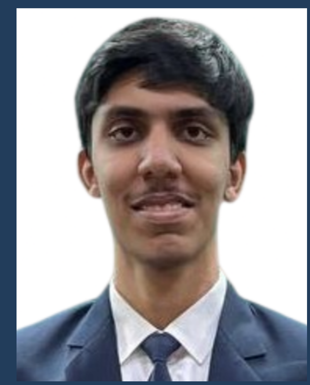
Processing Pipeline for Computing Time Series of 3D Glacier Surface Flow and Mass Balance



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Introduction

A time-series study of glacier change is essential for gaining insights into short-term and long-term trends in glacier dynamics, revealing the impacts of seasonal factors and global warming. However, generating large time series datasets for glacier monitoring requires a substantial amount of computation and time.

- We have developed an efficient pipeline for studying glaciers using SAR data.
- Multi-track SAR data are fused to compute time series of 3D glacier surface velocity over prolonged durations.
- Vertical displacements combined with glacier boundary are utilised for computing annual time series of glacier mass balance.
- We test the proposed pipeline on three valley type glaciers in the Chandra basin for the duration of 2017 to 2022.

Displacements from SAR

There are mainly **two** ways of extracting displacements using SAR data: InSAR and Sub-pixel Offset Tracking.

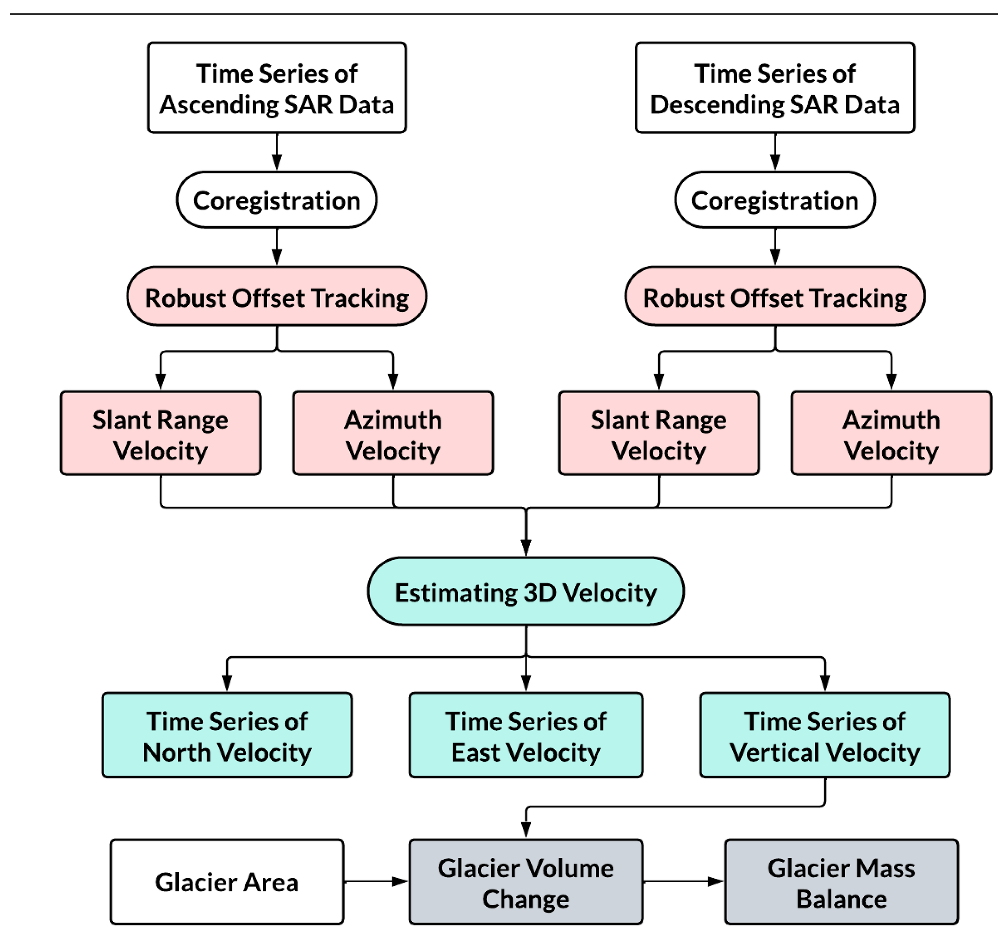
What is InSAR ?

It involves utilizing phase information of repeat orbit imagery to retrieve fine displacement of glaciers along slant range direction.

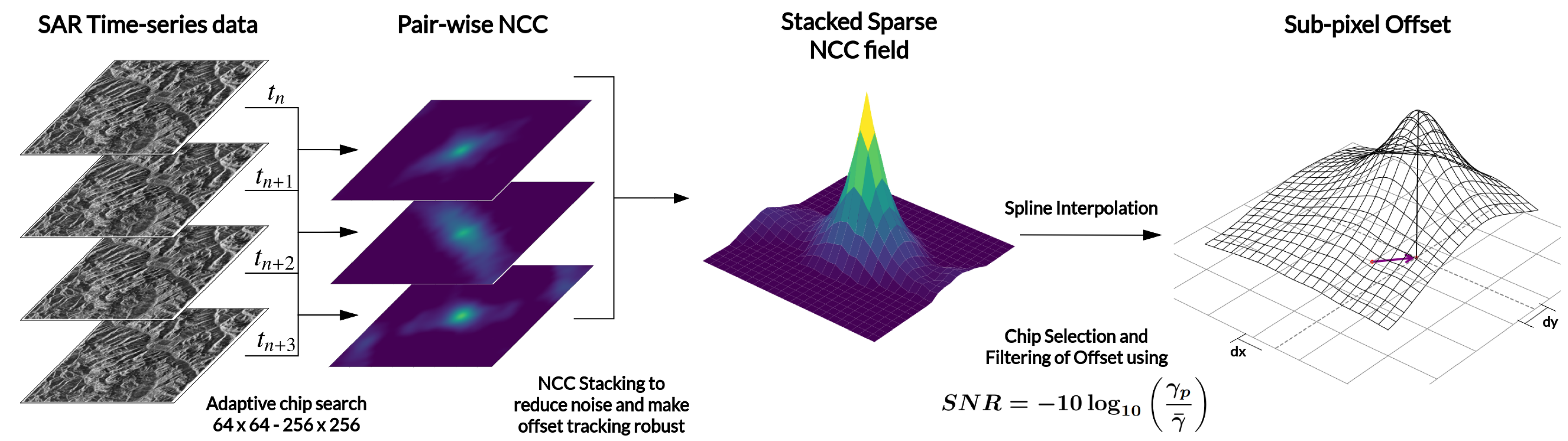
Why use Sub-Pixel Offset Tracking ?

- It measures displacements in both slant range and azimuth directions, unlike InSAR.
- It can track larger displacements, and thus is ideal for observing fast-moving glaciers.
- It can process more pairs as it isn't affected by temporal or perpendicular baselines.

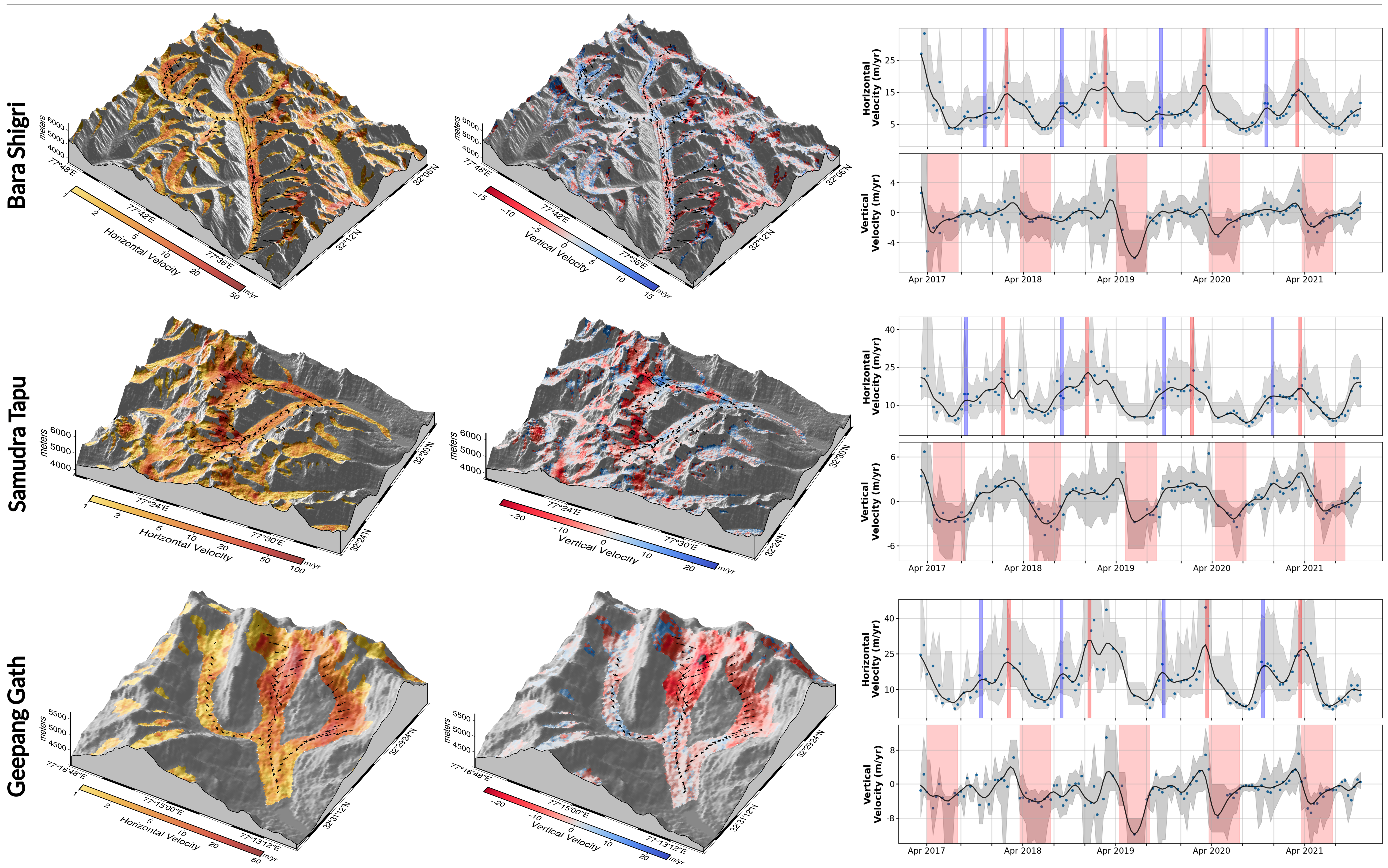
Methodology



Robust Offset Tracking Module



Results



Key Observations

- Accelerated accumulation and ablation are observed around March and July respectively.
- Two cycles are observed annually, with peaks occurring around April and November.
- Computational time for processing 240 ascending and descending images is 137 hours.

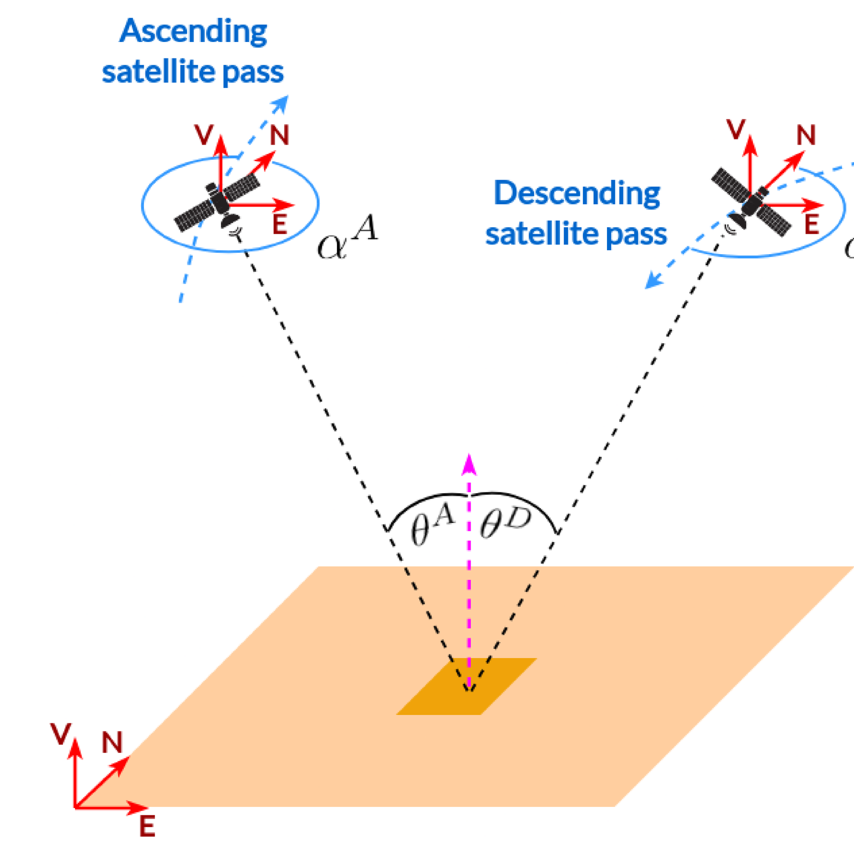
Pros

- It can track fast moving glaciers situated in the steep terrains of the Himalayan region.
- NCC Stacking enhances the robustness of offset tracking, evident from the scatter plot using the continuous 12-day data from 2021.

Cons

- Mass Balance calculations demand complete data for each pixel across the entire time-series.
- Achieving valid values for all pixels inside a glacier for entire time-series is challenging.

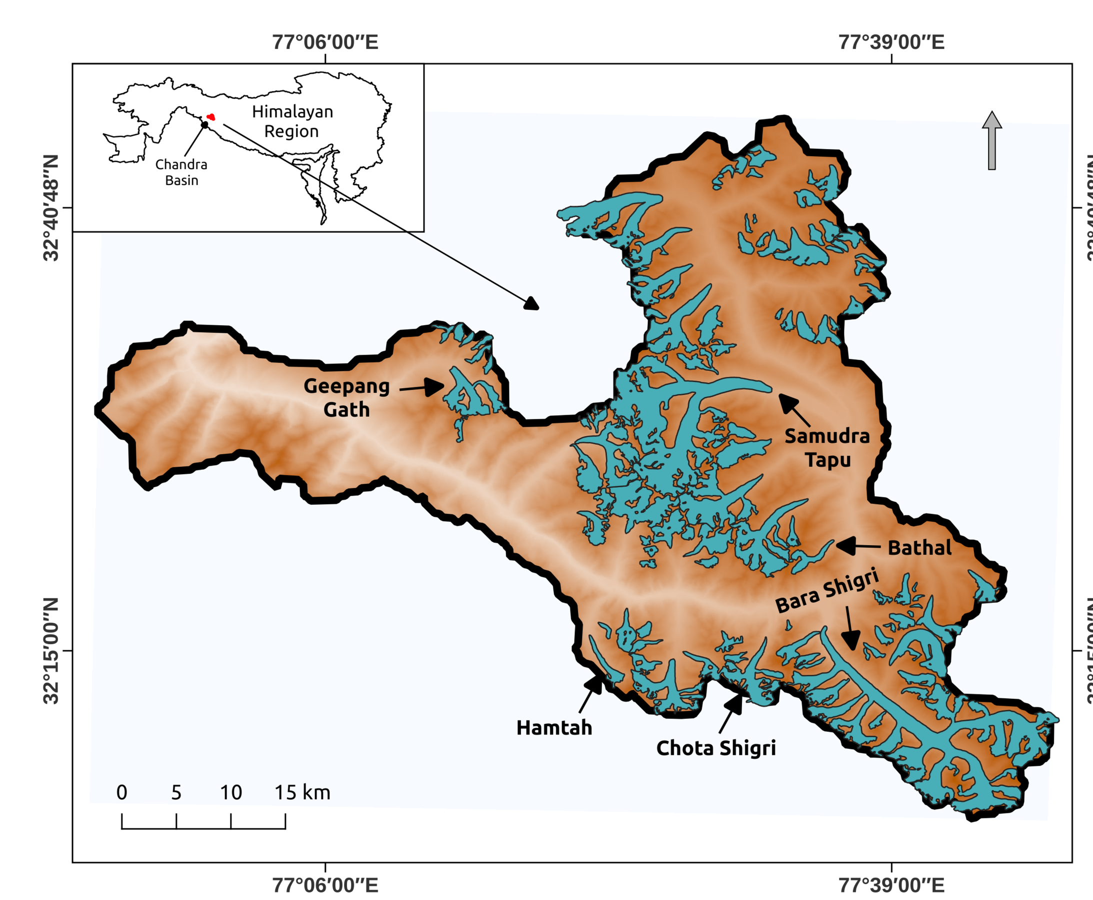
Estimating 3D Velocity



The 3D velocities are calculated based on the relation between ascending and descending track orientations as shown below.

$$\begin{bmatrix} -\sin\theta^A\cdot\sin\alpha^A & \sin\theta^A\cdot\cos\alpha^A & -\cos\theta^A \\ \cos\alpha^A & \sin\alpha^A & 0 \\ -\sin\theta^D\cdot\sin\alpha^D & \sin\theta^D\cdot\cos\alpha^D & -\cos\theta^D \\ \cos\alpha^D & \sin\alpha^D & 0 \end{bmatrix}\begin{bmatrix} v_N \\ v_E \\ v_V \end{bmatrix} = \begin{bmatrix} v^A_{LOS} \\ v^A_{AZ} \\ v^D_{LOS} \\ v^D_{AZ} \end{bmatrix}$$

Study Region



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