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Norwegian Avalanche Warning Service Program

Review

80
2014

By Grant Statham

RAPPORT

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Meteorologisk institutt

Norwegian Avalanche Warning Service Program Review

Prepared April 2014 for:

Norwegian Water Resources and Energy Directorate

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Preface

NVE contracted Grant Statham to visit the Norwegian Avalanche Centre in spring 2014. The purpose of the visit was twofold: 1. To visit members of our observer corps and give them feedback and inspiration, and 2. To evaluate our avalanche forecasts and varsom.no (what is good, what requires improvements).

Grant did three field visits, to the west coast, central South Norway and North Norway. In addition to field visits and discussions with observers and forecasters during the field visits, he gave two open presentations on avalanche risk management in Tromsø and Oslo (about 400 people in total). He also gave a presentation of preliminary findings and recommendations at NVE in Oslo on Friday 14 March and submitted the evaluation report in April.

We are now using the report and its recommendations as a basis for future improvements of the service. We appreciate the thoroughness and skills provided in the evaluations, Grant' contribution is a very valuable contribution to improving avalanche safety in Norway.

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Director Hydrology department

Rune Engeset

Head of Glacier, Ice and Snow Section

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1.0 INTRODUCTION

In March 2014 Grant Statham (Alpine Specialists, Canada) was hosted by the Norwegian Water Resources and Energy Directorate (NVE) to evaluate the effectiveness of the Norwegian Avalanche Warning Service (NAWS). NAWS is the result of collaboration by NVE, Norwegian Meteorological Institute (MET), Norwegian Public Roads Administration (NPRA), Norwegian National Rail Administration (JBV) and Norwegian Geotechnical Institute (NGI). NVE is responsible for the delivery of NAWS.

As per the terms of reference, the objectives of this project were to:

1. Visit members of NAWS's observer network and provide feedback and inspiration.
2. Evaluate NAWS's avalanche forecasts (www.varsom.no) and determine which aspects work well and where improvements are required.

In addition to observations and feedback provided during the March trip, a presentation of preliminary findings was made to NAWS staff in Oslo on March 14, 2014. This report, Norwegian Avalanche Warning Service Program Review, provides a follow-up to that meeting, with discussion and recommendations on specific points relating to NAWS.

2.0 BACKGROUND

It is interesting to note that for a country with such a long tradition of mountain skiing, Norway has only begun to produce public avalanche forecasts in the past several years. Until recently, this void in public safety was not seen as a priority because generations of cultural norms kept most Norwegians away from steep avalanche terrain; however, a change in social attitudes and modern ski equipment have altered that perception.

Today, people from around the world flock to Norway for its steep terrain, accessible backcounty, abundant snowfall, and spectacular combination of mountains and fiords. There are thousands of people skiing, snowboarding, snowmobiling, snowshoeing and driving their vehicles through avalanche terrain all over the country. Backcountry avalanche accidents and fatality rates are on the rise, as is a corresponding surge of public interest in backcountry avalanche safety.

Accordingly, NAWS is rapidly becoming a critical public safety service, and awareness of the www.varsom.no avalanche forecast is spreading across the country. NAWS published their first public avalanche forecast in January 2013. For such a young avalanche warning service, it is impressive to observe what NAWS has accomplished since then.

For the purpose of this review, the March trip to Norway included visiting eight of NAWS's forecasting regions, meetings with avalanche observers, forecasters and members of the public, and ski touring trips to gather snowpack and weather observations. Based on the results of this trip, and in combination with professional snow and avalanche experience from Canada, this report provides recommendations for enhancements to NAWS for future success.

3.0 TRIP ITINERARY

Mon. Mar 3	Travel with Emma Barfod to Hemsedal. Meet Markus Landrø and Per-Ola. Ski-area orientation and off-piste risk assessment of the Rubber Trees area.
Tues. Mar 4	Follow a standard observation trip to Morkedalen with Markus and Emma. Take snow profile observations at treeline.
Wed. Mar 5	Climb to the summit of the Skogshorn with Emma, Markus and Per-Ola, and then travel to Sogndal. Presentation on the topic of risk in Sogndal (150 people).
Thurs. Mar 6	Meet with Jostein Aasen and review his observation area and methods. Ski trip to Vanndalen (near Jostedal) for snow profile observations. Travel to Sogndalsdalen to view parking and other local ski areas.
Fri. Mar 7	Meet with Jans Tveit from the road authority in Leikanger. Review maps, plans and systems. Travel to Veitastrond to view roadway avalanche problems. Return with Emma to Gol in the evening.
Sat. Mar 8	Meet with Markus for observer network discussion and Varsom in general. Observation trip to Slettefjell to check wind-loading. Evening train to Oslo.
Sun. Mar 9	Travel to Alta in the afternoon with Birgit Rustad. Meet with Bjorn Michaelson to discuss his forecast area and observation techniques and hear his perspective on avalanche forecasting.
Mon. Mar 10	Travel to Storfjellet to meet with Tore. Discuss his area and observation techniques. Climb to summit at 850m; continue travel to Olderdaalen.
Tues. Mar 11	Meet with Birgit and Jan Arild Hansen to discuss his forecast area and techniques. Travel to Tamokdalen to meet with Aadne Olsrud and make an observation trip into his designated terrain. Travel to Tromsø for the evening. Meet with Audun Hetland to discuss risk behaviour and research.
Wed. Mar 12	Radio interview with NRK Troms (8 a.m.). Pouring rain. Worked on report, afternoon meeting scheduled at Meteorology office. Avalanche observations near Tromsø. Evening presentation on the topic of risk at the University of Tromsø (400 people). Night flight back to Oslo.
Thurs. Mar 13	Prepare for meeting at NAWS from 1-3 pm. Evening presentation on the topic of risk (75 people).

PART 1: AVALANCHE FORECASTING OPERATIONS – REGIONS AND OBSERVATIONS

4.0 AVALANCHE FORECASTING REGIONS

NAWS publishes daily avalanche forecasts for 25 regions (Figure 1) that span from Røldal in the southwest to Alta in the northeast. This is impressive regional coverage, with plans to add between one and seven more regions for 2015; however, extensive, country-wide coverage comes with its challenges. The most significant of which is data collection to support these forecasts (field-based observations of snowpack, avalanche activity and weather).

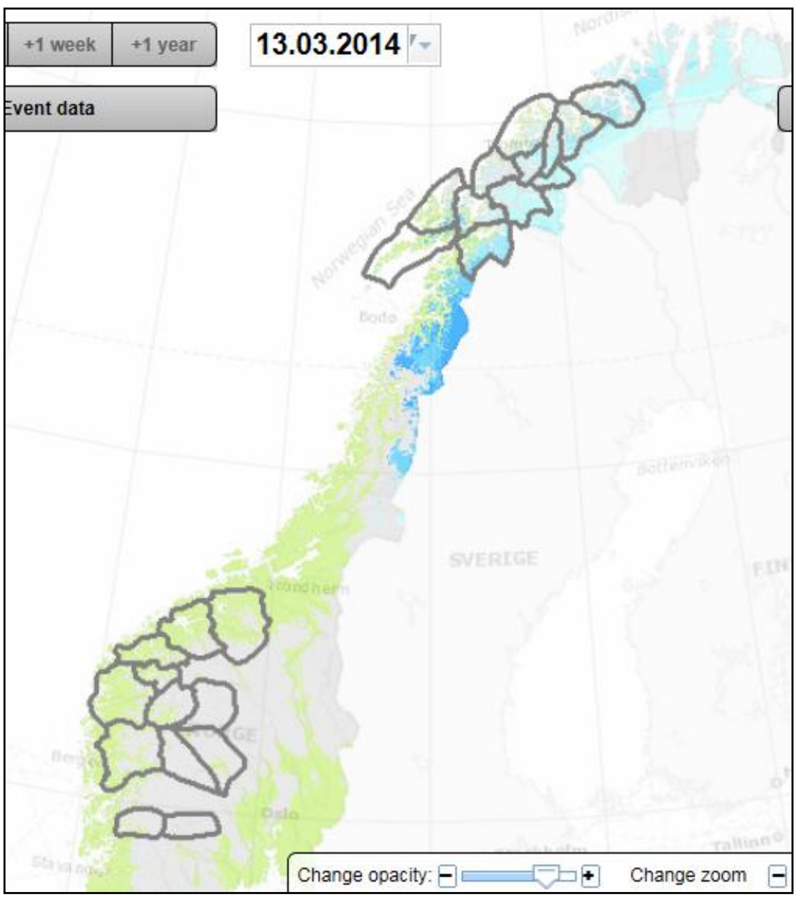

Figure 1: NAWS's forecasting regions in 2014 (Svartisen is not shown).

Norway's avalanche forecasting service is considered young, and its underlying infrastructure is still in its early developmental phase. NAWS's field-observer network and registered observations information exchange (*regobs*) is effective and growing, but field observations that are timely and of high quality remain a challenge. It is common for days to pass without a single observation being reported from certain regions. As such, forecasters are left to rely solely on modelled weather and snowpack data with no access to human-interpreted mountain observations.

In various regions, observers report that the outer-lying parts of their designated area is rarely visited, or sparsely inhabited; in some cases, the observers themselves never travel that far. The result is that field data is not being obtained from those parts and, therefore, snowpack is not being tracked.

In a country as challenged by field observations as Norway is at present, extensive regional forecasting coverage comes at the cost of resolution. Currently, forecasting of general trends in avalanche danger works well, but specifics on snowpack structure, avalanche activity and the capacity to make time-sensitive observations remain a challenge.

It is recommended that NAWS reviews the boundaries of its 25 regions with a plan for optimization. Consider removing areas within regions that are not inhabited, or where field observations are not made. Concentrate on places where people go, and where sufficient field data can be collected. Then, with time, consider regional expansion as the infrastructure to support field observations grows.

5.0 FIELD OBSERVATION NETWORK

Field-based observations of snowpack, avalanche activity and weather are the most important underlying components of any avalanche forecast. Without these observations, the forecaster is left guessing. This issue is the biggest long-term challenge for NAWS's forecasting program.

Norway is a large country with vast areas of untouched mountains. To counter this, NAWS has built up an impressive network of field observers whose job is to provide forecasters with on-the-ground, manual observations taken from specific sites across each region. There are two designated observers for every region, with 19 regions that provide forecasters with two sets of observations per week, and six regions that provide three sets of observations per week.

NAWS has developed the *regobs* software, which provides an excellent platform for the exchange of field observations between observers and forecasters. This is a public domain exchange, and also enables members of the public to share mountain observations. Internet-based platforms such as *regobs* or other types of social media are becoming more important for avalanche forecasters. Crowd-sourcing data is an effective modern technique, and the *regobs* platform is an excellent tool that facilitates this.

At present, the challenge with this system is the amount and quality of field observations that are received. While the infrastructure exists to facilitate recording and sharing of information, there remains variation in the methods used to make observations. Reasons for this include: the standards being taught to the observers are new and achieving consistency in methods and communication takes time; the inexperience of observers; and budget limitations that allow for only two to three sets of observations per week in each region.

In Canada, the early stage of professional development in the avalanche forecasting industry was one of strict standards for methods to observe and record data. The pioneers were Swiss and Austrian engineers who designed rigorous, scientific-style data collection methods. This precision spilled over into professional training, where those rigorous standards were taught, tested and examined. Today, all professional observers in Canada must pass an examination.

Developing standards and implementing them into professional training takes years, but the long-term benefits of a standardized avalanche industry are numerous. This will result in higher-quality field observations that forecasters are able to rely on.

6.0 WORKER SAFETY – FIELD OBSERVERS

Over the course of the two weeks in March, discussions were held with all field observers about their particular practices in regards to workers' health and safety. Field observers often work alone in the mountains, which can present significant risk. Specific policies, procedures and training must be in place to manage this risk.

NAWS has developed strong policy in this area by implementing a system of approved field-observation trips that are designed to ensure minimal or no exposure to avalanche hazard. This system reduces the avalanche risk to individuals, and every observer seemed well aware of their need to follow this system.

Given the policy described above, the greater risk seems to be a potential skiing accident. A twisted knee in the backcountry can have significant consequence to a person working alone. Again, NAWS has implemented policy in this area that requires mandatory local communication and check-in procedures. Check-in and contingency plans are extremely important in a country with as much remote terrain as Norway. NAWS should frequently remind their staff of the need for diligence in this regard, and provide any assistance required to help their observers establish proper local check-in procedures.

In addition to regular training, a culture of safety can be promoted by constant small reminders about its importance. One effective method employed by several Canadian companies is to dedicate time (five minutes) in every staff meeting to a safety-related topic. Over time, this kind of approach becomes engrained, and the culture of safety becomes second nature.

The subject of workers' safety requires constant diligence, and with almost 50 observers in the field, NAWS staff is well aware of the potential for an accident. The goal of preventative work (ranging from training to policy) is to minimize the consequences of such an occurrence. NAWS has invested significant effort to minimize the probability of an accident by promoting the following:

- A risk-averse culture
- Procedures for oversight of field observer trips
- Ongoing training
- Openness about near misses
- Recruitment of experienced staff whenever possible

Continuing work in this area should always be considered an ongoing priority.

7.0 STANDARD DAILY OBSERVATIONS

Variation in observation methods can also be reduced by implementing a required standard set of observations to be reported from every trip. These are non-optional observations that must be made regardless of location. See Figure 2 for an example of a daily summary form.

Observer's name	
Destination	
Elevation min	m
Elevation max	m
Temperature min	C
Temperature max	C
Freezing level	m
Average snowpack depth	cm
24-hr new snow depth	cm
Wind direction/speed	m/s
Avalanche activity	

Figure 2: A standard set of field observations required from every trip in the field.

In addition to completing these basic readings, observers could then undertake targeted sampling, which should be planned with the forecasters (see daily meeting). This sampling would be used to fill data gaps, test various hypotheses, and search for and test specific weak layers (see weak-layer tracking).

Even though that with training one learns the basic skills to make observations, safely knowing how, when and where to carry out these observations is the mark of a skilled observer. It is recommended that NAWS implement more rigour into their requirements for field observations, and facilitate better dialogue between forecasters and observers to plan for data collection.

8.0 WEAK-LAYER TRACKING

One of the easiest and most important things that NAWS could do to enhance its field observations and forecasts is to implement a system of naming and tracking persistent weak layers (PWLs). When PWLs such as facets, crusts or surface hoar are buried in the snowpack, they can be expected to cause avalanche problems for extended periods, commonly for weeks or even months. These layers should be given names, and their strength and behaviour tracked.

This is in contrast with transitory weak layers of new snow or decomposed/fragmented snow, which is typically associated with storm snow and wind slab problems. These ephemeral weak layers occur frequently (every storm), and usually disappear within days, thus are not worth naming and tracking.

In Canada, PWLs are named by the date on which they are buried. For example, the February 10 layer is widely known in Canada this winter (2014) as a difficult layer of facets and surface hoar. Layer names can also relate to specific days, such as the Christmas Layer, for example. Daily snow-study objectives almost always involve searching for, and testing specific weak layers.

By simply providing a reference name for the layer, forecasters and observers are then able to focus in on this specific weak layer, discuss it, test it and keep track of its properties. This applies across regional boundaries, so observers and forecasters from different regions are better connected by tracking and communicating about the same weak layers.

Observers should be responsible for testing and reporting on the distribution and strength of these weak layers. Listed below (Figure 3) is the critical information required for this.

Location (name, elevation, aspect)
Weak layer name
Weak layer grain type
Depth from surface
Harness of weak layer
Hardness of slab above layer
Compression/Extended Column test (x2)
Shear quality measurement

Figure 3: Required observations for tracking weak layers.

Forecasters should be responsible for consolidating data and providing a big-picture overview on the development of these PWL-related avalanche problems. They should be able to describe to observers where there is a lack of information and request testing in specific locations.

Formally tracking weak layers is a new technique, with no single proven method yet to be developed. NAWS forecaster Emma Barfod showed an example of a weak-layer distribution map, the idea of which holds great potential. See Figure 4 for an example of weak-layer tracking from Canada.

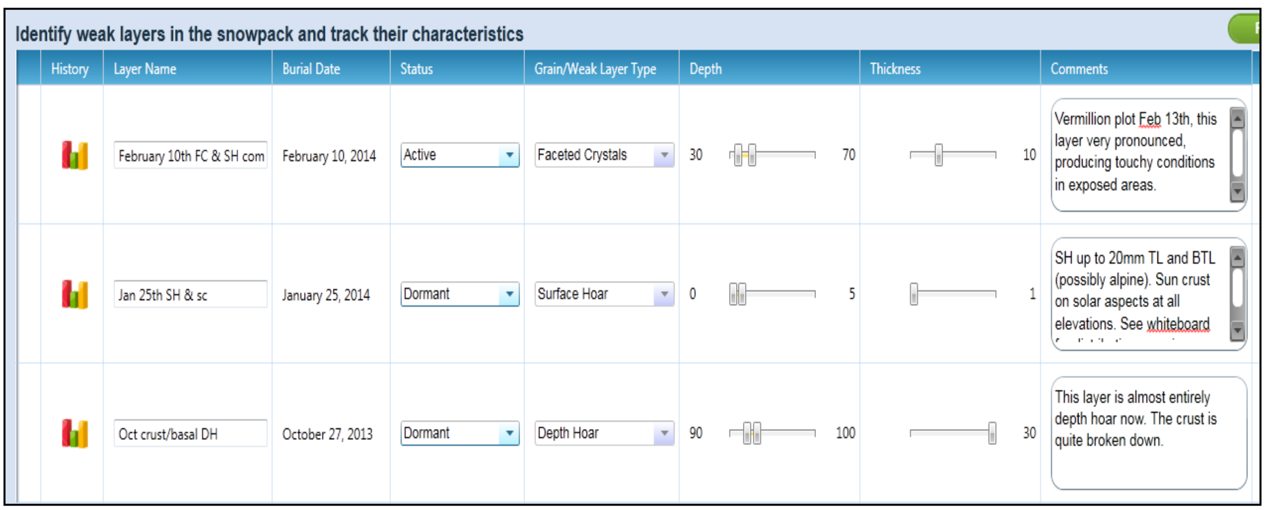

Figure 4: One method of weak-layer tracking (source: Parks Canada).

9.0 AVALANCHE OBSERVATIONS

A report of avalanche activity (or inactivity) is the single most important type of observation that a forecaster can receive in regards to avalanche danger. Occurring avalanches are direct evidence of an avalanche problem, and observing and reporting avalanche activity should be given the highest priority.

Reporting avalanche activity consistently between regions and observers requires a common technical language and method, which should become second nature for observers. Figure 5 and 6 are examples of an avalanche observation made near Tromsø on March 13, 2014.

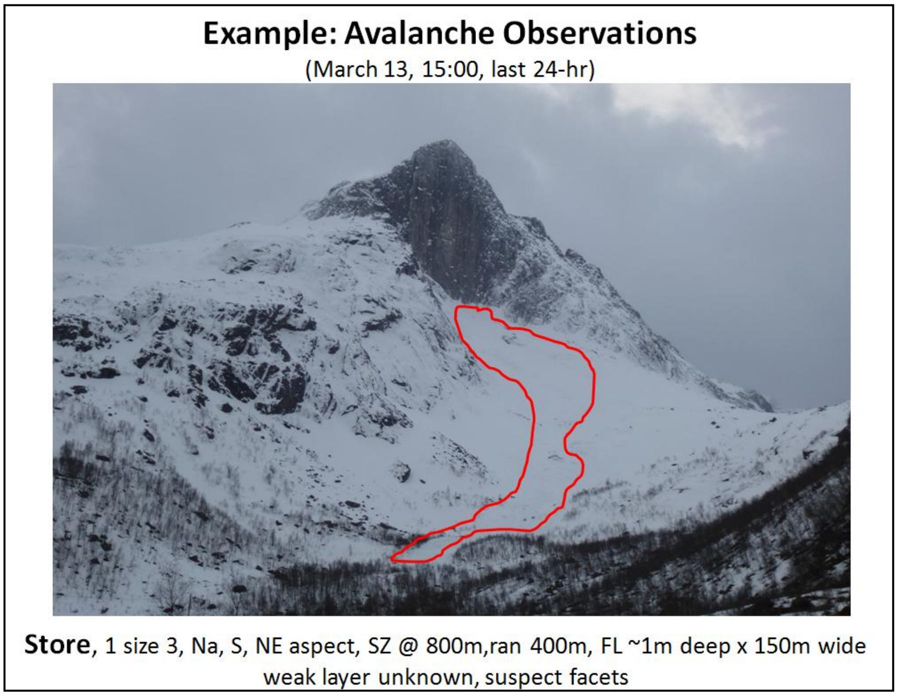

Figure 5: Example of an avalanche observation from Store on March 13, 2014.

Path name/date	Store
Avalanche size	3
Trigger type (natural, human, etc)	Na
Avalanche type (slab or loose)	S
Aspect	NE
Start zone elevation	800m
Distance to toe	400m
Failure plane (layer name, grain type)	Fc (date?)
Fracture depth	100cm
Fracture width	150m

Figure 6: Required fields for an avalanche observation using Store (Figure 5) as an example.

In order to implement avalanche observations in a standard way, NAWS should review its method for determining avalanche size. Observers require guidance to accurately and consistently estimate avalanche size; improvement could be made in methods for recording avalanche activity. The following table (Figure 7) shows the Canadian avalanche size classification system, which is based upon estimating the destructive potential of the avalanche.

3.3.6 Size

Estimate the destructive potential of the avalanche from the deposited snow, and assign a size number. Imagine that the objects on the following list (people, cars, trees) were located in the track or at the beginning of the runout zone and estimate the harm the avalanche could have caused.

Size and data code	**Destructive potential** (definition)	Typical mass	Typical path length
1	Relatively harmless to people.	<10 t	10 m
2	Could bury, injure, or kill a person.	10^2 t	100 m
3	Could bury and destroy a car, damage a truck, destroy a wood-frame house or break a few trees.	10^3 t	1,000 m
4	Could destroy a railway car, large truck, several buildings or a forest area of approximately 4 hectares.	10^4 t	2,000 m
5	Largest snow avalanche known. Could destroy a village or a forest area of approximately 40 hectares.	10^5 t	3,000 m

Note: Size 1 is the minimum size rating. In general, half sizes are not defined, but may be used by experienced practitioners for avalanches which are midway between defined avalanche size classes (i.e. size 2.5).

Figure 7: Canadian avalanche size classification system (source: CAA 2007).

The goal in avalanche forecasting is to develop common language that will facilitate easy and uniform communication about the magnitude of avalanches. When one considers that avalanche size and distribution represent half the contribution to the avalanche danger rating, it becomes apparent that methods of observing and reporting avalanche activity signify a critical function.

10.0 DAILY FORECASTER MEETING

In a country as large as Norway, with dozens of observers and forecasters distributed across the country, communication between staff in the avalanche forecasting service is critical. At this time, there are observers who largely operate on their own, detached from the everyday concerns of the avalanche forecasters. At the same time, forecasters are often in need of specific information and to receive it they must track down individual observers by phone.

An excellent way to focus daily efforts as a solution to this problem is to establish a daily morning operational meeting. Using Skype or conference call, a regularly scheduled meeting would bring together forecasters and observers from across the country for a somewhat face-to-face briefing about avalanche conditions. Forecasters would provide an overview on trends and patterns, and describe what data they require. Observers would describe what they are seeing in their regions, and how these patterns might connect to the big picture. Each party would leave the meeting briefed and more focused on what is required of them for that day.

This form of discussion requires structure and preparedness on behalf of the lead forecaster, the person responsible for chairing such a meeting. The meeting outline would look like this:

- The lead forecaster begins with an overview of conditions across the country, the weather forecast, and the expected trend in avalanche danger (10 min).
- A briefing on the snowpack itself, avalanche problems and the status of weak layers (10 min).
- A brief round-table discussion where observers and other forecasters comment on conditions specific to their area. Gaps in data and specific objectives for field trips and observations are also discussed.
- Total meeting time: 30-45 minutes.

The daily forecaster meeting would provide structure and focus, and creates a sense of teamwork among the NAWS staff and field observers. It brings together different opinions and facilitates consensus-building and consistency. It goes well beyond digital communication methods, such as *regobs,* to allow proper discussion on subtle snowpack details that cannot be captured otherwise.

All forecasting operations in Canada begin and end their day with such operational meetings. The plans made each morning set the tone for day, and the evening consolidation of observations and opinions helps form a common understanding of the conditions.

PART 2: VARSOM AVALANCHE WEBSITE

11.0 AVALANCHE HOMEPAGE

At www.varsom.no, the structure of the avalanche homepage and the presentation of the specific avalanche forecast regions are very functional. It is easy to find the region of interest and to identify the trend in avalanche danger within each region and across the entire country.

The top bar of each forecast region shows the 14-day danger trend, which is useful to determine the broader trend over time. The visuals are simple but highly effective. The danger symbols are consistent with the European Avalanche Danger Scale, and the symbols used to describe the avalanche problems are clear and easy to understand once the user has been made familiar with them.

12.0 AVALANCHE PROBLEMS

NAWS is presently listing more than 11 different types of avalanche problems on their website. See Figure 8.

1	Buried weak layer of loose new snow
2	Poor bonding between layers in wind-deposited snow
3	Buried weak layer of surface hoar
4	Buried weak layer of facets
5	Buried weak layer of depth hoar
6	Poor bonding to underlying crust
7	Loose snow
8	The snowpack is saturated and can be considered unstable from the ground and up
9	The snow is saturated and the top layer(s) become unstable
10	Accumulation of water above a crust
11	The snowpack is oversaturated of water

Figure 8: Avalanche problems listed on the www.varsom.no webpage.

While this list of avalanche problems is quite descriptive, it could be streamlined. The original concept of identifying avalanche problems was to simplify public communication and avoid listing too many possible combinations of weak layers and slabs. Problems such as buried crusts and buried facets that require similar terrain strategies in the field can be grouped under one heading.

Figure 9 provides an example of possible grouping for the problems listed above (Figure 8). When grouping avalanche problems, consider how a recreational backcountry user should respond to these problems in the mountains, and what kind of terrain they should choose and avoid. For example, the problems of surface hoar and windslabs each require distinctly different terrain choices, but the problems of buried crusts and buried facets require similar terrain choices. Group the problems based on the kind of terrain choices that best accompany each situation.

Problem name	Grouped problems from list in Figure 8
Wind slab	2
Loose snow	1, 7
Persistent slab	3, 4, 6
Deep slab	5
Wet snow	8, 9, 10, 11

Figure 9: Suggested groupings for simplification of Varsom avalanche problems.

Forecasters should also ensure that each avalanche problem they list on their forecast remains distinct from the others. Figure 10 shows an NAWS example where three problems are listed under Danger Level 2. The first impression shows little difference between these problems since all the headers read the same.

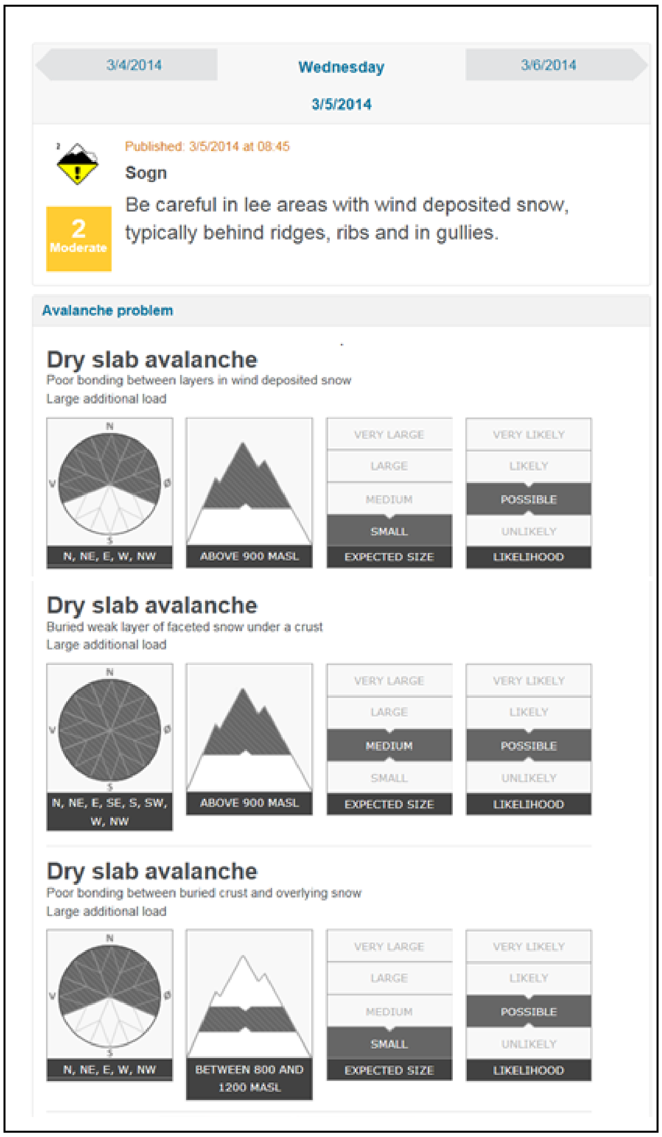

Figure 10: Three avalanche problems listed under DL2 look the same upon first impression.

Additionally, NAWS's avalanche problems are presented with the main, bold heading at the top, using terms such as **Dry slab avalanche**. Consider that the majority of avalanches throughout the winter are dry slab avalanches, so this distinction adds minimal value—its best to avoid generic labels as headers. Instead, the bold header should be the actual *type* of problem, such as a buried weak layer of surface hoar. Headings in this format immediately make clear what type of specific avalanche problem is being described (Figure 11).

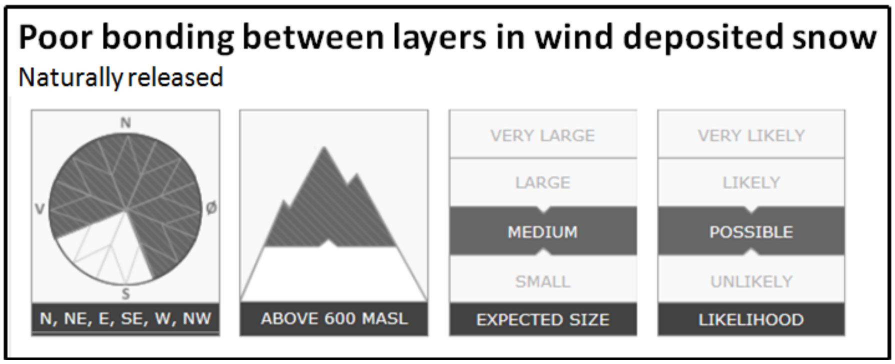

Figure 11: Avalanche problem with actual type of problem shown as the bold heading.

In summary, streamline and group avalanche problems together to simplify interpretation for users. To offer a clearer presentation of what the avalanche problem is, utilize the problem name as the bold heading for the description. See Figure 12 for an example of the windslab avalanche problem presented in a clear and simple fashion.

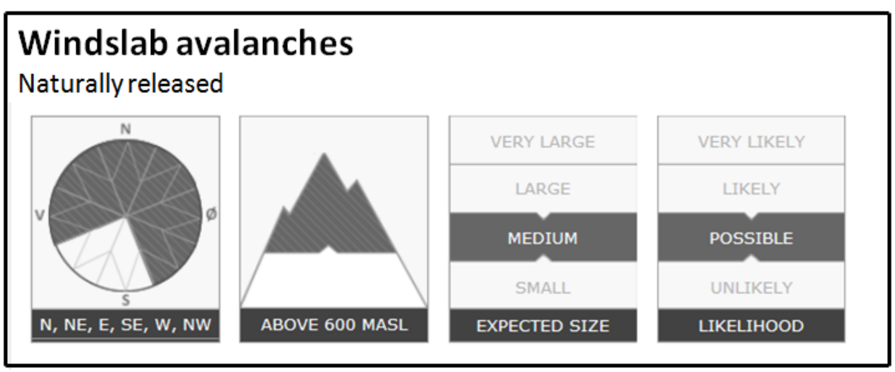

Figure 12: An example of a clearly presented windslab avalanche problem; previously shown as a "Dry slab avalanche – poor bonding between layers of wind deposited snow."

13.0 TEXT FORMATTING

Listed below the avalanche problems is the more detailed discussion about snowpack, weather and avalanche danger. Currently, this is presented as one large block of text under the single heading *Varslingstekst*. Readers will have an easier time following this information if it is presented in smaller blocks of text with bold headers. Three distinct paragraphs are recommended under the headings **Snowpack**, **Weather** and **Avalanche Danger**. See Figure 13 as an example.

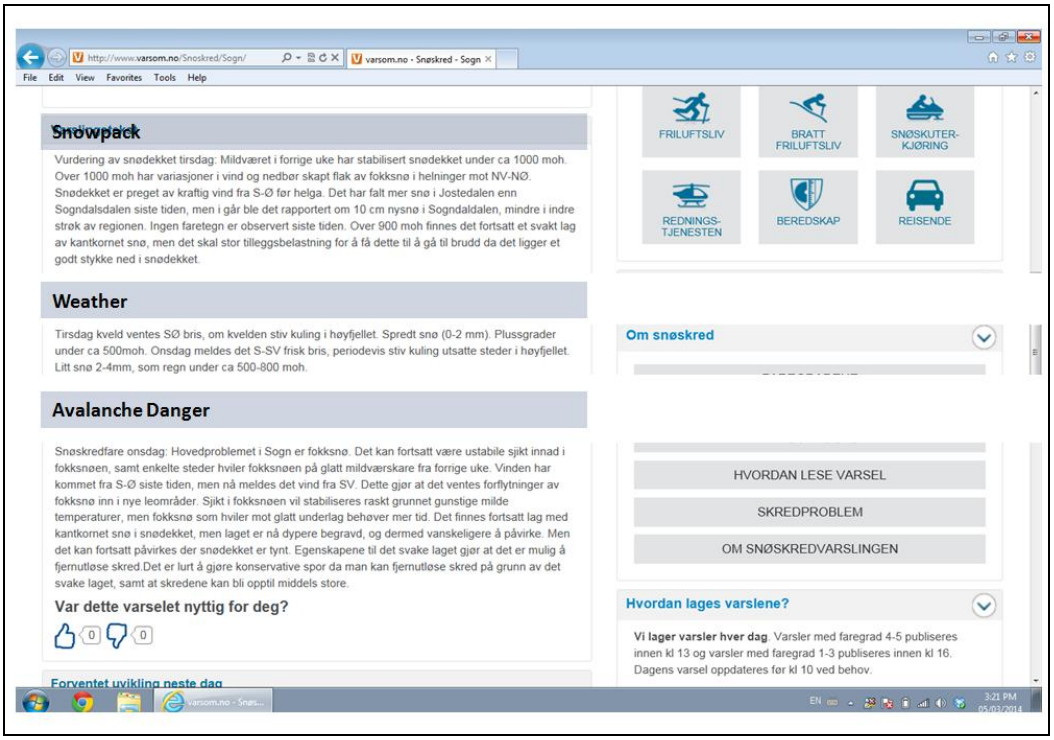

Figure 13: Example of *Varslingstekst* text broken into three distinct sections with bold headings.

14.0 PUBLISH TIMES

At present, when users visit www.varsom.no for an avalanche forecast, the most current forecasted information is not shown on the default screen between 1600 and 2400 hours. Consider that users would benefit from the most current available information for each region. NAWS's avalanche forecasts are updated for the next day at 1600 hours, but that information does not become the default screen until 2400. This means the user has click a tab to acquire the most current information rather than hit upon it immediately.

There are valid reasons for the current method, not the least of which is the evening skiing that is available in the Norwegian spring season. One asks if a person heading out at 1900 should be reading information prepared for the following day. If that information offers the most current assessment of the conditions, then the answer is yes.

Another simple way to add clarity to the date is to include the actual day of the week for all dates listed at the top of each tab (Figure 14). This may help users confirm that they are reading the most current information.

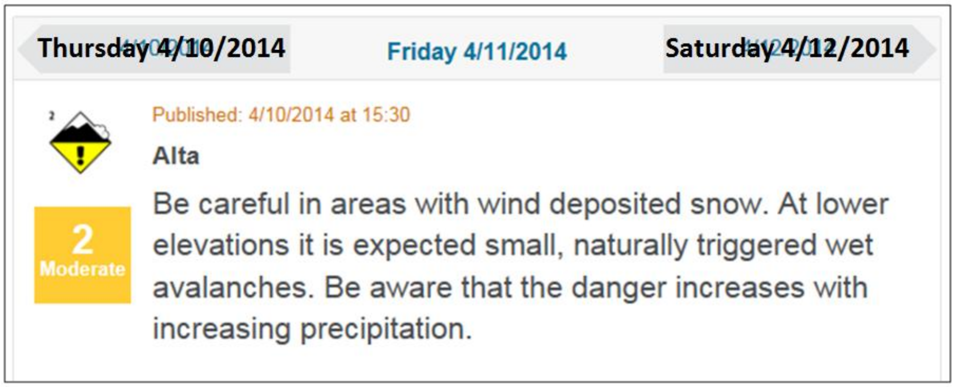

Figure 14: Example of days of the week named on all tabs at top of the forecast.

15.0 CONSOLIDATION OF WEATHER OBSERVATIONS IN THE FORECAST

While the avalanche forecast information provides an excellent analysis of the current and forecasted conditions, a true assessment of mountain conditions is incomplete without also checking recent weather observations. Many backcountry skiers will read www.varsom.no *and* be interested in weather observations from the past 24 hours (precipitation, temperature and wind-speed measurements).

This information is readily available using www.xgeo.no, but there is no obvious link to this site from the avalanche forecast. It is recommended that NAWS find a way to present regional weather observations on their avalanche forecast. This could be done in several ways:

1. Links directly to the www.xgeo.no pages (Figure 15); people can study the maps and determine the recent weather for themselves. Figure 15 shows the relevant maps for the Kåfjord region.

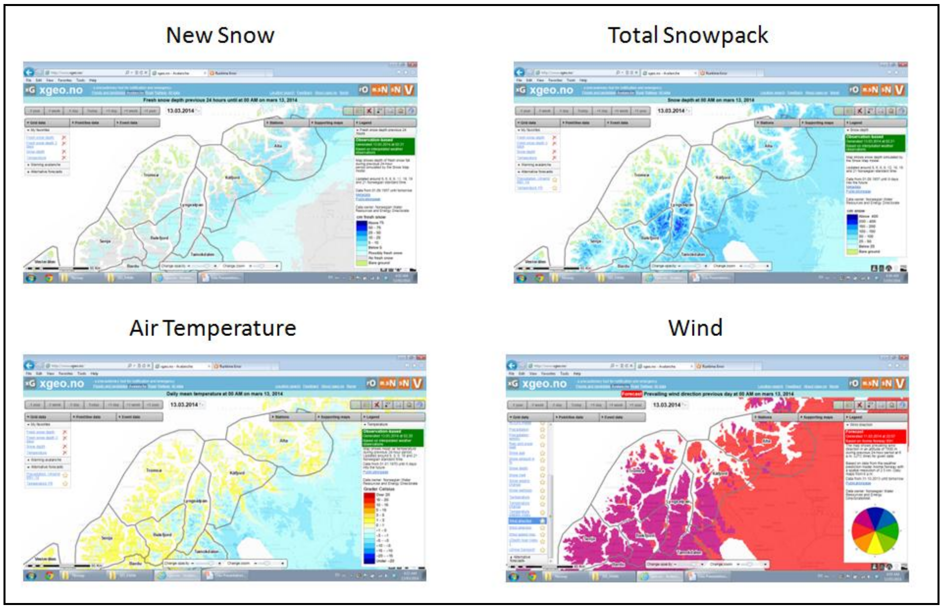

Figure 15: Maps of weather observation data for Kåfjord (source: www.xgeo.com).

2. A weather table listed beside the avalanche forecast that shows the past 24 hours of snowfall, temperature and wind. This could be automated by the development of software that pulls the weather data from www.xgeo.no and automatically populates a weather tables on the NAWS forecast. Figure 16 shows an example of how this data could be presented.

Kåfjord	
New snow (last 24-hours)	15cm
Total snowpack depth	50cm
Temperature	+1 C
Wind	W - 5m/s

Figure 16: Example of a weather table that could be automatically populated using data from www.xgeo.com (or manually populated by forecasters).

Providing easy access to real weather data adds significant value to the avalanche forecast for recreational users. Weather observations are an important supplement to the avalanche forecast—skiers will come to rely on www.varsom.no to determine the quality of backcountry ski conditions in addition to obtaining avalanche-related information.

16.0 COMMUNICATING LOW AVALANCHE DANGER

There was much discussion during these field trips about the concept of communicating low avalanche danger. Avalanche forecasters are cultured to warn and to look for problems in the snowpack; that is their primary duty. This can provide quite a challenge when there are no problems and the danger is low. However, confidently communicating low avalanche danger is very important and remains the mark of an experienced avalanche forecaster.

Without communicating low avalanche danger when appropriate, backcountry users who regularly follow the avalanche forecast will soon come to mistrust the forecast. Credibility is gained when forecasters speak equally about high and low avalanche danger, and encourage people to take advantage of stable conditions.

The mainstream media are not immune to this problem either. NRK radio in Tromsø said they always broadcast the avalanche forecast when the danger level is 3 or 4. This is excellent, but they should be encouraged to broadcast the danger ratings every day, regardless of level. Especially in a ski town such as Tromsø, communicating all types of avalanche conditions is an important way to reduce the sensationalism associated with avalanche accidents, and to create a more balanced view of ever-changing mountain conditions.

Additionally, instructional videos or other methods that teach people how to use the Varsom product should also provide instruction on how to use the forecast in all conditions. It is a modern reality that people want to ski in steep mountain terrain greater than 40 degrees; the best approach is to teach skiers how to recognize when to avoid such slopes and when to consider them. This approach will build credibility and respect for the NAWS avalanche forecast.

PART 3: OUTREACH

In addition to the products available on www.varsom.no, avalanche prevention work should also include outreach to individuals or target groups that do not read the avalanche forecast. Often these are the most difficult groups to reach, and different methods are required to meet the needs of different target audiences.

The concept of target audience should be paramount in avalanche prevention work. Products should be designed with different users in mind. For example, the same style of avalanche forecasts used for skiers may not be applicable for snowmobilers. Testing public-communication products on the target audience in the form of a survey or a different prototype is a very effective way to confirm if the method is effective.

Outreach examples that would be beneficial in Norway are discussed in sections 17.0 to 19.0.

17.0 SNOWMOBILERS

With the growing popularity of snowmobiling, and the incredible power of modern snow machines, avalanches are a significant risk to mountain snowmobilers. Local tourism offices seem to be a key point of contact as they distribute trail maps and provide local information to snowmobilers.

NAWS should consider outreach to local tourism offices in towns where snowmobiling is popular. Start with basic avalanche information and consider developing terrain ratings using the Avalanche Terrain Exposure Scale (ATES) for popular snowmobiling areas. Encourage the provision of snowmobile-specific avalanche training courses that are taught by snowmobilers (consider that a snowmobiler's teaching style and technique is quite different than that of a skier).

It seems that many snowmobilers in Norway operate "off the radar" due to the legalities of snowmobiling off groomed trails. Public recognition of this problem could shine some light on this area, and outreach designed specifically for this group seems necessary.

18.0 SKI AREAS – OFF-PISTE SKIERS

Ski areas are a place where people with no knowledge of avalanches can interface closely with avalanche hazard. It is commonplace for people to leave the boundaries of ski resorts to ski a backcountry run, sometimes encountering avalanche risk along the way. The majority of these people will be unprepared for avalanche terrain and carry no avalanche safety equipment, and will have not read the www.varsom.no avalanche forecast.

An effective place to reach off-piste skiers with basic avalanche safety messaging is at access points where people typically leave the ski-area boundary. Figure 17 shows an existing sign posted at the boundary of the Hemsedal ski resort. These types of signs can be designed with basic maps that illustrate the terrain and explain the risks ahead.

Figure 17: Warning sign at the boundary of the Hemsedal ski area en-route to the Rubber Trees.

Partnerships between NAWS and ski resorts would be an excellent addition to the avalanche forecasting program. More than any other operation in the country, ski resorts can provide real-time weather and snowpack observations that would aid forecasters in their evaluation of the current avalanche hazard. Hopefully, NAWS will have success in developing relationships with ski resorts in the future.

19.0 TRAILHEAD SIGNAGE

Places where people congregate present opportunities for delivering avalanche and backcountry safety messages. Parking lots and trailheads for popular backcountry areas are easy targets for these kinds of messages. A good example of this opportunity exists in the Sogndalsdale area, where parking lots for both the Togga and Frudalen areas already have some signage installed, but with no information that refers to backcountry safety (Figure 18).

Figure 18: Trailhead signage at the Togga trailhead area; an opportune place to install avalanche safety messages.

Avalanche safety signage for trailheads can be designed in a variety of ways; the key component is mapping or images that allow people to connect directly with the terrain. Highlighting crucial areas of danger is useful, along with basic safety messages about trip planning and rescue. Figure 19 shows one example of trailhead signage from Canada.

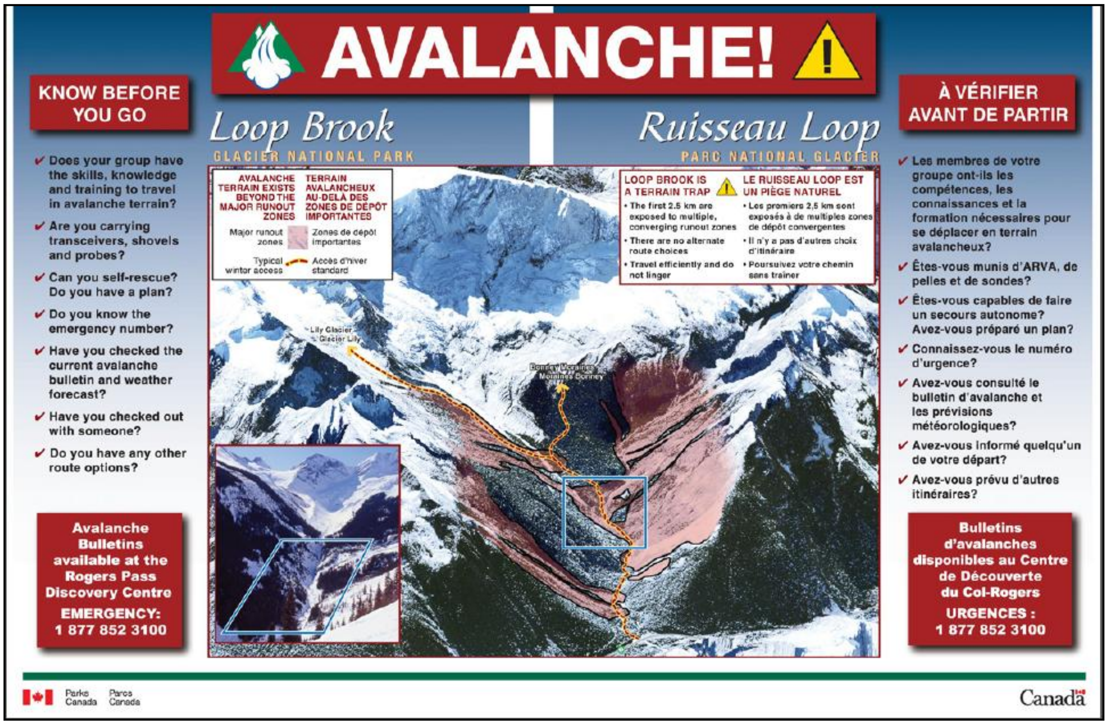

Figure 19: Parks Canada trailhead avalanche safety signage (source: Parks Canada).

It is recommended that NAWS develop a list of popular trailhead locations where signage would be useful, and develop a strategy for implementing them at these locations in the near future. Partnerships with local organizations can help fund projects like this.

20.0 SUMMARY OF RECOMMENDATIONS

Recommendation 1

NAWS should review the regional boundaries of their forecast regions in order to optimize them based on patterns of use and data availability (discussion in section 4.0).

Recommendation 2

NAWS should develop national standards for the observation and recording of snowpack, weather and avalanche observations. These standards should be strictly observed, taught and tested in observer and forecaster training (discussion in section 5.0).

Recommendation 3
NAWS should require a prescriptive set of observations that must be completed as a minimum requirement from every observer field trip, in combination with more flexible observations that vary depending on the specific situation (discussion in section 7.0).

Recommendation 4
NAWS and the observer network should begin to name, track and discuss persistent weak layers as they are buried and develop in the snowpack (discussion in section 8.0).

Recommendation 5
NAWS should reconsider its methods for classifying the size of avalanches, and implement a uniform system among the observer network for the observation and recording of avalanche activity (discussion in section 9.0).

Recommendation 6
NAWS should implement a morning forecaster meeting every day during the avalanche season. This should be a national meeting via conference call, chaired by the lead forecaster for the day. All observers and forecasters should attend this meeting prior to starting their day of work (discussion in section 10).

Recommendation 7
NAWS should review its list of avalanche problems in order to streamline them, and group them according to common patterns in terrain use. NAWS should also rename avalanche problems with simple labels, and ensure these labels form the bolded heading of each one shown on the forecast (discussion in section 12.0).

Recommendation 8
NAWS should reformat how it presents the text discussion *Varslingstekst* by creating three distinct blocks of text under the headers Snowpack, Weather and Avalanche Danger (discussion in section 13.0).

Recommendation 9
NAWS should review the timing of the forecast publication to ensure that the most current information is always the default screen, and thus, always obvious to users. Name each day of the week on the date tabs at the top of the forecast (discussion in section 14.0).

Recommendation 10
NAWS should make 24-hour weather observations easily accessible on the avalanche forecast pages to allow people easy access to precipitation, temperature and wind-speed measurements from each forecast region (discussion in section 15.0).

Recommendation 11
NAWS should provide basic avalanche safety products and promotional material in local tourism offices in areas where snowmobiling is popular (discussion in section 17.0).

Recommendation 12
NAWS should continue to develop partnerships with ski resorts in order to obtain real-time weather observations, and to install avalanche safety signage at popular backcountry access points where people leave the ski area (discussion in section 18.0).

Recommendation 13
NAWS should develop a list of trailhead and parking lot locations where avalanche safety signage would be beneficial, and begin to implement the installation of this signage (discussion in section 19.0).

21.0 CONCLUSION

NAWS has done a remarkable job of implementing a public avalanche forecasting service in a short period of time. All of the fundamental elements required to produce avalanche forecasts are established and on an improving trend. NAWS's forecasts are credible and accurate, and are a driving force behind the surge of interest in avalanche safety that Norway has experienced.

This report provides discussion and 13 recommendations for future actions that will help to improve the production and communication of avalanche forecasts in Norway. Some of these recommendations may take years or decades to see through, like setting national standards and implementing professional training, while others, like weak-layer tracking, will be easy to employ almost immediately.

Norway's professional avalanche industry is still young; with that comes great opportunity to lay the foundations that will determine its future. Factors like national standards, coordinated training and professional associations may seem daunting to establish, but looking back 20 years from now, these will be some of the most important developments that set the stage for this country's avalanche safety industry.

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Utgitt i Rapportserien i 2014

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