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Glacier Changes in the Nanga Parbat Region, NW Himalaya: A longitudinal study over 160 years (1856-2016)

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Against the background of the prominent Himalayan glacier debate of the past decade, global concerns were raised about the severe consequences of detected and expected changes in the South Asian cryosphere. Due to the lack of historical glaciological data in the Himalayan region, studies of glacier changes over long time periods are rare. The present study seeks to analyze and quantify glacier changes in the Nanga Parbat region between 1856 and 2016. Due to the steep topography and great vertical span, the debris-covered glaciers of the mountain massif are largely fed by avalanches of different size. This impact of snow and ice re-distribution by avalanches is often neglected in glacier mass-balances. Therefore, an integrated approach was used to investigate the glacier changes and the impact of avalanches. This approach includes (1) a re-photographic survey with images from several expeditions between 1934 and 2010, (2) mapping during own field surveys between 1992 and 2010, as well as (3) the analyses of remote sensing data (Corona, QuickBird, KompSat, Landsat, etc. and DEM) and (4) historical topographic maps.
The re-photographic survey allows for direct comparisons and illustrates glacier changes over a span of seventy years. Changes of glacier lengths were quantified by using remote sensing data and the topographic map of 1934. In order to calculate glacier surface changes, a digital elevation model (DEM) with a spatial resolution of 30 x 30 m^2 was derived from the digitized contour lines of the topographic map from 1934 and compared to SRTM-DEM (30 x 30 m^2) and ALOS-DSM. Based on remote sensing time-series, avalanche deposits on glaciers were mapped in order to identify their magnitude and frequencies. To calculate the potential glacier catchment, area of steep rock walls and the ratio between accumulation and ablation zones were calculated for each glacier basin. Our field based investigations show that the glaciers in the Rupal Valley are characterized by small retreating rates since 1856, when Adolph Schlagintweit mapped them for the first time; others such as the Raikot Glacier on the northern side of the Nanga Parbat are fluctuating since 1934.