

## **Remote Sensing and Forecasting Winter Weather's Impacts on our Roads**

Road Weather Information Systems (RWIS) consist of networks of Environmental Sensor Stations (ESS) operated by state departments of transportation (DOT) in the United States and by provincial ministries of transportation in Canada. In addition, systems are operated by airports, cities, counties, and toll road and bridge authorities. Extensive systems are also in place in a number of European countries.

An ESS can contain sensors to observe atmospheric, hydrologic, or pavement conditions. A typical ESS consists of a number of sensors embedded in the pavement surface in various travel lanes, in bridge decks, and in ramps. There are also many sites that contain sub-surface sensors of varying depth. These sensors measure or help determine pavement temperature, temperature at depth below the pavement surface, pavement condition (dry, wet, snow or ice covered, etc.) and concentration of deicing chemicals in liquid present on the road surface. It is important to remember that the pavement sensors represent conditions for a point and not necessarily for entire routes due to potential differences in road materials, shading, etc. With practice, pavement and sub-surface temperatures can be used to help predict the potential for snow accumulation and even fog formation.

Roadway sensors are connected to a Remote Processing Unit (RPU) that is attached to a meteorological tower adjacent to the highway. The RPU collects and processes the sensor measurements and transmits the information to a central server. Standard meteorological instruments are also attached to the tower that typically includes an anemometer, sensors for air temperature and relative humidity, and precipitation indicators. The precipitation indicator may be a simple yes/no device or a more sophisticated classifier that determines precipitation type and intensity. Some towers can also host a video camera that produces images of the roadway and nearby areas. Visibility sensors are added in some locations such as fog prone locations.

ESS were originally deployed for use by highway maintenance personnel to monitor road conditions and determine and adjust treatment strategies prior to and during winter weather conditions. Applying deicing chemicals while pavement temperatures are still above freezing (called anti-icing) can reduce the amount of chemical required to maintain a wet pavement condition compared to waiting until the pavement temperature drops below freezing and the snow or ice has bonded to the pavement surface. After an application of chemicals, personnel can monitor the chemical concentration to determine when reapplication of chemicals is necessary. ESS information is also used by meteorologists supplying pavement temperature and precipitation forecasts to highway and airport maintenance authorities to initialize pavement temperature forecast models and to monitor forecast accuracy. ESS observations also help the meteorologist by filling in spatial gaps in primary data sources such as ASOS and AWOS observations. As of spring 2006, state DOTs have deployed over 2,400 ESS across the nation (Figure 1).

It is very important for meteorologists and climatologists to understand that ESS are usually sited to capture a specific hazard to the surface transportation system. Hazards can range from monitoring water levels from adjacent creeks to high winds in mountain passes or dense fog potential in valleys. In some cases, the observations are only representative of the local area.

Users of these data must be able to obtain and understand station metadata to properly use ESS observations in general weather forecasting.

There are three main sources of RWIS/ESS data for the general meteorological community. A complete listing of 39 state DOT ESS web sites is maintained by the Federal Highway Administration's (FHWA) Road Weather Management Program ([www.fhwa.dot.gov/weather](http://www.fhwa.dot.gov/weather)). The ESS web site listing can be found at: [http://www.ops.fhwa.dot.gov/weather/best\\_practices/1024x768/transform2.asp?xlsname=SRCwebsites.xslt&xmlname=SRCwebsites.xml](http://www.ops.fhwa.dot.gov/weather/best_practices/1024x768/transform2.asp?xlsname=SRCwebsites.xslt&xmlname=SRCwebsites.xml).

A second source of ESS data is the Meteorological Assimilation Data Ingest System (MADIS). Developed by the National Oceanic and Atmospheric Administration's (NOAA) Earth System Research Laboratory, MADIS is a data management system that collects and disseminates observations from a variety of public and private mesonets. MADIS, found at <http://madis.noaa.gov/>, provides weather observations from more than 20,000 locations in North America including ESS, profilers, aviation observations and marine data. MADIS also provides some automated quality checking. As of fall 2006 MADIS was collecting ESS data from 25 different DOTs (in blue, Figure 2). NOAA has recently begun the transition of the MADIS functionality from its current, research state into NOAA operations within the National Weather Service's (NWS) Telecommunications Operations Center (TOC) that will support many users' needs.

The third source of ESS data is a new FHWA initiative called *Clarus*. *Clarus*, from the Latin word for "Clear", is a new data management system designed to meet the goal of collecting all state transportation agency ESS from across the nation. In addition, *Clarus* will make use of advanced quality checking algorithms for both atmospheric and pavement observations. Finally, *Clarus* will contain an extensive metadata library describing many aspects of ESS sites and sensors.

Information about *Clarus* can be found at <http://www.clarusinitiative.org/>. A proof of concept demonstration of the system capabilities will be concluded in December 2006. A regional demonstration will take place during much of 2007 and into 2008. FHWA and NOAA are coordinating the merging of the *Clarus* functionality with MADIS capabilities within the NWS' TOC and contained within a new NOAA operational system called the National Surface Weather Observing System (NSWOS).

For specific information on FHWA's Road Weather Management Program or *Clarus*, contact Paul Pisano at [Paul.Pisano@dot.gov](mailto:Paul.Pisano@dot.gov). For information on NOAA's Surface Weather Program or NSWOS, contact Jim O'Sullivan at [jim.osullivan@noaa.gov](mailto:jim.osullivan@noaa.gov).

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# ESS owned by State Transportation Agencies

An Environmental Sensor Station (ESS) is any site with sensors measuring atmospheric conditions, pavement conditions, and/or water level conditions.

