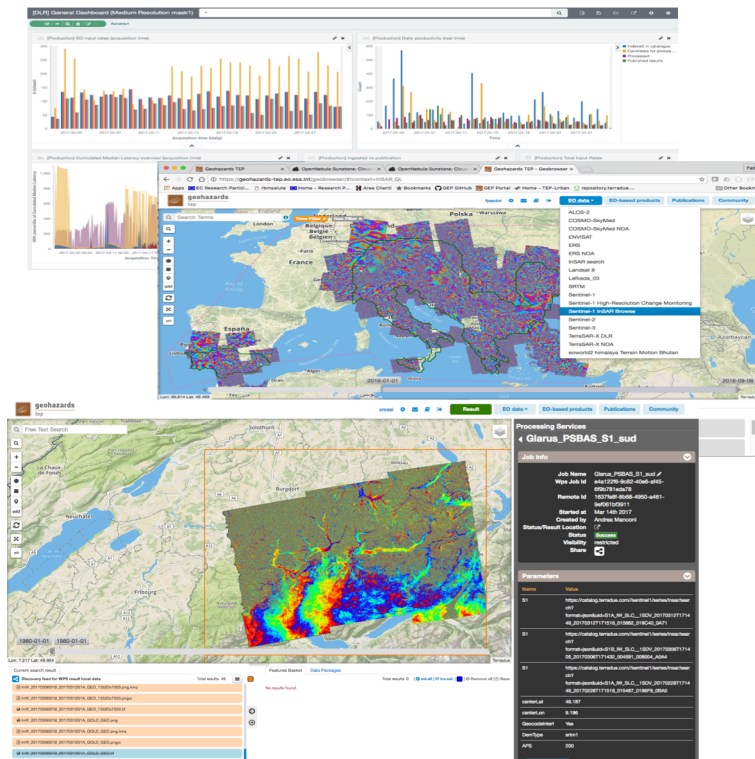


# Geohazards Lab - Satellite EO exploitation and processing services to support geohazards community

MDIS 2019

Theodora Papadopoulou, ARGANS Ltd. c/o ESA  
 Michael Foumelis, BRGM  
 Philippe Bally, ESA  
 Fabrizio Pacini, Terradue s.r.l.  
 Catherine Proy, CNES  
 Floriane Provost, ESA  
 Jolanda Patruno, RHEA Group c/o ESA

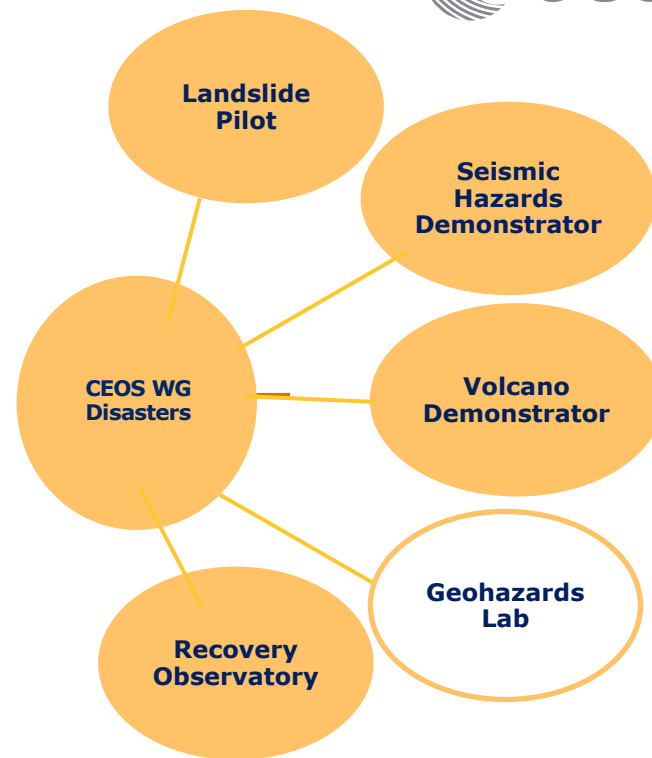


# GeoHazards Lab Initiative



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





- Access to the Geohazards Exploitation Platform including: data storage, processing software (InSAR and stereo-optical processing chains), e-collaboration environment;
- Man-power (staff & support under consultancy contract): scientific animation and promotion of information and results; support to coordination/governance.



- Access to the PEPS platform & products;
- Makes available CEOS and GSNL Pléiades collections through the GEP
- Man-power (staff & support contract): to support the scientific animation and promotion of EO products and results
- Shall make available CEOS and GSNL Cosmo-SkyMed collections through the GEP (already done for the Nepal event supersite). Further details TBD.



- Higher level science products derived from Sentinel-1 and TerraSAR-X data
- Access to the automated Sentinel-1 interferometric chain

## Geohazards Community

### Geoscience centers with EO expertise actively involved:

- BRGM [FR] provides in-kind contribution (labor) and leads the Geohazards Office
- CNR-IREA [IT] (via platform federation activities about InSAR data processing)
- CNRS EOST DSM processing and optical image correlation [FR]
- COMET [UK]
- IGME [ES]
- INGV [IT] (via the responsible of the Geohazards Supersites and Natural Laboratories initiatives)
- ISTERRE / Institut de Recherche pour le Développement (IRD) [FR]
- NOA [GR]

### Geoscience centres following closely the GLab activities:

- BGR [DE] (via SNGMS)
- NGU [NO]

# PEPS | French Access to Copernicus Sentinels



## What is PEPS?

- PEPS – Satellite data distribution platform for COPERNICUS Sentinel-1, Sentinel-2 et Sentinel-3 missions.
  - Full temporal and geographical coverage (all the globe since the beginning of mission)
- Data volume : 12 Po (17 millions of products)
- Data download via dedicated interface or automated scripts
- PEPS online processing (e.g. S-2 atmospheric correction , S-1 rectification on S-2)
- PEPS also offers a capacity to host processing chains on a high performance 'cluster'



<https://peps.cnes.fr>

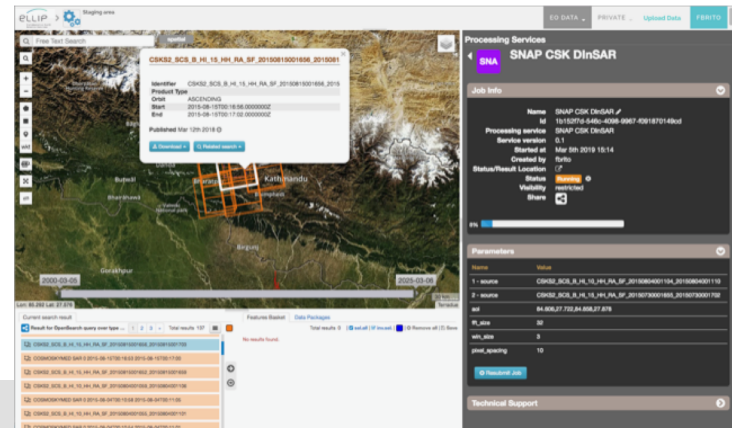
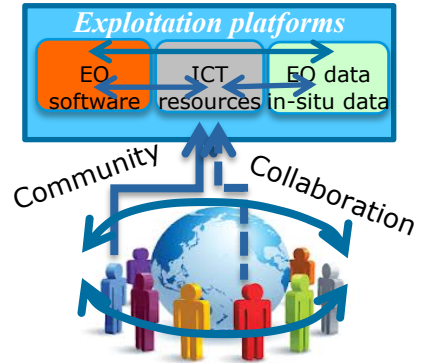


# Geohazards Exploitation Platform | GEP



- One of ESA's Thematic Exploitation Platforms
- 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 open EO data repositories
- Access to EO data archives and specific data collections from EO missions, provided under special arrangements in the framework of the CEOS WG Disaster and the GSNL

The fundamental principle is to move the User to the data and tools



## 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.

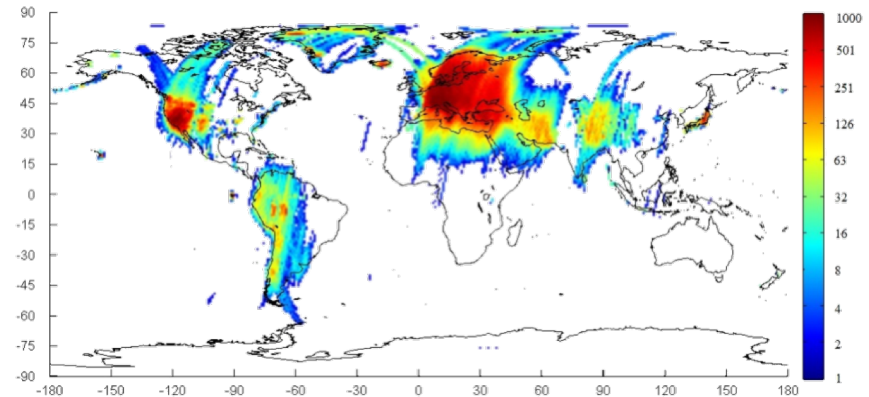
GEP has taken commitments about data access as per some recommendations associated to Fringe

- 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 VA4 (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**
- **Pleiades** (only processing)
- **RADARSAT-2**

**Spatial density of  
ERS & ENVISAT Level-0 data  
available as of December 2018**



**Over 100 Early Adopters worldwide (primarily users from Europe, but also in Asia, Africa and the Americas) from the public (mainly) and private sector.**

Typically geoscience centres in particular geohazard experts with skills in satellite EO that process, analyze, validate, integrate data to generate products for DRM purposes to be used by decision-makers (End Users).

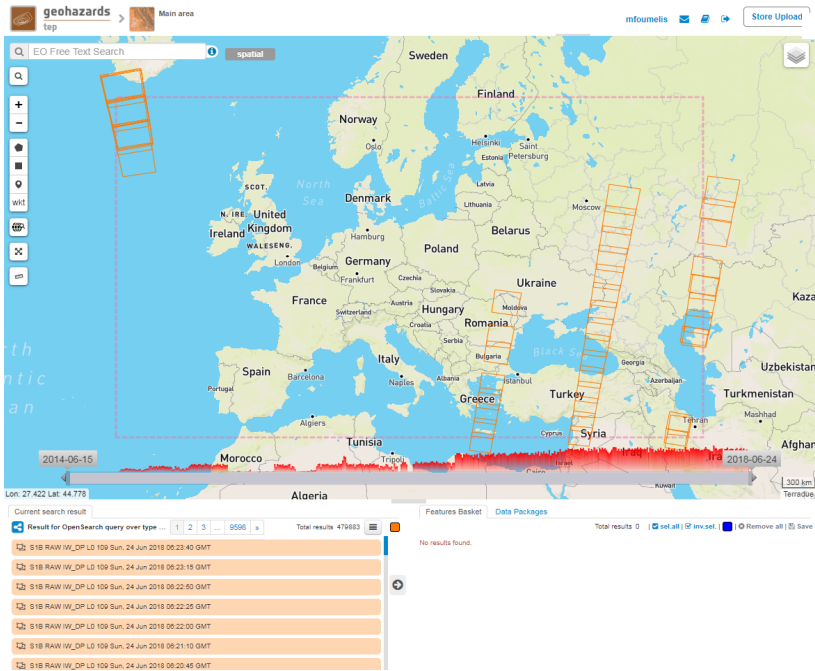
*End Users aren't intended to be direct users of the Geohazards Lab.*

Users come **from several groups:**

- users of **thematic activities of the CEOS WG Disasters** i.e. seismic, volcano, landslides and the R.O.
- the **GSNL users**
- other users of the **geohazards community** (the Geohazards Lab intends to support other users of the geohazards community that are not in CEOS WG Disaster activities)



# GEP | Hosted Processing Services



The screenshot shows the 'Processing Services' catalog. At the top, there's a navigation bar with 'EO Data', 'EO-based products', 'Community', and 'Private'. Below the navigation bar is a search bar with 'Filler services'. The catalog is divided into two columns. The left column contains services like RASTER, GMTSSAR ENVISSAT, COI, SNAC, SNAP InSAR, COIN, DIAPASON Sentinel-1, DIAPASON Stripmap, HASARD, FASTVEL, STEMP L-8, STEMP S-2, and eGEOS SAR Flood. The right column contains services like DIAPASON Stripmap, HASARD, FASTVEL, STEMP S-3, STEMP L-8, STEMP S-2, eGEOS SAR Flood, COMBI, GMTSSAR InSAR, SRTM x InSAR, ADORE DORIS, STAMPS PS, PSI Post-Proc, MineSAR, COREG, SBAS Stripmap, PF-ERS, GAMMA Level-0, and GAMMA DiInSAR. Each service has a small icon and a brief description.

On-demand processing services  
**FASTVEL**, **P-SBAS**,  
**MPIC-OPT**, **DIAPASON**,  
**SNAP InSAR**, **GMTSAR**,  
**COIN**, **SNAC**, **RASTER**  
 etc.

Automatic processing services  
**Sentinel-1 InSAR**  
**Browse (DLR)**, **VEGAN**  
**(NOVELTIS & INGV)**,  
**STEMP (INGV)**



# GEP | Systematic service - Data Driven Scheduled Processing






Supported by   
BELNET-BEGRID (Belgium)

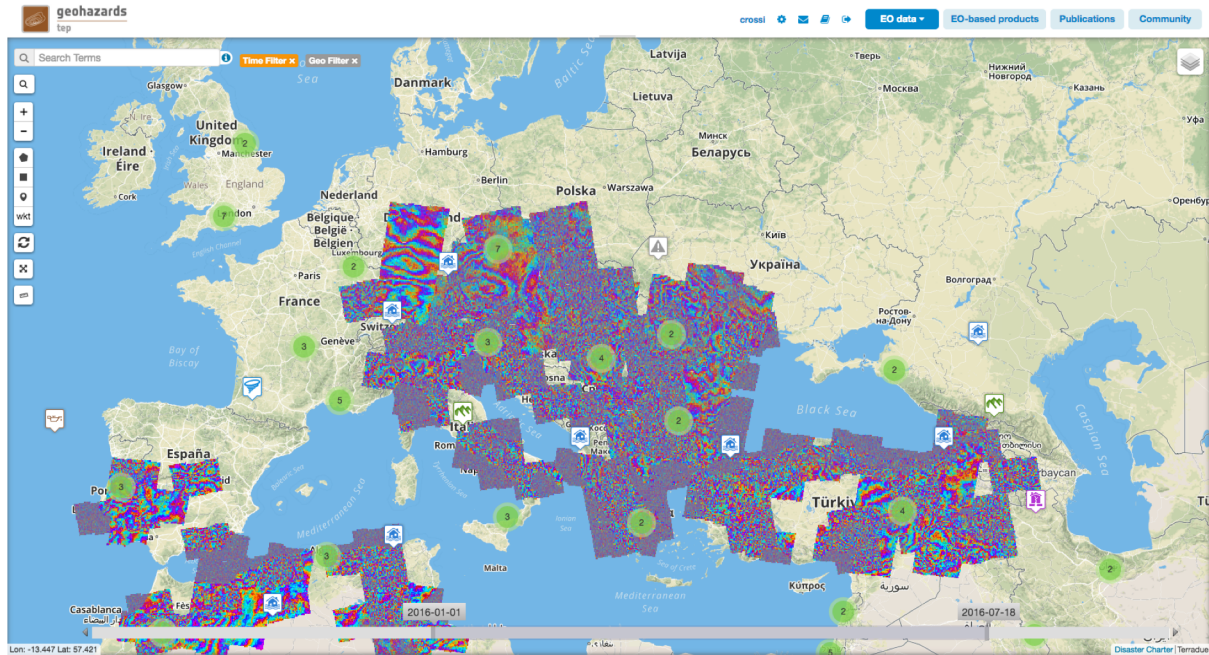


## DLR InSAR Browse Medium Resolution Service

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.



<https://geohazards-tep.eu>



# GEP | On-Demand service - User Driven Processing



**Processing Services**

### Giarus\_PSBAS\_S1\_sud

**Job Info**

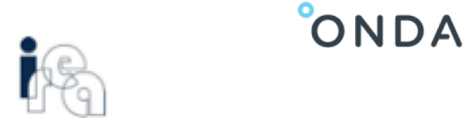
- Job Name: Giarus\_PSBAS\_S1\_sud / e4a122f6-9c82-40e6-af45-69b781eda78
- Wps Job Id: 1837fe8f-8b68-4950-a461-9ef061bf3911
- Remote Id: Mar 14th 2017
- Started at: Andrea Mancori
- Created by: Status: Success
- Status/Result Location: Visibility: restricted
- Share: [Share icon]

**Parameters**

Name	Value
S1	https://catalog.terradue.com/sentinel1/series/nsar/sar/ch?format=json&id=S1A_IW_SLC_1SDV_20170312T171449_20170312T171516_015662_018C40_0A71
S1	https://catalog.terradue.com/sentinel1/series/nsar/sar/ch?format=json&id=S1B_IW_SLC_1SDV_20170306T171405_20170306T171432_004991_008004_A0A4
S1	https://catalog.terradue.com/sentinel1/series/nsar/sar/ch?format=json&id=S1A_IW_SLC_1SDV_20170228T171449_20170228T171516_015487_0196F9_0B40

centerLat: 46.187  
centerLon: 9.196  
GeocodIdentif: Yes  
DemType: srtm1  
APS: 200

Will be supported by  **egi**  
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.



<https://geohazards-tep.eu>



# GEP | SNAP CSK DInSAR service

## Products generated on GEP based on GSNL data



CSK 20190513-20190529 (16 days)  
Name: SNAP CSK DInSAR Naples  
Id: [545bb721-76ce-4e10-9dbb-2b63a8b43d2f](#)

geohazards tep Main area

Free text search

Processing Services

### SNAP CSK DInSAR Naples

Job Info

Name: SNAP CSK DInSAR Naples  
Id: 545bb721-76ce-4e10-9dbb-2b63a8b43d2f

Parameters

Success  
The job was completed

Results

Found layers in the map

Technical Support

CSK ~7 months coherence  
Name: SNAP CSK DInSAR Istanbul 20171023-20180503  
Id: [10f67b55-7f4a-4708-a909-f54f1112fe16](#)

geohazards tep Main area

Free text search

Processing Services

### SNAP CSK DInSAR Istanbul

Job Info

Name: SNAP CSK DInSAR Istanbul  
Id: 10f67b55-7f4a-4708-a909-f54f1112fe16

Parameters

Success  
The job was completed

Results

Found layers in the map

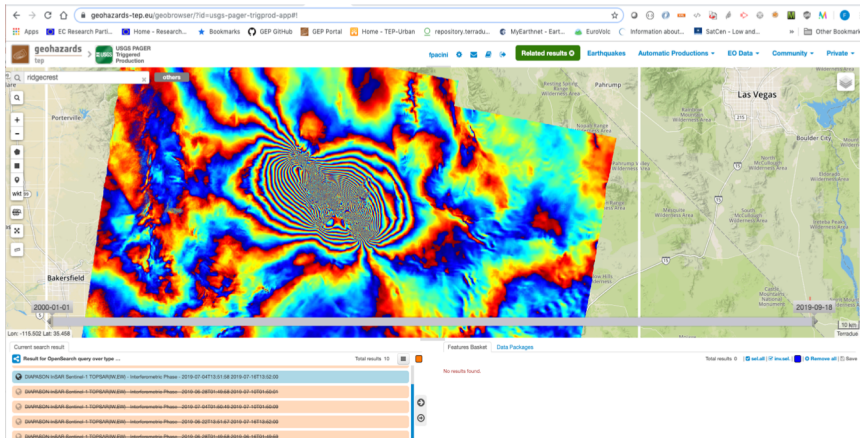
Technical Support



# GEP | Automatic Alerting System – USGS Pager



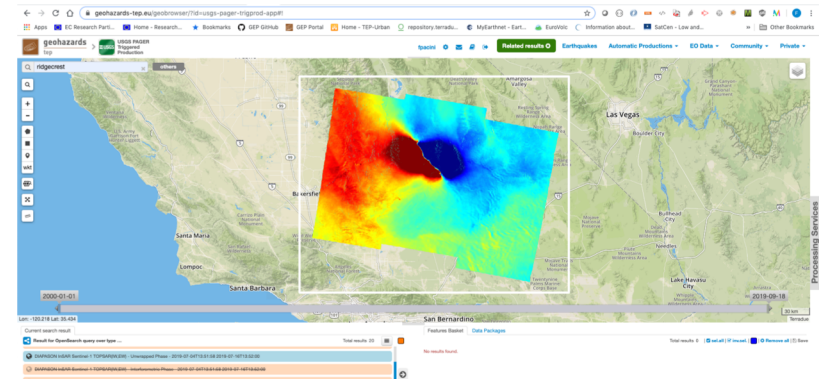
- **In operations** since July 2019
  - **Automatic trigger** based on USGS pager alerts
  - Productions with Sentinel-1 based DLR InSAR Browse and DIAPASON TOPSAR services are **triggered for each earthquake with a magnitude > 5 generating pre-, co- and post-seismic interferograms**
  - Production with Sentinel-2 based CNRS EOST MPIC-OPT service will start in October for Strike-Slip Fault Earthquakes
- **Available to GEP Early Adopters** in a dedicated thematic app
  - <https://geohazards-tep.eu/geobrowser/?id=usgs-pager-trigprod-app#!&context=Earthquakes>
- Example: The July 6th, 2019, 03:19 UTC Mw 7.1 earthquake in eastern California, southwest of Searles Valley



Interferometric Phase - 2019-07-04T13:51:58 2019-07-16T13:52:00

## DIAPASON InSAR Sentinel-1 TOPSAR(IW,EW)

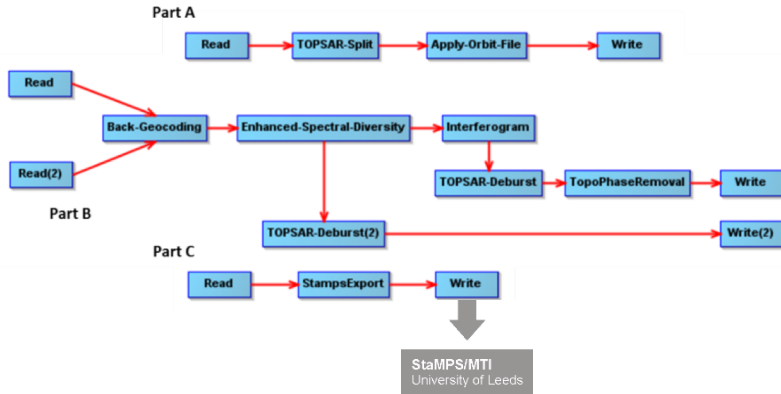
Unwrapped Phase - 2019-06-28T01:49:58 2019-07-10T01:50:01



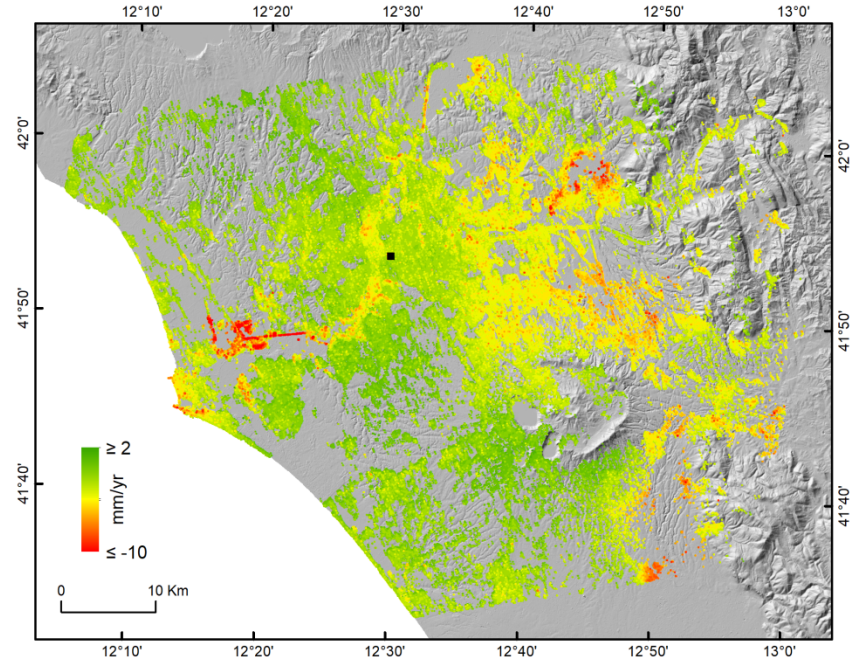
# GEP | SNAP-StaMPS Sentinel-1 PSI service (final steps of implementation)



ESA SeNtinel Application Platform SNAP  
Graph Builder Processing Chains



Sentinel-1 vertical displacement rates

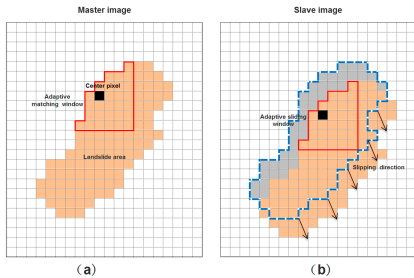


# GEP | Landslide app'

**3 main services** developed by CNRS-EOST Strasbourg

Developed for **landslide monitoring** **but** can be applied to other objects (eg. Earthquake, volcano, glacier, etc.)

## Pixel-offset tracking



**Measurement:** **Ground displacement**

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

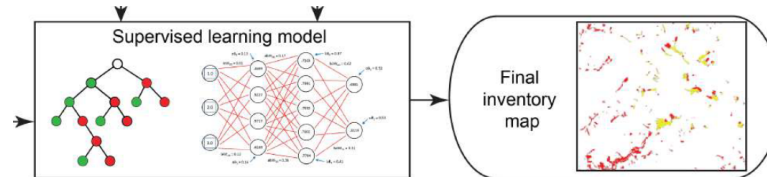


## Digital surface Model



**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 Examples



The image displays three examples of the geohazards web application interface. Each example shows a map with a search bar, navigation controls, and a metadata panel.

**Example 1: P-SBAS Subsidence in Jakarta**

Map: 2005-01-01

Search: Free text search

Metadata Panel:

Relative_orbit_number	47
Sensor	S1
Service_used_for_generation	EPOSAR
Software_version	CNR-IREA P-SBAS 28
Spatial_resolution	90, 90
Super_master_SAR_image_ID	S1A_IW_SLC_1SDV_20180108T22331
Used_DEM	SRTM_1arcsec
User_ID	mfourmelis
Value_unit	N/A, deg, deg, m, cm/yr, N/A, N/A, N/A,
Wavelength	0.055465760

Download | Related search | Load Dynamic Maps

Color scale: <5.00 to 0 LOS (cm/year)

**Example 2: DIAPASON InSAR Hawaii 2016-14 May**

Map: 2016-01-23

Search: Free text search

Metadata Panel:

Job Name	DIAPASON InSAR Hawaii 26-14 may
Wps Job Id	37653954-f5b1-4293-b3b2-247167efcbaa
Processing service	DIAPASON InSAR Sentinel-1 TOPSAR(W,EW)
Started at	May 28th 2018 21:50
Created by	PEBally
Status/Result Location	Success
Visibility	public
Share	

Parameters

Name	Value
master	https://geohazards-lep-ref.terradue.com/2api/data/collection/Sentinel-1/feature?format=atom&url=S1A_IW_SLC_1SDV_20180526T1043027_20180526T1043055_021806_020311_068266_FFF6
slave	https://geohazards-lep-ref.terradue.com/2api/data/collection/Sentinel-1/feature?format=atom&url=S1A_IW_SLC_1SDV_20180514T043027_20180514T043055_021806_020311_C29C
psfFile	0.5
unwrap	false

Resubmit Job

**Example 3: DIAPASON InSAR Kilauea Volcanic Eruption**

Map: 2016-01-23

Search: Free text search

Metadata Panel:

Job Name	DIAPASON InSAR Hawaii 26-14 may
Wps Job Id	37653954-f5b1-4293-b3b2-247167efcbaa
Processing service	DIAPASON InSAR Sentinel-1 TOPSAR(W,EW)
Started at	May 28th 2018 21:50
Created by	PEBally
Status/Result Location	Success
Visibility	public
Share	

Parameters

Name	Value
master	https://geohazards-lep-ref.terradue.com/2api/data/collection/Sentinel-1/feature?format=atom&url=S1A_IW_SLC_1SDV_20180526T1043027_20180526T1043055_021806_020311_068266_FFF6
slave	https://geohazards-lep-ref.terradue.com/2api/data/collection/Sentinel-1/feature?format=atom&url=S1A_IW_SLC_1SDV_20180514T043027_20180514T043055_021806_020311_C29C
psfFile	0.5
unwrap	false

Resubmit Job

P-SBAS Subsidence in Jakarta

DIAPASON Kilauea Volcanic Eruption



# 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**

2014-10-03

Lon: 34.453 Lat: -41.640

Current search result

- Result for OpenSearch query over type...
- Total results 20
- Nepal Earthquake 2015 - CNR IREA InSAR - Sentinel-1 - wrapped interferogram
- Nepal Earthquake 2015 - DLR IREA InSAR - Sentinel-1 - wrapped interferogram
- Nepal Earthquake 2015 - DLR IfRat tracking - Sentinel-1 - range displacement (segm. 1)
- Nepal Earthquake 2015 - TRE ALTAMIRA InSAR - Sentinel-1 - wrapped interferogram
- Nepal Earthquake 2015 - TRE ALTAMIRA InSAR - Sentinel-1 - Deformation Map
- Nepal Earthquake 2015 - IfRat tracking - Sentinel-1 - range displacement (segm. 2)
- Mexico City subsidence - ESA/DLR InSAR - Sentinel-1 - Deformation map

Data Packages

199 data packages found

Filter data pack

1 2 3 4 5 6 7 8 9 10 next

datapackageforcloudtoolbox

Q Set as current search

test5

Q Set as current search

ENVISSAT 1P over Marmara area

Q Set as current search

DISCUSS

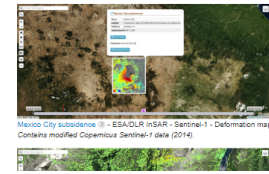
Log in

Providers of the EO sector are sharing their products on GEP in the framework of the Geohazards Lab Initiative: visit the Terrain Motion Demo in the Community area

ipadmi • Terrain start

In a CEOS initiative to promote and harmonize EO techniques for geohazards, service providers such as PLANETEK, TRE ALTAMIRA, GEOMATIC VENTURES, GAMMA REMOTE SENSING, CNRS-EOST and BRGM are providing access to terrain motion products on the GEP. Earth Observation techniques to monitor Terrain Motion provide key information to better understand hazards such as for instance earthquakes, volcanoes, landslides and ground subsidence. To raise interest and promote the use of these techniques the Terrain Motion Demo is a new exercise designed in the framework of the Geohazards Lab Initiative of the CEOS Working Group Disaster. The Geohazards Lab aims to establish an inclusive and comprehensive process to optimise the use of EO techniques with a primary focus on cloud based hosted tools and services. This includes publishing and providing permanent access to Third Party products via the GEP that is ESA's contribution to CEOS. The Terrain Motion Demo provides measurements based on different terrain motion techniques using Optical and Radar data from various missions (e.g. Sentinel-2, Pleiades and Sentinel-1). Some of the products generated were processed using GEP hosted services, while others were processed externally and then uploaded on the platform. Interested EO service providers are invited to contact the GEP to contribute to the Demo.

You can now start navigate and have a look at the different products via the Public Area on the GEP.



Mexico City subsidence - ESA/DLR InSAR - Sentinel-1 - Deformation map. Credits: ESA/DLR. Contains modified Copernicus Sentinel-1 data (2014).

Geohazards-Tep @esa\_gep

Follow

On the blog: Providers of EO sector sharing their Terrain Motion demo products on GEP - @CEOSdotORG Geohazards Lab initiative



Providers of the EO sector are sharing their products on G... In a CEOS initiative to promote and harmonize EO techniques for geohazards, service providers such as PLANETEK, TRE ALTAMIRA, GEOMATIC VENTURES, GAMMA REMOTE SENSI... discuss.terraeue.com



# Animate & Communicate Scientific Results



EUROPEAN SPACE AGENCY ABOUT US OUR ACTIVITIES CAREERS AT ESA FOR MEDIA FOR EDUCATORS FOR DIS



Colour Vision Introducing Sentinel-2 ESA > Our Activities > Observing the Earth > Copernicus > Sentinel-2

- Applications
  - Plant health
  - Changing lands
  - Water bodies
  - Disaster mapping

About the mission
 

- Facts and figures
- Satellite constellation
- Instrument
- About the launch

Operations and data
 

- Data flow
- Data products
- Essential groundwork

Multimedia
 

- Image gallery
- Video gallery
- Downloads
- 2018 calendar
- Documents & publications

Services
 

- Subscribe

## SENTINEL-2 MAPS INDONESIA EARTHQUAKE

On 17 October 2018 a 7.5-magnitude earthquake and tsunami hit Indonesia on 28 September, destroying homes and hundreds of lives. As the death toll continues to rise, the effects of this natural disaster are far-reaching, with hundreds of thousands of people seeking across food, water and shelter in the aftermath of this tragedy.

The European Union activated its Emergency Copernicus satellite mapping service a couple of hours after the earthquake to assist authorities. Copernicus has also produced grating maps showing the impact of the damage covering ten areas of interest. The tailor-made service continues to closely monitor the situation and provide assistance in the aftermath of the disaster.

The Copernicus Emergency Management Service is a key tool providing understanding of the situation on the ground, thus assisting the European Union's Civil Protection Mechanism, activated following a request for assistance from the government of Indonesia. The Emergency Response Coordination Centre is working 24/7 to mobilise offers of assistance to the affected areas.

One of the ways in which ESA is contributing to this area is through leading a range of activities in the framework of the Committee on Earth Observation Satellites (CEOS) Working Group on Disasters.

The Geohazards Office, led by the French Geological Survey (BRGM) leaves with practitioners on the exploitation of Earth observation processing services to assist hazard mapping and risk assessment. This is in the spirit of the International Forum on Satellite Earth Observation and Geohazards.



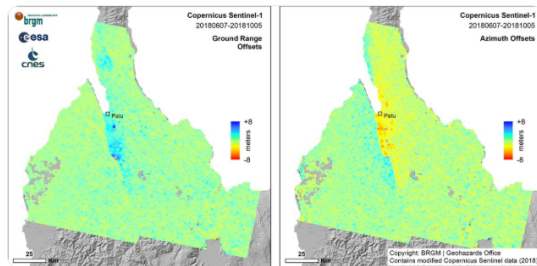
As shown in the images, the earthquake triggered deformations of several metres and a tsunami. Around 1400 people are reported to have lost their lives, hundreds have been hospitalized and many more thousands are thought to have been displaced. It has been estimated that up to 1.5 million people will be affected by these events.

The Vice-President of the country, Jusuf Kalla, has said that the final death toll could reach the thousands. The International Charter Space and Major Disasters was triggered by the Asian Disaster Reduction Centre on 29 September for this event. International collaboration is in place to organise Earth observation-based disaster response activities.

Scientific products such as the map created by BRGM are helping us to better understand hazards. Beyond this example it is foreseen that Earth



BRGM @BRGM\_fr · Oct 12  
 #PaluEarthquake Mw 7.5: #Sentinel1 from @CopernicusEU allowed the #BRGM scientists to produce a second map of the displacement field generated by the #earthquake in #Palu (#Indonesia, 2018-09-28) within the frame of the #Geohazard Office with @ESA and @CNES



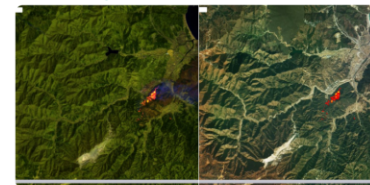
twitter BOT 1:14 AM  
<https://twitter.com/emmanuelmathot/status/7696744784901201>  
 Emmanuel Mathot @emmanuelmathot  
 #Insar #ItalyEarthquake #sentinel1 A&B with DIAPASON via @e @CopernicusEU https://geohazards-tp.eo.esa.int/t2api/share?url=https%3A%2F%2Fgeohazards-tp.eo.esa.int%2Ft2api%2Fjobs%2Fwps%2Fsearch%3Fid%3D%0a386d-0493a19f9ebd https://pbs.twimg.com/media/Cq5umX7XE  
 Twitter Aug 28th at 1:14 AM · (226KB) +  
<https://pbs.twimg.com/media/Cq5umXYAa83U.jpg> (169KB)

twitter BOT 7:33 PM  
<https://twitter.com/pmar/status/769950969803268096>  
 Petar Marinković @pmar  
 5/5: Big thanks to @esa\_gep for prompt dissemination #Sentinel  
 Twitter Aug 28th at 7:33 PM



Following

Monitoring #wildfires in #SouthKorea @DisastersChart with Sentinel-2 data from the @CopernicusEU programme. A fire spot could be captured near Okgye-myeon on Apr 5, 2019 using GEP services COMBI and STEMP-S2 developed by the providers of ESA's GEP platform @esa\_gep. #EO4society



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## Geohazards Exploitation Platform

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**Chernobyl's nature: Prypjat and Dnepr rivers amazing path**  
 Baumann, Andrea Bruno Graziano;  
 If someone hears about Chernobyl, then he will most probably think of the April 26th 1986 disaster in the nuclear power plant. But Sentinel-1 and Sentinel-2 caught a different eye on it. The rivers Prypjat, who passes by at the previous power plant, and Dnepr have a beautiful meandering watercourse!  
 Uploaded on February 27, 2017

January 29, 2017 Presentation Open Access View

**SBAS DInSAR processing on the ESA Geohazards Exploitation Platform**  
 Casu, Francesco, De Luca, Claudio, Zimmo, Ivana, Manconi, Andrea;

Community

Geohazards Exploitation Platform  
 The Geohazards Thematic Exploitation Platform or Geohazards TEP is an ESA funded R&D activity to exploit the benefit of new techniques for large scale on demand processing of EO data. It supports the geohazards community



# Geohazards Lab – EPOS collaboration

Proposition of collaboration between GLab and EPOS sent to EPOS TCS Satellite data:

- Inviting the EPOS community to discover and use EO processing services available on-line through the GEP platform. A Terrain Motion Demo and a brochure describing the GEP services is available (see image) to help users familiarize with cloud-based processing services.
- Sharing with the EPOS TCS Satellite Data, guidelines about the standards associated to EO based terrain motion measurements and take on board their views.

### SUPPORTING GEOHAZARDS USERS WITH CLOUD-BASED EO SERVICES

The Geohazards Exploitation Platform (GEP) is part of the Terrain Motion Exploitation Platform (TEM) initiative set up by ESA to provide an environment to process EO data and support the user community concerned about cloud-based services. The platform is in pre-operation with an Early Adopter programme, supporting approximately 100 user organisations in 35 countries whose access is governed by ESA.

#### On-demand Conventional Terrain Motion services

These services are based on Differential SAR Interferometry (DSI/SAR) to measure surface displacements occurring between two dates.

**Services available:**

- DIAPASON DInSAR**: The DIAPASON DInSAR service is developed by the French Space Agency (CNES) and maintained by TRC-Altamira. Two versions of DIAPASON are available supporting different acquisitions of ERS, Envisat and Sentinel-1 missions and TOPSAR acquisitions of Sentinel-1.
- SNAP DInSAR**: The SNAP DInSAR service provides an interferometric processor using ESA SNAP toolbox. Copernicus Sentinel-1 mission is supported.

Other services include GMTSAR, GAMMA DInSAR, ADORE, COCOS, P-INSAR.

#### On-demand Advanced Terrain Motion services

**Based on Radar data**

Advanced services for SAR time series analysis provide surface deformation measurements over point targets, called Persistent Scatterers, using multiple SAR acquisitions. Deformation monitoring is measured in the line of sight of the satellite and accuracy can reach sub-centimetre level depending on the observation period considered.

**Services available:**

- FASTVEL**: The FASTVEL service is developed by TRC-Altamira for generating differential interferograms and DInSAR based mean displacement velocity maps. Copernicus Sentinel-1 (E1) and ENVISAT missions are supported.
- TRC-INSAR processing chain**: developed by DLR/DFVLR for the generation of ground deformation time series and mean displacement velocity maps. Copernicus Sentinel-1 (E1) and ENVISAT missions are supported.

Other services include: SoSIMP.

#### Based on Optical data

Image correlation techniques provide surface deformation information from the combination of pairs or time series of satellite images. This kind of service provides maps of horizontal displacements. They are particularly suitable for monitoring large displacements (up to m) such as co-seismic slips (especially for strike-slip faults), lava flows from volcanoes or landslides. The techniques require very accurate co-registration of image time series.

**Services available:**

- MUSE-GPT**: The MUSE-GPT service is developed by CNES/CEST for the processing of optical image time series to monitor persistent surface motion. It enables on-demand processing of time series of Sentinel-2 as well as very high resolution imagery from Pleiades and SPOT-7.
- Advanced Earthquake Deformation**: North-South surface motion processed by MUSE-GPT between the Sentinel-2 acquisitions of 27/09/2018 and 02/10/2018. Credits: DR, SRTM3plus, Copernicus modified Copernicus Sentinel-2 data (2018-2018).

#### Systematic Services – application example to volcano monitoring

**The Sentinel-1 InSAR Browse** service is developed by DLR, Medium (50m spacing and 100m resolution) and High-resolution (20m spacing and 50m resolution) InSAR Browse provides interferometric products since 2015 and is updated for every new Copernicus Sentinel-1 acquisition. In particular, the High-Resolution InSAR Browse (20m spacing and 50m resolution) provides interferometric products on request over target areas defined by the user through the GEP operator (e.g. the 22 predefined volcanoes of the Volcano-2-Sat Case).

**Interferogram** generated by the InSAR Browse over the Subglacial Llanos, Ecuador (Sentinel-1A). Credits: DLR/DFVLR, Copernicus modified Copernicus Sentinel-1 data (2015-2017).

**The STEMP** service is developed by INGV in the framework of the Volcanoes Thermal Applications VOLTAAGE pilot of GEP. It generates surface temperature maps over volcanic areas from Landsat-8, Sentinel-2 and Sentinel-3.

Surface Temperature Map of Elvolcano, Bolivia, on 27/03/2017. A low flow in angle with yellow is clearly visible. Credits: INGV, Copernicus modified Landsat-8 data from EO4/NOAA Landsat Program.

#### Other services

**The VEGAN** Hot Spot and Vegetation Index systematic service is developed by NOVELTIS and INGV within the framework of the VEGAN project. It provides operational monitoring of volcanic eruptions by detecting temperature anomalies and the impact of the eruption on the vegetation through a vigor index. It is based on Sentinel-2 data.

Vegetation vigor maps of the 2017/2018, followed by the VEGAN service over the El Tago volcano, Guatemala. Credits: NOVELTIS, Copernicus modified Copernicus Sentinel-2 data (2018).

In the context of the **EO4 Working Group Disasters**, the GEP allows to access EO mission's data from different EO4 space agencies and provides an on-line environment to process imagery and share EO based products within a community of users. It also allows users to display their processing chains. In addition, external products from third parties can be published on the GEP. In particular through the **Geohazards Lab Initiative**, a **terrain motion mapping demonstration** is available to explain and show full scale results based on different terrain motion techniques using Optical and Radar data. In the spirit of the EO4 WG Disasters, the Geohazards Lab is also collaborating with EO practitioners of the geohazards community working on the standardisation and harmonisation of EO services and using the GEP to support this activity.

This proposition aims to foster:

- federation of EO cloud-based processing resources
- broader use of EO hosted processing services based on common standards
- interoperability of results obtained by different services and data providers

# 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

The screenshot shows a Twitter thread. At the top, ESA (@esa) posts: "A 7.5-magnitude earthquake and tsunami hit #Indonesia on 28 September, destroying s. Geological ted displacement J #Sentinel2". Below it, Sotiris Valkaniotis (@SotrisValkan) posts: "Shallow afterslip following M7.5 Palu #earthquake. 12-day interferogram (Oct4-Oct16) from ascending pair of #Sentinel1, w/DIAPASON at @esa\_gep. Patches of afterslip follow the ruptured plane (hangingwall), small higher peaks found along the trace. Each fringe is ~2.8cm LOS." The tweet includes two large differential interferograms showing color-coded ground displacement. A smaller inset map shows the earthquake location in Indonesia. Below the tweet, a quote tweet from Geohazards-Tep (@esa\_gep) is shown: "Differential Interferogram of the September 16 2018 Mw 5.3 earthquake Lake Muir, Perth, Australia DOI: doi.org/10.5281/zenodo... @OpenAIRE eu zenodo.org/record/1464715...". At the bottom, another tweet from Sotiris Valkaniotis is visible: "Released dataset: Differential Interferograms of the Sep.16 2018 Mw 5.3 #earthquake Lake Muir, Perth, #Australia. Produced with SNAP/DIAPASON at @esa\_gep doi.org/10.5281/zenodo...". The thread is timestamped "3:13 PM - 16 Oct 2018".



Thank you

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