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Wind and Snow Storm Impacts on Society

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1. Introduction

In November 2008 two damaging storms affected southern Finland. The storm on 10 November caused up to 29 m/s wind gusts over land areas. On 23 November the measured wind gusts reached 27 m/s, but it was accompanied with heavy snowfall, up to 30 cm in 24 hours. These cases offered a change to study wind storm impacts on Finnish society, but also to compare the storm impacts with and without heavy snowfall.

For both cases, we studied the Rescue Services rescue operations, Finnish Motor Insurers´ Centres statistics of paid compensations and media reports, and compared them to the observed weather. We also studied road weather observations in both cases. As preparedness for future storms, we derived wind storm and blizzard impact descriptions for Finland. Finally, in co-operation with Emergency Services College, we established localized call-to-action statements that can be distributed to public within storm warning messages.

2. Background

Hazardous weather conditions may have a great impact on society and different transportation means. Intensive low pressures can cause disturbances to aviation, rail and road transport. An example is from 2 February 2009, when the Heathrow airport in UK was closed for several hours due to heavy snowfall and the road traffic was also badly disturbed. A similar event occurred a week later, when the Paris airport was closed due to a windstorm.

Snowfall typically has a negative impact on driving conditions, as it decreases the road surface friction and reduces the visibility. Especially if the temperature is so low (<-5˚C) that salting is not effective, or if the snowfall intensity is too high for effective snow removal, there will likely be disturbances in traffic with high accident rates. An example from Finland is from Helsinki region on 17 March 2005, when dense snowfall hit the area during the morning rush hours. Almost 300 vehicles were involved in the crashes, 3 persons died and more than 60 persons were injured (Juga and Hippi 2009). These kinds of accidents highlight the role of efficient warning services as well as real-time monitoring of weather conditions.

In Sweden, western neighbour of Finland, based on a three-year study, 50% of all road traffic accidents during winter occur in slippery road conditions (Norrman et al. 2000). The highest accident risk in southern Sweden is when rain or sleet falls on frozen road surface. The second most hazardous road condition is when snowfall and hoarfrost formation occurs at the same time. In these conditions, accidents seem to occur in spite of full maintenance activity. So, in order to reduce the amount of accidents, public awareness should be increased.

3. Data and methods

The main data source for impact information in this study was the database of Finnish Rescue Services rescue operations. Besides exact time and location of each incident, the database included information about casualties and in most cases some information on the observed damage. This database includes only the accidents that caused rescue operations, and does not include good coverage of all type of accidents, for example building damage. Therefore, media reports of the damage in Finnish newspapers were also studied for the both storms. To understand impacts on traffic, the daily statistics of Finnish Motor Insurers´ Centres paid compensations were also examined.

The synoptic situation and weather observations of the both storms were analyzed. Especially the wind gusts during the storms were studied thoroughly, by using 3 second maximum wind gust of each 10 minutes from Finnish Meteorological Institutes ground observation stations. The presented impact descriptions are based on observed damage after certain measured gust speeds. The call-to-action statements were formulated in co-operation with Emergency Services College.

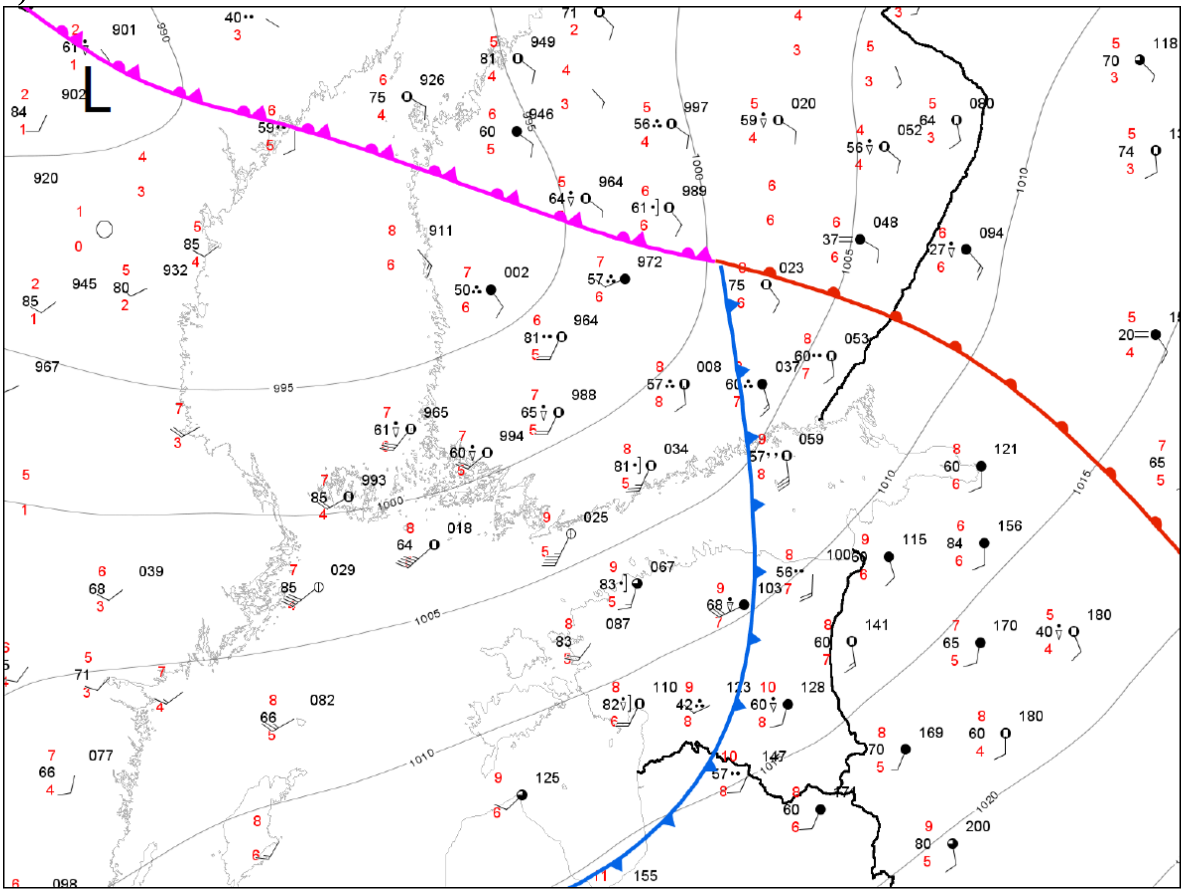
Road weather observations were also analyzed in both cases. Then the main focus was to examine the effect of precipitation (rain or snow) on driving conditions and road surface friction. For this purpose, friction measurements by Vaisala's DSC111 optical instrument were used. The device measures optically the depths of water, snow and ice on the road surface and makes an estimation of the state of the road and its friction value. The optical instrument has a range from 0.1 to 0.82. The measurements used in this study are maintained by the Finnish Road Administration.

4. Weather situations

The storm damage on 10 November was caused by an intense low that moved during the Monday the 10th over Scandinavia to northeast (Fig. 1a). Strong south-westerly wind gusts over 20 m/s were observed commonly in southern Finland, the maximum wind gusts over land area was 29 m/s, that was recorded at Vantaa airport. During the night the wind started to decrease. The temperatures during the event were several degrees above freezing, so the accompanying precipitation was rain.

On 22nd November a low center developed in south-eastern Europe and started to rapidly intensify and move north. In 36 hours it had became a very intense storm with center just south of Finland (Fig. 1b). The winds started to increase already in the morning on 23rd in southern and central Finland, but the maximum wind gusts, 27 m/s, we recorded during the event in the late afternoon at Tampere airport, where the gust speed stayed above 20 m/s over 5 hours. During the night the winds started to decrease. The storm was accompanied by heavy snowfall, up to 30 cm in 24 hours in southern parts of the country, and over 15 cm commonly in southern and central Finland (Fig. 2).

a)



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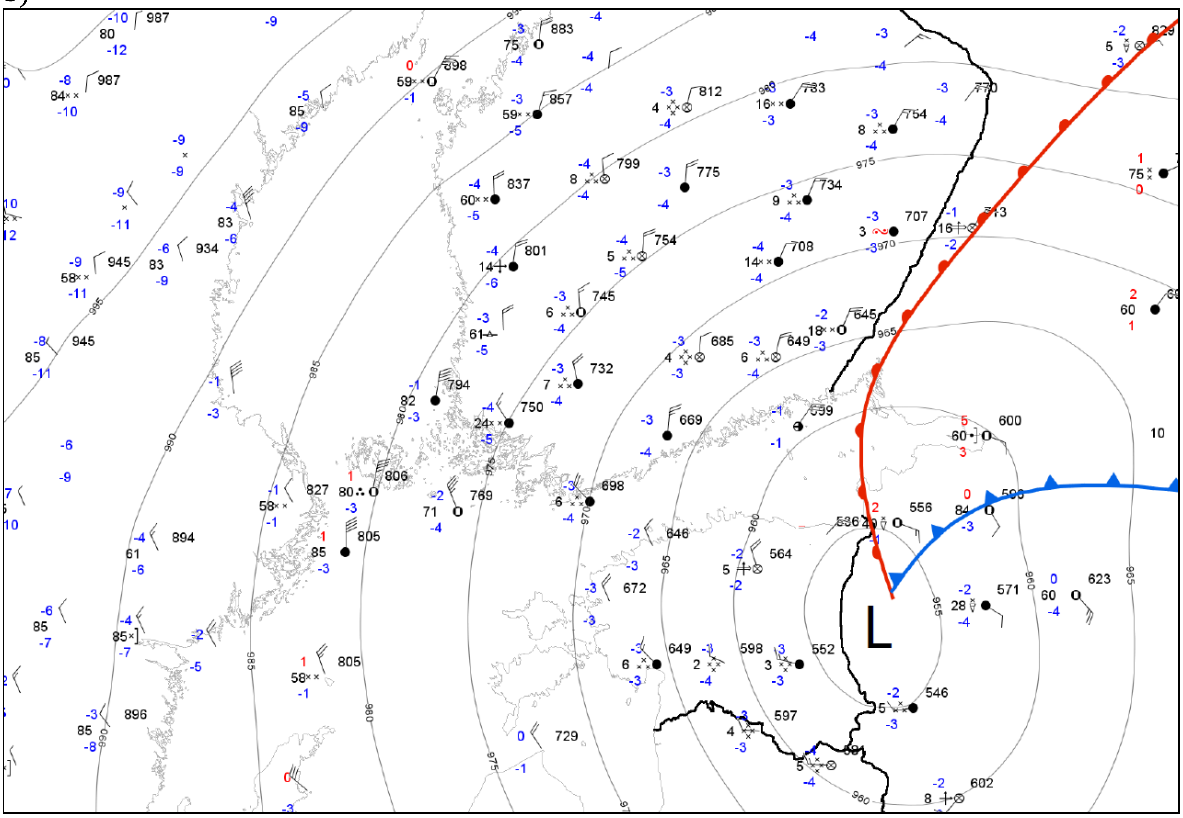


FIG. 1: Weather situations in Finland a) 10 November at 1800 UTC, and b) 23 November at 1500 UTC. The surface isobars are from Hirlam analysis.

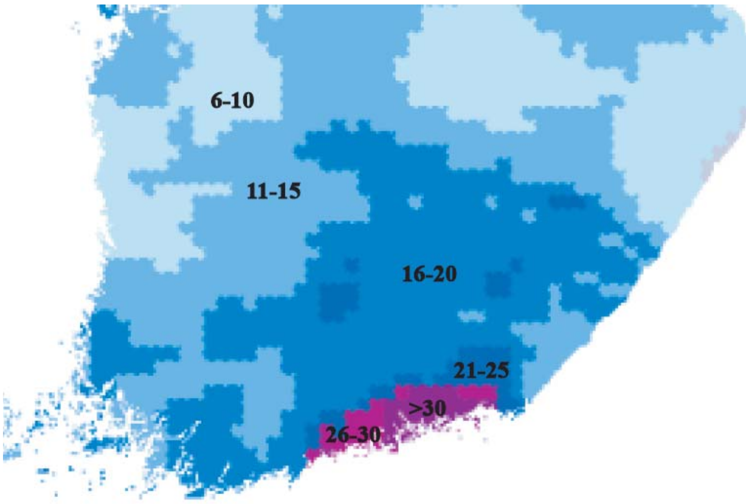


FIG. 2: Snow accumulation (cm) in southern and central Finland based on radar measurements during 23 November 0600 UTC - 24 November 2008 0500 UTC.

5. Weather related accidents

On 10-11 November the number of compensated traffic accidents in the statistics of the Finnish Motor Insurers' Centres was close to average. None of the provinces showed clear increase of compensated accidents occurring during the storm. The 23-24 November storm had instead clear indications of increase in the number of compensated traffic accidents. The total number of compensated traffic accidents in Southern and Central Finland was 824 with 112 injuries. The number of accidents was 73% higher than the two day average (477) of the whole year. On Sunday 23rd in the worst affected province, Uusimaa, the number of accidents (161) was fourfold the average of the other Sundays of the month. On Monday 24th the number (251) was more than three times the Monday average.

During 10 November, the total number of Rescue Services rescue operations was four times the normal, as the storm resulted in 801 rescue operations. In comparison, the 23 November blizzard affected to 534 weather related rescue operations resulting in doubling of the typical total number of operations in the affected area. In both cases 54% of weather related rescue operations concerned falling trees on roads. As the 10 November case had six traffic accidents of a car crashing into a tree blocking the road, the 23 November blizzard had 20 cases. In some cases the driver did not in poor visibility and slippery road conditions see the fallen tree early enough, in some cases the tree fell over a car. In the blizzard case, the number of Rescue Service reported traffic accidents was high, 145 cases, in which altogether 54 persons injured and one person died. In comparison, in the 10 November case Rescue Services reported 6 injured during the event.

The number households affected by power failures was estimated to be during the 10 November storm over 70 000, during the blizzard at least 41 000 households. The building damages were similar in both cases and included mostly detached roofs and failing scaffoldings. Several people were trapped in elevators during power failures.

6. Weather impacts on driving conditions

During the 10-11 November case (Fig. 3a) the temperature at Palojärvi station (30 km northwest from Helsinki) was relatively high and all precipitation was in the liquid form. So, the impact of precipitation on driving conditions was not at all as bad as in the 23-24 November case, although occasionally, when the rainfall was moderate, there was a small decrease in the road surface friction values. However, the strong wind gusts had a negative impact on driving conditions also in the 10-11 November case.

On 23 November the heavy snowfall (precipitation intensity up to 6 mm/h) caused a rapid decrease in road surface friction in southern Finland. Based on road weather observations at Palojärvi station, the friction values dropped from ca. 0.8 to 0.2 or below (Fig. 3b). The low friction values prevailed for almost 12 hours in spite of maintenance actions. In addition to the low road surface friction, the visibility was very poor and also the strong wind had a negative impact on the driving conditions, likely increasing the number of traffic accidents.

7. Preparedness for future storms

Understanding the consequences of severe weather on society helps develop preparedness for such events in the future. Knowledge on typical impacts of events can guide the formulation of several preparedness measures that aim to prevent casualties:

- General guidance for authorities and the public
- Call-to-action statements
- Site-specific action plans for people, private and public properties, and outdoor venues

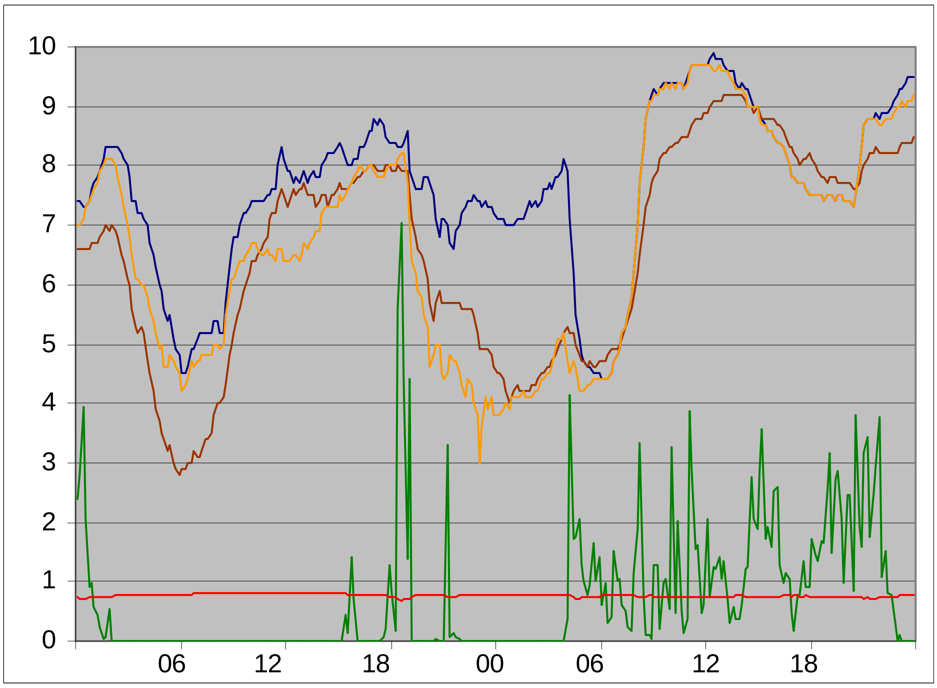
The impact information can also be used to mitigate property damage and ensure society's faster recovery by planning ahead, when severe weather is forecasted.

The impacts of certain severe weather on society, does not only depend on the intensity of the phenomena, but also on local effects like topography, vegetation, construction standards and local human behaviour. Therefore, the local effects should be considered when defining the typical impacts or safety rules for a certain area.

7.1 Impact descriptions

To understand the typical damage during wind storms in Finland, we collected damage reports near observation stations (within same town) and classified each report based on the preceding maximum wind gust. Based on wind gust observations of the two storms presented in this study, we gathered examples of damage that can occur with certain gust speeds (Table 1). Although, we would expect that with heavy snowfall trees would fall with smaller wind speeds, we did not observe any distinct differences between the cases with certain wind speeds. Some tree damage occurred already in surprisingly low wind gust speeds, in both cases. In some cases, possibly, the location of the observation station does not represent well the conditions in the damage location, for example if on elevated terrain. However, in these cases the soil was not yet frozen, but wet after the rainy and warm autumn. This likely had an impact on the tree damage, as earlier studies (Gregow et al. 2008) have shown that risk for wind damage to trees in Finland is highest during late autumn when the trees don't have support of frozen soil.

a)



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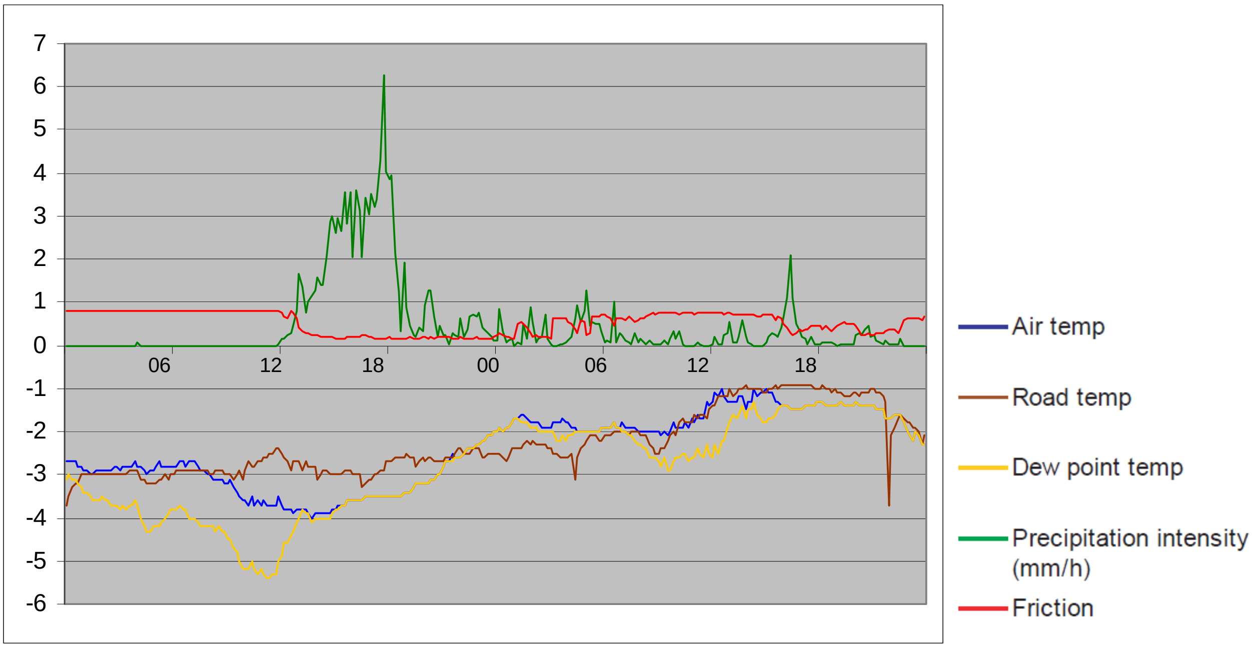

FIG. 3: Road weather observations at Palojärvi on a) 10-11 November and b) 23-24 November 2008. The measurements include road surface friction measurements by Vaisala's DSC111 optical instrument (Finnish Road Administration).

Impacts related to heavy snow is based mostly on reports from 23-24 November case (Table 1), with an addition from a similar weather event 22 December 2004, when a bus was pushed off road by approximately 20 m/s wind gusts. As some of the snow-induced damage reports were from media, and did not include exact time and location information, the snow accumulation prior the observed impacts are not included.

TABLE 1: Wind storm and blizzard impact damage chart for Finland.

Wind gusts (m/s)		Heavy snow fall
15	• Some fallen trees. • Risk for humans to be hit by a falling tree.	• Tree tops or trees may bend because of snow load. • Cars stuck in snowbanks, accidents on slippery roads. • Trains and trams delayed. • False fire alarms if blizzard snow reaches fire detectors.
17	• Trees fall down over roads. Also electric power lines, telephone lines and street lighting poles may fall down and cause danger, especially for road traffic. Trees can fall over cars[1]. Cars and humans possibly stranded between fallen trees. • Damage to mobile phone base stations may worsen the network. • Boats may come loose from mooring. • Some partly detached tin roofs. Trees fall over buildings. Banners and tarpaulins[1] on building facades and roofs may be detached. Building materials blow away from construction sites[1].	• In road traffic a large risk for collisions with objects on roads because of poor visibility and slippery roads.
20	• A lot of fallen trees. • Long lasting power failures cause problems such as people trapped in elevators, public facilities loose light, mobile phone network outages. • Whole tin roofs may be detached, felt and tile roofs may become partly detached. Advertising signs on building roofs in danger to fall down. Wind can shift lightweight outbuildings. Flagpole may fall over. • Piled shipping containers may fall down. Road signboards may break off.	• Delays in air traffic, some flights transferred to other airports. • Wind gusts may push cars off the slippery roads[2].
25	• Scaffoldings may collapse. • A lot of damaged roofs, also chimneys. Building windows may brake. Balcony glazing may become detached. • Airdomes may collapse or roof structure be damaged.	
28	• Lightweight outbuildings can be relocated. • Wide and long lasting power failures possible.	

[1]observed in 20 m/s, [2]observed in 22 December 2004.

7.2 Call-to-action statements

The locally typical severe weather impacts and accidents that can threat lives, can guide the formulation of general safety rules for public or call-to-action statements, which can be included in the storm warning messages during the most severe events. Call-to-action statements should provide localized guidance on what to do in response to the forecast (Troutman et al. 2001). Based on the observed impacts, in co-operation with the Emergency Services College, we have developed wind storm and blizzard call-to-action statements (Table 2). Their purpose is to save lives, and they are intended to be used only when the threat is imminent. The aim is to keep them as compact and clear as possible so that they are easily understandable when heard on the radio. Two levels of statements have been developed, to highlight the extremely dangerous events (Smith 2000).

8. Acknowledgements

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TABLE 2: Wind storm and blizzard call-to-action statements for Finland.

Wind storm	
General	Move indoors. Look out for falling trees and power lines.
Extremely dangerous situation	This is a very dangerous situation. Move immediately indoors away from windows. Look out for falling trees and power lines.
Blizzard	
General	Avoid unnecessary travelling. Look out for falling trees and power lines. Blizzard can cause very poor visibility.
Extremely dangerous situation	This is a very dangerous situation. Do not travel if it is not necessary. Look out for falling trees and power lines. Poor visibility makes it difficult to see barriers on roads and slipperiness increases the stopping distance.

9. References

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