Monitoring of active rock glaciers by means of digital photogrammetry

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Rock glaciers are creep phenomena of alpine/mountain permafrost and consist of a mixture of rocks (debris) and ice. The upper layer (= active layer) is only composed of rocks, its voids are not filled with ice. From a bird's eye view rock glaciers display a viscous flow-like landform with often prominent furrows and ridges. Typically, the front slope of intact rock glaciers is straight and steep. Rock glaciers may be lobate or tongue-shaped, their age is estimated at several thousands of years.

Active rock glaciers are creeping downhill by force of gravity. The annual flow velocities are in the range of centimeters to meters. This movement causes surface deformation, creating a topography as described above. In general, the rate of change of the flow velocity and of the rock glacier thickness is strongly influenced by climatic parameters, i.e., the mean annual air temperature and precipitation.

In the first part of our poster presentation we introduce our in-house developed software package ADVM (Automatic Displacement Vector Measurement) with which surface flow velocities and surface height change of rock glaciers can be measured semi-automatically by means of digital photogrammetric methods applied to digitized multi-temporal aerial photographs. In the second part results from two case studies are presented numerically and graphically.

The concept of the ADVM software is based on the automatic measurement of 3-D displacement/flow vectors of prominent features of the rock glacier surface, i.e. rocks and boulders, in aerial photographs taken in two different time periods. In order to cope with differing photo scales and flight line geometries we propose the use of quasi-orthophotos for digital image matching. Preliminary disparity maps between the orthophotos are computed using the normalized cross-correlation function. Based on this information of approximate locations of homologous points high-precision image matching is then only carried out at points, which had been selected using the Foerstner interest operator, applying the least-squares matching algorithm. As a result, precise 3-D displacement/flow vectors can be computed and the given preliminary digital terrain model(s) can be improved as well.

The ADMV software has been tested within the framework of two case studies which comprised the spatio-temporal analysis of the dynamic behavior of three active rock glaciers in the Austrian Alps, i.e., the Inneres and Aeusseres Hochebenkar rock glaciers in the Oetztal Alps and the Hinteres Langtalkar rock glacier located in the Schober group, Hohe Tauern range. Multi-year aerial photographs taken in the years between 1953 and 1999 were evaluated. From a geomorphological point of view the main findings are as follows: The analysis of the digital measurements obtained for the Aeusseres Hochebenkar rock glacier and the Hinteres Langtalkar rock glacier reveal a surface flow velocity field which increases nearly linearly from the root to the snout of the rock glaciers, with maximum values of 1-2 m/year. The quite active state of the two rock glaciers is mainly induced by their specific topographic situation. At the Inneres Hochebenkar rock glacier two active regions (present maximum horizontal flow velocities of up to 35 cm/year) are separated from each other by a rather inactive zone.

Mapping and visualization of the retreat of two cirque glaciers in the Austrian Hohe Tauern National Park

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The present work describes the reconstruction and visualization of the retreat of two small cirque glaciers since the Little Ice Age advance of 1850. The two neighboring glaciers, Goessnitzkees and Hornkees (see Fig. 1), are located in the Schober group (Hohe Tauern range, Austria). The detailed explanations refer to a research project which has been carried out by the Institute of Geography (University of Graz) and the Institute of Geodesy (Graz University of Technology) with financial assistance from the Hohe Tauern National Park Service. On the basis of prominent moraines (1850), old maps (1873, 1929) and metric aerial photographs (1954, 1969, 1974, 1983, 1992, and 1997) 9 glacial stages of the recent history of the glacier were reconstructed. All relevant data are stored in a digital database for glacier studies which is composed of 4 layers, i.e., digital terrain models, glacier boundaries/ masks, orthophotos, and collateral information. A comprehensive spatial-temporal