AVALANCHE PROBLEMS IN NORWAY – HOW WE USE THEM AND DOES IT WORK?

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ABSTRACT: After four seasons of national avalanche forecasting, we consider the avalanche problems as the most important element of our bulletin. Our system is based on inspiration from leading forecasting services; especially Canada, Tyrol, Switzerland and Bavaria. We use a set of main avalanche problems, with additional information on the weak layer of concern. The development continues, and we are now member of the Avalanche Problems working group in EAWS. In Norway, avalanche problems are used both in field observer training and work, production of bulletins, travel advice for the users, and in avalanche education. Our impression is that developing a systematic approach to avalanche problems has both increased the quality and usefulness of the bulletin, and made it easier for observers and forecasters to understand and describe the different avalanche situations in a common and logical manner. Each avalanche problem incorporates, in addition to the name and weak layer; the elements avalanche size, distribution and necessary trigger. These elements are also used in the Bavarian Matrix, which provides a direct link between the avalanche problems and the danger level. This has made the avalanche danger assessment and forecasting process more objective. All these elements are valuable information to the skilled recreational users and also for the professional users like the Norwegian Public Road Administration. Additionally, we provide a travel advice to the less skilled users, which aims at helping the user recognize and avoid the problem. Finally, does it work? Do we save lives? We asked our backcountry users, who responded that we do indeed. We will present our approach to avalanche problems and the results from the user survey.

KEYWORDS: avalanche problems, avalanche forecasting

1. INTRODUCTION

The main goal using avalanche problems is to help the users avoid avalanche accidents. The avalanche problems are presented on our warning web site www.varsom.no, both in the avalanche bulletins and in the online avalanche school.

Since the Norwegian Water Resources and Energy Directorate (NVE) with partners started up the Norwegian Avalanche Warning Service (NAWS) in January 2013 (Engeset 2013), the avalanche problems have been an important part of the bulletin (Landrø et al. 2013). However, the way the problems are organized and presented has developed from season to season, always with the intention to help the users to understand and handle different avalanche situations easier.

Gathering experience from the last four seasons inspired us to develop a system for avalanche problems that matches the needs of countries like Norway. We needed an effective system suitable for many large regions with relatively sparse data.

Since the winter 2014/15, the avalanche problems have been tightly connected to the systematic snow cover diagnosis (Kronthaler et al. 2013, Müller et al. 2015).

2. WORK LEADING UP TO THE AVALANCHE PROBLEMS WE USE TODAY

2.1 What is done in other countries?

Feedback and inspiration from other forecasting services has been an important part of the process; especially Canada, Utah, Tyrol, Switzerland Bavaria and the U.S (Reference Websites 2016). Visits, courses, exchange and direct feedback from other professionals have been very valuable.

Participating in the EAWS Avalanche Problems Working Group and Technical Advisory Board (EAWS, 2016c) has also been important. Working closely on the topic with other avalanche professionals from leading forecast services in Europe has been inspiring and educational.

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2.2 Feedback from our users

To find out how the users perceive and use the Norwegian avalanche problems, a user survey was carried out in spring 2016. A total of 526 people answered, 91% of them were backcountry skiers with basic (43%) or more than basic knowledge (41%) about avalanches.

When asked if and how they used the information in the avalanche problems (all elements including handling advice), a high number of users used the information both for tour planning and making decisions directly in the field (Fig. 1 and 2).

69% used the avalanche problems for tour planning almost every time; another 26% used it sometimes.

46% used the avalanche problems for slope evaluations almost every time, another 40% used it sometimes.

When asked about the effect, most of responders think the avalanche problems and the handling advice contribute to preventing accidents (Fig. 3 and 4).

We also asked if the users think it is difficult to understand how to use the information in the avalanche problems. Only 6% answered yes to this question. 53% answered that the avalanche problems are not hard to understand, 41% think it is a little bit difficult to understand (Fig. 5)

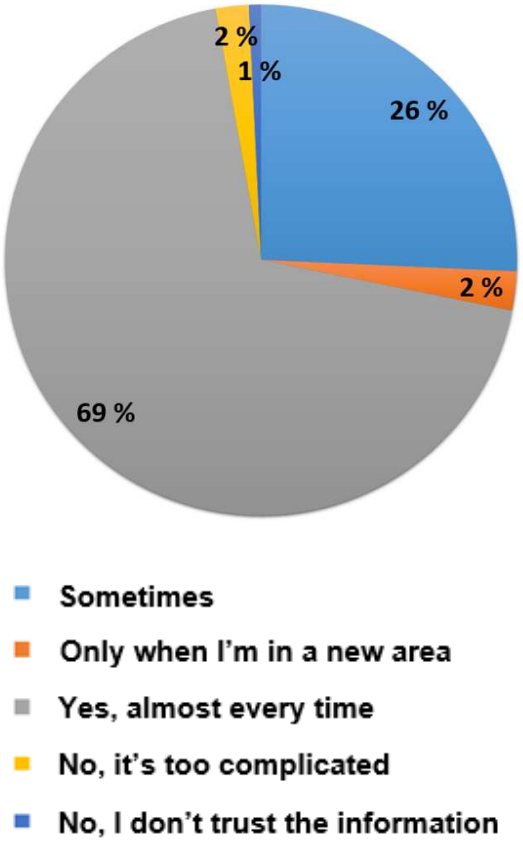

Fig. 1: The use of avalanche problems for tour planning.

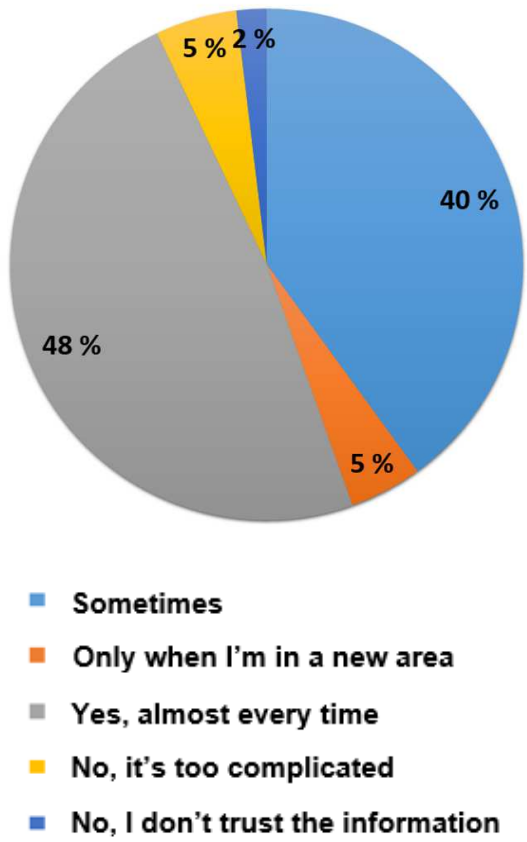

Fig. 2: The use of avalanche problems for decicions in the field.

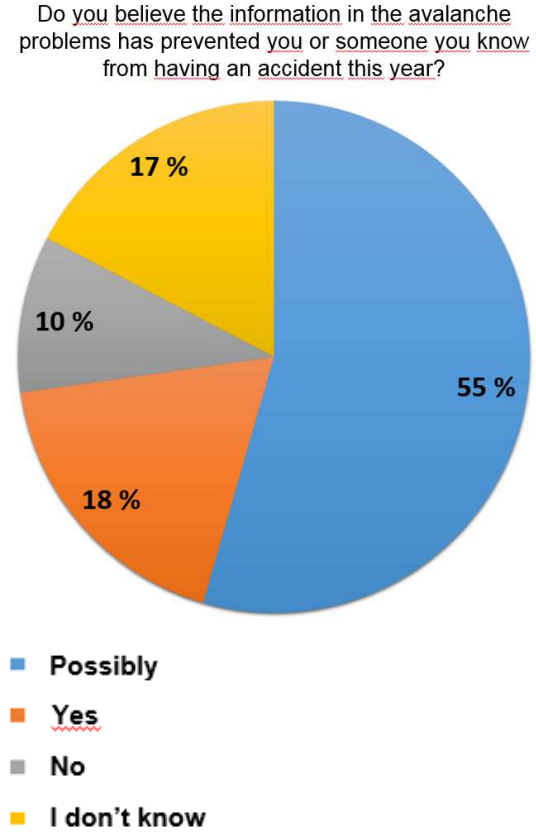

Fig. 3: The users think the avalanche problems has prevented accidents for themselves and people they know.

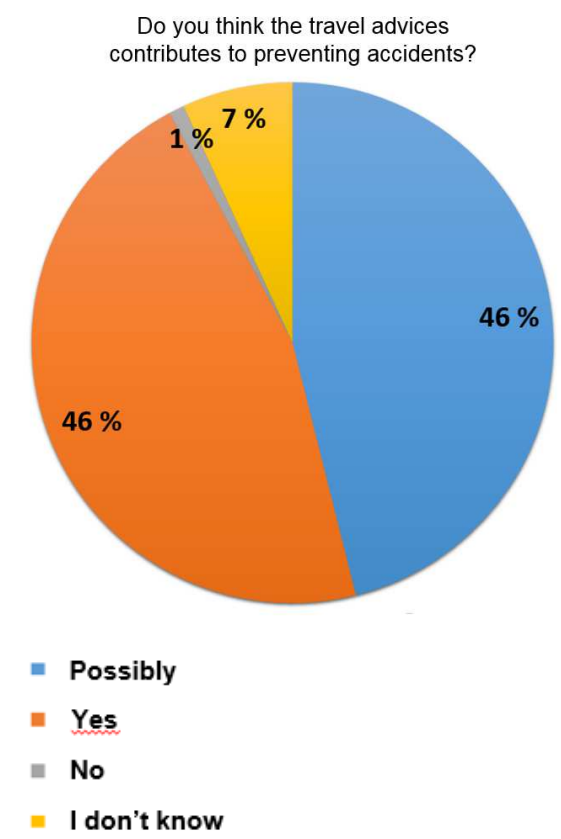

Fig. 4: The users think the avalanche problems has prevented accidents in general.

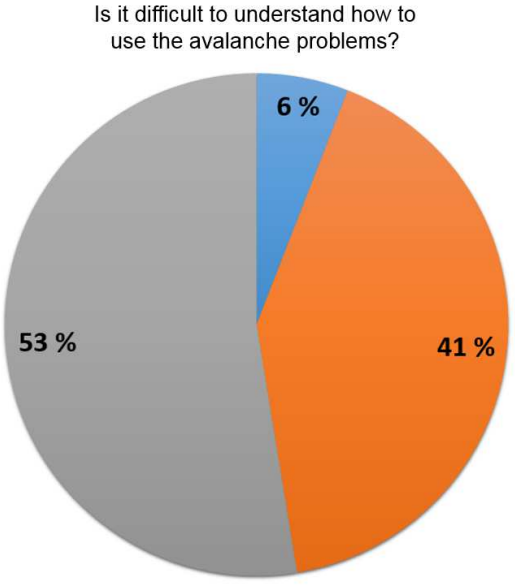

Fig. 5: How difficult do the users think it is to understand the avalanche problems?

3. NORWEGIAN AVALANCHE PROBLEMS - THE CURRENT VERSION

3.1 List of avalanche problems

The following list gives an overview of the avalanche problems issued by the NAWS during winter 2015/2016. The avalanche problem is listed in uppercase and options for weak layers of concern in lowercase.

1. DRY LOOSE AVALANCHES
- Loose dry snow (no weak layer)

2. WET LOOSE AVALANCHES
- Loose wet snow (no weak layer)

3. STORM SLAB
- Buried weaker layer of new snow
- Poor bonding between buried crust and overlying snow

4. WIND SLAB
- Poor bonding between layers in wind deposited snow
- Buried weaker layer of new snow
- Poor bonding between buried crust and overlying snow

5. PERSISTENT WEAK LAYER
- Faceted snow near the ground
- Faceted snow under crust
- Faceted snow above crust
- Buried weak layer of faceted snow
- Buried weak layer of surface hoar

6. DEEP PERSISTENT WEAK LAYER
- Faceted snow near the ground
- Faceted snow under crust
- Faceted snow above crust
- Buried weak layer of faceted snow
- Buried weak layer of surface hoar

7. WET SLABS
- Water gathering in/above snow layer
- Poor bonding between buried crust and overlying snow
- Faceted snow near the ground
- Faceted snow under crust
- Faceted snow above crust
- Buried weak layer of faceted snow
- Buried weak layer of surface hoar

8. GLIDE AVALANCHES
- Water/melting from ground

3.2 Properties of the avalanche problem

Fig. 6 shows an example of the bulletin in English, as presented on www.varsom.no. The elements in a complete avalanche problem are:

- Avalanche problem name
- Weak layer of concern
- Elevation range
- Aspect range
- Expected avalanche type
- Expected avalanche size
- Distribution of the problem
- Necessary trigger
- Probability of triggering
- Handling advice

All elements of the avalanche problems are stored in a forecasting database, which allows for automatic translation to other languages on the web site. The most relevant information in the bulletin is thus available in the English version of the bulletin. The text analyses are in Norwegian only (snowpack and avalanche analysis, avalanche danger assessment and the weather prognosis).

3.3 Handling advice

The handling advice contains information about:

- How to identify the problem
- How to avoid an avalanche

The advice is dynamic and changes according to the specific avalanche problem and the danger level. In the lower danger levels, the recreational users are considered the main target group, but for danger level 4-high and 5-very high, we further address the preparedness authorities responsible for roads, railroads and municipalities due to the increased possibility for large spontaneous avalanches.

Examples:

- Problem “Wind slab” at danger level 2-moderate:

  Advice: “Look for areas where the wind recently has deposited snow, typically behind ridges, ribs and in gullies. Remember that local wind effects will cause variation in where the wind slabs occur.
  An avalanche is easier to trigger where wind slabs are thin or soft. Be careful and keep distance to each other in steep (above 30 degrees) terrain with fresh wind deposited snow, especially convex terrain.”

- Problem “Persistent weak layer” at danger level 4-high

Advice: “Stay away from avalanche terrain and runout zones for avalanches. For authorities: Large avalanches can release spontaneously and in some cases reach roads/settlements.”

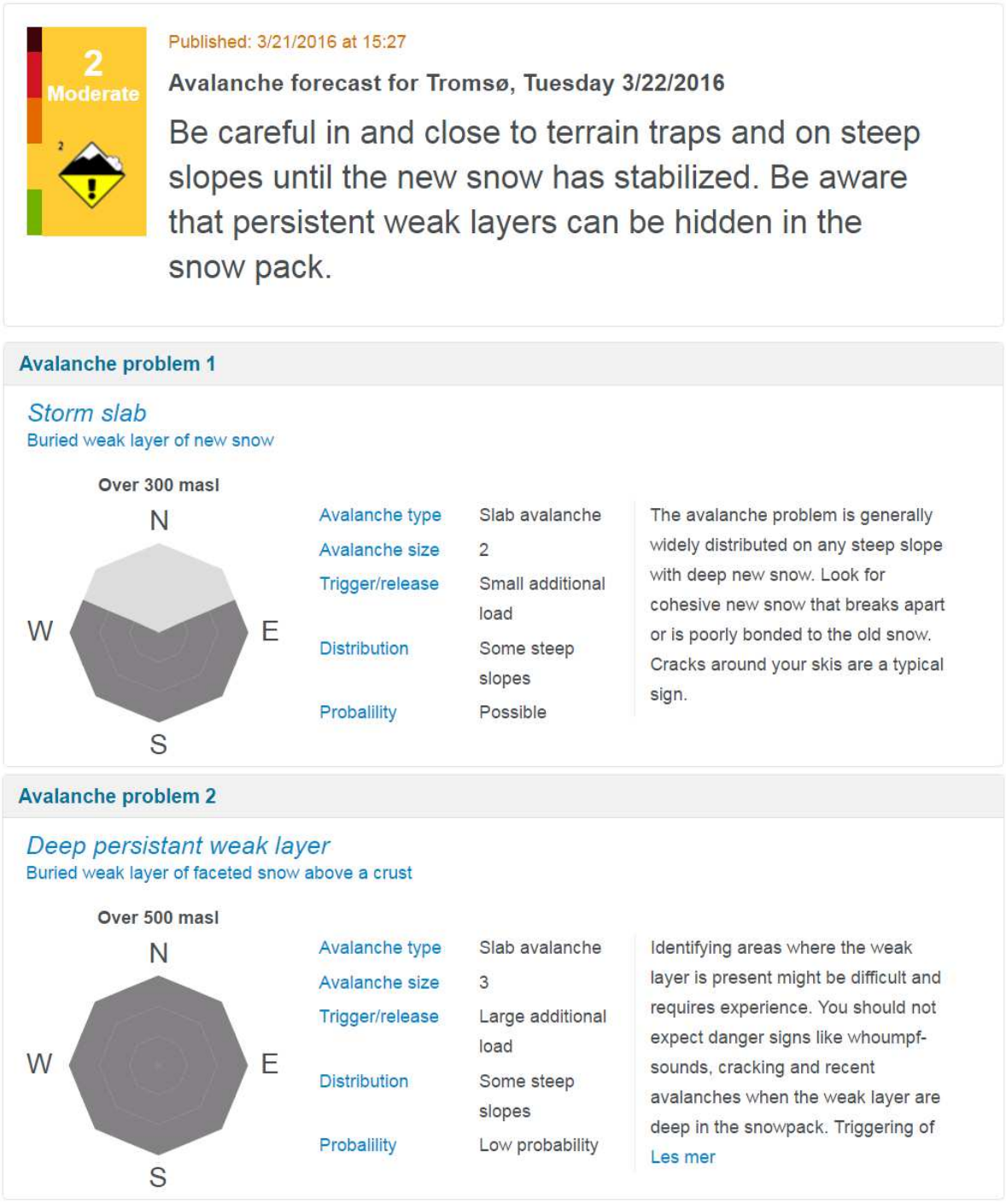

Fig. 6: The complete avalanche problems in the English version of the NAWS bulletin.

4. DISCUSSION – WHY DO IT THIS WAY?

4.1 Field observers' use of the avalanche problems

The field observers are trained to use systematic snow cover diagnosis (Krontahler et al. 2013, Müller et al. 2015) with focus on type of weak layers and their properties. Having large regions in Norway (4000 km^2 on average) with sparse data, this is important for the forecasters and crucial to obtain good bulletin quality.

The observers are encouraged to describe the processes within the snow pack relevant for their field observation to increase the spatial extend/relevance of each observation. This approach requires profound knowledge of dominating process leading to the development of weak layers. However, by applying the systematic snow cover diagnosis, the weak layer of concern can often be identified by less experienced observers, providing a good indication and/or validation of the dominating avalanche problem.

This qualitative approach requires profound knowledge of snowpack evolution from the observers and can be challenging for the less experienced observers at first. By having a system that is based on the systematic snow cover diagnosis, which is directly connected to the avalanche problems through the weak layer, the learning curve is steep but very efficient for most observers. Thanks to this approach, the observation reports has improved significantly in quality and are now a lot more useful for the forecasters than two years ago.

4.2 Forecasters' use of the avalanche problems

The avalanche problems provide a common language between observers and forecasters and have improved communication between the two groups.

Another important factor for the bulletin quality and consistency between forecasters has been the use of the Bavarian matrix (EAWS, 2016a). The main task for the forecasters is to pinpoint the avalanche problem(s), determining the relevant elements of spatial distribution, avalanche size and likelihood of triggering. These elements are then identified in the Bavarian matrix and provide a suggestion for the danger rating.

4.3 Why present all the avalanche problem details to the users?

We present all the elements in the avalanche problem in the bulletin, open for all users to see (Sec. 3.2).

For the less skilled users the full avalanche problem no doubt can feel like an overload of information. For them, the handling advice is the most relevant part of the avalanche problem/bulletin. It should be enough to understand and follow this advice to be safe.

4.4 Avalanche training

We have feedback from instructors that the avalanche problems, the definitions of each problem (provided as part of the educational pages on www.varsom.no) and the travel advice all are very useful tools in avalanche courses. The definitions of each avalanche problems are easily accessible online at any time. Our goal is to provide information good enough to be used on every avalanche course in Norway, and in a manner that makes it easier for the student to continue learning when they leave the course and have to use the bulletin and their knowledge in "real life".

User feedback documents that the users learn from reading the bulletins. The systematic approach with avalanche problems has structured the information in a pedagogically sound manner, increasing the learning effect.

4.5 Skilled and professional users

In single slope evaluation, the danger level is simply not enough information. You have to evaluate the avalanche problem(s) in the actual slope at hand. This is the case both for the road contractor deciding to open or close a road, the avalanche expert deciding to evacuate or not, and for the skier deciding to ski a slope or not.

The skilled users are interested in all the elements in the avalanche problem: "What is the weak layer? What avalanche size can the problem create? How sensitive is the weak layer?" If they get this information, the user can reason about why, when and where avalanches may be expected, and thus be able to think where they can find the problem and plan safe travel.

Another factor, which has been important for deciding to present all elements of the avalanche

problems, is to give professional users like avalanche experts in the Norwegian Public Road Administration (NPRA) and other professional users, the best possible foundation for making their decisions. The NPRA has been central in the development of the bulletin, and many of their professionals are observers and/or forecasters in the NAWS.

The regional forecast provides a good basis for making local evaluation and decisions about for example evacuation or opening/closing of roads. Knowing exactly what the danger level is based on, gives a better foundation for making their decisions.

4.6 Foreign users

Another important reason for presenting all the relevant elements is the possibility for automatic translation, which makes it easy to present the content of the avalanche problems in foreign languages.

The bulletin text is currently not accessible in other languages than Norwegian, however the avalanche problems have the same level of detail in English, including the handling advice. This makes key information of the bulletin accessible to English speaking users.

4.7 Illustrations / Icons

Throughout the four years of operation, NAWS has used avalanche problems, and we tested different versions of icons for the elements in the problem. Our experience is that people like icons, but it is difficult to find icons that everyone understand in the correct way.

So far, we have not used specific icons for each avalanche problem, the problem name is presented by text in a headline.

For the elements in each problem, we only present an icon for the aspect, the rest of the elements are presented in text (See fig.6). A few years ago, we used more icons for some of the elements, like for the probability of triggering and the additional load needed to trigger an avalanche, in addition to aspect and elevation, but the result was a visual overload of icons and some misunderstanding.

The current version with few icons gives a quite clean design that the users (at least the ones with some avalanche knowledge) seem to understand. Each key word is linked to educational articles on the topic to help the users understand the key elements in the bulletin better.

However, the question about optimal use of icons will for sure come up again.

5. CONCLUSION

The way the avalanche problems have been used throughout the entire forecasting chain (from field observation to bulletin) the last couple of years, has been well received by users, observers and forecasters.

The results from the user survey show that many of the users, at least the ones with some knowledge, find the avalanche problems useful and seem to use them the way we intended. They also believe the avalanche problems prevent accidents. This is very encouraging and inspires to continue using the avalanche problems.

Another good reason for using avalanche problems in the current manner is that the bulletin quality has improved over the last years. The systematic use of avalanche problems, the Bavarian Matrix and the systematic snow cover diagnosis are important reasons for the improvement.

6. ROAD AHEAD

6.1 The upcoming season

A change in design for the entire www.varsom.no website is planned before the season 2016-17. Some visual changes will also apply for the bulletin, but due to good feedback from our users, we see no need for changing the setup of the avalanche problems. The only change here will be a new and hopefully improved icon for indication of aspect and elevation.

6.2 Europe

NVE is member of the EAWS working group for avalanche problems (see chapter 2)

EAWS is now in a process where the Technical advisory board (TAB) has agreed on a preliminary list of avalanche problems (EAWS, 2016c):

1. NEW SNOW
2. WIND-DRIFTED SNOW
3. PERSISTENT WEAK LAYER
4. WET SNOW
5. GLIDE AVALANCHES (Optional)

At the time, the EAWS Avalanche Problems working group is also close to providing full definitions

for each problem, which will also be presented to the EAWS members this fall. The plan is to present the problems with full definitions for approval by the EAWS in June 2017.

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