Status Report on the Seismic Hazards Pilot

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WG Disasters #4
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Outline

- **Seismic Hazards pilot - Status**
- **Results from pilot work to date**
  1. **EO data access for pilot users**
  2. **EO processing**
  3. **Awareness - Promotion of results**
  4. **Observations strategy**
- **Issues and risks identified**

Seismic Hazards pilot - Status

Seismic Hazards pilot - Status

As of today:

- A Collaboration of **ESA, NASA, ASI, CNES, DLR, JAXA**, and other partners: **INGV, NOA, UNAVCO, COMET+, University of Miami, EU Centre, ISTerre/IPGP, BGS** and **CNR IRPI**.
- 19 users (BGS and CNR IRPI joined in July).
- Data Procurement Plan incl. AOIs defined by users to allocate the quota provided (e.g. ALOS-2, Cosmo-SkyMed).
- Validation of InSAR based velocity measurements is completed over California. Southwest Japan is in progress (under Obj. A).
- The GEP available since March help both EO data access and EO processing.
- Specific study of observational requirements for megacities in areas at high seismic risk.
- Continued collaboration of pilot group with Sentinel-1 mission Project Manager to optimize coverage of the tectonic mask during ramp up phase.

Seismic Hazards pilot - Objectives

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 GSNL**

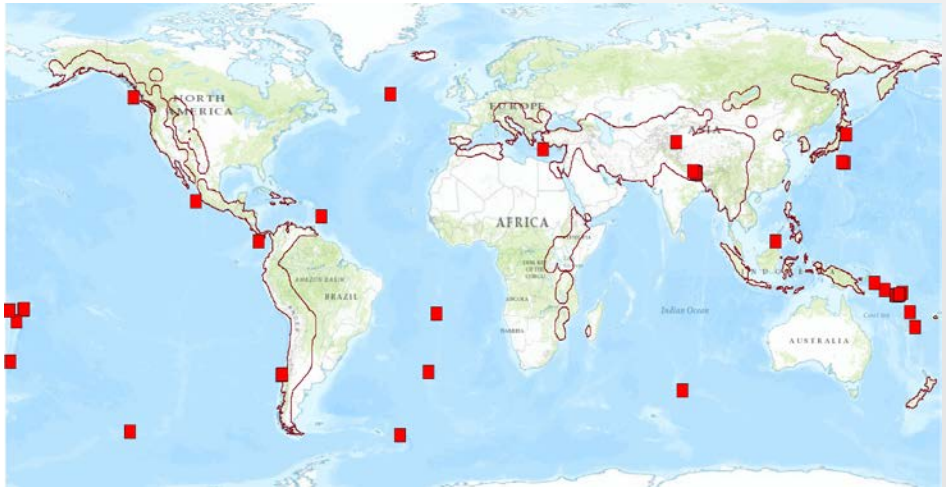
[role of EO: multiple observations focused on supersites]

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

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

Overview of activities

- Objective A: Validation of InSAR based velocity measurements is completed over California. Southwest Japan is in progress.
- Objective B: The Seismic Hazards pilot continues to support the GSNL initiative (e.g. data access or processing using the GEP).
- Objective C: Not many events to monitor over 2015, only 7 crustal earthquakes with Magnitude > 6 have occurred between January and July 2015 over land (5 in Nepal, 1 in China and 1 in Malaysia):
  - Nepal is covered by the Event Supersite
  - The M6 Malaysia event is not well covered by SAR imagery and is located in an area with strong temporal decorrelation
  - The M6.4 event in China does not have recent pre-seismic coverage.



Results from pilot work to date

1. EO data access for pilot users

EO data access for Pilot users

ESA has made an arrangement with ASI, DLR and JAXA to support data dissemination through the Geohazards Exploitation Platform (GEP):

-Automated engine harvesting COSMO-SkyMed metadata developed & implemented; allows to visualize data collections and download data (to authorized users).

-TerraSAR-X data are also harvested in an automated way. Users are re-directed to the DLR portal for downloading. Access granted after registration.

-ALOS-2 data accessible for download only by one user (Roberto Cuccu, ESA). After download, data are registered on the Geohazards Exploitation Platform (GEP).

-For a fair portion of the tectonic mask, dense ESA archive data (ERS, ENVISAT) are available (50+ tera) and work is on going to fully cover the area; Copernicus Sentinel-1 data are available through the Scihub https://scihub.esa.int/

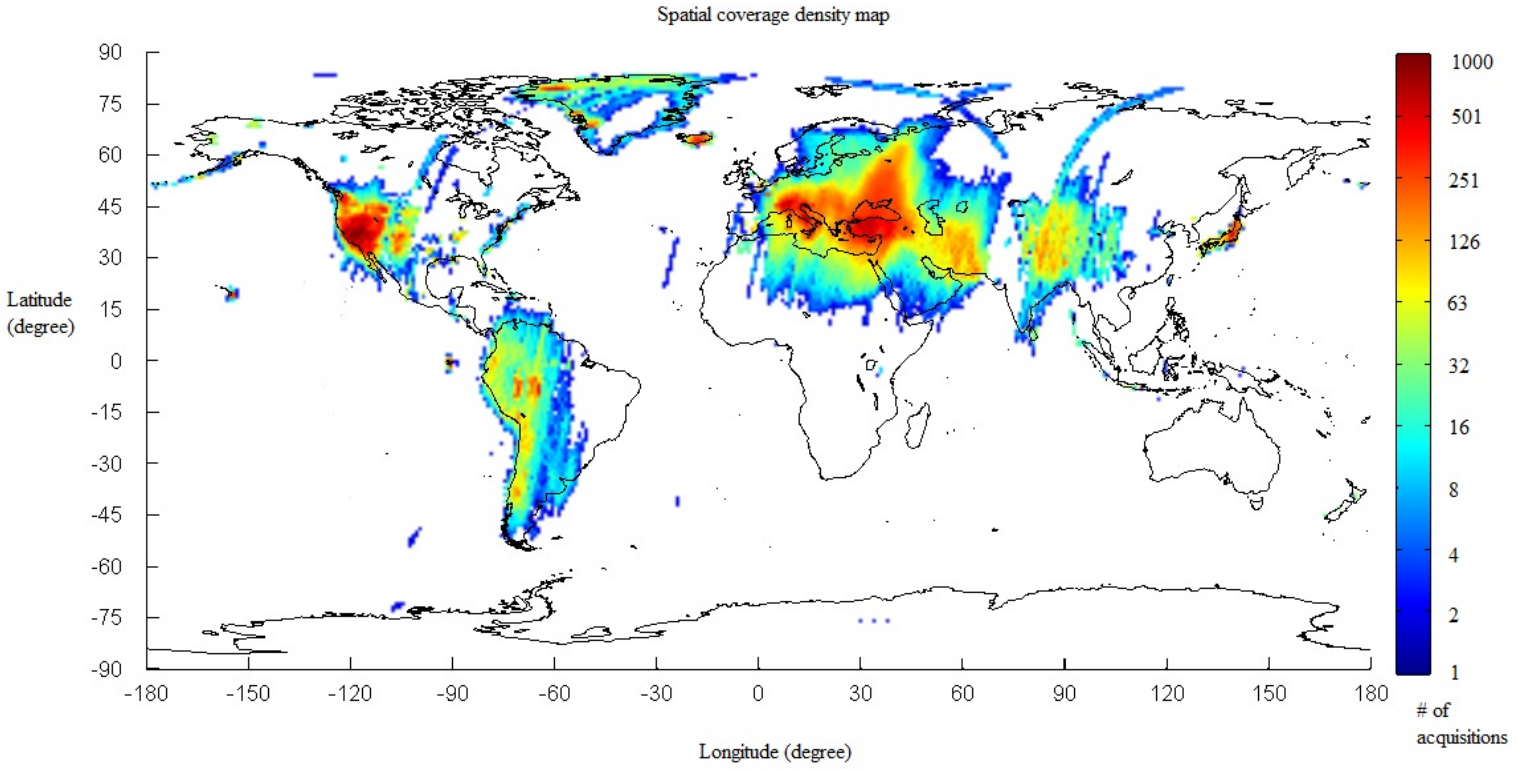
- A reflection has started on providing online access to VHRO and DEM data for visualization (not download), to support active fault mapping.

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

Sentinel-1 made available starting with CEOS Pilot targets and with the goal to gradually cover large community targets within 2016.

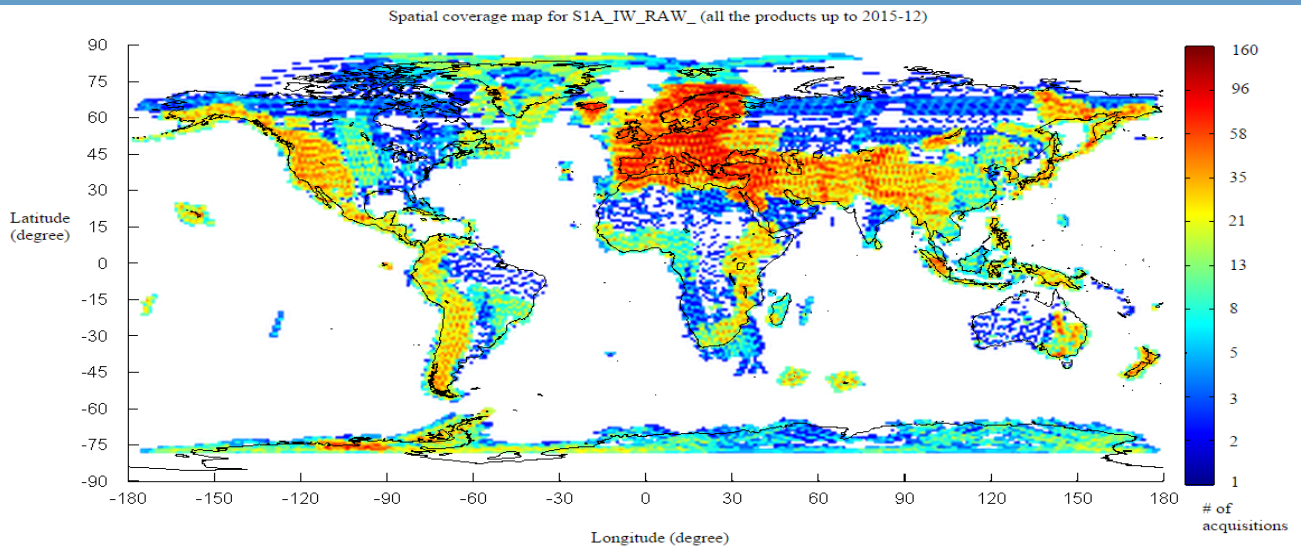
ERS & Envisat SAR data:

- Current ENVISAT ASAR IM Level-0 Data : > 60200 products (~30TB)
- Current ERS SAR IM Level-0 Data : > 56500 products (~28TB)

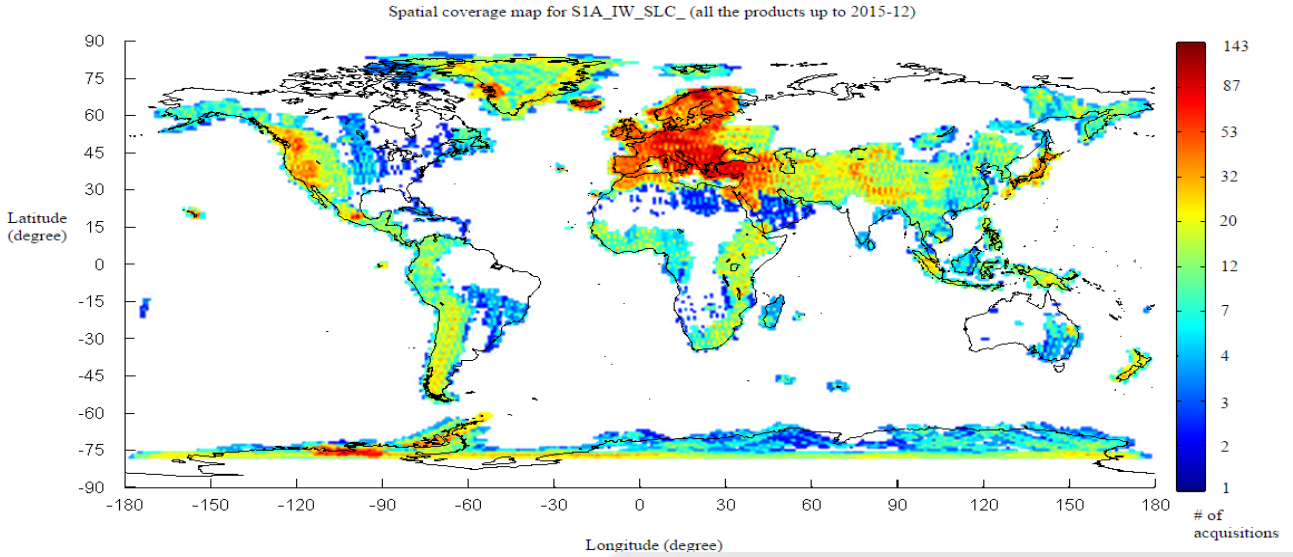


ERS & ENVISAT Level-0 data available as of Sept. '15

Available Copernicus Sentinel-1A SAR data



S-1 RAW data available as of September 2015



S-1 SLC data available as of September 2015

Yearly Quota 2015

Agency	ASI	CNES Pleiades	CSA	DLR	ESA	JAXA ALOS-2	NASA	USGS Landsat -8
Number of Images	300	50	2	-	*	100	-	-

*ESA: large dataset through the GEP (ERS & ENVISAT 60+ Tera and Copernicus Sentinel-1 gradually)
DLR (TerraSAR-X): no quota provided;
CNES (Spot): idem;
Freely available sources: no quota (e.g. USGS L8).

ALOS-2 & Cosmo-SkyMed quota: AOI's defined

Overview of ALOS-2 data (prepared by Erwan Pathier)

Requested images:

- Seismic Pilot-Objective C, Total 27 (up to 37) for Nepal Earthquake
- Seismic Pilot-Objective A, Total 67 (can be down to 57 if excluding Taiwan): Turkey (38 products), Nepal interseismic (10 products), Central Andean Subduction (9 products), Taiwan (10 products)

  Total 100 for Y2015

Overview of COSMO-SkyMed data (prepared by Barry Parsons)

Areas proposed: China (Haiyuan) and Iran (Shahdad).

2 scenes per area every 16 days would use ~90 scenes out of this allocation.

Further targets on creeping faults can be defined or as agreed in FRINGE it is possible to leave a significant amount of the allocation for earthquake response and postseismic studies.

A provisional order for COSMO-SkyMed was submitted to ASI for coverage over two creeping faults in China (Haiyuan) and Iran (Shahdad).

Total 300 for Y2015

-16 ALOS-2 images over Nepal (37 to be requested in Total under Obj. C) were accessed.

-6 Cosmo-SkyMed images over China and Iran are to be requested.

Results from pilot work to date

2. EO processing

Nepal Earthquake

A GSNL Eventsite

Satellite mapping following the Gorkha earthquake is a big activity in the geohazards and satellite EO community (for both emergency response, risk assessment, science).

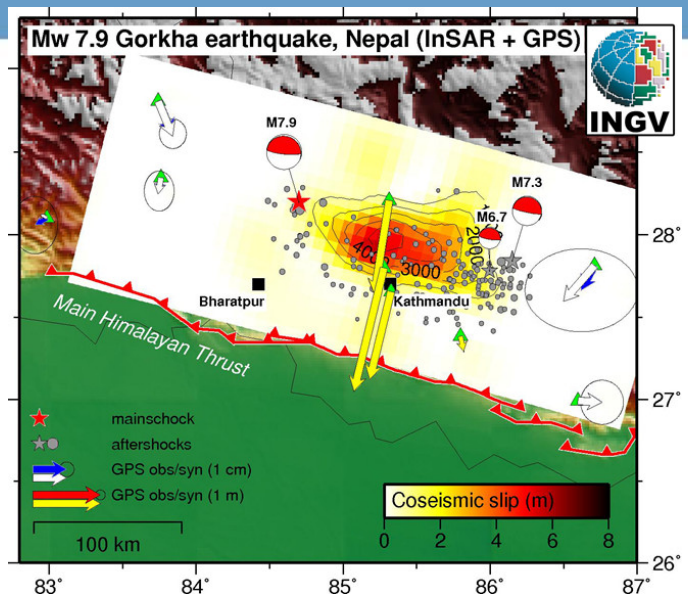
- Many sensors have acquired data (e.g. through the Charter, Copernicus, etc) and many groups have used them.
- **Earthquake triggered landslides** make a secondary disaster Inventories have been mapped using VHR Optical (for instance see British Geological Survey, ISRO NRSC, USGS and NASA)

The Geohazards Supersites activity offers data collections *free to the Supersite community, with normal licensing conditions*.

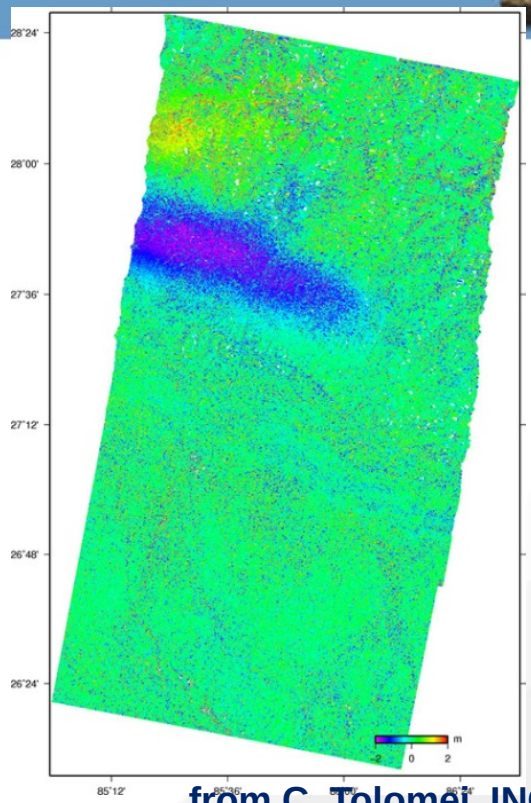
- **The Nepal earthquake has become an Event Supersite** (contributing: ESA, ASI, DLR, NASA, USGS, UNAVCO and IRIS), meaning collections of EO data will be gathered to monitor the area (for instance COSMO-SkyMed collections).
- Acquisitions of ALOS-2, Copernicus Sentinel-1 and Cosmo-SkyMed dedicated to the Nepal earthquake are available on GEP. For instance 27 ALOS-2 products for year 2015 (under Objective C).

Results from Nepal Earthquake Event Supersite community

These products are provided open access via direct request.



Source model from InSAR & GPS,
D. Cheloni, INGV



Coseismic displacement from Radarsat-2 (InSAR, MAI & OT),
S. Samsonov, NRCAN

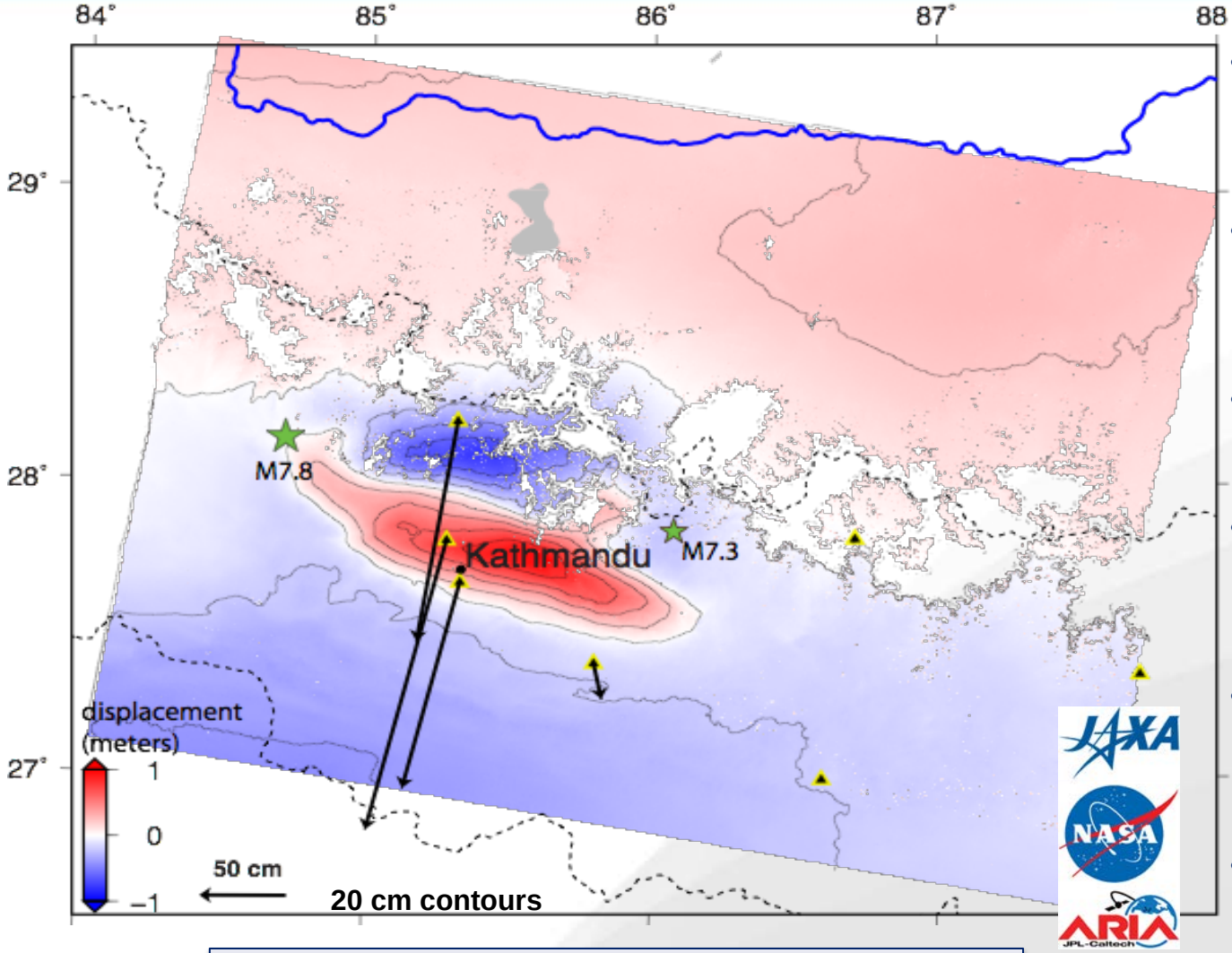
All open access products:

Sentinel-1 coseismic displacement map — **from C. Tolomei, INGV**
ALOS-2 coseismic displacement map — **from C. Tolomei, INGV**
Radarsat-2 coseismic displacement map (InSAR, MAI, OT) from S. Samsonov, NRCAN

Source model from InSAR & GPS — **from D. Cheloni, INGV**
Residuals of source model — **from D. Cheloni, INGV**
Coulomb stress transfer map — **from D. Cheloni, INGV**

http://www.earthobservations.org/gsnl.php?smid=1200

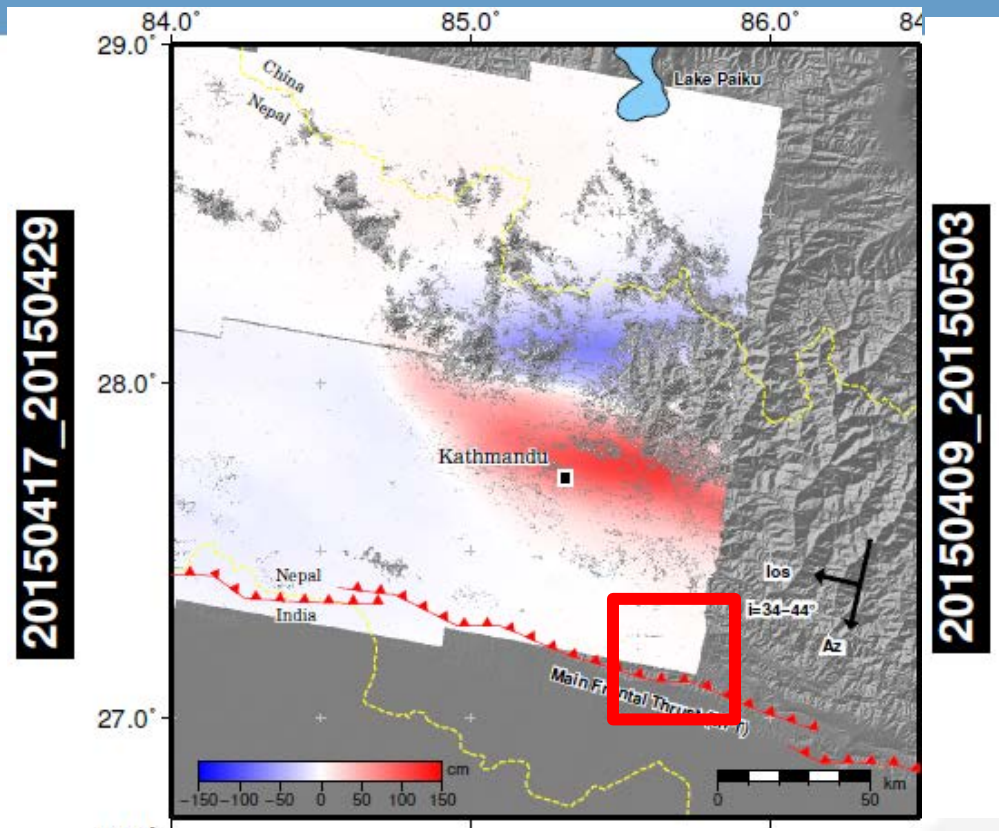
April 25 M7.8 Earthquake in Nepal caused surface deformation and damage over 170 km long zone



- Large fault slip at depth extended far southeast from epicenter (start)
- Uplift and southward motion of central Nepal, including Kathmandu
- Shaking affected cities, towns, and Himalaya mountains
- Extensive areas of landslides and avalanches in Himalayas
- SAR data from JAXA ALOS-2 via CEOS Seismic Pilot and PI project 1372
- GPS data from Caltech, Nepal Dept. Mines & Geology

Eric J. Fielding, NASA: ALOS-2 data

Measurement using Copernicus Sentinel-1A



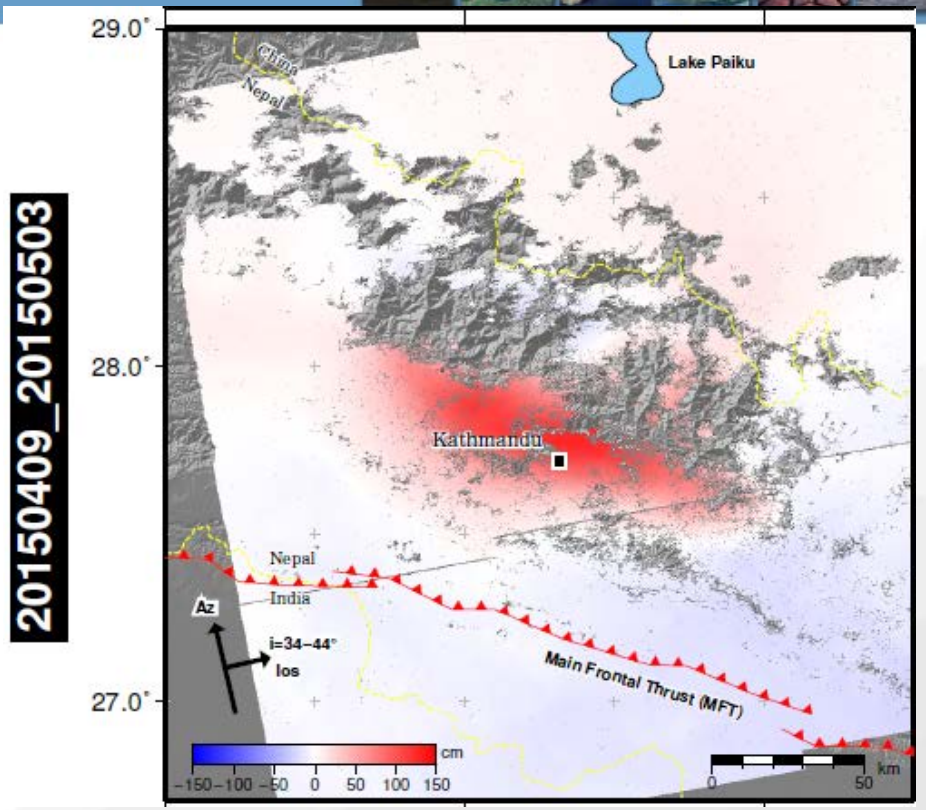


Figure from Elliott et al., in review 2015

Tim J. Wright, COMET: Sentinel-1 data

COMET Centre for the Observation and Modelling of Earthquakes, Volcanoes and Tectonics

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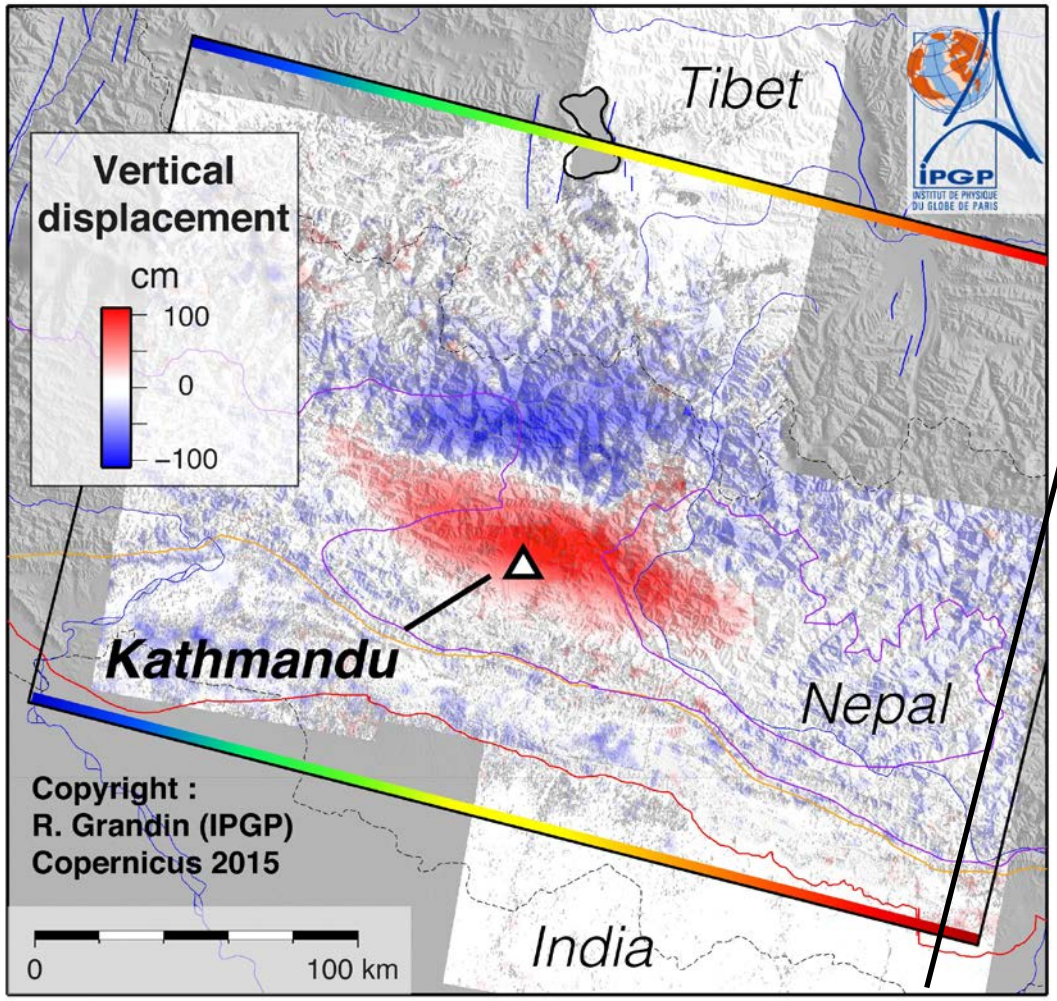
Nepal earthquake – 25th April 2015
Sentinel-1A

Coseismic displacement



Magnitude 7.8

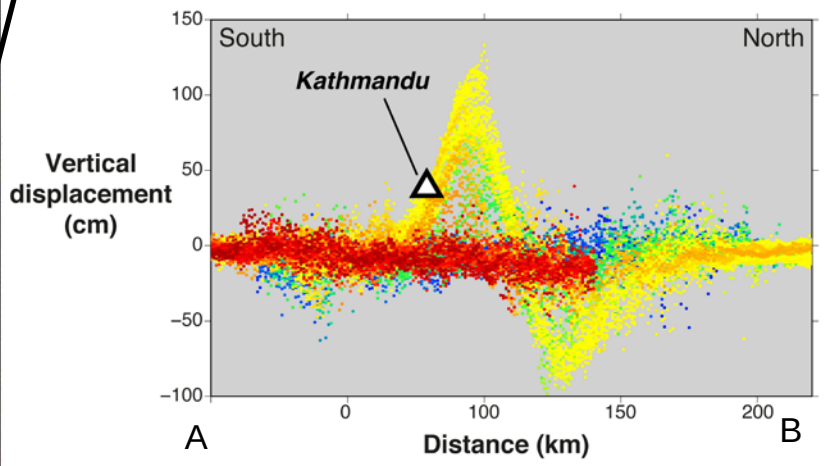
Death toll > 8000

Peak uplift ~1.3 m

Caused by ~4-6 m slip on nearly flat thrust fault at ~ 15 km depth

Paleaoseismology suggests occurrence of Magnitude 8.5+ in recent past

Stack profiles



*Presented during the last Dragon meeting in June 2015.

Raphael Grandin, IPGP: Sentinel-1 data

Nepal: Earthquake triggered landslides

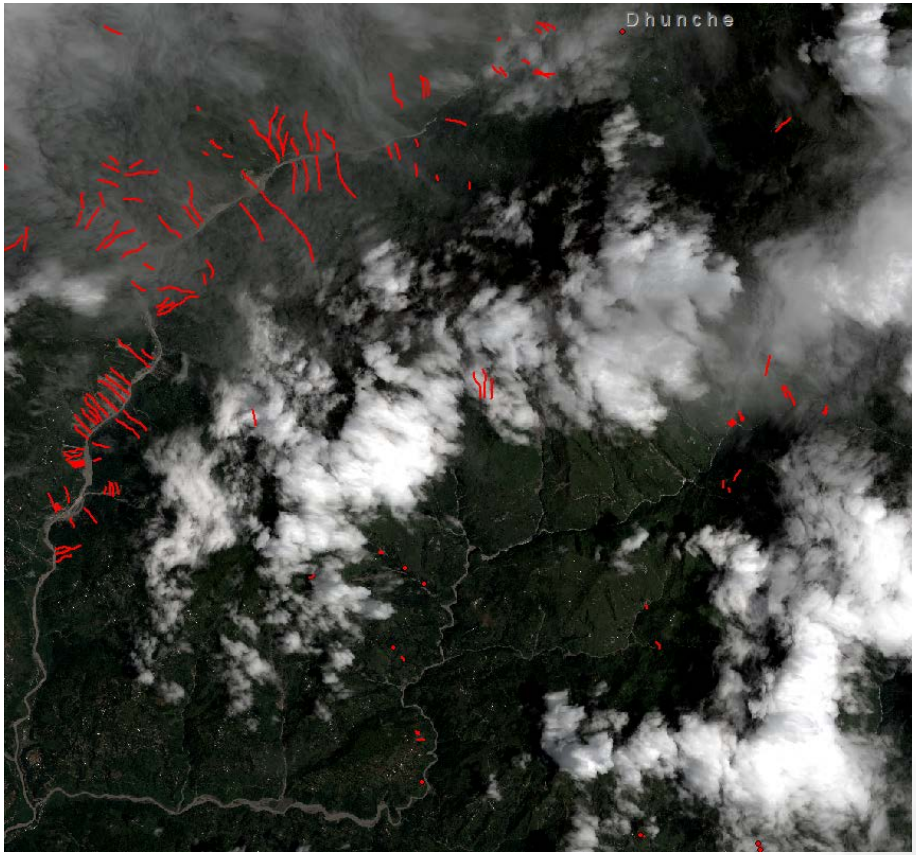
BGS and CNR IRPI became users of the CEOS Seismic Hazards Pilot for specific activity in Nepal.

- Request of 26 June from Dr Colm Jordan, Team Leader: Earth & Planetary Observation & Monitoring, British Geological Survey
- Request of 17 July from Fausto Guzzetti, Director of CNR IRPI

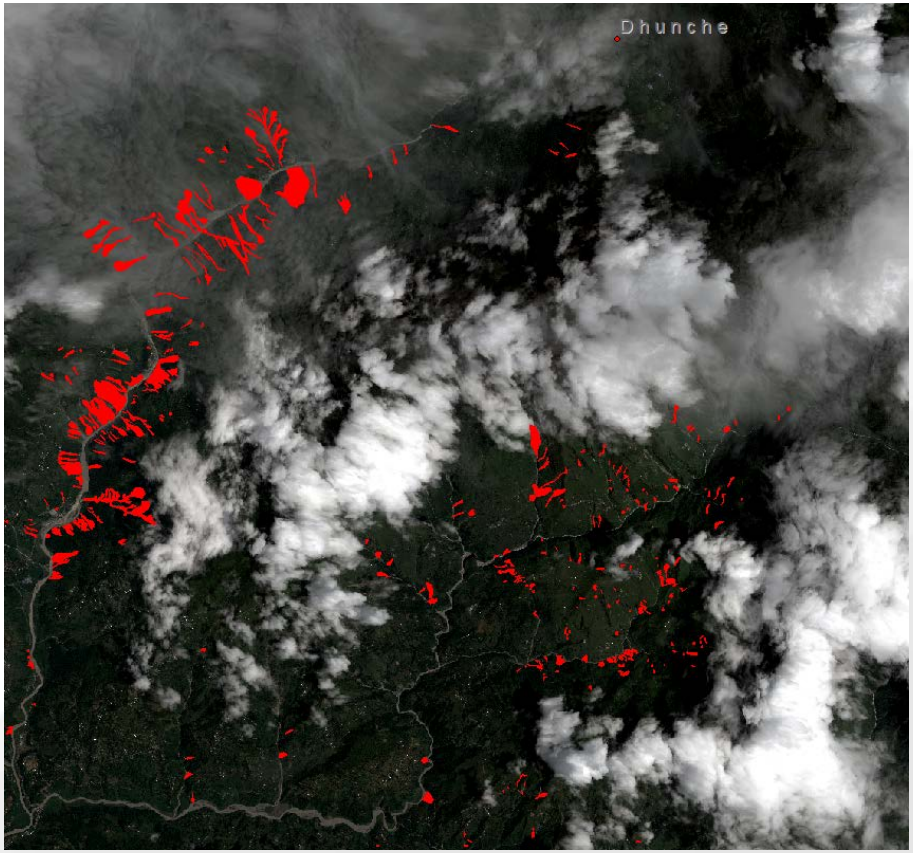
The EO data collections they intend to request overall are similar to the data requested by Seismic Pilot users in Nepal. In exchange their VA products will be shared.

CNES was initially requested to provide Pleiades, but due to the ISIS license restrictions (to non French users), ESA provided additional Pleiades data through the TPM contract for landslide mapping over Nepal.

Seismically-induced & monsoonal landslides at Dhunche



Seismically-induced landslides



Monsoonal landslides

Colm Jordan, BGS: Landslide inventories (Pleiades)

Helping pilot users with on demand processing

Current status of GEP

What the Geohazard Exploitation Platform provides:

• a **geobrowser** able to search & map data collections from platform repository and from repositories of CEOS partners contributing data from outside the platform

• Allows using **Cloud appliances** (on demand processing) and have the test data available (as if on an external drive)

• Allows use of a **Developer Sandbox** to develop and integrate new scientific applications and subsequently exploit them against larger sets of data & computing resources

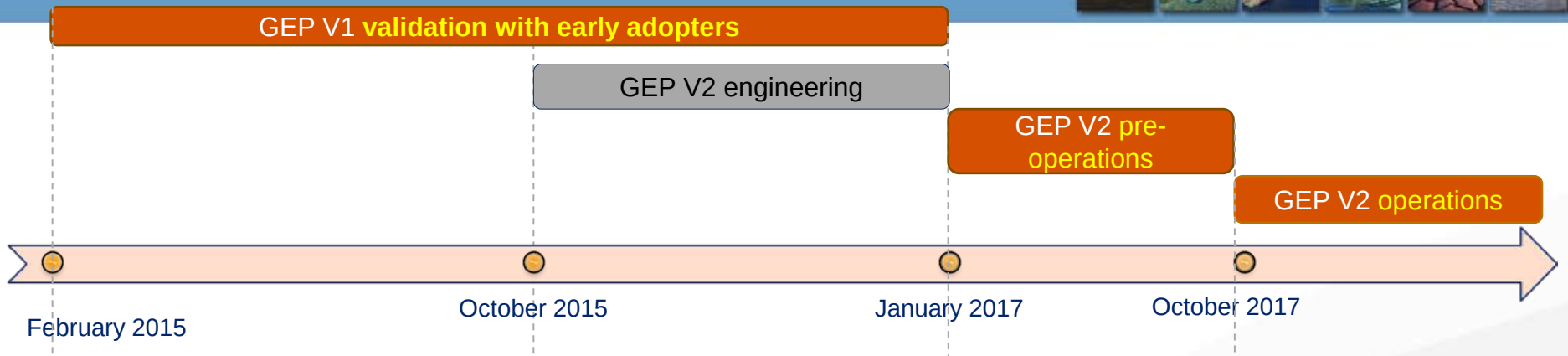
• Allows the users to **consume** via the geobrowser **Web Processing Services** exposed by the user's processing appliance as a Platform as a Service (PaaS) model.

• Exploits third party Web Processing Services such as **G-POD services**.

• Exposes appliances with **SBAS, GAMMA DInSAR, GAMMA L0, GAMMA, ROI-PAC, StaMPS, Doris , GMTSAR, PF-ASAR, Basic SSEP Toolbox, MATLAB and IDL, NEST v5.1, NEST Generic Toolbox, NEST Coreg, NEST InSAR**

• **Processors currently** under integration: **Sentinel-1 Toolbox, DIAPASON, NSBAS, S-1 INSAR QL Processor (DLR), SBAS hybrid, SBAS x S-1, pi-rate**

GEP Roadmap



Limited to **early adopters** (under invitation), evolution of the service on-going

Available:
- (evolving) EO Data Exploitation
- (evolving) New EO Service Development

Aim of the phase
- Test the first version of GEP
- Get user feedback & further tune the solution to user's needs

Open under invitations/approval, consolidation and limited evolution of the service

Available:
- EO Data Exploitation
- New EO Service Development
- (limited) New EO Product Development

Aim of the phase
- Maintain and evolve GEP user base
- Maintain GEP V1
- Design and implement GEP V2
- Conduct Pilot Projects
- Get user feedback on GEP V2 & further tune the solution to user's needs

Open, consolidated and stable service

Available:
- EO Data Exploitation
- New EO Service Development
- New EO Product Development

Aim of the phase
- Open GEP V2

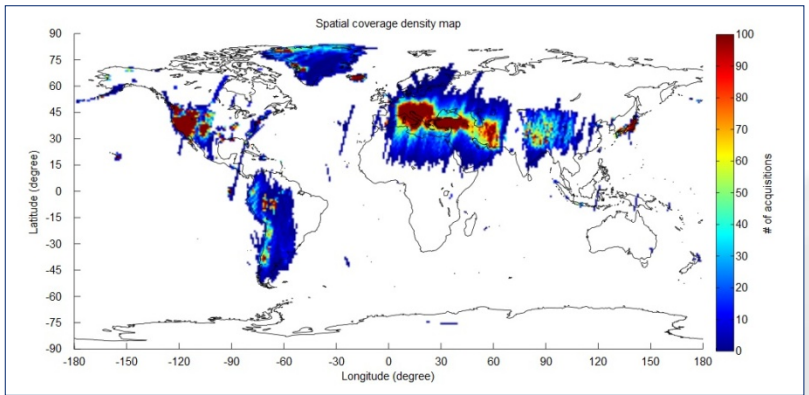
Who is on-board

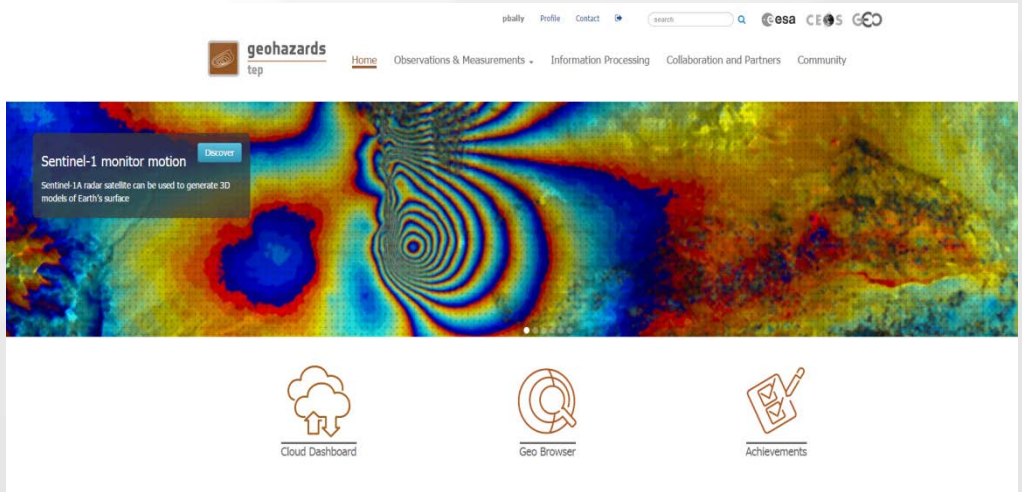
A Validation Phase started in March 2015 and continues today with 27 Early Adopters.

Country	Number of Users per Country
DE	1
ES	1
FR	4
GR	1
INT	2
IT	8
MA	1
PL	1
UK	4
US	1
Total	**24**

Primary Scenario	Number of Users per Primary Scenario
Scenario 1	12
Scenario 2	4
Scenario 3	3
Scenario to be specified	5
Total	**24**

Public or Private	Number of
PRIVATE	3
PUBLIC	21
Total	**24**





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

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
ICTP (Italy)	Morocco seismic activity

Volcanoes

Earthquakes

Landslides

PoC for applications: geohazards-tep@esa.int

Processing tasks on the platform from CEOS pilot users

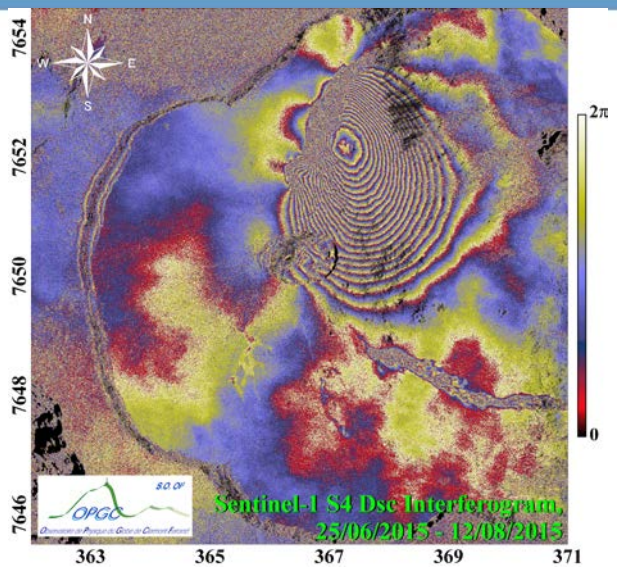
14 processing jobs launched in July

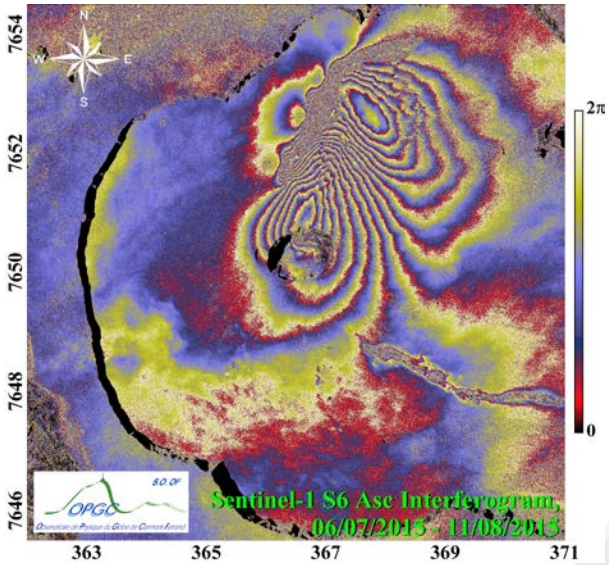
- **2 INGV (GAMMA L0)**
- **5 ISTerre (NSBAS)**
- **7 NOA (5 StaMPS, 2 ROI_PAC)**

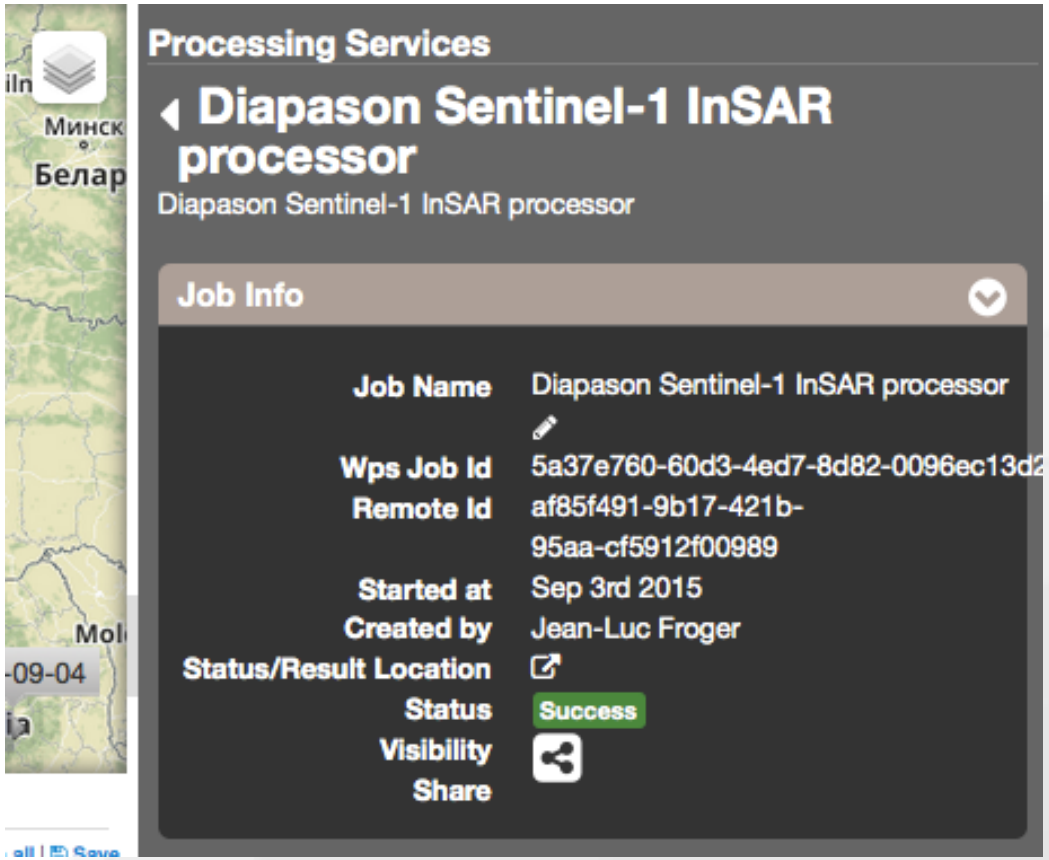
26 processing jobs launched in August

- **14 BGS (InSAR SBAS)**
- **12 ISTerre (NSBAS)**

Integration of the DIAPASON processor of CNES by Altamira Information







Piton de la Fournaise imaged by Sentinel-1
J.-L. Froger, OPGC, September 2015
Processor used: DIAPASON (by Altamira)

Results from pilot work to date

3. Awareness – Promotion of results

Awareness – Promotion of results

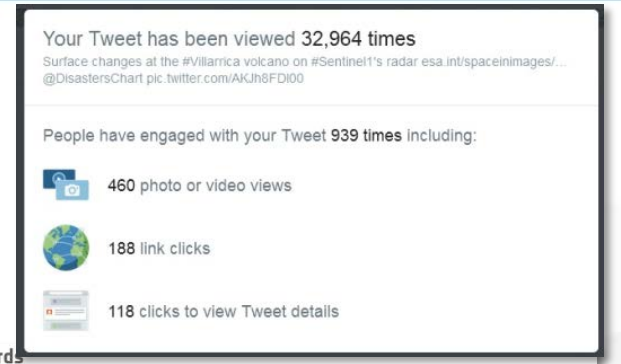
CEOS Pilot users can promote their results through:

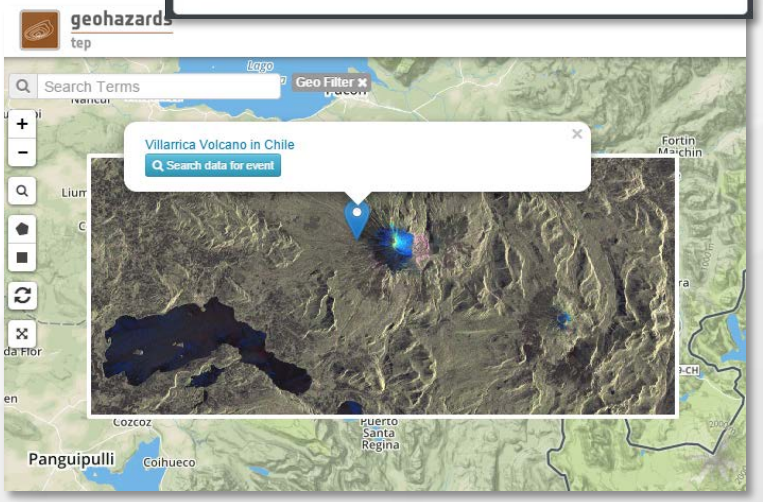
- **CEOS website (http://ceos.org/)**
- **GSNL portal (http://www.earthobservations.org/gsnl.php)**
- **Geohazards Exploitation Platform (https://geohazards-tep.eo.esa.int/). A substantial effort has been made on showing relevant data packages and EO based measurements from the broad geohazards community using satellite EO (not only results from CEOS Pilot users, not necessarily processed on the GEP).**
  - **When EO based products are published, users cannot download them unless specified upfront by the producer.**
  - **GEO-GSNL to improve the product dissemination for Supersites**
    - **Use the GEP platform, on a voluntary basis, to disseminate the research products.**

    For Event Supersites: linking the GEP geographic interface from the webpages on the GSNL site.

    For Permanent Supersites: a similar procedure could be implemented from the Supersite webpages.

Example of promotion of results on the GEP





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).

Publications

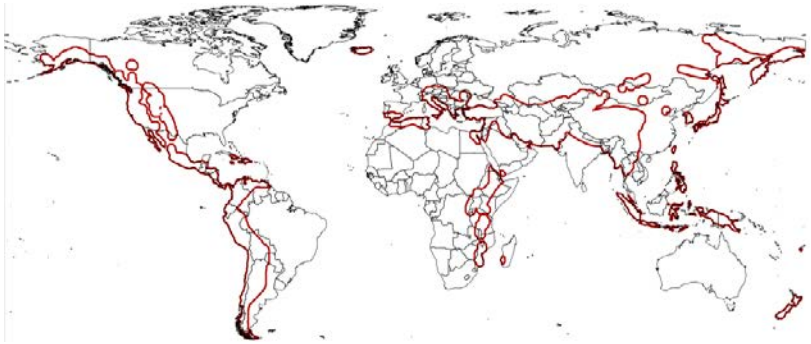
- Assessing impact of orbital errors on InSAR velocity and strain maps (**under Obj. A**)
  - Fattahi and Amelung (2015), “InSAR bias and uncertainty due to systematic and stochastic tropospheric delay”, submitted to JGR
  - Fattahi and Amelung, (2014), “InSAR uncertainty due to orbital errors", GJI
- A publication is being prepared by INGV (**under Obj. B**).
- Grandin et al. (2015), "Rupture process of the Mw=7.9 2015 Gorkha earthquake (Nepal): insights into Himalayan megathrust segmentation" submitted (**under Obj. C**)
- Fielding et al. (2015), Geodetic Imaging of the Coseismic and Postseismic deformation from the 2015 Mw 7.8 Gorkha Earthquake and Mw 7.3 Aftershock in Nepal with SAR and GPS submitted (**under Obj. C**)

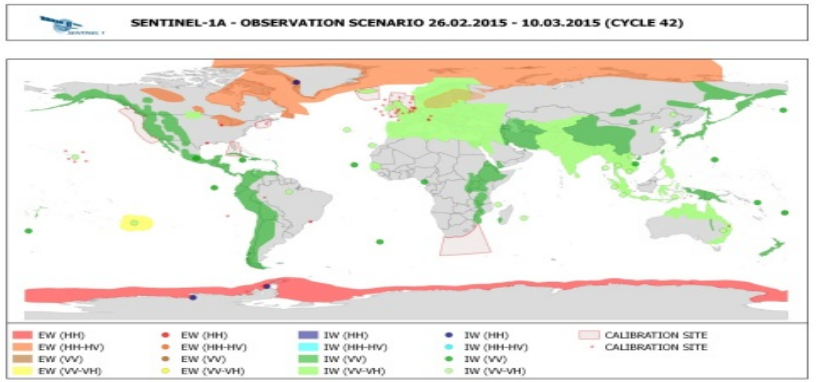
Results from pilot work to date

4. Observations strategy

Observations strategy

- **Continues exchanges between Seismic Hazards pilot lead and Sentinel-1 mission Project Manager in order to cover the entire tectonic mask.**





- **Study of the examination of the gaps of existing acquisition plans over megacities in areas of high seismic risk: Most sites are at least partially covered by SAR sensor and are:**

  -sites with high repeat coverage using Sentinel-1 and ALOS-2

  -sites with rare coverage using ascending or descending acquisitions from Radarsat-2, TerraSAR X, and COSMO-SkyMed.

https://sites.google.com/a/ingv.it/satellite-monitoring-of-geohazard-prone-megacities---satgeomeg/home

Issues and risks identified

Issues & risks identified

- Organizing data supply to users has been time-consuming.
- User base combines science users and end users; Difficult to identify end users in advance as earthquake location and time are not predictable (most pilot users are EO practitioners from the category of science users).
- Difficult to get detailed user feedback about the value of satellite data and how they exploited products.

Thank you!

Concept of streaming

New proposition: **beyond quota for data download explore data visualzation**
… the concept of « **streaming versus downloading** »

The pilot Leads are discussing with Airbus concerning EO data visualization to support Objective A). The requirement:
1. visualizing VHR (e.g. Pléiades, SPOT6-7) Optical imagery generally with stereo pairs
2. make perspective views with imagery overlain over topography (where one could construct profiles but not access the original data)
3. construct topographic profiles across active faults

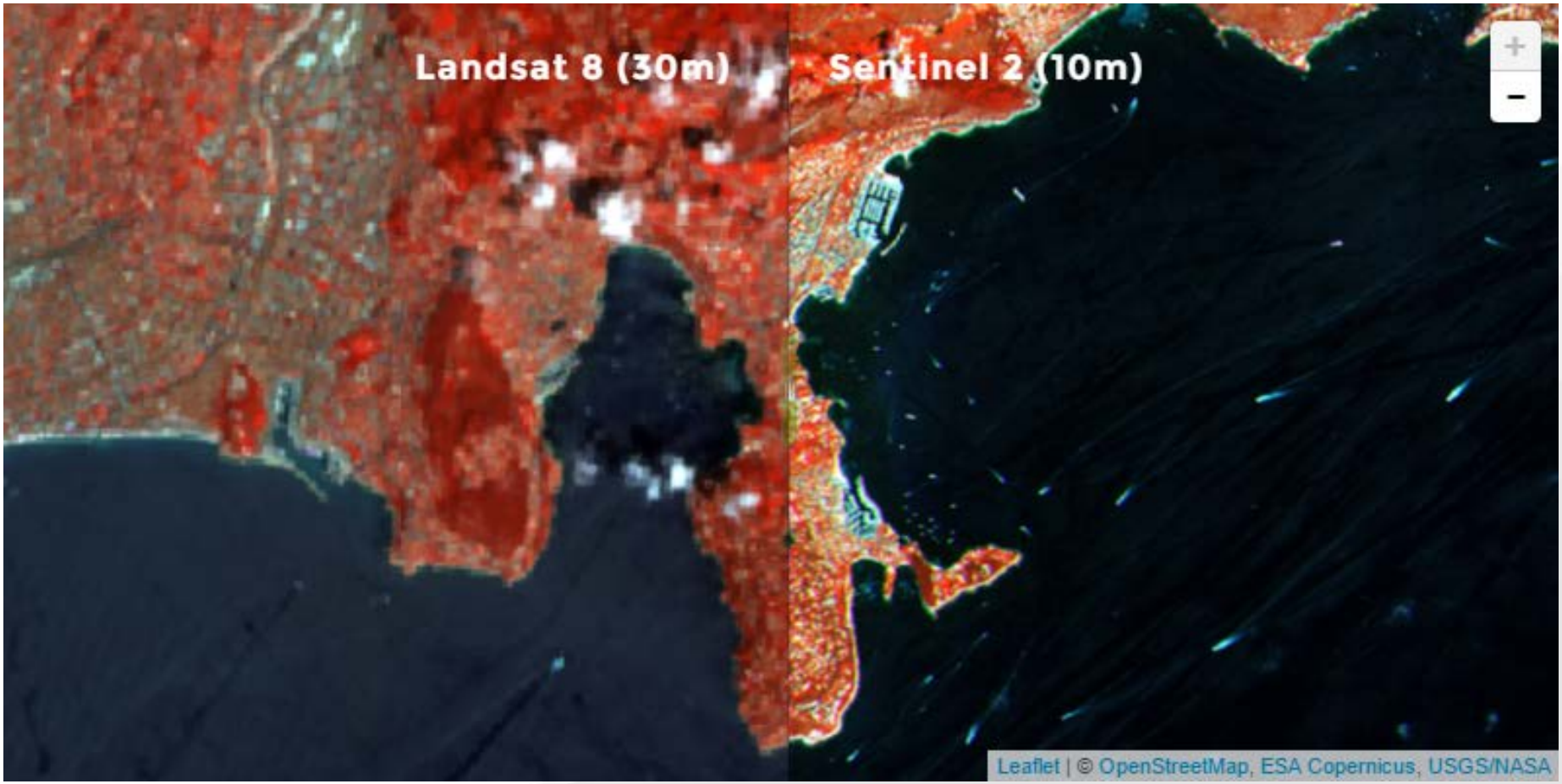
Solution: visualize data and DEM through the GEP (no download).

A quota is intended to be offered for a first trial year: 100,000km2 with Spot-6/7 i.e. a 50,000km2 extent using stereo pairs … to give an idea 100,000km2 represent 100 segments of 10km times 100km. Data selected by km2 not be scene. A precise DEM could be included (TBD).
There are also 10,000km2 with Pleiades i.e. a 5,000km2 extent using stereo pairs (TBD).

Copernicus Sentinel-2A available

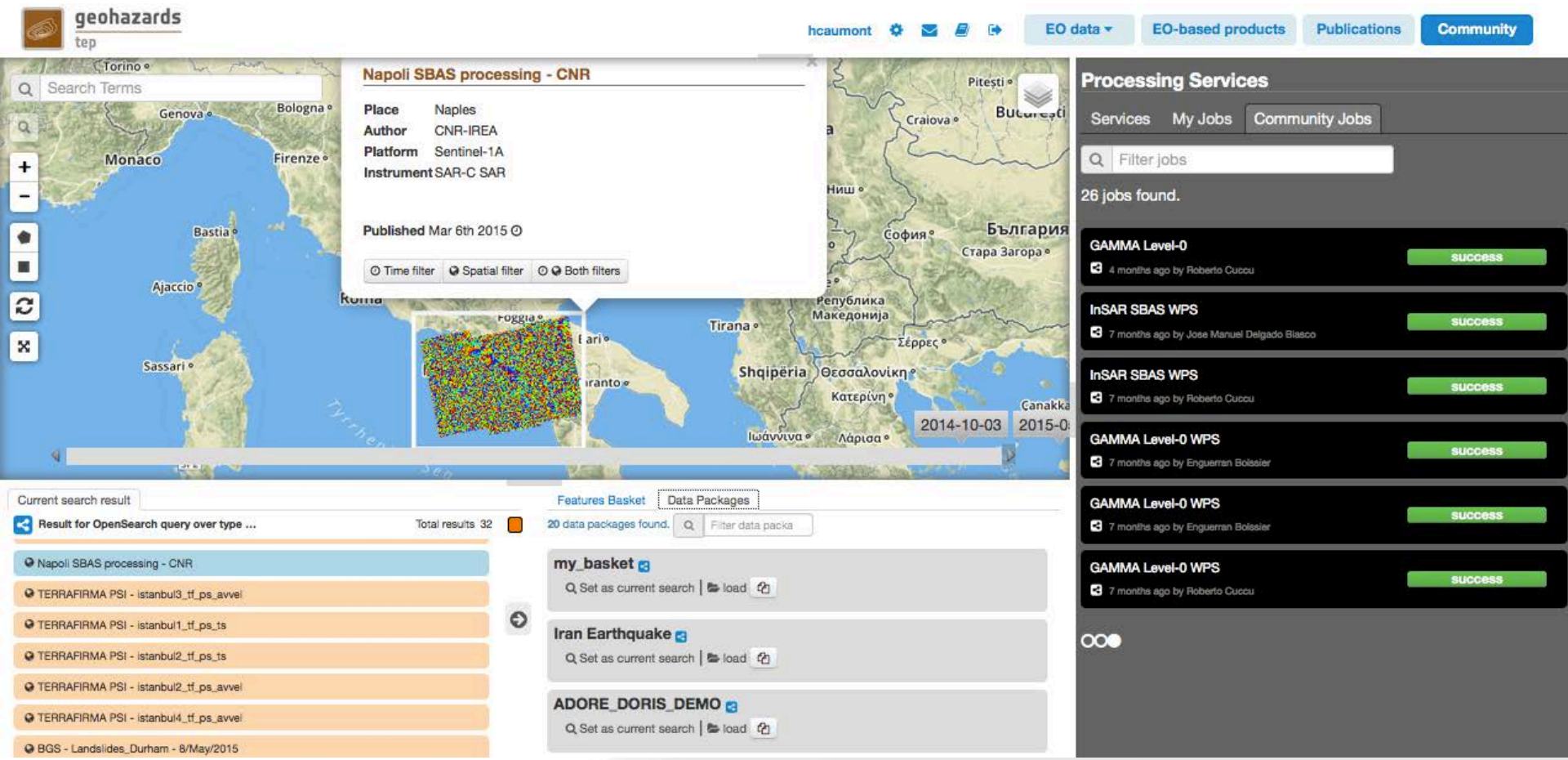
Newly available Copernicus Sentinel-2 will contribute to the CEOS WG Disasters

There is a strong synergy with Landsat-8 (they allow increased temporal sampling)

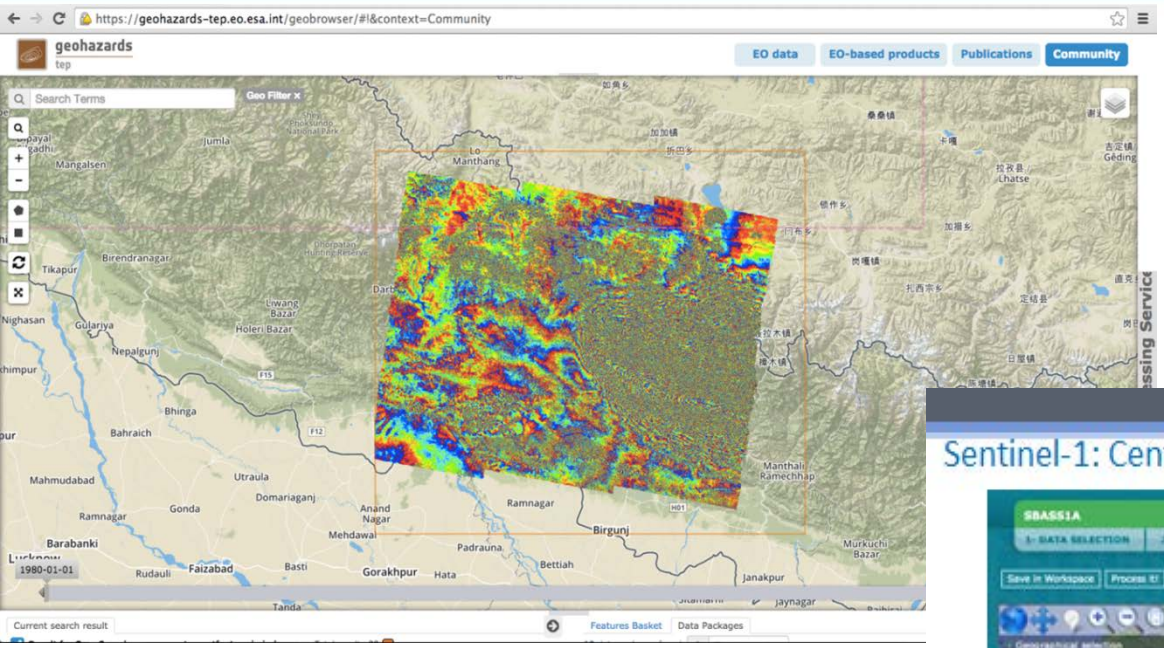


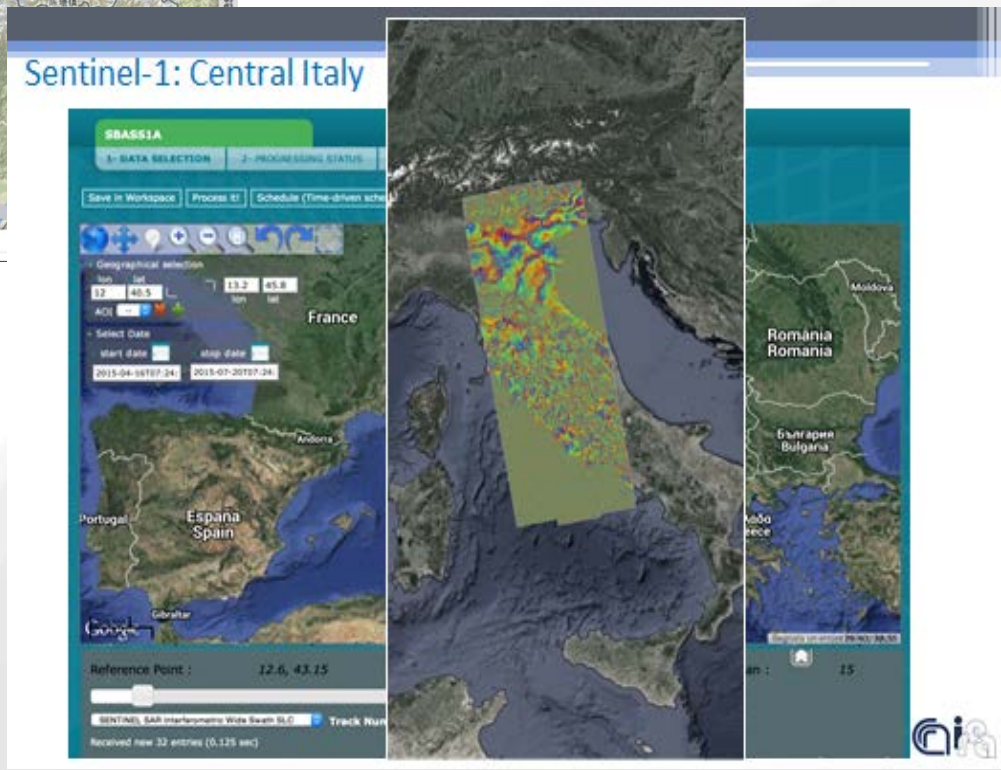
Source: http://remotepixel.ca/blog/sentinel2_July2015.html

GEP v0 – Overview



CNR-IREA: Results of SBAS S-1A processor (under integration)





Which fault slipped in the earthquake?

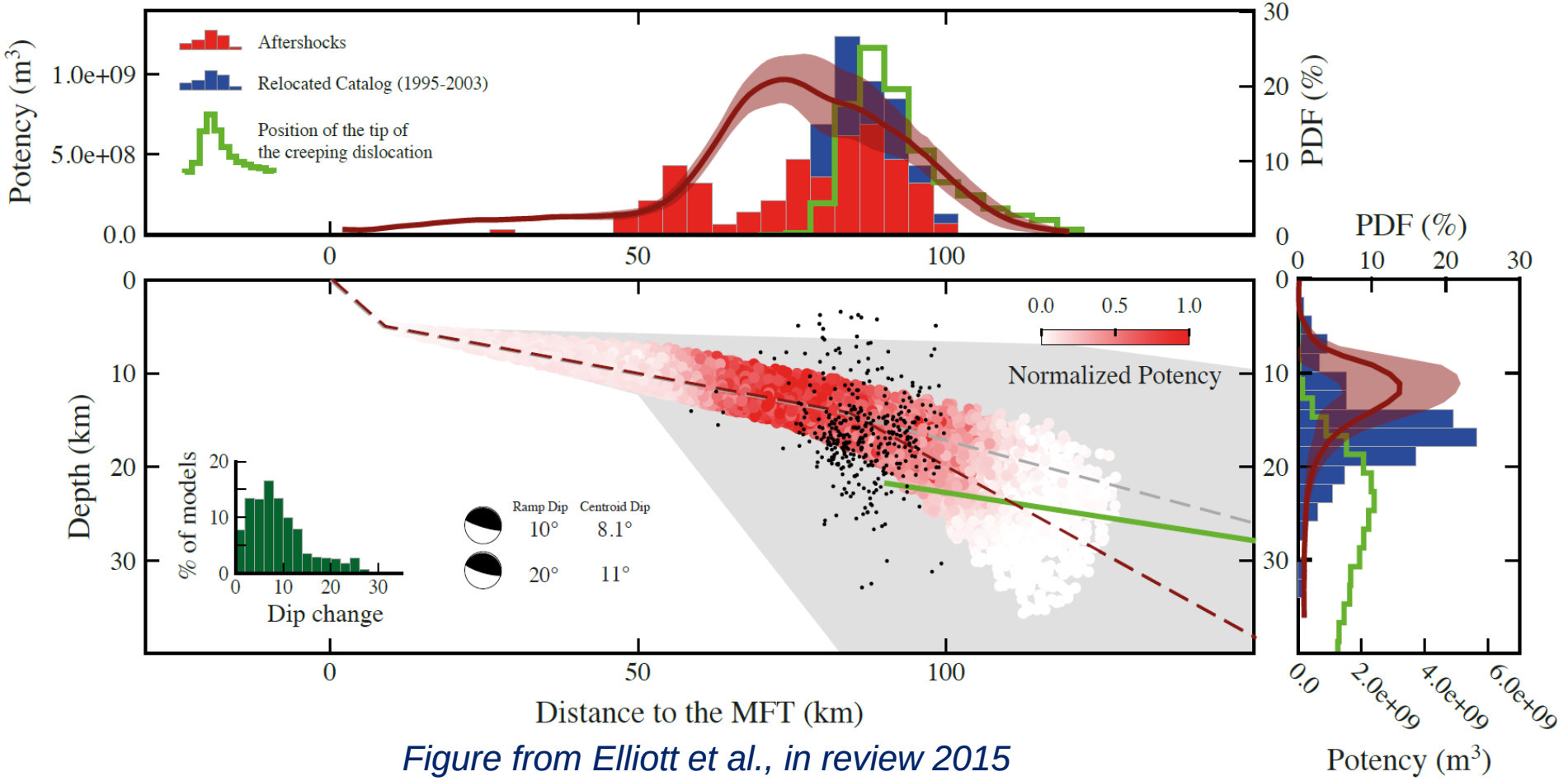


Figure from Elliott et al., in review 2015

Tim J. Wright, COMET: Sentinel-1 data