

Observed Changes in the Himalayan Glaciers: Multiple Driving Factors

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There is lack of credible knowledge about Himalayan cryosphere as is evident from the contradictory reports about the status of the glaciers in the region. Glacier behavior in Himalaya has to be understood and interpreted in light of the multiple driving factors; topography, climate and anthropocene. The observed changes in Himalayan glaciers, determined by studying a few hundred glaciers in the Himalaya, indicated that the glacier response varies across different ranges. Satellite images (1990-2015), DEM, altimetry data supported by selective field campaigns, were used to map the changes in glacier boundaries, snout, ELA, AAR, volume, thickness, debris cover and several other glacier parameters. The glaciers across the six ranges of Pir Panjal (PR), Greater Himalaya (GH), Shamasbari (SR), Zanaskar (ZR), Leh (LR) and Karakorum (KR) showed quite varied changes. It was observed that the glaciers in the KR show the least glacial area recession (1.59%) primarily due to the extreme cold winters with -18°C average temperature. Other glacial parameters like snout, ELA, AAR and glacier volume also showed very little changes in the KR during the period. The glaciers in the LR, with an average winter temperature of -60°C, have shrunk, on an average, by 4.19 % during the period, followed by the glaciers in the ZR showing a loss of 5.46%. The highest glacier retreat of 7.72% and 6.94% was observed in the GH and SR with the average winter temperature of -1.3°C and -6.2°C respectively. In the PR, almost all the glaciers have vanished during the last 6-7 decades due to the increasing winter temperatures. The glaciers in the Kashmir showed an overall recession of 26.40% in area which is one of the highest reported for the Himalayan glaciers. The glaciers in the valley showed the maximum reduction in thickness (2.56m) using the IceSat data from 2000-08 while as the Karakoram glaciers showed the least reduction in thickness (0.53m).

It was found that the maximum recession of glacial area was observed in the mountainous ranges with altitudes below 4500m asl. The glaciers above 5000m showed the lowest rate of glacial retreat in the region. The other parameters like snout retreat, ELA changes, volume and other parameters observed in all the six ranges also showed strong correlation with topography.

Detailed analyses of the topographic, climatic and black carbon emission data was carried out to understand the enhanced glacial recession observed in the Kashmir valley. The climate change signals are quite loud and clear in the region and the higher rates of recession are due to the significant increase in the observed minimum winter temperatures. In Kashmir, precipitation is falling more as rain than snow due to the warming in winter. Further, the concentration of black carbon in the valley is highest compared to the other high altitude station in the Himalaya (5.9 gm-2). All these factors are responsible for the decrease in the volume and extent of the glaciers in Kashmir Himalaya.