

Regional avalanche warning in Norway, a new concept for a large country

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ABSTRACT: Norway encompasses 324 000 km² of land area of which ca. 7 % are mountainsides steeper than 30 degrees. The country extends approximately 1700 km from south to north and features extreme variations in normal precipitation and temperatures from one region to another. A normal winter day can show several seasons in different parts of the country. Yet, the population is scarce and distributed all over the country, connected by long and avalanche prone transport routes through the mountains. This poses a major challenge for avalanche warning. Most weather observations are limited to inhabited areas in lowland terrain and there is no network of neither snow nor avalanche observations. Today, avalanche warnings are only issued for local objects of infrastructure and housing like the Oslo - Bergen railway or Highway 15 connecting east and west Norway. The NGI avalanche warning project in northern Norway which covers 22 000 km² is a regional approach that also involves local observers. General warnings for large areas at a time are only issued by the Meteorological Office when level high or very high is reached. The Norwegian government has plans to establish a regional avalanche warning service administrated by the Norwegian Water Resources and Energy Directorate. This paper presents a draft concept for such a warning service, technical and administrative challenges and suggestions for their solution based on current technical possibilities and 35 years of NGI avalanche warning experience

KEYWORDS: Avalanche warning, Norway, regional warning

1 INTRODUCTION

In 1972, the Norwegian parliament decided to start active research and operational avalanche warning in Norway (Lied and Kristensen, 2003). The task was divided, appointing the research to the Norwegian Geotechnical Institute (NGI) and the avalanche warning to the Norwegian Meteorological Institute (met.no). Historically, most avalanche accidents in Norway affect infrastructure and housing. During the large avalanche winter 1868 (161 fatalities) and 1979 (11 fatalities) most people were killed inside their homes (Kristensen, 1998). Therefore, the traditional focus of the Norwegian avalanche research and also avalanche warning has been on the protection of houses, roads and railroads. A major accident killing 16 soldiers during a military exercise in 1986 and an increasing number of recreational fatalities during the last 10 years has shifted the focus more towards the challenges due to active use of avalanche terrain in winter time.

The public demand for a more detailed and daily avalanche warning service has increased during recent years. Local authorities, responsible for the safety of their inhabitants, transporta-

tion industry and recreationists ask for an improved service to be able to plan their activities well ahead. Currently different options are discussed in Norway. This paper will give some suggestions based on the NGI experience of the last 35 years.

2 TERRAIN

Mountains and Norway are somehow synonyms. Seven percent of the total 324 000 km² of land area are steeper than 30 degrees. The population and infrastructure is mainly located along the valleys and the narrow shores of the fjords. Ca. 80% of the land area which is prone to avalanches and rock falls is mapped (Harbitz et al., 2001). These maps point out all areas with a potential avalanche hazard. The maps show that approximately 25.000 existing buildings are exposed to avalanche or rock fall danger in the country (Jaedicke, 2008). But also large sections of the road and railroad system are exposed to frequent avalanches.

3 Climate:

The climate in Norway is dominated by the south-westerly winds over the Atlantic Ocean creating a distinct weather gradient over the country. On the west side of the mountain chain that stretches all the way from the southern tip 1700 km to the north, annual precipitation is high and the winters are mild.

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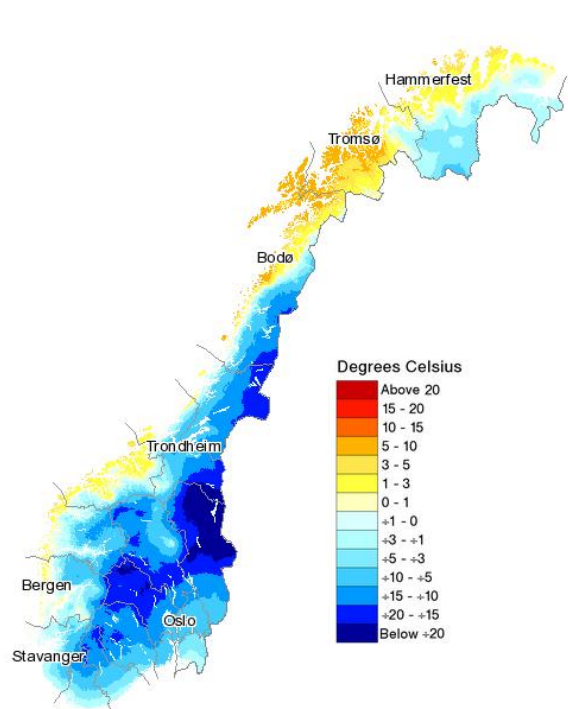


Figure 1. Daily mean temperature on 01. February 2009 (www.senorge.no)

On the east side of the mountains less precipitation is observed and temperatures can fall below $-30\text{ }^{\circ}\text{C}$ in areas far from the coast. Typically, the weather divides the country into two or even three distinct zones depending on the location where the low pressures hit the coast. It is not uncommon during a winter to observe $-10\text{ }^{\circ}\text{C}$ in Oslo while heavy rains is observed in Tromsø (Figure 1). The most avalanche prone weather situations are cold front precipitation events that can lead to heavy snow precipitation in short periods of time. Snowfall of 50 – 100 cm in 24h is frequently observed.

4 Avalanche warning today

The avalanche warning in Norway today is based on two different services. The Meteorological Institute issues avalanche warnings at danger level four and five for large areas of the country e.g. for one or several counties. These situations are often accompanied by heavy winds, strong snowfall and a general storm warning. Usually, the major roads crossing the mountains are closed in these situations. In recent years, also danger level three is mentioned from time to time in periods with public holidays. But there is no daily evaluation of the avalanche situation in the country.

The second avalanche service is customer financed and project based avalanche warning for selected objects issued by the Norwegian Geotechnical Institute (NGI). These projects cover selected road or railroad sections,

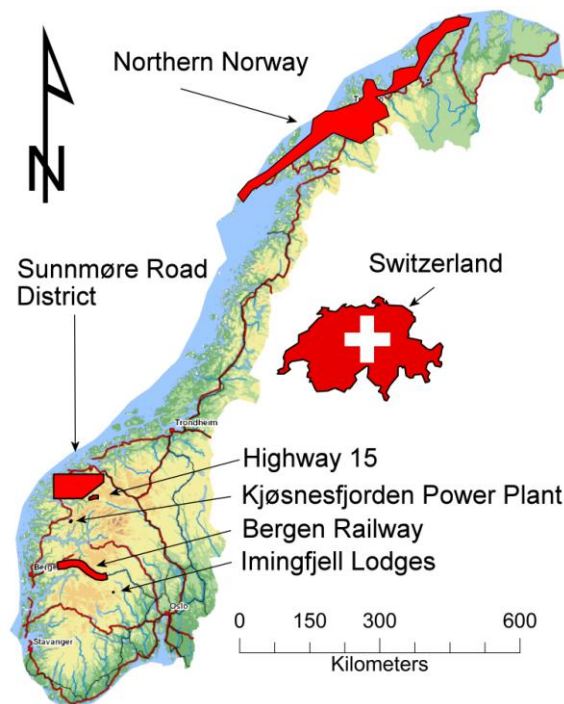


Figure 2. Areas with NGI project based daily avalanche warning (red). Map of Switzerland for comparison of areas.

avalanche prone residential houses or hydro power construction sites in the mountains. The warnings are usually issued daily based on local observations and weather stations. Currently, six warning projects are included in the NGI service (**Error! Reference source not found.**).

During public holidays in February and around Easter the NGI, in cooperation with the Meteorological Institute and mountain rescue groups, issues special avalanche bulletins twice a week to inform the public about the present avalanche danger and increase the public awareness in these periods of increased recreational activity in the mountains.

5 Available data

The Norwegian Meteorological Institute has today a network of 245 meteorological stations that observe the most important elements such as precipitation, wind and temperature. Additionally there are 364 stations that only observe daily precipitation. Most of these stations are located in inhabited areas with the consequence that only a small number is located in the mountains. The data are freely available to the public and the meteorological institute has put a large effort into making the data as accessible to users as possible (www.eklima.no, www.yr.no). In addition, many state agencies have their own network of stations. The most extensive network is maintained by the road authorities. These stations are often installed at locations where

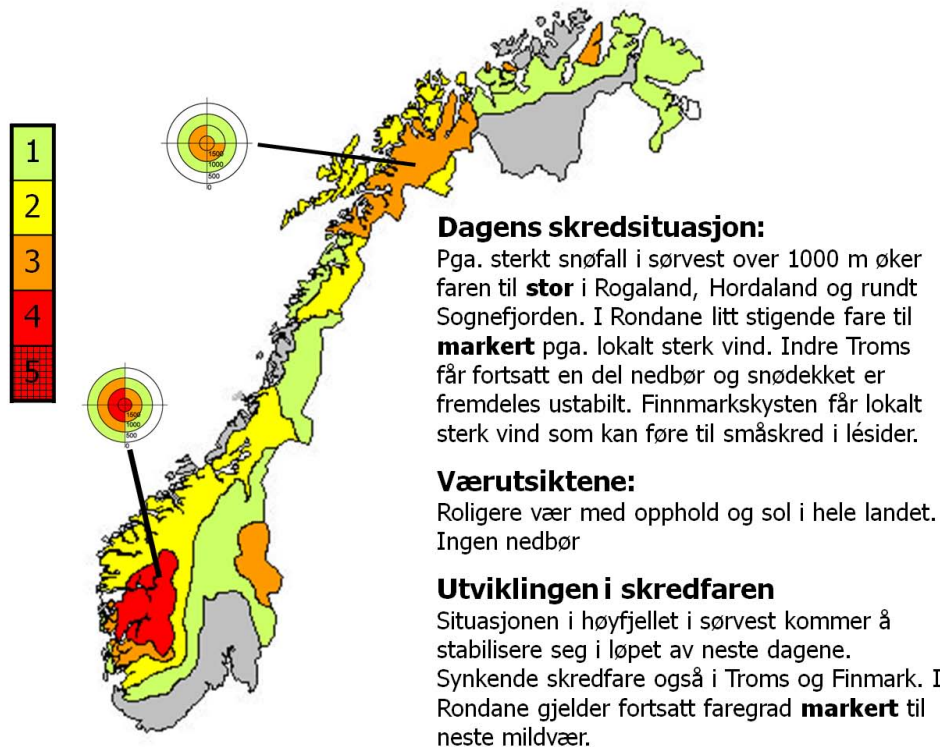


Figure 3. Example of a possible presentation of regional avalanche warning for Norway. The wind roses give additional information on aspect and elevation.

weather is critical for the traffic and therefore they also give important information that can be used for avalanche warning. Currently a joint venture project aims to stream the weather observations from all state owned stations into the central database administrated by the Meteorological Institute. The network of weather radars covers already large parts of Norway and will be improved further over the next years. Weather prognoses from both regional and global models are also freely available for the avalanche warning services. The Norwegian Water Resources and Energy Directorate produces in cooperation with the Meteorological office daily maps of snow cover, snow wetness, 24h and 72h accumulation (www.senorge.no). Unfortunately, regular snow property observations are today not available. An integration of all these various data sources into a readily available IT tool would be one of the first challenges for a future avalanche warning service to solve.

6 Concept for a future national service

By the start of 2009, the Norwegian Water Resources and Energy Directorate was appointed the coordinating responsibility for research and management of avalanche and landslide hazard in Norway. Currently a reorganization of the avalanche warning, to improve the service and meet the changing demands of

the society is considered. Higher mobility and increasing use of the mountains for recreation ask for more precise avalanche warnings and a better regional differentiation of the information.

It is obvious from the size of Norway (Fig. 2), and the scarce population that a future service cannot be established by simply following the Alpine concept of a detailed and highly advanced service for the entire country. Also local avalanche warning centres, as practiced in the USA and Canada, are less applicable in a country that has only 4.5 million inhabitants.

Therefore a two level approach is proposed for Norway.

- a) A daily regional warning that covers the whole country
- b) Project based local warning for selected and well identified objects

6.1 Regional avalanche warning

A regional approach to the avalanche warning would be a major improvement to today's situation. A group of avalanche experts would evaluate daily the situation in the whole country and issue a bulletin every morning consisting of a map and a text part. Publishing will be done through well established channels of the Meteorological office (www.yr.no), The Norwegian Water Resources and Energy Directorate (www.senorge.no) and NGI's snow avalanche site (www.snoskred.no).

A daily service will serve three main purposes:

- a) A daily evaluation of the current avalanche situation will be available to the public.
- b) A team of avalanche experts will be updated on the current situation at all times and can promptly assist in any emergency.
- c) By mentioning snow avalanche danger at all danger levels in the media every day, public awareness will increase.

This level of avalanche warning can largely be based on the existing network of weather stations and observations. It is also planned to involve voluntary local observers. Easy-to-use mobile registration solutions for field observations will be provided.

The daily bulletin would give a general description of the situation followed by a differentiation into larger geographical features, such as the east – west water divide and major fjord systems. The fraction of precipitation falling as snow at the coast is low and a differentiation into three or four elevation levels would also improve the value and acceptance of the warnings significantly.

This public avalanche warning service would be a part of the services delivered by the Norwegian government under the same obligation as the national weather service is issued for the public several times a day.

6.2 Local warning

For the safe operation of many activities, both professional and recreational, a more detailed avalanche warning is often needed. Examples are holiday housing, such as cabins and lodges, road and railroad sections, construction sites and permanent housing in avalanche hazard areas. In total, these locations only cover a small fraction of the total area of Norway that is exposed to avalanches.

For example, the railroad administration needs a detailed description of which avalanche paths are the most likely to release in the coming 24h. Another example may be that the coordinator at a construction site needs to know how long a team of workers can stay in the hazard zone while a new storm is arriving.

Detailed mapping in such areas is needed to identify the local hazards and risks. Adjusted observation and risk management routines need to be developed in close cooperation with the customer before such a service can be operational.

This kind of detailed avalanche warning will also in the future be based on special requests by customers who are ready to pay for the services. In addition to the current type of customers, tourist industry and local administration

could contract detailed warning for their recreational areas, such as alpine skiing resorts, popular offpiste ki areas, etc. This approach is analogue to the special weather services provided by private contractors to the offshore industry. Both are based on the general public service.

7 CONCLUSION

Public avalanche warning today is limited to situations with high or very high avalanche danger. Only selected areas receive a more detailed daily bulletin based on the needs of local contractors.

The public avalanche warning in Norway can easily be improved by issuing a daily regional bulletin that covers the whole country. Such a bulletin can largely be based on existing weather and snow observations but needs to be issued by a team of experienced avalanche experts. Established channels for publication of the bulletin can be used.

This public service should be financed by the government as an addition to the national weather service.

Special operations in avalanche terrain that need more detailed evaluations of the avalanche danger at their location will also in the future need to contract this to avalanche expert consulting companies.

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