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## How does climate change impact rockfall occurrence at low elevations? Insights from a regional data set of historical events

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Rockfall events occur particularly in steep mountain areas and represent a major hazard for infrastructure and settlements. Complex interactions between susceptibility and triggering factors pose a great challenge for forecasting and managing this hazard. The increased rockfall activity in the Alps during the hot summer of 2003 has contributed to the growing interest in the link between rockfall occurrence and climatic changes caused by global warming. Rockfall inventories contain geographical and typological information on rockfall events and can serve as an important basis for obtaining information on the impacts of global warming on rockfall activity. However, such inventories are often incomplete, and the recording standards have changed over time, which may impair comparability.

In the present study, data from the regional rockfall inventory of the canton of Grisons (CH) with more than 1300 rockfall events were used to analyze their frequency over time and with regard to the climatic factors temperature and precipitation. We considered events from 1950-2023, with most of the release zones lying below the permafrost boundary. To avoid biases due to varying recording standards and completeness of the data, several observation intervals were defined, for which the data was analyzed separately.

The results show an increase in rockfall events over the last twenty years, regardless of the volume of the events. The increase is particularly evident in the rising number of summer events. Together with the increasing ratio of summer events to the total number of events over the past twenty years and a clearly negative trend in the number of winter events to the total number of events, this reveals a potential link to climate change. The highest frequency of rockfall events was observed in the spring months. In addition, an increased frequency was identified in the summer months, which is in line with the results of other studies.

The results of the temperature analyses were less clear. There are both negative and positive deviations in the average temperature on the day of the event compared to the long-term average in connection with rockfall events. The analysis of the temperature amplitude also showed no decisive results. The analyses of precipitation proved to be difficult due to the high daily variability. However, an increase in events related to precipitation was observed. During the event week, precipitation sum tends to be higher than in the weeks without an event, which underlines the importance of precipitation as a trigger factor.

The results of the study underline potential impacts of climate change on rockfall occurrence. They further illustrate the complexity of the relationships between climatic factors, geographical conditions and rockfall events. Finally, the study also underlines the importance of complete and detailed hazard inventory data at regional level.