Geohazards Thematic Exploitation Platform | GEP

TAT | June 2021

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International Forum on Satellite EO and Geohazards

GEP designed in the context of:

- Geohazards Supersite initiative (GSNL)
- CEOS Disasters Working Group

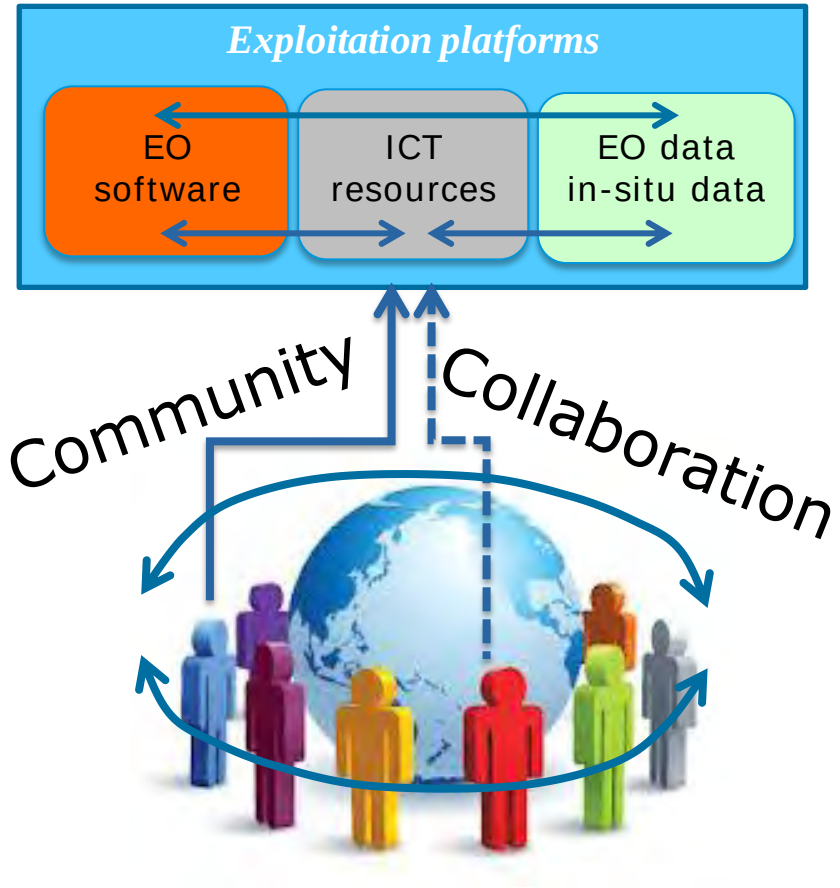
User-driven model for partnership and community building:

- Started from Int. Forum on Satellite EO and Geohazards organised by ESA and GEO in Santorini in 2012 (140+ participants)

ESA Thematic Exploitation Platforms | TEP

https://tep.eo.esa.int

“Move User activities to the Data”



tep
thematic exploitation platform

coastal tep
forestry tep
geohazards tep
hydrology tep
polar tep
urban tep
food security tep

Part of a set of R&D activities to create an ecosystem of interconnected Thematic Exploitation Platforms

Geohazards Exploitation Platform | GEP

https://geohazards-tep.eu

The Geohazards Exploitation Platform (GEP) is a cloud-based environment providing a set of EO processing services that allow mapping hazard prone land surfaces and monitoring terrain deformation.

tep
thematic exploitation platform
https://tep.eo.esa.int

geohazards tep
polar tep
coastal tep
hydrology tep
urban tep
forestry tep

GEP | Initial Consortium

https://geohazards-tep.eu

Consortium: **Terradue** [lead] (IT), **TRE ALTAMIRA** (ES), **CNR IREA** (IT), **DLR** (DE), **EOST-CNRS** (F), **ENS-CNRS** (F), **INGV** (IT)

- Develop a Platform based on **virtualization & federation of satellite EO data and methods**
- Provide innovative responses to the **geohazards** community needs (services & support)

➔ **On-demand processing** services to address AOI-specific analysis

➔ **Systematic processing** services to address needs for “common information layers”

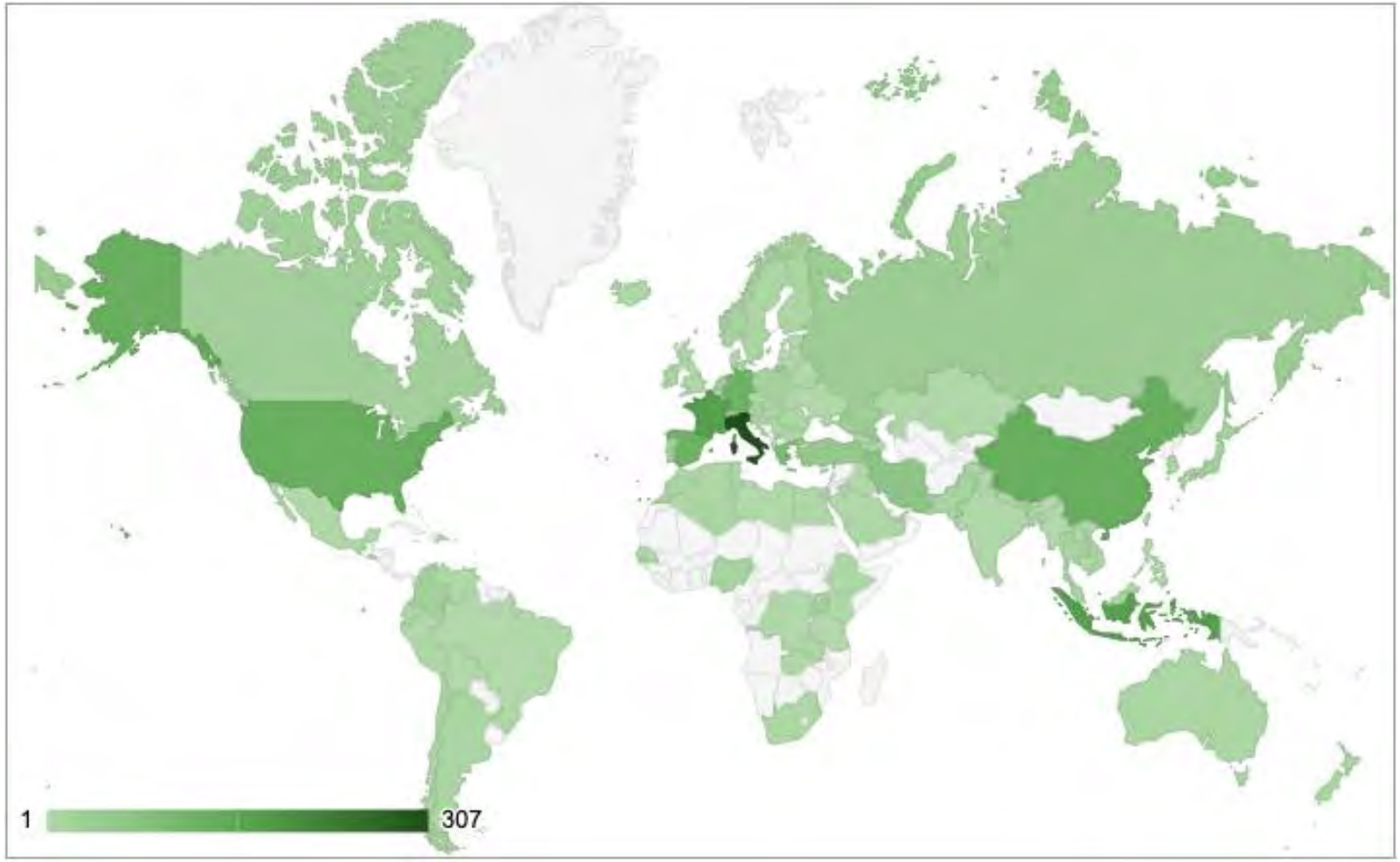
➔ **Massive Cloud Compute** power, managing multi-tenant resources

➔ **Access to Copernicus Sentinels-1/2/3 repositories**

➔ **Access to 70+ TB of EO data archives** (**ERS** and **ENVISAT**), and specific data collections from EO missions, such as JAXA’s **ALOS-2**, ASI’s **Cosmo-Skymed** and DLR’s **TerraSAR-X**, provided under special arrangements in the framework f the **CEOS WG Disaster** and the **GSNL**

GEP | Users Uptake (Geographic Locations)

Pre-Operations Reporting April 2021



#	Country	#users
1	Italy	307
2	France	169
3	Indonesia	167
4	United States	134
5	China	134
6	Spain	126
7	Germany	
8	United Kingdom	
9	India	
10	Greece	
11	Iran	
12	Switzerland	
13	Turkey	
14	Russia	
15	Canada	
16	Colombia	
17	Portugal	
18	Poland	
19	Netherlands	
20	Austria	
21	Japan	
22	Uganda	
23	Belgium	
24	Philippines	
25	Norway	
26	Thailand	
27	Pakistan	
28	Nigeria	
29	Morocco	
30	Mexico	
31	South Korea	
32	Brazil	
33	Chile	
34	Argentina	
35	United Arab Emirates	
36	Taiwan	
37	Romania	
38	Singapore	
39	Malaysia	

#	Country	#users
40	Algeria	10
41	Tunisia	9
42	Sweden	9
43	Australia	9
44	Luxembourg	8
45	Ireland	
46	Hungary	
47	Finland	
48	Vietnam	
49	Slovenia	
50	Peru'	
51	New Zealand	
52	Hong Kong	
53	Egypt	
54	Ecuador	
55	Nepal	
56	Czech Republic	
57	Cyprus	
58	Bangladesh	
59	South Africa	
60	Saudi Arabia	
61	Rwanda	
62	Perú	
63	Lebanon	
64	Kenya	
65	Kazakhstan	
66	Estonia	
67	Denmark	
68	Bulgaria	
69	Venezuela	
70	Ukraine	
71	Tanzania	
72	Sri Lanka	
73	Slovakia	
74	México	
75	Lithuania	
76	Israel	
77	India	

#	Country	#users
78	Iceland	2
79	Ethiopia	2
80	Dominica	2
81	Democratic Republic of the Congo	2
82	Czech Republik	2
83	Bolivia	2
84	Bhutan	2
85	Belarus	2
86	Zambia	1
87	Trinidad & Tobago	1
88	Swaziland	1
89	Serbia	1
90	Senegal	1
91	Republic of Kosovo	1
92	Qatar	1
93	Philippine	1
94	Peru	1
95	Malta	1
96	Lybia	1
97	Latvia	1
98	Laos	1
99	Kurdistan	1
100	Kenia	1
101	Guadalupe	1
102	Georgia	1
103	England	1
104	El Salvador	1
105	Dominican Republic	1
106	Danemark	1
107	Croatia	1
108	Cambodia	1
109	Brasil	1
110	Birmania	1
111	Bielorussia	1
112	Azerbaijan	1
113	Armenia	1
114	Albania	1
	Grand Total	**2298**

- The GEP has a total of **2298 registered users** from **114 countries** world wide

GEP | Advanced Users (Geographic Locations)

Pre-Operations Reporting April 2021

#	Countries	# of Users
1	Italy	55
2	France	40
3	Greece	39
4	Spain	34
5	United Kingdom	12
6	Uganda	11
7	Indonesia	11
8	Switzerland	10
9	United States	9
10	Germany	9
11	Turkey	6
12	South Korea	6
13	Thailand	5
14	Norway	4
15	India	4
16	Austria	4
17	Poland	3
18	China	3

The platform is also accessible via the **Network of Resources (NoR)** initiative

27	Sweden	1
28	Singapore	1
29	Rwanda	1
30	Portugal	1
31	New Zealand	1
35	Luxembourg	1
36	Lithuania	1
37	Hungary	1
38	Ethiopia	1
39	Ecuador	1
40	Denmark	1
41	Czech Republic	1
42	Cyprus	1
43	**Chile**	**1**
44	Brazil	1
45	Bhutan	1
46	Argentina	1
	Grand Total	**302**

- **302 users** (from **46 countries** and **134 organisations**) are carrying out **projects** on the platform with advanced access to GEP services

GEP Portal | Users visits and Geo-Distribution (Dec 2020)

GEP | Active Research Community

More than 8 papers based on GEP

results publish in high level peer-reviewed journals during last semester


COMMUNICATIONS EARTH&ENVIRONMENT

ARTICLE

OPEN

Surface rupture and shallow fault reactivation during the 2019 Mw 4.9 Le Teil earthquake, France

Jean-François Ritz, Stéphane Baize, Matthieu Ferry, Christophe Larroque, Laurence Audin, Bertrand Delouis & Emmanuel Mathot

The Rhône River Valley in France, a densely populated area with many industrial facilities including several nuclear power plants, was shaken on November 11th 2019, by the Mw 4.9 Le Teil earthquake. Here, we report field, seismological and interferometric synthetic-aperture radar observations indicating that the earthquake occurred at a very shallow focal depth on a southeast-dipping reverse-fault. We show evidence of surface rupture and up to 15 cm uplift of the hanging wall along a northeast-southwest trending discontinuity with a length of about 5 km. Together, these lines of evidence suggest that the Oligocene La Rouvière fault was reactivated. Based on the absence of geomorphic evidence of cumulative compressional deformation along the fault, we suggest that it had not ruptured for several thousand or even tens of thousands of years. Our observations raise the question of whether displacement from surface rupture represents a hazard in regions with strong tectonic inheritance and very low strain rates.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Article | Open Access | Published: 23 July 2020

Poorly known 2018 floods in Bosra UNESCO site and Sergiopolis in Syria unveiled from space using Sentinel-1/2 and COSMO-SkyMed

Deodato Tapete & Francesca Cigna

Scientific Reports 10, Article number: 12307 (2020) | Cite this article

881 Accesses | 2 Citations | 9 Altmetric | Metrics

Abstract

The instability situation affecting the Middle East poses threats to preservation of cultural


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Volume 223, Issue 2
November 2020

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Rupture kinematics of 2020 January 24 M_w 6.7 Doğanyol–Sivrice, Turkey earthquake on the East Anatolian Fault Zone imaged by space geodesy

Diego Melgar, Athanassios Ganas, Tuncay Taymaz, Sotiris Valkaniotis, Brendan W Crowell, Vasilis Kapetanidis, Varvara Tsironi, Seda Yolsal-Çevikbilen, Taylan Öcalan

Geophysical Journal International, Volume 223, Issue 2, November 2020, Pages 862–874, https://doi.org/10.1093/gji/ggaa345

Published: 16 July 2020 **Article history**


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Article | Open Access | Published: 04 June 2020

Sentinel optical and SAR data highlights multi-segment faulting during the 2018 Palu-Sulawesi earthquake (M_w 7.5)

Guillaume Bacques, Marcello de Michele, Michael Foumelis, Daniel Raucoules, Anne Lemoine & Pierre Briole

Scientific Reports 10, Article number: 9103 (2020) | Cite this article

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remote sensing

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Using Growing-Season Time Series Coherence for Improved Peatland Mapping: Comparing the Contributions of Sentinel-1 and RADARSAT-2 Coherence in Full and Partial Time Series

by Koreen Millard, Patrick Kirby, Sachi Nanilah, Amir Behnamian, Sarah Banks and Fabrizio Pacini

Department of Geography and Environmental Studies, Carleton University, Ottawa, ON K1S 5B6, Canada

Landscape Science and Technology Division, Environment and Climate Change Canada, Ottawa, ON K1S 5B6, Canada

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Remote Sens. 2020, 12(15), 2465; https://doi.org/10.3390/rs12152465

Received: 25 June 2020 / Revised: 27 July 2020 / Accepted: 29 July 2020 / Published: 31 July 2020

(This article belongs to the Collection Feature Papers for Section Environmental Remote Sensing)

Copernicus Sentinel-1, Sentinel-2, Sentinel-3 and US Landsat-8 data available globally

Via the GEP Data Agency Catalogue, the Platform currently makes available for processing the **global coverage** of the following data collections:

- **Sentinel-1A/B:** (RAW, SLC, GRD and OCN) synchronized* with the Copernicus Open Access Hub
- **Sentinel-2:** (MSI L1C) synchronized* with the Copernicus Open Access Hub
- **Sentinel-3:** (OLCI, SLSTR) synchronized* with the Copernicus Pre-Operations Data Hub
- **Landsat-8:** (OLI and TIRS) synchronized* with the USGS EarthExplorer

GEP is primarily focusing on InSAR and Optical processing with Sentinel-1 and Sentinel-2

* *metadata*: complete catalogues published in NRT.
data: different solutions according to use case incl. co-located data & processing, on-demand data fetching, caching, etc.

GEP | Other EO Resources

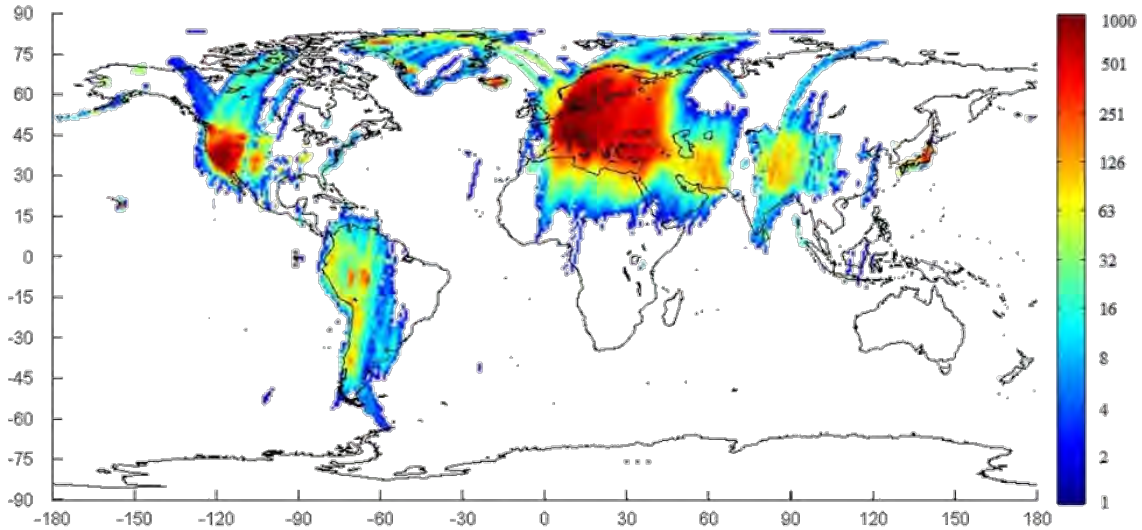
GEP has taken commitments about data access as per some recommendations associated to Fringe workshop

- The GEP provides on line access to ESA heritage EO missions data:
  - **ERS (SAR IM Level-0)**
  - **ENVISAT (ASAR IM Level-0)**
- Global coverage synchronized with the ESA OADS (70+ terabytes)

Through agreements with CEOS partners and project partners (CEOS Pilots and Geohazards Supersites), limited private collections of the following missions are made available for processing & download:

- **ALOS-2**
- **TerraSAR-X**
- **COSMO SkyMed**
- **RADARSAT-2**

Spatial density of ERS & ENVISAT Level-0 data available as of December 2017

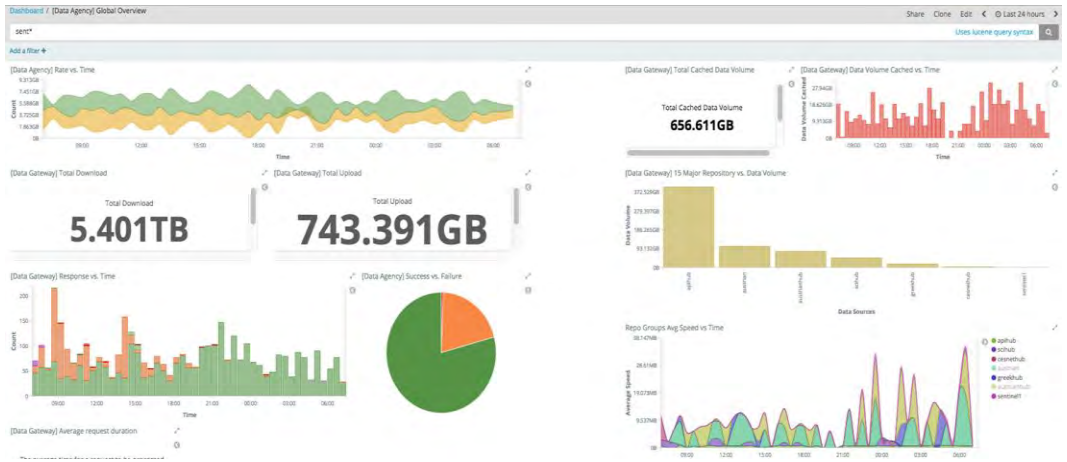


GEP | Cloud Platform - Data

Enhanced Data Gateway using OpenSearch

- Automatic multi-sourcing to optimise data access
- Programmable and systematic data caching
- Data usage accounting
- Personal cloud storage (repository)

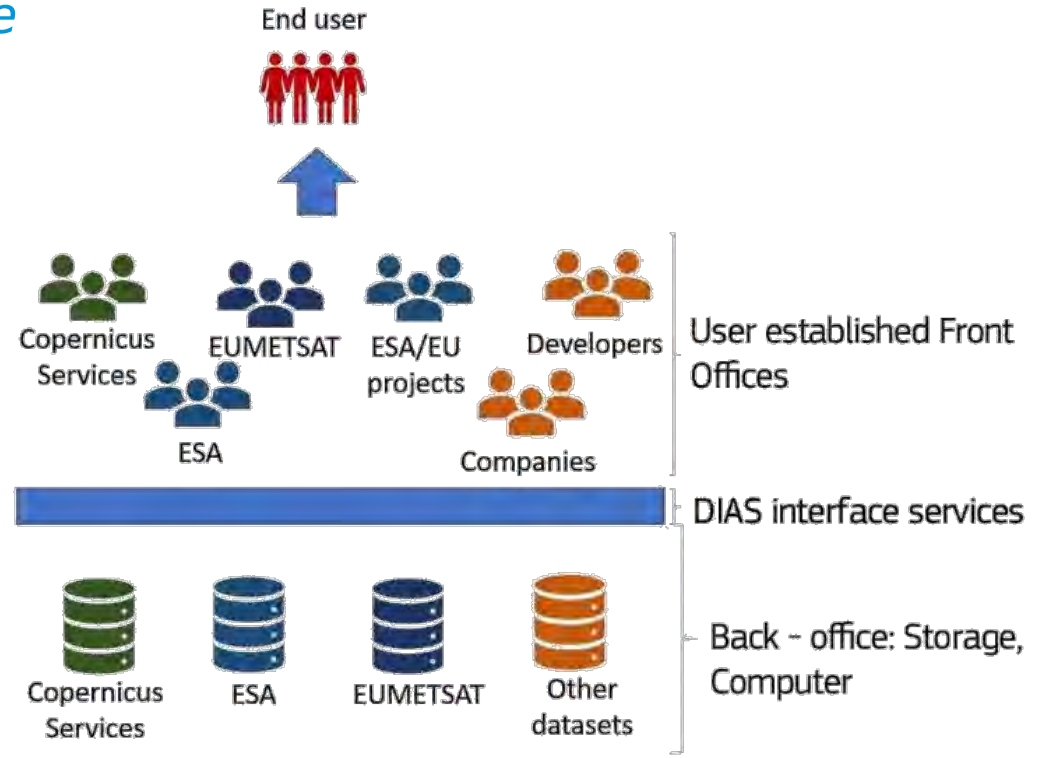
Daily figures



Supported Data Providers

Copernicus Data and Information Access Services | DIAS

The European Commission (EC) has launched an initiative to develop Copernicus Data and Information Access Services (DIAS) that facilitate access to Copernicus data and information from the Copernicus services.



By providing data and information access alongside processing resources, tools and other relevant data, this initiative is expected to boost user uptake, stimulate innovation and the creation of new business models based on Earth Observation data and information.

GEP | Cloud Platform - Computing

Continuous Integration and Deployment Environment with automatic packaging & deployment in production environments

Improved Production Center, with (auto)scalability allowing cost-effective data processing on Cloud Computing

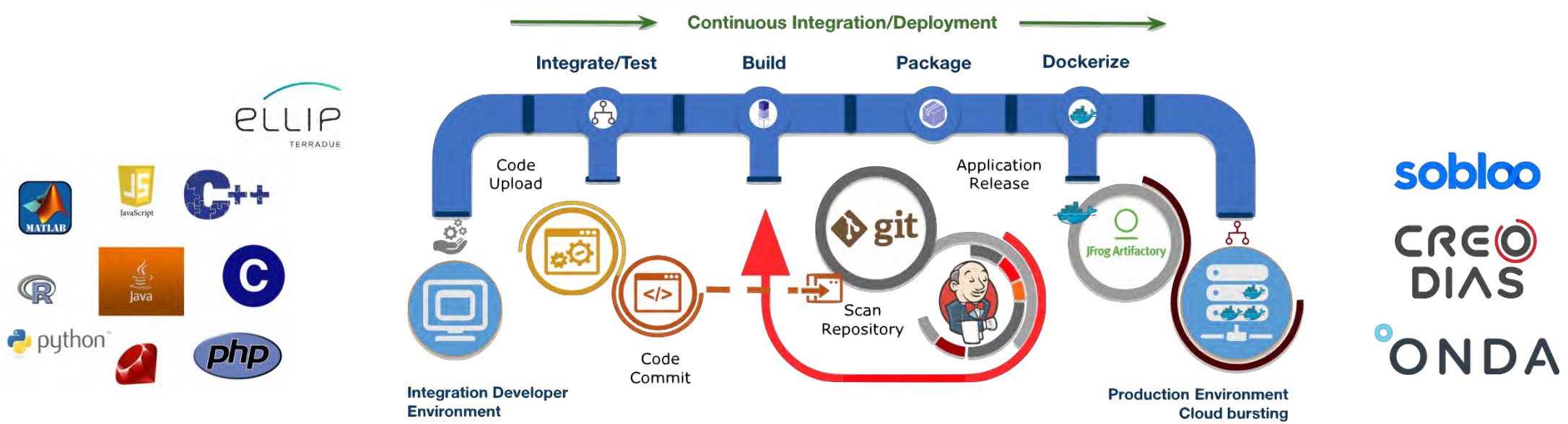
Deployment in multiple Cloud-based processing environments with no lock-in on a Cloud provider

GEP | Application Integration

Applications developed in any programming language supported

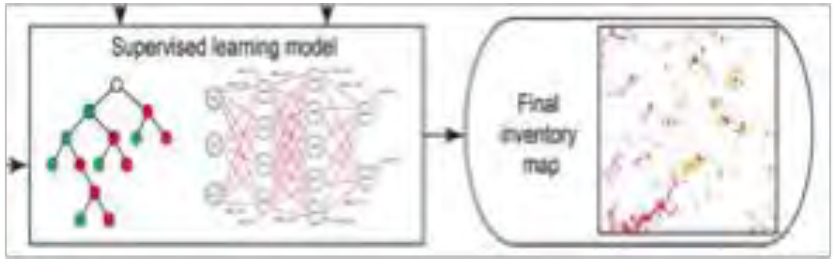
C/C++, Java, Python, Matlab and IDL

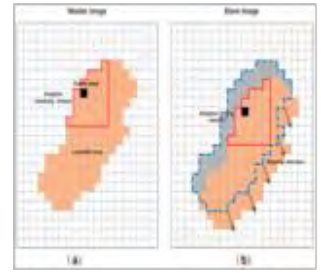
Continuous Integration and Deployment Environment with automatic packaging and deployment in production environments

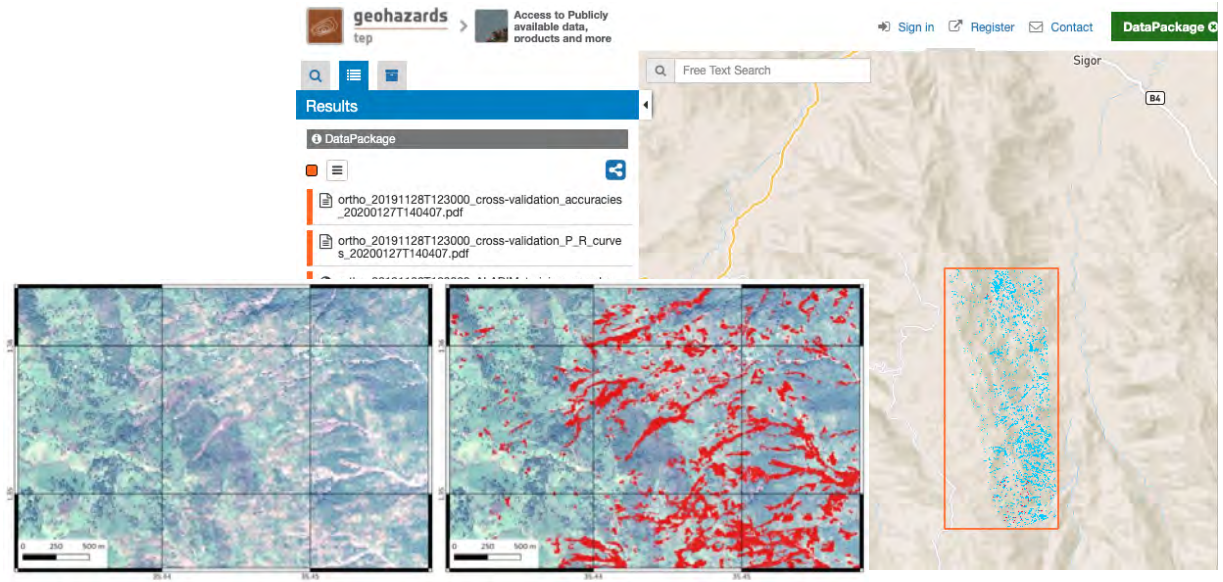


GEP | Algorithm Hosting

- CNRS-EOST Strasbourg developed 3 services for landslide monitoring using Sentinel-2 and Pléiades data measuring:
  - Earth surface deformation
  - Digital surface Model
  - Automatic landslide detection based on Machine Learning

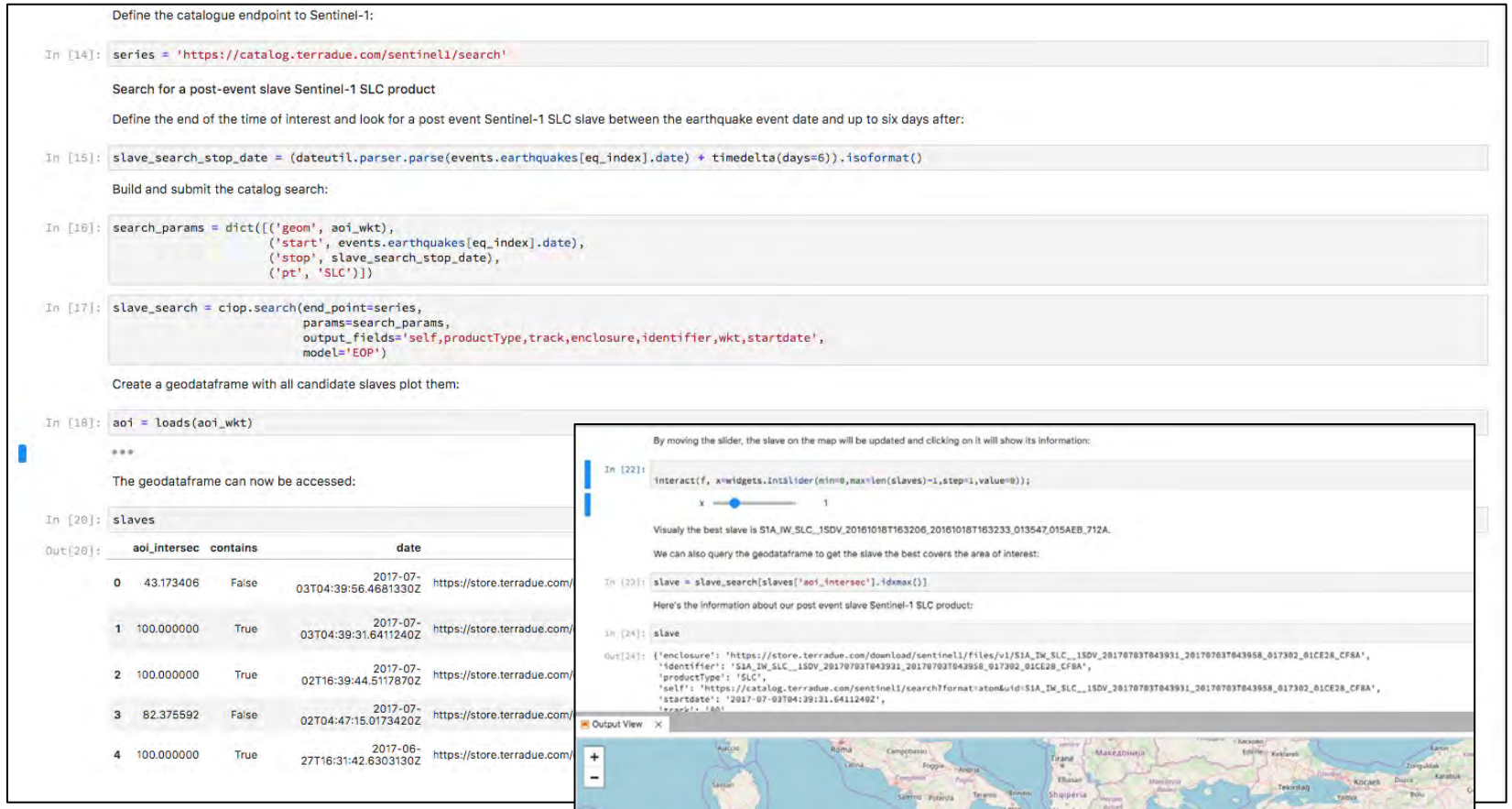






GEP | Data Exploitation: Target Reproducibility

- Exploring the Earth Observation Catalogues from a Jupyter Notebook accessing open APIs
- Analyse results as data structures
- Interactive processing and post-processing services enabling users to exploit and share the processing results



Define the catalogue endpoint to Sentinel-1:

```
In [14]: series = 'https://catalog.terradue.com/sentinel1/search'
```

Search for a post-event slave Sentinel-1 SLC product

Define the end of the time of interest and look for a post event Sentinel-1 SLC slave between the earthquake event date and up to six days after:

```
In [15]: slave_search_stop_date = (dateutil.parser.parse(events.earthquakes[eq_index].date) + timedelta(days=6)).isoformat()
```

Build and submit the catalog search:

```
In [16]: search_params = dict([('geom', aoi_wkt),
                               ('start', events.earthquakes[eq_index].date),
                               ('stop', slave_search_stop_date),
                               ('pt', 'SLC')])

In [17]: slave_search = ciop.search(end_point=series,
                                    params=search_params,
                                    output_fields='self,productType,track,enclosure,identifier,wkt,startdate',
                                    model='EOP')
```

Create a geodataframe with all candidate slaves plot them:

```
In [18]: aoi = loads(aoi_wkt)
```

***

The geodataframe can now be accessed:

```
In [20]: slaves
```

Out[20]:

	aoi_intersec	contains	date	
0	43.173406	False	2017-07-03T04:39:56.4681330Z	https://store.terradue.com/
1	100.000000	True	2017-07-03T04:39:31.6411240Z	https://store.terradue.com/
2	100.000000	True	2017-07-02T16:39:44.5117870Z	https://store.terradue.com/
3	82.375592	False	2017-07-02T04:47:15.0173420Z	https://store.terradue.com/
4	100.000000	True	2017-06-27T16:31:42.6303130Z	https://store.terradue.com/

By moving the slider, the slave on the map will be updated and clicking on it will show its information:

```
In [22]: interact(f, x=widgets.IntSlider(min=0,max=len(slaves)-1,step=1,value=0));
```

x 1

Visualy the best slave is S1A_IW_SLC__1SDV_20161018T163206_20161018T163233_013547_015AEB_712A.

We can also query the geodataframe to get the slave the best covers the area of interest:

```
In [23]: slave = slave_search[slaves['aoi_intersec'].idxmax()]
```

Here's the information about our post event slave Sentinel-1 SLC product:

```
In [24]: slave
```

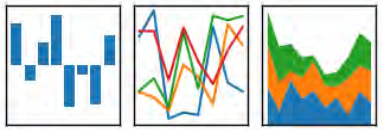
Out[24]:

```
{'enclosure': 'https://store.terradue.com/download/sentinel1/files/v1/S1A_IW_SLC__1SDV_20170703T043931_20170703T043958_017302_01CE28_CF8A',
 'identifier': 'S1A_IW_SLC__1SDV_20170703T043931_20170703T043958_017302_01CE28_CF8A',
 'productType': 'SLC',
 'self': 'https://catalog.terradue.com/sentinel1/search?format=atom&uid=S1A_IW_SLC__1SDV_20170703T043931_20170703T043958_017302_01CE28_CF8A',
 'startdate': '2017-07-03T04:39:31.6411240Z',
```

Output View

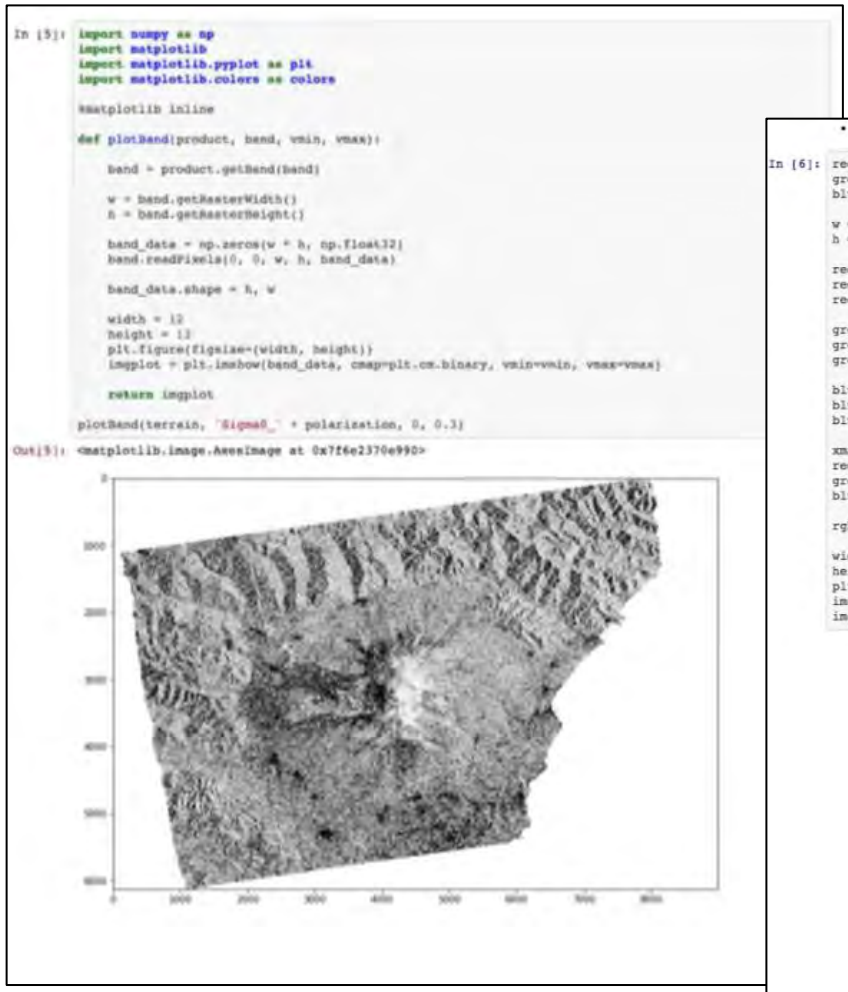
pandas

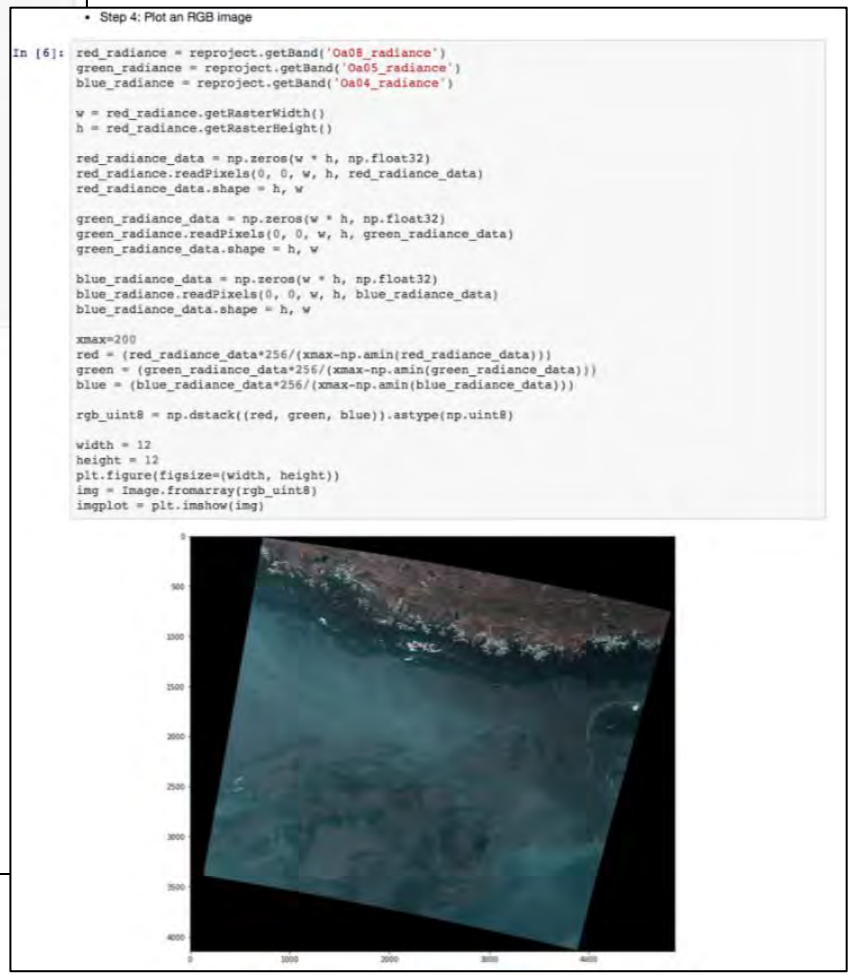
$$y_{it} = \beta' x_{it} + \mu_i + \epsilon_{it}$$



GEP | Data Exploitation: Access to EO Products

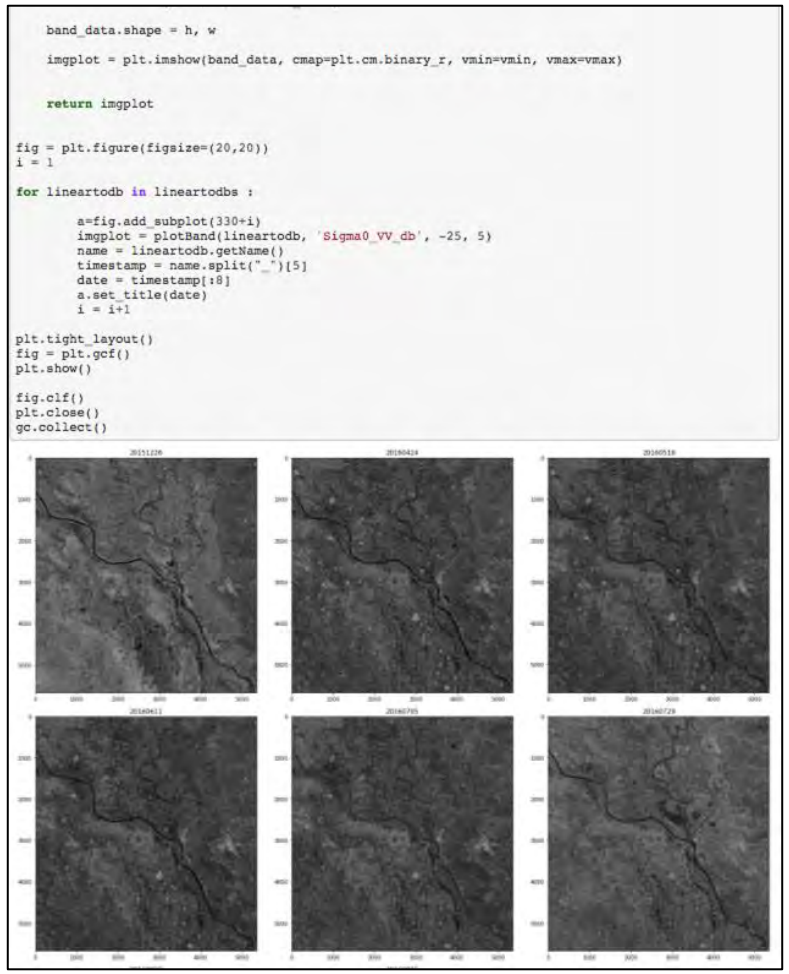
Notebooks documenting how to plot and analyse Sentinel data



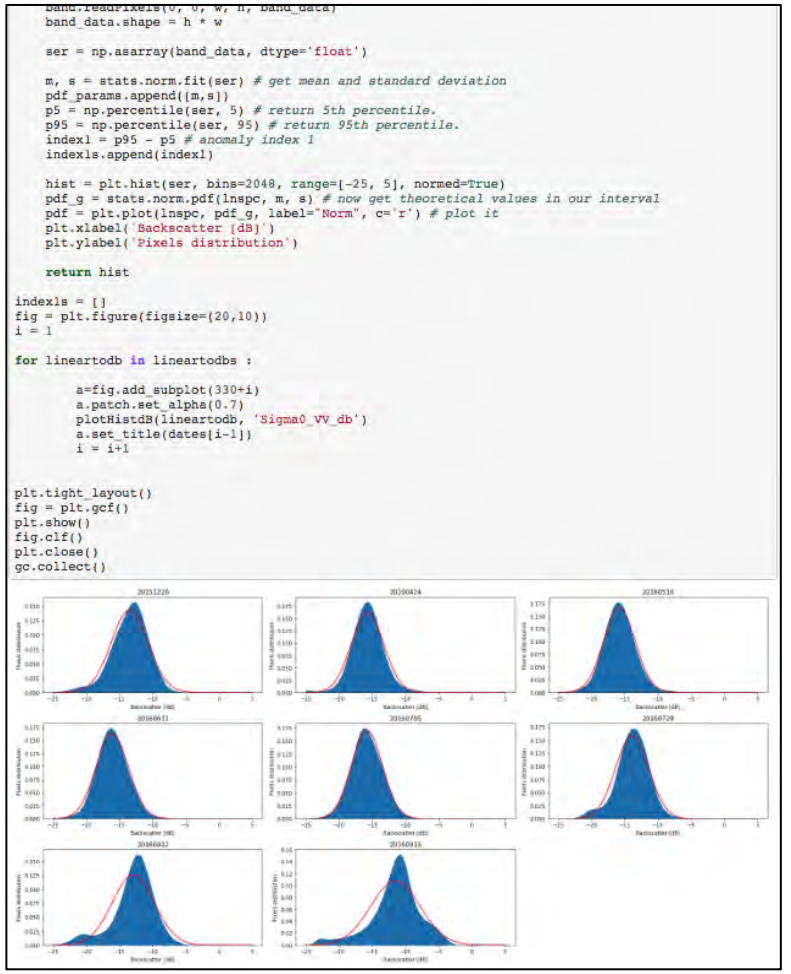


GEP | Data Exploitation: Time Series Analysis

- Notebook analysis of a stack of Sentinel-1 data
- Backscatter profiles for reference image used in flood analysis



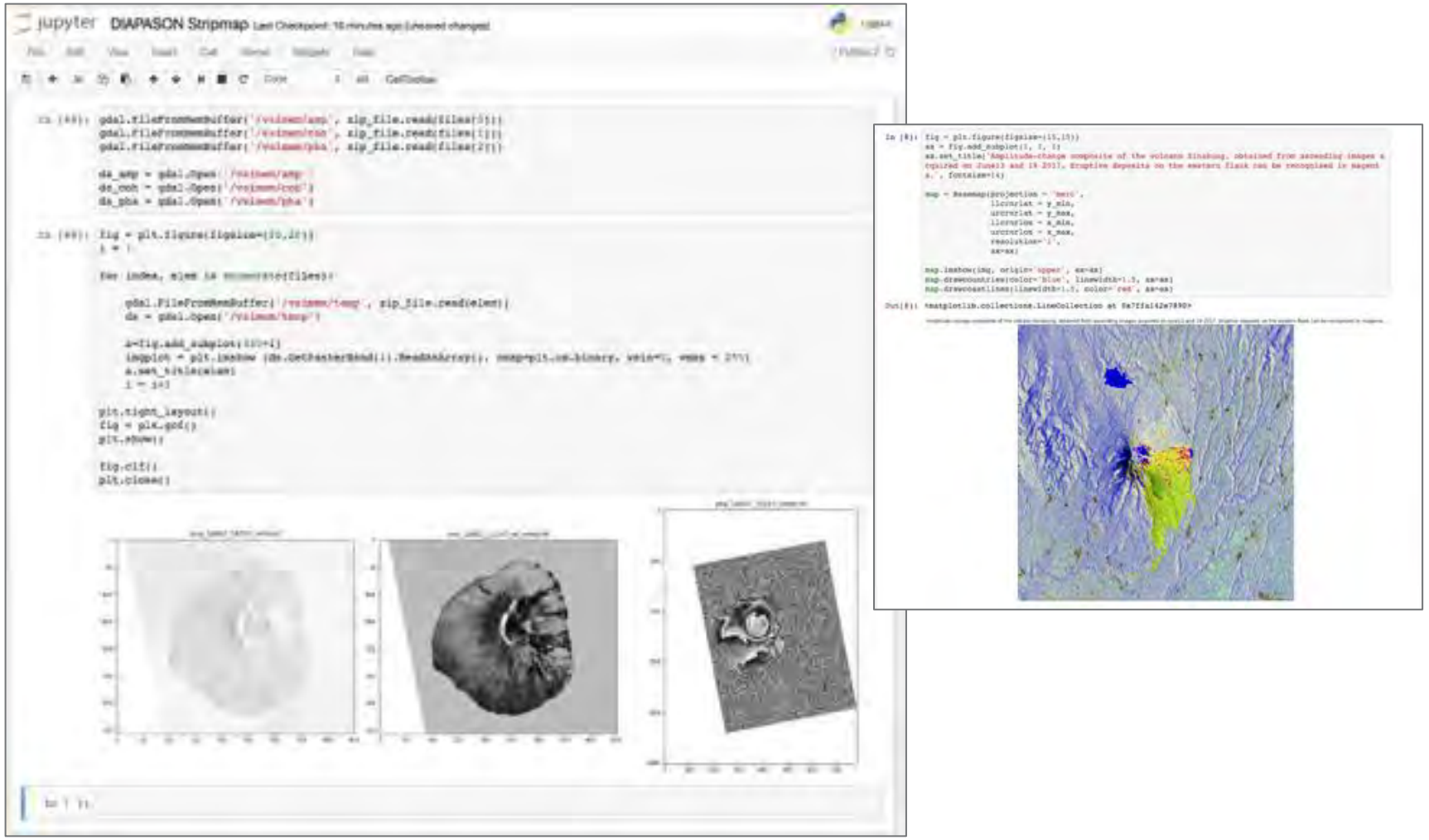
```
    band_data.shape = h, w

    imgplot = plt.imshow(band_data, cmap=plt.cm.binary_r, vmin=vmin, vmax=vmax)


    return imgplot


fig = plt.figure(figsize=(20,20))
i = 1

for lineartodb in lineartodbs :

        a=fig.add_subplot(330+i)
        imgplot = plotBand(lineartodb, 'Sigma0_VV_db', -25, 5)
        name = lineartodb.getName()
        timestamp = name.split("_")[5]
        date = timestamp[:8]
        a.set_title(date)
        i = i+1

plt.tight_layout()
fig = plt.gcf()
plt.show()

fig.clf()
plt.close()
gc.collect()
```



```
    band_data.shape = h * w

    ser = np.asarray(band_data, dtype='float')

    m, s = stats.norm.fit(ser) # get mean and standard deviation
    pdf_params.append([m,s])
    p5 = np.percentile(ser, 5) # return 5th percentile.
    p95 = np.percentile(ser, 95) # return 95th percentile.
    index1 = p95 - p5 # anomaly index 1
    index1s.append(index1)

    hist = plt.hist(ser, bins=2048, range=[-25, 5], normed=True)
    pdf_g = stats.norm.pdf(lnspc, m, s) # now get theoretical values in our interval
    pdf = plt.plot(lnspc, pdf_g, label="Norm", c='r') # plot it
    plt.xlabel('Backscatter [dB]')
    plt.ylabel('Pixels distribution')

    return hist

index1s = []
fig = plt.figure(figsize=(20,10))
i = 1

for lineartodb in lineartodbs :

        a=fig.add_subplot(330+i)
        a.patch.set_alpha(0.7)
        plotHistdB(lineartodb, 'Sigma0_VV_db')
        a.set_title(dates[i-1])
        i = i+1


plt.tight_layout()
fig = plt.gcf()
plt.show()
fig.clf()
plt.close()
gc.collect()
```

GEP | Data Exploitation: Invoking Services

- Invoking GEP services from a notebook
- GEP Processing Service over active volcano (Fogo) through a OGC API



GEP | New Initiatives / Projects

Extend and diversify sources of funding through new stakeholders, by providing access to services in support of:

- The **International Charter**: Space and Major Disasters
- **EPOS**: Satellite Data Thematic Core Service
- **Alpine Region**: Landslide Geo-Information Services (EO4Alps)
- World Bank Landslide Hazard Inf. System for Disaster Risk Financing
- Indonesian government: capacity building on hazard & risk mapping (via ESA & Asian Development Bank collaboration agreement)
- Various training programmes organised with partner organisations such as IGME, INDRA, IGN, BRGM and AUTh; for training classes in Indonesia, Greece, Germany, UAE, Spain, Switzerland...

GEP | Services Offering

- Copernicus Sentinel EO missions complemented by commercial High Resolution Optical & Radar missions and geohazards community derived products
- The deployment of processing services relies on several Copernicus DIAS and Cloud providers, in a constant search of optimization of the overall costs
- Publicly available price-list
  - GEP Service packs onboarded on the NoR marketplace

https://nor.cloudeo.group/geohazards-tep-gep-operational-algorithm-hosting

GEP | Services Offering

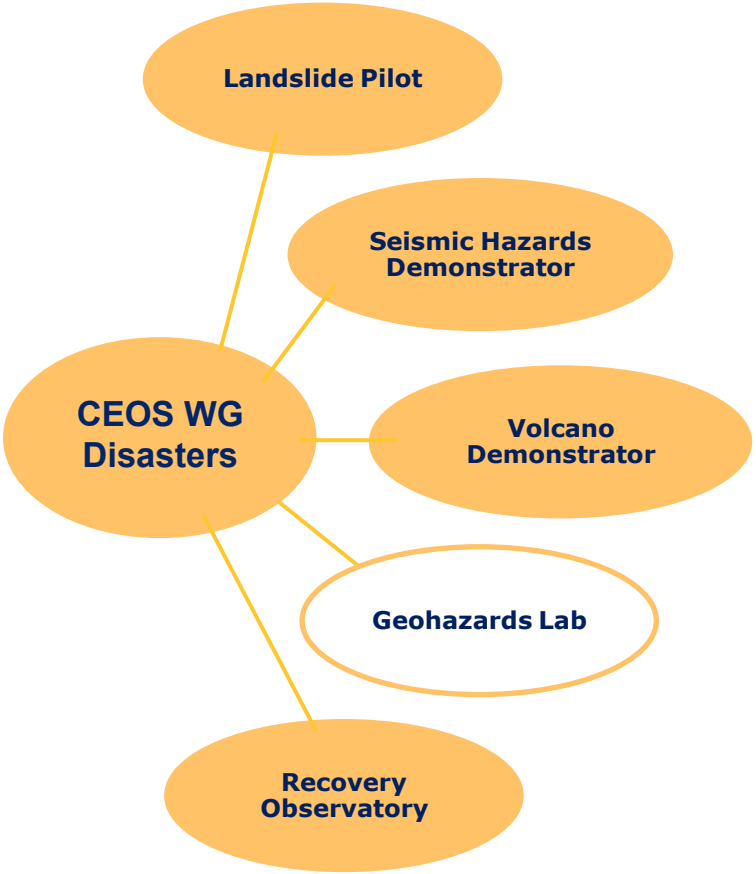
- The hosted EO services on GEP are provided either on a pay per use basis or via subscription
  - These services encompass on-demand and systematic generation and delivery of Value Added products, as well as the ability for expert users to integrate customized EO services.
- The service production cost is based on tailored components including
  - Cost for EO data (when licensed, commercial data are used),
  - Cloud processing resources
  - Support from VA service owners (including license fees when relevant) and the cost for the Platform operations

GEP | Target Users

- Privileged channel for subscribers to the GEP Services to renew their subscriptions, or newcomers to engage with us
  - Geohazards analyst (i.e. principal investigator, researcher, scientific engineer, PhD student, trainee) interested in data processing
  - A service or data provider interested to connect resources for their use via the Platform,
  - An organization interested in receiving training in specific topics
- GEP is ready to help you in leveraging ESA and European Union initiatives for requesting sponsorship (vouchers) for your forthcoming GEP activities (http://bit.ly/GEP-NoR)

CEOS Working Group Disasters | Geohazards Lab

The **CEOS WG Disasters** aims to **increase and strengthen satellite Earth observation contributions to the various Disaster Risk Management (DRM) phases** and to **inform decision-makers and major stakeholders on the benefits of using satellite Earth Observations** in each of those phases.



Geohazards Lab: *An initiative within WG Disasters*

A platform with federated resources to provide data access and an online processing and e-collaboration environment to exploit EO data to assess geohazards and their impact

- ✓ Supports and complements the **CEOS WG Disasters activities** (on-going pilots, follow-on activities and the RO), **GSNL**, **GEODARMA** and users from the broader geohazards community.
- ✓ Maximize use of EO techniques and cloud processing by the EO expert community
- ✓ Achieve acceptance of EO products by the non-EO scientific community and decision makers

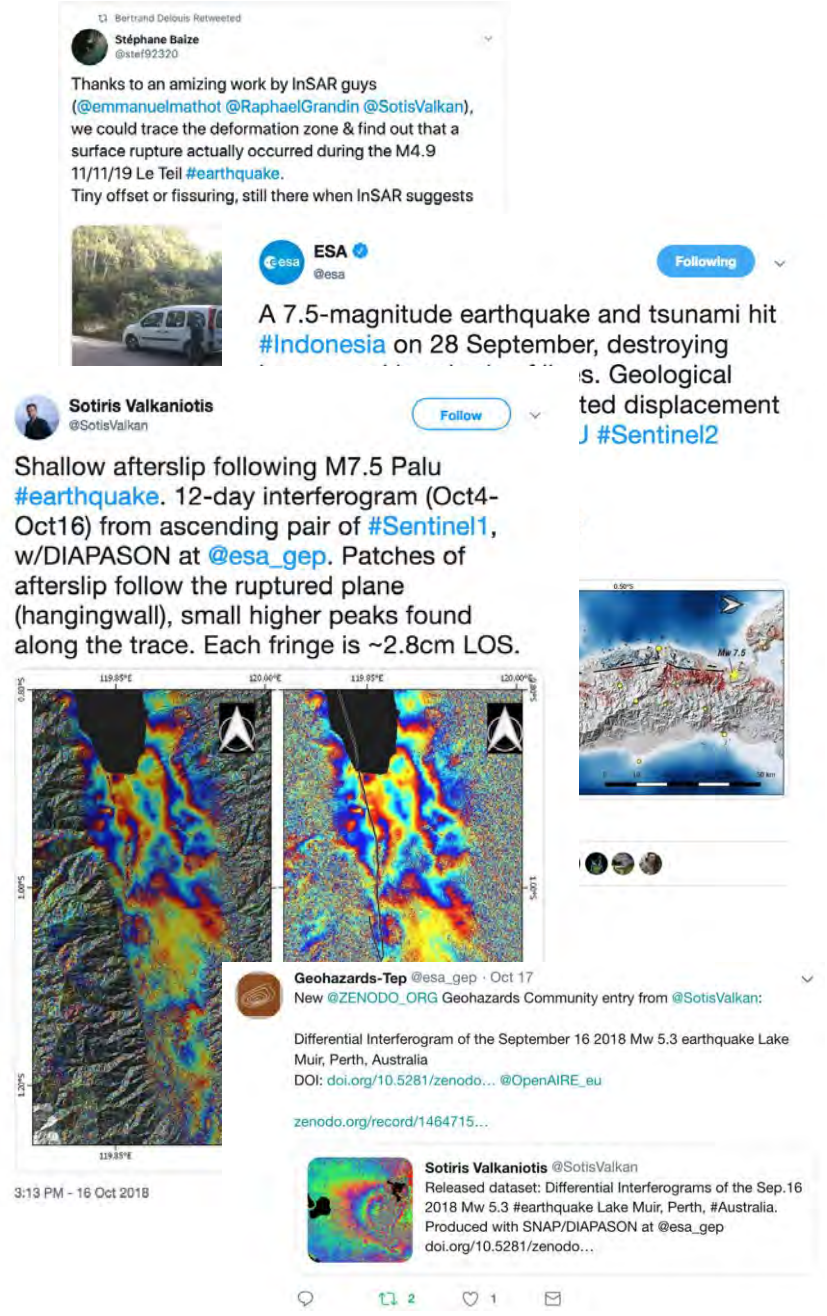
Geohazards Lab - Take-home Messages

Benefit from **fast access** to EO data, **storage** capacity and **processing** resources offered by platform-based solutions

A hosted processing platform is a **partnership** that needs the support of scientist/developer to offer operational services providing value added information to the community

Platform **e-collaboration** and **reproducible knowledge** promote innovation and response capacity

Communities remain owners of their created assets, and decide how to share these on the platforms



GEP On-Demand and Systematic Services

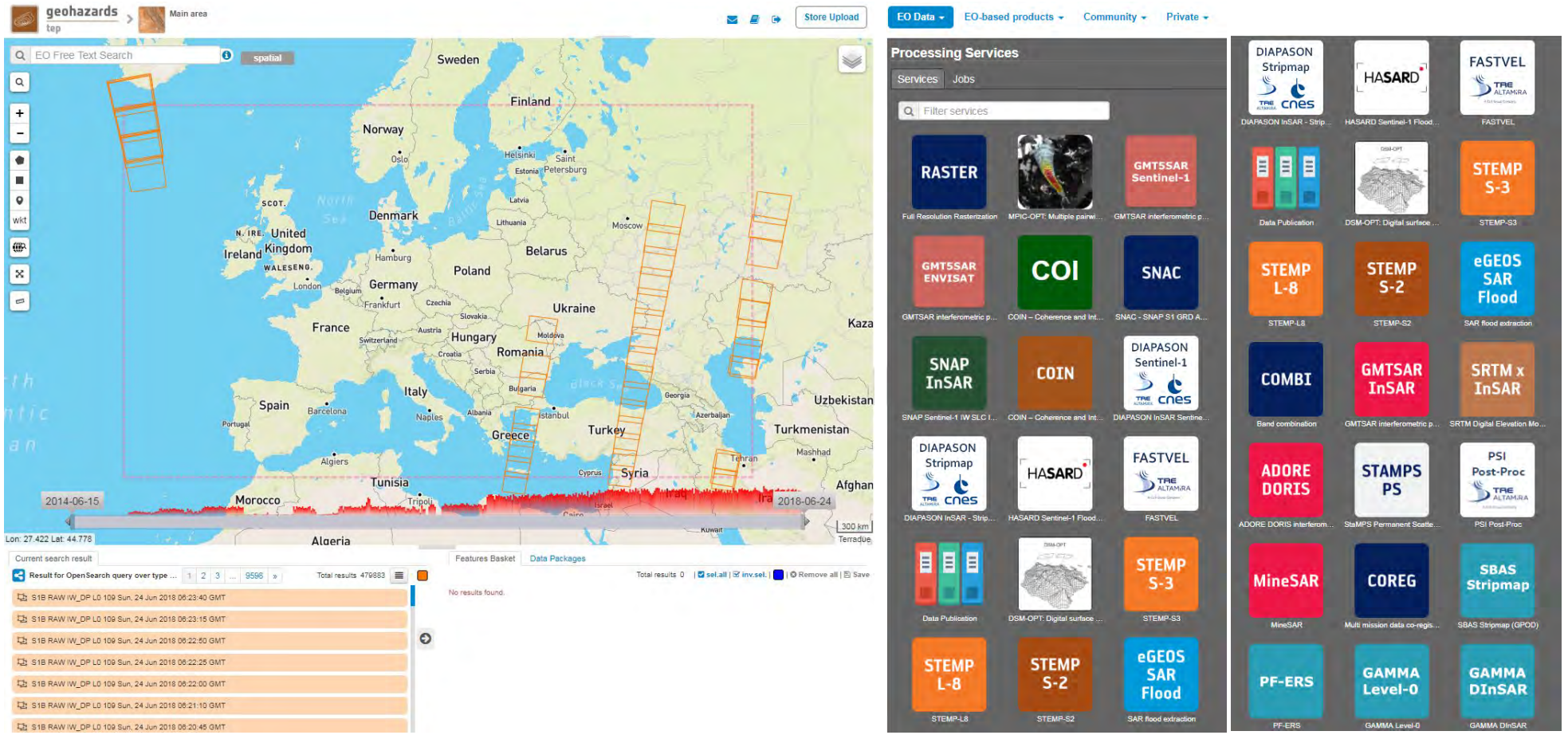
TAT | June 2021

Michael Foumelis | Aristotle University of Thessaloniki (AUTh)
Fabrizio Pacini | Terradue s.r.l.

Geohazards Services Portfolio

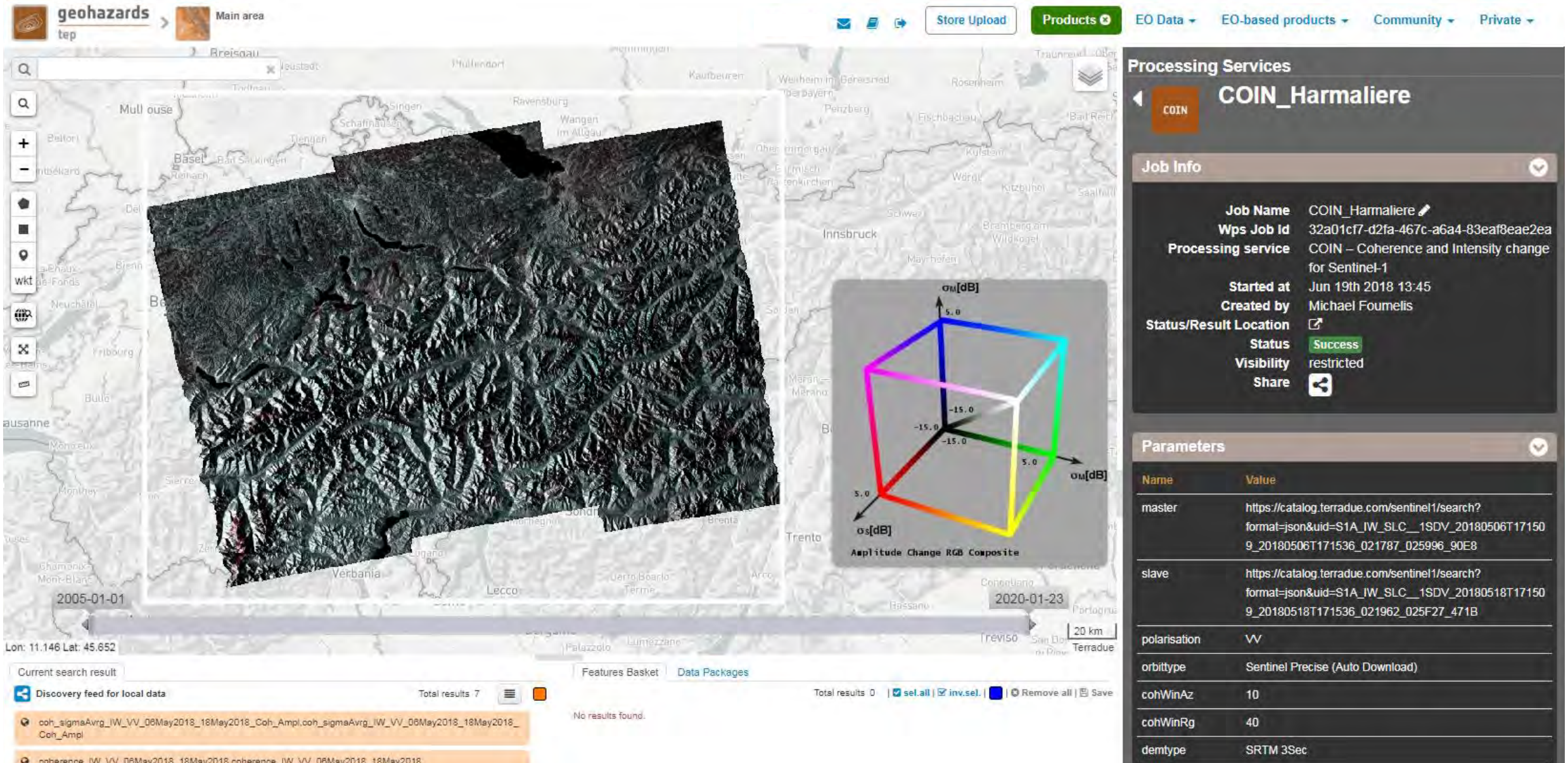
- **25+ on-demand services** using Optical & SAR data grouped in Thematic Apps organized by Community Managers
- New basic services providing full resolution, band combinations and change detection imagery for rapid **online visualization**
- **Systematic and event-triggered** services delivering continuously updated information
- Service Portfolio to grow with new Initiatives and Projects
  - World Bank Landslide Hazard Inf. System for Disaster Risk Financing
  - EO4Alps Landslide Geo-Information Services for the Alps
  - Disasters Charter Processing Environment

GEP | Hosted Processing Services

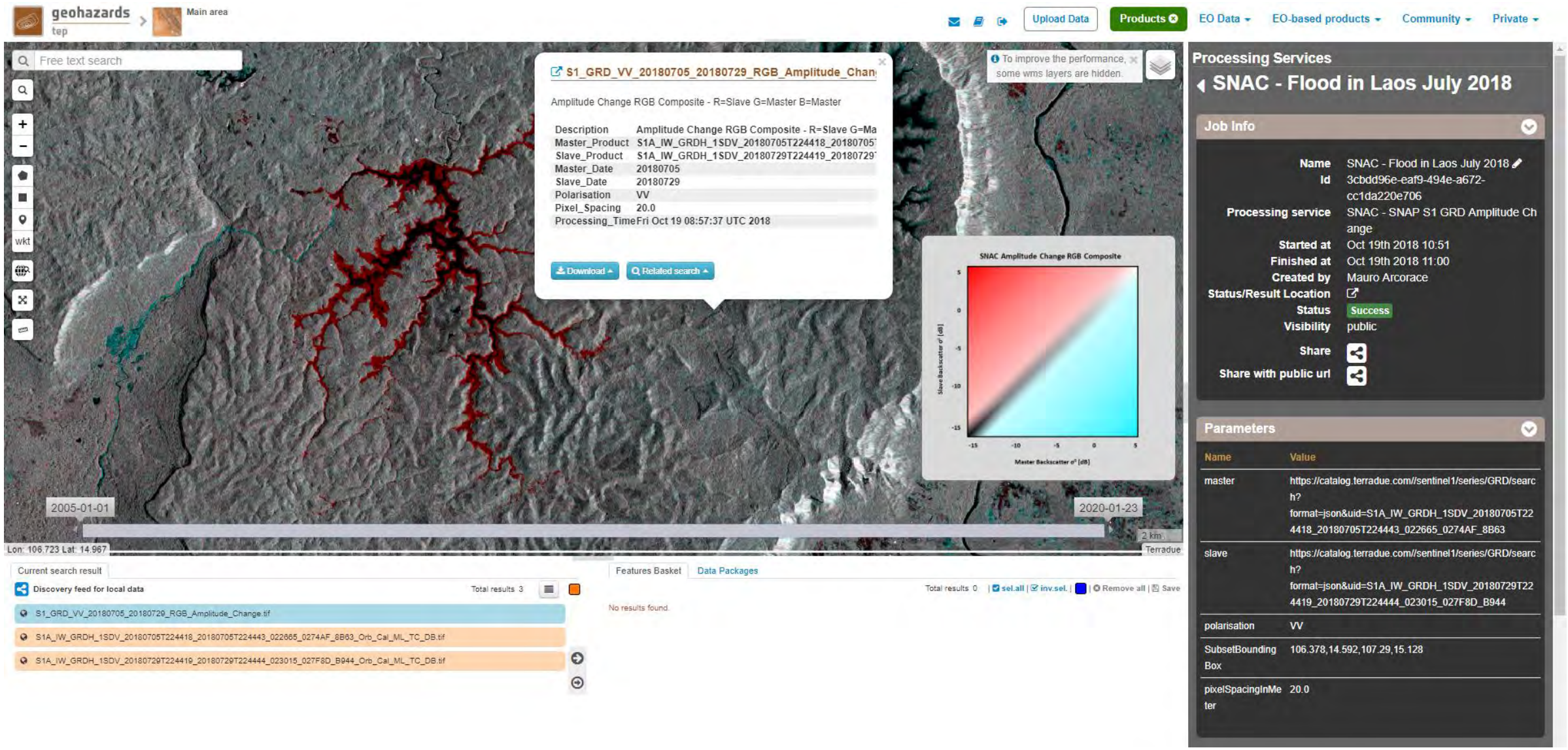


The platform is continuously expanding including a broad range of on-demand and systematic products and services, to support EO practitioners and end-users to better understand geohazards and their impact [10.1109/IGARSS.2019.8898304].

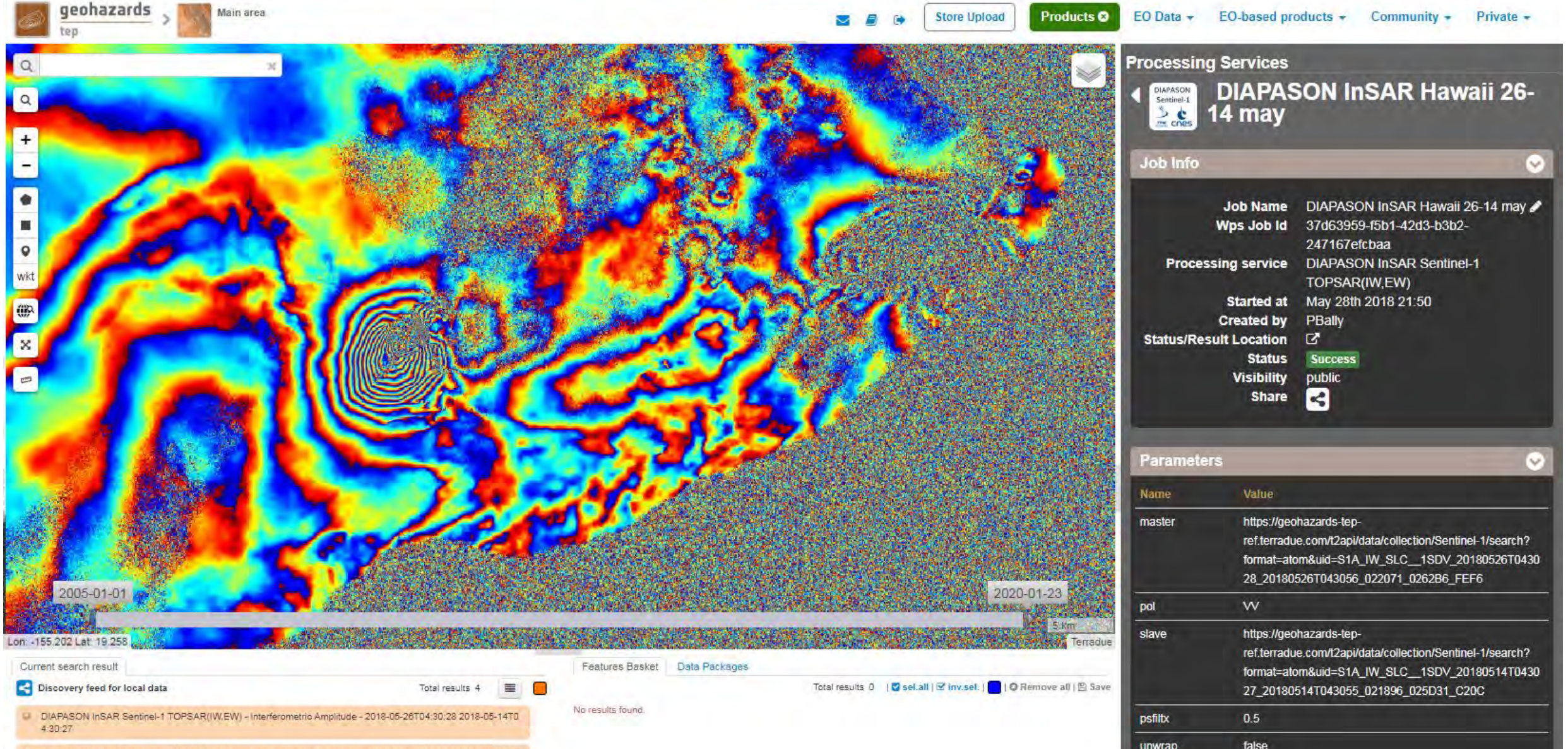
Examples of GEP Services | COIN (Alps region)



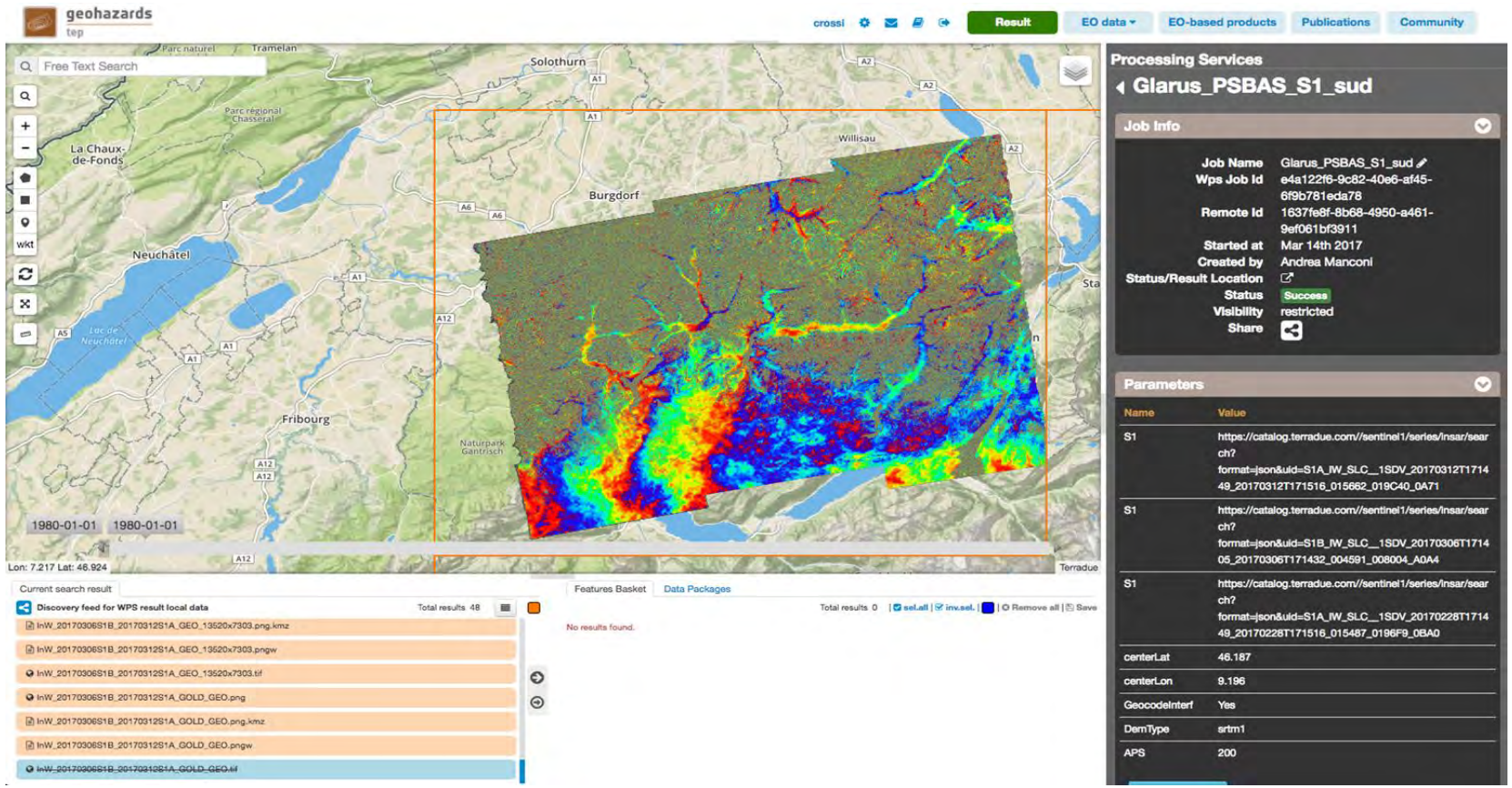
Examples of GEP Services | SNAC (Floods in Laos)



Examples of GEP Services | DIAPASON (Kilauea Eruption)



GEP | P-SBAS On-demand Processing Service



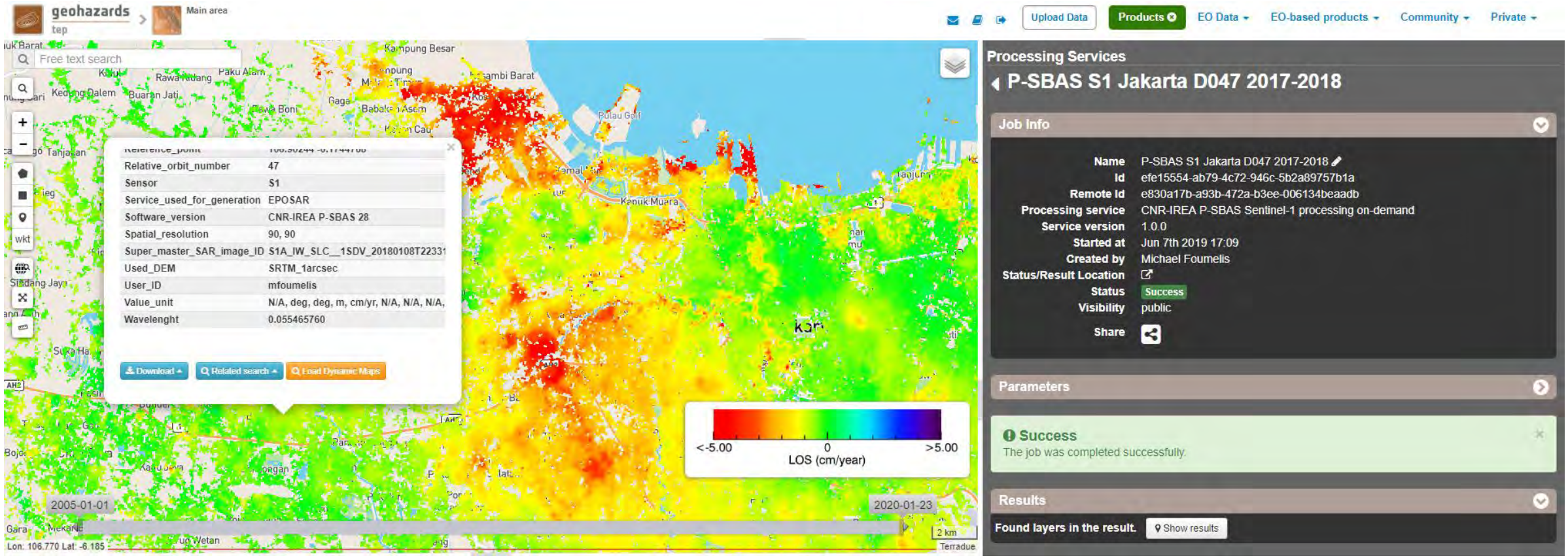
https://geohazards-tep.eu

Will be supported by BELNET-BEGRID (Belgium)

CNR-IREA P-SBAS Sentinel-1 processing on-demand

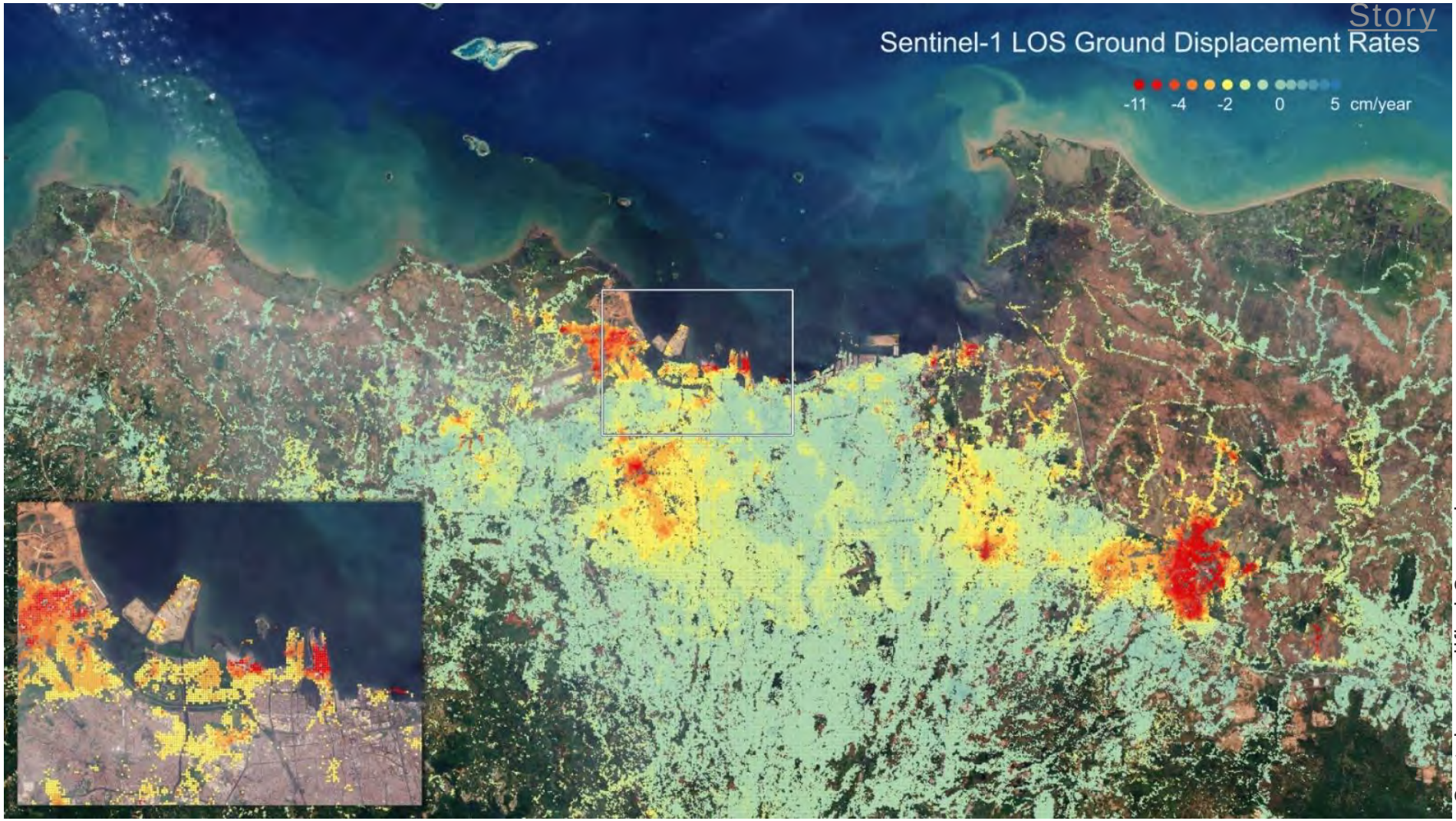
P-SBAS stands for Parallel Small BAseline Subset and it is a DInSAR processing chain for the generation of Earth deformation time series and mean velocity maps. Input: SLC (Level-1) Sentinel-1 data.

GEP | P-SBAS Subsidence in Jakarta



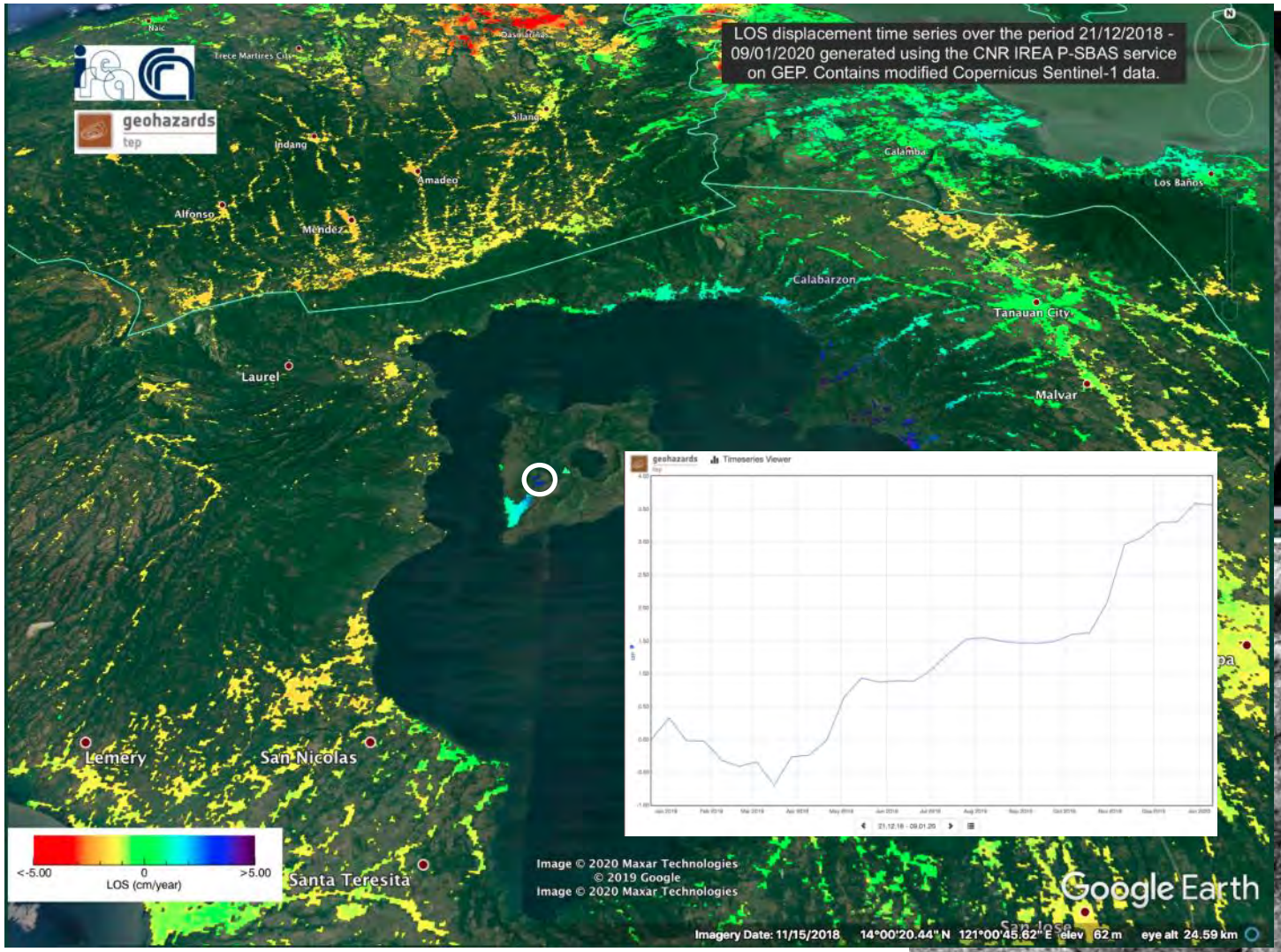
Using Satellite Information to Help Rebuild After a Disaster

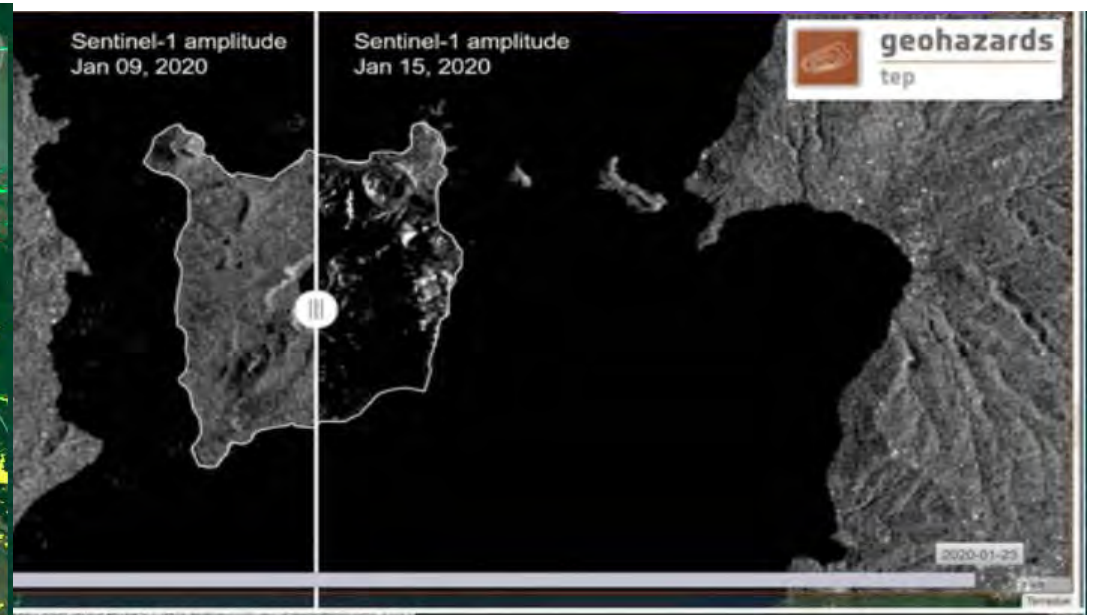
ESA Web Story

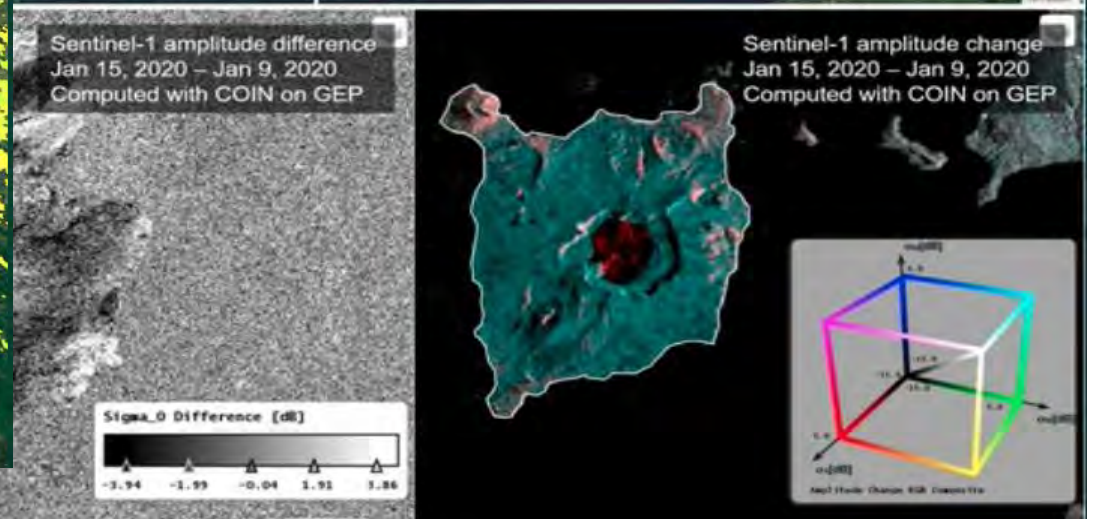


Contains modified Copernicus Sentinel-1 data (2015-2020), processed by BRGM via GEP

GEP | P-SBAS Taal Volcano (Philippines)







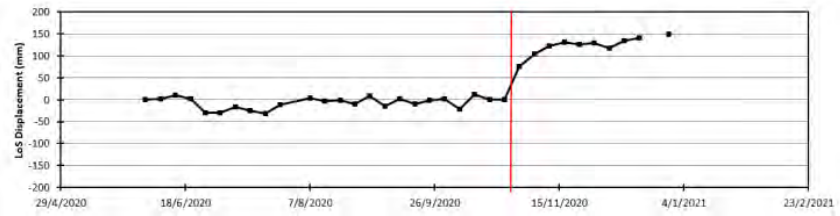
SNAPPING | Surface motioN mAPPING service

by AUTh, MJaen & Terradue

SNAPPING
SURFACE MOTION MAPPING

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

Samos (Greece) M7.0 2020 Earthquake



A two step process:

SNAPPING IFG

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

SNAPPING PSI

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

geohazards tep

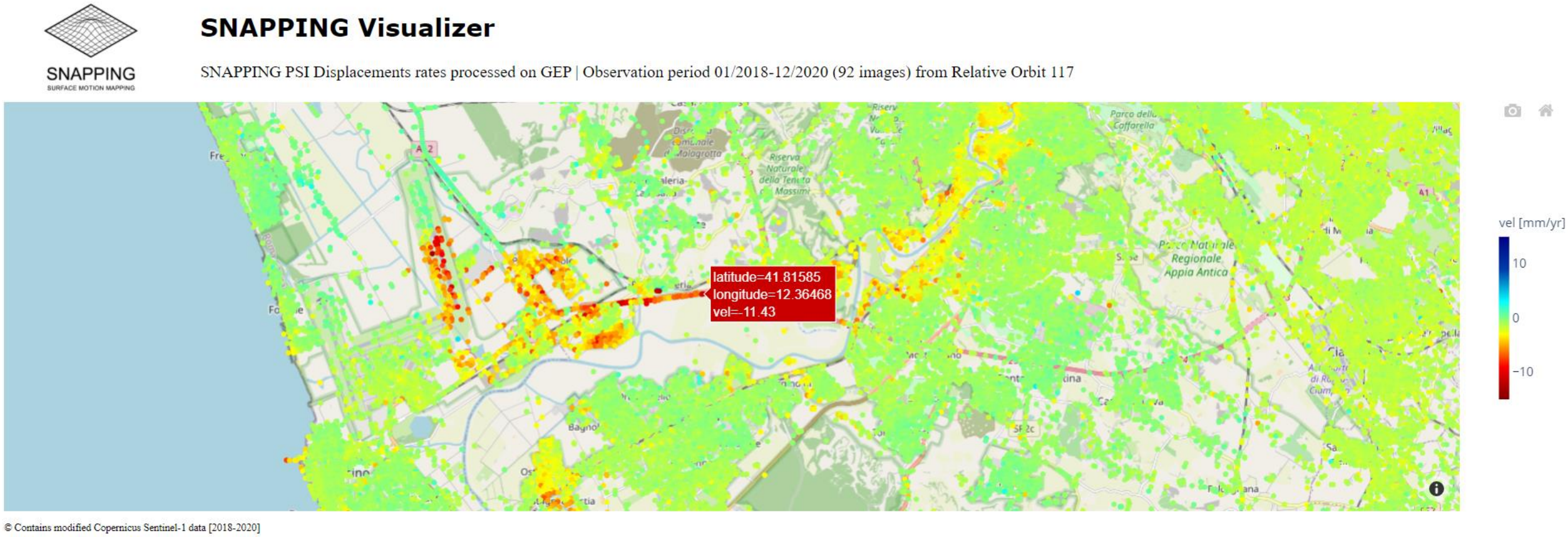
EO.Lab Earth Observation & Geospatial Applications Lab

G.I. Microgeodesia Jaén Universidad de Jaén

TERRADUE Advancing Earth Science

SNAPPING Visualizer | Rome (Italy)

Tailored visualization as (off-line) standalone HTML file accessible to end-users with limited internet access and without the need for ingestion into any geospatial database for inspection of measurements.

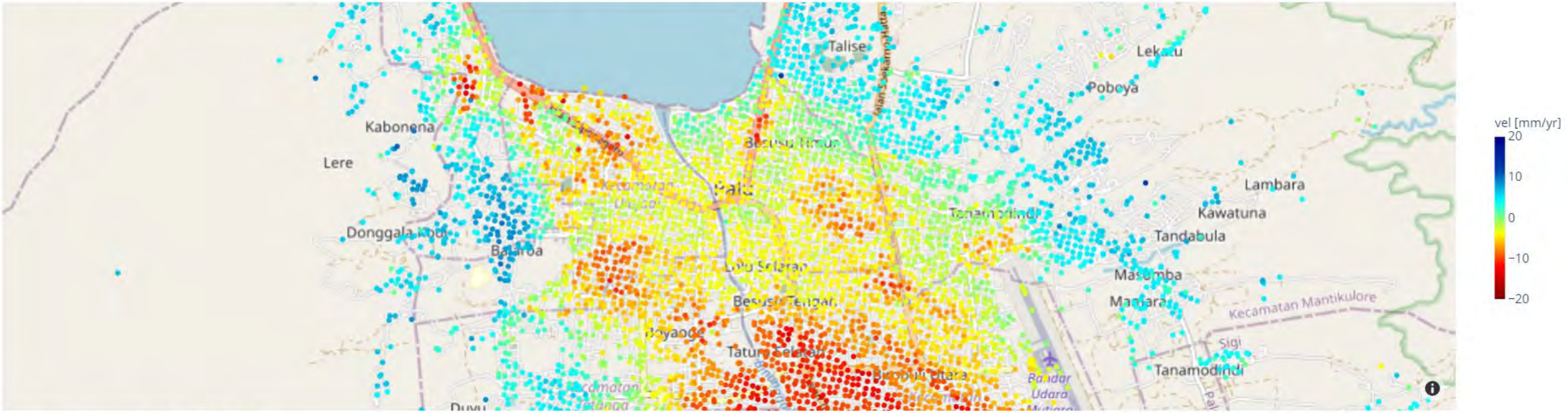


SNAPPING Visualizer | Palu (Indonesia)

SNAPPING
SURFACE MOTION MAPPING

SNAPPING Visualizer

SNAPPING PSI Displacements rates processed on GEP | Observation period 10/2018-12/2020 (115 images) from Relative Orbit 134

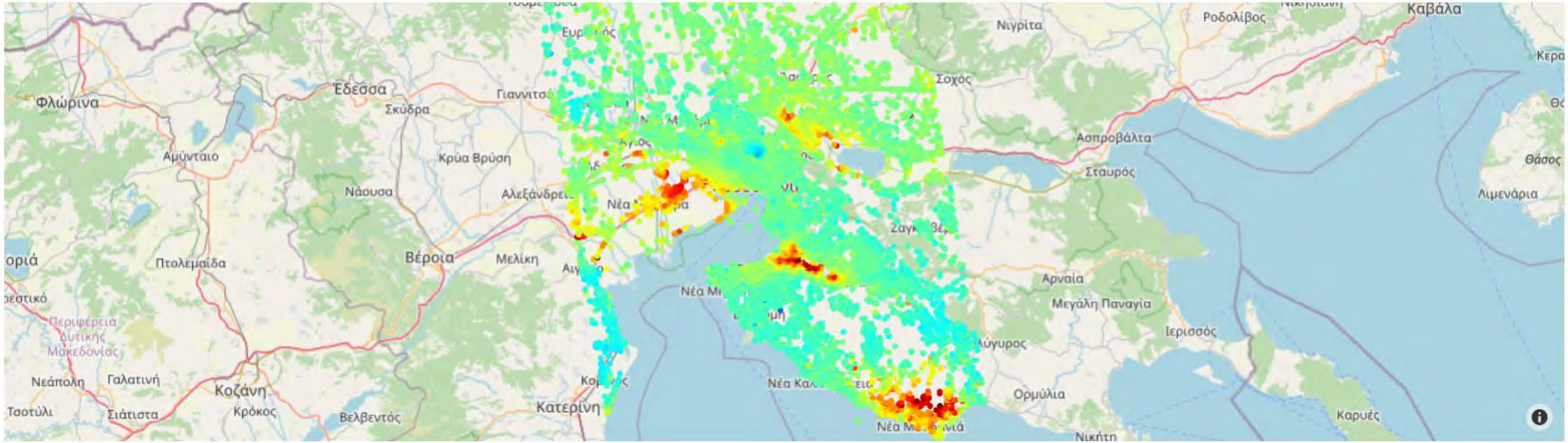


SNAPPING Visualizer | Thessaloniki (Greece)

SNAPPING
SURFACE MOTION MAPPING

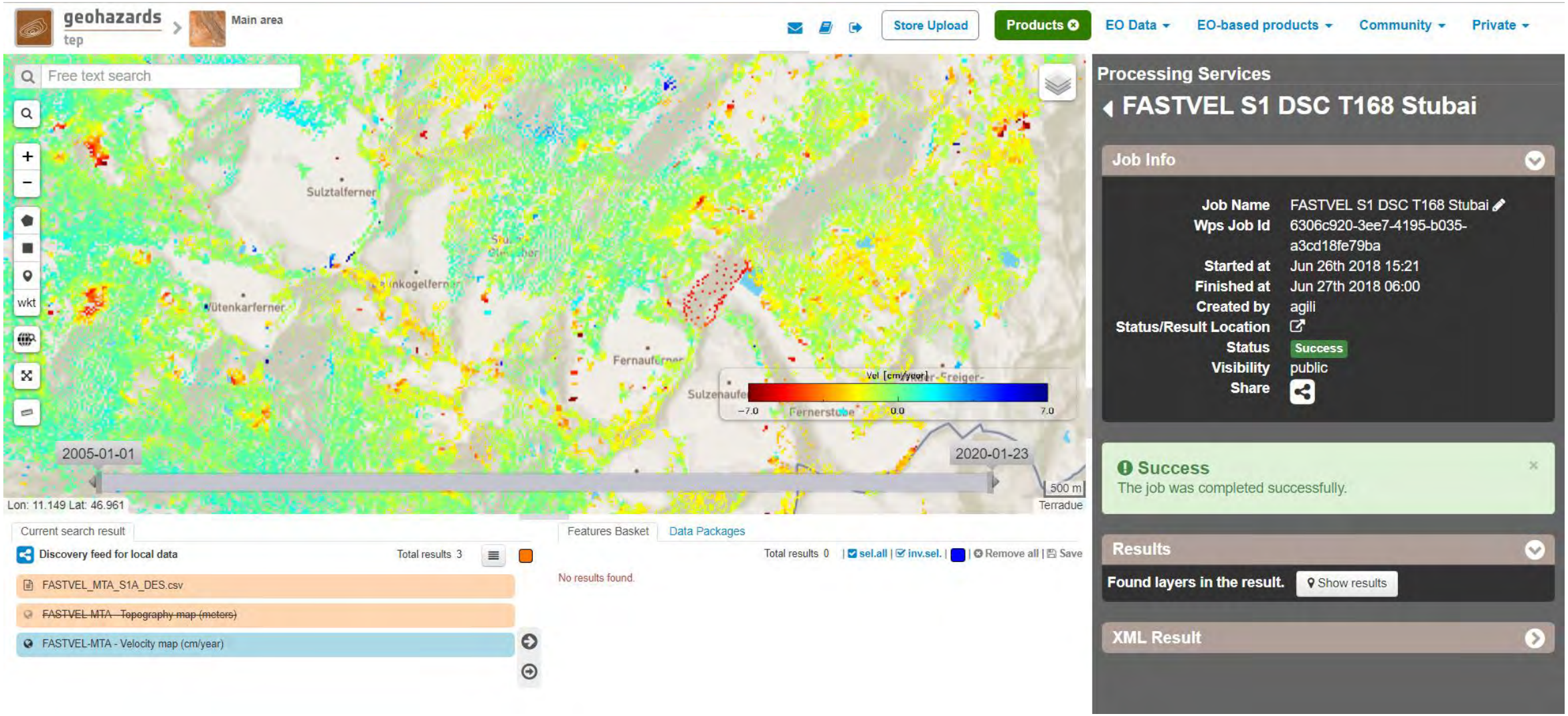
SNAPPING Visualizer

SNAPPING PSI Displacements rates processed on GEP | Observation period 04/2015-12/2020 (138 images) from Relative Orbit 102



© Contains modified Copernicus Sentinel-1 data [2015-2020]

GEP | FASTVEL Landslides over French Alps

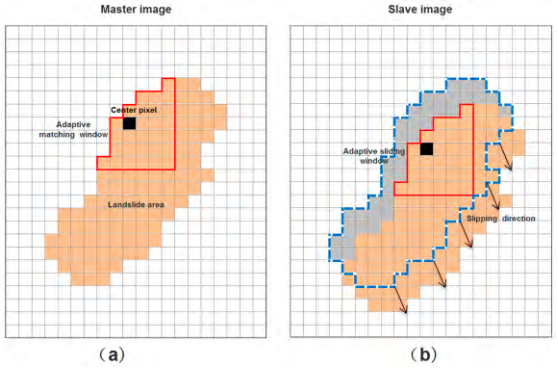


GEP | Landslide app'

École et observatoire des sciences de la Terre
Université de Strasbourg

3 main services developed by CNRS-EOST Strasbourg
Developed for landslide monitoring **but** can be applied to other objects (e.g. Earthquake, volcano, glacier, etc.)

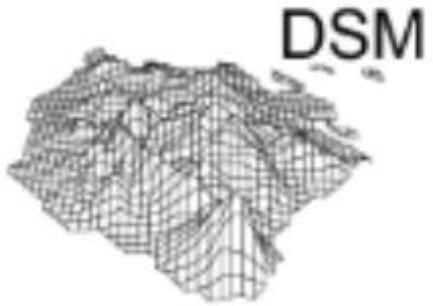
Pixel-offset tracking



Measurement: Ground displacement
Application: local to regional scale
Satellites: Sentinel-2, Pléiades and VHR satellites (coming)

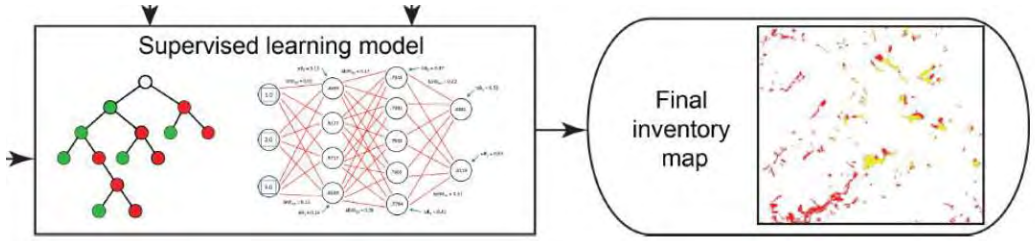
MPIC | ALADIM | DSM-OPT

Digital surface Model



Measurement: surface elevation
Application: local to regional scale
Satellites: Pléiades and other tri-stereo VHR satellites (coming)

Automatic landslide detection based on Machine Learning (Random Forest)



Measurement: landslide areas (polygon)
Application: regional scale
Satellites: Sentinel-2, Pléiades and VHR satellites (coming)

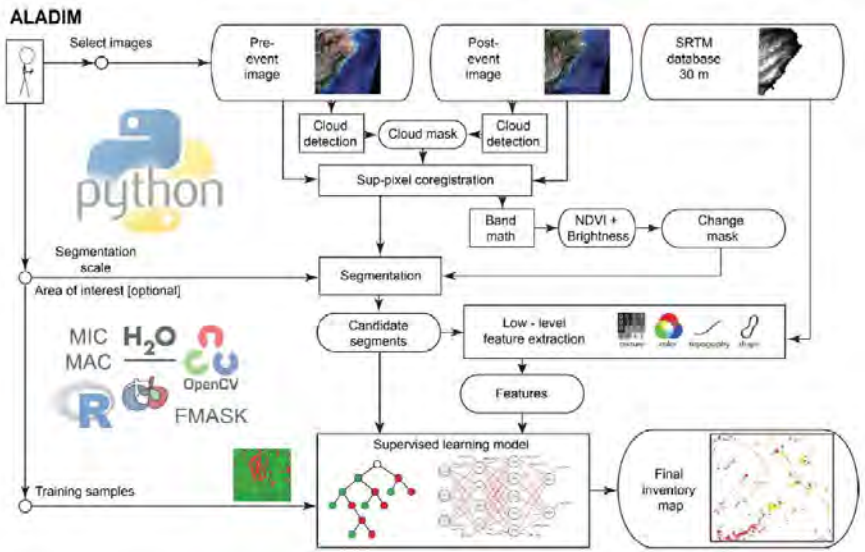
GEP | ALADIM service

Automatic Landslide Detection and Inventory Mapping

Now available on GEP for Sentinel-2

Earthquakes or typhoons can trigger numerous landslides (> 1000)

- **6.7-magnitude earthquake, 2018,** northern Japanese island of Hokkaido



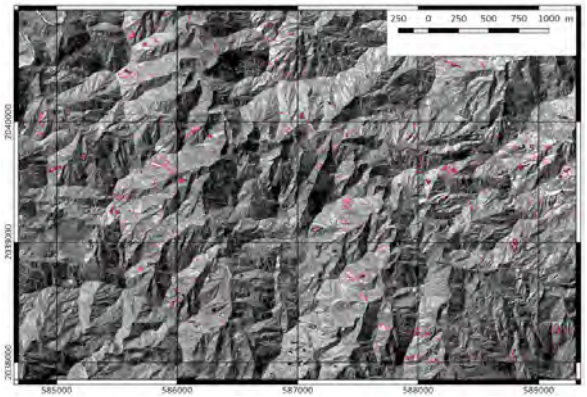
ALADIM provides landslide maps automatically with:

- Reduce human working time (only to build the training set)
- Estimation of the detection accuracy

→ Rapid-mapping for emergency response

- **Landslides detected** over Macaya National Park (Haiti) after Cyclone Matthew in 2016, from Spot-6 and -7

- **Landslides detected** over Taiwan after Tropical Cyclone Komen in 2015, from Sentinel-2 data

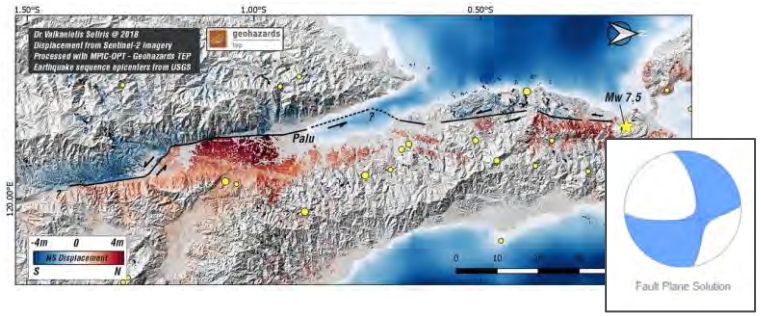


GEP | MPIC-OPT service

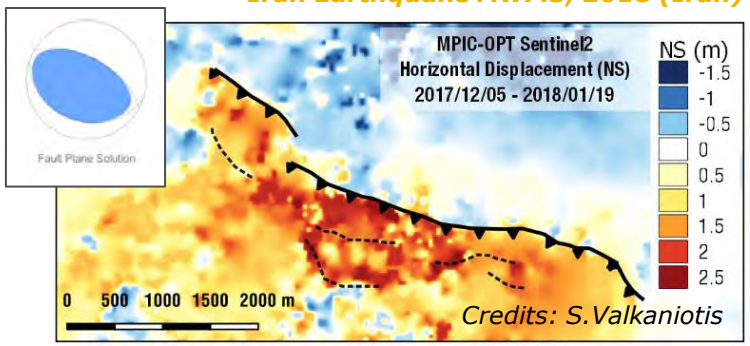
Multiple-Pairwise Image Correlation for the monitoring of surface deformation from optical image time-series

Example of application 1:
Diachronic displacement

- ***Palu Earthquake Mw7.5, 2018 (Indonesia)***

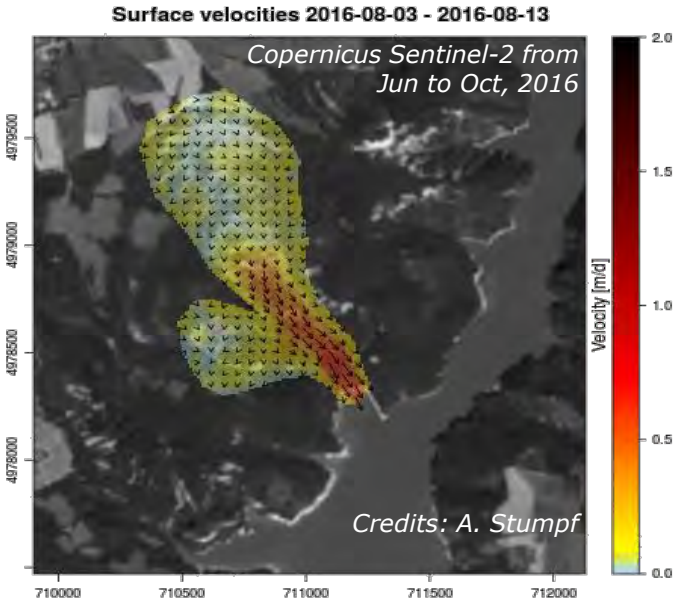


- ***Iran Earthquake Mw7.5, 2018 (Iran)***



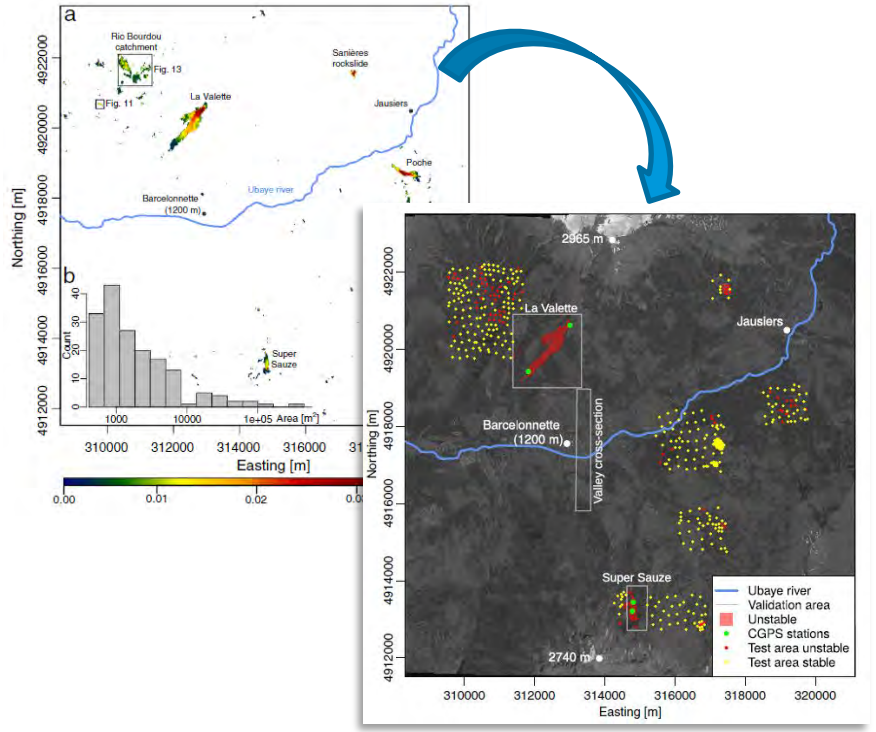
Example of application 2:
Displacement time series

- ***Harmalière landslide (French Alps)***



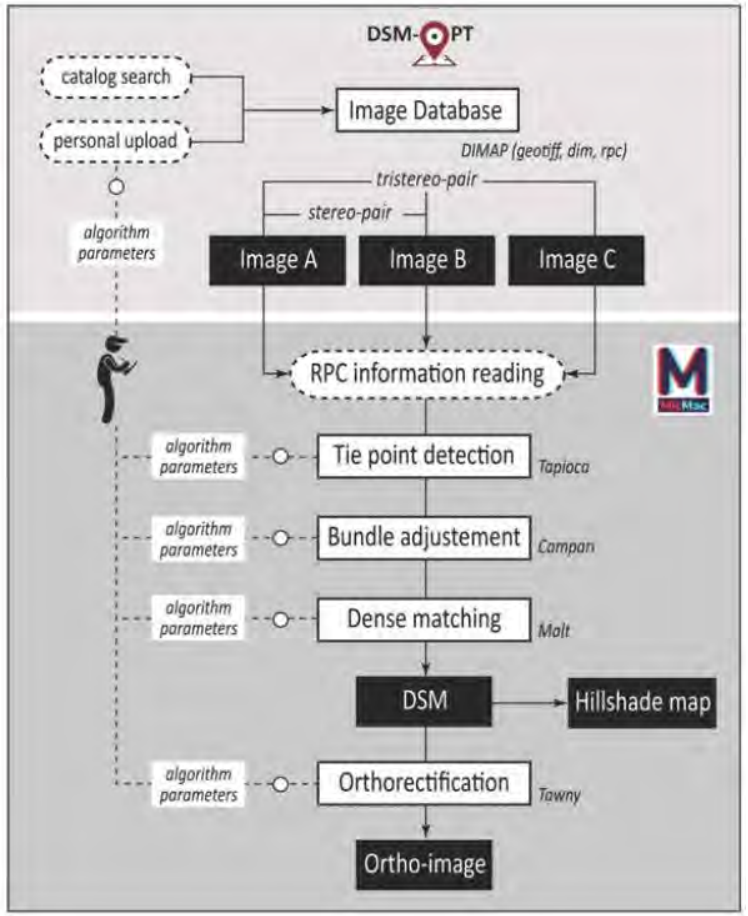
Example of application 3:
Detection of Persistent motion

- ***Ubaye Valley (French Alps)***

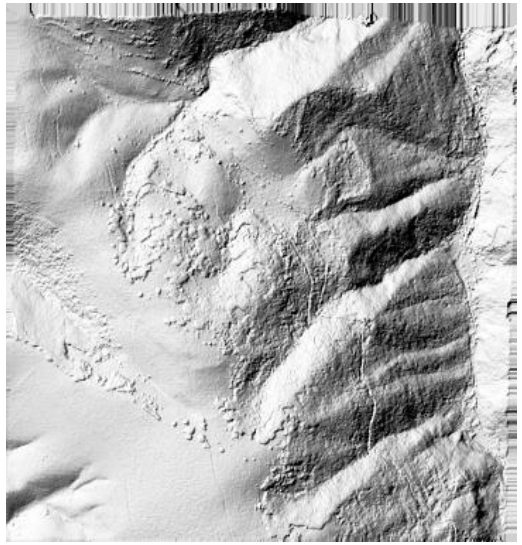


GEP | DSM-OPT service

Digital Surface Models (DSM) and ortho-images from stereo- and tri-stereo satellite images acquired by the VHR Pléiades satellite constellation



Hillshade from DSM , *Pléiade image 2016, Italy*



DSM, *Pléiade image 2016 Strasbourg city (France)*

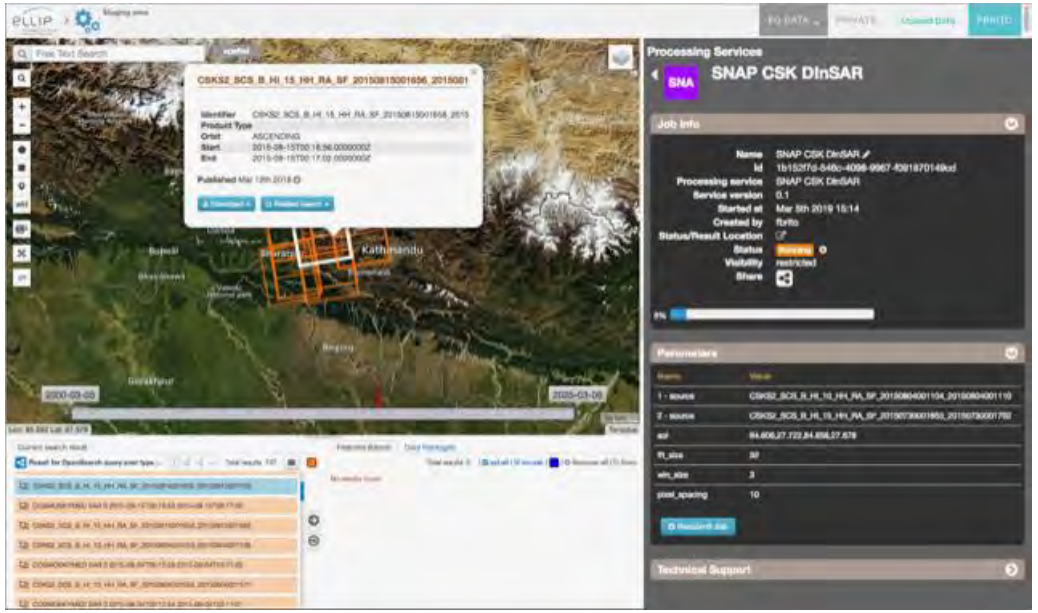
Integration of Services | SNAP COSMO-SkyMED DInSAR

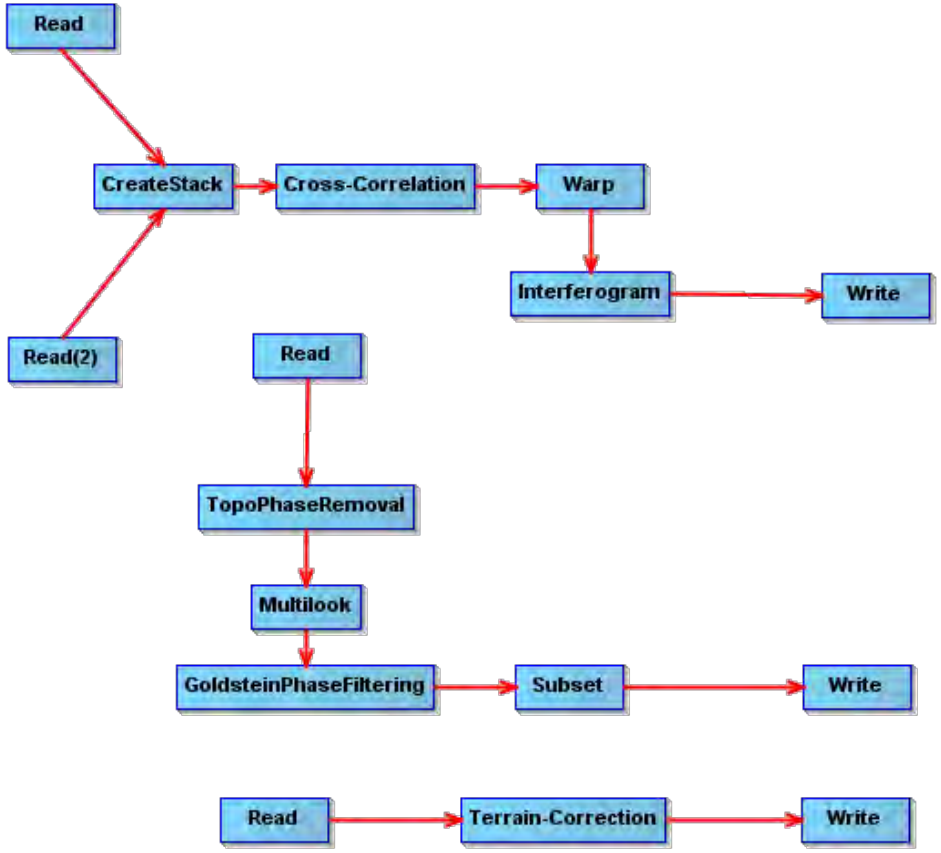
Expansion of SNAP services on GEP to support TPM interferometric processing

CSK_Stack_CrossCor_Wrap_Ifg.xml

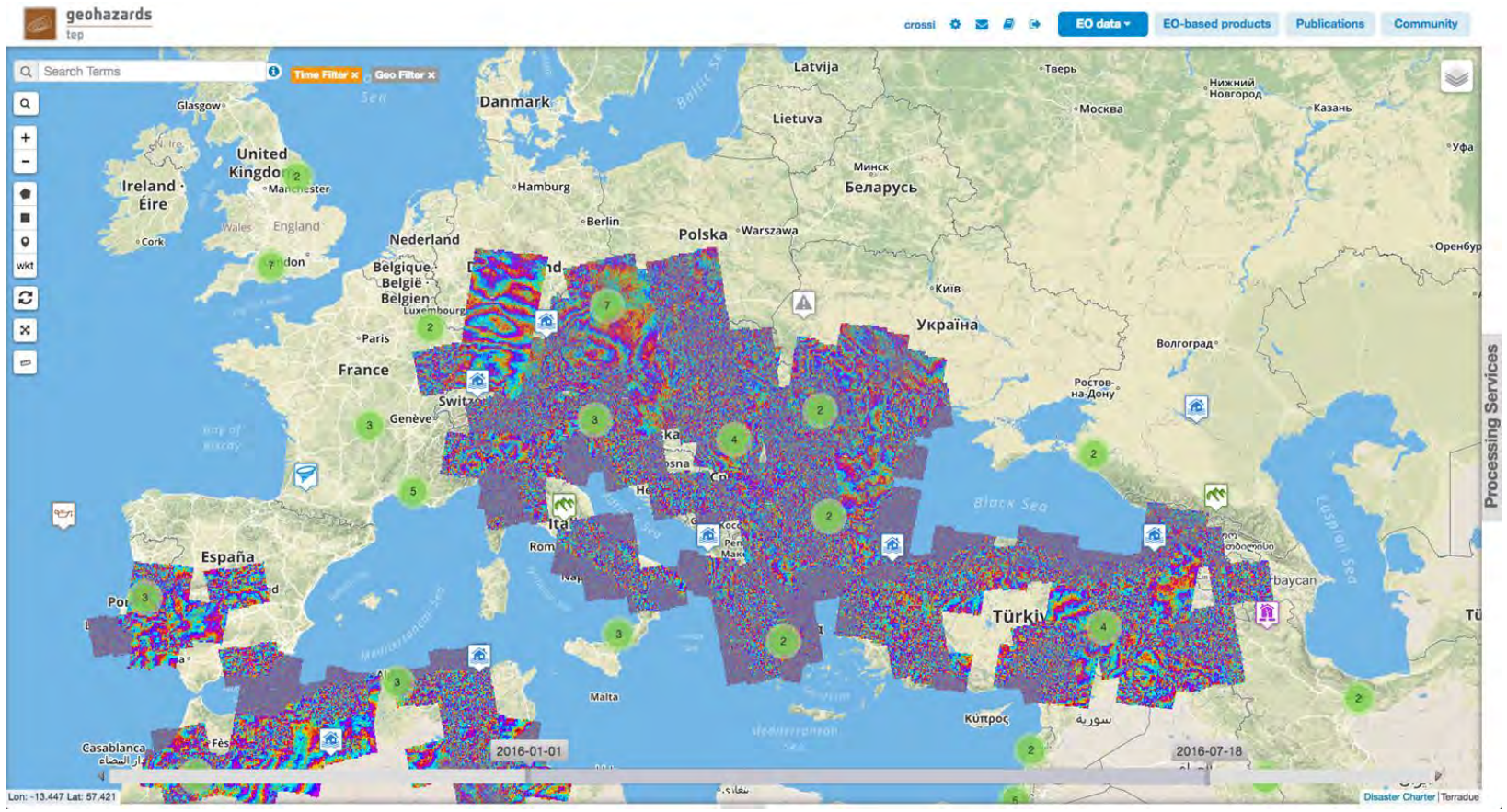
CSK_TopoRem_ML_Flt_Sub.xml

CSK_TC.xml





GEP | Systematic - Data Driven Scheduled Processing



https://geohazards-tep.eu

Supported by
BELNET-BEGRID (Belgium)

DLR InSAR Browse Medium Resolution Service

It's a data driven systematic processing. The service has followed a ramp-up process starting from Dec 2016 until Aug 2017:

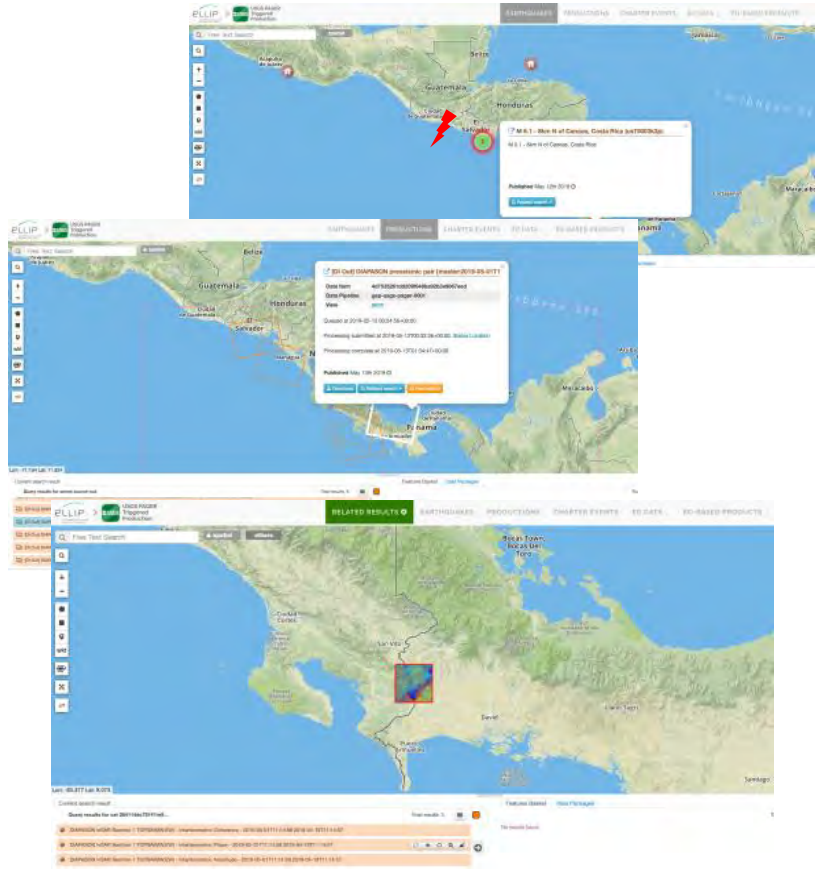
- **EU Tectonic area**
- **World tectonic area (25%)**
- **World tectonic area (40%)**

It currently processes 150+ Sentinel-1 SLC pairs per day.

New GEP functionality under implementation:
Triggering services based on seismic events polled from external systems

- **Automatic production** of **deformation maps** with different GEP processing services
  - **Actuators** are event-based components able to start specific data discovery, ingestion, caching and processing workflows (**USGS pager**, **@INGVterremoti** twitter feed based on the earthquake magnitude, **Copernicus EMS** rapid mapping and risk & recovery feeds and **UNOSAT/GDACS** disaster feed)
  - Services shall be triggered for each earthquake with a magnitude > X, based on the actuators feed

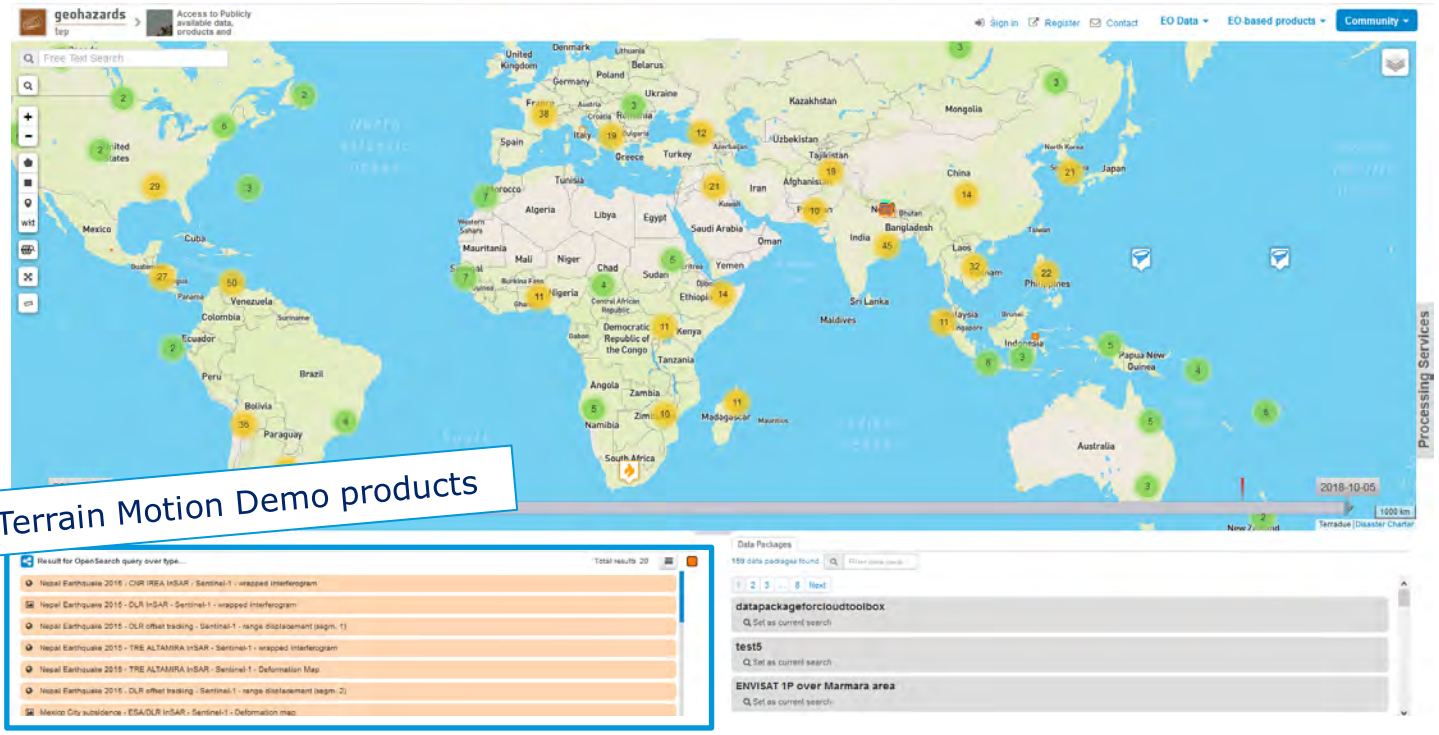
- **Publication** of generated maps in a specific index in the GEP catalogue linked to the originating event



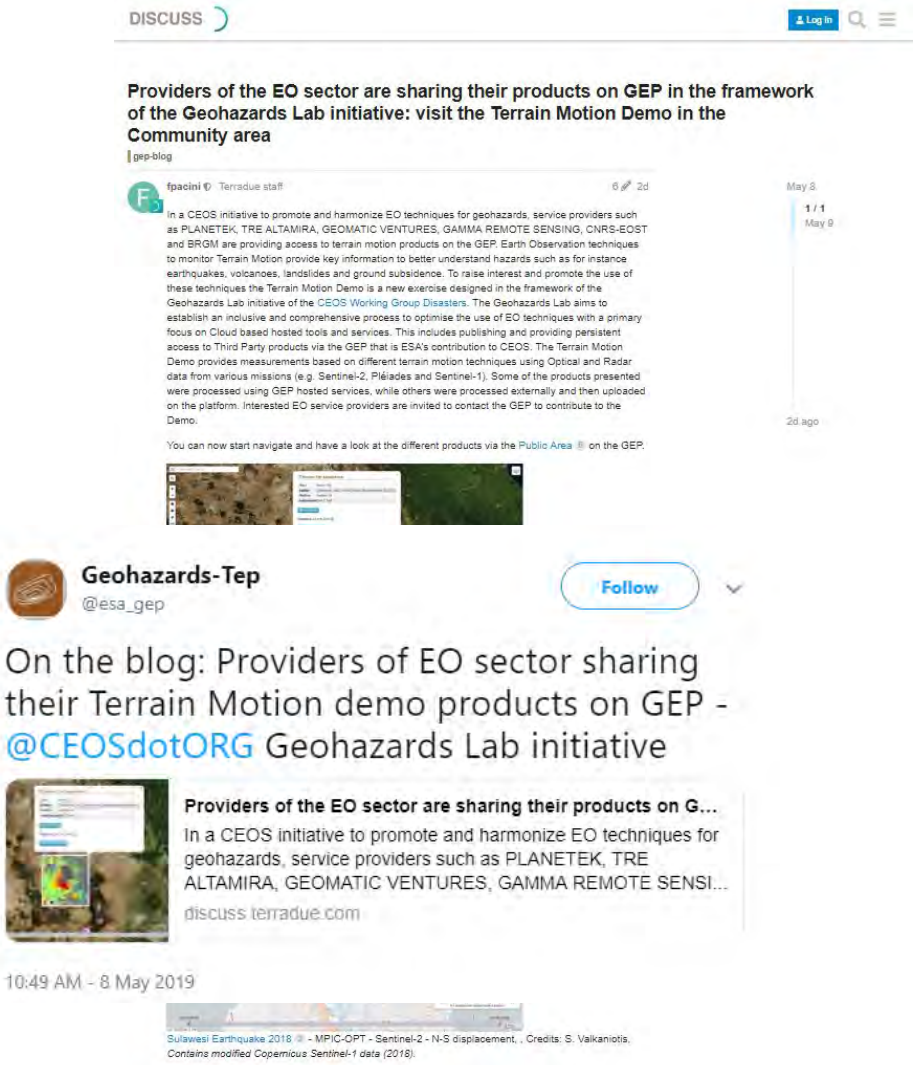
GEP | Terrain Motion Demo

Promote use of EO for Geohazard applications

Demonstration of Ground Motion Services' products on different sites based on different terrain motion techniques using Optical and Radar data and publication on GEP.



Terrain Motion Demo products



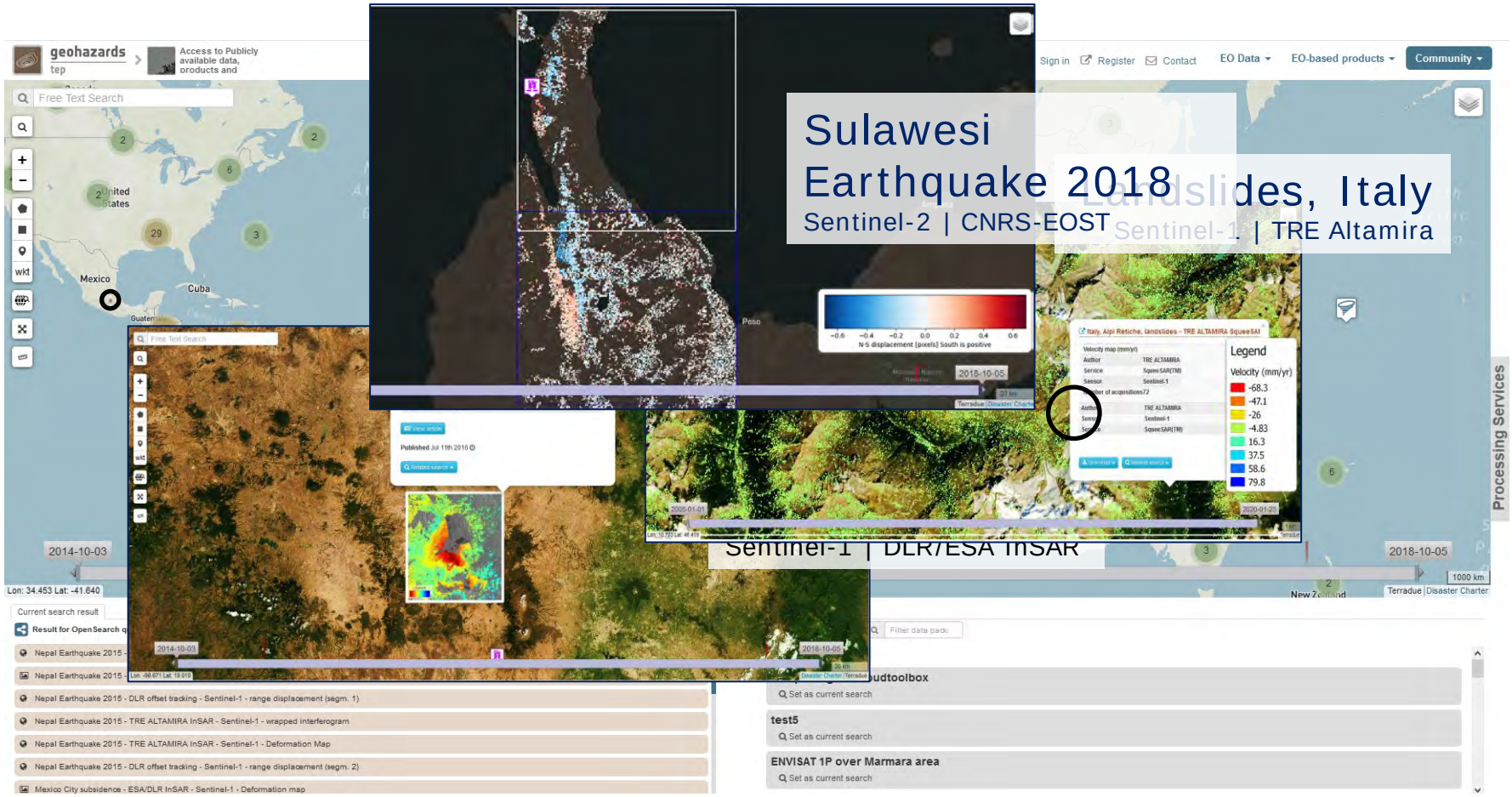
GEP | Terrain Motion Demo

Geohazards
Earthquakes, Volcanoes, Ground subsidence & landslides

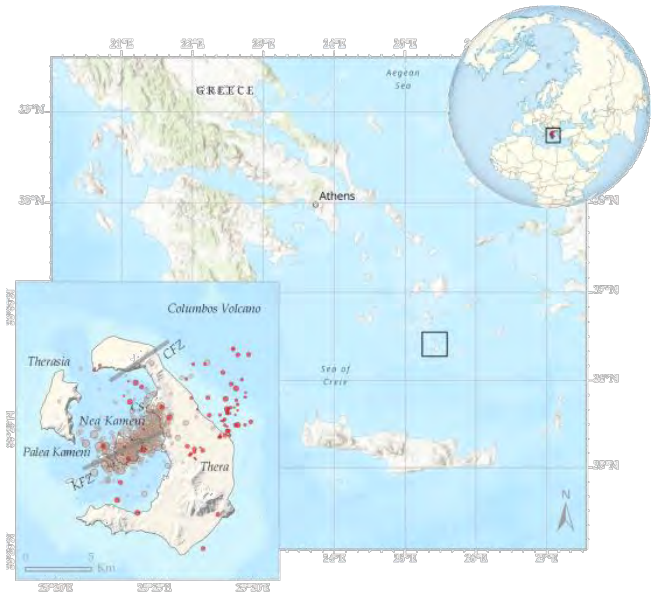
EO satellites
Sentinel-1 & 2, ERS-1&2, Envisat, TSX, CSM, Pléiades…

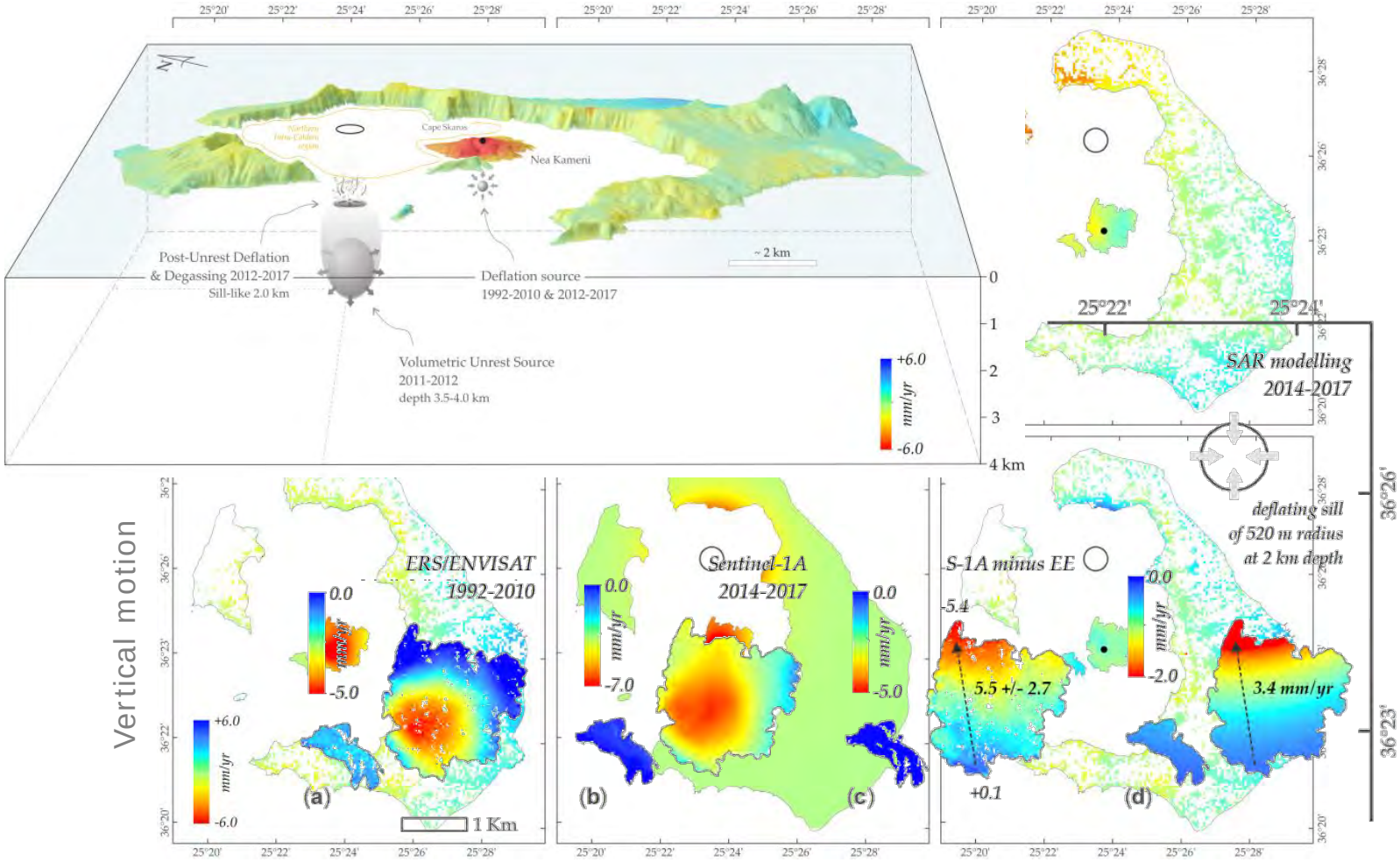
Providers
DLR, INGV, EOST , TRE-ALTAMIRA, GAMMA, CNR-IREA, Planetek, BRGM, AUTh…

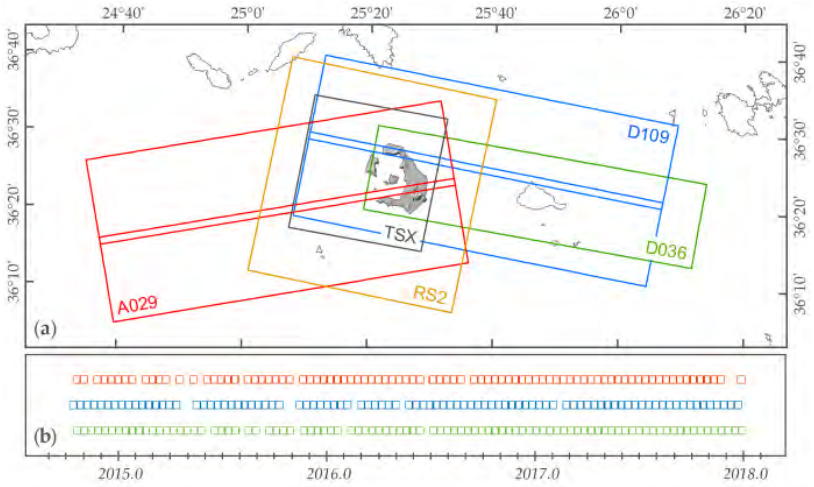
Ground Motion Processing
Diapason, SNAP, MicMac, P-SBAS, MPIC-OPT, GAMMA, PSinSAR®, SqueeSAR®



Scientific Publications | Santorini Volcano Post-Unrest

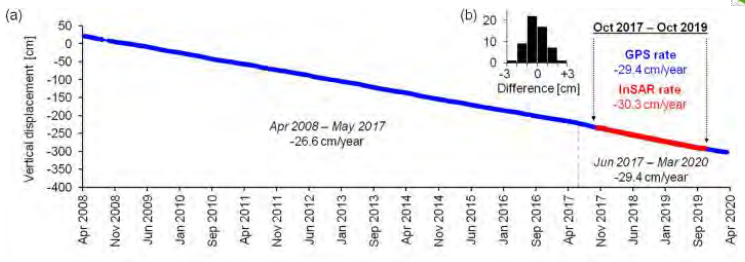


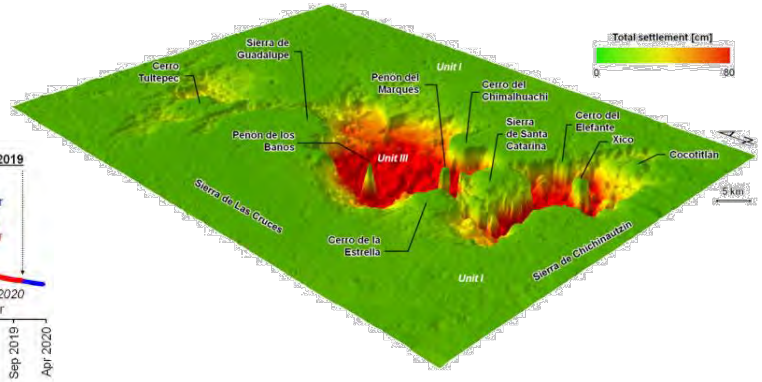


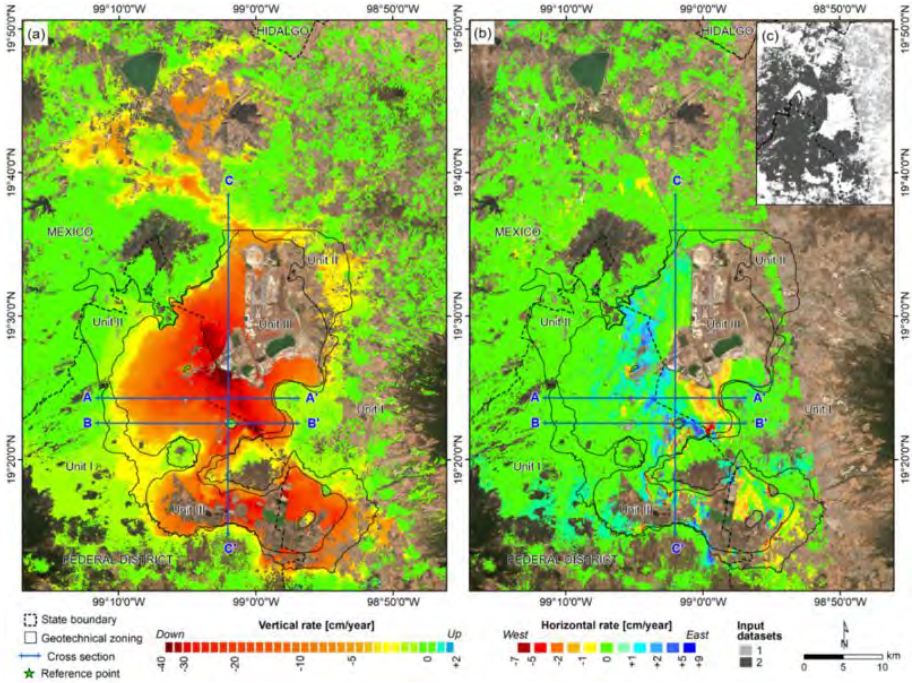


Papageorgiou, E., Foumelis, M., Trasatti, E., Ventura, G., Raucoules, D. & Mouratidis A., 2019. Multi-sensor SAR geodetic imaging and modelling of Santorini volcano post-unrest response. *Remote Sensing*, 11(3), 259, https://doi.org/10.3390/rs11030259.

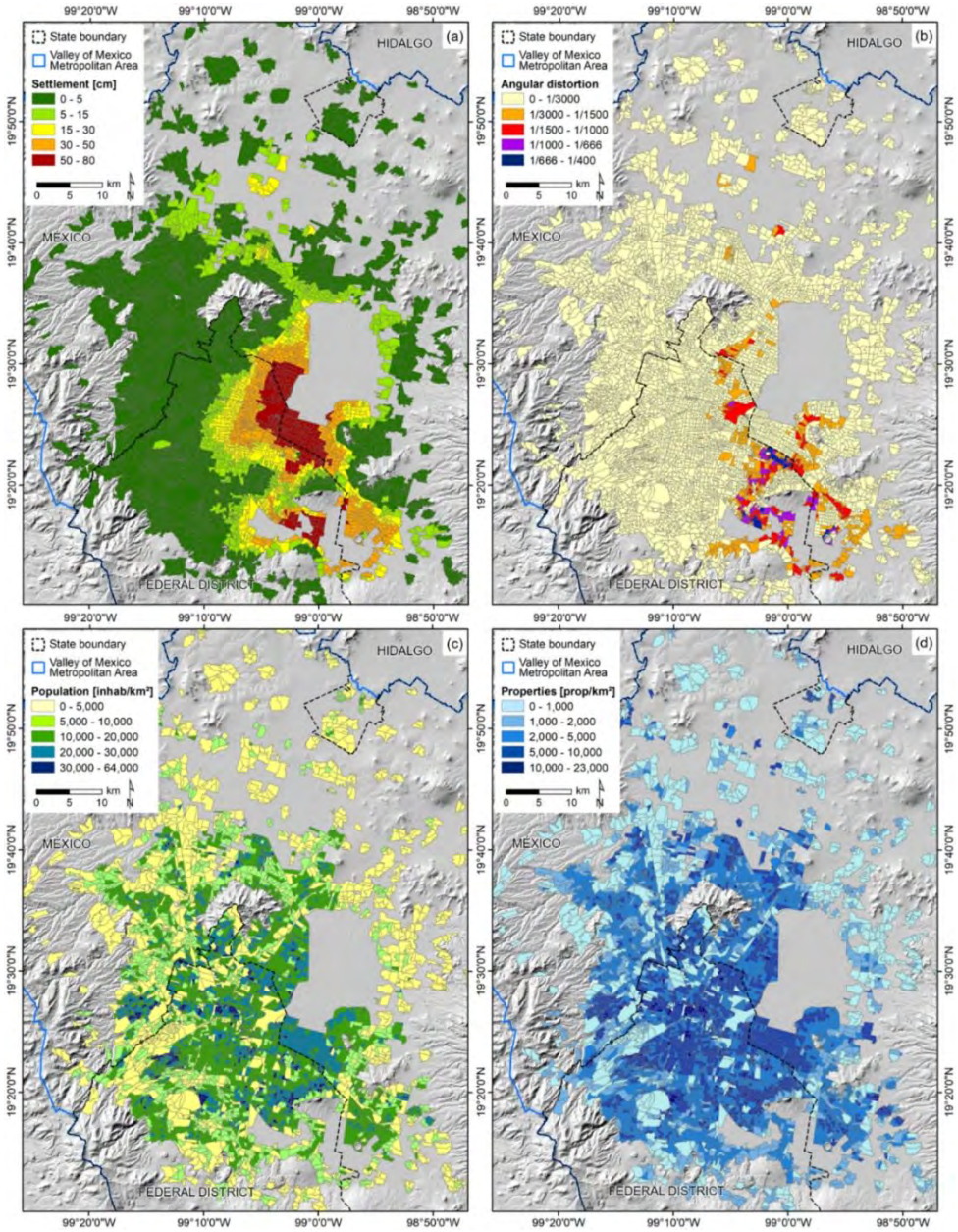
Scientific Publications |
Mexico City Subsidence & Risk



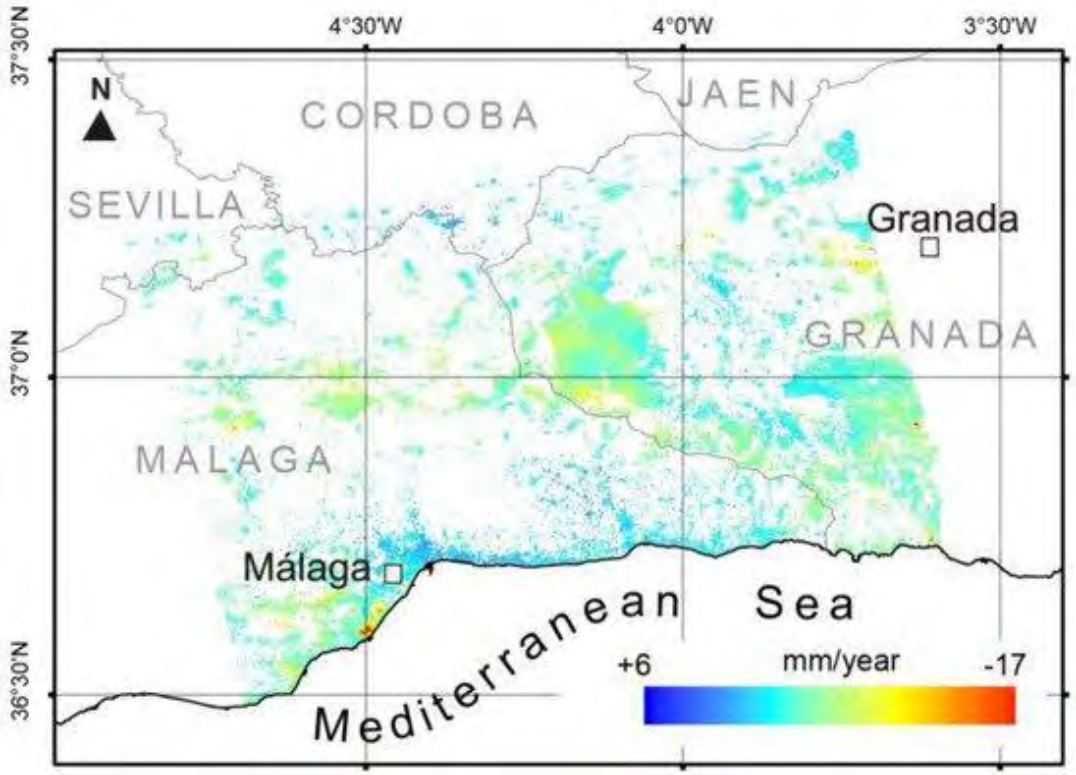


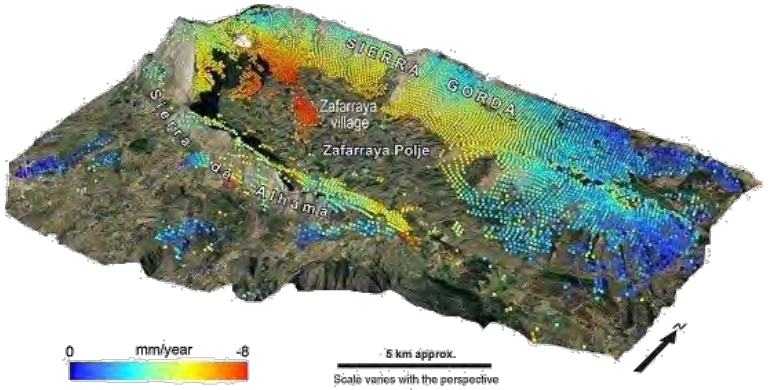


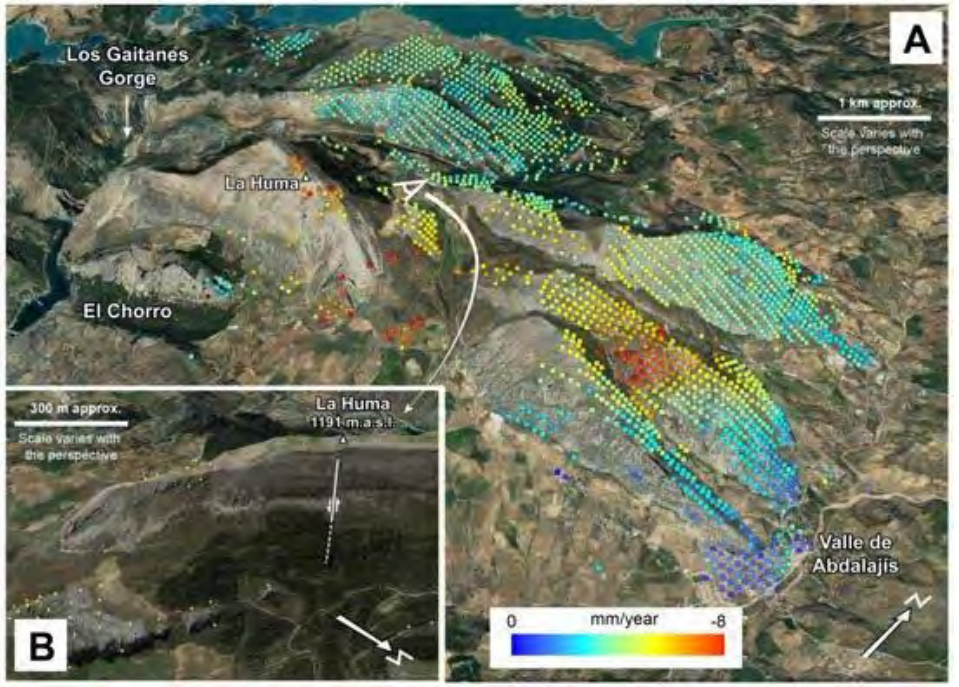
Francesca Cigna, Deodato Tapete, 2021. Present-day land subsidence rates, surface faulting hazard and risk in Mexico City with 2014–2020 Sentinel-1 IW InSAR, Remote Sensing of Environment, 253, 112161,https://doi.org/10.1016/j.rse.2020.112161.



Scientific Publications | Human-induced Subsidence & Hazard Identification

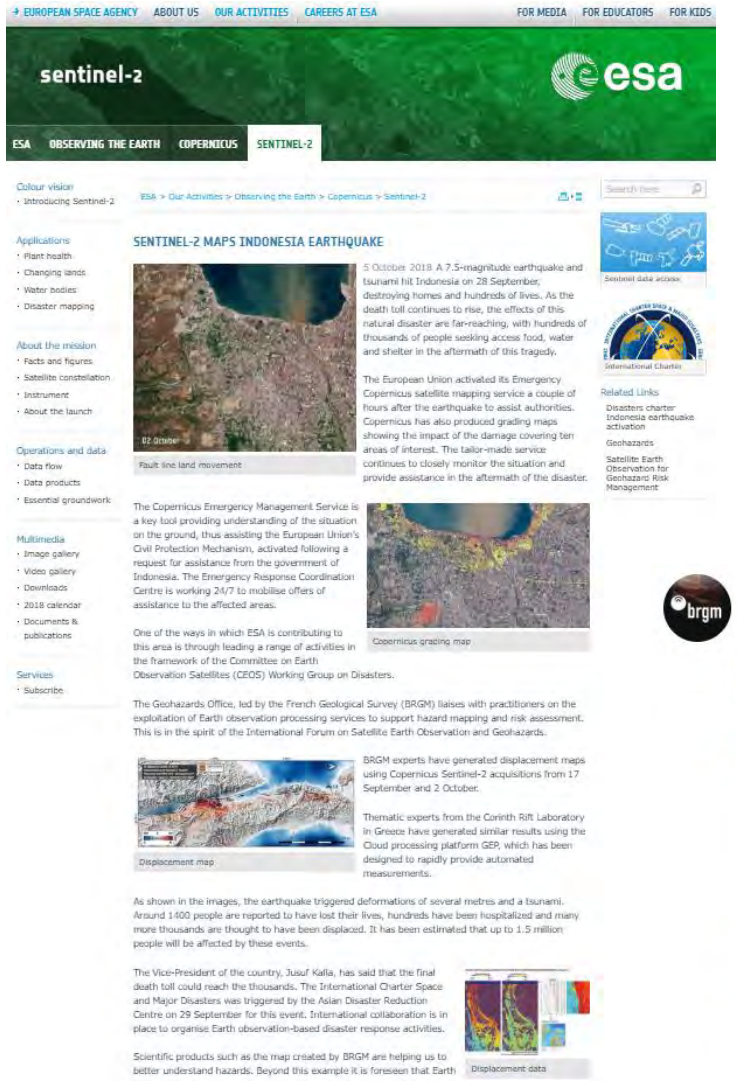




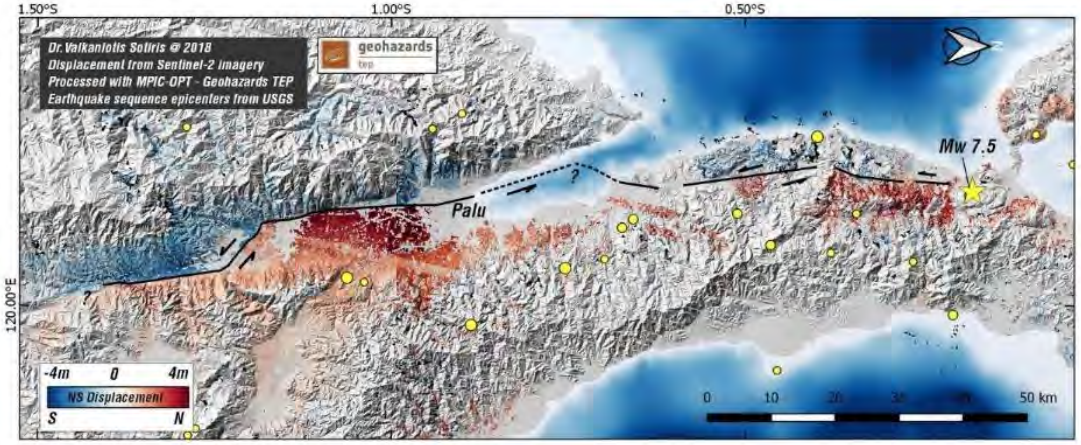


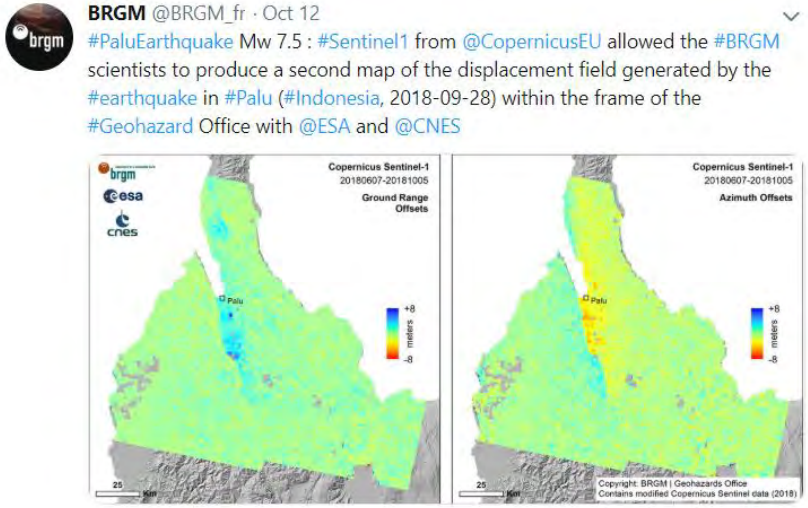
Galve, J.P.; Pérez-Peña, J.V.; Azañón, J.M.; Closson, D.; Caló, F.; Reyes-Carmona, C.; Jabaloy, A.; Ruano, P.; Mateos, R.M.; Notti, D.; Herrera, G.; Béjar-Pizarro, M.; Monserrat, O.; Bally, P. **Evaluation of the SBAS InSAR Service of the European Space Agency's Geohazard Exploitation Platform (GEP)**. *Remote Sens.* 2017, *9*, 1291.

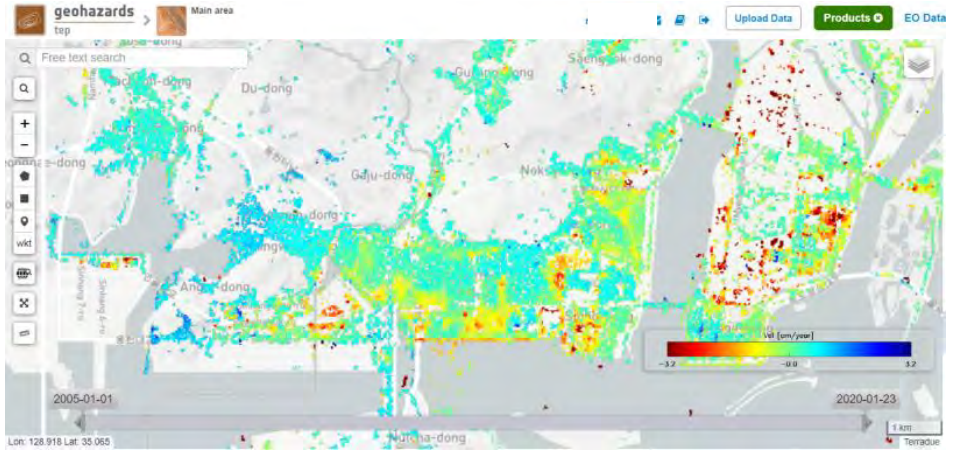
Animate & Communicate GEP Scientific Results



Sulawesi Earthquake (Indonesia)







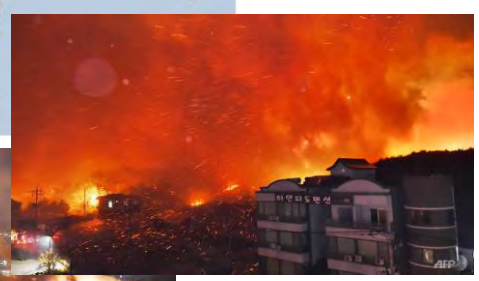
Animate & Communicate GEP Scientific Results

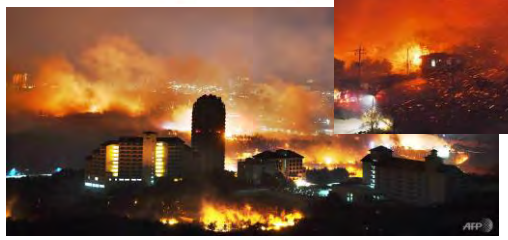
South Korea fires

April 5th, 2019:

Strong wind fans fire in the north of South-Korea
About 400 homes and 500 hectares of land were destroyed
4000 people moved

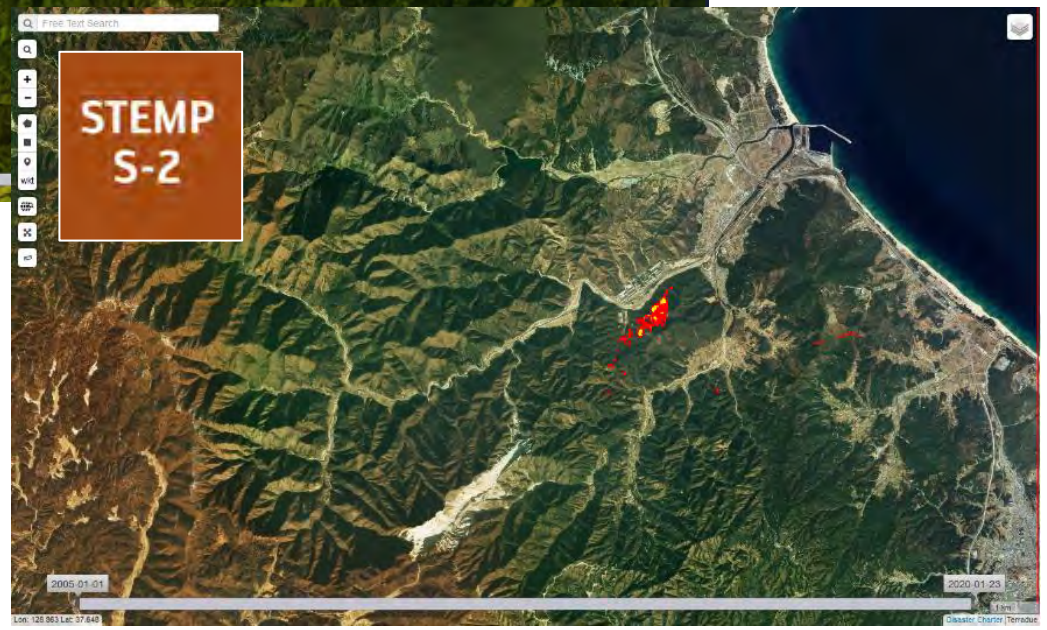
Declared as **National Disaster** by South-Korean authorities on the 5th.





Sentinel-2 acquisition on the 5th!

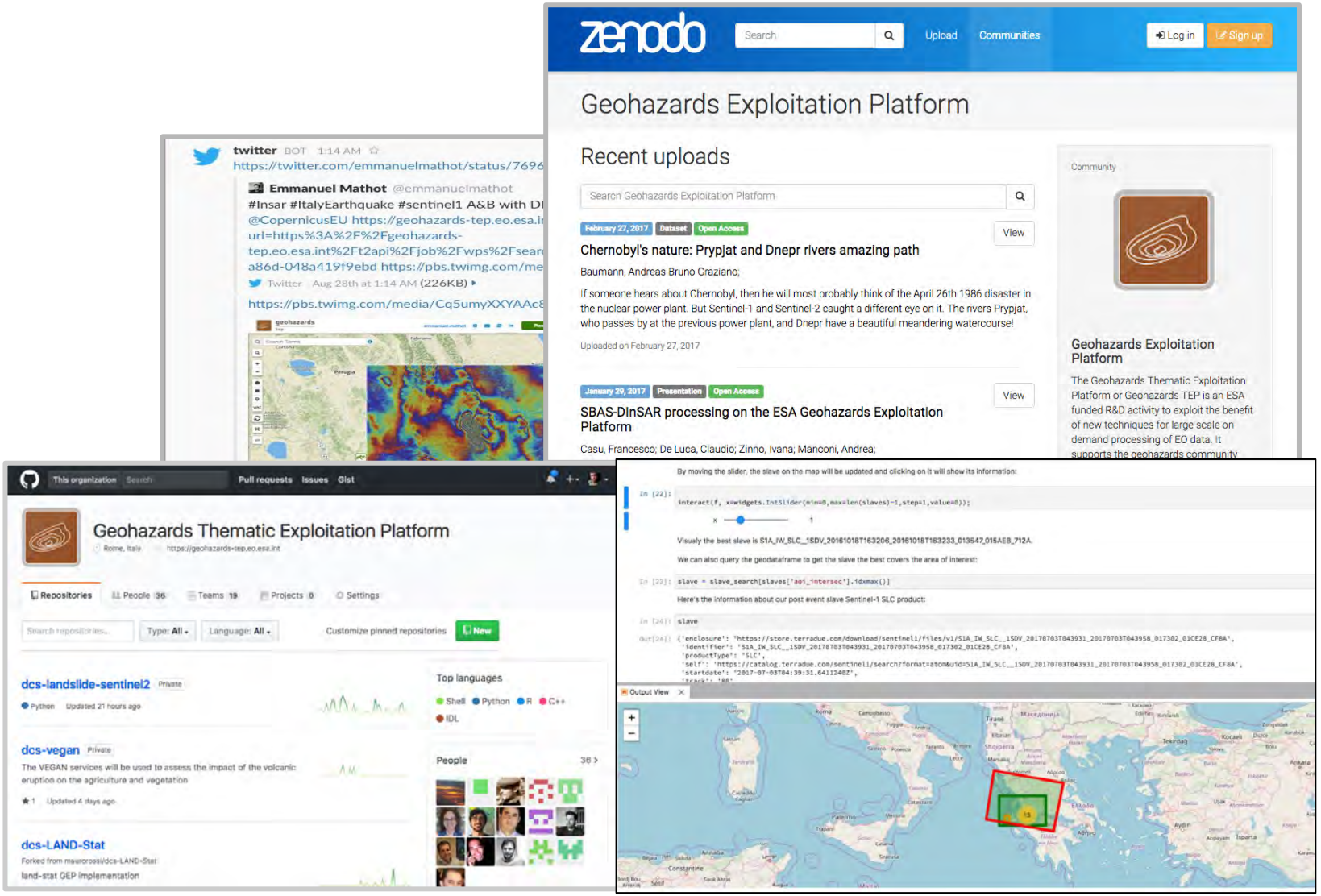
COMBInation of **bands 13,12,2**



Surface Temperature Map (STEMP): automatic detection of areas on fire.

GEP | Knowledge Hub Resources

GitHub, Zenodo,
Twitter, Forums,
Notebooks ...



GEP Hosted Processing Demonstration

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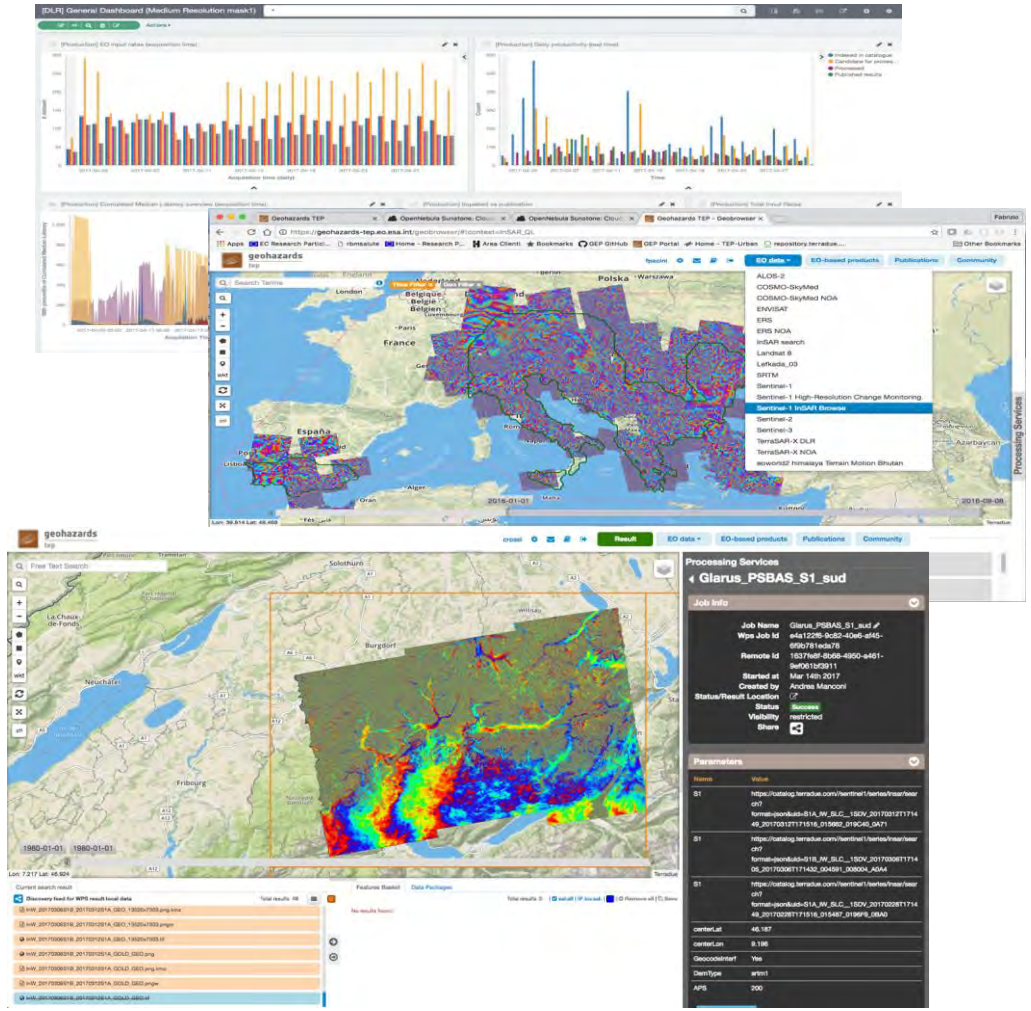


Michael Foumelis | Aristotle University of Thessaloniki (AUTh)
Fabrizio Pacini | Terradue s.r.l.

GEP Hosted Processing Services

EO Data

ONDA DIAS products order

ONDA DIAS products order

ONDA DIAS products order

ONDA DIAS products order

ONDA DIAS products order

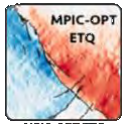

Data Publication

Seismic

SNAP CSK DInSAR

DIAPASON InSAR - Strip...

GMT5SAR InSAR - Senlin... GMT5SAR InSAR - Stripmap



Volcanoes

SNAP CSK DInSAR

DIAPASON InSAR - Strip...

GMT5SAR InSAR - Senlin... GMT5SAR InSAR - Stripmap

Band combination

STEMP S2 Full

RGB Composites with Sen...

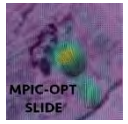
Landslides

MPIC-OPT Multiple pairwi...

ALADIM-S2 Automatic LA...

ALADIM-VHR Automatic L...

DSM-OPT Digital surface ...



Subsidence

SBAS Stripmap (GPOD)

FASTVEL

PSI Post-Proc

Floods

Full Resolution Rasterization

Band combination

RGB Composites with Sen...

HASARD - SAR-based flo...

Fire

Full Resolution Rasterization

Band combination

RGB Composites with Sen...

Sentinel-2 Burned Area An...

GEP Demo
Public Processing Jobs

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Seismic Events

Co-Seismic Ground Displacement

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Fabrizio Pacini | Terradue s.r.l.

GEP Service Jobs | Kaikoura Earthquake

- Job ID | COMBI S2 RGB:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3Ddf9d8ccb-00cf-4232-815f-33362101d631%26key%3D84233b40-f7bb-4b01-b6f2-ad8f99e06ea3

- Job ID | DIAPASON DInSAR:

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- Job ID | MPIC-OPT Offset Tracking:

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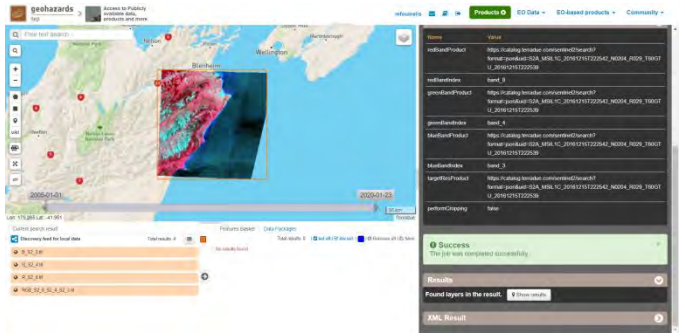

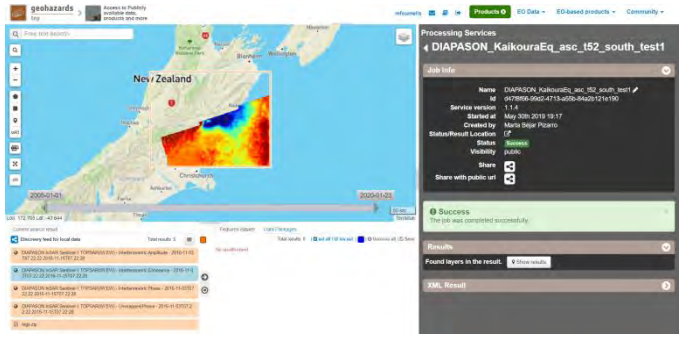

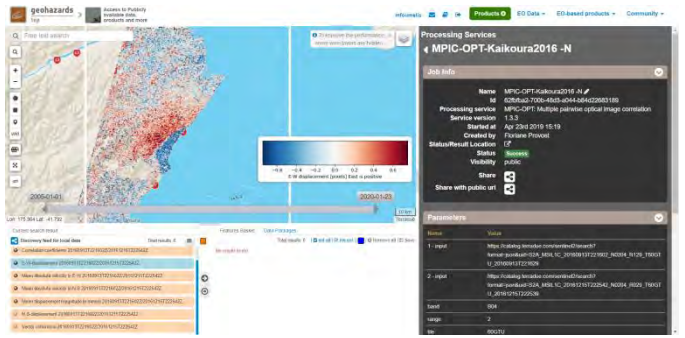

GEP Service Jobs | Croatia 2020 Earthquake

- Job ID | P-SBAS IFG:

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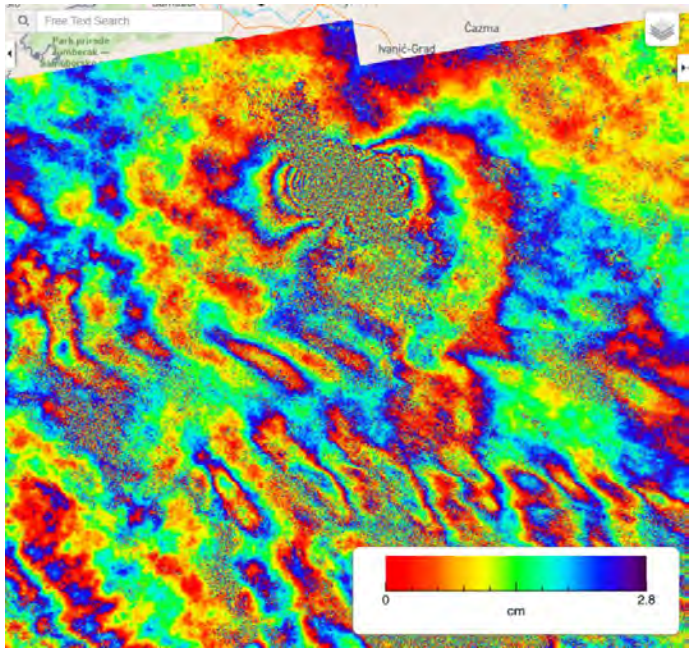

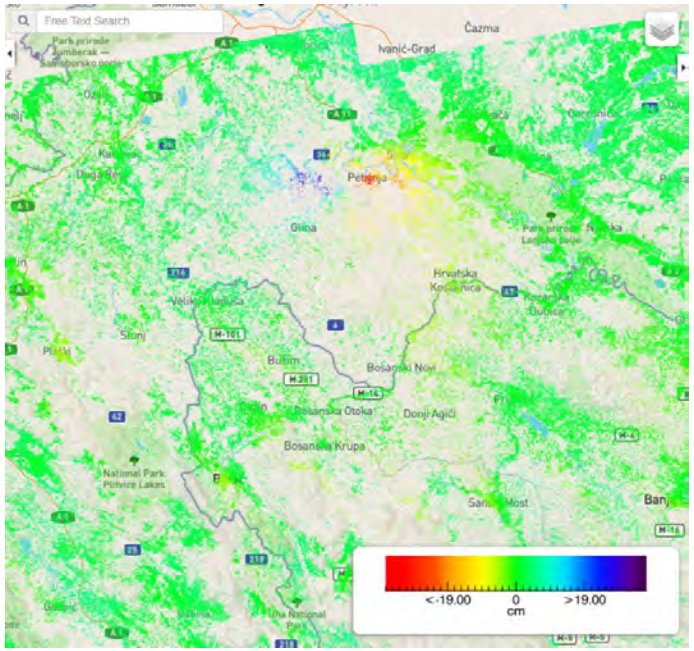

GEP Service Jobs | Samos 2020 Earthquake

- Job ID | SNAP DInSAR:

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- Job ID | DIAPASON DInSAR:

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- Job ID | P-SBAS IFG:

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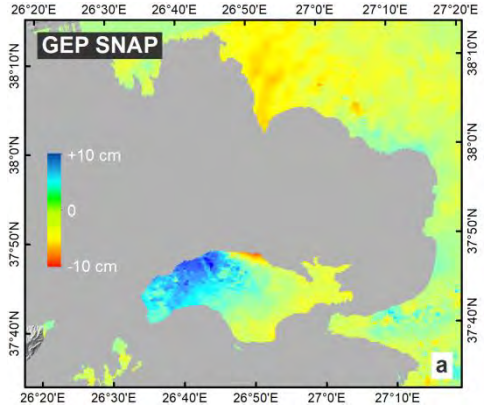
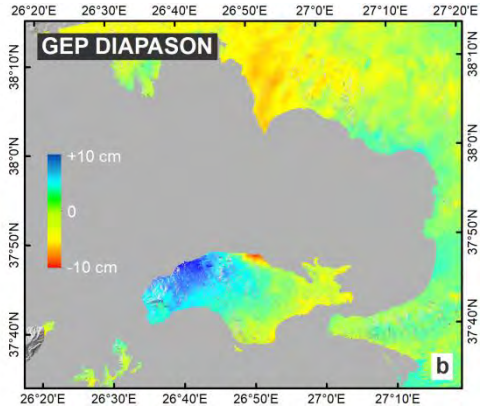
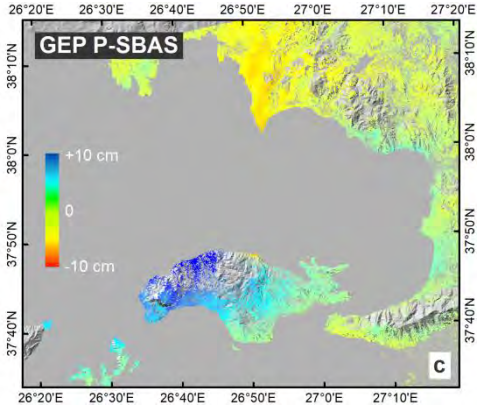
  Ascending Track 131







GEP Service Jobs | Thiva (Greece) 2020 M4.4 Earthquake

- Job ID | P-SBAS IFG Ascending:

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- Job ID | P-SBAS IFG Descending:

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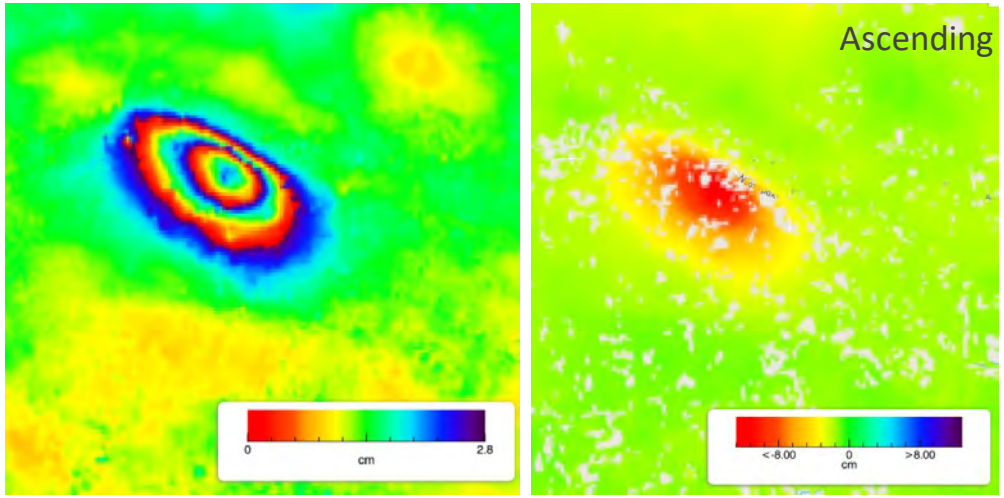

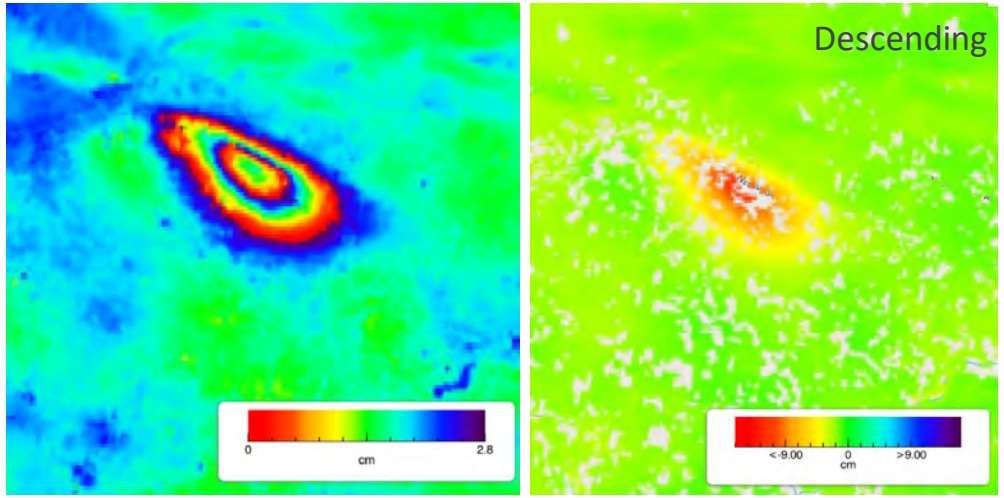

GEP Service Jobs | P-SBAS Sulawesi 2018 Earthquake

- Job ID | P-SBAS:

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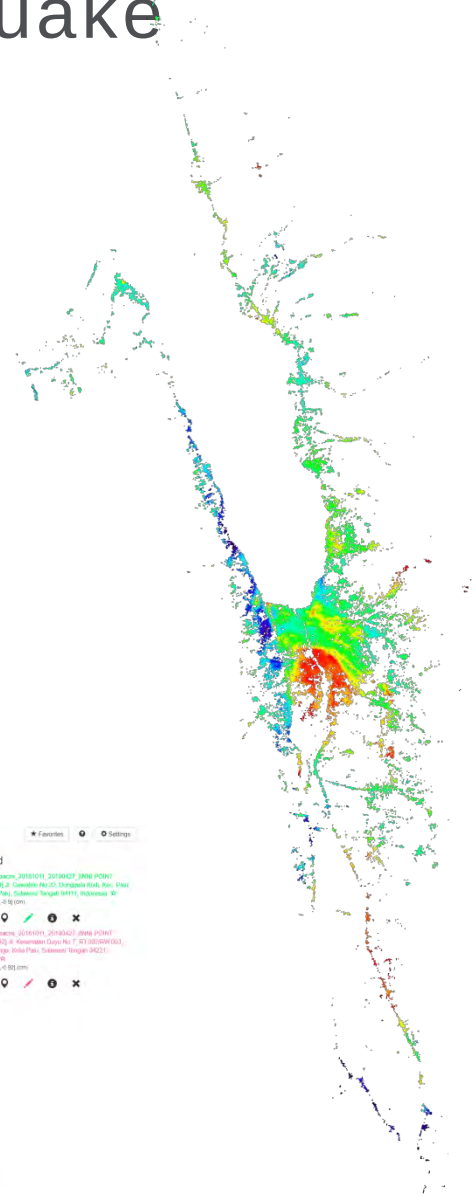
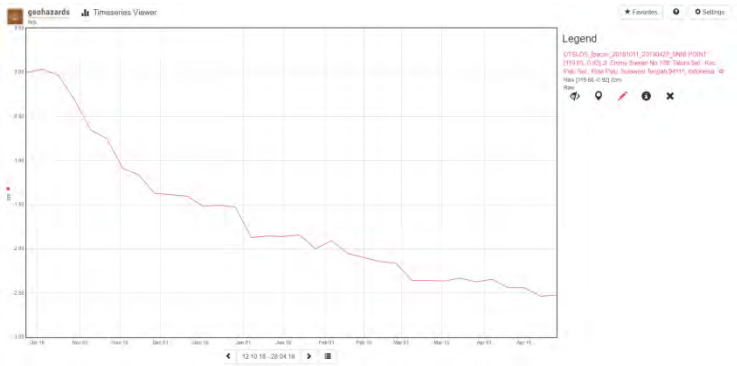
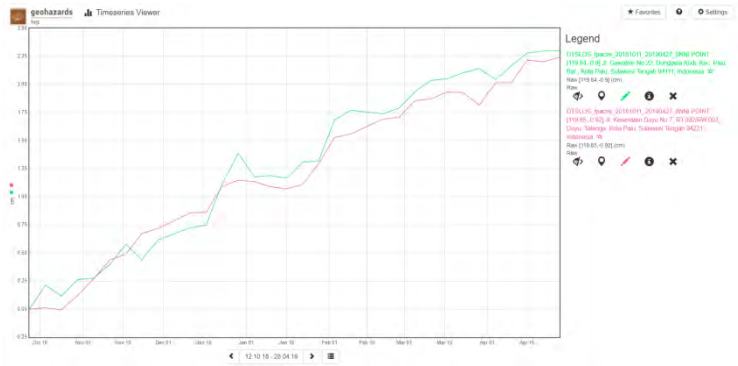
- Seach by Location: **Sulawesi (Indonesia)**







GEP Service Jobs | Sulawesi 2018 Earthquake

- Jobs ID | MPIC-OPT:

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  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D3f85168a-80a1-4949-a486-8424326fa96d%26key%3Dcb7fe172-55bf-409e-9285-6f52e008c99a

- Data Package ID | MPIC-OPT:

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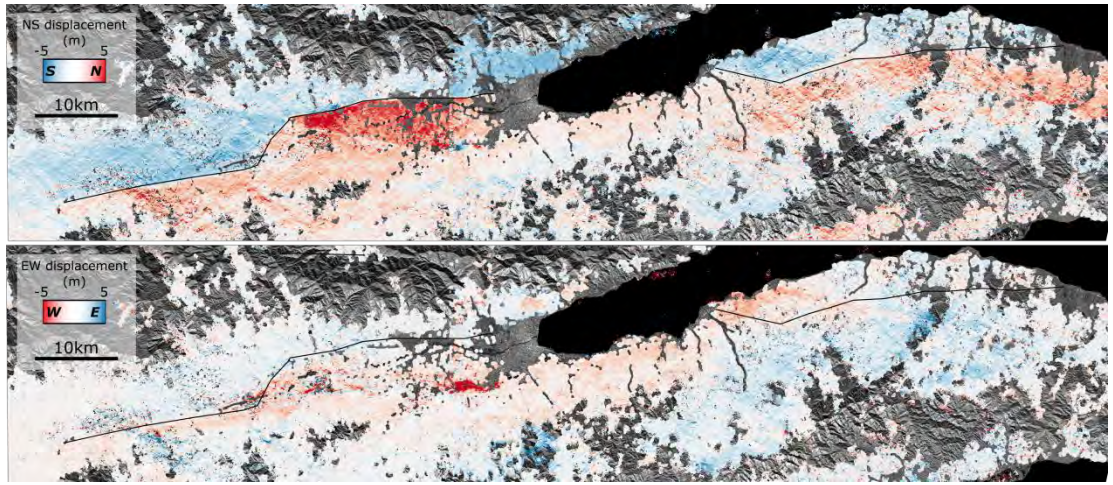


Volcanic Eruptions

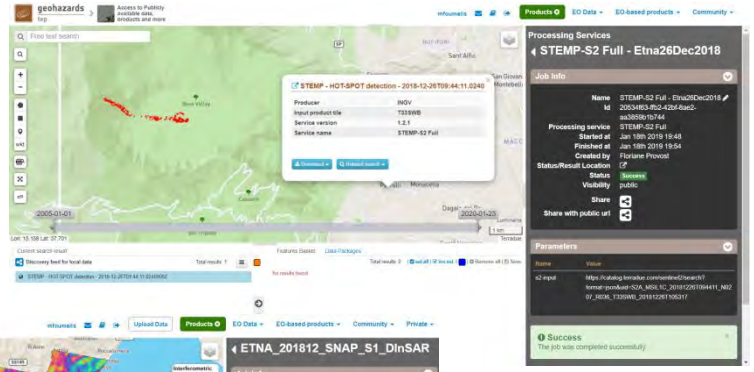
TAT | June 2021

Michael Foumelis | Aristotle University of Thessaloniki (AUTh)
Fabrizio Pacini | Terradue s.r.l.

GEP Service Jobs | STEMP-S2 Etna Volcano Eruption

- Job ID | STEMP Eruptive Hot Spot:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D20534f63-ffb2-42bf-8ae2-aa3859b1b744%26key%3D3db56de0-0e83-4c87-94ba-b50a3c2e009a



- Job ID | SNAP DInSAR:

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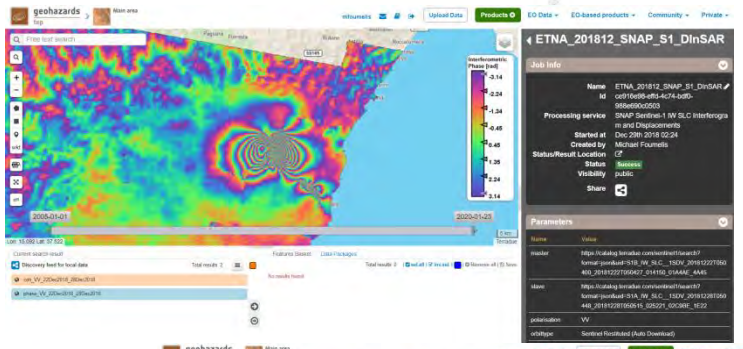
  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3Dfa90d033-6c55-442b-a5e9-70b20d0bb3f4%26key%3D58af8162-1362-4f17-944e-5e5e09992d61



- Job ID | S2 Band Combination:

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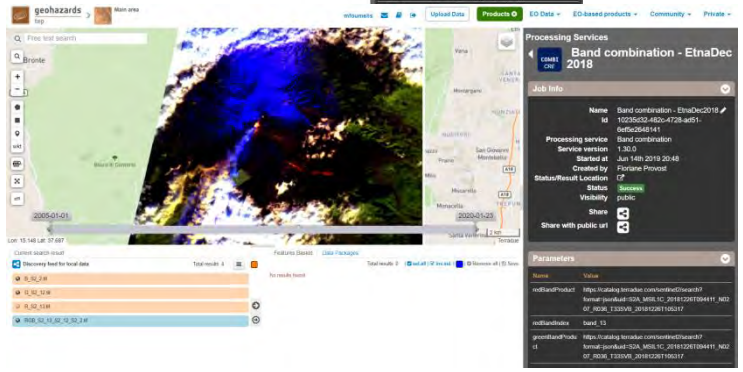


GEP Service Jobs | Kilauea Volcano (Hawaii)

- Job ID | SNAC - SNAP S1 GRD Amplitude Change:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D1edbd0f9-e7e8-4027-96f9-85d020d24cf3%26key%3D494b3edb-553e-437f-83c9-f55642116cc4

- Job ID | Sentinel-2 Band Composites:

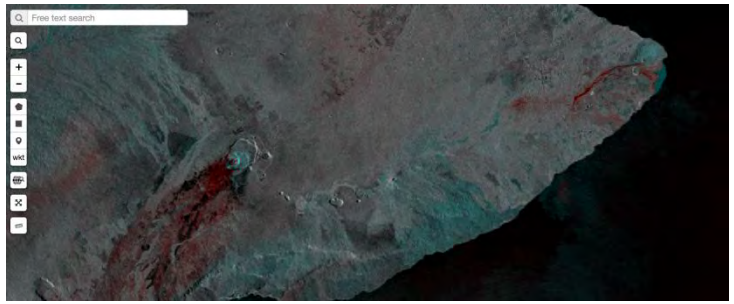
  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D93a1ebd6-413a-41fe-ba02-5a6ebc9802d1%26key%3Db9756054-f575-4a76-a7db-fb7944832b76

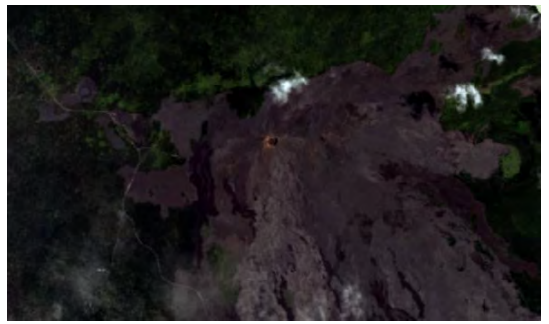
  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D19841ae9-c0e5-4ff3-abd0-23d07a06899b%26key%3D79765ec5-5b3b-41bd-8579-0eba055986d4

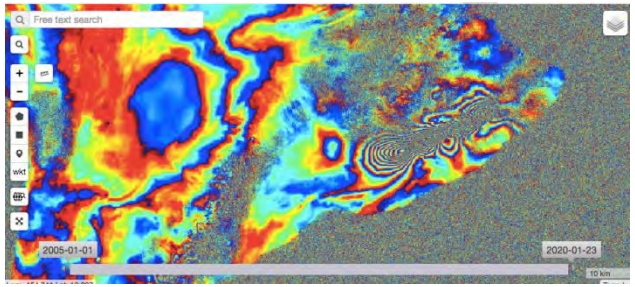
  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D5735eb7b-8920-4fea-97bb-a9ab5e16e6a0%26key%3Dc42ee765-5701-4d89-aec8-2abc2020c38d

- Job ID | DIAPASON DInSAR:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3Da617573b-0329-420f-9f45-d7fa1aa6f02e%26key%3Db08e6668-abab-4d1d-92a8-58d223b56e18





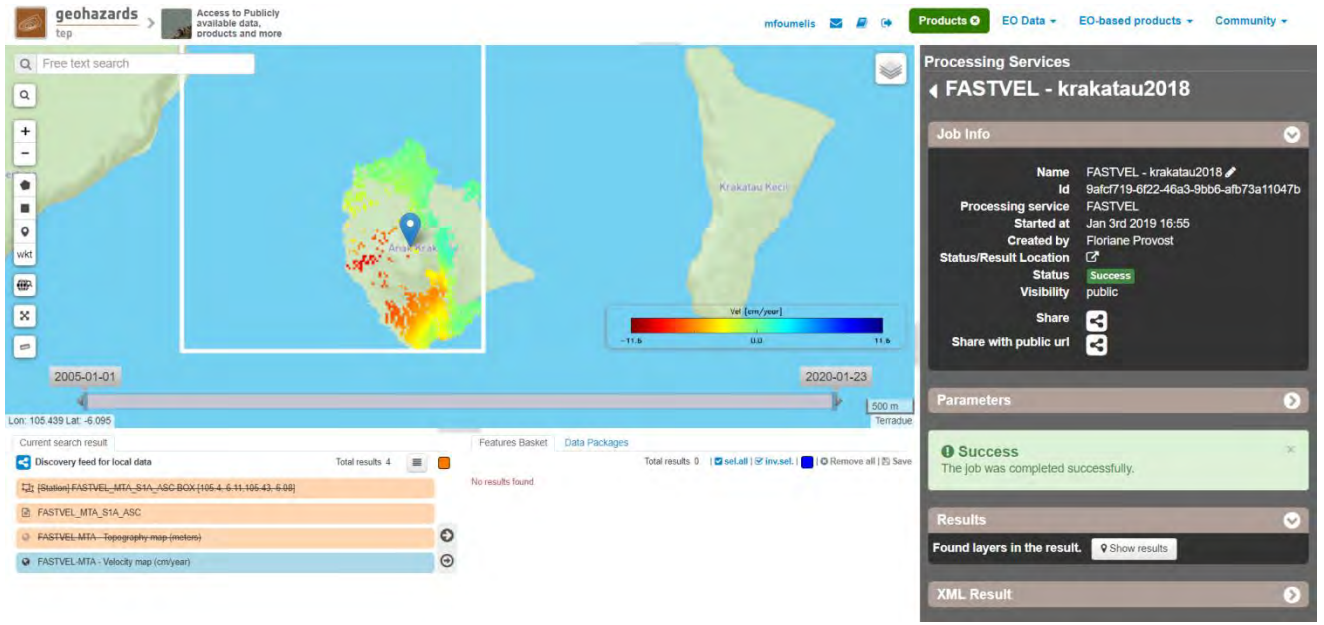


GEP Service Jobs | FASTVEL Krakatau Precursory Motion

- Job ID | FASTVEL:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D9afcf719-6f22-46a3-9bb6-afb73a11047b%26key%3Db58fa298-2e81-4469-901f-259868db76a7

- Seach by Location: **Krakatau**



GEP Service Jobs | Taal Volcano Eruption 1/2

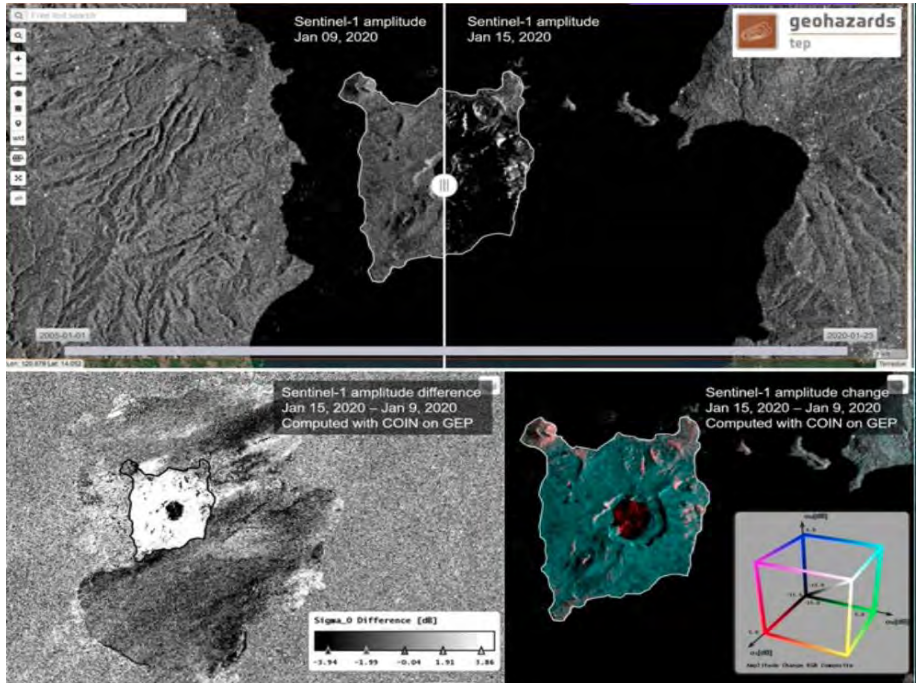
- Job ID | SNAC - Amplitude Change - Taal Volcano:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D116e3aad-f86e-4f7f-be0d-f597b58cd86d%26key%3D1be058a8-1797-44c8-96b6-a3b883abf7c5

- Job ID | COIN – Taal volcano Jan2020:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3Da7b6ca20-1dc8-47b3-8b68-18f3b45ffa29%26key%3Dd27ee21e-f1dd-463e-ac31-e43ddc3bcdc4

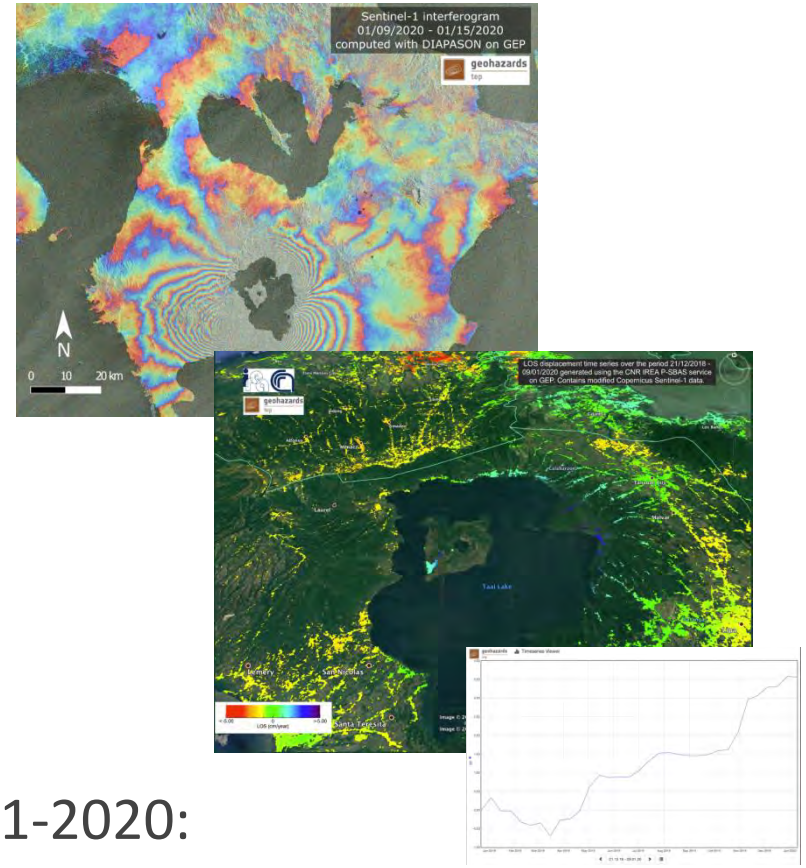
- Seach by Location: **Taal**



GEP Service Jobs | Taal Volcano Eruption 2/2

- Job ID | DIAPASON - Taal 20200115-20200109:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D6de3a5ba-1288-439b-bfdf-78e865b3656f%26key%3De1b62aaf-ae95-4baf-927a-3d5fb3d3cbd5



- Job ID | SNAP S1 Taal Volc Desc:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3Db1d65c70-a028-4225-8427-2b3628edf006%26key%3D5f2d2091-8fc9-46e1-8a88-19821029dbd0

- Job ID | P-SBAS Sentinel-1 Taal volcano 21-12-2018 to 09-01-2020:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D3b4b4ab0-d412-4962-bc5f-9b02fd54a8e2%26key%3D5dfdf221-c409-43a3-a288-e902f0f3832e

Landslides

TAT | June 2021

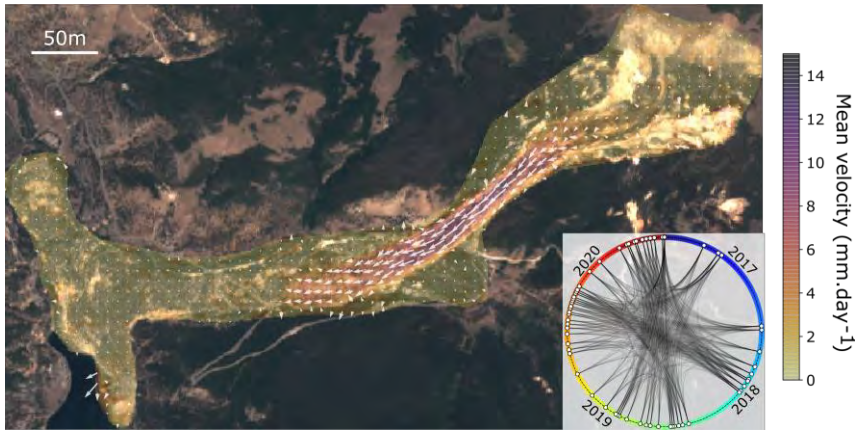
Michael Foumelis | Aristotle University of Thessaloniki (AUTh)
Fabrizio Pacini | Terradue s.r.l.

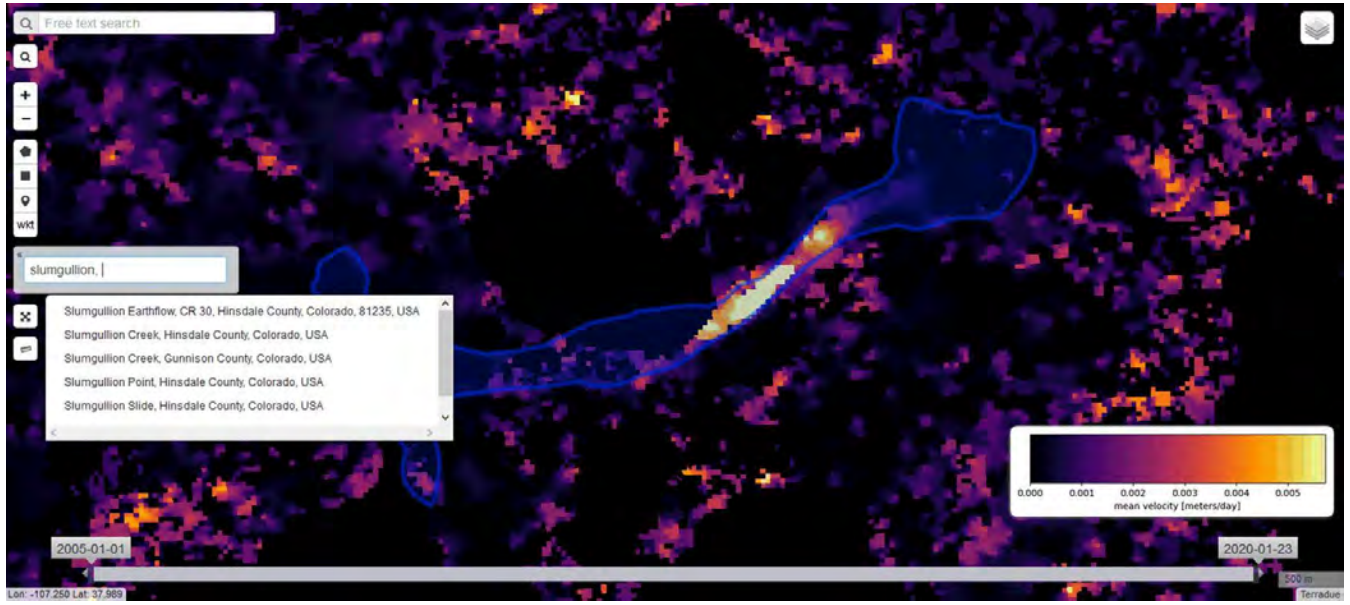
GEP Service Jobs | MPIC-OPT Colorado (USA) Landslide

- Job ID | MPIC-OPT:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D3fc4fb23-716c-4401-afee-090af6e85704%26key%3D847e07eb-14d9-4f6f-8dc8-73931ee6f2a4

- Seach by Location: **Slumgullion**





Flood Events

Inundation Mapping

TAT | June 2021

Michael Foumelis | Aristotle University of Thessaloniki (AUTh)
Fabrizio Pacini | Terradue s.r.l.

GEP Service Jobs | Floods in Laos

- Job ID | COIN S1 Coherence Intensity Time Series:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3De16c69f9-30b7-49ea-b431-445fe5cea916%26key%3Df5bf8a57-31ef-461e-a65d-979febee90d5

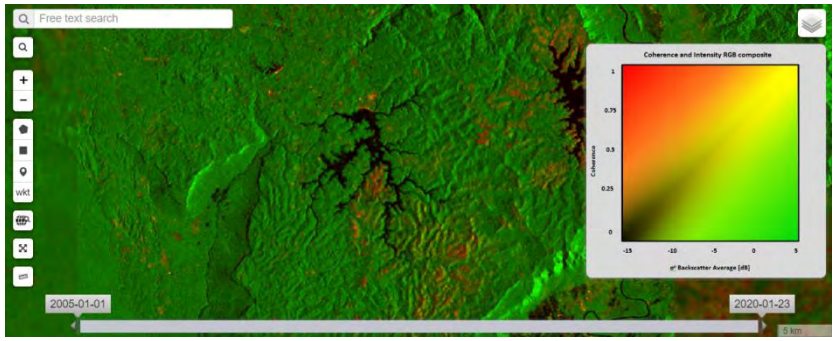
  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D3a6f0aff-b331-4e14-9ada-a17cfb9ee223%26key%3D20ee5aa2-16d6-46d2-9938-6e23c559cc05

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3Dca31292d-3b9c-4dd3-880c-19f31b55e732%26key%3D9ca4d64f-5ba6-4123-8eee-cdf477a5242d

- Job ID | S-1 Band Combination Time Series:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3Ded83f73d-3c7f-4968-b260-17ea8c8cd33e%26key%3Dec379324-61ef-4836-98e4-eaab016b9f5e

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3De19c772a-4d93-4c75-b6e1-ea4a212bc6a6%26key%3D9ddfed04-06e6-48f1-a011-ba31f245201d



Fires

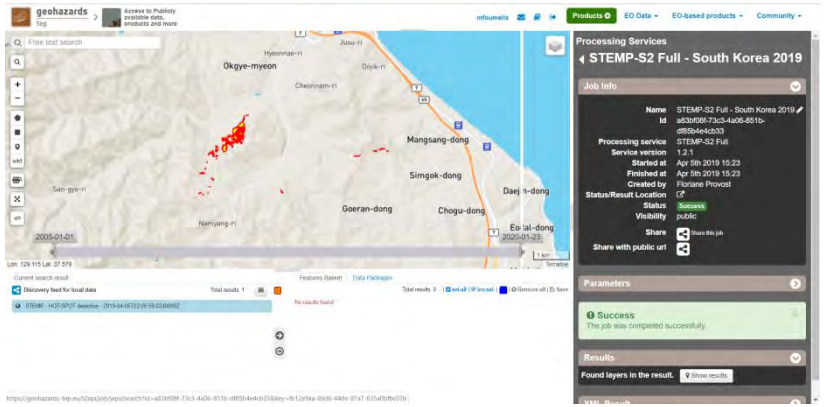
TAT | June 2021

Michael Foumelis | Aristotle University of Thessaloniki (AUTh)
Fabrizio Pacini | Terradue s.r.l.

GEP Service Jobs | Fires in South Korea

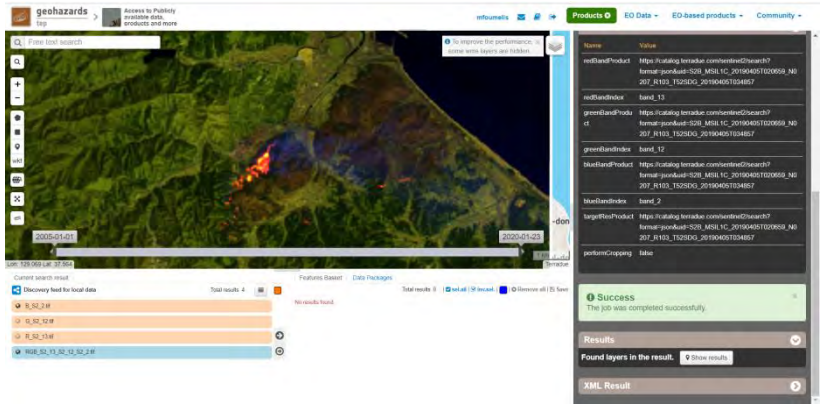
- Job ID | STEMP S2:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3Da83bf08f-73c3-4a06-851b-df85b4e4cb33%26key%3Dfb12e9aa-86d8-44de-87a7-635a0bfbc07b



- Job ID | S2 Band Combination:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D1fa75424-9bf3-4f5b-8a88-40b8f1ce9884%26key%3De56c713d-4e23-4c56-89a5-68ef97c37fa



Land Subsidence

Terrain Motion

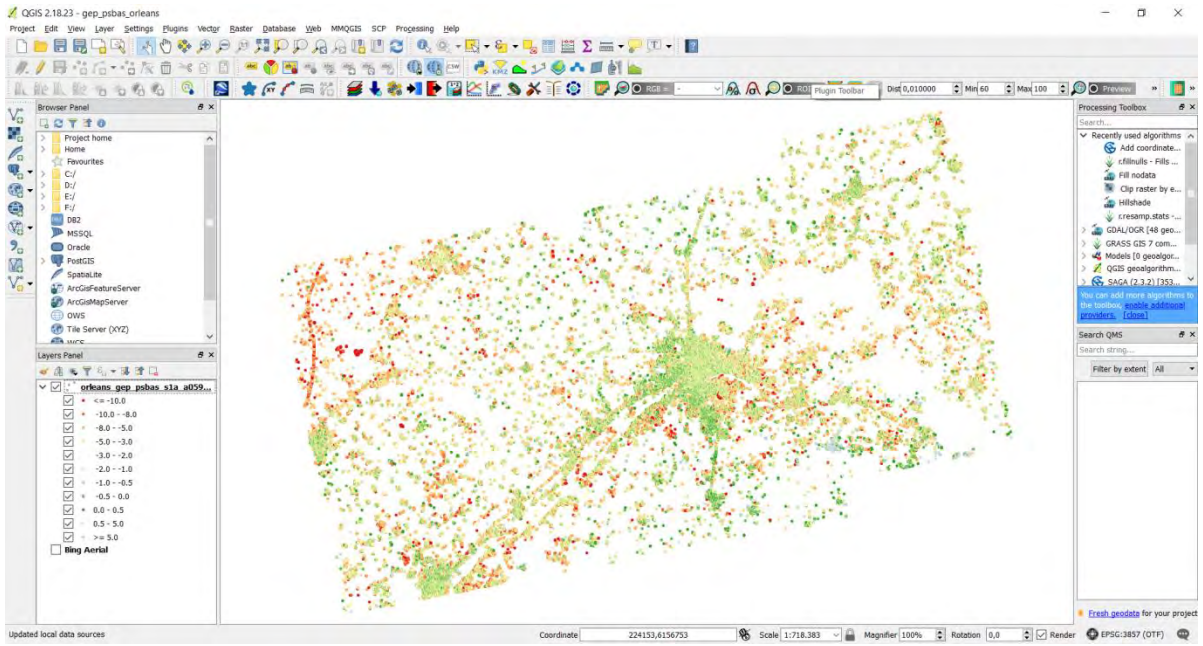
TAT | June 2021

Michael Foumelis | Aristotle University of Thessaloniki (AUTh)
Fabrizio Pacini | Terradue s.r.l.

GEP Service Jobs | Subsidence in Orleans

- Job ID | P-SBAS Sentinel-1:

https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3D59f5d57a-41fb-423f-8129-25ab14535938%26key%3D2777af75-b0f1-470b-8894-083d5ebb885f&id=esaapp

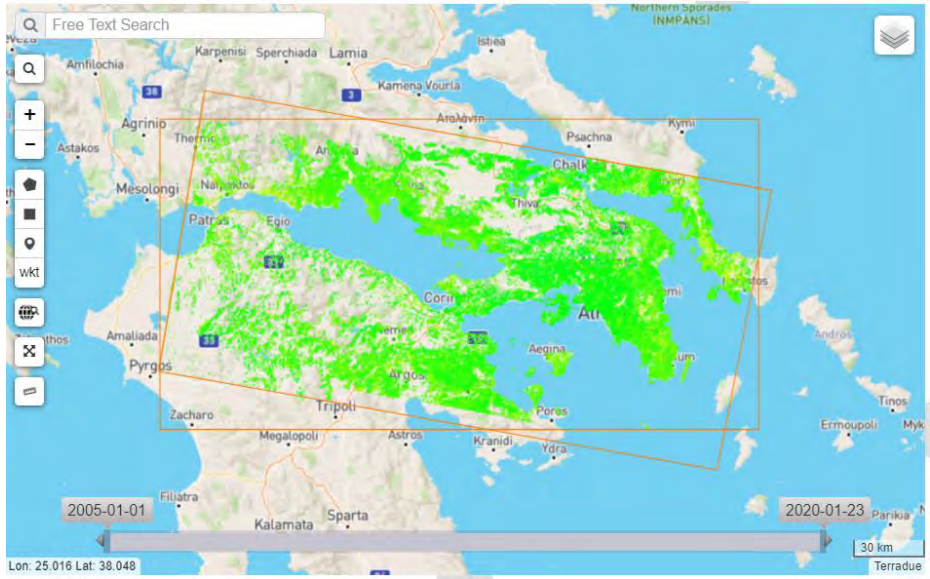


GEP Service Jobs | Ground Displacement Corinth Gulf

- Job ID | P-SBAS S1A Athens D007 201504-201812 - NEW:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3Dbbee35d7-6a3f-4f9c-ab1c-3abb76f9aa9f%26key%3D4eff828f-48b4-4489-8008-421da2004b49

  Observation period 201504-201812 (S1A 185 scenes)

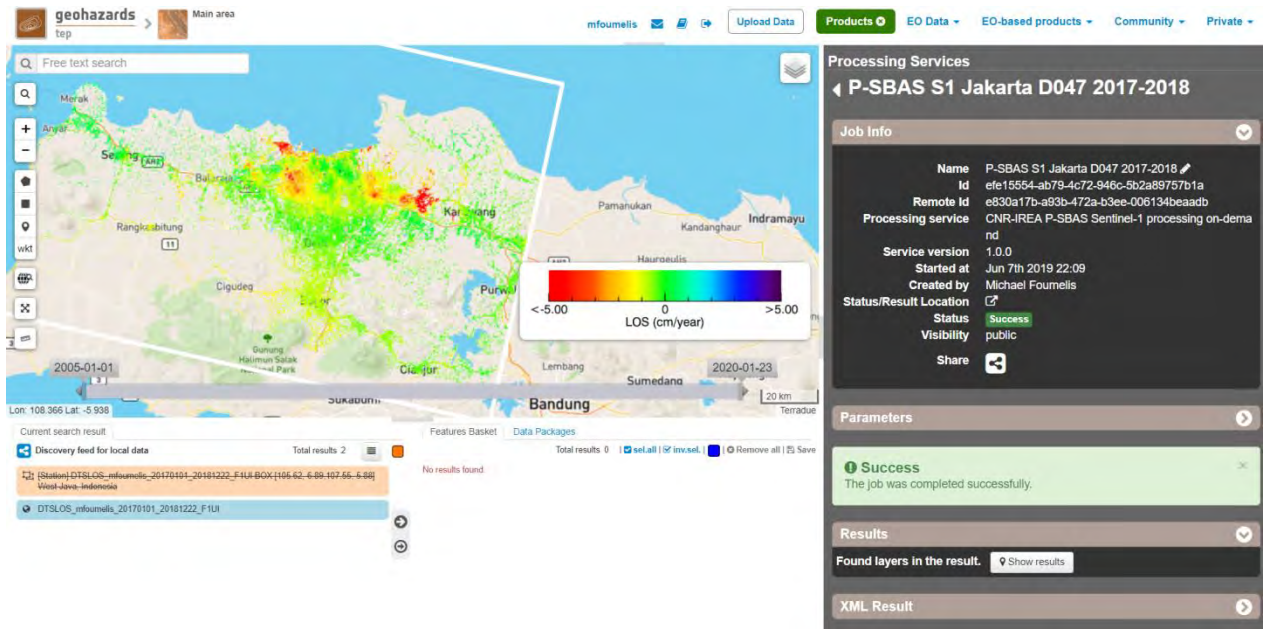


GEP Service Jobs | Subsidence in Jakarta

- Job ID | P-SBAS Sentinel-1:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3Defe15554-ab79-4c72-946c-5b2a89757b1a%26key%3D345c03ad-4603-4b22-8896-3465d903267d

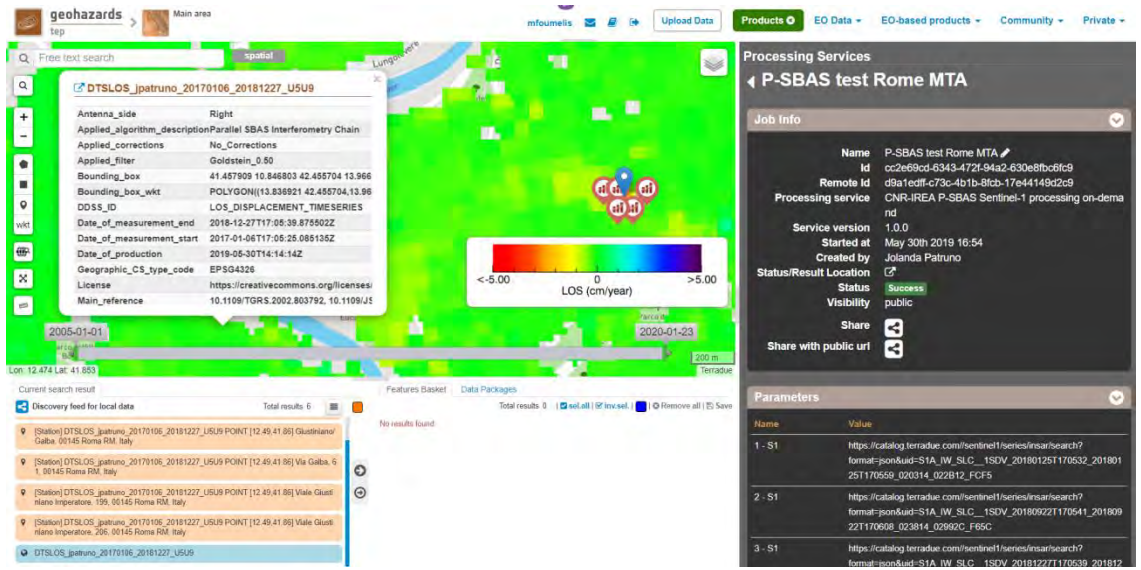
- Seach by Location: **Jakarta**

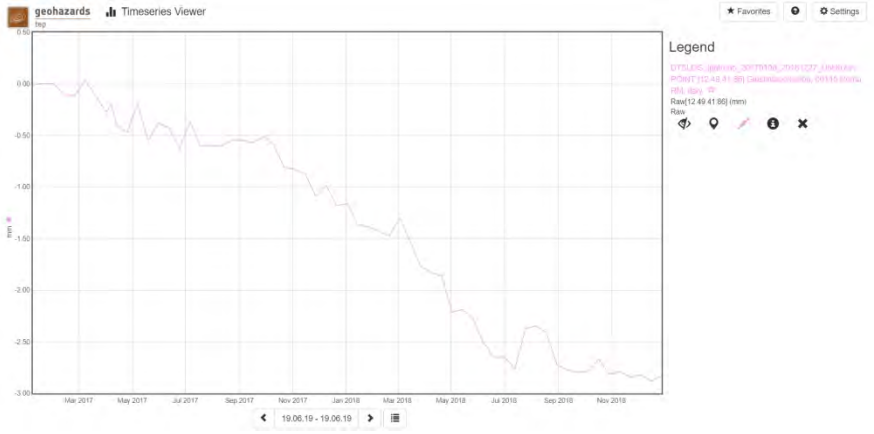


GEP Service Jobs | Subsidence in Rome

- Job ID | P-SBAS Sentinel-1:

  https://geohazards-tep.eu/t2api/share?url=https%3A%2F%2Fgeohazards-tep.eu%2Ft2api%2Fjob%2Fwps%2Fsearch%3Fid%3Dcc2e69cd-6343-472f-94a2-630e8fbc6fc9%26key%3D5c128370-e4a8-45a3-9fa3-c9eff6471183





THANKS

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