Delineation of rock avalanche deposits on glaciers from different remote sensing data

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Glacial headwall retreat is often related to slope movement processes such as rock falls or rock avalanches from the over steepened cliffs. Due to the effects of climate change it is expected that such events will occur more frequently in future, especially in subarctic regions where permafrost degradation, the relief of slopes as a result of glacier recession, and changes in the ice cover will render slopes more susceptible to mass movements. In order to evaluate the effects of climate change with respect to the size and frequency of rock falls/ avalanches in glacial environments, it is essential to have detailed historical inventories. Regarding this, the use of remote sensing data shows a high potential for the spatio-temporal identification of rock fall/ avalanche deposits on glaciers, especially over large and inaccessible areas.

In this case study, we focus on the detection of major rock fall/ avalanche deposits in the Vatnajökull National Park located in southeast Iceland, which contains - beyond the Polar Regions - the largest glacier in Europe, the Vatnajökull ice sheet. Many outlet glaciers, each with distinct characteristics, are part of this massive ice sheet. Three major rock fall/ rock avalanche events on outlet glaciers (Morsárjökull, Svínafellsjökull and Svöludalsjökull) are investigated in this study. The main aim is to semi-automatically delineate sediment depositions on glacier tongues originated from mass wasting by means of object-based image analysis (OBIA) using various remote sensing data. In OBIA, pixels are grouped into objects (usually based on spectral of functional homogeneity) that serve as basis for the classification. OBIA enables the semi-automated detection and classification of complex natural phenomena due to its capability to address spectral, spatial, textural and contextual properties of target classes and allows the integration of different data sets and data derivatives. Post-event remote sensing data, i.e. optical satellite images (e.g. SPOT-5, Landsat), synthetic aperture radar (SAR) data (e.g. TerraSAR-X, Sentinel-1) and digital elevation models (DEMs - e.g. ArcticDEM, Tandem-X DEM), are used independently as basis for the analyses. Band ratios of optical data, texture descriptive features of SAR and DEM data, and normalized SAR backscatter and coherence values are applied for the delineation of rock fall/ avalanche deposits. Classification accuracy is assessed by comparing outcomes to reference polygons obtained from visual image interpretation. The results derived from the various data sources are evaluated with respect to achieved accuracy metrics and transferability to other sensors with different spectral or spatial resolutions. By doing so, the most suitable remote sensing data for delineating rock fall/ avalanche deposits on glaciers using OBIA will be identified.

In further consequence, a detailed inventory of past rock falls/ avalanches could be compiled applying the developed classification routines on historical and recent remote sensing data. Better knowledge about the occurrence, location and size of rock falls/ avalanches onto glaciers is useful to estimate the regional effects of climate change and can have implications for glacier tourism, which is an important economic factor in Iceland.