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Monsoon-influenced glacier retreat in the Ladakh Range, Jammu and Kashmir

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While the majority of glaciers in the Himalaya-Karakoram mountain chain are receding in response to climate change, stability and even growth is observed in the Karakoram, where glaciers also exhibit widespread surge-type behaviour. Changes in the accumulation regime driven by mid-latitude westerlies could explain such stability relative to the monsoon-fed glaciers of the Himalaya, but a lack of detailed meteorological records presents a challenge for climatological analyses. We therefore analyse glacier changes for an intermediate zone of the HKH to characterise the transition between the substantial retreat of Himalayan glaciers and the surging stability of Karakoram glaciers.

Using Landsat imagery, we assess changes in glacier area and length from 1991-2014 across a ∼140 km section of the Ladakh Range, Jammu and Kashmir. Bordering the surging, stable portion of the Karakoram to the north and the Western Himalaya to the southeast, the Ladakh Range represents an important transitional zone to identify the potential role of climatic forcing in explaining differing glacier behaviour across the region. A total of 878 glaciers are semi-automatically identified in 1991, 2002, and 2014 using NDSI (thresholds chosen between 0.30 and 0.45) before being manually corrected. Ice divides and centrelines are automatically derived using an established routine. Total glacier area for the study region is in line with that Randolph Glacier Inventory (RGI) and ∼25% larger than the GLIMS Glacier Database, which is apparently more conservative in assigning ice cover in the accumulation zone. However, the RGI appears notably less successful in identifying glacier termini. Preliminary analysis of glaciers in our study area suggest an overall areal decline of -17.21±7.50% between 1991-2014., a figure more similar to the Zanskar ranges to the south than the Karakoram to the north. No evidence of surge-type behaviour is observed in the study area over this period. Glaciers tend to be small (median area 0.25 km^2): even larger valley glaciers in the Ladakh Range are an order of magnitude smaller than the average area of surge-type glaciers in the Karakoram. Area loss increases to the northwest of the range: relative loss at sample sites to the westernmost and easternmost ends of the study area is -14.47 ± 3.13% and -12.68 ± 3.93% respectively – likely explained by a lower mean altitude in the west (5456 m a.s.l. vs 5732 m a.s.l.). These observations suggest that glaciers in the Ladakh range are retreating due to changes in monsoon-derived accumulation patterns, as in the Himalaya proper. Glacier characteristics and behaviour are drastically different to that of the Karakoram, and no obvious indicators of resistance to warming provided by westerly accumulation patterns are observed. From these observations, we speculate that stability observed in Karakoram glaciers to the immediate north must be largely explained by non-climatic mechanisms, such as surge activity, or that the climatic factors responsible for the Karakoram behaviour are extremely localised.