Transportation and Moisture: What is the Point?

Improving Decision Making Abilities by Measuring Atmospheric Moisture Values Will Save Lives and Resources

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Introduction

For the past thirty five years government agencies in the United States and Europe have been monitoring weather conditions along our road system. The agency division responsible for the maintenance of our roads is also responsible for the safety of our road system during times of adverse road conditions. In the past three decades these agencies have used fixed Road Weather Information Systems, known as RWIS, to monitor road conditions and make decisions on how to maintain safe driving conditions. The RWIS stations have become fairly advanced with stations capable of detecting de-icing chemicals on the road, measuring the freeze point of liquid on the road by actually freezing the liquid and even monitoring conditions non-intrusively with sensors on the side of the road. The usage of RWIS by road maintenance authorities has been proven to increase the level of service, which in turn means better road conditions and lives saved. Winter maintenance personnel from several agencies indicated that use of RWIS decreases salt usage, and anti-icing techniques limit damage to roadside vegetation, groundwater, and air quality (in areas where abrasives are applied).[1] The major challenge road authorities face with RWIS is the difficulty in authorizing enough RWIS sites to provide a dense weather network needed for accurate decision making. The Federal Highway Administration ESS siting guide recommends that RWIS sites are spaced every 30 miles.[2] That kind of weather infrastructure in the United States is difficult to gain funding for most agencies given the size of the country and distribution of population. What is needed is a solution that can assist in filling in the gaps between data points with a much smaller investment in infrastructure, while still providing data similar to that of RWIS sites. This new data network would not replace the existing RWIS station, nor stop the addition of stations, but instead add to the network of road weather information.

The next key issue is determining which weather variables should be monitored by this "filler network." Of all the road conditions currently monitored by RWIS stations and other means, no one within the community would argue that the single biggest variable to monitor is pavement temperature. The temperature of the pavement is critical because it does not typically match the air temperature at most times and conditions of the year. Second, it is such a critical variable to decision makers, because a pavement temperature above freezing means there will be little to no impact on road conditions during a snow/ice event. Pavement temperatures also determine how effective road chemicals are when road temperatures are below freezing. Beyond pavement temperature, the choice for the next most useful value has been debated for decades. One value, which has seen little attention over the years most likely due to its lack of understanding not because of its importance, is dew point. This poorly understood weather parameter has a huge impact on road transportation. The reason for its huge impact is the problems caused by dew point on our road system go unnoticed by the driver. Heavy rain, ice or snow has a very visible impact on the road, and the driver typically takes notice and makes adjustments to their driving behavior. Atmospheric moisture values on the other hand are nearly impossible to see, making them even more deadly because of the lack of change in driving behavior.

What is Dew Point?

As we all know the amount of moisture in the air is not a constant. It changes just like everything else in the atmosphere. It even changes as you go higher or lower in the atmosphere. Meteorologists have several values they use to quantify the amount of moisture in the air; however, the most common are dew point and relative humidity. Of these two, relative humidity has become the most commonly used parameter by the general public for reasons that are not totally understood. Although some possible reasons are media sources tend to talk about relative humidity, public perception is that relative humidity is easy to understand (10 percent is low and 90 percent is very high), and dew point might be perceived as complicated. The truth is relative humidity is the tough one to truly understand. Dew point, on the other hand is much easier and has a direct correlation to moisture interaction with the roadway. Dew point is the temperature at which the air must be cooled for saturation of the air to occur. Dew point is a value reported in either degrees Fahrenheit or Celsius, depending on how air temperature is being reported. Dew point follows a very important law of atmospheric science. The dew point temperature can be equal to the air temperature, but never higher than the air temperature. The dew point makes understanding the amount of moisture in the air simple. A dew point of 10° F is an example of dry air and a dew point of 70°F is an example of very humid air. The relationship between the air temperature and the dew point temperature is also important. When the difference between the air temperature and dew point are very large it takes a lot of additional moisture to saturate the air, where as when they are close together the air is nearly saturated. This is especially important in the winter with the onset of a snow storm. Snow falling from the clouds can be impacted by the amount of moisture in the air near the surface. When the difference between the air temperature and dew point is large it will take a longer time (if at all) before snow begins reaching the ground, where as when the difference is small snow fall begins reaching the ground immediately.

Dew point is a critical value to monitor for the pavement because the temperature of the pavement can (and does) fall below the dew point of the air. When this occurs, condensation begins to occur on the pavement surface. If the surface of the pavement is below freezing then frost begins to form on the surface. Frost may appear harmless on vehicle windshields or roof tops; however, on a road surface it is just as dangerous as ice or snow. If the pavement surface is below the dew point but not yet at freezing, dew (or liquid) water begins to form on the pavement surface. If the pavement temperature then falls below freezing the water freezes, becoming one form of black ice. Black ice is even more dangerous because it freezes from a liquid to a solid; it freezes clear, which means it is invisible to the driver.

How does the pavement surface fall below the dew point and cause problems for vehicles? There are two situations when this commonly occurs. The first is when the pavement temperature cools rapidly and falls below the dew point. This most commonly happens during the winter with bridge decks and elevated road surfaces. On a clear, calm night, surface heat from the day is released back to the upper levels of the atmosphere. Bridges and elevated structures cool quicker than the surrounding air and can many times fall below the dew point of the air, causing frost to develop on the bridge if it is below freezing. The second situation is when air with a higher moisture content moves in over a cold surface. This can happen in many different types of weather scenarios. One example is when moist ocean air moves inland and over a roadway that has been allowed to cool earlier in the night. Almost all situations of dew point related road problems occur at night when pavement temperatures are coolest, and the pavement temperature can be below the dew point.

Mobile Weather

RWIS measures both the pavement temperature and the atmospheric dew point at a given site, providing the information we need to make decisions about dew point related road weather events. However, RWIS only gives us this information at its fixed location. Pavement temperature and dew point can change dramatically over short distances. Given that we only need pavement temperature or dew point values to change by one degree to cause pavement temperatures to drop below the dew point. So being able to monitor conditions as we move through different micro climates would be key. Collecting weather data using a vehicle first began with the creation of a vehicle mounted infrared pavement temperature system in the 1990s. These systems have become very popular, and today nearly all winter maintenance vehicles are equipped with such a system. The sensors are installed to give supervisors the ability to see pavement temperature around their area of responsibility, and give snow plow operators one last decision point before applying chemical. The infrared sensor reacts quickly to the changing temperatures of the road surface, and measures the air temperature from a separate sensor hidden from the sun and engine heat. The data is then brought back to an in-vehicle display unit mounted on the dashboard of the truck. As an alternate solution, the data can be connected to a chemical spreader and display the temperatures within the spreader display.

This data was only available to the driver until the advent of Automatic Vehicle Location (AVL) technology. AVL is a system that combines a digital cellular modem, a GPS receiver, and a device to collect the vehicle data and periodically transmit the data to a central location. In the early days of AVL a vehicle would have to return to the garage, so the data could be collected wirelessly by a single communication node. Today, with the improvement of digital cellular coverage and reduction in data communication costs, data can be brought back nearly real-time. A central office is then able to see the location of all the vehicles in the fleet, individual vehicle health, and driver operations. The major functions for an AVL system today are to maximize deployment of operations, fleet management, and resource management. Several of the systems have begun to collect the air temperature and pavement temperature data from the infrared sensors, but mainly as an afterthought.

The Future of Weather Data

What if the mobile weather data collected and displayed by the AVL system was a primary function instead of an afterthought? By collecting air temperature, pavement temperature, dew point, and relative humidity you begin to create a true mobile weather station from a vehicle. If you then combine data from all the vehicles in a fleet you create a mobile weather network. The vehicles provide the infrastructure needed to offset the lack of RWIS data; they can be equipped affordably, and they move around, which makes them an excellent source of additional weather data points. Imagine if other types of vehicles beyond winter maintenance vehicles were also equipped, such as police, sanitation, and utility vehicles. The benefits of this concept would be similar to the benefits seen over the years from RWIS technology. The additional data points would provide decision makers with better information, resulting in better operational decisions. The mobile data would also improve the value of the fixed RWIS sites, because now you are able to fill in holes in the data. In the example of dew point detection, areas of frost or black ice could be identified, unlike today where we sometimes rely on the first accident to trigger a response.

The U.S. federal program known as “Clarus” was created to gather all road weather data into a central electronic location, was also designed to incorporate mobile weather data. By combining mobile fleet weather data in one metropolitan area, you could be viewing data from state departments of transportations, counties, and cities all from a single source. This data could also be fed into a Maintenance Decisions Support System (MDSS) to improve the MDSS software’s ability to make localized treatment recommendations. MDSS is a software system that analyzes near real-time road weather data, road weather forecasts, and actions of the winter maintenance operations to make treatment and operation recommendations to the decision maker. MDSS requires the most accurate real-time data so that it has a good understanding of what is happening on the roads. By combining mobile and fixed weather data you will greatly improve the decision making capability of the MDSS.

In the future, additional weather parameters could also be sensed by a moving vehicle, providing even more information about the conditions on the roadway. One slightly surprising outcome of collecting dew point and relative humidity from a vehicle is that it opens up several non-winter applications. The process of applying roadway paint markings and vegetation control all require real-time knowledge of the humidity levels in the air. In the past, operations would require the use of data from fixed RWIS or airport observations (many miles away and possibly hours old) for this key piece of information.

Quixote Transportation Technologies, Inc. (QTT) is the first company in the world to commercially offer a sensor product that incorporates pavement temperature, air temperature, dew point and relative humidity in a single mobile platform. The product, known as Surface Patrol® HD, is an enhancement to the company’s standard Surface Patrol product, which was released in the late 1990s, and only measured air temperature and pavement temperature. Surface Patrol HD is the solution to this critical need for mobile weather data. The system can also be integrated into an AVL system to begin the process of collecting multiple weather parameters from a moving vehicle. The biggest benefit of the Surface Patrol HD is the addition of data points between RWIS stations, making the entire road weather network rich with data. Mobile weather data is the future of road weather information, not replacing RWIS, but instead enhancing and improving the overall weather network.

References

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2. *U.S. Department of Transportation - "Road Weather Information System Environmental Sensor Station Siting Guidelines", April 2005 (http://ops.fhwa.dot.gov/publications/ess05/ess0501.htm)*