Land Motion Monitoring Service Of Switzerland Through Interferometric Multi-Temporal Analyses Of Sentinel-1 SAR Data

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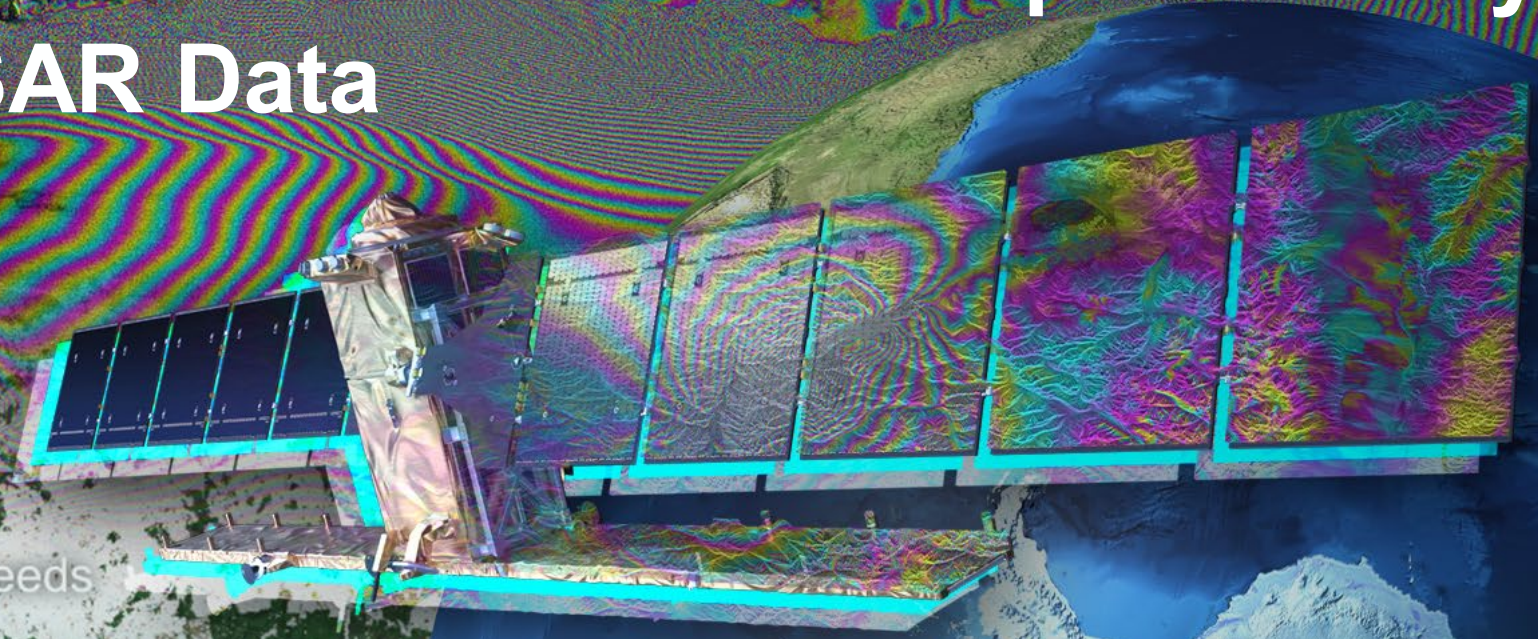
sarmap SA



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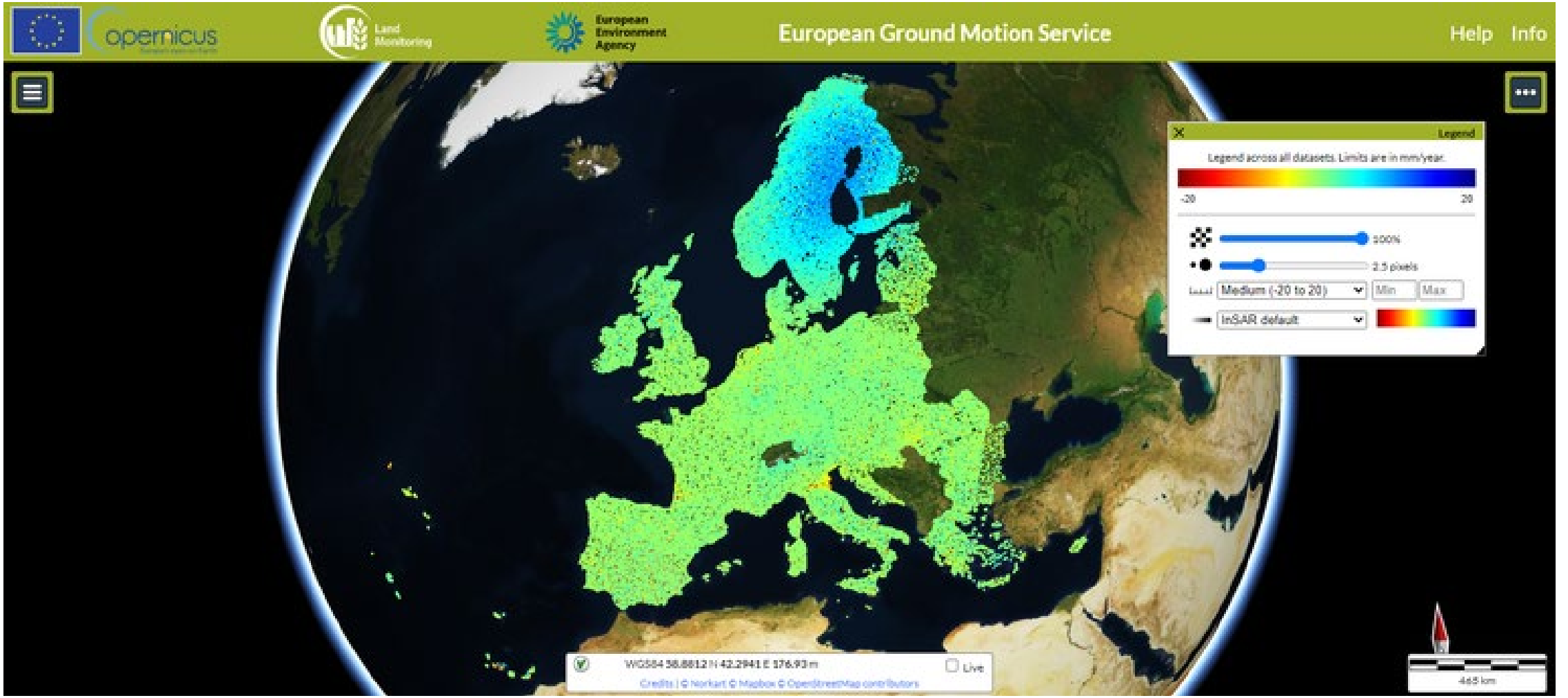
→ THE EUROPEAN SPACE AGENCY

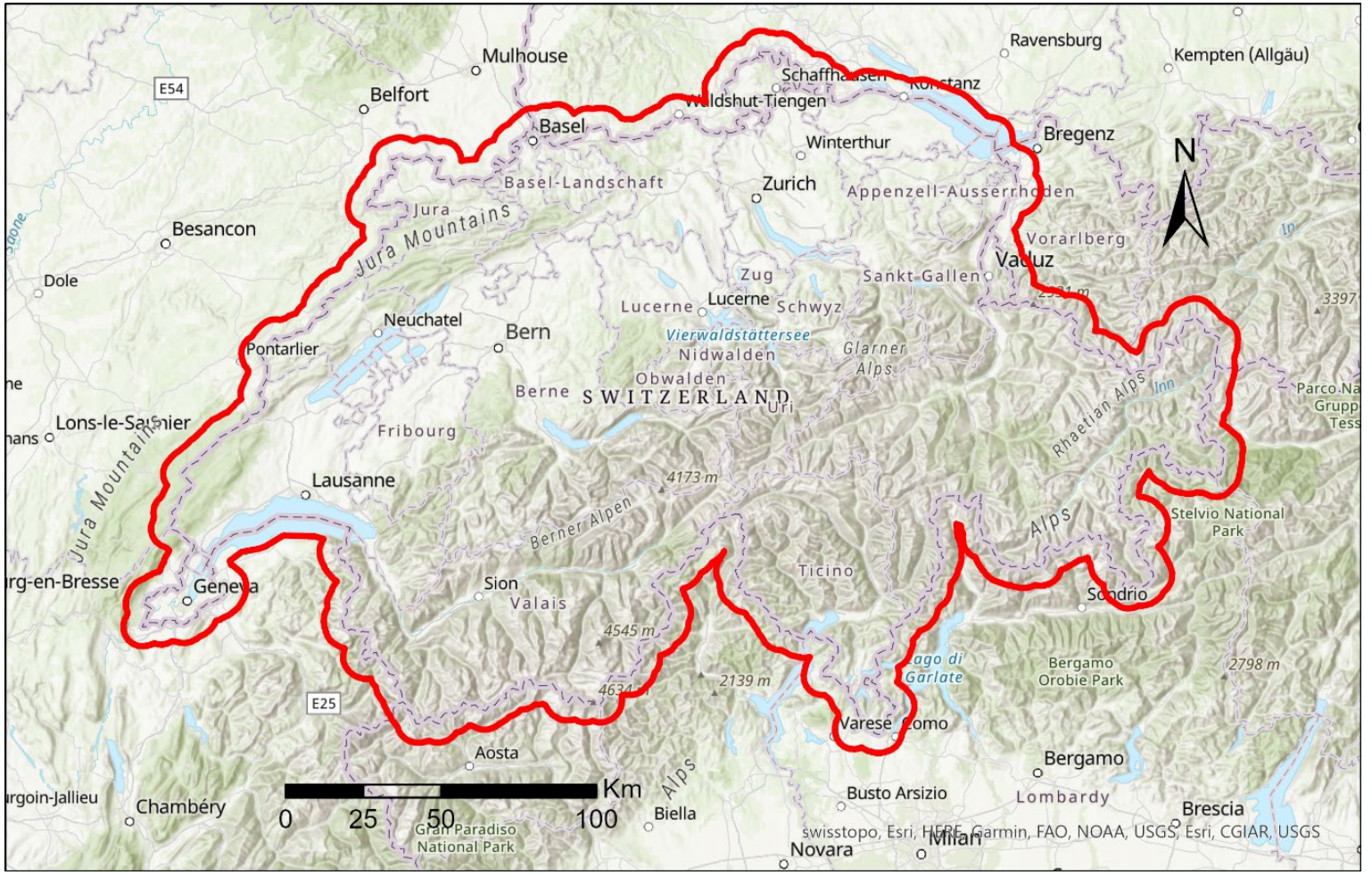
Context



European Ground Motion Service

Study Area

The area of interest covers **Switzerland** and **Liechtenstein**, including a 5 km buffer, for a total surface of approximately 50’000 km^2.



Area of interested, including Switzerland, Lichtenstein and a 5 km buffer

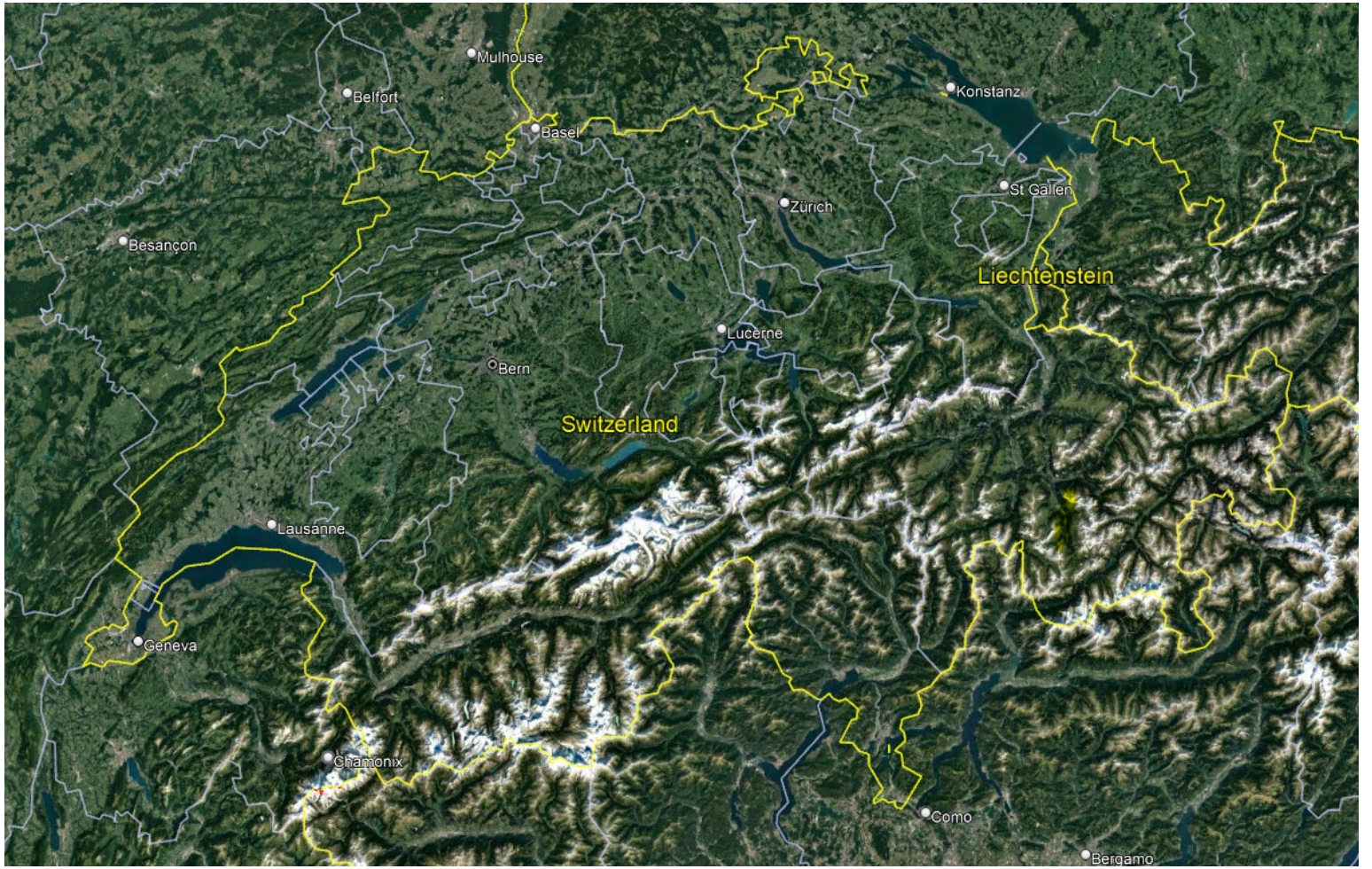
Study Area

Swiss Beauties

Study Area

Southern Switzerland is characterized by prominent topography, as it includes more than the 13% of the Alps, comprising several peaks higher than 4’000 m above sea level. In fact, **the Alps cover 60%** of Switzerland.

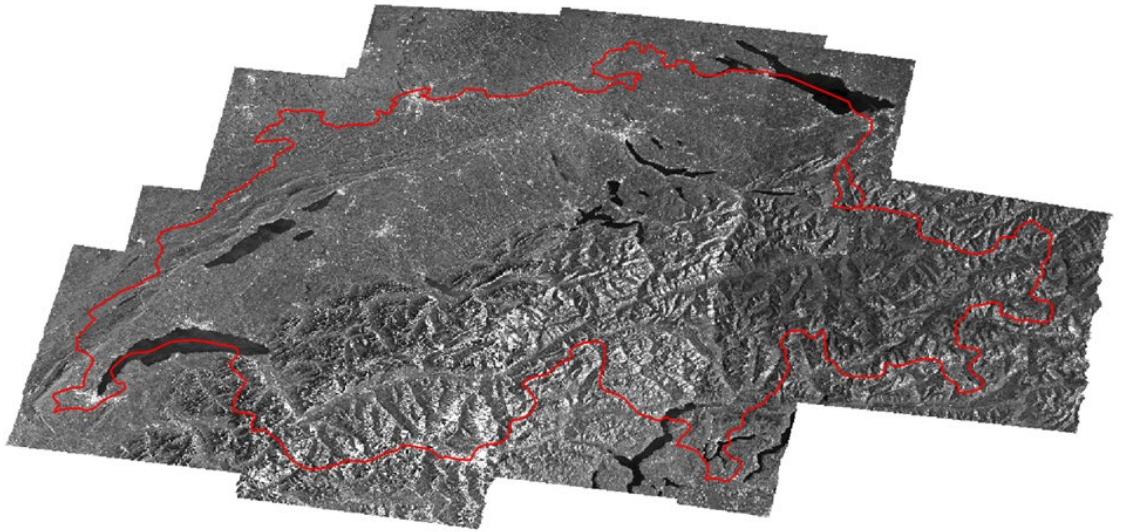
More than **30%** of the Country is covered by **forests**.



Switzerland and Liechtenstein, Satellite Optical image

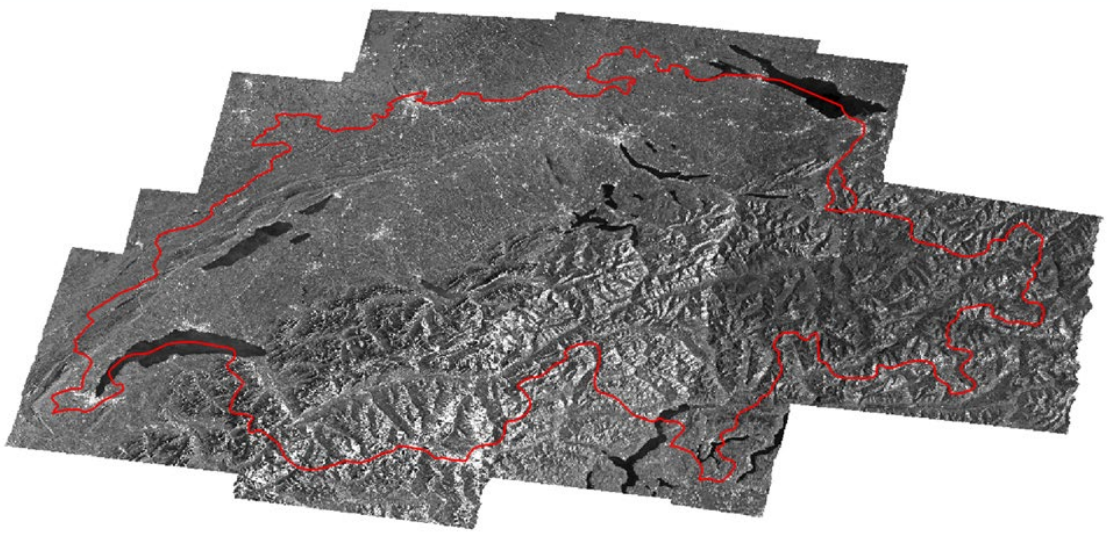
Sentinel-1 datasets

The area is covered by **5** different S1 **tracks**, 2 ascending and 3 descending, from October 2014 up to now. The approximate number of **acquisitions per track**, up to November 2022 is about **400**, characterized by a 6-day revisiting time, which is showing a regular sampling with no data gaps starting from November 2015.



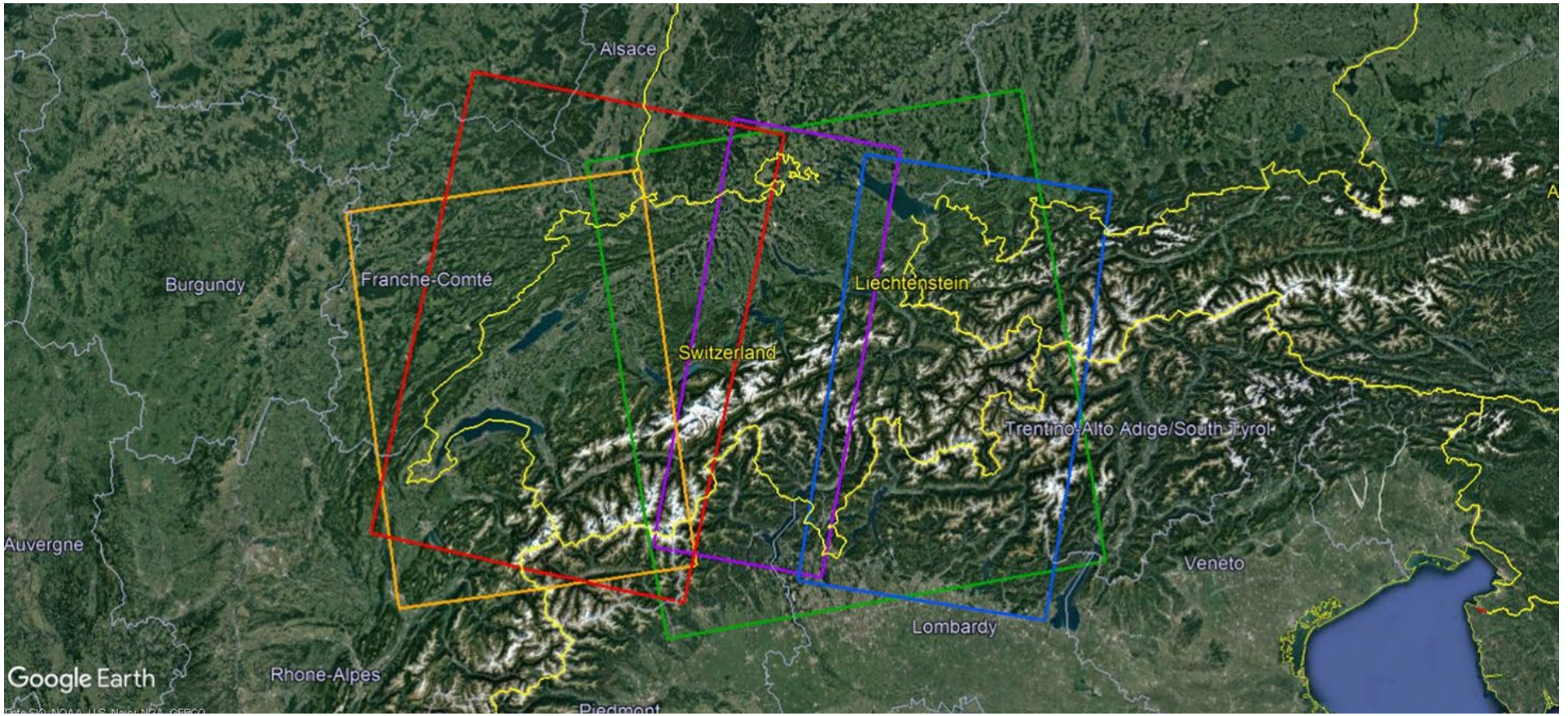
Ascending

Descending



Mosaics of ascending and descending Sentinel-1 data over the area of interest

Sentinel-1 datasets



Coverage of Sentinel-1 ascending and descending tracks over Switzerland. Time line of Sentinel-1 temporal gaps per track.

Methods

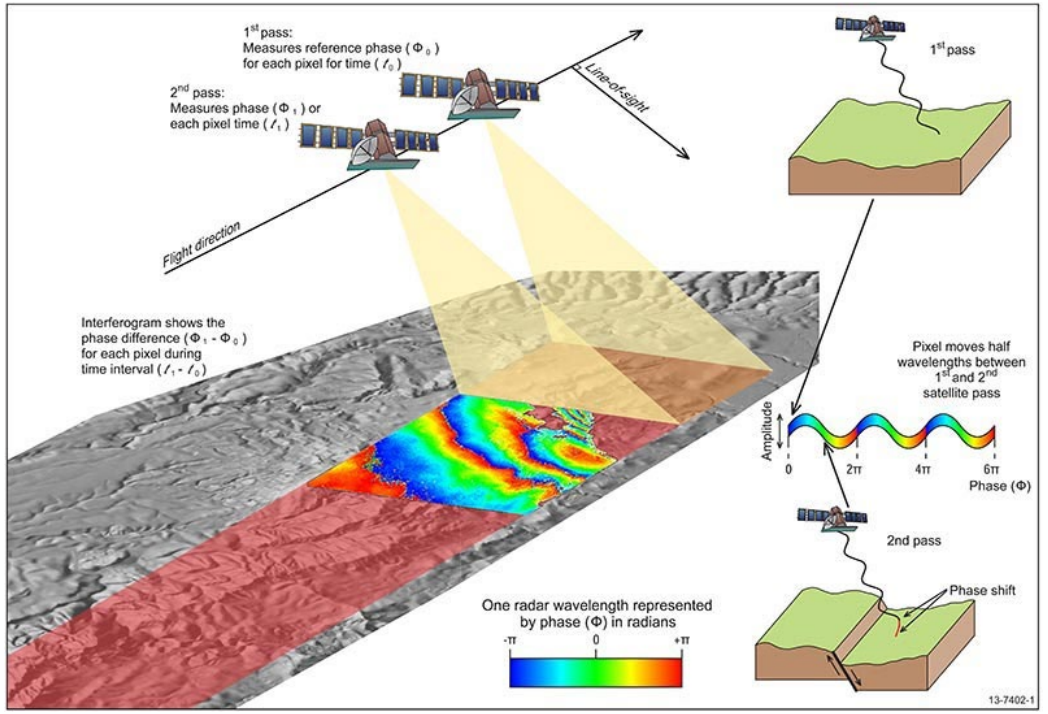


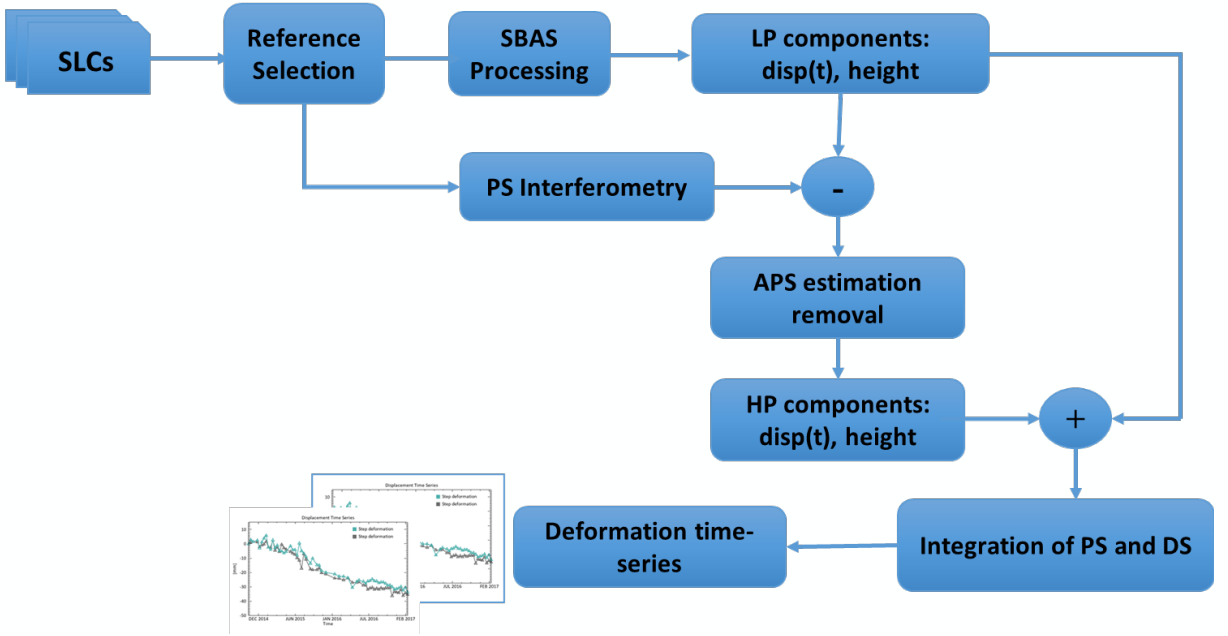
Image: Geoscience Australia

Persistent Scatterers (PS)

+

Distributed Scatterers (DS)

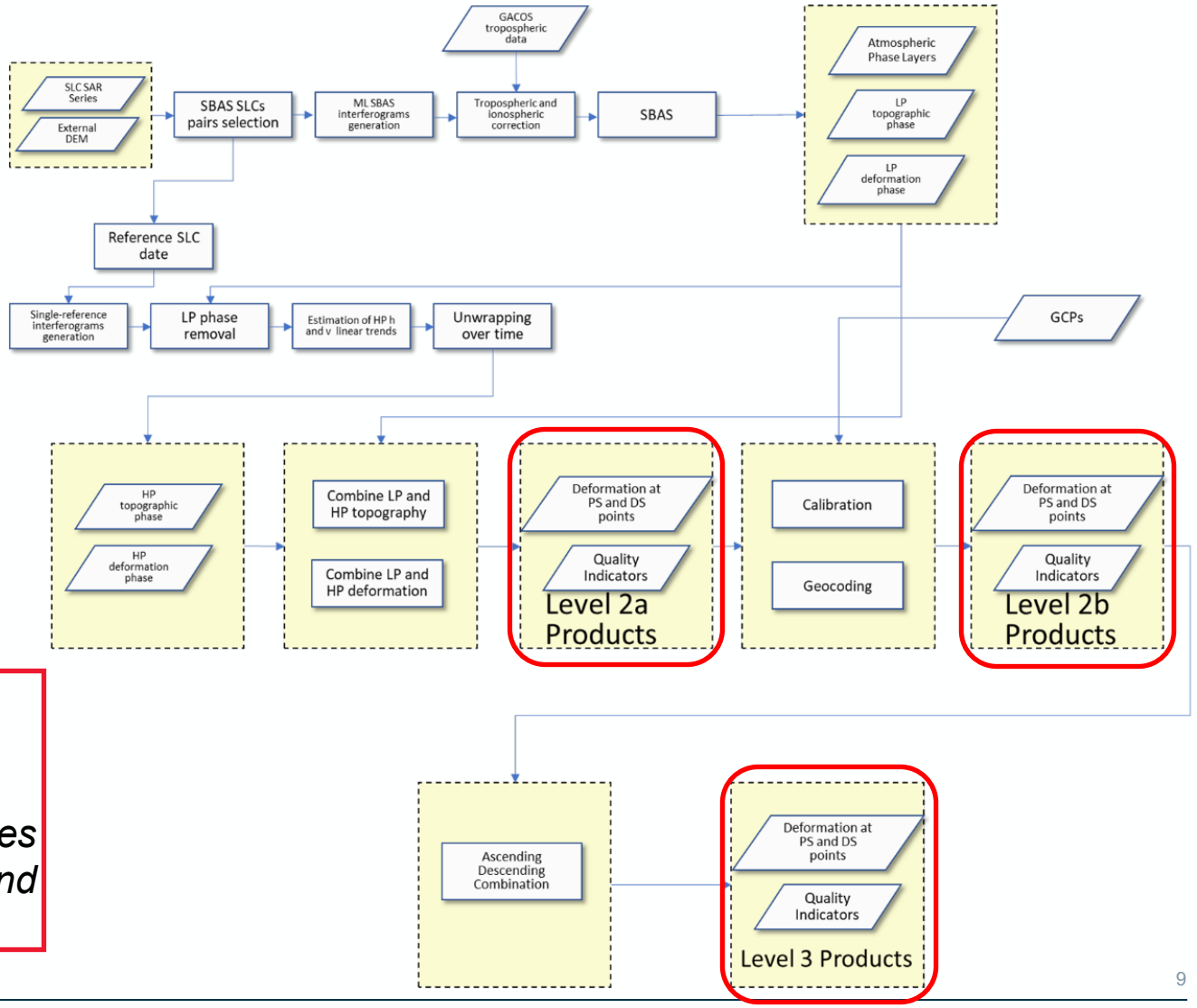
Enhanced-SBAS Workflow



Methods

The end-to-end workflow of the production chain includes the following steps:

- **S1 Data Ingestion**, transferring S1 data from external repositories into the service storage facilities;
- **Core Processing**
- **Quality Control** procedures for ensuring product quality before delivery the results to Swisstopo.



More details:

Tomorrow, 12th – Sept, Poster Session

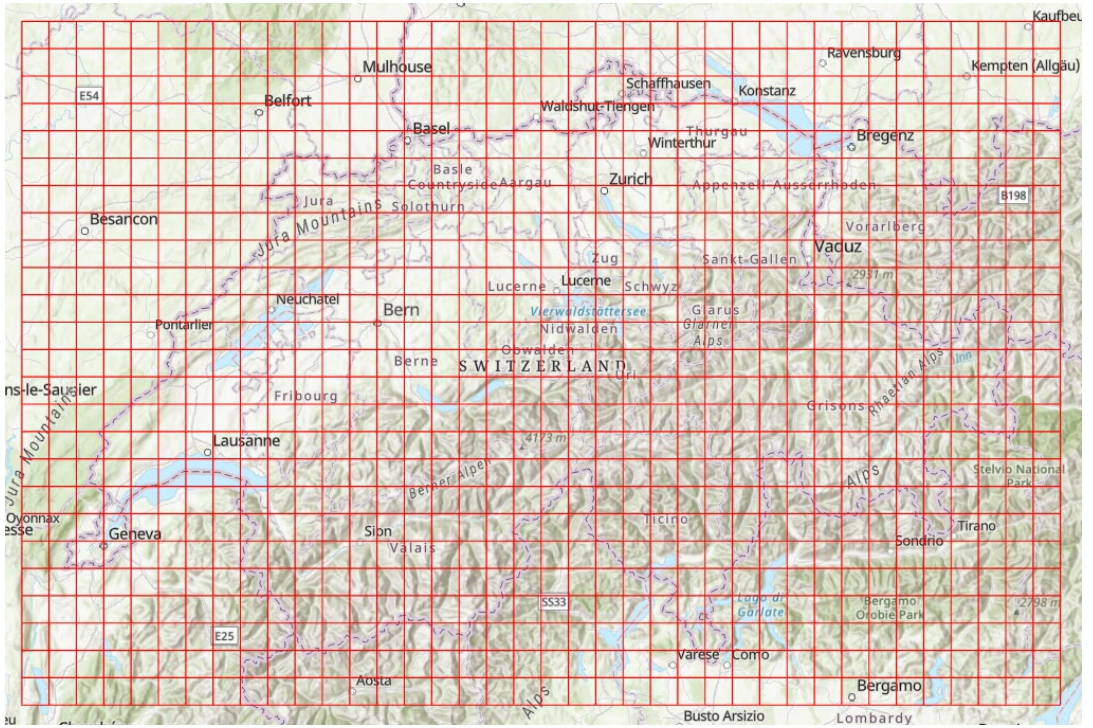
Comparison of the latest multi-temporal InSAR techniques measuring surface deformation on permanent and distributed scatterers, A. Cantone et al.

Products

The generated products consist of:

- Level 2a: **Slant-Range Line-of-Sight (LOS) surface deformation** time series for ascending and descending datasets;

- Level 2b: **Geocoded Line-of-Sight (LOS) surface deformation** time series for ascending and descending datasets in map geometry;



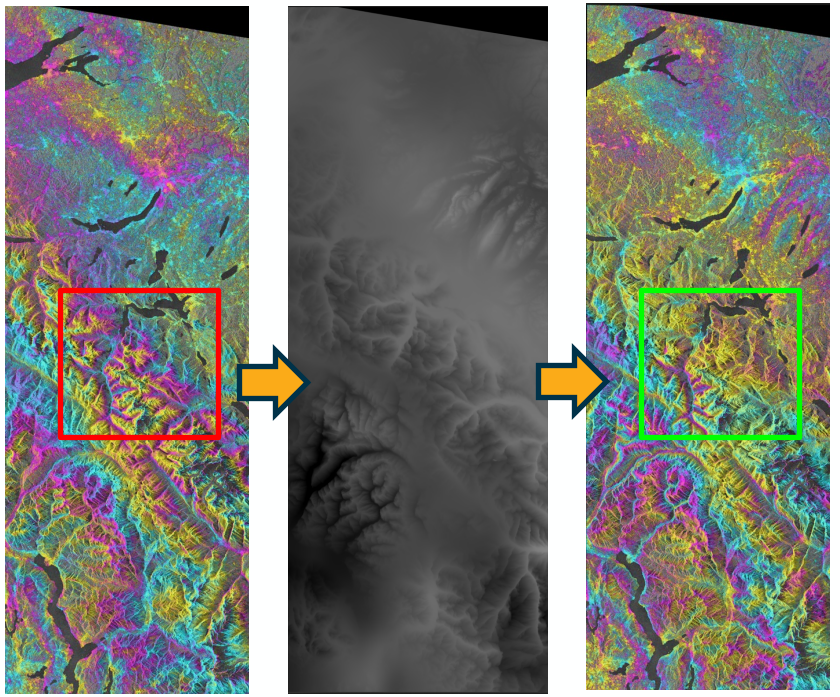
- Level 3: Combination and projection of deformation results obtained from the overlapping ascending and descending datasets to calculate **vertical and east-west deformations** starting from the LOS results.

The Level-2 products are delivered to Swisstopo in .shp and .gdb formats. They are provided divided in tiles, on a regular grid provided by Swisstopo, where every tile is covering a surface of 10 km x 10 km

Challenges – Atmospheric Correction

Atmospheric Correction:

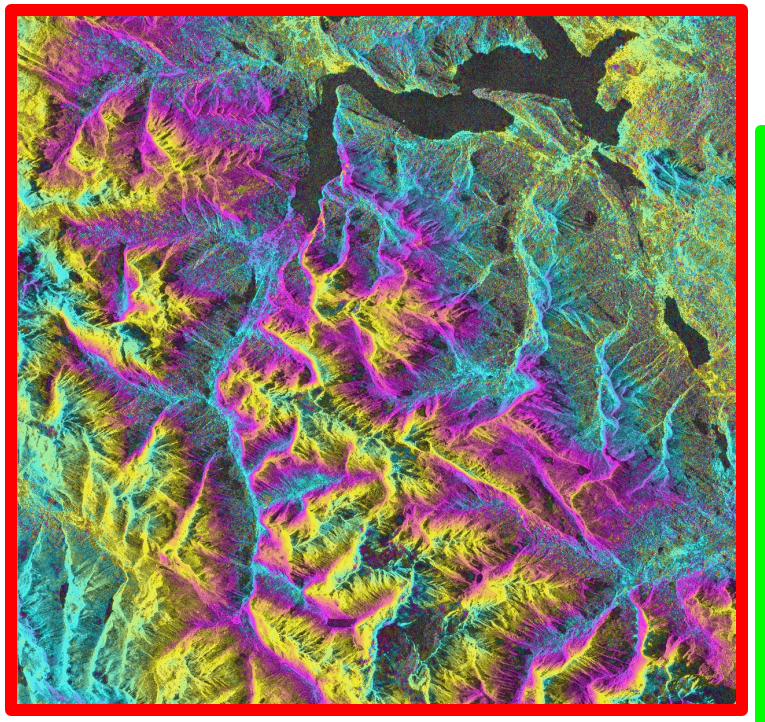
1) GACOS tropospheric correction (www.gacos.net)



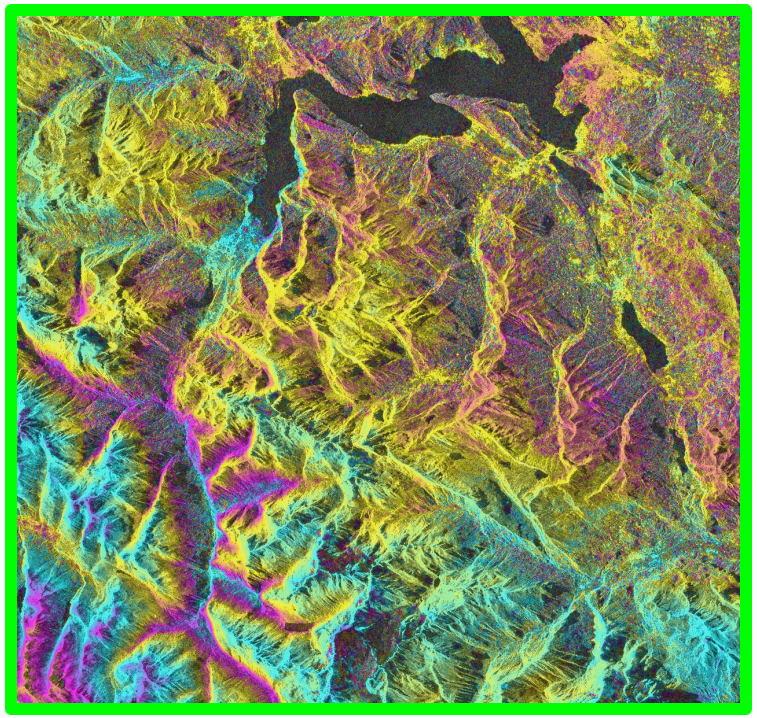
Filtered Interferogram

GACOS difference

Filtered Interferogram corrected with GACOS



Filtered Interferogram - zoom

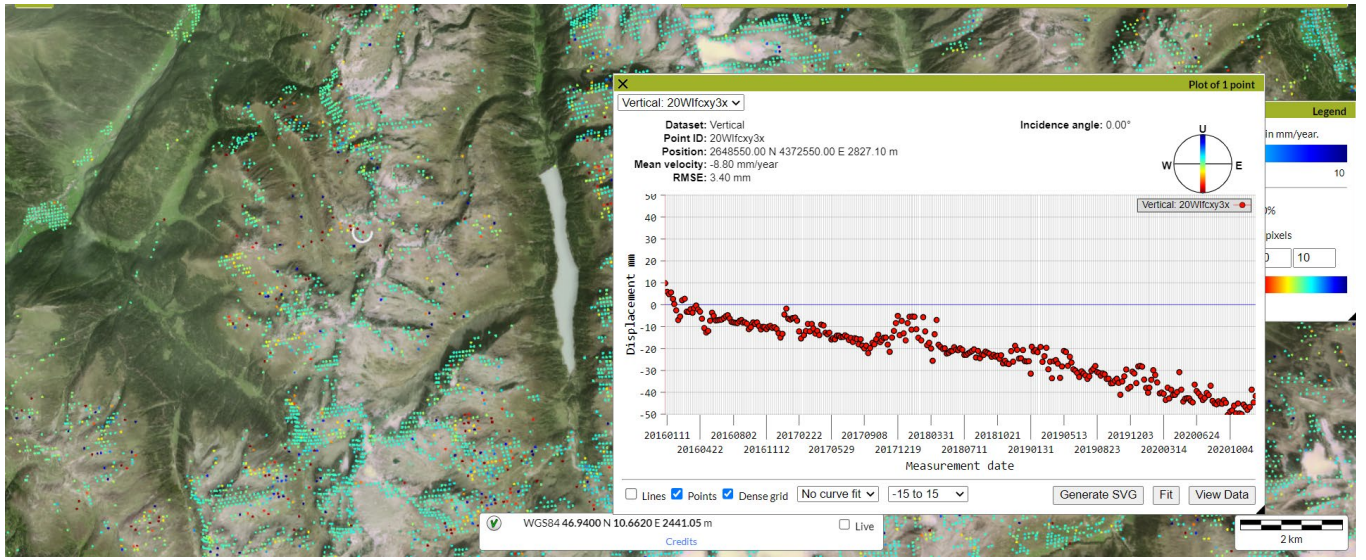


Filtered Interferogram corrected with GACOS - zoom

2) Phase – heigh correlation

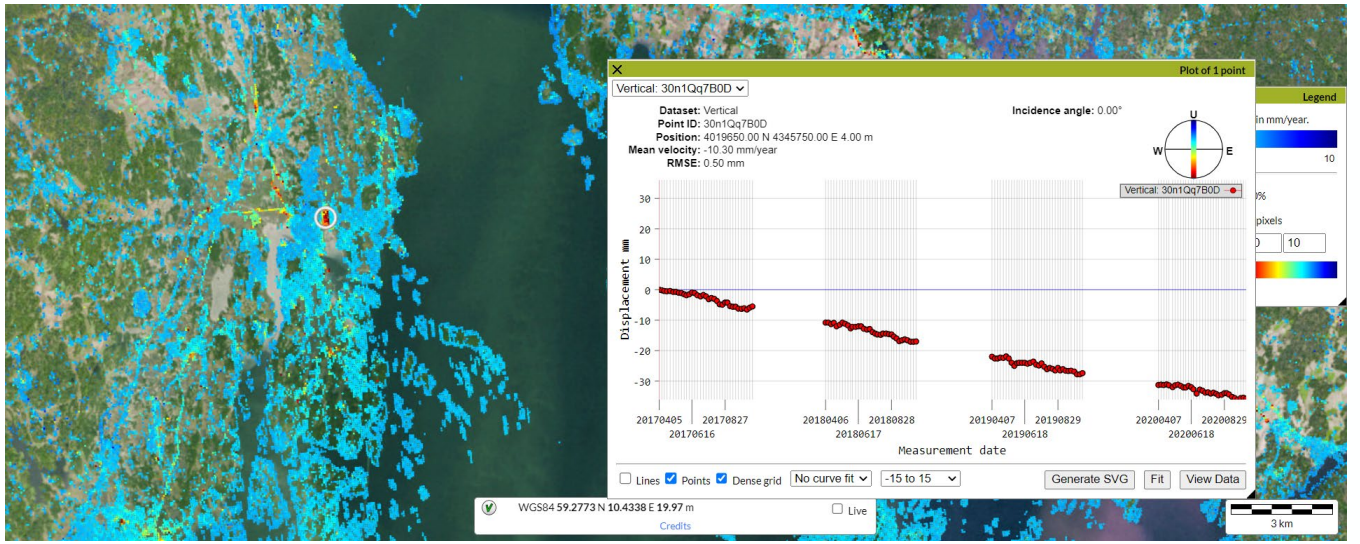
3) Multi-temporal high-pass and low-pass SBAS filter

Challenges – Snow Cover

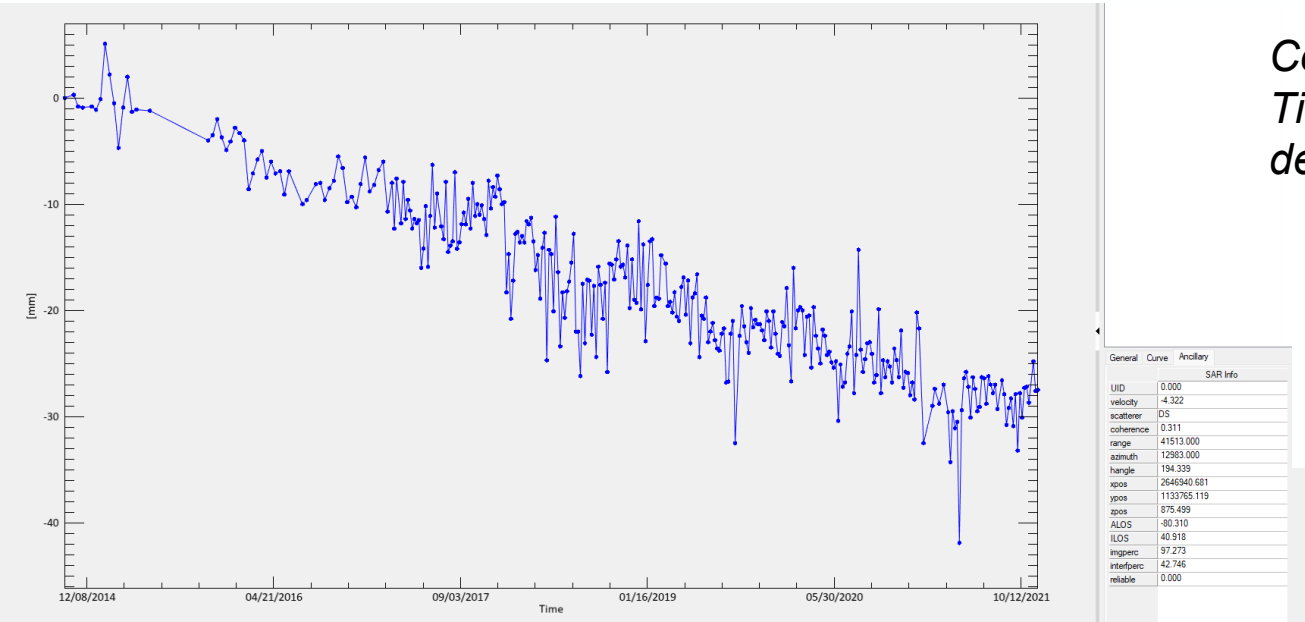


Continuous Time series of deformation

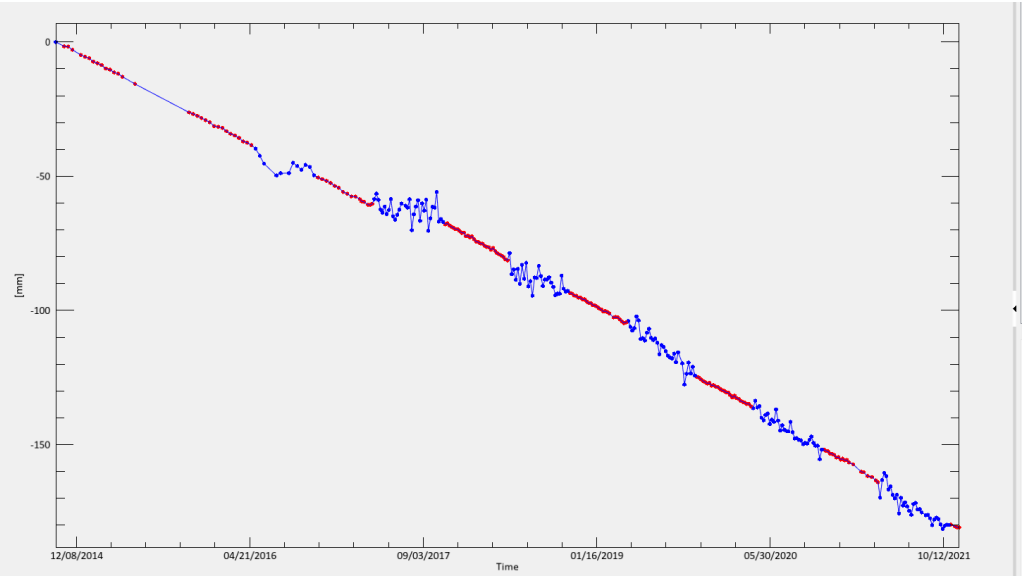
Interpolated time series of deformation

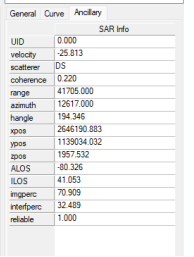


Challenges – Snow Cover



Continuous Time series of deformation





Interpolated time series of deformation over areas affected by snow

Quality Control

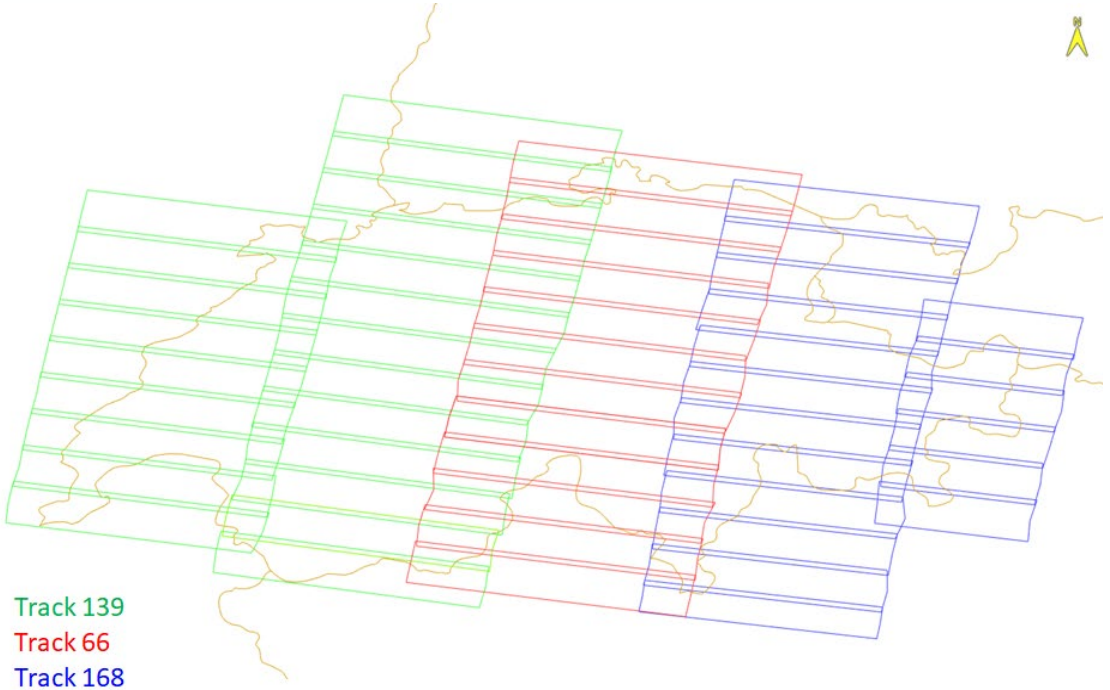
The quality control (QC) procedures are divided into automatic QC and operator QC.

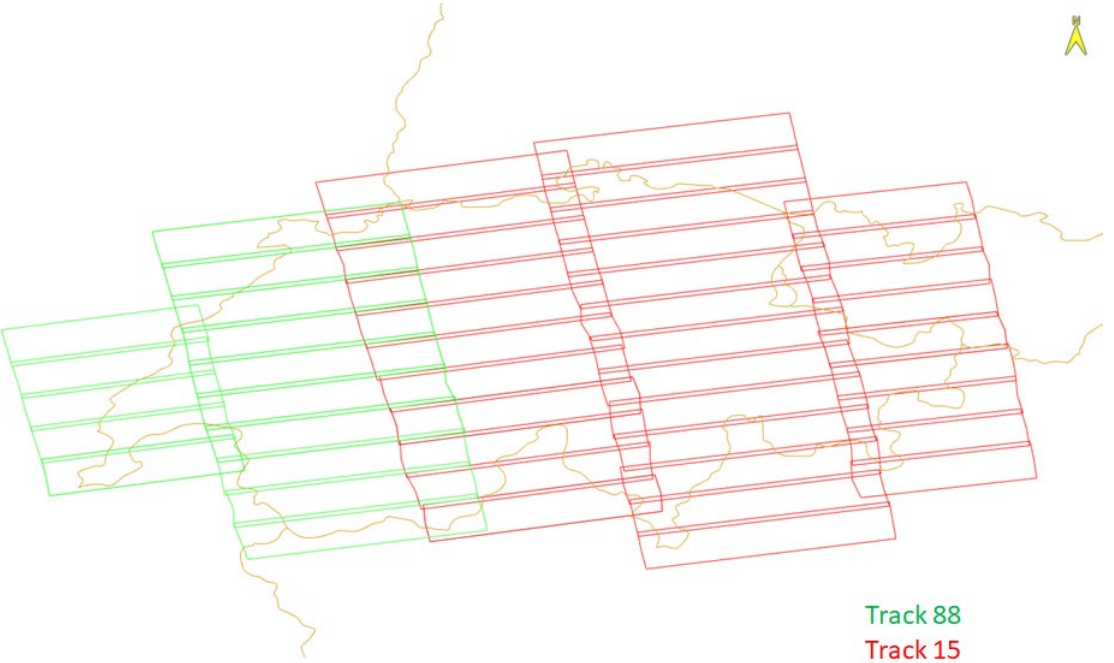
- the analyses of point-wise indicators (coherence maps, precision maps, points density, deformation RMSE with respect to a smooth fitting model),
- some quality indicators at sparse locations (comparison with **GNSS data**, consistency of stable targets)
- other quality indicators (**short-time interferogram variograms** before and after atmospheric calibration, consistency of overlapping areas).
- The additional operator QC are focusing on a visual assessment of **deformation maps reliability** / realism leveraging also on a priori knowledge about the expected deformation behavior.
- **Point density based on CORINE** Land Cover Classes
- **Point density map** (available for PS, DS and PS+DS)
- **Consistency of overlapping areas** among tracks
- Validation with provided **GPS points**

Quality Control

Consistency of the velocities on the overlapping areas

- Mean difference < 1 mm/yr
- Standard Deviation < 2 mm/yr

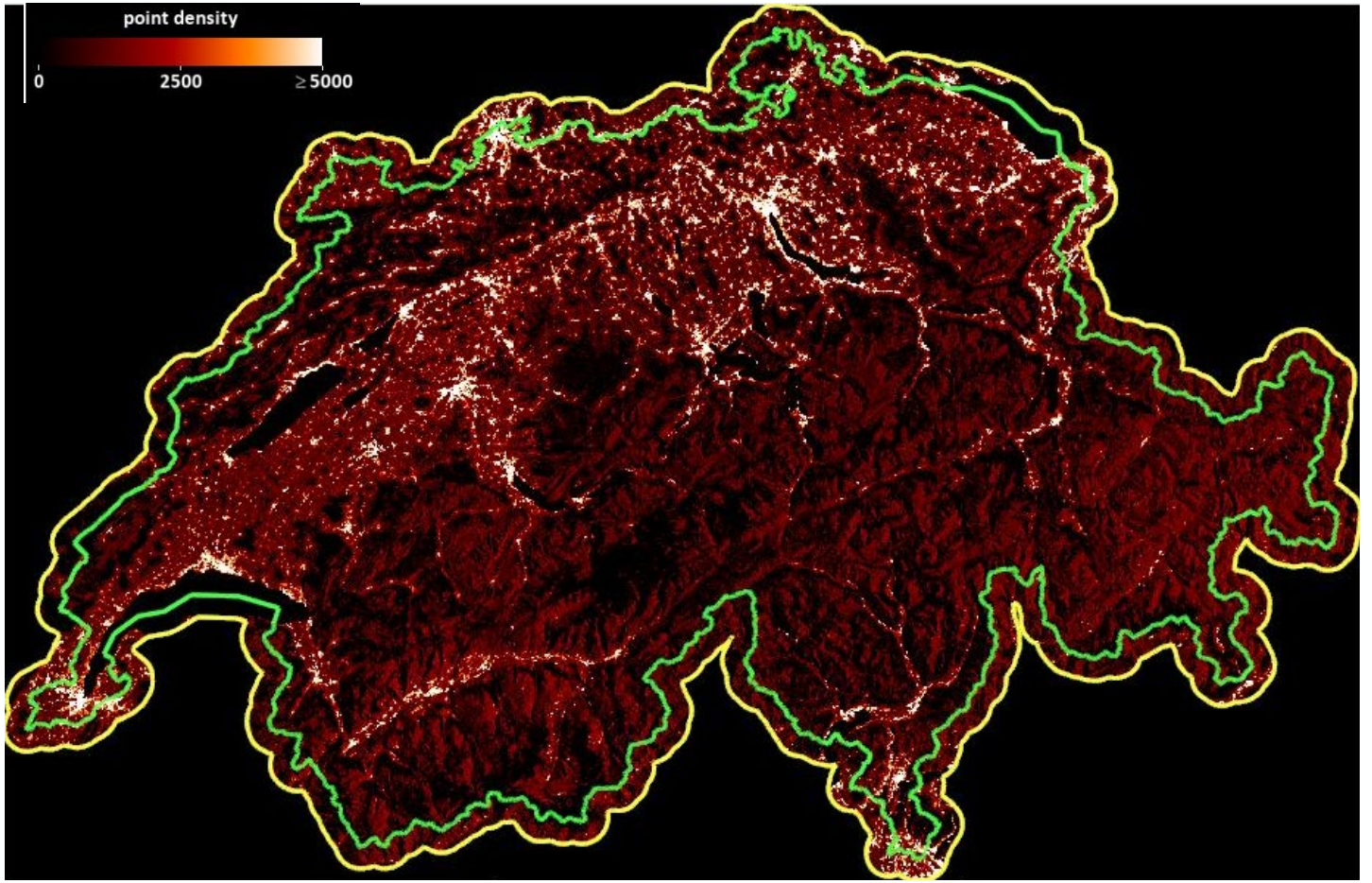




Comparison of the mean deformation velocities with stable GPS points:

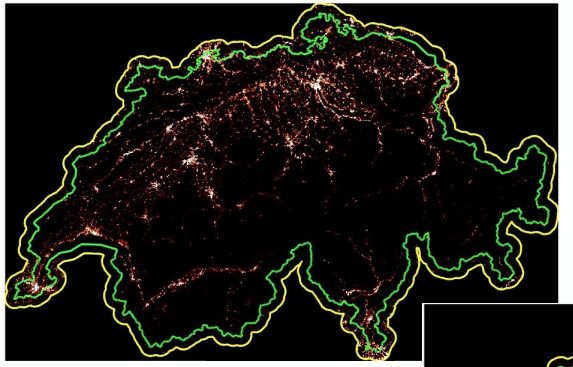
- Mean difference < 0.2 mm/yr
- Standard Deviation < 2.8 mm/yr

Quality Control

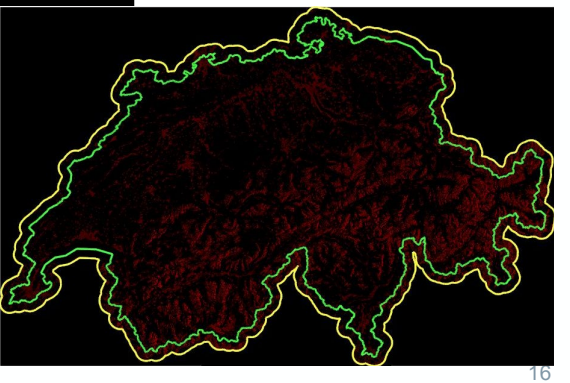


Point density map (250 m x 250 m grid) – PS + DS ascending geometry

Land Cover Class (cf. CORINE Land Cover, Version 2018)	Point density per km^2
1.1.1 Continuous urban fabric	5,000 – 10,000
1.1.2 Discontinuous urban fabric	1,000 – 5,000
1.2 Industrial, commercial and transport units	1,000 – 5,000
3.3 Open spaces with little or no vegetation	400 – 1,000



Point density map - PS (250 m x 250 m grid) ascending geometry



Point density map - DS (250 m x 250 m grid) ascending geometry

Products

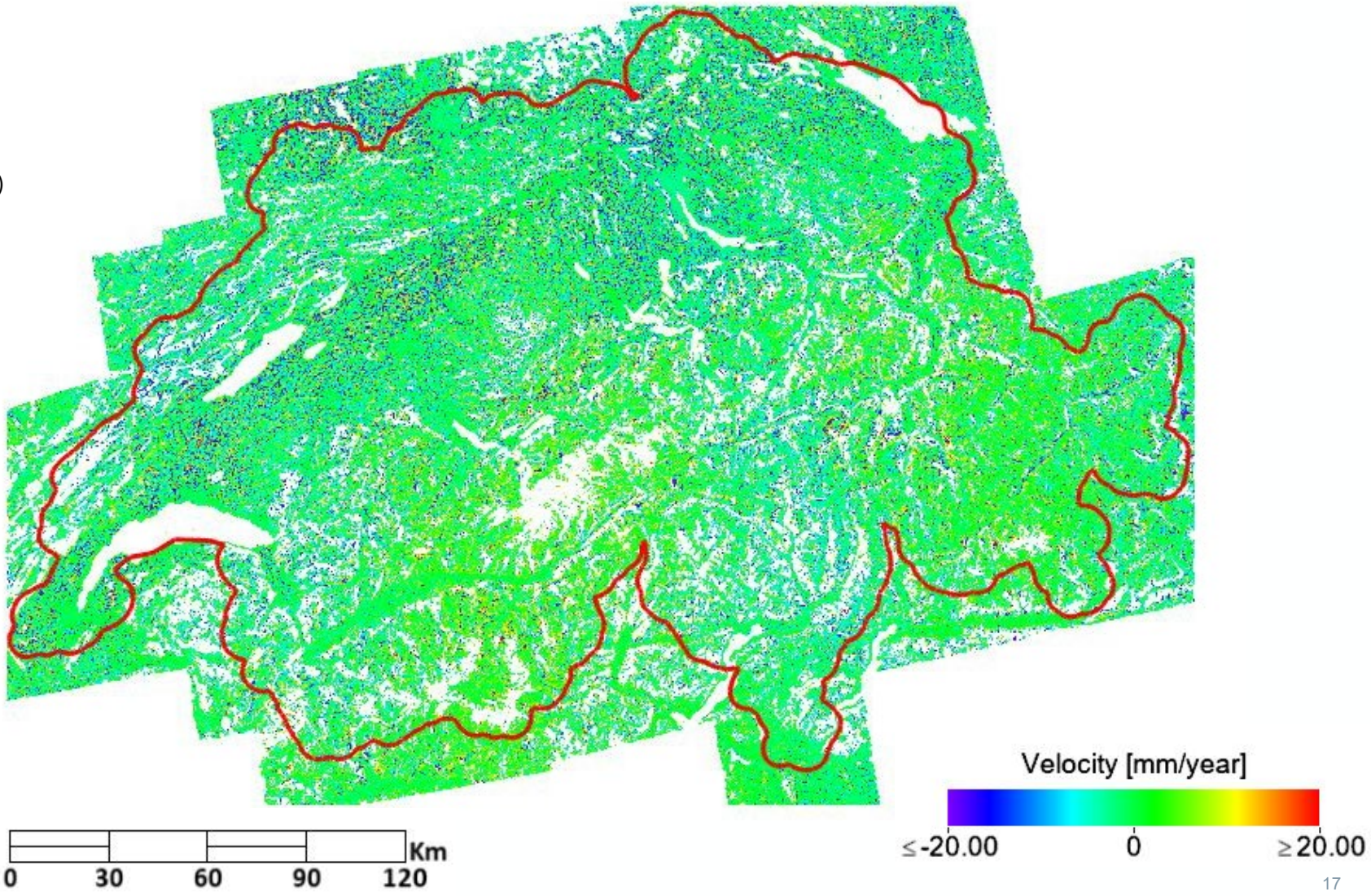
Level 2 Products:

- PS -> 5m x 15m
- DS -> 30m x 30m

- FID (progressive number counting the points, starting from 0)
- UID (unique identification number)
- Xpos
- Ypos
- Zpos
- Range
- Azimuth
- Scatterer (PS or DS point)
- Velocity (mean historical velocity in mm/year)
- Coherence (coherence value of the point)
- ALOS
- ILOS
- H Angle (hading)
- Imgperc
- Interfperc
- D_YYYYMMDD (one for each input date)

Level 3 Products:

- Vertical and Horizontal velocity maps
- 30 x 30 m resolution



Conclusions

- Historical analysis
- Yearly updates
- Capability of measuring slow deformation trends
- Provision of a national scale deformation map

Thank you for your attention

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