Himalayan glacier dynamics study using integrated use synthetic aperture radar and optical datasets

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Himalayan glaciers are one of the largest source of freshwater in form of ice, outside the Polar Regions. The great rivers of South Asia namely Indus, Ganges and Brahmaputra have its origin in Himalayas and Tibet. The melt water from permanent ice in form of glaciers and seasonal snow, along with ground water provides the essential base flow in these rivers, especially during spring and summer time period. Remote sensing has played vital role in regular monitoring of these resources, as traditional methods of monitoring these dynamic variables using field based instruments or surveys is nearly impossible, due to vastness and remoteness of Himalayan terrain. The present study highlight use of optical and synthetic aperture radar (SAR) data for mapping and monitoring of glacier surface velocity and various glacier zones. This study have used Landsat-8 and Sentinel-1 SAR data in InSAR mode for estimating the glacier velocity using feature tracking and interferometry based methods. Landsat-8 data from PAN band at 15 m spatial resolution was used at annual interval during 2013-2017 time for estimating glacier velocity in all major Himalayan glaciers such as Gangotri, Siachen, Bara Shigri, Milam and Zemu. The mean surface velocity of main Gangotri glacier during 2013-2014 time was estimated to be 18.21 m/year. Previous attempts with Interferometric SAR (InSAR) data for glacier velocity suffered from loss of coherence due to high temporal interval of SAR images and high velocity of Himalayan glacier. This study used InSAR data from SENTINEL-1A and 1B satellites at 6 day temporal interval (during winter of 2016-2017) to derive glacier velocity for all major Himalayan glaciers. High coherence was obtained for all main glaciers, which resulted in accurate line of site (LOS) glacier velocity estimates for main glaciers. The time series of SAR data from SENTINEL-1A and 1B and Indian RISAT-1 MRS satellites were also used for major glaciers such as Siachen, Bara Shigri, Gangotri and Zemu, for creating SAR image time series composites, and to identify and map radar glacier zones such as debris ice, bare ice zone, percolation-refreeze zone at different elevations, wet snow and dry snow zones. The generated surface or LoS glacier velocity map can used for finding the glacier depth and volume using physical glacier flow models, where surface velocity is used as boundary condition. Similarly, the glacier zones derived from SAR data, can used to mark the equilibrium line altitude (ELA) of a glacier, which can be used for glacier mass balance studies.