

## USERS' RATING OF THE SWISS AVALANCHE FORECAST

Kurt Winkler<sup>1\*</sup> and Frank Techel<sup>1</sup>

<sup>1</sup> WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland

**ABSTRACT:** User surveys are an important instrument to verify and improve quality and usability of avalanche warning products. In February 2014, we queried 2500 users and compared their ratings with the previous survey from 2008. The aim was to spot strengths and weaknesses of the Swiss avalanche warning products which were completely revised in 2012. The revision involved a new bulletin structure that follows the information pyramid as recommended by the European Avalanche Warning Services (EAWS). Also, the danger descriptions are now translated automatically with a predefined set of phrases. The results from the survey indicate that the goals of the 2012 revision were achieved as, for example, users rated their knowledge about the current avalanche warning exactly in the order of the information pyramid. The language quality of the automatically translated danger descriptions were rated even better than the normally written and manually translated parts of the avalanche bulletin. In addition, the survey reveals user group specific aspects such as the evaluation by mountain guides who rated both, prediction quality and avalanche danger, significantly lower than other groups. However, the overall user rating of the forecasting accuracy has risen slightly but significantly to 83%. To know preferences and needs of users and specific user groups is essential to further improve avalanche forecasts with regard to content and usability.

**KEYWORDS:** avalanche forecast, warning, communication, user survey

### 1. INTRODUCTION

How "good" is the avalanche bulletin and how can we improve it? The hit rate is probably the most important parameter defining the quality of an avalanche forecast, and thus a lot of effort and research has been invested to quantify the accuracy of the forecasted danger level (e.g. Jamieson et al., 2008; Schweizer et al., 2003). As avalanche warning is a complex field, greater enhancements in regard to content remain demanding, as already the measurement of a hit rate is difficult.

The usable content of an avalanche bulletin is just the part which arrives in user's mind. Thus, Semmel et al. (2009) investigated benefit and comprehensibility of different icons. They recommended to use both, icons and highlighted text for the most important contents (what we did in the new Swiss avalanche bulletin). Burkeljca (2013) measured the time survey participants needed to answer a set of questions after reading different avalanche bulletins, but not the knowledge at a certain time-span after having read the bulletin.

In this study, we evaluate how users rate the quality of the Swiss avalanche bulletin based on two surveys (2008, 2014). The 2014 survey reflects the situation after the complete revision of the Swiss avalanche bulletin, which is operational since the beginning of winter 2012-2013.

The new Swiss avalanche bulletin, published at [www.slf.ch](http://www.slf.ch), has been described in Ruesch et al. (2013) and in Winkler et al. (2013). Two daily editions in four languages are only possible since a fully automated translation is now available. The main goals of the new bulletin were not improvements in regard to its content, but to make more of our (limited) knowledge usable for the reader. The new bulletin was optimized for web and smartphones and strongly reflects the information pyramid as recommended by the EAWS (2009): the most important information first. Thus users with little time find immediately the most important information.

Before 2012, the Swiss avalanche service indicated the slope type as part of the danger zone (e.g. "steep slopes", "lee slopes"; 2<sup>nd</sup> level). As this kind of information was not used by other avalanche services, and to avoid conflicts with the danger patterns, they were abandoned with the renewal of the bulletin. Instead, we included the danger patterns in the information pyramid (Fig. 1). The danger patterns indicate the most promi-

---

\* Corresponding author address:

Kurt Winkler, SLF, Flüelastrasse 11, 7260 Davos Dorf, Switzerland  
tel: +41 81 4170127  
email: [winkler@slf.ch](mailto:winkler@slf.ch)

nent danger (e.g. "snow drifts", "wet avalanches as the day progresses"; Harvey 2012).

In this paper we describe and analyse the two surveys to get insights to the following questions:

- Who uses the avalanche bulletin? Do we reach all the different groups travelling in avalanche terrain equally?
- Has the user's knowledge improved?
- What are the preferences and what is the confidence of the different user groups, and have they changed with time?

It goes beyond the scope of this paper to present the outcome of all of the about 70 questions asked in the surveys. This will be done later on [www.slf.ch](http://www.slf.ch). Here we only present a selection of interesting findings.

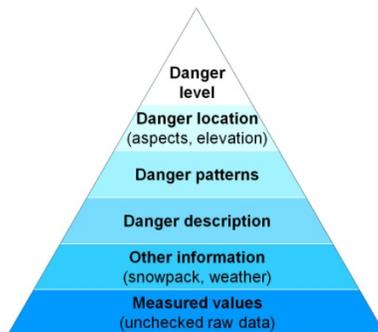


Fig. 1: Information pyramid in the Swiss avalanche bulletin: the most important information first.

## 2. SURVEYS

The two surveys were posted on the website of the Swiss avalanche warning service [www.slf.ch](http://www.slf.ch) from 11 March to 29 April 2008 and from 18 February to 5 March 2014. In addition, the 2014 survey was advertised on the SLF app "White Risk", as in 2014 about half the access to the avalanche bulletins came from the app. Some questions were identical in the two surveys. This allowed tracking the changes following the introduction of the completely revised avalanche bulletin and over time.

The survey was available in German, French, Italian and in 2014 additionally in English.

After a plausibility check, 2038 participants remained in the 2008 survey and 2475 in the 2014 survey. These high numbers manifest the interest in the avalanche bulletin and represent a robust data pool for statistical analysis.

The answers were unverified self-declarations. Thus, in questions concerning the knowledge of

the avalanche bulletin and the own experience, the given values must not necessarily be correct (Semmel, 2009). However, as an eventual bias would be similar in both surveys, this problem is only relevant to the absolute values, but not when comparing questions.

## 3. ANALYSIS

Differences between categorical variables were tested for significance using the Wilcoxon rank sum test. The level of significance was  $p < 0.05$ . To analyse the equality of two proportions, data were cross tabulated and the chi-square statistic calculated. The t-test was used for numerical variables (Crawley, 2007).

Comparing the different datasets, we could seldom find differences by using common parameters for ordinal data as median or mode. Therefore, to investigate differences, we assumed the predefined responses to be equal in distance and allocated numerical values to the different categories, starting with 5 for the best rating and 1 for the worst. This allocation to a Likert scale is supported by response options being as symmetrical as possible and by an equidistant presentation in the survey. We only used these numerical values to calculate mean values in order to show differences between the datasets.

## 4. USERS OF THE AVALANCHE BULLETIN

Participants were users of the avalanche bulletin, but do not necessarily represent snow sport participants in general. Usually, people familiar with a topic participate more often in surveys. This explains the high numbers of touring/freeride days and the large proportion of mountain guides (5%) and (volunteer) winter tour leaders (24%) among the participants. As both surveys have been performed via the same channel, no bias is expected between them.

Are there any specific user groups which we don't reach well with the avalanche bulletin? Concerning experience and avalanche education, we cannot answer this question due to the respondent's bias toward trained participants. For the other groups, it would be interesting to compare the ratio in the survey with the ratio of winter backcountry users. Unfortunately, we do not know who ventures into the backcountry and how often. Instead, we used demographic data of people caught by avalanches from the SLF avalanche data base.

#### 4.1 Activity

More than 99% of the participants were active backcountry tourers or freeriders and most of them practice this extensively. The mean value was 27.6 days touring/freeriding per year and thus even higher than 2008 (20.5 days). This number corresponds to data in a survey by Zweifel et al. (2012, not published in the paper: 24 days) and highlights the bias towards experienced backcountry users if compared to a survey in which Swiss residents were asked directly in a phone interview (Lamprecht et al. 2008, mean value backcountry tourers: 10 days).

The huge majority of participants were backcountry tourers (96%; in 2008: 86%). The proportion of freeriders remained stable (52%, multiple answers were possible). Mere freeriders, excluding those who also go touring, rarely participated in the survey (3%). This means that freeriders were adequately represented only as long as they practice backcountry touring as well.

Skis were used by 86% of the backcountry tourers and 83% of the freeriders. This proportion is higher than in 2008 ( $p < 0.001$ ). The portion of snowshoe hikers remained unchanged (8%), while snowboards were less frequently used.

#### 4.2 Gender

Women were a minority, even if their proportion has risen significantly from 13.8% in 2008 to 17.2% in 2014 ( $p = 0.002$ ; Fig. 2). The 2014 value matches the proportion of females in the accident data base (17.1%,  $n = 689$ ; hydrologic years 2003/04-2012/13, hereafter 2004-13). We are uncertain whether this proportion really reflects the proportion of women recreating in the Swiss backcountry. Procter et al (2013) reported a proportion of one third in South Tyrol (Italy) and Lamprecht et al. (2008) even 52% female tourers. In any case, as the ratio of women is the same in our survey and in the accident data base over the last 10 years, we do not consider women of being underrepresented in the survey and thus presumably also not as users of the website of the avalanche service.

Compared to the other languages, German speaking women are over- and Italian speaking women underrepresented (18.2%,  $p = 0.02$  and 9.0%,  $p = 0.001$ ).

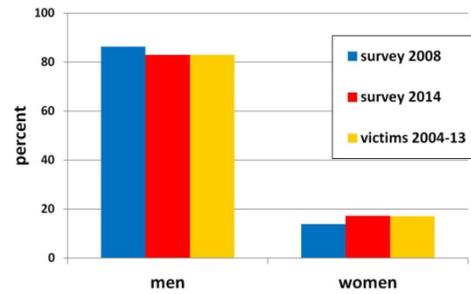


Fig. 2: Gender of survey participants and people caught by avalanches.

#### 4.3 Age

With 41 years, the median age from the participants of the 2014 survey was 5 years older than in 2008. This significant increase can be partially explained by an increasing number of older people using the web and by younger people preferring the App (the survey was placed on the web only, although advertised on the App). On the other hand, avalanche accident data show that winter sport participants are getting older: the median age of people caught by avalanches increased from the 10-year period 1994-2003 to 2004-2013 from 32 to 39 years. Comparing the latter period with the surveys, we noted no significant difference. Thus, we do not interpret the increasing age as a bias in the survey, but as a trend in demography of backcountry users.

30-year old respondents were the most frequent in both surveys, but in the 2014 survey a second peak showed the about 50-year old people (Fig. 3). Interestingly, the peak of accidents switched from the 30-year-olds in the 1994-2003 period to the 50-year-olds in the 2004-2013 period. This change was found for backcountry touring, but not for out-of-bounds skiing (even when most of the freeriders in our survey are backcountry skiers as well). The risk of being caught by an avalanche increases with the duration of the exposure. Thus, we weighted the participants with their number of backcountry touring days and calculated the weighted age ratio. The result was an even more pronounced peak for the about 50-year-olds (Fig. 3, bottom).

Comparing surveys and accidents, we found two groups more frequently present in the accident database than in the survey: the about 50-year old backcountry tourers and young freeriders.

It remains unknown, if these groups take a higher risk or if they responded less to the survey. Either way, a special effort is needed to better address them.

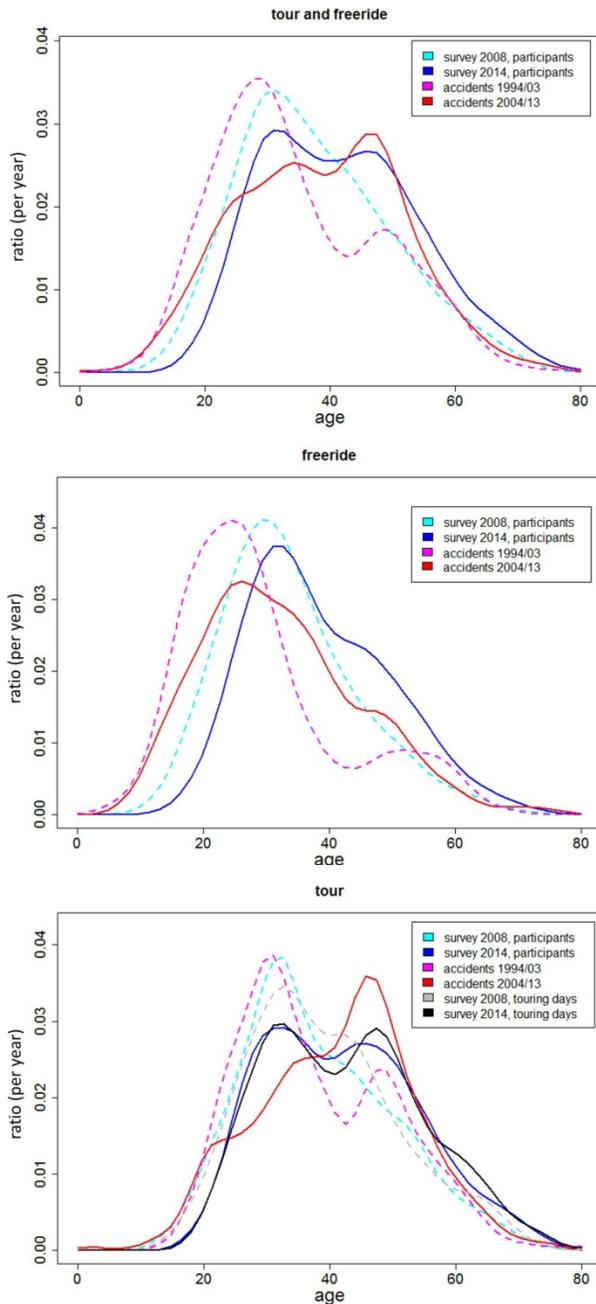


Fig. 3: Age of people caught by avalanches and age of the survey participants. Top: freeride and touring; centre: freeride (note that most of the freeriders are backcountry tourers as well); bottom: touring and touring weighted by days of activity.

#### 4.4 Language

The proportion of the different languages within snow sport participants in Switzerland is unknown. Thus, we compared the languages of the participants with Switzerland's resident population (Fig.

4). French and Italian participants were strongly underrepresented in the 2008 survey. Their significant increase in the 2014 survey can be seen as a direct consequence of the new avalanche bulletin being released now consistently in all four languages. German still remains slightly overrepresented, but this might also be caused by foreign tourists or by a different touring-ratio in the different language-groups.

Participants in the 2014 survey and visitors of the avalanche warning site 2013-2014 showed no bias between the languages.

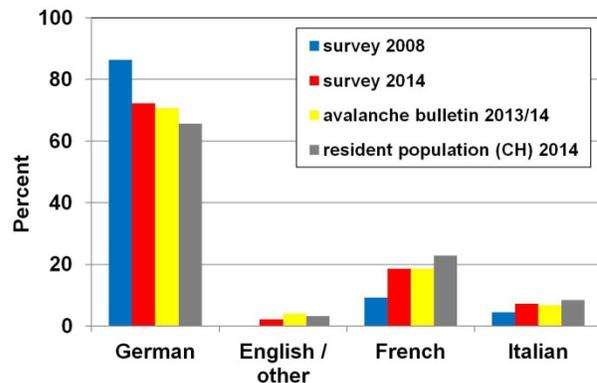


Fig. 4: Proportion of the different languages in the surveys, for the requests of the avalanche bulletin (web only) and for the resident population of Switzerland. English was not available in the 2008 survey.

## 5. USER'S RATING

### 5.1 Knowledge of bulletin content

Users rated their knowledge about the current avalanche warning exactly in the order of the information pyramid. Their knowledge concerning the danger degree and the most critical aspects and elevations has significantly increased (1<sup>st</sup> and 2<sup>nd</sup> level of pyramid) since the re-launch of the Swiss avalanche bulletin (Fig. 5).

The introduction of danger patterns was clearly seen as an improvement (39% "much better" and 39% "a little better"). Users ranked them on place three, corresponding to their place in the information pyramid. Even though the danger patterns were introduced in the bulletin only two winters ago, they were already significantly better known than the previously used slope type ( $p < 0.001$ ).

The danger description (4<sup>th</sup> level of our pyramid) was equally well known as before. Snow cover and weather (5<sup>th</sup> level), now presented in a more structured way, was significantly better known

( $p < 0.001$ ), but still did not reach the state of knowledge of the information provided at the higher levels of the pyramid.

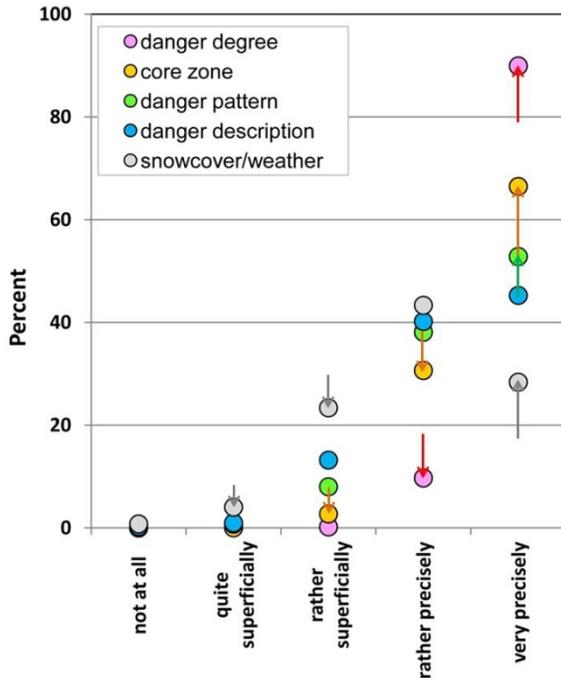


Fig. 5: Answers in the 2014 survey to: "If you venture on your own responsibility into outlying terrain away from secured ski runs, how precisely do you know the details from the avalanche bulletin ordinarily?" Differences (to 2008) were indicated with arrows when greater than 4% (all of them are significant).

### 5.2 How important is the avalanche bulletin?

More than 80% of the participants rated the avalanche bulletin as very important for themselves (Fig. 6). The morning edition (8 am, an earlier edition is not possible due to lack of field-observations) was more important for freeriders than for backcountry tourers (mean value 3.9 and 3.7, respectively,  $p < 0.001$ ) and contrarily for the evening edition (5 pm; 4.58 for freeriders and 4.65 for tourers,  $p = 0.002$ ). More pronounced and independent of activity was that users strongly favoured the evening edition (mean value 4.63) over the morning edition (mean value 3.69,  $p < 0.001$ ).

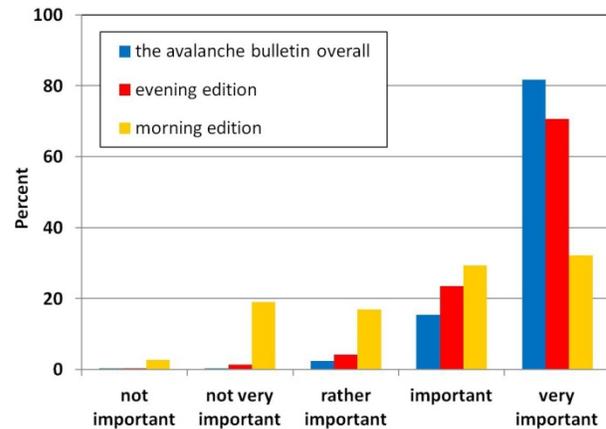


Fig. 6: Answers to: "How important is the avalanche bulletin to you?"

### 5.3 Forecasting accuracy

The forecasting accuracy was assessed with the question "How much do you personally appreciate the avalanche bulletin forecasting precision?" In the 2014 survey, the forecasting accuracy was rated with a mean value of 83.2%, which is slightly but significantly higher than in the 2008 survey (82.6%,  $p = 0.04$ ). As it was not defined, what the "forecasting accuracy" really means, and as the real regional avalanche danger generally remains unknown even in hindsight, the absolute number should be interpreted more as a level of confidence than an exact forecasting accuracy. Interesting are differences between user groups (2014 survey):

- We could not find any influence on age, but women rated the accuracy higher than men (84.3% to 83.0%,  $p = 0.001$ ) and Italian speaking participants higher than other participants (85.0% to 83.1%,  $p = 0.01$ ).
- Mountain guides rated the accuracy in both surveys lower than the others (81.0% to 83.4%,  $p = 0.01$ ).
- Considering the seven main climate regions of the Swiss Alps, we noted no geographical differences.

### 5.4 Evaluation of the avalanche danger

The question "If in your opinion the avalanche bulletin is not right, do you then think the situation is usually..." gives insight into regional discrepancies in the use of the danger degree by the avalanche service, but also on differences in the rating between different user groups.

The overall rating was very similar in the two surveys (Fig. 7). After excluding "I don't know", 50.1%

(2008: 50.2%) of the participants considered the differences being symmetrical (the bulletin being equally often too high and too low). The other half of the participants saw a systematic offset, thereof 63.5% towards a less dangerous situation than forecasted. This value did not differ significantly from the 2008 survey (61.6%), nor with gender nor age, but we found anomalies between different regions and user groups (Tab. 1):

- Compared to the other regions, users rated the avalanche danger in the inner-Alpine regions significantly more often more dangerous than indicated in the avalanche bulletin. The snowpack structure in the inner-Alpine regions (cantons Valais and Grisons) with their more continental climate is usually more unfavourable than on the northern and southern flanks of the Alps (Techel et al., 2014). Other regional differences were not significant.
- French speaking participants were the only group with a majority rating the danger to be more often more dangerous than indicated.
- Mountain guides, winter tour guides and (very) experienced participants rated the avalanche danger in both surveys significantly lower than other participants.
- Participants who undertake backcountry tours rated the danger lower ( $p < 0.001$ ). This may be linked to their greater experience in the assessment of the avalanche danger. In contrast, snowshoe hikers are often less experienced and rated the real danger higher than the other participants ( $p < 0.001$ ).

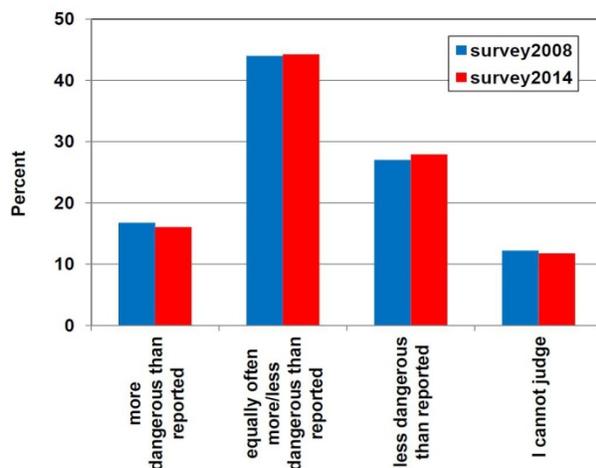


Fig. 7: Answers to: "If in your opinion the avalanche bulletin is not right, do you then think the situation is usually..."

Tab. 1: Answers to the question above (see Fig. 7). Values show the ratio "more dangerous than forecasted" to "less dangerous than forecasted". The mean value is also given ("all participants"). Shown are all user groups with significant differences to the rest of the participants in the 2014 survey, \* also had significant differences in the 2008 survey too. Groups who rated the danger lower are highlighted green, the others red.

user group	all others	p
all participants	0.58	
inner-Alpine regions	0.68	0.01
French speaking	1.26	<0.001*
mountain guides	0.31	0.02*
winter tour leaders	0.38	<0.001*
experience (very) high	0.44	0.01*
backcountry tours	0.56	0.03*
snowshoes	0.93	0.02*

### 5.5 Satisfaction with the new bulletin

The absolute ratings as well as the comparison with the old bulletin (Fig. 8) showed users were satisfied with the new product. It is notable that the information content is rated significantly better too.

Special attention was given to the translation of the danger description, now carried out automatically with a catalogue of phrases and published without any proof-reading or manual corrections. Winkler et al. (2014) compared the language quality of danger descriptions originating from the new bulletin with those from old bulletins (translated by professional translators). We asked the users to rate the language quality for the text in the "snow-cover and weather" section (which is still manually written and translated) as well as in the danger description (originating from our catalogue of pre-defined phrases and automatically translated). The danger descriptions were rated better than the text in the snow cover and weather section. However, the differences were only significant in German (which is the original language of the catalogue and the manually written text), and with all answers from all languages pooled together (mean value 4.44 for the danger descriptions and 4.38 for "snow cover and weather",  $p < 0.001$ ).

Comparing the individual languages against all the other languages, users rated German texts comparatively better and French texts worse. Interestingly, this was the case in both languages for both types of text (mean values: 4.47 (German) against 4.36 (French) for the danger description; 4.40

(German) against 4.31 (French) for "snow cover and weather", all  $p < 0.02$ ).

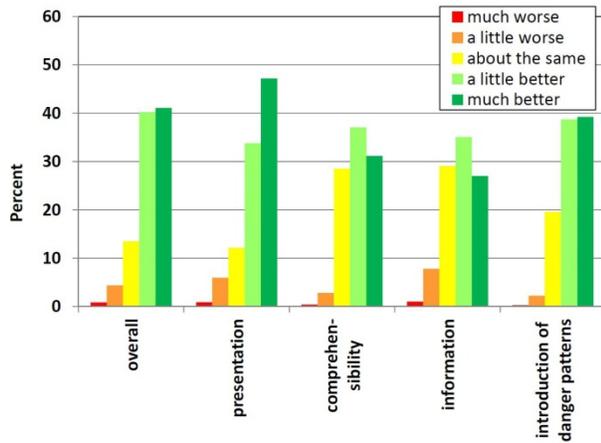


Fig. 8: Answers to the question: "How do you judge the "new" avalanche bulletin compared to the "old" one?"

## 6. SUMMARY AND CONCLUSIONS

Two surveys – before and after the renewal of the avalanche bulletin – showed that it is possible to improve an avalanche bulletin without having neither more information nor more knowledge or better analyzing tools. We significantly raised the user's satisfaction and the user's knowledge by making our (limited) knowledge better accessible. With the new bulletin structure following the information pyramid, particularly the knowledge about the three top pyramid levels (danger degree, danger location and danger patterns) has increased.

Survey participants declared to know the danger degree so well that no substantial increase seems possible any more (90% "very precisely" and 9.7% "rather precisely"). As participants of the survey were visitors of the avalanche bulletin website, and as a self-declaration is not always correct, it would be interesting to test backcountry users' knowledge out in the field. In such a study in South Tyrol, Italy, in 73% of the cases at least one person in the group had read the avalanche bulletin, but only 2/3 of them reported the danger level correctly (Procter et al., 2013).

The huge majority of participants in our surveys were backcountry tourers, and about half of them were freeriders too. Mere freeriders were practically inexistent in the survey and therefore presumably on the avalanche warning website too. Reaching them could be a major enhancement of the impact of the avalanche warning. Avalanche bulletins focus on the conditions in the backcountry and not on frequently skied out-of-bounds

slopes. Also, we note a lack of knowledge about avalanche release in frequently skied out-of-bounds terrain or on heavily frequented backcountry tours. Issuing a bulletin specifically addressing freeriders might improve the use of the bulletin by freeriders.

Participants in the 2014 survey spent more days out in the snow than six years ago. The about 50-year-olds were in 2014 the most active backcountry tourers, and at the same time also those most frequently caught in avalanches. They, and young freeriders, were more frequently present in the accident database than in the survey. It remains unknown, if these groups take a higher risk or if they visit the avalanche bulletin to a lower extent. Either way, a special effort is recommended to better address these groups.

French and Italian speakers were strongly underrepresented in the first survey. In the second survey, they were much more present and nearly reached the proportion present in the population. It seems obvious, that this has been achieved by all avalanche warnings being now strictly edited in four languages.

A perfectly balanced forecast would have the same proportion of users estimating the real danger to be under- as overestimated. For our bulletin, half of the participants considered the differences being symmetrical. The other half of participants saw a systematic offset, with 63.5% towards a bulletin being too often too high. As avalanche bulletins contain life-critical warnings, an underestimation of the danger may be dangerous. Thus, a slight bias toward an overestimation of the danger seems less evil than a systematic underestimation. The ratio of participants considering the danger to be more often over- than underestimated varied with region and user group:

- Survey participants rated the avalanche bulletin to underestimate the danger more often in the inner-Alpine regions in Valais and Grisons (having a more continental climate). Although backcountry skiers seem to adapt their behaviour in these regions with a frequently poorer snowpack by selecting easier tours, the proportion of accidents is still comparably higher (Teschel et al., 2014). This suggests that Swiss avalanche forecasters may underestimate the danger originating from a poor snowpack (or overestimate the danger elsewhere), and thus use the danger degrees more restrictively in the inner-Alpine regions.

- French-speaking participants assumed the avalanche danger more often to be underestimated. A more frequent use of the Lower Valais (region with often unfavourable snowpack structure) probably cannot fully explain this difference, thus it should be investigated whether the application and understanding of the avalanche danger degrees is the same in France as in Switzerland.
- The Swiss avalanche bulletin is written in Davos, in the very east of the country. The forecasting accuracy was rated of equal quality in the Davos region as everywhere else. Although a direct insight into avalanche terrain is essential, the forecasters do not need to have it necessarily themselves in all the regions - as long as there is a dense network of reliable observers and automatic stations.
- (Very) experienced participants, mountain guides and volunteer tour leaders rated the avalanche danger significantly lower than other users. Well-trained people are at least as often involved in avalanche accidents as less experienced people (Burtscher and Nachbauer, 1999). It seems as if trained mountaineers compensate their extra skills in evaluating the avalanche danger by taking more freedom of action and in the end have a similar risk.

In our study users clearly favoured the evening edition over the morning edition. Adapted to countries with one bulletin per day this suggests that an issue date in the evening would be preferred. The introduction of danger patterns was clearly seen as an improvement, and they were already well known in the second year of operational use.

In our case, better communicating the avalanche danger has gone along with a large extension in the line of products. Thanks to better editing tools, this was possible without an increase of work load in operational service. Thus, making the limited knowledge better accessible for the users improved the avalanche bulletin in a very efficient way. We showed the new bulletin being better than the old, but how does an optimized avalanche bulletin really look like? In answering this question, we would see a great potential to improve avalanche bulletins around the world.

#### ACKNOWLEDGEMENTS

We thank all the numerous participants of the survey for taking the time to answer our questions

and Nico Grubert and Johann Seiwald for their work on the questionnaire.

#### REFERENCES

- Burkeltja J. 2013: Shifting audience and the visual language of avalanche risk communication. In: Proceedings ISSW 2013. International Snow Science Workshop, Grenoble, France, pp. 415–422. ANENA, IRSTEA, Météo- France
- Burtscher M., Nachbauer W. 1999. The effects of training on the risk of avalanche fatality. In: Skiing trauma and safety, ASTM STP 1345, American Society for Testing and Materials, 12: 45-49
- Crawley M. 2007. The R book, John Wiley and Sons Ltd., 1st Ed., 2007
- EAWS, 2009. Report of results. 15th European Avalanche Warning Services Conference, Innsbruck, 16-17 June 2009
- Harvey S., Rhyner H., Schweizer J. 2012: Lawinenkunde, Bruckmann Verlag GmbH, München
- Jamieson B., Campbell C., Jones A. 2008: Verification of Canadian avalanche bulletins including spatial and temporal scale effects. *Cold Reg. Sci. Technol.*, 51(2): 204-213
- Lamprecht M., Fischer A., Stamm HP. 2008: Sport Schweiz 2008: Das Sportverhalten der Schweizer Bevölkerung. Magglingen: Bundesamt für Sport BASPO.
- Procter E., Strapazon G., Dal Cappello T., Castlunger L., Staffler HP., Brugger H. 2013: Adherence of backcountry winter recreationists to avalanche prevention and safety practices in northern Italy. *Scand J Med Sci Sports*. doi: 10.1111/sms.12094
- Ruesch M., Egloff A., Gerber M., Weiss G., Winkler K. 2013: The software behind the interactive display of the Swiss avalanche bulletin. In: Proceedings ISSW 2013. International Snow Science Workshop, Grenoble, France, pp. 406–412. ANENA, IRSTEA, Météo- France
- Schweizer J., Kronholm K., Wiesinger T. 2003: Verification of regional snowpack stability and avalanche danger. *Cold Reg. Sci. Technol.*, 37(3): 277-288.
- Semmel C., Hellberg F., Schwiersch M., Gebhardt M., v.Rützen A., Wiedemann P., Mair P. 2009: Risikokommunikation anhand des Lawinenlageberichtes. Endbericht und Untersuchungsdokumentation, Projekt AC 2.1: Sicherheitsforschung im alpinen Raum
- Techel F., Zweifel B., Winkler K. 2014 (submitted). Avalanche risk in backcountry terrain based on usage frequency and accident data. *Nat. Hazards Earth Syst. Sci.*
- Winkler K., Bächtold M., Gallorini S., Niederer U., Stucki T., Pielmeier C., Darms G., Dürr L., Techel F., Zweifel B. 2013: Swiss avalanche bulletin: automated translation with a catalogue of phrases. In: Proceedings ISSW 2013. International Snow Science Workshop, Grenoble, France, pp. 437–441. ANENA, IRSTEA, Météo-France
- Winkler K., Kuhn T., Volk M. 2014: Evaluating the fully automatic multi-language translation of the Swiss avalanche bulletin. In: B. Davis et al. (Eds.): CNL 2014, LNAI 8625, pp. 44–54, 2014.
- Zweifel B., Techel F., Björk C. 2012: Who is involved in avalanche accidents? In: Proceedings ISSW 2012. International Snow Science Workshop, Anchorage, USA, pp. 234–239.