Date of Submission	11/07/2025

IPL Project (IPL-Number) Annual Report Form

Period of activity under report
from 1 January 2024 to 1 January 2025

1. Project Number and Title:

Monitoring and comparison rock glaciers kinematic process using SAR interferometry and offset-tracking in Western Himalaya, Inner Qinghai-Tibet and Alps.

2. Main Project Fields

Select the suitable topics. If no suitable one, you may add new field.

(1) Technology Development

☑***A. Monitoring and Early Warning,*** B. Hazard Mapping, Vulnerability and Risk Assessment

(2) Targeted Landslides: Mechanisms and Impacts

A. Catastrophic Landslides

(3) Capacity Building

B. Collating and Disseminating Information/ Knowledge

(4) Mitigation, Preparedness and Recovery

A. Preparedness

3. Name of Project Leader

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Core members of the Project:

Nicola Casagli, Full Professor, DST-UNIFI

Veronica Tofani, Full Professor, DST-UNIFI

Xiaoqing Chen, Professors, IMHE-CAS

4. Objectives (5 lines maximum)

The main objective of this project is to retrieve surface velocities from typical rock glaciers in Western Himalaya, Inner Qinghai-Tibet and Alps using both Interferometrical and offset-tracking techniques. Spatial and temporal time-series analysis reveals rock glacier kinematic process in different places, indicating hazards response to climate change.

5. Study Area

The study areas will be the Karakoram (Western Himalaya), Sanjiangyuan (Qinghai-Tibet) and Valle d'Aosta

(Italian Alps), specifically selected due to their high sensitivity to climate warming and susceptibility to ground instability phenomena.

6. Project Duration

The duration of the project is three years.

7. Report

1) Progress in the project (30 lines maximum)

This year, IMHE-CAS collaborated with DST-UNIFI to explore an integrated remote sensing approaches to identify active rock glaciers involving with different techniques. InSAR offers high-precision monitoring of surface deformation and is particularly effective for detecting slow rock glaciers. The VV-polarized backscattering coefficient reflects the surface roughness and heterogeneity of glaciers, making it well-suited for capturing dynamic surface changes such as snowmelt, sliding, and surface water accumulation, as it can clearly detect reflectance characteristics of snow- and ice-covered areas. The Normalized Difference Snow Index (NDSI) directly indicates snow and ice mass balance and is most effective for identifying snow cover on glacier surfaces. The typical case are located in Tianshan Mountains.

Firstly, we employ multi-temporal SBAS-InSAR to obtain ground slow surface deformation, Further, backscattering coefficient variation of Sentinel-1 VV polarization are exploited by Google earth engine. Then, the temporal abnormal trend of the Normalized Difference Snow Index (NDSI) derived from Landsat 8 spectral data are estimated. Finally, we proposed an data fusion method through selecting and combining the optimum factors, enabling accurate mapping of glacier spatial distribution. A total of 213 active glaciers were identified, achieving an overall accuracy of 82.63% (Figure 1). Different techniques demonstrate respective performance depending on glacier type (Figure 2): InSAR is proved to detect active bare glaciers, considering that bare ice surface generates high-coherence scattering and undergoes slow deformation. Polarization techniques are most sensitive to relict rock glaciers due to rapidly melting rock glaciers with mixed ice-rock surfaces undergo seasonal deformation and exhibit strong scattering variability. For clean glaciers, high NDSI abnormal values and significant variation trends. This approach offers an efficient and accurate means for glacier monitoring, providing reference for disaster mitigation caused by climate change research in the Apls and other periglacial environments.

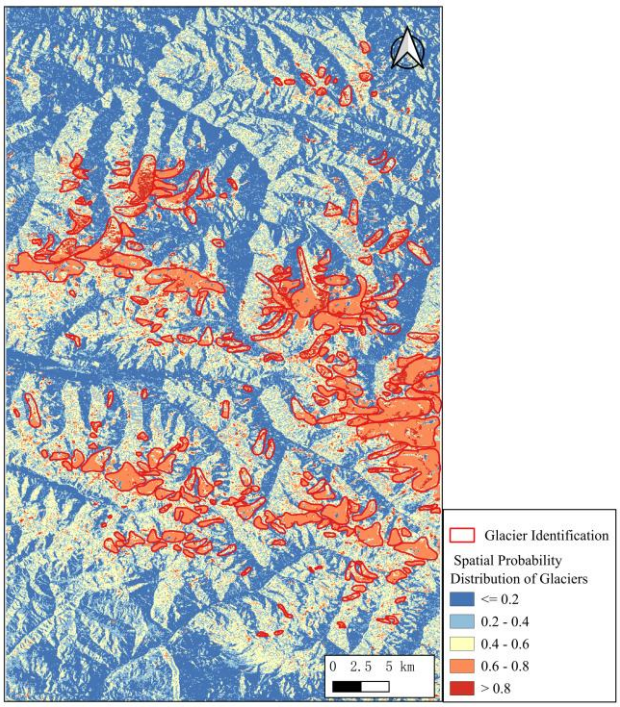

Figure 1 Probability Map of Glacier Spatial Distribution

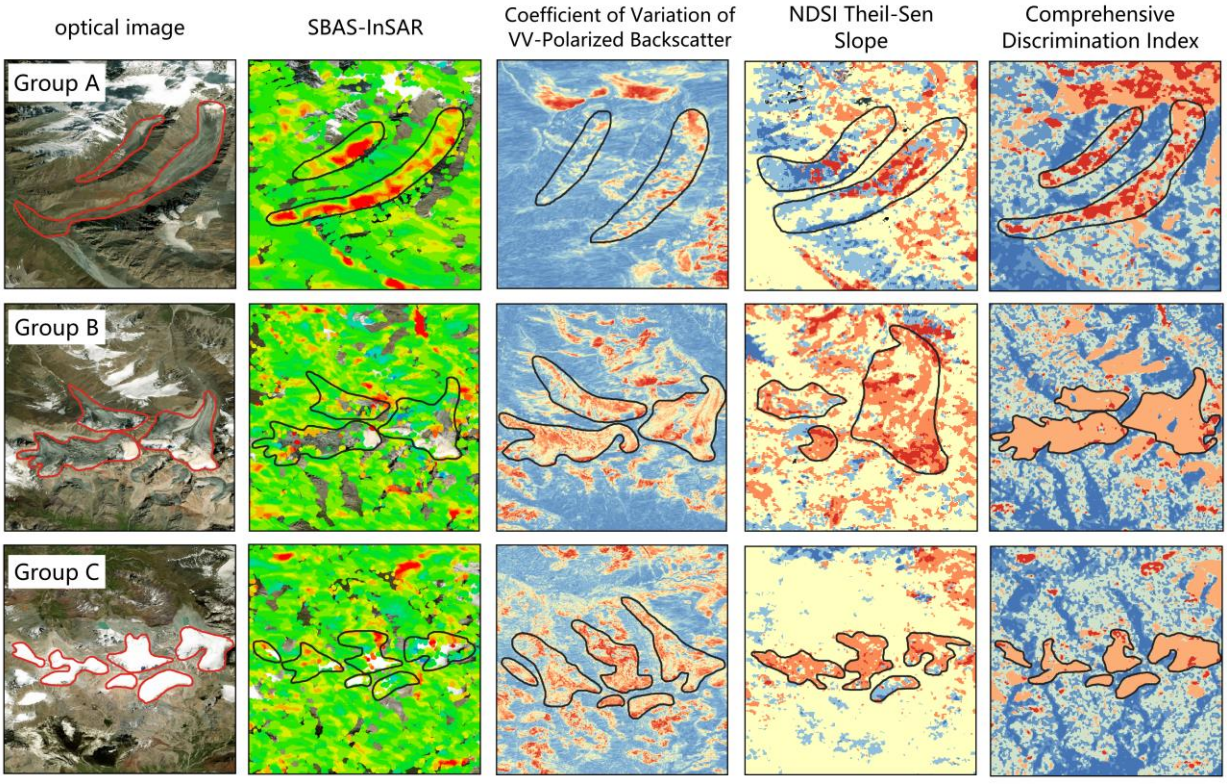

Figure 2 Comparison of Typical Glacier Identification by Multiple Remote Sensing Techniques

2) Planned future activities or statement of completion of the Project (15 lines maximum)

In the next phase of our research, we plan to select representative regions across multiple international sites for comparative analysis including the field investigation. By integrating varying climatic conditions,

geomorphological characteristics, and glacier activity states, we aim to compare the spatiotemporal distribution patterns and deformation behaviors of glaciers in different regions. This study will provide a scientific basis for understanding the evolutionary patterns and deformation mechanisms of glaciers worldwide. The project is scheduled for completion by the end of 2025.

3) Beneficiaries of Project for Science, Education and/or Society (15 lines maximum)

The final rock glacier inventory map (location, spatial distribution, time-series deformation pattern, type) will be transferred to local civil protection agencies and international landslides research councils (*e.g.*, ICL, ICIMOD, LEWS). Our monitoring result will be written in a report, and some interesting conclusions are intended to be submitted to the journal LANDSLIDES. PhD students or researchers on both sides will visit and exchange under the support of this project. The detailed fee will be covered by other research projects or fundings.

4) Results (15 line maximum, e.g. publications)

Our final result is the regional active rock glacier inventory maps in different area across Asia, Central Asia and Europe. The detailed processing and related comparison result will publish the academic paper. In addition, our research work will be present in international conference, willing to provide valuable suggestion for stakeholders.

Note:

1) If you will change items 2-7 from the proposal, please write the revised content in Red.
2) Please fill and submit this form to ICL Network <icl-network@landslides.org>
3) Reporting year must be one or two years (Maximum).