APPLICATIONS OF NUMERICAL SIMULATIONS TO INVESTIGATE SNOW ACCUMULATION FOR THE ESTIMATION OF AVALANCHE RISK IN MOUNTAINOUS TERRAIN

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Abstract: Severe weather events in a mountainous region in East-Iceland are mapped by numerical simulations. The simulations provide an insight into the wind pattern and the precipitation distribution in a region where avalanches due to rapid snow accumulation in strong winds pose a threat to planned constructions. Two cases are presented to illustrate how areas with high snow accumulation can be located and how different weather types contribute to different locations of potential snow accumulation.

Keywords *– Extreme storms, avalance risk, Iceland, numerical simulations, MM5*

1. INTRODUCTION

In connection with planned construction of a power line in the mountains in East-Iceland there is concern about accumulation of snow and risk of avalanches. No meteorological observations have been made in the area, but observations have been made in the fjords at the east coast for several decades. The observations and the avalanche history from the inhabited areas along the coast indicate that avalanches occur almost exclusively in northeasterly storms. The winds are usually strong, but excessive precipitation in short time may lead to avalanches even though the winds are only moderate (Ólafsson, 1998). In an attempt to shed some light on the precipitation and winds in the mountains in question during weather events that may lead to large avalanches, a total of 12 weather events have been simulated at high resolution with the numerical model MM5 (Grell et al., 1995). The events were chosen by a quasi-subjective evaluation of all major weather events that were likely to be able to produce major avalanches in the period 1956-2003. Strong winds and heavy precipitation over an extended period (a few days) were the main criteria in the choice of events. The setup of the the simulations is as explained in Rögnvaldsson et al. (2004) and the horizontal resolution is up to 300 m. The simulations are forced with boundaries from the ECMWF.

In this paper, two cases are presented in order to illustrate the method and the conclusions that can be drawn from numerical experiments of this kind.

2. CASE I: 20 – 24 January 1978

Figs. 1 and 2 show the simulated 78 hrs accumulated precipitation and the surface wind field during the maximum winds in a weather event that lasted from 20 to 24 January 1978. The dominating direction of the flow is from the southeast and the simulation indicates that there were more than 200 mm of precipitation in the mountains. The maximum precipitation is not in the mountains at the coast, but further inland, where the mountains slope towards the southeast and the simulation indicates that there were more than 200 mm of precipitation in the mountains. The maximum precipitation is not in the mountains at the coast, but further inland, where the mountains slope towards the

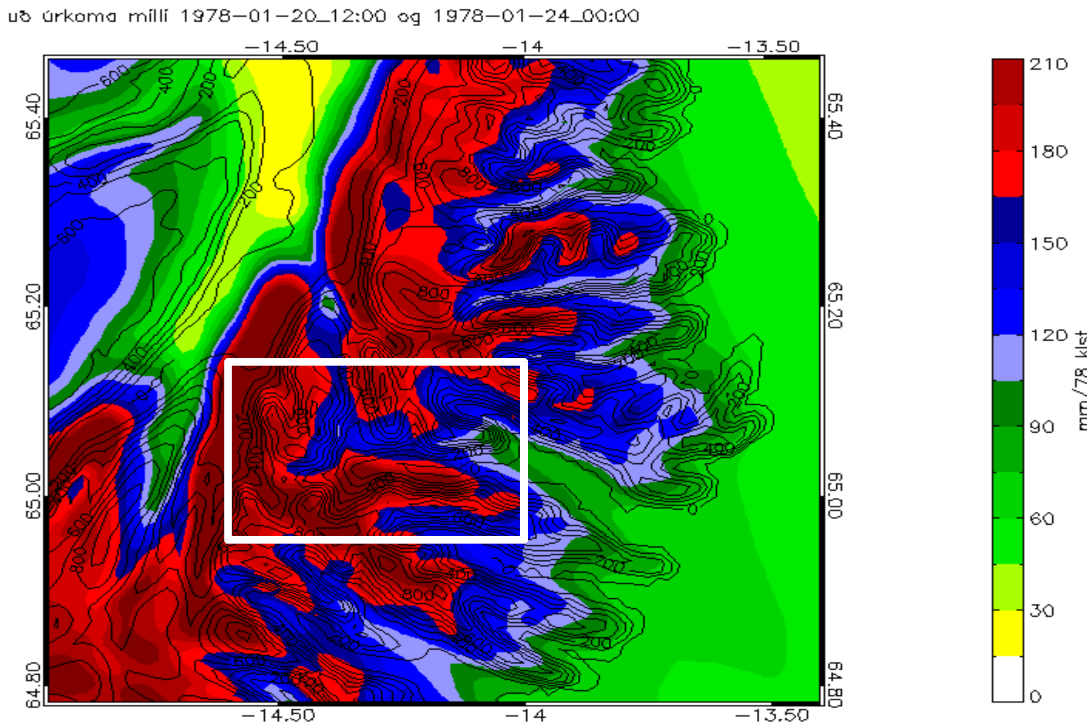

Figure 1. Accumulated simulated precipitation from 20 January 1998 (12 UTC) to 24 January 1978 (00 UTC). Terrain contours are with 100 m intervals. The box indicates the area of interest in this study.

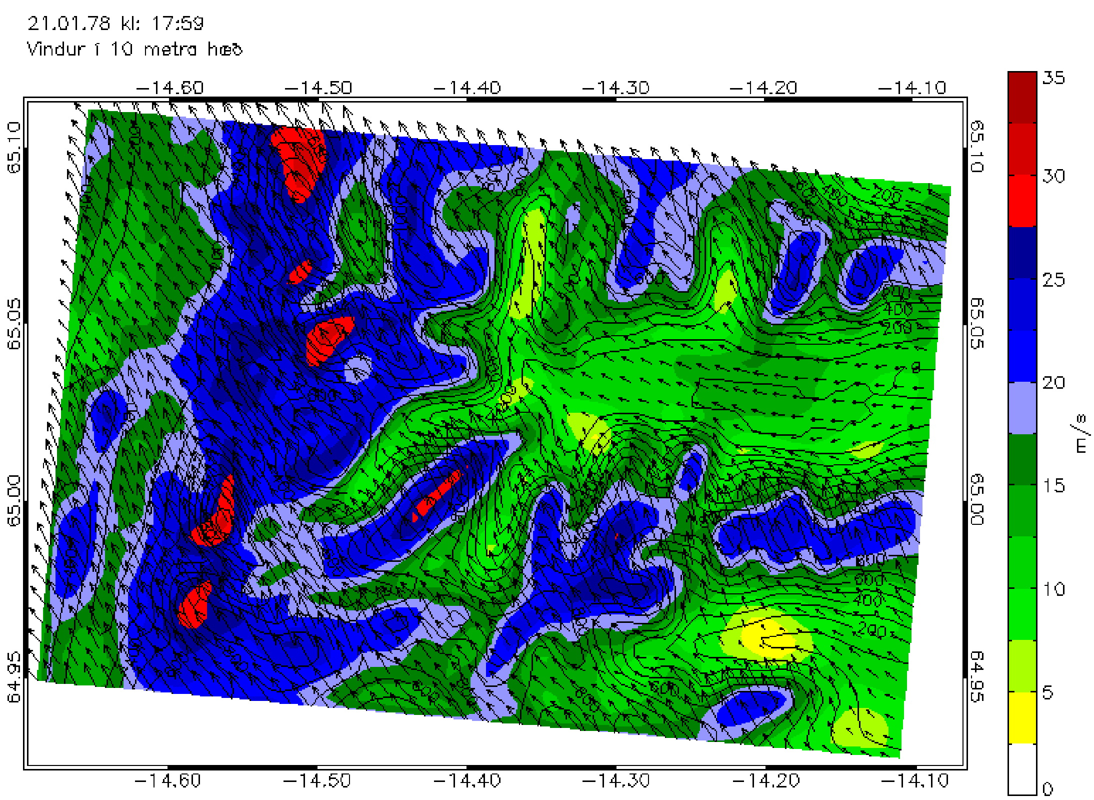

Figure 2. Surface wind vectors on 21 January 1978 (18 UTC). Terrain contours are with 100 m intervals.

large valley penetrating in from the NNE. The wind field (Fig. 2) shows several areas where there ara very strong winds (about 30 m/s), dropping down to 10-15 m/s in the next gridbox. In these areas, much snow can accumulate and large avalanches are likely to occur. The greatest risk of avalanches is presumably in the east part of the valley in the middle of the box and in the slopes at the western edge of the box.

3. CASE II: 3 – 6 November 2002

Figs. 3 and 4 show the simulated 123 hrs accumulated precipitation and the surface wind field during the maximum winds in a weather event that lasted from 8 to 13 January 1998. In this case the prevailing winds are from the northeast and the precipitation pattern is somewhat different from the 1978 case. In this case, the coastal mountains receive about 30% more precipitation than the mountains of interest for this study (in the box).

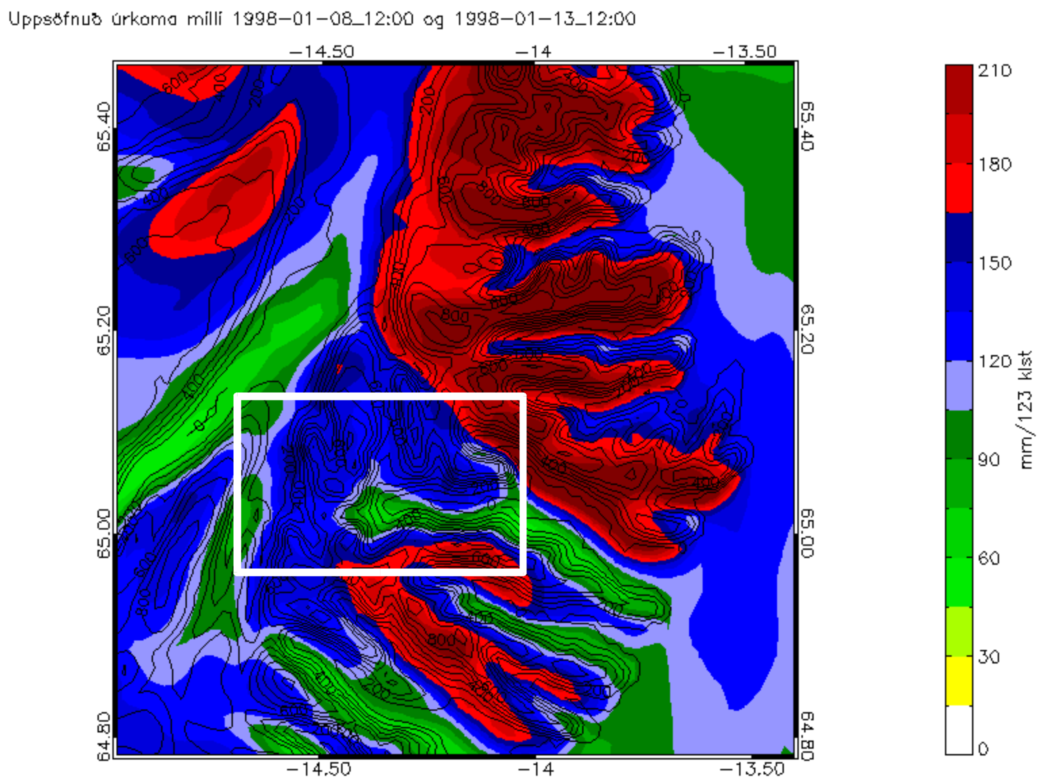

Figure 3. Accumulated simulated precipitation from 8 January 1998 (12 UTC) to 13 January 1978 (00 UTC). Terrain contours are with 100 m intervals. The box indicates the area of interest in this study.

As in the 1978 case, the simulated wind field reveals locations with potential for great snow accumulation, i.e. where the winds drop rapidly in the along-flow direction, but not unexpectedly, these locations are not the same as in the southeasterly flow in the 1978 case. There is little doubt that there is greater snow accumulation in the coastal mountains than in our area, but there are a few locations inside the box where the wind field indicates strong accumulation.

4. DISCUSSION

In this study, there is very limited observational data to validate the simulations. The errors in the precipiation observations during snowstorms are too great for these observations to give more than an indication of the true precipitation, and these observations are not presented here. The quality of the numerial simulations used in this study must therefore be evaluated by other studies with the same tools.

From a total of 12 cases, there is in general a tendency for higher amounts of precipitation in the region of interest when the winds are from the east or southeast, than in northeasterly winds. This indicates that large avalances in our

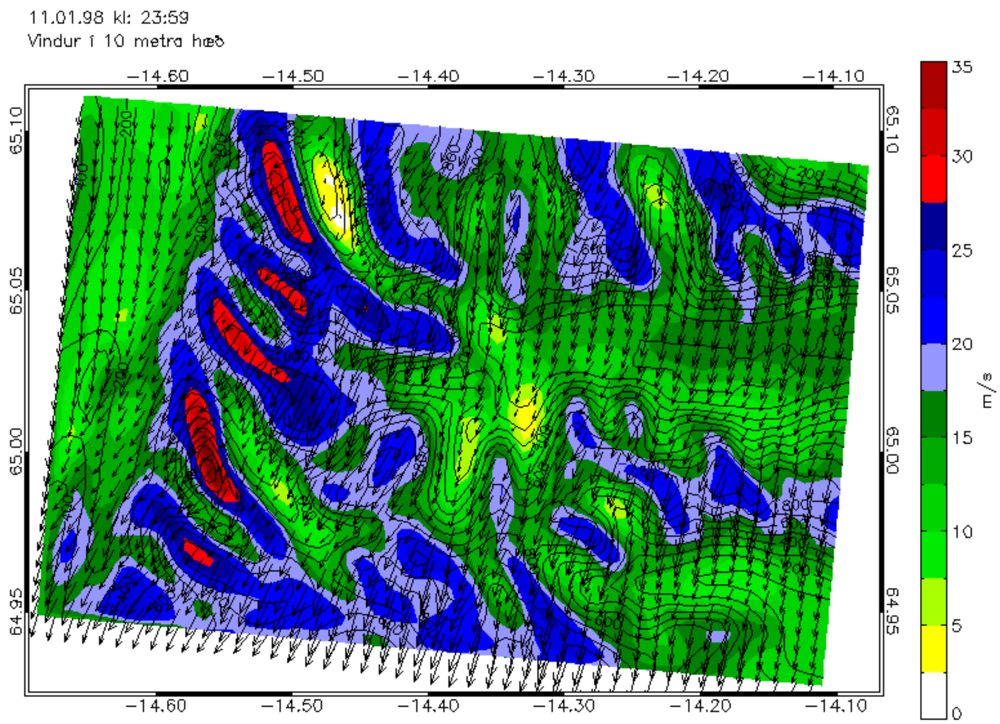

Figure 4. Surface wind vectors on 12 January 1998 (00 UTC). Terrain contours are with 100 m intervals.

area may, unlike in the nearby coastal areas, be favoured in southeasterly windstorms rather than northeasterly windstorms.

5. CONCLUSIONS

This study illustrates how numerical simulations of severe weather events can be of help to map the mesoscale pattern of precipitation and wind in mountainous regions. The result is in this case helpful to indicate areas of great snow accumulation for the estimation of avalanche risk.

REFERENCES:

Grell, G. A., J. Dudhia, and D. R. Stauffer, 1995: A Description of the Fifth-Generation Penn State/NCAR Mesoscale Model (MM5). NCAR/TN-398+STR. National Center for Atmospheric Research, Boulder, CO, 107 pp.

Ólafsson, H.,1998: Veður fyrir snjóflóðahrinur Neskaupstað 1974-1995 (Weather related to avalanche episodes in Neskaupstaður, E-Iceland, 1974-1995), Tech. Rep., Icelandic Meteorol. Office, Reykjavík, Iceland (In Icelandic).

Rögnvaldsson, Ó, P. Crochet, and H. Ólafsson, 2004: Mapping of precipitation in Iceland using numerical simulations and statistical modeling. *Meteorol. Z.*, **13**, No. 3, 209–219.