Experiences from a heavy avalanche season 2013, caused by a weak snow layer, and leading to several road closures in Northern Norway.

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ABSTRACT: During the last week of March and first days of April 2013 a significant large number of avalanches hit roads and cut off all infrastructures to several villages in Troms district, Northern Norway. Some villages were isolated due to road closures up to 7-8 days. Active avalanche control using DaisyBell where initiated to reduce closure time on roads with different result.

The series of uncommonly destructive avalanches were an eye-opener to the Norwegian Public Roads Administration (NPRA) and our avalanche team. Here we present an overview of affected roads during the avalanche season, discuss the major events and lessons learned. One of the specific events is the naturally triggered "Kattfjordeidet avalanche" which covered a length of 2,2 km of road. Could this have been predicted? The snowy winter gave useful experiences, further discussed, like the importance of specific local knowledge, communication with local snow plowers, the importance of investigating the snowpack at each site, discovering weak layers and addressing the possible consequences at once.

1 INTRODUCTION

1.1 Norwegian Public Roads Administration – NPRA

The Norwegian Public Roads Administration is responsible for the planning, construction and operation of the national and country road networks. The public road network of Norway counts 93800 km in total (2012).
On matter pertaining to national roads, the Public Road Administration is under the direction of the Ministry of Transport and Communications. On those related to county roads, the Regional Director is subordinated the county legislature.
The Public Roads Administration encompasses five regional offices. In Northern Norway (N-Norway) this office is located in the city of Bodø.

The objective of the Norwegian Public Roads Administration: To develop and maintain a safe, eco-friendly and efficient transport system. This is being done on a sound, professional basis by interaction with politicians, users and other interested parties

Figure 1: Overview Europe with Norway in black

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1.2 Background

N-Norway is long and narrow, situated along the Norwegian Sea and the Barents Sea. Its latitude, between 65°N and 71°N, is comparable to Alaska, Greenland and Sibir, although the climate is much milder, with warm water from the Mexican Golf reaching the Norwegian Sea through the North Atlantic Current.
The climate is very humid, mainly because of precipitation along low pressure fronts entering from the Atlantic Ocean, followed by orographic precipitation in the mountains. Heavy precipitation is expected with wind direction from west - north.
The winter in N-Norway may last 7 - 8 months from October/November until May.
In winter time, snow results in severe avalanche related problems on N-Norwegian roads. The NPRA is responsible for the management and safety on national highways and protection against snow avalanches. The daily surveillance is performed by contractors supported by NPRAs geologists or by consults. In 2013 our avalanche data base shows approximately 600 different avalanche and landslide sites along the public roads in N-Norway. Mainly low traffic roads makes it extremely expensive “per person” to build avalanche measures and therefore most of the sites does not contain physical avalanche protection.

The winter 2012/2013 showed to be the worst avalanche season since year 2000. Several roads were closed for consecutive days due to avalanches and avalanche danger. What did the NPRA learn from this event? What can be done to the timing of closing and opening a road below an avalanche path? How can the NPRA become better at predicting avalanches on specific sites?

In the following, weather and snow reports from the winter 20012/2013 are studied and evaluated. The decisions made are questioned and the knowledge from this experience will help develop the handling of avalanche threatened roads in the future.

2 WEATHER AND SNOW SITUATION WINTER 2012/2013 IN TROMSO AREA

2.1 Solar radiation

Troms is located north of the polar circle and experiences the polar night from November 27th to January 15th in Tromsø city. After January 15th the days gradually becomes longer, and May 20th the midnight sun occurs.

2.2 Temperature and precipitation

At Kvaloeysletta, 63 m.a.s.l. there is a weather station. Data on temperature and precipitation is taken from this station. There are local variations which will be shown later, and the need of more specific weather data is also discussed. (Figure 2).

Figure 2 Overview of part of Tromsø Area with the Kattfjoreidet avalanche in blue. The detour is to get to the city center of Tromsø from the villages on the west side of the avalanche.

The first snow fell in the middle of October. Persistent snow cover first occurred in the end of November. During January precipitation measured 165 mm from the weather station at Kvaløysletta. First half of February was cold without precipitation, later, February 23rd-25th showed positive temperatures up to 800 masl. This resulted in rain all the way up to the peaks on Kvaløya area and up to 800 masl further inland in Tromsø area. Wet snow avalanches were observed below 600 masl during this period.

The following two weeks consisted of temperatures below zero and little precipitation. This led to the forming of a thick rain crust in all exposures covering all mountains in Tromsø area, see figure 4. This crust later showed to form a perfect layer for avalanches to slide on.

The end of March had small variations in temperature below zero and precipitation approximating coherent over 4 mm per day. The new snow gradually covered the rain crust and buried it deeper. At the same time a layer of faceted crystals developed between the crust and the new snow. The week prior 30.03.2013 the weather station measured 46.3 mm precipitation. Wind varying from S-V-N in late March made the new snow cover relatively compact. March 25th the avalanche forecast, Varsom.no, gave information on 30 – 50 cm new snow during the next 3 days. The first days of April had 20-30 mm precipitation simultaneously with strong winds, more than 10 m/s, from S-W-N.

Several avalanches in the back country were reported in Tromsø area during the last days of March and beginning of April.

2.4 Snow observations in the area

Predicting the avalanche danger in Norway on a national basis is relatively new and the first official bulletin was presented 14.01.2013 (Farstveit, Engelien and Tveit 2013 and Engeset 2013).

Here, observations studied are from the area close to Kattfjordeidet, during the months February, March and April. Information from the weatherstation at Kvaløysletta is used together with info from Varsom.no (Kosberg et al. 2013) and xgeo.no (Barfod et al. 2013)

The snow cover in the middle of February had no significant problematic layer. After the warm and wet period during the end of February, observers reported a rain crust with variations in thickness in the region Tromsø. In the middle of March a layer of faceted crystals developed above the rain crust. This was later buried by new snow. (see profil from Kjetil Brattlien 18.3)

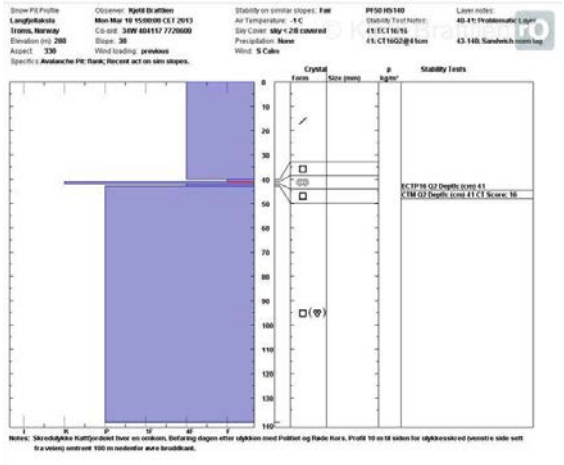

Figure 3: Snowprofile, March 18th by Kjetil Brattlien.

The precipitation kept coming in the end of March and beginning of April. The reports from observers still had a layer of rain crust, followed by faceted crystals, covered with compact snow. The problematic layer had only been buried deeper.

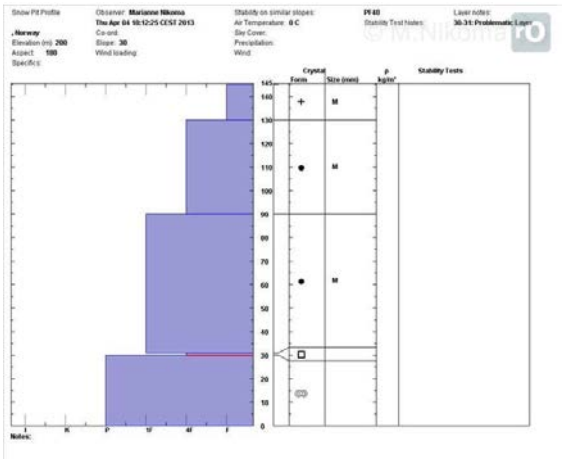

Figure 4: Snowprofile, April 4th by Marianne Nikoma.

The Norwegian avalanche forecast for the region Tromsø, gave a danger level 4 High, during the days: 28.3 – 29.3 – 30.3 -1.4 – 2.4 - 3.4. (see Varsom.no).

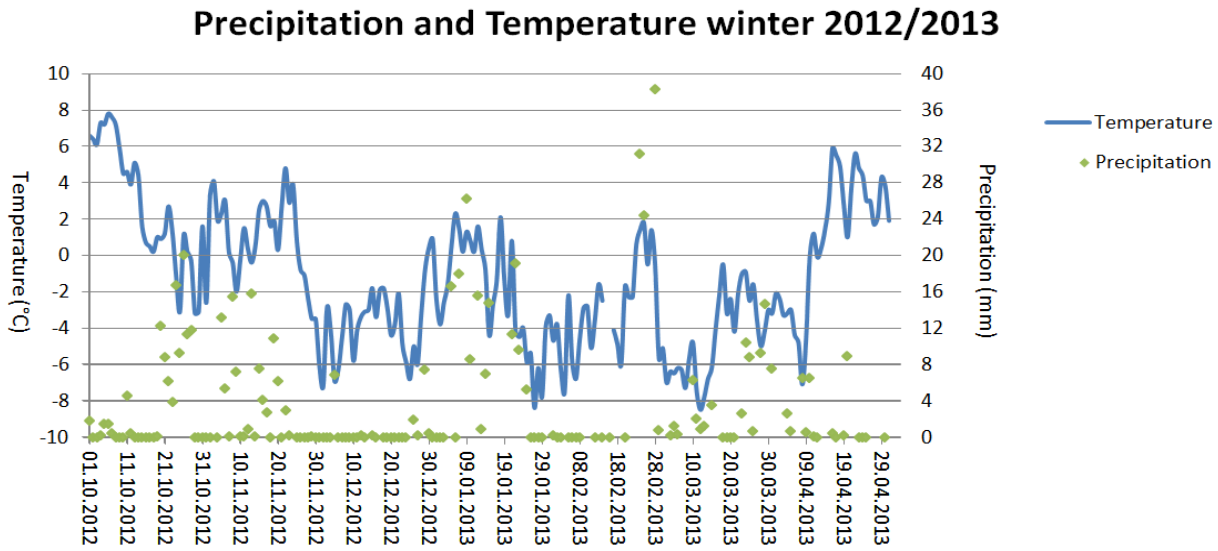

Figure 5: Precipitation and Temperature through winter 2012/2013 measured at Kvaloeysletta, in the period 01.10.2012 - 01.05.2013.

3 AVALANCHES IN TROMS DISTRICT MARCH/APRIL 2013

Figure 6 Overview of Tromso, Kvaløya and Senja area. Gryllefjord, Senja Fv 862 and Kattfjordeidet avalanche are marked with red arrows.

On "Kattfjordeidet" road FV 862 was closed due to an avalanche on March 30th. It kept closed for 16 days consistently. It was considered reopened on April 4th when a new avalanche hit. After this, several days were used to evaluate the risk of even more avalanches and it was tried to release remaining snow artificially by the use of a Daisybell. The triggering of avalanches is done by a gasexplosion from a "bell" hanging under a helicopter close to the surface of the release area of the suspected avalanche. No snow was triggred and the road was closed all until April 14th.

During the same period, the small village of Gryllefjord was isolated for 7 days due to four avalanches striking their only road FV 243. The road got closed due to an avalanche blocking the road and the risk of new avalanches. The avalanches did occure and kept the road closed for the upcoming 7 days.

FV 862 on Senja Island was closed several times between March 30th and April 4th. The road was closed after the first avalanche hit the road on March 30th. After this, 9 more avalanches struck the road between Senjahopen and Mefjordvær, a 14 km long road through alpine mountain terrain. Also here a DaisyBell was used in the mean of triggering snow still hanging on the slopes.

4 AVALANCHE AREA KATTFJORDEIDET

4.1 Geographic details

Kattfjordeidet is located in the valley Kattfjorddalen, 16 km west from Tromso. The U-shaped valley from Henrikvik in the

northeast to Nordfjordbotn in the southwest is connected with the county road FV 862.
The avalanche mountain side Kattfjordeide from the mountains Straumsaksla (784 m.a.s.l.) and Langfjellaksla (765 m.a.s.l.), is mainly directed north. The slope gradient varies from 25 degrees near the valley floor, to 60 degrees near the mountain top.
The avalanches were released naturally in the typical slope gradient of 30 – 45 degrees.
The shape of the terrain shows a convex surface which is perfect for avalanche triggering. The mountainside also has limited vegetation.

In a normal winter from October/November to April/May, the snow depth is around 2m at valley bottom. The treeline is approximately 300 masl and the thin tree forest does not give any contribution to avalanche protection of road FV 862.

4.2 County roadsjekk FV 862
Road FV 862 extent from Brensholmen to Tromso city, through Kattfjordeidet, 56 km. Detour route is around Stamfjorden, 90 km. There is no avalanche protection from Kattfjordeidet avalanche area.

4.3Avalanche history
All avalanches hitting roads should be registered in NVDB, the NPRAs own avalanche record. Registrated avalanches at Kattfjordeidet is limited to a slush avalanche January 2004 and one slush avalanche in February 2006(Ref NVDB). Then there are no registrations until the event during Easter 2013 where three avalanches struck the road. It is suspected due to different reasons that avalanches often fail to reach the record. Therefore contact with local people living in the avalanche area is important to get the full avalanche history on a specific site. The frequency of avalanches on the Kattfjoreidet site is thought to be around 20 years.

4.4 Avalanche Kattfjordeidet 2013

On March 30th a dry snow avalanche hit the road on Kattfjoreidet. The avalanche struck one driving car on FV 862 and two parked cars were buried in snow. A cabin was swept away together with a toilet on a pulloff. Luckily no people where physically harmed.

On April 4th a dry snow avalanche hit the road. Covering also the last avalanche path now all together 2.2 km of road was buried in snow, (Figure 2).
On this day there were representatives from the NPRA together with the local snow plower evaluating if the conditions would allow for an opening of the road. During April 4th the weather was calm and sunny. There were no signs of snowdrift at the time though there was a little bit of wind during a few hours the night before. The weather station on Kvaløysletta showed only little precipitation though the local plower could report almost 20 cm of new snow during the night. The discussion of reopening was not over when the avalanche triggered naturally with a 900m long fractureline. It covered more than 2 km of road and the depth on the road was about 6m on the deepest.

Figure 7: Avalanche struck road 04.04.2013

The avalanche got massive media attention, and was the largest in Troms district during this period. The collapsing layer was the faceted crystals and the hard rain crust made a perfect low friction sliding path. Avalanches close by, released artificially showed the same collapsing layer and also slid on the crust. All these avalanches where abnormally large. The returnperiod of avalanches in Kattfjord is

thought to be around 20 years. Still the size is considered to be a 100-year event.

5 DISCUSSION

Large amount of snow came during the end of March and beginning of April. During this period moderate winds varied from N-W-S. Still, on an already stable snow cover these conditions would probably not have caused huge avalanches. During this winter though, a week layer above a hard rain crust formed the perfect conditions for avalanches to trigger and to go huge. According to the avalanche forecast the risk of large avalanches was high (4, High, see Varsom.no) several days in the end of March and beginning of April.

It seems like the more seldom a known avalanche path avalanches, the harder it is to predict the event. At the time of the Kattfjordeidet avalanche, the general opinion among “normal” people was that the conditions were calm. No avalanches had triggered the last 24 hours and weather situation according to measurements showed no warning signs. The risk had gone down from 4 to three on the avalanche Bulletin(Varsom.no). The local snow plower had information on snow conditions that were not picked up by the weather stations closest to the sites.

Due to the close communication with the contractor, an inspection was done before making the open/keep closed- decision. Since the avalanche triggered while discussing, the result might have turned out differently if the snow had stuck an hour more to the mountain. Luckily it did not and hit a closed road. If there had been more information available on snowdrift and precipitation on the specific site it might have helped on the decision. The main reason not to open was, as mentioned, the plowers information on the snow falling the night before. A weather station on site would have given data on the local precipitation. Then there would have been more information pointing towards keeping the road closed.

No written documentation on dry avalanches existed on the site. When evaluating the avalanche danger in an area and the risk of naturally triggered avalanches reaching roads, the avalanche history of the specific site is important to consider. Is this slope a regular avalanche site? After investigating the avalanche register on Kattfjordeidet, no dry avalanches were reported. But also here the local knowledge showed differently and reported on the 20-year return period. A better record would have given valuable information.

If all the information on snow and weather conditions had been known, the group of people discussing reopening might not even have been in the area. Could we have known this by studying snow profiles and avalanche bulletins more closely? Or by keeping closer contact with the local snow plowers? The reason for not opening FV 862 after more than three days of calm weather was mainly due to the scepticism from the local plower. The area he was worried about was exactly the area triggered naturally on April 4th.

The knowledge of the local habitants seems to be indispensable. This event shows the NPRA how high valued these people are for making the decision of when to close and when to open roads. The NPRA are responsible for several roads in different areas, which all have different topography and weather conditions. To know in detail when and where the avalanche will come is hard, specially without any written knowledge on earlier events.

Also the severity of the week layer should be discussed. Stability test from early - middle of March shows ECT over 15, and shear quality 2 (Q2), which shows a relatively stable snow cover. What developed after loading with 0.5 – 1 m snow, could maybe have been predicted?

The severity of a week layer, discovered early in the season was perhaps underestimated by the NPRA during Easter in Troms county.

On April 4th, the danger level according to the Bulletin was 3, considerable. The day prior it had been 4, still the avalanche triggered on the 4th. Investigating weather and snow cover information during this perion, does not show signs of increasing danger level on the 4th. If the situation occurs again, the same decisions might be taken.
The information that could have been a trigger to higher avalanche danger level, was the information the local contractor had. Again showing how important local information is.

6 CONCLUSION

The event lasting from March 30th-April 8th resulted in more than 20 avalanches reaching road in Troms County. Roads were closed up to 16 days. Only half the avalanches released on already closed roads. Most of these roads were closed due to an earlier avalanche.

When the goal is to close roads before the avalanche hits, many roads should have been closed earlier. At the same time, the acceptance of a closed road is becoming lower. People are used to getting were they want, when they want, in a safe way. So the NPRA has a high pressure from the local habitants both on closing a dangerous road and keeping it open as much as possible.
-The documentation on the NPRAs avalanche register, NVDB, is poor. The documentation on avalanches is important for the understanding of future events. Where documentation is poor, talking to local habitants often give crucial information on earlier events that does not show in NVDB.
-The local knowledge about the weather on a specific site is crucial for the evaluation of the avalanche danger on site. Local people cooperating with the NPRA are very useful and put in indispensable information.
-Weather stations on site can help to pick up differences in precipitation and wind which is important to evaluate the local avalanche danger.
-When snow-observations show a week persistent layer one should be very observant when avalanches start triggering on this layer. And consider the risk of similar events in the total extend of the layer.
- Better contact with local habitants and contractors/plowers. This can never be said too often.

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