climate change initiative

→ PERMAFROST

Rock glacier velocity (RGV)
New parameter of the ECV permafrost

Line Rouyet[1,2], Lea Schmid[2], Philipp Bernard[3], Tazio Strozzi[3], Andreas Kääb[4], Cécile Pellet[2], Reynald Delaloye[2]

permafrost cci

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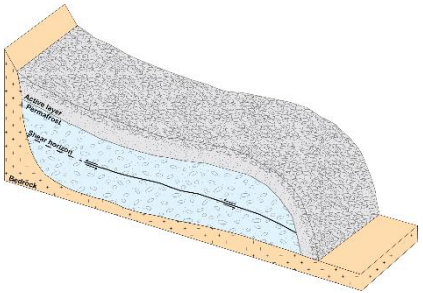
Mountain permafrost and rock glaciers

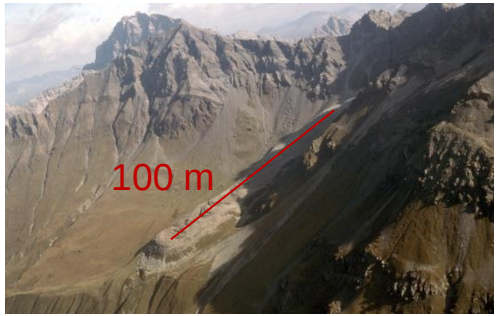
Permafrost ECV is traditionally documented by **Ground Temperature** (GT) and **Active Layer Thickness** (ALT).

However, **mountains** are characterized by large variability over short distances, with sparse in-situ measurements and difficulties for permafrost models to represent fine-scale variability.

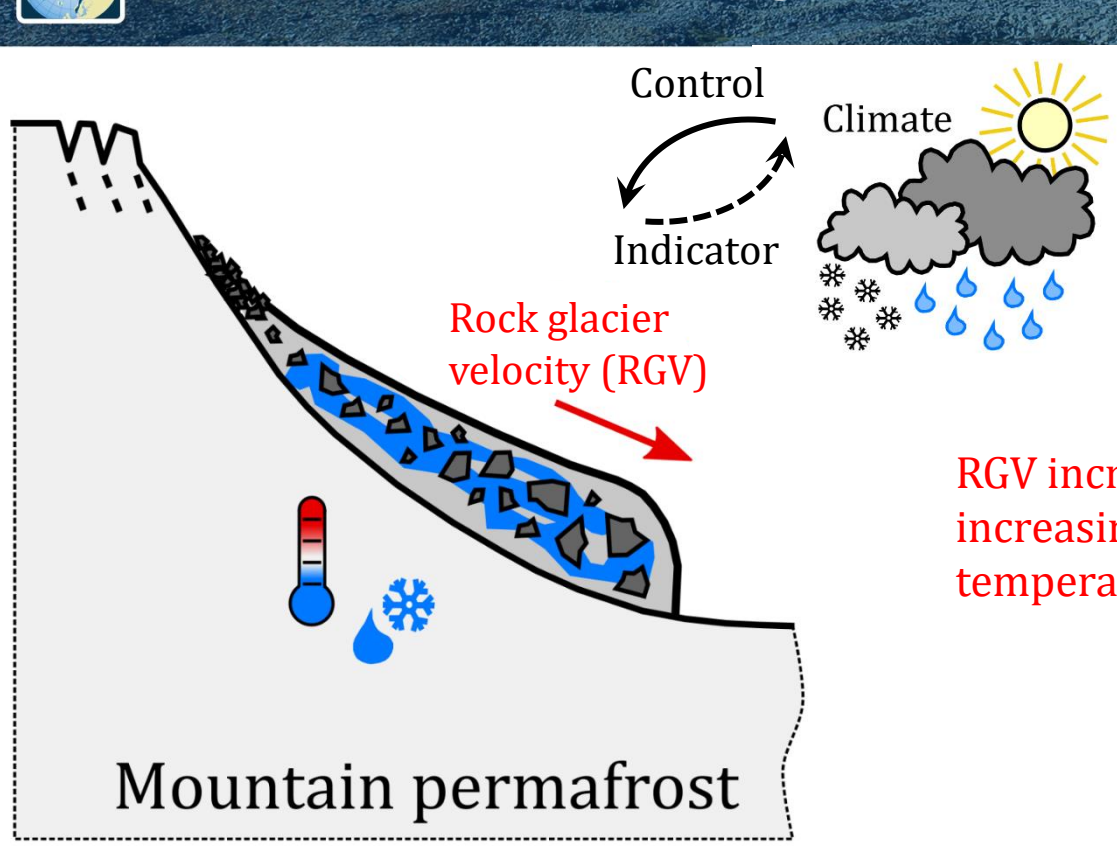
- **Need for other proxies** to document permafrost changes.
- **Rock glaciers:** easily identifiable evidence of permafrost occurrence.

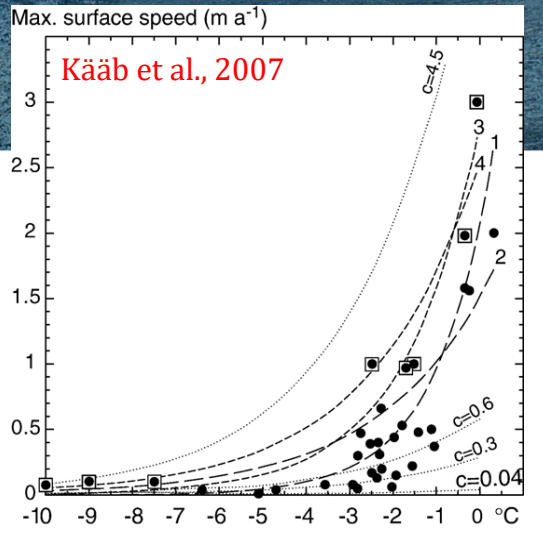
"Rock glaciers are **debris landforms** generated by the **former or current creep of frozen ground (permafrost)**, detectable in the landscape with the following morphologies: **front, lateral margins** and optionally ridge-and-furrow surface topography" (RGIK, 2023).



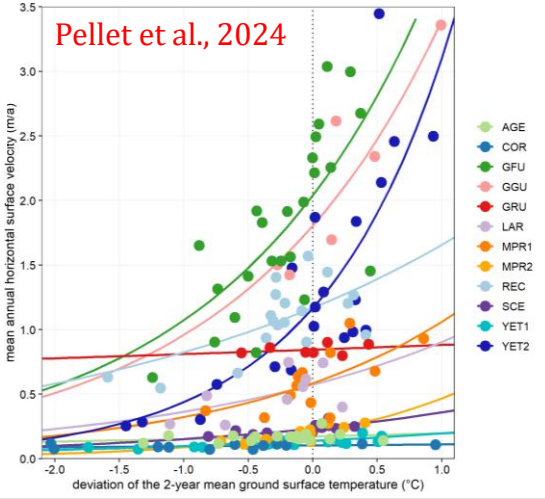


RGV as climate change indicator





RGV increases with increasing ground temperature.

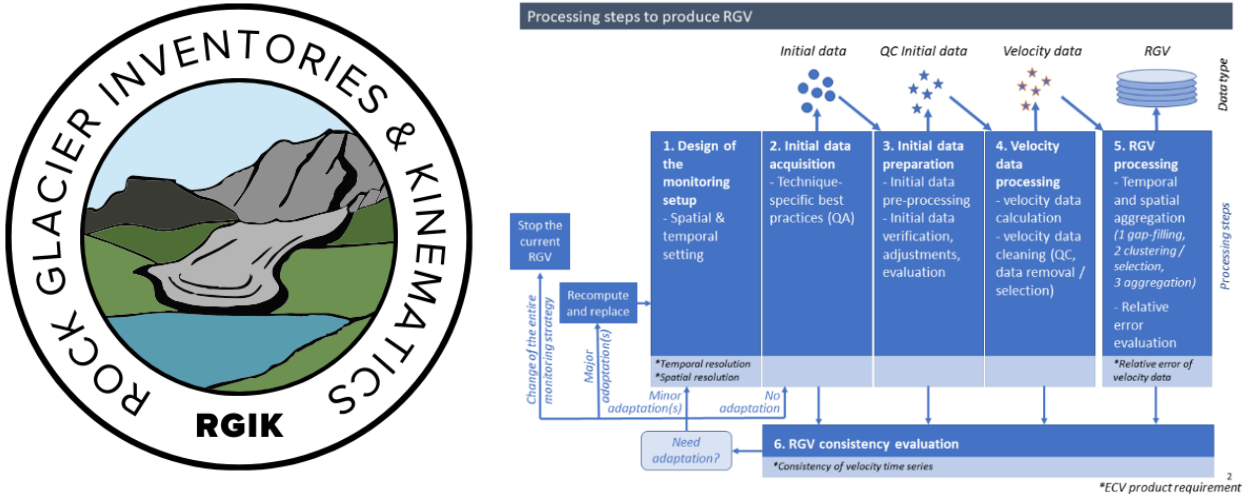


RGV as ECV parameter

The **Rock Glacier Kinematics and Inventories (RGIK)** International Permafrost Association (IPA) Action Group (2018-2023) has recently transitioned into an IPA Standing Committee (June 2024).

RGIK made **guidelines for RGV generation** (on www.rgik.org).

Rock Glacier Velocity (RGV) is defined as “a **time series of annualized surface velocity values** expressed in **m/y** and measured/computed **on a rock glacier unit** or a part of it**”** (RGIK, 2023).

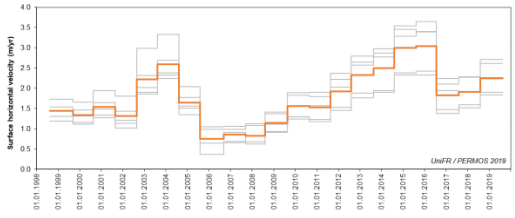


IPA Action Group Rock glacier inventories and kinematics

Rock Glacier Velocity as an associated parameter of ECV Permafrost

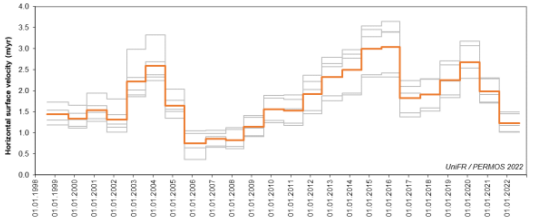
Baseline concepts

(Version 3.2)



Practical concepts

(Version 1.2)



www.rgik.org *(Action Group website)*

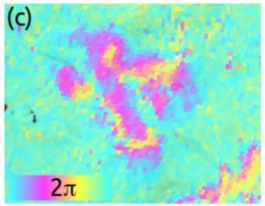
22.05.2023

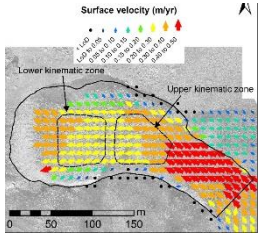
RGV as ECV parameter

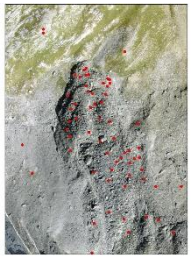
RGV has been integrated as a **new associated product to the ECV Permafrost in the implementation plans of GCOS and GTN-P.**

The RGIK guidelines contributed to define the **ECV product requirements.**

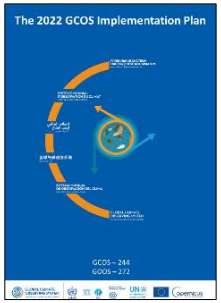
The guidelines are currently generic. **Best practices for specific techniques** must be developed.



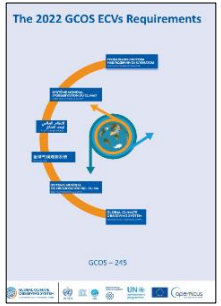




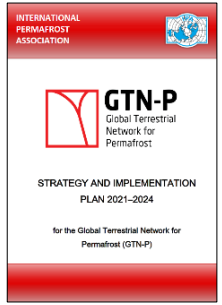
GCOS implem. plan

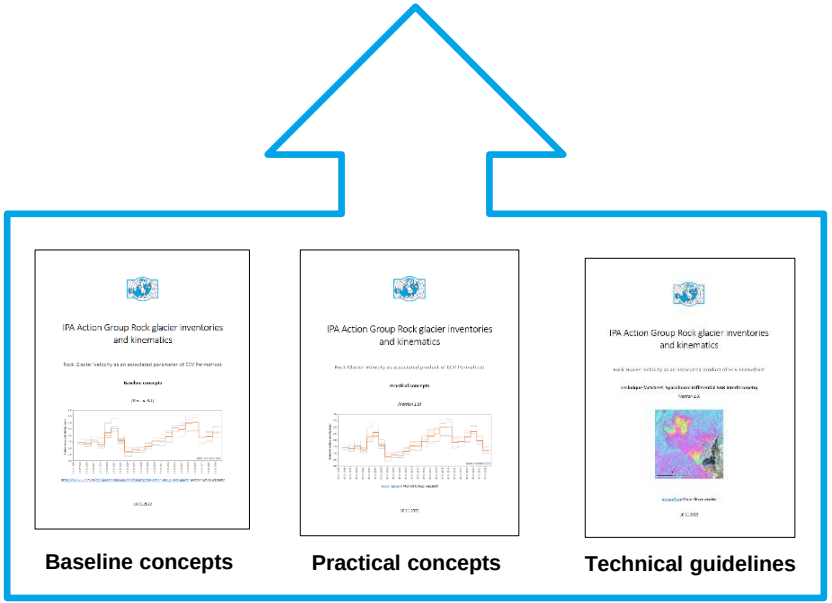


GCOS ECV req.

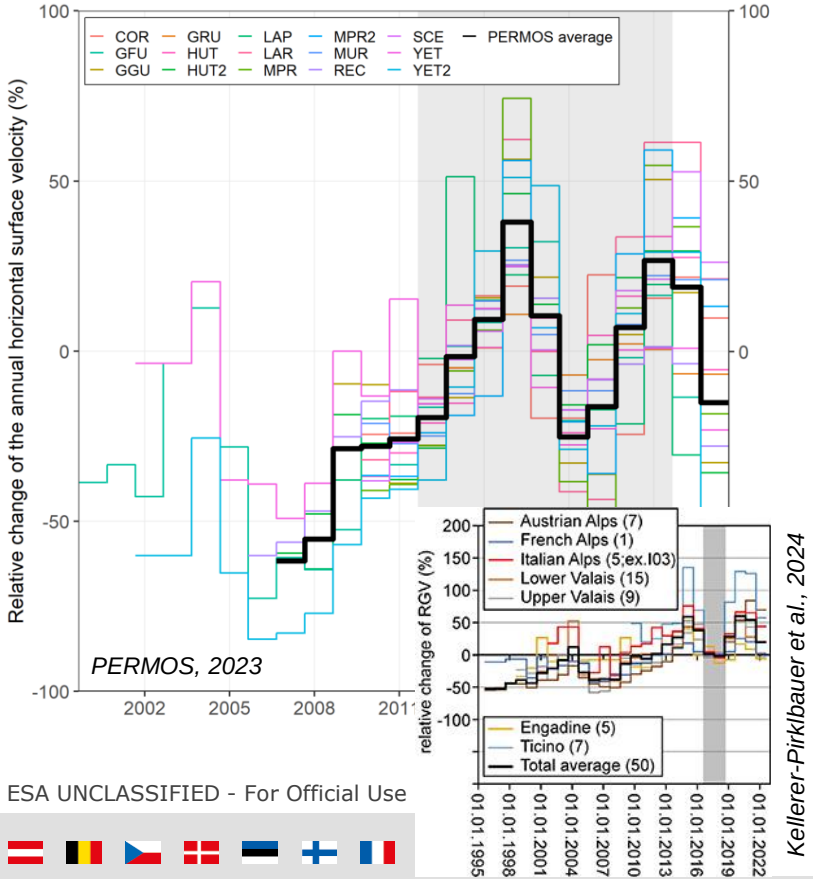


GTN-P implem. plan

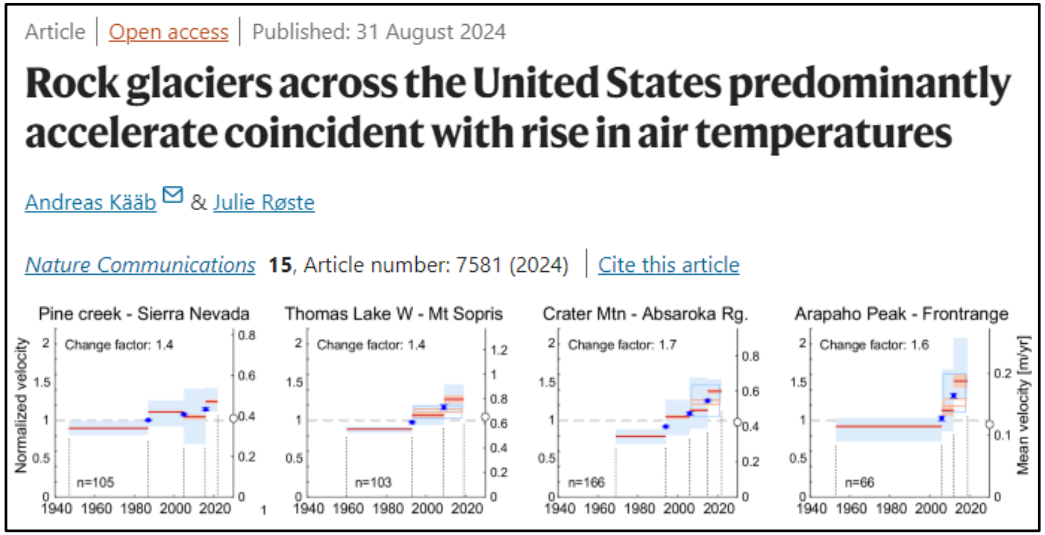




Current RGV – regionally & globally



Kellerer-Pirklbauer et al., 2024



Article | Open access | Published: 31 August 2024

Rock glaciers across the United States predominantly accelerate coincident with rise in air temperatures

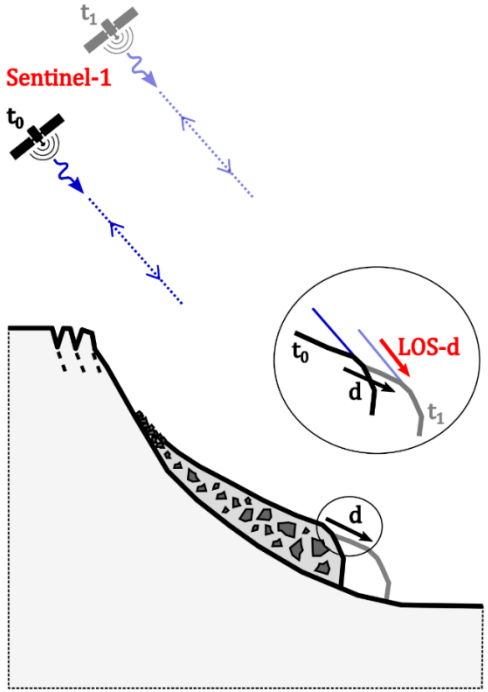
Andreas Kääb & Julie Røste

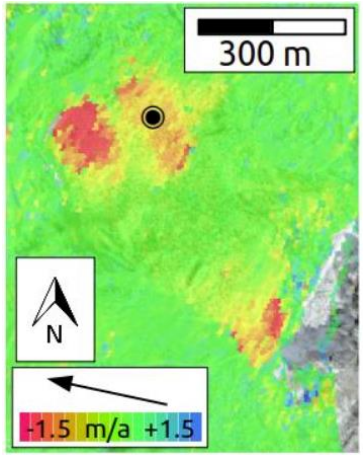
Nature Communications **15**, Article number: 7581 (2024) | Cite this article

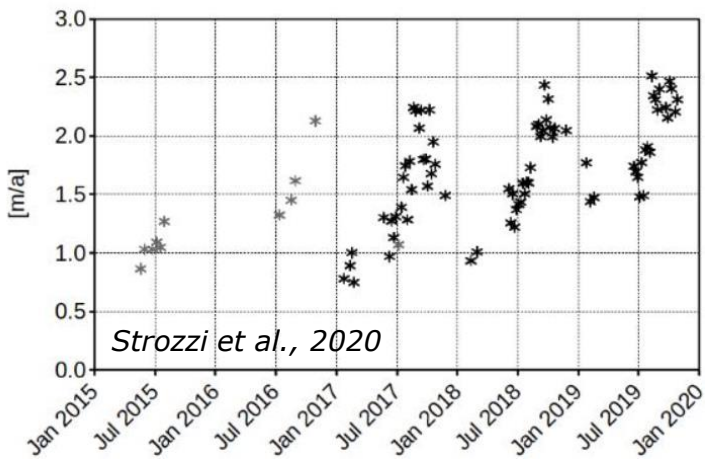
InSAR-RGV

permafrost cci

Towards upscaling using satellite remote sensing

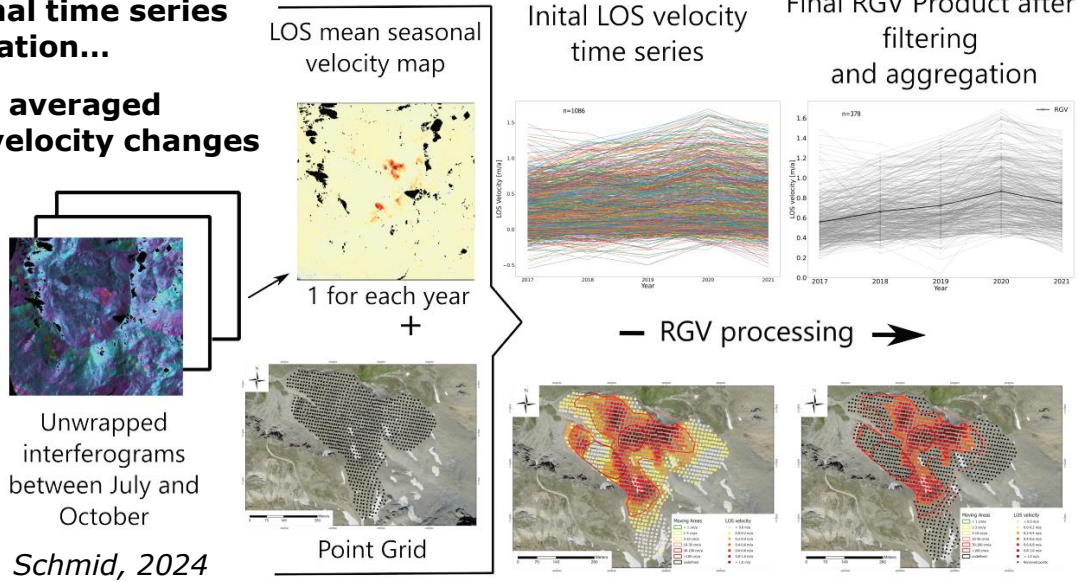




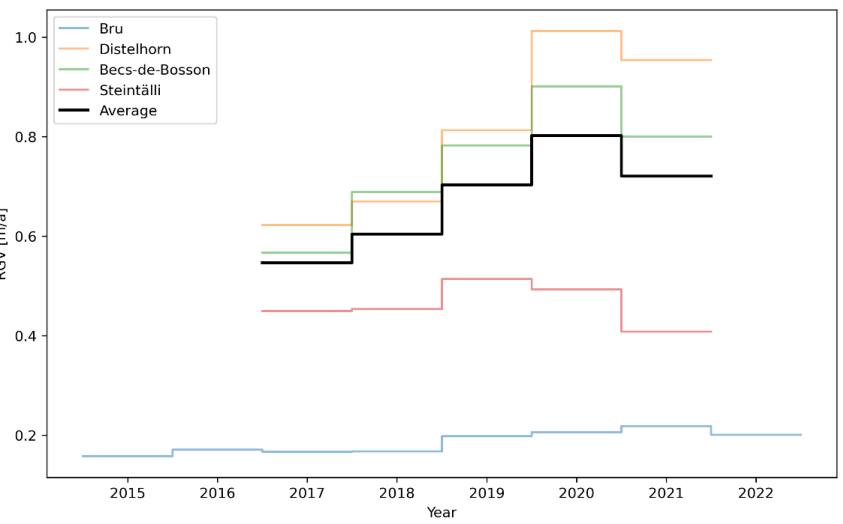


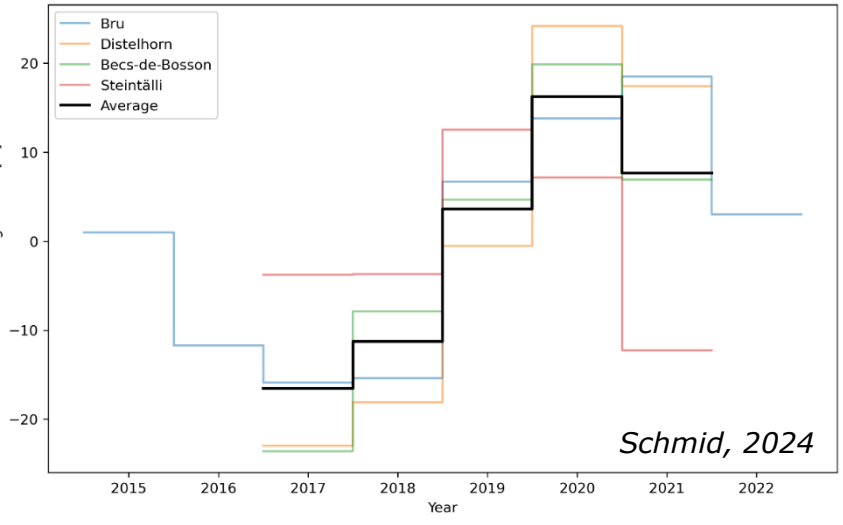
From seasonal time series at single location...

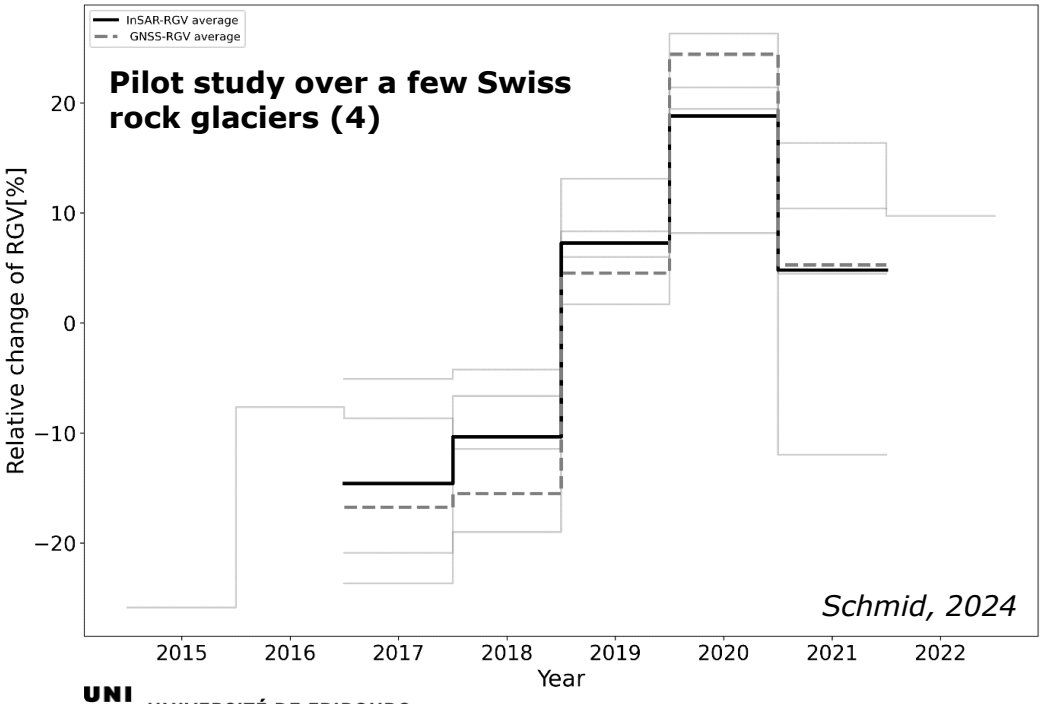
...to spatially averaged interannual velocity changes



InSAR-RGV







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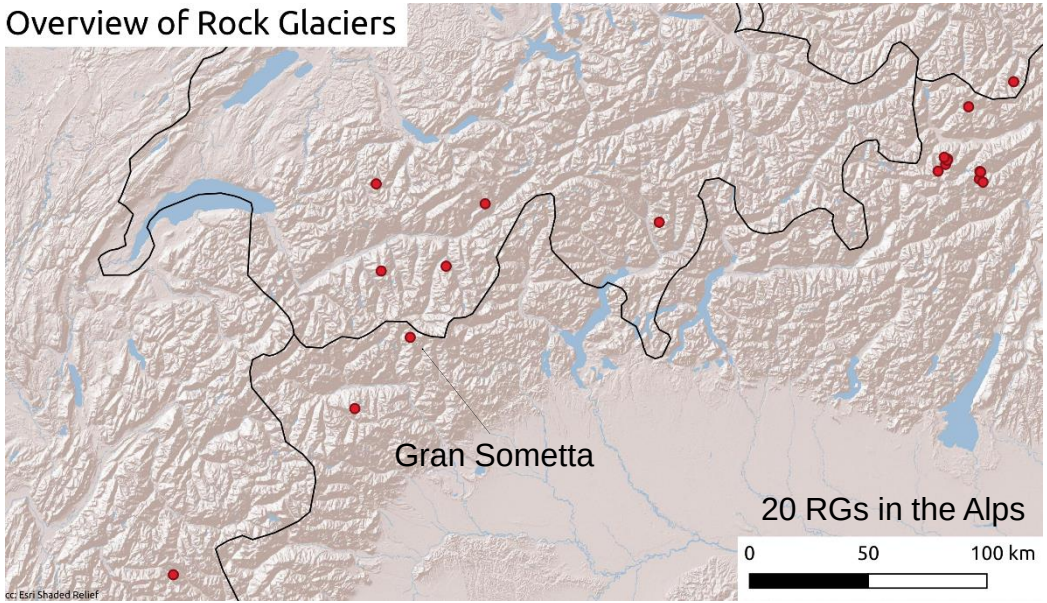
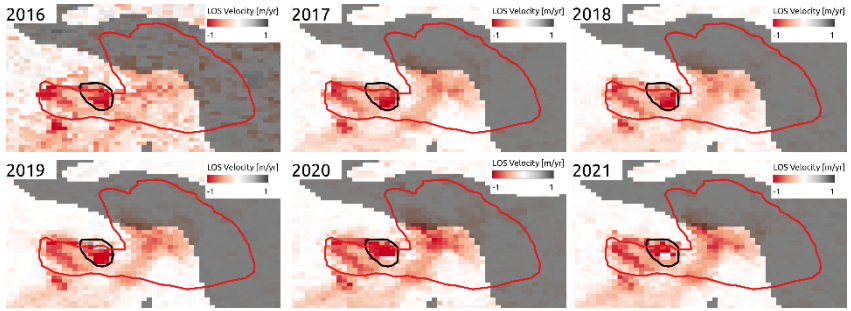
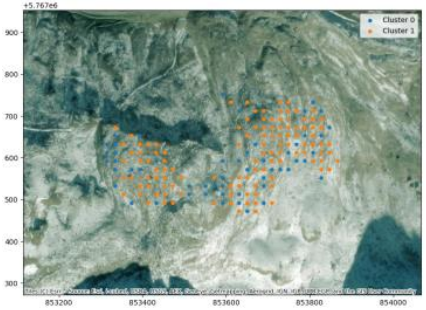
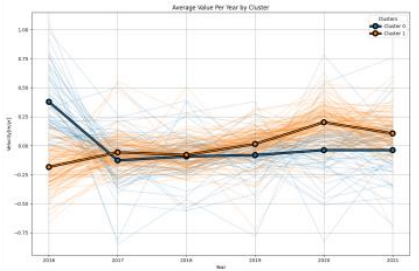
RGV in the Alps









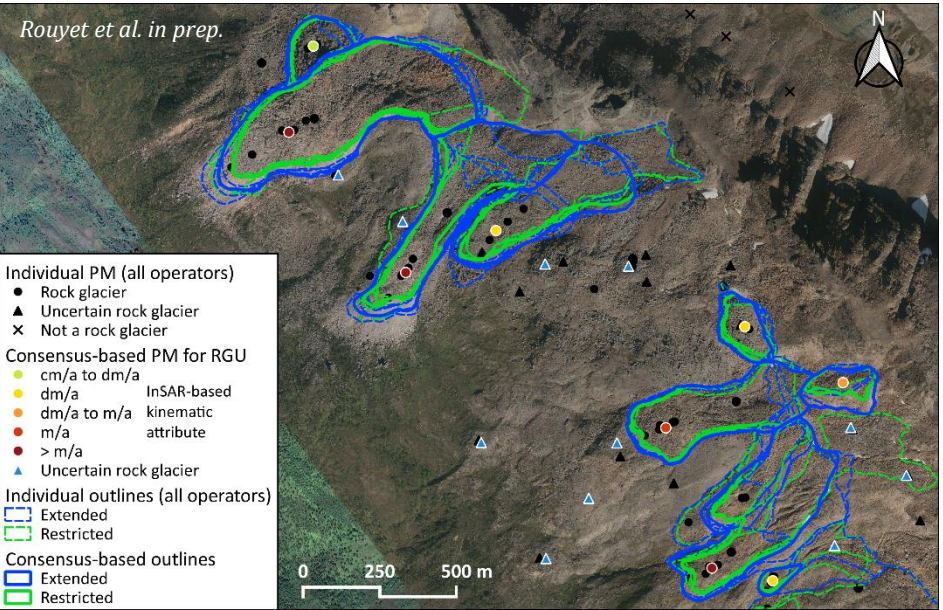
Ongoing - refinement of the procedure and automation (masking, coherence thresholding, filtering, unwrapping error correction, clustering) **for systematic generation over more landforms in the Alps.**

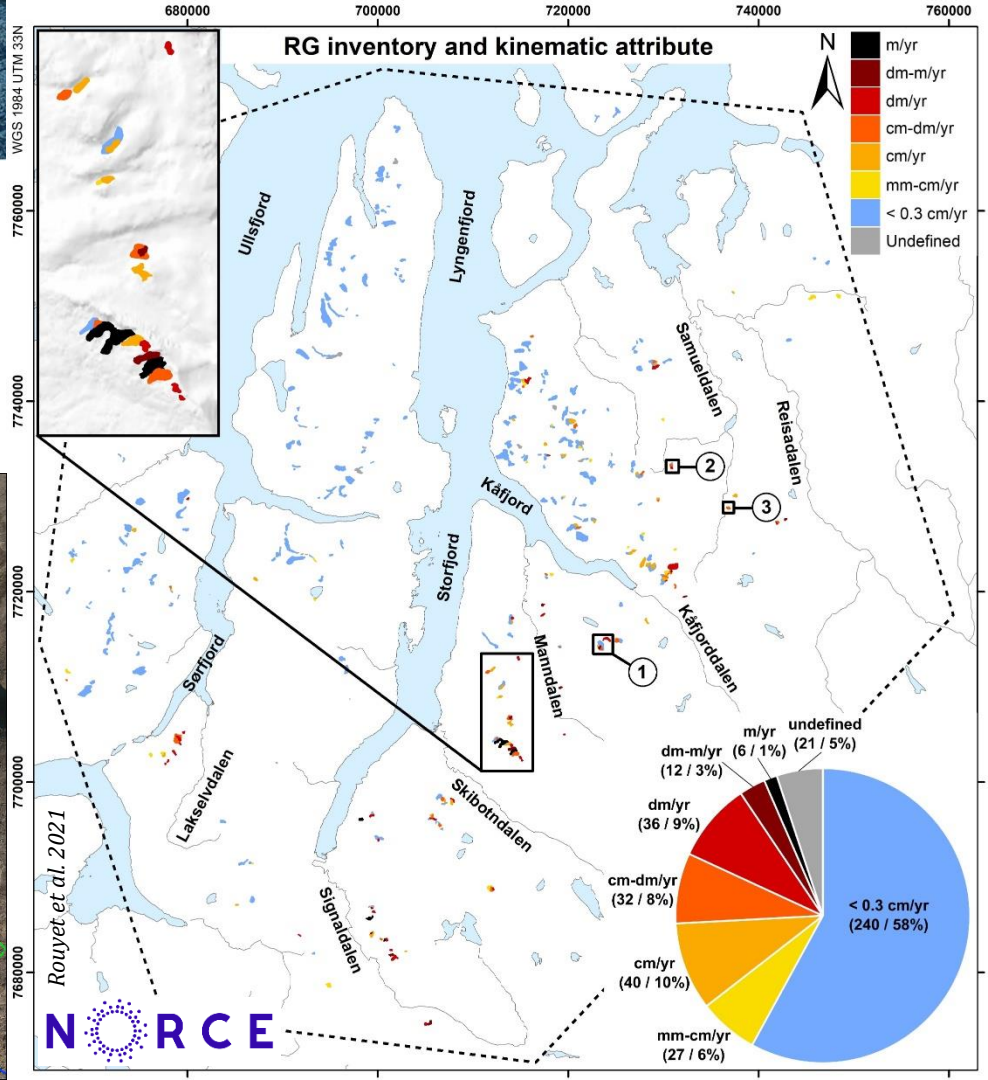
GAMMA REMOTE SENSING

RGV in Norway (Troms)

- Similar effort has started in the European Arctic.
- Ádjet pilot area for RGV:

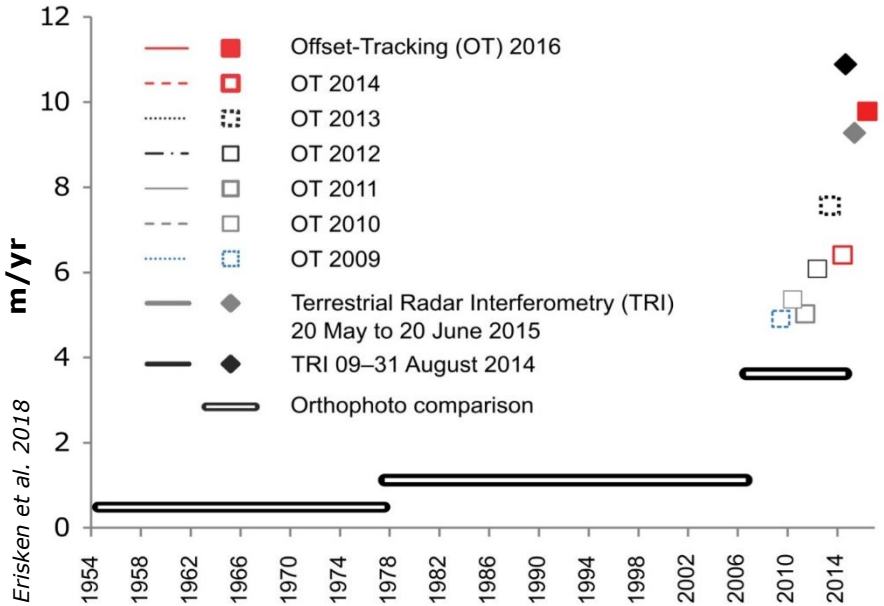
  High density of rock glaciers with a wide range of velocity, requiring a **combination of InSAR + SAR offset tracking + optical feature tracking**.





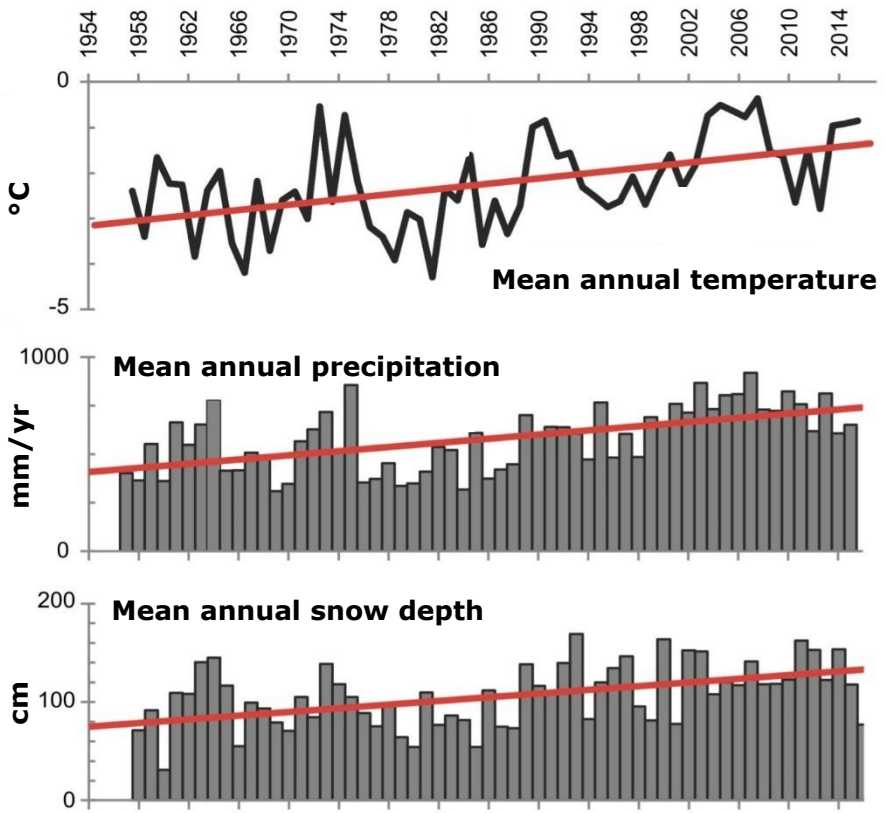
RGV in Norway (Troms)

Temperature and precipitation have increased, simultaneously to the rock glacier velocity.

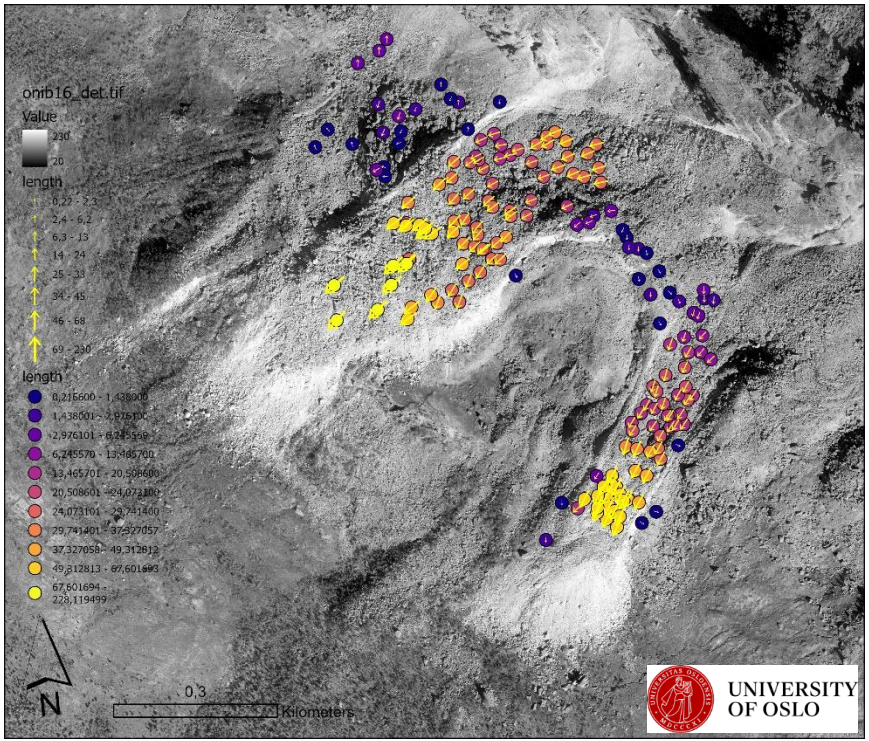


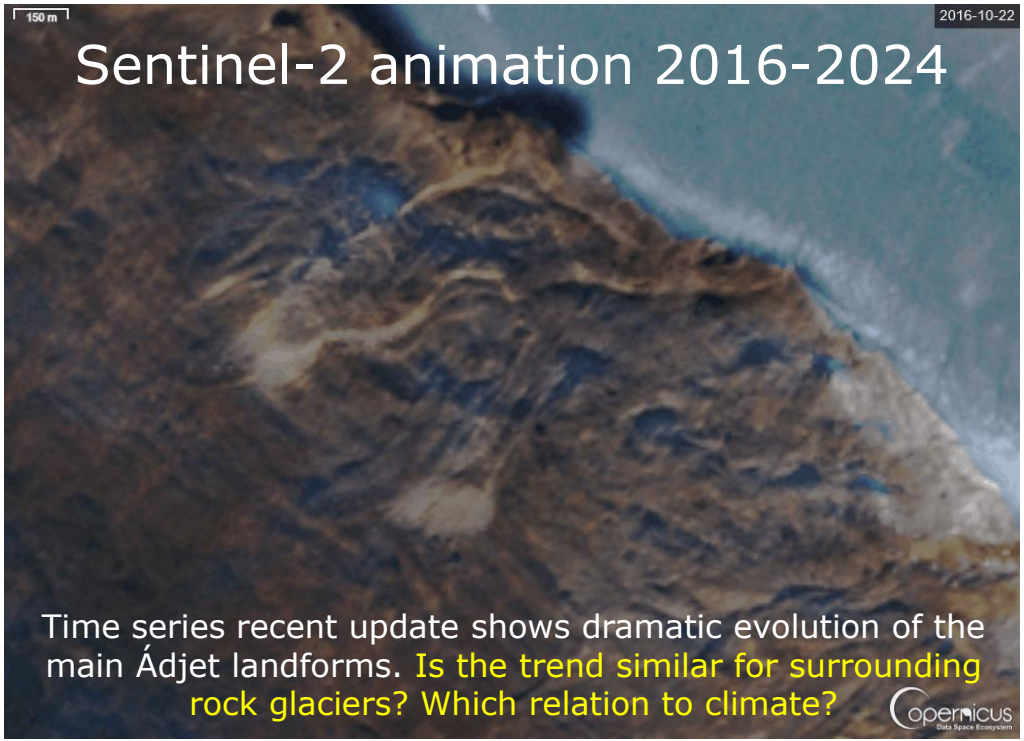
The rock glacier has **accelerated** the past 62 years, **mostly during the last decade**.

Erisken et al. 2018

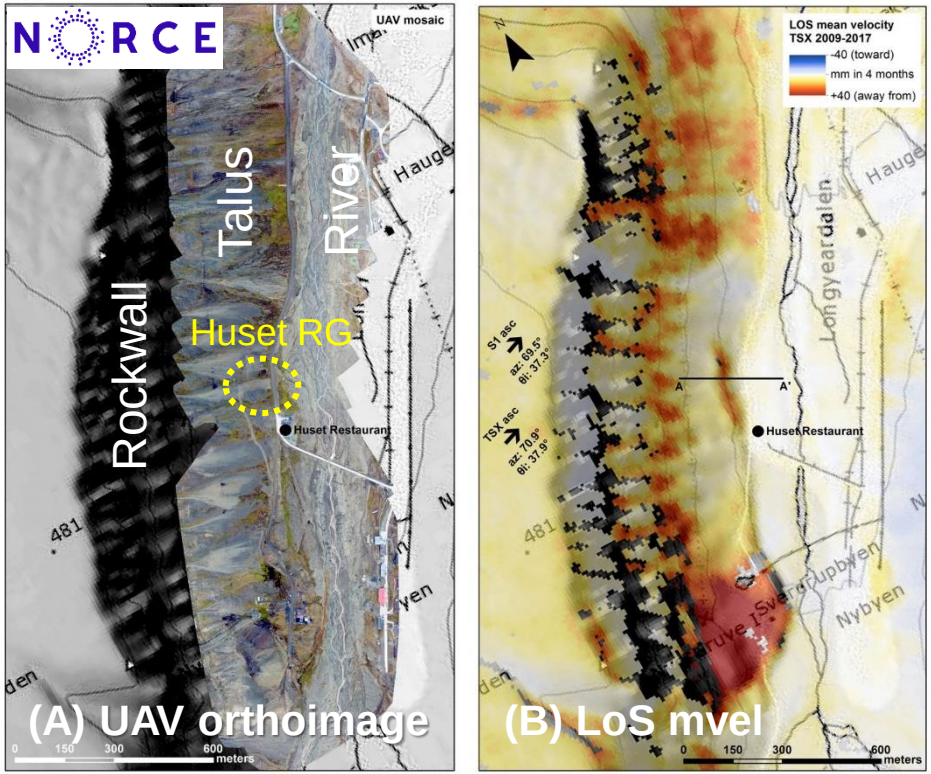


RGV in Norway (Troms)

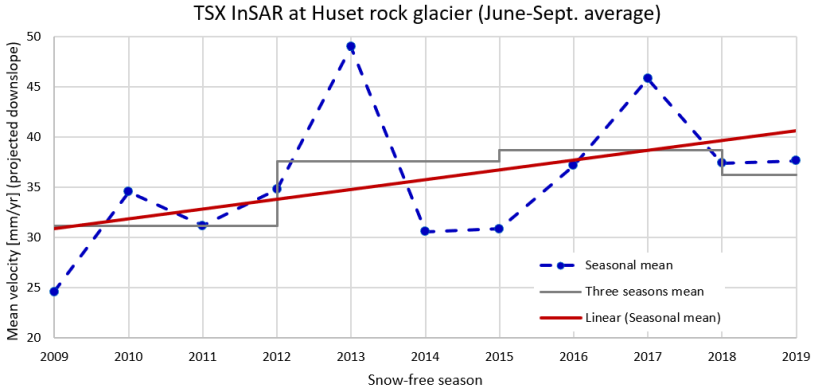




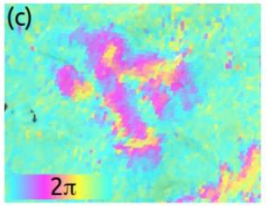
RGV in Norway (Svalbard)

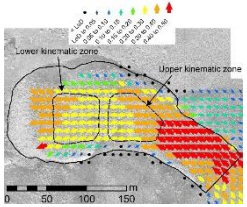


- In Svalbard, **most talus rock glacier are creeping at low rate**. Example: Huset RG, Longyeardalen. Velocity: 2-5 cm/yr.
- Due to **large seasonal variability**, interannual changes are harder to distinguish and interpret.
- However, the InSAR trends highlight **acceleration** (~1 mm/yr), **consistent with in-situ** (~1.6 mm/yr) (Huset GPS, Matsuoka et al., 2019).



Conclusion

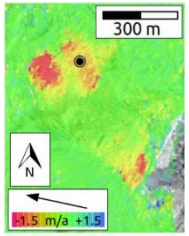




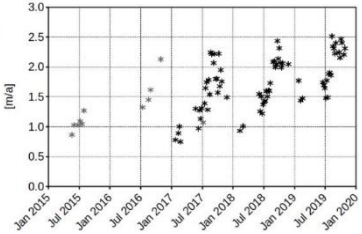
Radar **Optical**

Remote sensing

for RGV monitoring

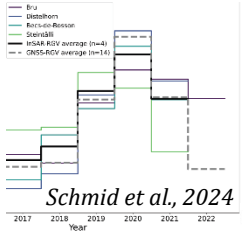


Stozzi et al., 2020

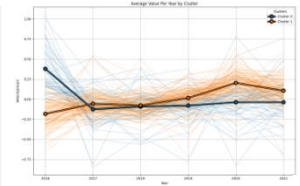


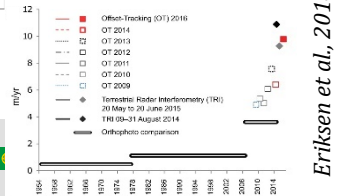
From seasonal time series at selected locations on single landforms…

- Rock glacier velocity (RGV) has been accepted as **new parameter of the Essentiel Climate Variable (ECV) Permafrost.**
- RGV already operationally used at the national level and systematically monitored at several locations worldwide. The time series show **increasing velocity trends.**
- **Satellite/aerial remote sensing** can complement in-situ data to increase the number of the landforms that are monitored.
- Further research still needed to consistently generate RGV at large scale and exploit RGV as **regional/global indicator**.



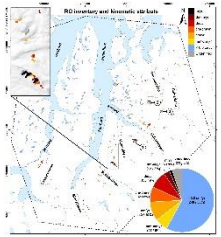
Schmid et al., 2024



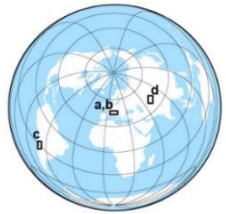


Eriksen et al., 2018

…to spatially-averaged interannual velocity changes



Rouyet et al., 2021



Pellet et al., 2023

…to regional/global monitoring

climate change initiative

→ PERMAFROST

Thanks for your attention!

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New parameter of the ECV permafrost

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