DELINEATION OF ROCK AVALANCHE DEPOSITS ON GLACIERS FROM DIFFERENT REMOTE SENSING DATA

Barbara FRIEDL1, Daniel HÖBLING1, Jirathana DITTRICH1, Dirk TIEDE3, Thorsteinn SAEMUNDSSON2, Snævarr GUDMUNDSSON3 & Gro B.M. PEDERSEN4

1Department of Geoinformatics - Z_GIS, University of Salzburg, Salzburg, Austria; 2Faculty of Life and Environmental Sciences, University of Iceland, Reykjavik, Iceland; 3South East Iceland Nature Research Centre, Hofn, Iceland; 4Institute of Earth Sciences, University of Iceland, Reykjavik, Iceland

(*Corresponding author: barbara.friedl@sbg.ac.at)

(1) Introduction

Glacial headwall retreat is often related to slope movement processes such as rock falls or rock avalanches from the oversteepened 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 depositions on glaciers, especially over large and inaccessible areas.

(2) Objectives

The main objectives of this case study are:
- to semi-automatically delineate major rock fall/avalanche depositions on glacier tongues originated from mass wasting by means of object-based image analysis (OBIA), and
- to test the applicability of various remote sensing data, i.e. optical satellite images, synthetic aperture radar (SAR) data, and digital elevation models (DEM), for semi-automated mapping of the debris deposits.

(3) Study Area

The study area is located in southeast Iceland in the surroundings of the Öraefajökull area in the Vatnajökull National Park. This national park contains - beyond the Polar Regions - the largest glacier in Europe, the Vatnajökull ice sheet.

Several outlet glaciers, each with distinct characteristics, are part of this massive ice sheet. Three major rock fall/rock avalanche events on the outlet glaciers Morsárjökull, Svinafellsjökull and Svaldalsjökull are investigated in this study.

(4) Data

Post-event remote sensing data, i.e. optical satellite images, SAR data and DEMs, were used independently as basis for the analyses. The high rock avalanche deposits on glaciers from different remote sensing data were delineated using object-based rule-sets adapted for the different optical, SAR and DEM data sets. A canny edge extraction algorithm was used to support the delineation of the rock avalanche deposits as single objects. Band ratios of optical data, e.g. brightness, Normalized Difference Snow Index (NDSI), texture descriptive features, i.e. Gray-Level Co-Occurrence Matrices (GLCMs), and normalized SAR backscatter values were applied for the classification.

(5) Methods

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. Image segmentation algorithms were used to group pixels into objects (based on spectral or functional homogeneity) that usually serve as basis for subsequent classification. The extent of the debris cover on the glacier was automatically delineated using object-based rule-sets adapted for the different optical, SAR and DEM data sets. A canny edge extraction algorithm was used to support the delineation of the rock avalanche deposits as single objects. Band ratios of optical data, e.g. brightness, Normalized Difference Snow Index (NDSI), texture descriptive features, i.e. Gray-Level Co-Occurrence Matrices (GLCMs), and normalized SAR backscatter values were applied for the classification.

(6) Results

Morsárjökull

Svaldalsjökull

Svinafellsjökull

(7) Validation

Classification accuracy was assessed by comparing outcomes to reference polygons obtained from visual image interpretation. By doing so, the most suitable remote sensing data for delineating rock fall/avalanche depositions on glaciers using OBIA was identified.

(8) Discussion & Conclusion

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 on 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.