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Spatial and temporal variability of rock fall in a (peri)glacial environment: a LiDAR-based, multi-year investigation of rock fall release zones and volumes, Kitzsteinhorn, Austria

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Rock instabilities in high mountain areas pose an important threat to man and infrastructure. Numerous observations from the European Alps suggest an increasing occurrence of rock fall events that might stand in direct relation to recent atmospheric warming. Laboratory testing of rock- and ice-mechanics indicates that rising temperatures potentially have a distinct destabilizing effect on steep rock faces underlain by permafrost. However, unbiased field data on spatial and temporal distribution of rock fall events in high alpine environments is usually scarce. Most investigations rely on strongly biased visual observations and/or sporadic optical measurements. This contribution addresses the need for more systematic and objective field data by presenting a multi-year TLS (terrestrial laserscanning) data series from a high alpine (peri)glacial environment, which is corroborated by data from local weather stations, near-surface rock temperatures, and visual observations.

The presented work has been conducted within the currently running research project MOREXPERT ('Developing a Monitoring Expert System for Hazardous Rock Walls') whose study area is located at the Kitzsteinhorn (3.203 m), Hohe Tauern Range, Austria. The area surrounding the Kitzsteinhorn is easily accessible (tourist infrastructure, cable car) and possesses numerous rock faces that are intensely affected by glacier-permafrost interactions.

Four scan positions that offer views of different rock faces have been selected for the acquisition of TLS data. The investigated rock faces, which predominantly consist of calcareous mica-schist, differ in height, slope, aspect, and discontinuity orientation. Scanned rock faces include Kitzsteinhorn N and NW face, Magnetkoepfl W and E face, Maurerkogel E face and Schmiedinger W face. The beginning of the TLS campaign at the Kitzsteinhorn dates back to July 2011. Since then scans have been repeated at an interval of 1-2 months during the summer season (June to October). All scans (n = 41) were conducted using a RIEGL LMS-Z620. The resulting spatial resolution varies between 0.1 and 0.5 m and object distance (i.e. distance between scanner and rock face) ranges from 250 to 500 m.

Post-processing of TLS data enabled to precisely identify rock fall release zones, rock fall volumes and surface changes of the Schmiedingerkees glacier (lowering rate of approximately 1.5 m per year). Since 2011 a total number of nine rock fall events with a volume exceeding 100 m^3 have been recorded – with the largest reaching a volume of approx. 500 m^3. All were triggered from areas that have been exposed by the retreating Schmiedingerkees glacier over the last 1-2 decades. Thus, glacial debuttressing and subsequent exposure to atmospheric influences might be considered as the dominant destabilizing factors.

Temporal clustering of rock fall events over the first three seasons (2011 to 2013) tentatively indicates a bimodal occurrence pattern with a first maximum during snowmelt (May/June) and a second distinct peak during the warmest period of the year (August).