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Geodetic glacier elevation changes in the Karakoram and western Himalaya mountain ranges

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Glaciers in the Karakoram and western Himalaya contribute to the discharge of the Indus River and its tributaries, which account for 90 % of Pakistan's food production and 13 GW of hydroelectricity (Cook et al., 2013; Qureshi, 2011). The amount of meltwater originating from the mountainous, glaciated catchment areas is 1.5 times greater than the discharge generated downstream along the Indus (Immerzeel et al., 2010). Hence, well-founded knowledge of the extent and nature of changes in
glaciers supports downstream hydrological planning and water resource management.

The present study quantifies glacier elevation changes by using SRTM (C- or X-band) and TanDEM-X Digital Elevation Models (DEM). The bistatic TanDEM-X mission is highly suitable for interferometric processing due to a high spatial resolution and only 3 sec time lag between the overpasses of the twin satellites TanDEM-X and TerraSAR-X. The TanDEM-X processing is based on a differential interferometric approach, which facilitates the phase unwrapping in steep mountainous terrain. In case different radar frequencies were used for DEM generation, a penetration depth correction was applied to the computed elevation differences. Very precise differential GPS measurements collected in selected study sites evaluate the accuracy and height sensitivity of the derived TanDEM-X DEMs.

The results show large-scale glacier elevation changes for a 12 year period (2000-2012). A general trend of elevation loss was found in the western Himalaya study sites with maximum thinning rates observed in the Lahaul-Spiti region (-0.65 ± 0.43 m yr^{-1}) compared to the western Jammu Kashmir (-0.48 ± 0.53 m yr^{-1}) and eastern Jammu Kashmir region (-0.25 ± 0.47 m yr^{-1}). Glacier elevation changes in the Karakoram region are less negative (-0.09 $\pm$ 0.12 m yr^{-1}). The presented method is very suitable for monitoring small and comparatively fast-flowing glaciers (e.g. surge-type glaciers), but is also applicable to large, debris covered glacier tongues with reduced flow speeds.