A CONTRIBUTION TO A BETTER UNDERSTANDING OF THE METEOROLOGICAL TRIGGERING CONDITIONS OF PAST DEBRIS FLOWS

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INTRODUCTION

Through their unpredictable and sudden occurrence, debris flows represent a major hazard in many mountainous regions all over the world. The understanding of the triggering factors of such events is crucial for hazard assessment, forecasting of events and for early warning systems. In the recent past, many studies have been published on rainfall conditions, minimum thresholds, duration-intensity relationships or on antecedent moisture conditions leading to debris-flow triggering. These studies were normally based on archival records or directly observed events and therefore often had a rather limited temporal coverage.

In our contribution, we present a reconstruction of past triggering condition based on an exceptionally long (dating back to 1864) and complete record of past debris-flow activity and meteorological time series in the Zermatt Valley, Swiss Alps (Fig.1).

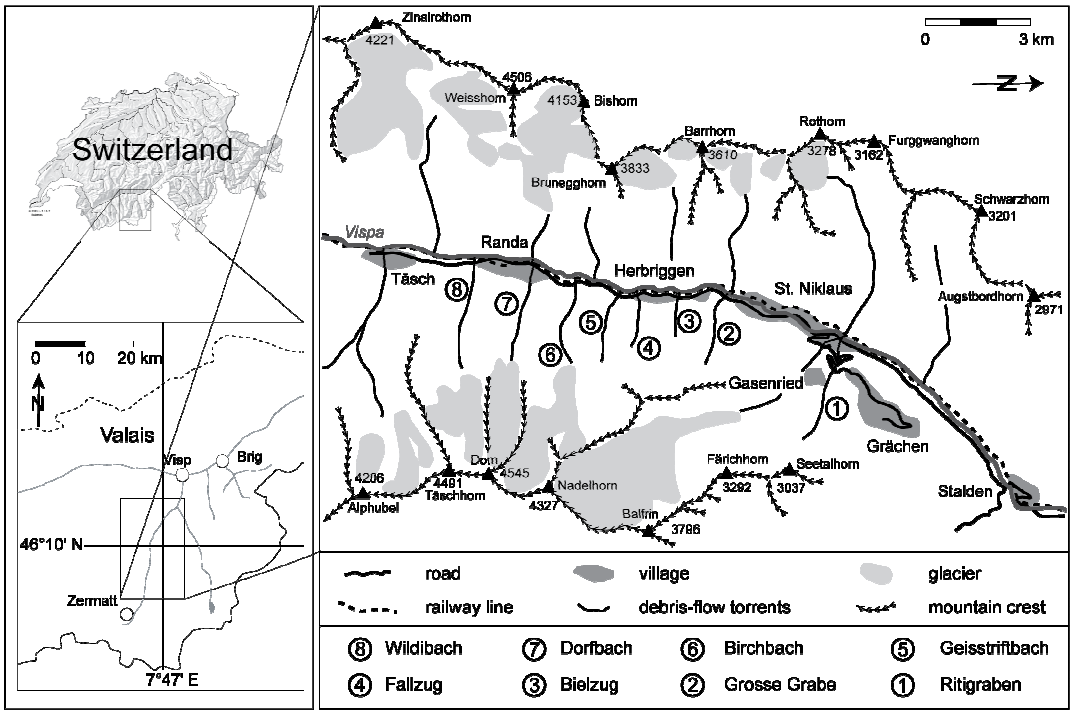

Fig. 1 Location of the eight torrents in the Zermatt valley where the debris-flow occurrence and triggering conditions have been investigated.

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Through the integration of tree-ring data, archival records, runoff data as well as daily precipitation and temperature data from three meteorological stations in the valley, the timing and amounts of rainfall involved in each debris-flow event have been reconstructed. Based on this reconstruction, statistical tests and a logistic regression model have been applied to filter out the relevant parameters for the triggering of debris flows.

PRELIMINARY RESULTS

First results show that the debris-flow season in the study region lasts from May to October with August being the month with the highest occurrence of debris-flow events (36%) whereas events in May and October remain very scarce with 4% and 7%, respectively. More than half of the debris flows were triggered by short-duration, high intensity convective rainfalls lasting at a maximum one day and only 11.5% of the events were released after persistent advective rainfall of more than 2 days. Towards the end of the debris-flow season in September and October, the percentage of long-lasting rainfall events considerably increases as compared to the summer months of July and August when local thunderstorms seem to represent the main triggering factor. Total precipitation sums involved in debris flow triggering ranged from below 20 mm for short-duration events to up to over 50 mm on average for the long-lasting rainfalls and were generally lower for events during July and August than very early or late in the debris-flow season. Significant differences in the characteristics between triggering and non-triggering rainfall events since 1981 could be seen in the total amount of rainfall involved, storm duration and in temperature. In contrast, it seems that antecedent rainfall did not affect the release of events.

First results of the logistic regression model indicate that triggering of debris flows in the Zermatt valley is solely influenced by precipitation parameters and that temperature does not have a significant influence. These findings indicate that material production and availability does not represent a limiting factor for the release of debris flows.

OUTLOOK

Further investigations will focus on changes in the seasonality of debris-flow occurrence over time and on the improvement of the logistic regression models. In addition, we will define the percentage of rainfall events with a certain intensity that led to the release of a debris-flow event. We will also have a look to the future and investigate how many events over a certain threshold are to be expected in a future greenhouse climate.

Keywords: debris flow, triggering, reconstruction, rainfall, advective, convective, tree ring, dendrogeomorphology, Swiss Alps