HOW WELL DO INSAR MEASUREMENTS ALIGN WITH ROCK GLACIER DELINEATIONS IN THE AUSTRIAN ALPS?

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(1) Introduction

Rock glaciers are key indicators of permafrost dynamics and hydrological processes in alpine regions. Understanding their kinematics is crucial for assessing permafrost evolution, geomorphological hazards, and water resources.

Earth observation (EO) data, particularly Interferometric Synthetic Aperture Radar (InSAR), offer tools for detecting rock glaciers, estimating their velocities, and analysing seasonal and long-term movement trends.

This study uses Sentinel-1 data to evaluate the applicability of InSAR-derived displacement measurements in improving rock glacier mapping and understanding their movement patterns.

(2) Motivation & Objectives

We investigate how well InSAR-derived surface displacement measurements align with rock glacier delineations from an existing inventory created through manual interpretation (Wagner et al., 2020).

By integrating InSAR-derived displacement data, we aim to:

(1) Evaluate the suitability of InSAR results for confirming or disconfirming rock glacier locations.

(2) Propose ways to improve the mapping of rock glaciers by using InSAR results for:

- Identifying rock glaciers
- Improving rock glacier delineations
- Estimating rock glacier movement rates

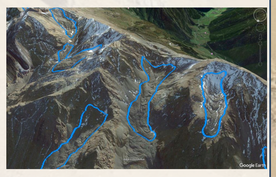


Fig. 1. Rock glaciers in the existing inventory (Wagner et al., 2020)

(3) Study Area & Data

The study focuses on the Ötztal region in the Austrian Alpen, a periglacial environment with numerous active and inactive rock glaciers. This area is characterised by complex topography, steep slopes, and permafrost conditions, making it a suitable test site for evaluating InSAR performance in rock glacier studies.

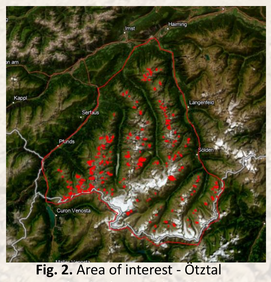


Fig. 2. Area of interest - Ötztal region in the Austrian Alps

Data:

Sentinel-1 scenes for April-October 2021 in Interferometric Wide Swath (IW), acquired in descending orbit. These are complemented by the Copernicus Digital Elevation Model (DEM).

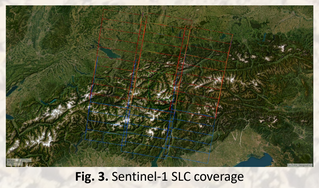
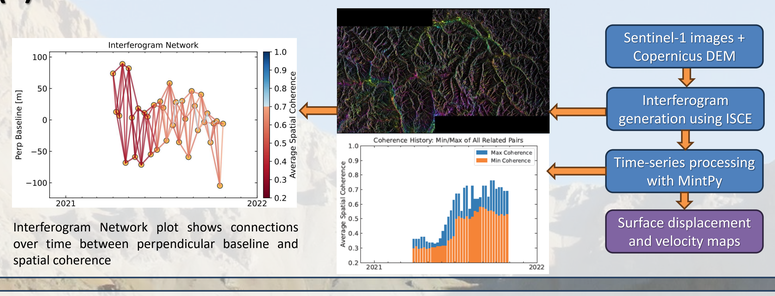


Fig. 3. Sentinel-1 SLC coverage

(4) Methods



Interferogram Network plot shows connections over time between perpendicular baseline and spatial coherence

To derive surface displacement and velocity maps from Sentinel-1 SAR imagery, a standard InSAR processing chain was implemented.

1. **Data Pre-processing:** Sentinel-1 SAR images and the Copernicus DEM were used as input data.
2. **Interferogram Generation:** Using ISCE (Interferometric Synthetic Aperture Radar Scientific Computing Environment), we generated interferograms that capture phase differences between SAR acquisitions.
3. **Time-Series Analysis**: MintPy (Miami InSAR Time-series software) was applied to perform time-series processing and phase unwrapping, allowing for the extraction of displacement over time.
4. **Velocity Map Extraction:** The output was used to produce average line-of-sight (LOS) velocity maps and assess the spatial and temporal movement patterns of rock glaciers.

(5) Results & Discussion

Preliminary results indicate a generally high but variable degree of alignment between InSAR-derived displacement patterns and the existing rock glacier inventory of Wagner et al. (2020). This was confirmed by a visual assessment of the match between InSAR results and the rock glacier outlines.

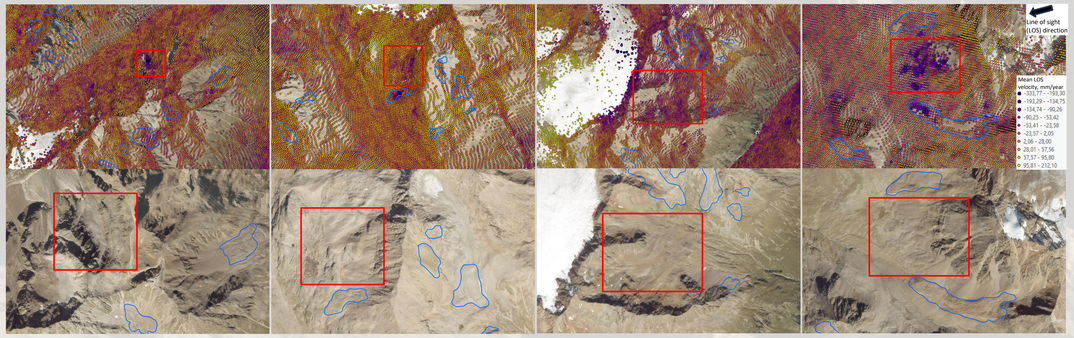
InSAR-derived displacement data demonstrate high potential for:

(a) Detecting previously unmapped rock glaciers.

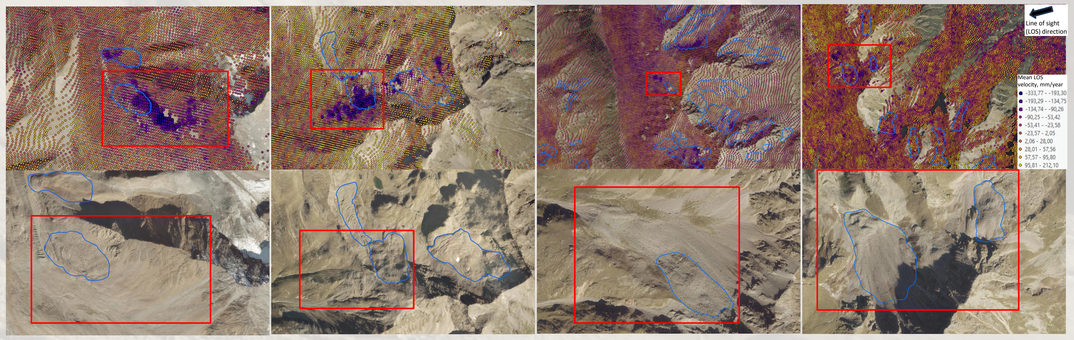
(b) Reshaping delineations of existing inventories. The spatial patterns of movement rates provide a valuable means for confirming the presence of a rock glacier or revealing mismatches where inventory delineation may require adjustment.

(c) Understanding of movement rates of individual rock glaciers. Some rock glaciers move in a clear and steady way, while others show varying internal movement patterns or differences due to terrain complexity or InSAR limitations. Such insights help to determine when and where deformation occurred, contributing to a better understanding of rock glacier behaviour.

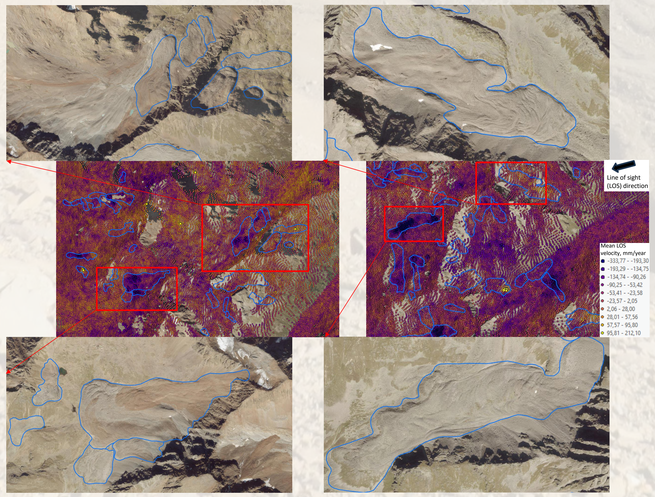
(a) Detecting previously unmapped rock glaciers

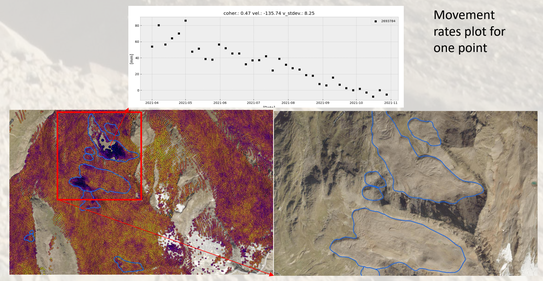


(b) Reshaping delineations



(c) Movement rates within a rock glacier





Movement rates plot for one point

(6) Conclusion

Our study demonstrates the potential of InSAR for rock glacier mapping, updating existing delineations, movement rate analysis of rock glaciers.

These findings can contribute to advancing rock glacier research, supporting permafrost monitoring, and informing water resource and hazard management strategies in alpine environments.

References

Wagner, T., Ribis, M., Kellerer-Pirklbauer, A., Krainer, K., Winkler, G., 2020. The Austrian rock glacier inventory RGI_1 and the related rock glacier catchment inventory RGCI_1 in ArcGis (shapefile) format [dataset]. PANGAEA. https://doi.org/10.1594/PANGAEA.921629

Background picture: © Benjamin A. Robson.

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