TOWARDS A METHOD FOR ESTIMATING THE RISK OF WET SNOW ICING IN A MOUNTAINOUS REGION

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Abstract: By the use of high-resolution numerical modeling, the potential for wet snow icing is mapped in a mountainous region in North-Iceland. The process of mapping the wet snow icing potential is as follows: a) the relative frequency of wind directions when there is risk of wet snow icing is established from observations, b) winds and precipitation patterns are simulated for typical values of static stability in strong winds from 16 directions, c) the wet snow icing potential is calculated for each wind direction, based on b), d) the mean wet snow icing potential is calculated based on a weighted average from a) and c). Next step in developing the method should be based on a comparison between the calculated wet snow icing potential and icing observations where they are available.

Keywords: *wet snow, sleet, icing, , risk, Iceland, mm5, numerical simulations*

1. INTRODUCTION

Wet snow icing on structures can be a serious problem in many mountainous areas in the world. In strong winds, heavy precipitation and temperatures close to freezing, wet snow may accumulate on structures such as overhead power lines. If sufficiently thick, the accumulated wet snow may cause the structures to break. The risk of wet snow icing can therefore be an important factor in the planning of new overhead power lines. Generally, the risk of severe weather increases when moving from low elevations to high elevations. However, although useful in some cases, a primitive rule of this kind is often of very limited use, particularly when it comes to wet snow icing. In fact, there is a strong need for more advanced methods to help to estimate the relative and absolute risk of icing. In this paper a first step towards developing a method to calculate the wet snow icing risk is taken. The method is based on synoptic weather observations and high-resolution numerical simulations. First, the frequency of wind directions during conditions of wet snow icing is estimated from synoptic weather observations. Secondly, the wind speed and precipitation distribution in the region of interest are estimated from numerical simulations. Thirdly, a wet snow potential is calculated from the simulations of wind and precipitation for each wind direction. Finally, a composite potential of wet snow icing is calculated, based on a weighted average of the wet snow icing potential for different wind directions. The above process is carried out for a region in N-Iceland shown in the black box in Fig. 1. A similar numerical study was made for a region in NE-Iceland in connection with snowdrift and road construction (Ólafsson and Rögnvaldsson, 2005).

2. DATA AND NUMERICAL SIMULATIONS

Data from 5 synoptic weather stations (Fig. 1) is used to assess the wind directions during conditions of wet snow icing. The numerical model MM5 (Grell et al. 1994) is used for the numerical simulations. The Eta boundary layer scheme and the Reisner2 microphysical schemes were employed. The initial and boundary conditions of the simulations are uniform and stationary. The wind speed is 20 m/s at the surface, but increasing to 35 m/s at 800 hPa. The square of the Brundt-Väisälä frequency (N^2) is $1.6x10^{-4}$ Hz^2 below 800 hPa, but $0.8x10^{-4}$ Hz^2 above 800 hPa. The flow is simulated for each of the 16 wind directions until the pattern of precipitation and winds is close to stationary (less than 3 hours). The numerical setup includes 40 sigma levels. Precipitation is retrieved from simulations with a horizontal resolution of 2.5 km, while winds are obtained by simulating with a resolution of 500 m. Post-processing of data is done within the IDL framework to which the numerical data is exported using mm5idl (Rögnvaldsson and Rögnvaldsson, 2004).

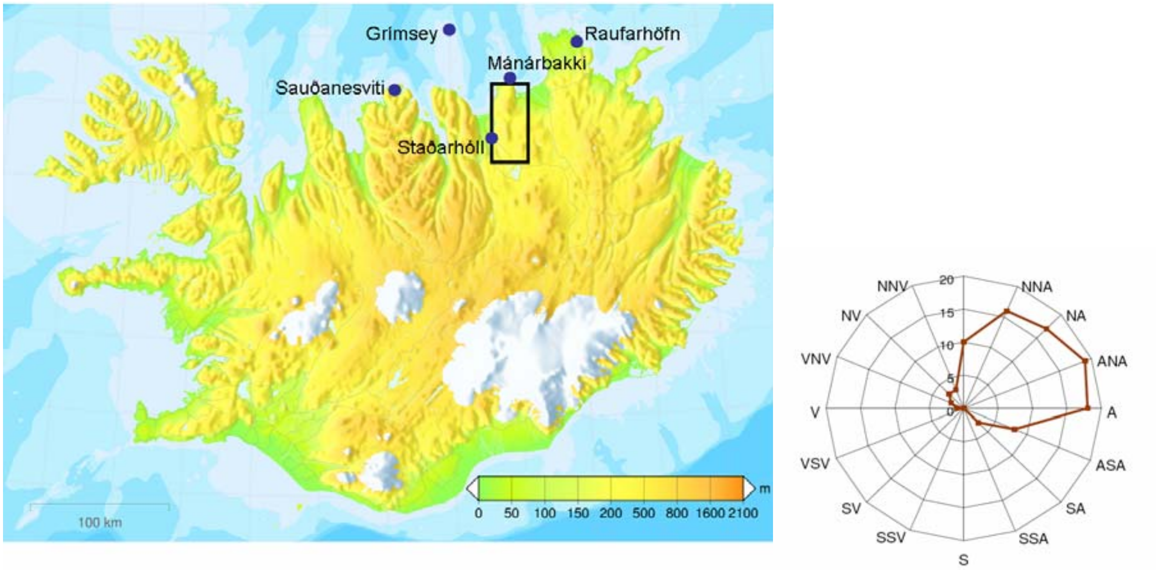

Figure 1: Left: Location of the area where the wet snow potential has been calculated. Weather stations providing data for the estimation of wind directions during potential icing events are also shown. Right: The frequency of wind directions during wet snow icing, based on a composite of the data from the weather stations in the map on the left side.

3. WET SNOW ICING

The intensity of wet snow icing depends on several parameters which are discussed thoroughly in for instance Makkonen (2000). The accumulation of ice mass (M) can be described by the following equation

$$dM / dt = \alpha_1 \alpha_2 \alpha_3 w V A \tag{1}$$

where α_1, α_2 and α_3 are efficiency factors that are partly related to the microphysical properties of the particles, w is the density of precipitation particles in the airflow, V is the wind speed and A is the area exposed to the flux of the precipitation particles. The collision efficiency is positively correlated with the wind speed and A increases as the icing increases. The accumulation of wet snow icing is in other words a non-linear function of wind speed. Here, we define a wet snow icing potential as

$$I = R V^{3/2} \tag{2}$$

where R is the precipitation intensity (mm/3h) and V is the wind speed. In our simulations, precipitation is only produced through orographic lifting. Far away from mountains, R is consequently close to zero.

4. RESULTS

The frequency of wind directions during potential wet snow icing at 0-400 m.a.s.l. (strong winds, temperature 0 to +2°C and intense precipitation) (Fig.1, right) is established by a subjective composite of about 30 years of continuous observations at the weather stations shown in Fig.1(left). Figure 2 shows the simulated wind speed and precipitation in flow impinging from the ENE. The wind varies from about 20 m/s to 35 m/s and the orographic precipitation intensity has values of up to about 7 mm in 3 hours. These values can be characterized as realistic. The wet snow risk potential in flow from the ENE, according to Equation (2) is shown in Fig.3 and the directionally averaged mean wet snow icing potential (using the distribution in Fig.1, right) is given together with some possible routes for overhead power lines in Fig.4.

5. DISCUSSION

The wet snow icing potential calculated in this study (Figs. 3 and 4) does to some extent correlate with the height of the topography. There are however important deviations from this. These deviations arise

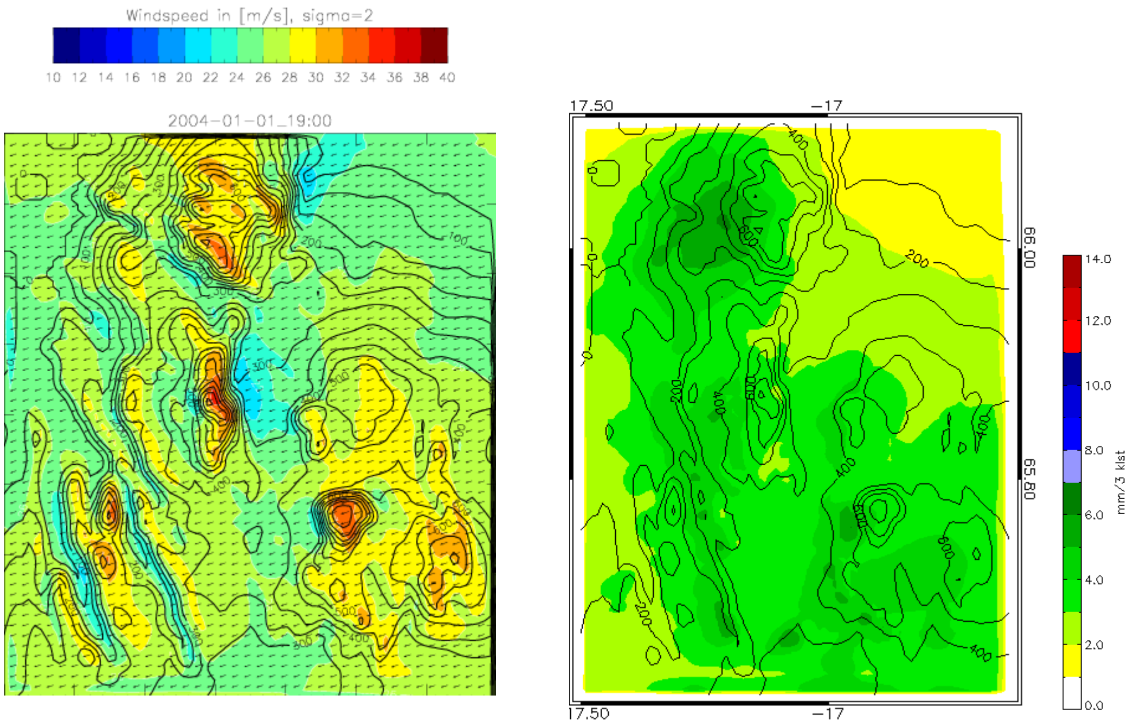

Figure 2: Simulated stationary flow from the ENE. Left: Surface winds (m/s). Right: Precipitation (mm/3h).

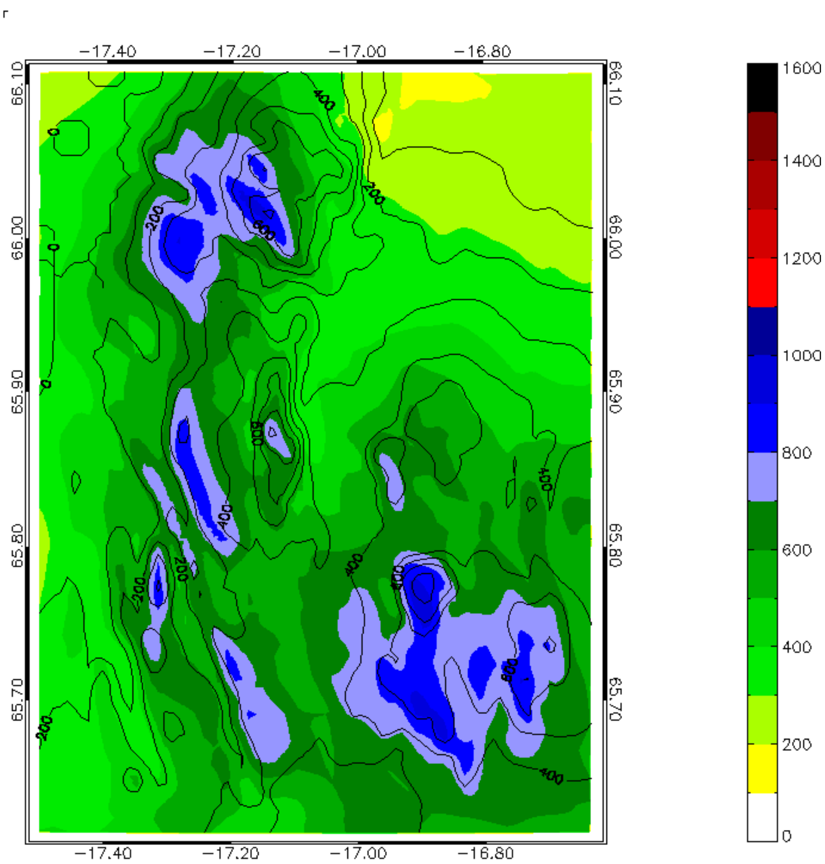

Figure 3: Topography with 100 m intervals and wet snow icing potential in winds from ENE, based on the flow in Fig.2 and Eq.(2).

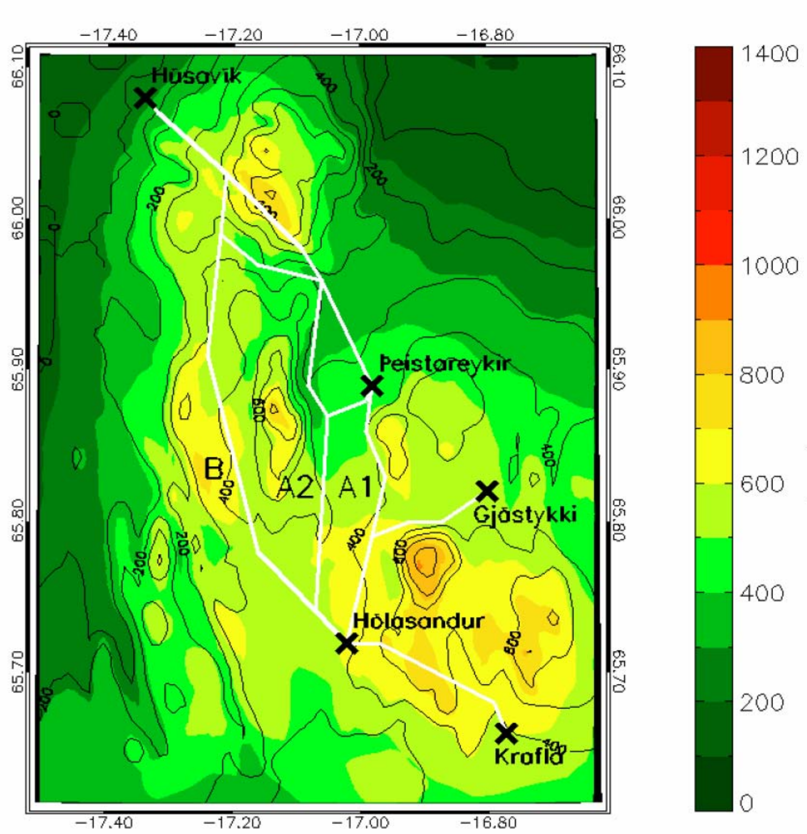

Figure 4: Directionally weighted average of the wet snow icing potential, topography with 100 m intervals and planned overhead power lines.

mainly from the variability in the winds, but also from spill-over of precipitation (Fig.2) The patterns of wind and precipitation in Fig. 2 are largely consistent with what can be expected from conceptual knowledge of winds and precipitation in complex terrain. There is a list of factors of uncertainty associated with the calculations in this study, some of which may be dealt with in future work of improving the method. Some of the main potential sources of errors are associated with the ability of the numerical tools to simulate the winds, and in particular the precipitation. Elements of the icing process such as the efficiency of particle accumulation are only to a limited extent taken into account. More importantly, wet snow icing may take place locally in weather conditions quite different from those simulated. In weaker winds with a different vertical profile of wind and temperature, the wind pattern may be somewhat different from the results presented in Fig.2.

6. CONCLUSIONS AND FUTURE WORK

A method for calculating potential for wet snow icing has been presented. The icing potential is calculated for a region in Northern Iceland and the results have been helpful for planning of overhead power lines. In order to validate the calculations and to connect the wet snow icing potential to the wet snow icing risk, a comparison with icing observations and local weather is needed.

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