SNAPS - Snow, Ice and Avalanche Applications

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ABSTRACT: The SNAPS project focuses on snow and avalanche services for transport infrastructure in selected areas within the Northern Periphery in Iceland, Norway, Sweden and Finland. The main tasks of the project are: development of near-real time snow cover maps with remote sensing, and avalanche and snow-drift forecasts. The focus in the project is on selected target roads where the forecasts will be implemented.

The main avalanche forecasting tools that will be developed are of two types: 1) A statistical analysis on weather and avalanche data is performed. The result will be in the form of likelihood of avalanches reaching the road given certain weather conditions. 2) Snow models are being tested and improved. Results from the HARMONIE high resolution numerical weather prediction model is used as an input to the Crocus snow model. Experiments are being made using the snow cover maps in the process.

An important part of the project is the implementation of information to road users. Groups of road users are created in each target area which receive updates on the project and help develop methods of giving road users information. In Iceland, road users have the possibility of signing up for a test product where information on different levels of avalanche danger and possible upcoming danger are given by text messages in mobile phones.

KEYWORDS: Avalanches, avalanche forecasting, transport, snow models, snow maps

1. INTRODUCTION

SNAPS (Snow, Ice and Avalanche Applications) is the name of a co-operative project including partners in Iceland, Norway, Sweden and Finland, focusing on snow and avalanche services for transport infrastructure. Snow avalanches can be a problem in all of these countries and cause threat to roads and other transport routes. Some avalanche forecasting services exist in all of these countries but the levels are different and the methods as well. The project is funded by the Northern Periphery Programme (NPP) which aims to help peripheral and remote communities on the northern margins of Europe to develop their economic, social and environmental potential (NPP website: www.northernperiphery.eu).

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The main partners in the project are expert institutes in snow and/or avalanche science. Transport authorities as well as municipalities are associated partners. In the avalanche part of the project the aim is to:

- Transfer knowledge and methods between the countries.
- Analyze weather, snow and avalanche data with the same methods in all target areas.
- Test the potential for utilizing satellite snow data in avalanche forecasts.
- Run already existing snow models based on the HARMONIE numerical weather prediction model for the target areas.
- Work on methods and visualization of avalanche forecasts tailored to the needs of transport authorities.
- Develop tools for disseminating information on avalanches and avalanche danger to road users.

Figure 1: Part of the Hwy 15 in Stryn, Norway. Photo K. Kristensen, NGI.

2. ANALYSES ON AVALANCHES, SNOW AND WEATHER DATA

A statistical analysis on the correlation between weather factors and avalanches is carried out using a nearest-neighbour method. The main hypothesis is that days with similar weather should have similar avalanche activity. Hence, by looking at avalanche activity on certain days in the past with similar weather as forecasted, one can assume that the avalanche activity will also be similar. A Nearest-neighbour method with, among other features, a higher temporal resolution described by Kristensen and Larsson (1994) and further developed (Singh and Ganju, 2004) is used instead of the classic nearest-neighbour method.

In the classical method a certain number of similar days is found in the dataset (typically 10). Avalanche activity registered during those days is used as an estimate for avalanche activity in future days (Buser,1989 and Singh, 2004). In the method used in the SNAPS project, instead of using a certain given number of neighbour days, the allowed range for each weather parameter is defined and all days that fall inside this parametric range are used as the nearest-neighbours. This approach means that in case of rare events only few or even none neighbours are found instead of using a given number of past days that might be quite far off. For common events, a large group of similar days can be used increasing the accuracy of the estimated avalanche activity. Obviously, the base unit does not need to be one day it can be either longer or shorter periods and can be different for different weather parameters.

Four different road stretches in three countries are the target roads for the avalanche forecasting part in SNAPS. Availability and quality of weather data differs from site to site. Typically, wind, temperature and precipitation data are available but the distance from the site to the weather observation station varies. In some cases snow depth measurements are available as well. As a part of this project automatic snow depth sensors are installed in or close to avalanche starting zones within target areas. The instrument (SM4 snow sensor) indirectly measures snow depth with a series of thermistors mounted with a fixed interval on a pole. A by-product is the temperature profile of the snow pack and air temperature data. The snow depth measurements will be incorporated in the statistical analysis where that is appropriate.

Preliminary results for the target road in Iceland, Súðavíkurhlíð, are displayed in Table 1. The first row shows that weather observations where wind speed is over 12 m/s from NW and the 3 hour precipitation is over 8 mm are 20. Out of these 20 observations 80% or 16 are followed by at least one avalanche within 6 hours from the weather observation.

Table 1: Part of the first results based on data from the road Súðavíkurhlíð in Iceland. The results are based on four weather factors: Temperature (not shown in the table, it is always <-1°C for the first rows), wind speed and direction and precipitation. The results are sorted after avalanche frequency.

Wind (m/s)	Wind	3 hour precipitation (mm)	Number of observations	Avalanche occurrences frequency (%)
>12	NW	>8	20	80
0–4	SW	>8	2	50
>12	NE	>8	74	43
4-12	SW	>8	13	38
0-4	SE	>8	11	36
0-4	NA	>8	13	23
>12	SW	>8	33	21
4-12	SE	>8	26	19
4-12	NW	>8	6	17
>12	SE	1-8	149	15
0-4	NW	1-8	84	12
4-12	NW	1-8	228	11
...	...	...	...	...

The results in this table indicate that NW snowstorms with high wind speeds are frequently followed by avalanches. NE storms are more common but are not as strongly related to avalanches. Some further work need to be done to obtain the best results. The parametric range can be altered and the number and type of weather factors.

The whole dataset will be analysed like this and the results will be in the form of written guidelines regarding the weather factors that potentially lead to avalanche activity. These guidelines and the nearest-neighbour method itself will then become part of the avalanche forecast. The method can be run with the input of parameters from the weather forecast for the next days.

3. SNOW MAPS AND MODELS

A part of the SNAPS project focuses on snow maps in near real-time produced from satellite data. Some of these maps show certain characteristics of the snow, e.g. the wetness of the surface. This may be of use for avalanche forecasters, e.g. for monitoring snow layering over a widespread area and evaluating the snow drift potential.

Snowmodels have been used as an avalanche forecasting tool in some countries for years. An example of this is the French CROCUS model. In France it has been used as a part of a chain of models: SAFRAN-CROCUS-MEPRA where SAFRAN is a weather model, CROCUS a numerical snow model and MEPRA is an expert model predicting snowstability (Duran, et al., 1999). In areas where optical data such as snow pits are rare due to small population density and the extent of the area, automatic snow and snowstability models may be important tools for avalanche forecasters. This is the case in the Northern Periphery Regions of the Nordic countries.

The goal in SNAPS is to get snow models up and running for the target areas. The idea is to use a small scale weather model that is in operation in this region and attach a already developed snow model to that. HARMONIE is a numerical weather prediction model (Driesenar, 2012) that is currently used or being tested in this area. It runs at a relatively small scale. The aim is to use the HARMONIE model to feed CROCUS with weather data and the possibility of adding MEPRA to the chain explored.

4. AVALANCHE FORECASTING FOR TRANSPORT AUTHORITIES

An important part of SNAPS is the practical application of the result from analyses and model work. Institutes that have expertise in avalanche science are working together with transport authorities in the countries in order to develop avalanche forecasts tailored to their needs. This includes development of the format and visualization of the forecast. Geographical Information Systems will be used for the visualization part showing the predicted degree of danger (avalanche probability) on different parts of the road.

5. DISSEMINATION OF INFORMATION TO ROAD USERS

Another important part of SNAPS is the communication with the users of the road. In Iceland, a list of road users has been created and a text message system developed. During fall 2011 frequent travelers of the road on Súðavíkurhlíð were offered to receive messages from this system and take a part in a test run for the first winter. Two hazard levels were defined: 1) avalanche hazard but the road is still open and 2) road is closed due to avalanche hazard.

Four different text messages have been defined (*the text in italic can be changed.*):

A. Súðavíkurhlíð: Avalanche hazard possible *later today*, *Wednesday*

B. Súðavíkurhlíð avalanches: Alert status is declared *today, Wednesday at 11 AM*

C. Súðavíkurhlíð avalanches: Danger status is declared *today, Wednesday at 12 AM*. The road is closed.

D. Súðavíkurhlíð avalanches: Danger status is called of *Thursday at 17:30*. The road is open.

This means that road travellers may first get a warning with message A in their cell phones when the forecast indicates avalanche danger in the near future. Stage B means that there is avalanche hazard on the road even though it is not closed.

The idea is to give road users chance to make decisions based on better information than before. The road Súðavíkurhlíð connects two towns in Iceland and many people travel the road daily to get to work, school, services such as grocery stores, etc. It is also used for transport of goods and products. In general Increased information to road users can help directing the traffic to safer periods or alternative roads, where that is an option, making the transport safer and more efficient.

The text message system was used for the first time during an avalanche cycle in the Ísafjörður area at the end of January 2012. Roughly 40 people in Súðavík village had already signed up on the list and got exactly the messages listed above. Similar messages were also displayed on the public web site of the Icelandic road administration (ICERA). People from the group contacted ICERA after the avalanche cycle and were content with their experience as travellers. They got some time to get to their homes before the severe weather culminated. A total of 23 avalanches hit the road during the cycle.

6. CONCLUSIONS

SNAPS is a three year project that will come to an end in 2014. Therefore, the final results are yet to appear. SNAPS is a unique avalanche project in many ways. Specialists in satellite data, weather models, snowdrift models and snow avalanches are working together and this dialogue has led to new ideas and experiments. Avalanche research and forecasting development focusing on this northern periphery area as a whole is also new. The project has led to a closer cooperation between transport authorities and avalanche specialists in the area. Furthermore, the dissemination of information to road users has met positive attitude in Iceland, where it has been tested.

7. NEXT STEPS

This upcoming winter the operation of the avalanche forecast will be tested with the tools and knowledge already available, including the first findings of the statistical analysis. Further work will be carried out with the nearest-neighbour method and the tool will be used in real time in connection with weather forecasts. The aim is to develop HARMONIE-CROCUS chain and implement it either directly to the avalanche forecast or by adding MEPRA to the chain. The snow maps and the SM4 snow depth sensor will further strengthen the toolbox for avalanche forecasting. However, it will take time to develop the best interaction between the different tools as well as the format of the forecast and presentation to road travellers.

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