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Morphometry-based mapping of debris-covered glaciers

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Glaciers are sensitive climate indicators and thus the object of climate change- and environmental monitoring. Remote sensing techniques are often the only way to analyse glaciers in remote mountain regions and to monitor a large number of glaciers simultaneously. Although there exist several glacier mapping methods, the results are often not good enough for in-depth conclusions. In particular, this applies to debris-covered glaciers. For several glaciers at Mount Everest (Nepalese Himalaya), in the Bernina Massif (Swiss Alps) and in the northern Tien Shan (Kazakhstan/Kyrgyzstan) a morphometry-based glacier mapping (MGM) has been carried out. Whereas the debris cover of the glaciers in the Bernina Group and in the northern Tien Shan is mainly limited to the middle moraines, the glacier margins and the front, the major part of the Nepalese Mount Everest glacier-tongues is heavily covered by debris and displays manifold forms of “cryokarst”.

The morphometric analysis is based on DEMs generated from ASTER- and SRTM3 data and - for the Bernina Massif - also on the Swiss DHM25, Level02 (©Swisstopo). One approach of the MGM method focuses on curvature characteristics. Combining plane and profile curvatures in a cluster analysis, both the surface and the margins of the valley glaciers - including the debris-covered parts – could be very well identified in the Bernina Group and the northern Tien Shan. Clearly, the number of the identifiable distal glacier portions depends on both the resolution and the quality of the DEM.

However, due to the different characteristics of the Himalayan debris-covered glaciers, the approach using curvature as the only mapping criterion is very useful to describe

the surface characteristics of these glaciers. Yet, their delineation is mostly not possible. Hence, the MGM method has to be applied to these glaciers in a more complex way. This approach includes beside the curvature both slope and altitude. In addition, statistical parameters like standard deviation and diversity of the curvature and the thermal band of ASTER were used to improve the model. The final results look rather promising.

ASTER data and self-generated ASTER DEMs of the Mt. Everest Region for the years 2001, 2002, 2003, and 2005 demonstrate the developed method's potential to analyse and monitor glacier changes even there.