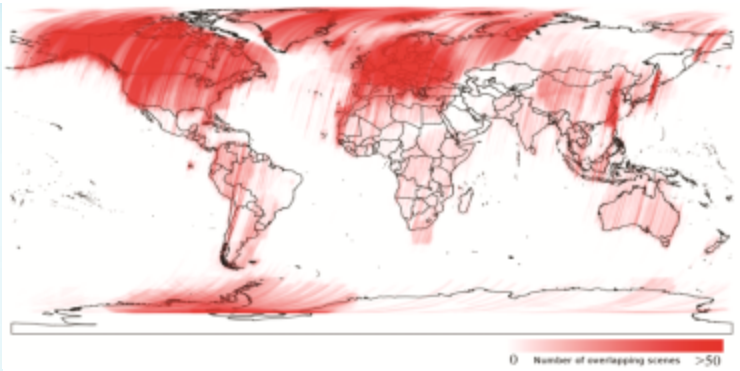
The Geohazards TEP
State of project, Jan 2017

Philippe Bally

Presented at M.Albani at CEOS WGISS, 3-6 April, Annapolis (USA)



Objectives of the geohazards community:

A. Support the generation of **globally self-consistent strain rate estimates** and the mapping of **active faults** at the global scale by providing EO InSAR and optical data and processing capacities to existing initiatives, such as the iGSRM

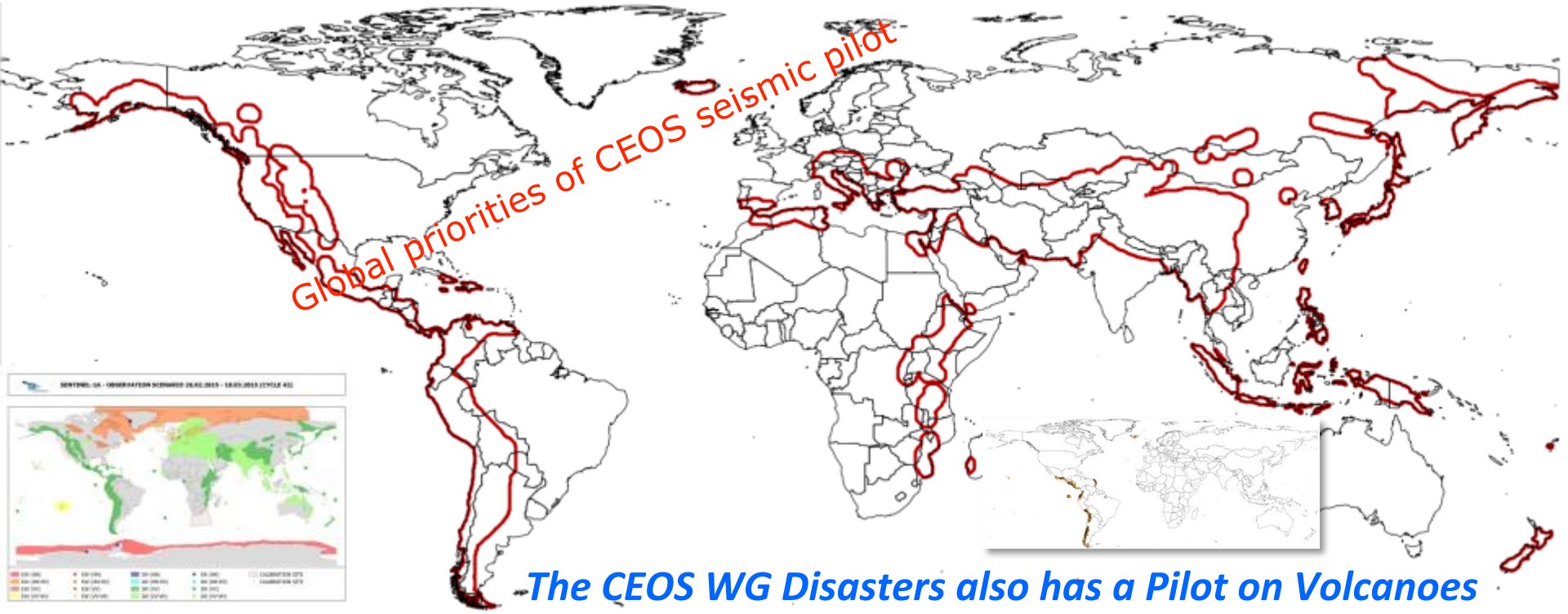
[role of EO: wide extent satellite observations]

B. Support and continue the Geohazards Supersites (GSNL) for seismic hazards and volcanoes

[role of EO: multiple observations focused on supersites]

C. Develop and demonstrate advanced science products for **rapid earthquake response**.

[role of EO: observation of earthquakes with M>5.8]



The CEOS WG Disasters also has a Pilot on Volcanoes

The Geohazards TEP (GEP):

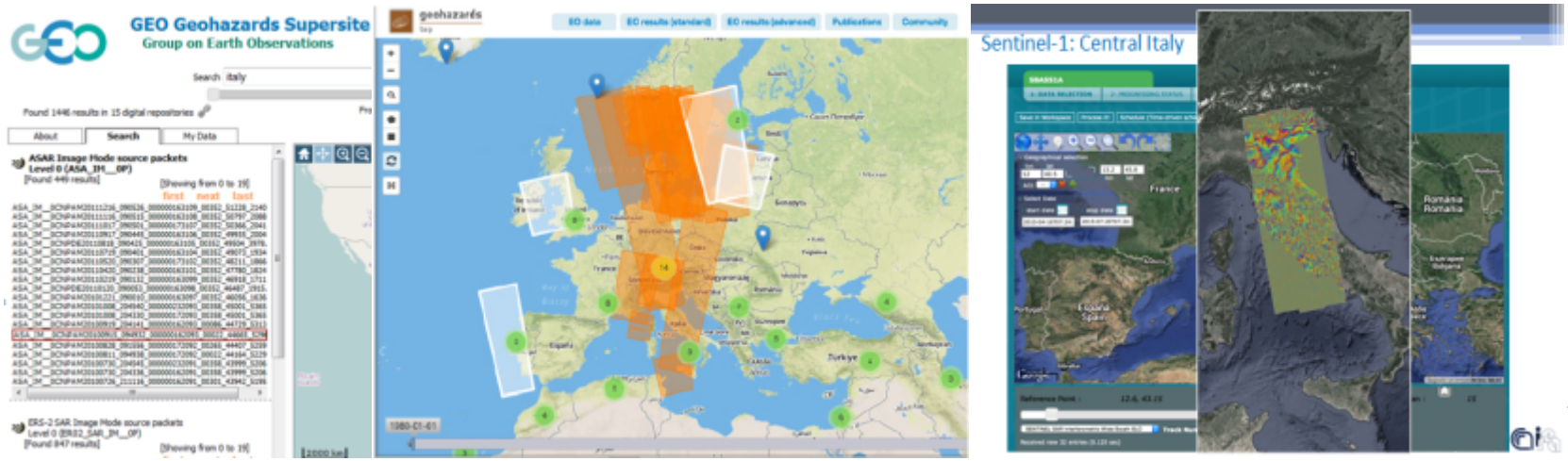
An ESA originated **R&D activity on the EO ground segment** to demonstrate the benefit of new technologies for large scale processing of EO data.

Designed in the context of the Geohazards Supersite initiative (GSNL) and the CEOS Disasters Working Group which adress a Task of the **Disaster Societal Benefit Area of the intergovernmental Group on Earth Observations (GEO).**

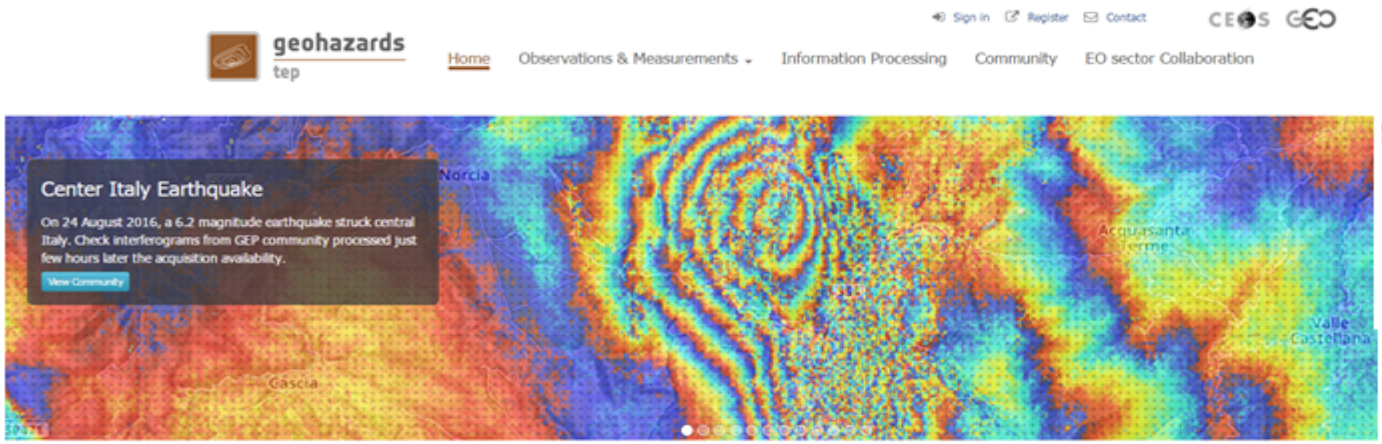
A model for partnership and community building that is user driven. Started from the **International Forum on Satellite EO and Geohazards** organised by ESA and GEO in Santorini in 2012 (140+ participants from 20 countries, 70+ organisations incl. international organisations, public institutes, space agencies, universities & private sector).

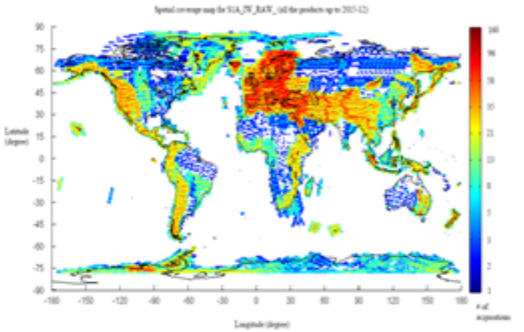
Overview of the GEP:

- ESA is developing the geohazards platform (GEP) that is based upon the **virtualization & federation of satellite EO methods** to support the geohazards community.
- An enhancement of the precursor SSEP platform (GPOD) designed to support the **Geohazard Supersites** (GSNL) and the **Geohazards community** via the CEOS WG Disasters.
- An ESA funded **R&D activity** to demonstrate the benefits of an exploitation platform for large scale hazard mapping and monitoring and to link with with large science networks.
- A 2 years Contract starting on 22 October 2015; Team: Terradue (IT), CNR IREA (IT), INGV (IT), DLR (DE), ALTAMIRA Information (ES), University of Strasbourg (F), ENS/ CNRS (F).



GEP: an innovative response





Background

Geo Browser

Activities

An Exploitation Platform sourced with **data and processing** relevant to the GeoHazards theme:

- EO data **storage** concerning wide extent tectonic analysis for which large data stacks are needed (typically 1000+ and 5000+ scenes and larger)
- Access to **advanced processing tools** (e.g. InSAR and Optical based)
- A **collaborative** work environment and scientific animation
- 2016: **32 users** on board; end of 2017: **60 users**
- One of the *6 Thematic Exploitation Platforms* originated by ESA
- Follows the GPOD, SSEPand TEPQwin precursors

Over 2016-2017 the GEP will have 10-20 new projects

Since October 2015 the GEP includes six new partnerships that bring **new applications and new end-users**:

- ALTAMIRA Information with **SPN processing services** (commercial chain)
- CNR-IREA with SBAS based **Sentinel-1 Surveillance service**
- DLR with **systematic InSAR Browse** processing
- UNI. STRASBOURG with MICMAC based **optical processing for landslides**
- ENS/CNRS with the **validation of the platform services** by experts
- INGV for optical data pre-processing for **volcanoes monitoring**

Each will bring 1 user and the GEP will identify 25 new users during the project execution.

Two ESA GSP projects on Innovation in the area of Disaster Risk Reduction will bring 7 additional users: Altamira Information, CNR IRPI, INGV, IGME, NKUA, e-geos, Deimos Space and NOA.

- **This will make 60 users in end 2017**

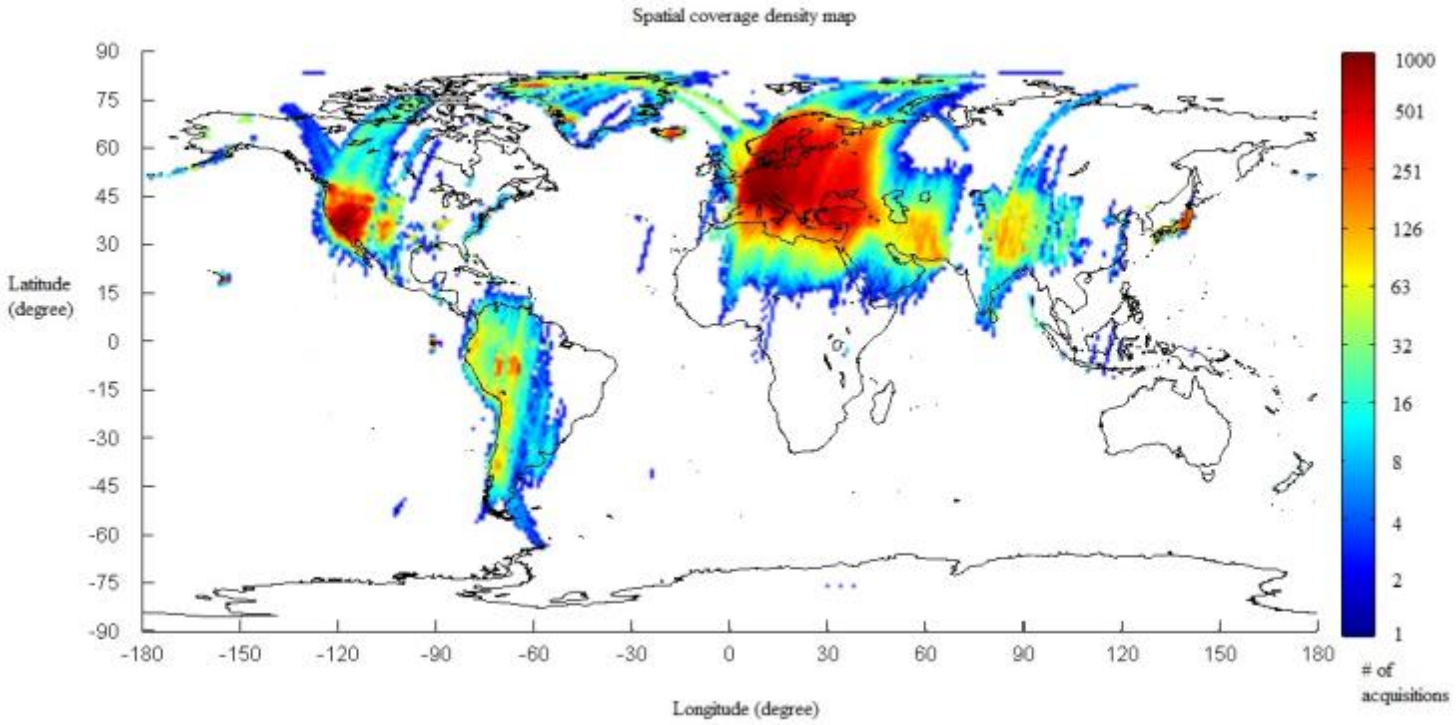
Available ERS, Envisat & Copernicus Sentinel-1 SAR & Sentinel-2 data

Sentinel-1 made available (in raw as well as SLC format) starting with CEOS Pilot targets and with the goal to gradually provide global coverage.
Sentinel-2 are made available on the platform since March 2016.
Sentinel-3 data will be available shortly.

ERS & Envisat SAR data:

- **Current ENVISAT ASAR IM Level-0 ta**
- **Current ERS SAR IM Level-0 Data**

(70+ terabytes)

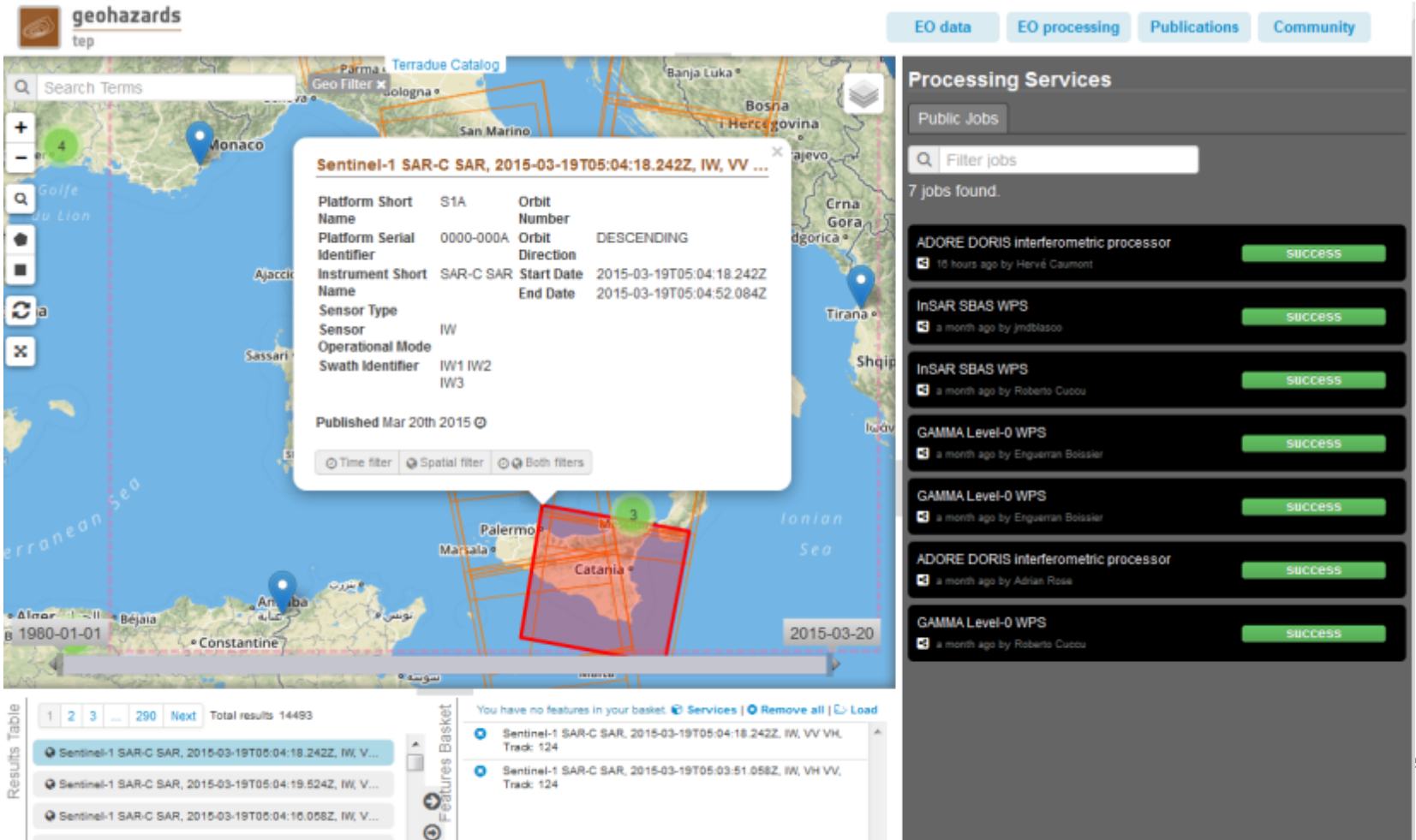


ERS & ENVISAT Level-0 data available as of February 2016.

Available Sentinel-1 data

Sentinel-1 data **(same coverage as SciHub)** is directly available in GEP for launching **EO processing** services (no dissemination)

Portal: https://geohazards-tep.eo.esa.int, contact: geohazards-tep@esa.int



scenarios for Users (see User Request Form URF):

Scenario 1) EO Data Exploitation which allows a user to discover/select data and pre-existing processing service; **process** data; and visualize/ analyse or select and apply data manipulation tools to the result
Scenario 1) New EO Service Development which allows a user to discover/select a data sample and software components; engineer (or upload) and validate an application (such as a processor); and **deploy the application on the platform** for use also by other users.
Scenario 1) New EO Product Development, which allows a user to Authenticate; alternatively upload and deploy a new processor; discover/select data; process the data; and eventually **publish the resulting product**.

Example: the Italian earthquake of 24 August 2016

- **On 24 August 2016 at 3:36 CEST an Mw 6.0 earthquake hit Central Italy ina sparsely populated area. Many buildings in the villages of Amatrice, Accumoli and Arquata del Tronto collapsed and caused nearly 300 fatalities.**
- **The day of the earthquake the Seismic Pilot was activated by INGV, to provide access to EO data to all pilot contributors and generate scientific support products for Obj. C. JAXA, CSA, ASI, and ESA accepted to support the pilot requests.**
- **The Copernicus EMS was activated by the Italian Civil Protection authority for Rapid Damage Mapping.**

The 24 August earthquakes in the areas of Rieti, Ascoli Piceno, Perugia, L'Aquila e Teramo:

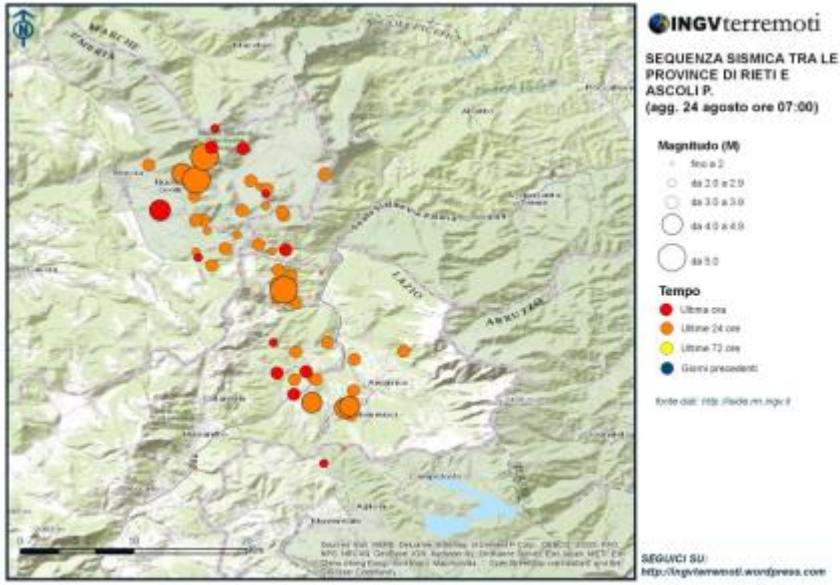
Concerning **Damage Mapping for Disaster Response**: the Copernicus EMS service was activated by *Presidenza del Consiglio dei Ministri - Dipartimento della Protezione Civile - Centro Situazioni*.

Concerning **Science Products for Earthquake Response**: The *CEOS Seismic Pilot* led by ESA and INGV was activated on 24 August to provide EO data and EO derived science products (Pilot Objective C: advanced products for operational sismology). ESA's GEP is offered to access/exploit/share data & results.

Mandated users exploiting EO data:

- INGV (convention about modelling & interpretation)
- CNR IREA (convention about INSAR based deformation mapping)

Both collaborate and share measurements



The 24 August earthquakes in the areas of Rieti, Ascoli Piceno, Perugia, L'Aquila e Teramo:

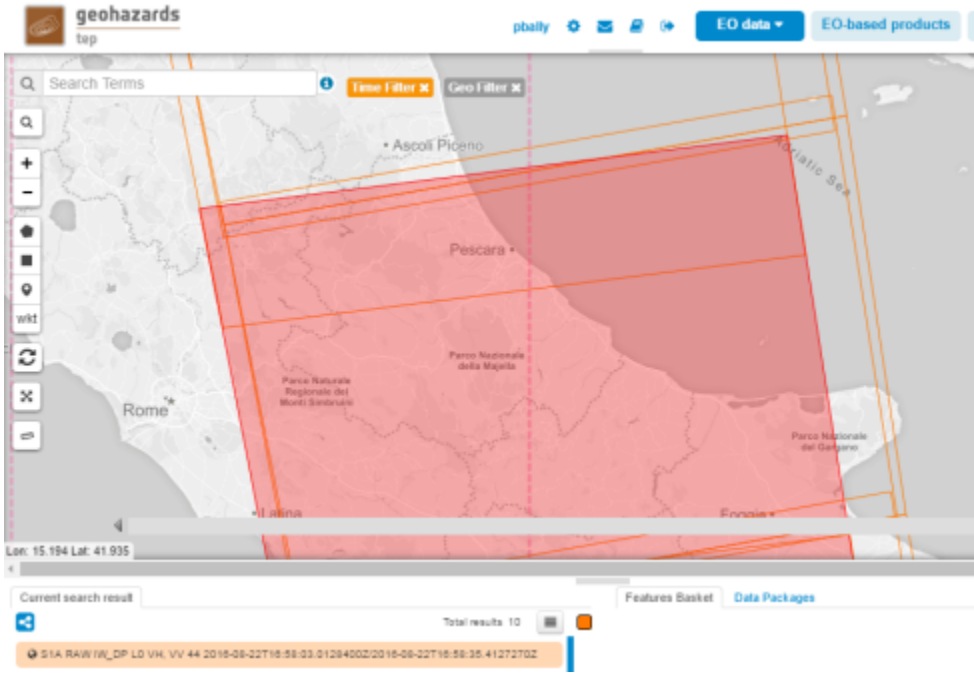
EO data collections accessed or planned to be accessed via CEOS:

- **Cosmo Skymed** acquisitions of 24 (1), 25 (3) and 26 August
- JAXA's **ALOS-2** acquisition of 24 August
- **Sentinel-1 A** (26 & 27 August) and **Sentinel-1 B*** (27 & 28 August)
- **Pleiades** data (incl. Tristereo) planned
- **Radarsat-2** planned, **TerraSAR-X** awaiting feedback

The Geohazards Exploitation Platform developped by an Italian team led by Terradue is used:

- as repository to share the **CEOS data collection**
- As repository for third party **VA results** (e.g. INSAR maps)
- as **processing environment** for hosted INSAR chains

*: S-1B not yet in full operations but data will be made available for this event

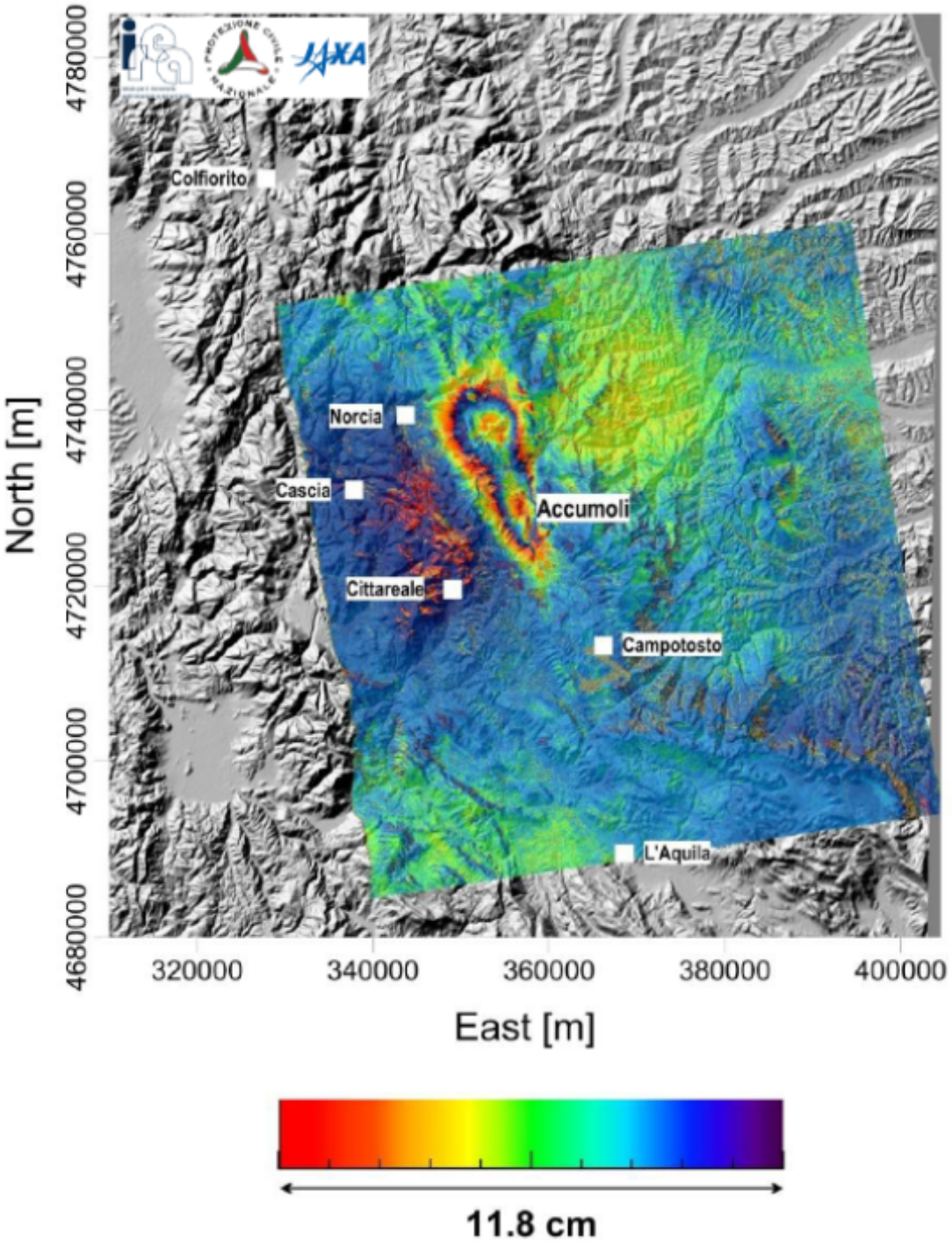


First EO based report issued by INGV

ALOS-2 based Interferogram produced on 25 August:

3 pre-event (01/07/15, 09/09/15, 27/01/16) acquisitions and 1 post-event (24/8/16) acquisition (L band SAR data).

Credits: Gruppo di lavoro IREA-CNR & INGV, 2016 Sequenza sismica di Amatrice: risultati iniziali delle analisi interferometriche satellitari, DOI: 10.5281/zenodo.60935

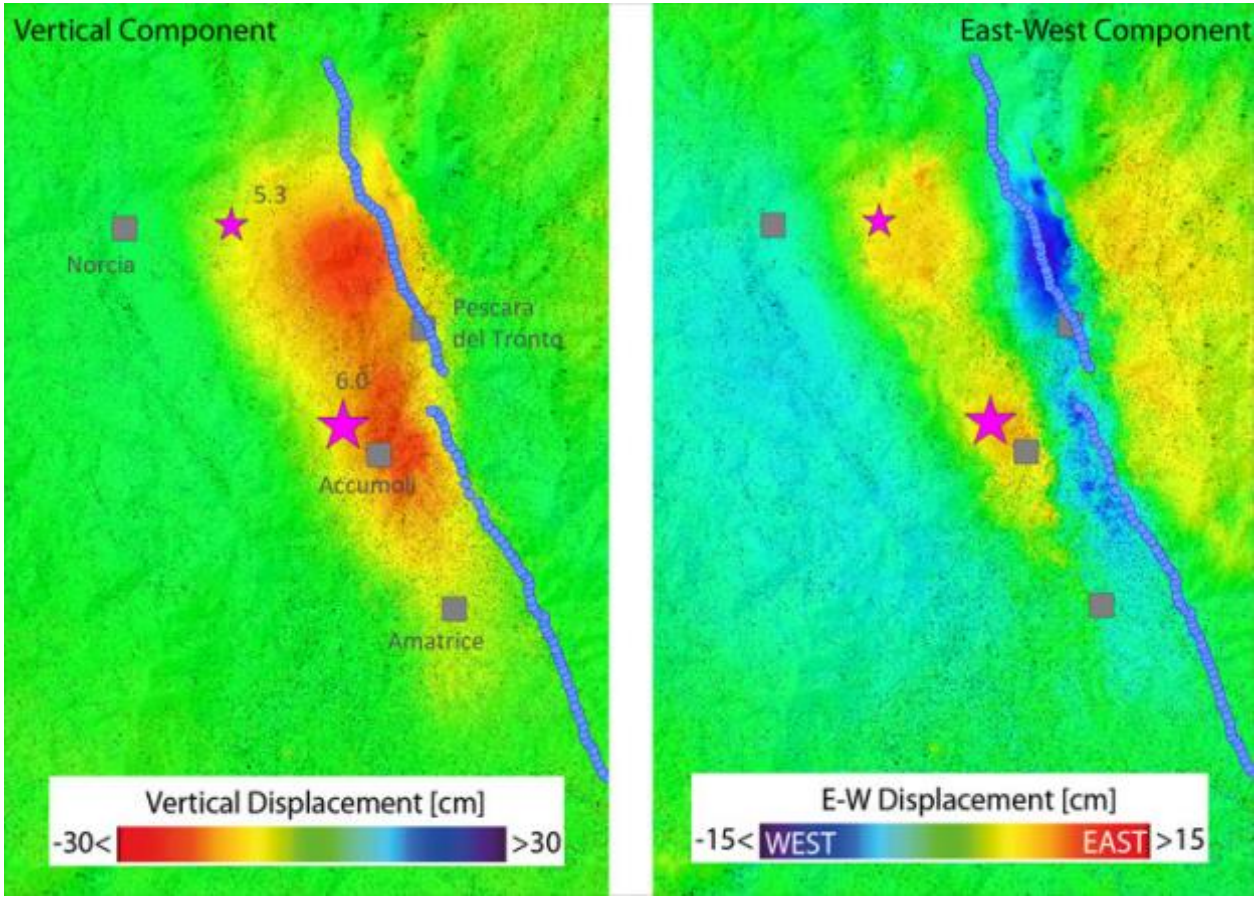


First EO based displacement map by CNR IREA:

Sentinel-1 based Ground displacement product generated by CNR IREA:

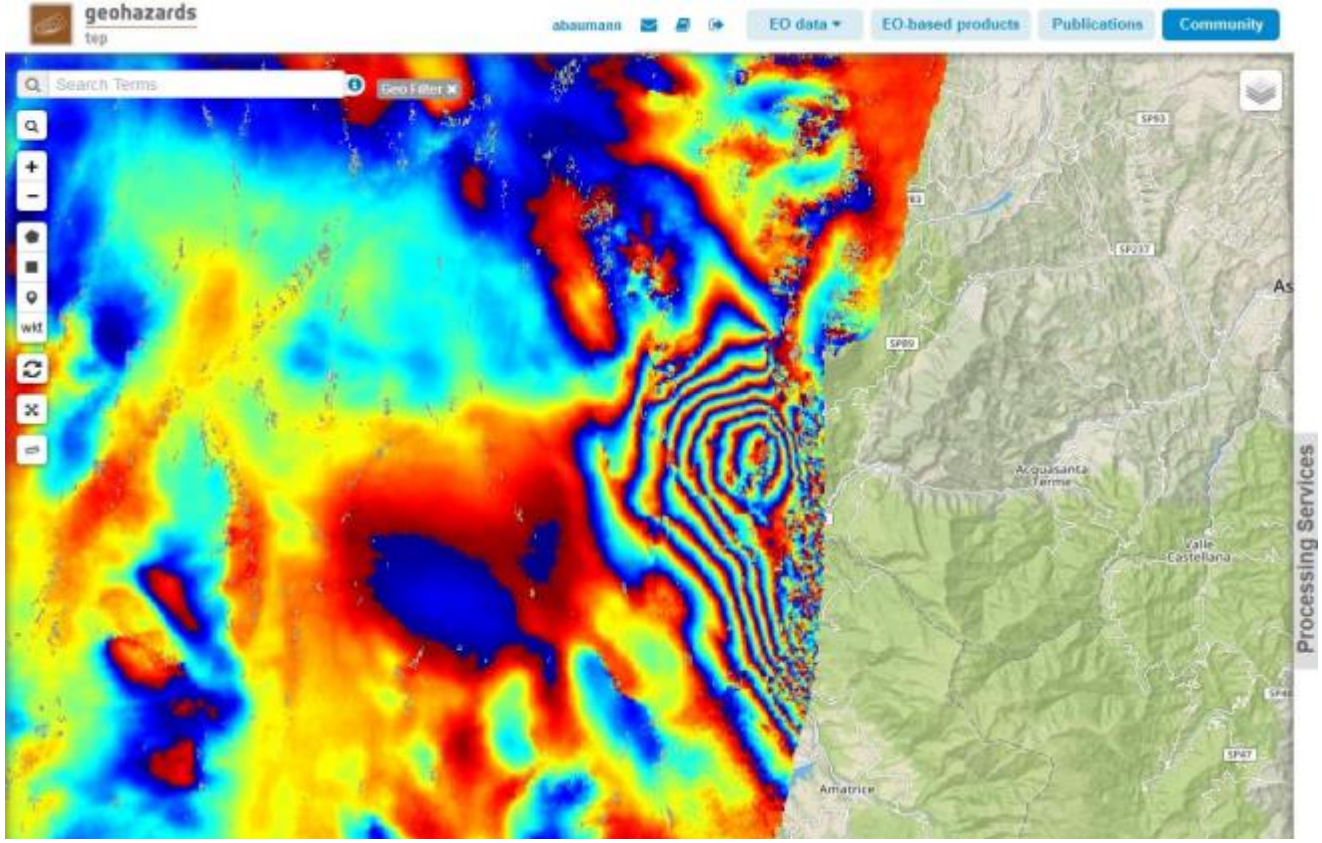
Scientists from CNR IREA combined Sentinel-1 radar acquisitions over central Italy from before and after the 24 August 2016 earthquake: 15 August, 21 August and 27 August 2016.

The result shows vertical ground subsidence, reaching about 20 cm in correspondence to the Accumoli area, and lateral movement of up to 16 cm. The blue line indicates the location of the fault trace.

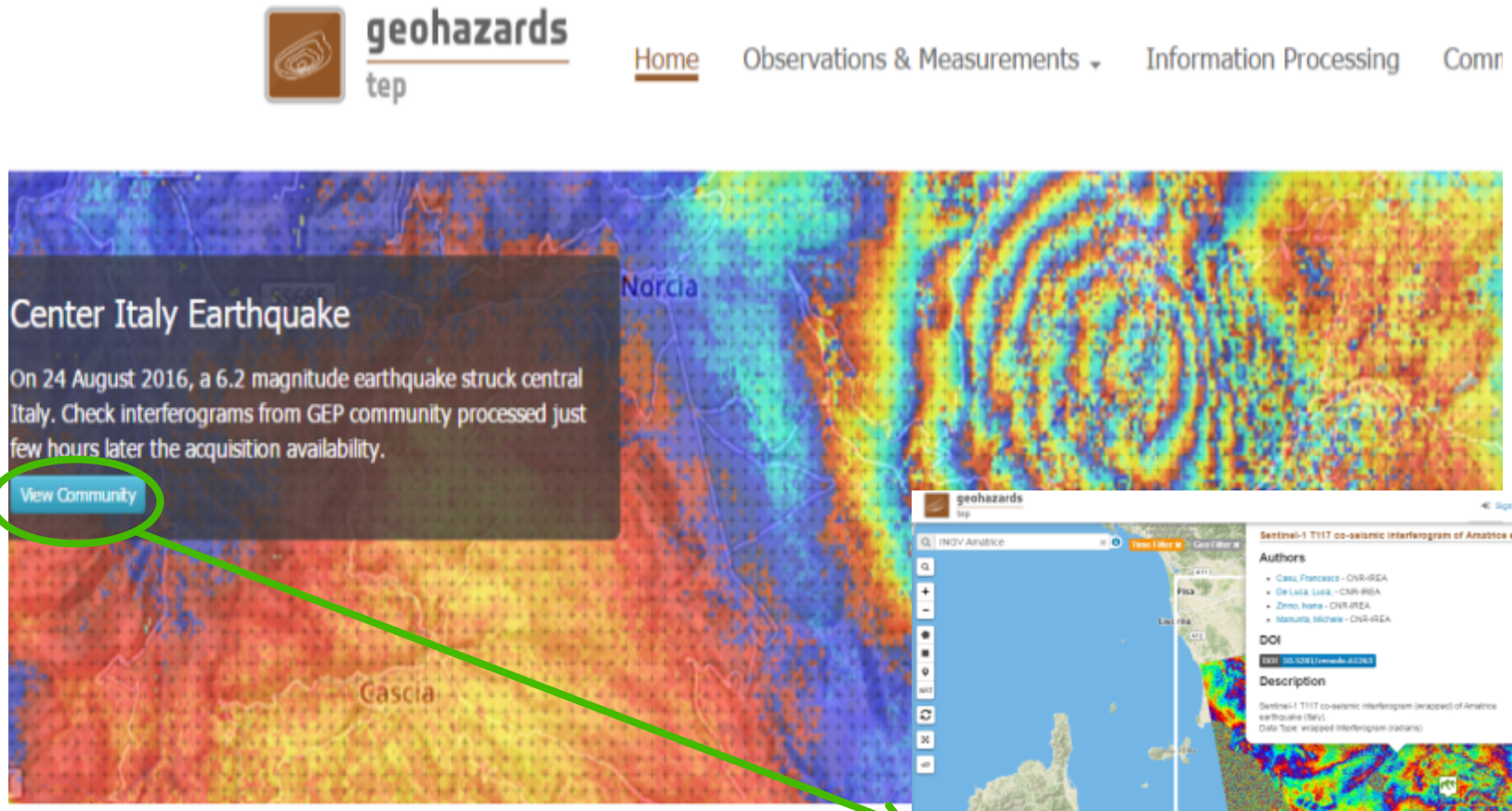


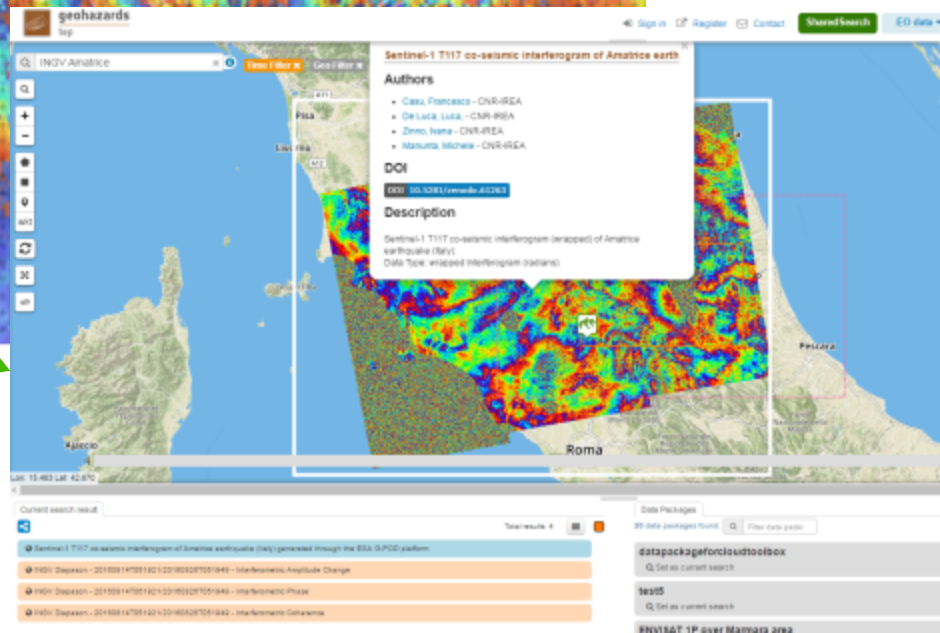
First result generated on-line on the GEP

Differential SAR interferogram generated through a small baseline 18 days pair of SAR images acquired by the Sentinel1 constellation (pre-event image acquired on 09/08/2016 and post-event image acquired on 27/08/2016).
This result was generated by INGV using hosted processing on the GEP .The processing chain is the DIAPASON chain of CNES integrated in the GEP by TRE ALTAMIRA. Sentinel1 data are copyright of Copernicus (2015).



Example of promotion of results on the GEP for the Central Italy Earthquake (1)





All products generated on GEP for the Central Italy earthquake were gathered under a link on the carousel of GEP's homepage: direct access to results

Example of promotion of results on the GEP for the Central Italy Earthquake (2)

Blog (full archive)

How to publish scientific results on the GEP community map

Cloud services for science Wherever you are working from to generate InSAR products (e.g. in the lab, on the GEP Cloud processing services), you might want to reach-out the Geohazards community active on the GEP Portal. This is made easy as GEP can connect to powerful Cloud services such as...

7 days ago

Example of hosted processing using S-1 data in the aftermaths of the 2016 Central Italy EQ

See the interferogram created by INGV using Sentinel-1 acquisitions of 14 and 26 August.The product was generated using the DIAPASON chain of the French Space Agency, CNES. DIAPASON is one of the hosted processing chains of the GEP. This is one of the many measurements generated by the Community.....

6 days ago

2016 Central Italy Earthquake: GEP publishes EO data collections in support of the CEOS Seismic Pilot

Following the request from INGV, the GEP is providing access to EO data from CEOS Contributors to authorised users. See first collections of ALOS-2 data as well as Sentinel-1A and 1B data. More datasets as Pleiades, Sentinel-2, Radarsat-2, TerraSAR-X and COSMO Skymed will...

6 days ago

2016 Central Italy Earthquake: ESA announcing the first Sentinel-1 based measurements after the Earthquake

On 24 August, an earthquake struck central Italy, claiming at least 290 lives and causing widespread damage. Satellite images are being used to help emergency aid organisations, while scientists have begun to analyse ground movement. The Italian peninsula is prone to earthquakes owing to the...

7 days ago

2016 Central Italy Earthquake: GEP publishes EO data collections in support of the CEOS Seismic Pilot

gep-blog

abaumann

Following the request from INGV, the GEP is providing access to EO data from CEOS Contributors to authorised users. See first collections of ALOS-2 data as well as Sentinel-1A and 1B data.

More datasets as Pleiades, Sentinel-2, Radarsat-2, TerraSAR-X and COSMO Skymed will follow.

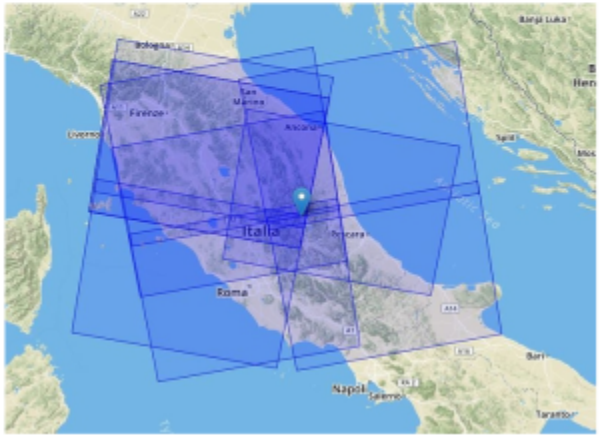
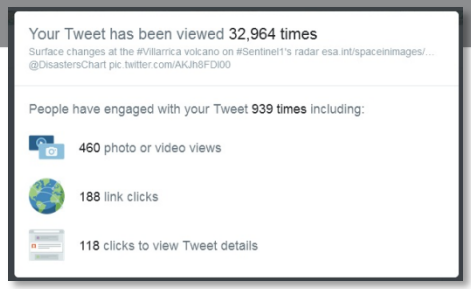


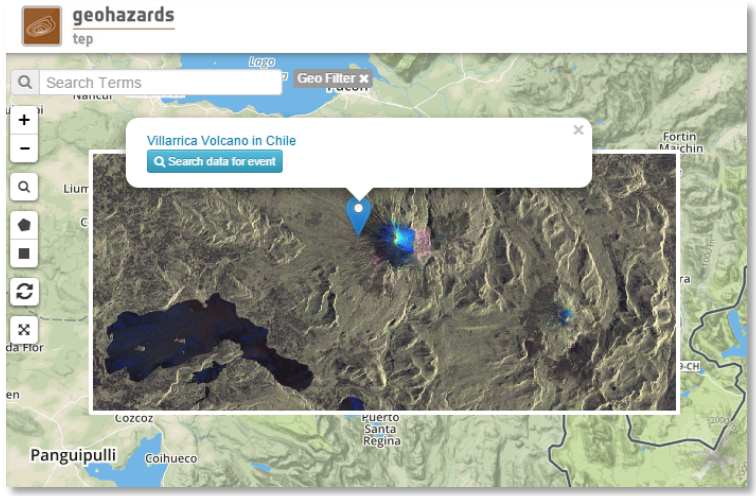
Figure 1: *Footprints of the «2016 Central Italy EQ - Sentinel-1» data package.*

A number of posts were published on the GEP Blog concerning CEOS data collections, first products generated by CEOS Seismic pilot team etc.

Other Examples of achievements so far

GEP Validation started March 3rd 2015:





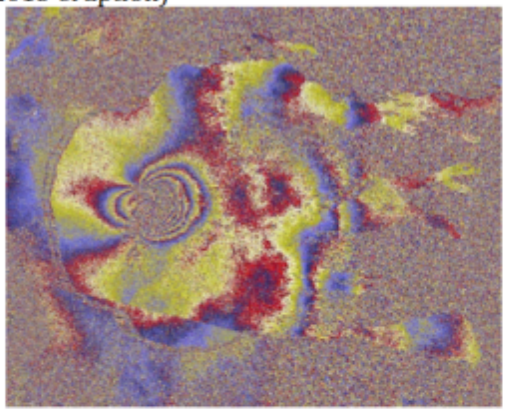
Sentinel-1A based change image of Villarrica eruption (Chile) using pre-event (20/02/2015) and post-event (04/03/2015) acquisitions.
International Charter Space & Major Dissaters activated on 3 April by ONEMI (Chile).
Blue: increase of the radar backscatter (melting of snow and ice)
Cyan: surface roughness increase (melting of snow and the accumulation of volcanic material (volcanic ash, lava flows and tephra)
Work performed by DLR on 5 March in the framework of the ASAPTERRA project originated by ESA (R&D action).

Integrating chains for on demand processing with geohazards community:

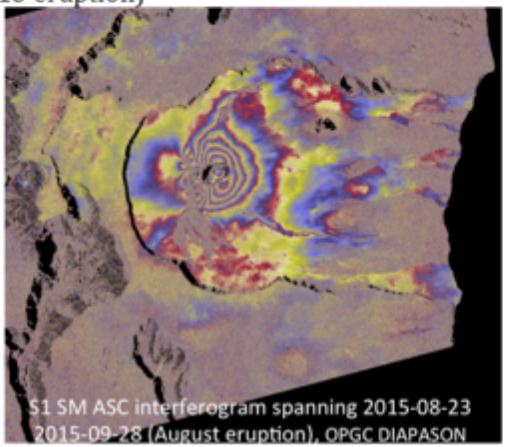
Altamira Information integrated an S-1 INSAR chain for on demand service delivery: **automated version (blackbox, for non expert users) of CNES's DIAPASON**.

Will help reach public and private users not able or willing to tune INSAR chains.

Exploitation of S1 data for the monitoring of Le Piton de la Fournaise, La Reunion,
With IW mode (February 2015 eruption)

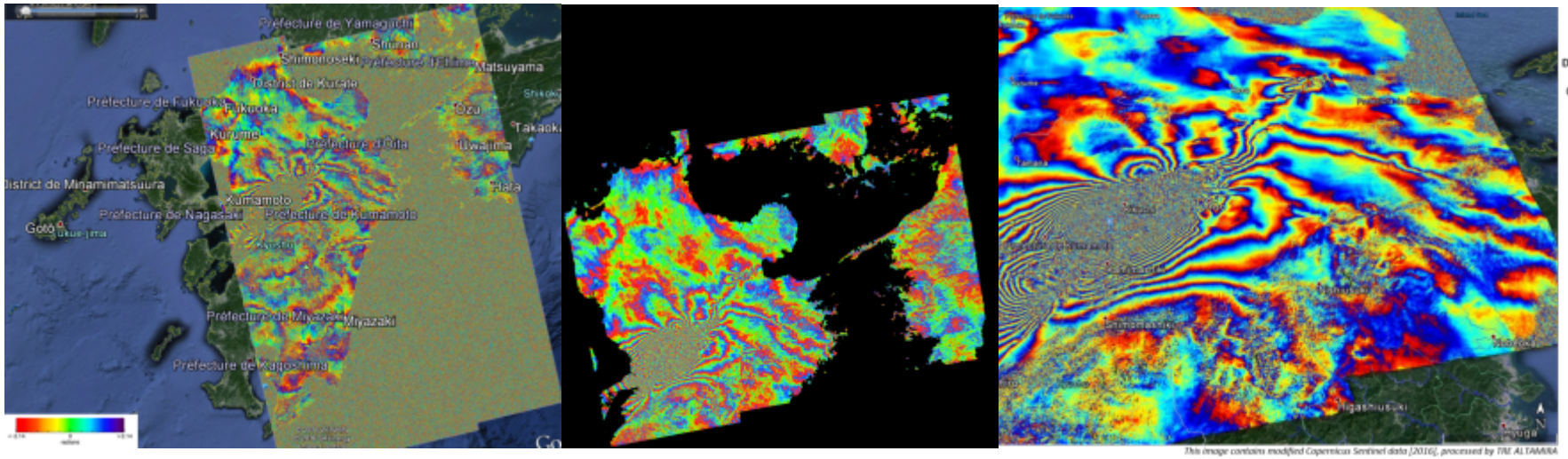


With SM mode (August 2015 eruption)



Cloud based DINSAR after the Kumamoto earthquake in Japan:

Integrated SBAS, DIAPASON and the InSAR Browse to exploit Sentinel-1:

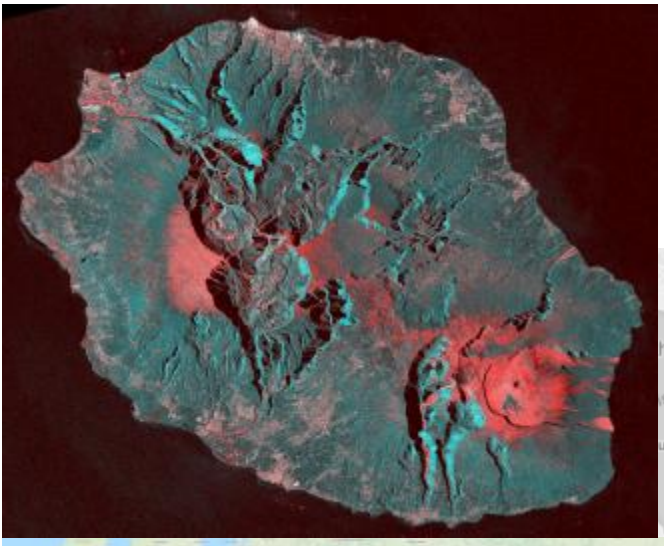


Terrain motion measurements to support advanced earthquake response.

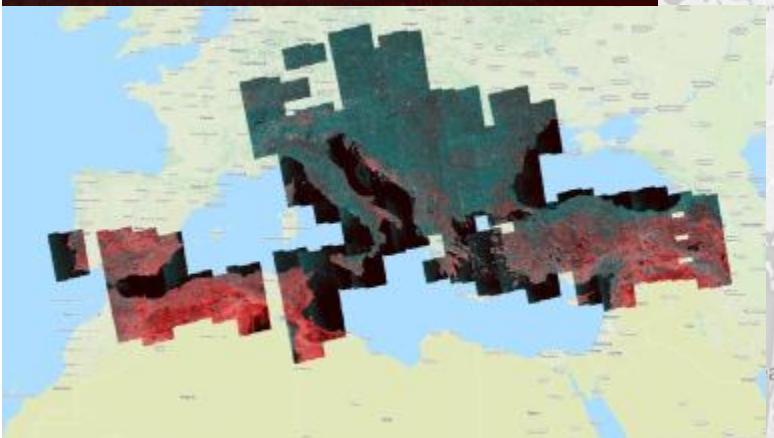
Sentinel-1 interferogram of Kumamoto earthquake, on the island of Kyushu in southwest Japan, in April 2016:
SBAS chain of CNR IREA (Left),
DLR InSAR Browse chain (Centre)
DIAPASON Processing Service of CNES/Alltamira Information (Right).

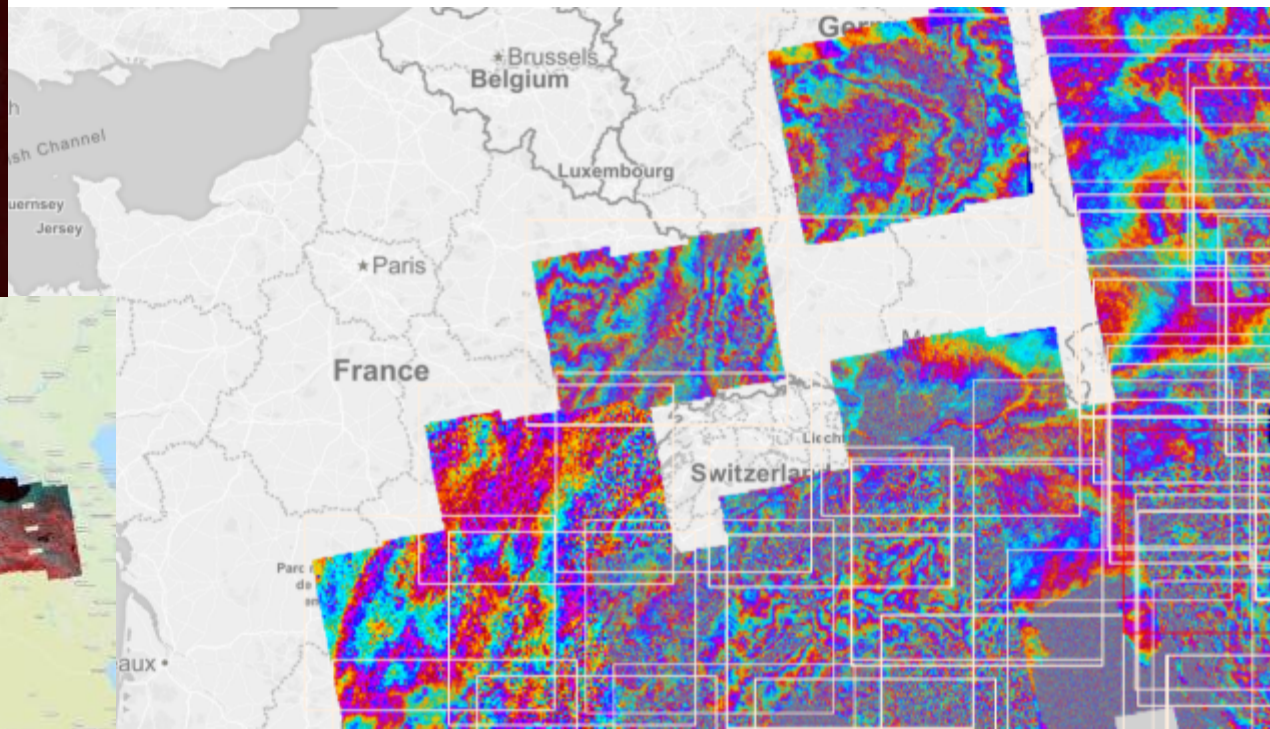
Integrating DLR's chain for *systematic processing* of S-1 INSAR pairs:

Systematically *processing all S-1 pairs* over european tectonic areas: **amplitude, coherence & interferograms for all 12 Day pairs.** 285 interferograms/cycle= 24 / day. 950+ pairs processed to date. *Free browse images at 200m resolution*.



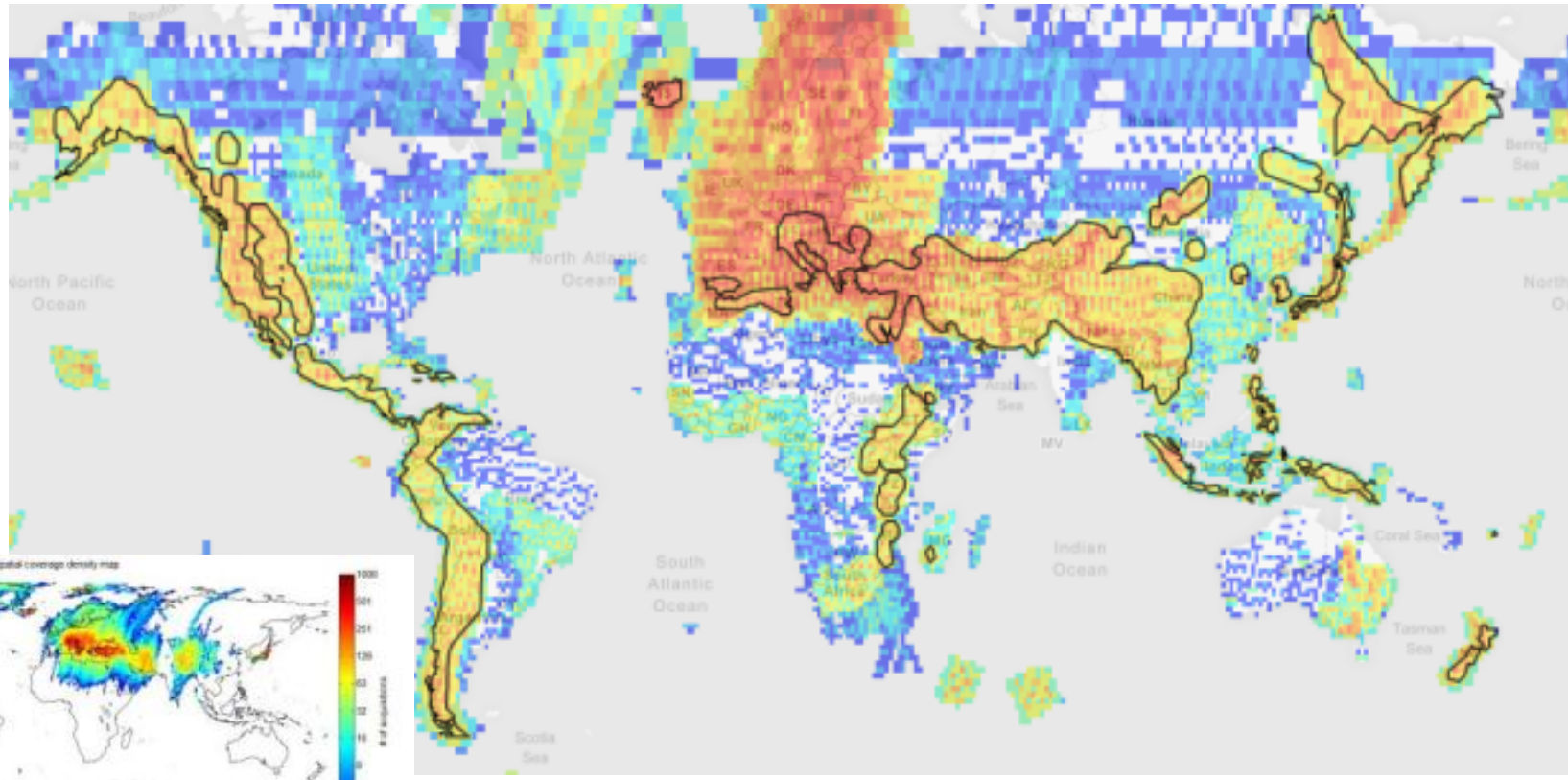
Left: coherence (R) and amplitude (G, B) over la Réunion. Bottom Left: collection of coherence & amplitude composites over Europe. Bottom right: Examples of DEM corrected inteferograms. Credits DLR.

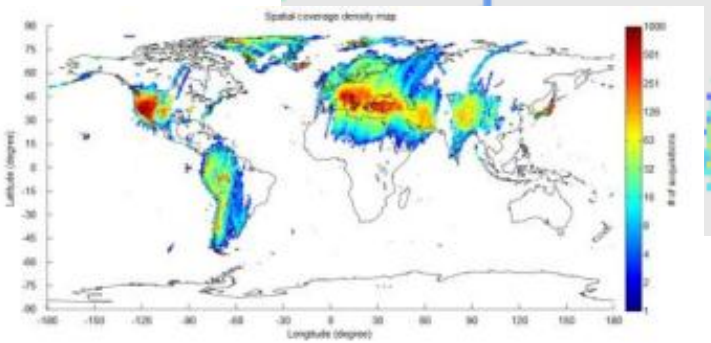




Improving access to data collections relevant to geohazards community:

Defined geographic priorities (black contour) and managed to make available related archive data and new S-1 collections (this image shows S-1 acquisitions); GEP is fetching S-1 using multisourcing (ASF, PEPS, etc.). Also 70+ Tera of ERS & ENVISAT data made available on line (bottom left).





Achievement 4:
Engaged a substantial user group:

Number of users engaged in pre-operations to test available services (already integrated): 30+ single user-projects spanning 14 countries including 8 European countries.

- 14 projects focused on processing using applications already integrated:
  - SBAS
  - ROI_PAC
  - GAMMA
  - DORIS
  - DIAPASON
- 4 projects integrate processors or new services:
  - New services based on SBAS (CNR-IREA)
  - NSBAS (ISTERRE)
  - New services based on DIAPASON (Altamira Information)
  - Sentinel-1 InSAR-QuickLook (DLR)
- 3 projects will concentrate on large scale or systematic production
  - Country wide measurements using SBAS
  - Systematic processing InSAR-QuickLook

Country of User	Number of User organisation
DE	1
ES	1
FR	4
GR	1
IT	7
MA	1
PL	1
UK	3
US	1
Total	22

Examples of *Early Adopters, Validation Phase started in March 2015* (1)

User organisation	Areas
Ecole Normale Supérieure de Paris (France)	Etna, Italy and Corinth Rift, Greece
DLR IMF (Germany)	European tectonic mask
Altamira Information (Spain)	Test sites on landslides and earthquakes
ISTerre / Institut de Physique du Globe de Paris (France)	Subduction zones of Latin America, the NAFZ and Tibet.
INGV Roma (Italy)	Alto Tiberina Fault and Fogo Cape Verde
INGV Roma (Italy)	Marmara, East sector of NAFS
INGV Roma (Italy)	Haiti and West Java
ETH (Switzerland)	Large surface deformations caused by landslides in Bhutan Himalaya
NOA (Greece)	Geohazard sites in Greece
SATIM (Poland)	Silesia & Warsaw (Poland)
Obs. Physique du Globe de Clermont-Ferrand (France)	Piton de la Fournaise in La Réunion, Cordon del Azufre / Lastarria in Chile–Argentina
INGV Catania (Italy)	Etna & Campi Flegrei / Vesuvius
British Geological Survey (UK)	Urban areas of Great Britain
University of Leeds (UK)	Active deformation in the Alpine-Himalayan belt
ESA	Over calibration sites: Rain forest, Germany (DLR targets), Australia Milan, Chicago, Sao Paulo
ESA(Progressive Systems SLR)	Greater Cairo, South Rayan dune field, Middle Egypt province and Aswan province
CNR IREA (Italy)	Tests on Italian volcanoes and Hawaiian and Japanese volcanic and seismic areas
Universita De L' Aquila (Italy)	Abruzzo region: L' Aquila and Teramo for post-seismic ground displacements
University College of London (UK)	UK landslides
University of Rabat(Morocco)	Morocco seismic activity

Volcanoes

Earthquakes

Landslides

Subsidence

Examples of *Early Adopters, Validation Phase started in March 2015* (2)

User organisation	Areas
CNR ISSIA (Italy)	Indonesia
IPGP (France)	Asia, N& S America, Indian Ocean
Universidad de Concepcion (Chile)	Southern Andean zone
Laboratoire de Dynamique Terrestre et Planétaire (France)	South America active volcanoes and tectonics
BRGM (France)	French coast subsidence
AIM CEA (France)	La Reunion
National Cartographic Center (Iran)	Iran
Instituto Geologico y Minero de Espana (Spain)	SouthEast Spain
USGS (USA)	Latin America volcanoes
CVGHM (Indonesia)	Indonesian and Mexican volcanoes

Volcanoes

Earthquakes

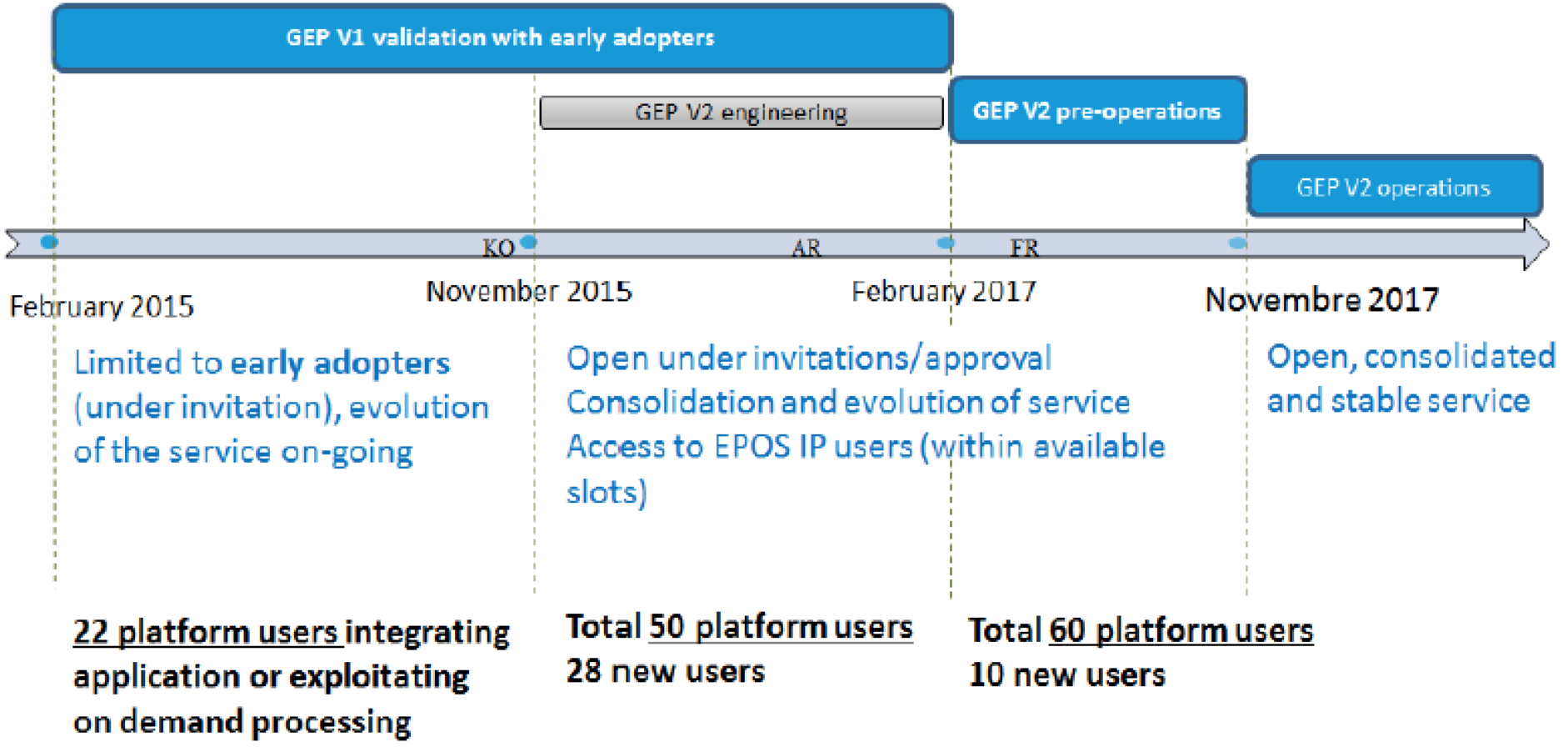
Landslides

Subsidence

- **32** users up to early September 2016
- **5** of them being **CEOS pilot users** (4 Seismic pilot users and 1 Volcano pilot)
- Mainly **European users,** but also **5 users from Asia** (Indonesia and Iran), **Africa** (Morocco), **South America** (Chile) and **North America** (USA).

PoC for applications: geohazards-tep@esa.int

GEP Roadmap


GEP V1 validation with early adopters
GEP V2 engineering
GEP V2 pre-operations
GEP V2 operations
KO
AR
FR
February 2015
November 2015
February 2017
Novembre 2017
Limited to early adopters (under invitation), evolution of the service on-going
Open under invitations/approval
Consolidation and evolution of service
Access to EPOS IP users (within available slots)
Open, consolidated and stable service
22 platform users integrating application or exploitating on demand processing
Total 50 platform users
28 new users
Total 60 platform users
10 new users

Thank you

18 Two young boys look at parts of the city previously devastated by the 2004 Boxing Day earthquake and tsunami on December 23, 2009 in Banda Aceh, Indonesia. (Ulet Ifansasti/Getty Images) #