

A new concept for avalanche warning in Switzerland

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ABSTRACT

During the past 60 years the Swiss Federal Institut for Snow and Avalanche Research (SLF), which is in charge of the avalanche warning in Switzerland issued national avalanche bulletins three to four times a week at around 9 a.m. Due to technical reasons, these bulletins could not be compiled earlier and only contained information on the current snow, weather and avalanche hazard conditions i.e. they did not contain any forecast. Especially for ski-mountaineers, off-piste skiers or climbers the bulletins were issued too late. Progress in meteorology, snow and avalanche research as well as new developments in sensor, communication and information technology make it now possible to continuously gather and process information about the snow and weather situation and to assess the avalanche hazard risk more accurately. Therefore, the SLF has started a number of projects to improve the avalanche service in Switzerland over the next few years. For the winter 97/98 the SLF has already introduced a number of new features. Firstly, the avalanche bulletin is now being issued daily at 5 p.m. and contains a forecast for the following day as well as an outlook for the nex few days. Secondly, the SLF introduced regional avalanche bulletins, covering areas of about 1000 - 5000 km². The regional bulletinst are issued daily at 7 a.m. and give more detailed information than the national forecast. Thirdly, the SLF is setting up a network of remote snow and weather stations which are connected to a snow and avalanche information system linking up local, regional and the national avalanche centres. The infomation system allows to access and exchange information between all the people who are involved in avalanche safety in Switzerland.

1 INTRODUCTION

For more than 60 years the Swiss Federal Institute for Snow and Avalanche Research (SLF) is responsible for avalanche warning in Switzerland (Meister, 1994) during winter time. The information about snowcover characteristics, snow conditions and hazard levels is distributed among the public by avalanche bulletins or by personal advice given on the phone.

During the past decades, an increasing amount of people has undertaken backcountry activities. Additionally, since winter 1950/51, the Swiss government and the Swiss communities have made big efforts to protect villages, main roads and railway lines by permanent protective structures, avalanche hazard mapping, early artificial release by explosives and improved avalanche warning (Tschirky, 1997). Therefore a clear trend in the reason for avalanche fatalities can be observed: The number in settled areas or on roads has decreased while the number of avalanche victims in the backcountry has increased. Accordingly to this evolution the group of main customers has changed from members of avalanche protection services and of avalanche commissions, that are responsible for the safety of

infrastructures, to mountain guides, ski instructors, ski tourers, mountaineers, off piste skiers and snowboarders.

Taking this change into account but not forgetting severe storm conditions with critical situations for villages and having a new technical infrastructure, the avalanche warning service aspires denser information and wants to inform people more on time. Other European countries have reacted to these changes as well as can be seen in several comments in the protocol of the 8th European meeting of avalanche services (Mair, 1997).

2 AVALANCHE WARNING IN SWITZERLAND 2000

In 1996 SLF has started the project "avalanche warning CH-2000" in order to improve avalanche warning in Switzerland on a local, regional and national scale (Russi and Stucki, 1996). The main goal of the project is the improvement of the forecasting resolution in time and space and thus the quality of avalanche bulletins.

For this purpose four complementary subprojects have been launched: Project IMIS (Intercantonal measuring and information system) focuses at the construction of a network of automatic weather stations delivering data about the weather and snowcover around the clock. In addition to

national, regional & local level

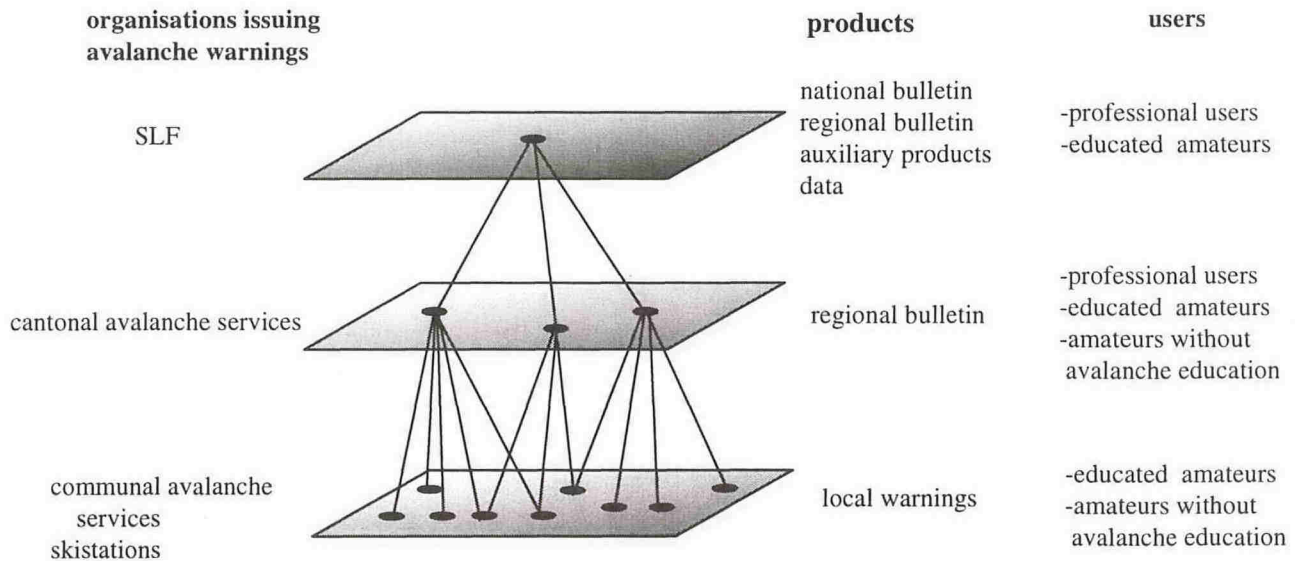


Figure 1: Avalanche warning on a national, regional and local scale.

the weather stations, local, regional and national centres for avalanche warning are established and equipped with software and hardware. To collect, archive and distribute the data a relational snowdatabase (RSDB) is constructed within the second project: "snow and avalanche database". Complementary to the construction of the database a visualization tool is built to show the data in different ways (mainly time series and maps). The third project "forecasting models" aims at supporting the avalanche expert through forecasting tools: a snowpack model (Lehning et al., 1998), local models and regional judgement models are distinguished. Project "Info-Service" is devoted to the dissemination of avalanche relevant information by electronic means. In a first step a software package called InfoBOX has been developed which allows to download and display all SLF-products and data from automatic stations and observers to local centres. In the future more and more information will be distributed via Internet.

Figure 1 shows how different users (ski tourists, cantonal and communal avalanche warning services) of SLF-products are supported by different products devoted to the local, regional and national level. SLF aims at doing avalanche warning on a national (national bulletin) and regional scale (regional bulletin). The local level is supported by a concept for information exchange with the national and regional level and by software, hardware and courses offered by SLF. NXD (Buser, 1989) and InfoBOX (Zimmerli et al., 1997) are two examples of software for local avalanche centres.

The four projects have already lead to practical consequences at the beginning of winter 1997/98. The Swiss national avalanche bulletin has become a forecast product which is constructed daily at 5 p.m.. One regional bulletin is disseminated in the morning at 7 a.m. for Nord- and Mittelbünden. The software InfoBOX has been installed in about 100 locations in Switzerland and 37 new automatic stations built. Data for InfoBOX is retrieved from

the RSDB and data of automatic stations is augmented by modelled data (new snow height, dew point temperature difference and an index for surface hoar).

3 THE NATIONAL AVALANCHE BULLETIN

Until the winter 96/97 the national avalanche bulletin was prepared three or four times a week and published at about 9 a.m. The content of these bulletins was a report of the actual snow and avalanche situation for the current day. Since the beginning of the winter 97/98 the national avalanche bulletins have been issued daily at 5 p.m. (the translations in French and Italian at 6.30 p.m.). In contrast to the bulletins in the past, the new national avalanche bulletin contains a forecast of the avalanche hazard for the next day. Even though these forecasts are associated with an uncertainty, it is a big advantage for e.g. a ski tourist to plan a tour on the basis of a bulletin issued at 5 p.m. with validity for the next day than on the basis of a bulletin issued at 9 a.m. with validity for the current day. Because in winter 97/98 only one regional avalanche bulletin for Nord- and Mittelbünden existed, the avalanche warning service decided to issue a correction of the national avalanche bulletin in the morning, if the avalanche hazard level was underestimated.

The users of the bulletin are multifaceted and include mainly people with a profession in the wintery mountains (mountain guides, ski instructors, rescue services, avalanche protection services) and people spending their free time apart from ski slopes (ski tourists, mountaineers, off piste skiers, snowboarders). For the avalanche protection services data from automatic stations and the stations operated by observers are also available (see figure 1). Especially for off piste skiers and snowboarders the regional avalanche bulletins are issued in the early morning (see figures 1 and 4).

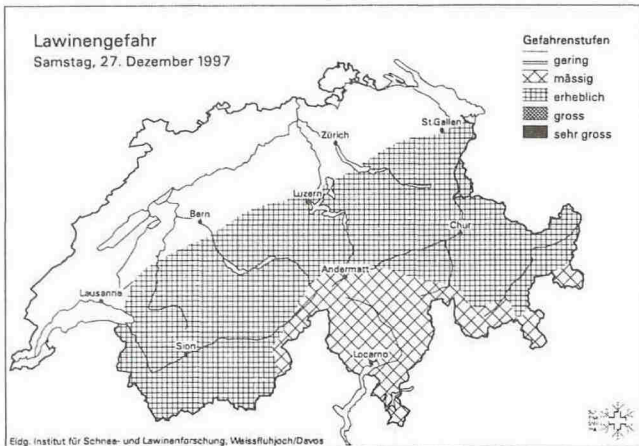


Figure 2: Swisswide hazard map of the forecast for December 27th 1997

The approved systematic structure of the national avalanche bulletin was maintained (Meister, 1994). Because of the new publishing time some adaptations were made. The avalanche bulletin consists now of the headline, a short text and the four subsequent paragraphs: General, Short Term Evolution, Forecast of the hazard levels, Trends.

The "Headline" contains the logo and name of the institute, a product description, a serial number and the date of redaction.

The "short text (flash)" consists of a few key words outlining the most important elements of the avalanche bulletin. Usually the region with the highest hazard level is mentioned here.

In the "General" paragraph the user can find information about the main weather evolution - especially the evolution of wind and temperatures - within the last 24 hours, amounts of new snow in different regions and snow cover conditions in a qualitative (structure, layering, solidity) and quantitative (snow cover thickness at 1500 or 2000m sea level, comparison with the average annual conditions) manner. The actual situation determines which information is given.

"Short Term Evolution" contains the main weather

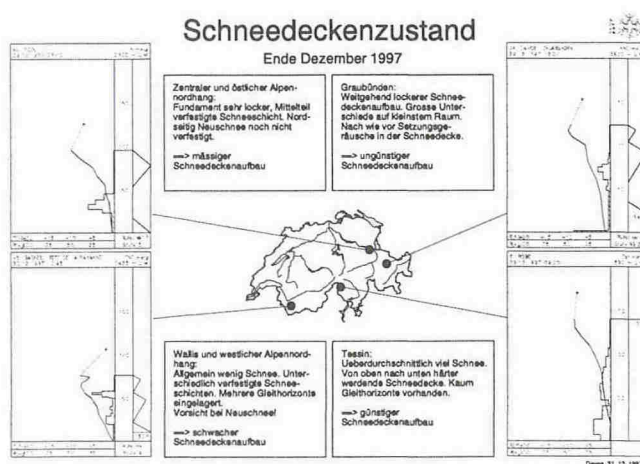


Figure 3: Map of snow cover conditions for the end of December 1997

evolution that is important for the forecasted avalanche danger. Normally it contains forecasts of precipitation, temperature and wind. The consequence for the evolution of the hazard level is given and can be seen as a transition to the following paragraph.

The paragraph "Forecast of the Hazard Levels" is the central part in the avalanche bulletin. The hazard level is described for the next day by using one of the five hazard levels of the European Avalanche Hazard Scale (Meister, 1994). Switzerland is divided into different climatological regions. Regions with the same hazard level are united. The regions with the highest hazard level are mentioned first and for each hazard level the particularly critical altitudes, sections of terrain and slope exposures and any points to be noted in particular for various user groups are pointed out. At the end of this paragraph additional information is given if necessary. For example the user can find here a reference to possible wet snow avalanches or a short explanation of the hazard level used in the bulletin.

The last paragraph describes in short terms the expected evolution of the weather and avalanche hazard for the following two days.

In addition to the national avalanche bulletin the avalanche warning service offers some auxiliary products to the public:

- an avalanche hazard map (see figure 2)
- map of snow cover thickness
- map of new snow amounts
- map of snow cover conditions (see figure 3).

4 THE REGIONAL AVALANCHE BULLETIN

Regional avalanche bulletins complement the national bulletin in time, space and users. They are published every day at 7 a.m. describing the situation of the avalanche hazard in the morning and give a forecast for the current day. As the product concentrates on a region of an area of about 5000 km² the avalanche hazard can be described more precisely than in the national bulletin and is shown on a hazard map (see figure 4), using the same symbols as for the national hazard map (see figure 2). This map, extended by graphs which point out the most critical terrain parts, is the heart of the product. The Flash, a textual abstract, weather information and current data from automatic stations are further contents of the bulletin. The structure of the document has been devoted to easy understandability in order to be able to communicate avalanche danger also to tourists that do not have a high standard of avalanche education. But still the consumer has to know what the five levels of the avalanche hazard scale mean and how to apply them in the field for making a yes/no decision. Optimally the bulletin should be present at any ski lift, cable car and tourist offices.

During the winter 1996/97 a regional bulletin for Nord- and Mittelbünden has been tested and given to avalanche experts in the region for a local verification. This local control has shown agreement in 91% of the 121 bulletins (Brabec et al., 1997). For the winter 1997/98 this regional bulletin has become operational and is published daily via Fax and Internet and is now tested in practice.

For the area around Gotthard a test has begun at the beginning of winter 1997/98. Gotthard is one of the most interesting areas for avalanche warning in Switzerland because it is positioned in the centre of the Swiss Alps around Andermatt (see figure 2). Therefore weather influences from all directions have to be taken into account. Its size is about 1000 km². In addition to the evaluation of the bulletin during the day regional experts are also involved in the bulletin construction process. A draft of the bulletin is sent to them by fax and has to be returned within 20 minutes. This feedback is then directly incorporated into the final version of the bulletin. For the second half of the winter no suggestion is given to them but an empty form containing only weather information and data from automatic stations. At the end of the winter an evaluation of these two methods of co-operation will take place and decided how to proceed in the future for further regions.

5 DATA BASIS

To make up avalanche bulletins data have to be collected first all over the country. This concerns meteorological and nivological parameters, field tests to check the snow cover stability, observations of snow cover characteristics, avalanches and accidents. Meister (1994) describes the Snow and Avalanche Information System, which the avalanche bulletins are based on, in detail. Since 1994 different innovations have been introduced which made it possible to carry out the new concept of avalanche warning. Further innovations have to be introduced to complete the information needed. This chapter discusses the progress that has been made in datacollection.

Since the new national avalanche bulletin is a forecast, weather information is more important than before. Different precipitation, wind, temperature and more forecasts are available from the SMA MeteoSwiss and the

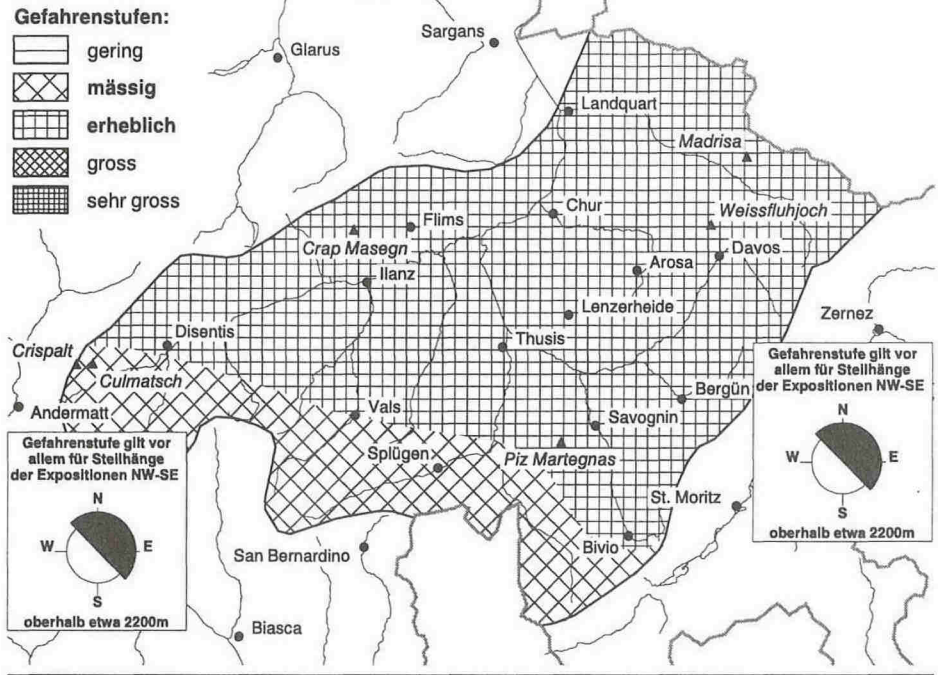
Regionales Lawinenbulletin für Nord- und Mittelbünden

Bulletin Nr. 027 - Samstag, 27. Dezember 1997 - 07:00 h (gültig für 24 h)



Weiterhin erhebliche Schneebrettgefahr nördlich des Alpenhauptkammes

Mit kräftigen Westwinden sind in kammnahen Hanglagen neue Triebsschneeeansammlungen entstanden. Trotz einer vielerorts tragfähigen Schicht innerhalb der Schneedecke ist das Fundament verbreitet noch locker und schwach. Deshalb ist auf Varianten und Skitouren eine umsichtige Spurenanlage wichtig.



Tendenz Lawinengefahr: **Wetter, Wind, Lufttemperatur heute Mittag auf 2000 müM.:** **mässiger Wind aus W** **-4 °C**

(Quelle: SMA)

Bis Sonntag keine nennenswerten Niederschläge mehr. Aufhellungen. Während oberflächennah eine Verfestigung der Schneedecke zu erwarten ist, bleibt das Schneedeckenfundament weiterhin schwach.

Aktuelle Schnee- und Wetterdaten von heute (06:00 h):

Schneestation	Schneehöhe	Neuschnee 24h	Schneestation	Schneehöhe	Neuschnee 24h
Madrisa 2140m	94 cm	ca. 10 cm	Culmatsch 2270m	72 cm	0 cm
Weissfluhjoch 2540m	119 cm	ca. 10 cm	Porta d'Es-cha 2725m	121 cm	ca. 5 cm
Crap Masegn 2330m	110 cm	ca. 5 cm	Piz Martegnas 2430m	53 cm	ca. 10 cm

Windstation	Lufttemperatur	Temperaturänderung 24h	Windrichtung	Windstärke	Böen 24h
Weissfluhjoch 2693m	-11 °C	-8 °C	NW	37 km/h	71 km/h
Crispalt 3028m	-12 °C	-4 °C	NW	21 km/h	65 km/h
Piz Martegnas 2670m	-10 °C	-6 °C	W	19 km/h	81 km/h

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Figure 4: Regional avalanche bulletin NR 027 of winter 1997/98 for Nord- and Mittelbünden

German Weather Service (DWD). Model output is directly received and interpreted.

Now as before the basis for avalanche warning are the data from the conventional stations operated by observers. Today 80 stations are dispersed all over the Swiss Alps between 1000 and 2500 m asl. Since the beginning of the winter 1997/98 about 50 stations have been measuring twice a day. First between 7 a.m. and 8 a.m. (normal daily measurement) and second between 12 a.m. and 14 p.m. For the second observation only the amount of new snow, the snow cover thickness, observed avalanches during the morning and his own judgement of avalanche hazard are determined. This second measurement was introduced to have additional and current information for preparing the national avalanche bulletin at 5 p.m.

For two years a new network of automatic stations has been established. Nowadays the data of 37 new stations are available. Provided with solar energy these IMIS stations are autonomous and can hence be positioned everywhere. In fact, these stations are built for local avalanche warning and have to contribute to solving a local problem, but the measurements from most of them are also usable for the national avalanche warning service. These automatic stations are positioned between about 2000 and 3200 m asl and lead to a further horizontal and vertical condensation of the network. A further advantage of such stations is the hourly availability of data.

6 VERIFICATION

Verification of hazard levels is an important task to check the quality of avalanche bulletins and to learn how to improve avalanche warning. In Switzerland it is made by means of questionnaires, that are delivered from users of avalanche bulletins. In winter 1996/97 a new set of four questionnaires has been introduced to report observations concerning snow properties, avalanches and accidents and to announce a personal evaluation of avalanche hazard (Stucki, 1996; Stucki and Brabec, 1997). This additional information from mountain guides and skitourers gives an impression of the people's personal observations in the field and is included in the bulletin. How this feedback is evaluated is shown in Brabec and Stucki (1998). The overall estimation shows that in winter 1996/97 about 64% of the feedback was in agreement with the bulletin, 32% differed by 1 degree of hazard and 4% by 2. The symmetric distribution of differences indicates that the degree of hazard was neither systematically over- nor underestimated.

7 FURTHER WORK TO BE DONE

One of the present jobs is to continue the development of regional avalanche bulletins. In this context the question of how to work together with local decision makers has to be answered. By offering additional regional avalanche bulletins the complementarity of the national and regional avalanche bulletins will be improved: The general and forecasted information in the national avalanche bulletin can then, in the morning and for the different regions, be refined and precisioned or also corrected if necessary. For the winter 1998/99 an extension of the regional bulletin area to Wallis is planned which will be the final test for regionalization in Switzerland. Where regional centres will be built up is still an open question which will mostly depend on the interest and the financial engagement of the Swiss cantons.

For the members of the avalanche warning service further developments of computer based tools is important for a fast and efficient use of the available data. Also operations to generate the bulletins are being simplified.

Simultaneously to a further evolution of avalanche warning products the education of the different users is also very important.

8 CONCLUSIONS

In the winter 1997/98 about 180 new national and 120 regional avalanche bulletins have been issued and first experiences could be gathered. As could be expected the forecasted precipitation amounts are one of the major uncertainties to predict avalanche hazard. Normally these forecasts overestimated the real amount of new snow. Therefore the predicted avalanche hazard levels did not underestimate the real hazard levels and for the national avalanche bulletins no corrections in the morning had to be made. The estimated uncertainties could be described in the text and communicated to the users. For the region of Nord- and Mittelbünden a new actual judgement could be published in the morning. In fact, there were only a few days with a lower avalanche hazard level in the regional than in the national avalanche bulletin.

The tests with the regional avalanche bulletins are a good opportunity to improve the co-operation with local avalanche services and to intensify communication.

Although not yet systematically evaluated, the feedback of users is widely positive. That is why the new concept for avalanche warning in Switzerland is effective and new improvements help to prevent avalanche accidents.

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