Monitoring slope deformations with InSAR and unmanned aerial vehicle (UAV) photogrammetry

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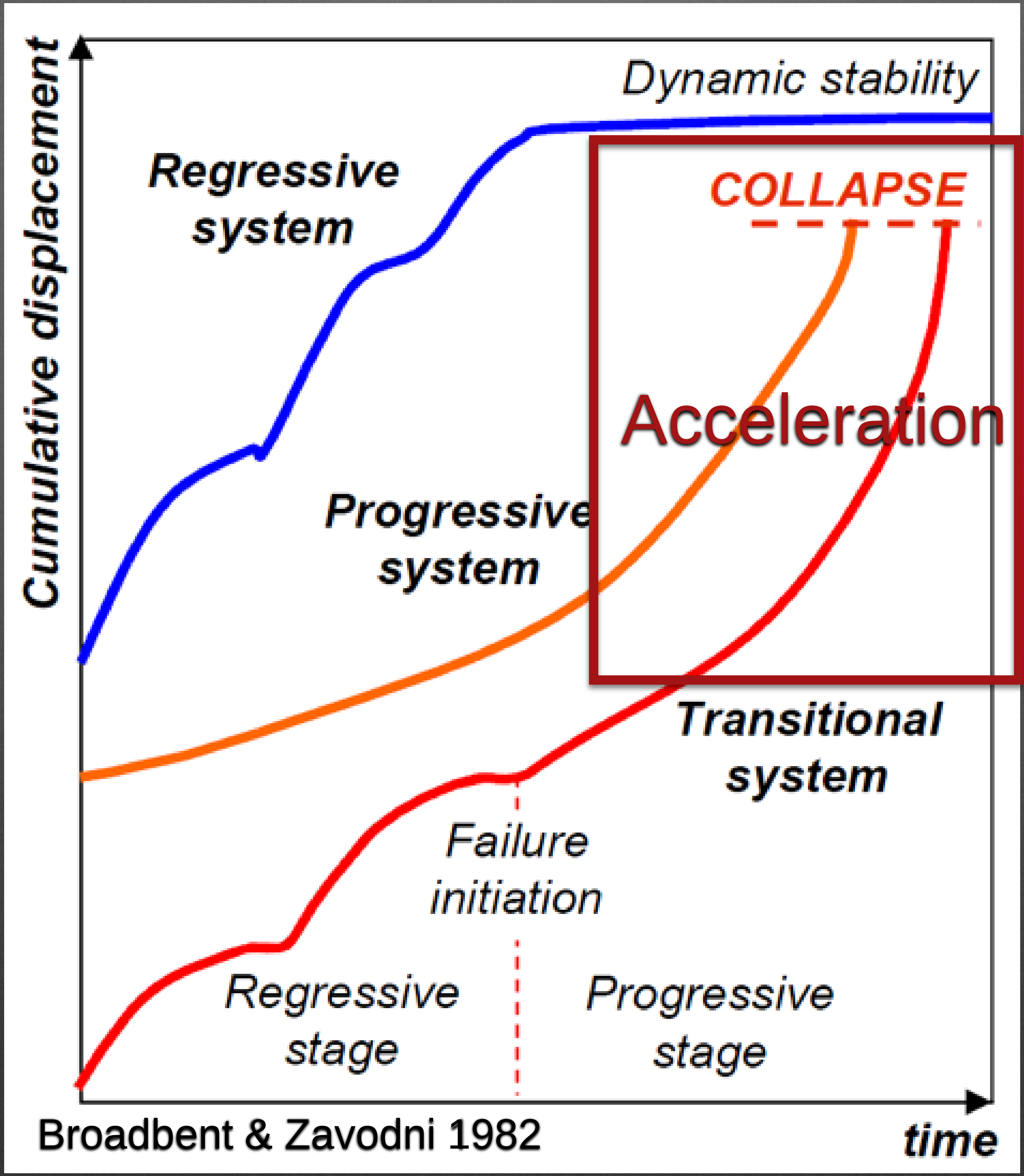
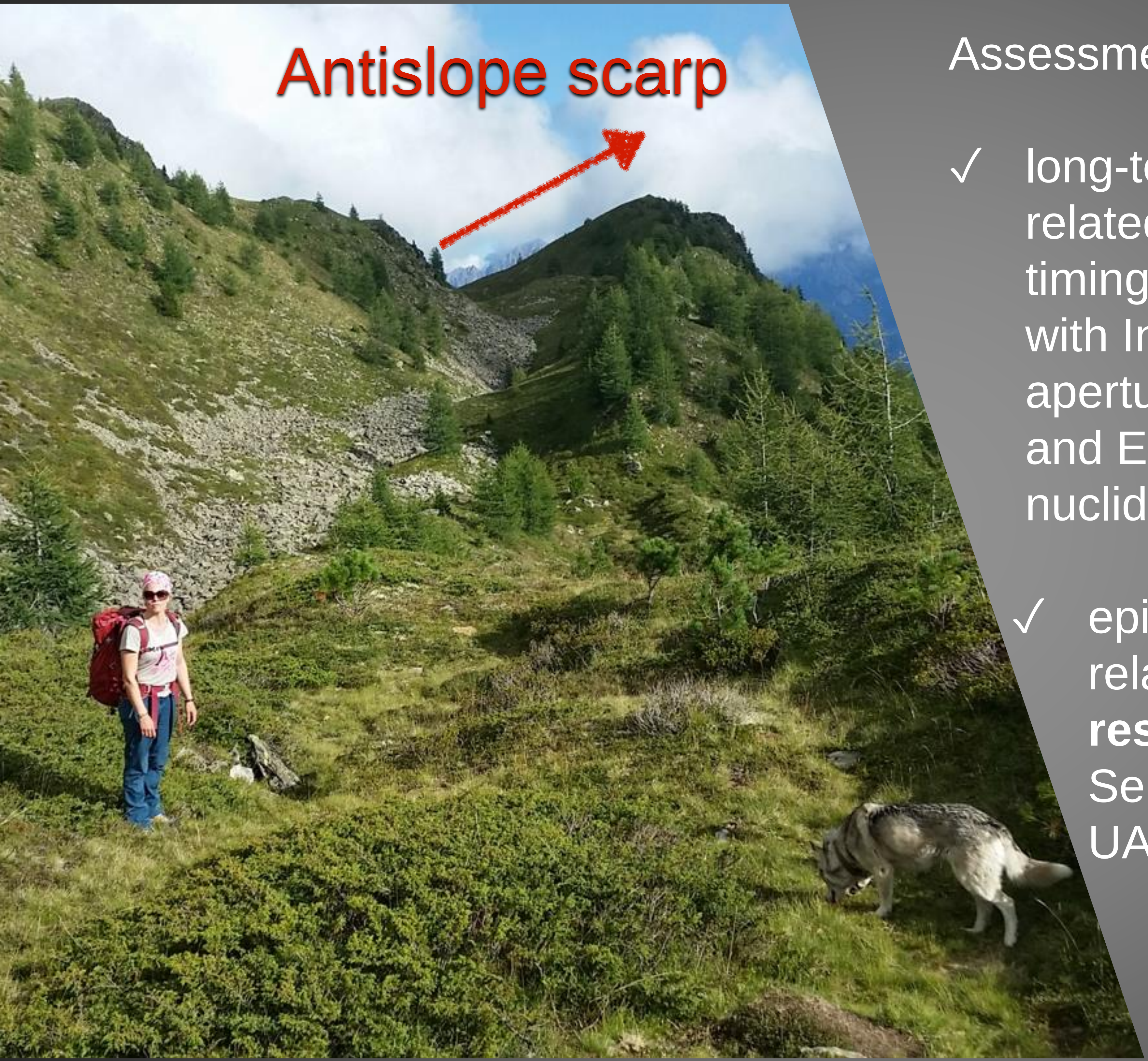
Deep-seated gravitational slope deformations (DSGSD) are slowly deforming rock slopes that fail only partially, with relatively low displacement rates (cm-mm/yr)

VIGILANS will develop a beyond-state-of-the-art monitoring system to assess, where slow moving slope deformations could develop into catastrophic failures

Project period: June 2018 - May 2021

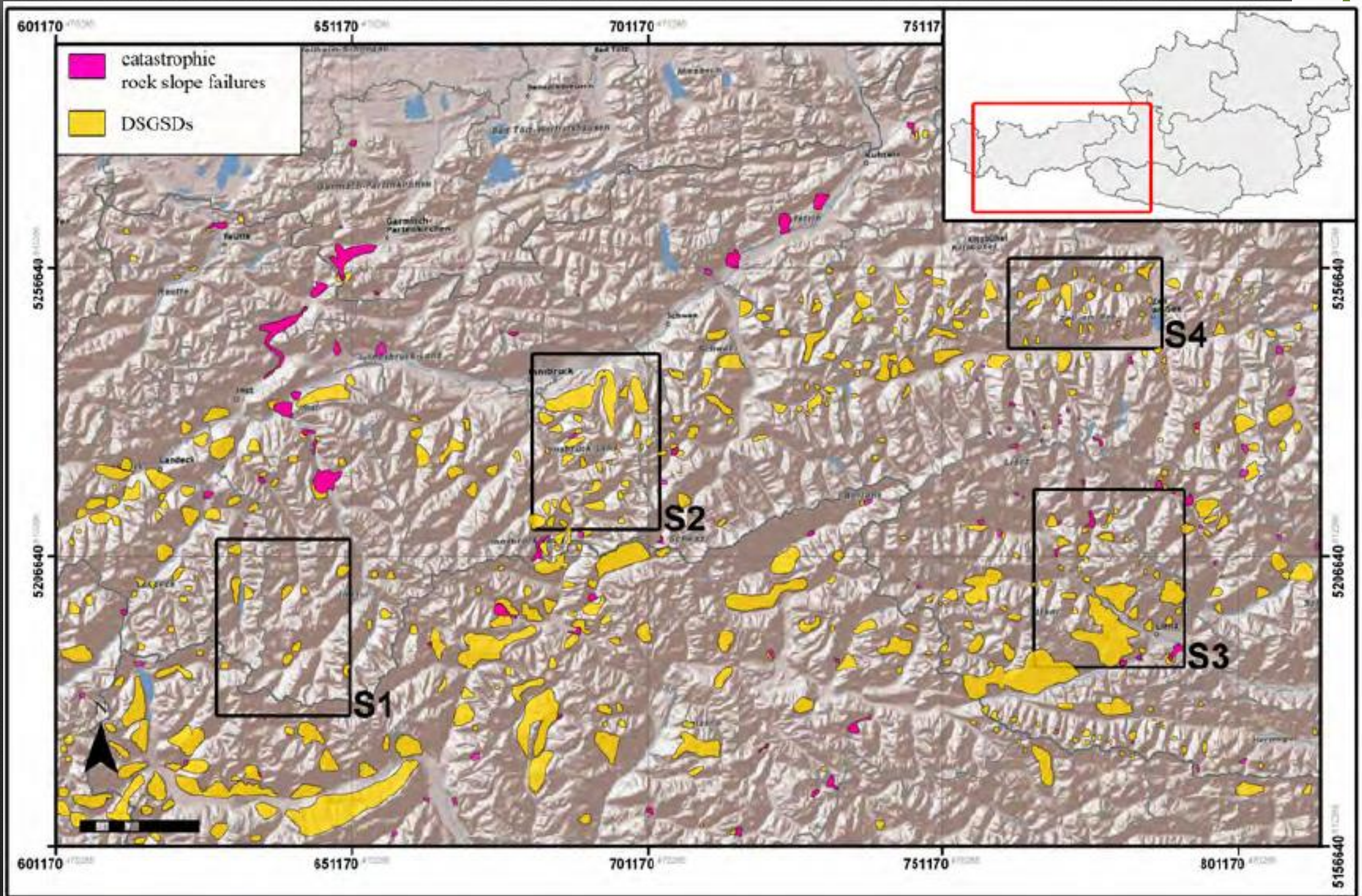


progressive failure model



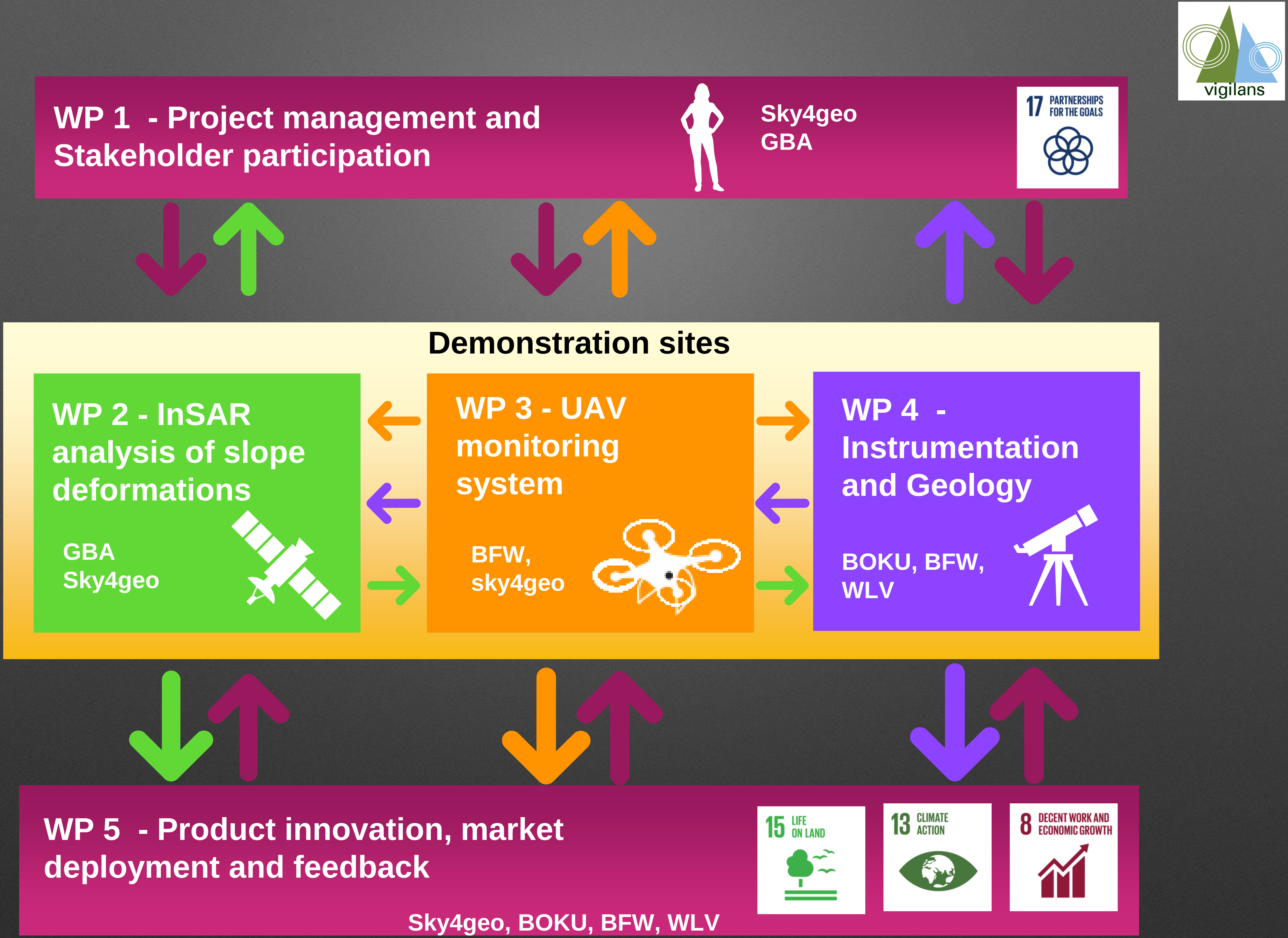
Assessment of acceleration

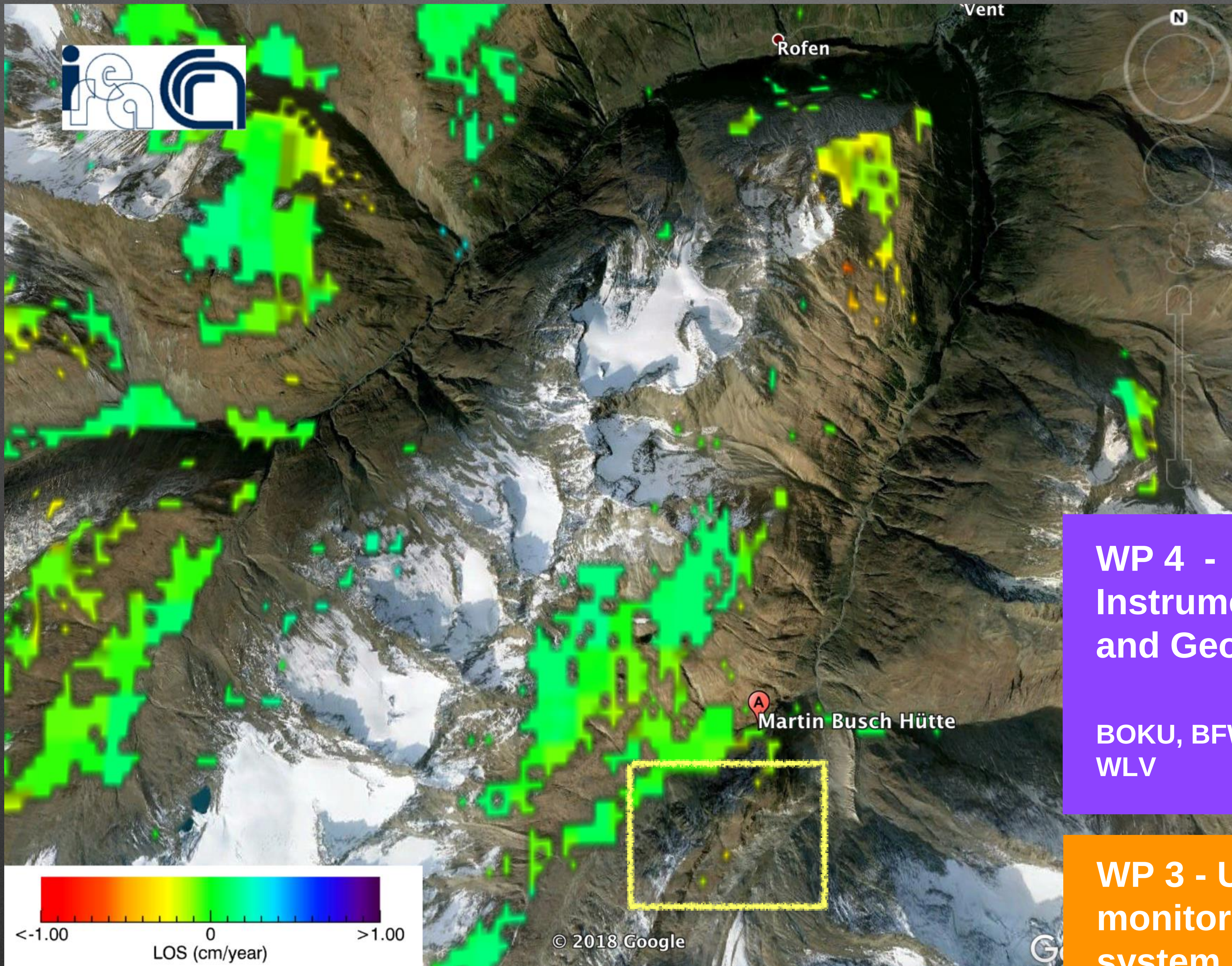
- ✓ long-term creep-like deformation related to **progressive failure** and timing of past failures = **baseline** with Interferometric synthetic aperture radar (InSAR) of ERS and ENVISAT (or cosmogenic nuclide dating)
- ✓ episodic/seasonal acceleration related to **hydro-mechanical response** = InSAR with Sentinel-1 & TerraSAR-X and UAV derived 3D models



Marc Ostermann, GBA

Demonstration sites


WP 1 - Project management and Stakeholder participation
Sky4geo
GBA
17 PARTNERSHIPS FOR THE GOALS
Demonstration sites
WP 2 - InSAR analysis of slope deformations
GBA
Sky4geo
WP 3 - UAV monitoring system
BFW,
sky4geo
WP 4 - Instrumentation and Geology
BOKU, BFW,
WLV
WP 5 - Product innovation, market deployment and feedback
Sky4geo, BOKU, BFW, WLV
15 LIFE ON LAND
13 CLIMATE ACTION
8 DECENT WORK AND ECONOMIC GROWTH
vigilans



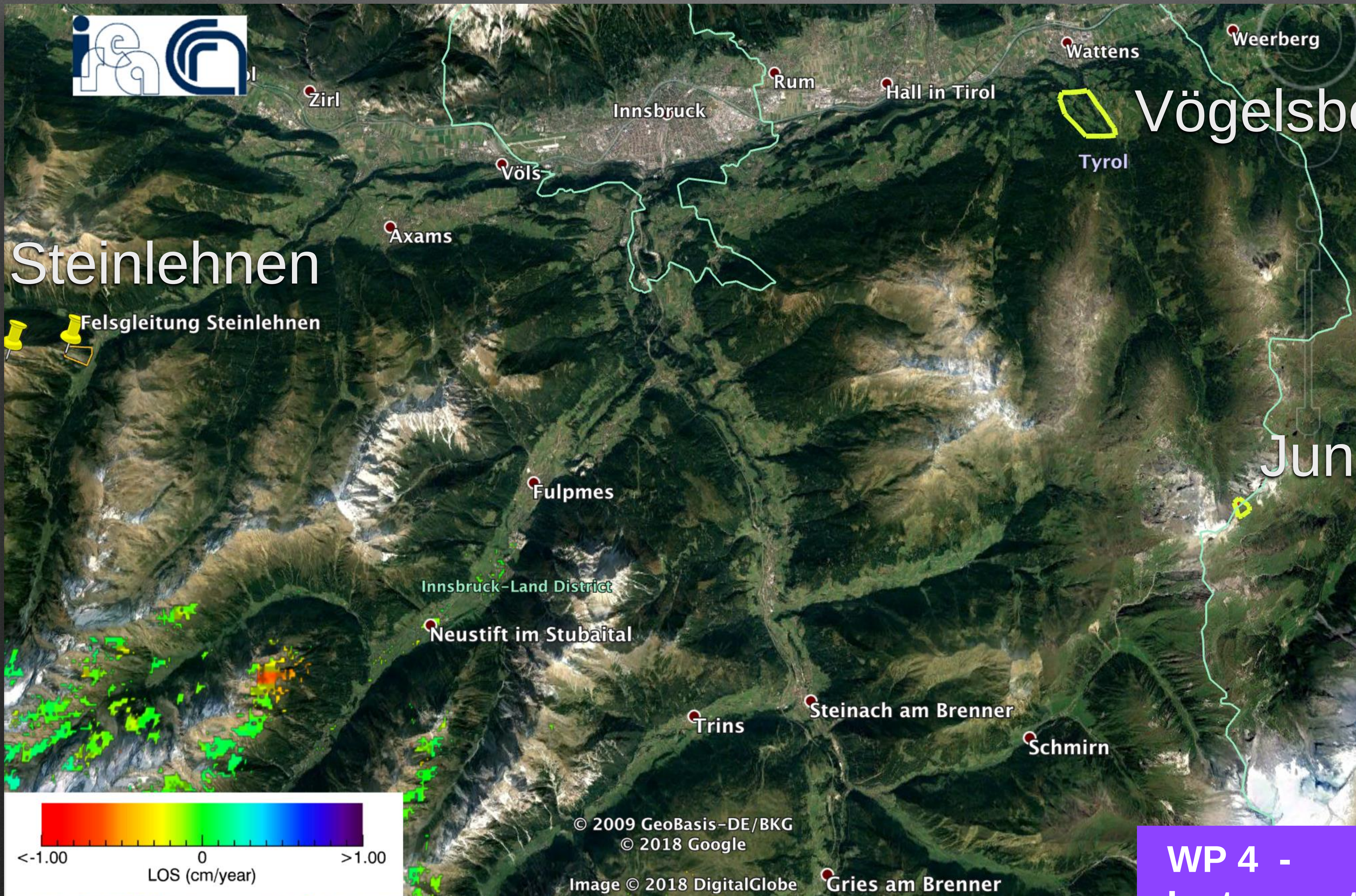
Envisat 20021012_20100717 SBAS processed in GPOD environment

WP 4 - Instrumentation and Geology

BOKU, BFW, WLV

WP 3 - UAV monitoring system

BFW, sky4geo



Envisat 20021012_20100717
SBAS processed in GPOD environment

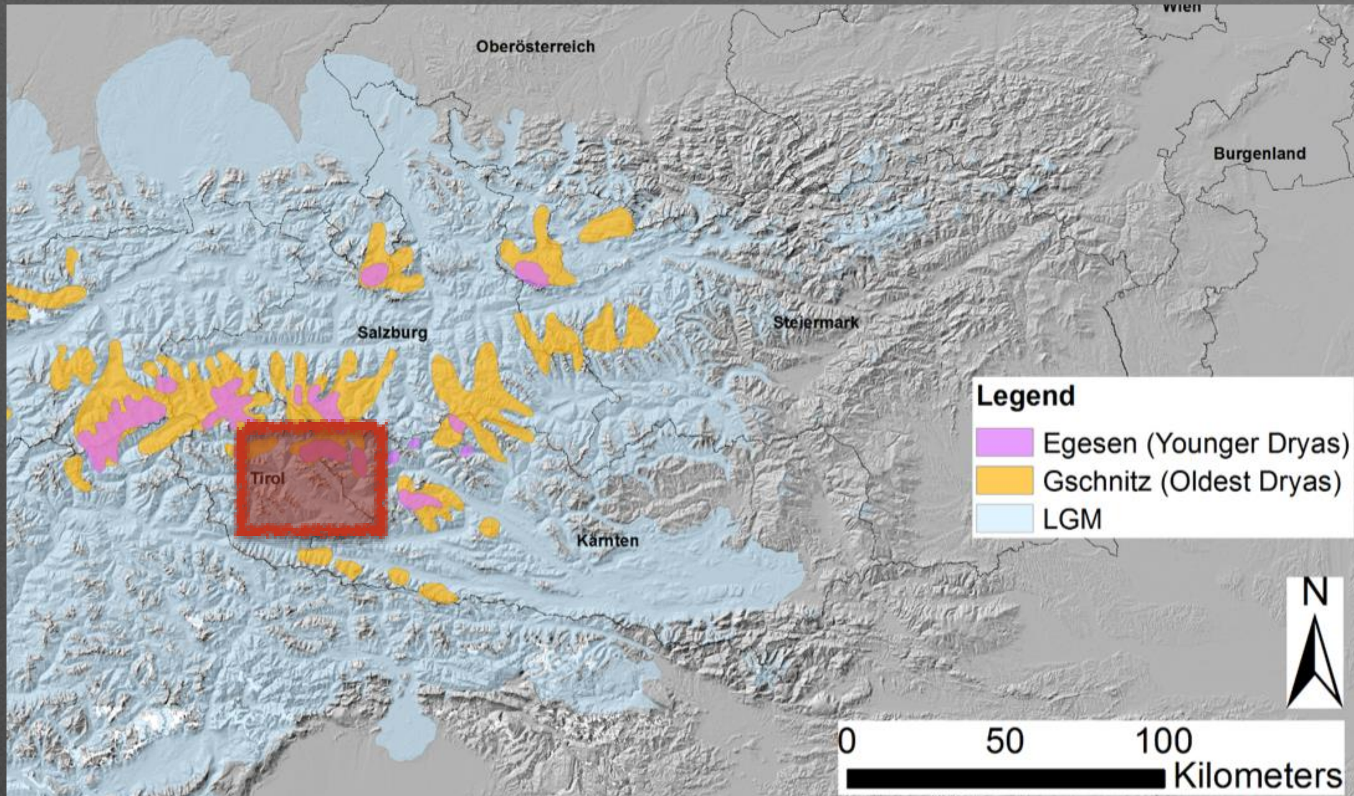
WP 4 - Instrumentation and Geology

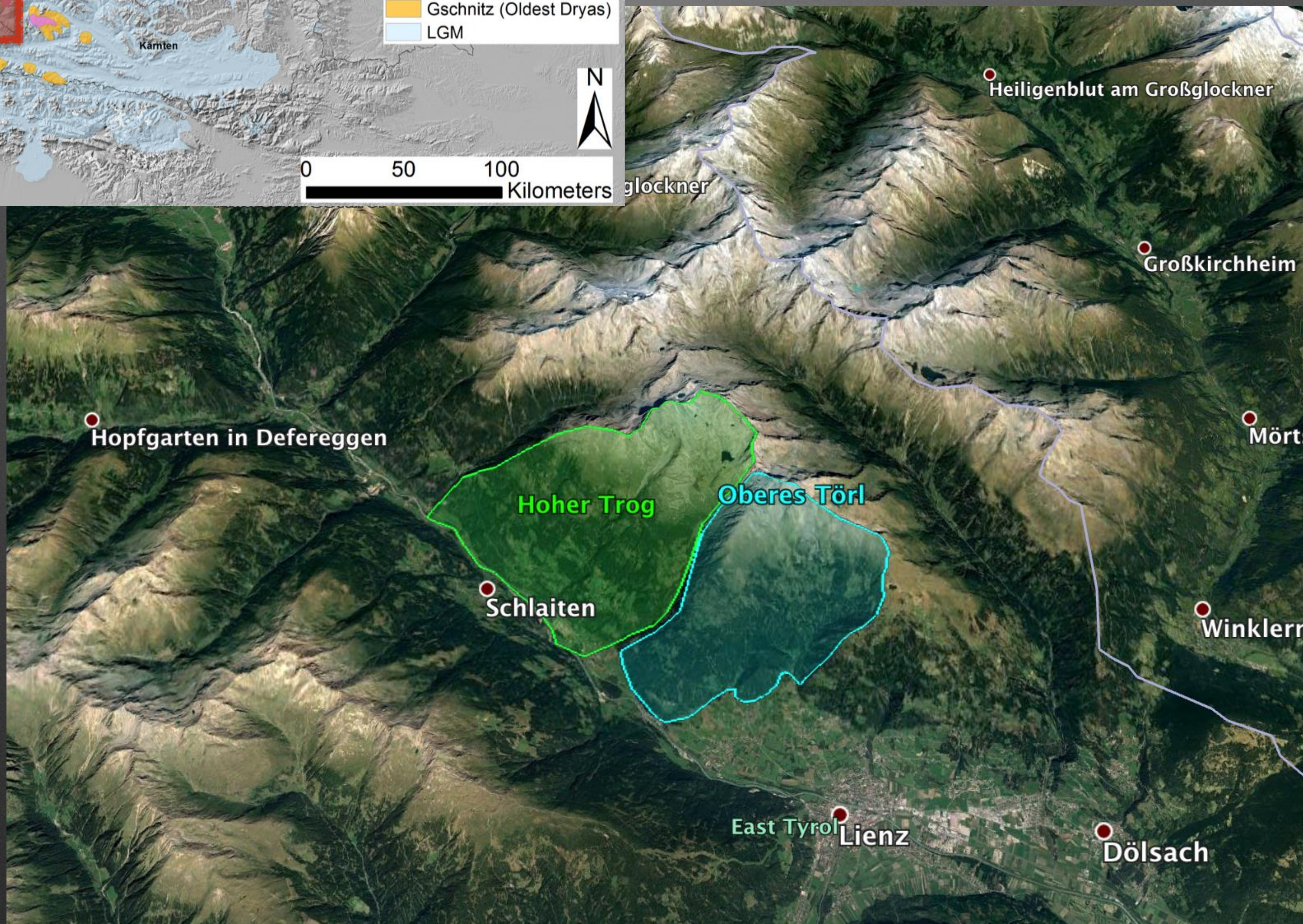
BOKU, BFW, WLV

Junsjoch 3D model based on UAV images from Phantom 4 and Inspire1

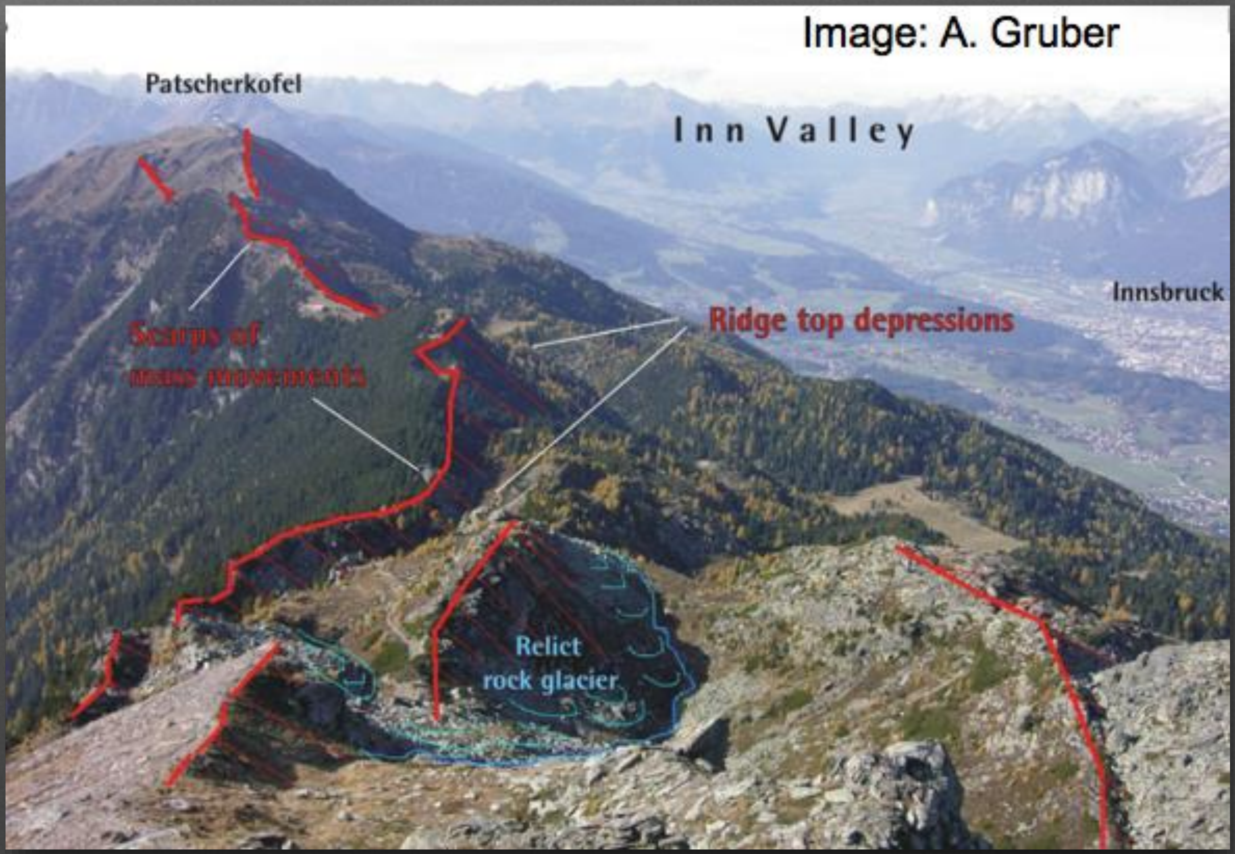
WP 3 - UAV monitoring system

BFW, sky4geo


Oberösterreich
Wien
Burgenland
Salzburg
Steiermark
Tirol
Kärnten
Legend
Egesen (Younger Dryas)
Gschnitz (Oldest Dryas)
LGM
N
0
50
100
Kilometers


Heiligenblut am Großglockner
Großkirchheim
Hopfgarten in Defereggen
Hoher Trog
Oberes Törl
Schlaiten
Winklern
East Tyrol
Lienz
Dölsach

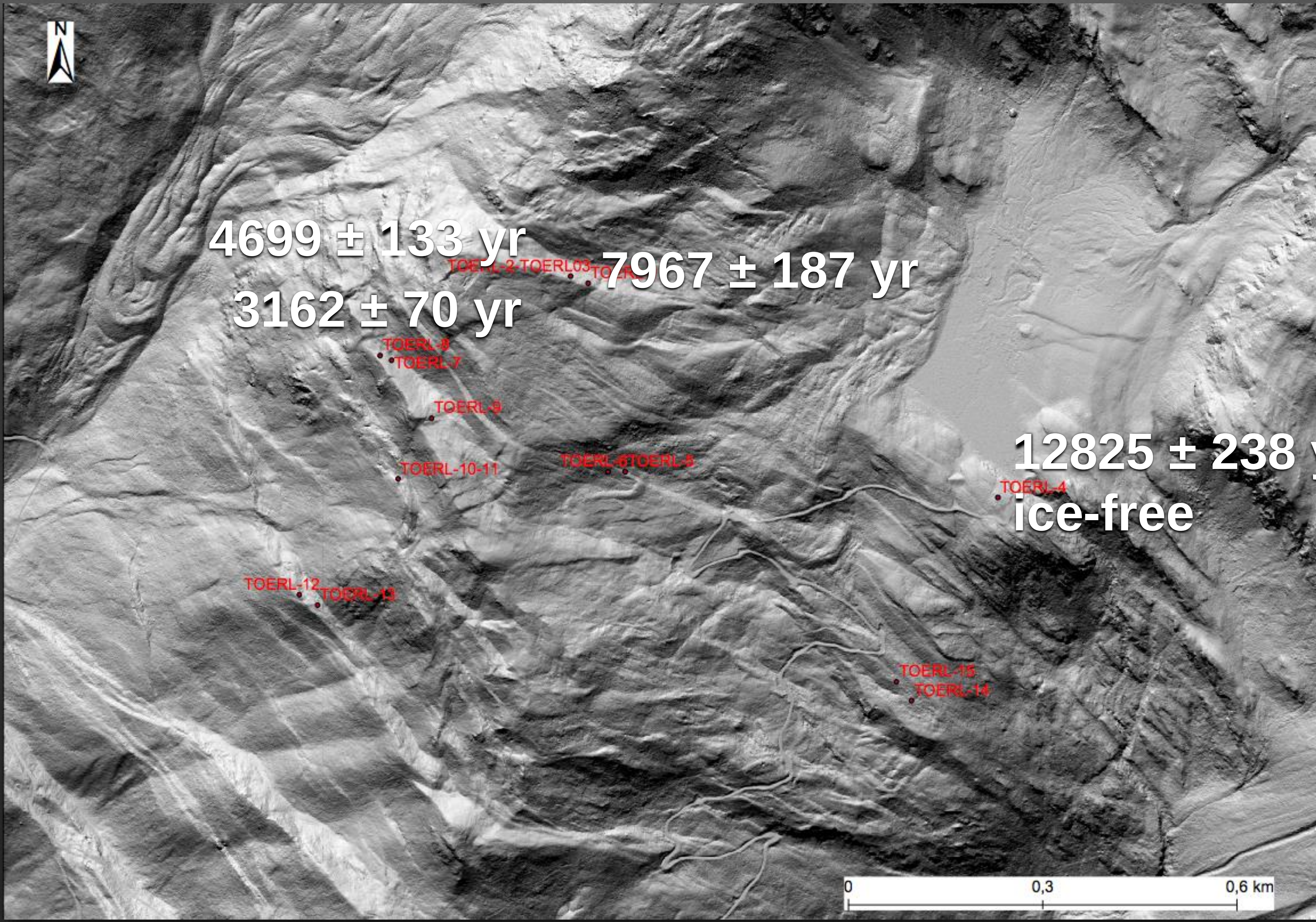
Fully open Back scarp



Trenches

Morpho-tectonic elements

Double ridges



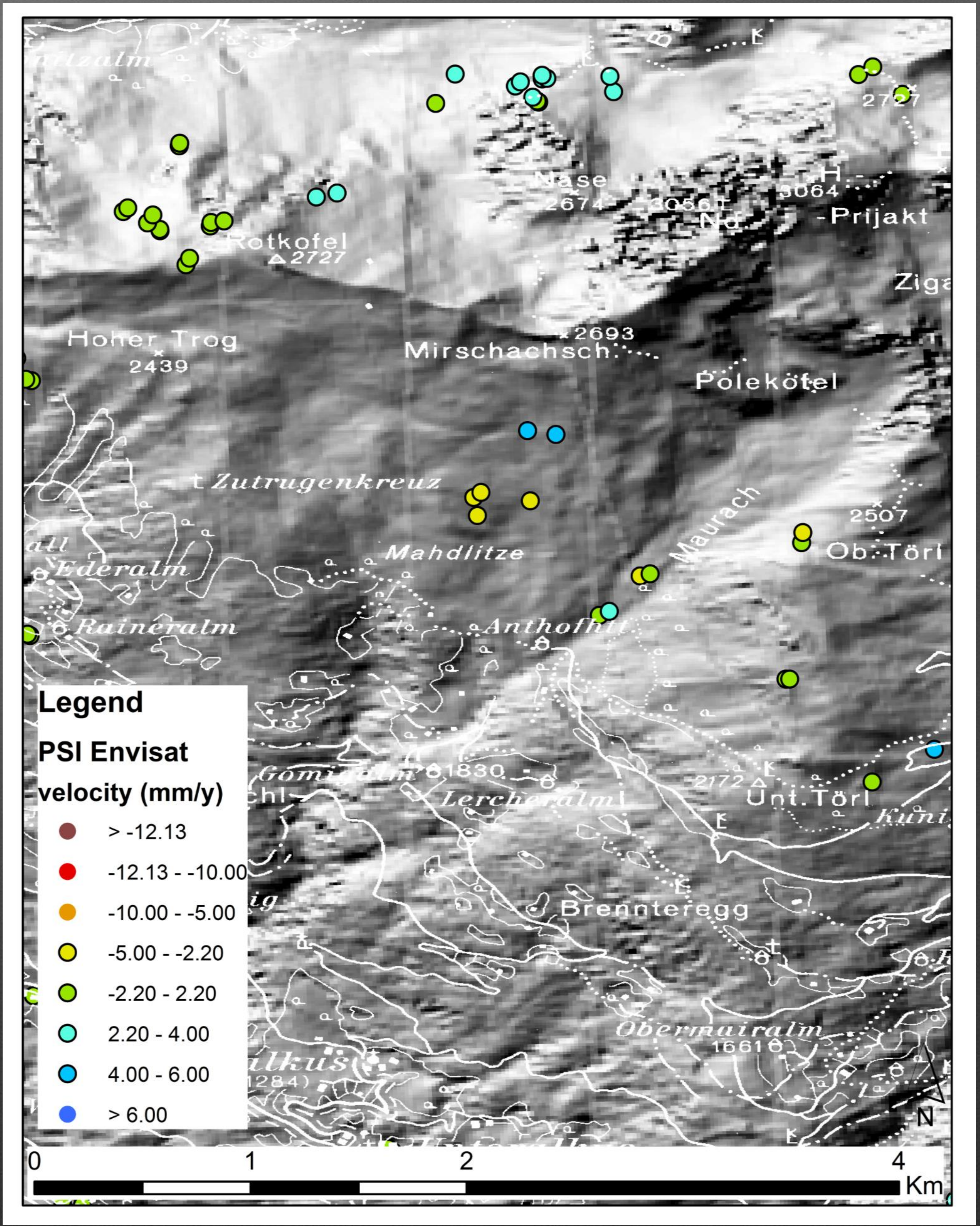
DSGSD Hoher Trog active since post-Younger Dryas and during Holocene = ^{10}Be surface exposure dates on antithetic scarps


7967 ± 187 yr
2.1-2.5 mm/yr
4699 ± 133 yr
1.2-1.6 mm/yr
3162 ± 70 yr

STAMPS-PSI
26-January 2004 and 28 June 2010
ENVISAT track 394 descending

√**subsidence at higher counterscarp of 4.4 mm**

uplift beneath head scarp of about 5.0 mm



WP 2 - InSAR analysis of slope deformations

GBA
Sky4geo

TerraSAR-X
Sentinel-1

vigilans

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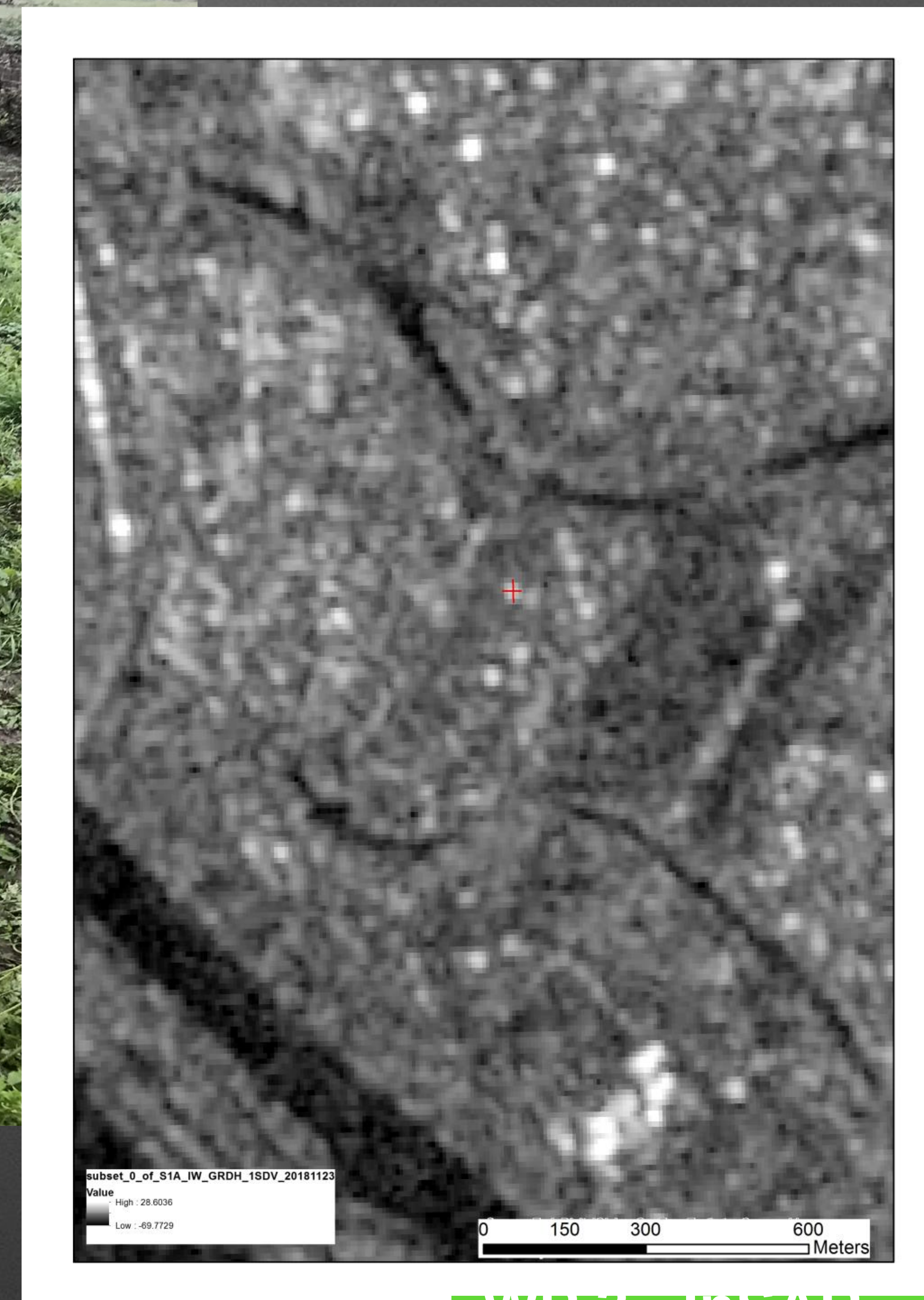


WP 2 - InSAR analysis of slope deformations

GBA
Sky4geo

Corner reflectors designed by GBA are tested in Vienna, and will be installed next year in spring/ early summer

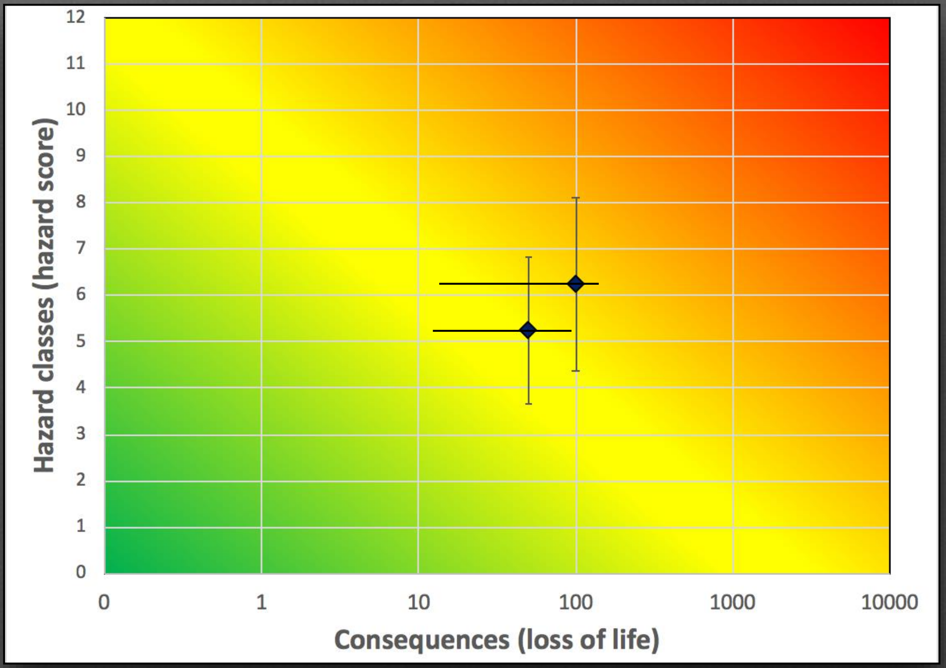
Displacement rates

- Past displacement rates
- Past failure events
- Increase of rock fall activity
- Acceleration

Next steps

- Model feasibility with PSI visibility, density with digitised DSGSD inventory (GBA)
- TerraSAR-X SBAS processing (Sky4geo) S4 Saalbach-Hinterglemm (RSG Graz??)
- surface deformations based on UAV 3D models Junsjoch und Vögelsberg
- RTK drone tests in December
- Corner reflectors to be installed in Vögelsberg, Marzellkamm, Lienz…

9 criteria for Hazard classification of unstable rock slopes



Morpho-tectonic elements

- Back scarp
- Potential sliding structures
- Lateral release surfaces
- Morphotectonic expression of rupture

Kinematic feasibility analysis

- Planar, wedge or toppling?

Displacement rates

- Past displacement rates
- Past failure events
- Increase of rock fall activity
- Acceleration

vigilans

after Hermanns et al. 2014