14th Congress INTERPRAEVENT 2021
Norway – Paper
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# Evaluation of the Extraordinary Avalanche Situation in January 2018 in Switzerland

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**Keywords:** Avalanches; Prevention; Preparedness; Recovery; Science; Case Study or Practice Report

## Abstract

In January 2018, heavy snowfalls caused an extraordinary avalanche situation in Switzerland with an extent not observed since the avalanche winter of 1999. The amount of precipitation was far above the long-term average und in parts of the Swiss Alps even twice the average. For the first time since 1999, the highest danger level *5–Very High* was forecast for a 36-hour period and for most regions of the Swiss Alps. We present key findings of the analysis of this extraordinary event and show that the mitigation efforts taken after the catastrophic events in February 1999 were effective. Despite very high avalanche activity, there was no loss of life and damage to property was limited.

## Introduction

In January 2018, heavy snowfalls caused an extraordinary avalanche situation with an extent not observed since the avalanche winter of 1999. The amount of precipitation was far above the long-term average und in parts of the Alps (Valais and Grisons) even twice the average. For the first time since 1999, the highest danger level *5–Very High* was forecast for a 36-hour period and most regions of the Swiss Alps. Despite very high avalanche activity, there was no loss of life and damage to property was limited. The events allowed assessing whether the mitigation efforts taken after the catastrophic events in February 1999 were effective. In the following, we will present some key findings of this

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event analysis. More detailed information is provided in the full report (Bründl et al., 2019), which is available in German and French.

## Weather, snow and avalanche situation

The winter started early in 2017. In most areas of the Swiss Alps, snow depth was already above-average by the end of December 2017 and it further increased in the first days of 2018. The snowfall limit during the precipitation period varied and was partly as high as 2000 m a.s.l. In this period, some very large avalanches already occurred and safety measures had to be taken. The main precipitation period started in the evening of 20 January 2018. Until the morning of 23 January 2018, the sum of new snow above 2200 m a.s.l. was 100–150 cm in most regions of the Swiss Alps from the Valais to the lower Engadine.

By the end of the snowfall period snow depth were extraordinarily large. The return periods for the snow depth on 23 January were at many stations between 20 and 100 years compared to the snow depth maximum observed in January (Fig. 1). Most of the stations with a snow depth return period of more than 50 years were located in Valais. Since January 2018 was generally warmer than the long-term average, a strong increase of snow depth with elevation was observed. Snow depth at elevations between 1000 and 1600 m a.s.l. was locally below average in particular on the northern slopes of the Alps.

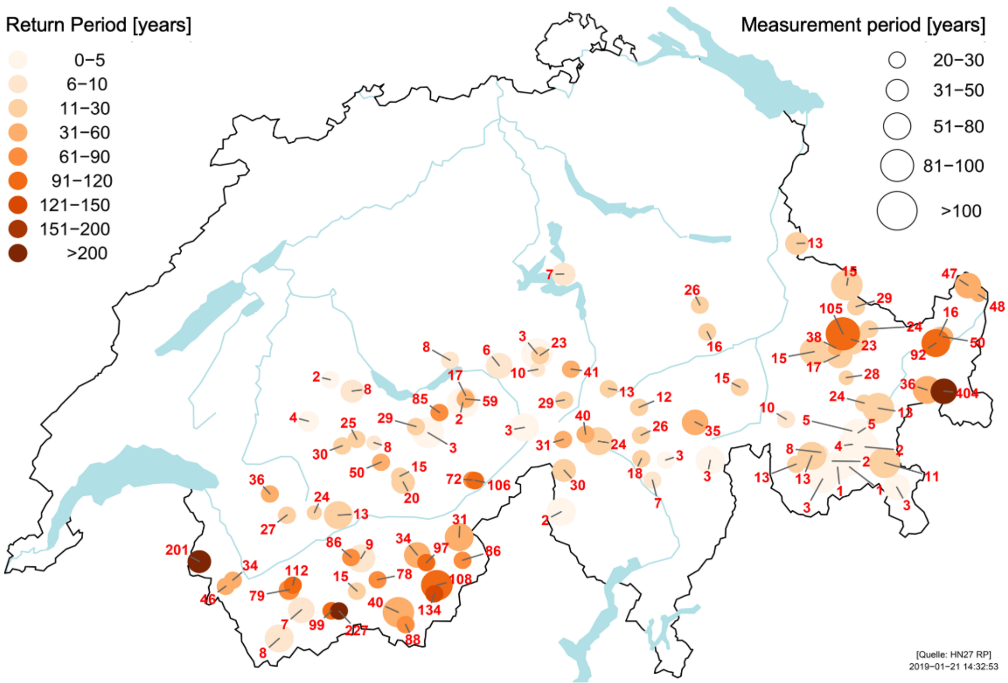


**Figure 1 Return period (numbers in red) of snow depth on 23 January 2018 compared to the maximum values in January at measurement stations above 1500 m a.s.l. The darker the circles the higher the return period. The larger the circles the longer the measurement period.**

The 3-day avalanche period from 21 to 23 January 2019 was the most intense since 1999 as expressed with the avalanche activity index (AAI, Schweizer et al. 2003). The AAI is the sum of all observed avalanches weighted by size and type of triggering. On 22 and 23 January many large and very large natural avalanches were observed (size 4 and 5). The highest activity was observed in Valais and northern Grisons (Fig. 2).

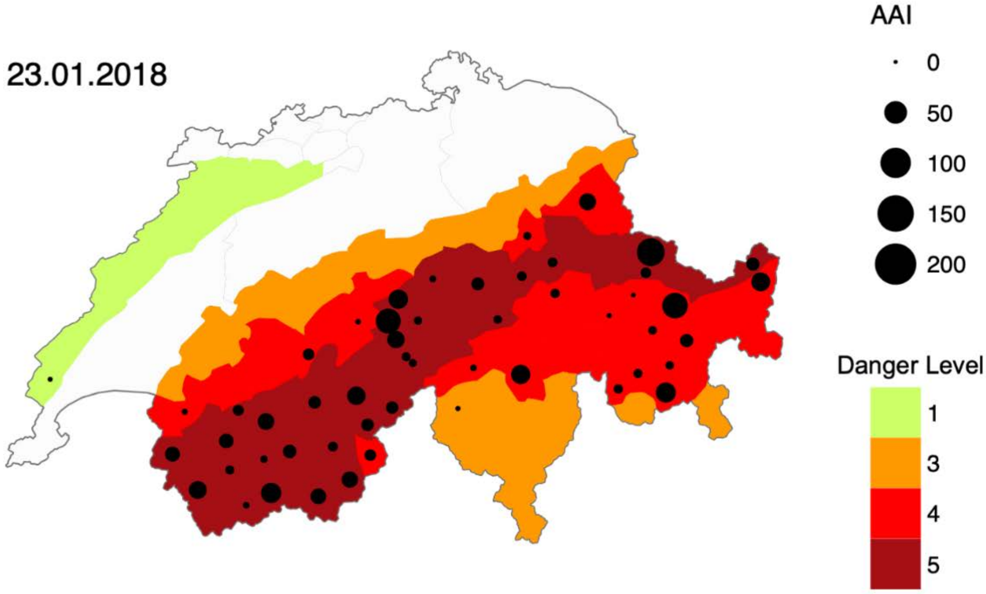


**Figure 2 Avalanche danger level forecast on 22 January, 17:00, for 23 January and avalanches reported by SLF observers expressed as regional avalanche activity index (AAI). Due to poor visibility and accessibility most likely not all avalanches were recorded. The regions with highest avalanche activity roughly coincide with the areas where danger level *5–Very High* was forecast.**

For the first time, SPOT6 satellite images were used to comprehensively map avalanche activity during an extraordinary avalanche situation (Bühler et al., 2019). On the pictures taken on 24 January 2018, the outlines of in total 18,737 avalanches were manually mapped. Comparing the mapped avalanches with the forecast avalanche danger level allowed verifying the avalanche forecast. Results indicate that the forecast was correct in most regions, with some over- and under-forecasting. For instance, in the region of Davos, the forecast danger level was *4–High* and the avalanche activity was very high (AAI≈100) (Fig. 2) suggesting that the danger level *5–Very High* would have been more appropriate.

## Damages and interrupted transportation lines

Although the avalanche situation was extraordinary, damages were comparably low and no people were killed in settlements or on roads. Nevertheless, a few avalanches hit inhabited houses, but no people were harmed. According to the SLF avalanche data base, 25 avalanches caused damage to buildings, 55 affected roads, railway and power lines, and 83 avalanches caused damage to forests. Only two permanently inhabited buildings suffered damage; most of property damage concerned agricultural buildings and mountain huts. Snow creep pressure caused damage amounting to 5.7 million Swiss Francs, mostly in Grisons.

Roads and railway lines had to be closed due to avalanche danger. The Gotthard highway had to be closed due to a debris flow and was kept closed due to avalanche danger for 22 hours. The Gotthard railway line had to be closed for 38 hours. Mountain railway lines were closed in total for about 30 days (Fig. 3). Further damages were recorded at power lines and mountain cable ways.

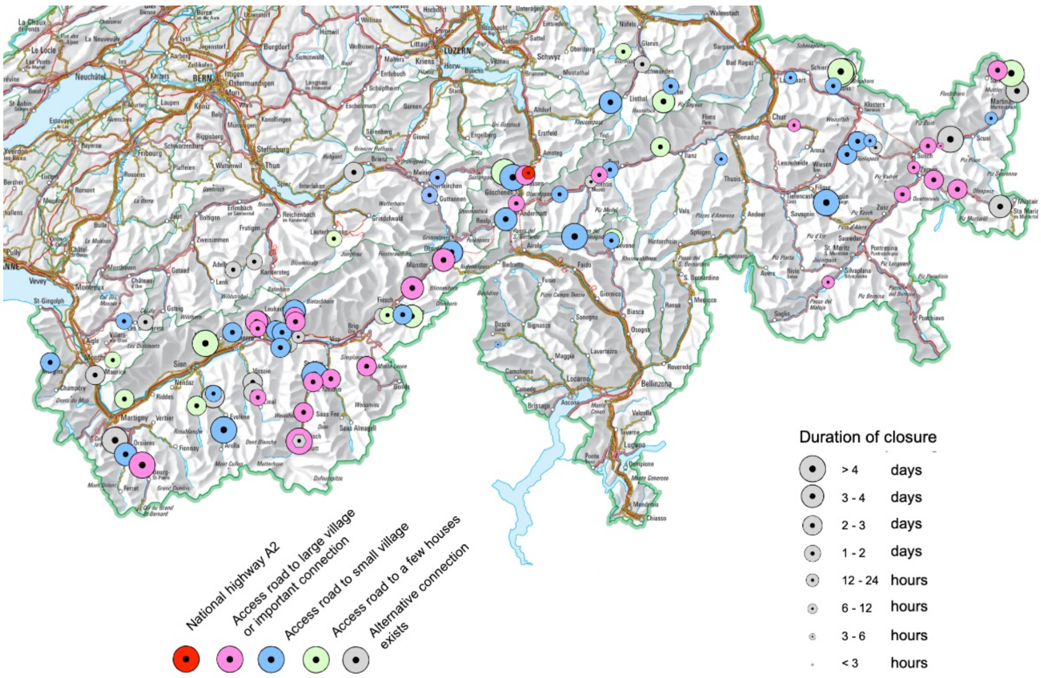


**Figure 3 Road closures between 21 and 25 January 2018. Different colours indicate the relevance of the access road and circle size refers to duration of closure. For instance, the national highway A2 (red circle) had to be closed after a debris flow; due to avalanche danger it was kept closed for 22 hours.**

Damage to forests amounted to 18,000 $m^3$ of timber. The overall damage was not high considering the extraordinary meteorological event. A few single events significantly contributed to this damage; for instance at Alp da Schlans (Trun, Grisons) an avalanche destroyed 200-year old trees (4,000 $m^3$ of timber).

# Effectiveness of integral avalanche protection

Integral avalanche protection denotes the combination of various mitigation measures such as structural measures, land use planning, biological measures and organizational measures including artificial avalanche release. Integral avalanche protection has been considerably improved in Switzerland in the last decades. The analysis of the avalanche winter 1999 showed that integral avalanche protection had stood the test. Some gaps were identified in all fields of integral avalanche protection but mainly concerning organizational measures. Most of the issues identified, such as the revision of hazard maps in areas where avalanches exceeded the limits of red or blue zones, or the construction of additional permanent avalanche protection were addressed in the last 20 years.

Snow depths were unusually high and many snow supporting structures were almost filled with snow by the end of the precipitation period in January. Since maximum snow depth is usually observed in April at the elevation of most starting zones, there were concerns that the structures could be fully covered with snow in the further course of the winter. As February and March were dryer than on average, only locally some supporting structures were fully buried. In most of the structures, the maximum snow depth was 1 – 2 m below the 100-year return period snow depth. Nevertheless, the large snow loads caused some damages at supporting structures such as bent supports or tilted or broken beams. Overall, the damage to structures was lower than in the avalanche winter 1999.

In 2018, 98% of the communities with avalanche exposed areas, had avalanche hazard maps implemented in communal land use planning. Very few avalanches did run beyond the limits of existing hazard zones. This positive outcome was related to rain at lower elevations. Between 1000 and 1600 m a.s.l., the snowpack was moist at the surface, which contributed to comparably short runout distances due to a change in flow regime from dry to wet. In areas with high avalanche activity such as the Saas and the Matter valley, many avalanches stopped within the red hazard zone and only some avalanches reached the blue hazard zone. Whereas no avalanches exceeded the hazard zones in the main flow direction, some avalanches laterally did run past the limits.

Evaluating the work of local avalanche safety services during the avalanches situation in February 1999 revealed a need for improving training, organization and communication between the services as well as between the national forecasting centre at SLF and local services. In response to these findings, the project “Intercantonal early warning and crisis information system IFKIS” was initialized in 2000. It included the development of an education and training programme for avalanche professionals, a checklist for the organization of avalanche safety services and the development and implementation of an information system (Bründl et al., 2004).

To assess the effectiveness of these measures taken after the avalanche winter 1999, we conducted interviews with 36 members of in total nine local avalanche safety services. The interviews revealed that safety services were much better organised and trained in January 2018 than in 1999. Most of the members of these services attended the basic and advanced courses “Snow and Avalanches” annually organised by the SLF. Since 2000, far more than 1000 people attended these courses, conducted alternatively in German, French and Italian. The analysis also showed that responsibilities should to be defined more clearly in some services, e.g. with regard to information and/or evacuation of remote buildings or the closure of road sections, where responsibilities of communities and road departments

overlap. Many services face difficulties in recruiting junior staff, as some of the experienced members in leading positions will retire in the next years.
The safety services stated that the available weather and snow related information has much improved since 1999. However, due to the change from the information system IFKIS introduced after the winter 1999 to the Common Information Platform GIN (Heil et al., 2014) after the floodings in 2005, they complained about the complexity and the decreasing user-friendliness of the information systems. They asked for a simple information system available on mobile devices, where the relevant information can easily be accessed and interpreted right in the field, where they have to make their decisions. Many avalanche safety services had to deal with glide-snow avalanches, which proved very difficult since their release can hardly be predicted. Moreover, many services were challenged by the varying snowfall limit. It was unclear how rain at mid and low elevations affected snow instability and avalanche runout.

In recent years, artificial avalanche release has become an indispensable part of integral avalanche protection. The number of remote avalanche control systems (RACS) such as gas exploders (Gazex) or avalanche towers (Inauen-Schätti or Wyssen) has much increased in the last years. In March 2018, 550 systems were in operational use in Switzerland, including about 250 for the protection of settlements, roads or railway lines; in comparison, in 1999, only 25 systems were in use. The RACS worked very reliably and only a few problems were recorded.

Alarm systems in avalanche tracks automatically close traffic routes when sensors register an avalanche release. The number of systems increased from four in 1999 to about 30 in 2018. The interviewed avalanche professionals reported that these systems worked very reliably. Doppler-radar systems observing avalanche tracks from the opposite slope detected many avalanches and infrasound systems for detecting avalanche releases provided useful information supporting safety services in their decisions. We conclude that thanks to better training and organization of avalanche safety services as well as technological advances, the effectiveness of organisational measures greatly improved since 1999.

## Conclusions

Although the new snow amounts and snow depths were extraordinary resulting in very high avalanche activity, the avalanche situation in January 2018 was less severe than in February 1999. Analysing the events showed that investments in improving integral avalanche protection taken since 1999 – especially with regard to organisational and temporary preventive measures – have paid off. Technological progress and modern information systems, well-educated and well-organised avalanche professionals working in communities and for infrastructure providers all contributed to improved avalanche safety. In settlements and on transportation routes, no people were killed during the days in January 2018 when the highest avalanche danger level was forecasted for most regions of the Swiss Alps. The analysis also showed that processes such as glide-snow avalanches are still not sufficiently understood and that the effect of climate change on the formation and dynamics of snow avalanches requires further research.

## Acknowledgements

We thank the Federal Office for the Environment FOEN for financially supporting the event analysis and the commission for avalanche and rockfall protection under the lead of Reto Baumann (FOEN) for valuable comments on the analysis and its conclusions.

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