Event coordinators:

Lauryna Šidlauskaitė   Justas Kažys   Jonas Kaminskas

PROCEEDINGS OF THE 20TH SIRWEC CONFERENCE, DRUSKININKAI, LITHUANIA (14-16TH JUNE 2022)

2022

USING MOBILE OBSERVATIONS TO DRIVE MAINTENANCE DECISION MAKING

Jim McCaa
Vaisala OYJ, Keilaranta 19, 02150 Espoo, Finland,
jim.mccaa@vaisala.com

Summary

Accurate measurement of road weather conditions is the foundation for both ongoing road maintenance operations and forecasting upcoming treatment requirements. Here we describe the evolving role of mobile sensing devices in providing situational awareness and forecasts for winter maintenance. Results from a study evaluating the impact of mobile observations on road weather forecasts are presented.

Road maintenance is heavily affected by weather conditions, and knowledge of current conditions combined with forecasts of anticipated conditions across the network factor in the decision making process for treatment. Forecasts used to determine likely future road conditions are impacted by direct measurements from both stationary weather stations and moving devices. Here we consider forecasts of temperature and road surface state made by numerical weather prediction models and temperature and road surface state measurements collected by Vaisala MD30 devices attached to snowplows. We focus on periods of heavy snowfall and resulting treatment activity. The mobile sensing devices collect data otherwise unavailable from stationary measurement locations, though their placement on operating plows raises some issues with representativeness of the measurements.

Body

Data from mobile sensing devices complements a traditional network of Environmental Sensing Stations (ESS) by providing more complete network coverage, albeit at less frequent intervals. Mobile device data has been used since the 1980's as a static data source for network thermography, but advances in mobile communication in the last twenty years have enabled real-time communication of vehicle data and allowed integration with maintenance decision support systems [1,2].

Use of professional-grade dedicated equipment attempts to employ vehicles as mobile Road Weather Information System (RWIS) stations. This is a different proposition from opportunistic automobile sensor data, with a smaller number of purpose-built sensors delivering higher-quality data from vehicles such as snowplows, transit buses, and service trucks. Data is typically displayed both in the vehicle for the benefit of the vehicle operator and transmitted to the cloud for centralized analysis and distribution.

To combine both data sources into a consistent network analysis, mobile sensing data is displayed in near-real-time for situational awareness and used on a regular interval to update road weather forecasts. In the absence of mobile sensor observations, the state of a road network is determined subjectively by interpolation from nearest ESS, analysis of model output, and radio communication from the field. However, geo-located mobile sensor data can be analysed more quantitatively, leading to more efficient use of materials and better planning for operations.

Here we examine a road forecasting system capable of assimilating mobile sensor observations and using them to adjust the model state through a radiative coupling process for temperature, and by direct inclusion of water layer thicknesses. The impact of the mobile sensing data can be estimated by looking at the frequency and magnitude of the adjustments made to the model when they are available.

As an example of this type of analysis, we will review the impact of a set of Vaisala MD30 sensors [3] on water layer thicknesses during a snowfall event in Fort Collins, Colorado. Table 1 is a contingency table comparing the percentages of segments of the city's road network that are measured and/or forecast to be in a dry, wet, or frozen state. Data was collected over 34 hours beginning with the onset of the snow event. The table shows that approximately 11% of the measured segment required an adjustment to the model-analysed state, primarily because the road weather model occasionally over-forecast dry conditions.

Table 1. Comparison of forecast road state and measurements (prior to forecast adjustment) during a significant snow event. Numbers reflect the percentage of the road network where the forecast and measurements agree and disagree, prior to assimilation of the measured data.

[%]	**Forecast dry**	**Forecast wet**	**Forecast snow/ice**
Observed dry	0	0	0
Observed wet	0.29	1.1	0.64
Observed snow/ice	7.9	2.1	88

The times during which the forecast required adjustment were not spread evenly over the duration of the event. Figure 1 plots the evolution of this and shows that most of the forecast adjustment occurred near the end of the event. Visual inspection of associated dash-cam video revealed that this was in part a result of clean-up operations being conducted by the snowplows on which the sensors are monitored.

A more detailed analysis of the event and seasonal results are included in the conference presentation. While direct display of mobile data helps operators make treatment decisions, one of the reported factors in deviating from MDSS recommendations is the difference between forecast and observed conditions [2], so harmonizing observations and forecasts through data assimilation can facilitate better uptake of MDSS recommendations. It also extends the value of mobile observations by propagating the impact of the data into network analysis over subsequent hours.

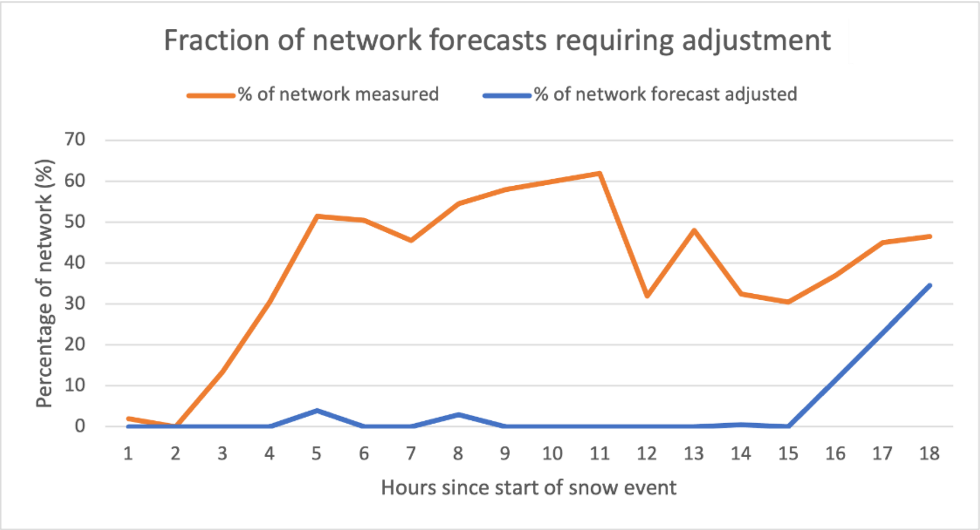

Fig. 1. Change in time since the beginning of a snow event of the fraction of the road network measured, and the fraction of the network where the forecast of the road weather model was adjusted as a result of the measurement.

References

[1] Jonsson P., Riehm M. **2012**. Infrared Thermometry in Winter Road Maintenance, *Journal of Atmospheric and Oceanic Technology*, *29*(6), 846-856.

[2] El-Rayes K, Ignacio E-J. **2022** Evaluating the Benefits of Implementing Mobile Road Weather Information Sensors. A report of the findings of ICT-R27-SP47. Illinois Center for Transportation Series No. 22-004. Research Report No. FHWA-ICT-22-004. Illinois Center for Transportation, Rantoul, IL. *https://doi.org/10.36501/0197-9191/22-004*

[3] MD30 datasheet. Vaisala OYJ, Vantaa, Finland. Retrieved 1 April 2022. *https://www.vaisala.com/sites/default/files/documents/MD30-Datasheet-B211719EN.pdf*