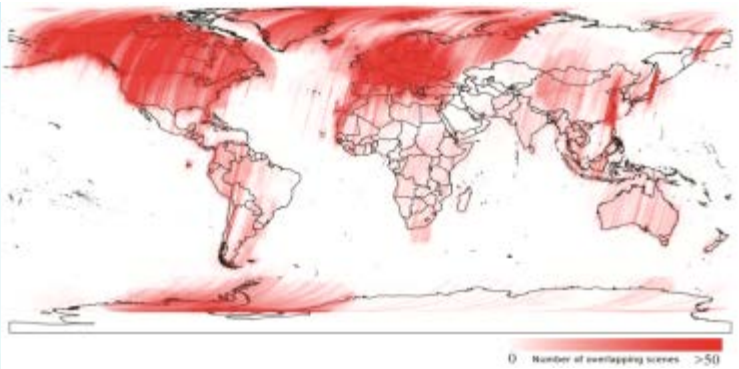
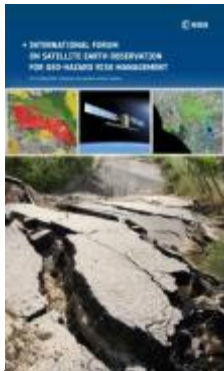
Satellite EO to support Disaster Risk Management

Philippe Bally

ESA, 15 October 2015





ESA Facts and Figures

- Over **40** years of experience
- **20** European member states
- Cooperation agreement with **8** European states (Bulgaria pending) + Canada
- **5** establishments in Europe, ~**2200** staff
- Over **70** satellites designed, tested and operated in flight
- **17** scientific satellites in operation
- **6** types of launchers developed

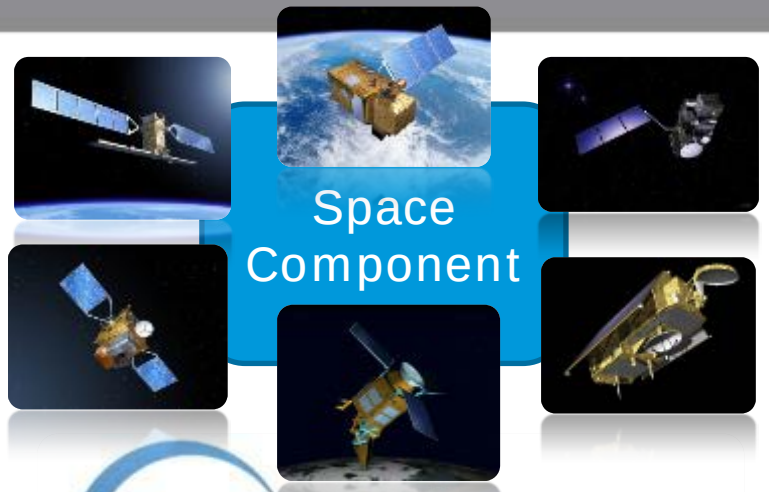
Satellite EO at ESA

Long-term (decadal) continuous, consistent data

What is Copernicus?

European ***independence*** & contribution to ***global Earth observing*** **system**

Global, timely and easily accessible information



ESA participation to DRM activities:

- what can ESA provide using Earth Observation (EO) technologies ?

✓ **ESA operate satellite missions (ERS, ENVISAT: tools for crisis mapping)**

✓ **participate to the International Charter Space & Major Disasters**

➢ ***EO data***

✓ **has EO application development programmes (e.g. GSE feeding into EC GMES)**

✓ **participate to international activities to develop EO applications**

➢ ***end-to-end services to users***

Group on Earth Observations

International Charter Space & Major Disasters (CHARTER)

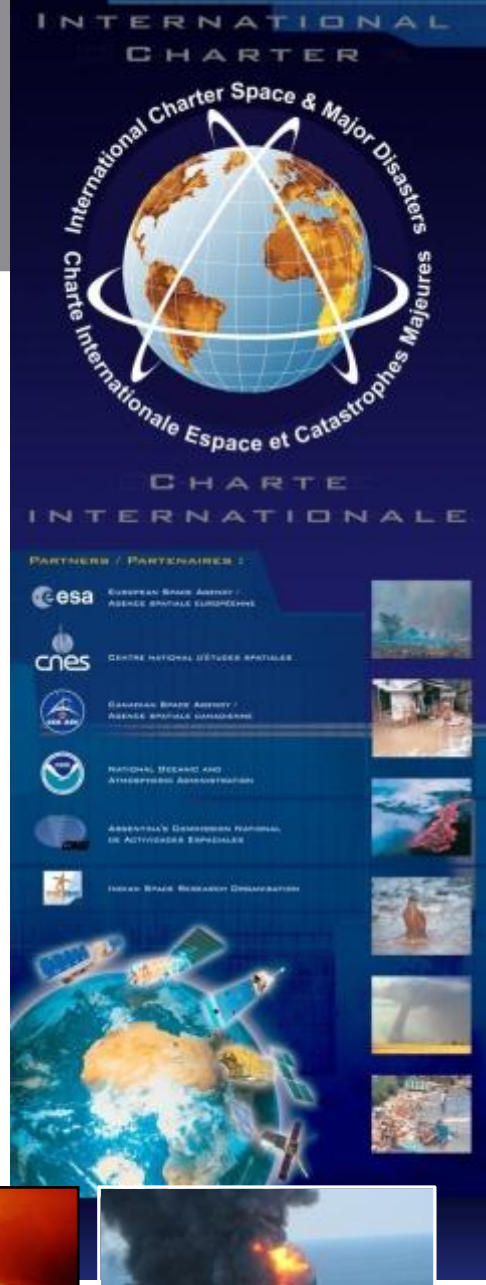
Global Earth Observing System of Systems (GEOSS)

Global Monitoring for Environment & Security (GMES)

Integrated Global Observation Strategy (IGOS)

The International Charter:

- **A unified system of space data acquisition / delivery in case of natural or human-made disasters**
- **15 space agencies (5 European agencies: CNES, ESA, UKSA , DLR, EUMETSAT)**
- Data delivery to **civil protection agencies, emergency & rescue services**; Also available to **Humanitarian Aid actors of the UN** since 2003.
- Operational : 24 hrs on-duty-operator
- **Charter activations: +/-**40 events/ year



Mandate of the Charter

The Charter only supports the **phase of immediate response** to a disaster.

Charter activations generally last for about 1-4 few weeks.

420+ disasters covered in 110+ countries worldwide

GREEK FIRES ACTIVATIONS: AUGUST 2007 & AUGUST 2009

ANCIENT SITE OF OLYMPIA

ATHENS – DENSELY POPULATED AREA

DO NOT YET KNOW FULL EXTENT OF FIRES/DAMAGE

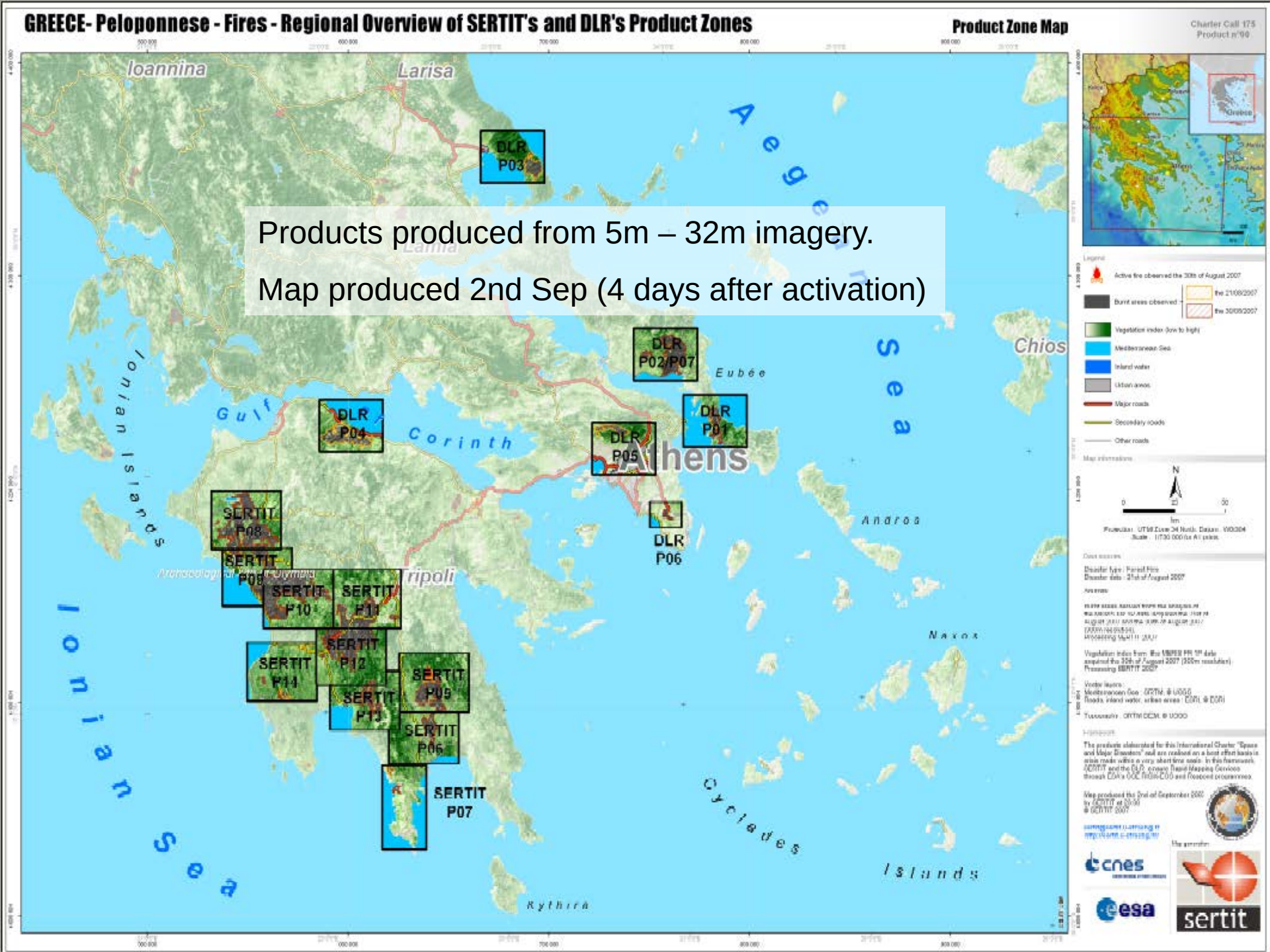
SOME FIRES COMING TO AN END, OTHERS JUST STARTING

Fires: August / September 2007

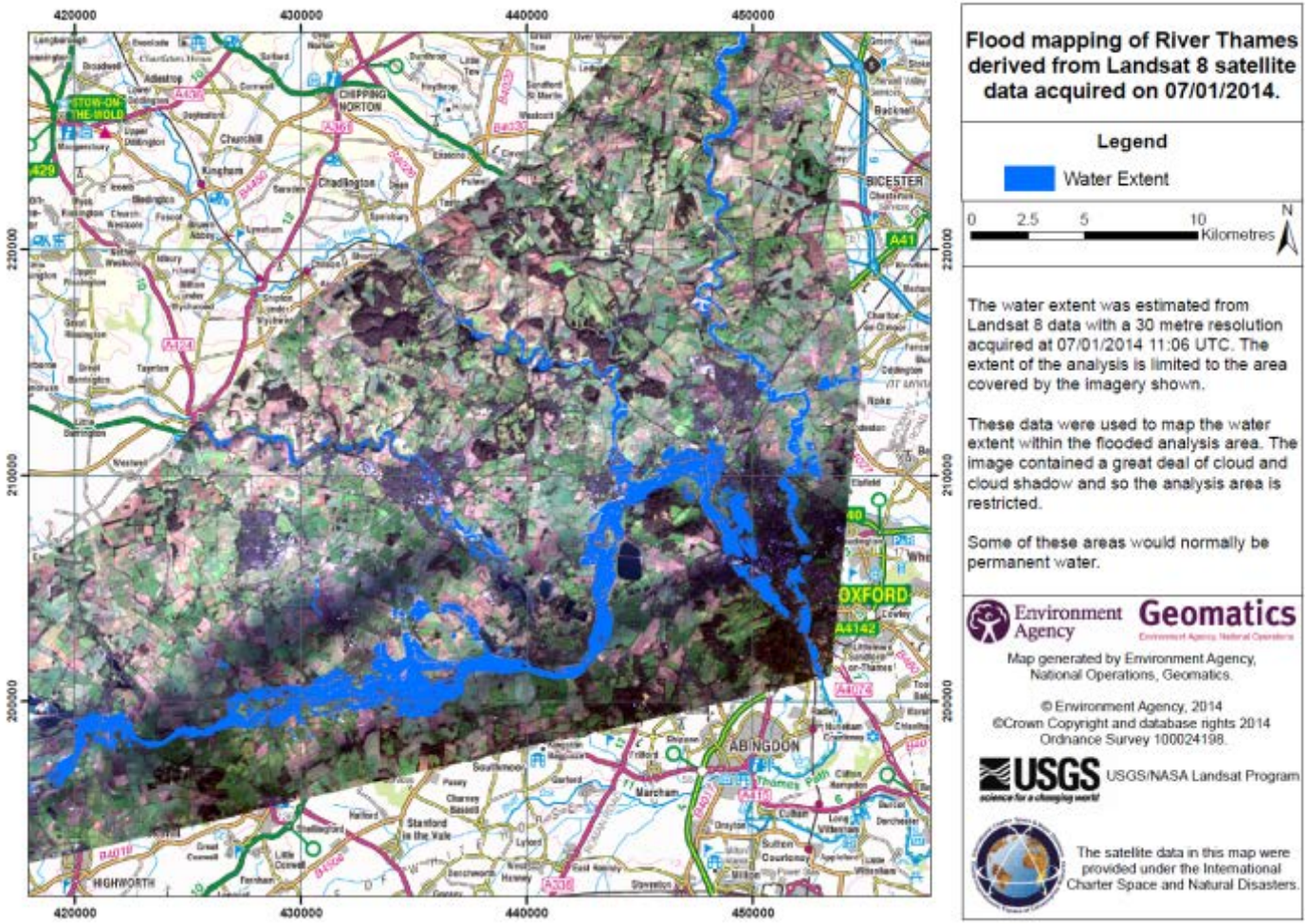
Activation: 29th August 2007

Time (10 days)

Date	AOIs provided by AU	Imagery acquired	Map produced
28/08		MERIS FR (300m) (21-27/08) Landsat (30m)	
29/08	Entire Greece		
30/08	8 circular AOIs, radius 30km	MERIS FR (300m)	Overview map using MERIS (30th Sep) Video, using MERIS (21-30/08)
31/08			Athens and Peloponese maps using MERIS
01/09		SPOT 5 (10m) DMC (32m) MMRS (175m) HRTC (35m)	
02/09		SPOT 5 (10m) DMC (32m)	
03/09	Circular AOI radius (7.5Km) - active fire discovered on recent imagery.		Maps using DMC and SPOT over some AOIs
04/09		SPOT 5 (10m) Landsat (30m) Formosat (8m)	Maps over most AOIs using Landsat, DMC, SPOT
05/09		Formosat (8m)	Maps produced using Formosat, SPOT
06/09		Formosat (8m)	Maps produced using Formosat, SPOT


GREECE- Peloponnese - Fires - Regional Overview of SERTIT's and DLR's Product Zones
Product Zone Map
Charter Call 175
Product n°00
Products produced from 5m – 32m imagery.
Map produced 2nd Sep (4 days after activation)
Ioannina
Larisa
Aegean Sea
Chios
Eubée
Gulf
Corinth
Athens
Ionian Islands
Andros
Naxos
Cyclades
Islands
Ionian Sea
Rythira
DLR P03
DLR P02/P07
DLR P01
DLR P04
DLR P05
DLR P06
SERTIT P08
SERTIT P09
SERTIT P10
SERTIT P11
SERTIT P12
SERTIT P13
SERTIT P14
SERTIT P06
SERTIT P07
Active fire observed the 30th of August 2007
Burnt areas observed
the 21/08/2007
the 30/08/2007
Vegetation index (low to high)
Mediterranean Sea
Inland water
Urban areas
Major roads
Secondary roads
Other roads
N
0
20
50
km
cnes
esa
sertit

Floods in the UK, January 2014.



Product generated by Environment Agency, National Operations, UK using Landsat-8 imagery of 8 January 2014.

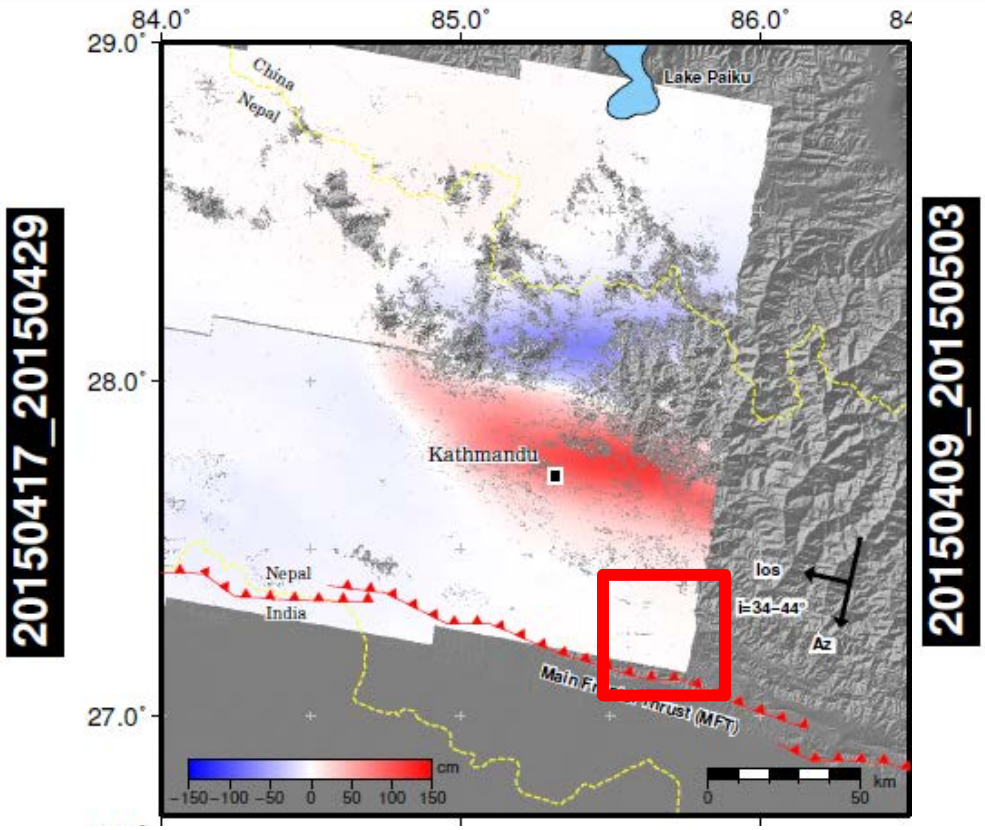
EO Services & Risk Management cycle

- **Emergency Response**,
  - Rapid Crisis Mapping & Damage Assessment,
  - Situation Mapping.

- **Prevention, Preparedness, Recovery, Reconstruction**
  - Detailed Damage Mapping,
  - Risk Assessment.
    (Floods, Fires, Geo-Hazards)

- **All phases**
  - Reference Mapping,
  - Digital Elevation and Digital Terrain models,
  - LU/LC cover Mapping,
  - Asset Mapping.

Understanding hazards using Sentinel-1



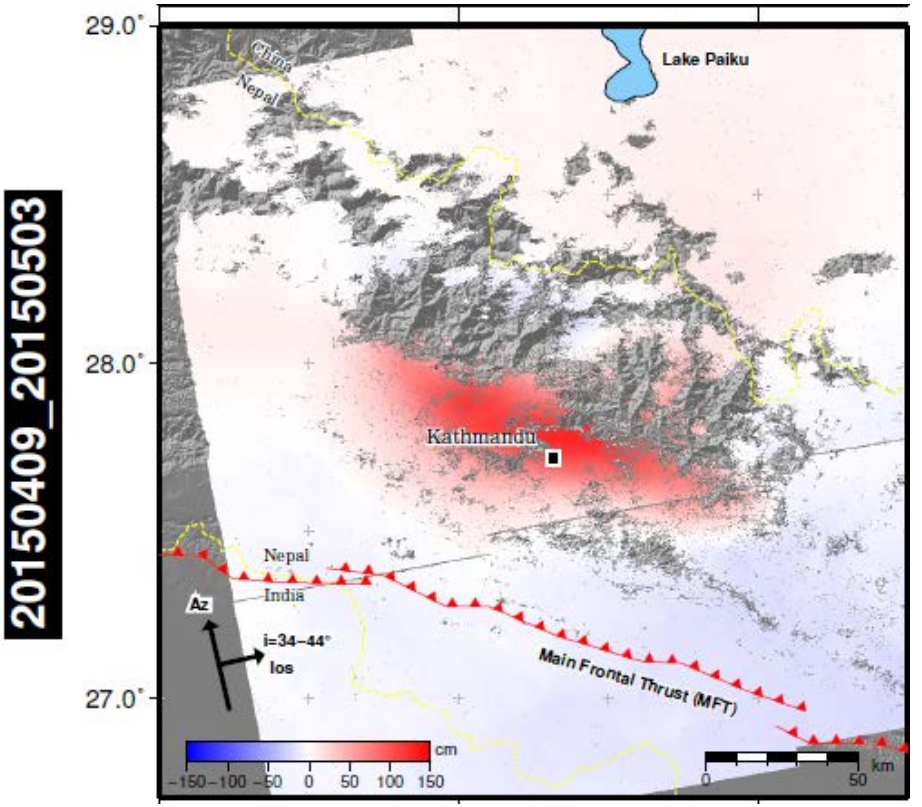


Figure from Elliott et al., in review 2015

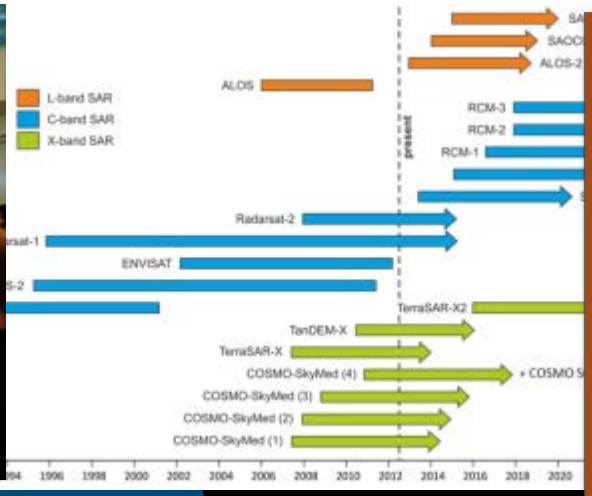
Tim J. Wright, COMET: Sentinel-1 data

COMET Centre for the Observation and Modelling of Earthquakes, Volcanoes and Tectonics
NATURAL ENVIRONMENT RESEARCH COUNCIL
NERC SCIENCE OF THE ENVIRONMENT
UNIVERSITY OF LEEDS
UNIVERSITY OF CAMBRIDGE
esa
seom scientific exploitation of operational missions
INSARAP
European Space Agency

Example of international collaborations:

The “Santorini Conference” organised by ESA and GEO:

- **140+ participants from 20 countries** including European countries, the US, Canada, Japan and China.
- **70+ organisations**: international organisations, public institutes, space agencies, universities & private sector.



Example of the CEOS WG Disasters: thematic pilots

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

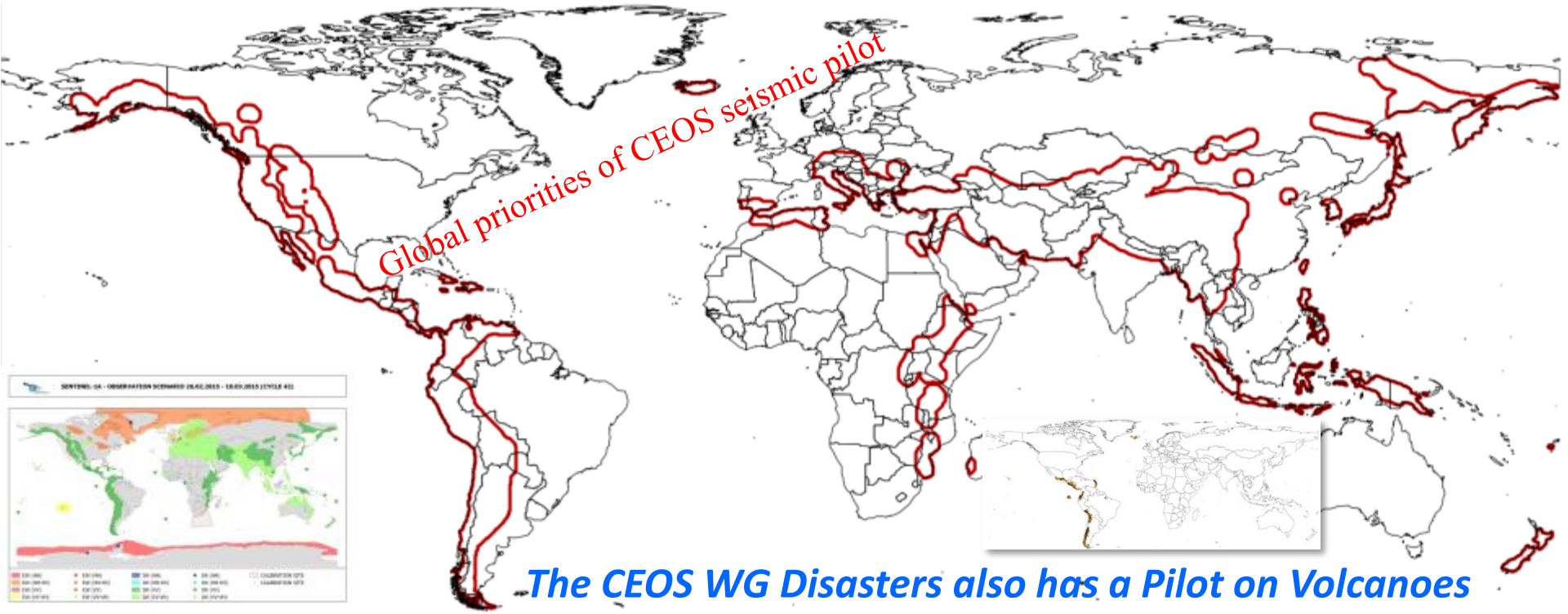
[role of EO: wide extent satellite observations]

B. Support and continue the GSNL 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

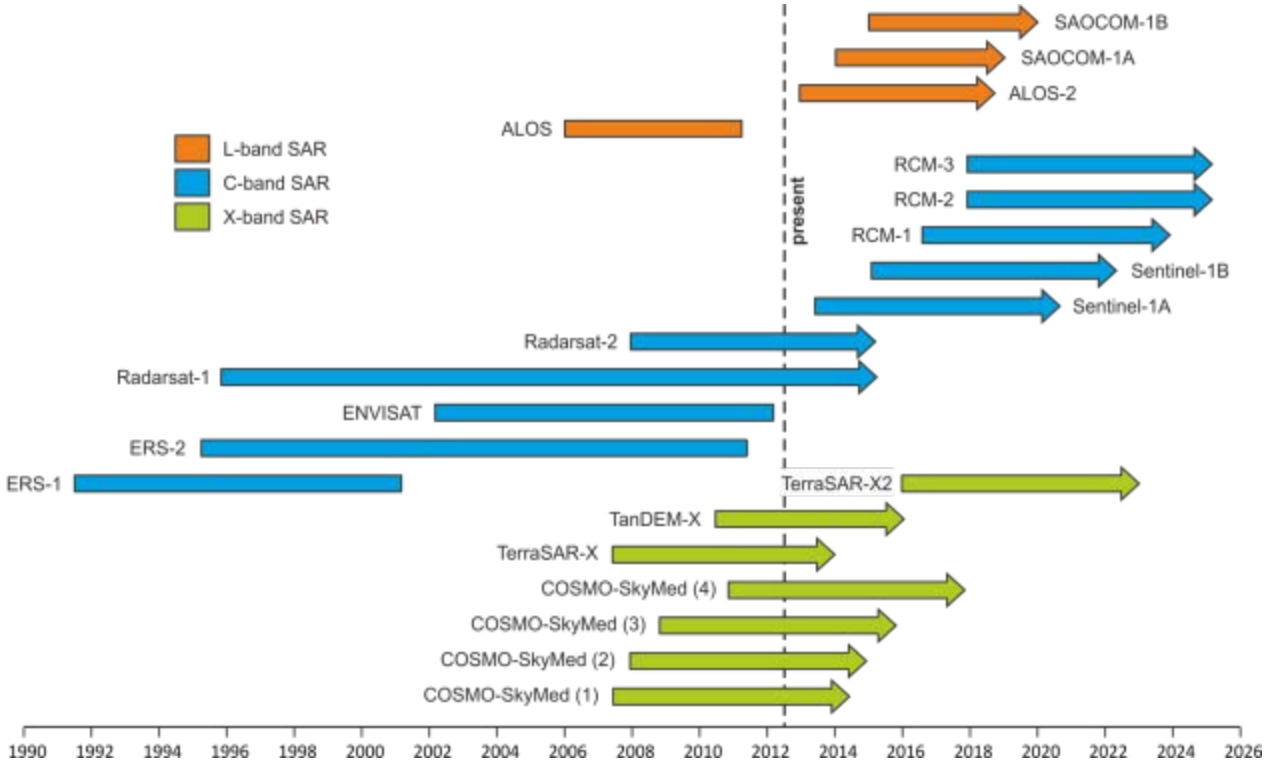
Innovation in space

ESA is operating EO missions providing very large collections of large files

Sentinel-1: three Terabyte per day (projection: 10 Tera with S1-A & S1-B)

One year ~ 1 Petabyte

ERS & ENVISAT data over **world tectonic regions ~1 month** of S1-A acquisitions



EO data Supply vs Consumption
(from the Santorini conference)

Theoretical(*) volume of data acquired by Sentinel-1 (~465-700 scenes per day i.e. 23-35 000 000 km^2)

173-260 times extent of Greece

[*assuming 17-26% duty cycle]

Volume of production similar to Terrafirma (~750/yr equivalent to 43 000 000 km^2)

EO Supply capacity **200 - 300 times** larger than levels of exploitation of current levels of service delivery

ESA has started to apply **innovative approaches: TEPs**

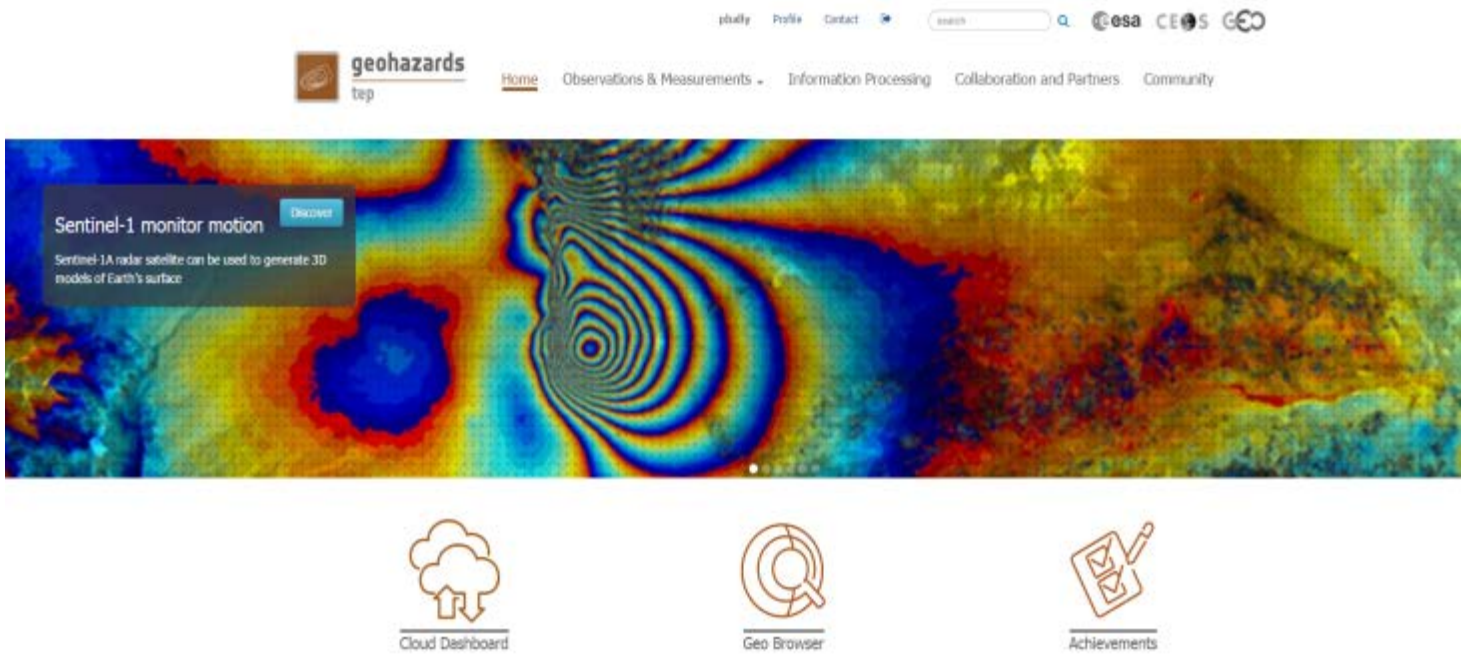
The Thematic Exploitation Platforms (TEP)

ESA has started **Thematic Exploitation Platforms** initiative covering six thematic areas: hydrology, polar, coastal, forestry, urban & geohazards.

The **Thematic Exploitation Platforms goals** are:

- **Facilitate use** & processing of large datasets (including non-space data) by a large number of users (science and non-science)
- Processing services, software (e.g. toolboxes, etc.) and computing resources
- Provide an **environment for services development**, integration and exploitation
- Federate user communities around common scientific & thematic objectives
- Promote **shared science objectives** & better use of satellite EO
- Collaboration tools (e.g. knowledge base, open publications, social networking)

The Geohazards Exploitation Platform



An Exploitation Platform under development and validation that is sourced with **data and processing** relevant to the GeoHazards theme:

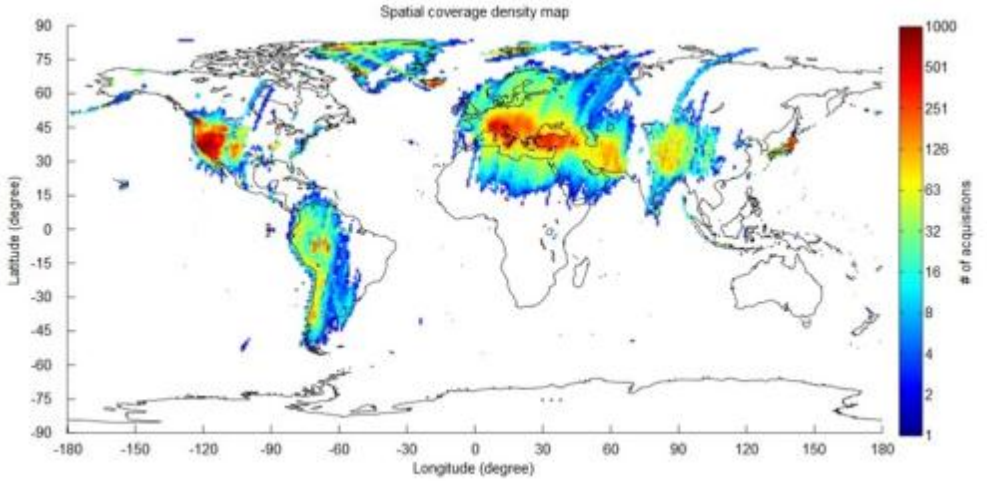
- EO data **storage** concerning wide extent tectonic analysis for which large data stacks are needed (typically 1000+ and 5000+ scenes and larger)
- Access to **advanced processing tools** (e.g. InSAR and Optical based)
- A **collaborative** work environment and scientific animation
- 2015: **22 users** on board; end 2017: **60 users**
- One of the *6 Thematic Exploitation Platforms* originated by ESA

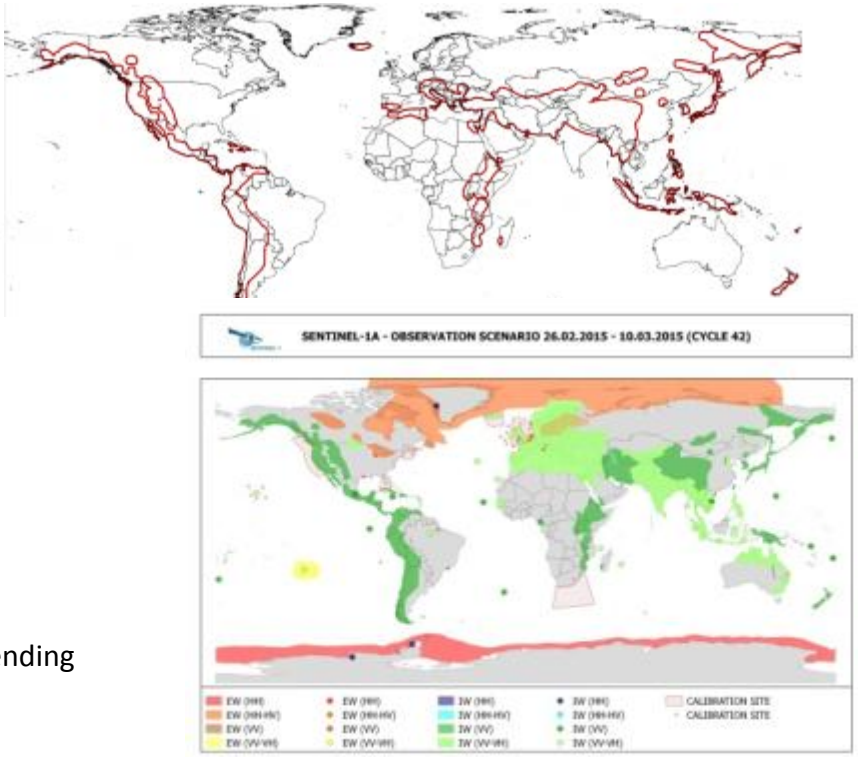
Available ERS, Envisat & Sentinel-1A SAR data

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:

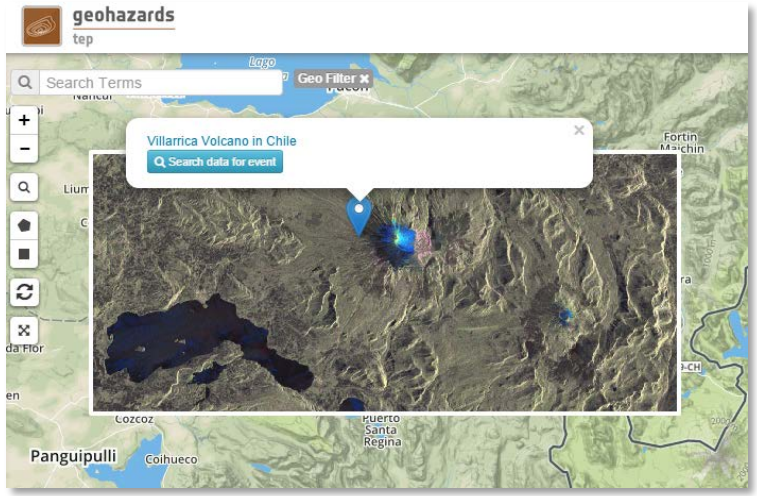
- Current ENVISAT ASAR IM Level-0 Data : > 60200 products (~35TB)
- Current ERS SAR IM Level-0 Data : > 56500 products (~25TB)





Top: Current coverage of ERS & ENVISAT L0 data available
Top Right: priority areas of the geohazards community
(CEOS WG Disasters, Seismic Pilot)
Right: Operations plan of Sentinel-1 (green: once every two cycles in ascending and descending, light green: all cycles)

GEP Validation started March 3rd:



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).

Examples of *Early Adopters*

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 Univ. Blaise Pascal (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

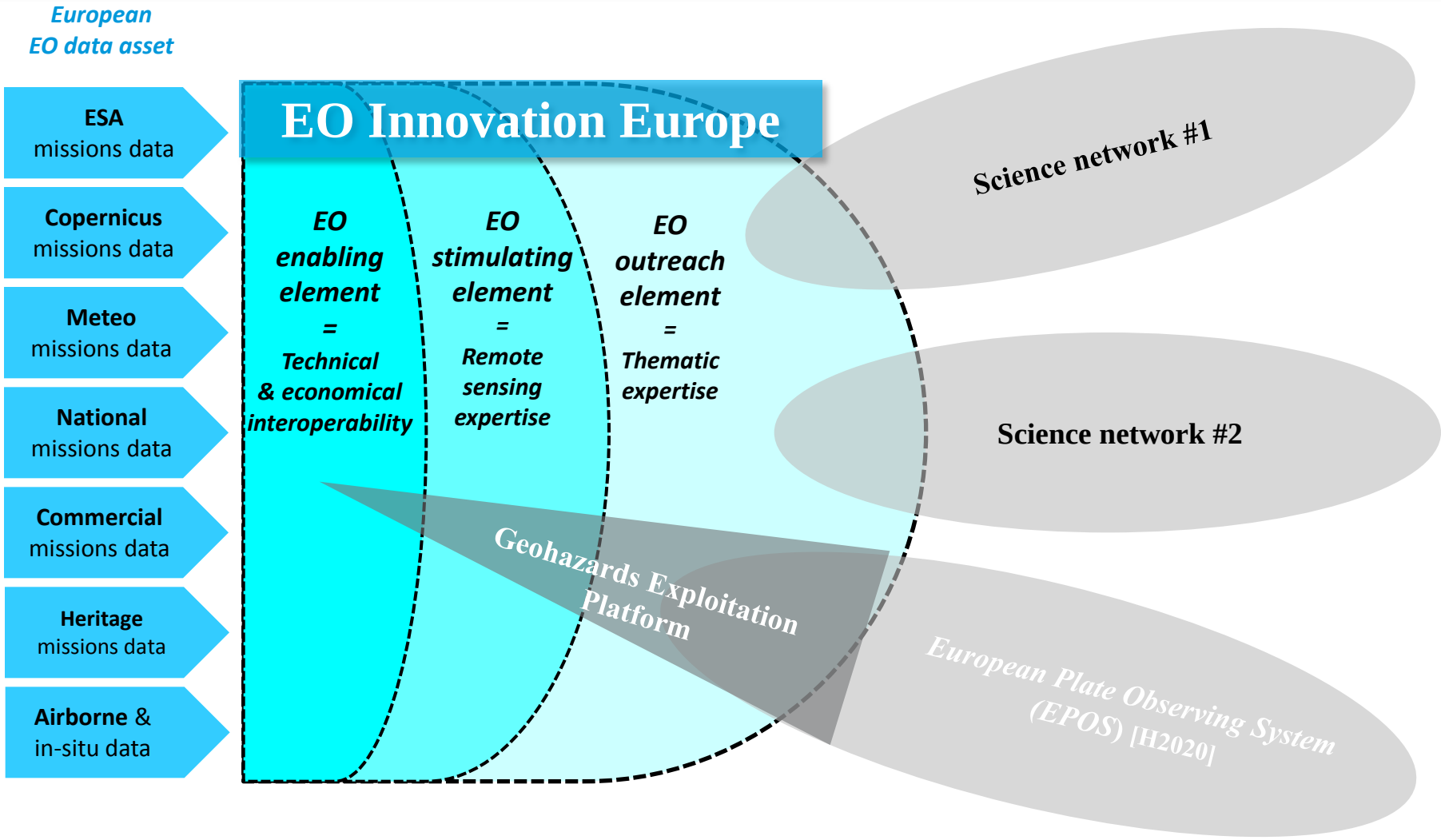
Volcanoes

Earthquakes

Landslides

PoC for applications: geohazards-tep@esa.int

Exploitation platforms within *EO Innovation Europe*
→ linked with large science networks and ecosystems



Take home messages

- The DRM user community is broad with varying needs according to the **hazard type**
- Users include **science users** and **operational users**
- Needs depends on which **phase of the DRM cycle** (Response, Mitigation)
- **Acceptance of satellite EO** methods by users is increasing
- Newly available and planned **EO missions are making a big change**
- Overall the **space segment** is evolving and there is R&D on the **ground segment**
- There are new ways to work with **EO methods and new ICT techniques** to improve the contribution of satellite EO and grow the user base

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) #