# Glacier Surface Velocity in Major Glacier of Karakoram and Himalaya under Variable Climatic Conditions by using Landsat-8 Satellite Data

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**Abstract:** *The Himalayan glaciers are a natural stockpile which performs a significant function in the going to influence the runoff of various seasonal rivers that pass across the Indo-Gangetic plains, delivering clean water to the world's second - largest most inhabited nation. Evaluation of permafrost-ice thickness for better protection of this water supply throughout the present climate change and water shortage situation it is highly necessary. The current thesis aims to identify a fitting approach to answer this issue to measure the extent and withdrawal of glaciers in Central Himalayas. Monitoring of temperate glacier behavior has become extremely important as an measure of the local impact of global warming, for economic and security purposes. Throughout the literature the most discussed vector throughout ice dynamics is the velocity of ice from distant sensed photographs. In the present study surface velocity of glacier namely GLIMS Id_G075997E36267N, GLIMS Id_G077682E34933N, Imja and Kolahoi glacier is calculated with the help of the using the satellite image data of the Landsat 8 with the panchromatic image i.e. Band 8 of the resolution 15 meters.*

*The glacier velocity is variable in last few decades according to the calculation and the previous research studies and iin this study we apply an image-correlation algorithm in the domain to obtain the glacier velocity. The results shows indicates that the flow patterns are related to the terrain complexity.*

**Key Words**: **Kolahoi glacier, Surface velocity, Complexity, Landsat-8, Cross-correlation**

## 1. Introduction

### 1.1. Overview

Mountain glaciers have the higher influence of the water resources and the economic activity of a region, firstly on a local scale but it also have effect on changing in the global sea level on global scale, in other words it's have the societal impact. Moreover, mountain glaciers are sensitive to climate forcing and are thus relevant indicators of past and present climate changes (IPCC, 2013).Satellite imagery, with its global coverage and repeated attainment, declare a unique probability to scalethe spatial and temporal modulation affecting mountain glaciers.

In distinct eye-gaze tracking using regular image of the satellite allowing us to manufacture the velocity field, which are most important and esteemed collection of the data to get knowledge and figure out dynamical process for example impact on climate due to glacial motion, surging and glacier surge or growth and formation of the glacial lakes and also associated dangerous condition and the risks.

North Western Himalaya (NWH), a part of third pole, contains one the largest reserves of fresh water in the form the glaciers and snow caps outside the Polar region. The Himalayan range is bordered on the northwest by the Karakoram and the Hindu Kush ranges. The region has the largest area under seasonal and perennial snow cover whose melt contributes significantly to major rivers including the Ganga, the Indus, the Jhelum, the Beas, etc. (Aggarwal et al., 2018) However presence of the surging feature product in the glaciers gives an opportunity in measuring the glacier velocity in the high mountain Asia.

According to the author (Trouvé et al., 2007)Monitoring temperate glacier activity has become more and more necessary for economical and security reasons and as an indicator of the local effects of global climate. However, the temporal sparsity of velocity data has made it difficult to explain the nature of the relationships between thinning, acceleration and retreat in these glaciers. Because of the difficulty of reaching high-altitude glaciers in risky mountainous areas, up to now, only 1% of the existing world temperate glacier have been monitored, mostly by ground measurements, which often provide information only once or twice a year at a few points.

As per the author (Huang & Li, 2009)Glaciers and ice caps provide among the most visible indications of the effects of climate change. Recent evidence suggests an acceleration of glacier mass loss in many areas all over the world.

The surface ice velocity has a major impact on the health and fate of the glacier. Measurement of ice velocity can help in modeling the glacier dynamics. This article presents sub-pixel image correlation technique (COSI-Corr) for calculating ice velocity of Gangotri glacier from Landsat 8 data. It is difficult to obtain sufficient ice velocity data withconventional glaciological techniques (field measurements) due to the frequent loss of stakes and difficulty in the handling of measuring instruments at the site. A number of researchers have also used SAR interferometry/speckle tracking to map glacier ice velocities. However, it has been reported that SAR based works have limitations in highly rugged terrains like the Himalayas and especially for fast-moving glaciers like Gangotri glacier.(Paper & Geology, 2016) As the previous study on the glaciers satellite imagery from(Copland et al., 2009) more recently, measurements of surface velocity of glaciers havebeen possible with the availability of remote sensing data and yielded a number of interesting insights into their dynamics.

## Study Area

The glacier with the GLIMS Id_G075997E36267N is located at 36°16'58.8"N 75°56'15.4"E and it is situated at the Yarkand river in the Jammu Kashmir, GLIMS Id_G077682E34933N is located at 34°56'49.4"N 77°42'26.9"E and it is situated in the Ladakh, Imja glacier is located at Nepal and Kolahoi glacier is located in Liddar valley at Pahalgam in Jammu and Kashmir. Glacier velocity is vary with the variation in the time interval and the climatic conversion, glacier velocity varies and its situation is intense and serious. During the winter and summer the studying of the glacier velocity done in the glaciers region it helps to improve the improve the understanding of relationship between glaciers and the climatic monsoon.

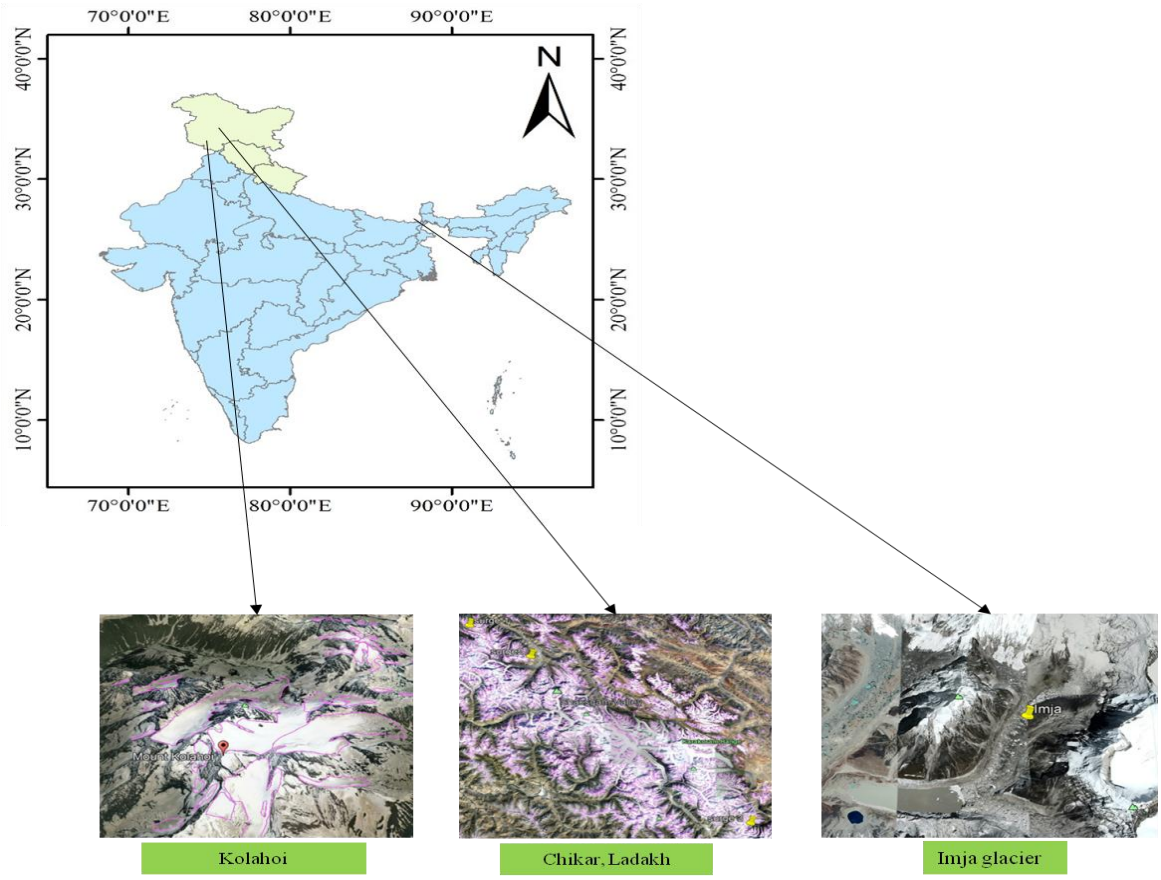



**Figure_1: Location of the Study Area**

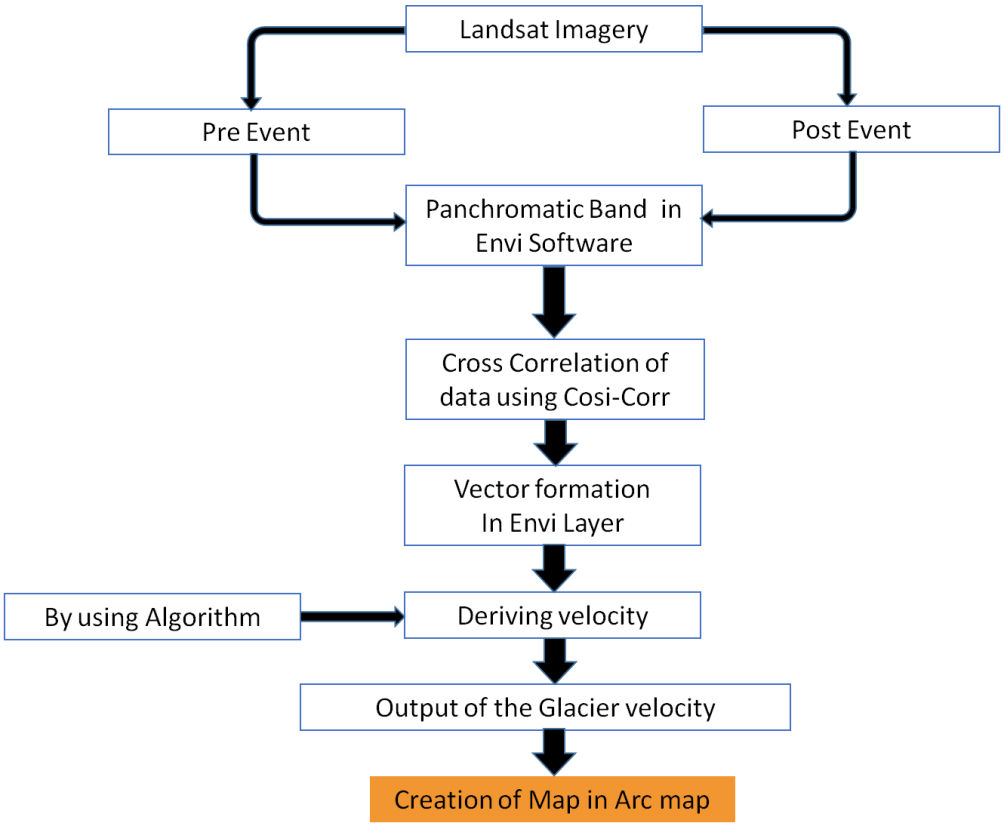
## Dataset

In this research details have been collected from the United States Government's science arm, i.e. The United States Geological Survey (USGS) Earth Explorer of the Earth Observation Satellite Landsat 5, Landsat 8 and Sentinel 2 used data only from the Landsat 8 satellite for the measurement of glacier depth and snout length, and for the glacier surface velocity. The resolution panchromatic data B8 (15 m) will be used for the glaciers surface velocity derivation.

## Methodology

The methodologies implemented in this paper to collect Karakorum, western and eastern Himalayan glacier surface flow velocities & Glacier dynamics. Using COSI-CORR (Co-registration of Optically Sensed Objects and Correlation), an unit in ENVI image processing program, the research conducted by(Sattar et al., 2019) Glacier-surface velocity is obtained through image-to - image correlation at a sub-pixel-level. The method executes co-registration and compares pictures from optical satellites to measure the displacement resulting. For this analysis, I use two Landsat 8 Pan bands, with a time period of 1 year, to deduce the glaciers' surface velocity for test glaciers.

$$\text{Glacier velocity } \{U=\sqrt{a^2+b^2}\}$$



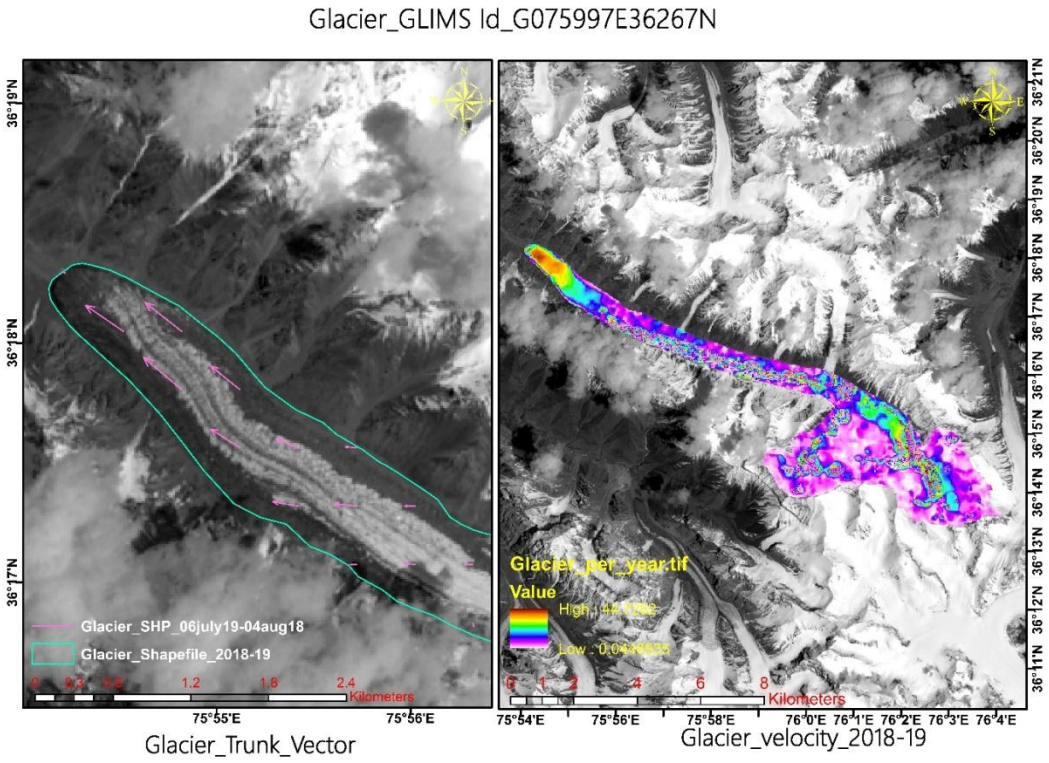

**Flow chart used to obtaining the glacier velocity by using Cosi-CORR technique**

## Cosi-CORR

It is a series of items which was produced under IDL (Interactive Data Language) and completely implemented under ENVI. Using a few orthoimages it is a method for detecting shifts in sub-pixels. The COSI-Corr tool was chosen to determine the exact stream velocity and yield of the PRG after analyzing the yields of the previously described mechanisms. The removal chart was collected using the geospatial tool, as well as the fields for the vectors. Pictures were selected and orthorectified from the pre-occurrence and after-occasion. Using the recurrence correlator array, the photos were then connected to each other using a search window from 256 to 256 pixels (max value) to 8 to 8 pixels (min estimate), with a stage size of 8 pixels and a veil cap of 0,9. The stream heading vector memorandum was then rendered utilizing the vector field instrument to progress East-West and North-South in the COSI-Corr chart. The yield requires the signal-to - noise (SNR) ratio used to eliminate commotion from the output. The files have been transformed to a consistent ArcGIS format (.img) for removal picture and the stream path.shp vector for stream direction.

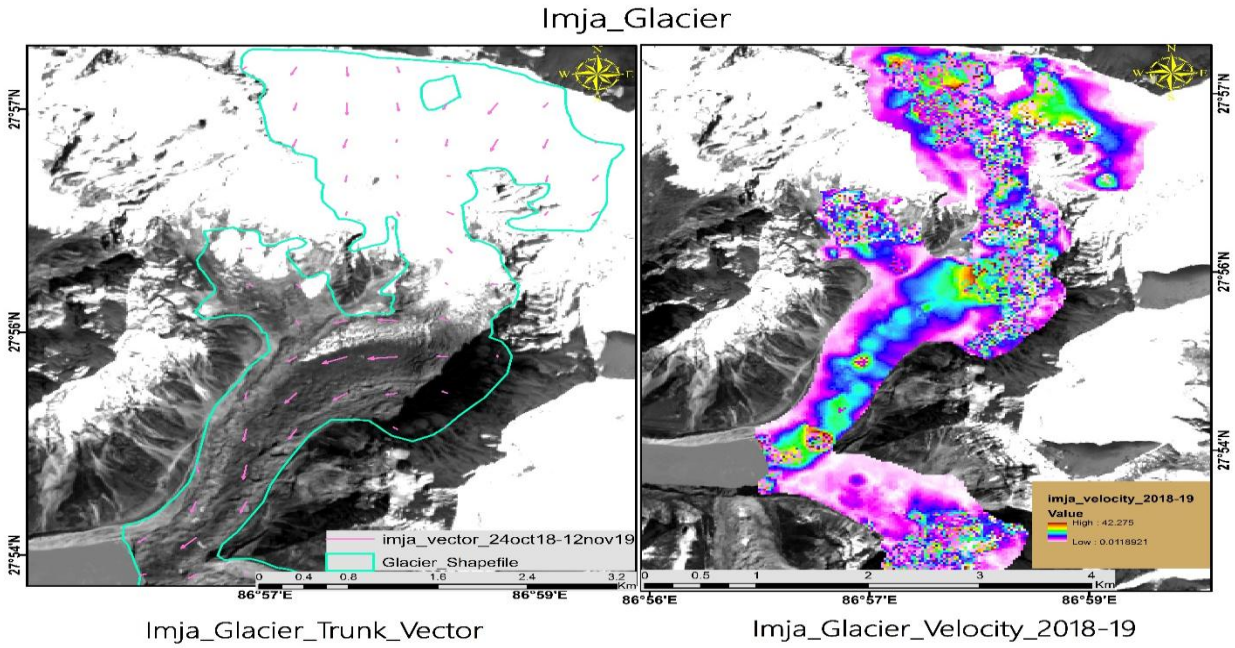
**Results**

**Generated Maps of the Glacier Velocity:**



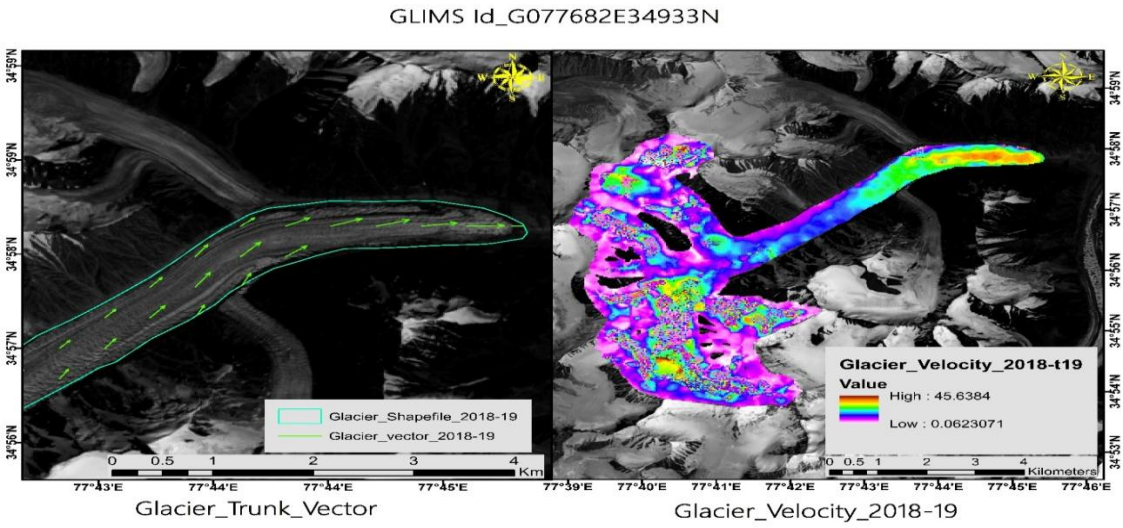

**Map of GLIMS Id_G075997E36267N Velocity 2018-19**

- In case of Glacier of GLIMS Id_G075997E36267N having in the above figure, displacement is estimated to range between 0.045m/year to 44.73m/year highest positive values are seen the length of the core trunk of the glacier.
- Where there is a change in direction of the path flow, the velocity reduces while speedy up again after shifting the direction. On the higher reaches of the glacier, in the accumulation zone, the velocities are lower. It may also be noted that the direction of flow of GLIMS Id_G075997E36267N Glacier is in the North-East direction, i.e. towards the satellite sensor. Therefore, the velocities on the main trunks glacier having the GLIMS Id_G075997E36267N appear in surging range of the glaciers, indicating their movement toward the satellite sensor.



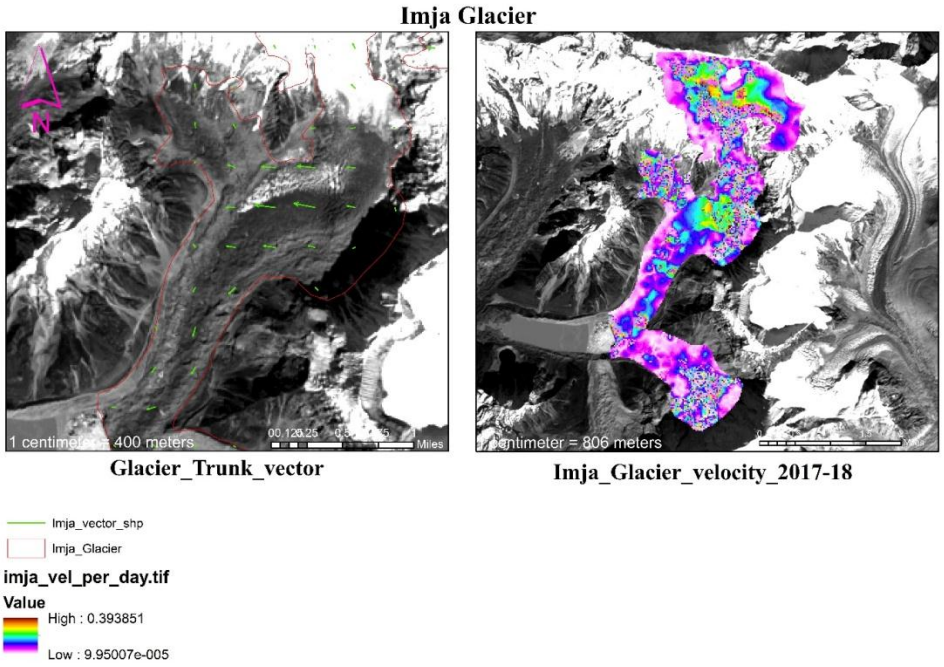

**Map of Imja glacier Velocity 2018-19**

- In the case of Imja Glacier, it is estimated that the displacement ranges from 0.0119m / year to 42.275m / year on the core trunk and in the middle of glacier.
- Where there is a change in direction of the flow route, the velocity varies while speedy up again after shifting the direction. On the higher reaches of the glacier, in the accumulation zone, the velocities are lower. It may also be noted that the direction of flow ofImja Glacier is in the North-East direction, i.e. towards the satellite sensor. Therefore, the velocities on the main trunks Imja glacier appear in retreating range of the glaciers, indicating their movement toward the satellite sensor. The Imja glacier is situated in the Nepal and the ablation zones state that the negative mass balance in the glacier.



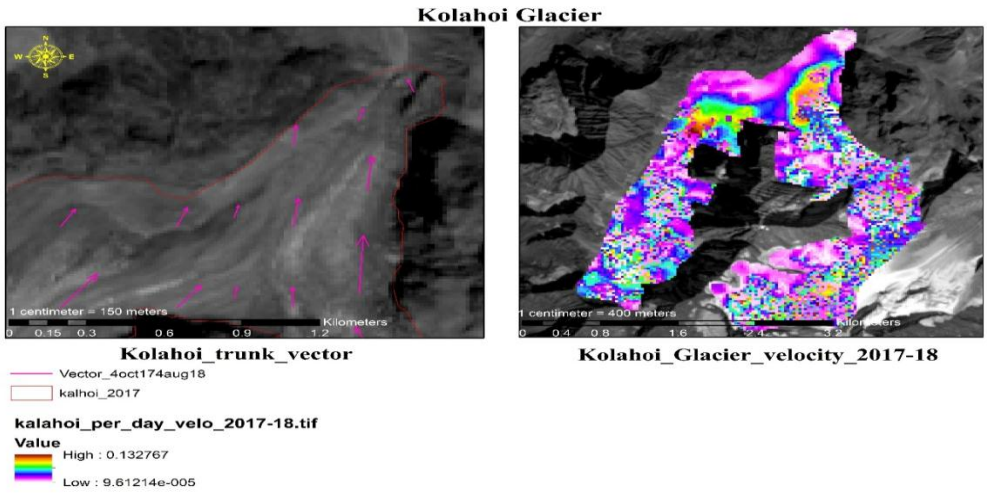

**Map of GLIMS Id_G077682E34933N Velocity 2018-19**

- In case of Glacier having GLIMS Id_G077682E34933N in the above figure, displacement is estimated to range between 0.0623m/year to 45.6384m/year highest positive values are seen the length of the core trunk of glacier of Ladakh.
- Where there is a change in direction of the path flow, the velocity varies while speedy up again after shifting the direction. On the higher reaches of the glacier, in the accumulation zone, the velocities are lower. It may also be noted that the direction of flow of GLIMS Id_G077682E34933N Glacier is in the North-East direction. Therefore, the velocities on the main trunks glacier having the GLIMS Id_G077682E34933Nappear in surging range of the glaciers, indicating their movement is that the higher in the main trunk of the glacier. The tributary glacier of this is coinciding in the frontal zone of the glacier, which results that the velocity of the glacier is get may exceed and increase in the glacier.



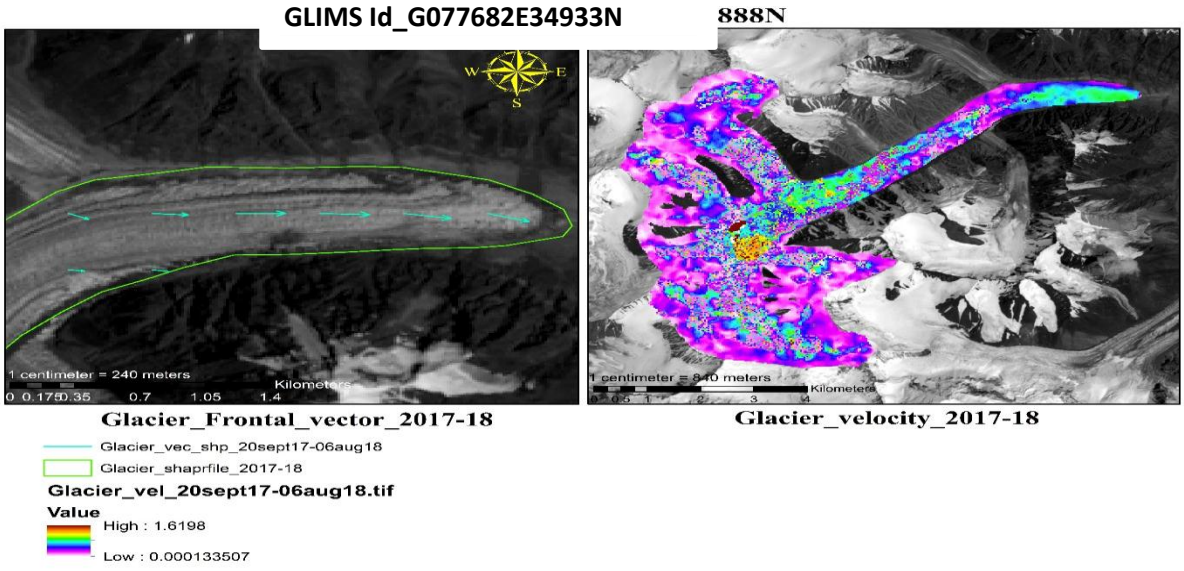

## Map of Imja Glacier Velocity 2017-18

- In case of Imja Glacier having in the above figure, displacement is estimated to range between 9.95e$^{-005}$m/day to 0.394m/day highest positive values are seen the length of the core trunk of glacier.
- Where there is a change in direction of the path flow, the velocity varies while speedy up again after fluctuating the direction. On the higher reaches of the glacier, in the accumulation zone, the velocities are lower. It may also be noted that the direction of flow of Imja Glacier is in the North-East direction. Therefore, the velocities on the main trunks Imja glacier appear in retreating range of the glaciers the middle segment of glacier is having the superior velocity due to the some variation and magnitude in the glacier as validate is done in this study of the year 2017-18, the retreating velocity of the glacier is being validate as the day to day validation which indicating their movement toward the ablation zone of the glacier.




**Map of Kolahoi Glacier velocity 2017-18**

- In case of Mount Kolahoi Glacier having in the above figure, displacement is estimated to range between $9.612e^{-005}$m/day to 0.133m/day highest positive values are seen the length of the core trunk of glacier.
- Where there is a change in direction of the path flow, the velocity shrinks while immediate up again after shifting the path. On the higher reaches of the glacier, in the accumulation zone, the velocities are lower. It may also be noted that the direction of flow of Kolahoi Glacier is in the North-East direction. Therefore, the velocities on the main trunks of Kolahoi glacier appear in retreating range of the glaciers, indicating their movement toward the ablation of the glacier. The retreating velocity of the glacier is being validate as the day to day validation which indicating their movement toward the ablation zone of the glacier.




**Map of GLIMS Id_G077682E34933N Velocity 2017-18**

- In case of Glacier having GLIMS Id_G077682E34933N in the above figure, displacement is estimated to range between 0.0623m/year to 45.6384m/year highest positive values are seen the length of the core trunk of glacier of Ladakh.
- Where there is a change in direction of the path flow, the velocity varies while speedy up again after shifting the direction. On the higher reaches of the glacier, in the accumulation zone, the velocities are lower. It may also be noted that the direction of flow of GLIMS Id_G077682E34933N Glacier is in the North-East direction. Therefore, the velocities on the main trunks glacier having the GLIMS Id_G077682E34933N appear in surging range glaciers, indicating their movement is that the higher in the main trunk of the glacier because the tributary neighbor glacier is being get connected to this glacier. The tributary glacier of this is coinciding in the frontal zone of the glacier, which results that the velocity of the glacier is get may exceed and increase in the glacier. As per the study it is clear that the glacier is being surging trend, the study is being done and the result is being as in the above map.

## Conclusion

The intensity of the glacier surface is calculated using open source development COSI-Corr based on a cross-correlation authoritarian parenting Landsat's panchromatic satellite imagery. The annual surface velocity of the glaciers profile is describing the variation in the velocity over the glacier under the variable climatic conditions in the previous years, glaciers of the Jammu and Kashmir and Ladakh is having the accumulation criteria and the glacier of the Nepal Imja glacier and Lidder valley Mount Kolahoi glacier is having the trend of the ablation which can easily understood that the climatic effect on the glacier on the major glacier of the Karakorum and Himalaya.

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