INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE

Department of Civil Engineering
Geospatial Engineering

Project 2:
To estimate glacier surface ice velocity of Bara Shigri Glacier, Himachal Pradesh using Sentinel-1 GRD (Ground Range Detected) data.

Subject : CEN-612 Digital Image Processing

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1. Introduction

A glacier is a body of ice and recrystallised snow plus refrozen meltwater, on land and moving by deformation under its own weight. A necessary and sufficient condition for a glacier to exist is an excess of snowfall over snowmelt at some locality for a long period of time, enough to build an ice sheet thick enough to make it under its own flow. They are important features of our earth for they are a potential source of fresh water, along with their control over sea level and the role of ice sheets on the climate.

The glacier flows under its own weight due to gravity as it tends to thicken in the upper parts and thin in the lower parts, thus increasing its surface slope. This thickening and thinning can be result of elevation difference, temperature difference, snowfall over higher elevation areas, etc. Although glacier has a tendency to flow, it isn't fast enough to be perceptible directly to the eye, unless in exceptional cases. Speeds are generally of the order of meters per week or meters per month. These glacier velocities are usually measured using standard surveying techniques, though they can also be measured with remote sensing techniques.

2. Study area

Bara Shigri glacier (32°11'53.11"N, 77°38'41.18"E), meaning "Great Glacier", lying north of Parvati Parvat, located in Lahual-Spiti region of Himachal Pradesh was selected for studying its surface velocity. Bara Shigri feeds the Chandra River in the north, which later after its confluence with the Bhaga River is known as the Chenab River.

3. Data and Methods

The dataset used is "SENTINEL-1 Interferometric Wide Swath Level 1 Product" obtained from NASA's EODIS platform, for year 2019 and 2020 of month of October. The change was studied for a period of one year by using offset tracking tool of SNAP software. Firstly, the orbit file correction was applied to get the precise satellite position, followed by the thermal noise correction and calibration to account for the backscatter differences due to thermal noise and to correctly relate the pixel value to SAR backscatter. The output images were then coregistered using DEM-assisted coregisteration tool, and subset was taken. The subset of the coregistered image was processed using offset-tracking tool, and the output velocity map was geocoded using Range-Doppler terrain correction tool. The final output was then imported into QGIS and further processed to generate the map of the glacial velocity for the glacier.

4. Results and Interpretation

The flow of the glacier is from south to north. From the figure 1 and 2, it can be inferred that mostly the areas having altitude more than 4800 m are experiencing surface ice velocity of more than 0.08 m/day. Some unusual results were also observed on the eastern side of the map, where few areas have darker tones (orange and red), even though the profile is relatively flatter compared to the profile of the whole glacier. The high velocity of surface ice in higher altitudes could be due to fresh snowfall, while high surface velocity at the lowest areas could be due accumulation of moraines, as the glacier is known for its moraines as well as the sudden changes in water flow levels.

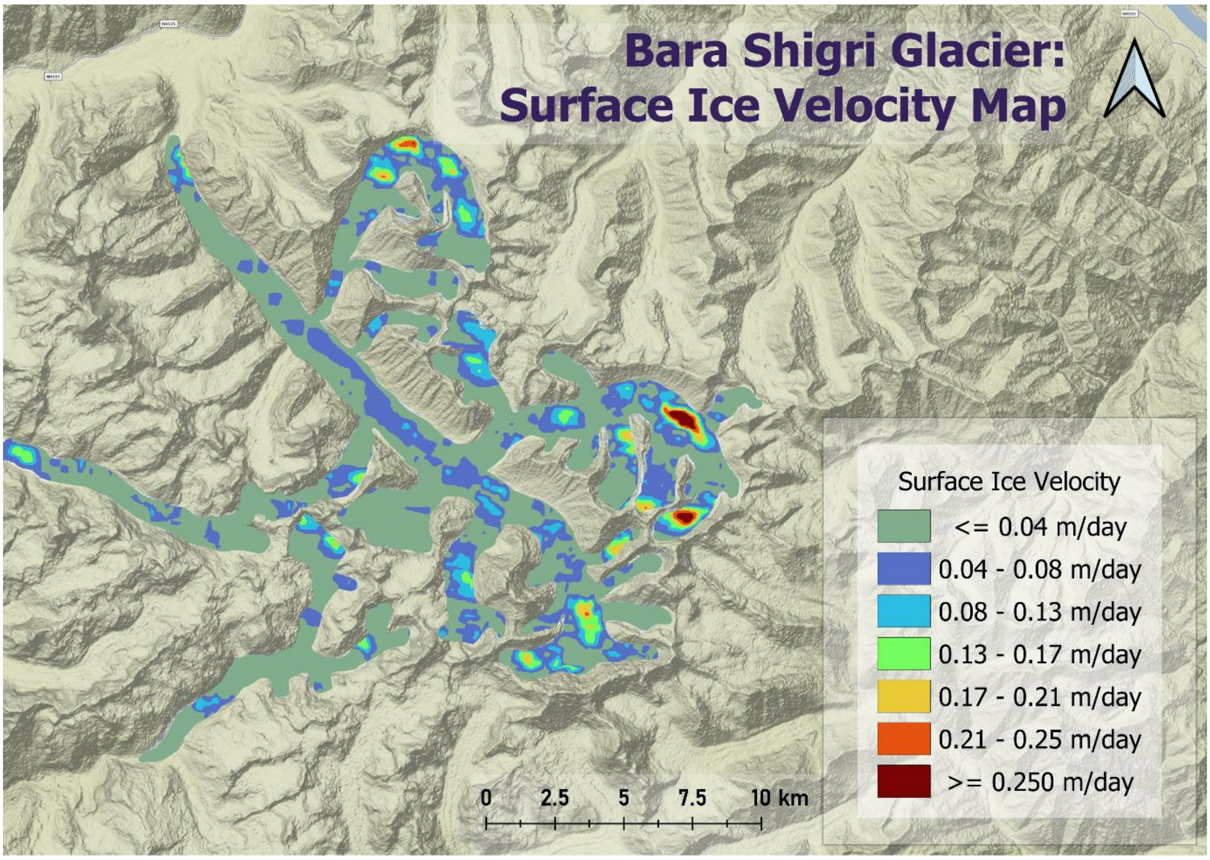

Figure 1 Surface ice velocity map

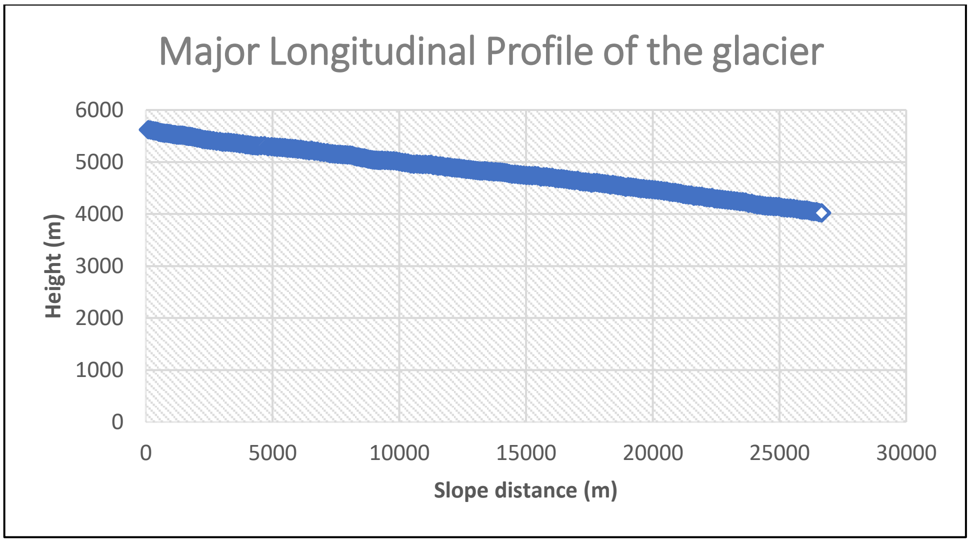

Figure 2 Major longitudinal profile, measured from south to north.