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Spatial distribution of glacier area changes in the Himalaya using remote sensing and regression trees: a case study from Sikkim

Adina Racoviteanu, Mark Williams, and Noah Molotch

University of Colorado, Institute of Arctic and Alpine Research and Geography Department, Boulder, United States (racovite@colorado.edu, 3034926388)

A detailed assessment of spatial trends in glacier patterns is critical in regions such as Himalaya, where concerns have been raised about the impact of snow and glacier changes on regional water supplies. Due to sparse field measurements, remote sensing has proven to be be useful to quantify changes in Himalayan glaciers in the last decades. However, the factors that govern glacier changes at various spatial scales are still not well quantified. Here we present a novel approach for the Himalaya, which uses regression trees to understand how various topographic and climatic factors influence the rates of glacier change. Glacier area, the dependant variable in the statistic models is derived at different time steps from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) sensor, Landsat TM, and older topographic maps. Glacier outlines are obtained using standardized semi-automatic methods for delineation of clean ice and debris covered ice (band ratios, thermal information and topography). Topographic parameters include: geographic location; orientation with respect to the monsoon; slope; aspect; solar radiation and elevation, most of these derived from the SRTM DEM. Climate parameters include data from the Tropical Rainfall Measuring Mission (TRMM), MODIS and ground stations.

The test analysis is performed in Tista basin of the Sikkim Himalaya, situated in the wet (monsoon-influenced) part of the Himalaya. In a previous study we computed a change in glacierized area of -28% in the last four decades, and a rise in glacier termini by +676 m based on topographic maps and ASTER/Landsat data. In this analysis we attempt to explain the observed glacier changes by applying the model at regional scale. The goal is to compare and contrast spatial patterns of glacier changes in the dry western Indian Himalaya (Ladakh and Lahul-Spiti) with the wet, monsoon-influenced Eastern Himalaya.