EGU24-8327, updated on 14 Oct 2024
https://doi.org/10.5194/egusphere-egu24-8327
EGU General Assembly 2024

Multi-annual Rock Glacier Velocity (RGV) products based on InSAR

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Rock glaciers are debris landforms resulting from the creep of mountain permafrost. Whereas motion rates are related to multiple structural, topographic and climatic factors, and range from a few cm/a to multiple m/a, their interannual variations are primarily linked to those of the thermal state of the permafrost. With the objective to provide a novel climate change indicator suitable for mountain permafrost environments, the established parameters of the Essential Climate Variable (ECV) Permafrost Active Layer Thickness (ALT) and Permafrost Temperature (PT) have been complemented in 2021 by Rock Glacier Velocity (RGV). RGV is an annualized rock glacier velocity time series documenting the creep rate of mountain permafrost. Relative velocity changes extracted from multiple sites are needed to robustly represent the climate signal. However, RGV production on the basis of in-situ measurements is costly and therefore restricted to some specific sites. We propose a new approach to extract RGV using spaceborne Synthetic Aperture Radar Interferometry (InSAR). We used Sentinel-1 SAR images (wavelength: approx. 5.55 cm) between 2015 and 2022 to compute and average (stack) interferograms with short temporal baselines of 6 to 12 days, extract multiple spatially distributed velocity time series and identify dominant trends through clustering. Pilot results on selected rock glaciers in Switzerland show good agreement between InSAR-based RGV and in-situ measured RGV from the Swiss Permafrost Monitoring Network PERMOS, especially regarding the relative change of velocities. Despite some limitations, the method makes it possible to systematically extract time series for a large amount of rock glaciers, thereby contributing to further use RGV as climate change indicator. Future research will focus on testing the method on additional rock glaciers, with an emphasis on rock glaciers suitable for analysis with 12-day interferograms (current Sentinel-1 repeat-pass). We aim to produce time series in multiple mountain ranges worldwide, providing a comprehensive dataset of InSAR-based-RGV products.