ON INDICATOR PATH AVALANCHES FOR LOCAL AVALANCHE FORECASTING

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ABSTRACT: Avalanches are clear signs of instability and thus often considered as the best predictor for further events. In fact, avalanches that release at the beginning of a period with high avalanche activity are called indicator path avalanches. We evaluate whether such indicator path avalanches exist and whether they can be used to improve local avalanche forecasting. Long-term avalanche occurrence data for three areas in Switzerland were analyzed. In the region of Davos, the Salezertobel avalanche was found to have a precursor function, but only if it was of a certain size. In the Urseren valley which runs about west to east from Realp to Andermatt, two indicator path avalanches were found: the Böschenlaui on the northern slopes of the valley and the Lochtal-, Lauital- and Spitzegglaui avalanches on the southern slopes. In the Upper Engadine valley, four adjoining avalanches were considered and analyzed as a single indicator path avalanche. Results suggest that even if indicator path avalanches can predict other avalanches to follow, the quality of the forecast remains rather poor. Whereas there is a good chance that the release of an avalanche in an indicator path is followed by other avalanches, there are too many situations when some of these avalanches release but not the one in the indicator path. Based on our analysis, it seems not feasible to forecast other large avalanches simply based on the avalanche occurrence in an indicator path – still the size of the indicator path avalanche was indicative of the magnitude of the subsequent avalanche activity.

1. INTRODUCTION

Avalanche occurrence is the prime indicator for avalanche danger assessment – a so-called class I factor (McClung and Schaerer, 2006). However, avalanche occurrence data are often not available at the time of the forecast – and even afterwards we may not know where and when exactly during the storm the avalanches released – which strongly hampers verification of the prediction (Schweizer, 2008; Schweizer et al., 2003). Occasionally, an avalanche reaches the valley bottom or hits the road early in the storm – a clear sign of instability and maybe the last indication the avalanche control service needed to close the road.

These type of avalanches that release at the beginning of a period with high avalanche activity, are called "indicator" path avalanches by avalanche professionals as they indicate a high probability of further avalanche events in that specific area. Obviously these indicator paths are also the best location for installing avalanche detection systems (Rice et al., 2002; Statham et al., 1997). An indicator avalanche needs to have a high frequency of occurrence. Perla and Martinelli (1978) suggested evaluating the stability conditions in frequently releasing avalanche paths. If frequent paths were moderately unstable, then instability could be expected on the infrequent paths. However, whether a reliable forecast for infrequent paths is possible based on observations of a frequent path – an indicator path – has so far, to our knowledge, not been studied.

In the presented work, we will preliminarily explore whether such indicator path avalanches exist, how they look like, and whether they can be used to improve local avalanche forecasting.

2. DATA AND METHODS

Three regions in Switzerland, namely the Urseren valley in canton Uri as well as the regions of Davos and Zuoz in canton Grisons, provided the base of the analysis as they have a well-documented avalanche cadastre. We focused on avalanche paths, which have the potential to act as precursors for a following period with high avalanche activity. We explored the three days before and after the potential indicator path released. An indicator path should apparently not have a high number of preceding events. In the following we will only report in detail on the analysis for the region of Davos.

For the region of Davos avalanche activity has been recorded ever since the SLF has been founded and regular observations at Weissfluhjoch

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started (1936). However, data quality varies; it is particularly good between the 1950s and the 1990s when avalanches were consistently reported in the so-called Winterberichte. We focused on the period 1950-1951 to 2011-2012 (61 years). Moreover, all avalanches recorded since the winter 1955-1956, about 7000 in total, are compiled in a GIS. In most cases, occurrence data include length, width, perimeter, date and type of release, and type of avalanche. The time of release is rarely reported; most often for avalanches that caused considerable damage.

New snow and total snow depth data used for the analysis were recorded in the study plot at Weissfluhjoch (2540 m a.s.l) above Davos.

To assess whether a given indicator path has predictive power performance measures such as the probability of detection and the probability of non events were calculated (Doswell et al., 1990; Wilks, 1995).

3. RESULTS

Based on the avalanche occurrence data we first evaluated whether any of the avalanche path that shows a high frequency is suited as indicator path. In the region of Davos three paths frequently released in about the last six decades: Breitzug, Brämabüel and Salezertobel. The Salezertobel avalanche path had the highest frequency with roughly one avalanche per year (Schweizer et al., 2009). Only for the Salezertobel avalanche, the majority of avalanches releasing in the region of Davos, did not occur before the Salezertobel avalanche, but on the same day or one of the three following days. Brämabüel and Breitzug did not perform well and seem not suited as indicator.

The further the Salezertobel avalanche run, the better it fulfilled the requirement of an indicator avalanche (Figure 1). Only the very large ones reaching either the road (before 1984) or nowadays the snow shed can be considered as precursors; thirteen such avalanches were recorded in the last 61 years. In cases the Salezertobel avalanche was small, i.e. had a short run-out length, usually high avalanche activity was recorded in the area, but about one third of the recorded avalanches released before the Salzertobel avalanche run. On the other hand, when the Salezertobel avalanche was very large, i.e. reached the level or the road (or shed), avalanches occurring on previous days were typically rather small. Large avalanches – comparable in size to the Salezertobel avalanche – almost always occurred on the same or one of the following days (Figure 2).

For example, in the avalanche period of 26-27 January 1968 when many large avalanches reached the town of Davos and caused 13 fatalities, the Salzertobel released in the evening of 26 January a few hours before the first fatal avalanche run into town. The Salezertobel avalanche was only preceded by one avalanche in that morning about 10 km south of town. (Yet we definitely do not want to say that the fatal avalanches would have been predictable.)

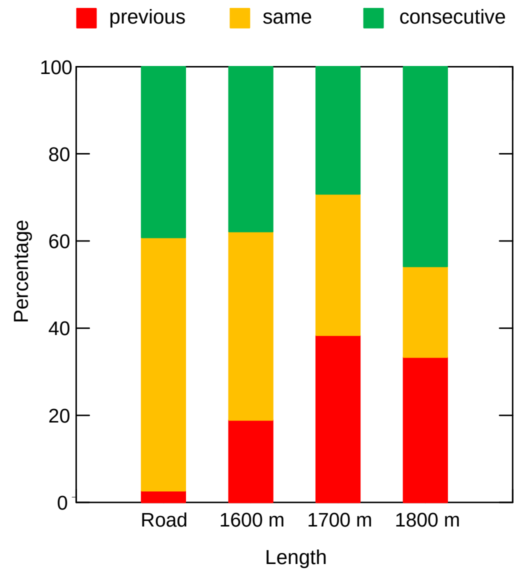

Figure 1: Number of avalanches that released on one of the 3 previous days, on the same day or on the consecutive three days in the region of Davos when the Salezertobel avalanche released. Data are grouped according to the run-out length (size) of the Salezertobel avalanche. The road/shed is at 1560 m a.s.l.

The release of the Salezertobel avalanche was closely related to new snow depth as previously shown by Schweizer et al. (2009). It frequently released when the 3-day sum of new snow depth reached a maximum (Figure 2).

Whenever the Salezertobel avalanche released other avalanche activity in the region of Davos was recorded. In other words, considering the predictive power the false alarm ratio is zero (provided the records are complete). On the other hand, the probability of detection is low, as the indicator avalanche is still a rare event and very many avalanches were recorded when the Salezertobel avalanche did not occur.

For the regions of Urseren and Zuoz indicator paths avalanches were identified as well. In the Urseren valley that runs about west to east two paths have the potential to act as indicator: one on the southern slopes and one on the northern slopes – depending on the direction of the incoming storm.

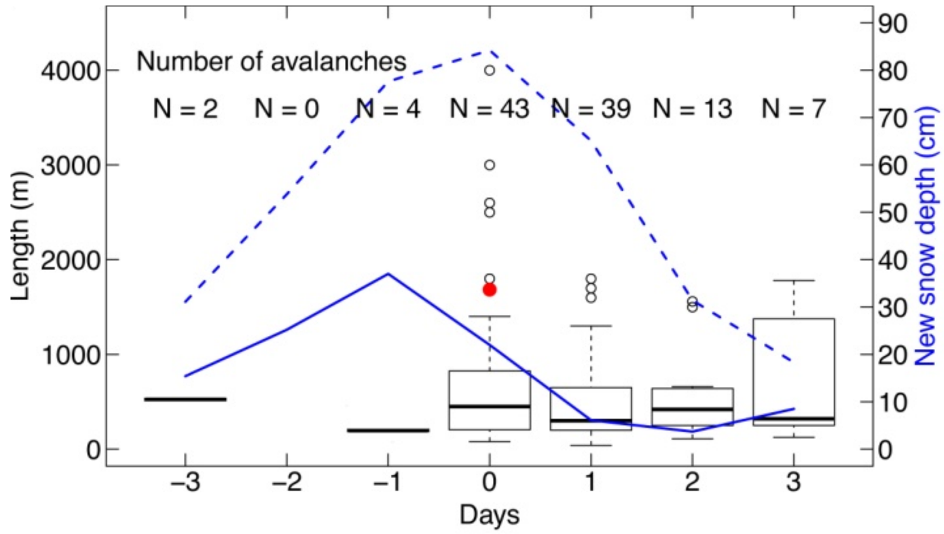

Figure 2: Length distribution of the avalanches recorded in the region of Davos on the 3 days before, on the same day and during the 3 days after the Salezertobel avalanche run to the road/shed. Boxes show interquartile range, black lines the median, whisker 1.5 times the interquartile range and open dots indicate extreme values. Red solid dot indicates mean length of the Salezertobel avalanche. Blue solid line shows the new snow depth (24 h), dashed blue line the 3-day sum of new snow as measured at Weissfluhjoch.

4. CONCLUSIONS

We have explored three avalanche datasets to find frequently releasing avalanches that can serve as indicator avalanche, i.e. release early in a storm and are followed by other major activity. In all three regions one or several paths in combination were found to fulfill this requirement.

On the release of the indicator avalanche, in particular if it is of large size, other avalanches will always follow. The indicator path is thus a reliable predictor of other avalanche activity. However, as its frequency is still relatively low, there will be many other situations when avalanche activity is recorded, but the indicator path did not release; in most cases the preceding avalanches were rather small. Nevertheless, this means, if one would rely on the indicator path, many avalanche situations would be missed. It is therefore not possible, to forecast avalanches simply based on observing an indicator path. As with other predictor variables in avalanche forecasting, the variable cannot be used alone and the predictive power is unbalanced in terms of sensitivity and specificity.

Still, monitoring indicator paths with avalanche detection systems may provide valuable data for the prediction of large, often disastrous avalanches.

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