDOT stations data that were assimilated into MM5. The MM5 FDDA results show that the assimilation of the NDOT data generally improved model results and provided more accurate forecasts of temperature and winds in northern Nevada. The effect of improving MM5 forecasts by using FDDA is demonstrated in Figure 2.

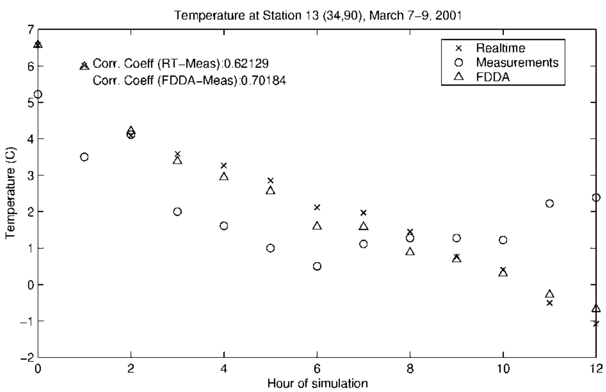

Figure 2. Time series of the surface temperature as observed (o), simulated without the data assimilation (x), and simulated with the data assimilation (Δ) at station 13 (Washoe Valley) during 00-12 UTC on March 7, 2002

2.4 Applications of Local Data Assimilation in Complex Terrain

The National Oceanic and Atmospheric Administration (NOAA) Cooperative Institute for Regional Prediction has been involved in RWIS research and development for a number of years. In collaboration with the Salt Lake City NWS WFO, the initial effort was focused on real-time collection of weather observations from Utah Department of Transportation (UDOT) RWIS platforms. A specialized web interface to MesoWest observations was also developed (Horel et al. 2002a). Access to RWIS observations in other states (Montana, Nevada, Washington, and Wyoming) followed.

FHWA support as part of the COMET program has provided a framework to extend those initial efforts to focus upon the spatial and temporal continuity of weather systems as they progress across the rugged terrain of the western United States. The primary transportation corridors in the Intermountain West are emphasized: (1) Interstate 80 across Nevada, Utah, and Wyoming and (2) Interstate 15 across Utah, Idaho, and Montana. The unique challenges faced by NWS forecasters and winter road maintenance decision makers in regions that are sparsely sampled by RWIS and conventional meteorological observations are of particular interest. The specific goals of this project are:

- Facilitate and improve access to RWIS observations in the Western United States
- Increase utilization of RWIS and weather observations for the 2002 Winter Olympics (Horel et al. 2002b), including dissemination and evaluation of special weather statements issued by the Salt Lake City WFO on hazardous winter weather along major transportation corridors in northern Utah
- Develop and evaluate RWIS applications of weather data in areas of complex terrain on the basis of local data assimilation (Lazarus et al. 2002)
- Establish guidance on factors that affect the utility of RWIS and weather observations for RWIS decision making in complex terrain

Work on all of these project goals is underway. Weather support for the Olympics was judged to be a great success with minimal weather impacts upon roadways. Access to RWIS data is now available from locations within the following states: Colorado, Idaho, Montana, Nevada, Oregon, Washington, and Wyoming (see Figure 3). For further information and access to surface weather observations throughout the western United States, see www.met.utah.edu/mesowest.

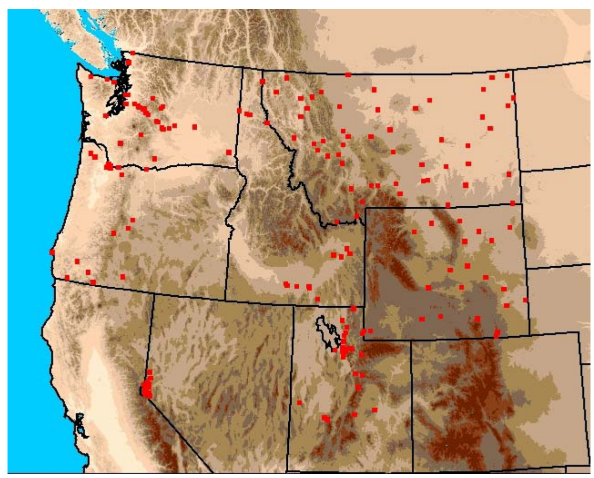

Figure 3. Locations of RWIS stations accessible via MesoWest during summer 2002 (www.met.utah.edu/mesowest) superimposed upon the terrain in the West (mountain pass stations in Colorado available during the winter season are not shown).

2.5 The New York Integrated Weather Data Network (NYIWDN)

The State University of New York at Albany (SUNYA), New York State Department of Transportation (NYSDOT) and the NWS, funded by the FHWA, have teamed up to develop the New York Integrated Weather Data Network (NYIWDN). This system includes plans to create a mesonet from existing and planned sensors, integrate mesonet data into NWS operations, archive mesonet data, and provide improved surface state weather prediction capabilities.

Currently, the NYSDOT network has 40 ESS in place with the ability to dial into 28. The expectation is to expand the count by 25 over the next two years and by a total of 50 within the next three years. ESS data collected by the RWIS and other non-NYSDOT systems in the network are helping researchers identify local anomalies important for predicting road surface state.

When complete, the network will combine data from various data networks including the NWS co-operative observers, NWS rain and snow spotter system, Geostationary Operational Environmental Satellites (GOES), AWIPS, and ASOS. Data provided by the network will be used as input for various operational analysis and forecasting tools as they become available, thereby increasing the effectiveness and accuracy of these systems in forecasting floods and run-off, ice accumulation, severe thunderstorms, and other weather threats. Operationally, integration of the data will produce greater lead-times in issuing warnings and forecast updates to the traveling public.

3. SUMMARY

Through these projects and the COMET partnership, the FHWA Road Weather Management program is making great progress in promoting weather services needed for the safe and efficient operation of roadway infrastructure. The COMET research projects have demonstrated success in improving several aspects of operational forecasting. These projects are helping to improve the accuracy of data, determine the amount of data needed, and provide improved mechanisms for data collection and distribution. The researchers are working to identify and resolve inconsistencies in current observational practices and data collection. To date, results have found that the data are of good to very good quality, though some inconsistencies may exist due to poor sensor siting, non-aspirated sensors, and poor calibration. These project results present some real opportunities for further research and improved operational practices. Once completed, the findings from these projects will be published and widely distributed.

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