TEN YEARS EXPERIENCE WITH THE FIVE LEVEL AVALANCHE DANGER SCALE AND THE GIS DATABASE IN SWITZERLAND

Andreas Stoffel* and Roland Meister
Swiss Federal Institute for Snow and Avalanche Research SLF
Switzerland

ABSTRACT: In 1993 the European avalanche warning services agreed on a standardized, five level avalanche danger scale. Since then, this danger scale has been in daily use in Switzerland. The organization of the warning service and the experience with this avalanche danger scale over a period of 10 years from winter 1993/94 to winter 2002/03 are described. The Swiss Alps are subdivided into 117 spatial units, covering a total area of 26'114 km^2. These spatial units were formed by dividing the Swiss first order administrative boundaries with the basic meteorological and climatologic regions of the Swiss Alps. In regard to dry slab avalanches, a 10-year mean score of 2.12 with respect to the five levels (1-5) was found, with no significant trend and varying frequency distributions from one year to another. The regions with the highest mean danger scores in the 10-year period are the northern Gotthard massif (central Switzerland) and the Great Saint Bernard massif (close to the French border, near Mont Blanc). Low mean danger scores are found in the lowlands of southern Switzerland. In the last winters, forecasters tended to apply higher altitudes but wider aspect sectors for the especially exposed terrain parts. These results may help to improve the forecasting methods and danger communication as started in Colorado's avalanche danger rose.

Keywords: avalanche forecasting, avalanche danger scale, Swiss Alps, mountain climate.

1. INTRODUCTION

Avalanche warning has been a key task of the Swiss Federal Institute for Snow and Avalanche Research (SLF) in Davos since it has been set up over half a century ago. The Swiss avalanche bulletin evolved since then from weekly written reports to daily reports and maps for different user groups like backcountry skiers, ski resort safety managers, mountain road authorities or inhabitants in mountain regions. A good avalanche report covers the variation in space and in time. First of all the degree of danger should be clearly communicated.

This paper presents the experience with the use of the five level avalanche danger scale over a period of 10 years from winter 1993/94 to winter 2002/03. In 1998 a GIS application, the bulletin-graph-editor (BULLED), was developed to visualize past, current and future avalanche hazard estimations (Stoffel et al., 2001). BULLED is a database- and map-based tool compatible to the text-based avalanche bulletin. Avalanche danger estimations are parameterised, stored and accessed by a static division of Switzerland into spatial units. Based on this unique database, spatial and statistical analysis was performed to gain a long term overview with the five level avalanche danger scale.

2. HISTORICAL BACKGROUND

In Switzerland the avalanche warning developed since the end of the second world war (Ammann et al., 2001). Since the very beginning in the year 1945, the avalanche warning reports were weekly reports, with general indications of the snow situation and the avalanche danger. Later on, they were issued more frequently. Not standardized danger-adjectives characterized the danger level. From 1985 to 1993 an avalanche danger scale with seven levels (Föhn, 1985) was in use (Table 1). Already then the spatial distribution of the endangered areas was important, thus danger-adjectives were combined with the adjectives 'local' and 'widespread'. This danger scale did not increase continuously and

* *Corresponding author address:* Andreas Stoffel, SLF, Flüelastrasse 11, CH-7260 Davos Dorf; tel: +41 81 417 02 43; fax: +41 81 417 01 10; email: stoffel@slf.ch

the public was sometimes confused about the usage of the danger-terms.

In France and Italy the situation was completely different. The avalanche danger reports distinguished between spontaneous avalanching and triggered avalanching (e.g. by skiers) on the base of an eight level scale. In Austria and Germany, the reports worked with two different scales one for mountain transportation routes and inhabitants and the other for travel in backcountry terrain. In northern America a well-established avalanche danger scale with four different levels (low, moderate, high, extreme) was in use.

Since 1983 the intention grew to coordinate and to harmonize the European avalanche warning system, finally resulting in the five level avalanche danger scale which was established in 1993 in the Alps and elsewhere. The levels were defined by five steadily increasing danger-adjectives 'low', 'moderate', 'considerable', 'high', 'very high' and described by snowpack stability and avalanche triggering probability (Meister, 1994). The term 'considerable' ('erheblich' in German; 'elevé' in French) was subject of wide discussions in the years before, but with the exact definitions, it was accepted also in the countries where roman languages are spoken (Pahaut, 1996).

The conversion rules between the old Swiss avalanche danger scale and the five level danger scale are indicated in Table 1: old levels 3 and 4 converted to new 3, old levels 5 and 6 to new 4, old 7 to new 5.

Table 1: Avalanche danger scales in Switzerland and the frequency of use for each danger level

Old Swiss avalanche danger scale (1985-1993)	Freq. (%)	Five level avalanche danger scale (since 1993)	Freq. (%)
1 low	30.2	**1 low**	**20.6**
2 moderate local	37.8	**2 moderate**	**47.7**
3 considerable local	24.1	**3 considerable**	**28.9**
4 high local	4.9		
5 considerable widespread	2.1	**4 high**	**2.5**
6 high widespread	0.8		
7 very high widespread	0.1	**5 very high**	**0.3**
	100		100

3. THE AVALANCHE BULLETIN

3.1 Organization

A characteristic of the Swiss avalanche warning system is the fact, that the reports always covered the whole area of the Swiss Alps. This is atypical for the federal administration in Switzerland and also in contrast to the systems in the surrounding countries, where the avalanche warning reports are organized from regional centres since the beginning. During the period of 10 years from winter 1993/94 to winter 2002/03 twelve forecasters shared the job to issue the avalanche bulletin. This period can be grouped in two completely different subperiods with different premises, which coincide with the location where the avalanche bulletin was edited.

a) Davos Weissfluhjoch (2600 m a.s.l.): 1993-1997 (4 winters); 3 to 4 forecasters in weekly service cycles; the avalanche bulletin was of the type 'now casting'; not daily edited, but always when the situation changed distinctively and always on Friday; issued at 9 a.m.; daily terrain access for all forecasters as the office was situated some 1000 m higher than the living places; one supervisor to check the contents and text of the avalanche bulletin, which was structured in the following paragraphs: *general - snowpack - danger level(s) [d=0] - forecasts [d=1,2]*.

b) Davos Dorf (1500 m a.s.l.): 1997-2003 (6 winters); 4 to 6 forecasters in service cycles of three weeks (three consecutive services as 'regional forecaster', 'national forecaster' and 'supervisor'); the avalanche bulletin was of the type 'forecasting'; briefing sessions at 3 p.m. and daily edited and issued at 5 p.m.; terrain access in the forecaster's discretion; supervisor service (in the last week of the service cycle) to coordinate the content and text of the avalanche bulletin, which was structured in the following paragraphs: *general - short time evolution - danger level(s) [d=1] - trend [d=2,3].*

These differences are important for a better understanding of the following analysis. In both periods, the forecasters at SLF analyzed the situation based on four basic resources: data from a network of observation stations measuring meteorological and snow cover parameters, results from weather and avalanche danger forecast models, user feedback (e.g. toll-free phone or fax, internet forums) and own terrain access. Depending on the forecaster's skill or experience and in relation to the actual situation, all elements were mixed or one was favored.

The basic idea in the avalanche bulletin is to estimate the avalanche danger as an area-wide index (danger level). In addition to the danger level, the especially exposed terrain parts in regard to altitude, aspect sector and terrain types are described each time. This means, that for an actual situation the danger level is valid not only for the slopes at risk, but also for the area as a whole.

This systematic is rather simple to use and leads to sentences like: "Central parts of Swiss Alps: moderate avalanche danger, special attention should be paid to steep slopes above about 2000 m a.s.l. and the aspects from west, passing north to northeast". This system has also been adapted as danger plots or 'altitude aspect graphs' (AAG), which are part of the public avalanche danger maps, see Schweizer and Föhn (1996) or Brabec et al. (2001).

It is assumed, that the especially exposed terrain parts for low danger levels lie above relatively high altitudes and in narrow aspect sectors, whereas for high danger levels, they lie above relatively deep altitudes and cover wider aspect sectors or even all aspects.

3.2 The GIS solution

Already in the mid eighties maps helped to analyse the growing amount of data provided by the nationwide observation network. A Geographic Information System (GIS) was introduced in 1993 and since then computer based graphical products were realized. Stoffel et al. (2001) developed GIS applications to support the forecasters but also to edit products addressed to the public like avalanche danger maps, snow depth maps or snowpack stability maps.

Further developments and the introduction of regional avalanche reports led to a computer aided system to assist the avalanche warning process (Brabec et. al., 2001). This software package includes the following main modules: AktuellPlus (a GIS based viewer to get a quick overview over the current and past weather, snow and avalanche conditions in the Swiss Alps), BULLED (bulletin graph editor, a GIS application to visualize past, current and future avalanche danger estimations), NEX_MOD/NXD-REG (a statistical avalanche danger model) and REGBUL (an editor for the regional reports).

Based on BULLED the present analysis was established. BULLED is a database- and map-based tool compatible to the text-based avalanche report. Avalanche hazard estimations are parameterised, stored and accessed by a static division of Switzerland into 117 spatial units (Figure 1). These spatial units were formed by dividing the administrative boundaries of 14 alpine cantons (e.g. Valais, Uri, Grisons), those of 7 weather- and snowpack-based climatologic regions (Table 2) and some common mountain massifs (e.g. Gotthard or Silvretta). A dominant role in the Swiss mountain climatology is assigned to the main alpine divide which was separated in BULLED as a band with a width of about 20 km.

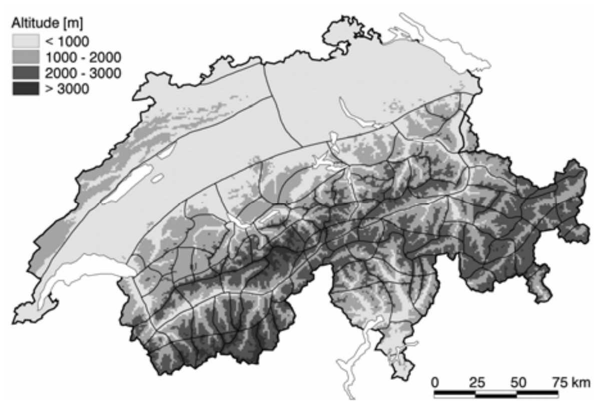

Figure 1: Topography of Switzerland and the 117 spatial units.

The mean area of all spatial units is 223 km^2 and the median altitude corresponds to 1955 m a.s.l. The largest alpine spatial unit is 'Entlebuch' in the northern Prealps (765 km^2) at a median altitude of 880 m a.s.l., the smallest one is 'Engstligen' in the Bernese Alps (37 km^2) at a median altitude of 2142 m a.s.l.

4. CLIMATE IN SWITZERLAND

Climate in Switzerland is basically influenced by the interaction between topography and the movement of the atmospheric pressure systems. The topography is generally structured by the Jura (a low mountain range in the north-western part of the country), the midlands (between the lakes of Geneva and Constance) and the Alps (Figure 1). The deepest point is situated at 193 m a.s.l. (Lago Maggiore, at the southern alpine versant) and the highest elevation, less than 50 km away, culminates at 4634 m a.s.l. (Dufourspitze in Valais). Switzerland is open to climatic influences from the Atlantic. North-westerly airflows bring snow precipitation mainly to the northern alpine versant. Cyclones from the Mediterranean Sea often cause heavy snow falls on the southern alpine versant. Both weather types may overlap along the main alpine divide. Schüepp et al. (1978) give a general overview of Switzerland's complex climate. The mean monthly air temperatures range from –15 to +21 °C. The mean annual precipitation is 500 to 3500 mm.

Above about 800 m a.s.l., a more or less regular seasonal snowpack is usual. Its duration is varying between one and twelve months, the latter indicating the glaciered zones above about 3000 m a.s.l. At 1500 m a.s.l. the snow depth usually reaches a maximum in mid February (ranging from 30 to 250 cm), at 2500 m a.s.l. this is the case in mid April (ranging from 100 to 800 cm).

5. METHODS

The goal in this paper is to analyse the long-term usage of the five level avalanche scale in the Swiss avalanche bulletin. This is achieved by analysing the danger levels as well as the altitude and aspect sectors of the especially exposed terrain parts stored in the BULLED database.

Ten winters (1993/94 to 2002/03) were examined, each with a time span of 151 days (from December 1st to April 30). In the leap years (1996 and 2000) February 29 was suppressed. Only danger levels assigned to dry slab avalanches were analysed. The danger level for wet snow avalanches are not daily mentioned in the avalanche report and therefore not examined in this paper.

The daily danger score is defined by the following simple conversion rule: low:=1; moderate:=2; considerable:=3, high:=4; very high:=5. 'Danger level' is appointed in this paper to the adjectives (as an integer value 1-5), whereas 'danger score' means a calculated value (as a real number).

In the first four winters (1993/94 to 1996/97), when the 'now casting' system was in use, a new bulletin was not published daily, but every 1.7 days on a 4-year average. Therefore the actual avalanche levels (and all additional parameters) were assigned to the missing days until a new bulletin was published. In the 10-year period there were six days with extraordinary situations and more than one bulletin per day. For these days, only the main edition (9 a.m. or 5 p.m.) was taken into account for the analysis. The raw data were extracted from BULLED, statistics calculated in Excel and reintroduced into the GIS and a statistical software (SPLUS).

6. RESULTS

Each winter has its own characteristics concerning mean avalanche danger levels, snow depth, snowpack stability and avalanche activity. The analysis of the long-term usage of the five level avalanche danger scale covers the climatologic mean conditions over a 10-year period. In addition a time series for the mean avalanche danger score, mean altitude and aspect of the especially exposed terrain parts for each winter is presented.

6.1 10-year mean avalanche danger score

The climatologic mean conditions are reflected in Figure 2 showing the 10-year mean of the avalanche danger score in the Swiss Alps. The distribution is dominated by a north-south gradient. The narrow band of the northern Prealps has a mean danger score of 1.9 to 2.1. The northern alpine versant and wide parts of Valais and Grisons appear as a geographical unit with mean danger scores of 2.1 to 2.3. High gradients structure the affiliated regions to the south, showing the deepest danger score region in mid and south Ticino and the southern valleys of Grisons. The mean for the whole area of the Swiss Alps is 2.12. The values of the basic climatologic regions, as they have been defined over fifty years ago for the Swiss avalanche warning service is shown in Table 2. The highest danger scores (>2.3) are calculated for the northern Gotthard massif, the most eastern parts of the upper Valais (Goms) and for the south-western corner of the Valais (Great Saint Bernard, Grand Combin).

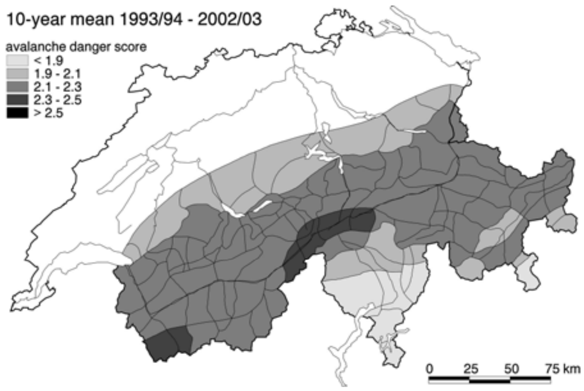

Figure 2: 10-year mean avalanche danger score in the Swiss Alps.

Analysing the spatial units, the highest mean danger score with 2.39 is found in the unit 'northern Urseren/Göschenen' (151 km^2, 2227 m a.s.l.), the lowest score is 1.61 for 'Malcantone, Ticino (311 km^2, 741 m a.s.l.). The value for the spatial unit 'Davos' (228 km^2, 2267 m a.s.l.), where the avalanche bulletin has been edited over all this time, is 2.14. This value just matches the overall mean.

Table 2: Climatologic regions in Switzerland

Region	Area (km^2)	Area (%)	Median altitude (m a.s.l.)	Mean danger score
1 Bernese Alps	5480	13.2	1430	2.12
2 Central Alps	3535	8.5	1330	2.14
3 Eastern Alps	2276	5.5	1290	2.13
4 Valais	4886	11.8	2250	2.22
5 North/central Grisons	4239	10.2	1960	2.18
6 Ticino	3295	7.9	1460	1.84
7 Engadine	2401	5.8	2310	2.07
->Swiss Alps	(26114)	(63)	(1730)	**2.12**
Swiss Midlands and Jura	15383	37.1	590	NA
Switzerland	41497	100	1310	

Special attention is paid to the distribution of the especially exposed terrain parts as they have been mentioned in the avalanche report. The mean values for each danger level in the 10-year period are plotted in Figure 3. The mean directions for the aspect sector of all danger levels lie in a narrow band from N to NE, namely at 6 degree (for 'low'), 20 degree (for 'moderate'), 24 degree (for 'considerable'), 5 degree (for 'high') and 0 degree (for 'very high'). The detailed annual analysis following in chapter 6.2 shows the variations in danger level, altitude and aspect usage over the 10-year period.

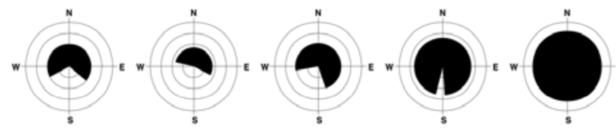

Figure 3: Altitude aspect graph (AAG) of the especially exposed terrain parts for each avalanche danger level ('low' to 'very high' from left to right); outer circle 1000 m a.s.l., equidistance 500 m.

6.2 Mean avalanche danger score for the 10 winters from 1993/94 to 2002/03

A typical Swiss winter is characterized by two to five heavy precipitation periods. Settled weather occurs mainly in midwinter when the country is influenced by anticyclones. Avalanche danger and activity depends primarily on the cycle of these weather patterns, but regional influences are very complex. In Figure 4 the mean danger scores as described in chapter 5 are illustrated for all ten winters from 1993/94 to 2002/03.

The variations can be explained by the main weather and snowpack characteristics as they are listed in the annual reports of SLF and summarised in Appendix A.

The highest danger scores are found at the main alpine divide for the winters 1993/94, 1994/95, 1995/96, 1996/97 and 2000/01. Whereof in winter 1994/95 only the western and central part are prominent. In the winters 1997/98, 1998/99 and 1999/00 the score is rather evenly distributed, with the highest scores in the high altitude parts of the Bernese Alps and central Alps. A more distinct distribution of the mean avalanche danger score is found in the winters 2000/01, 2001/02 and 2002/03.

In some of the winters, the inner alpine parts of the Swiss Alps show deeper danger scores than the direct surroundings; e.g. 1994/95 for the eastern

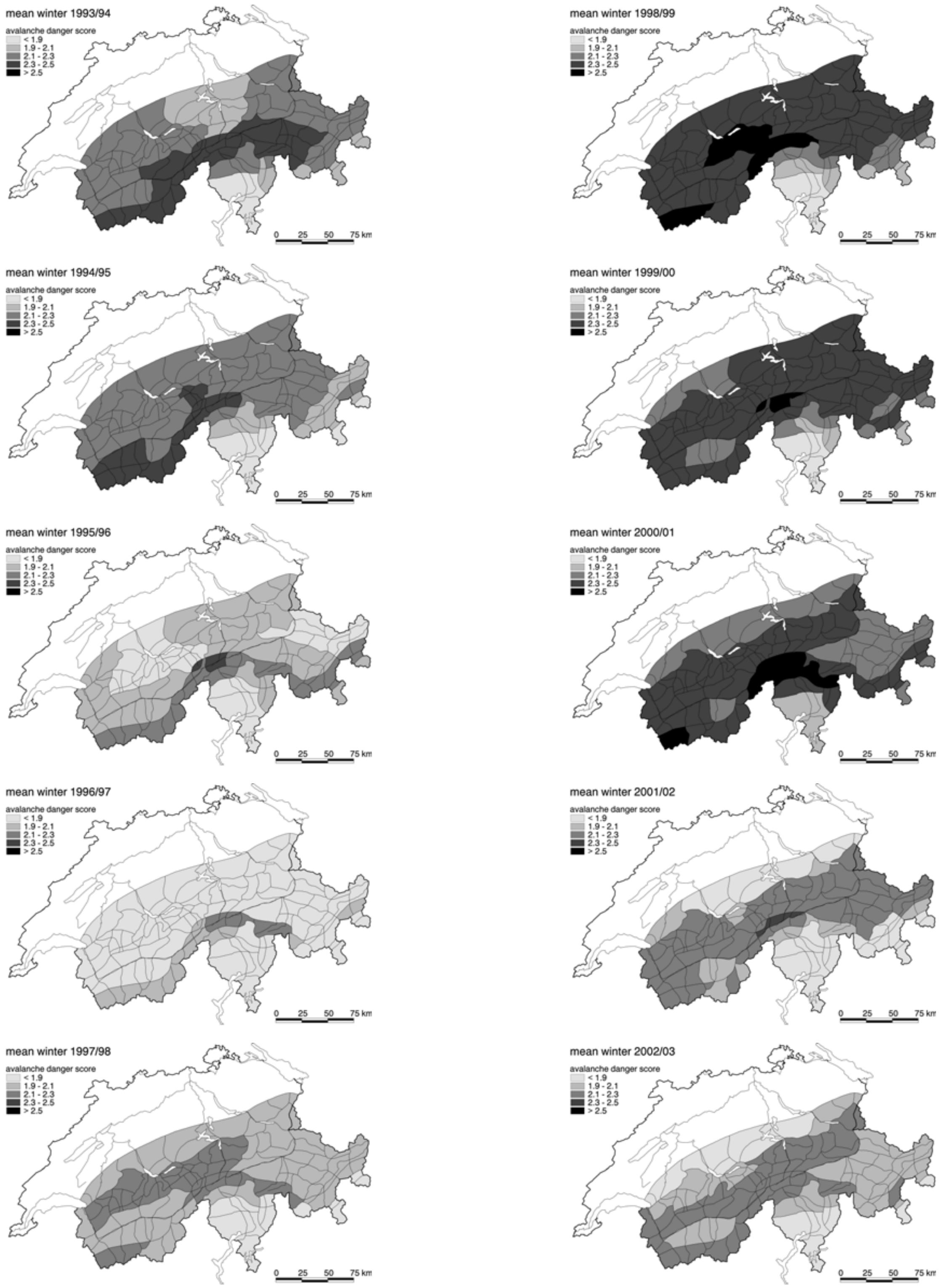

Figure 4: Mean avalanche danger scores for the Swiss Alps in the ten winters from 1993/94 to 2002/03

part of the central Valais, 1999/2000 for the central Valais and the upper Engadine, 2000/01 for the eastern part of the central Valais or 2002/03 for the central Valais.

The winter with the lowest mean avalanche danger score is 1996/97 (1.80). High values only result for the western and central parts of the main divide.

The winter with the highest mean avalanche danger score is 1998/99 (2.35). A strong gradient appears between the Bernese Alps and the central parts of Ticino. Values higher than 2.5 are found in the northern parts of the Gotthard massif, the south-western Valais and the eastern Bernese Alps.

The time series for the mean avalanche danger score in Figure 5a shows no typical trend. The first four winters when the ‘now casting’ system was used show a slightly decreasing trend and a mean of 2.03. For the subsequent six winters with ‘forecasting’ system the mean is 2.17.

Interesting results arise from calculating the usage of the different avalanche danger levels for each winter (Figure 5b). More or less constant is the percentage of usage of the level ‘moderate’, which is applied almost half of the days (exact figures are given in Table 1). The usage of the danger levels ‘low’ and ‘considerable’ is laterally reversed because the levels ‘high’ and ‘very high’ are applied rarely.

The statements on the most exposed terrain parts are rather difficult to estimate and of special interest in this context. Concerning the mean altitudes the time series in Figure 5c shows a slight trend to higher values for the danger level ‘moderate’. This trend to higher mean altitudes is more evident for the danger levels ‘considerable’ and ‘high’. Apparently lower mean altitudes are common in the winters 2001/02 and 2002/03 for the danger level ‘low’. This is explained by a change in the application of the danger level ‘low’ where the most exposed terrain parts are not mentioned any more in the bulletin, but still entered in BULLED.

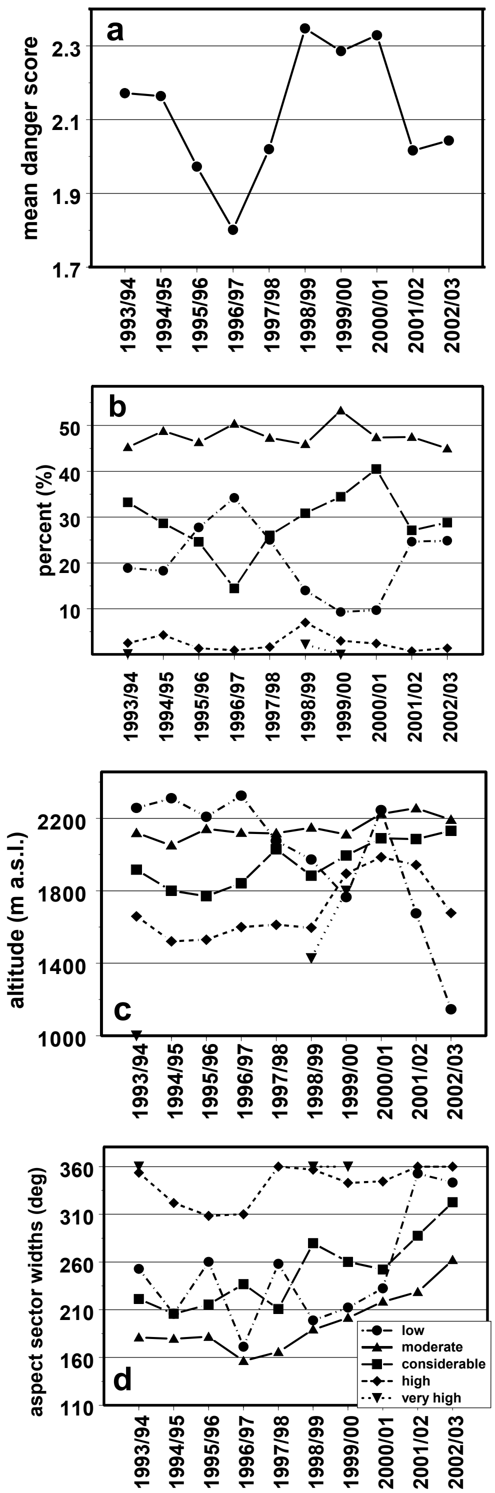

Figure 5: Time series for a) the mean avalanche danger scores, b) the percentage of usage of the different danger levels, c) the mean altitudes above which the especially exposed terrain parts were expected and d) the mean aspect sector widths where the exposed terrain parts were expected; Swiss Alps, 10 winters 1993/94 to 2002/03; symbols in b), c) and d) indicate danger levels and are explained in d).

The mean aspect sector widths of the especially exposed terrain parts (Figure 5d) show a trend to wider angles nowadays than ten years before, in particular for 'moderate' and 'considerable'. For the danger level 'low' the wider angles in the winters 2001/02 and 2002/03 are also explained by a change in the application of the danger level in the bulletin where the most exposed terrain parts are not mentioned any more, but still entered in BULLED.

It may be summarized, that the mean values of the annual avalanche danger show no distinct trend in the last ten years. A slight increased mean value in the period with the 'forecasting' system may be derived. The especially exposed terrain parts show opposite trends in regard to the application of altitude which tends to higher values that are less restricting, whereas the application of aspect sectors is tending to wider angles and therefore is more restricting. These trends are found mainly in the period with 'forecasting' system.

6. CONCLUSIONS AND OUTLOOK

Based on a unique GIS database for 117 spatial units, the experience with the five level avalanche danger scale over a period of 10 years from winter 1993/94 to winter 2002/03 in the Swiss avalanche bulletin was analysed. The 10-year mean avalanche danger score shows a spatial distribution which is dominated by a north-south gradient. The highest mean avalanche danger scores were found for the northern part of the Gotthard region. The lowest mean danger scores were found for the southern lowlands of the canton Ticino. Some differences were found analysing the avalanche danger during two subperiods when the avalanche report was edited in a 'now casting' system (four winters 1993/94 to 1996/97) and a 'forecasting' system (six winters 1997/98 to 2002/03) respectively. The mean values of the avalanche danger score for a whole winter show no significant trend in 10 years. The especially exposed terrain parts show opposite trends in regard to altitude with an application that is less restricting, whereas the application of aspect sectors is more restricting.

The Swiss avalanche service has gone through many changes within these 10 years. Some may affect the results of this study e.g. the change of location and forecasting system, the changing staff of forecasters, the expansion of the observer and automatic weather station network and the development of data analysis tools. This development has to be considered for the interpretation of the results as well as the different weather and snowpack characteristics during the 10-year period.

Only few of the most interesting results for the spatial and temporal variations of the avalanche danger could be presented here. No attention was paid to the exact day-to-day evolution of the avalanche danger, which would be subject of avalanche danger verification (Schweizer et al., 2003).

Also still missing are comprehensive comparisons between the avalanche danger levels issued in the Swiss avalanche bulletin and the ones issued by the avalanche services in the surrounding countries.

In avalanche bulletins the danger level should be clearly communicated and detailed information about the primarily endangered altitudes, slope angles, terrain types and aspect sectors are important. Taking into account the briefness of the written avalanche report, maps and AAGs improve the danger communication. A first attempt to visualise the danger level on a GIS-based topographical map was presented by Leuthold et al. (1996). A recent development in the form of an AAG is found by the Colorado Avalanche Information Centre (CAIC) avalanche danger rose, where a danger estimation is given for all aspects and altitudes, see http://geosurvey.state.co.us/avalanche/danger_rose_defs.html. One special feature of this visual representation is the possibility to include pockets of the next (higher) danger level. A similar AAG approach can be found by Durand et al. (1999) within the French Safran-Crocus-Mepra (SCM) chain. These SCM-graphs are valuable tools for the forecasters, but not daily published so far with the avalanche reports.

All these versatile graphical possibilities help to improve the avalanche danger communication to the public. A similar approach may be applied to avalanche danger verification schemes and avalanche danger model scenarios.

7. ACKNOWLEDGEMENTS

We would like to thank the avalanche forecasters at SLF: Ernst Beck, Sievi Gliott, Hans-Jürg Etter, Frank Tschirky (†), Thomas Stucki, Stephan Harvey, Thomas Wiesinger, Monique Aebi, Dario

Schwörer, Benjamin Zweifel and Chris Pielmeier. We also appreciate the helpful comments of Jürg Schweizer and Jakob Rhyner during the internal review.

8. REFERENCES

Ammann, W.J., Föhn, P.M.B., Meister, R., 2001. Le Service des avalanches en Suisse: Hier - Aujourd'hui - Demain. ANENA; 'Bilan et Perspectives de 30 années de gestion du risque d'avalanche en France'; Actes de colloque, Grenoble.

Brabec, B., Meister, R., Stöckli, U., Stoffel, A., Stucki, T., 2001. RAIFoS: Regional Avalanche Information and Forecasting System. Cold Regions Science and Technology, 33, 301-311.

Durand, Y., Giraud, G., Brun, E., Mérindol, L., Martin, E. 1999. A computer-based system simulating snowpack structures as a tool for regional avalanche forecasting. J. Glaciol., 45(151), 469-484.

Föhn, P.M.B., 1985. Das Schweizerische Lawinenbulletin. Mitteilung Nr. 38, SLF Davos.

Leuthold, H., Allgöwer, B., Meister, R., 1996. Visualization and Analysis of the Swiss Avalanche Bulletin using GIS. ISSW 1996, Banff, Canada, Proceedings, 35-40.

Meister, R., 1994. Country-wide avalanche warning in Switzerland. ISSW 1994, Snowbird, UT, USA, Proceedings, 58-71.

Pahaut, E., 1996. La prévision du risque d'avalanche en France (1), ANENA, Grenoble, Neige et Avalanches, 76.

Schüepp, M., Bouet, M., Bider, M., Urfer, Ch., 1978. Regionale Klimabeschreibungen. Klimatologie der Schweiz; Beiheft zu den Annalen der Schweizerischen Meteorologischen Zentralanstalt.

Schweizer, J., Föhn, P.M.B., 1996. Avalanche forecasting – an expert system approach. J. Glaciol., 42(141), 318-332.

Schweizer, J., Kronholm, K., Wiesinger., T., 2003. Verification of regional snowpack stability and avalanche danger. Cold regions science and technology, 37, 277-288.

Stoffel, A., Brabec, B., Stöckli, U., 2001. GIS applications at the Swiss Federal Institute for Snow and Avalanche Research. 21st ESRI International User Conference, Redlands, CA, USA.

APPENDIX A

Qualitative and quantitative snow and avalanche overview; Swiss Alps, winters 1993/94 to 2002/03

Winter	*Snow depth*	*Snowpack stability*	*Avalanche activity*	*Avalanche fatalities*	*Mean danger score*
1993/94	Close to average, with a slight surplus in January and March, particularly in Engadine	Poor, but improving during the warm March	Low in general, but high in December and January	21	2.17
1994/95	Low until mid January, but high during April, with new long-term maximum in the western Alps	Unfavorable, but improving with increasing snow depths	High in December and in the first half of January	20	2.16
1995/96	Very low, with absolute minimum during February and March in the central parts of Grisons	Poor, caused by low winds and high temp.-gradients; ram hardness less than 100 N	Low concerning spontaneous avalanches; high for triggered ones.	17	1.97
1996/97	Early and intensive onset during November, afterwards adjusting to the average	Good, few potential weak layers; modification by strong winds during February	High during November and December and again in May	24	1.80
1997/98	Rather low, but not in Ticino and southern Grisons where the values strongly exceeded the average	Poor at the beginning, namely in western parts and in Grisons; fair to good elsewhere	Very low, except during some pronounced short periods in April	13	2.02
1998/99	Partly new long-term maximum in February (below 2000 m) and in April (above 2000 m)	Good at beginning; fair to poor during February; good for the rest of the winter	Extraordinary high during three consecutive periods in January/February	36	2.35
1999/00	Early onset of snow; higher than average in the northern parts, but lower in the central and southern Alps	Poor, since the beginning, especially in Grisons and the southern Alps	In general low; high on some midwinter days, e. g. end of January	20	2.28
2000/01	Permanent snow cover >1500 m: >180 days; very high in Ticino and Engadine, fair elsewhere	Very poor, stamped by the interactions of precipitation periods and cold phases	High, but hardly any damages; critical for backcountry touring	32	2.33
2001/02	Lower than average, except in some short periods in March; new long-term minimum in Engadine	Fair in the northern regions, poor elsewhere, depending on aspects	Rather low for spontaneous avalanches, fair for other types	24	2.02
2002/03	From November to February very high above 2400 m rather poor below 2400 m; adjusting to mean conditions during March	Poor after a surface hoar formation in December, which was buried by new snow; fair after mid February	High for wet avalanches in the beginning, low afterwards, with a peak in February	21	2.04
mean				23	2.12