



Unraveling Spatial and Temporal Heterogeneities of Very Slow Rock-Slope Deformations with Targeted DInSAR Analyses

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remote sensing



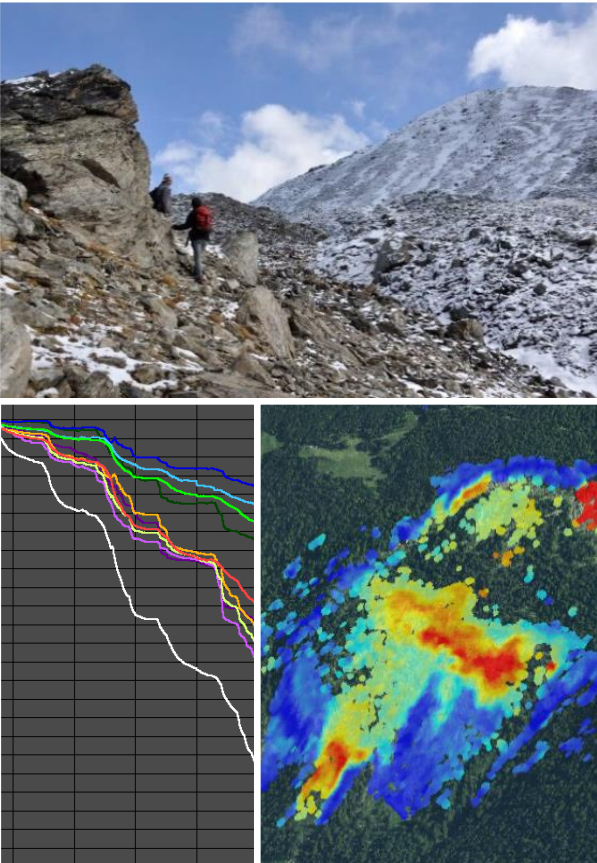
Article

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Deep Seated Gravitational Slope Deformation (DSGSD)

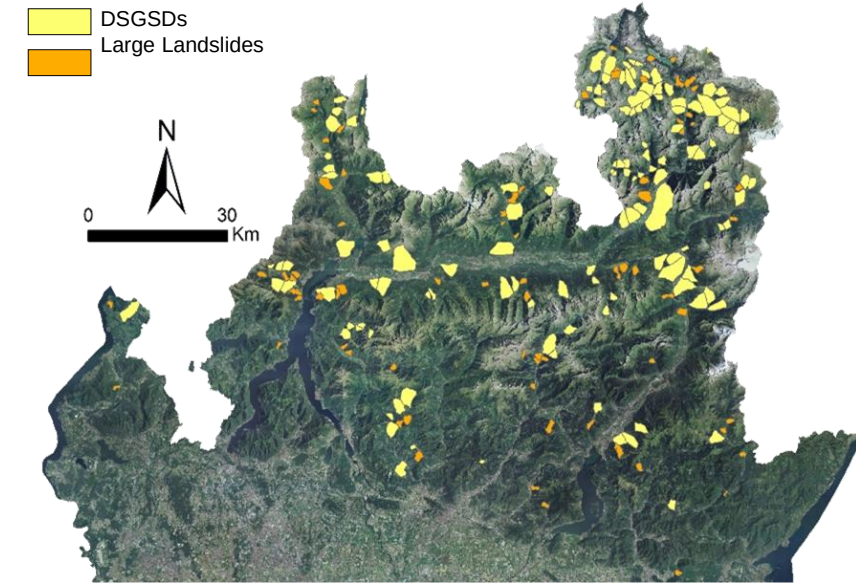
DSGSD: high volume (km^3), slow evolution

- Diffused in alpine environment (>1200 m a.s.l.)
- High relief slope (>1000 m a.s.l.)
- Morphostructural evidence

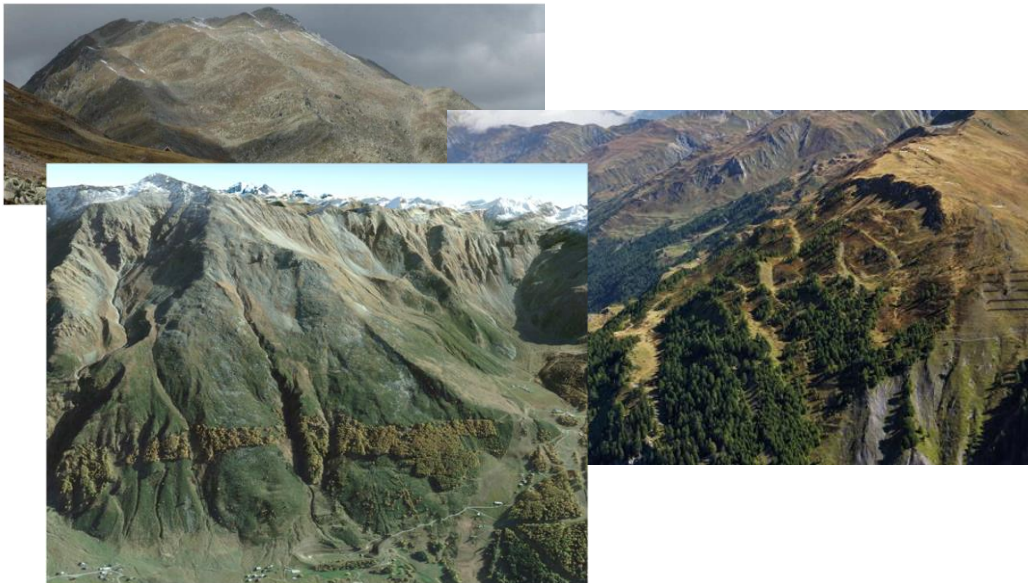
Risk factors: slow movements + possible catastrophic evolution

Importance of characterization of activity and kinematic

→ InSAR methods



Crippa et al. 2021

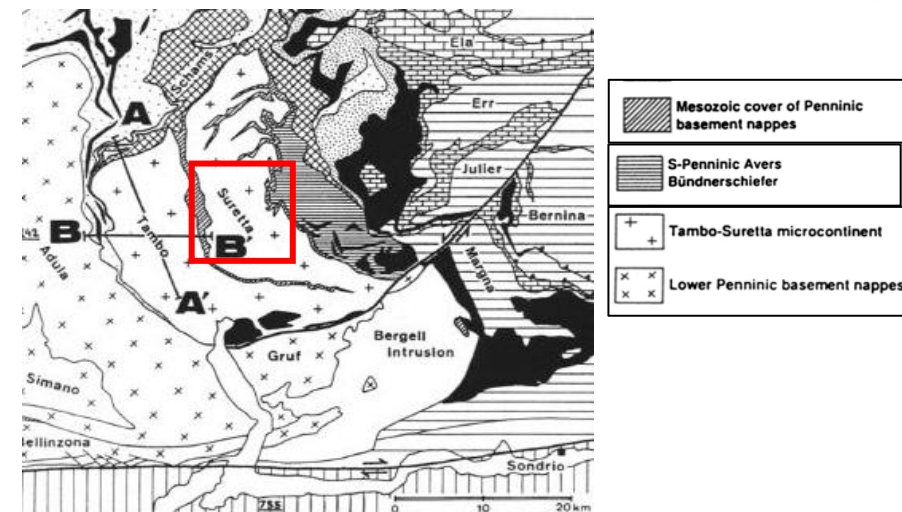


Problems:

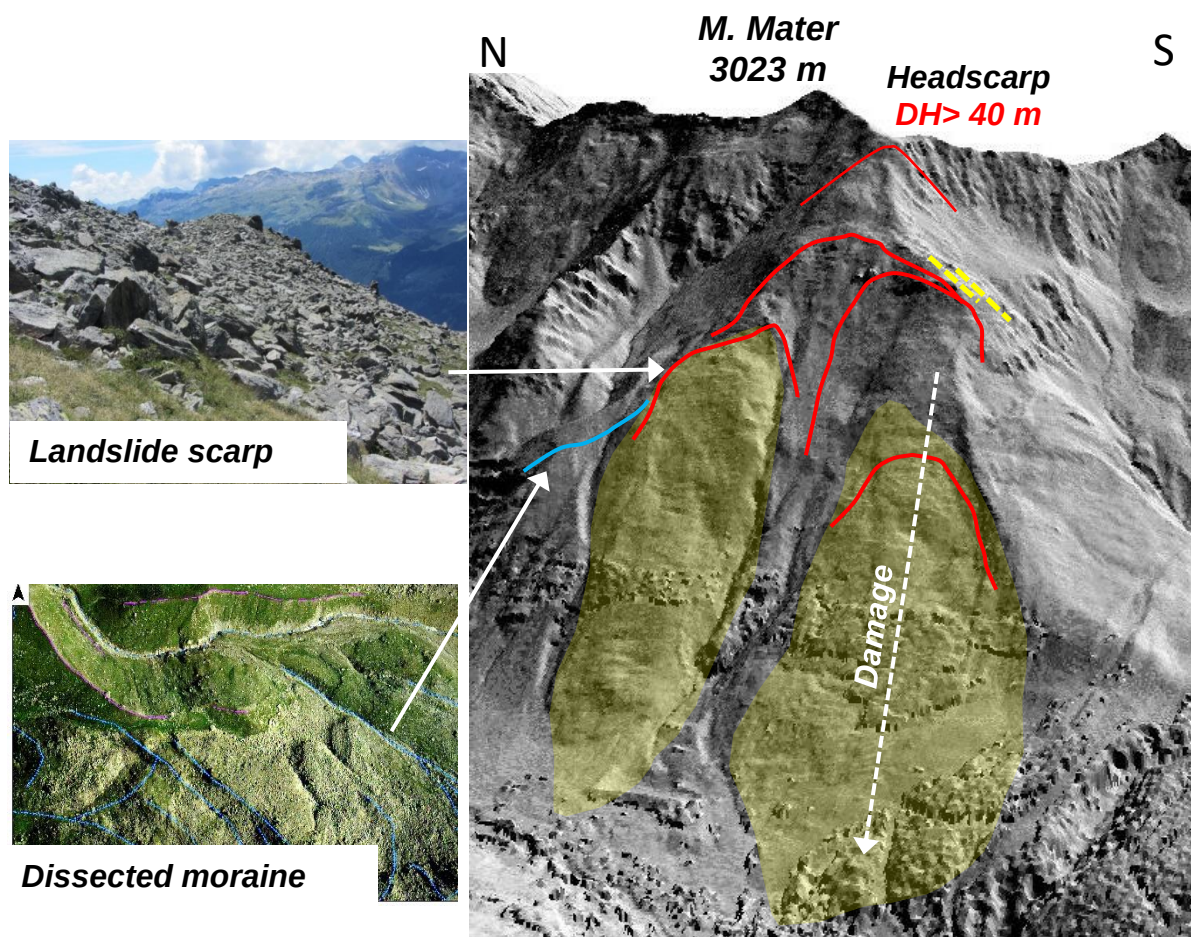
- **Slow displacement rate** (< 5 cm/a)
- **Heterogeneous** (space / time)
- **High volumes**

The Mt. Mater DSGSD (Valle Spluga)

- **Suretta & Tambò nappes (Penninic)** → Stella-Timun complex
- **Mica schists + paragneiss & Mesozoic metasedimentary cover**



Baudin et al. 1992



Landslide scarp

Dissected moraine



Trenches



Deformed toe, debris

- **Brittle deformation**
→ highly damaged
- **Deglaciated slope**
→ debuttressing
→ stress release

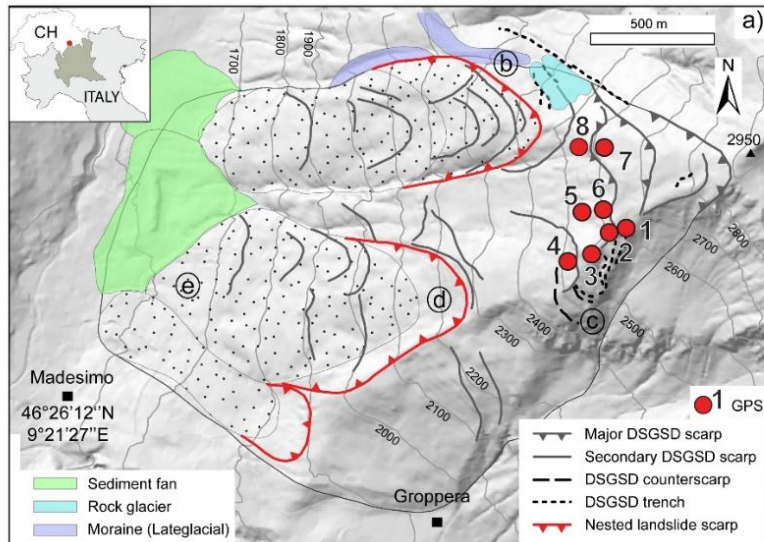
Mt. Mater DSGSD - Targeted DInSAR approach

Very **slow rates** (< 5 cm/yr), **heterogeneity**, **environment**: **close to DInSAR limits**

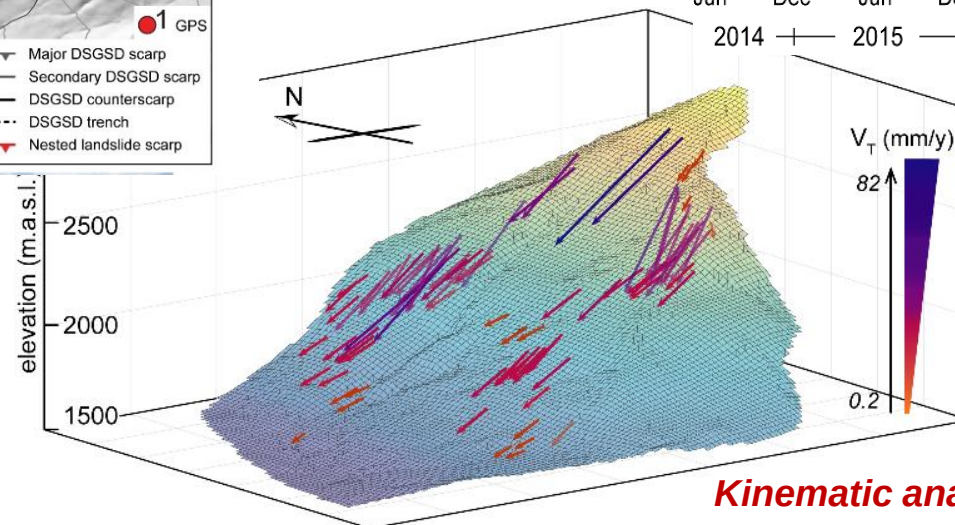
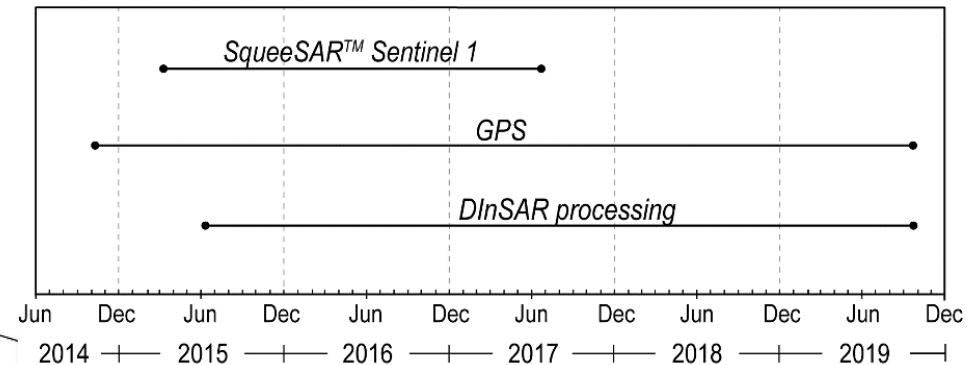
→ Geological/Geomorphological data + GNSS + 2DInSAR analysis + **targeted DInSAR processing**

→ Unravel spatial and temporal heterogeneities: **segmentation + seasonal response**

Morpho-structural mapping



Activity analysis - DInSAR products, GPS (2014-19)



Kinematic analysis (2DInSAR)

Targeted DInSAR approach

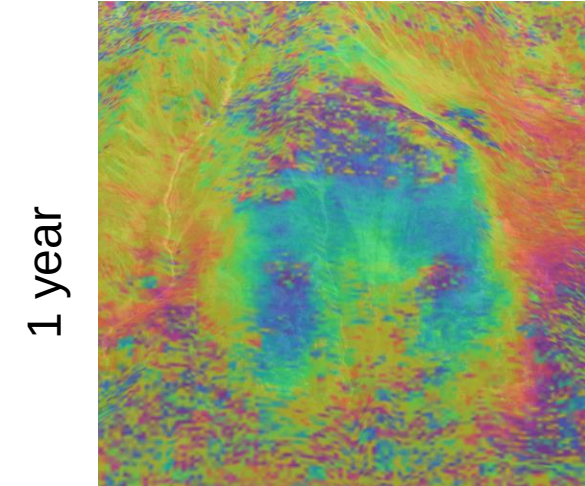
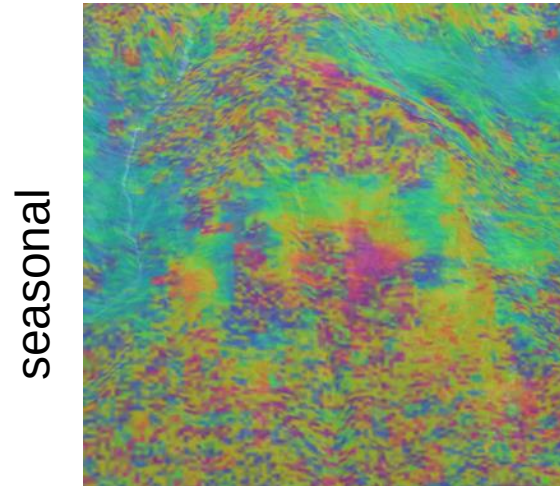
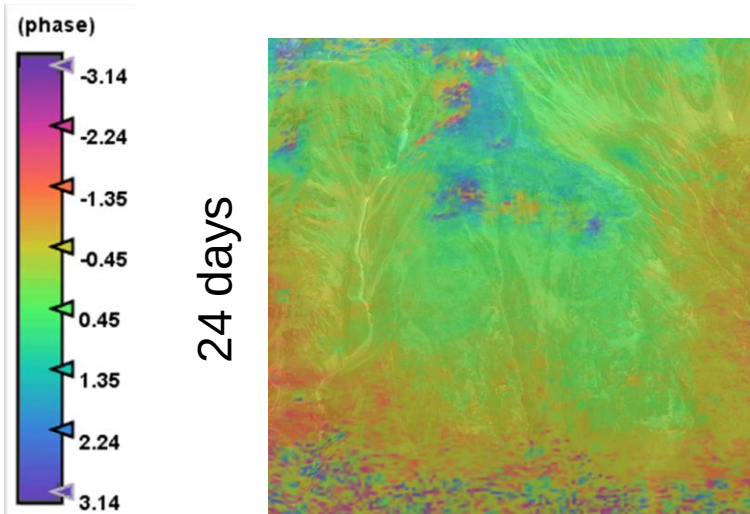
DSDSD in alpine environment:

- Low **Signal to Noise Ratio**
- Relief : high **atmospheric effect**
- Climate : **snow cover effect**



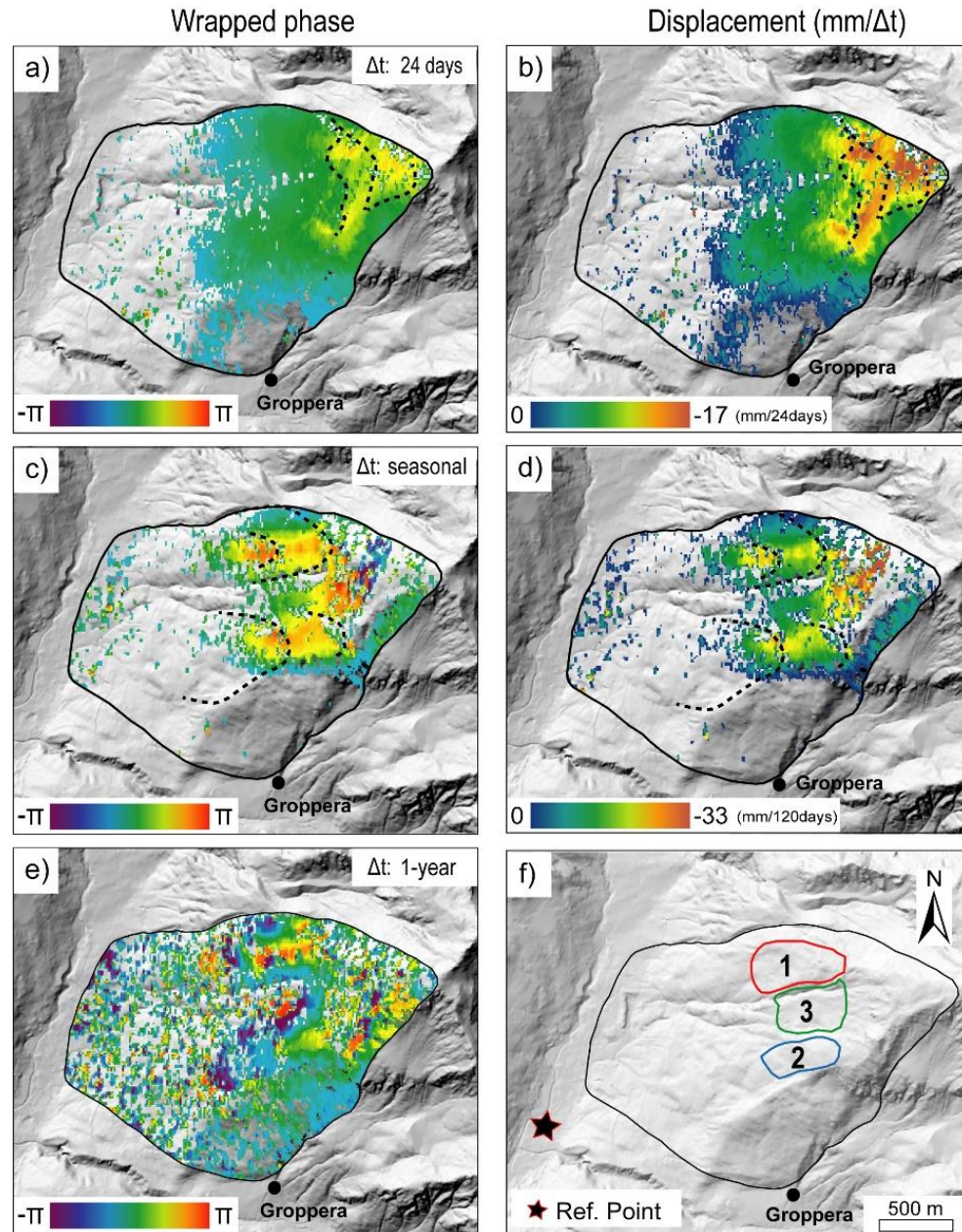
Targeted DInSAR approach

- Sentinel 1A-B (C band)
- Δt : 6 days
- Image selection
- Temporal Baseline selection for processing



Targeted DInSAR approach: Integration of DInSAR (different temporal baseline as **52 interferograms with different temporal baselines (24 days, seasonal, 1 year)**, morpho-structural data and **GPS**

Results - Style of activity: spatial heterogeneity



Multi temporal baseline DInSAR processing

→ different processes (depth, rate)

- **24-day:**

→ shallow movements → 10 mm/month

→ debris / periglacial

- **“Seasonal” (5-9 months)**

→ sliding along DSGSD scarps

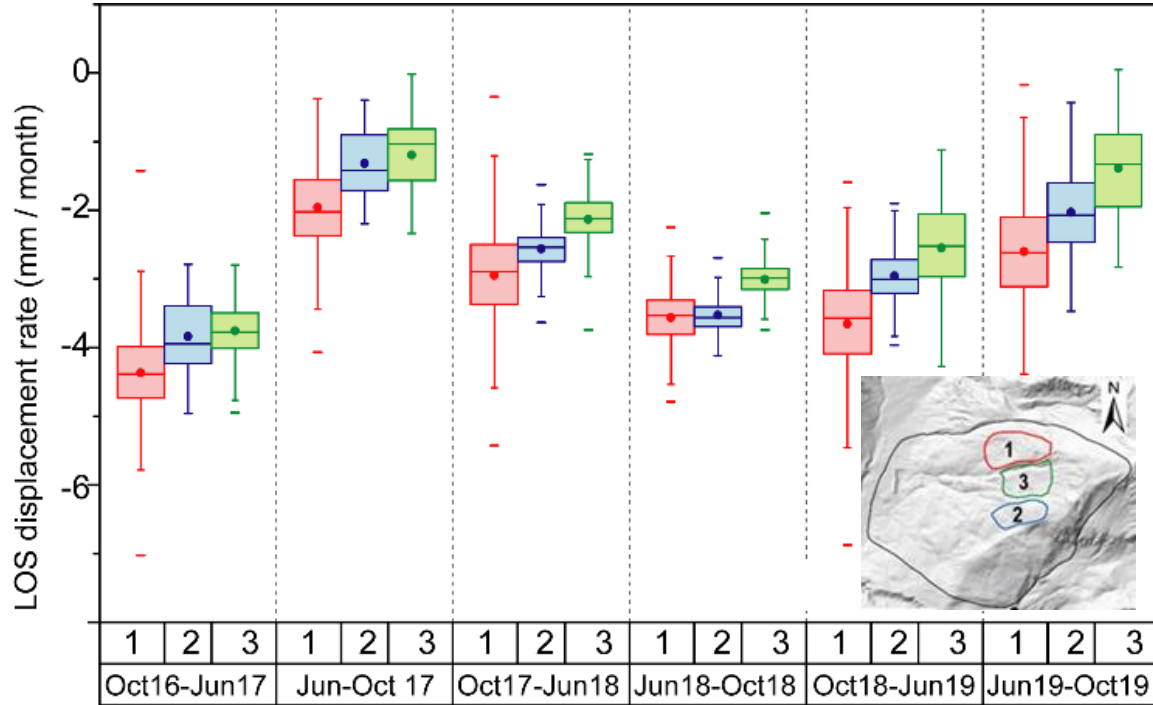
→ nested rockslides (3-5 mm/yr)

- **1-year**

→ background DSGSD signal

Separate deep & shallow movements

Results - Style of activity: temporal



“Seasonal” interferograms

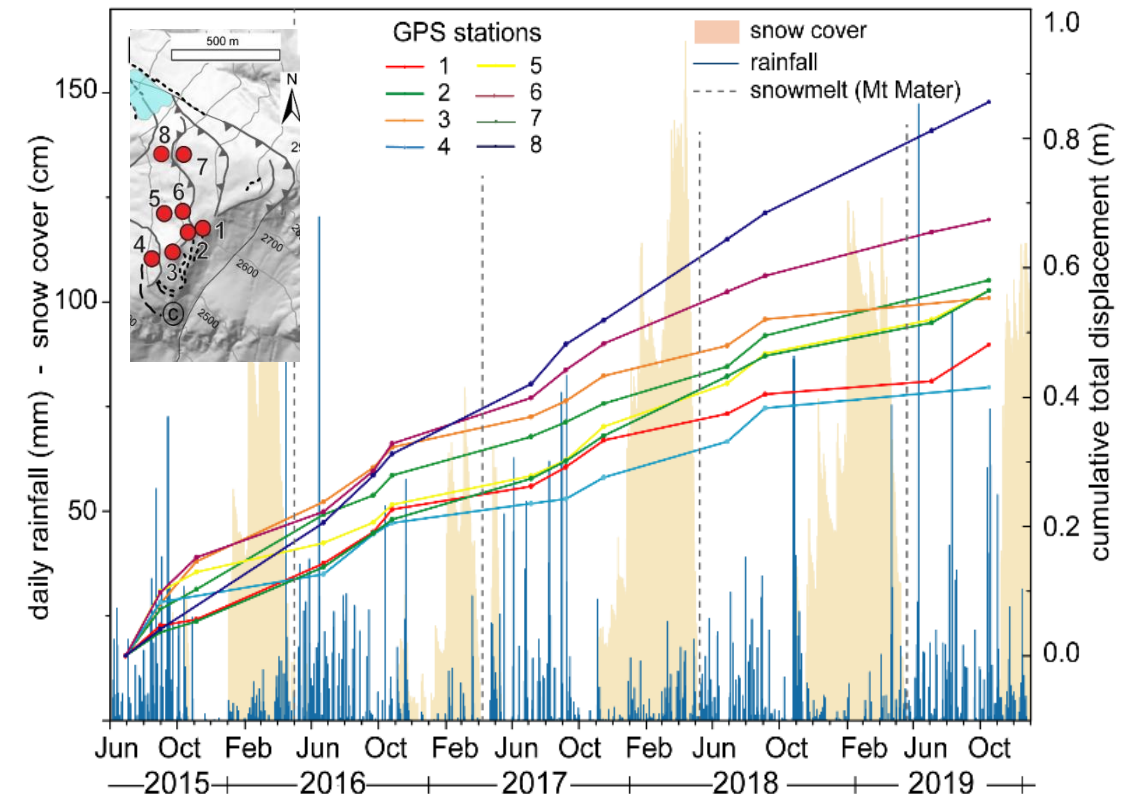
- Separate sectors, **different rates**
- DSGSD Vs nested rockslides
- Seasonal **variability**

Hydrological forcing:

- Snowmelt + rainfall
- **Transition** between DSGSD and Rockslide

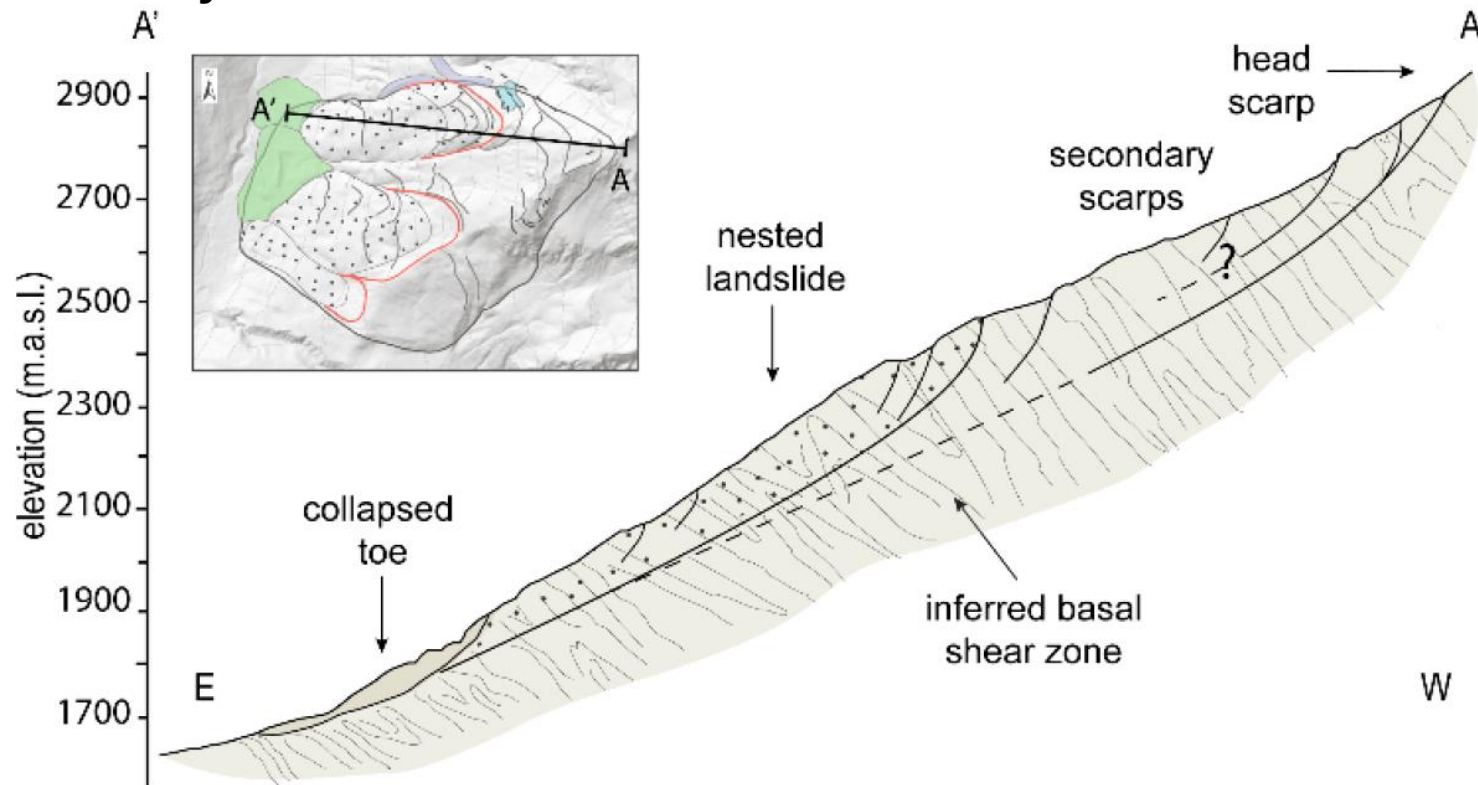
GPS measures

- “Seasonal” response **confirmed by GPS**
- Upper sector: more sensitive to **hydrological inputs**
- GPS confirmed DInSAR displacement rate (underestimate by PS data)



Integrated interpretation of DSGSD mechanisms and conclusion

- **Deep basal shear zone** (>150 m) with main **translational** kinematics.
- **Upper sector** (2700 -2900 m.a.s.l.) + periglacial debris with **high displacement rate** (10mm/24gg).
- **Midslope sector** (2600 -1700 m.a.s.l.) two shallower nested landslides **displacement rate 3-5mm/month**
- **Hydrological sensitivity**



- **DInSAR** processing, **targeted on multiple temporal baselines**, unravel the mechanisms, temporal trends of activity and forcing factors of heterogeneous DSGSD.
- Remote sensing **results** require detailed **geological and morpho-structural field constraints**.