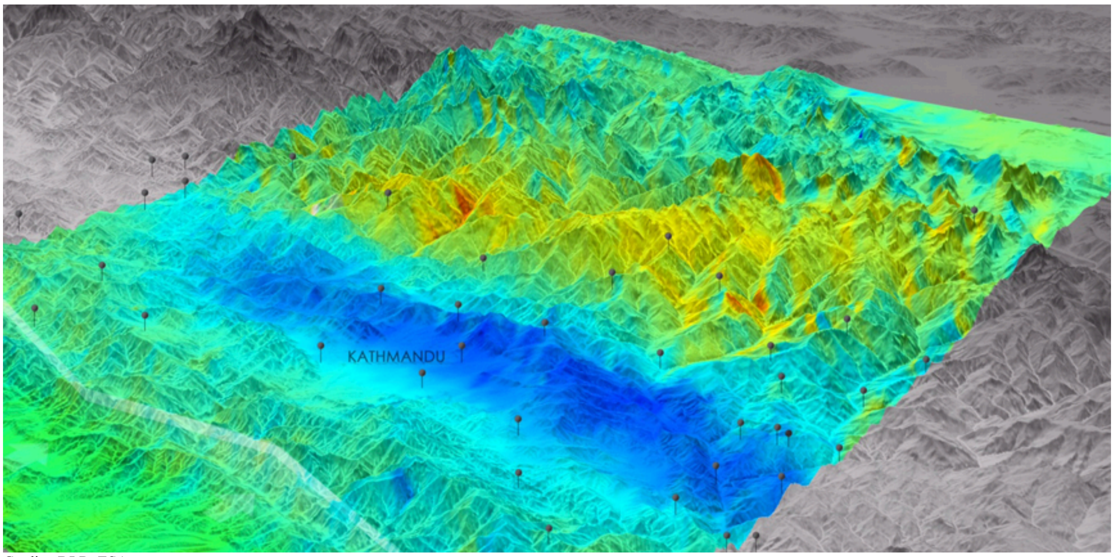

Credits: DLR, ESA.

CEOS WG Disasters
The Geohazards Lab initiative

Draft 2.0

CEOS WG Disasters
March 9, 2017

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Executive Summary

The Geohazards Lab aims at addressing priorities of the *Sendai Framework for Disaster Risk Reduction 2015-2030* using Earth observations (EO). At the 2016 GEO Plenary in Saint Petersburg the decision was made that Disaster Risk Reduction (DRR) is one of the three priority themes for the next few years. The main goals of the Geohazards Lab are to provide users with:

- a mechanism to access to satellite EO data (e.g. based on yearly quota as typically done through CEOS Pilots),
- a processing environment to exploit satellite EO data (possibly without downloading them) and in situ data to support DRR and resilience measures, during all disaster risk management phases, whenever satellite EO is required and taking into account their combination with other sources of data (in-situ ground observations, socio-economic, model outputs, etc.).

The Geohazards Lab is a new initiative within the CEOS WG Disasters to enable greater use of *observation data and derived products to assess geohazards and their impact*. The CEOS WG Disasters activities are focusing on Disaster Risk Management (DRM) with:

- DRR, addressing needs from both science users in geoscience centres and end users from mandated DRM organisations and workings directly with both types of users outside the disaster response phase,
- Disaster Response, addressing needs from science users in geoscience centres; as a baseline the Geohazards Lab fully articulates with operational initiatives such as the International Charter Space & Major Disasters, Sentinel-Asia and Europe's Copernicus Emergency Management Services; it is not interfering with them for data access in the crisis time; outreach to end users is possible based on the 2015 agreement between CEOS and the Charter that makes it possible to expose CEOS results in the disaster response phase to the Charter operational team (the so called Project Manager).

The Geohazards Lab is following-on the Seismic Hazards Pilot and collaborating with CEOS Pilots in relevant themes (e.g. in the Seismic, Volcano and Landslides Pilots), the Recovery Observatory and the newly started GEO-DARMA initiative. It is designed to help CEOS Pilots and the Recovery Observatory by providing them with a processing environment in complement to the EO data exploitation activities conducted by the Pilots that is not duplicating nor interfering with their data access mechanism. While the CEOS Seismic Pilot is intended to finish in 2017 the Geohazards Lab will take over and expand its activities. Discussions are in course concerning the possibility of hosting the Volcano activities in the framework of the Geohazards Lab. This depends on what form the new activity following-on after the end of the Volcano Pilot will take in 2017, that is either as a new CEOS WG Disaster initiative or as an integral part of this initiative. As far as the GEO-DARMA initiative is concerned, the intention is to obtain support from the Geohazards Lab for EO processing when relevant for activities such as risk assessment for mitigation purposes. Both activities are aiming to establish an inclusive and comprehensive process to address DRR requirements from local and national users by using EO technologies efficiently.

The Geohazards Lab activity shall be realized against preset milestones, described in section 11 and will be based on voluntary data contributions in kind from space agencies (estimation of data volumes is described in section 12) and contributions from Pilot partners of the geohazards community, primarily geoscience centres engaged in hazard and risk applications based on terrain motion mapping. The Geohazards Lab aims to continue to provide hosted processing as already demonstrated with the Seismic Hazards pilot. It will fully articulate with on-going Pilots, follow-on activities and the Recovery Observatory (RO) in particular concerning data delivery and will develop synergies with them. The activity is addressing two challenges identified in the precursor CEOS Pilots:

- enabling EO applications with massive volume and/or intensive processing computing, such as in the case of terrain motion monitoring based on InSAR or stereo-optical data,
- increasing access to users in regions where it is difficult to download large EO data products while the results of Cloud based processing generally are much smaller files.

The initiative is focusing on the sharing of resources to provide a scientific environment for EO data processing and e-collaboration for DRR purposes with both expert users (science users that develop, test or operate advanced services using EO) and end users (organisations with a mandate in DRM that will integrate EO based measurements in their operational environment). The Geohazards Lab is not providing committed services and primarily provides a scientific processing capability to support DRM with primary focus on DRR. It is originated by space agencies with a long term vision about supporting geoscience centres so they can exploit EO data, share results and compare measurements in space and time thanks to a geospatial infrastructure guaranteeing the persistency of measurements and known quality levels of the processing (for creating long-term observatories of relevant parameters on relevant sites). The Geohazards Lab aims to articulate in an orderly fashion with global, regional and national EO based disaster response capabilities. As an example it is building on the agreement in place since July 2015 between the International Charter and the CEOS WG Disasters.

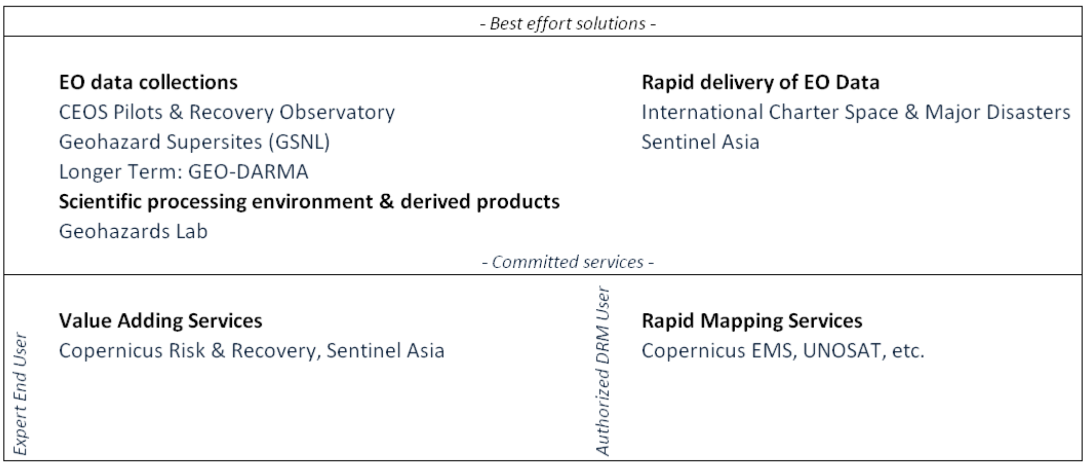


Figure 1: the context of EO based DRM initiatives with examples of EO capabilities for DRM.

1. Background

The precursor CEOS Pilots were primarily concentrating on defining an observational strategy (ensuring data are acquired in advance) and delivering EO data collections to a pre-defined group of users engaged to exploit them and provide feedback. They are primarily looking at DRR i.e. hazard and risk assessment not on an emergency basis and also, to a limited extent disaster response. An overview of the different EO capabilities contributing to DRM is given in Annex 1. For instance, to cite two examples, Pilot activities conducted on an emergency basis include the study of volcanic unrest and eruption (CEOS Volcano Pilot) and advanced tectonic products for earthquake response for scientific analysis (CEOS Seismic Pilot).

Overall, for emergency response, the baseline is the collaboration with existing EO disaster response capabilities (see list in Annex 2) providing damage mapping such as for instance the International Charter Space and Major Disasters, with whom, the Copernicus EMS, Sentinel Asia, etc. Through such collaboration the Geohazards Lab will generate advance science products for scientific analysis (primarily aiming to scientific users) during the response phase. Since July 2015 the CEOS WG Disasters has an agreement in place with the International Charter to allow sharing such products with the Charter Project Manager to allow reaching end users access them.

The Geohazards Lab aims to continue providing access to data alongside the procedures managed by the CEOS Data Coordination Team (DCT) and to expand hosted processing and e-collaboration as already tested since 2015 with the precursor Geohazards Exploitation Platform within the Seismic Hazards. The Geohazards Lab is proposed as a shared and open environment to support hosted processing and user federation with e-collaboration (e.g. knowledge base, open publications, social networking).

2. Concrete objectives

The main themes in the scope of the proposed activity are geohazards already addressed in the CEOS WG Disasters framework i.e. primarily looking at *seismic hazards, volcanoes and landslides*.

Much of the focus of disaster activity is currently on the high-profile response phase (see Figure 2) during which rapid action can save lives. Satellite EO is a recognized solution for enabling more efficient relief actions and supporting aid actors with objective and up to date information. It is however widely accepted that increased efforts on risk reduction during the mitigation and warning phases of a disaster will save more lives and protect property by reducing the exposure of populations to the hazard. An enlarged CEOS action plan should consider the entire cycle of risk management (mitigation, warning, response and recovery), especially considering existing efforts with regard to response, principally through the Charter, Sentinel-Asia and Europe's Copernicus programme, its end to end services based on the Copernicus Sentinel missions and other contributing missions, as described in Figure 3. A clear conclusion is that DRM activities today would be greatly enhanced by a significant new contribution from the satellite-EO community. While much has been improved in the last ten years, major gaps remain with regard to critical disasters, especially in the area of disaster risk reduction.

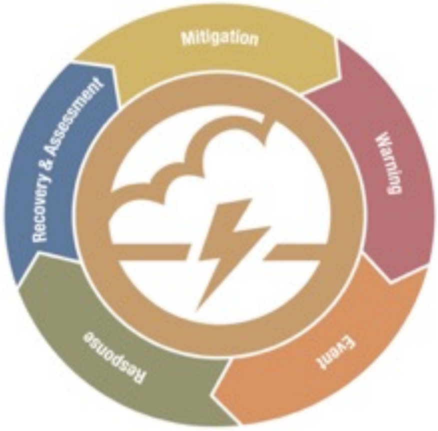


Figure 2: DRM phases: DRR and disaster response. The Geohazards Lab is addressing both DRR and disaster response and articulates with operational EO based response initiatives.

Disaster Response Capabilities:	Example:	Access:	Content:
Operational capability for EO data	International Charter	Predefined users	EO data (VA on a case by case basis)
Operational capability for end to end services	Copernicus EMS, Sentinel Asia, etc.	Predefined users	VA services
	UNOSAT	UN users	
Scientific capability	Geohazards Lab	Predefined users	hosted processing and e-collaboration

Capabilities for DRR (not on an emergency basis)	Example:	Access:	Content:
Operational capability for EO data	International Charter via CEOS	CEOS users	Transfer of data through agreement with CEOS WGD
Operational capability for end to end services	Copernicus Risk & Recovery, Sentinel Asia, Servir, etc.	Predefined users	VA services
Scientific capability	Geohazards Lab	Predefined users	Advanced VA products, hosted processing and e-collaboration

Figure 3: Capabilities of different DRM initiatives based on satellite EO.

Based on concrete objectives that are directly derived from the 'International Forum on Satellite EO & Geohazards' (c.f. section 2) the Geohazards Lab intends to support the following activities:

Concerning DRR activities not on an emergency basis:

- Pursue and expand global tectonics mapping activity such as strain rate mapping (e.g. with the LiCSAR service of COMET); expand from local to regional the reconnaissance mapping of active faults using stereo optical data and derived DEMs to ensure that a reference coverage is available in advance over priority areas and to provide fresh coverage in case of significant deformations. This is as per Objective A) of the seismic hazards community.
- Pursue support to the GSNL initiative with on-line services (e.g. the SISTEM service integrated by INGV) as per Objective B) of the seismic hazards community.

- Collaborate with other CEOS Pilots that are still pursuing their activities and other follow-on activities such as the Volcano pilot follow-on activity and newly started Landslides Pilot e.g. to support the pilot to initiate long-term measurements of the deformation rate of continuously active landslides (in complement to ground based measurements) in order to document landslide activity in relation to climate change, and favor the use of EO data for a frequent updating of landslide catalogues, as per Objective B) of the Landslide Pilot community; while these pilot are organising data delivery to support users, the Geohazards Lab proposes to provide complementary resources such as tools and hosted processing helping to exploit these EO data collections.
- Support the Recovery Observatory activity by providing access to tools and hosted processing about geohazards related issues relevant to the RO deployed (such as for instance with the Haiti RO starting in 2017).
- Develop a collaborative framework with geoscience centres to ensure a consensus methodology for product generation is adopted and to demonstrate relevance of advanced EO products to a broader base of users (see Collaboration with the Charter); concerning geohazards geoscience centres typically are End Users (e.g. recipient of the EO data in the Charter jargon) and they have a role to do science as experts and, in some instances, to advise DRM authorities.

Concerning activities on an emergency basis:

- Pursue science products based on terrain motion mapping e.g. advanced tectonics mapping using Sentinel-1 for earthquake response (deformation maps, source models, etc.) as per Objective C) of the seismic hazard community, landslides monitoring and volcano deformation monitoring; expand this capability with VHR SAR missions (e.g. Cosmo-Skymed, TerraSAR-X, Radarsat) to provide interferograms and motion maps within a virtual constellation; expand this capability with VHR Optical based measurements such as stereo based DEMs and deformation maps.
- Pursue other advanced science products e.g. for landslide monitoring, thermal signatures of volcanic eruptions.
- Collaborate with EO based disaster response capabilities such as the International Charter Space & Major Disasters, the Copernicus EMS and Sentinel Asia (see section 8): articulate with these initiatives to make sure users are aware and work with these capabilities; on a case by case and best effort basis, propose new products complementary to the damage mapping they provide (for instance InSAR based tectonic products such as earthquake source models as used in the context of the 2016 earthquakes in central Italy; or optical-based rapid detection of landslide affected areas after major earthquake or storms).

Examples of the activities proposed by the Geohazards Lab are given if Figure 4 below.

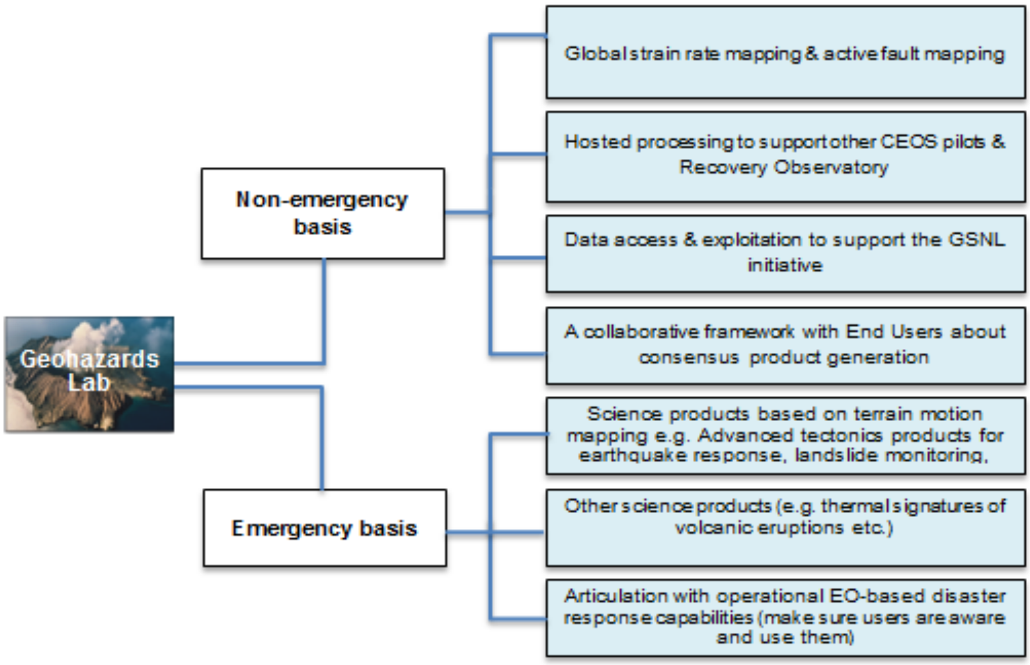


Figure 4: Potential activities of the Geohazards Lab. The geohazards lab is primarily focusing on science users and end users working on hazard mapping and risk assessment for DRR, it also contributes to activities in the emergency response phase although this is not about disaster response users but science users on a best effort basis. Any activity focusing on disaster response users is managed by operational capabilities such as for example the International Charter with whom the Geohazards Lab will collaborate to reach end users involved with disaster response.

The Geohazards Lab offers access to data and a processing and e-collaboration environment with hosted processing chains. The mission of the Lab is to enable geoscience users to exploit satellite EO, by making available tools and processing chains. The activity will fully articulate with other CEOS WG Disaster activities delivering data to users so that hosted processing can be used in a broad fashion across all CEOS DRM activities.

Overall the activities proposed under the Geohazards Lab are encompassing different types of EO assets provided by contributing agencies, not just EO data delivery:

i. EO data combining both the conventional dissemination of EO data collections from CEOS contributing agencies and the on-line access of EO data (e.g. Data as a Service DaaS),
ii. Processing chains and tools (e.g. open source services and proprietary services available on-demand or as systematic services for monitoring purpose),
iii. Infrastructures that support data access, provide processing tools and services and an e-collaboration environment to help the community grow. The proposed infrastructures to provide all the above functionalities are for instance examples of Cloud based processing environments to support geohazard users are described in Annex 4 and one example amongst others is the ESA Geohazards Exploitation Platform (GEP) already demonstrated in the CEOS Seismic Pilot.

The Geohazards Lab is based on mainstreaming data exploitation by adding to the focus of data delivery (the baseline contribution of CEOS Agencies so far) to on-line processing, keeping some level of conventional data dissemination for some cases (e.g. for data sources for which permission issues do not allow on-line exploitation) and maximising on-line processing when relevant i.e. via a platform environment where the mutualisation of resources and hosted processing will allow to ensure timely and cost effective access to EO based services.

Geographic priorities: the geohazards community has defined and presented its observational strategy in the framework of the CEOS WG Disasters (c.f. report 2013-10-30_CEOS DRM Observation Strategy). Priority areas include global regions concerned with seismic and volcanic hazards and landslides. For instance the global tectonic mask provided to the CEOS WG Disasters includes large portions of Land surfaces as illustrated in Figures 5.a,5.b & 5.c.

Figure 5.a: geographic priorities of the seismic hazards community.

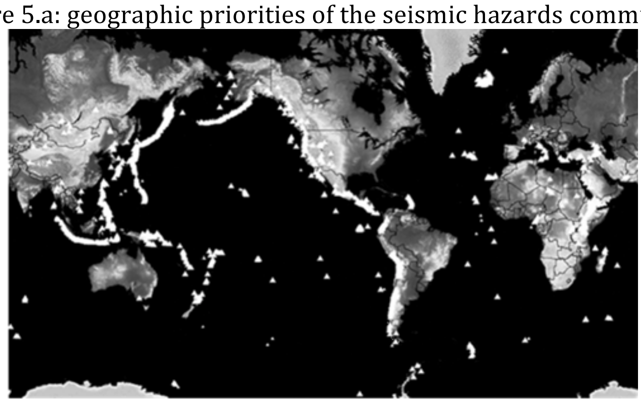


Figure 5.b: geographic priorities of the volcano community.

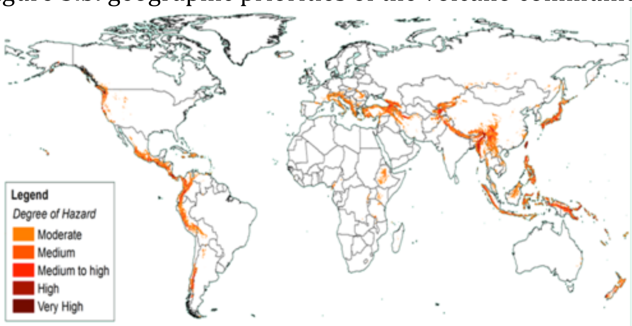


Figure 5.c: geographic priorities of the landslide community; the Global Landslide Hazard Distribution, GDLND as derived from the landslide hotspot map at global scale published by Nadim et al. (2006). Uses input from CHRR, NGI and CIESIN, 2005.

3. Users and Benefit

The user base of the Geohazards Lab includes a range of users and practitioners of satellite EO with an interest in observing and measuring hazards and risks related to geohazards (e.g. landslides, earthquakes, volcanoes, etc.). The views, needs and objectives of these users are captured in the Santorini report (available at: http://esamultimedia.esa.int/docs/EarthObservation/Geohazards/esa-geo-hzrd-2012.pdf) and further consultation and workshops such as illustrated in figures 6.a and 6.b here below. The type of users concerned includes those involved with the Pilots of the CEOS WG Disasters.

Figure 6.a: Consultation of the geohazards user community at the International Forum on Satellite EO and Geohazards organized by ESA and GEO in Santorini in May 2012.

Figure 6.b: Consultation of the expert users at the international workshop on new methods for Disaster Risk Reduction organized by ESA on 29 November 2016 in Frascati.

3.1. Types of users

The Geohazards Lab is aiming to provide advanced science products to different types of users:

- **EO experts: *geoscience centres already contributing to the Geohazards Lab precursor activities:*** EO experts process, analyse, validate, integrate the EO satellite data (using ground based data) to extract the maximum amount of information useful for DRM, and generate a simple, synthetic information product which can be understood and used by decision-makers to take effective decisions. Examples of geoscience centers already contributing to precursor seismic activities such as the GEP are INGV, CNR-IREA and CNR IRPI in Italy the ARIA center of NASA JPL and USGS in the USA, NOA in Greece, BGS and COMET/Univ. Leeds & Bristol in the UK, CNRS EOST, ENS, IPGP, ISTerre and BRGM in France.
- ***geoscience centres doing research or mandated to provide technical advice to national DRM authorities***. Geoscience centers such as geological surveys, geophysics centres looking at tectonic hazards and volcano observatories are the first line users focused on the scientific use of data that aim to understand the physics of geohazards and better characterise, understand and model such risks. In many cases, they have an advisory role in decision making of DRM authorities.
- ***national DRM authorities*** can be considered as second-line users. As a baseline the Geohazards Lab articulates with national disaster response activities and with international EO disaster response capabilities such as the International Charter, Copernicus EMS, Sentinel Asia, etc. in order to make sure users are aware and use them. The Geohazards Lab will fully take into account the role of national and international initiatives with an operational mission. The main contribution of the Geohazards Lab will be to help develop or reinforce the ability of geoscience centres to support national DRM authorities.
- ***other users that may benefit from the Geohazards Lab*** include national user organisations in the context of international development; beyond DRM authorities a range of national users have information needs related to natural hazard risk management such as for instance authorities in charge of basin for water resources management (reservoir monitoring against erosion and landslides, etc.), of transportation, energy and extractives, etc.
- in addition ***users from industry*** may benefit from the capability (e.g. civil engineering, insurance, etc.) although the Geohazards Lab is more focus on science than end to end solutions such as provided by Value Adding service providers.

The user base of the Geohazards Lab is intended to expand thanks to several targeted activities:

- The e-collaboration capability (social media, persistence of geospatial information published and maintained, geo-tagging of relevant publications, etc.). This is already the case with the GEP (today 47 user organisations and a target of 60 by early 2018).

- An activity to federate geoscience centres about raising awareness and initiatives to achieve adoption of new methods (e.g. the consensus product generation concerning advanced tectonic products for earthquake response, as described in section 3.2).

3.2. Benefit to users

The Geohazards Lab will provide access to scientific processing for a range of supply chains relevant to the geohazards community, such as for instance terrain motion techniques based on SAR interferometry or stereo-optical data; in the longer term the capability could expand to include thermal signatures of active volcanoes and atmospheric ash cloud monitoring, etc. Many products (such as for instance 'deformation maps') may also be relevant as long-term observation parameters to document the activity of processes for better hazard quantification in relation to changing forcing parameters. For instance, EO-derived tectonic strain maps or landslide activity maps are relevant for a better quantification of seismic/gravitational hazard.
The range of measurement techniques that can be supported by the Geohazards Lab is broad and while EO based terrain motion is already adopted by End Users in some countries such as for instance in Italy (see CEOS Seismic Pilot Sustainability Plan) or Switzerland (see the Federal Guidelines for landslide hazard mapping) and the UK (as with the British Geological Survey as nationally mandated geoscience centre for emergencies related to geohazards) this is generally new for many users.

Although the research is complete for advanced EO products such as terrain motion maps (e.g. InSAR based tectonics product to support earthquake response), a consensus methodology for product generation and guidelines on interpretation by the users are required in order to avoid confusing the users about the content of advanced products such as those relating to co-seismic terrain deformations. This is illustrated in Figure 7 below.

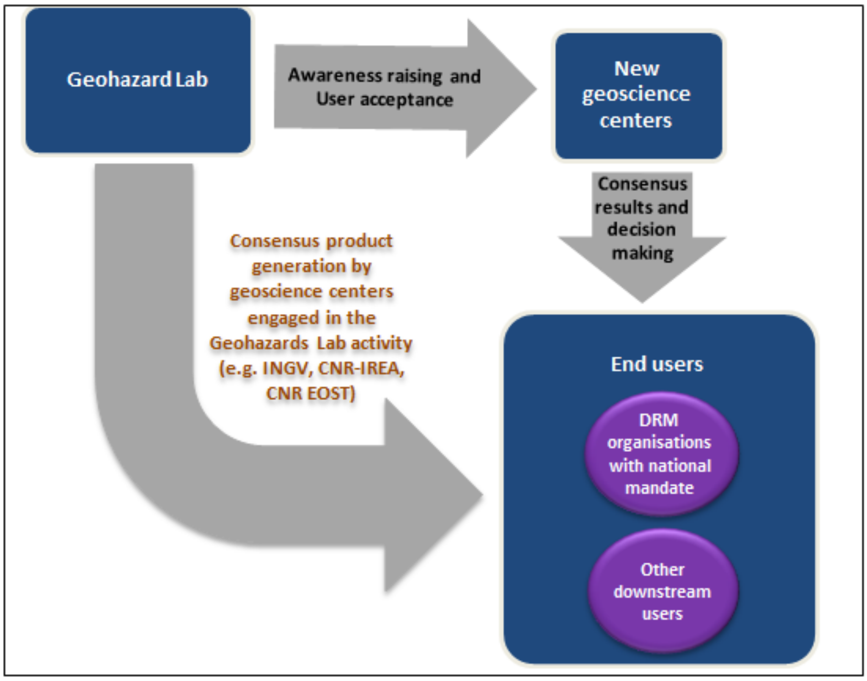


Figure 7: EO information flow from the Geohazards Lab to the end-users, example with advanced scientific products i.e. products by expert users engaged in the CEOS initiative potentially delivered to DRM end users (as e.g. in the case of Italy in the Seismic Hazards pilot) on a best effort basis.

For each type of user, the Geohazards Lab brings different benefit:

- ***EO experts/Geoscience centers already contributing to the Geohazards Lab precursor activities:***

i. the seismic expert user team (partners) will have access to CEOS data, in some cases based on predefined quota and processing chains and will be able to collaborate on-line to agree on consensus results.
ii. the volcano, landslide and RO expert user team can gather their data collections for easy access on the Geohazards Exploitation Platform (GEP) and have access to processing chains.

- ***Geoscience centers doing research or mandated to provide technical advice to national DRM authorities*** will retrieve (in case of other geoscience centers) advanced science products to analyse the events and the impact and better support the decision making process.

- ***National DRM authorities*** will benefit the expertise of the Geohazards Lab in satellite EO products combined with the event and impact analysis by geoscience centers for higher accuracy in decision making, resilience measures and risk management.

4. The proposed programme of work of the Geohazards Lab

In response to the concrete objectives from the user community, as described in section 2, the Geohazards Lab intends to execute the activities described here after. Targets associated to these activities are defined in section 10.

1. Pursue & expand the activity to provide on-line processing with users (e.g. geoscience centres and other users working with them) already engaged with precursor platforms such as the GEP (see Annex 3 & 4).
   - Provide access to users: this comprises current geohazards users from the Seismic Pilot plus some users of the Landslide pilot and the Volcano pilot follow-on activity; these users requested interested to continue access the platform for exploiting satellite data. Supplying data is not the priority of the geohazards Lab but this will continue to be supported as and when needed such as for Seismic Hazards as per the precursor Seismic Pilot. The Seismic Pilot sustainability report is providing analysis of the data volumes exploited during the Pilot and an analysis of volumes expected for the Geohazards Lab follow on activity on this theme.
   - Expand capabilities to make sure that processing results are consistent across user groups and in time: the knowledge base resulting from using hosted processing for geohazards may be accumulated between different user groups and over time by exploiting such products and access them over sequences and successive events in the case of future hazard impacts (over an area where historical measurements have already been provided and properly archived); the persistency of the products provided via the Geohazards Lab will support this.
   - Coordinate the CEOS agencies mutual efforts in the realm of on-line processing for geohazards, enhancing complementarity and identifying possible cooperation between different parallel projects.

2. Unify access and exploitation of the assets (e.g. as an integrated hybrid platform) provided by CEOS contributors concerning the scientific processing and e-collaboration. The Geohazards Lab intends to link (i.e. federate several space agencies and contributors) bringing systems to support hosted processing; the main goals are to:
   - make sure that users are aware of the assets available, that the method to access them is clear and that the results generated are shared (e.g. through cataloguing and publication) in an open and orderly fashion; to support this the following functions are already guaranteed by CEOS contributors: cataloguing external and internal EO data sources and processing chains, publishing and sharing results.
   - unify the method to access services, be it with separate platforms or federated platforms, via common orchestration of distributed resources, chaining of distributed processing services or integration of common tools and data; this includes linking the series of processing chains (e.g. the GEP calls a service integrated on PEPS via WPS, etc.) or just integrating the same chain in different environments (e.g. in two platforms and the effort for the integration is shared)

- support a common authentication and authorization framework to allow users to exploit services, tools and data with a single identity
- allow service integrators to develop algorithms and tools in a common shared environment, being a separated or federated set of platforms
- establish shared governance rules

3. Liaise with existing CEOS WG Disasters activities and the DCT to:
   - make sure that the data delivery operations of CEOS activities (Pilots, GSNL, Recovery Observatory, etc.) is executed in a smooth fashion via the CEOS WG Disasters DCT i.e. do not overlap or duplicate with them
   - exploit complementarity with them to provide them, if needed, with hosted processing to help pilot partners and the Recovery Observatory maximise the impact of their work

The collaboration of the Geohazards Lab with other CEOS WG Disasters activities, and the link with data access mechanisms under the CEOS WG Disasters are described in section 8.3.

Overall the collaboration of platforms under the Geohazards Lab will improve how users exploit EO in an on-line environment. In particular it will be connected to Copernicus DIAS to access EO mission data from EO missions such as for instance Sentinel missions.

5. Contributions

- *First screening of contributions from CEOS members:*

CEOS agencies that have expressed interest in joining the initiative include ESA, DLR and CNES (ESA also started to present the initiative to ASI, CSA, USGS and JAXA and some geohazards community actors). Contributing to the Geohazards Lab may take one or several of the following forms:

i. EO data – *potential sources, examples:* Sentinel-1 and Sentinel-2 from Europe's Copernicus programme, TerraSAR-X from DLR, Pléiades & SPOT-6 from CNES, Cosmo-SkyMed from ASI and ALOS-2 from JAXA to cite the highest data volumes in regards to community needs;
ii. Processing chains and tools - *examples:* DIAPASON (CNES), the InSAR Browse service (DLR), the SNAP S-1 terrain motion service (ESA) alongside with a broad range of Optical & SAR based processing chains such as for instance MPIC-OPT (CNRS EOST, France), SBAS (CNR IREA, Italy), STEMP (TU Delft, NL, and COMET, UK), SISTEM (INGV, Italy), etc. This combines open source services and proprietary services available either off-line or as hosted on-line processing as on-demand or systematic services;
iii. An infrastructure for processing and e-collaboration - *examples:* the components to support such a capability will be brought via CEOS contributing agencies and with contributions from partners of the geohazards community; identified contributions already include capabilities such as the GEP (ESA) and some CEOS agencies have started to define how to contribute with relevant infrastructure and middleware components. In addition the activity should take stock of capabilities available or in development within the geohazards community.

Contribution from ESA:

- Access to ESA missions data ex archive: ERS SAR and ENVISAT ASAR data will be made available over the areas of the Supersites (GSNL) and over extended areas for tectonic analysis e.g. strain rate assessment, active faults mapping, etc.
- Access to Sentinel-1A & 1B and Sentinel-2A data in line with the Copernicus Data Policy.
- Access to the Geohazards Exploitation Platform (see Annex 4) including in particular: data storage and ICT resources, including transparent access to other cloud providers processing resources; Query interface to select the data (GeoBrowser), interoperability with the data viewers, processing software to ease the use of EO data to support geohazard science including EO data preparation toolbox such as SNAP concerning ESA data, new software and workflows in particular InSAR and stereo-optical processing chains (for instance the MPIC-OPT processing chain developed by CNR EOST), etc.
- Scientific animation of the geohazards community about EO data, information and results provided by the Geohazards Lab of CEOS under the supervision of the Lead of the Geohazards Lab. This would be based

on scientific animators working with the GEP in the framework of ESA activities to regarding relevant thematic objectives (see section 9) and including the collaboration with the GSNL (see section 8.2).
- Support the Lead of the Geohazards Lab for coordination of the Geohazards Lab activities with other CEOS WG Disasters.

Contribution from DLR:
DLR shall contiribute on the Geohazards Lab, on a voluntary basis by:
- Supplying TerraSAR-X data at no cost for scientific use that can be organized by interfacing with DLR's existing data access platform established for the Geohazard Supersite initiative and used also for the CEOS Disaster pilots. Additional data support outside the quotas already approved for Supersites and AOIs of Disaster Pilot projects require a case-by-case decision in coordination with the commercial TerraSAR-X partner Airbus.
- Providing higher level science products to the user community derived not only from Sentinel-1 but also from TerraSAR-X data, exploiting its resolution and high geometric quality. This can be motion products for earthquakes or automated change detection maps derived from polarimetric analysis.
- Providing further access to the automated Sentinel-1 interferometric chain (GEP, run by ESA) for international users.
- Supporting and participating in discussions on future product generation standards and interoperability between missions.

Contribution from ASI:
ASI will potentially provide COSMO-SkyMed data and shall make available CEOS and GSNL Cosmo-SkyMed collections through the GEP (already done for the Nepal event supersite). Further details TBD.

Contribution from CNES:
CNES intends to provide:
- Access to up to 20000km2 of Pleiades data per year
- Processing services developed by the French Solid Earth community within the forM@Ter data centre including systematic InSAR processing, DEM processing and optical image correlation.
- Potential contribution to a pool of specific human resources dedicated to the Geohazards Lab initiative

- *First screening of contributions from the geohazard community:*

Members of the geohazards community that have been exposed to precursor systems such as the Geohazards Exploitation Platform include INGV (IT), CNR-IREA (IT), CNRS EOST (FR), ISTerre (FR), IPGP (FR), NASA JPL (USA), USGS (USA), COMET (UK), NOA (GR) and other geoscience centres directly or indirectly engaged with CEOS WG Disasters activities.

This encompasses members of the volcano, seismic hazard and landslide communities. Concrete contributions from the geohazards community include:

Contribution from INGV:

- INGV supports the idea of the Geohazards Lab, since it is an evolution of the GEP (already used by INGV researchers), it is compliant with the GSNL 2.0 goals (improve the scientific community collaboration to provide better support to DRR), and intends to coordinate with the existing national and international operational support schemes and frameworks. The INGV contributions will be defined in more detail later, however it is anticipated that INGV is interested in the EO data access and processing capacities provided by the Geohazards Lab to generate scientific products useful in the global context of DRR.

Contribution from CNRS EOST:

- CNRS-EOST (as lead of the French Landslide Observatory) to estimate landslide properties by exploiting the Geohazards Lab capability and provide value-added products (e.g. landslide activity maps) to be published on the platform. Note that the Lead of the CEOS WG Disasters Landslides Pilot is Jean Philippe Malet from CNRS EOST. The capability intended to be exploited include the optical-based chains integrated by CNRS EOST on the GEP such as the Optical based MPIC-OPT service for terrain motion based on the MicMac processing chain developed by Institute Geographique National and Institut de Physique du Globe under an initiative of CNES started in 2013.

Contribution from CNRS IPGP :

- IPGP, in collaboration with IGN, is involved in developing an optical-images correlation tool, MicMac, and its preprocessing tools, in order to compute DEM from any optic satellite sensors providing simple or multi stereo images. This software package is open-source. The code, MicMac, following same methodologies, allows as well computing maps of displacement between two satellite acquisitions of the same scene. In the framework of the Geohazards Lab initiative IPGP will continue such developments to improve multi-sensor capabilities as well as correlation of diachronic images to measure changes. Result of application to earthquakes and volcanic events will be published on the platform. In addition, IPGP will continue its effort to compute high resolution DEM in active tectonic regions worldwide to build a body of data to be used to map active faults. This high resolution topography will also serve as an archive in case of major event, such as earthquake or volcanic eruption, to allow quick re-tasking of satellite acquisitions to compute post-event DEM allowing 3D deformation measurements to be used in non-emergency studies, but potentially as well in emergency situations, assuming that technical capabilities and human resources would have been assigned to such task.

Contributions from COMET:

- Access to COMET-LiCSAR results from Sentinel-1. These will include interferograms, coherence maps and line of sight time series for the tectonic belts,
- Access to strain maps produced by COMET-LiCSAR from the integration of InSAR and GNSS results,
- Rapid access to interferograms and other EO data sets produced by COMET when we respond to Earthquakes and Volcanic Crises,
- Links to COMET's modelling results for earthquakes and eruptions,
- Access to COMET's InSAR training material and provision of training courses,
- Implementation of COMET-LiCSAR processing tools on other processing environments of the Geohazards Lab,
- Collaboration with Geohazards Lab contributors bringing processing environments to maximise benefit to users (e.g. share results, jointly publishing them, sharing processing resources, sharing training resources, etc.)

Contribution from ISTerre/Institut de Recherche pour le Développement (IRD):

- Testing the platform use for volcano monitoring; promoting its use in volcanoes observatories (in particular in Indonesia or South America); developing tools for ground displacement assimilation in mechanical models. Sharing results and utility assessment with the community.

Contribution from CEO-YachayTech:

The recently created Earth Observation Center (EOC) in Yachay Tech University in Ecuador will conduct research in the field of remote sensing and geo-information sciences. Data from satellites, planes, drones and geophysical surveys contribute to understand our planet, secure our environment and manage our resources which clearly will transform and improve the understanding of Earth. The EOC will be applied to problems across a whole spectrum including volcanic monitoring, earthquake studies, climate change and El Nino event, pollution, deforestation and forest degradation, natural resources exploration, among others. The CEO will work together with other public institutions in charge of natural disaster management and monitoring.

- Access to EO products (interferometer, thermal anomalies) from volcanoes in Ecuador
- Access to EO products from visible data represented as disaster areas, vulnerability and risk maps.
- Access to EO products from earthquake monitoring using interferometry
- Access to EO products and maps from areas affected by earthquakes.

6. Examples of how the Geohazards Lab will support DRR

Here below, examples of achievements from the Seismic Hazards pilot are described, including examples from other expert users of the geohazards community.

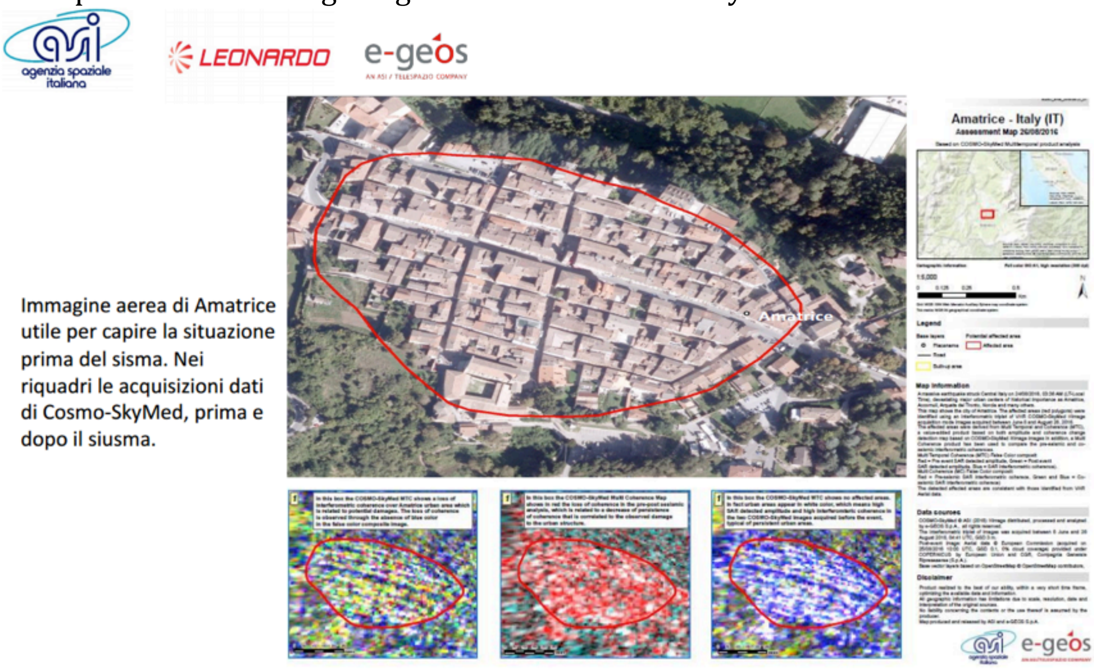
6.1. Examples from the Seismic Hazards Pilot & the GSNL

The contribution of the Italian Space Agency ASI at national level for geohazard emergencies in Italy:

On 24 August 2016 at 3:36:32 CEST an earthquake hit Central Italy. It measured 6.0 on the moment magnitude scale and its epicentre was close to Accumoli in a depth of 4±1 km. Buildings in the villages of Amatrice, Accumoli and Arquata del Tronto collapsed and caused nearly 300 fatalities.

As the national responsible organization for the provision of satellite EO data in the context of disaster response in Italy, ASI has organized the tasking and delivery of imagery to help better understand the hazard.

While the Italian Civil Protection was currently in action and had requested support to the Copernicus Emergency Management Service (EMS) with damage mapping services, ASI organized the provision of additional data collections to estimate terrain displacements due to the earthquake and therefore support the geohazard analysis performed by specialist agencies and decision makers. The example in the following image is based on Cosmo-Skymed data.



ASI also has agreements with other space agencies to organize data acces for geohazard emergencies in Italy. For example the **Italian Space Agency** (ASI) and the **Japan Aerospace Exploration Agency** (JAXA) have signed an agreement in end 2016 to strengthen their cooperation on Disaster Risk Management by using data from Earth Observation satellites.

Central Italy Earthquakes: EO products to expert users and decision makers.

In the context of the CEOS WG Disaster, the CEOS Seismic Pilot is looking at earthquake hazards and has strong links with the Geohazards Supersites and National Laboratory (GSNL) initiative of GEO. Objective C) of the CEOS Pilot is focusing on advanced science products for rapid earthquake response. Typically this concerns events that are not Supersite Events of the GSNL. The same day as the earthquake hit Central Italy, the CEOS Seismic Pilot was activated by the specialists of INGV, the National Institute of Geophysics and Volcanology of Italy, which is the main Center of Competence for seismic and volcanic risks, committed to provide real time, 24/7 monitoring and scientific support to the Italian Civil Protection (DPC). The aim was to provide access to EO data to a variety of pilot contributors, and generate advanced science products to support the emergency activities. This is complementary to the Copernicus Emergency Mapping Service (EMS). The EMS was activated by the national civil protection authorities and generated damage maps, situation maps and other products to help search and rescue.

The CEOS Seismic Pilot activation generated a range of specialised products useful to support seismological analysis. They were mainly based on both VHR SAR missions such as Cosmo-SkyMed and HR SAR missions such as JAXA's ALOS-2 PALSAR mission (Figure 8) and the Copernicus Sentinel-1 mission (Figure 9). The InSAR products were ground deformation maps, identifying also earthquake effects as fault scarps and landslides, and seismic source models. Optical data (e.g. stereo VHR Optical data such as CNES's Pléiades data) were also used to generate additional products, such as reconnaissance maps of newly formed active faults, and precise DEMs.

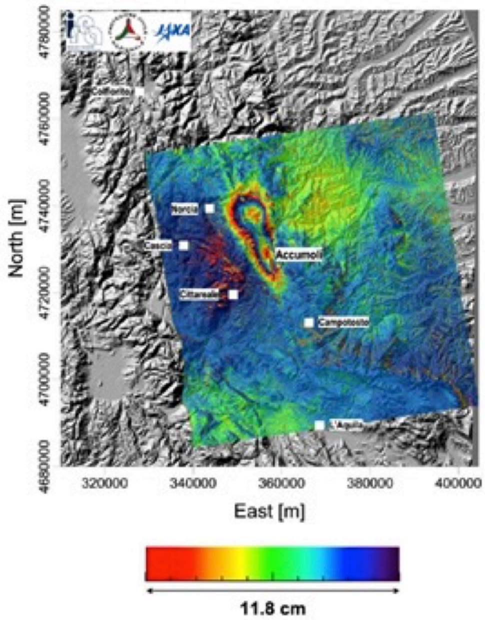


Figure 8. Interferogram generated by CNR-IREA, exploiting ALOS-2 acquisitions of 27th January 2016 and 24th August 2016.

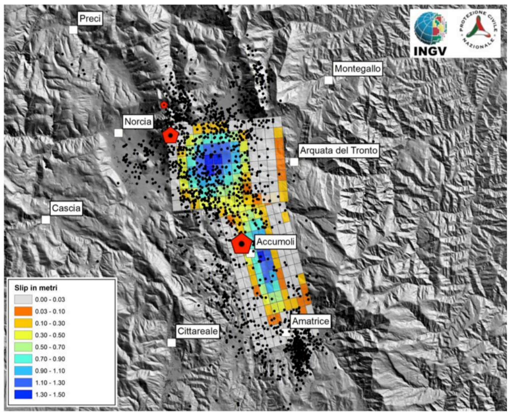


Figure 9. Preliminary earthquake source generated by INGV exploiting the terrain motion measurements from ALOS 2 and Sentinel-1 acquisitions from before and after the 24th August earthquake. These data were modeled to calculate the location, geometry and amount of slip on the source fault. The slip is distributed mainly in two patches with maximum values of about 1.4m.

A number of InSAR interferograms were produced using Sentinel-1, Cosmo-SkyMed and ALOS-2 data and the same datasets (Figure 10) were subsequently

used to constrain source models of the fault ruptures (e.g. the source model in Figure 11).
The Amatrice source was independently modeled by INGV using strong ground motion data from the RAN accelerometric network. The kinematic model shows a fault geometry and a bimodal slip distribution similar to that obtained from InSAR data (Figure 12).

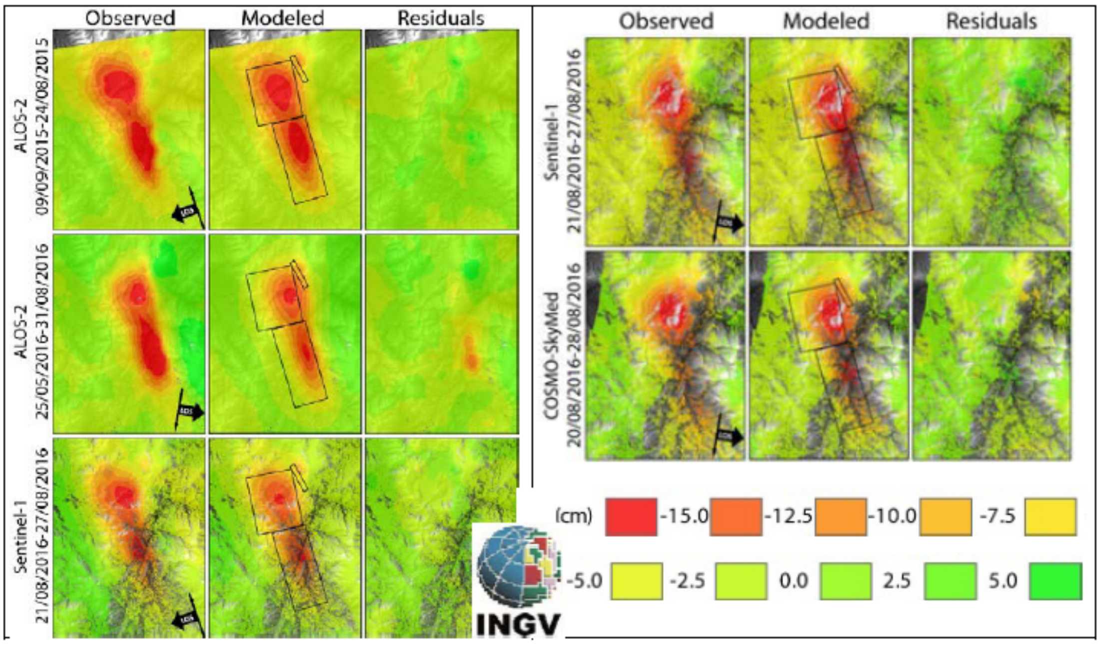


Figure 10 - Input InSAR datasets and results of the source modeling generated by INGV. For each dataset the inverted data (Observed column) the model simulation (Modeled column) and the difference (Residuals column) is shown. These results refer to the source model shown in Figure 11. Note that COSMO-SkyMed data and ALOS-2 data post August 24, were provided by ASI as part of the national response to the emergency.

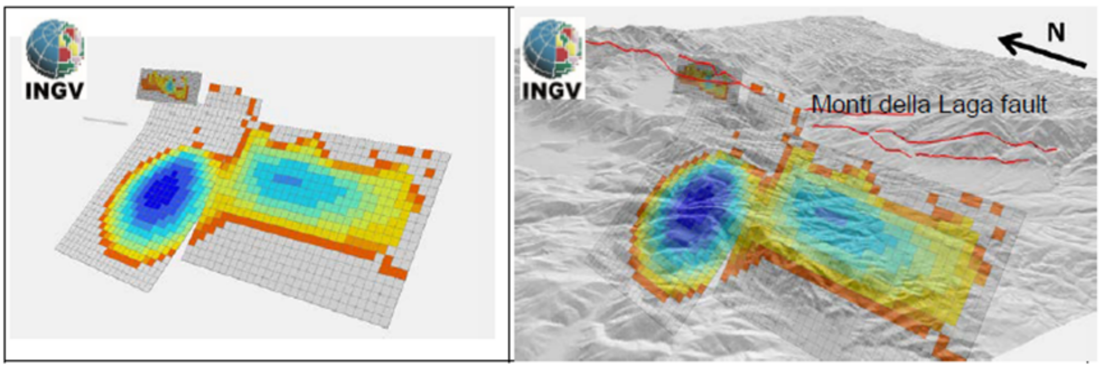


Figure 11 - The source model for the August 24 Amatrice earthquake. It is composed of two nearly co-planar ruptures. The northern rupture shows deeper and stronger slip. The shallow small fault at the northern end simulates the gravitational deformation observed in the Monte Vettore western flank (see Figure 9). This is not connected with the deep slip and is likely not directly related to the fault dislocation. Credits: INGV.

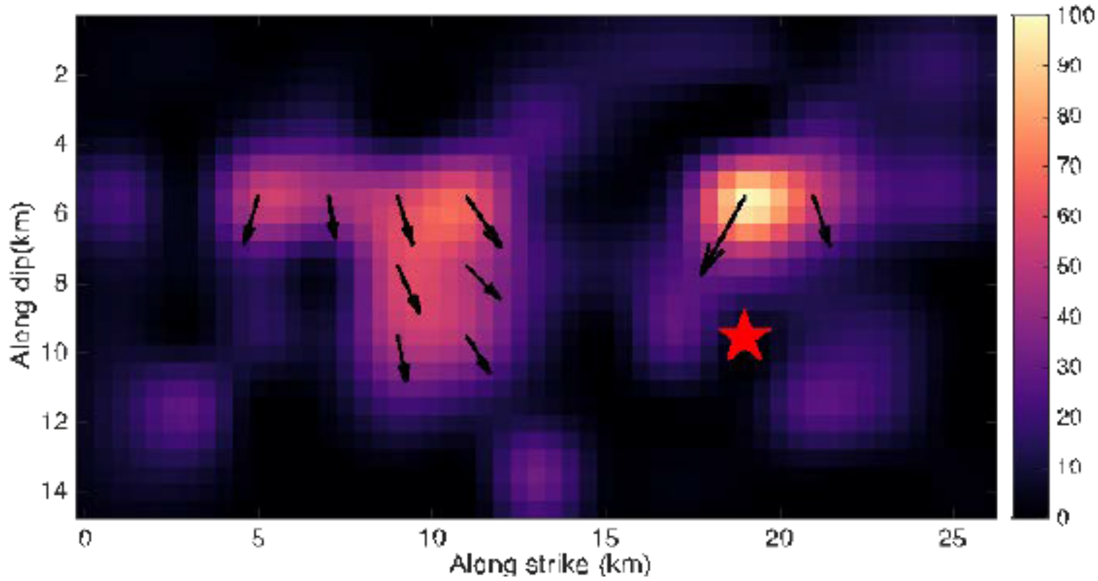


Figure 12 - Slip distribution obtained by the kinematic source modeling using RAN accelerometric data. The analysis by INGV combines satellite EO and non satellite data and is provided to national authorities involved with the crisis. Credits: INGV.

For the Mw 5.9 earthquake that hit Visso on 26 October and the Mw 6.5 that hit Norcia on 30 October, INGV produced ALOS-2 and Sentinel-1 interferograms (Figures 13 and 14). The source model revealed that the main rupture occurred on the Monte Vettore-Monte Bove fault, extended NNW for over 25 km (Figure 16). All COSMO-SkyMed data and ALOS-2 data post August 24, processed by INGV were provided by ASI as part of the national response to the emergency.

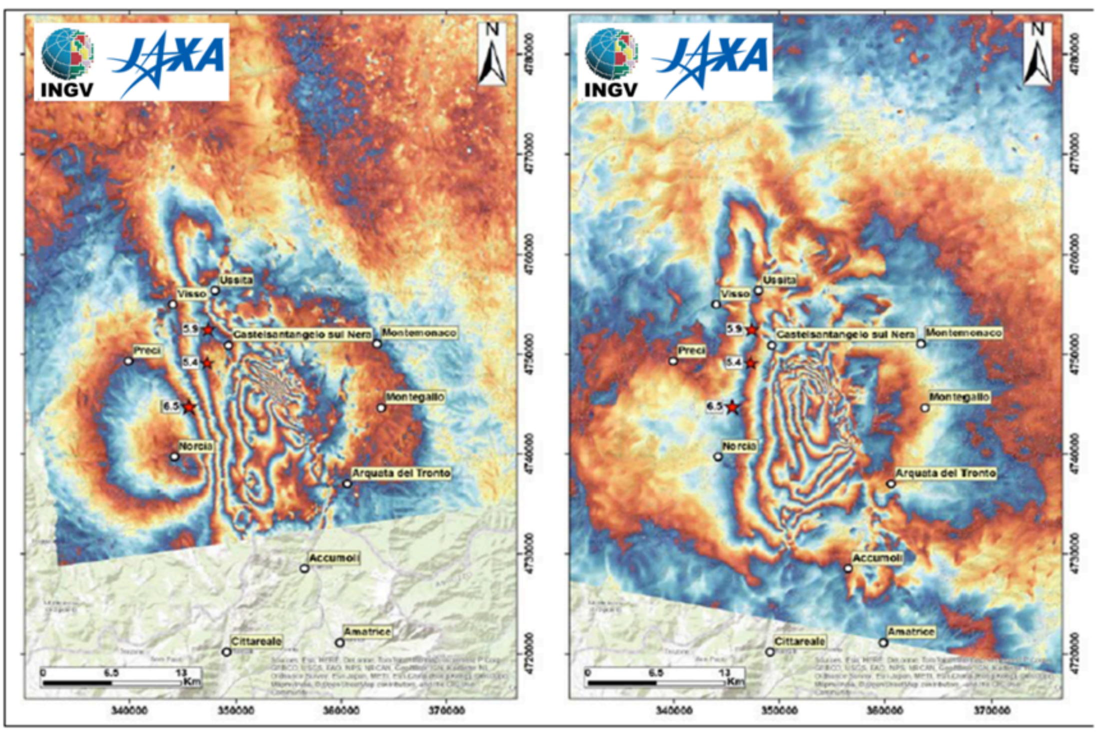


Figure 13 - ALOS 2 interferograms showing the cumulated ground deformation caused by the October 26 (Visso) and 30 (Norcia) earthquakes. The left image shows an ascending interferogram covering the period August 24 - November 02, 2016. The right image shows a descending interferogram covering the period August 31 - November 09. The main-shocks of October 26 and 30 are shown as red stars. Each colour fringe represents 12 cm of Line of Sight ground displacement. Credits: INGV, JAXA data provided by ASI.

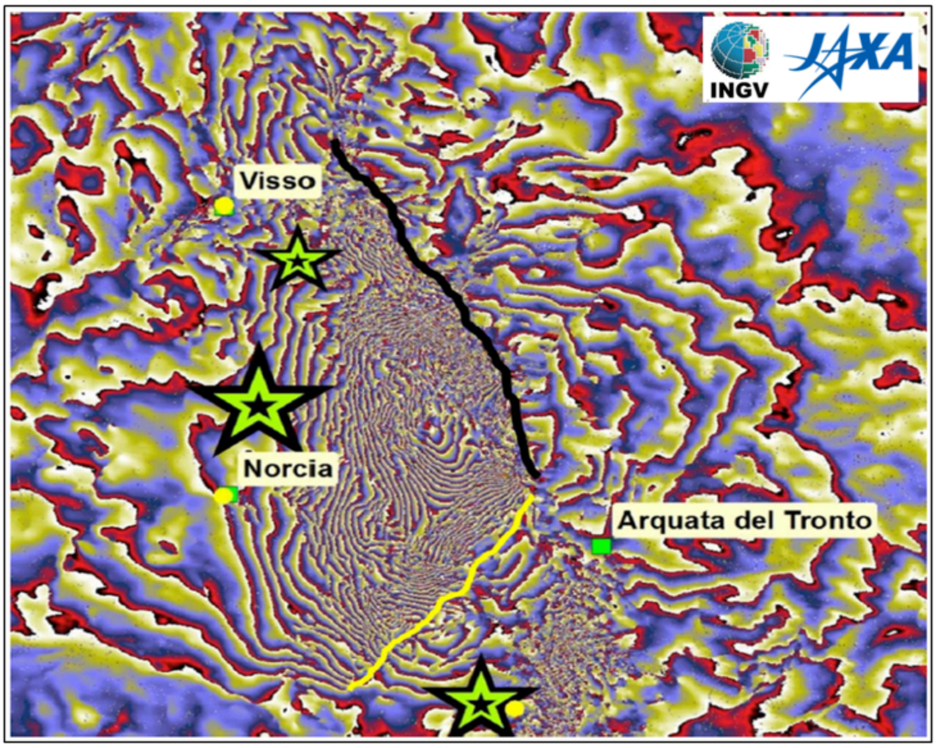


Figure 14 - A detail of the descending Sentinel 1 interferogram, showing the linear fringe discontinuities corresponding to ground breakage. The black line has been identified with a co-seismic scarp with 1-2 m displacement on the Monte Vettore fault (see photos in Figure 15). The yellow line has not been verified into the field but may represent the surface expression of a lateral fault which has been modeled by the inversion of InSAR data. Credits: INGV, JAXA data provided by ASI.

Figure 15 - Field photographs of the large normal fault scarp caused by the October 30 mainshock of Mw 6.5. The scarp corresponds to the fringe discontinuity mapped in all the interferograms. Credits: INGV.

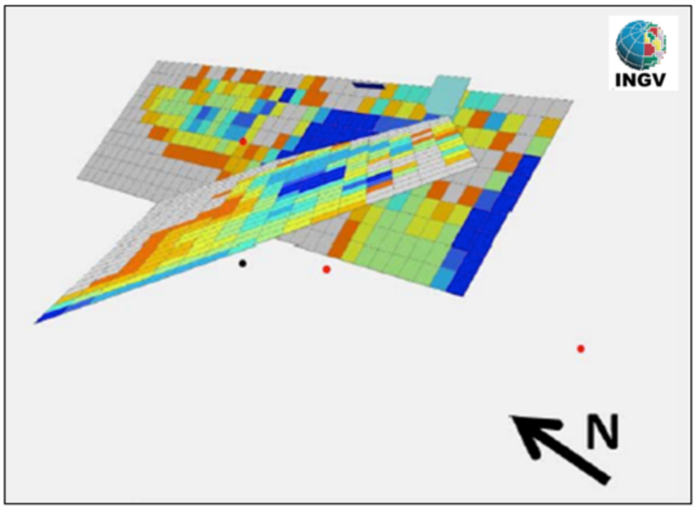


Figure 16 - The source model for the October 26 and 30 events. The main rupture occurred on the Monte Vettore-Monte Bove fault, extended NNW for over 25 km. Credits: INGV.

The April 2016 Ecuador earthquake: EO based products delivered by experts to national DRM authorities via the Italian DRM authorities.

The Institute for Electromagnetic Sensing of the Environment (CNR-IREA) contributes to the Seismic Hazard pilot and is Center of Competence (CoC) on DInSAR[1] for the Italian Civil Protection Department (DPC). In case of major (Mw >6) and shallow depth earthquakes occurring within the Italian territory, CNR-IREA has the mandate to rapidly provide the DPC with DInSAR Earth surface deformation maps, as soon as the first post-seismic SAR[2] acquisition is available.

DPC may also ask for displacement measurements related to earthquakes that occur abroad, in the framework of international collaborations with foreign authorities, as in the case of the earthquake that stroke Ecuador on 16 April 2016 (Figure 17).

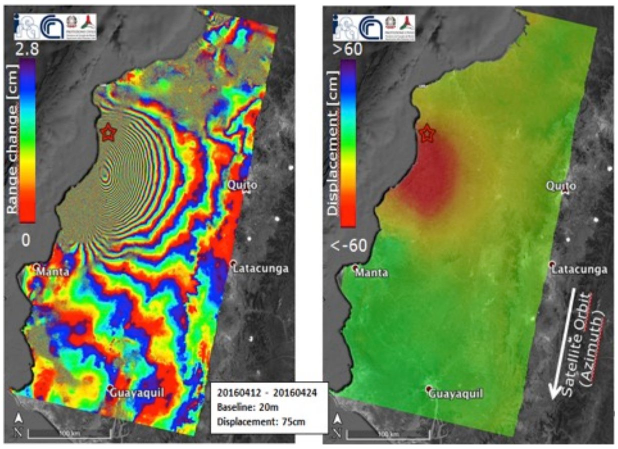


Figure 17. Interferogram and displacement map generated by CNR-IREA, exploiting two Copernicus Sentinel-1 acquisitions of 12 and 24 April 2016.

For this event, on April 17, 2016, the Ecuador government asked assistance to the Directorate-General Humanitarian Aid and Civil Protection of the European Commission. On this basis and under the coordination of the United Nations, Italy logistical support and technical experts to be provided for the evaluation of strategic buildings on site.

Within this frame, DPC asked CNR IREA a detailed report on the surface deformations due to the mainshock, which was also forwarded to the Ecuadorian authorities of civil protection. Through Objective C) of the CEOS Pilot, CNR IREA generated and shared results based on Sentinel-1 data. The deformation maps were used by DPC and other DPC CoCs to understand the extent of the area affected by displacements and better focus the DRM activities of decision makers. Moreover, these maps can be used to model the seismogenic fault in order to increase the knowledge on the earthquake and its causes.

[1] DInSAR : Differential SAR Interferometry
[2] SAR : Synthetic Aperture Radar

The 2015 Nepal Event Supersite: an international effort to better understand the impact of the Gorkha earthquake.

The area of Nepal deeply affected by the M7.9 earthquake of April 25, 2015, became an Event Supersite soon after the main shock, following requests from the geophysical scientific community to the Geohazard Supersite and Natural Laboratory initiative of GEO (www.earthobservations.org/gsnl_es_nepal.php).

Many CEOS agencies started to acquire satellite data over the Supersite, and ESA, ASI, CSA, DLR, NASA, USGS provided access at no-cost to GSNL users for these data. JAXA provided ALOS-2 data for the earthquake through the Seismic Hazards pilot Objective C. Data from ground networks were provided by UNAVCO and IRIS.

A number of scientific products were generated –among others- by INGV, NASA JPL, COMET, CNR-IREA and IPGP to measure the displacement and were combined with geological data to map the precise shape of the fault plane at depth and the amount of relative slip of the fault limbs.

The Event Supersite page provided reference to the data resources and also, for the first time, to several scientific products freely shared in digital form to allow re-use by scientists.

The data and the products were also provided to:

- end-users such as decision making bodies e.g. National Disaster Management Authority (NDMA) and National Emergency Operation Centre (NEOC)
- local scientific institutions in charge such as the National Society for Earthquake Technology (NSET) and other academic institutions
- the international scientific community, through scientific papers or web-stories.

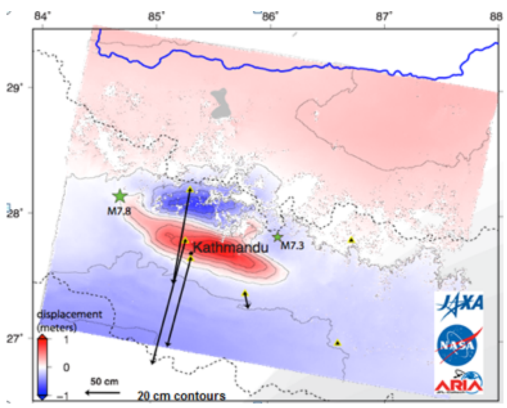


Figure 18. ALOS-2 deformation map generated by JPL NASA shows uplift and southward motion of central Nepal, including Kathmandu.

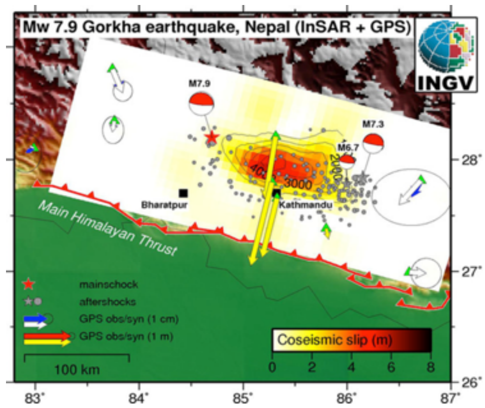


Figure 19. Source model from InSAR and GPS generated by INGV.

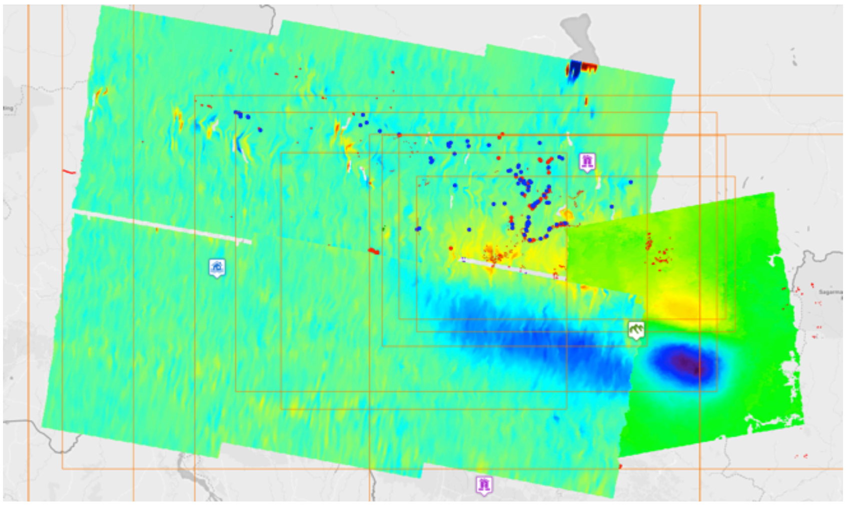


Figure 20.a: illustration of scientific products generated using or published by the precursor system GEP in the context of the 25 April Gorkha earthquake. Centre: displacement map generated by DLR using Sentinel-1 data acquired on 17 & 29 April 2015 (see 20.b); Right: displacement map generated by CNR IREA following the magnitude 7.3 aftershock of 12 May 2015; superimposed dots (blue and red): map of combined landslide features produced by an international team including British Geological Survey, Durham University, ICIMOD, MDA and NGA in spring 2015. Over the illustrated area four icons represent Charter activations over the last ten years including the activation about the Gorkha earthquake.

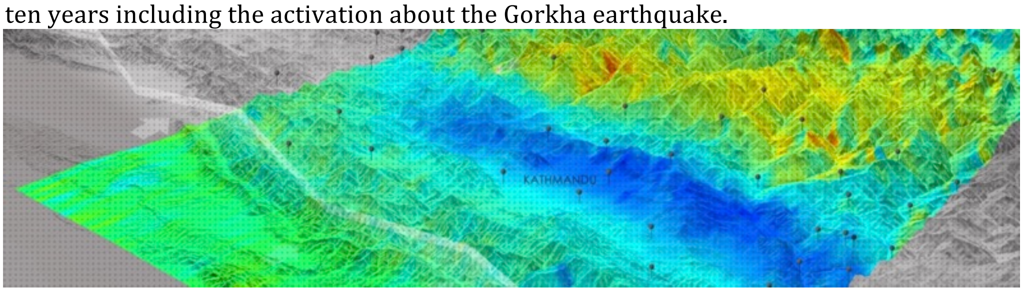


Figure 20.b: illustration of the Sentinel-1 based displacement map generated using pixel correlation and showing the large terrain motion induced by the Gorkha earthquake in Nepal. The map was delivered by DLR to ESA and published on the platform. Credits: DLR, ESA.

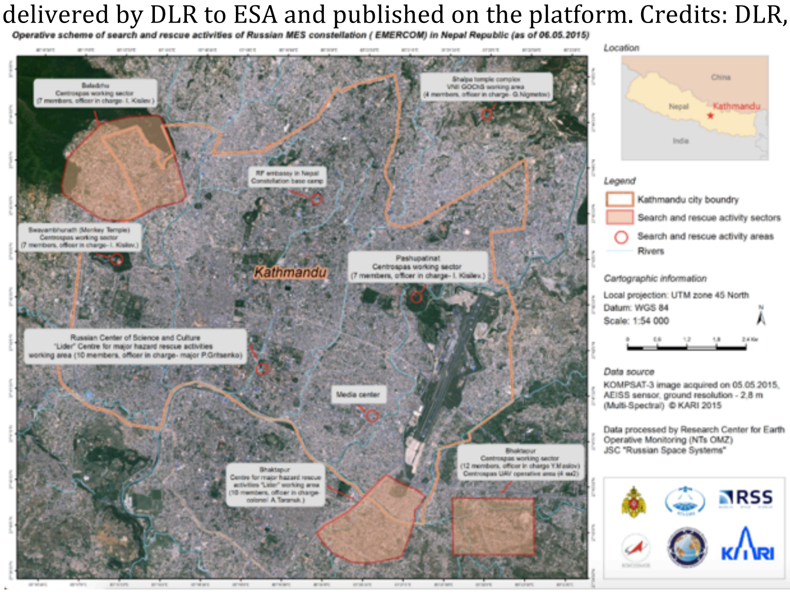


Figure 20.c: illustration of a satellite based Damage Mapping product generated in the context of the Charter activation 459 following the requests from the Disaster Management Support (DMS) Programme Office of the Indian Space Research Organisation (ISRO), UNITAR/UNOSAT on behalf of UNICEF. In parallel the Charter was triggered by the National Disaster Reduction Center of China (NDRCC). While the CEOS WG Disaster pilot activities concentrate on scientific products to

better characterize the hazard, the Charter activation provides support to assessment the hazard impact with Damage Mapping products.

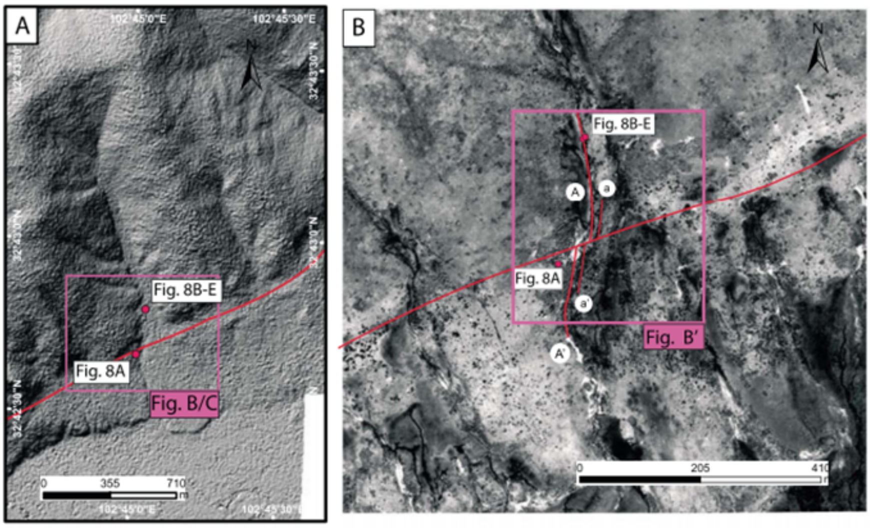


Figure 21: illustration of VHRO based analysis of active faults in the case of the Longriqu fault zone, eastern Tibetan Plateau; Credits: Claire Ansberque, Olivier Bellier, Vincent Godard, Cécile Lasserre, Mingming Wang, et al.. The Longriqu fault zone, eastern Tibetan Plateau: Segmentation and Holocene behavior. Tectonics, American Geophysical Union (AGU), 2016, 35.

6.2. Examples from other themes of the geohazards community

Central Italy

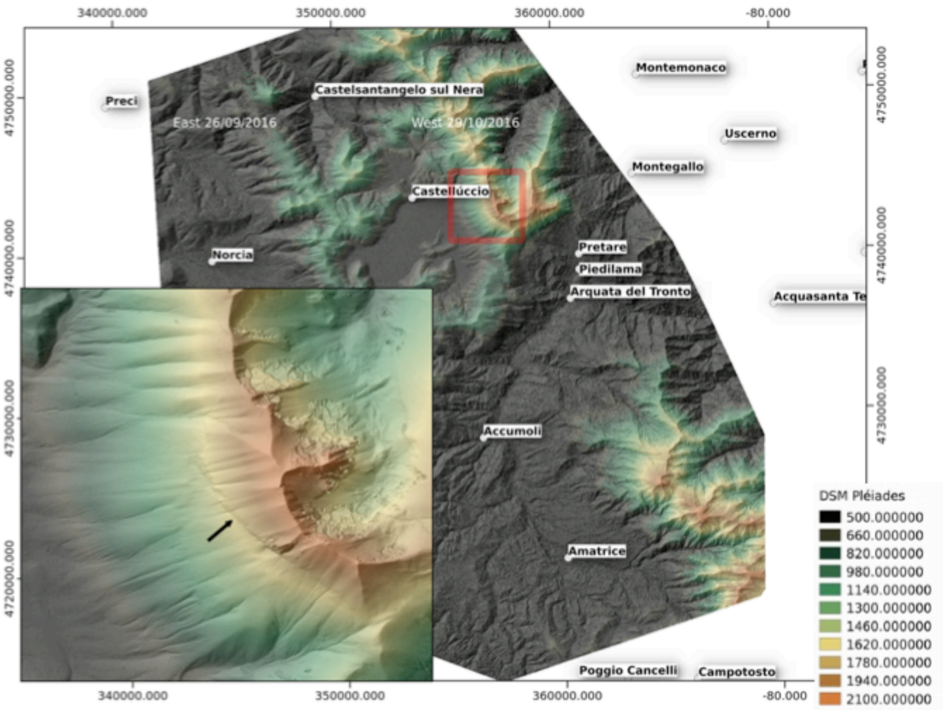


Figure 22: Illustration of VHRO based analysis of the surface rupture of the Central Italy earthquake sequences after the Mw 6.6 30 October earthquake processed; the high resolution DSM has been processed by the algorithm DSM-OPT currently being implemented on the GEP. Credits: CNRS EOST.

French Alps

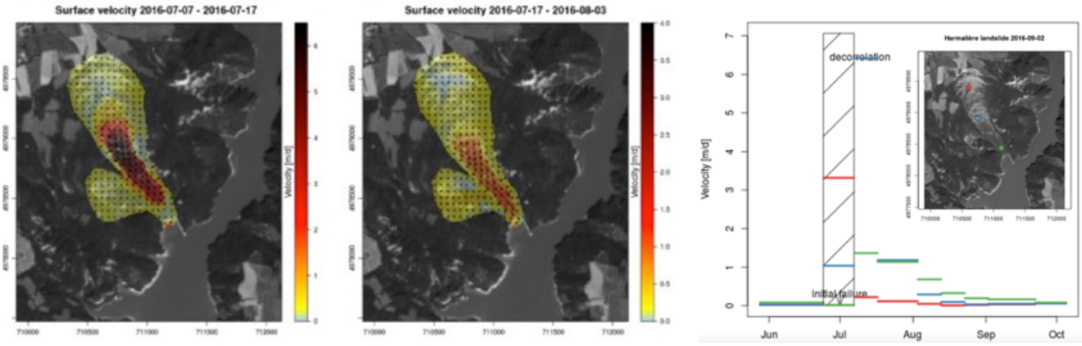


Figure 23: Illustration of VHRO based analysis of the displacement pattern (e.g. displacement rate maps, in m.day^{-1}) presenting the failure development of the Harmalière landslide (French Alps) in summer 2016 from series of Sentinel-2 images. The displacement maps have been processed by the algorithm MPIC-OPT currently being implemented on the GEP based on the MICMAC chain of Institute Geographique National and Institut de Physique du Globe. Credits: CNRS EOST, IPG, CNES.

7. Taking lessons from precursor Pilots of the CEOS WG Disasters

The assessment of the impact and utility of CEOS WG Disasters activities relevant to the Geohazards Lab is related to the CEOS Seismic Hazards and is described in the *Sustainability Report*.

8. Collaborations

8.1. Collaboration with GEODARMA

GEO-DARMA is a new initiative under GEO supported by space agencies as follow-on action to the "Sendai Framework for Disaster Risk Reduction 2015-2030", aiming to support operational risk reduction activities through the implementation of end user priorities in line with the "Sendai Framework", on a trial basis in several regions of the developing world (such as Latin America, South Asia and Southern Africa).

The activity shall be able to contribute to GEO-DARMA concerning active fault mapping and strain rate mapping (Objective A) in regions of interest identified by GEO-DARMA, which coincide with 40% of the priority areas of the tectonics community and similarly with rapid earthquake response (Objective C) in the instance of an event occurring in priority areas.

On a best effort basis GEODARMA should have access to data, tools and processing resources provided by the Geohazards Lab according to its priority needs and areas. This will require an orderly prioritization of users and needs.

The Geohazards Lab initiative is complementary to the new GEODARMA initiative, a global, top down and multi-hazards activity looking at DRM users and long term activities on a global basis (with primary focus on developing countries). It is proposed that the Geohazards Lab contributes to GEODARMA for priority DRM themes, users and regions to be defined in the framework of the international consultation that GEODARMA is conducting.

8.2. Collaboration with the Supersites initiative (GSNL) of GEO

As described in section 2, the Geohazards Lab proposes to collaborate with the Geohazard Supersites and Natural Laboratory initiative (GSNL), a voluntary international partnership that started in the frame of GEO in 2010 aiming to improve, through an Open Science approach, geophysical scientific research and geohazard assessment in support of Disaster Risk Reduction. The GSNL focuses on areas with scientific knowledge gaps and high risk levels: the Supersites and the Natural Laboratories. For these areas a joint effort is carried out: space agencies provide satellite imagery at no cost for scientific use, the monitoring agencies provide access to ground-based data and the global scientific community exploits these data to generate state of the art scientific results in support of DRM at the local scale. The coordination of each Supersite is normally attributed to local geohazard scientific institutions and researchers which are

already operationally providing authoritative geohazard information to support the local decision makers.
GSNL has succeeded so far to improve data access (EO and in situ) over the Supersites. In some cases GSNL has used the capacities provided through the GEP, and there are requests from the community to use more GEP services. The improved data access and processing capacities have in general benefited the quality of scientific results and, for those Supersites where operational scientific support is provided to decision makers, it has generated a positive impact on the prevention and response activities of the DRM users.

The GSNL objectives, based on the GSNL implementation plan 2.0 are:

1. to enable the global scientific community open, full and easy access to a variety of space and ground-based data, focusing over selected, high risk areas of the world: the Supersites and the Natural Laboratories;
2. to promote the conditions by which state of the art geohazard science is generated by the global scientific community over the selected sites;
3. to communicate scientific results useful for geohazard assessment to authoritative bodies and other stakeholders, supporting informed decision making in Disaster Risk Management activities at the selected sites;
4. to promote innovation in the development and testing of technologies, processes, and communication models, to enhance data sharing, global scientific collaboration, knowledge transfer and capacity building in geohazard science and applications;

The Geohazards Lab is expected (as the GEP and SSEP before it) to facilitate the achievement of these goals and is supported by the GSNL initiative.

8.3. Collaboration with other CEOS WG Disasters activities

The Geohazards Lab will interact with the current activities such as the Recovery Observatory, the Landslide Pilot and any other on-going activity e.g. a Volcano pilot follow-on activity that will be pursued beyond 2017, and it will interact with new initiatives under CEOS WG Disasters such as for example GEODARMA.

As described in section 2, the Geohazards Lab proposes to collaborate with other CEOS Pilots that are still pursuing their activities on community data gathering (e.g. the newly started Landslides Pilot); While these pilots are organising data delivery to support users, the Geohazards Lab proposes to support data access and to provide complementary resources such as tools and hosted processing helping to exploit these EO data collections; it is thus complementary to the CEOS Pilots as it will in practice develop links with processing platforms to allow running hosted processing on local data collections (e.g. free and open L8 or S2 data).

Like the CEOS pilots and the CEOS WG Disasters DCT are focused on the delivery of data collections for predefined thematic activities with users, the Geohazards Lab provides a mechanism to access data and, in addition, a scientific processing and e-collaboration environment.

As illustrated in Figure 24, the Geohazards Lab will fully articulate with the Data Coordination Team (DCT) to make sure it does not interfere with data ordering and delivery of other CEOS WG Disasters activities. Since the Seismic Hazards follow-on is the Geohazards Lab, data ordering will be organised for this theme by the Geohazards Lab coordination team while for all other themes the Geohazards Lab will rely on the CEOS pilots and follow–on activities. Provided licenses and permissions about data exploitation allow it, the Geohazards Lab will allow users to upload data collections provided by a CEOS WG Disaster Pilot and run hosted processing. This was already successfully tested using ESA's precursor GEP within the Seismic Pilot in support to a user of the CEOS Landslide Pilot (CNRS EOST); the GEP system allows to ensure that the data collection uploaded for on-line processing is only visible and accessible to this user.

The hosted processing activity will provide additional access to data, primarily open and free data, in complement to the conventional data delivered in CEOS following the DCT procedures. All data delivery activities under the Geohazards Lab will be managed and accounted according to CEOS procedure. The Geohazards Lab will also provide access to imagery for processing and not download i.e. the user will download the EO based measurement not the data. In that case too data accessed (for processing but not downloaded) will be accounted and reported to the DCT.

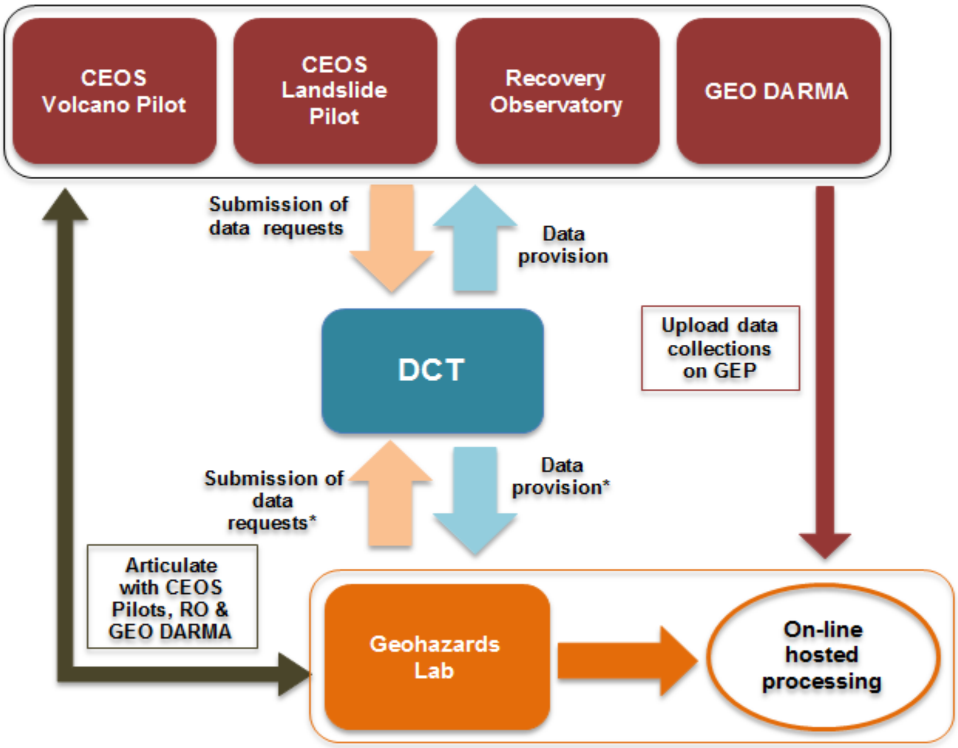


Figure 24. Data ordering, delivery and access flow. * note: for its Seismic Hazard users data ordering is managed by the Lab following the CEOS DCT. The Lab is also supporting the CEOS Pilots & Recovery Observatory by providing them with an EO processing capability.

8.4. Collaboration with the CEOS WGISS activities

The CEOS WGISS and the CEOS Future Data Architecture team are currently working on the evolution of the data access architectures for the CEOS agencies user communities. The driver is to foster the exploitation of EO satellite data by offering additional data access paradigms, to "bring users to the data". To validate the technologies in support to the paradigm, the CEOS agencies are performing two pilots, the ongoing Data Cube Pilot and the proposed CEOS Exploitation Platform pilot.

The Geohazards Lab, being a distributed virtual environment in which the users - individually or collaboratively - have access to data and processing tools, fits perfectly with the Exploitation Platform concept, is a relevant contribution from ESA and the other involved CEOS agencies to the CEOS Exploitation Platform pilot. It is thus included into the CEOS Exploitation Platform workplan and its results will be presented in the context of the CEOS WGISS and FDA activities.

The Geohazards Lab will collaborate with the WGISS by supporting the realisation of a WGISS pilot; one contribution already identified is in the form of the GEP platform proposed by ESA. A workplan has been written to prepare the pilot exercise.

8.5. Collaboration with nextGEOSS

The GEOSS portal offers a single Internet access point for users seeking data, imagery and analytical software packages relevant to all parts of the globe. The current plan of the GEOSS evolution, as expressed by the nextGEOSS project, goes in the direction of extending the GEOSS Common Infrastructure towards support for data processing, by interconnecting processing platforms coming from different agencies.

The GeoHazards Lab, as a distributed virtual environment aggregating geohazards data and services from several agencies, can thus provide a relevant contribution to the GEOSS evolution and the nextGEOSS project. A first discussion has started between ESA and nextGEOSS project Lead DEIMOS (PT) and partners engaged with geohazards activities such as for instance NOA (GR) and CNR IREA (IT) to include the Geohazards Lab and its services within the GEOSS Common Infrastructure.

8.6. Collaboration with the International Charter and other EO based disaster response capabilities

Collaboration with the International Disasters Charter

A good example of the power—and potential of satellite EO —can be seen in the International Charter Space and Major Disasters (www.disastercharter.org), an international collaboration among space agencies that uses space technology to aid in response to disasters. When a disaster occurs, the International Charter grants access to satellite data at no cost and in a rapid fashion.

The Charter aims to help better organise and mobilise national disaster management resources during emergencies and the international relief community concerning situations where humanitarian assistance is required. The only users that can submit requests are Authorized Users, a predefined list of organisations with a mandate concerning disaster risk management.

The Charter is focused on hazards with rapid on-set scenarios, in the immediate response phase, and aims to service operational users, wherever a disaster occurs. Since its inception in 2000 it has delivered services 500+ times in 119 countries. To cite the Charter and its dramatic evolution over the last decade as progress toward EO-based risk assessment may be surprising, given the Charter's response-only focus. Yet the Charter remains a striking example of what space agencies working together can achieve. By raising the profile of satellites in disaster response, the Charter has greatly increased the DRM community's interest in EO satellite data and EO-based solutions.

Currently, the CEOS pilots have an agreement in place with the Charter for data sharing after a Charter activation. In July 2014 the Charter Board has communicated to the Chair of the CEOS WG Disaster following the request from CEOS to obtain access to data from the Charter for the purposes the DRM activities conducted by the CEOS Pilots. In July 2015 the Charter Board has communicated to the Chair of the CEOS WG Disaster with a procedure to implement this agreement.

In July 2015 the Charter Board has communicated to the CEOS Seismic Pilot Leads following the request to obtain support concerning the dissemination of CEOS Seismic Pilot results to appropriate users. In this official letter the Charter agreed that products from the CEOS Seismic Pilot and the Geohazards Supersites (GSNL) can be shared with the Charter during an activation.

As a first priority the CEOS WG Disasters activity intends to articulate with the Charter, make sure users are aware and use it. For geohazards, Authorized Users generally request a Charter activation and designate Charter End Users working with them; typically they are recipient of data and specializing in hazard and risk analysis. In addition, a new activity is proposed in the CEOS context to complement the Charter data delivery with advanced tectonics products derived from InSAR processing to estimate terrain motion and model the earthquake source.

The Charter mandate is to provide EO data for the immediate response phase. In the case of geohazards such as earthquakes, volcanoes and landslides, as illustrated in Figure 25, specific tasking and data delivery are defined by the Charter in its so-called scenarios. These scenarios are focused on data supply (not value adding) and are dedicated to damage mapping (and not terrain motion mapping nor tectonic products).

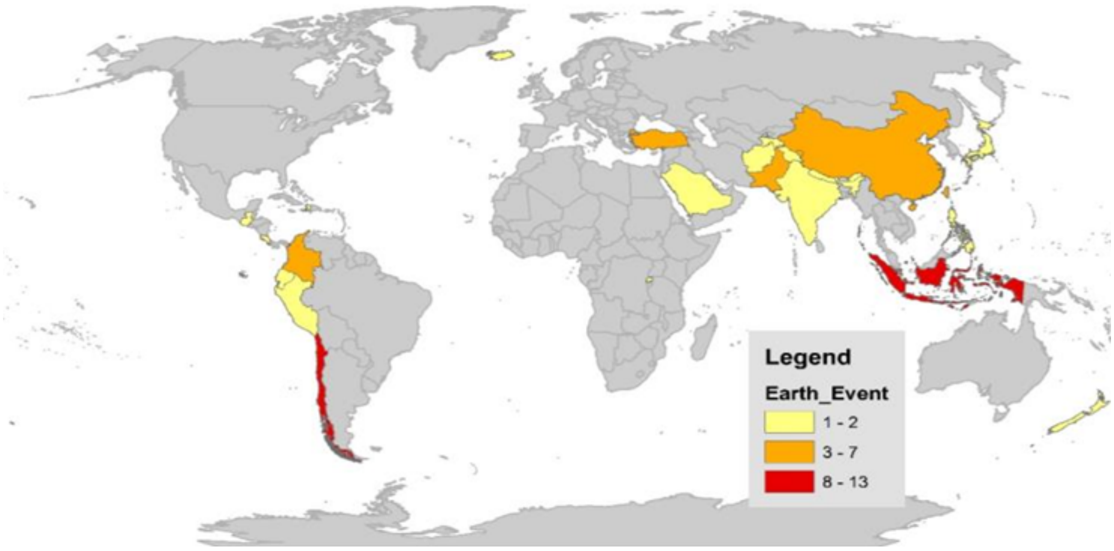


Figure 25: 2007-2015 Geographical distribution of Charter activations caused by solid earth related events (earthquake, tsunami, volcanic eruption, landslide caused by earthquake, subsidence); these events correspond to a third of the totality of Charter activations. Charter activations in geohazard themes represent 21% of Charter events and spread over 27 countries.

The collaboration with the Charter enables to complement the Charter disaster response activity with science products (e.g. advanced tectonic products) that are separate and complementary; they are not concerned with Damage Mapping (the main target of the Charter) but a better characterization of the hazard through scientific measurements exploited by specialist geoscience centres through a consensus product generation methodology to carefully generate advice from technical data. This may help DRM users in the decision making process.

Therefore the Charter activities and the Geohazards Lab activity would be aligned (not overlapping) and complementary (for the relevant hazard types):

- *On an emergency basis*: the activation is triggered by a Charter Authorized User and managed by the Charter and its PM; the Geohazards Lab activity is conducted in parallel and separate i.e. there is no interaction concerning operations; in particular, the Geohazards Lab is able to generate advanced products using open and free data such as Sentinel-1, Landsat-8 or Sentinel-2 collections (for instance the precursor GEP is currently demonstrating these functions within the CEOS Seismic Pilot); other EO data sources may be exploited depending on the CEOS contribution agencies and through the Data Coordination Team (see section 6.3). As a baseline the Geohazards Lab is not requesting data to the Charter during activations.
- *Not on an emergency basis*: a capacity development activity is conducted by the Geohazards Lab to promote the Charter and the Geohazards Lab and achieve better adoption by relevant DRM mandated users (the geoscience centres helping Charter AUs and involved as Charter End Users). Charter data can be accessed and exploited through the current Charter-CEOS WG Disasters agreement, that allows access to data from a Charter activation.

Connection between the Charter and the Geohazards Lab:

- There are no connections between the Charter and the Geohazards Lab concerning operations. The data access mechanism of the Lab is the CEOS WG Disasters Data Coordination Team (DCT). After the Charter activation, Charter data can be accessed and exploited through the current Charter-CEOS WG Disasters agreement that allows access to data the Charter.
- The primary users of the Geohazards Lab are geoscience centres, they generally are not Civil Protection Agencies. They sometimes collaborate with DRM users that are Charter Authorized Users. They are able to provide scientific advice, this is separate from providing rapid mapping services, which anyway isn't the goal of the Geohazards Lab.
- The Geohazards Lab will clearly inform users that the measurements generated do not intend to substitute to end-to-end disaster response mapping service such as damage mapping products delivered in the context of the Charter, Sentinel Asia, the Copernicus EMS, etc.
- The type of geo-information provided by the Geohazards Lab does not concern Damage Mapping but advanced products. However such products might be relevant in the context of Charter activations and, as a baseline, the measurements generated with the Geohazards Lab can be shared with the Charter.
- In the longer term the CEOS WG Disaster will take the opportunity of the Charter-CEOS agreement to explore options about sharing notifications of activities conducted by the Geohazards Lab and sharing measurements generated using the system.

Other EO based disaster response capabilities
Further to collaborating with the International Charter, as any CEOS WG Disasters activity, the Geohazards Lab intends to articulate with EO based disaster response capabilities such as the EMS and the Risk and Recovery services of the Copernicus program of the European Union, Sentinel Asia, the UNITAR/UNOSAT and UN OOSA, etc. to make sure users are aware and use them. It is also anticipated to propose collaborations with these capabilities in the framework of the International Working Group on Satellite based Emergency Mapping (IWG-SEM).

The European COPERNICUS Emergency Management Service (COPERNICUS EMS http://emergency.copernicus.eu/) is active since 2005. It provides information for emergency response in relation to different types of disasters, including meteorological hazards, geophysical hazards, deliberate and accidental man-made disasters and other humanitarian disasters as well as prevention, preparedness, response and recovery activities. Copernicus EMS can be triggered by EU Member State civil protection agencies and several European Agencies. Mapping products are provided free of charge and generally full and open in access.

Sentinel Asia (SA https://www.aprsaf.org/initiatives/sentinel_asia/) is a space-based disaster management support system in the Asia-Pacific region (SA) under Asia-Pacific Regional Space Agency Forum (APRSAF), active since 2007. SA was established in 2005 as a voluntary collaboration between regional space agencies and disaster management agencies for humanitarian purposes. It covers not only response phase with satellite based emergency services but also mitigation preparedness phase with capacity building, early warning system for specific disasters using satellite-based data, and others. SA aims (a) to improve safety in society by Information and Communication Technology (ICT) and space technologies, (b) to improve the speed and accuracy of disaster preparedness and early warning and (c) to minimize the number of victims and social/economic losses.

9. Theme specific objectives of the geohazard community:

The concrete targets defined in section 7 are associated to the objectives defined in section 2 are focused on data access, information products and a processing environment to support analysis and e-collaboration. Underlying the objectives described in section 1 the following is the synthesis of 'theme specific' objectives for seismic hazards, landslides and volcanoes. They are derived from the Memorandum of the International Forum on Satellite EO and Geohazards and the elaboration of precursor Pilots under the CEOS WG Disasters.

Objectives associated to seismic hazards 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 [Wide extent satellite observations]; this is focusing on representative portions of the global seismic belt (Alpine-Himalayan Belt, and subduction zones of South America).

B. Pursue the GSNL for seismic hazards [Satellite observations focused on supersites]; access and use satellite EO and in situ data to better understand and monitor supersites.

C. Exploit EO data to derive advanced tectonic products for rapid earthquake response. [Observation of earthquakes with M>5.8]; access and use satellite EO to characterize earthquakes.

D. Access and use satellite EO during the crisis for rapid damage mapping [Articulate relationship with Copernicus, Charter and Sentinel-Asia, and role if any of CEOS]; explain and promote EO capabilities for damage mapping in the disaster response phase.

Similarly there are concrete objectives associated to the Volcano community and to the Landslides community and they are described in the International Forum on Satellite EO and Geohazards (http://esamultimedia.esa.int/docs/EarthObservation/Geohazards/esa-geo-hzrd-2012.pdf).

Objectives associated to landslides community:

A. Establish best practices to integrate satellite EO to support landslide risk management, and in particular use SAR and Optical data for both landslide inventory mapping and landslide permanent monitoring.
B. Demonstrate the contribution of satellite EO by delivering EO products for defined pilot regions to see how different datasets could provide 1) nowcasting/forecasting information on the space/time evolution of large active landslides and 2) improved situational awareness in a disaster, and aid in response/recovery with respect to landslides with different triggering mechanisms such as earthquake triggers and rainfall triggers.
C. Work across earthquake, volcano, and flood pilots to apply best practices for SAR and Optical imagery integration in defined regions.
D. Additional objective of the landslide pilot: Improve coordination and sharing of satellite acquisitions and data products in support of landslide hazard/risk

management across the existing flood, seismic, and volcano pilots to maximize utility of CEOS contributions;

Demonstrate the value of satellite EO in the context of integrated landslide management practices (including landslide hazard and risk mapping, and landslide long-term surveying).

Objectives associated to volcano community:

The CEOS Volcano pilot represents a stepping-stone towards the long-term goals of the Santorini Report on satellite EO and geohazards with respect to volcanic activity, namely: 1) global background observations at all Holocene volcanoes; 2) weekly observations at restless volcanoes; 3) daily observations at erupting volcanoes; 4) development of novel measurements; 5) 20-year sustainability; and 6) capacity-building. Specifically, the pilot aims to:

A. Demonstrate the feasibility of integrated, systematic and sustained monitoring of Holocene volcanoes using space-based EO;
B. Demonstrate applicability and superior timeliness of space-based EO products to the operational community (such as volcano observatories and VAACs) for better understanding volcanic activity and reducing impact and risk from eruptions;
C. Build the capacity for use of EO data in volcanic observatories in Latin America as a showcase for global capacity development opportunities.
D. Additional objective: improve coordination of satellite data acquisition over volcanoes, demonstrate efficiency of EO-based monitoring methodologies as a complement to in-situ measurements, and support and continue the GSNL initiative

It is noted that the Volcano community is discussing with the CEOS WG Disasters to expand the capability demonstrated with the CEOS Volcano pilot to address information needs on a more global basis compared to the pilot experience (primarily Latin America).

10. Targets associated to the Geohazards Lab activity

The concrete targets associated to the objectives defined in section 2 are focused on data access, information products and a processing environment to support analysis and e-collaboration.

- **Targets associated to the Geohazards Lab**

The following describes targets associated to the Seismic Hazards community.

A.1) EO data to support global strain rate mapping (e.g. iGSRM) and fault reconnaissance mapping at regional and global scale:

- Wide extent & repeat InSAR data to build the global strain model (continuous observations over large areas using SAR data such as Sentinel-1, ALOS-2 and RCM) Coordination and sharing of data acquisition burden among SAR data providers
- Optical ortho-rectified imagery to build regional or global maps of active visible fault (e.g. using Pléiades and other types of VHRO data ex archive) and to map deformations (combining with fresh acquisitions over hot spots)

A.2) Derived geo-information products to support strain rate mapping and fault reconnaissance mapping:

- Fault mapping at a regional/global scale
- Ground displacement for historical events based on InSAR analysis and optical imagery when appropriate
- Wide extent & repeat ground displacement mapping to contribute to the global strain model (continuous observations over large areas using SAR data such as Sentinel-1, ALOS-2 and RCM)
- Demonstration of EO-based strain rate measurements (over representative sites)
- Demonstration of methodologies and tools to produce large-area to global strain rate estimates
- Validation of these techniques to measure strain rates
- Study of past earthquakes during the satellite era using InSAR stacks and, when appropriate, optical data stacks
- Access to relevant Digital Elevation Models

A.3) A processing environment to support active fault mapping and global strain rate mapping:

- Providing a cost effective approach for exploiting stereo optical data
- Massive InSAR processing for global strain rate mapping

A.4) An e-collaboration environment to support active fault mapping and global strain rate mapping:

- Sharing results and animate the geohazards community

B.1) EO data to support the GSNL:

- While the Supersite EO data are obtained independently of the Geohazards Lab activities, the data will be (on request) hosted and/or distributed from the Geohazards Lab infrastructure in a coordinated way with the other data distribution platforms/infrastructures which support the Supersites regionally (e.g. UNAVCO, EPOS, etc.)

B.2) Derived geo-information products about supersites and natural laboratories:

Also for the scientific products generated for the single Supersites, and again within a coordinated effort with other infrastructures, the Geohazard Lab will provide:

- InSAR products over supersites (multi-mission).
- Access to Digital Elevation Models
- Access to combined satellite EO and (non-space) in situ measurements

B.3) A processing environment to support the GSNL:

- Provide a processing environment that shall exploit both EO satellite and in-situ data to help the GSNL community and enhance capacity building

B.4) An e-collaboration environment to support the GSNL:

- Share results and animate the geohazards community

C.1) EO data to support earthquake response:

- Rapid supply of co-seismic data for event sites (SAR stacks and optical pre and post-event images)
- Collection of InSAR data to support fundamental research on earthquake fault mechanics using observations of the early post-seismic phase. These observations (up to months after the event) are now possible thanks to the multiple sensors available through event supersites under the GSNL

C.2) Derived geo-information products to support advanced tectonics in earthquake response:

- Rapid supply of co-seismic ground displacement from analysis of SAR and optical imagery
- (Semi-) automatic fault modelling, prediction of damage distribution, rapid calculation of Coulomb Stress changes on neighbouring faults (derived from above)
- Seismic source models
- Maps of geological surface effects

- Post-seismic ground velocity maps
- A procedure to exploit EO based data and derived products in accordance with the working practices of mandated users (in particular geoscience centres supporting End Users concerning geohazard risks)

C.3) A processing environment to support earthquake response:

- Integration and exploitation of processing chains to generate tectonic products
- Guidelines for consensus product generation

C.4) An e-collaboration environment to support earthquake response:

- Sharing results and animating the geohazards community in the context of earthquake events

The following target is common for the entire geohazards community.

D.1) Collaboration with EO based disaster response capabilities:

- Awareness and promotion: Present and explain the contribution of EO based disaster response solutions and their complementarity with EO based solutions to support tectonics
- Awareness and promotion: Take the opportunity of international presence activities (events, working groups, etc.) to promote complementary EO based capabilities
- Collaboration with the Charter about accessing Charter data packages based on the current Charter-CEOS WG Disasters agreement; establish communications links to make the Charter aware of activities conducted by the Geohazards Lab that might be relevant to them; provide feedback to the Charter about EO data supplied by the Charter to users of the CEOS WG Disasters.

11. Milestones for the next three years

Action plan for 2017:

- Identify contributors and users.
- Identify a Coordinator, responsible of :
  - receiving data requests
  - approving requests (after consultancy from the expert users)
  - ordering data and coordinate with the DCT
  - making available the data
  - making available the advanced science products
  - liaising with expert users and end-users for any issues that concern data order, data access and data exploitation
  - reporting on activities
  - developing links with other WG Disasters activities
  - making sure results are published
  - maintaining a list of all activations with information such as the timeliness of facts (data request, data order, data provision, first result etc.), requestor, the data distribution list, the number and type of data provided, the results, publications based on the results etc.
- Define procedures for the organisation of EO exploitation in the ecosystem that is offered by the Geohazards Lab.

Action plan for beyond 2017:

- Q4 2017 - Required data volumes identified and agreed
- Q3 2018 - Define procedures to access and use processing chains.
- Q4 2018 - Develop a procedure to make data available in a timely fashion.
- Q4 2018 - Define a protocol with CEOS agencies that contribute to the Geohazards Lab. As a baseline ESA will provide access to the GEP. This protocol is to develop collaboration with agencies willing to contribute to the processing environment (e.g. platform resources federation).
- Q1 2020 - Develop a collaborative framework with geoscience centres and coordinate with them for bridging the gap with end users.
- Q2 2020 - Help end users better understand advanced EO methods.
- Q3 2020 - Implement processing chains and demonstrate the generation of advanced tectonic products for several earthquakes per year using hosted processing under the Geohazards Lab.
- Q3 2020 - Implement processing chains for risk mitigation purposes.

12. Baseline data volumes

Based on the Sustainability Report of the Seismic pilot that are under preparation, possible yearly volumes of data required for 3 years for are described below. This concerns data collections to be downloaded by users.

Agency	ASI Cosmo-Skymed	CNES Pleiades	CSA RADARSAT	DLR TerraSAR-X	ESA Sentinel-1 & 2	JAXA ALOS-2
Number of Images per year for Seismic Hazards	200-400	50-100	50-100	100-200	open	50-100

Other EO data collections (SAR and Optical including VHRO) are intended to be exploited with processing without download (EO data are accessed by the processing environment but the user can only download the value adding product).

13. Governance

The Geohazards Lab partners will be organized as any activity of the CEOS WG Disasters with Lead persons managing the user community and reporting to the CEOS; in addition:

- *as far as data access is concerned:*

Data access for the Geohazards Lab partners will be organized as for any activity of the CEOS WG Disasters: the Geohazards Lab leads will manage requests through the CEOS DCT.

- *as far as EO processing is concerned:*

Processing resources from the different systems contributing to the Geohazards Lab will be based on voluntary effort from CEOS agencies and partners. EO processing within the Geohazards Lab will organized with an *integrated accounting system* for the resources (data, software, storage and processing power) exploited in the framework of the activity. The overall Geohazards Lab activities will be performed on a “best effort” basis with coordination from a Lead and a co-Lead to be designated by the CEOS WG. It is expected that the governance of the resources accessed by the Geohazards Lab will be according to the asset and resources that contributors provide. This will be primarily driven by CEOS contributors (e.g. space agencies) alongside with partners to be defined including geoscience centres of the geohazards community.

Annex 1 – Overview of international initiatives looking at satellite EO and DRM

Comparison with existing EO based DRM mechanisms

	Scope	Type	Provision	Phase of emergency management cycle	VA services	Activation	Disaster types covered
Geohazards Lab	Global	Best effort	Advanced science products (e.g. terrain motion products)	All phases	Internal	Predefined expert teams	Geohazards
Charter	Global	Best effort	EO data and VA products	Response	External	Authorized DRM organisations	Natural or man-made disasters
Copernicus	Global	Committed Service	VA products (Reference Maps, Delineation Maps and Grading Maps)	All phases	Internal	DRM organisations	Natural or man-made, emergency situations and humanitarian crises
Sentinel Asia	Asia-Pacific	Committed Service	VA products and information services	All phases	Internal	ADRC & JPT member countries	Natural disasters
UNOSAT	Global	Committed Service	Geo-spatial information based on field-collected, satellite & GIS data and web services	Response	Internal	UN decision makers, member states, international organizations and non-governmental organizations	Natural or man-made, emergency situations and humanitarian crises
Servir	Africa, Himalayas & SE Asia	Broad scope*	EO data, geospatial information, predictive models and science applications and tools	All phases	Internal	Auto-activation	Natural disasters, environmental changes and ecological threats

* Note: see https://servirglobal.net/about-Servir

Annex 2 – List of major international initiatives looking at satellite EO and DRM

The international Charter Space & Major Disasters:
Link: https://www.disasterscharter.org/web/guest/home

The Copernicus EMS and Risc & Recovery services:
Link: http://emergency.copernicus.eu/

The Sentinel Asia initiative:
Link: http://global.jaxa.jp/article/special/sentinel_asia/index_e.html

The Servir initiative of NASA and USAID:
Link: https://www.servirglobal.net/

The UNOSAT programme of UNITAR:
Link: https://www.unitar.org/unosat/maps

Other relevant EO based capabilities for DRM may have been omitted in this preliminary list.

Annex 3 - Overview of precursor hosted processing platform activities

The Geohazards Lab will gather tools and processing chains, primarily based on EO data and brought via the contribution of CEOS members. Access to the individual service chains depends upon the protocol to expose and provide them in the Geohazards Lab. This shall be defined within the Lab governance.

This Annex is describing platform based on hosted processing that contribute to the geohazards community.

The Geohazards Exploitation Platform of ESA's TEP initiative:

An overview of the GEP is on line at:
http://esamultimedia.esa.int/docs/EarthObservation/Geohazards/2017_ESA_GEP_Overview.pdf

An illustration is given with Figure A-4.1) below with currently identified service chains from ESA's precursor GEP. Examples of processing results on the GEP are given with Figures A.2) and 3). Illustrations of the GEP environment with the dashboard and the dashboard metrics applied to a service running on the GEP are given with Figure A-4.4) and A-4.5) respectively.

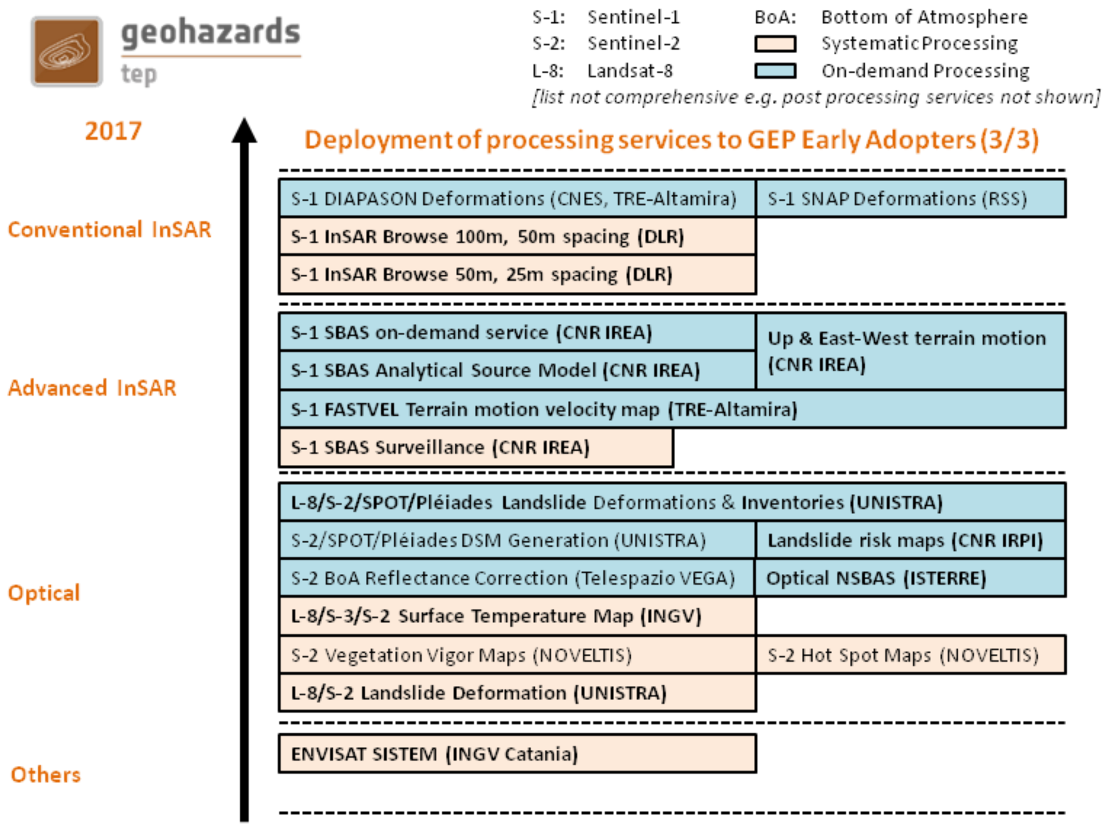


Figure A-4.1): Example of EO based service chains integrated in the Geohazards Exploitation Platform GEP. These encompass Optical and Radar based chain, some of them are concerned with terrain deformation mapping using stereo optical data or InSAR, other chains are concerned with thematic mapping applications relevant to geohazards. Credits: ESA, Terradue.

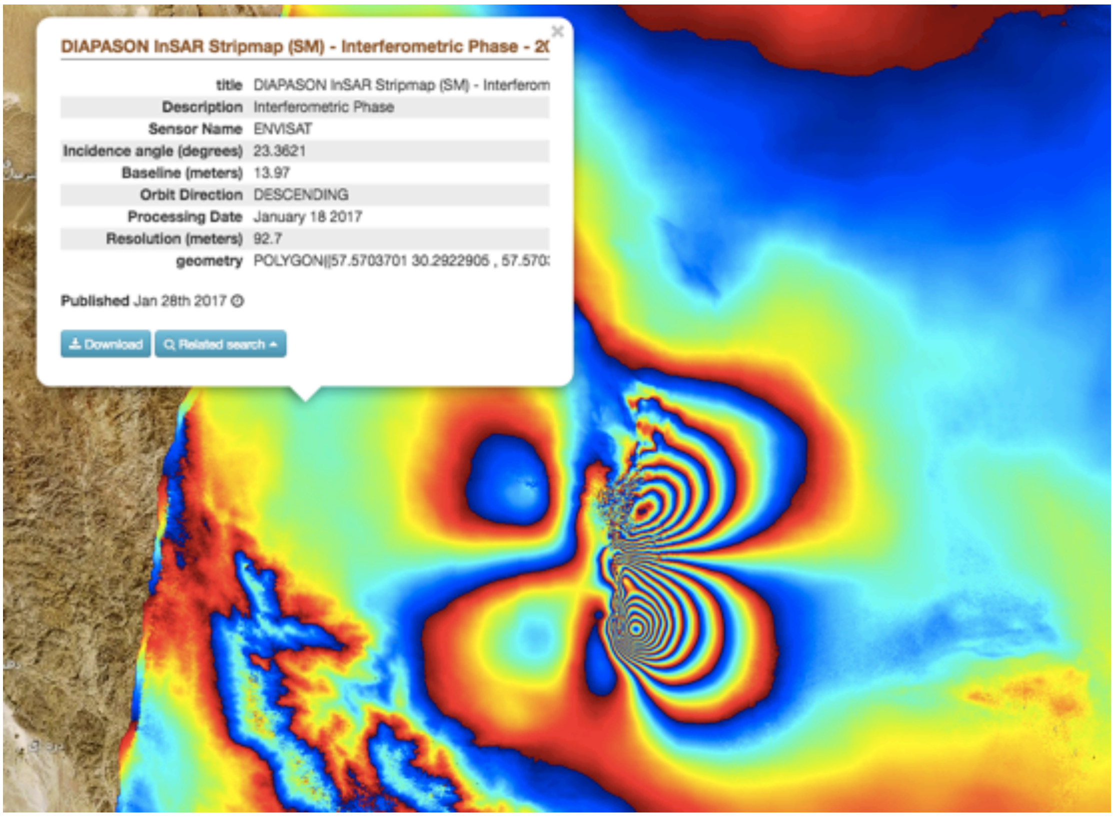


Figure A-4.2): Example of processing result based on the DIAPASON processing chain of CNES using co-seismic data of the ENVISAT ASAR sensor; the interferogram is representing deformations due to the December 2003 Bam (Iran) Mw 6.3 earthquake. Credits: ESA, Terradue.

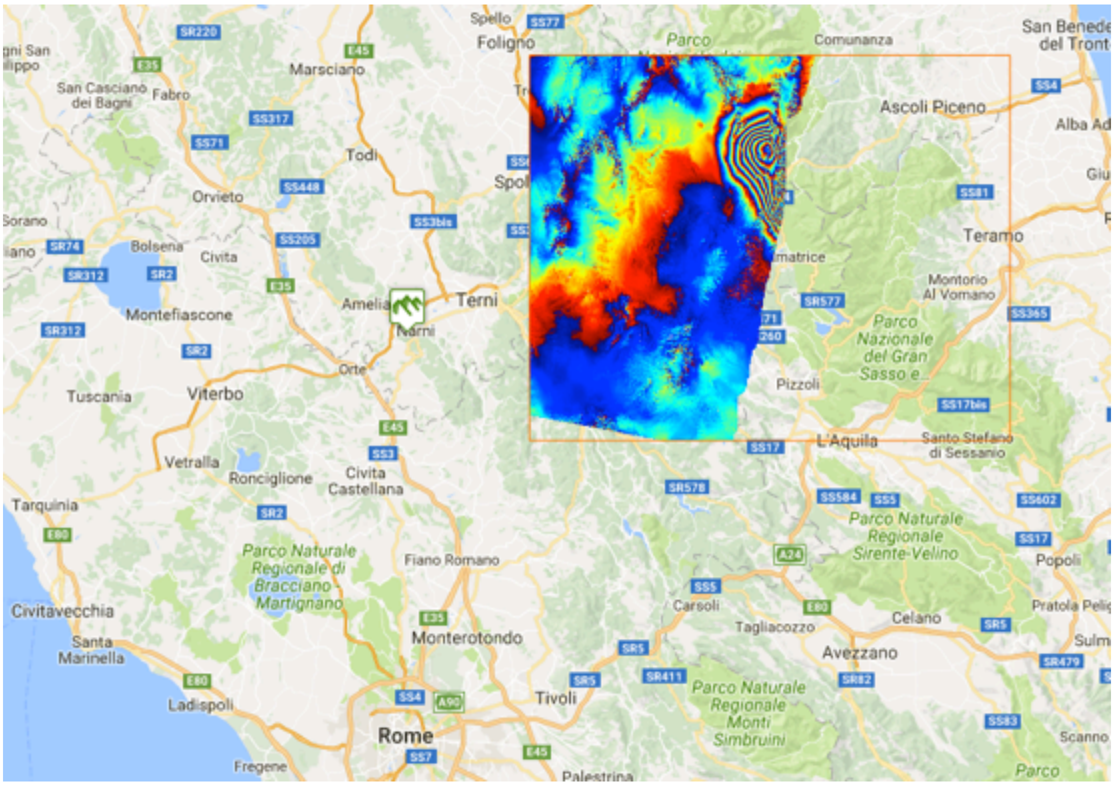


Figure A-4.3): Example of processing result based on the DIAPASON processing using Sentinel-1 co-seismic data of 20 and 26 august 2016; the interferogram is representing deformations due to the 24 august 2016 earthquake of magnitude 6.2. Credits: ESA, Terradue; Sentinel data: copyright Copernicus.

Figure A-4.4): Example of platform dashboard to support monitoring the performance of hosted processing chain with metric; Top Left : catalog latency (delay of representation of EO metadata in the platform catalog) ; Top right : caching activity (activity to collect an on-line series of EO data used to trigger processing chains) ; Bottom Left : comparison between data ingestion and product publication on the platform ; Bottom Right : EO data ingestion activity against time.

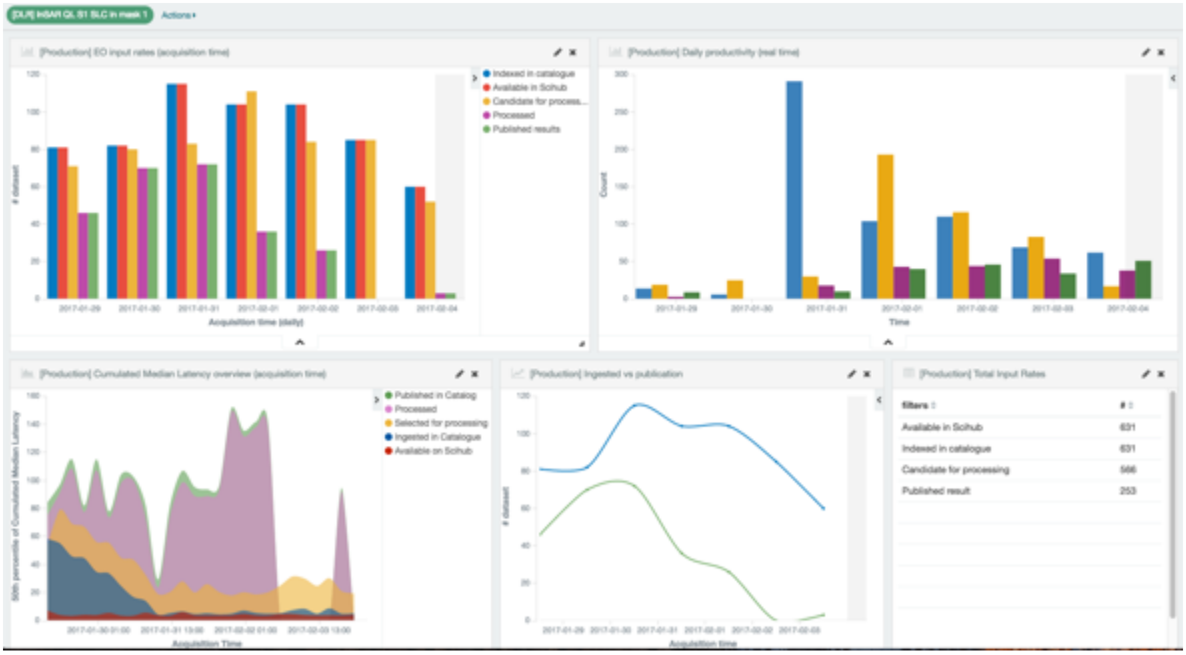


Figure A-4.5): illustration of platform dashboard with the example of the systematic InSAR Browse service of DLR operated on the GEP ; Top Left : rates of production of service represented against the EO data acquisition time (the five colored bars represent the amount of EO metadata in the catalog, the amount of EO data in the data source Scihub, the EO data selected for processing, the data processed and the corresponding product published in the platform geobrowser); Top right : same as Top Left but according to real time (production instead of acquisition); Bottom Left : Latency of production (for the 5 components of the production rate described with the Top Left illustration) ; Bottom Right : comparison between ingestion of EO data and publication in the platform geobrowser.

The initiative with Formater and the PEPS (France):
xxx

The initiative with CODE.DE and GEOFRAM (Germany):
xxx

The LICSAR initiative of COMET initiated by NERC (UK):

COMET/University of Leeds is leading an international effort to build a strain rate model constrained by GPS and InSAR for the Earth's tectonic belts. Funding in the UK has been secured for 2013-2018 from the Natural Environmental Research Council through the Centre for the Observation and Modelling of Volcanoes, Earthquakes and Tectonics (COMET+) and a large grant, "Looking inside the Continents from Space" (LICS; PIs Parsons and Wright).

The project platform is available at: http://comet.nerc.ac.uk/COMET-LiCS-portal/

The excerpt below, from the LICS proposal explains the approach: "Despite the success of InSAR to date, only a small proportion of the world's faults systems have InSAR measurements of interseismic deformation. Intermittent acquisitions with sometimes long intervals between them and large variations in orbital position mean that often there is not the sufficiently large number of high-quality interferograms required to properly mitigate the various error sources. However, using Sentinel-1A every point in the tectonic belts will be observed twice in each 12-day repeat cycle (on ascending and descending passes); every 3 days on average with the second Sentinel-1B now in operations. The shorter repeat times and tighter orbital control and regular acquisitions for Sentinel-1 data will markedly improve the coherence of interferograms relative to previous satellite missions and allow time-series InSAR methods to be automated.

The aims and objectives are to produce radically-improved estimates of time-dependent surface deformation in the Alpine-Himalayan Belt and East African Rift using radar data from Sentinel-1. The team will use these to better characterise the seismic hazard for the region and to determine the appropriate dynamical models that describe the observed deformation.

The project's specific objectives are grouped into three interlinked themes:

A. To make a fundamental advance in the measurement of tectonic deformation at high spatial resolution, utilising new data from the Sentinel-1 mission, by:

- Developing time-series methods and algorithms for their routine application across large regions using data from Sentinel-1.
- Assimilating constraints from numerical weather prediction models to reduce the impact of atmospheric noise.
- Improving the orbital model for Sentinel-1 to eliminate significant long-wavelength orbital errors.

B. To improve assessment of seismic hazard in the Alpine-Himalayan belt by:

- Constructing high-resolution velocity and strain-rate fields for the region.
- Using high-resolution imagery and elevation models to map unknown faults.
- Assessing time-dependent hazard following major earthquakes.

C. To understand how the continents deform in space and time, and how this is controlled by the strength distribution in the lithosphere, by:

- Modelling observations of time-dependent earthquake cycle deformation to constrain the rheology of fault zones.
- Testing competing hypotheses about continental collision using 3-dimensional numerical models with new constraints on rheological variations.
- Establishing the factors that control the mechanism of continental extension in the East African Rift.

The project will deliver fundamental new data sets that will have wide academic and non-academic impact. We expect the new views that will emerge on continental tectonics from this effort to influence strongly the scientific agenda for the coming decades."

Annex 4 – Examples of EO based capabilities of the geohazard community

Further to end to end services such as the Copernicus EMS and the Copernicus Risk & Recovery services, Sentinel Asia, Servir, UNODSAT, etc. there are EO based capabilities specialized in geohazard applications.

Further to hosted processing platforms (see Annex 4) already exposed to the geohazard user community, there is a range of EO based capabilities available to the geohazards user community:

The Advanced Rapid Imaging and Analysis Project (NASA/JPL):

When an earthquake occurs, seismic data provide an initial estimate of magnitude and location. However, for large earthquakes, we can improve our situational awareness once we know the full extent of the rupture — large earthquakes result from several 100's of kilometers of fault breaking, not just a point on the map corresponding to the epicenter. Rapid GPS and InSAR measurements from impacted regions combined with modeling can often tell us where and how much a fault ruptured, constraining these values more reliably than is possible using seismic data alone. Determining the geometry of the ruptured fault is critical for improving rapid estimates of the distribution and intensity of earthquake shaking (e.g., ShakeMaps). Accurate seismic shaking information is necessary for post-event fatality and loss estimates in support of recovery efforts.

The Advanced Rapid Imaging and Analysis (ARIA) project is collaboration between the Jet Propulsion Laboratory, which is operated under contract with NASA by the California Institute of Technology (Caltech), and the Caltech Division of Geological and Planetary Sciences (http://aria.jpl.nasa.gov). A prototype data system has been built that automates the generation of geodetic imaging products, including co-seismic deformation and damage proxy maps, from SAR imagery and GPS data. We have recently developed algorithms for using SAR data to identify regions that have experienced damage. Integrating these SAR-based damage proxy maps into existing loss estimation models could give responders more accurate information on economic losses, estimated fatalities. The ARIA geodetic co-seismic deformation products are then used along with seismic waveforms for modeling the distribution of slip on finite faults that ruptured in the earthquakes. New development is underway to include analysis of high-resolution optical imagery to measure co-seismic deformation and estimate damage.

The ARIA project is also working on monitoring hazards with SAR and GPS data, especially volcanic hazards, by time series analysis of InSAR and GPS data. The ARIA group has recently started a new collaboration with the US Geological Survey (USGS) National Earthquake Information Center (NEIC) called Rapid Earthquake Products from Analysis & Imaging for Response (REPAIR), which is funded under the NASA Disasters Applications program.

The USGS NEIC has the national mandate to provide timely, accurate, and complete information on global seismicity. For larger events, the Prompt Assessment of Global Earthquakes for Response (PAGER) system provides fatality and economic loss impact estimates. These PAGER estimates are generated rapidly following a large event, and are updated as more data constraining the shaking distribution of the earthquake become available. The PAGER estimates are often the first earth observation-based models for how much damage has been caused by a significant earthquake, and it can take days to weeks for agencies to construct synoptic pictures of damage that are more detailed than the PAGER estimates.

The ARIA group is working with the USGS to extend the fault modeling algorithms already in use at the NEIC so that they enable combined modeling of geodetic and seismic data to improve the accuracy of the earthquake fault location, fault slip and improve predicted shaking estimates. ARIA will also develop algorithms for using SAR-based damage proxy maps in PAGER loss estimates that are used to assess population areas at risk from an earthquake. These REPAIR integrated products can be used to enhance the information available to response and recovery agencies, by giving a more accurate inventory of regions most affected by the shaking. ARIA and the USGS NEIC will jointly develop the REPAIR modelling algorithms and the resulting products to aid situational awareness and decision support.

The SSARA initiative:

The ASF and UNAVCO are pleased to announce the release of a beta SSARA Federated API. Using this single access point, users will soon be able to search for SAR images archived at both ASF and UNAVCO. To interact with this beta federated querier please visit the Interactive API Tool for Accessing Synthetic Aperture Radar Data and select the "SSARA Federated API Query" tab. For further usage details on the SSARA Federated and ASF API visit http://www.asf.alaska.edu/program/sdc/asf_api. UNAVCO/WInSAR, the Alaska Satellite Facility (ASF), and the Jet Propulsion Laboratory (JPL) are collaborating in an information technology and data management development project to design and implement a seamless distributed access system for Synthetic Aperture Radar (SAR) data and derived interferometric data products. A seamless SAR archive will increase the accessibility and the utility of SAR science data to solid Earth and cryospheric science researchers.

Specifically, the project will provide simple web services tools to more seamlessly and effectively exchange and share SAR metadata, data and archived and on-demand derived products between the distributed archives, individual users, and key information technology development systems such as the NASA/JPL ARIA projects that provide higher level resources for geodetic data processing, data assimilation and modeling, and integrative analysis for scientific research and hazards applications. The proposed seamless SAR archive will significantly enhance mature IT capabilities at ASFs NASA-supported DAAC, the GEO Supersites archive, supported operationally by UNAVCO, and UNAVCO's WInSAR and EarthScope archives that are supported by NASA, NSF, and the USGS in close collaboration with ESA/ESRIN.

As part of the proposed effort, data/product standard formats and new QC/QA definitions will be developed and implemented to streamline data usage and enable advanced query capability. The seamless SAR archive will provide users with simple browser and web service API access tools to view and retrieve SAR data from multiple archives, to place their tasking requests, to order data, and to report results back to data providers; to make a larger pool of data available to scientific data users; and to encourage broader national and international use of SAR data. The new ACCESS-developed tools will help overcome current obstacles including heterogeneous archive access protocols and data/product formats, data provider access policy constraints, and an increasingly broad and diverse selection of SAR data that now includes ESA/ERS/ENVISAT (and upcoming Sentinel mission), CSA/Radarsat, JAXA/ALOSPALSAR, DLR/TerraSAR-X satellite data and NASA/UAVSAR aircraft SAR data. The list will continue to expand with NASA/DESDynI further increasing the need to efficiently discover, access, retrieve, distribute, and process huge quantities of new and diverse data.

SSARA Project Objectives:

1. Develop and implement a federated metadata query and data and data product download capability from distributed airborne (NASA UAVSAR) and spaceborne SAR archives at ASF and UNAVCO/WInSAR.
2. Define and make available new QC parameters and products that will enhance the usability of data and data products from these existing NASA-funded collections.
3. Implement a web services enabled terrain correction service for interferometry (InSAR) using NASA SRTM data at SDSC.
4. Enhance ASF InSAR processing service to access distributed data collections, utilize terrain correction service, and generate enhanced QC products. Establish processed data products archive."
- From www.asf.alaska.edu

- *The RASOR platform (CIMA Foundation):*

The RASOR project aims to develop tools for fast and reliable multi-hazard risk assessment, applicable to several natural hazards worldwide and fit for usage in all phases of the disaster management cycle. The services offered by RASOR tools will be able to produce detailed and accurate risk information within minutes of computing time and without the need for costly and time consuming local ground data. This is achieved by using the latest generation of satellite data and related technology such as Digital Terrain Models (DTMs), Digital Elevation Models (DEMs) and land use information.

The RASOR tool supports all phases of the disaster management cycle:

• Prevention phase: Risk prevention and mitigation are traditionally based on risk analyses. Since RASOR can be applied worldwide, it will offer a benchmark for all local risk assessments. RASOR can also be used as a first step of a two-stage risk assessment, identifying areas, locations and scenarios that require special attention in the second, more detailed step. In data-poor regions, such as developing countries, RASOR may be the only reliable source of risk information available.
• Preparedness phase: Similar to its applications in the prevention phase, the rapid risk assessment tools offered by RASOR can help to establish contingency plans and prepare response actions. In data-rich regions, RASOR can act as a first step in a course to- fine approach. In data-poor regions, RASOR may be the only available source of information to prepare for natural disasters.
• Response phase: During the response phase, detailed and reliable risk information is extremely valuable, for example for selecting emergency measures that should minimize the damage and for NGO's sending aid to people. A risk assessment can help to direct special precautions during unexpected and sudden events taking place as a disaster evolves. Being rapid is all the more important in such situations.
• Recovery phase: Immediately after the disaster has taken place, the RASOR tools can provide a first damage estimate and outline the affected areas. This type of information can be used by insurers and governments for financial negotiations and for planning of restoration work.