
Journée C2ROP « Télédétection pour les aléas gravitaires »

Jardin du Lautaret – 28 mai 2025

L'usage du radar interférométrique terrestre pour les instabilités rocheuses et les glissements de terrain superficiels

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Gamma Remote Sensing

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Outline

- Motivation for terrestrial radar interferometry
- Introduction to terrestrial radar imaging systems
- Examples of monitoring rock instabilities and landslides:
 - Ghirone landslide (TI)
 - Kandersteg rockfall (BE)
 - Buseno rockfall (TI)
 - Innertkirchen rockwall (BE)
 - Gugla and Dirru rockglaciers (VS)
 - Breithorn Landslide (VS)
 - Brienz/Brinzauls landslide (GR)
 - Val Canaria landslide (TI)
- Conclusions and outlook

Terrestrial Radar Imaging Systems

Synthetic Aperture Radar concept



Frequency: 17.2 GHz
Rail length L : 2 m
Azimuth resolution
($\lambda R/2L$): 0.2 deg.
4 m @ 1km

Real Aperture Radar concept 1



Frequency: 9.45 GHz
Dish diameter : 0.9 m
Azimuth resolution:
2 deg.
4 m@100m

Real Aperture Radar concept 2



Frequency: 17.2 GHz
Antenna length L : 2.1 m
Azimuth resolution
($\lambda R/L$) : 0.4 deg.
8.47 m @ 1km

Gamma Portable Radar Interferometer (GPRI)

FM-CW radar interferometer

Frequency: 17.1 -17.3 GHz

Wavelength: 0.0176 m

Acquisition time: < 1 min

Operational range: 30 m to >10 km

Antenna fan-beam: 0.4×60 deg.

Transmit power: 100 mW

Transmit bandwidth B: 200 MHz

Range resolution ($c/2B$): 0.75 m

Azimuth length L: 2.06 m

Azimuth resolution ($\lambda R/L$):

8.47 m@1km, 16.93 m@2km



Gamma Portable Radar Interferometer (GPRI)

FM-CW radar interferometer

Instrument displacement sensitivity:

0.125 mm@20 dB SNR

0.030 mm@30 dB SNR

DEM height sensitivity:

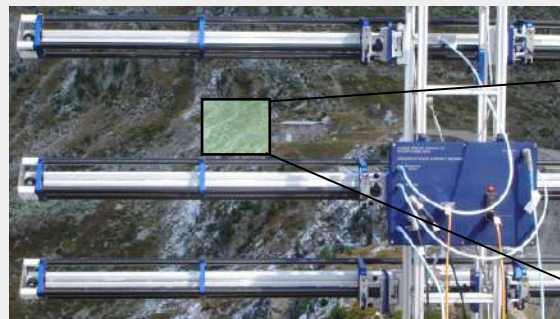
< 50 cm@1km

with 25 cm baseline and 20 dB SNR

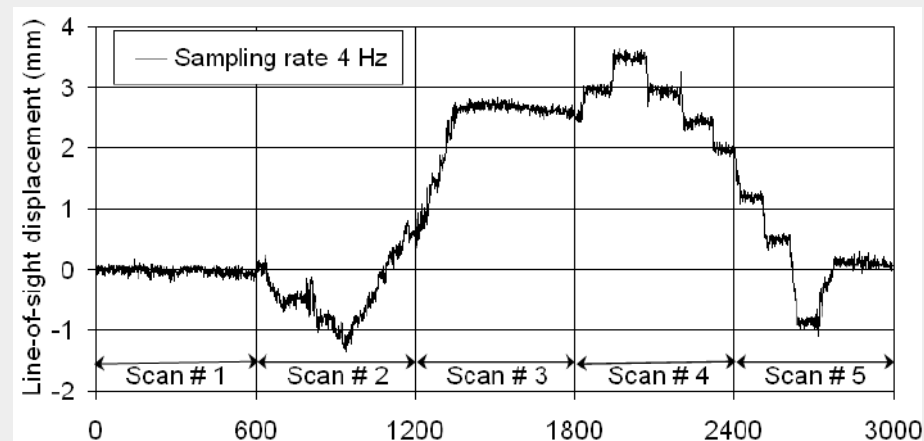
Rotational scans of >180° feasible

@ ~10°/s

Weight: ~45 kg



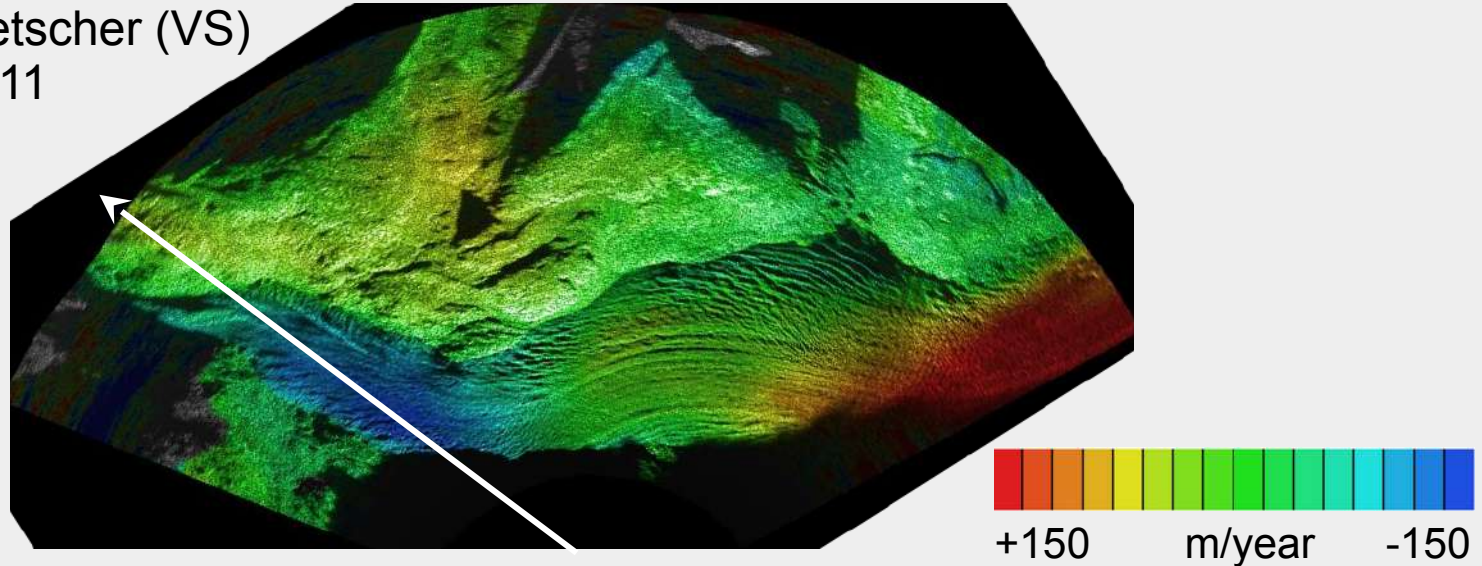
distance 285 m



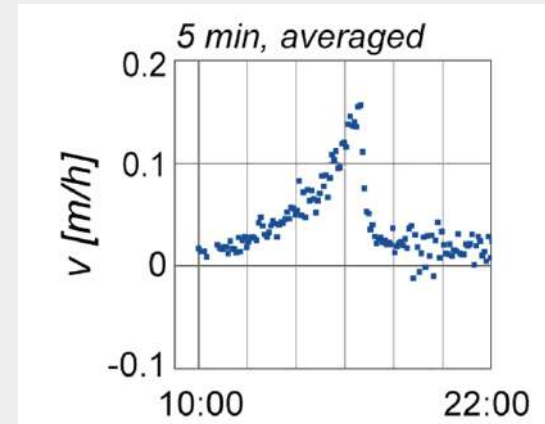
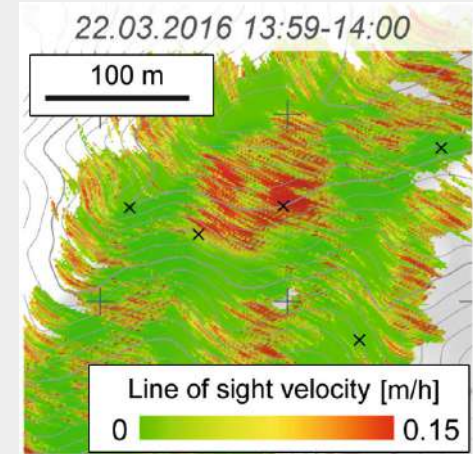
Gamma Portable Radar Interferometer (GPRI)



Grosser Aletschgletscher (VS)
27.06.2011



Ghirone Landslide (TI)

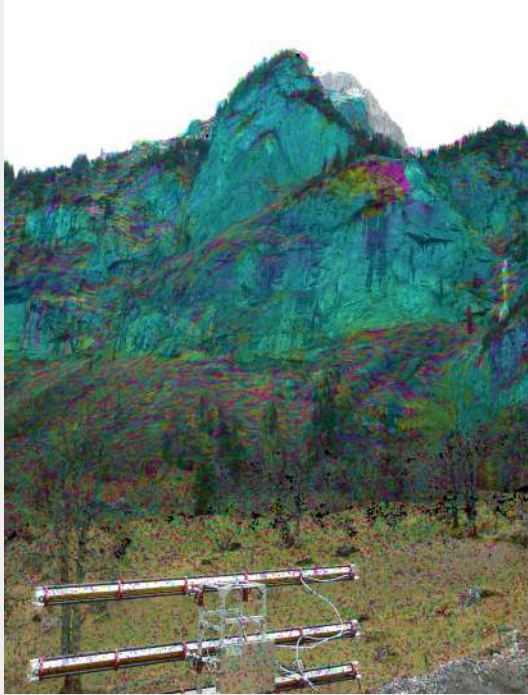


Kandersteg Rockfall (BE)

11.01.2023 → 01.02.2023

26.12.2022

23.02.2023

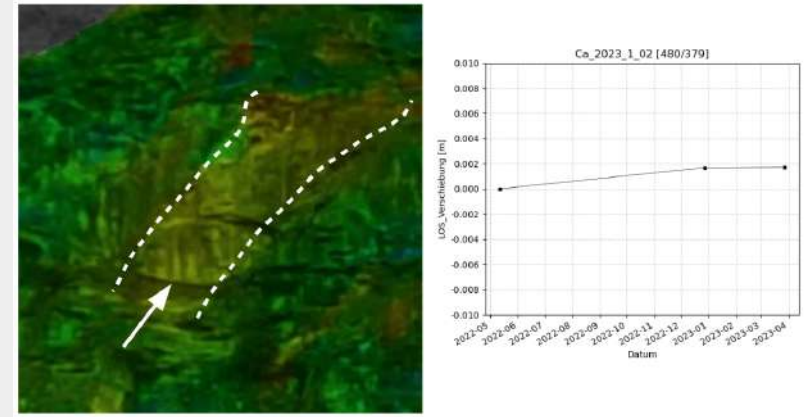
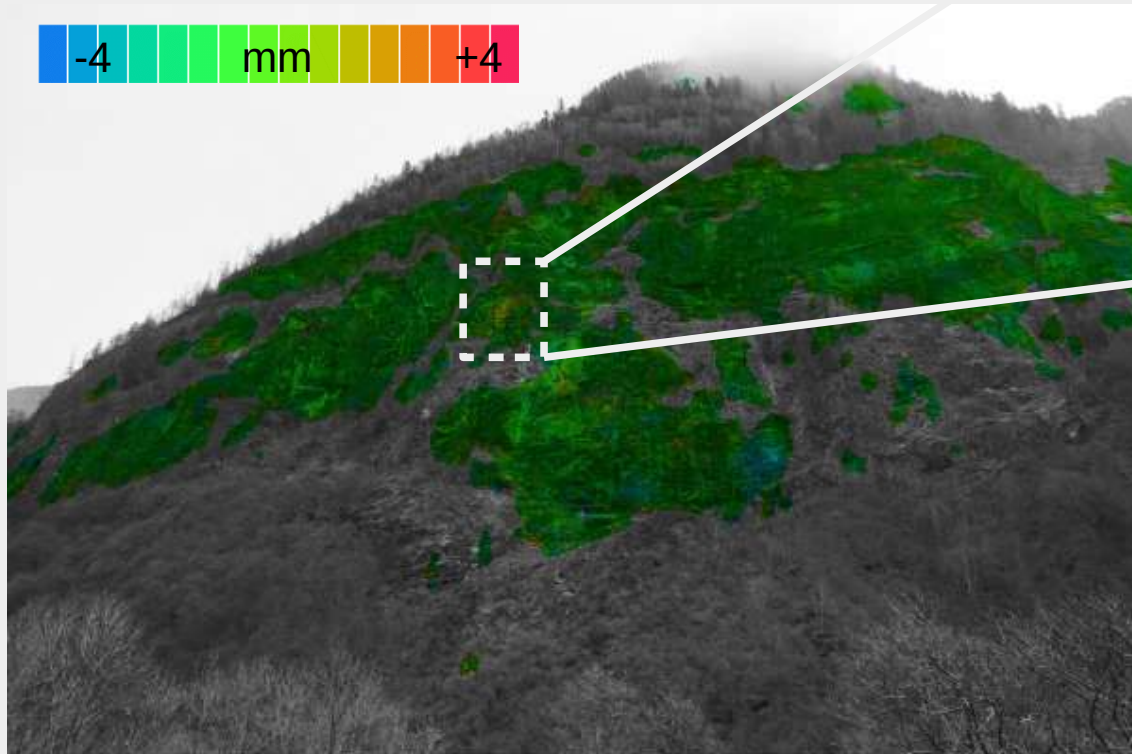


$2\pi \Leftrightarrow 8.72 \text{ mm @ } 17.2 \text{ GHz}$



Buseno Rockfall (GR)

11.05.2022 → 27.03.2023

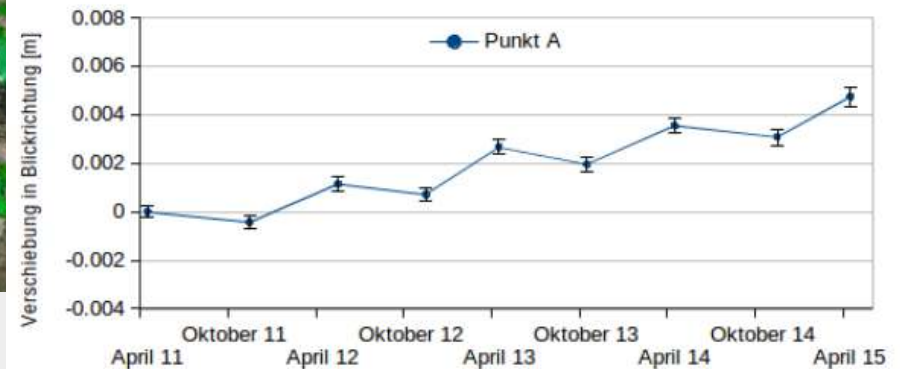
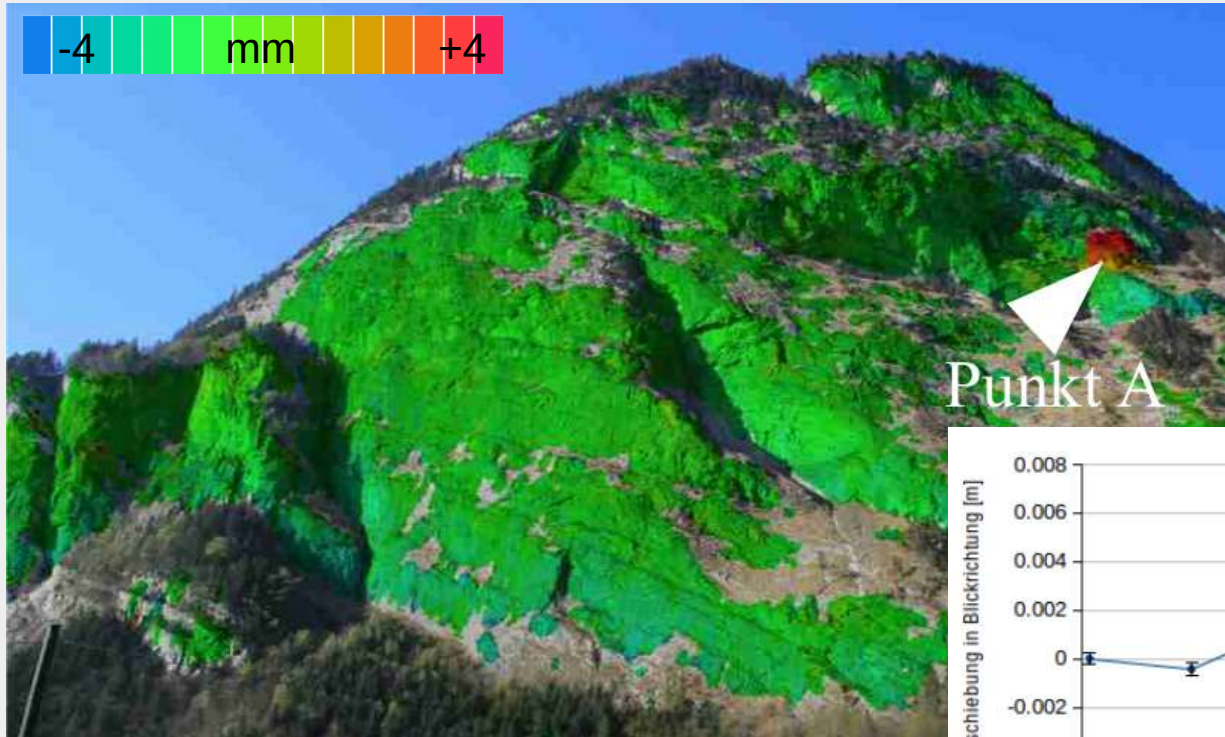


Rockfall on 22.09.2023

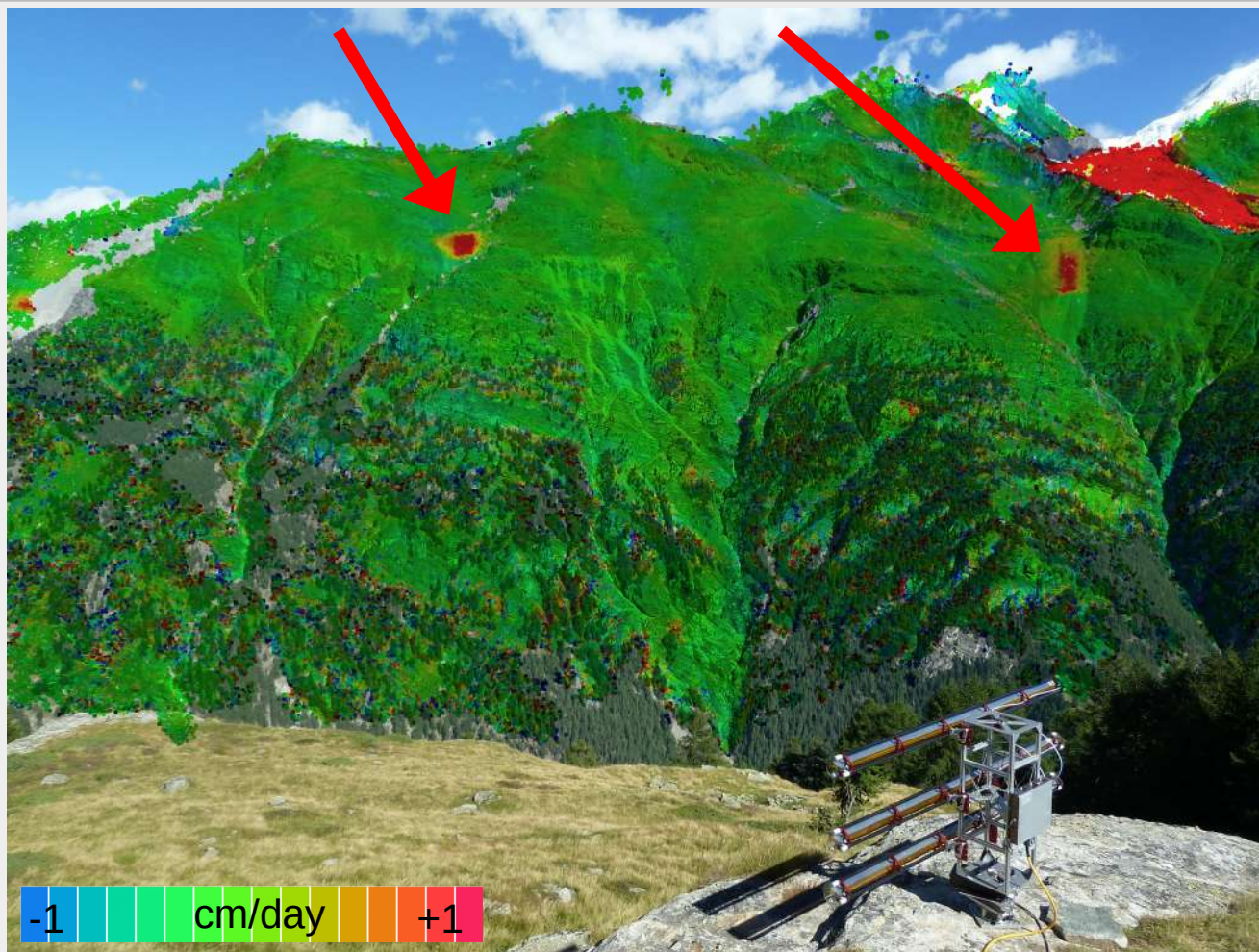


Innertkirchen Rockwall (BE)

2011 → 2015



Gugla and Dirru Rockglaciers (VS)

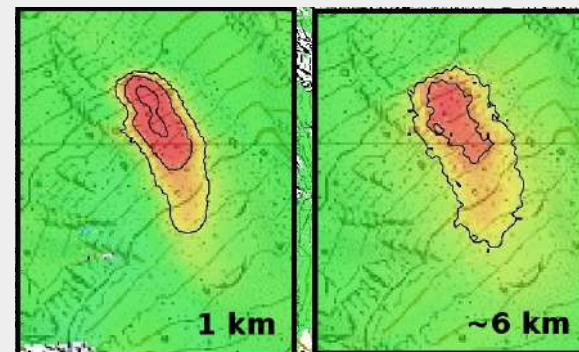


21.08.2011

Hobärg glacier

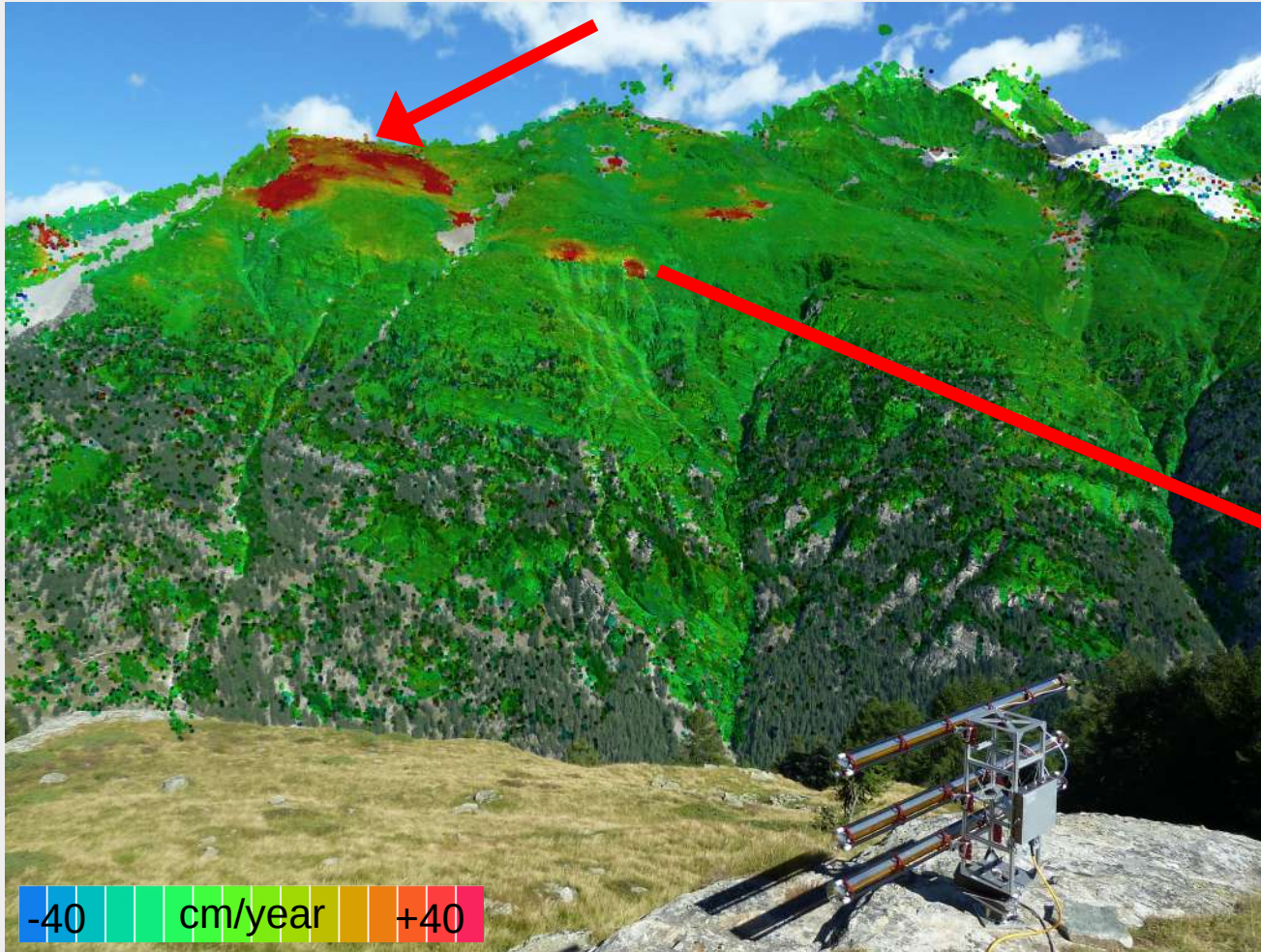
Grabengufer rockglacier

20.7.2010 1-3.9.2010

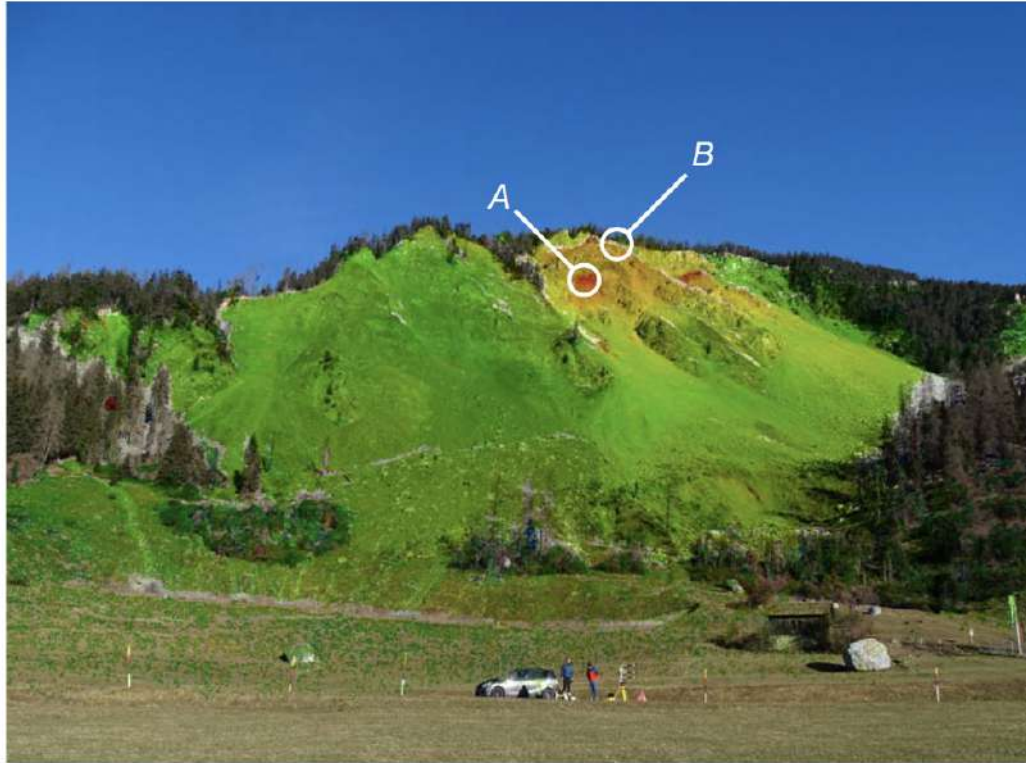


Breithorn Landslide (VS)

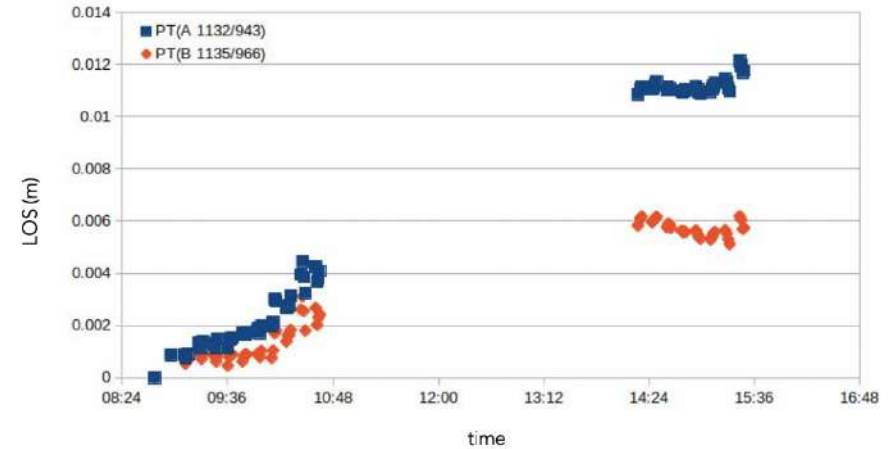
21-26.08.2011



Brienzen/Brinzauls Landslide (GR)

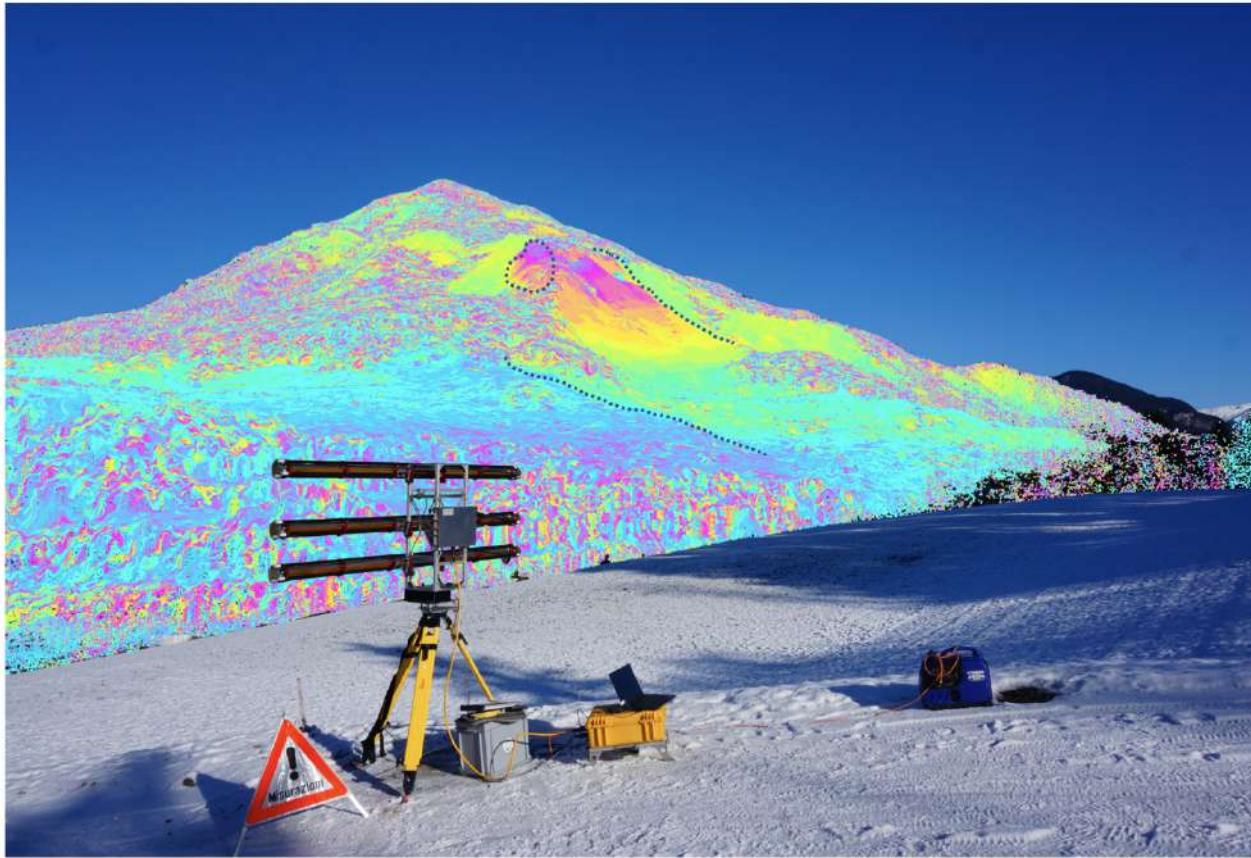


LOS displacements



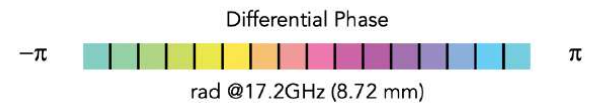
15 January 2020

Brienzen/Brinzauls Landslide (GR)



Snow covered

22 January 2020
10:46 – 18:19



Brienz/Brinzauls Landslide (GR)

Slope failure event with a mass wasting of about 1.2 Mm³ on 15.06.2023



<https://www.nbcnews.com>



<https://www.swissinfo.ch>

Brienzen/Brinzauls Landslide (GR)



Gemeinde/Cumegn
Albula/Alvra

<http://www.albula-alvra.ch>

Information zum Brienzer Rutsch
Brienzen/Brinzauls – Vazerol – Surava – Tiefencastel

9. Oktober 2020

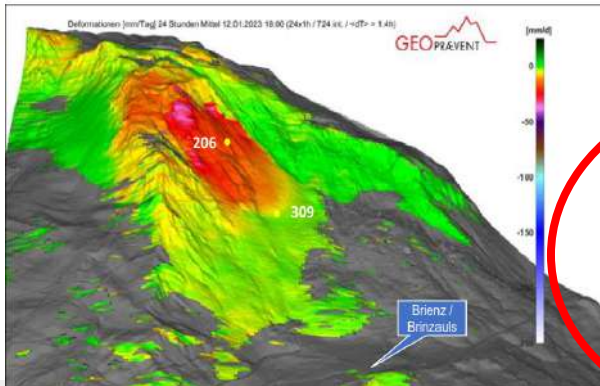
Rutschung im Dorf

Die Rutschung Dorf verbleibt auf einem ungefähr konstanten, aber hohen Geschwindigkeitsniveau. Die Geschwindigkeit im Dorf liegt bei ca. 1.10 m/Jahr, westlich des Dorfes bei ca. 1.40 m/Jahr.

Rutschung am Berg

Der so genannte «Grosstrend» der Rutschung Berg ist nach wie vor abnehmend; dennoch sind die Geschwindigkeiten immer noch auf einem sehr hohen Niveau.

Seit Juni führten fünf Niederschlagsereignisse jeweils zu starken Beschleunigungen in den Bereichen «West», «Insel» und an der «Front», die allerdings jeweils wieder sehr rasch abklingen. Das letzte Ereignis vom 2. bis 4. Oktober 2020 war etwas weniger ausgeprägt als die vier Ereignisse seit Juni.



Die aktuellen Geschwindigkeiten
der Rutschung Berg
(in Metern pro Jahr):

- Insel: bis 7,0 m
- Plateau und Front: 1,8 – 2,6 m,
- Szenario West: 6,6 m,
- Rücken Caltgeras: bis 1,8 m.

Landslide “Village”
1.10 -1.40 m/year
(~2.5 cm/week!)

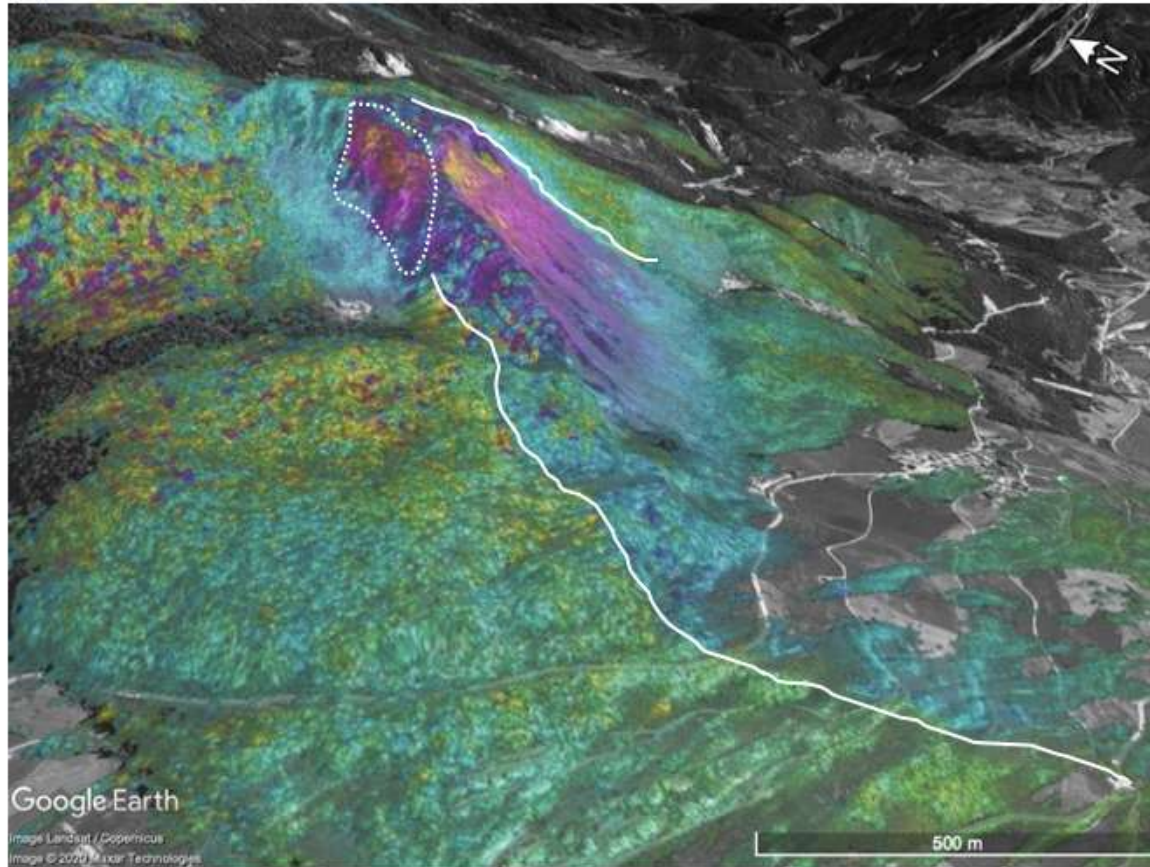
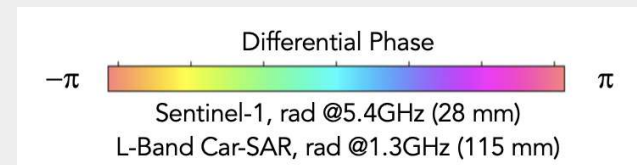
Landslide “Mountain”
Up to 7 m/year
(~2 cm/day!)



Brienzen/Brinzauls Landslide (GR)

20-24 January 2020

Car-borne GAMMA
L-Band SAR



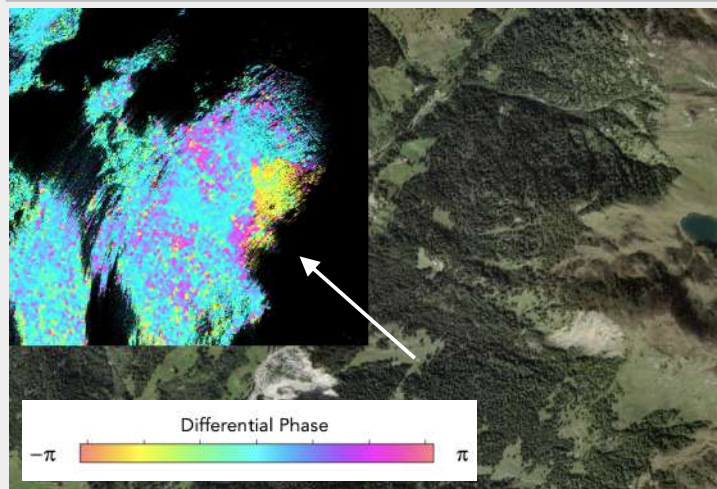
GAMMA L-Band SAR campaigns



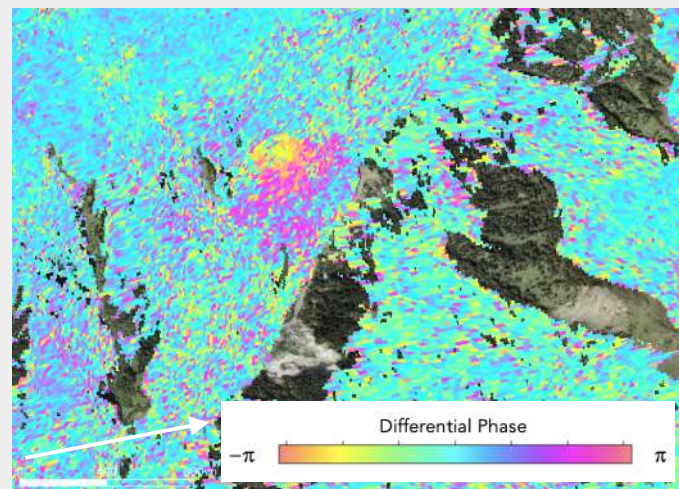
Radar Electronics, GNSS antennas,
HGuide n580 INS, Antennas: 15 kg.
Radar operates 1275 to 1400 MHz, 1-10W output
Power required: 80W while acquiring data, 40 when idle
GNSS antennas required for INS
Communications via SSH



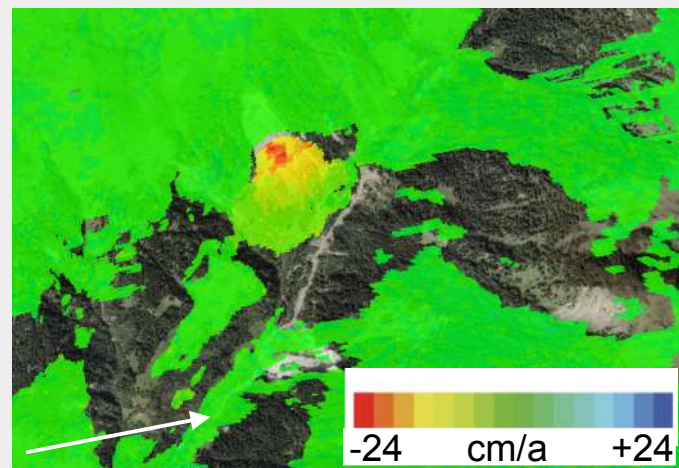
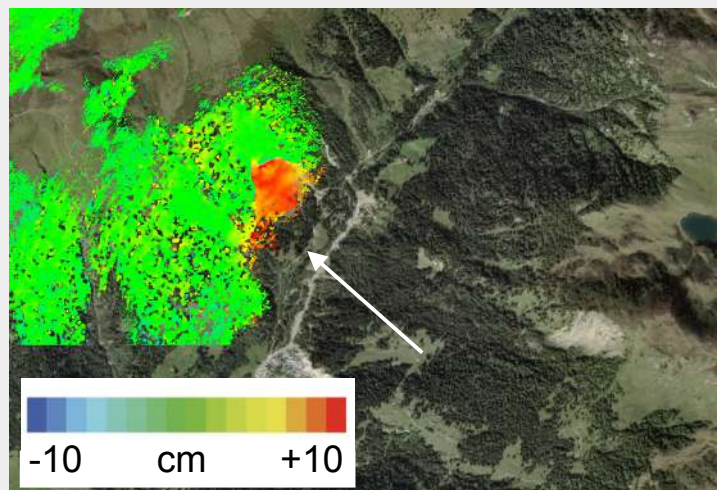
Val Canaria Landslide (TI)



Left : GSL-1
20240703_20240923
113.2 mm @ 1.325 GHz



Right : SAOCOM-1
20240724_20241012
117.6 mm @ 1.275 GHz
SBAS 2020-2024
(Bperp < 750 m;
 Δ time < 270 days)



Conclusions

Our findings highlight that a multi-frequency and multi-platform approach coupled with the use of multiple InSAR techniques enables the best coverage and extraction of ground displacement information in alpine regions

