# Lessons Learned from Collaborative Research on Road Weather Observations and Predictions by Universities, State Departments of Transportation, and National Weather Service Forecast Offices

ROAD WEATHER MANAGEMENT

# Summary

## INTRODUCTION

From 2001 to 2003, the Federal Highway Administration (FHWA) Road Weather Management program partnered with the National Weather Service (NWS) to conduct five research projects through the Cooperative Program for Operational Meteorology, Education and Training (COMET) (www.comet.ucar.edu). The goal was to create teams of personnel from State Departments of Transportation (DOT), NWS Weather Forecast Offices (WFO), and universities to foster collaborative and productive relationships between meteorological and transportation agencies. These teams were to use data from Road Weather Information Systems (RWIS) to improve the utilization of these data in both weather and transportation operations and to create new predictive algorithms for use in road maintenance activities. Such advances in road weather management ultimately will improve safety and mobility on the roads, and DOT productivity in operations.

This document summarizes the five research projects, including research results and lessons learned. It concludes with general recommendations for all State DOTs to inform future collaborative research efforts.

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

www.tfhrc.gov

U.S. Department of Transportation
Federal Highway Administration

1

## PROJECT 1—PENNSYLVANIA

**Partners:** Pennsylvania State University (PSU), Pennsylvania DOT (PennDOT), and the NWS WFO in State College, PA

**Title:** "Developing an Interactive Mesonet for PennDOT"

**Description:** This project's primary goal was to develop a mesoscale environmental monitoring network, or mesonet, of observing stations across Pennsylvania. Mesonet development included accessing data from environmental sensor stations (ESS) that are operated by many different agencies. The stations (and their affiliated agency or organization) included in the project were:

- RWIS (PennDOT).
- Automated Surface Observing Systems (ASOS) (NWS and Federal Aviation Administration (FAA)).
- Automated Weather Observing Systems (AWOS) (FAA).
- Commonwealth of Pennsylvania Air Monitoring System (COPAMS) sites (Pennsylvania Department of Environmental Protection).
- Precipitation gauges in the Integrated Flood Observing and Warning System (IFLOWS) (Pennsylvania Emergency Management Agency).

Hourly data from these stations, derived parameters, geonavigated graphics, and time series displays are stored in a database and can be accessed online at http://pasc.met.psu.edu/MESONET.

**Research Results:** Creating the mesonet was a challenge. Most of the environmental sensing platforms used different reporting formats, communication protocols, polling times, and storage capacities. After these issues were resolved, researchers designed a quality control system using Oklahoma mesonet standards (http://okmesonet.ocs.ou.edu). To integrate RWIS and other data into the Advanced Weather Interactive Processing System (AWIPS), the NWS primary forecaster workstation, and the Pennsylvania State Climate Office database, researchers chose to collect 19 parameters from the different networks; these parameters contribute to augmenting or improving general surface observations, climatology, forecast verification, modeling, or the welfare of the traveling public. This integration required precise geospatial information, which was not available from RWIS and COPAMS stations. To create comprehensive metadata files for the 82 RWIS sites, State Climate Office personnel visited each site with a global positioning system (GPS) and digital camera. This project also involved preparing and delivering training sessions for State DOT personnel. Training topics included fundamentals of weather, products available from the NWS, use of RWIS data, and winter weather forecasting techniques.

**Lessons Learned:** Data integration was difficult because of different data formats, instrument siting and maintenance issues, and communication problems. The partners strongly recommend that State DOTs begin to use wireless communication technology for RWIS to increase polling times and transmission reliability. To best utilize environmental data, quality control is very important, as is deciding what metadata to include in the data set (wind speed, precipitation rate, roadway surface conditions, etc.).

2

## PROJECT 2—IOWA

**Partners:** Iowa State University, Iowa DOT, and the Des Moines, IA NWS WFO

**Title:** "Improved Frost Forecasting through Artificial Neural Networks"

**Description:** A previous partnership between the Iowa DOT and Iowa State University produced a frost prediction model. This project used data from Artificial Neural Network (ANN) to develop and test a prediction system that could be coupled with the frost prediction model to improve roadway frost forecasting. The ANN uses artificial intelligence to assign weights to different relationships in a training dataset to predict one variable based on a range of other variables. The project also compared RWIS data to AWOS and ASOS data to determine if the different systems were comparable.

**Research Results:** Researchers found that predictions of pavement temperature, air temperature, dew point, and wind speed that were derived from the ANN matched RWIS data more often than did model output statistics derived from NWS nested grid model forecasts. Frost predictions using the ANN data were very accurate when proper verification techniques were employed. In fact, the ANN system performed better than did a contracted forecasting agency. When comparing observing systems, the partners found that RWIS temperature measurements have a high bias when wind speeds are light, because temperature and humidity sensors are not aspirated like AWOS and ASOS. RWIS wind speed observations were typically a few knots lower than observations from the AWOS and ASOS sensors, probably due to siting differences. Real-time comparisons of the different observing systems can be viewed at http://mesonet.agron.iastate.edu/compare. Systemic differences can be quantified to facilitate calibration and improve use of the combined dataset.

**Lessons Learned:** The research revealed that frost prediction modeling using ANN data is a promising application that requires further testing and validation. The partners noted that developing a neural network forecasting system is very labor intensive. They also determined that data calibration in mesonets is necessary to account for differences in station siting. Because of high bias temperature readings at RWIS sites during certain conditions, it is recommended the sensors be aspirated.

## PROJECT 3—NEVADA

**Partners:** The University of Nevada Desert Research Institute (DRI), Nevada DOT (NDOT), and the NWS WFO in Reno, NV

**Title:** "Use of Road Weather Information Systems in the Improvement of Transportation Operations in the Complex Terrain of Western Nevada"

**Description:** In western Nevada, predicting local weather features is extremely difficult because of small-scale terrain features and large variations of weather over short distances. A dense network of observing stations is needed to support transportation managers and forecasters. This was achieved by integrating and archiving data from NDOT RWIS stations, NWS stations, and other mesonet stations. Researchers also aimed to improve NWS operational forecasts through better model guidance and assimilation of State DOT data. Another goal was testing the NDOT IceCast™ Pavement Model to evaluate the sensitivity of various parameters.

**Research Results:** Partners developed programs to automatically access and store NDOT RWIS data in a database at DRI's Western Regional Climate Center and to transfer data from NDOT to the NWS. Interactive graphical displays of the data are available at www.ndot.dri.edu. To improve NWS operational forecasts, DRI staff ran the PSU/UCAR (University Corporation for Atmospheric Research) mesoscale model (MM5) (http://box.mmm.ucar.edu/mm5/) with and without the RWIS dataset. They found that model runs with NDOT RWIS data included verified better against ground truth (e.g., NWS ASOS) for observations of air temperature and wind speed. Tests of the IceCast pavement model revealed that predicted pavement temperature is most sensitive to air temperature changes, and to total cloud cover and precipitation.

**Lessons Learned:** Researchers found that an interactive Web site with environmental data is useful for transportation and meteorological stakeholders. They concluded that mesoscale forecasts in complex terrain can be improved by using RWIS data. Finally, the project determined that predictions of air temperature, precipitation, and cloud cover are critical to accurate pavement condition forecasting.

## PROJECT 4—NEW YORK

**Partners:** State University of New York at Albany, New York State DOT (NYSDOT), and the NWS WFO in Albany, NY

**Title:** "The New York Integrated Weather Data Network"

**Description:** This project aimed to create a mesonet that integrated NYSDOT RWIS data and other data sources. However, the project's focus shifted to analyzing RWIS data quality and comparing this data with NWS sensor stations.

**Research Results:** Difficulties downloading data from RWIS stations that use proprietary software required the project partners to limit research activities. Data from three RWIS stations were downloaded manually to analyze reporting differences when compared to data collected from NWS ASOS sensors at the Albany, NY, airport.

**Lessons Learned:** Researchers noted that environmental data can be used for various NYSDOT and NWS applications. They proposed identifying road segments that are prone to weather-related difficulties and using selective localized climatologies to create generalizable models, which could benefit both operational groups.

## PROJECT 5—UTAH

**Partners:** University of Utah, Utah DOT, and the NWS WFO in Salt Lake City, UT

**Title:** "Applications of Local Data Assimilation in Complex Terrain"

**Description:** This project extended a previous effort funded by Utah DOT to implement road weather decision support for winter maintenance activities. The partners improved access to RWIS observations in several western States and evaluated assimilation of RWIS data in complex terrain.

**Research Results:** During this project, the University of Utah expanded the MesoWest mesometeorological network (www.met.utah.edu/mesowest/) from approximately 2,500 surface observing stations to more than 6,000 stations in California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. To predict weather in adjacent valleys independently, researchers developed anisotropic weighting functions (in which properties differ according to the direction of measurement) for a data assimilation system that was used to resolve errors affecting the analysis of weather observation data.

**Lessons Learned:** This project has created a legacy of positive interaction between all three organizations. Other benefits have been extensive, including improved weather predictions, understanding of winter storm impacts, use of mesometeorological networks, and data sharing.

## CONCLUSION

The COMET projects encouraged partners to share environmental data and facilitated advanced meteorological modeling to enhance road weather forecasts. Ultimately, these efforts will help researchers develop advanced tools for winter maintenance managers, traffic managers, and the traveling public. Lessons learned from these projects can help all State DOTs improve how they manage RWIS networks and achieve maximum utility from RWIS investments.

Key recommendations for responsible agencies:

- Develop and maintain detailed records of RWIS station metadata (e.g., location data, instrument complement, data formats, calibration statistics, and maintenance history), especially when ESS in a single system are procured from different manufacturers.
- Ensure free access to the RWIS data so that proprietary systems do not hinder research progress and operational activities.
- Use reliable and fast data communications (e.g., wireless technology) with remote platforms, whenever possible.
- Maintain open communication between State DOTs and researchers so that personnel can easily obtain the status of RWIS networks (e.g., stations down in work zones).
- Foster working relationships with local universities and NWS weather forecast offices to improve safety, mobility, and productivity (e.g., localized monitoring and prediction of road weather conditions).
- Supplement RWIS observations with those from other surveillance systems, such as ASOS, AWOS, and public and private mesonets.
- Institute quality control standards for all environmental data used in operational applications.
- Examine environmental observations and forecasts from other sources carefully to understand differences that can affect decisionmaking.
- Develop training courses to help maintenance and traffic managers understand weather observing and sources of road weather information.

## REFERENCES


"Collaborative Research on Road Weather Observations and Predictions by Universities, State Departments of Transportation, and National Weather Service Forecast Offices," FHWA-HRT-04-109, available in Fall 2004.

Pisano, P., et al., "An Overview of Surface Transportation Weather Research Conducted through the Cooperative Program for Operational Meteorology, Education and Training (COMET)," (http://www.ops.fhwa.dot.gov/weather/best_practices/AMS_COMET.pdf), December 2002.



**Researcher**—This study was performed by Desert Research Institute, Iowa State University, State University of New York, Pennsylvania State University, and University of Utah, in a contract through the Cooperative Program for Operational Meteorology, Education and Training (COMET).

**Distribution**—This summary is being distributed according to a standard distribution. Direct distribution is being made to the Resource Centers and Divisions.

**Availability**— The full report, "Collaborative Research on Road Weather Observations and Predictions by Universities, State Departments of Transportation, and National Weather Service Forecast Offices," FHWA-HRT-04-109, will be available in Fall 2004 and may be obtained from the FHWA Report Center by e-mail to report.center@fhwa.dot.gov, by fax to 301–577–1421, by phone to 301–577–0818, or online at http://www.fhwa.dot.gov/weather.

**Key Words**—Mesonet, (Artificial) Neural Network, IceCast pavement model, Integrated Weather Data Network, MesoWest mesometeorological network.





FHWA-HRT-04-101
HRDO-04/7-04(1M)E

U.S. Department of Transportation
Federal Highway Administration