



Weather factors triggering the massive car crashes on 3 February 2012 in the Helsinki metropolitan area

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ABSTRACT

Rapidly worsening driving conditions due to low temperature and dense snowfall with very poor visibility may result in severe pile-ups on the highways. Here we investigate a pile-up event that occurred on 3 February 2012 in the Helsinki metropolitan area in southern Finland. Then, very cold air was advected from southeast in over Finland, resulting in the formation of sea-induced convective snowfall over the still partly ice-free Gulf of Finland. The most intensive snow band hit the Helsinki metropolitan area, causing a rapid simultaneous decrease of visibility and road surface friction just before noon. Car pile-ups occurred in many locations and several hundreds of cars were crashed and 43 injured persons were taken to hospital. Regarding the predictions made in the Finnish Meteorological Institute (FMI), the location and intensity of the precipitation band was well predicted with HARMONIE mesoscale model. The FMI road weather model predicted the state of the road quite well, and the derived novelty forecast parameter, coefficient of friction, corresponded relatively well to the friction observed with the optical DSC111 device. FMI had issued a warning for poor driving conditions already on the previous day. However, driving speeds were not substantially lower than on a “normal” day, probably due to the local feature of the weather hazard. A similar costly pile-up event occurred in the Helsinki region in March 2005. Preventing such accidents from occurring calls for efficient co-operation between weather service providers, road authorities and maintenance contractors, as well as efficient warning services for the drivers.

Keywords: Snowfall, low friction, poor visibility, car pile-ups, road weather forecasts.

1 INTRODUCTION

Winter weather has large impact on the fluency and safety of transportation. During snowy and icy conditions, the braking distances can be fourfold compared to bare road conditions [Haavasoja and Pili-Sihvola, 2010 [1]]. That is why snow and ice removal from the pavements is so important. Efficient road maintenance calls for accurate road weather observations and forecasts. Operational automated Road Weather Information Systems (RWIS) were developed to provide precise real-time information about local weather and road conditions, and RWISs have been used already for several decades. In Finland, the observation network (governed by the Finnish Transport Agency) consists of more than 500 observation stations. More than one hundred of the stations are equipped with optical DSC111 instruments that measure the layer thicknesses of water, snow and ice on the road and also give an estimate of the prevailing road surface friction coefficient. The information from the road weather stations are gathered into the RWIS, and the system can warn about slippery conditions for example by colour coding. The information provided by the RWIS can also be used to operate variable speed limits and message signs, which are efficient tools in traffic management during hazardous weather conditions. Some main roads in Finland are equipped with such systems, but the extension of the network is unfortunately limited by high monetary costs.

Road Weather forecast Models (RWMs) are required to overcome e.g. the timing and focusing of the road maintenance actions. The forecast data and possible maintenance recommendations can be delivered to the



customer via a Maintenance Decision Support System (MDSS). The primary function of a RWM is to predict the road surface temperature as well as the hydrological state (and slipperiness) along the road network. A RWM uses external forcing input from an operational Numerical Weather Prediction (NWP) model. One widely used RWM is METRo (Model of the Environment and Temperature of Roads), which was originally developed in Canada. For example in the USA, METRo is used as a source of road weather forecast information in MDSSs [Linden and Drobot, 2010 [2]]. In Finland, an RWM was developed by the Finnish Meteorological Institute (FMI) in the late 1990's and it has been running operationally since the year 2000. The present output parameters of FMI's RWM include surface and ground temperatures as well as thicknesses of water, snow and ice layers on the road surface, from which the state of the road (snowy, icy, wet etc.) can be derived [Kangas et al., 2012 [3]]. A new additional forecast parameter, road surface friction, was also introduced recently.

Whenever there is a sudden simultaneous reduction of road grip and visibility (e.g. due to blowing snow or a dense snow shower), the situation can get really dangerous and severe pile-ups are possible especially in dense traffic on the highways. Such events have occurred e.g. in the Helsinki region in southern Finland in March 2005 and in the Czech Republic and Austria in March 2008 [Juga et al., 2012 [4]]. All those events were triggered by sudden snowfall. Recently, on 3 February 2012, severe pile-ups occurred again in the Helsinki metropolitan area. This event is investigated here; the information from a nearby road weather station is used to analyze the road conditions at the time of the occurrence of the main accidents, and the accuracy of the forecasts in this event is also reviewed.

2 THE WEATHER SITUATION LEADING TO THE ACCIDENTS

The beginning of February 2012 was very cold in most parts of Europe. This was due to a strong anticyclone over north-western Russia, central Norway and UK (Fig. 1) which caused the spreading of very cold air from Russia towards the west. The cold air was advected over the partly ice-free Gulf of Finland by steady easterly to south-easterly winds. On 3 February the temperature in the Helsinki region was $-15...-20$ °C. The relatively warm sea water induced the formation of snow showers, which were organized into several parallel bands (Fig. 2). Sea-effect snowfall is a surprising and sometimes also hazardous weather event that can have high impact on traffic [Juga, 2010 [5]]. The strongest snow band hit the Helsinki metropolitan area, causing occasionally dense snowfall. The snow band kept its location for several hours and the total snowfall amount during the day was 5-10 cm, based on radar measurements and precipitation gauge observations. The harsh winter conditions triggered the occurrence of severe traffic accidents.

Sea-induced snow bands existed over the Gulf of Finland already during the preceding day, i.e. on 2 February and they were clearly visible in radar images. Numerical weather forecasts indicated a change in the direction of the air stream, from north-easterly to easterly or south-easterly. This would mean that the snow bands would hit the Finnish coastal area on 3 February. In addition, the Finnish Meteorological Institute (FMI) operates a high resolution numerical weather prediction model (HARMONIE) with a horizontal resolution of 2.5 km. This model predicted the most intensive snow band to hit Helsinki. This is why FMI issued a warning on 2 February for poor road conditions for Uusimaa County, which covers the Helsinki metropolitan area and surroundings. In the morning of 3 February, a warning for very bad road conditions in Uusimaa County was issued.

Fig. 2 shows the snowfall area at midday on 3 February. The heaviest snowfall was located just a few km north or northeast of the Helsinki city centre and the snowfall area stretched 20 to 30 km to the easterly and northerly direction from the city centre. To the westerly direction the snowfall area extended up to 100 km along the coast, but the snowfall was not as heavy as in the easterly and north-easterly direction.

The locations of the main pile-ups are shown in Fig. 3, also the locations of the nearest road weather observation stations and weather cameras are marked there. The two main pile-ups took place 10 to 15 km northeast from Helsinki city centre; the first one occurred along highway 4, which leads to the north from Helsinki; the other one occurred along the east-west directed ring road No. 50. The car crashes totally jammed all traffic coming towards the city centre from the north along highway 4 (see Fig. 4b).

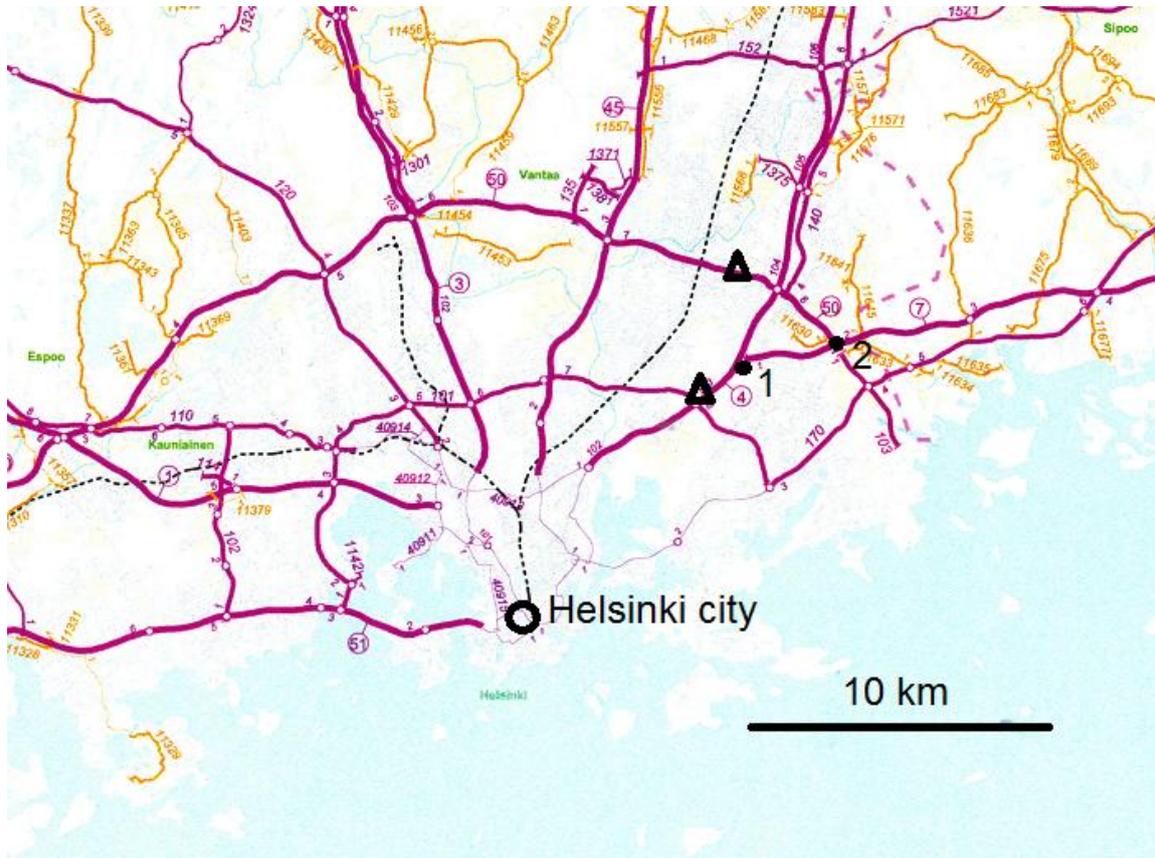


Figure 3. Road network in the Helsinki metropolitan area. The locations of the main pile-ups are marked with triangles; locations of road weather observations: 1 = Jakomäki RWS and road weather camera, 2 = Porvoonväylä road weather camera. The highway codes (=numbers) are marked within circles on the map (source: the Finnish Transport Agency (FTA)).

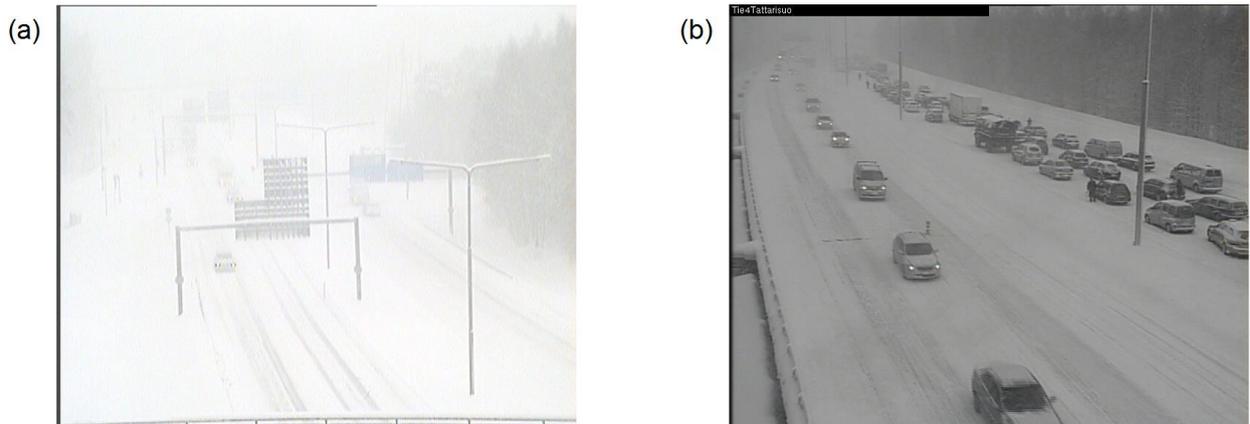


Figure 4. Scenes from (a) Porvoonväylä road weather camera at 12:28 LT and (b) Jakomäki road weather camera at 12:51 LT, the locations are shown in Fig. 3. Photos by the Finnish Transport Agency (FTA).

The visibility was occasionally substantially reduced by the dense snowfall (Fig. 4a). Fig. 5 shows a time series of visibility, layer thickness of snow on the road and road surface friction, observed at Jakomäki road weather station by highway 4. The coefficient of friction, C_f , is a good measure of slipperiness. Values of $C_f < 0.2$ are typically measured on black ice, or when the ice is covered by loose snow for example; on bare road, when the

grip is good, C_f has a value around 0.8. From Fig. 5 it appears that early in the morning the friction coefficient (C_f) was low (<0.2). Then C_f rose to ca. 0.5 at 04-05 UTC (06-07 LT), probably due to ploughing, or on the other hand, wearing of snow and ice due to traffic. The visibility was occasionally reduced by snowfall and after 05 UTC (07 LT) C_f decreased rapidly as the amount of snow on the road increased. At 09 UTC (11 LT) the visibility decreased to a minimum of 360 m. By the time of the pile-ups (around 11:45 LT) C_f was ca. 0.15 and visibility was 400-500 m, but at the “windscreen level” probably much lower. At the same time, the layer thickness of snow on the road increased rapidly.

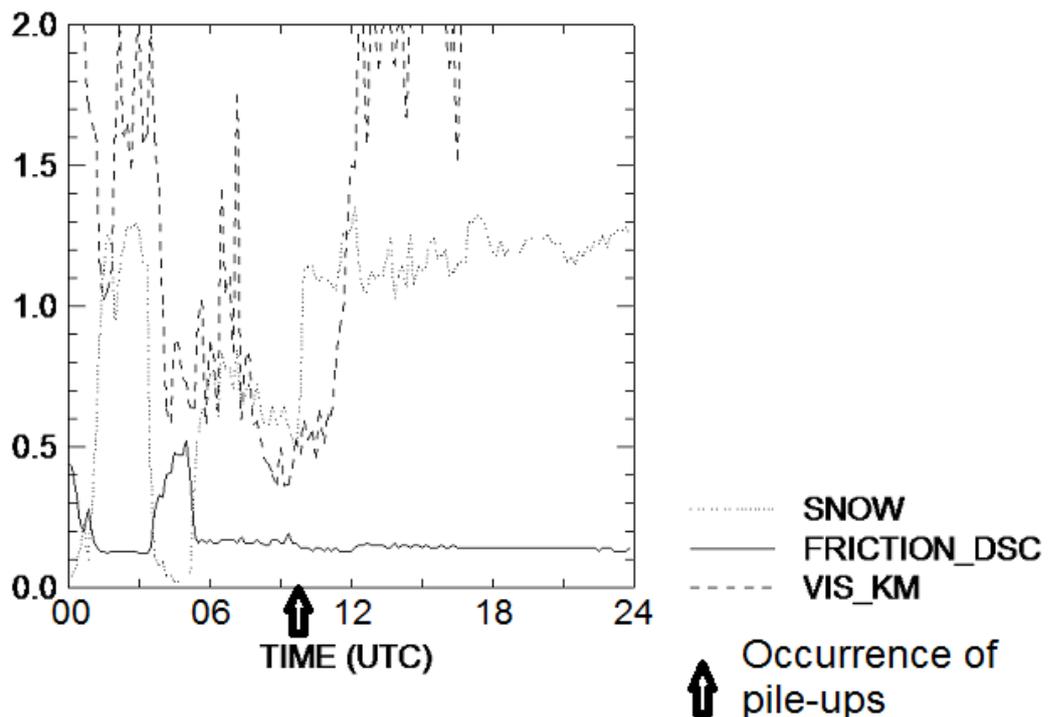


Figure 5. Jakomäki RWS observations on 3 February 2012: The layer thickness of snow (in equivalent mm), the coefficient of friction (C_f) on the road surface measured by an optical DSC111 device (scale of C_f : 0.1-0.82), and horizontal visibility (in km). The occurrence (timing) of the worst pile-ups (around 9:45 UTC or 11:45 LT) is marked by an arrow on the horizontal time-axis (RWS data source: FTA).

3 THE CONSEQUENCES OF THE CAR PILE-UPS

The main pile-ups occurred around midday on 3 February. There were several car crashes already during the morning, disturbing traffic, but the most severe crashes paralyzed the road traffic especially in the eastern part of the Helsinki metropolitan area. The ring road No. 50 (see Fig. 3) is an important traffic route in the east – west direction. A lot of cargo is transported along that road and the main harbour in Helsinki is located near the eastern end of the road. Also the passengers heading to the Helsinki-Vantaa airport from the eastern or western suburbs typically use that road. On 3 February, highway No. 4 and the ring road No. 50 were almost totally closed for several hours in the afternoon, disturbing traffic badly. Traffic jams occurred also on other locations of the Helsinki metropolitan area. In total, 690 vehicles were involved in the crashes, based on the estimate of the Rescue Service; 43 injured persons were taken to the hospital and the amount of slightly injured persons was much larger. The traffic became gradually normal during the evening (with lowered speeds), but there were a lot of crashed cars still by the roadways. The cleaning of the road sides took several days or even weeks; the investigation of the crashes, the evaluation and repairing of crashed cars as well as the processing of payments from traffic insurances took naturally a lot of longer time. Costs for insurance companies were estimated at 1 m€.

For the sake of comparison, a similar severe car crash event occurred in the Helsinki Metropolitan area on 17 March 2005 [Juga et al., 2012 [4]]. In that case, a dense snowfall during the morning rush hours triggered pile-

ups in four locations on the main highways coming towards Helsinki city. Then, almost three hundred cars were crashed, more than 60 people got injured and unluckily, three persons died.

4 ROAD WEATHER FORECASTS DURING THE EVENT

As already mentioned in Section 2, the FMI high resolution model HARMONIE predicted the sea-effect snow well. The operational HIRLAM-model, which is a bit coarser model with a horizontal resolution of ca. 7.5 km, also predicted some snowfall for Helsinki in this case. The HIRLAM-forecast is used as a background material for the FMI road-weather model, either directly or edited by the duty meteorologist, depending on the case. The road weather model predicts the state of the road, including the coefficient of friction based on statistical equations. Fig. 6 shows the friction forecast for Jakomäki RWS, compared to the measured friction by optical DSC111 instrument.

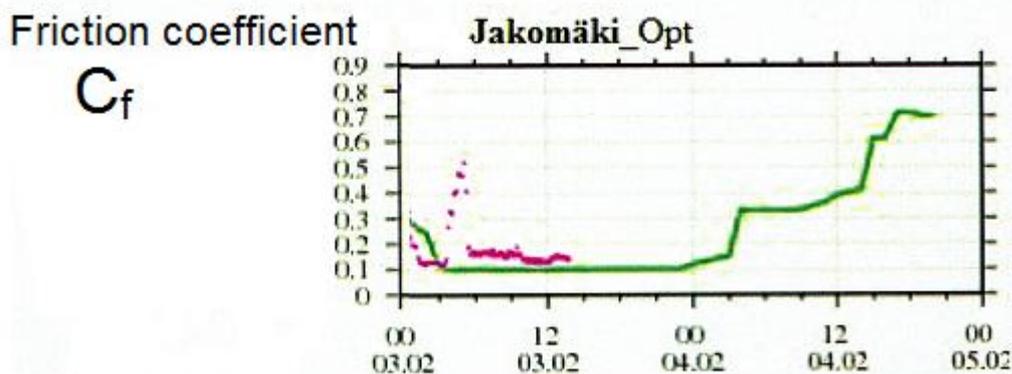


Figure 6. Predicted friction coefficient by the FMI road weather model (green curve) and observed friction coefficient measured by Vaisala's DSC111 instrument (pink curve), in Jakomäki RWS (location in Fig. 3), from 3 February 2012 00 UTC (02 LT) on.

From Fig. 6 it appears that both the predicted and observed friction coefficients were low on 3 February between 00 and 12 UTC, except for the observed friction having a peak upwards around 04-05 UTC (06-07 UTC), as already shown in Section 2, Fig. 5. This time interval of better grip was probably due to ploughing and/or wearing of snow and ice due to traffic flow. The effect of traffic is taken into account in the FMI road weather model in an average way (not based on traffic intensities on individual days). However, the effect of ploughing (or salting) is not included in the model yet; that might be the reason for the model not predicting the temporal improvement of grip at 04-05 UTC. When analyzing the forecast for this specific location more thoroughly it appeared that the model predicted the layer thickness of snow on the road quite well, but the layer thickness of ice was too large in the forecast. Anyway, the signal for poor grip prevailing most of the day was accurate.

5 CONCLUDING REMARKS

Studying this weather event shows that the simultaneous reduction of visibility and grip on the road is dangerous especially in heavy traffic. Rapid worsening of driving conditions calls for real-time road weather information and recommendations that need to be delivered to maintenance contractors (e.g. through a MDSS) and to the drivers. Some useful tools for supporting transport safety and fluency under adverse weather events might be for example:

- Real-time road weather products for the drivers: e.g. road condition analysis and forecasts for different road stretches (routes).
- Variable speed limits and message signs (providing weather related guidance and information).
- Wireless data transfer of road surface conditions, obstacles, traffic flow etc. from vehicle to vehicle as well as between vehicles and infrastructure (cooperative systems are currently under development).
- Communication strategies involving TV, radio, websites and other modern communication systems.



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