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Glacier changes in the Karakoram region mapped by multi-mission satellite imagery

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Glaciers in the Karakoram region exhibit stable and advancing termini positions accompanied by less negative or even positive surface mass balances in comparison to the adjacent Greater Himalaya Range and the Hindu Kush mountains. Moreover, a large number of surge-type glaciers is found in the Karakoram.
We used optical satellite imagery to derive an updated inventory of glaciers in the Karakoram and analyzed termini position changes of 1200 glaciers for a 36 year period. As a result, we found ∼85% of the studied glaciers with stable or advancing termini. Only 13% of the glaciers retreated and were mainly located at the north-western and eastern margins of the mountain range. Additionally, 101 glaciers are known as surge-type glaciers, whereof 10 were first observations within the present study. For each glacier group (surge-type, advancing, stable, retreating), we further analyzed dimensional characteristics like glacier length, area, mean slope and mean elevation. Stable and advancing glaciers are mostly (90%) shorter than 10 km, whereas surge-type glaciers are longer with median lengths of 11.3 km. Glacier surface velocities were derived from different SAR sensors (ERS-1/-2, ENVISAT, ALOS PALSAR, TerraSAR-X) and different years (1992-2013) using feature tracking methods. Hence, we were able to provide a Karakoram-wide coverage of SAR based surface velocities and their seasonal and interannual variations for selected study sites. High resolution TerraSAR-X data is highly suitable to derive displacements of very small (e.g., ∼10 km in length) and comparably fast flowing valley glaciers (up to 1.8 m/day), e.g., during an active surge phase. We complement our analysis with selected case studies of glacier volume and mass change differencing using SRTM (2000) and recent TanDEM-X (2011-2013) digital elevation models. As a result, we were able to accurately quantify the relocation of mass during an active surge phase.
The anomalous behavior of glaciers in the Karakoram in contrast to adjacent mountain ranges was analyzed by multi-temporal and multi-mission satellite data to provide relevant new observational information on the current state of glaciers in the Karakoram. Cloud and illumination independent, high resolution SAR imagery made the investigation of very small glaciers possible, for which in-situ or other observational data currently are very rare. Moreover, the combination of different remote sensing based methods enable the identification of surge-type glaciers in remote and mountainous regions.