Date of Submission	10/06/2026

IPL Project (IPL-Number) Annual Report Form

Period of activity under report
from 1 January 2025 to 10 June 2026

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 Tianshan , 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)

In 2026, this framework was expanded by integrating multi-source remote sensing data, including optical spectral indices, SAR polarimetric and texture features, land surface temperature, InSAR-derived deformation rates, and glacier surface velocity. NDSI was used to distinguish snow and ice, while SBAS-InSAR provided annual mean surface deformation rates for mapping slow glacier movement. VV and VH polarizations were combined using a weighted approach to generate enhanced backscatter features. Three models—Random Forest (RF), XGBoost, and Convolutional Neural Network (CNN)—were implemented in a classification framework for rock glacier identification and mapping.

A total of 386 glaciers were identified in the Ili River Basin, Tianshan, with a total area of approximately 519.11 km²(Fig.1). Among them, 44 rock glaciers were mapped in the northern Tianshan, 237 in the eastern Tianshan, and 106 in the southern Tianshan. Debris-covered glaciers are mainly distributed at elevations of 3500–4100 m, on slopes of 10°–20°, and within specific slope-aspect settings (Fig. 2).

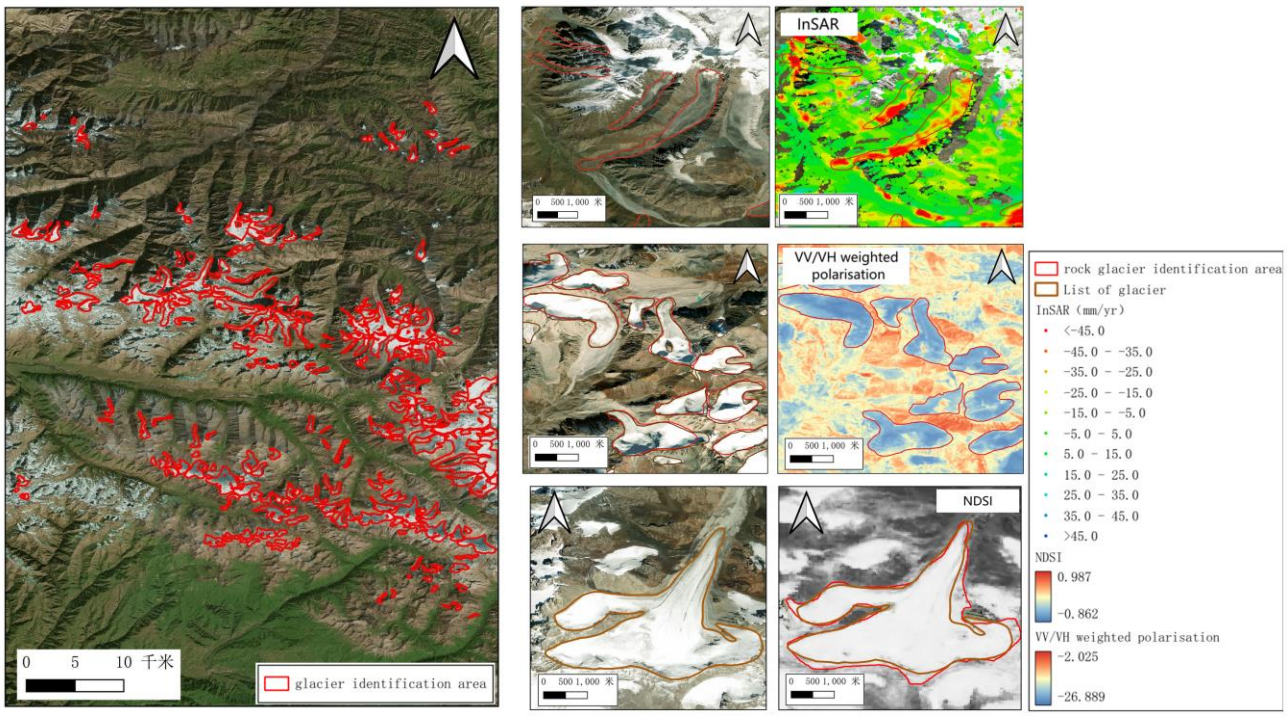


Fig1. Rock glacier identification of the eastern Tianshan Mountain using multi- remote sensing data

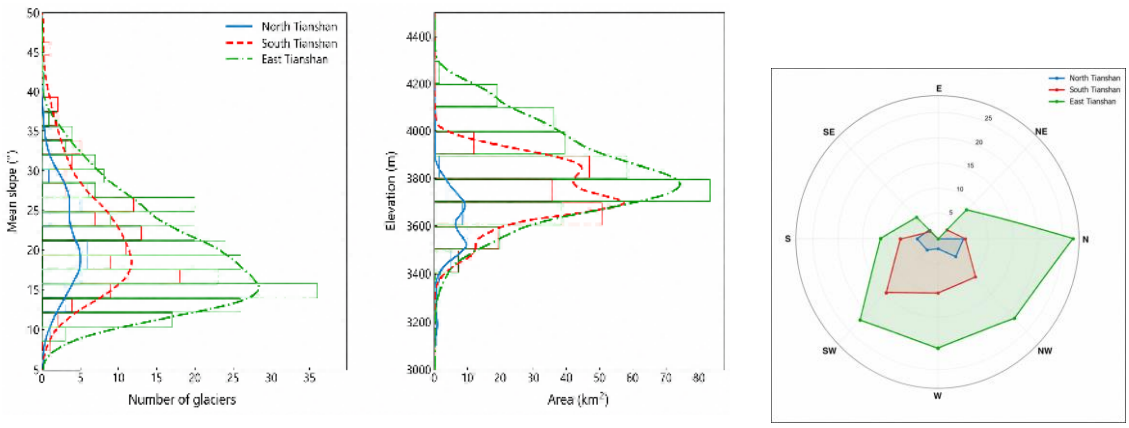
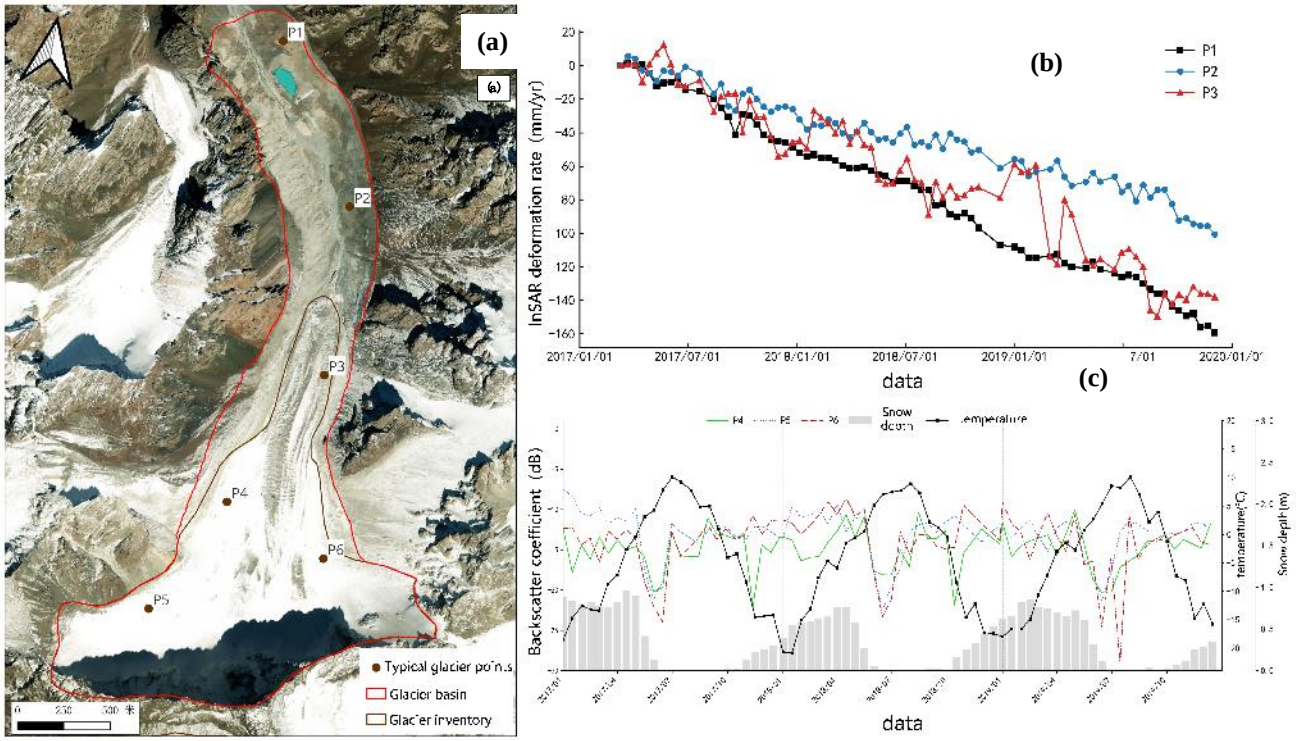


Fig2. Rock glacier distribution characteristic

SHAP analysis was used to evaluate the contribution of multi-source remote sensing variables. Results show that InSAR deformation rate, glacier surface velocity, and VV texture features were the controlling factor for the development of rock glacier, indicating that kinematic and surface-roughness information is essential for distinguishing active debris-covered glaciers from surrounding bedrock and moraine deposits.

Typical rock glaciers near the highway corridor were selected for detailed analysis(Fig3(a)). Time-series InSAR results revealed continuous negative deformation in debris-covered and transition zones(Fig3(b)), while VV-polarized backscattering(Fig3(c)) showed strong seasonal responses during the ablation period. These results indicate that multi-source remote sensing can not only improve rock glacier mapping accuracy, but also provide useful indicators for identifying potentially hazardous glacier sources along transportation corridors.



(a) Remote sensing image of a typical rock glacier (b) InSAR time-series diagram (c) time-series diagram of VV polarization, snow-melt, and rainfall

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

In the next phase, the rock glacier identification framework will be further improved by integrating multi-temporal deformation measurements, land surface temperature, and road exposure indicators. Representative rock glaciers will be selected for comparative analysis across different mountain regions (e.g., the Alps and the Tianshan). Future work will focus on delineating active rock glacier source areas prone to debris flow initiation and strengthening the linkage between rock glacier kinematics and downstream hazard potential. The results will be compiled into an academic paper and may provide technical support for glacier hazard monitoring and transportation corridor risk management.

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

The final rock glacier inventory (including location, spatial distribution, time-series deformation patterns, and classification types) has been delivered to local civil protection agencies. The monitoring results will be further reassessed to emphasize potential risks to nearby infrastructure, and the final map will be documented in a technical report. Key findings are intended for submission to Landslides. PhD students and researchers from both sides will also conduct reciprocal visits and academic exchanges under this project, with costs covered by other research funding sources.

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

Our final result is the regional active rock glacier inventory maps in different area across,Tianshan,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).