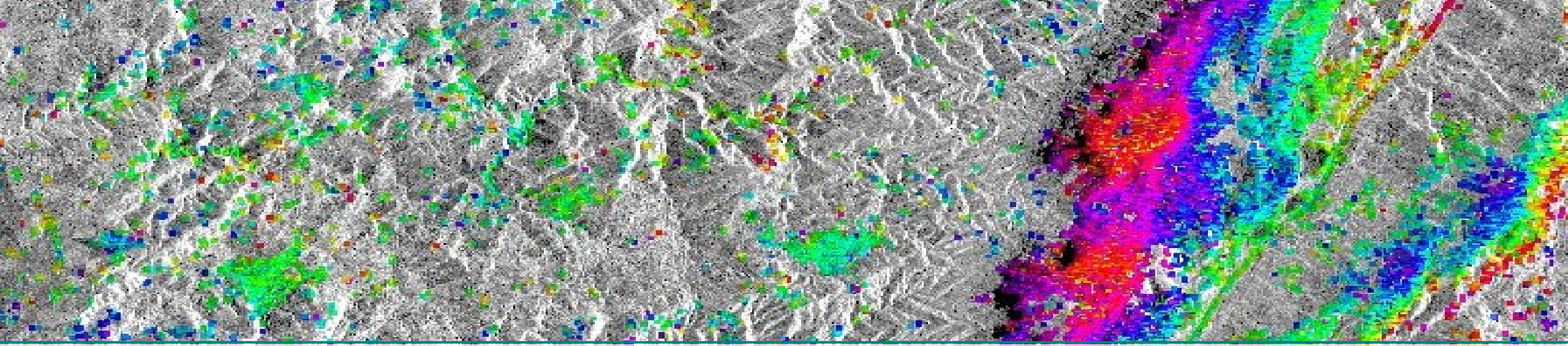
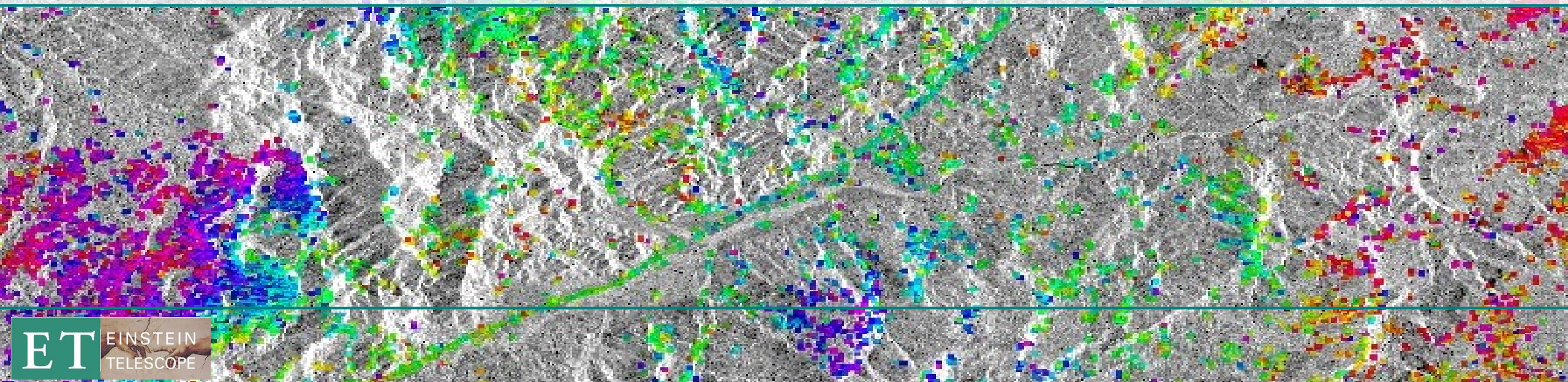


Ground Vertical Displacements Of NE Sardinia

Dott. Francesco Dessì, PhD – University of Cagliari

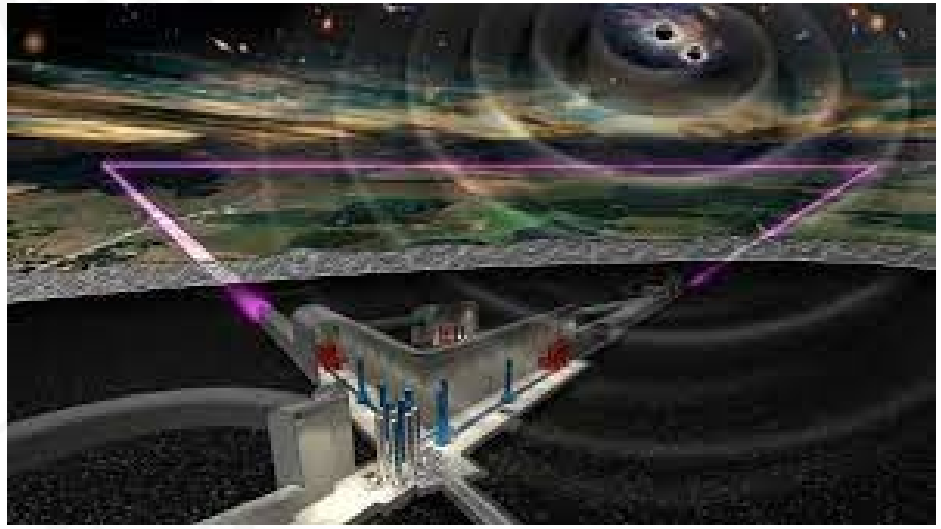


ET EINSTEIN TELESCOPE

Project scenario

The Einstein Telescope (ET) is a proposed underground infrastructure to host a third-generation, gravitational-wave observatory. Currently, two European candidate-sites are competing to host it: one is located in the area of Sos Enattos in Northern Sardinia (Italy), the second is in the Meuse-Rhine Euregion. The choice of the most suitable site to host this unique research infrastructure will be decided by an international commission. The site-characterization analyses are under way and the final decision is expected by the end of 2024.

The present study is part of the geological characterization of the site of Sos Enattos, and is focused on the evaluation of the surface deformations of its area by means of Synthetic Aperture Radar (SAR) data. In this framework, the PSI (Persistent Scattered Interferometry) technique with SAR data provided by Sentinel-1 mission is the proposed approach for the analysis of a long time-series imagery.



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Study area

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Abstract

- Scopework: Measure ground deformation in SOS ENATTOS area with Remote Sensing data – SAR
- Overview of StaMPS PSI processing chain
- Methodology application: issues and workarounds
- First results and developments

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Sentinel 1 ESA

- The constellation covers the entire world’s land masses on a bi-weekly basis, sea-ice zones, Europe's coastal zones and shipping routes on a daily basis and open ocean continuously.
- The Sentinel-1 mission is based on a constellation of two satellites (A and B units). Sentinel-1 carries a C-band Synthetic Aperture Radar (SAR), and provides continuity of ERS and ENVISAT SAR types of missions. It allows all-weather and day/night imaging capability.

Copernicus
Europe’s eyes on Earth

esa
European Space Agency

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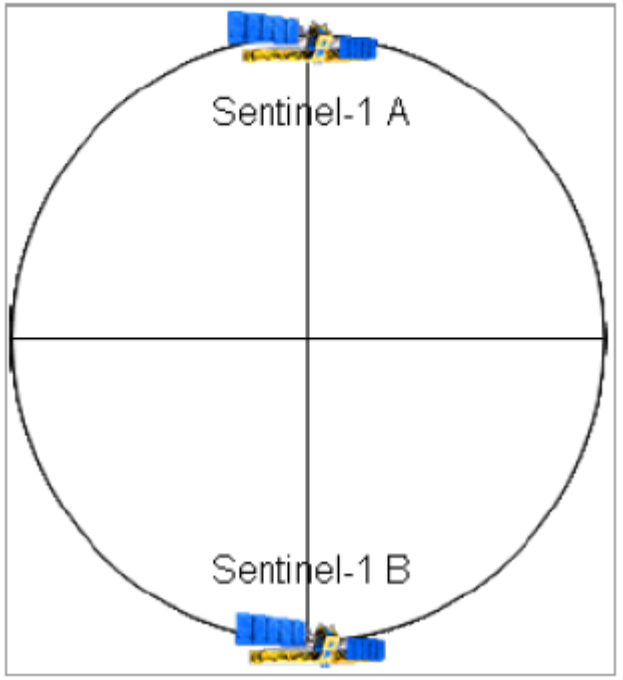
Sentinel 1 orbit

- SENTINEL-1 is in a near-polar, sun-synchronous orbit with a 12 day repeat cycle and 175 orbits per cycle for a single satellite. Both SENTINEL-1A and SENTINEL-1B share the same orbit plane with a 180° orbital phasing difference. With both satellites operating, the repeat cycle is 6 days.



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Sentinel 1 operational modes

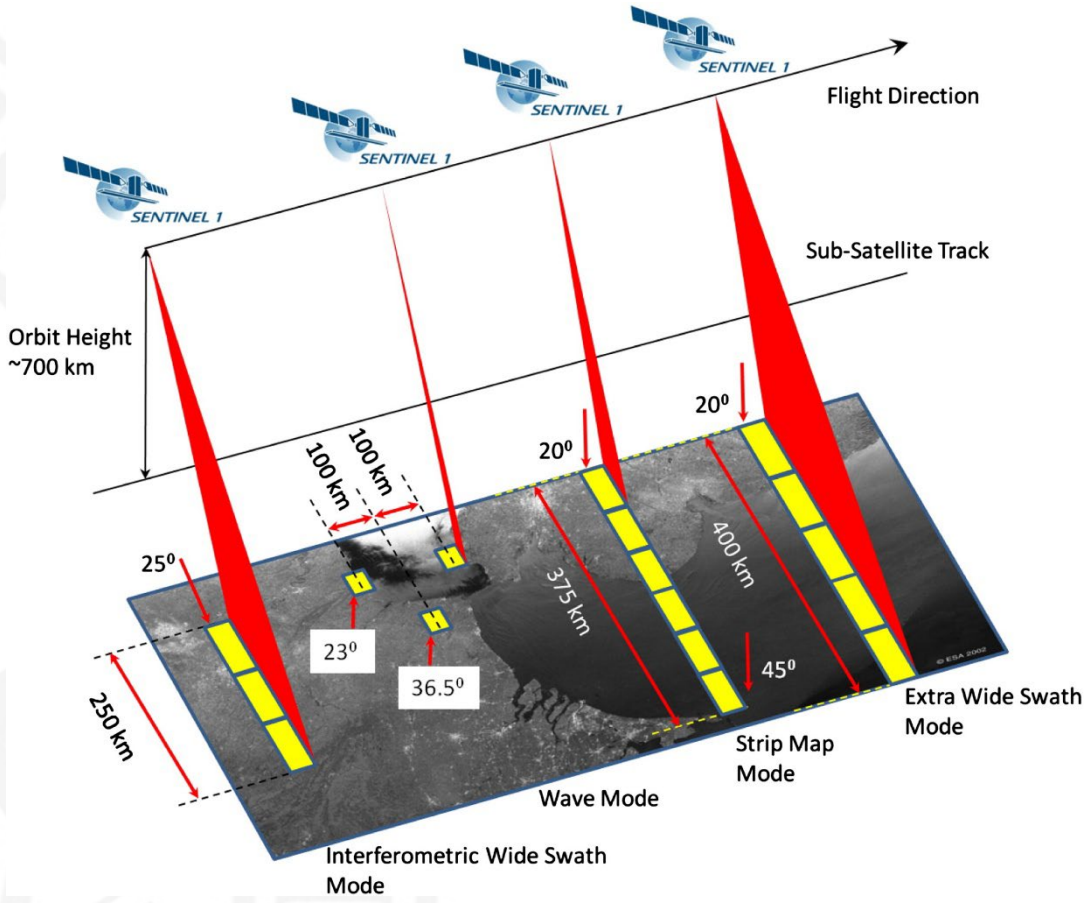
- Main modes:

1) Interferometric wide-swath mode at 250 km and 5×20 m spatial resolution

2) Wave-mode images of 20×20 km and 5×5 m spatial resolution (at 100 km intervals)

Additional modes:

- Strip map mode at 80 km swath and 5×5 m spatial resolution
- Extra wide-swath mode of 400 km and 20×40 m spatial resolution



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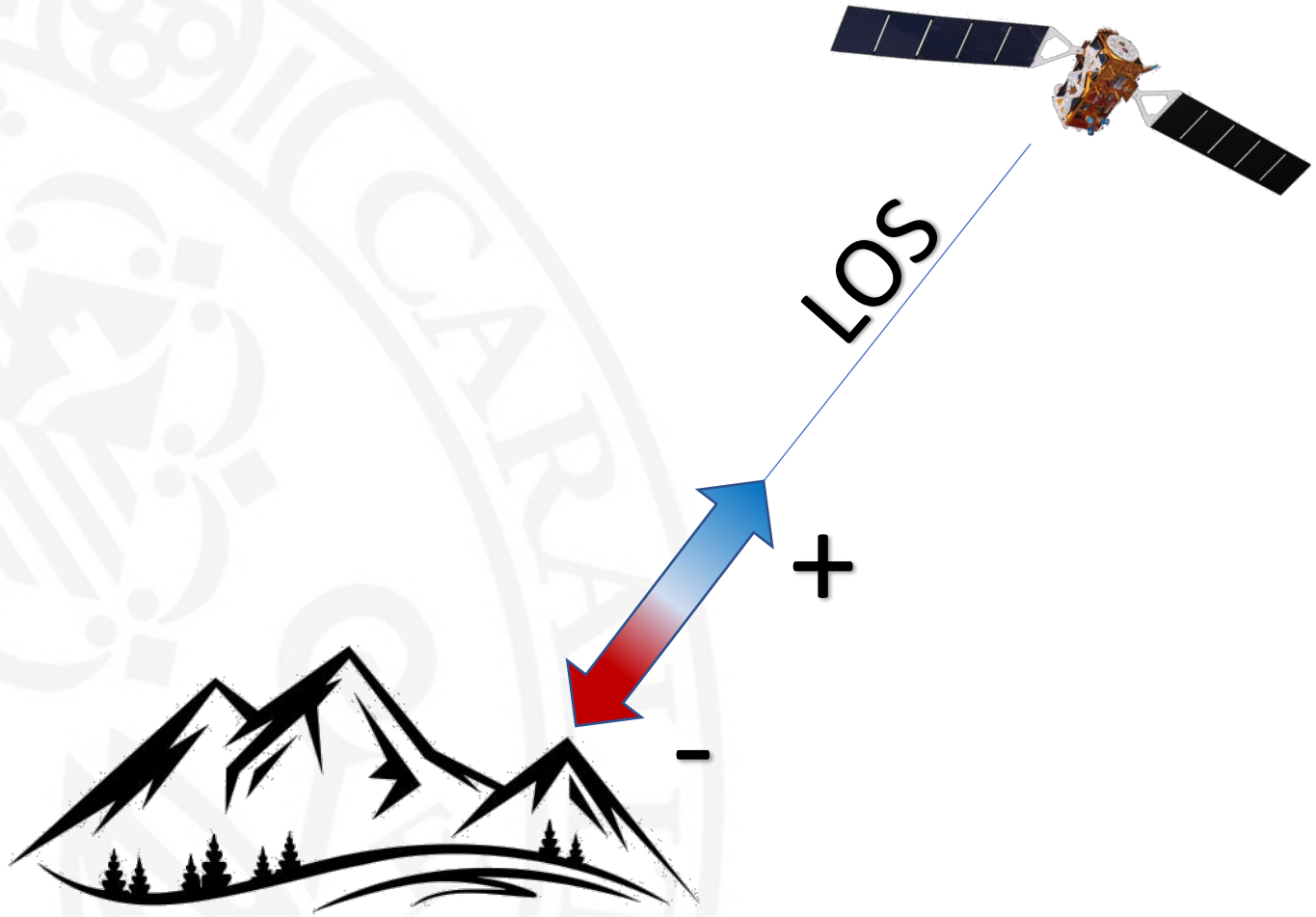
Some basics

- SAR does not see things from directly on top, or nadir, like we do with most optical sensors.

- We view things from an angle on the side, also known as line of sight, or LOS.



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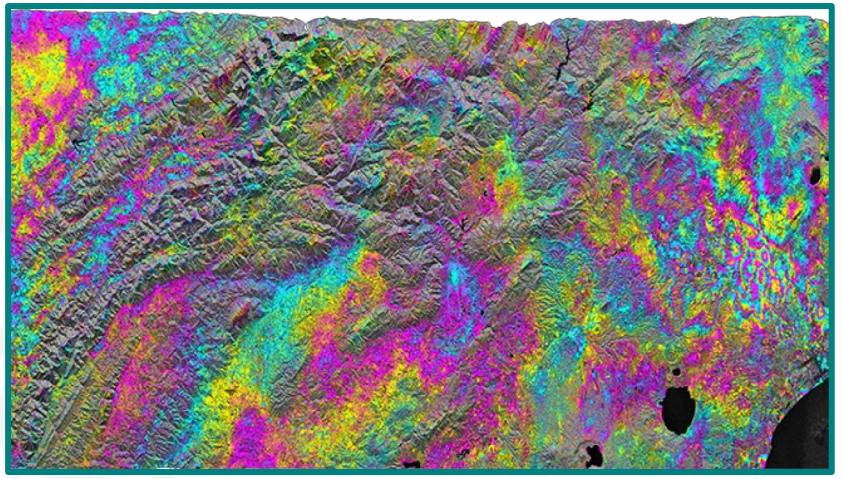
Some basics

- SAR can be used to monitor and track displacement by using the phase that is collected alongside its amplitude.
- The phase change shows minor shifts on the ground surface related to when a specific part of the wave hits the ground at what time.
- The change in time can be tracked in between images and used to find ground surface change!



Sentinel-1 Interferogram

InSAR = Interferometric SAR

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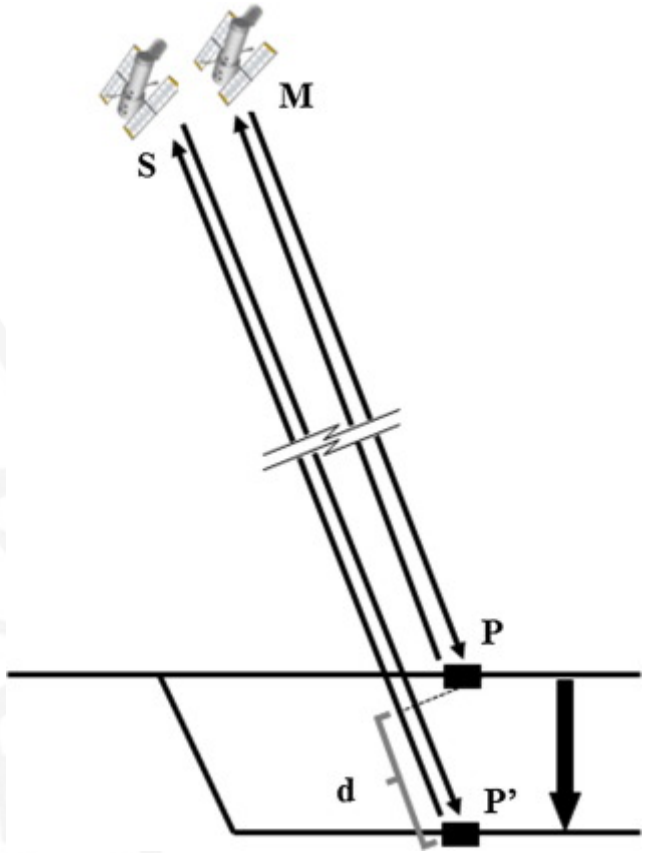
PSI – Persistent Scatterer Interferometry

- Persistent Scatterer Interferometric technique involves the observation of radar phase changes measured for repeat acquisitions. Large numbers of permanent scatterers are analyzed to determine velocity of movement along sight. The method allows to measure terrain movements with an error of 1.2 mm/year.

StaMPS (Stanford Method for Persistent Scatterers) is a software package that implements an InSAR persistent scatterer (PS) method



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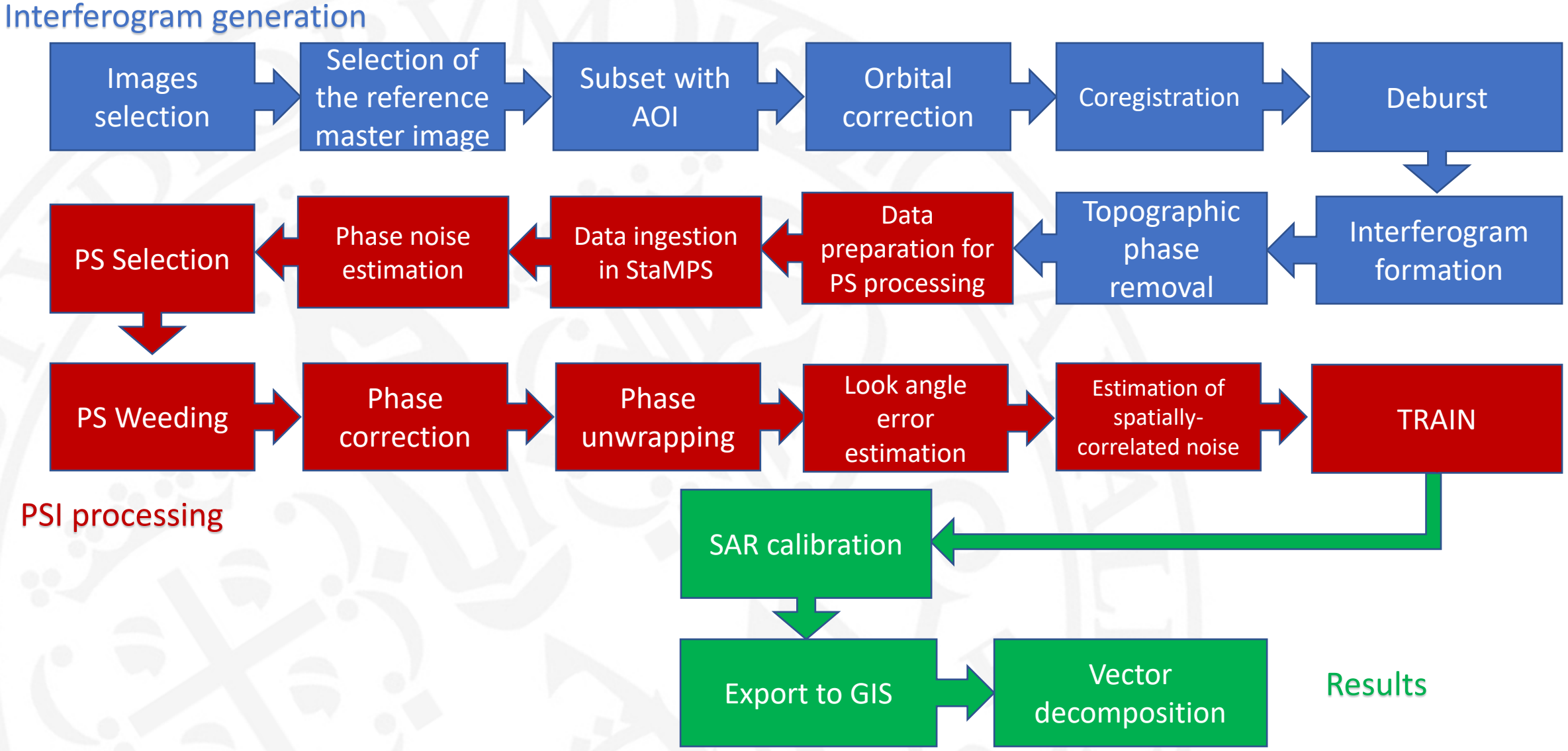
Processing workflow



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First test

- A first test has been carried out with a dedicated workstation: a Linux environment with all softwares, libraries, scripts (Matlab license, Python,...)
- A small area (250 square kilometers) in Sos Enattos surroundings has been processed in order to get Vertical Velocities from Sentinel 1 data.
- For the first performance test has been utilized 46 images acquired by descending orbit and 48 images acquired by ascending orbit
- Time span is from January 2021 to July 2022

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Some issues..

- SAR data is heavy (around 4 GB for each input image)
- Even with a relatively powerful workstation (multi core CPUs, RAM, SSD disks) processing time takes a **lot of hours or days**

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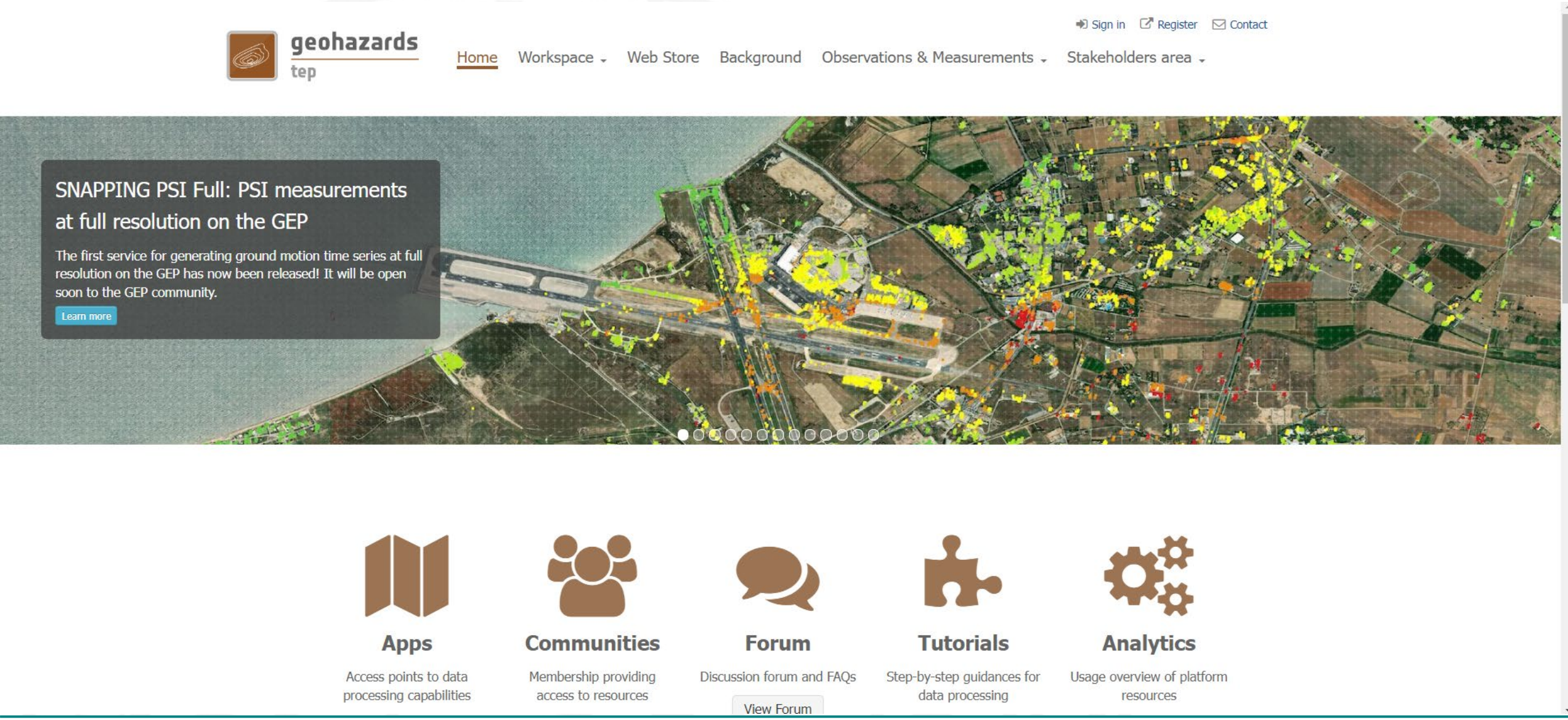
Workaoround https://geohazards-tep.eu



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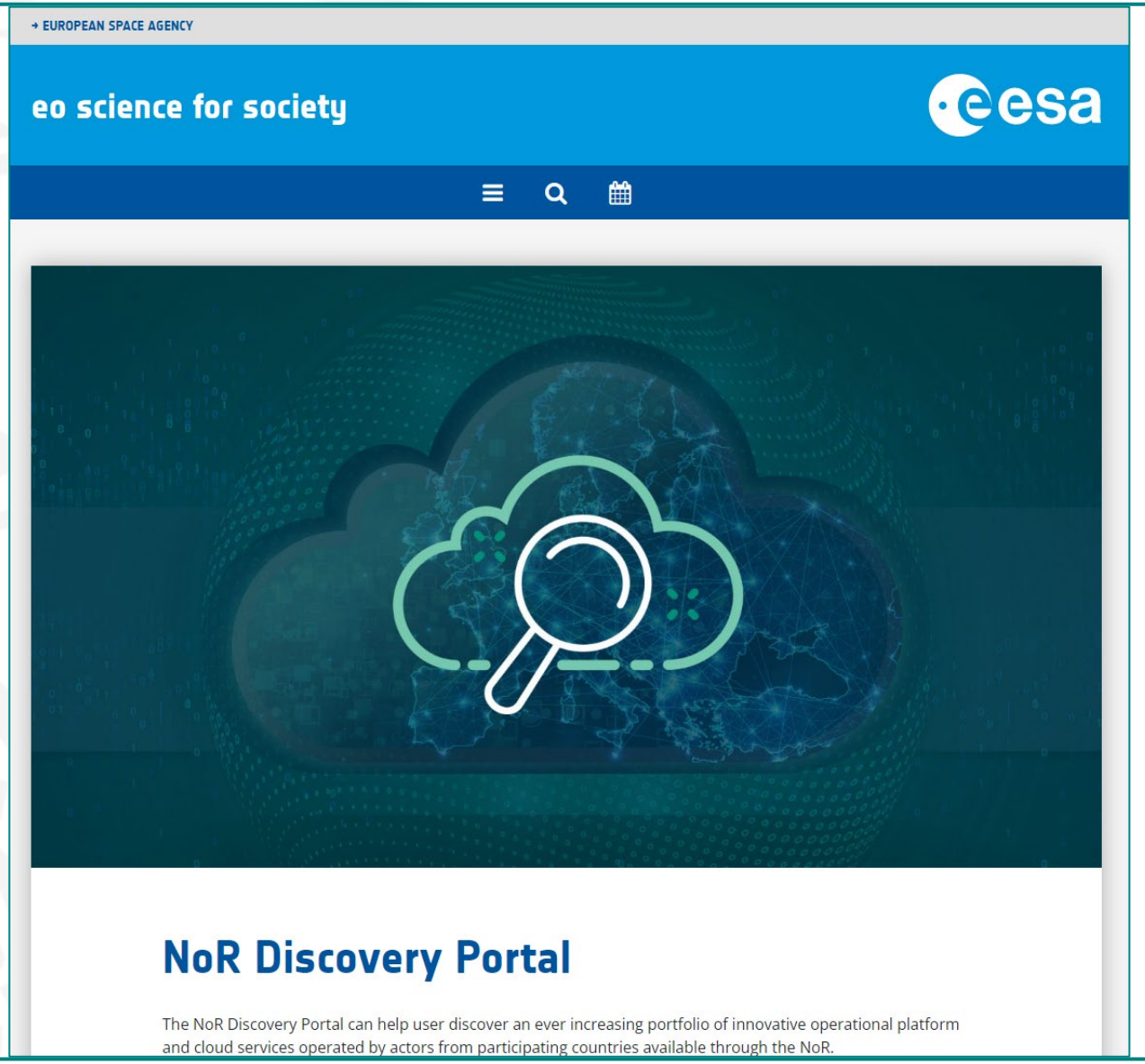
ESA NoR Sponsorship



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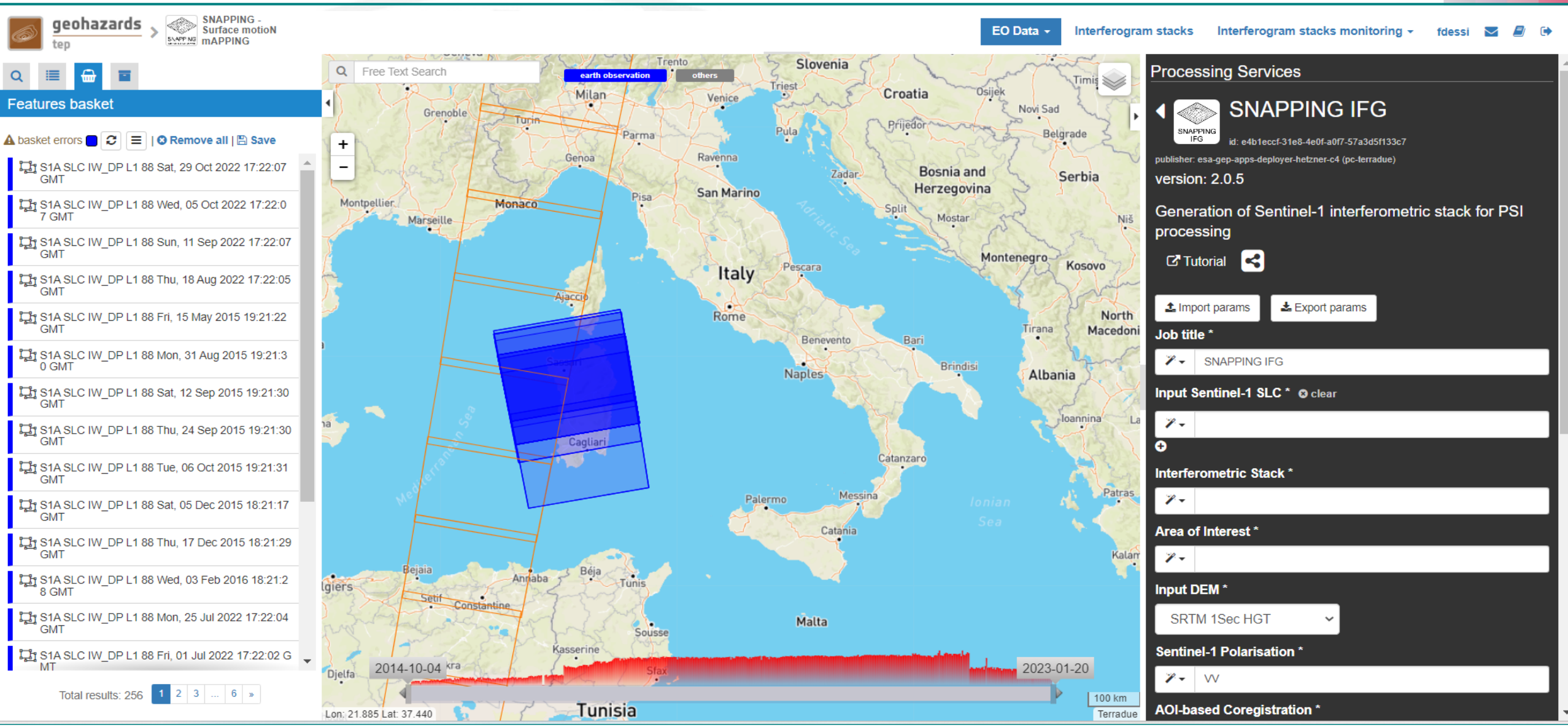
SNAPPING service



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A good improvement!

- More than 2400 square kilometers as investigated area
- Around 8 years of acquisitions from May 2015 to October 2022
- More than 400 images
- Faster processing time (only 8 hours for PSI calculation related to Descending orbit)

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LOS Velocities – Ascending orbit

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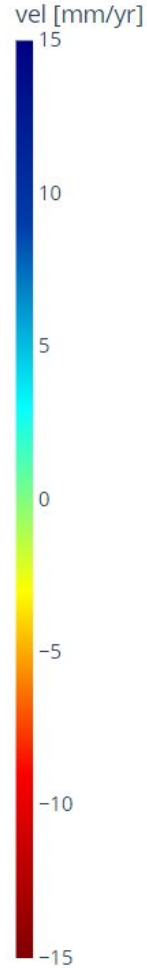
LOS Velocities – Descending orbit



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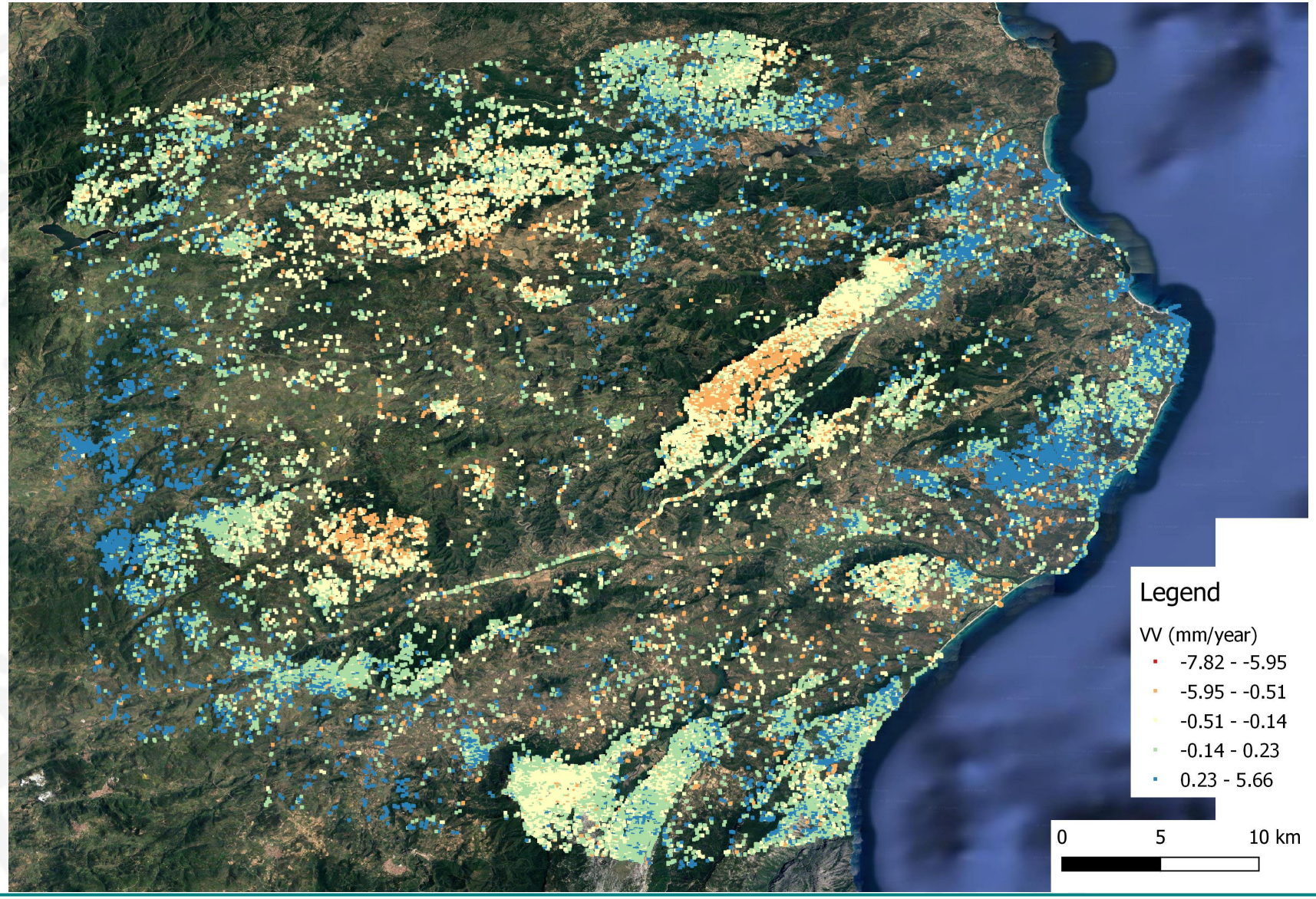
Vector decomposition – GIS – Vertical velocities



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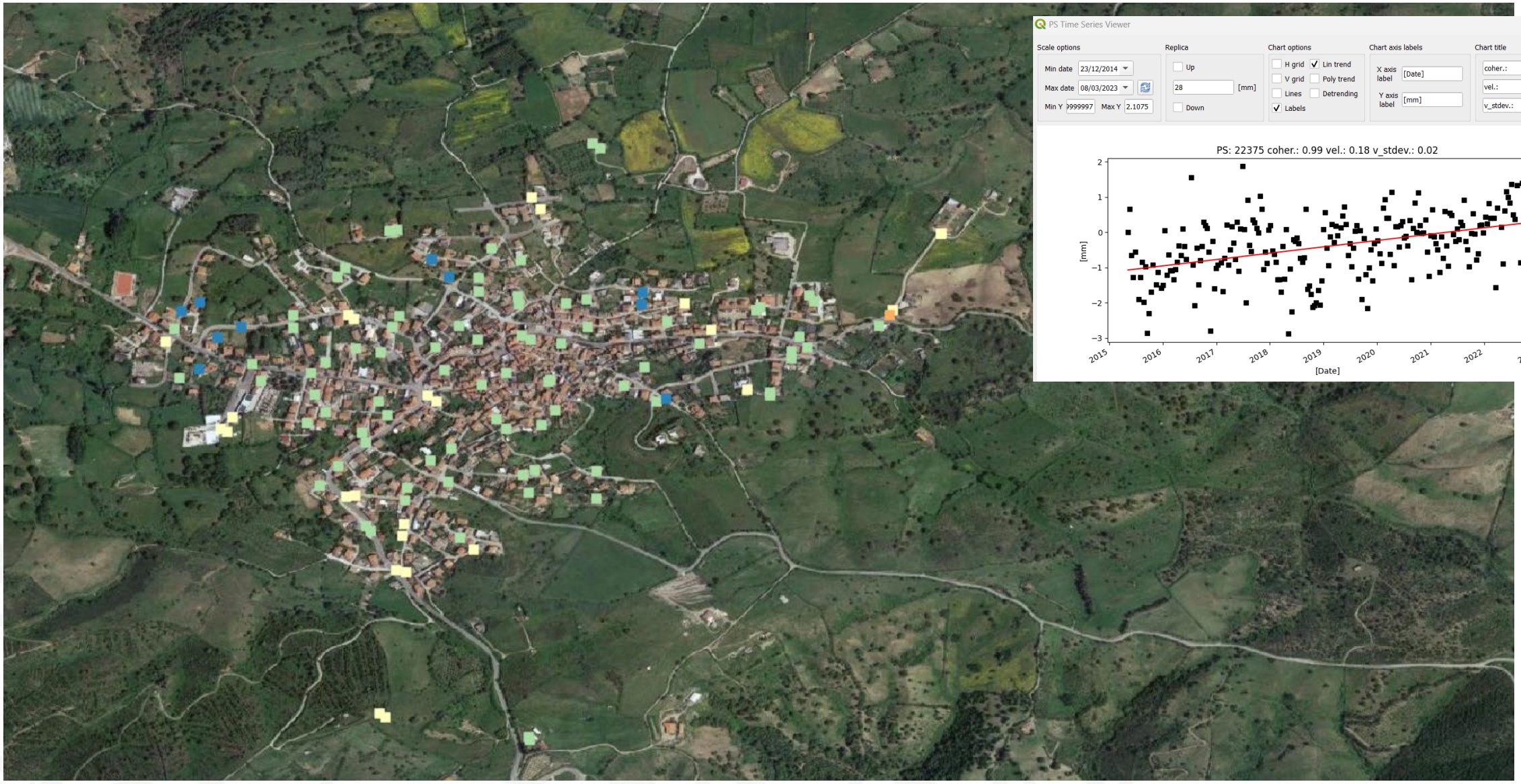
Time series – Lula town



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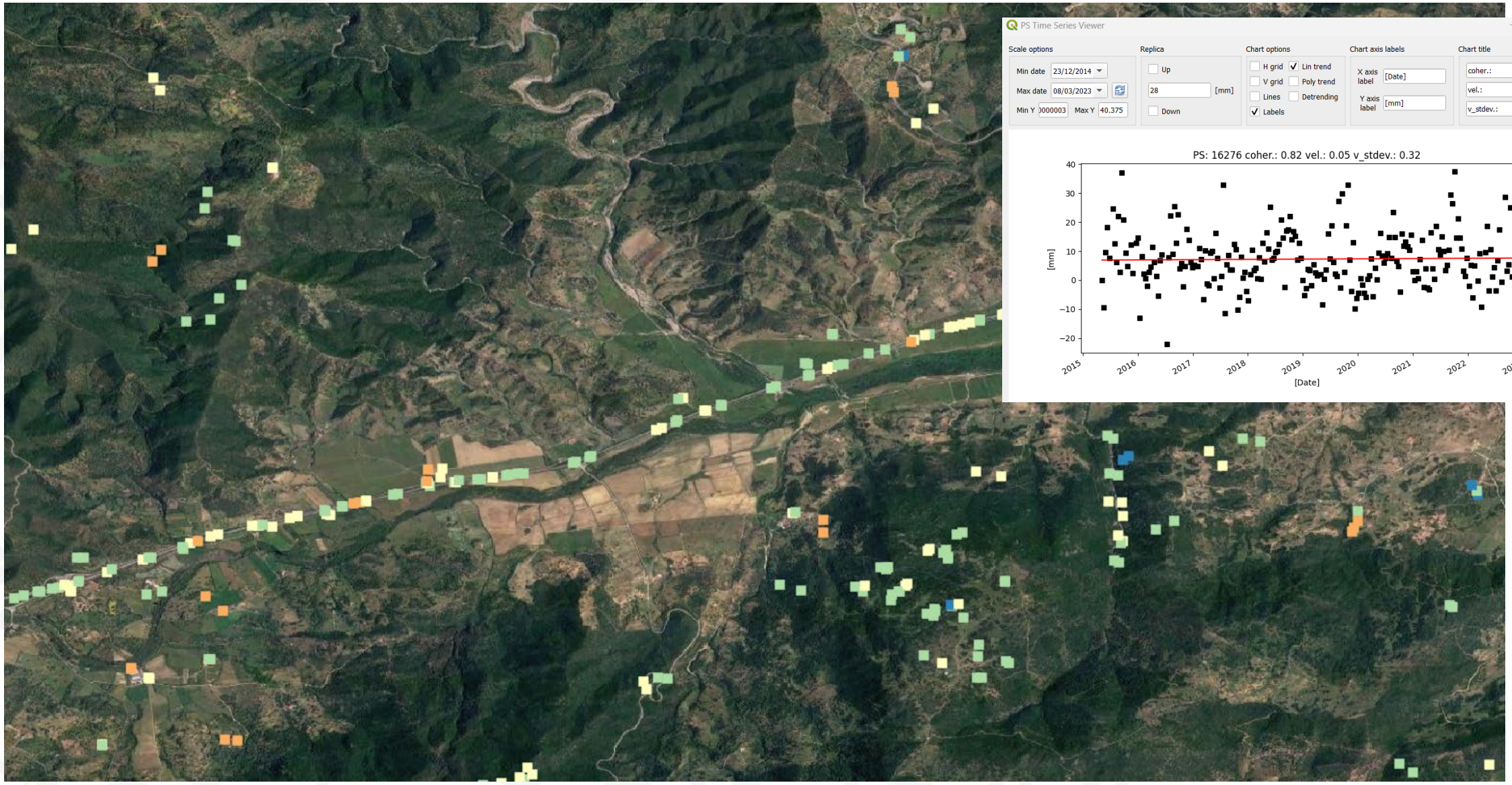
Time series – Roads



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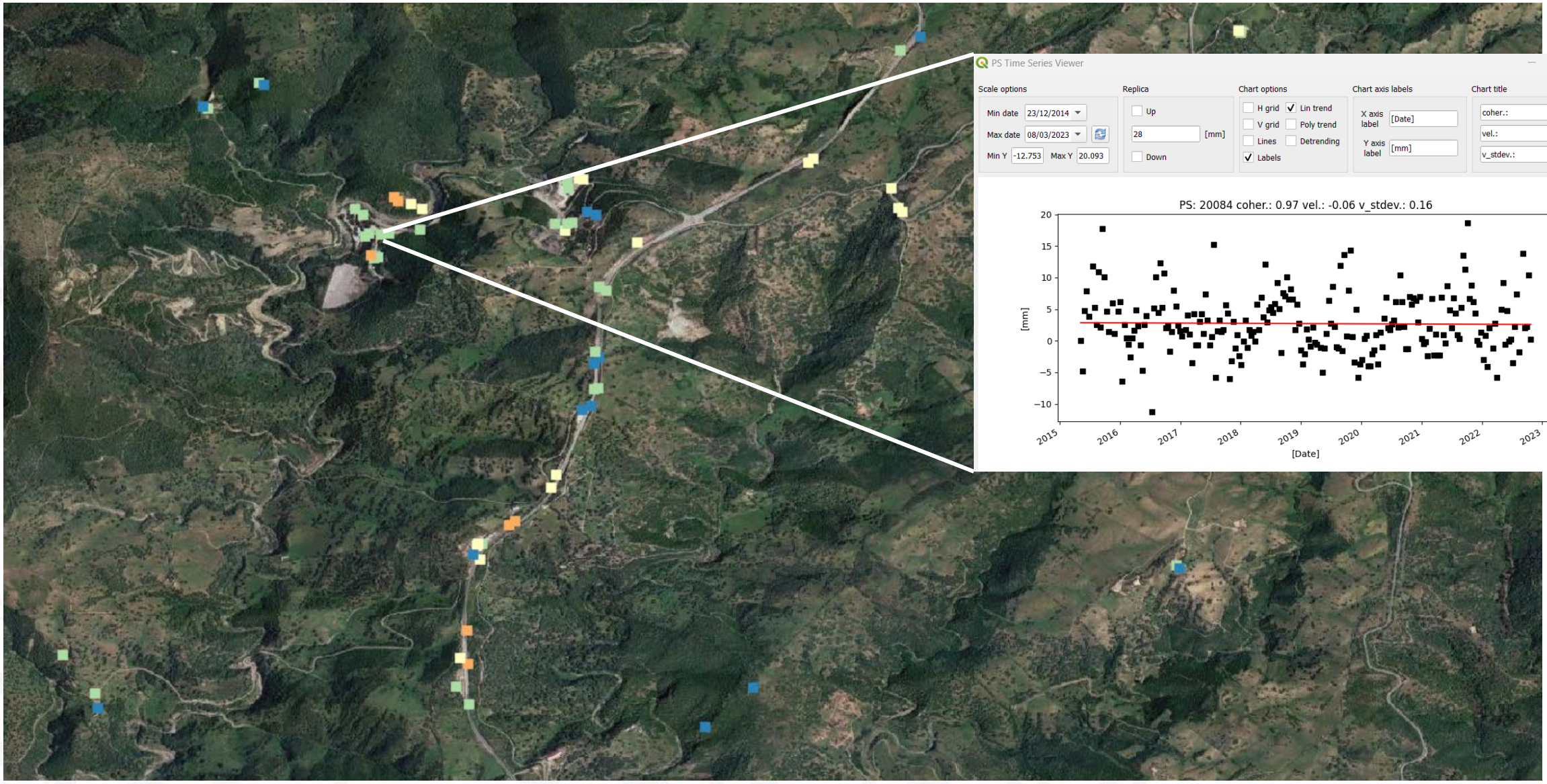
Time series – Sos Enattos mining site



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Future

- It is possible to extend this procedure to next months acquisitions in order to get a continous monitoring system

- It is possible to apply decompostion formulas in order to get W-E displacement

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Scientific Publications

- First results has been presented as a poster at EGU General Assembly in Vienna

https://doi.org/10.5194/egusphere-egu23-14807

- A scientific article with title «**Measuring land deformation through PSI technique in NE Sardinia (Italy): Roads to Einstein Telescope**» has been submitted and is currently under review at Springer Nature editor (Open Access)

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