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

Rockglaciers in Northern Tien Shan
The Ile and Kungöy mountain ranges at the border between Kazakhstan and Kyrgyzstan contain a high number of large and comparatively fast (> 1m/yr) rockglaciers and is of interest as dry-season water resource and source of natural hazards.

Aim of the work
Rockglaciers are the best visual expression of mountain permafrost and can be mapped directly using remotely sensed data. Studies carried out in various parts of the European Alps have shown surface acceleration of rockglaciers over the two last decades. 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. We aim at quantifying the rate of movement and relative changes of rockglaciers over time with matching of repeat optical data and satellite SAR interferometry (InSAR). In this contribution, we focus on the potential of recent high spatial resolution SAR data.

Rockglacier and slope instability inventory
By visual analysis of InSAR data we estimated the surface deformation rate of rockglaciers and other mountain slope instabilities. Deformation rates are expressed using different classes. Classification of the process types and validation of the aerial extent was done using optical imagery provided by Google and Bing maps. 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 DEM from TanDEM-X data. Our inventory includes so far more than 500 objects over an area of more than 3000 km². Currently, work is ongoing to validate and refine the inventory.

Matching of repeat optical data
Synergies between optical and InSAR data will be considered for long-term monitoring of rockglaciers. Historical rates of motion are computed from repeat optical data.

Outlook
Shorter InSAR repeat intervals (e.g. 6 days for Sentinel-1 or 14 days for PALSAR-2) would improve the monitoring capability on active rock glaciers.

SAR interferograms
SAR interferograms with short baselines and time intervals between 1 day and one year from the ERS-1/2 tandem mission (1998-1999), ALOS-1 PALSAR-1 (2006-2010), ALOS-2 PALSAR-2 (2014-2016) and Sentinel-1 (2015-2016) were considered.

Phase unwrapping
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.

Chon Aksu (Kalgan Tash) Foto: T. Bolch
Ordzhonikidze rockglacier on Google Earth imagery

Area A
ERS-1/2
09.06.1999
10.06.1999
2x ε = 2.8 cm

Area A
PALSAR-1
17.08.2007
02.10.2007
2x ε = 11.8 cm

Area A
Sentinel-1
11.08.2016
04.09.2016
2x ε = 2.8 cm

PALSAR-2
06.03.2015
20.03.2015
2ε = 11.8 cm

PALSAR-2
17.08.2007
02.10.2007
2ε = 11.8 cm