ROAD WEATHER MEASUREMENTS ALONG ROAD STRETCHES

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ABSTRACT

Conventional road weather monitoring network contains fixed road weather stations along the road network. That kind of monitoring system gives information about prevailing road condition and road temperature only for the certain points where the station is located. Nowadays it is possible to do mobile measurements along the roads. Vaisala Ltd has developed a remote sensing monitoring device to measure road surface temperature (DST111) and the state of the road (DSC111) optically. The DSC111 device makes an estimation of prevailing road surface friction, too. Both DST111 and DSC111 devices are possible to install into the roof of car and do mobile measurements by driving. The devices are measuring road weather related parameters every third second, so by driving 80 km/h observations are measured every 70 meters or so. Mobile measurements enable continuously observation data on the roads with very high resolution.

Road condition and road temperature may vary lot even within short distances. Variation can be critical especially when temperature is around zero degree. Then in some places temperature can drop below zero and road surface can become slippery because of ice on the surface whereas other road stretches are wet or damp due to higher road surface temperature.

Finnish Meteorological Institute has done mobile measurements using Vaisala DST111 and DSC111 devices on winters 2006-2010. This study presents results of some of the most interesting mobile measurement cases. One of the cases is measurements before and after salting which reveals how the road slipperiness improves after the road maintenance. Another case present very large variation on road surface temperature and slipperiness as well.

Introduction

Driving conditions are often challenging because of ice and snow on the road surface in Finland during winter time. Winter season with ice and snow may exist up to six months every year. Slippery road condition raise the traffic accident risk. Road maintenance operations, like salting and snow removal, are carried out to improve the driving condition.

Special road weather models are helping meteorologists and road maintenance personnel when doing road weather forecasts and scheduling road maintenance operations. Road weather models are focusing on the road surface. FMI has developed own road weather model and it has been in operational use since spring 2000 [Kangas et al., 2006]. The model is forecasting e.g. road surface temperature and road condition. The newest output parameter is forecasted friction [Hippi, 2010].

Road weather modeling is very challenging because of the local environmental circumstances, like hills and valleys, nearness of iceless lakes and seas have a strong influence on microclimate and local road weather. Road surface temperature as well as road condition and slipperiness may vary significantly even within a short distances. Near zero temperatures can be very dangerous because of unexpected slipperiness when some places are icy whereas other places are dry or wet.

There is a road weather station network along the Finnish main roads with more than 500 stations. Some 100 of those are installed with Vaisala DSC111 sensor which measures optically thickness of water/ice/snow on the surface and makes an estimation of prevailing friction, too (see Fig. 1) [Vaisala, 2005a]. Another road weather monitoring tool is road weather cameras along the roads. The amount of cameras is almost 500 in Finland at the moment.

Figure 1: Vaisala DSC111 instrument

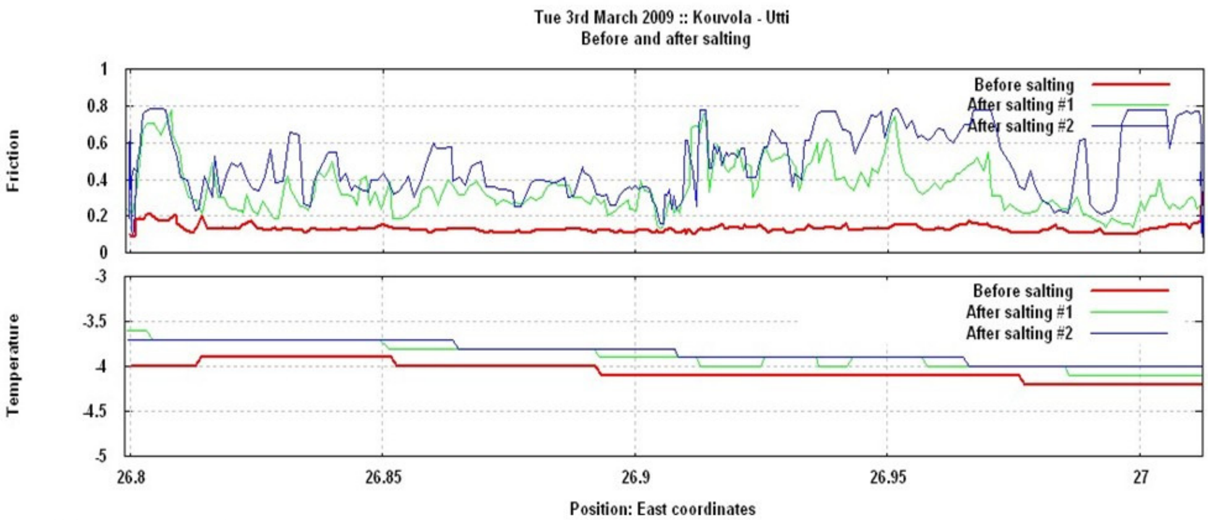
Mobile measurements

Mobile measurements have been carried out during winters 2006-2010 in Finland and the measurement campaigns have been part of road weather projects ColdSpots [Hippi et al, 2008] and ROADIDEA [Saarikivi, 2010]. Vaisala DSC111 and DST111 [Vaisala, 2005b] were installed into the roof of the car as can be seen in the Fig. 2. DST111 instrument measures optically road surface temperature. Results of the measurement cases give lots of valuable information about the spatial and areal variation of road surface temperature and condition as well as road surface friction. The information of the observations have been used as a background information when developing the road weather model and planning the future of road weather modeling.

Several interesting weather and road condition situations were managed to measure during the mobile measurement campaigns. One of the most interesting cases was a measurement before and after salting, presented on Fig. 3. The figure is presenting mobile measurements in Kouvola region and the driving route was about 12 kilometers long. The same road stretch was measured three times. The first measurement drive started at 18:21 and the road was very slippery because of a thin ice layer on the surface. Measured friction was very low (red line). The second drive started 50 minutes later at 19:11 and grip was improved significantly (green line). The last drive was carried out later starting at 19:37 and the grip was still improved (blue line). Road surface temperature was quite stable during all measurement cases (lower panel).

Figure 2: Vaisala DSC111 installed in the roof of car.

This example presents how quickly the road condition improves after salting because the ice layer melts. The information of road maintenance operations is not included into FMI's road weather model so this example shows how big errors may become because of the lack of the information of salting and/or snow removal. FMI's road weather model is forecasting the expected worst case scenario that could happen without any road maintenance operations.



Measurement cases:

- **Before salting 18:21**
- **After salting #1 19:11**
- **After salting #2 19:37**

Figure 3: Measured road surface friction (upper panel) and road surface temperature (lower panel) before and after salting in Kouvola region 3rd March 2009.

Figure 4 presents the mobile measurements for 30.1.2007 when large temperature and slipperiness variations were measured within short distances. Measurements are presented as a function of distance and time. The vehicle drove along the highway 1 from Helsinki to Turku and in the middle of measurement session near Turku the car turned back towards Helsinki. The day was cold; the road surface temperature was mainly between -10 and -20 C degrees (Fig. 4 top). Road salting is not possible in such cold temperatures because salt loose the effectiveness to melt ice when temperature is -6 C degrees or colder. There can be seen pretty large fluctuation in the road surface temperature even within short time periods and distances. Car's measurements as well as measurements from road weather stations are plotted to the figure (stars and circles) and those are mainly pretty close to each other. However, a couple of outliers can be found. Temperature from road weather station presents road surface temperature whereas car's measurements present air temperature. The reasons for the fluctuation were studied. Some of the cold places are situated in the valleys, on the crossroads, on the rest stops or on the city areas. However, there seems to be lots of fluctuation that cannot be found easily explained.

There was all the time at least tiny ice or snow cover on the surface (Fig. 4 middle). On the highway the ice or snow layer was mainly so tiny that driver couldn't even notice it. The peaks in the middle of observation part and in the beginning and in the end are from parking places or rest stops. Also, the friction (Fig. 4 bottom) varies much along the test period. There are time period between 9:30 and 10:00 when friction is all the time pretty bad. The surface was very slippery and the driver confirmed that also. Surprisingly, the friction varies sometimes quickly from the 0.2 to 0.8 through the whole scale.

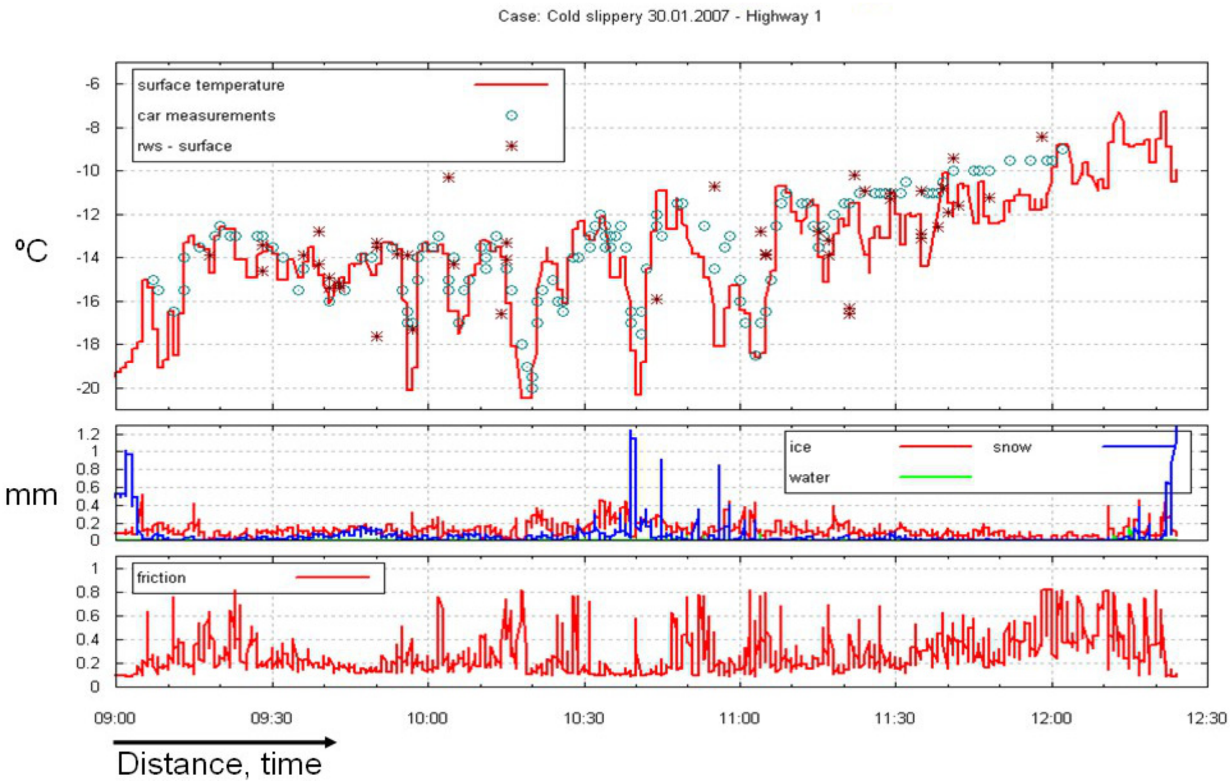


Figure 4: Road weather measurements 30.1.2007 presented as a function of time and distance. On the top: Road surface temperature (line mobile measurements, circles car measurements, stars road weather station,). In the middle: Thickness of water, ice and ice layers in mm:s. On the bottom: Value of friction.

Mobile measurement campaign was concentrating on Helsinki metropolitan area on winter 2009/10. Measurements were carried out regularly by driving same route every Tuesday in the morning and in the evening. Observations were like thermal and friction mapping giving climatological information of places which are usually colder and/or more slippery than other places.

Summary

Mobile measurements give valuable information about the variation of road surface temperature and road condition with very high resolution in space and time. Road weather stations are very useful when monitoring the prevailing road weather but the information from the places situated between the road weather stations is missing.

Road condition improves quickly after road maintenance operation. The information of salting and snow removal should be included into road weather model to get better initialize state and better short time road weather forecasts.

There can be large temperature and slipperiness variation even within short distances along the road stretches. An explanation for the variation can be found in many cases but not always. It is very challenging to do precise road weather forecasts because local environmental features should be taken into account.

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