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Inventory and state of activity of rockglaciers in the Ile and Kungöy Ranges of Northern Tien Shan from satellite SAR interferometry

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The best visual expression of mountain permafrost are rockglaciers, which, in contrast to the permafrost itself, can be mapped and monitored directly using remotely sensed data. Studies carried out in various parts of the European Alps have shown surface acceleration of rockglaciers and even destabilization of several such landforms over the two last decades, potentially related to the changing permafrost creep conditions. Changes in rockglacier motion are therefore believed to be the most indicative short- to medium-term response of rockglaciers to environmental changes and thus an indicator of mountain permafrost conditions in general.

The ESA DUE GlobPermafrost project develops, validates and implements EO products to support research communities and international organizations in their work on better understanding permafrost characteristics and dynamics. Within this project we are building up a worldwide long-term monitoring network of active rockglacier motion investigated using remote sensing techniques. All sites are analysed through a uniform set of data and methods, and results are thus comparable. In order to quantify the rate of movement and the relative changes over time we consider two remote sensing methods: (i) matching of repeat optical data and (ii) satellite radar interferometry. In this contribution, we focus on the potential of recent high spatial resolution SAR data for the analysis of periglacial processes in mountain environments with special attention to the Ile and Kungöy Ranges of Northern Tien Shan at the border between Kazakhstan and Kyrgyzstan, an area which contains a high number of large and comparably fast (> 1m/yr) rockglaciers and is of interest as dry-season water resource and source of natural hazards.

As demonstrated in the past with investigations conducted in the Swiss Alps, the visual analysis of differential SAR interferograms can be employed for the rough estimation of the surface deformation rates of rockglaciers and other slope instabilities into different classes (e.g. cm/day, dm/month, cm/month and cm/yr). More sophisticated SAR interferometric approaches like Persistent Scatterer Interferometry (PSI) or Short Baseline Interferometry (SBAS) are only able to detect points moving with velocities below a few cm/yr respectively several dm/yr in the Line-Of-Sight (LOS) direction, because of phase unwrapping issues. For our analysis in the Tien Shan we considered SAR interferograms with short baselines and acquisition time intervals between 1 day and approximately one year. Satellite images from the ERS-1/2 tandem mission in 1998-1999, ALOS-1 PALSAR-1 between 2006-2010 (46 days nominal repeat cycle), ALOS-2 PALSAR-2 between 2014 and 2016 (14 days nominal repeat cycle), and Sentinel-1 between 2015 and 2016 (12 days nominal repeat cycle) were used. Images acquired along both ascending and descending geometries and during summer (snow-free) and winter (frozen snow) conditions were employed. For topographic reference and orthorectification we computed in-house a Digital Elevation Model from TanDEM-X acquisitions of ascending and descending orbits. Phase unwrapping to derive the LOS displacement was attempted only locally for selected landforms with a moderate (e.g. < 50 cm/yr) rate of motion.

Our inventory of rockglaciers and other periglacial processes in the Northern Tien Shan includes so far more than 500 objects over an area of more than 3000 km2. In future, our inventory will be compared to other existing inventories compiled in field or with air photos. In addition, the long-term monitoring of rockglacier motion will be performed taking advantage of the synergies between repeat optical and radar satellite data. The combined approach is useful for the confirmation of the activity, filling spatial and/or temporal gaps, computing the historical fast motion of rockglaciers from optical data and the slow motion from SAR interferometry, and to compare multi-annual rates of motion (optical data) with seasonal activities (SAR interferometry).