COUNTRY-WIDE AVALANCHE WARNING IN SWITZERLAND

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ABSTRACT

The method of avalanche warning in Switzerland is described. It is the duty of the Swiss Institute for Snow and Avalanche Research not only to carry out research work, but also to give ongoing avalanche warnings. For this purpose, Avalanche Bulletins, covering the whole Swiss alpine area have been published during the past fifty years.
In this context, the European Avalanche Hazard Scale has been in use since 1993. This five-part scale is described here in detail.
It has been shown that above all, younger skiers are not aware of the danger posed by avalanches. More public relations work must therefore be carried out both through courses and in the media. Those in charge of the protection services in mountain regions are also appreciative of precise interpretations of the hazard scale.
Verification of avalanche hazard using questionnaires and analysis of avalanche accidents serves to improve avalanche warning.

INTRODUCTION

In Switzerland, avalanche warning has been based for more than 50 years on the recommendations made by the Swiss Institute for Snow and Avalanche Research in Davos. The most best-known means by which information is communicated to the public is the Avalanche Bulletin, issued in the winter months. In addition, personal advice is also given on the telephone. As for what action to take in view of the hazard assessment, the users themselves are largely responsible; the recommendations of the Institute only represent support of a general nature.

The Swiss Avalanche Bulletin gives brief information regarding snow conditions in the Swiss Alps. It describes both the degree of current regional avalanche hazard, and that anticipated in the immediate future, using a hazard level. The consistent structure and the standardized terms used are intended to assist the user in making decisions in situations involving possible avalanche hazard.
The Avalanche Bulletin is intended to make a contribution to reducing winter accidents in the mountains.

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It is aimed at all those who are exposed to possible avalanche hazard under winter conditions in the mountains, either in their leisure time or due to their profession. This includes skiers and snowboarders, cross-country skiers, mountain guides, ski instructors, ski tour leaders, members of the army, members of the avalanche protection services, those in charge of community avalanche services and avalanche commissions, members of the police and rescue services, as well as the inhabitants of mountain villages.

AVALANCHE HAZARD VERSUS RISK

Definition of avalanche hazard

"Hazard" very generally means a dangerous process which may potentially occur, such as, for example, an earthquake, a tidal wave, a mud slide, or specifically an avalanche. This hazard, this dangerous process, is described by the probability of occurrence and the expected extent of the event. The term "hazard" says nothing as to whether the process in particular will really occur and whether in an individual instance it will actually lead to injury to people or damage to property. The actual occurrence of damage depends on whether, at the time of the dangerous process taking place, people and/or property are situated in the area which it affects (here: in the path of the avalanche). In relation to avalanche hazard, the following definition may be used: the term "avalanche hazard" describes the probability of occurrence and the possible extent of avalanches in a particular region, whereby the precise time of triggering and the areas the avalanche will affect are determined by chance.

The term "risk", i.e. the potential damage, presumes on the one hand a hazard, and on the other hand also objects which are potentially at risk. Although in the Avalanche Bulletin, the avalanche hazard and not the avalanche risk are described, the difference, briefly, is as follows. If an avalanche takes places in a remote, unforested mountain valley where there are no people or property, there is certainly an avalanche hazard, but no avalanche risk in this location. If, however, this avalanche penetrates into a populated mountain valley, thus endangering lives and property, in addition to the avalanche hazard, there could also in this case, under certain circumstances, be a significant avalanche risk.

"Avalanche hazard" basically means the possibility of an avalanche occurring which at worst may cause damage. The potential process is at the focus; whether, and to what extent, a risk exists, depends on the localities and the conduct of the people concerned.

Outline of avalanche hazard levels

The extent of the avalanche hazard depends on several factors, as follows:

- On the probability of it being triggered, which depends on the natural stability of the snow cover and which can be increased by the impact of human beings (skiers, detonations, etc.). The probability of triggering (and thus the avalanche hazard) is low if the snow cover stability is high. Conversely, the possibility of triggering is high if the snow cover stability is low.
- On the surface distribution, and the frequency of dangerous slope areas.
- On the size and type of the anticipated avalanches.

- On the force of the layers of snow which are subject to movement (avalanche volume) and the thickness thereof.

In assessing avalanche hazard, the probability of an avalanche being triggered, i.e. the probability of a potential dangerous process occurring, and the expected extent thereof, must be given due consideration. A large number of wet snow slides with a low starting height from a rocky south-facing slope could, under certain circumstances, represent a smaller hazard than one large single dry slab avalanche with an initial size of one meter.

Moreover, a determining peculiarity arises; other than in the case, for instance, of tidal waves or landslides, the "dangerous process" of the avalanche can be initiated by human influence. If someone enters upon a dangerous slope, the existing natural potential for the avalanche to descend may be considerably increased by this additional stress. In this case, of course, the avalanche risk is no longer nil (80 per cent of skiers who ended up buried alive have triggered the avalanche of surface snow themselves).

THE EUROPEAN AVALANCHE HAZARD SCALE

Principles

In April 1993, the avalanche warning services of the alpine nations came to an agreement on a uniform European Avalanche Hazard Scale. Since this time, the target public in all countries can rely on the same warning levels, which represents a huge advantage for ski tours in other countries. There were some difficulties at the beginning, above all in interpreting the content of the avalanche hazard levels in various languages (German, French, Italian, Spanish, English); after one winter with experience in daily use, in May 1994 further minor changes were made to individual hazard levels in the various languages, so that also by way of analogy, and taking account of the varying nuances of language, a satisfactory solution has been found.

The standard European Avalanche Hazard Scale has five progressively increasing hazard levels: low - moderate - considerable - high - very high. These hazard levels are defined by the snow cover stability and the probability of an avalanche being triggered.

The "**snow cover stability**" means the ratio between the srength/resistance of the snow cover and the pressures to which it is exposed. Since the snow cover is not an unchanging medium and is exposed to a whole variety of weather conditions during the course of one winter, and since the ratio of solidity to pressure can vary enormously in the various layers of snow or at different places (e.g. at various altitudes or various slope exposures), the snow cover stability forms the essential basis in accounts of avalanche hazard, although directly, it can only be measured at great expense and at individual points in the terrain. One therefore has to rely on indirect methods for estimating snow cover stability, e.g. on measurements in test fields or on snow profile records with Rutschblock tests.

The "**probability of an avalanche being triggered**" is a statistical measure which is directly dependent on the snow cover stability. In the European Avalanche Hazard Scale, the

individual hazard levels are described in more detail with the corresponding probabilities of an avalanche being triggered. In this connection, an indication is given both of the state without external influence (for spontaneous avalanche descents), and of the extent of probability of an avalanche being triggered in the event of additional stress (by skiers, artificial detonations of explosives, etc.). In particular instances, a difference is made between high and low additional load. High additional load is understood to be, for instance, the effect on the snow cover of a group of skiers traversing a steep slope very close together. Piste vehicles in hazardous areas of terrain or deliberate avalanche detonations (with mine throwers, hand detonation or detonation from a helicopter) also produce high additional loads. Low additional loads arise from individual skiers or walkers crossing the danger zone.

Explanations on the different hazard levels

In the Avalanche Hazard Scale, the avalanche hazard increases progressively from one level to the next, whereby the stability of the snow cover decreases at a constant level and the hazard zones spread out over the land in terms of number. The additional stress which is required to initiate triggering decreases at the higher levels.

Level 1: Low hazard

The snowpack as a whole is firmly secure. Self-triggering (spontaneous slides) will hardly occur other than smaller slides on steep slopes. For artificial triggering, even on extremely steep slopes, high levels of additional stress on the snow cover are required (e.g. through detonations).

The conditions outside secured zones may generally considered to be safe. The hazardous zones are few, limited to extremely steep slopes, and easy to locate.

As a long-term average, this level is used in Switzerland on about 33 per cent of all days. About 7% of all fatal accidents occur at this level.

Level 2: Moderate hazard

The snowpack is only moderately bonded on some steep slopes which are described in the avalanche bulletin in general terms by altitude, exposure or nature of terrain. If they choose their route carefully, skiers thus have a predominance of favourable conditions. Nevertheless, the possibility of triggering an avalanche should not be gnored, especially in the case of additional stress, e.g. a group of skiers ascending or descending close together. Moreover, on steep slopes with unfavourable snow cover conditions, the possibility of an avalanche being triggered by an individual should not be excluded. Traffic routes and populated areas are hardly at risk at all from spontaneous avalanches, as these will, at most, arise in isolated instances. In principle, securing measures in the area of controlled ski descents are not necessary either.

As a long-term average, this level is used in Switzerland on about 36 per cent of all days. About 26 per cent of all fatal accidents occur at this level.

Level 3: Considerable hazard

The snowpack is only moderately or poorly bonded on many steep slopes. Above all, on the steep slopes having the exposure conditions and altitude indicated, even a small additional stress, for instance caused by a single skier, could trigger an avalanche.

The danger of spontaneous avalanches may vary a great deal; with a weak snow cover structure and not much snow depth, only occasional instances of medium-sized avalanches need be expected. However, if the level is announced where there is new snow, or in conjunction with the warming effects of the day, depending on the influence of the weather, isolated instances of large avalanches must be anticipated. This then determines detonating activity (above all when there is new snowfall) or closing of areas at certain times (above all, when the temperature rises) for exposed parts of traffic routes, and above all in the area of ski runs which have to be secured. Ski tours and descents outside secured zones require experience and the ability to assess avalanches. Steep slopes at the altitude and with the exposure conditions indicated should be avoided where possible.
As a long-term average, this level is used in Switzerland on about 24 per cent of all days. About 48 per cent of all fatal accidents occur at this level.

Level 4: High hazard

The snowpack is poorly bonded on most steep slopes. Even where there is only minor additional stress, triggering is probable. Depending on the snow cover structure and quantities of new snow, a large number of spontaneous medium-sized avalanches, and an increased number of large avalanches, must be expected.
Parts of traffic routes and populated areas in the locality affected by such avalanches are likely to be endangered. Increased detonation and closures are called for in terms of safety measures.
Conditions outside secured zones are unfavourable.
As a long-term average, this level is used in Switzerland on about 5 per cent of all days, putting together levels 4 and 5 of the old Swiss Avalanche Hazard Scale. About 13 per cent of all fatal accidents arise at this level.

Level 5: Very high hazard

The snowpack is generally poorly bonded and thereby largely unstable. Numerous large spontaneous avalanches may be expected, which requires comprehensive safety measures (closures, in certain circumstances also in the form of evacuations, etc.).
Ski tours should not be recommended and are mostly not even possible.
As a long-term average, this level is generally used in Switzerland on about 2 per cent of all days, putting together levels 6 and 7 of the old Swiss Avalanche Hazard Scale. About 6 per cent of all fatal accidents occur at this level.

THE SWISS AVALANCHE BULLETIN

Bases of the avalanche warning

Other than in the neighbouring countries (Austria, Germany, Italy, France), in Switzerland, the Avalanche Bulletin is drawn up centrally at the Swiss Institute for Snow and Avalanche Research (SLF) on Weissfluhjoch/Davos. For fifty years, since the Second World War, this task has been carried out by the Institute and the maintenance of an observation network has been ensured; this requires a comprehensive data gathering, transfer and archiving concept.

Currently, the following significant basic elements of data are gathered together in the "Snow and Avalanche Information System" at the SLF:

- Hourly:
  - Data from 64 ANETZ stations of the Swiss Meteorological Institute (SMA) in Zurich, with 15 measuring parameters relating to the current weather
  - Data from 11 ENET mountain stations at altitudes from 2000 m to 3200 m with 9 measuring parameters
  - Information from telephone calls from the whole of Switzerland on the current avalanche situation
- Daily:
  - Data from 75 comparative stations at altitudes from 1100 m to 2700 m with 13 measuring parameters and 5 estimated measurable variables; this includes the determination of local avalanche hazard level
  - Data from 60 climate stations of the SMA with 10 measuring parameters
  - Reports from 10 prognosis models of the SMA with estimation of the precipitation, temperature and wind conditions
- Every Fortnight
  - Data from 35 measuring points with 3 measuring parameters
  - Data from 40 snow profile samples in the test fields
  - Data from 30 to 50 snow profile samples in slopes at altitudes from 2000 m to 3000 m, including Rutschblock tests.

The most significant basis for avalanche warning must still be seen as the observations made at the specially equipped comparative stations. Without the precise and conscientious daily work of the station operators, even today, a country-wide avalanche warning procedure would be unthinkable. In this connection, the height above sea level and the local topography of the observer stations are not the only relevant factors, but also the fact that the observations take place simultaneously at all stations.

For a comprehensive assessment of the avalanche hazard for an area of 25,000 km^2, it is essential for this data to be gathered and immediately transmitted to the central office on the Weissfluhjoch. Above all, reference will also be made in future to the observer stations which have been in operation for thirty or even fifty years, despite the increasing number of automatic stations.

Automatic weather stations serve to consolidate; providing topographical-climactic network consolidation on the one hand, and consolidation of measuring capacity in terms of time on the other.

The snow profiles facilitate analysis of the influence of the weather on snow cover stability. In particular, the slope profiles give direct information on the probability of avalanches beeing triggered over weak layers, because in general, a Rutschblock test is also carried out.

Preparation of the avalanche warnings

The group "Avalanche Warning Service" (LWD = *Lawinenwarndienst*) at the SLF is responsible for generating the Avalanche Bulletin and for providing advice by telephone. It is the job of the four group members, all of whom have more than 15 years' experience in the profession, all with daily duties in running the network, in accident analysis, in maintaining the Institute's own weather forecasting operation and in research and administration, and all with experience as mountain guides, tour leaders, ski teachers or in mountain sport, to distil the essential elements of the current situation from the comprehensive basis of data.

The following four parameters are undoubtedly significant for every avalanche specialist in assessing avalanche hazard:

- New snow:
  Intensity of snowfalls, total quantities of new snow, increase in snow cover, thickness of new snow, penetration depth, settling quotients.
- Wind:
  Wind strength, wind direction, turbulence, maximum gusts, transporting of snow, drift index.
- Temperature:
  Air temperature, adiabatic effects, sunshine, albedo, long-wave radiation, gradient formation, absorption.
- Snow cover structure:
  Layering, granularity, hardness, solidity, stability index, waterequivalent, temperature gradient, quantitative comparisons with standard values, profile types.

With the aid of the measurements at the conventional and automatic observer stations, taking into account any measuring errors and observation gaps, and always bearing in mind the reports from the warning services of the surrounding countries, an assessment of avalanche hazard is produced daily for the whole of Switzerland.

In this context, over the last few years, computer-assisted analysis has acquired a central significance. The information system was designed as a "Geographical Information System" (GIS) on the basis of the map. Important calculations such as total formation of new snow, difference and gradient formation in temperature measurements, interpolations, group formation and graphic analyses with isolines can thus be implemented very rapidly, facilitating the work to be carried out, and they have thus become indispensable aids.

In additional, two operational avalanche warning models, which have been derived from research projects at the SLF during the course of the past few years, are available for use on a daily basis:

- Statistical warning model on a comparative station basis (NEX_MOD):
  For comparative stations with an observation history of 5 or more years, the 10 days with similar weather conditions and snow basis are listed. From this,

in accordance with the data gathering forms, the principle factors predisposing to avalanches are derived. In addition, the model gives information about the hazard level selected in the past. The results of this warning model are available daily at 9.00 am.

- Deterministic-statistical warning model for major avalanches (DET_STAT): This provides for 12 index stations the probability (as a percentage) of the incidence of valley avalanches causing damage, but is only activated in periods with heavy snowfall.

The task now consists of allotting an avalanche hazard level to all regions of the Swiss Alps using all these documents and incorporating personal experience.

Swiss distinctive features

In the cross-border negotiations on the European Avalanche Hazard Scale, interpretations diverged as to whether, with regard to the individual levels, in addition to snow cover stability and the probability of an avalanche being triggered, also indication as to the concrete effects and corresponding recommendations for the most important user groups should be given. The French and Italians give no indications as to effects and recommendations. The Austrians and the Germans consider such indications to be useful. In Switzerland, these additional indications for user groups were already included in the old avalanche hazard scale of 1985.

After a country-wide survey of the major interest groups, the Swiss Institute for Snow and Avalanche Research decided to continue to give indications with regard to effects and recommendations, with the additional aim of making the Avalanche Bulletin more comprehensible.

The **Effects and Recommendations for Traffic and Residential Areas** contain indications for those in charge of safety in the cantonal and district avalanche protection services, for those in charge of federal and private railways, as well as for those in charge of pistes for mountain railways. Included in the safety measures are on the one hand the active measures, with detonation of avalanches (mostly understood as "securing measures"), and on the other hand, more passive measures such as the closing of traffic routes or ski runs (ski pistes and descent routes), finding shelter, or evacuations (in very critical conditions) from individual locations or entire local areas, etc. The safety measures to be taken in individual instances vary from case to case, and lie within the sphere of competence of those in charge of safety. The **Effects and Recommendations for Persons outside secured Zones** refer at first to skiers. Persons leave secured zones if they undertake a ski tour or mountain trek, if they undertake an alternative descent outside the secured ski runs, either on skis or on a snowboard, or when they are on open country as part of their job. For these people, the individual avalanche hazard levels contain key words which describe the effects and recommendations .

The indications as to "conditions" relate in this connection exclusively to the avalanche hazard. Type of snow (powder, heavy wet snow, brittle frozen snow) or external weather conditions (fog, high winds) are not commented upon in the avalanche bulletin.

It is advantageous to gain experience in assessing avalanches in the various mountain courses run by the Swiss Alpine Club *[Schweizer Alpenclub]*, ski associations, from "Jugend + Sport", in mountaineering schools or the military.

These **recommendations** annexed to the European Avalanche Hazard Scale in Switzerland should in reality be used as such. Once one has made one's own assessment on the ground, it is up to each individual to decide how to behave in view of the avalanche hazard and what risks one is prepared to take.

Content of the Avalanche Bulletin

The wealth of information available does not favour the generation of a clear and comprehensible Avalanche Bulletin. The systematic structure of the Bulletin, with one heading, one short text (flash) and four subsequent paragraphs, serve to make it easy to use.

- **Heading**: Issuing office, serial number, date of issue
- **Short text** (flash): The essential elements of the current avalanche situation are listed in a few key words at the head of the bulletin.
- **General**: Here, a few sentences deal with the typical weather situation, with indications as to precipitation, wind and temperature, divided up into regions if necessary. Any recorded avalanches are also mentioned here, if appropriate.
- **Snow cover**: Depending on the situation, there then follow the most important indications as to the snow cover from a qualitative point of view (structure, layering, solidity) and/or in quantitative terms (totals of new snow, total snow height at standard sea level, comparison with the average annual conditions).
- **Hazard levels**: This is the central section of the Avalanche Bulletin. Summarized according to regions, the actual hazard level is described by one of the five adjectives of the European Avalanche Hazard Scale combined with the characterizations "avalanche hazard", "danger of slab avalanche", or "danger of wet snow avalanches". The regions with the highest hazard level are listed first. Within the summarized regions with the same hazard level, there follow indications as to the particularly critical altitudes, sections of terrain and slope exposures, as well as any points to be noted in particular by various user groups.
  Each region or part region is only allotted to one hazard level, where required divided up into different altitudes. Expressions such as "other areas" or "remaining regions" are avoided if possible. If a grading relating to the type of avalanche appears necessary, i.e. if, for example, wet snow avalanches are to be expected in addition to dry slab avalanches caused by the wind, an indication to this effect is found at the end of this section.
- **Trend**: The expected evolution of the avalanche hazard is described in brief.

Since in all sections, respectively all regions must be taken into account, emphasis must be placed on a brief formulation; the time taken to speak the text should not exceed three minutes. Summaries and generalizations cannot be avoided. Central significance is given to

the section "hazard levels", in contrast, for instance, to the Italian avalanche bulletins, where more attention is focused on the description of the state of snow cover.

All regions in the Swiss Alps have clearly allotted to them one of the five avalanche hazard levels of the European Avalanche Hazard Scale. These levels are specified using the five adjectival descriptions - low, moderate, considerable, high, and very high. The descriptions of snow cover stability and the probability of an avalanche being triggered are standardized across Europe in terms of the individual hazard levels.

It is not possible to indicate the stability of individual slopes in the Avalanche Bulletin. Its contents do not extend beyond a general estimation of the current, regional situation. However, it does warrant that all regions of the Swiss Alps will be dealt with equally. Extreme territory and peak regions above 4000 m are generally not mentioned in the Avalanche Bulletin.

Spreading

The best means of dissemination continue to be recorded telephone messages, fax and teletext. Amended or abbreviated publications of Avalanche Bulletins in newspapers give rise to a lot of concern and often occasion misunderstandings, with fatal consequences.

Despite the rapid service of a private translation company, publication in the other national languages (French and Italian) is delayed by about one hour. Unfortunately, for the present, automated translation cannot be contemplated; for this purpose, a disproportionate number of standard formulations would have to be introduced. However, at the SLF, attempts are currently being made to compile extracts from the Avalanche Bulletin in several languages for parts of regions. The outcome of the first concrete tests was very promising.

MAKING USE OF THE AVALANCHE BULLETIN

By referring to the regional avalanche hazard in the Avalanche Bulletin, a person embarking on a ski tour can gain an overwiew of the avalanche situation. Those in charge of safety measures will find indications as to which critical locations must be particularly watched in fulfilling their duty of securing the traffic. Inhabitants of mountain regions are also alerted when the danger of avalanches is high, above all, when road closures or even evacuations of populated areas are considered advisable.

Nevertheless, the Avalanche Bulletin cannot in any of the aforementioned situations replace the duty of local assessment, above all in view of the fact that the avalanche situation can rapidly change.

In assessing the risk involved, it is therefore necessary to proceed in a systematic way that integrates one's own local observations. The following procedure is suggested both to safety experts in the area of roads and ski runs, and to safety wardens in open ski terrain.

Regional assessment:

Through hazard levels (low, moderate, considerable, high, very high), the Swiss Avalanche Bulletin provides an indication as to the general situation for the territory of the Swiss Alps, i.e. for about 25,000 km². It may be used to assess the extent of the current avalanche hazard in the different regions. Moreover the particularly dangerous sections of terrain are defined, and a time framework of 6 to 24 hours may be covered.

Local assessment:

Using his own measurements or observations, the responsible person must make an adjustment for a ski region, for instance in respect of a single mountain valley of about 25 km². A more precise categorization should be made, for instance with the levels, low - moderate - high, assessing the various slopes and well-known avalanche characteristics individually. Here, observations on previous avalanches should also be incorporated. Decisions on actions to be taken typically cover time periods of 0.5 to 6 hours.

Assessment of individual slopes:

Finally, with regard to an area of about 0.025 km², a decision must be made as to whether or not it may currently be traversed. This is therefore the most difficult level and demands definitive assessment within a short period, i.e. within a few minutes.

In the last stage, the consideration of the risk aspect plays a decisive role. After avalanche accidents, it often emerges that the most elementary precautionary measures were disregarded.

In this connection, preventive work represents a further duty of the Swiss avalanche warning service: above all in the case of inexperienced younger skiers, it is important to use the Avalanche Bulletin to increase understanding of hazardous circumstances in the mountains. There are several issues with which experienced skiers may be presumed to be familiar, but which must be repeatedly mentioned in courses or in information sheets for beginners. How does one interpret the hazard levels indicated in the Avalanche Bulletin? What is a shaded slope? What is the significance of weak intermediate layers in the snow cover?

However, the following points must also repeatedly be stressed: how to orientate oneself using a map? What does the yellow indicator board "Achtung Lawinengefahr" *["Warning: danger of avalanche]* mean at the beginning of controlled ski runs? What consequences should one be prepared for when undertaking a ski tour alone? Why should one not set off on a ski tour at midday? What is the use of the avalanche transceiver for people buried under snow? Why is it necessary to keep your distance on steep slopes? Why is it imperative to stop skiing in steep convex, blind terrain?

VERIFICATION

"Verification" means the subsequent independent checking of avalanche hazard. Three methods are basically possible:

- Additional measurements and field tests
- Avalanche accident analyses
- Observations by skiers.

Until a few years ago, records of slope profiles and Rutschblock tests could be used as a good basis for subsequent assessment of the avalanche hazard. This method proved so usefull that over time, it has been integrated into the operational avalanche warning. The fax machine represents a transfer medium ensuring rapid communication of evaluations. Using these communicated field records, the Avalanche Warning Service constantly updates the announcements on the state of the snow cover. Analysis of these slope profiles is thus directly integrated into the current Avalanche Bulletins. Accordingly, profiles with Rutschblock tests can only be used for verification if for any reason they are not received until after the Avalanche Bulletin was issued.

The situation is similar in the case of the activity reports of avalanche detonation operations. If these are transmitted in time, the results of these important field tests are also taken into account in the current assessment itself.

Avalanche accidents may be used for verification of the avalanche hazard levels if the necessary caution is applied. In this connection, however, it is essential to take into account the fact that the situation may change over time. The extent of an avalanche accident moreover also depends on chance occurrences, as is proven by various extraordinarily grievous events over the last few years, even when the avalanche hazard level was generally low. This fact should not be ignored by the courts in particular.

The best verification is clearly provided by questionnaires. Ski tourists and mountain guides "test" a large number of slopes on their routes. An initial survey operation in the winter 1993/94 yielded the astounding result that in 47 per cent of cases, the conditions on the terrain were in accordance with those indicated in the Avalanche Bulletin. However, cause for concern is provided by the fact that 32 per cent of respondents assessed the avalanche hazard to be higher than indicated in the Avalanche Bulletin. The questionnaire was instigated already some years ago and showed similar results.

CONCLUSIONS

Thanks to permanent avalanche protection, to upkeep of mountain forests, to improvements in skiing equipment and improved and faster rescue methods, the number of avalanche victims in the Swiss Alps has not grown over the last 50 years, despite increased mobility (the average number of fatalities per winter is 26).

Using its pure research, its findings generated in conjunction with practicians, and not least, also using the Avalanche Bulletin, the SLF aims to make every effort in future to contribute still further to minimizing damage.

After the first winter, the experiences with the five-level "European Avalanche Scale" have been positive, not only in Switzerland, but also in all participating alpine countries. In addition, the systematic structure of the Avalanche Bulletin made it easier to understand - a fact thet was appreciated by the users.
The bases for avalanche warning are composed of hourly, daily, and fortnightly data sets gathered together at the "Snow and Avalanche Information System" at the SLF central station at Weissfluhjoch/Davos. The most precious data are the hourly data, which can be compared with long-term climatological databases. This system was designed as a GIS on the basis of exact maps.
In addition, two operational avalanche warning models are available for use on a daily basis.
For safety experts as well as for backcountry skiers, an overall application method for the requisite on avalanche hazard and avalanche risk is proposed to be usefull: Regional assessment, local assessment and assessment of individual slopes.
Questionnaires, spread among mountaineers are a valuable mean of keeping in touch with the users of the Avalanche Bulletin who appeaer to be generally satisfied by the services it provides.

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Overview of the European Avalanche Hazard Scale

	Deutsch	Français	Italiano	English
	Gefahrenstufe	Indice de risque	Scala del pericolo	Hazard level
1	Gering	Faible	Debole	Low
2	Mässig	Limité	Moderato	Moderate
3	Erheblich	Marqué	Marcato	Considerable
4	Gross	Fort	Forte	High
5	Sehr gross	Très fort	Molto forte	Very high

European Avalanche Hazard Scale

	Level of hazard	Snowpack stability	Avalanche probability
1	Low	The snowpack is generally well bonded and stable.	Triggering is generally possible only with high additional loads** and on few very steep extreme slopes. Only a few small natural avalanches (sluffs) possible.
2	Moderate	The snowpack is moderately well bonded on some steep slopes*, otherwise generally well bonded.	Triggering possible with high additional loads**, particularly on the steep slopes indicated in the bulletin. Large natural avalanches not likely.
3	Considerable	The snowpack is moderately to weakly bonded on many steep slopes*.	Triggering possible, sometimes even with low additional loads**. The bulletin indicate many slopes which are particularly affected. In certain conditions, medium and occasionally large-sized natural avalanches may occur.
4	High	The snowpack is weakly bonded in most steep slopes*.	Triggering probable even with low additional loads** on many steep slopes. In some conditions, frequent medium or large-sized natural avalanches are likely.
5	Very high	The snowpack is generally weakly bonded and largely unstable.	Numerous large natural avalanches are likely, even in moderately steep terrain.

Explanations:

* generally described in more detail in the avalanche bulletin (e.g. altitude, aspect, type of terrain etc.)

** additional load:
- high: e.g. group of skiers, piste machine, avalanche blasting
- low : e.g. skier, walker

– steep slopes: slopes with an incline of more than about 30°.

- moderately steep terrain: slopes with an incline of less than about 30°.

– steep extreme slopes: particularly unfavourable in terms of the incline, terrain profile, proximity to ridge, smoothness of underlying ground surface