Geophysical Research Abstracts
Vol. 20, EGU2018-7444, 2018
EGU General Assembly 2018

Landslide characterisation based on multi-temporal terrestrial laser scanning in the cirque of the Austre Lovénbreen

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The slopes surrounding the Austre Lovénbreen glacier (79°N, Ny-Alesund, Svalbard) were selected to study the occurrence, spatial distribution and temporal evolution of landslide processes in the high arctic. In addition, the impact of ongoing glacier retreat and warming-induced permafrost degradation on landslide formation mechanisms is investigated by analyses of multi-temporal terrestrial laser scanning (TLS) data and geological field surveys.

The cirque of Austre Lovénbreen glacier is located in the basement rocks of the Kongsvegen Group which is composed of the Nielsenfjellet, Steenfjellet and the Bogegga Formation. For this study particular focus is placed on low strength and penetrative foliated phyllites of the Nielsenfjellet Formation. The area was chosen because this rock type is prone for different landslide processes including deep-seated rock slides, shallow soil slides, solifluction, rock avalanches and falls.

In the study area, the landslide inventory was mapped during a field survey in 2017 and by the analysis of multi-temporal TLS data. TLS was performed annually since 2012 and provide high resolution digital elevation models of the slopes and thus enable the detection of topographical changes induced by landslides. Ortho-images, aerial photographs taken since 1936 and ground based photographs taken during the field campaign provide additional information about the different slope processes. With the help of differential maps derived from terrestrial laser scanning and photogrammetric models slope and landslide processes are identified and mapped using geographic information systems.

During the field campaign several shallow translational soil slides with depths ranging from 1-5 m were observed. The basal shear zones of the soil slides were formed directly on the contact between the soil layer and an underlaying glacier ice layer. The frequently occurrence of these type of failure mechanisms at different heights of the slopes shows that the underlaying ice layer can be found up to 100 m above the Austre Lovénbreen valley glacier as was shown through previous GPR studies conducted in the area. Field observations suggest that formation of the shallow soil slides is related to a mass loss of the valley glacier i.e. loss of the retaining effect at the foot and/or the reduction of shear strength at the contact between the soil and ice layer most probably due to temperature increase and water infiltration. Furthermore, on all slopes solifluction sheets and lobes were observed indicating active shallow soil creep. Surprisingly, no characteristic structures indicating deep-seated rock slides were found in the area even though the slopes are steep and composed of intensively fractured low-strength phyllitic rock masses.

The presented study provides a preliminary insight into landslide processes that occur in slopes of the high arctic affected by glacier retreat and permafrost degradation.