# Development Project ColdSpots: Towards More Detailed Road Condition Forecasts

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**ABSTRACT**

The objective of the three-year project "ColdSpots" (2005-07) was to improve present road weather and condition forecast methods and models by establishing and utilizing a novelty database which covers detailed local information on problematic road sections in Finland. A wealth of information has long been available in various databases, such as registers of road structures and traffic accidents, feedback on road maintenance activities and quality control data. However, this information has been unavailable to the developers of weather forecast models, until now. ColdSpots was initiated in 2005, with first analyzing the available road weather information and compiling the necessary databases. During the second phase, 2006-07, problematic local road weather features and possibilities to improve road weather modelling were studied. On the second part mobile temperature and friction measurements were carried out along the highways. Mobile measurements revealed valuable information about prevailing circumstances along the roads whereas traditional fixed road weather station network reveals information only for specific spots. There can be found several features affecting to the local road condition. Prevailing and past weather, environmental features and road construction affects to the local road weather. Also, traffic and road maintenance activities can change the road condition.

**Keywords:** Road weather modelling, road weather observations, mobile measurements, friction.

## 1. INTRODUCTION

Road condition can vary much along road stretches and that can cause tricky driving circumstances for drivers. Learning how the circumstances vary along the road stretches and what cause the variations it is possible to improve road weather forecasts and optimize road maintenance activities.

Project ColdSpots was started after serious winter time accidents in Finland. In the first part of ColdSpots project the slippery and dangerous road stretches were collected to the database [1]. That information was collected by asking for road maintenance personnel who have a lot of hands-on experience. The database was fulfilled with the information of winter time car accidents. A test set of some fifty most problematic locations were selected for the ColdSpots places. On the second part of this project local road weather features were studied and field measurements carried out along the highways [2]. Also, possibilities to improve numerical road weather models were researched.

The aim of this project was to study how the circumstances like friction, state of the road and road surface temperature vary along the road stretches. By understanding reasons affecting to the local road weather it could be possible to do better road weather forecasts for places which are susceptible for slipperiness.

This project was done in co-operation with two Finnish weather partners Foreca and Finnish Meteorological Institute and an infrastructure service company Destia (formerly Finnish Road Enterprise).

## 2. LOCAL ROAD WEATHER

Road weather circumstances can vary dramatically even within short distances. However, the magnitude of the variation is due to prevailing weather situation. There can be found several types of local features which have something to do with the local road weather (Table 1). Those features can be divided into three main categories which are meteorological and geographical circumstances and road construction features [3]. Also, traffic and road maintenance activities affect to the local road weather. Prevailing weather can vary in short distances, especially cloudiness and precipitation can vary locally. But usually local road weather is a combination of many factors.

Geographical features were studied in this project. Altitude and especially latitude are pretty obvious features and they are commonly embedded to the numerical weather model. Other features are more or less tricky and often relatively small scale phenomena. Temperature can vary because of screening and shaded road in the middle of forest can be icy instead of road on an expanse area is open and dry. The impact of screening is a function of season and the angle of the sun. It has only a small impact in the middle of winter in January, but in March the temperature variation caused by screening can be up to 10 degrees in southern part of Finland [4]. Also, a direction of slope has a big influence to prevailing road surface temperature and state of the road. For example nearness of water is complicated. An open water area may bring moisture and warmer air mass, but when the water area is covered by ice it has no influence to the surrounding area. City area is usually some degrees warmer than countryside. One problem considering environmental features is the instability, because some of the environmental features can transform in the course of time. For example shaded areas can be disappeared because of felling of trees.

Road construction profiles vary along road stretches. The construction material as well as the depth of the material is not homogeneous. Often thermal features, porosity and albedo vary and may transform in the course of time. The construction information is usually poorly documented; sometimes there can be found no information at all.

Traffic and road maintenance activities are other features affecting to the local road weather. Traffic has several effects to the surface and the atmospheric boundary layer; tyres wear the surface, traffic mix the air layer near the surface meanwhile cars induce heating and cause shading. The influence of traffic is depended of traffic volume and velocity of cars. Road maintenance activities, like snow removal and salting, can modify the road conditions dramatically. Due to snow removal the thickness of snow and/or ice decreases whereas salting melts ice. However, failed road salting can produce the surface even more slippery. Different or on separate time carried out maintenance activities can cause differences to the road conditions.

| ***Meteorological*** | ***Geographical*** | ***Road construction*** | ***Other*** |
|---|---|---|---|
| Solar radiation | Latitude | Depth of construction | Traffic |
| Terrestrial radiation | Altitude | Thermal conductivity | Maintenance activities |
| Air temperature | Topography | Thermal diffusivity | |
| Cloud cover and type | Screening | Density | |
| Wind speed | Sky-view factor | Emissivity | |
| Humidity / Dew point | Landuse | Albedo | |
| Precipitation | Topographic exposure | | |

Table. 1. Quantities affecting to the local road weather [3].

## 3. COLDSPOTS PLACES

“ColdSpots” is a place where icy and slippery conditions and accidents exist more often due to slipperiness. ColdSpots places were defined by the knowledge of road maintenance personnel who have lots of experimental knowledge of road places which need more care and control than other places. Other ColdSpots information was collected from traffic accident database by picking up the accidents happened during icy conditions.

Collected ColdSpots places have different kind of features:

- An open area with large sky-view factor and radiative cooling.

- A valley with cool air pooling during the night.
- A coastal area near the sea or a lake where lot of moisture advection.
- An elevated spot, a hill top with lower temperature and forced uplift of moving air.
- A special place like bridge, curve, ramp or passing line.

Project team visited at the ColdSpots sites at the highway E18 in south-western part of Finland. Figures 1-4 are taken at the visited ColdSpots sites. According to team's public opinion many of the ColdSpots places don't look as danger as they may be. Road can be slippery and it is hard to notice. Slipperiness can be unexpected incidence for drivers when other road stretch is dry.

Fig 1. Anerio lake: An open area, the lake on the right.

Fig 2. Halikko bridge may be slippery, strong wind can cause extra risk.

Fig 3. Ikela hill: An open area leading to a hill.

Fig 4. Koikkala curve: Road curving on a hill, poor visibility.

## 4. ROAD WEATHER MEASUREMENTS

Road weather observations are an important issue when monitoring slippery conditions and scheduling salting or snow removal operations. Fixed road weather stations gives well information of prevailing situation for that certain point. Usually that information is not perfectly usable for road stretches situated between the road weather stations.

### 4.1 Fixed road weather station network

There are almost 500 road weather stations along the roads in Finland. Especially in southern part of Finland main roads are pretty well covered by road weather stations. Most of the road weather stations are situated in places which are for some reason difficult for road maintenance activities. Road weather station measures typical weather parameters (air temperature, road surface temperature, humidity, wind, precipitation) but also

state of the road and electrical conductivity. New optical measurement devices can define prevailing value of friction. Road weather cameras give visual information about prevailing road conditions.

**4.2 Mobile measurements**

In ColdSpots project mobile measurements were carried out by driving a car along the main roads in southern and western part of Finland. There were two different kind of measurement devices attached to the track back of the vehicle (Figures 5-6); one device measures road surface temperature and the other measures the thickness of snow, ice or water on the surface and it also defines the value of friction [5, 6]. The observations were done every fifth seconds and the data was stored continuously. Spatial resolution was as good as about 110 meters when driving 80 km/h. The vehicle was equipped with a GPS (global positioning system) receiver so the exact location of the car at the each time step was possible to identify afterwards.

Fig. 5. Vaisala DST/DSC 111 optical measurement device.

Fig. 6. Mobile measurement devices attached to the vehicle.

**4.3 Compared measurements**

Mobile measurements were carried out in January and February 2007. The goal was to carry out mobile measurements during icy and freezing circumstances along the main roads in Finland. The winter was pretty short and the real winter season finished already in February. Totally 11 mobile measurement series were carried out in good winter conditions. Those observation series gave well information about the road weather, though. The results of the mobile measurements were compared with the observation from road weather stations which were picked from the moments when the vehicle passed by the road weather station.

Figure 7 presents the mobile measurements for 30.1.2007. 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. 7 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 perioids 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. 7 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. 7 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.

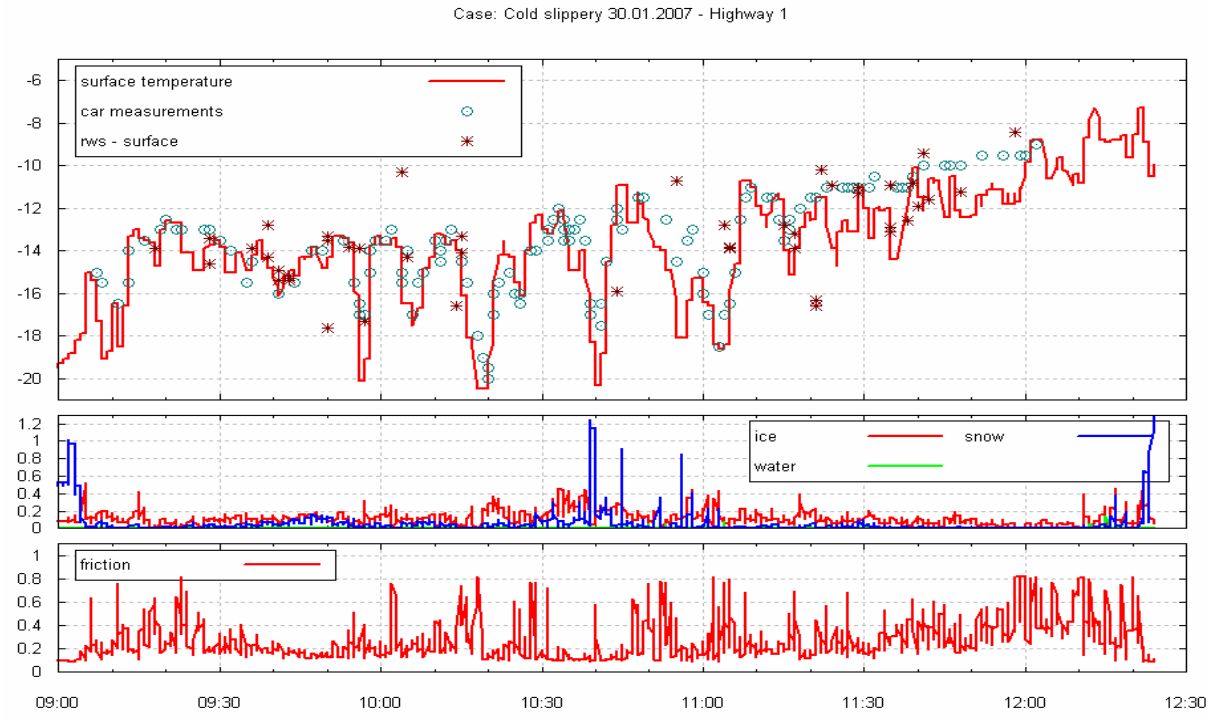


Fig. 7. Road weather measurements 30.1.2007 presented as a function of time and distance. On the top: Road surface temperature (line mobile measurements, stars road weather station, circles car measurements). In the middle: Thickness of water, ice and ice layers in mm:s. On the bottom: Value of friction.

Other mobile measurements were carried out also in freezing temperatures. Friction was mostly a bit better and the temperature variation smoother. Otherwise there were pretty much fluctuation also on other measurement series.

## 5. MODEL DEVELOPMENT

The bottlenecks of road weather modelling were studied and analyzed. One of the aims of this project was to study possibilities to do more accurate road weather forecasts especially for those stretches or spots where slippery conditions exist more often by improving existing road weather models. Existing models are energy balance models so the physic behind the environmental features must be solved. It became clear that some of the environmental features can be take into account to the road weather model. Such features are screening and slopes affected by topography. Other features are more or less complicated or impossible to take into account when developing accurate road weather models. Also, local circumstances would be difficult and laborious to maintain. Traffic is partly embedded to the road weather model already now. Road maintenance activities could be possible to take into account but the activity information is not entirely collected in Finland.

Thermal mapping could be suitable tool to improve road weather forecasts [7]. The system is already in use in many countries. Thermal mapping means temperature measurements along the roads in different weather situations. The technique provides climatic temperature map of the road network. Using that information it would be possible to do statistical corrections to the road weather models outputs.

## 6. CONCLUSIONS AND FUTURE RESPECTIVITIVES

There can be a lot of fluctuation in road weather circumstances even within short distances. Several types of features can be found which can affect to the local road weather. The main reasons are meteorological, environmental and road construction features. In addition, traffic and road maintenance activities affect to the local road construction. The reason for the fluctuation can be mostly explained but not always. To improving existing road weather models by taking into account local environmental or road construction features is not easy or even impossible. Some of the features can be embedded into the road weather model but not all.

Furthermore, some geographical features can be transformed in the course of time. Thermal mapping could be one solution when modelling local and precise road weather conditions in the future.

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