24rd Climate Day
02. - 04. April 2024
TU Vienna

CAUT!ON
Landslides in high-alpine environments : climate change impacts, exposure, and policy implications

PRANDSTÄTTER Lukas[1], ECHTLER Pia[3], FEY Christine[1], FORMAYER Herbert[2], FUCHS Sven[3], KEILER Margreth[4] KLISHO Tatiana[2], KUSCHEL Erik[1], LEHNER Fabian[2], MAYER Andrea Carina[4] POLDERMAN Annemarie[4] RIEDER Harald[2], VOIT Klaus[1], ZANGERL Christian[1]

BOKU University - Institute of Applied Geology (IAG) (1), - Institute of Meteorology and Climatology (BOKU-Met)(2), - Institute of Mountain Risk Engineering (IAN)(3), Vienna
Austrian Academy of Sciences - Institute for Interdisciplinary Mountain Research (4), Innsbruck

Introduction

Rock falls, rock avalanches and rock slides are a common hazard in alpine terrain and are major factors of alpine landscape evolution. They are characterized by a complex combination of geological, hydrological, geomechanical and meteorological processes. In the Alps in particular, landslides have the potential to cause serious damage to both humans and infrastructure.

As global warming progresses, the meteorological and climatological factors that influence landslide formation will change. Especially, in high mountain environments, climate change related factors like, the rise in mean and extreme temperature, the change in the precipitation characteristics, thawing of permafrost and the retreat of glaciers are progressing rapidly (IPCC, 2021).

Figure 1: Installation of temperature sensors on the Stubai Glacier

Structure of the project

- Analysis of the local meteorological conditions before rock fall and rock avalanche events, which were determined from the event inventory.
- Creation of an event database for the period 2006 to 2017. Carrying out statistical analyses to identify events in which permafrost, glacier retreat or meteorological extremes could have led to slope failure.
- Building of an in-situ rock slope laboratory for long-term monitoring of rock slopes, equipped with various types of sensors, and carrying out remote sensing campaigns with TLS and UAV as well as geological surveys.
- Creation of an inventory of buildings exposed to natural hazards and assessment of the population at risk in the case studies. Assess the economic effects of landslide impacts on the local level of remote alpine valleys by examining commuter flows and considering the evolution of resident populations.

- Stakeholder participation centers on establishing a shared comprehension of landslide hazards, exposure, and vulnerability. Collaborative efforts aim to develop adaptation strategies for reducing risk.

Examples of preliminary results

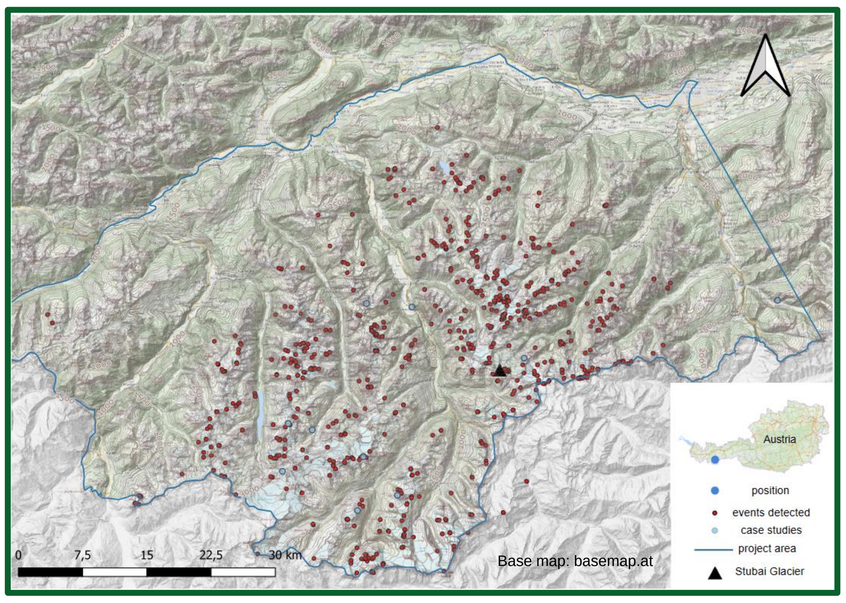

Figure 2: Selected study area framed in blue. The red dots mark events from the rock fall inventory, the selected case studies are marked by blue dots. The black triangle marks the location of the rock slope laboratory on the Stubai Glacier.

- Rock fall inventory (Fig.2) documents 700+ events from 2006 to 2017, exceeding 50 m³ in volume.
- Seven locations report volumes reaching 100,000 m³.
- Analysis of regional inventory highlights increased rock falls in areas impacted by glacier retreat and permafrost degradation.
- High rock fall activity observed on north-western slopes (Fig.3) of Schaufelspitze.
- Installation of measuring instruments (Fig.1) in June 2023, with first data readout (Fig.4) in fall.
- Preliminary results show there is a common interest in ensuring the resilience of mountain communities facing climate change and finding ways to deal with resulting uncertainties.
- Stakeholders are indicating they want comprehensive risk management alongside disaster prevention plans.

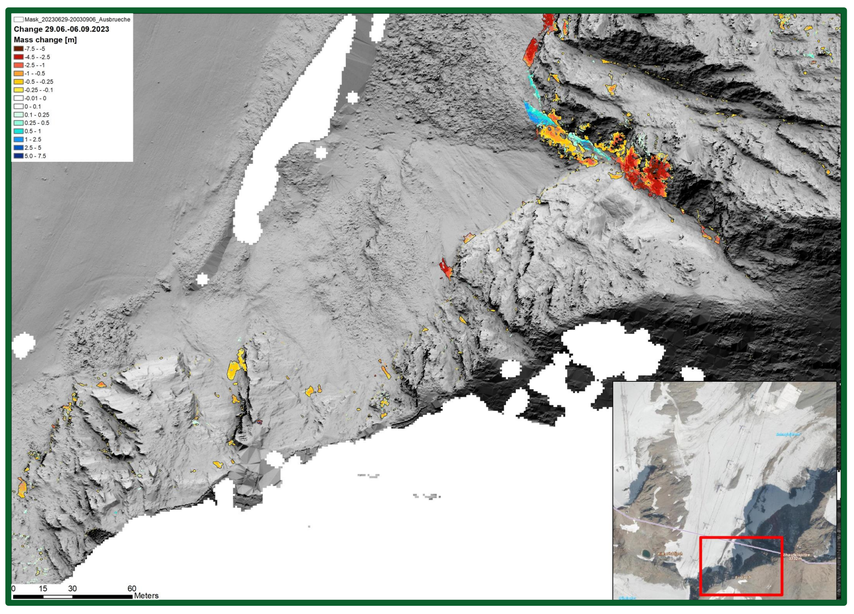

Figure 3: Change in mass on the northwest face of the Schaufelspitze between August and September 2023.

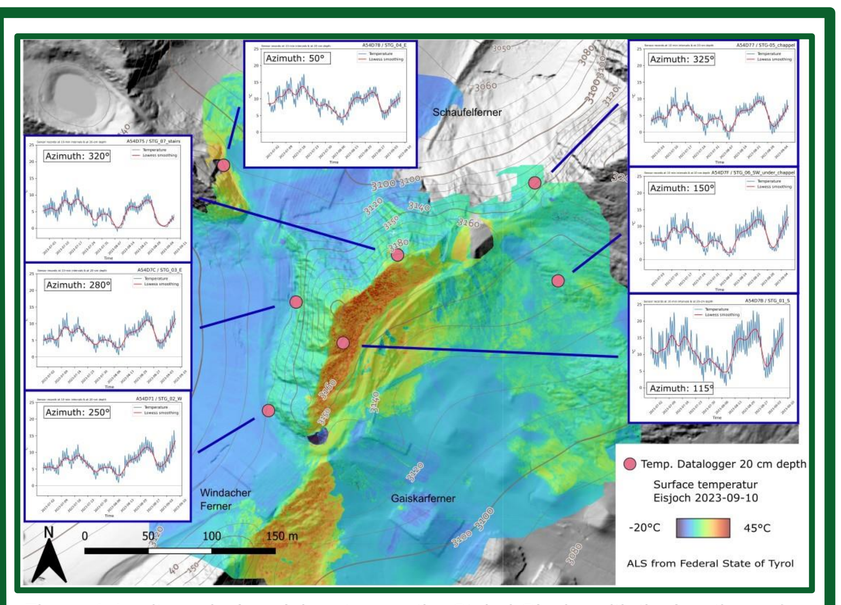

Figure 4: In-situ rock slope laboratory on the Stubai Glacier with the locations of the temperature data loggers and the thermo-orthomosaic of the rock surface temperature based on UAV-thermography.

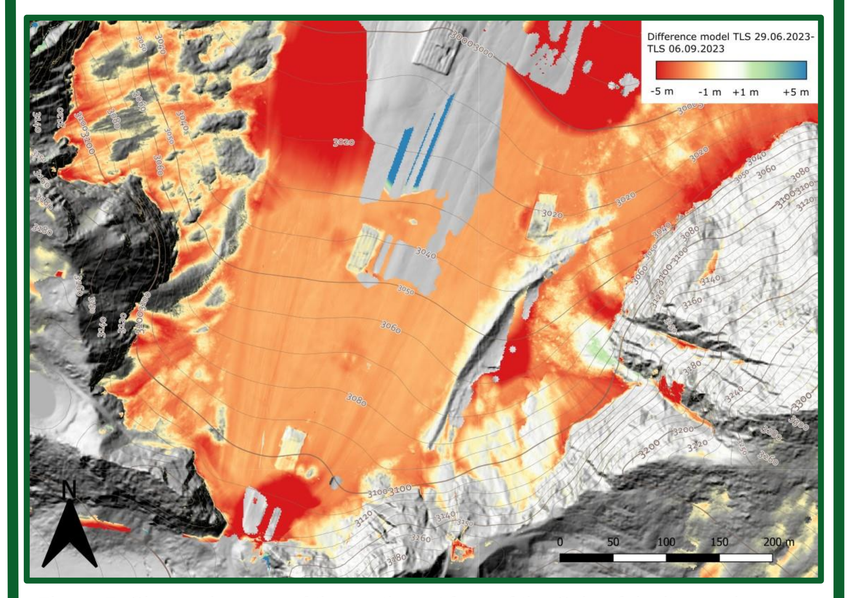

Figure 5: Change in mass of the northwest face of the Schaufelspitze and Schaufelferner between the TLS campaigns 29.06.2023 and 06.09.2023.

Outlook and conclusion

- The location of the in-situ rock slope laboratory (Fig.4) on the Stubai Glacier has proven to be excellent, as a large number of changes in the high alpine terrain can be observed there (Fig.5).
- Additional temperature, UAV and TLS measurements.
- Comprehensive statistical analyses of the meteorological data in relationship to the events.
- Installation of temperature loggers (1m depth), fiberglass-extensometer and crack meter to measure deformation in-situ.
- Detailed geological surveys will be conducted
- Further search will be conducted for rock fall and rock avalanche inventory event dates.
- Organisation of a third stakeholder workshops and evaluation of the data.
- Vulnerability assessment of selected areas.

Acknowledgements-Financial support

- This project was made possible by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) as part of the Austrian Climate Research Program (ACRP) of the climate and energy fund.
- The Stubaier Bergbahnen KG for their cooperation and support in setting up the rock slope laboratory.
- The mayors of the municipalities of Gries im Sellrain and Kaunerberg for their help in organizing the workshops.

Literature

IPCC (2021): Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. - Cambridge University Press;