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Mapping clean and debris-covered glaciers from Palsar coherence images

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Glaciers are widely recognized as sensitive indicators of climate change. In order to quantify this change accurately on a regional scale, a glacier inventory with vector outlines in a digital format is mandatory. Such inventories are presently compiled in all parts of the world using satellite data and later provided to the GLIMS glacier database. While automated glacier mapping from multispectral classification techniques (e.g. thresholded ratio images) is in general quite easy and accurate, most of the workload is still required for the editing of debris-covered glacier tongues during post-processing. For most glaciers, this is straightforward given that sufficient contrast (e.g. due to illumination differences) allows to recognize the boundary with the surrounding terrain. However, for many glaciers large uncertainties remain or it can even be impossible to delineate them. Hence, a number of semi-automatic approaches have been developed to assist in the correct interpretation of debris-covered glacier parts.

So far, the techniques developed to map debris-covered glaciers include the consideration of topographic characteristics derived from a DEM (e.g. slope, curvature), neighbourhood analysis, thermal bands, object oriented classification, high resolution LIDAR DEMs, artificial neural networks, or elevation changes derived from DEM differencing. In general, the results of these methods remain noisy and need to be corrected by manual editing. Here we present a method that provides precise extents of debris-covered as well as clean glaciers using ALOS PALSAR coherence over images acquired with a 46 days time lag during the snow-free period in summer. The method utilizes the motion-related decorrelation of glaciers in contrast to the highly coherent surrounding alpine areas. The method has been developed within the framework of the ESA project GlobGlacier and is demonstrated for a region with abundant heavily debris-covered glaciers in the Himalaya (Kashmir).

While the strong contrast in the coherence images depicts glacier extents precisely, the images have up to now only been used to support manual digitization. Though it seems possible to derive glacier extent directly from the coherence, there are several features that show a similar loss of correlation during the 46 days period. In particular, unstable slopes at steep lateral moraines and the ever changing network of rivers in front of a glaciers terminus must be inspected. The method also identifies clean glaciers accurately. This is highly valuable in regions where glaciers are located under frequent orographic clouds. We have also analyzed the coherence in terms of the related surface velocities to test the wider applicability of the approach. In particular, we identified the possibility to discriminate debris-covered glacier tongues from directly connected regions of creeping permafrost.