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Glacial lakes amplify glacier recession in the central Himalaya

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The high altitude and high latitude regions of the world are amongst those which react most intensely to climatic change. Across the Himalaya glacier mass balance is predominantly negative. The spatial and temporal complexity associated with this ice loss across different glacier clusters is poorly documented however, and our understanding of the processes driving change is limited. Here, we look at the spatial variability of glacier hypsometry and glacial mass loss from three catchments in the central Himalaya; the Dudh Koshi basin, Tama Koshi basin and an adjoining section of the Tibetan Plateau. ASTER and SETSM digital elevation models (2014/15), corrected for elevation dependant biases, co-registration errors and along or cross track tilts, are differenced from Shuttle Radar Topographic Mission (SRTM) data (2000) to yield surface lowering estimates. Landsat data and a hypsometric index (HI), a classification scheme used to group glaciers of similar hypsometry, are used to examine the distribution of glacier area with altitude in each catchment.

Surface lowering rates of >3 m/yr can be detected on some glaciers, generally around the clean-ice/debris-cover boundary, where dark but thin surface deposits are likely to enhance ablation. More generally, surface lowering rates of around 1 m/yr are more pervasive, except around the terminus areas of most glaciers, emphasising the influence of a thick debris cover on ice melt. Surface lowering is only concentrated at glacier termini where glacial lakes have developed, where surface lowering rates are commonly greater than 2.5 m/yr.

The three catchments show contrasting hypsometric distributions, which is likely to impact their future response to climatic changes. Glaciers of the Dudh Koshi basin store large volumes of ice at low elevation (HI > 1.5) in long, debris covered tongues, although their altitudinal range is greatest given the height of mountain peaks in the catchment. In contrast, glaciers of the Tama Koshi store large amounts of ice in broad accumulation zones and are more equidimensional (HI -1.2 to 1.2). Glaciers flowing onto the Tibetan Plateau have a similar hypsometric distribution to glaciers of the Dudh Koshi, but terminate at a higher altitude overall, approximately 500 m higher than glaciers of the Dudh Koshi or Tama Koshi. We estimate the approximate Equilibrium Line Altitudes (ELA) of the last 15 years to be above a substantial portion (66%- Dudh Koshi; 87%- Tama Koshi; 83% Tibetan Plateau) of the glacierised area for all three catchments. Future ice recession may therefore be governed primarily by glacier hypsometry, but is likely to be amplified by the continued development of new, or growth of current glacial lakes.