CR2.2 - Glacier Monitoring from In-situ and Remotely Sensed Observations. EGU2016-166

Monsoon-Influenced Glacier Retreat in the Ladakh Range, India

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Introduction and Aims

The majority of glaciers in the Himalaya-Karakoram mountains are receding in response to climate change, but stability and even growth is observed in the Karakoram. Changes in the accumulation regime driven by mid-latitude westerlies are proposed to explain such stability relative to the monsoon-fed glaciers of the Himalaya (fig. 1), but a lack of detailed observations presents a challenge for understanding climate regimes in the region. We therefore assess glacier variation in the Ladakh Range – an intermediate zone bordering the Karakoram to the north and the Western Himalaya to the south – to characterize the transition in behavior between the substantial retreat of Himalayan glaciers and the anomalous stability of Karakoram glaciers, and identify the dominant climatic forcing in the region.

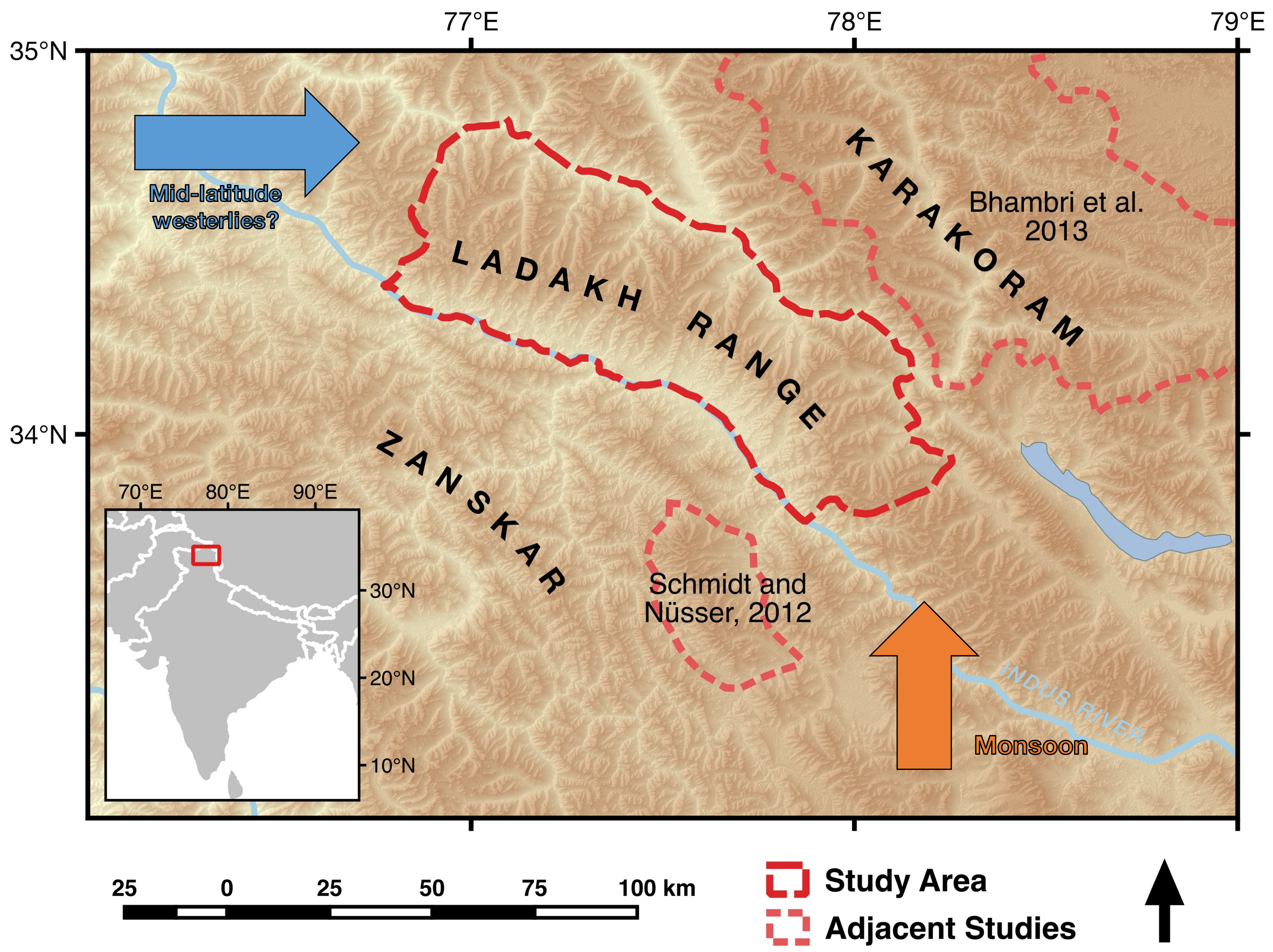

Fig 1: Location map identifying study site, relevant adjacent studies, and large-scale climatic influences.

Methodology

Using Landsat 5, 7, and 8 imagery, we assess changes in glacier area and length from 1991-2014 across a ~140 km long section of the Ladakh Range, Jammu and Kashmir (fig. 1). Glaciers are semi-automatically identified at end-ablation seasons 1991, 2002, and 2014 using NDSI (with thresholds chosen between 0.30 and 0.45) before being manually corrected. Ice divides and centrelines are automatically derived from the resulting shapefiles using an established routine (Kienholz *et al*. 2014).

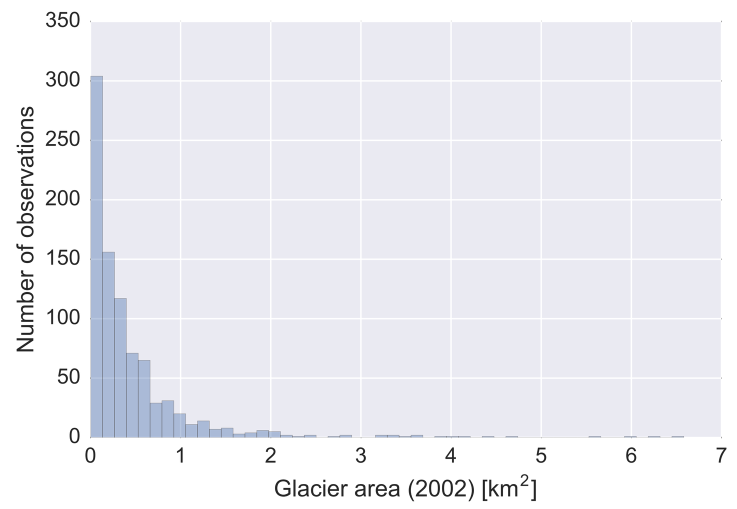

Fig 2: Distribution of ice polygon areas in 2002.

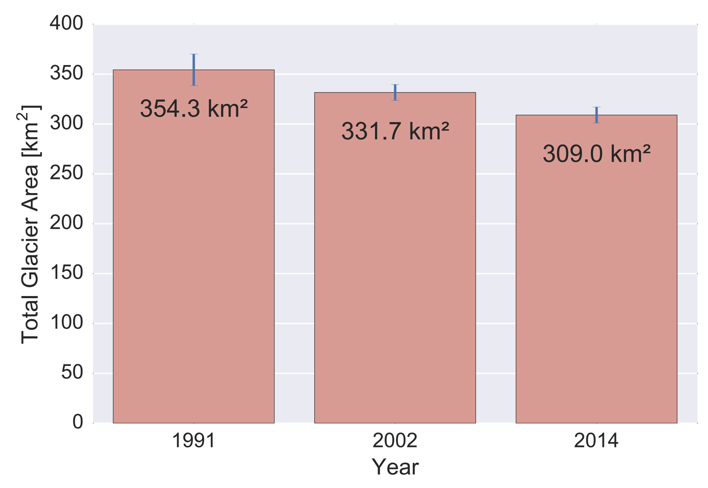

Fig 3: Comparable ice area at each time period.

Table 1: Table displaying total glacier areas and area changes.

	1991	2002	2014
Total Area (km²)	354.3 ± 15.8	331.7 ± 8.0	309.0 ± 8.0
Δ since 1991 (km²)	–	-22.7 ± 17.8	-45.3 ± 17.8
Δ since 1991 (%)	–	-6.4 ± 5.0	-12.8 ± 5.0

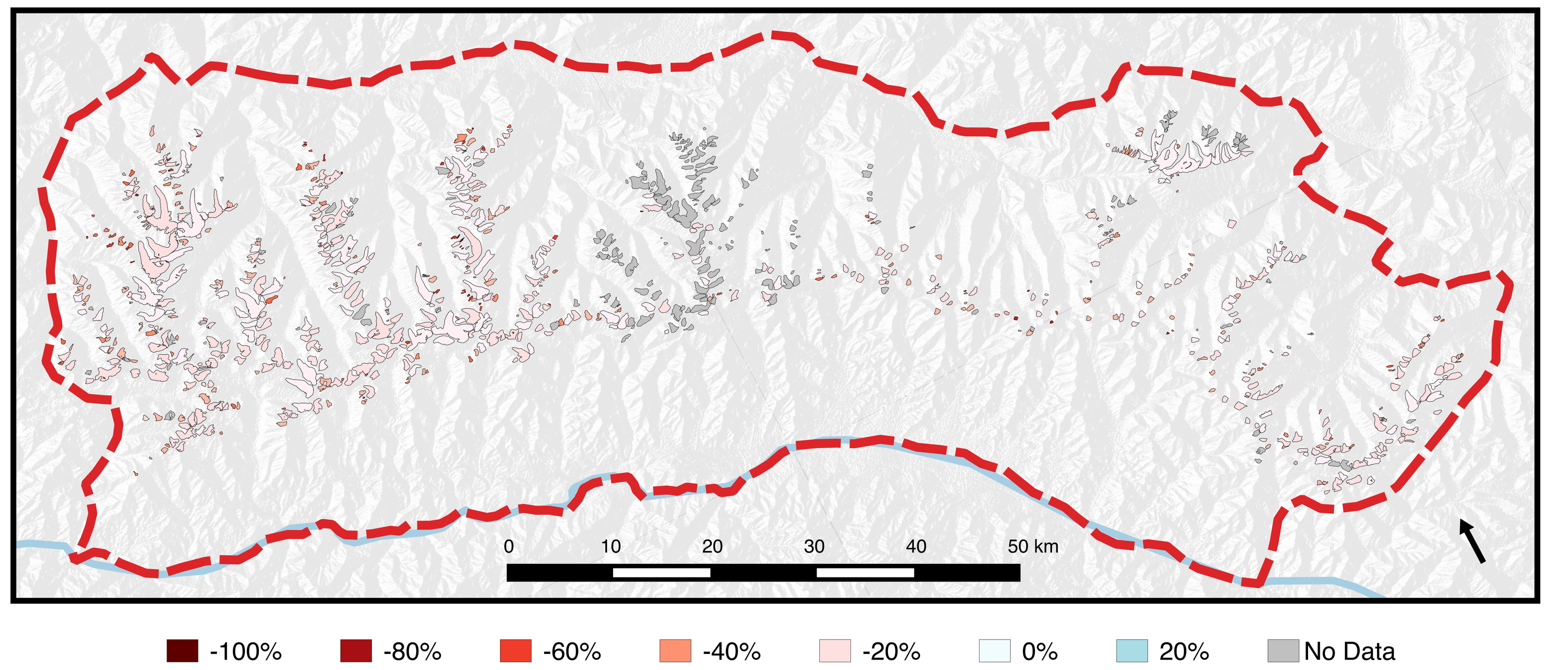

Fig 4: Relative change in glacier polygon area between 1991 and 2014.

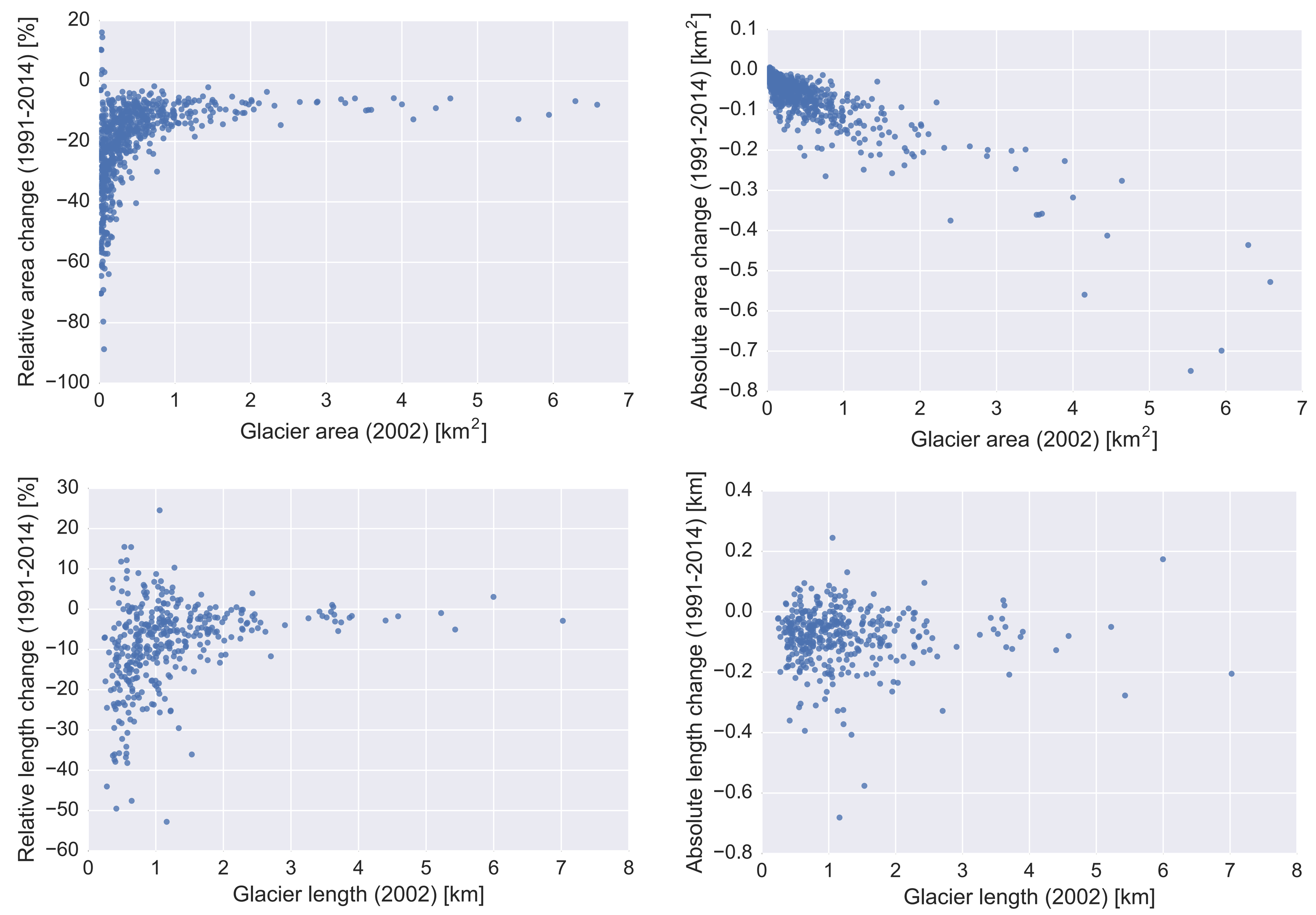

Fig 5: Graphs showing relative and absolute changes in glacier area and length between 1991—2014.

Results

875 glaciers are identified, covering an area of 402.4 ± 8.6 km^2 in 2002. Glaciers are small (median 0.24 km^2): even larger valley glaciers are an order of magnitude smaller than the large Karakoram surge-type glaciers (fig. 2). Total glacier area for the study region is in line with that Randolph Glacier Inventory (Pfeffer *et al*. 2014) and ~25% larger than in the GLIMS Glacier Database (Bajracharya *et al*. 2014), which is more conservative in assigning ice cover in the accumulation zone. However, the RGI provides inconsistent terminus positions in comparison to the other two datasets.

Cloud cover in 1991 and 2014 means that only a subset of 663 glaciers is available for multitemporal comparison across all 3 time periods (fig. 4). Between 1991 and 2014, glacier area decreased by 12.8 ± 5.0 % (fig. 3; table 1), a figure in line with observed changes in the Zanskar ranges to the south (table 2). Contrasting with the Karakoram, no evidence of surge-type behaviour is observed in the study area over this period.

Glacier length change is notably more varied than glacier area change (fig. 5) due to the automated routine identifying different tributaries to classify as the longest in different years.

	Kang Yatze Massif	Ladakh Range	Karakoram
Study	Schmidt & Nusser (2012)	This Study	Bhambri *et al.* 2013
Temporal Coverage	1991—2010	1991—2014	1989—2011
Area change	-7.5%	-12.8 ± 5.0%	+0.9 ± 3.0%
Change rate	-0.4 % a^{-1}	-0.6 % a^{-1}	+0.04 % a^{-1}

Table 2: Headline glacier changes from this study and two comparable adjacent studies (see fig. 1).

Conclusions

Glaciers in the Ladakh range are retreating in line with the Himalaya proper. Unlike the Karakoram, no obvious indicators of (i) resistance to warming provided by westerly accumulation patterns, or (ii) surging are observed. We suggest that the Ladakh Range glaciers are primarily influenced by the monsoon climate regime and thus mark the southern boundary of the ‘Karakoram Anomaly’. This is in a agreement with recent findings that surging and geodetic stability are primarily located northeast of the Karakoram, in the Kunlun Shan area (Kääb *et al.* 2015).

References

Bajracharya, S. R., *et al.* (2014). *ICIMOD*; **Bhambri, R., et a. (2013).** *The Cryosphere*, 7(5), 1385–1398; **Kääb *et al.* (2015).** *The Cryosphere*, 9(2), 557–564; **Kienholz, C., et al. (2014).** *The Cryosphere*, 8(2), 503–519; **Pfeffer, W. T., *et al.* (2014).** *Journal of Glaciology*, 60(221), 537-552; **Schmidt, S., & Nüsser, M. (2012).** *Arctic, Antarctic, and Alpine Research*, 44(1), 107–121.

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