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Impact of permafrost degradation on debris flow initiation – a case study from the north Italian Alps

Bodo Damm (1) and Astrid Felderer (2)

(1) University of Vechta, ISPA, Applied Physical Geography, Vechta, Germany (bodo.damm@uni-vechta.de), (2) Umweltbundesamt Wien, Umweltfolgenabschätzung & Klimawandel, Spittelauer Lände 5, A-1090 Vienna, Austria

Atmospheric warming in high mountain environments causes a range of impacts, including glacier recession, reduction of permafrost extent and distribution as well as changes in thermal permafrost properties. Furthermore, it is likely that climate change affects the occurrence of natural hazards, like shallow landslides and debris flows, as their initiation is related to the degradation of the cryosphere.

The present study demonstrates the importance of recent atmospheric warming for the spatial distribution of debris flow initiation in a central alpine area of the Italian Alps (Europe). It is primarily based on the modelling of the spatial distribution of permafrost using a database of geomorphologic, hydrologic, and physical permafrost indicators and the CRYOSNOW-approach.

There is first evidence that it is possible to quantify the regional debris flow hazard potential based on field survey, in-situ measurements, climate data analyses, and GIS-based simulations for different climate scenarios and variable geomorphic stability. In particular, permafrost degradation due to increasing mean annual air temperature (MAAT) since the end of the Little Ice Age (LIA) caused mechanical instabilities of sediments and slopes. In the study area it can be shown that almost half of the debris flow initiation zones originate in areas with loose rock that were still stabilized by glacier ice and/or permafrost about 150 years ago.

Compared to present conditions the permafrost area would decrease by approximately 72% by the middle of the 21st century with regard to an increased air temperature of +1 to +2 K. Moreover, glaciers widely disappear in this scenario. This may presumed to be a moderate increase of temperature in relation to the predicted climate development of the IPCC. Ongoing glacier recession and permafrost degradation increase the amount of instable debris as well as the potential of debris flow detachment zones in the future.

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