EGU General Assembly 2022

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Outstanding Student & PhD candidate Presentation contest

EMOD-SLAP

Extending the integrated monitoring of deep-seated landslide activity into the past using free and open-source photogrammetry

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Background photo: J.Branke 23.10.2019

27th May 2022

Problem statement

- Measurements since 2016 on a Deep-seated gravitational slope deformation (DSGSD)
- Is it possible to **reconstruct past movement behavior** of the landslide using historical aerial imagery?
- How large are the expected **uncertainties**?
- Historical aerial imagery archives
  - dating back to the 1950ies

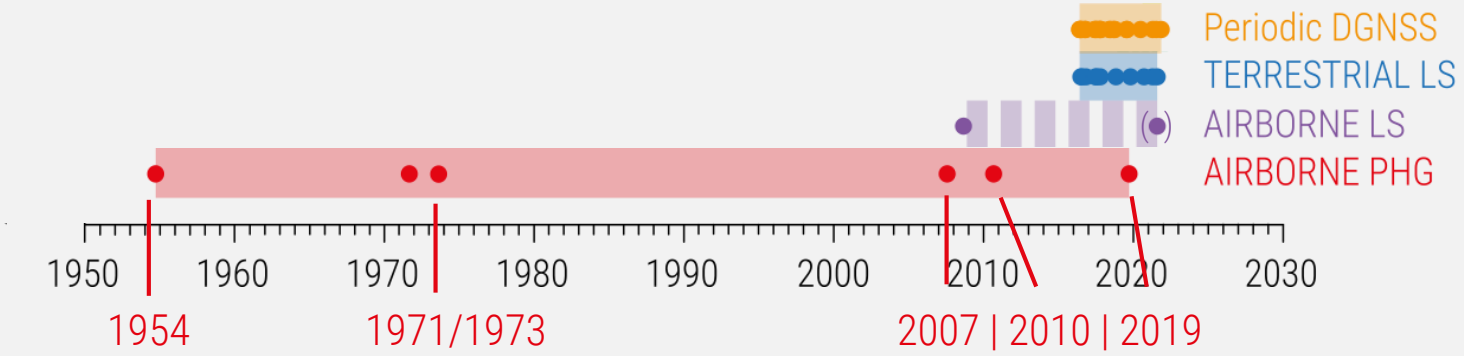


Photo J.Branke 10.08.2020

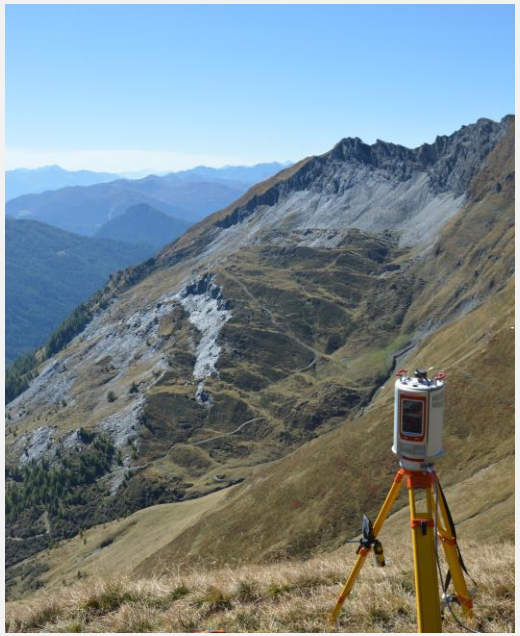
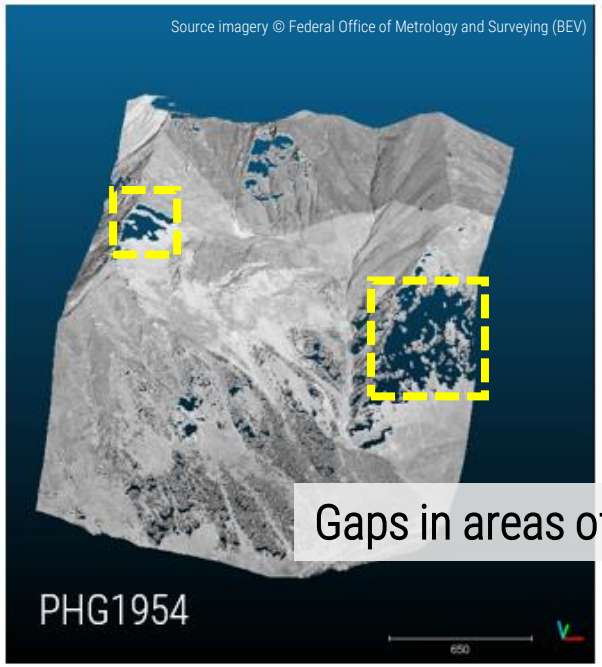
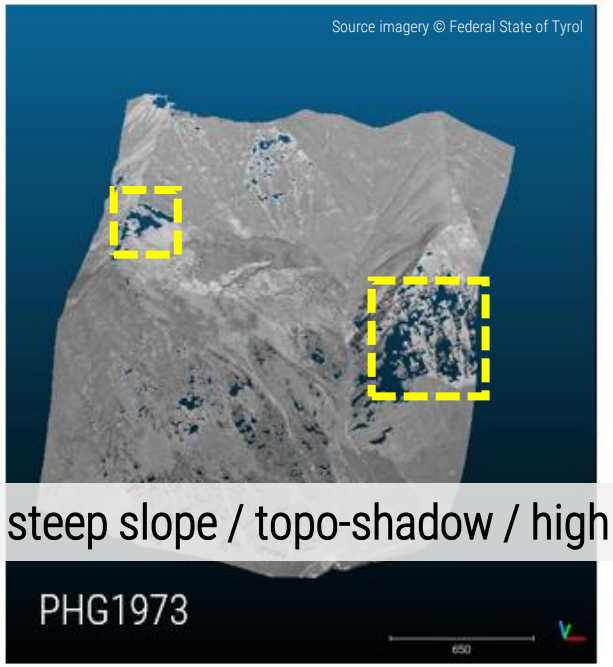


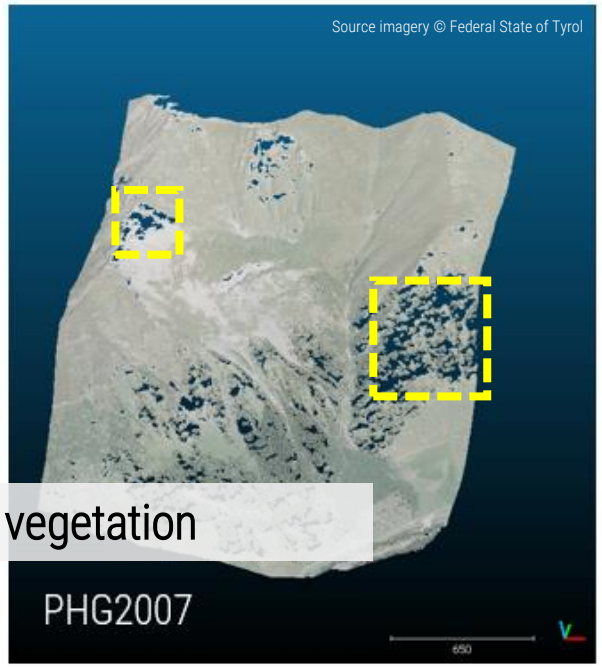
Photo J.Branke 05.10.2018

Historical aerial imagery of 1954. Source: Federal Office of Metrology and Surveying (BEV)

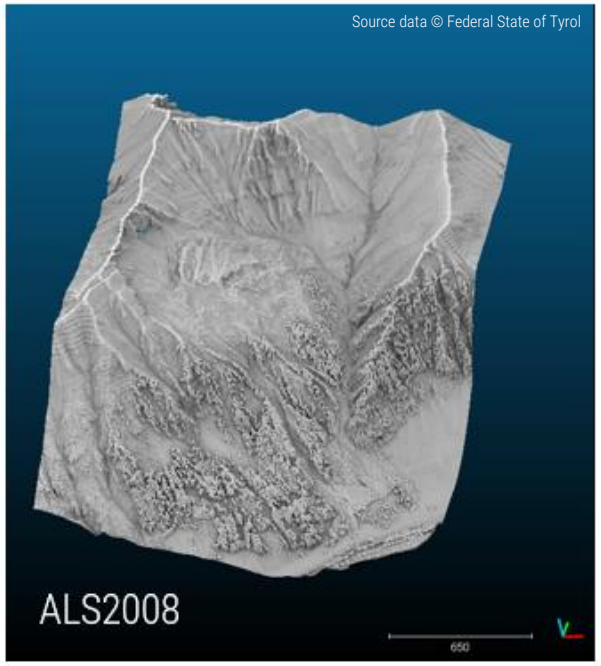
3D point clouds

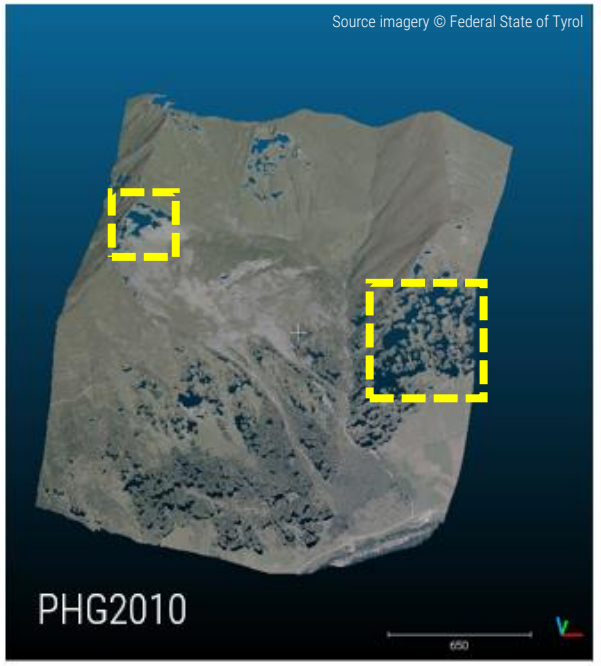


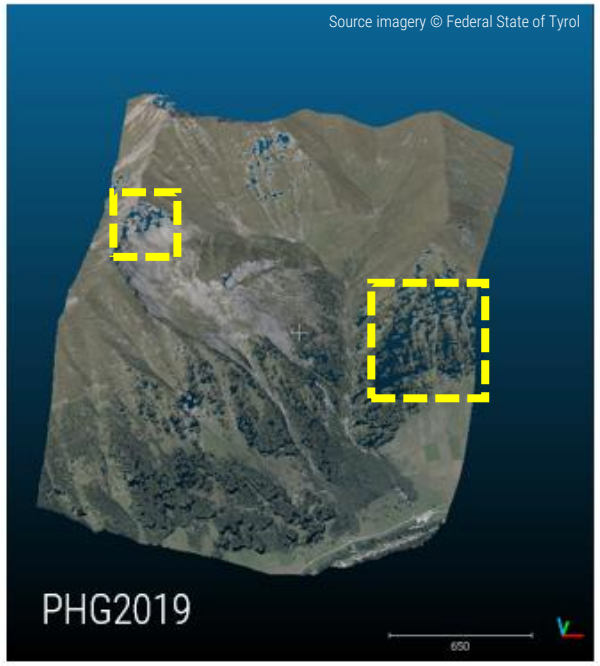




Gaps in areas of steep slope / topo-shadow / high vegetation



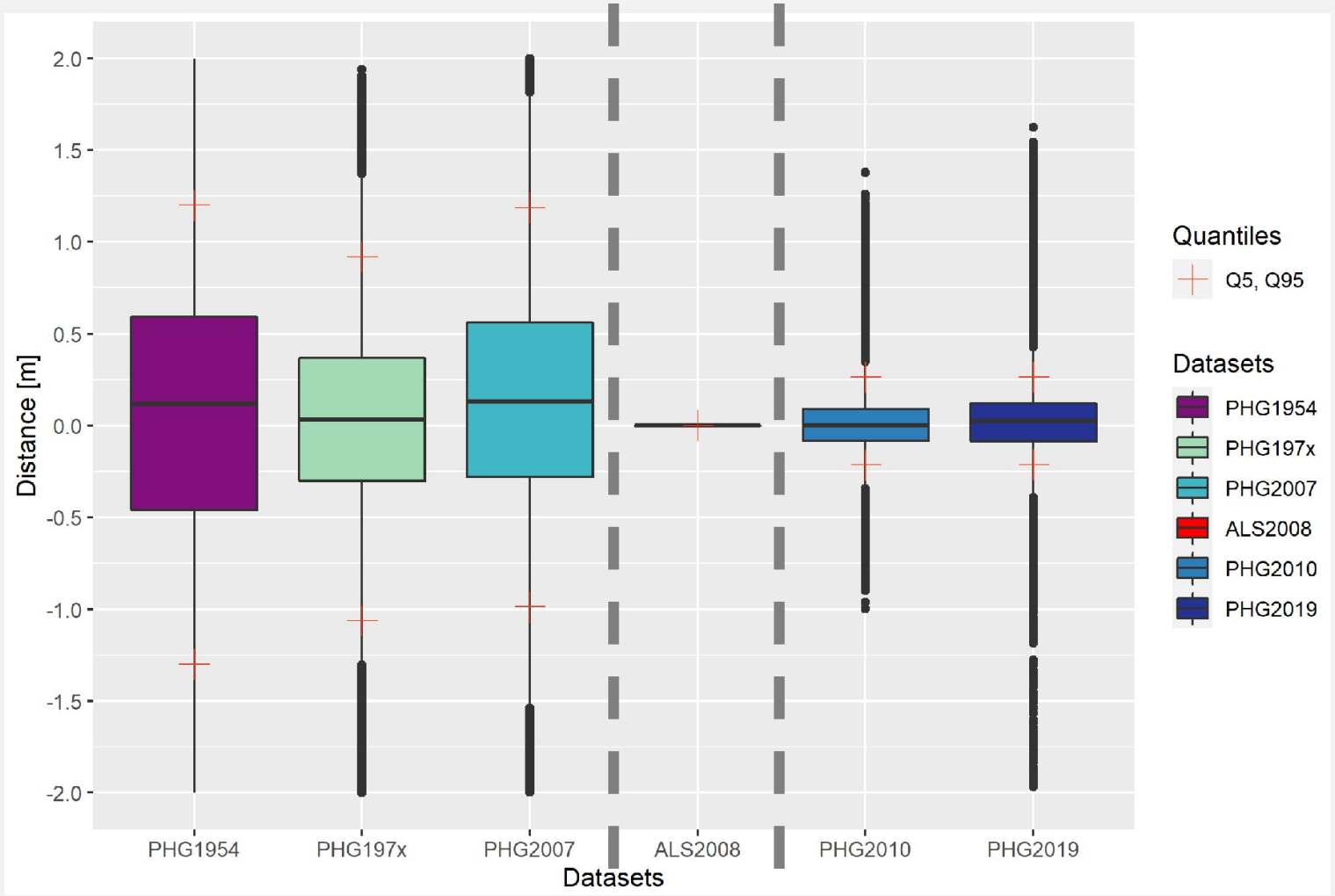




Accuracy assessment

How large are the expected **uncertainties**?

Multiscale Model to Model Cloud Comparison (M3C2) distances
Lague et al. 2013, *ISPRS J. Photogramm. Remote Sens*



analogue scanned imagery

→ ± 1.2 m
(95% quantile)

Reference

digital imagery

→ ± 0.3 m
(95% quantile)

IMage CORRelation (IMCORR) results

Ambient Occ. Hillshade & Digital Terrain Models (DTMs)

▲ DGNSS blocks

⟶ IMCORR vectors

Rate 2.5D [m/a]

- 0 - 0,25
- > 0,25 - 0,5
- > 0,5 - 0,75
- > 0,75 - 1
- > 1 - 1,25
- > 1,25 - 1,5
- > 1,5

Photo J.Branke 23.10.2019

2.5D Displacements within uncertainty range

2.5D Displacements up to 40 m in 65 years

Photo position

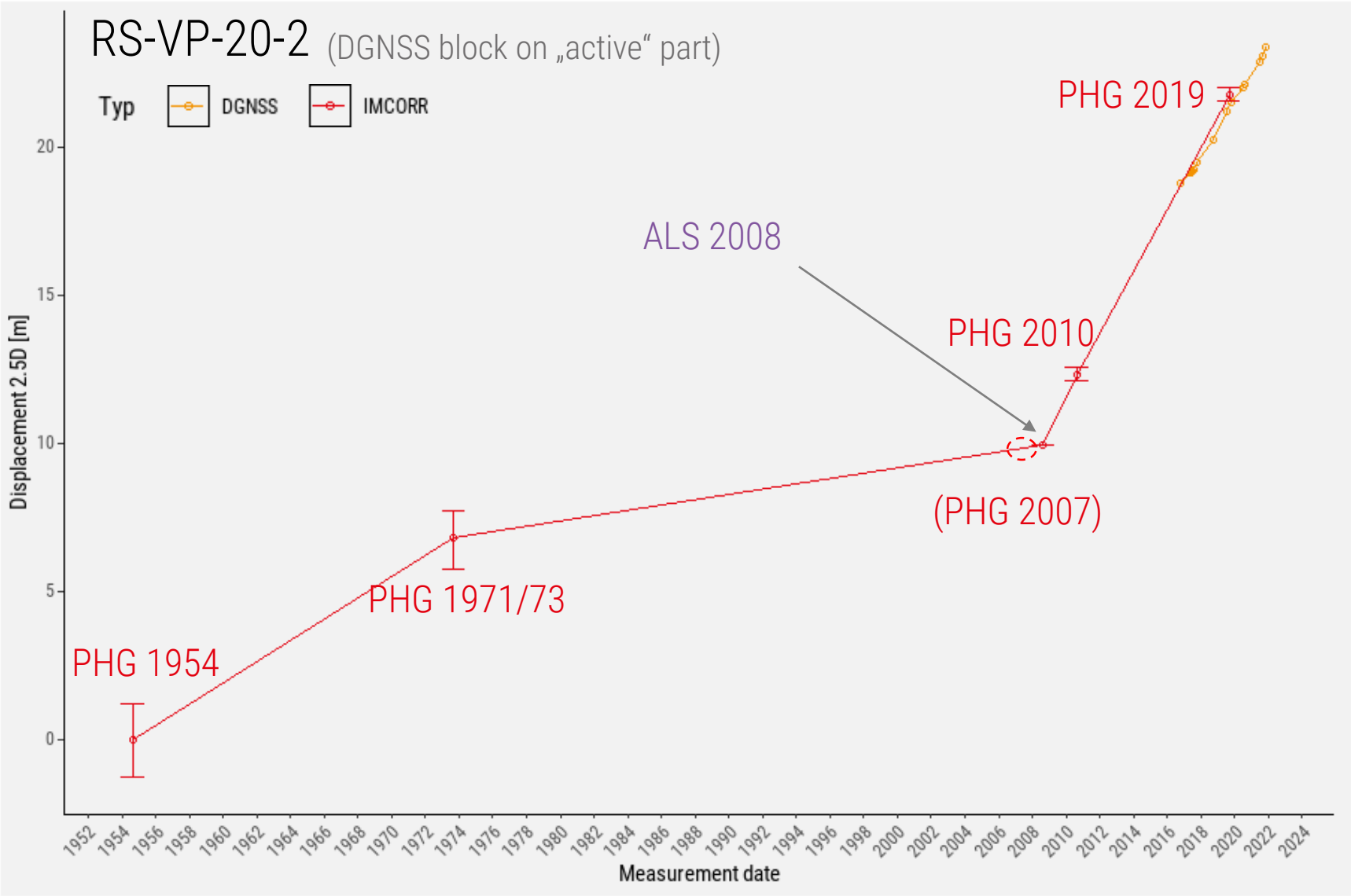
No correlation in areas of interpolated terrain and areas of high surface movements (e.g. block fields)

0 100 200 300 400 500 m

Background: Orthoimagery 2019 - Office of the Tyrolean Regional Government - Devision of Geoinformation
Limited to to 0°-180° aspect (N-NE-E-SE-S)

IMage CORRelation (IMCORR) results

Is it possible to reconstruct past movement behavior of the landslide using historical aerial imagery?



Take away messages

Lessons learned

- Problems in photogrammetric reconstruction:
  areas of high vegetation / steep and shadowed slopes

- Depending on the type of historical aerial imagery different **uncertainties** occur:
  ± 1.2 m for point clouds from scanned analogue imagery
  ± 0.3 m for point clouds from digital imagery
  → Statements limited to “fast” moving landslides

- IMCORR time series perform well in non-vegetated areas
  - Problem: highly active moving and rotating blocks / vegetation

Proceeding to work with the data

- Model cascading processes
- DSGSD → secondary natural hazards (e.g. rock fall, debris flow)

Photo J.Branke 23.10.2019

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Thank you

Do you have any questions?

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http://remote-sensing.mountainresearch.at/monitoring_reissenschuh/index.html

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Background photo: J.Branke 23.10.2019

Study site

- "Reissenschuh"
- Deep-seated gravitational slope deformation (DSGSD)
- Partly covered by low and high vegetation
- Currently active part:
  - Elevation range: 1750 – 2200 m
  - Area: 0.3 km²
  - Movement in the order of 1 m/a

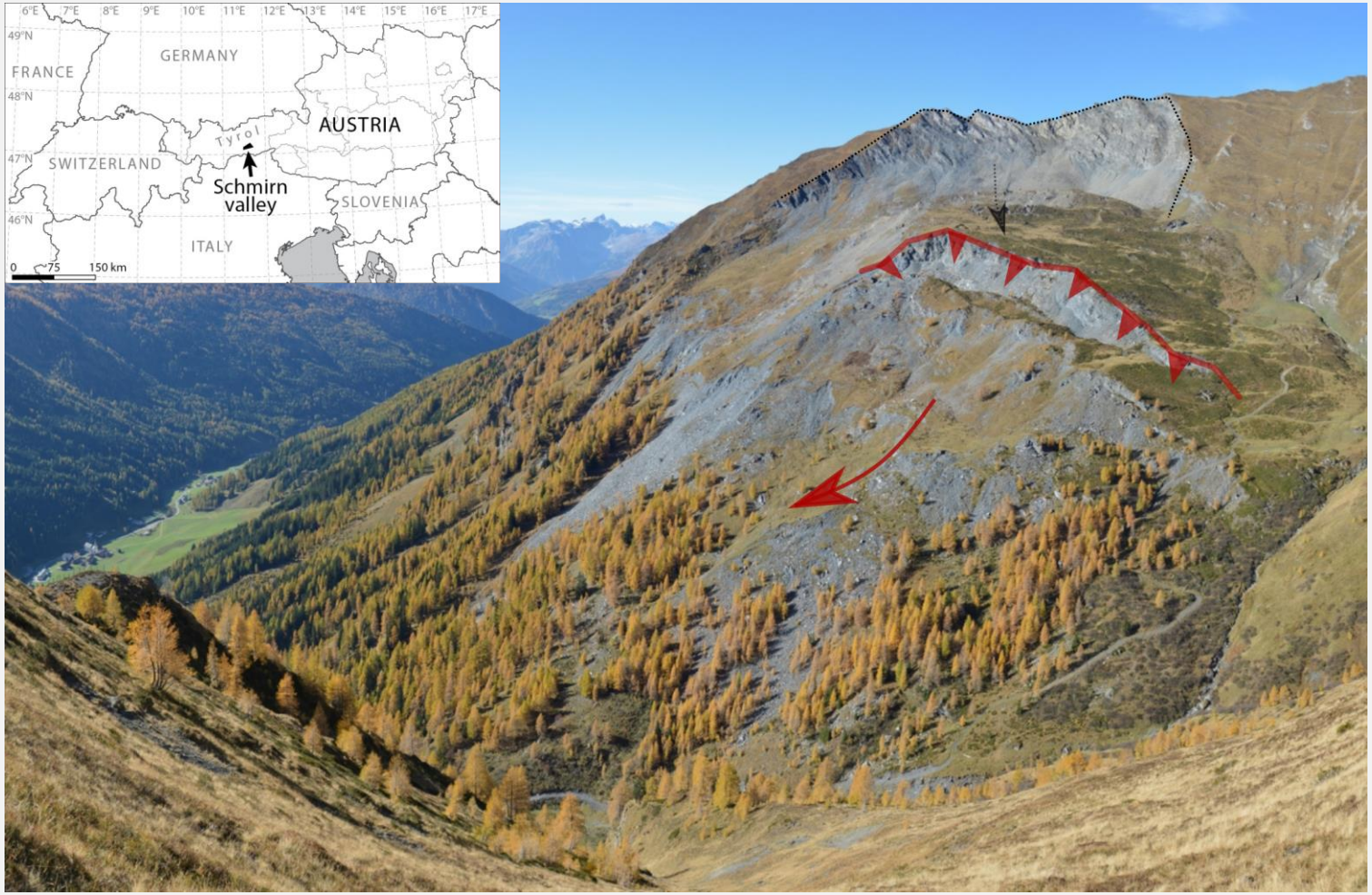


Photo J.Branke 23.10.2019 | Map Pfeiffer et al. 2018 *Remote Sensing*

Free and open-source workflow

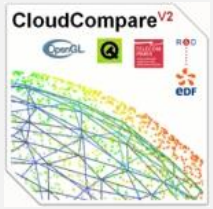
I. Pre-processing

Camera positions - reprojecting
Measurement of the fiducial marks

II. Photogrammetry

MicMac
Rupnik et al. 2017, *Open Geospatial Data, Software and Standards*
Rough georeferencing in MicMac workflow with camera positions (x, y, flight altitude)

III. Post-processing



Statistical outlier filter
Extent cropping
Fine registration with Iterative Closest Point (ICP) on stable areas with Airborne Laser Scanning (ALS) 3D point cloud as reference
Zinßer et al. 2005, *PRIP 2005*

IV. Accuracy assessment

Multiscale Model to Model Cloud Comparison (M3C2) distances on non-moving, randomly chosen, distributed (elevation, aspect, planarity, curvature, slope, distance to next) areas (20x20m, n=100) between PHG and ALS 3D point clouds
Lague et al. 2013, *ISPRS J. Photogramm. Remote Sens.*

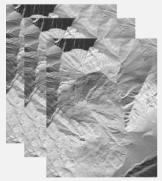
V. Derivation of 2.5D vectors

Rasterization DSM / DTM
DEMs of Difference

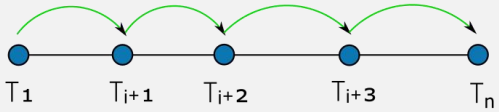
IMage CORRelation (IMCORR)
Scambos et al. 1992, *Remote Sensing of Environment*
Ambient Occ. Hillshade & Digital Terrain Models (DTMs)

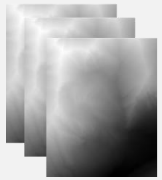
Building of IMCORR time series

IMage CORRelation (IMCORR) method & results

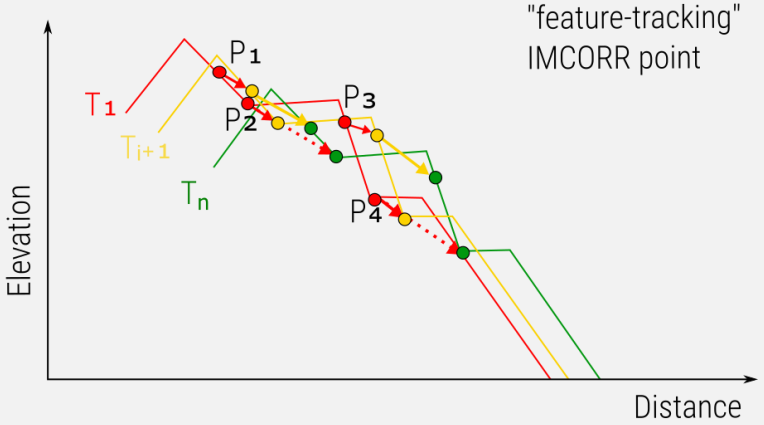


Ambient Occ. Hillshade

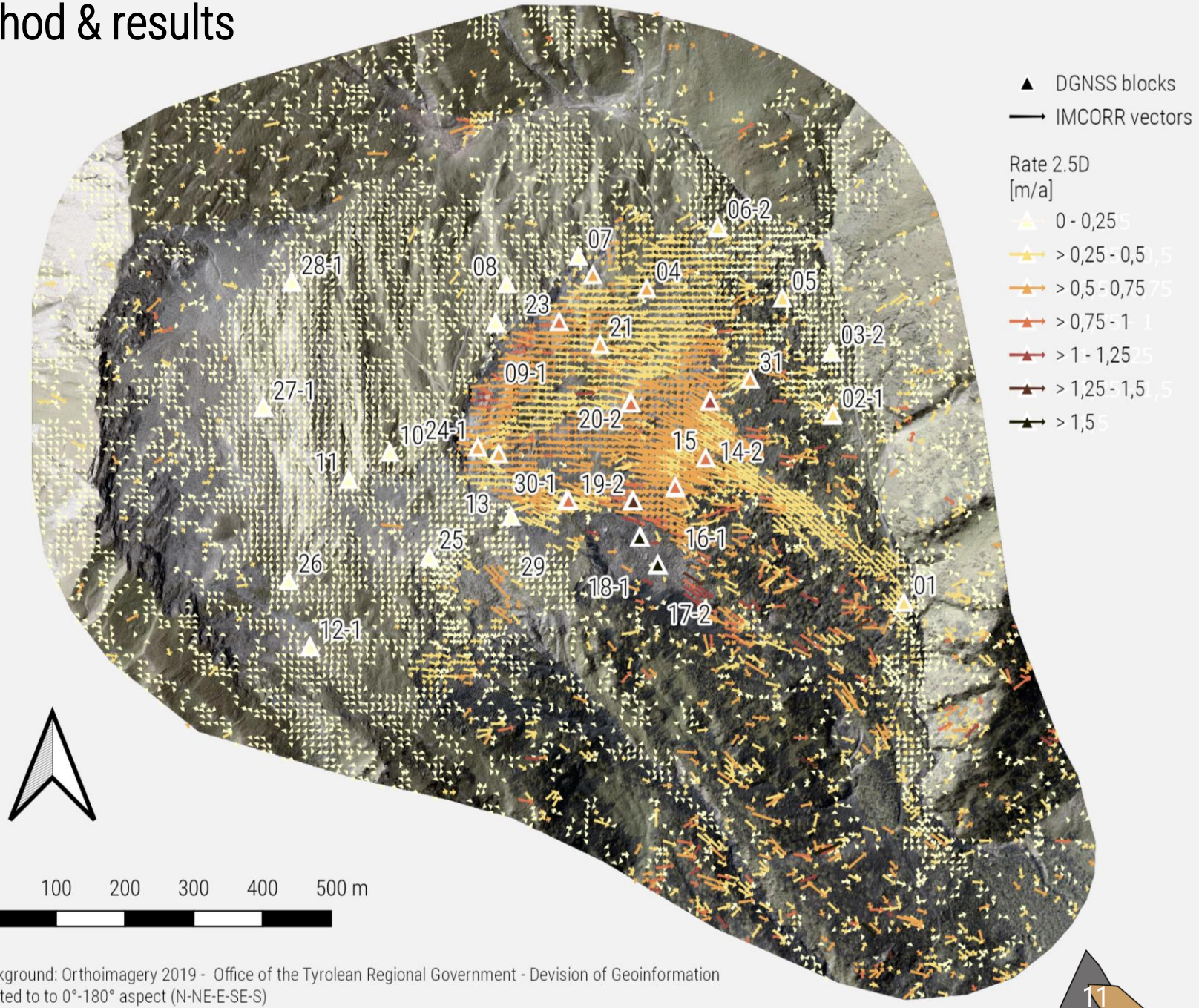




DTMs



Method: Scambos et al. 1992,
Remote Sensing of Environment



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