



Mass changes of debris covered glaciers in Langtang Himal 1974-1999 revealed by Hexagon and SRTM data

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Glacier mass balances are good indicators of climate change due to the glaciers' sensitivity to changing temperatures and meteorological conditions. However, glacier mass balances are difficult to obtain due to the lack of continuous measurements, especially in remote areas such as the Himalaya region. Attempts have been done to estimate glacier mass changes based on satellite images. Debris covered glaciers complicate these efforts, as their surfaces are not easily distinguished from surrounding, ice-free, terrain. Generation of Digital Elevation Models (DEMs) from stereo satellite images is time consuming but offers a valuable source of data, especially in remote areas. We generated DEMs of 1974 (KH-9 Hexagon) and 2010 (ASTER) and used the 2000 SRTM (Shuttle Radar Topographic Mission) as a reference DEM to analyse the planimetric and volumetric changes of debris covered glaciers in Langtang Himal. We found a decrease in ice coverage of about 2% with similar absolute losses in 1974-1999 and 1999-2010 and a specific mass loss of $0.48 \pm 0.18 \text{ m w.e.}^{-1}$ in 1974-1999, despite thick debris cover. The highly variable debris-cover thickness may explain the different pattern of surface lowering obtained on the same glacier and between glaciers.