RSI - A GLIMPSE OF THE FUTURE FOR WINTER MAINTENANCE

Esben Almkvist[a], Eric Zachrisson[a], Jörgen Bogren[b], Torbjörn Gustavsson[b], Peter Hagberg[a].

[a]*Klimator AB, Holtermansgatan 1A, 411 29 Göteborg, Sweden;* [b]*Department of Earth Sciences, Göteborg University, Box 460, SE 405 30 Göteborg, Sweden.*

Corresponding author: esben.almkvist@klimator.se

With self-driving cars and trucks around the corner(1), there will be challenges for winter weather forecasts to be accurate, so that the autonomous vehicles can adjust their speed and actions according to the risk of encountering low friction. The maintenance vehicles are also likely to be automated, which requires them to connect to a routing program according to the current and future weather conditions. Even with human drivers it is possible to increase the efficiency of the maintenance operations by creating optimized routes based on road condition forecasts.

In southern Sweden, RSI (Road Status Information) – a system to monitor the winter weather, plan maintenance operations and track performance – has been used by several major Swedish road maintenance organisations during the past three winters (2015-2018). In particular, during the winter 2017-2018, the south-eastern district of Blekinge was selected as a test area for automatically generated and optimized (by B&M Systemutveckling AB) salting and ploughing routes, which could be directly transmitted to the maintenance vehicles (operated by Svevia AB).

A major feature of the RSI system is the inclusion of roughly 500 connected vehicles, using in-car sensors and a software developed by Nira Dynamics AB, to perform accurate friction measurements. The connected cars can also transmit weather related data, such as air temperature and wind shield wiper information, which serves as a proxy for precipitation or wet roads.

Fig. 1 presents the features of the RSI system in the Gothenburg area during a passing snow storm. There are many warnings from the vehicles due to the snow as seen in (**a**), which is also seen in (**e**) which shows low friction. The road coverage, accumulated over an hour, is normally 80-90% during the day as seen in (**b**) and dropping to a minimum of 10-20% during the night. The performed and recommended future maintenance activity is shown in (**c**), while the residual salt amount is shown in (**d**). The default map layer is the road status, here mostly melting snow, which is shown in (**f**).

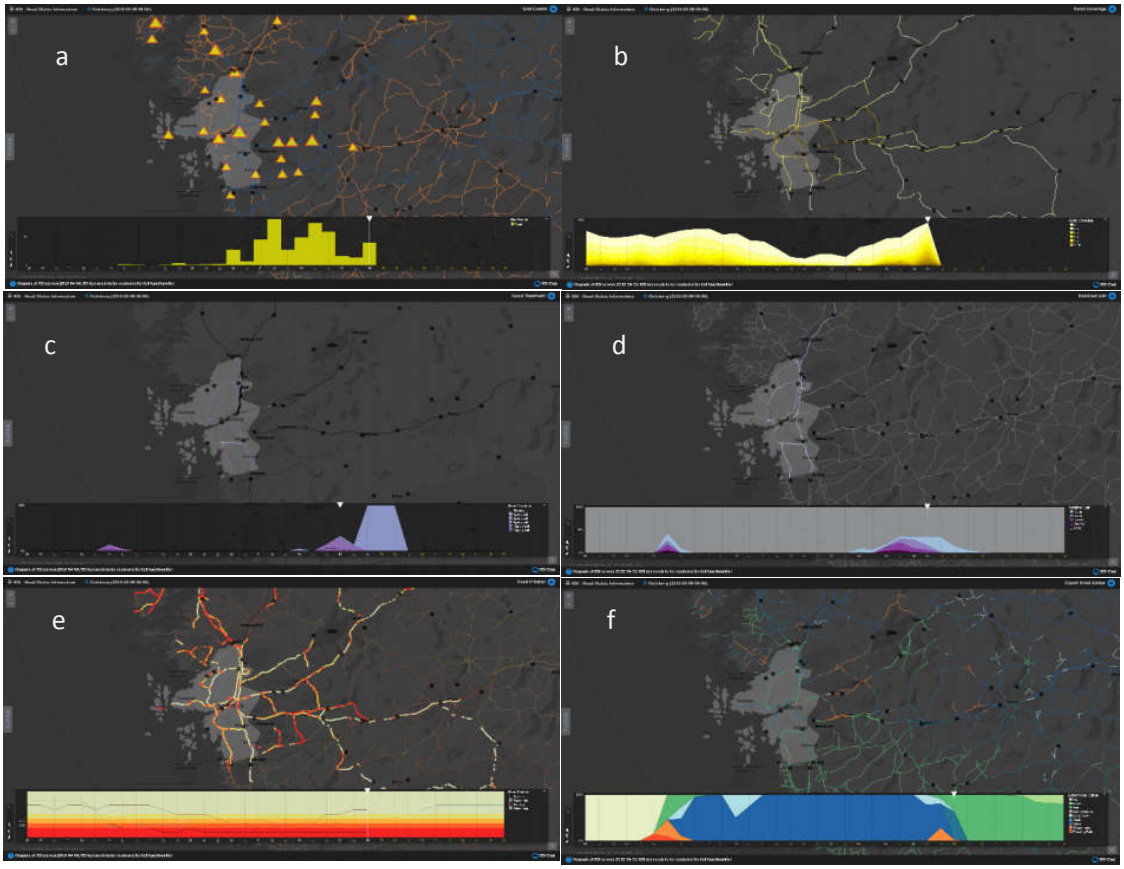

Fig. 1. The RSI application, displaying the view at 2018-03-06 09:00. The lower bar shows past and forecasted conditions in the selected maintenance region. (**a**) shows warnings when the friction drops below 0.25 μ, (**b**) shows the road coverage percentage of the connected vehicles, (**c**) shows the registered salting and ploughing activity at 07:00, (**d**) shows the residual salt amount, (**e**) shows the measured (thick lines) and modelled (thin lines) friction and (**f**) shows the road status two hours ahead at 11:00.

The forecasts in the RSI system are calculated with a typical energy balance model(2,3,4), which includes GIS data modeling(5,6,7) and recent developments of radiation calculation(8,9,10) to achieve accurate route based forecasts. The accuracy (mean absolute error) of the surface temperature 4 hour forecast for an arbitrary segment, validated by cross-validating RWIS-station data, is 0.75-0.78ºC from December to February. For the RWIS-stations more than half of them (413 out of 714) had a mean absolute error less than 0.5ºC degrees for 4 hour forecasts of surface temperature in January.

By including friction data from the vehicles it is possible to adjust several factors that are important for the friction of the roads, e.g. snow/ice amount on the roads, maintenance activities and surface temperature. Furthermore, by combining climate model and vehicle data it is possible to interpolate/extrapolate vehicle measurements to assess the road conditions on nearby roads. This was tested for distances of 10-20 km during the period 2018-03-06 to 2018-03-08 before and after two snow storms passing southern Sweden. This model was able to determine low or high friction with an accuracy of 95%. The low friction cases were correctly estimated 98% of the time, while only giving 5.5 % false warnings. Thereby it is possible to establish, with high

certainty, the prevailing road conditions, which provides a basis for precise road condition forecasts and valuable information for autonomous vehicles in winter weather.

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