

METHODS USED IN OPERATIONAL AVALANCHE FORECASTING AROUND THE GLOBE
- A COMPREHENSIVE STUDY

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ABSTRACT: Operational avalanche forecasting is done in a large number of countries around the globe and has a great impact on both infrastructure and human life protection. However the exact availability, the spatial cover of the forecasts, the available resources for the forecasters and the methods used for forecasting vary from country to country. These factors are determined by the exact area and climate of the snow covered regions, the specific methods used for the local conditions and the various co-operations with the local governments and stakeholders. In the current study we present the results of a survey conducted among the different avalanche forecasting agencies and organizations around the world on the specific operational methods used, with a special emphasis on the human influence within the decision making process for the specific avalanche bulletin.

KEYWORDS: operational avalanche forecasting, avalanche bulletin, survey, statistical analysis, snow avalanche

1. INTRODUCTION

With the rapid development of outdoor tourism more and more people travel to the backcountry without the experience-based knowledge of the local conditions. This relative lack of information can have a big influence on the user's decision making framework on avalanche terrain. These people are heavily relying on the information from the regional avalanche and weather forecast. However as these may vary even from region to region their understanding can be demanding. Sometimes even contradicting information are drawn while comparing the forecasts with the local observations, and without exactly understanding the background of these differences the user may end up confused.

We have conducted a global online survey across various operational avalanche forecasting agencies to get a better understanding of the various forecasting methods and practices used. According to our experience the content, the representation and the interpretation of the local avalanche forecast

-as it's usually tailored to the local conditions-can widely vary from country to country. For instance the presentation of the actual information can consist of different elements eg. different types of charts, graphics or text description. Also various methods are in use in the measurement and decision making process. This altogether can make it difficult for the average user to comprehend and process the exact information content of the forecast, especially when traveling outside of his/her local area.

With the results of this survey we intend to promote and facilitate the deeper understanding of the regional avalanche forecasts for the backcountry users and to facilitate future improvements of the forecast for avalanche professionals. In the current work we will only highlight some of the most interesting preliminary points, with a special emphasis on the human factor when creating the forecast, while a more detailed analysis, including other aspects of the survey will follow in the respective paper.

2. METHODS

An on-line survey was sent to more than 50 avalanche services in 27 different countries

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throughout the world. The survey consisted of 12 sections including question on the institutional background, area of coverage, numerical models, weather data, snowpack observations and personal experience used for the forecast, the publishing method of the bulletin, if any avalanche and avalanche accident database is built, the educational background of the forecasters and any educational activities of the organisations.

In the following study we will discuss the results based on the answers from 19 different organizations from Austria, Canada, Czech Republic, Germany, Japan, Schotland, Spain, Switzerland and the US. As of now we are still expecting answers from a number of organizations, and we will update our findings in the future according to that.

3. RESULT AND DISCUSSION

Avalanche bulletins include a large amount of human decision making. According to our knowledge and the survey results as of today no single avalanche bulletin is produced based on solely automated measurements, simulations and decision making. This is of course understandable as the snowpack and the weather conditions together usually form very complex systems always varying on both the temporal and the spatial scale. Even with detailed protocols, numerical tools, automated data measurements already existing, this makes experience based human decision making a very important asset during the avalanche forecasting process.

This large weight of the human factor is also very well highlighted in our survey results in all phases of the bulletin production, starting from the field measurements, through to the numerical modelling, and up to the final decision making.

As a main example for the final decision on the daily avalanche forecast only ca. 40% of the organizations use any written protocol (and even this is usually a specific protocol of the given organization), while at the rest of the organizations the bulletin based mostly on the long term personal experience of a group of decision-makers. This human based decision making is also highlighted in the low number of

cases where any kind of numerical models are used to aid the process. At certain organisations RAMMS [Lehning et al., 2002] or SNOWPACK [Bühler et al., 2010] is used, however in most cases none of these or any similar models are applied. This highlights the fact, that even against careful validation these models are still ranked behind the human experience.

Furthermore we found that the number of automated measurement stations used (both to measure weather parameters or the changed in the snowpack) is also very low. Even though this may have financial and technical reasons, but can also possibly emphasise the importance of the complex set of variables drawn through the manual field measurement in the experience based decision making process of the observers.

Most of the times manual snowpack and stability measurements build the foundation for the bulletin. In most cases these are conducted daily, however there is variation between the organisations if they conduct these at constant locations throughout the season or vary the locations on a daily basis. Most frequent data recorded during these manual measurements in the field are location, elevation, weather data, inclination, aspect, total snow depth, layer boundaries, grain type and size, snow hardness measured by hand and stability test results. Interestingly however snow temperature profile and the moisture/liquid water content are only measured in ca. 50% of the cases. Instrumented snowpack measurement were also not commonly reported among the responders, only ca. 30% use any of these in the field.

Except for very rare and well justified cases stability tests are always made in the field. Compression test, extended column test, propagation saw test and the slope cut test are the most widely used methods, while Rutschblock, fracture character test, deep tap test and snow profile checklist aka Lemons are not so frequently used evaluation methods. Interestingly in more than 60% of the organization manual snowpack observations are only made up to a depth of 1.5 meters. This can be attributed to either no deep weak layers expected in that area or that these are accounted for based on the seasonal snow

cover history, once again highlighting the importance of human decision making in the process.

One important aspect of the human decision making is the education system of the operational personal behind it. For field observers the picture is quite mixed, in ca. one third of the cases there exists an official course structure to train field observers. In the rest of the cases they are usually chosen based on their experience level, sometimes providing them with a protocol, sometimes not even that, and sometimes even no previous experience is required of them.

In contrast ca. 70% of avalanche services provide an official course for the decision-makers, in some cases even including one-on-one training. In the rest of the cases decision-makers are chosen based on their experience level without official educational requirements.

If we look at the human decision making from the users side there is a very positive tendency as ca. 75% of organizations publish educational materials for the end users and ca. 70 % also do so for professionals. Furthermore ca. 55% of the responding organizations also provide hands on training in avalanche awareness.

4. CONCLUSION

As of today the human experience can not be superseded in avalanche forecasting. This is also demonstrated by our survey results: the human contribution is still the most important factor in both observations and decision-making. Human decision making is a complicated process, largely based on a complex set of observations (some of them may even be non-conscious) and a huge amount of previous experience. Describing these in detail in an avalanche bulletin is not only not feasible in most of the cases, but would also result in long and detailed analysis most users wouldn't care to read or be able to understand, and would require large amounts of extra work. And even though at some organizations written protocols and clear guidelines exist, the final decision is still always human based. This leaves a large gap between the final official assessment of the avalanche situation (shortened usually to a

page long bulletin) and the end-user's understanding. Basically there is no means to explain the individual decision process of the official bulletin in detail to the user in each single case. Furthermore both decision making from the organisational side and assessing the bulletin from the user's side includes a large amount of bias, based on the previous experiences of the individuals. This is most cases is usually even unconscious, making a full understanding of the background of one's decision just as more demanding. These results all highlight the importance of avalanche education. If we want the end-users of the bulletins to get a good and deep understanding of the specific bulletin (that only contains a fraction of the information the official decision was based on), and build it in a sensible way into their own decision making, we need them to be educated in a systematic and detailed manner. However this education should not only be about avalanche rescue and some basic understanding of the forecast, -as it's done in a lot of cases-, but also to get a deep understanding of the snowpack, the physical processes shaping it, and the willingness to make one's own field observations and gain further experience (e.g. dig more pits).

Fortunately avalanche education is becoming more and more widespread and avalanche forecasting organizations also take it on themselves to provide educational material and training for both professionals and amateur users. However according to our opinion it would be very important to understand that in order to bridge the gap between the bulletins provided by the professionals and the end-users the quality and systematic structure of the avalanche education is of great importance.

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