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A COMPACT ROAD WEATHER STATION AND A MOBILE ROAD CONDITION MONITOR

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Summary

Road weather stations (RWS) were introduced originally to monitor weather conditions at specific road locations comprehensively to allow forecasting of slippery driving conditions caused by adverse weather. This approach is mostly still in use, resulting in an expensive set of measured parameters. The introduction of mobile road condition measurements has further challenged the current approach of equipping fixed RWS. We report a new approach to outfitting an RWS with the most essential measurements to allow economic and timely winter maintenance as well as warning of drivers about slippery conditions. Measuring surface condition, friction, depth of contamination and temperature readings of air, surface and dew point can be done with a simple set of optical sensors, which are easy to install and cost-effective. Fixed RWS are very useful to follow short term trends in surface condition and temperature development. Mobile surface condition monitors complement the RWS information by providing surface conditions in between the stations and a more representative picture even at the station. We also report a new design of a compact mobile road condition monitor.

Introduction

Commercial fixed optical surface condition sensors were introduced nearly 20 years ago [1]. The trend has been to favour optical sensors in lieu of invasive road sensors due to challenges in installing sensors into road surface. These challenges include traffic arrangements, special tools and material as well as a demanding environment for invasive sensors, especially in areas, where studded tires are used. However, the cost of a typical fixed road weather station is still quite high, typically from 20 000 to 60 000 €. The reason is that the stations often include many meteorological measurements, which are not necessary for the main purpose of the stations.

In our approach we limit the measurements and the sensors of a fixed road weather station to a minimum. We pay attention to the importance of any measurement for the purpose of being able to initiate proper action of winter maintenance or warn a driver. For this purpose, the most essential parameters are surface condition, coefficient of friction, amount of contaminant and road surface temperature reading. Being able to make short term forecasting, dew point temperature would be helpful. For a longer forecast time ground temperature readings may be needed. All this data is available with just two sensors, one is an optical road condition monitor and the other an optical surface temperature and dew point sensor.

Information about salt concentration or amount on the road surface is often desired to be able to estimate, whether additional salt is needed to avoid slippery conditions, when a moist road surface is cooling down or there is some precipitation. Measuring salt remotely is challenging. Nevertheless, we do get information about salt by measuring optically friction, which is essentially the same as being able to observe water and ice on the surface. Since a freezing road surface does not become slippery at a fixed temperature determined by concentration, there is often time to add salt, while friction is trending to lower readings [2, 3]. When the surface temperature is not yet below 0 °C, friction does not indicate the salt concentration. However, there are simple rules to determine, whether there is enough residual salt. If it has been a long time since the last salting, the salt amount will be very low. If there is some precipitation, that will effectively dilute any practical amount of salt. We need near 0 °C about 1% concentration of NaCl to be on safe side. If we are expecting one centimetre of snow, we need about 10 g/m² of salt. That amount of residual salt will not survive under traffic for many hours.

Fixed road weather stations can follow the trend of surface condition and temperature development. However, previous research has shown that fixed RWS cannot produce surface conditions reliably in adverse weather conditions mainly due to a fairly small size of the measurement spot not being representative of the road surface [4]. Further, the distance between fixed RWS is typically tens of kilometres leaving long sections of road network not measured at all. The recent introduction of mobile road condition monitors can help with this challenge [5].

We report new developments of a compact road weather station and a compact mobile road condition monitor to tackle the challenges of road weather measurements.

A Compact Road Weather Station

The model name of the new road weather station is RWS10. It consists of two sensors, one is RCM411R Road Condition Monitor modified for remote measurements and the other RTD411 Road Surface Temperature and Dew Point sensor. The measurements of the two sensors include:

- surface condition
  - dry, moist, wet, slush, ice, snow or frost
- friction
- water and frozen layer thickness
- surface temperature
- air temperature
- dew point temperature
- atmospheric pressure

- wind speed
- ground temperature.

In addition to the sensors, there is a small cabinet containing a battery (7 Ah), a battery charger and a GSM modem for communication. The modem sends the data to a server once a minute. Figure 1 shows an RWS10 installed on a street light pole. The battery is charged overnight, while the street lights are on, and the battery takes care of the next daytime.

The data can be followed on a web map service at *roadweather.online*. Figure 2 shows the web interface of the map service. On the right side of the view there is a list of daily data and on the left a map of the station location and graphs of measured values. The data is also available through an API service or as a numeric file to be studied as a spread sheet.

Figure 1. The compact road weather station installed on a wooden street light pole. The cabinet is on the other side of the pole at the height of the traffic signs.

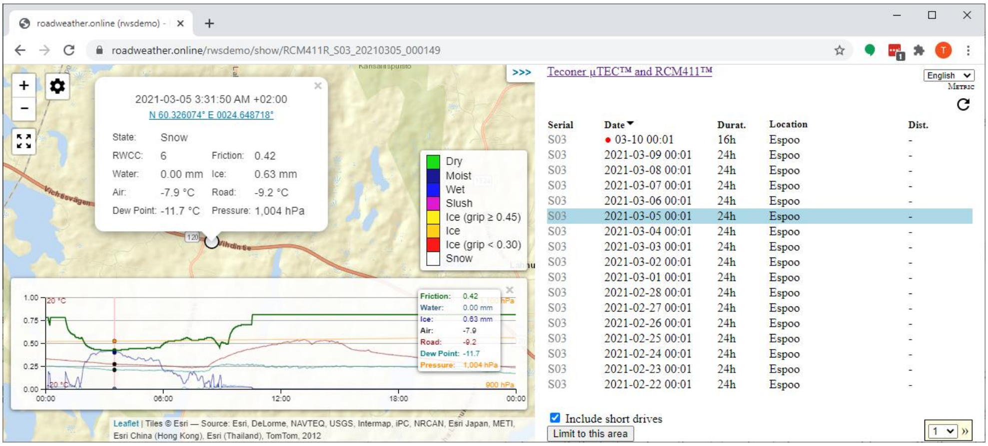

Figure 2. A web interface to the station data. A numeric window of data is available at a given time stamp. The example shows a case of light snowfall causing reduced friction before the final dry out at noon.

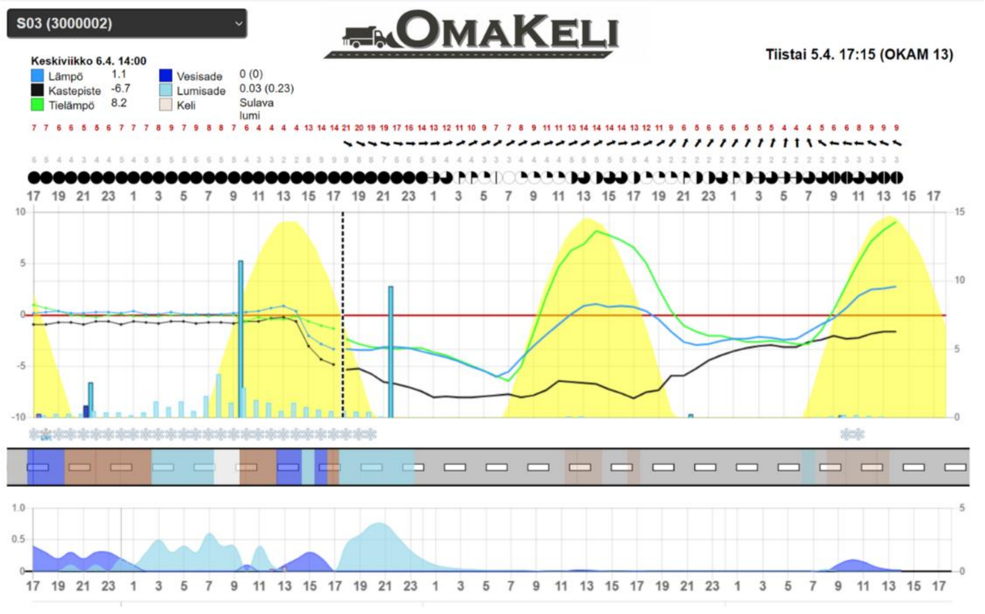

Figure 3. Omakeli road weather forecast supplied by Saaneuvos Oy. The forecasted parameters include air, dew point and surface temperature, precipitation amount of rain and snow, wind speed and direction, and road surface condition.

It is possible to generate warnings for a given weather condition at the selected station in the *roadweather.online* service. The warnings are transmitted as an SMS message to listed phone numbers. There is also available a road weather forecast service called Omakeli supplied by Saaneuvos Oy. Figure 3 shows the user interface of the Omakeli forecast.

A Compact Mobile Road Condition Monitor

Finding a suitable location in a vehicle for a mobile optical road condition monitor may be challenging. The size of the sensor should be small enough to allow installation optimally to keep the sensor window clean for extended periods. With this target in mind, we have designed a small new road condition monitor. Figure 4 shows the new sensor installed near the left mirror of the vehicle.

Figure 4. The new compact Road Condition Monitor RCM511 installed by a magnet near the left mirror.

There are a few various fixing methods for the sensor. The most straightforward way is to use a magnet for fixing the sensor on steel surfaces of the vehicle. There are also available special fixing parts to a trailer tow ball or to a screw-on tow hook in the front of a vehicle. The sensor can be powered from a cigarette lighter socket or the trailer socket.

The measurements of the sensor include surface state, friction and layer thickness of water and frozen contaminants. Air temperature, dew point and surface temperature measurements are available with an optional sensor. Figure 5 shows an Android application of a user interface to the measured data in the vehicle. The application supports taking photos or videos.

If mobile measurements are taken with buses or trucks, it may be better to use a black box cellular modem for data transmission, since then all the

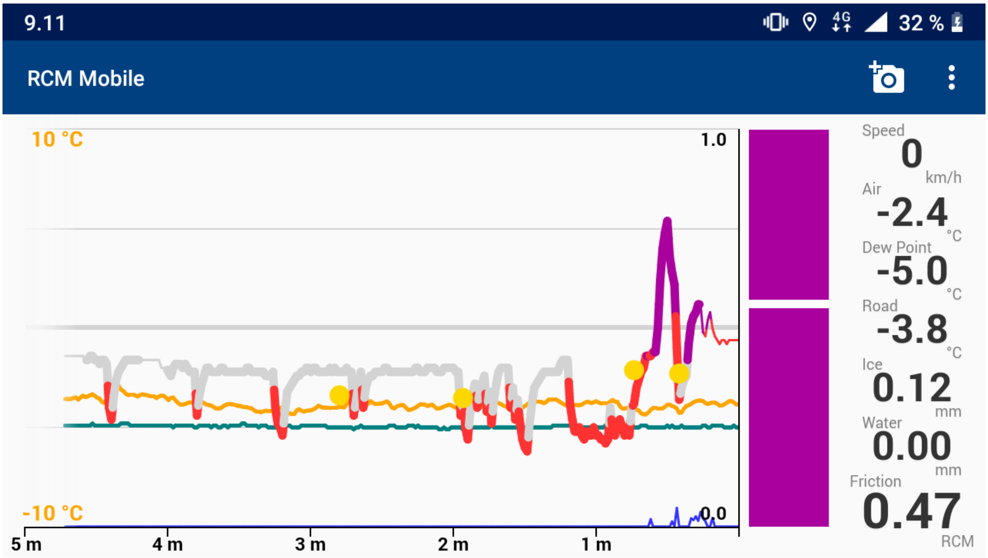

Figure 5. The user interface in the vehicle shows numerical and graphical data in an Android application. The thick line corresponds to friction and is coloured by the surface state. The yellow spots are braking friction measurements. The sensor data is transmitted to the roadweather.online cloud server for web browsing.

drivers of the vehicle do not have to know about the mobile measurement. Android turns out to be an unstable system for long periods and may require occasional intervention. When using a black box solution, it is still possible to follow the data in the vehicle with a similar Android application.

Conclusions

We have developed a compact road weather station RWS10 and a compact mobile road condition monitor RCM511 with real-time data collection and a map interface to the data. The target has been to concentrate on the most important measurements and an easy installation to keep the total cost at a minimum. Fixed road weather stations provide accurate trend information, whereas mobile measurements complement the picture by providing information in between the stations. By adding weather forecasts to the system, it is possible to build a full-service Road Weather Information System (RWIS). Furthermore, road condition measurements and weather forecasts enable calculating the required amount of salt or de-icer chemical in a given situation. This level is often called Maintenance Decision Support System (MDSS). We estimate that by using a compact approach it is possible to build an MDSS with a fractional price of a typical MDSS currently in use.

Acknowledgements

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