Nationwide Sentinel-1 PSI Surface Motion of Greece Using On-Demand SNAPPING Service of the Geohazards Exploitation Platform

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University of Leeds, UK | 11 - 15 September 2023.

Earth Observation and Geospatial Applications Lab

Center of Interdisciplinary Research and Innovation (CIRI-AUTh)

- The Aristotle University of Thessaloniki (www.auth.gr) is the largest public University in Greece established in 1925.
- The Earth Observation and Geospatial Applications Lab of AUTh (EO.Lab, https://eolab.geo.auth.gr) resides within the Department of Physical and Environmental Geography, School of Geology, Faculty of Sciences.
- The expertise of EO.Lab members spans across a variety of Earth Observation and Geospatial Information Science-Technology domains, including Remote Sensing , SAR Interferometry, Photogrammetry, Surveying and Geodesy, GNSS, LiDAR and Sonar.

Integration of the interdisciplinary CEO^2 (Center of Earth and Ocean Observation) team in CIRI

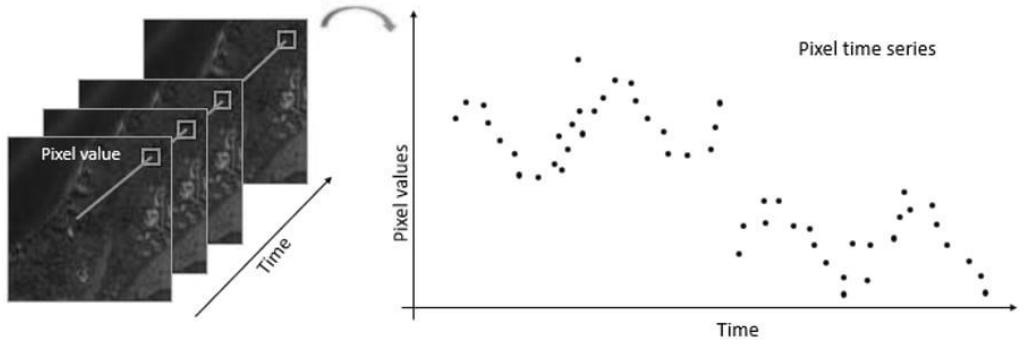
CIRI-AUTH
CENTER FOR INTERDISCIPLINARY RESEARCH AND INNOVATION
Aristotle University of Thessaloniki

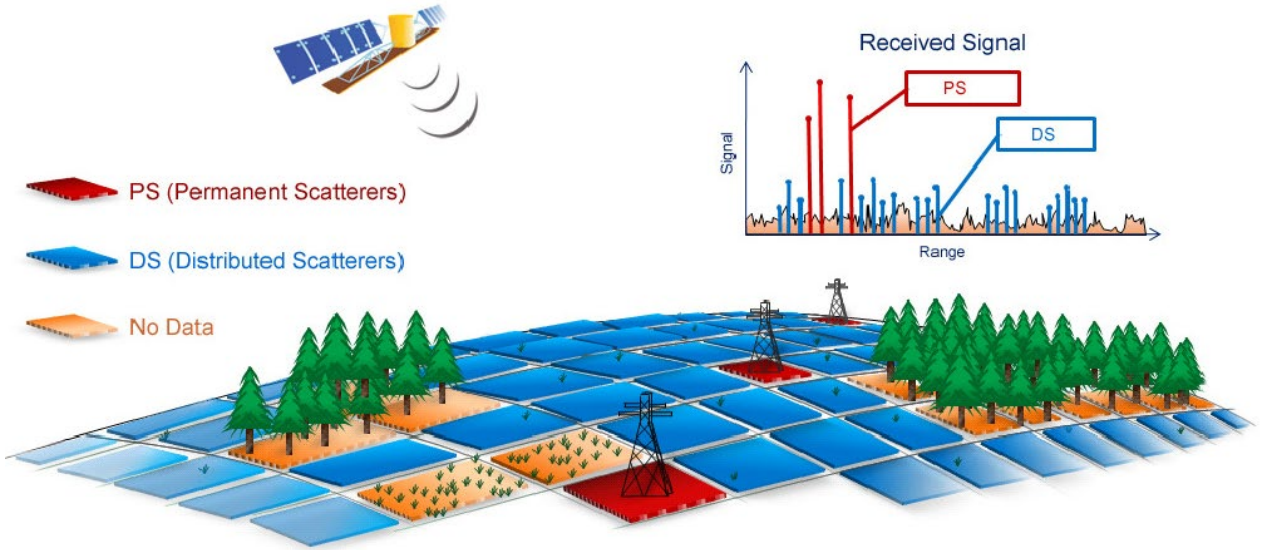
https://kedek.auth.gr

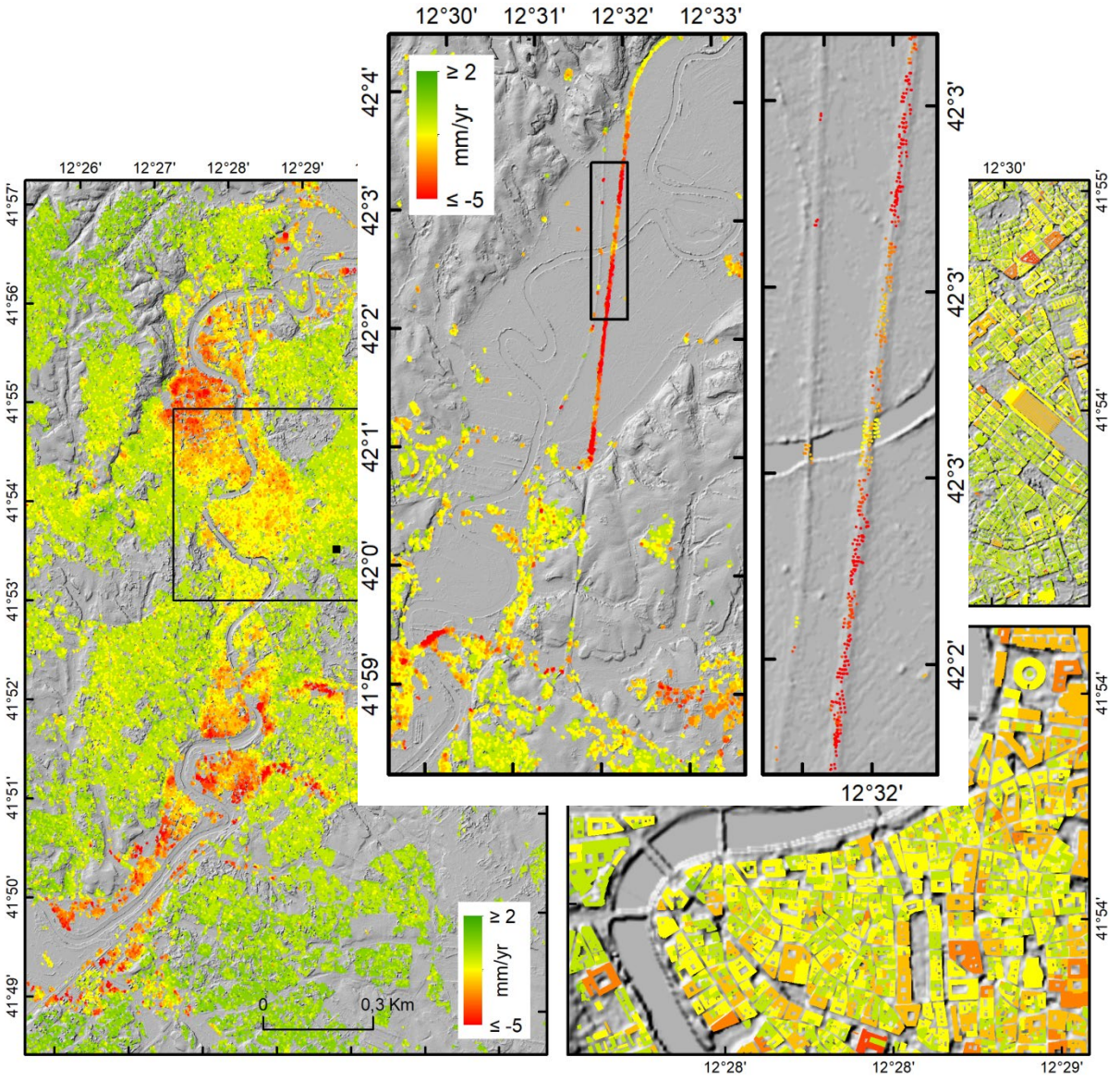
The main mission of **CIRI** is the promotion and development of interdisciplinarity in an open and collaborative environment of excellence, which utilizes the research infrastructures of AUTH at the local, national and European level, expands the University's synergy with society and contributes to the economic and social development of the country.

Persistent Scatterers Interferometry (PSI)

Exploit temporal and spatial characteristics of interferometric signatures from point targets remaining 'stable' over time





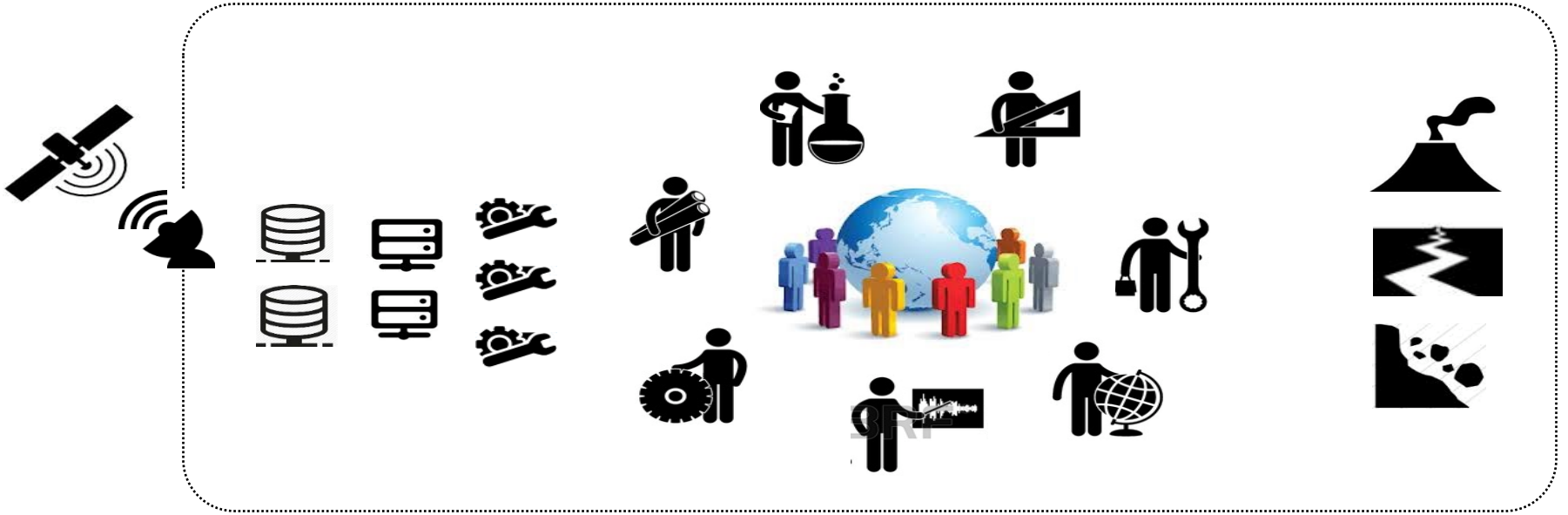


Delgado Blasco, J.M.; Foumelis, M.; Stewart, C.; Hooper, A. Measuring Urban Subsidence in the Rome Metropolitan Area (Italy) with Sentinel-1 SNAP-StaMPS Persistent Scatterer Interferometry. *Remote Sens.* **2019**, *11*, 129. https://doi.org/10.3390/rs11020129

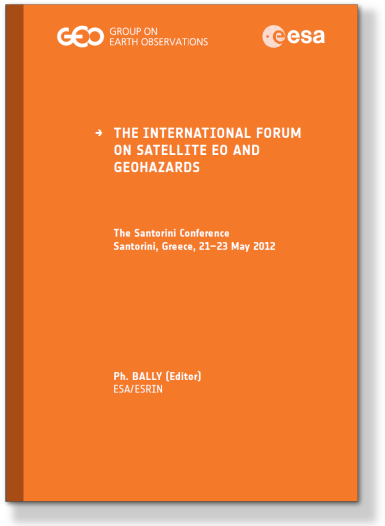
Geohazards Exploitation Platform | GEP

https://geohazards-tep.eu

The GEP is a cloud-based environment providing a set of EO processing services that allow mapping hazard prone land surfaces and monitoring terrain motion.



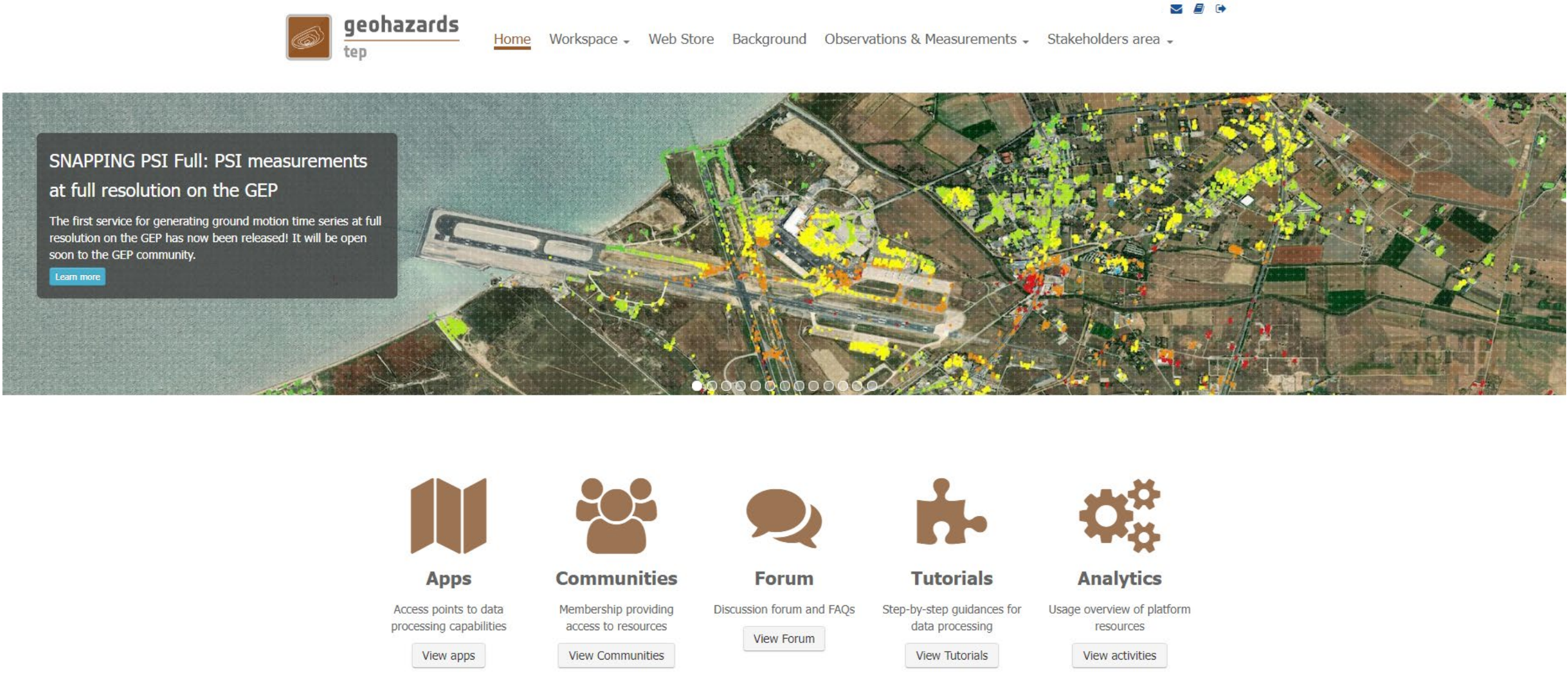
International Forum on Satellite EO and Geohazards organized by ESA and GEO in Santorini in 2012 (140+ participants)



geohazards tep

Geohazards Exploitation Platform | GEP

https://geohazards-tep.eu



SURFACE MOTION MAPPING | SNAPPING SERVICE ON GEP

A multi-temporal interferometric service that produces measurements of surface displacements based on ESA SNAP and StaMPS software packages

SNAPPING IFG

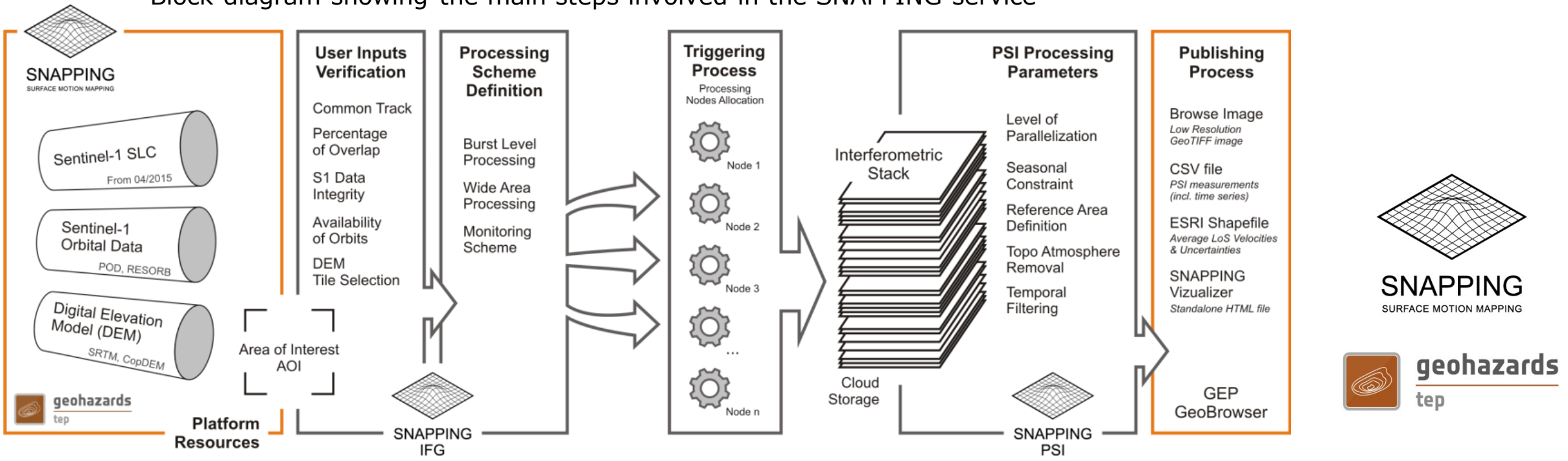
SNAPPING PSI

Two step process

The first consists in setting-up **SNAPPING IFG** processing pipeline to generate the interferogram stack

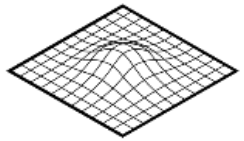
In the second step the interferogram stack is channeled to the **SNAPPING PSI** pipeline for time series analysis

Block diagram showing the main steps involved in the SNAPPING service



Family of SNAPPING Services

SNAPPING
SURFACE MOTION MAPPING



SNAPPING PSI Med

A service focusing on the delivery of PSI measurements at reduced spatial resolution (spatial averaging of point targets within a 100x100 meters radius to allow wide-area coverage in a relatively short time. The SNAPPING PSI Med service is proposed for inspection of areas of large extent to identify sites where more dedicated analysis is required.

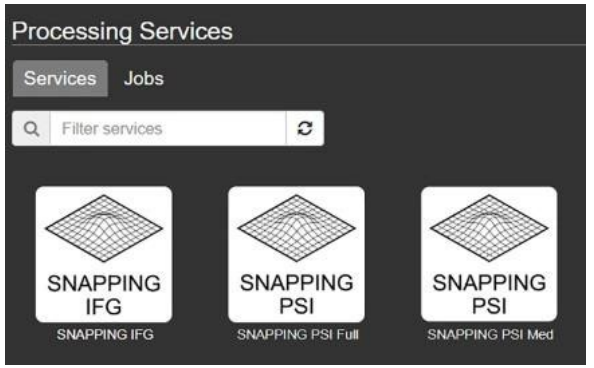
SNAPPING PSI Full

Full sensor resolution PSI service applicable for a detailed regional investigation of surface motion, as well as for building-level and infrastructure monitoring. Persistent Scatterers (PS) targets represent surface features stable over the observation period, mainly man-made objects and non-vegetated natural terrain.

SNAPPING PSI+ (PS/DS)

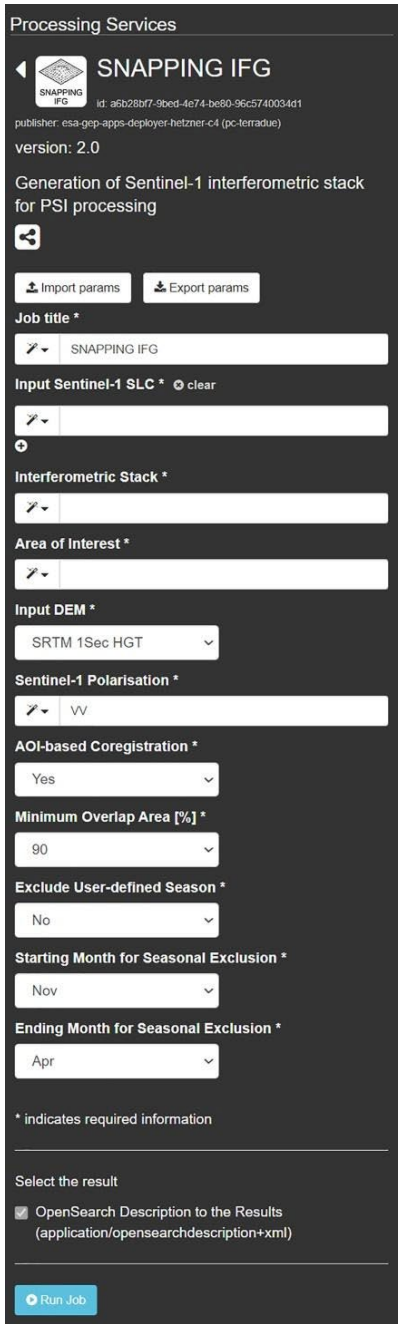
Tailored interferometric processing on both PS and Distributed Scatterers (DS), providing optimum measurement densities. DS are typically identified over homogeneous ground, non-cultivated lands and deserted areas.

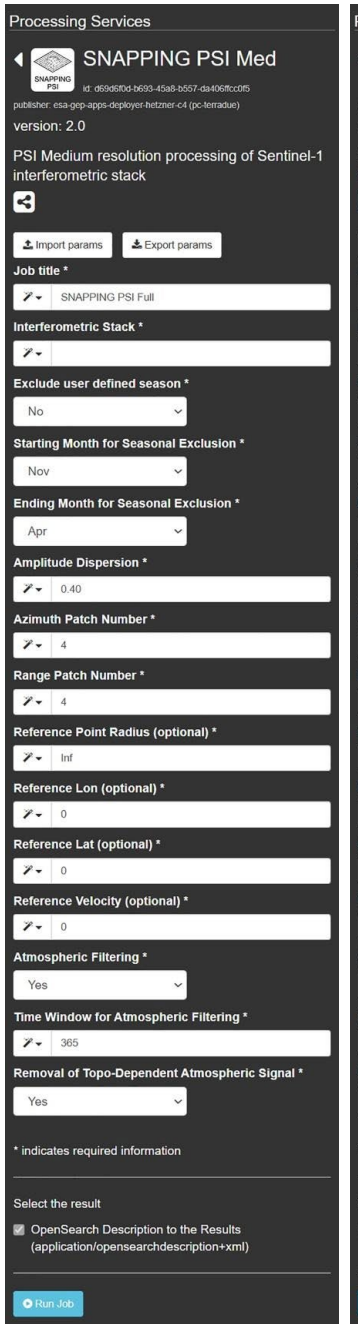
SNAPPING | GEP Interface

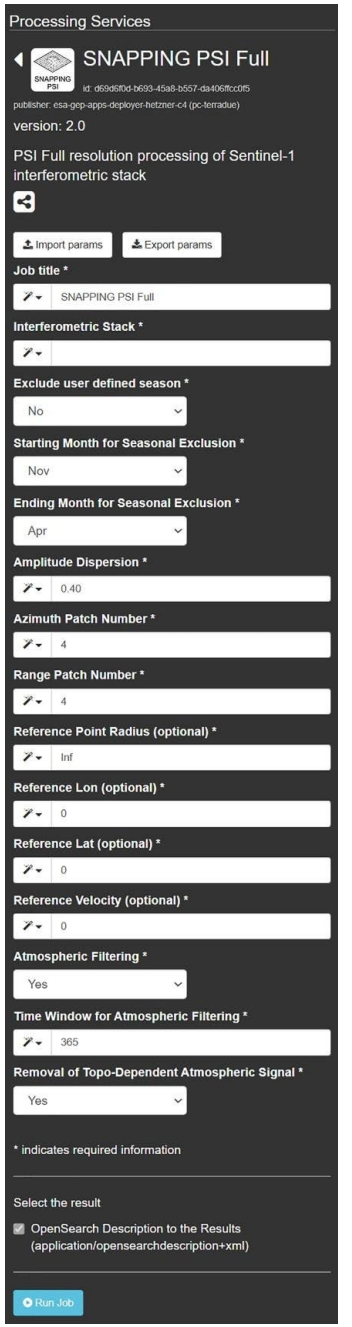


User interfaces of SNAPPING IFG and PSI (Med and Full resolution) services on GEP, including default processing parameters.

The interfaces refer to version 2.0 of the services released in July 2022.





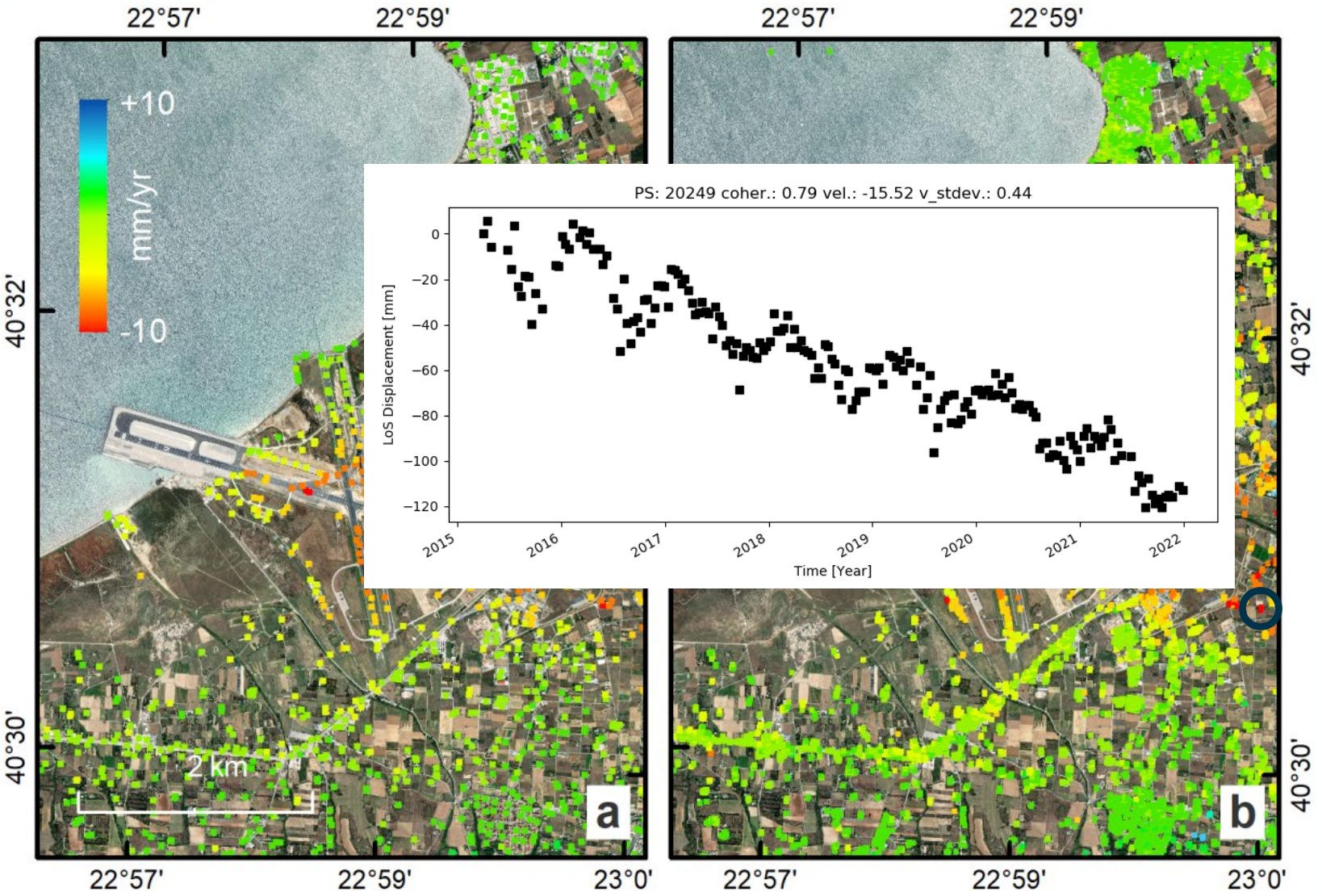


SNAPPING | Med & Full Resolution services

SNAPPING
SURFACE MOTION MAPPING

Sentinel-1 PSI average LoS displacement rates for the period 2015-2020 over Thessaloniki International Airport using the SNAPPING PSI (a) Med and (b) Full resolution services. The improved density of measurements using PSI Full service is shown.

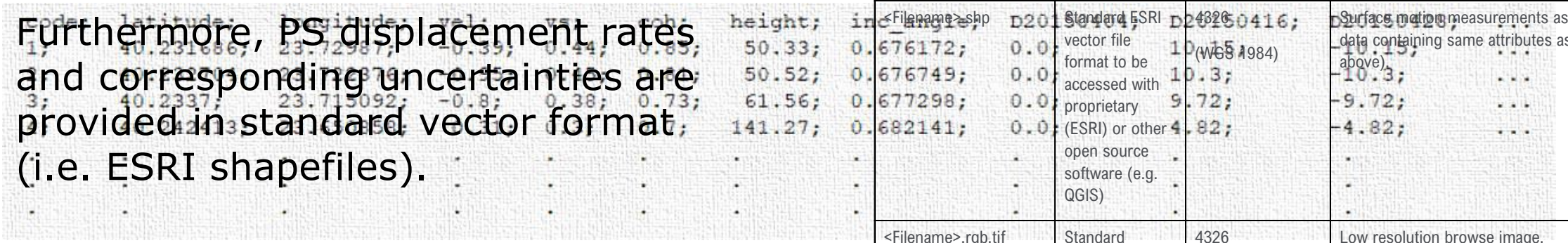
SNAPPING PSI Full led to ~1500% increase of PSs (total of 16500 targets) compared to the corresponding PSI Med solution (1120 targets).



SNAPPING PSI Outputs

The SNAPPING measurements are provided as a text file in **Comma Separated Values (CSV) format** containing information about each point target.

Furthermore, PS displacement rates and corresponding uncertainties are provided in standard vector format (i.e. ESRI shapefiles).

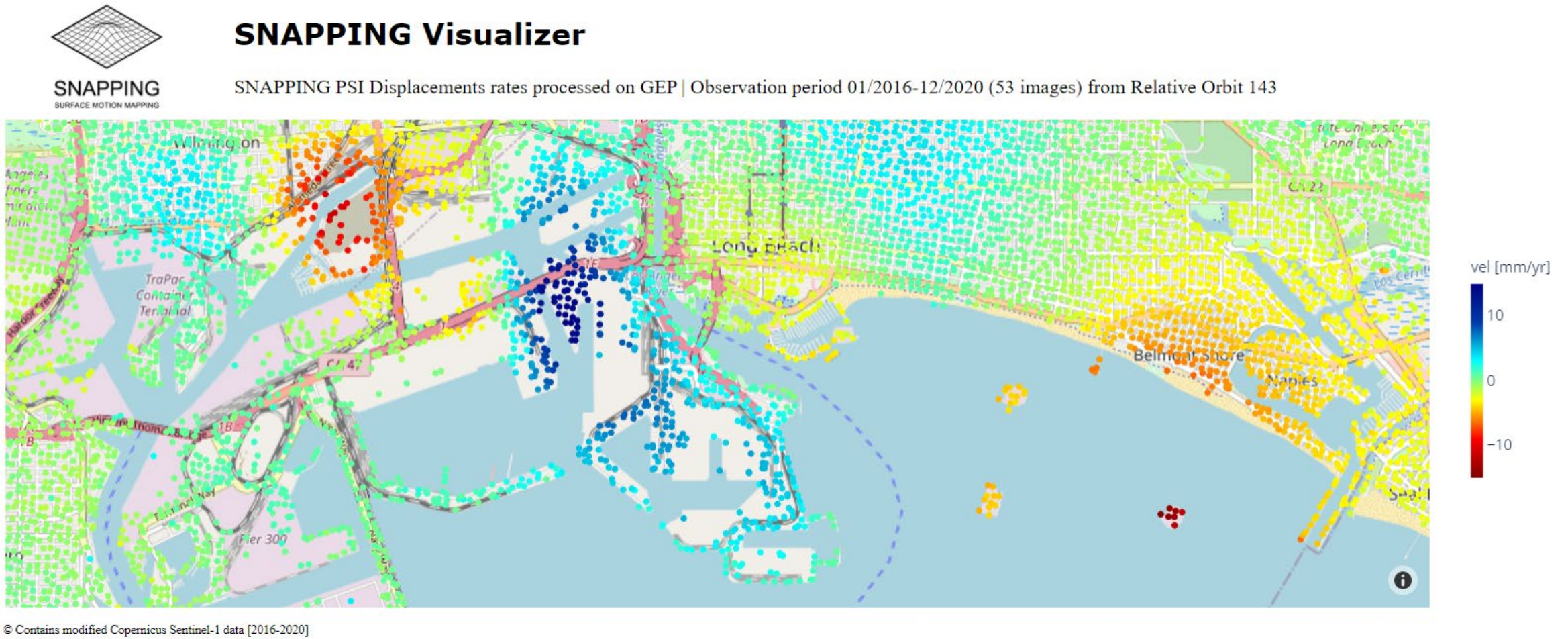


File	Format	EPGS	Description
<Filename>.csv	Standard Comma-Separated Values file	4326 (WGS 1984)	Tabulated surface motion measurements with following attributes: ID, Latitude, Longitude, Vel, Vs, Coh, Height, Inc_Angle, YYYYMMDD (as YYYY: year; MM: month & DD: day).
<Filename>.txt	Standard text file that contains plain text	Not applicable	Processing metadata, including detailed information on the version of the service used, production date, EO sensor, start/end of the measurements, number of images etc.
<Filename>.shp	Standard ESRI vector file format to be accessed with proprietary (ESRI) or other open source software (e.g. QGIS)	4326 (WGS 1984)	Surface motion measurements as point vector data containing same attributes as CSV file (see above).
<Filename>.rgb.tif	Standard GeoTIFF file	4326 (WGS 1984)	Low resolution browse image.
<Filename>.legend.png	Standard Portable Network Graphics raster file	Not applicable	Colour scale (as raster image) corresponding to browse image file (i.e. Filename.rgb.tif).
<Filename>.html	Standard file in Hypertext Markup Language	Not applicable	Standalone visualization file showing surface motion point measurements (average motion rates in mm/yr) as overlaid on OpenStreetMap background.

SNAPPING Visualizer

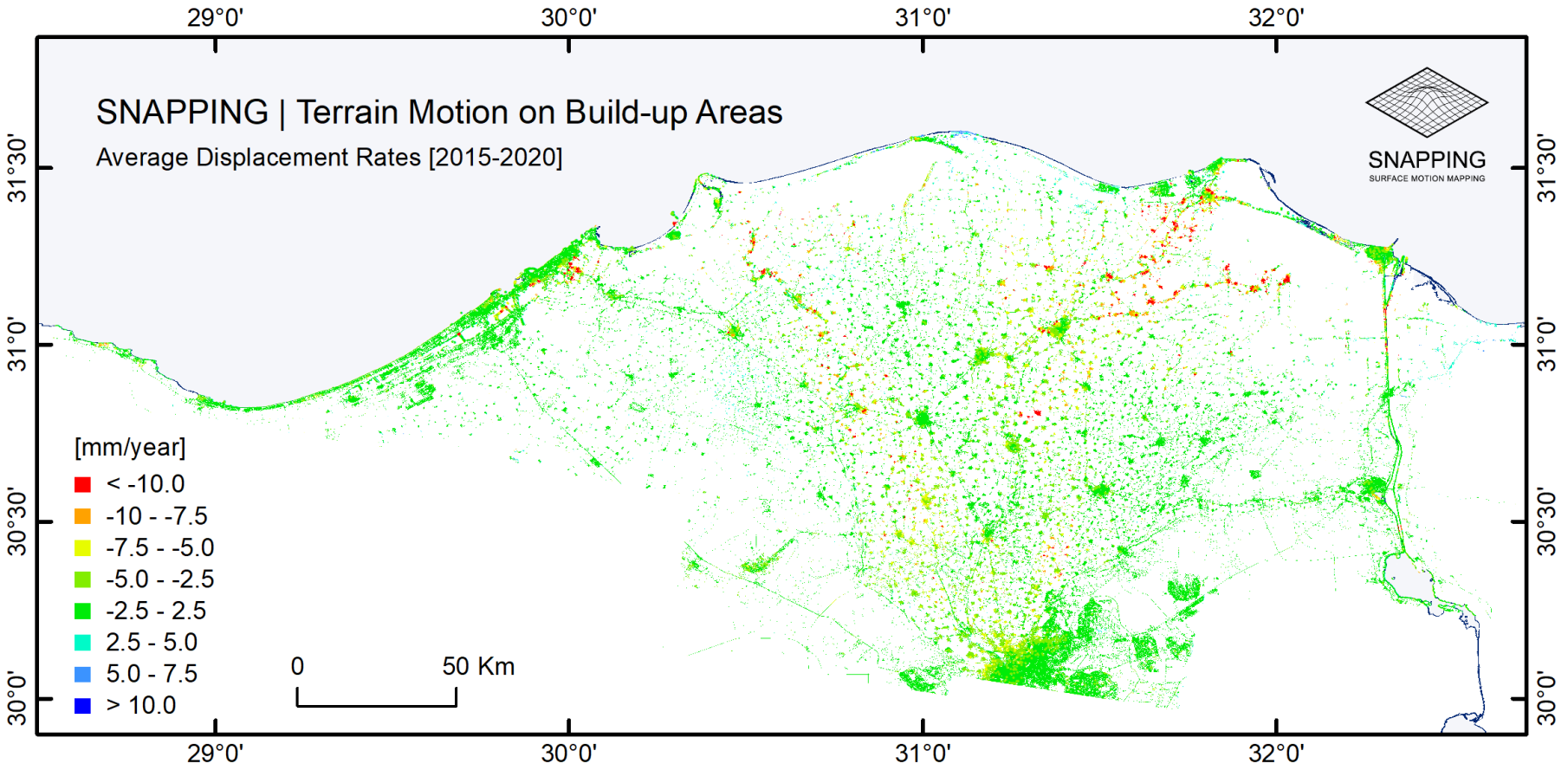
SNAPPING
SURFACE MOTION MAPPING

A standalone HTML (off-line) visualization file is also provided to facilitate proper inspection of data by end-users without the need for ingestion into any geospatial database.



Wide Area InSAR Processing | Nile Delta (Egypt)

Terrain motion over build-up areas of the Nile Delta as defined by the ESA WorldCover 2020 product



Contains modified Copernicus Sentinel-1 data (2015-2020), processed on GEP by NARSS/AUTh

Processing supported by ESA NoR sponsorship involving the National Authority for Remote Sensing & Space Sciences (**NARSS**) of Egypt, the Aristotle University of Thessaloniki (**AUTh**) in Greece and the French Geological Survey (**BRGM**)

Sentinel-1 Tracks:
Descending 065 & 167

Observation Period:
2015-2020 (~6 years)

Nu of Sentinel-1 Scenes:
517

Nu of PS points:
~516k

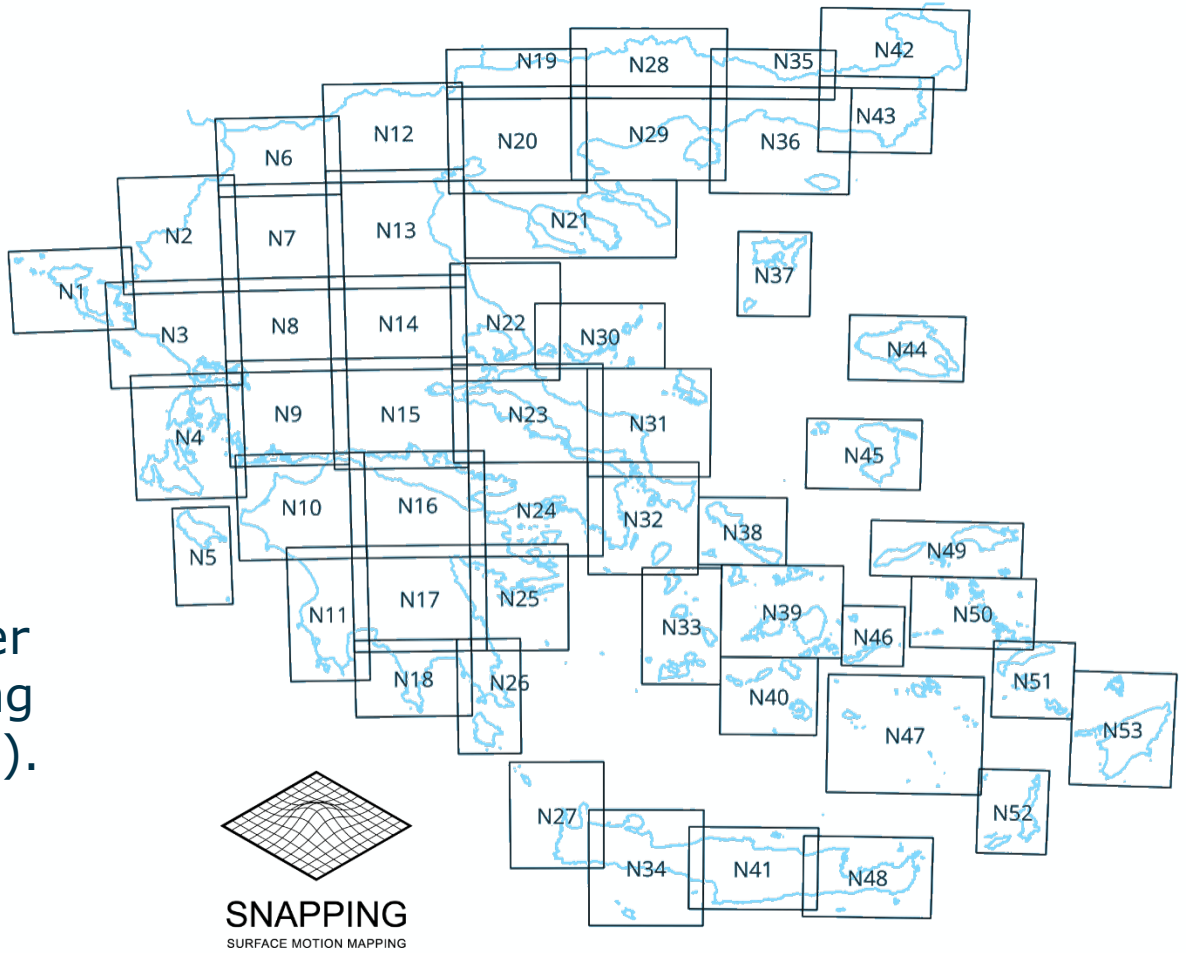
Processing Strategy for SNAPPING PSI Greece

A dedicated processing scheme based on SNAPPING PSI Med was developed to ensure coverage of entire land surfaces (including isolated islands), while minimizing propagation of error sources.

The Greek territory (**~132k sq.km**) was thus splitted into **54 tiles** of approx. 90 x 90 km, having spatial overlap not lower than 10 km.

The totality of Copernicus Sentinel-1A archive over Greece in descending orbits was exploited covering the period from **04/2015** to **12/2021** (~7 years).

In practice, 174-198 observation dates per tile were processed.

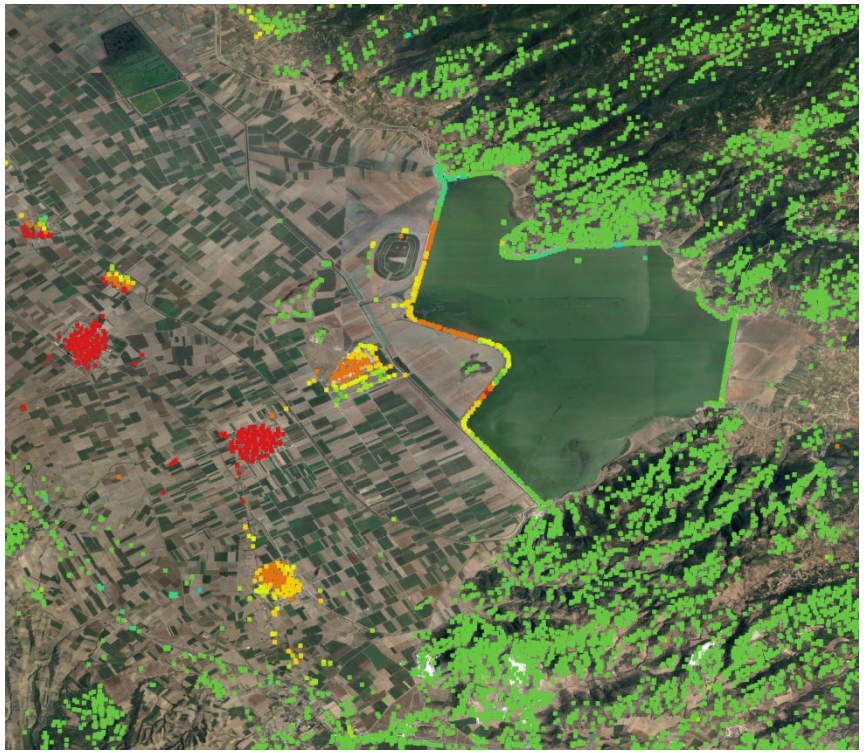


SNAPPING InSAR GReece

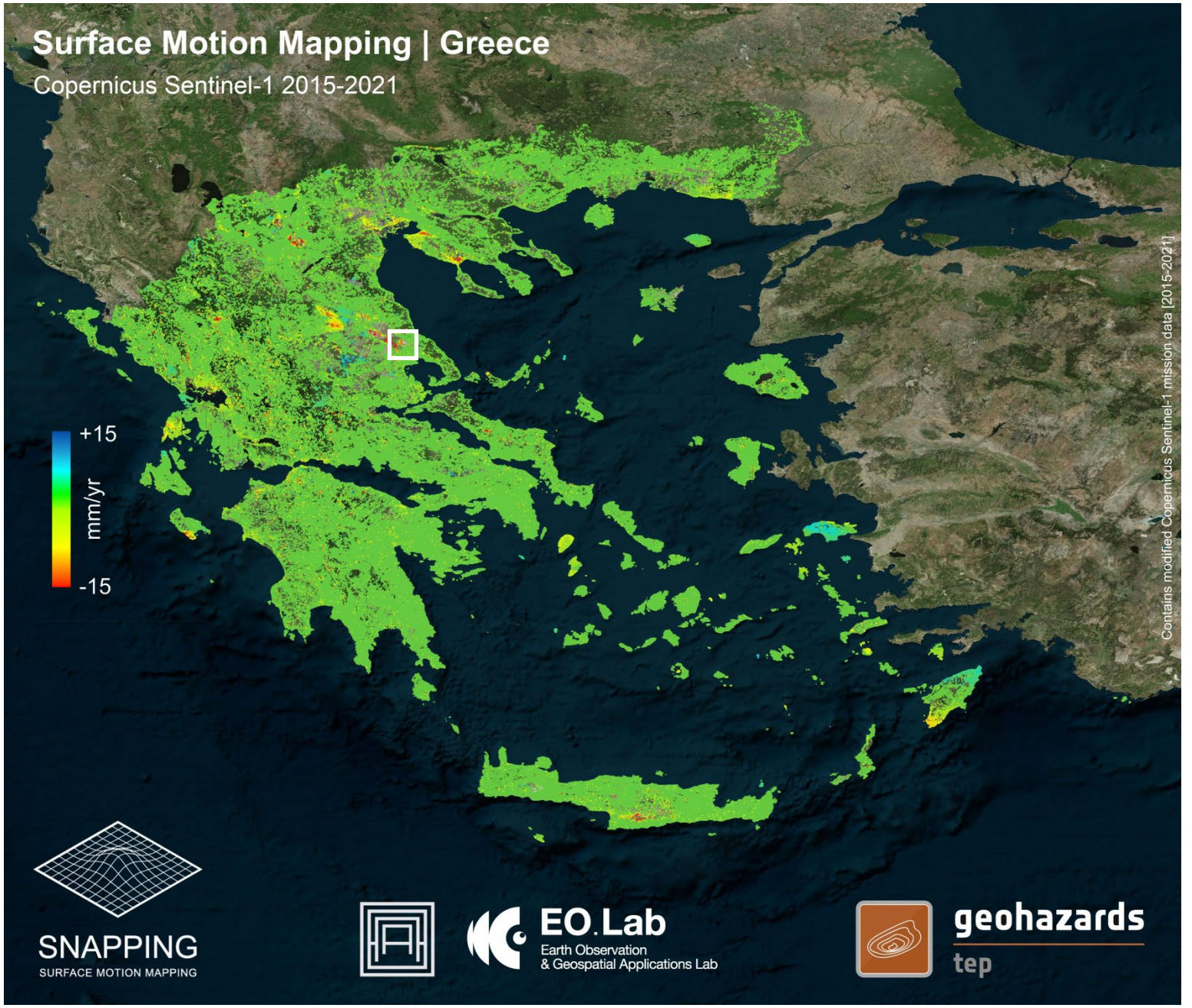
Copernicus Sentinel-1 Tracks

D153 | D080 | D007 | D109 | D136 | D138

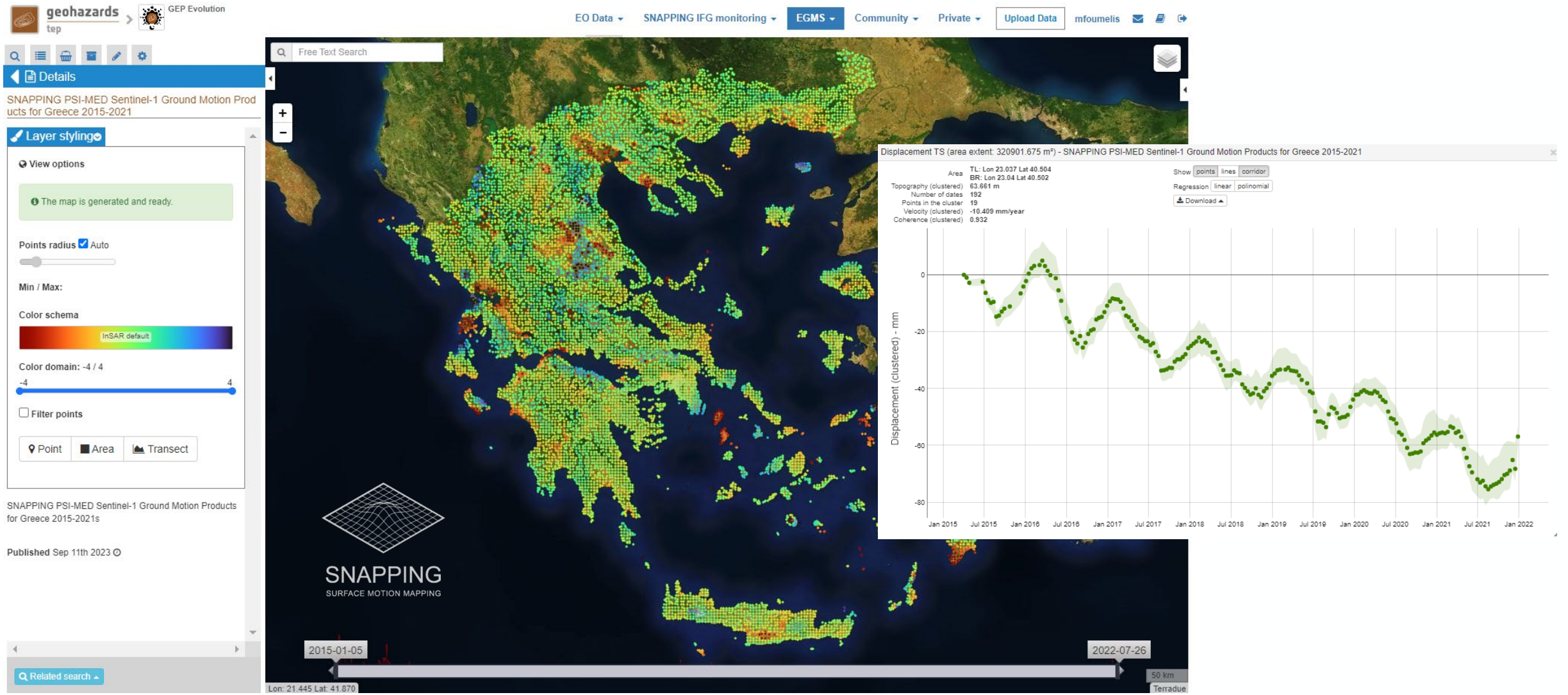
4180 SLC scenes



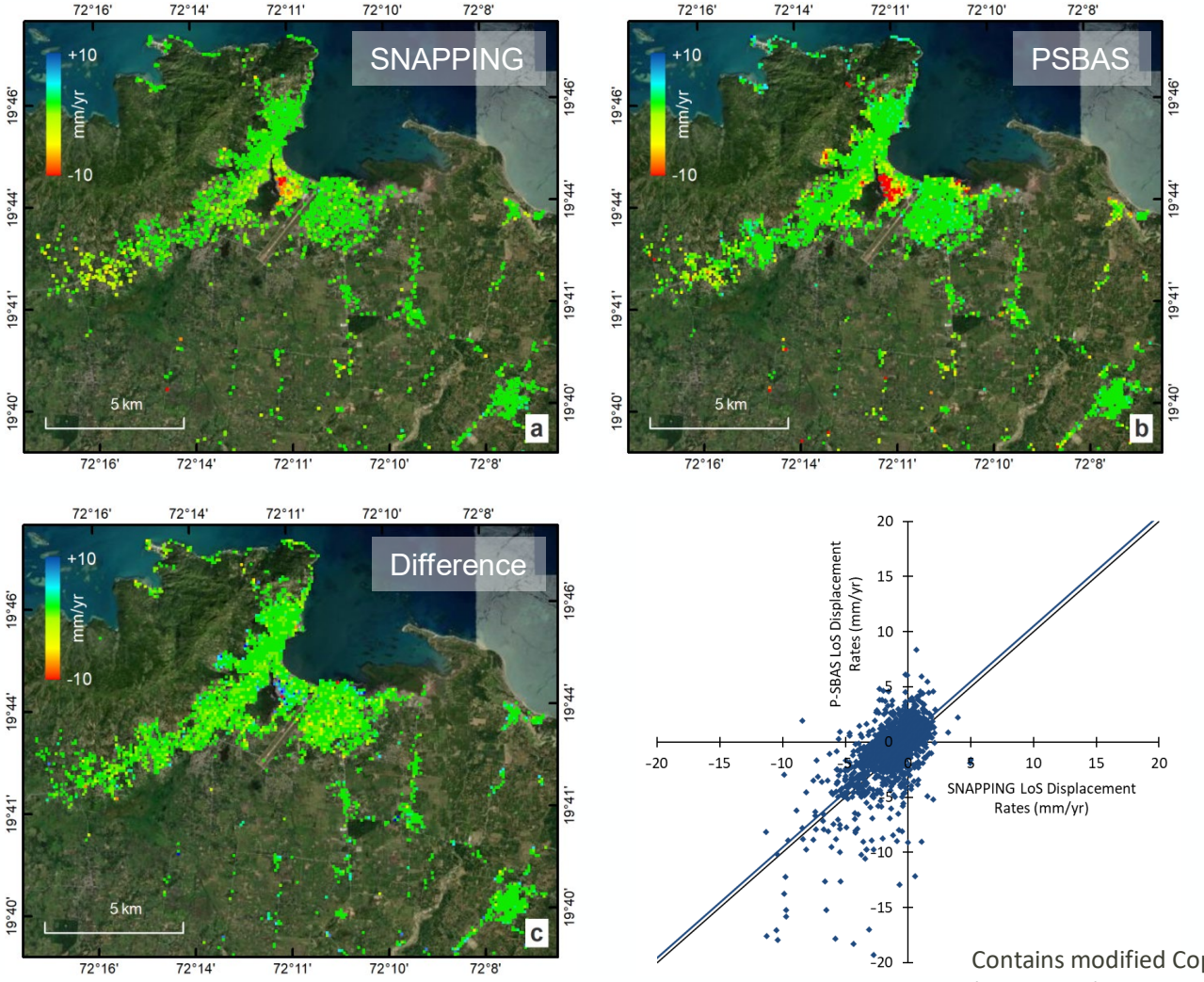
A total of ~4M point measurements at medium resolution covering 132k sq.km2



Product Visualisation on GEP



Verification of SNAPPING PSI Measurements

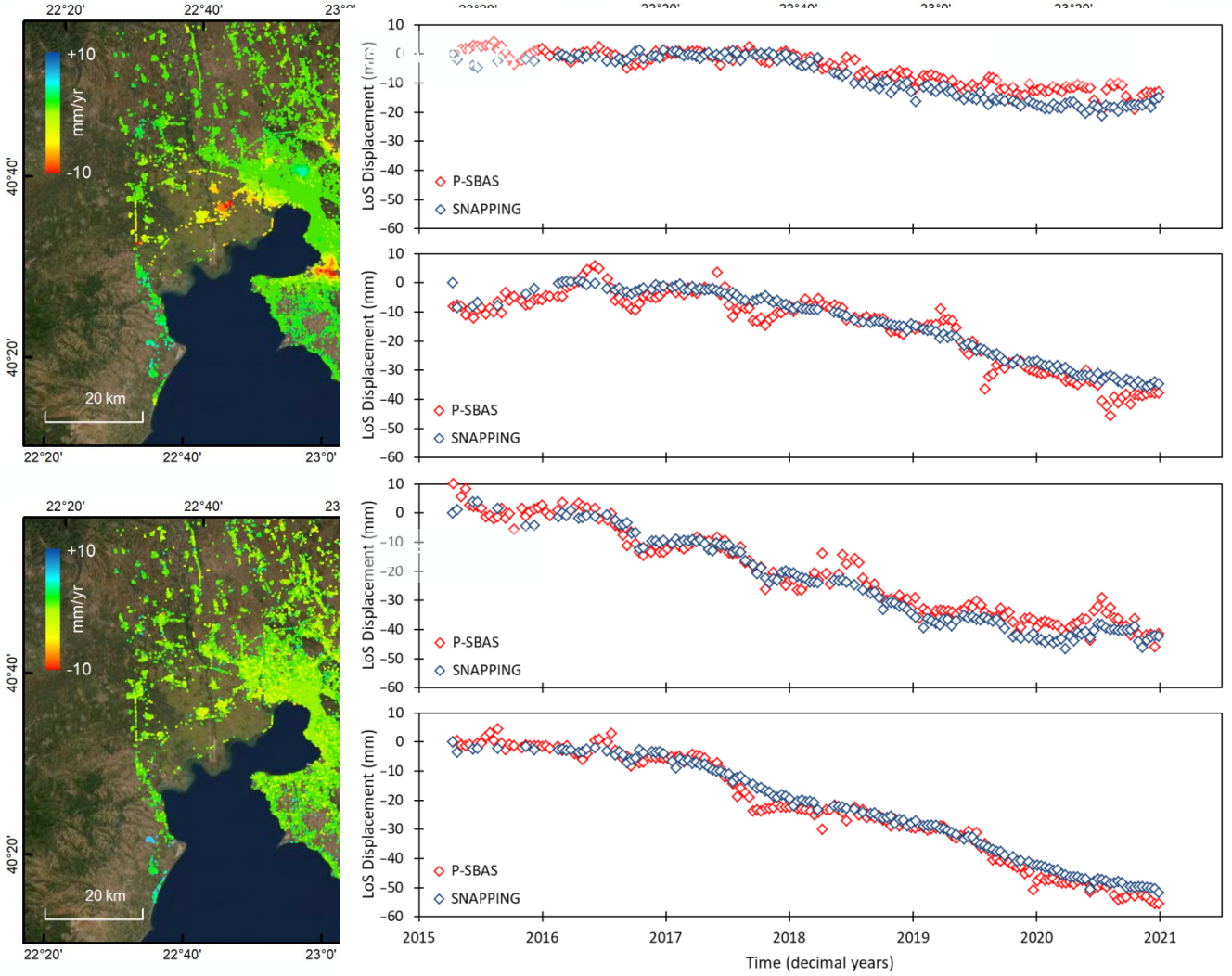


Contains modified Copernicus Sentinel-1 data (2017-2019), processed AUTh on GEP.

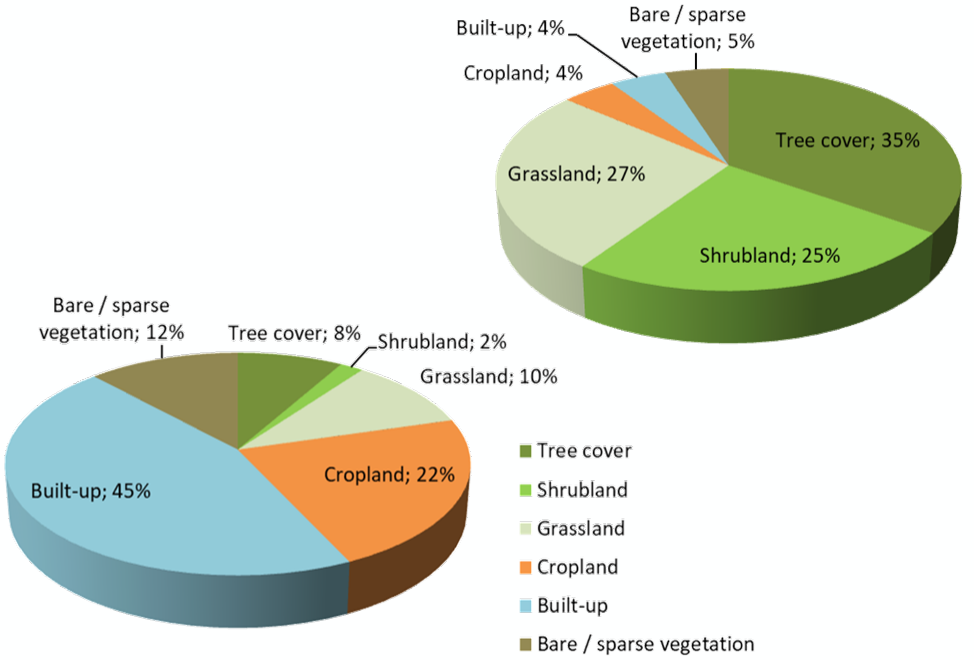
Sentinel-1 LoS displacement rates over **Cap-Haïtien (Haiti)** for the period 2017–2019 based on (a) **SNAPPING PSI Med** and (b) **P-SBAS** services. Differences between the solutions (SNAPPING minus P-SBAS) are spatially shown (c), and the dispersion of the calculated motion rates is also plotted.

Most differences are within the error estimates of the technique. Note that only neighboring points (100 m radius) between the independent solutions are shown.

Verification of SNAPPING PSI Measurements

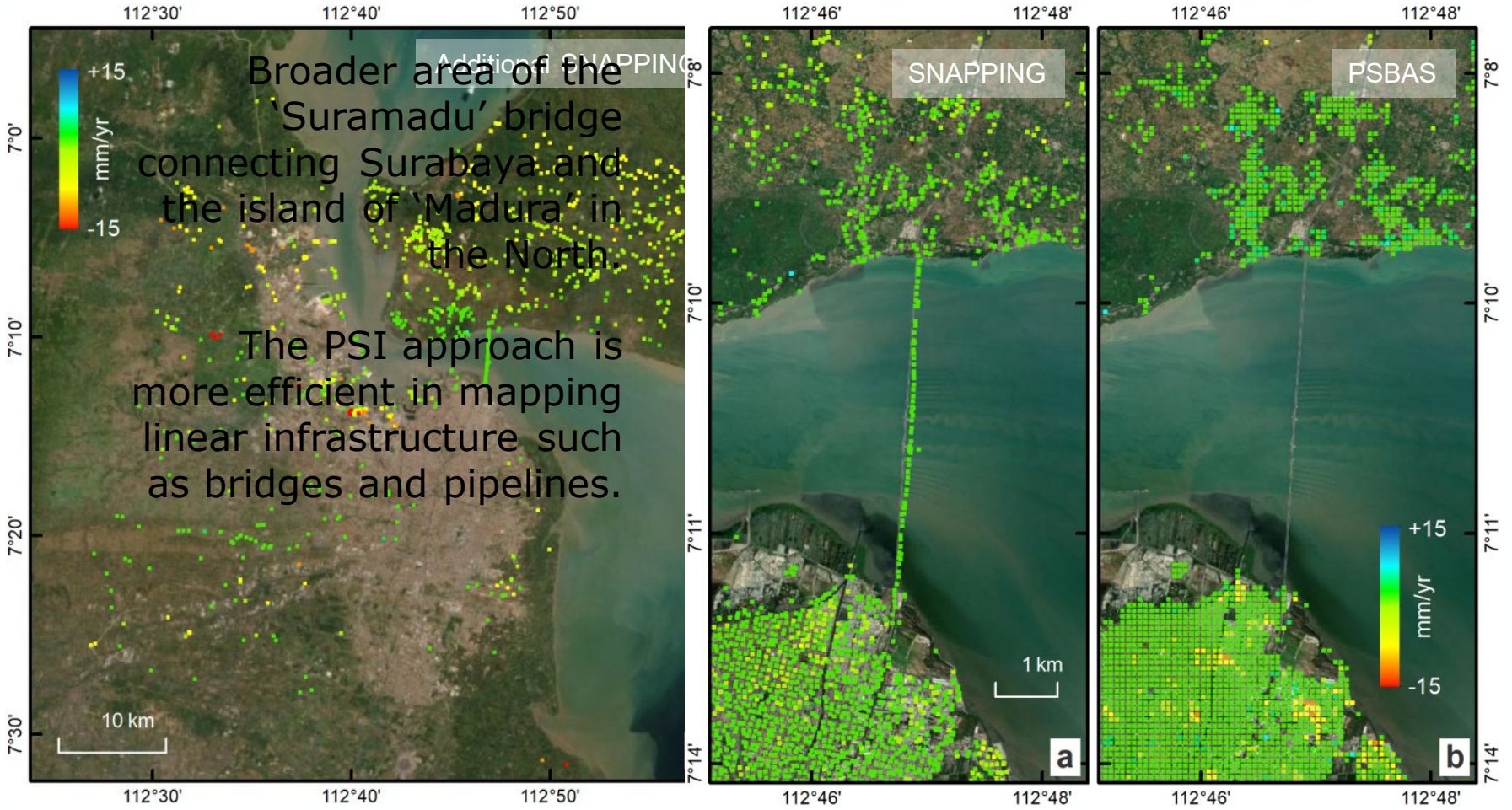


Sentinel-1 LoS displacement rates over the broader **Thessaloniki (Greece)** for the period 2015–2020 based on **SNAPPING** and **P-SBAS** services.



us Sentinel-1 data
h on GEP.

Verification of SNAPPING PSI Measurements

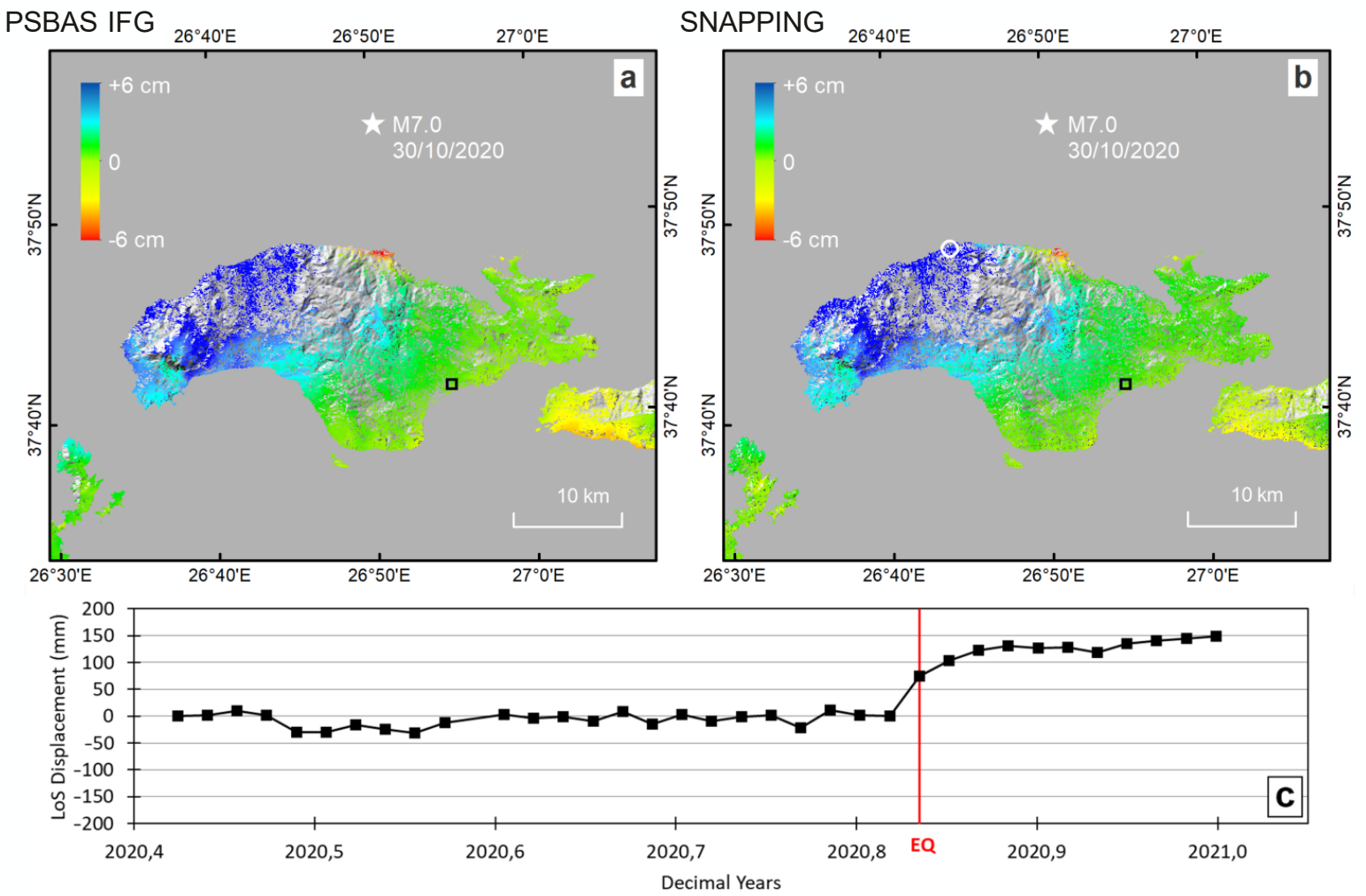


Sentinel-1 LoS displacement rates (2015–2020) by SNAPPING PSI Med and P-SBAS services over **Surabaya (Indonesia)**.

Please note that datasets do not share common references (see manuscript for details).

Contains modified Copernicus Sentinel-1 data (2015-2020), processed AUTh on GEP.

Verification | Moderate Co-seismic Motion

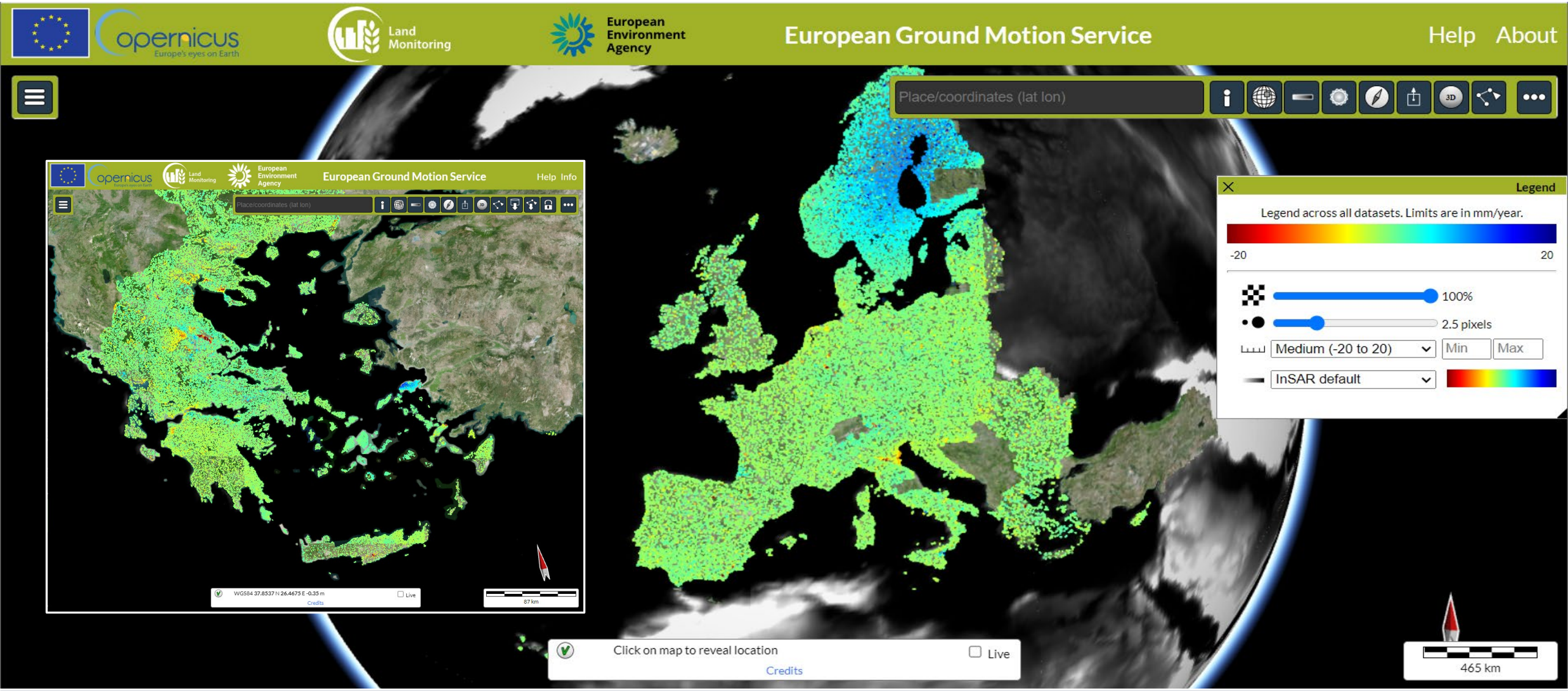


Co-seismic Sentinel-1 displacement field (24 October 2020–30 October 2020; ascending track 131) for the Samos M7.0 earthquake-based P-SBAS service (in IFG mode) at 100 m resolution (unwrapped and converted to LoS displacements) and corresponding displacements as extracted from SNAPPING PSI time series at medium resolution.

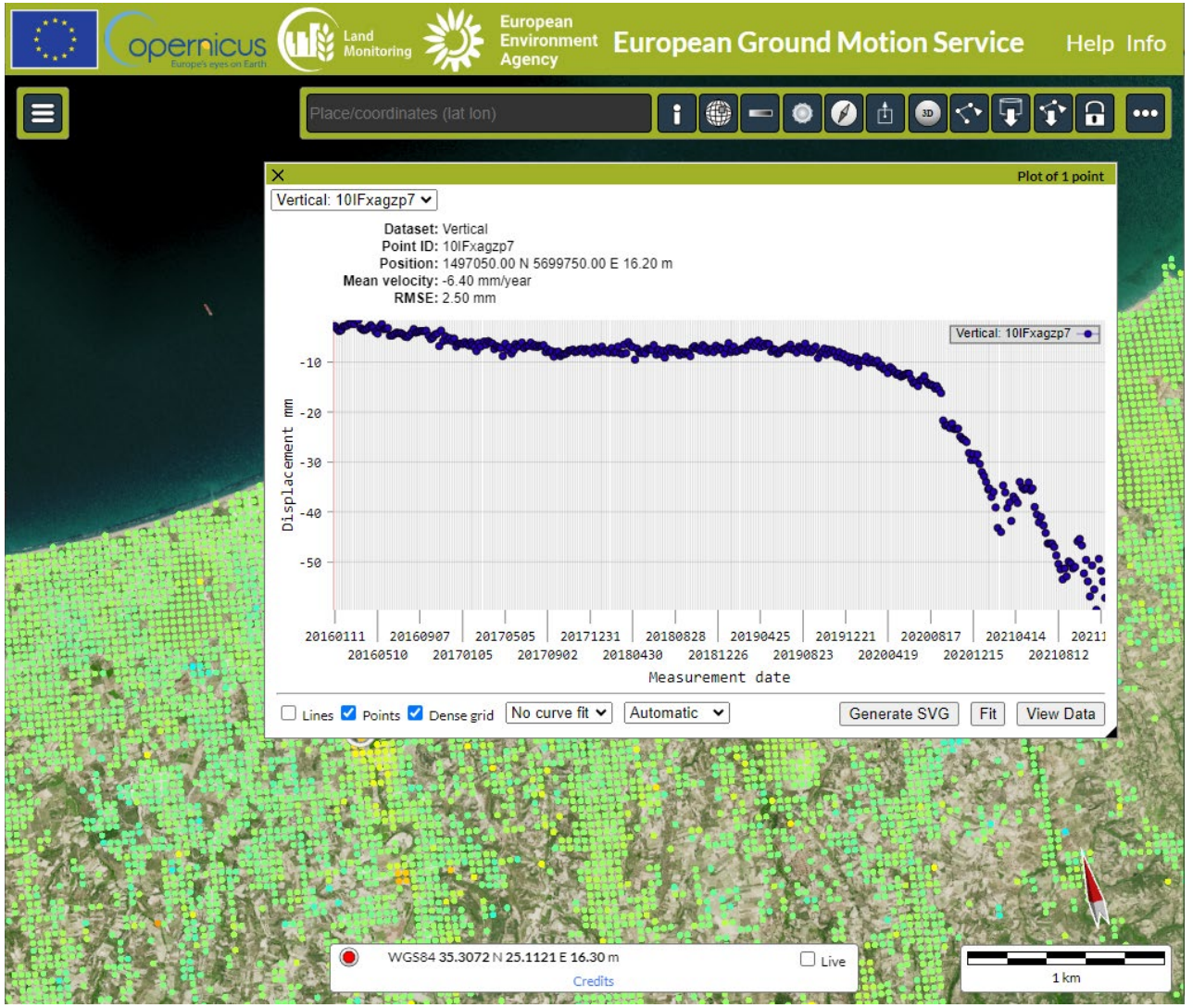
SNAPPING point measurements are averaged to 100 m grid for consistent representation among the techniques.

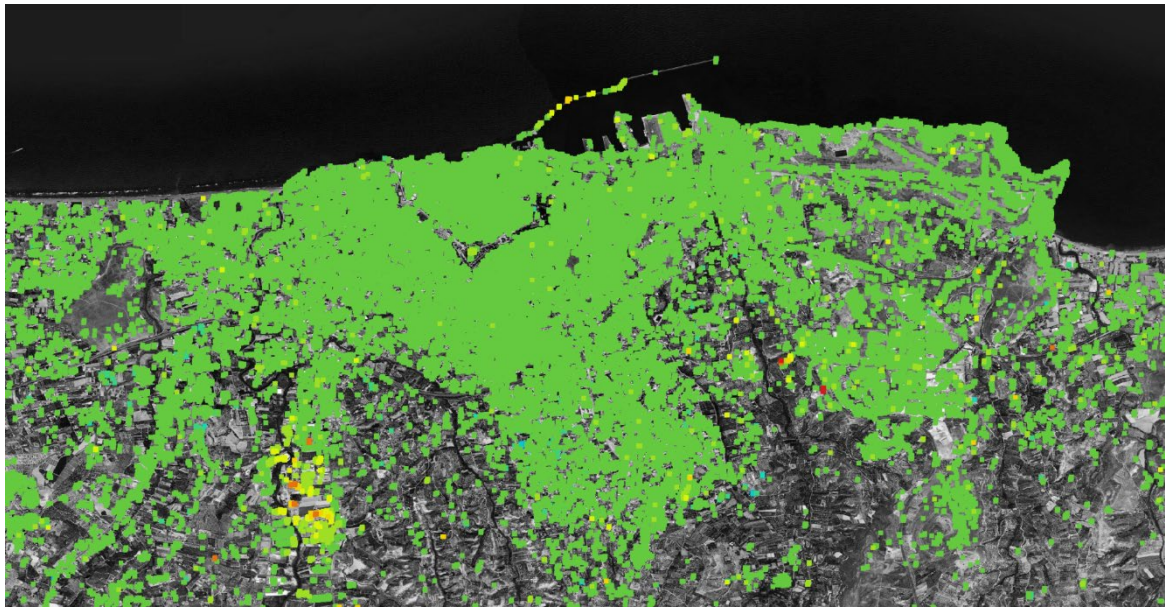
European Ground Motion Service (EGMS)

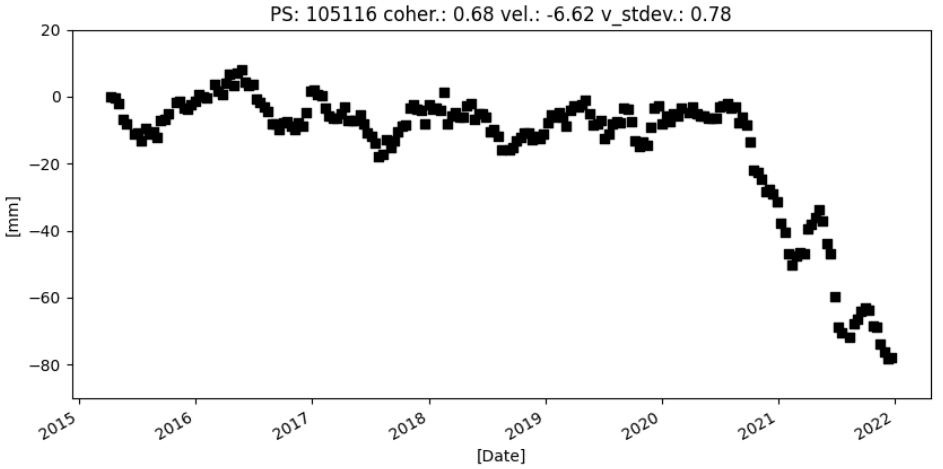
https://egms.land.copernicus.eu



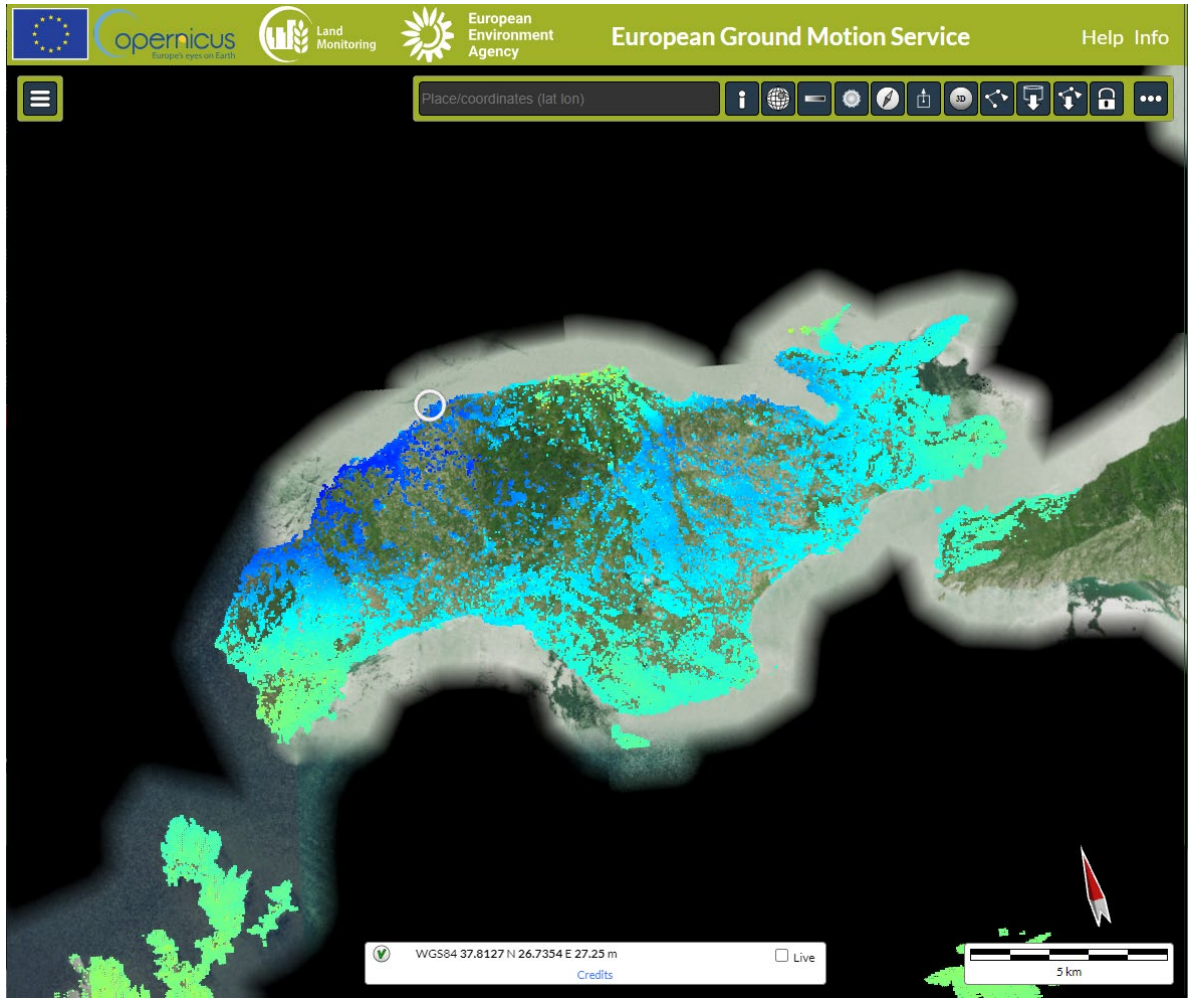
SNAPPING PSI Med vs EGMS | Heraklion, Crete

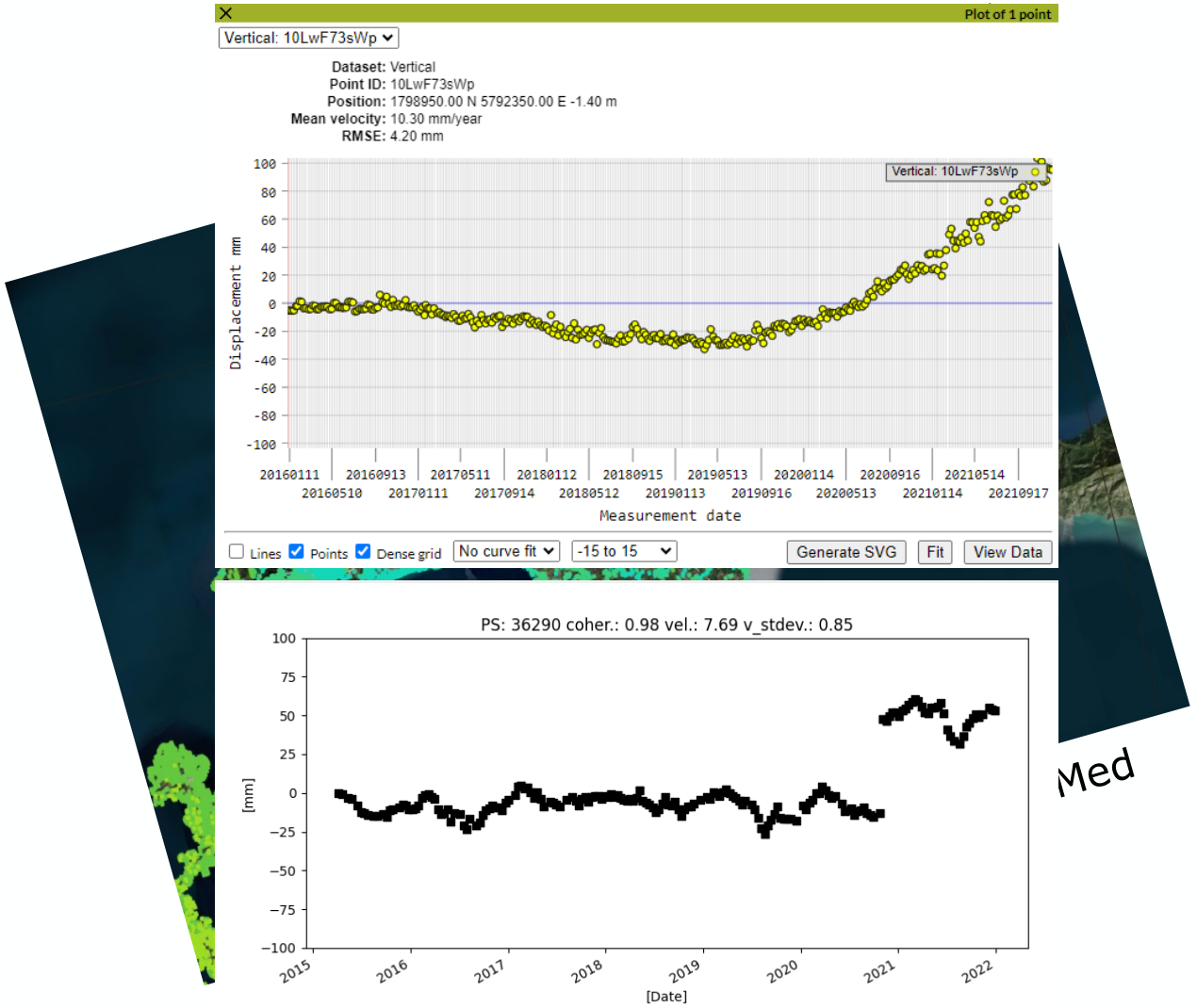






SNAPPING PSI Med vs EGMS | Samos Is.

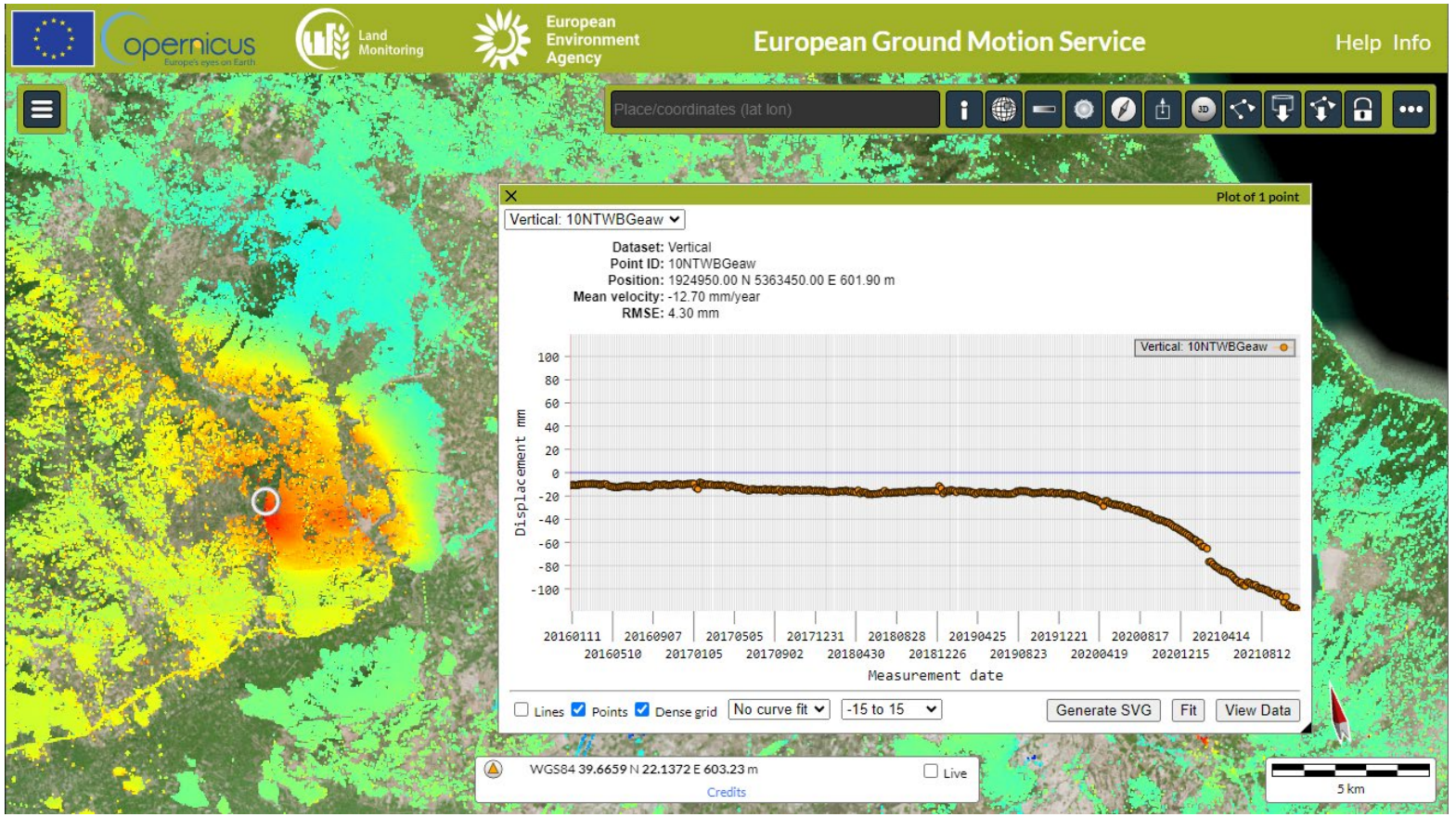


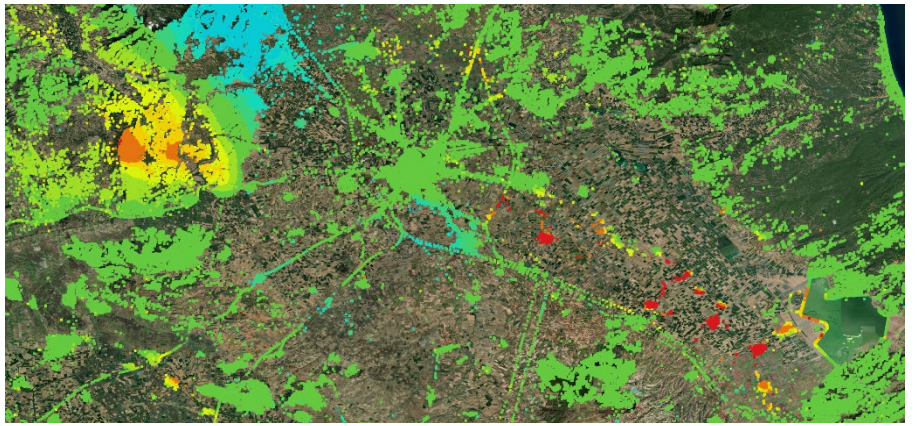


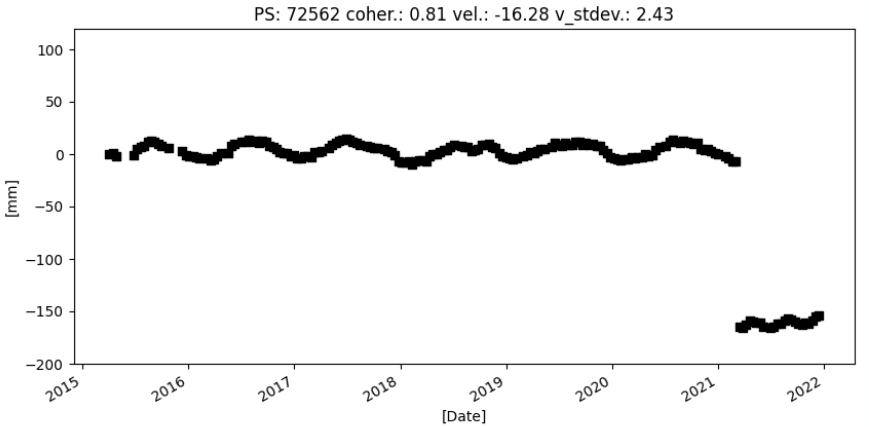
Contains modified Copernicus Sentinel-1 data (2015-2021)..

SNAPPING PSI Med vs EGMS | Tirnavos M6.3 Eq.

In March 2021, an earthquake of magnitude 6.3 struck central Greece, close to Tyrnavos a town about 230 km north of Athens. It was felt across the country damaging a number of houses but drawing no casualties.



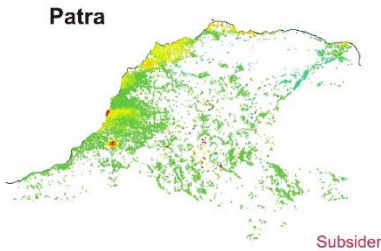




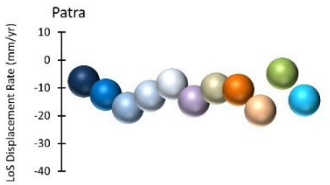
Contains modified Copernicus Sentinel-1 data (2015-2021)..

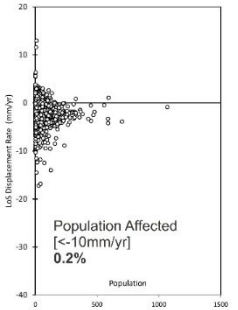
SNAPPING Greece | Ground Displacements in Urban Centres

Patra

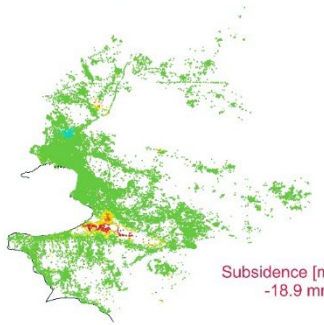


Subsidence [max]
-32.6 mm/yr

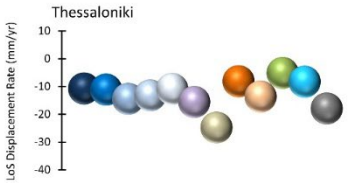


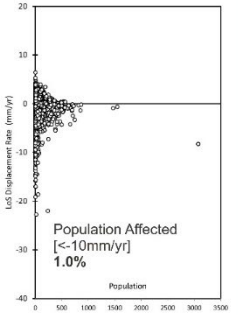


Thessaloniki

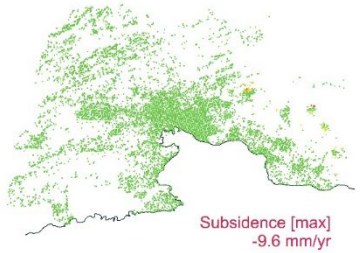


Subsidence [max]
-18.9 mm/yr

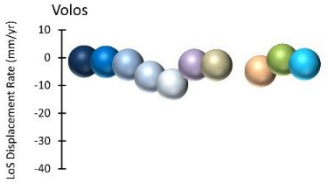


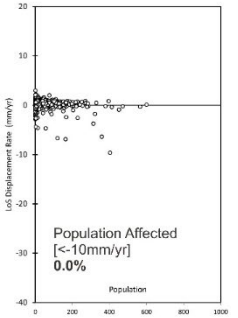


Volos

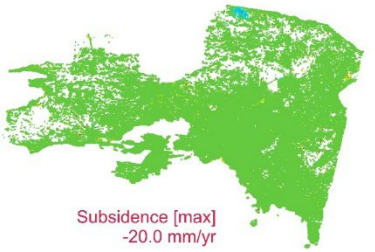


Subsidence [max]
-9.6 mm/yr

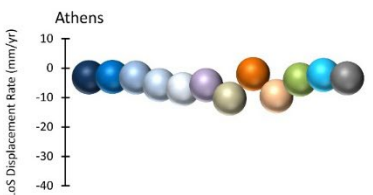


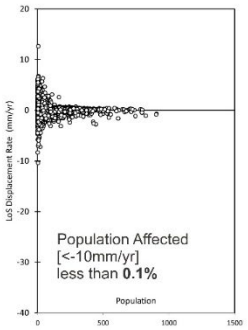


Athens

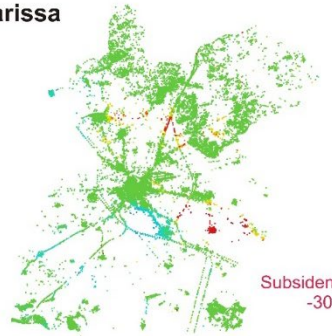


Subsidence [max]
-20.0 mm/yr

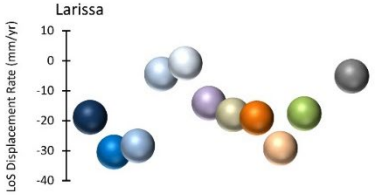


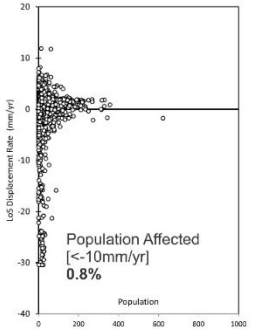


Larissa



Subsidence [max]
-30.4 mm/yr



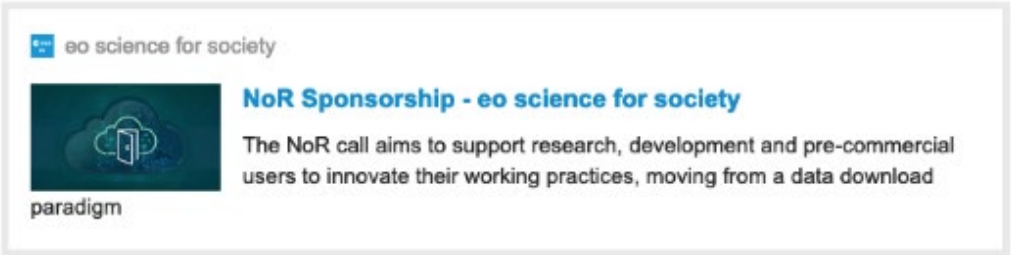


SNAPPING
SURFACE MOTION MAPPING

- Continuous urban fabric (S.L. : > 80%)
- Discontinuous dense urban fabric (S.L. : 50% - 80%)
- Discontinuous medium density urban fabric (S.L. : 30% - 50%)
- Discontinuous low density urban fabric (S.L. : 10% - 30%)
- Discontinuous very low density urban fabric (S.L. : < 10%)
- Isolated structures
- Industrial, commercial, public, military and private units
- Fast transit roads and associated land
- Other roads and associated land
- Railways and associated land
- Port areas
- Airports

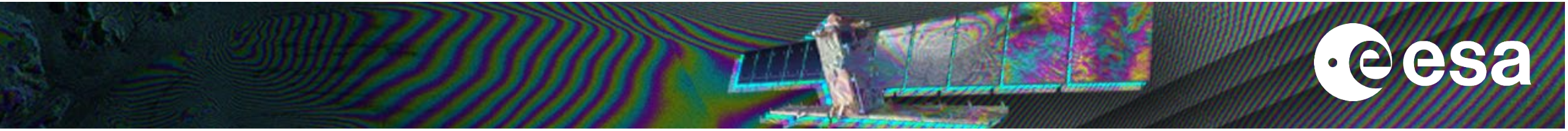
Acknowledgements & Sponsorship Opportunities

The processing performed under the SNAPPING InSAR GReece activity was supported by the **ESA Network of Resources (NoR)** initiative.



NoR is a privileged channel providing science support for:

- Geohazards analysts (i.e., principal investigator, researcher, scientific engineer, PhD student, trainee) with EO data processing goals.
- Service providers or data providers, interested to connect their resources to be used via the Platform.
- Organizations interested in running user community trainings.



Thank you

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EO.Lab
Earth Observation
& Geospatial Applications Lab

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