



## **Glacier Changes in the Nanga Parbat-Himalayas (Northern Areas of Pakistan) over the last 70 Years**

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The Himalaya displays one of the largest glacier concentrations outside the polar regions. Despite this fact, long-term measurements to detect the impact of global warming on glaciers are seldom. The Nanga Parbat area in northern Pakistan is a special exception, as the glaciologist Richard Finsterwalder has already investigated glacier dynamics of this mountain massif in the 1930s.

The aim of the presented study is to detect the changes of the Raikot Glacier over the last 70 years. For this purpose, we use a multi-temporal and multi-scale approach, which is based on repeat terrestrial images as well as satellite data (Corona, ASTER, Landsat, Quickbird). The usage of repeat terrestrial images which were taken at the same location in the 1930s, 1990s and 2000s enables the identification of long-term changes in selected sections of Raikot Glacier. For change detection of the entire glacier we use multi-temporal satellite images. In order to analyse temporal and spatial dynamics over the last 40 years we use three different satellite sensors (Corona, Aster and Landsat). Moreover, to monitor and to analyse recent small-scale changes over the last few years we apply very high resolution satellite data (Quickbird). To quantify the changes of the Raikot Glacier we classify the satellite images into glacier-covered and glacier-free areas. The multi-temporal comparison between 1934 and 2006 indicates a total glacier retreat of up to 250 m. Yet, the glacier retreat was interrupted by a significant advance between the 1960s and 1990s. This period of positive mass-balance is also observable in the European Alps. Since the 1990s, the Raikot Glacier has been shrinking, but in total the rate of retreat is very small. This low retreat rate can be confirmed by the comparison of Quickbird images of 2003 and 2006 which show only

small changes between debris-covered and debris-free glacier regions.