CEOS Geohazards Lab Implementation Plan

29 September 2017

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<tr>
<td>CEOS Geohazards Lab
Concept Phase: April 2017 – Q1 2018
Implementation Phase: Q1 2018 – Q1 2021
Theme area: geohazards (earthquakes, volcanoes, landslides)</td>
<td rowspan="2">CEOS Proposal Development Lead:
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Main partners against objectives: I – INGV. II – INGV, COMET, III – CNES, IV – ESA, V & VI - CNRS EOST

CEOS Implementation Lead: ESA (governance of platform resources federation TBD among the contributing CEOS agencies)

Contributing projects:
Geohazard Supersites and Natural Laboratories (GSNL), Geohazards Exploitation Platform (GEP), form@ter, LiCSAR, FP-7 Center of Excellence for EO-based Monitoring of Natural Disasters (BEYOND)

Potential Contributing Projects:
LiCSAR, InSAR-based Global Strain Rate Model (iGSRM), CEOS WGISS, nextGEOSS, GEODARMA</td>
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<td>Geographic areas of focus:
I: areas covered by the GSNL
II: CEOS Pilots and follow-on activities areas
III: Recovery Observatory areas
IV: GEO-DARMA priority areas
V & VI: Geographic targets cannot be defined in advance</td>
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<td>Partners:

<u>CEOS space agencies:</u>
ESA, CNES, ASI, DLR.

<u>Other partners:</u>
INGV, COMET+, BRGM, CNRS EOST, CNRS IPGP, ISTerre, CNR IREA</td>
<td>Objectives:
Based on theme specific objectives that are directly derived from the ‘International Forum on Satellite EO & Geohazards’ the Geohazards Lab intends to support the following activities:

Concerning DRR activities not on an emergency basis:

I. Support the GSNL initiative with on-line services
E.g. provide access to processing tools for GSNL users.
II. Support with on-line services other CEOS Pilots that are still pursuing their activities and other follow-on activities such as the Seismic Hazards Consolidation Phase activity, 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 favour the use of EO data for a frequent updating of landslide catalogues, as per Objective B) of the Landslide Pilot community; while the pilots and follow-on activities 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.
III. Support the Recovery Observatory (RO) activity by providing access to tools and hosted processing about geohazards related issues relevant to the RO deployed
IV. Support GEO-DARMA by providing access to tools and hosted processing about geohazards in the priority areas (as these are described in the GEO-DARMA implementation plan) for risk assessment</td>
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	Concerning activities on an emergency basis: **V. Pursue and support the generation and distribution of advanced science products based on terrain motion mapping** (covering at least 10 events per year) *for instance advanced science products for earthquake response using Sentinel-1 InSAR (deformation maps, source models, etc.) as vv Objective C) for events of magnitude greater than 5.8, landslides monitoring products and volcano deformation monitoring products; expand this capability to provide interferograms and motion maps using VHR SAR missions (e.g. Cosmo-Skymed, TerraSAR-X, Radarsat); expand this capability to provide stereo based DEMs and deformation maps using VHR Optical based measurements.* **VI. Pursue and support the generation and distribution of other advanced science products** (number of events covered per year TBD) *E.g. for landslide monitoring, thermal signatures of volcanic eruptions.* **CEOS objectives:** - Demonstrate how satellite EO can be used to improve geohazards monitoring and response. - Improve collaboration and sharing of EO products to maximise the benefit from CEOS contributions. - Take advantage from the use of lessons learnt from the CEOS seismic pilot.

Description:

In response to the concrete objectives from the user community, as described above, the Geohazards Lab is **a platform or a group of interoperable separate platforms with federated resources which shall provide data access and a processing and e-collaboration environment to exploit EO data to assess geohazards and their impact**. It intends to execute the activities described here after.

1. Pursue the CEOS WG Disasters and GSNL activities related to geohazards 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.
   - 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

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.

Philosophy of the Geohazards Lab:
The main contribution of CEOS agencies is access to processing services and tools and an e-collaboration environment. This complements the WG Disasters activities and has no implication with their own data access mechanisms (organized by the DCT).

Key pilot outputs/deliverables:
The Geohazards Lab activities will result in integration and validation of tools, generation of information products and e-collaboration of the scientific community.
The following describes targets associated to the Seismic Hazards community.

A.1) 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.2) An e-collaboration environment to support active fault mapping and global strain rate mapping:

- Sharing results and animate the geohazards community

B.1) Access to data and products 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.)
- Access to Digital Elevation Models
- Access to combined satellite EO and (non-space) in situ measurements

B.2) 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.3) An e-collaboration environment to support the GSNL:

- Share results and animate the geohazards community

C.1) A processing environment to support earthquake response:

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

C.2) An e-collaboration environment to support earthquake response:

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

CEOS outputs/deliverables:
Tools and services
Federation of processing platforms

Expected key outcomes:

- Increase access to hosted processing
- Increase the number of users that access on-line tools to support DRM
- Increase the type of users in the different segments of the user base (address more types of hazards)
- Increase awareness/promotion about satellite EO and DRM for different relevant themes (landslides, seismic hazards, volcanoes): if requested help Pilot Leads of other thematic activities of the WG Disasters to promote results (e.g. publish geospatial results on the Geohazards Lab).

Key user communities and benefit:
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.

The users are ***EO experts/Geoscience centers already contributing to the Geohazards Lab precursor activities:***

- the seismic, volcano, landslide and RO expert user team
- the GSNL users
- GEP Early Adopters

Some of these users had access to can gather their data collections for easy access on the Geohazards Exploitation Platform (GEP) and have access to processing chains. EO experts process, analyze, 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 end users

CEOS Seismic Hazards Consolidation Phase user:

Yachay Tech University: The Center of Earth Observation of the Yachay Tech University 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 optical 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.

GSNL and CEOS Seismic Hazards Consolidation phase user:

INGV: INGV is interested in the processing capacities provided by the Geohazards Lab to generate scientific products useful in the global context of DRR.

Milestones and schedule:

Concept Phase: April 2017- Q1 2018

Currently, there is a process of elaboration and discussion between CEOS agencies and other partners (that are contributing or shall potentially contribute) of the Geohazards Lab in order to better define the activities and key outcomes.

Implementation Phase: Q2 2018 – Q1 2021

Year 1:

1. Expand integration of services and tools to better meet community needs
2. Document procedures to access and use processing chains.
3. Define 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).
4. Enhance procedure to make data available in a timely fashion.
5. Develop a Web site
6. Start promoting hosted processing and raising awareness (capacity building, training courses, workshops)
7. Analyse geohazards community requirements

Year 2:

1. Develop collaborative framework with geoscience centres and other initiatives to define common standards/methodologies
2. Start harmonization and improvement of EO results
3. Continue integration of services and tools

4. Validation and use of services and tools
5. Finalize definition of procedures to access and use processing chains.

Year 3:

1. Complete validation and full scale demonstration of services and tools
2. Summarize lessons learnt.
3. Complete implementation of geohazards community requirements
4. Complete harmonization and improvement of EO results

EO data requirements:

As a baseline, the Geohazards Lab does not intend to request EO data. The users from the CEOS pilots and follow-on activities will use the data endorsed by CEOS for these activities. On a case by case basis, provided permission is granted, these data could be accessed/uploaded on-line for processing using the Geohazards Lab.

Main contributions by partner:

CEOS agencies that have expressed interest in joining the initiative include ESA, ASI, DLR and CNES. 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;
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 contribute on the Geohazards Lab, on a voluntary basis by:

- 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 shall support the Geohazards Lab on a voluntary basis by:

- Facilitating access to COSMO-SkyMed data collections through the GEP for CEOS and GSNL activities (as already done for the Nepal event supersite);
- Testing & demonstrating hosted processing services available in the GEP to analyse COSMO-SkyMed and Sentinel-1 SAR data for CEOS projects (e.g. support to Recovery Observatory activity) to generate terrain displacement science products;
- Participating to the Geohazards Lab activity about methodologies for product generation, standards and interoperability between EO missions and EO based processing chains.

Contribution from CNES:

- 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.

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 BRGM:

1. *Support scientific animation geohazard community* in particular:
   - *Help CEOS WG Disasters about community requirements* regarding the observational strategy for geohazards. Definition and consolidation of optimum observation scenarios, based on scientific and users' requirements, to maximize their benefit in monitoring of geohazards.
   - *Support scientific animation* of Geohazards community on the GEP: in liaison with the CEOS WG Disaster team via ESA (e.g. linking to the GEP responsible persons at Terradue and at CNR IREA and the Head of the Scientific Advisory Committee of the GSNL at INGV) provide support for the animation of expert users in relevant CEOS activities (e.g. the landslides pilot, the recovery observatory, etc.). Support user animation and federation with e-collaboration (knowledge base, open publications, social networking etc.).
   - Develop *collaborative framework* with geoscience centres and collaborate with relevant initiatives (GSNL, CEOS Pilots, nextGEOSS project, iGSRM, etc.)

   Coordinate with geoscience centres for bridging the gap to end users e.g. by linking EO based solutions for geohazards relating to CEOS WG Disasters activities.
2. *Harmonize and improve acceptance of platform based EO techniques* working with both expert users and end users:

- *Define consensus methods in liaison with geohazard practitioners of EO* with the goal to harmonizing processing results and achieving greater acceptance by end users for geohazard applications.
- *Establish methodology to support generation of reference ground deformation processing services* to support historical analysis and back analysis using hosted processing; this shall be using robust scientific methods, including a geo-database of extracted EO-based information and a method to combine EO and non EO data for improved back analysis (talking into account deformation phenomena).

Help end user better understand advanced EO methods: coordination with geoscience centres for preparation of guidelines for science products generation for geohazards, including "how to" instruction tutorials with examples.

3. *Demonstrate and promote hosted processing services* to support Geohazards; organise and execute a test and promotion campaign, in particular:
   - *Develop appropriate test & demonstration plan* for hosted processing chains on GEP to ensure integrity of services after hardware changes or software updates.
   - *Demonstrate reference ground deformation mapping* using terrain motion processing and historical EO data over a representative test site

   Support expansion of hosted processing on GEP addressing the various geohazard domains. Identify geohazard users' requirements in terms of advanced products and monitoring needs and support their scientific and technical development on GEP (e.g. adaptation of chains to additional data sources, customization of workflows to improve usability of services, etc.).

Contribution from CNR-IREA:

CNR-IREA, as a long-date partner of ESA in the development of the Geohazards TEP, is strongly interested in the development of the Geohazards Lab and will support it by:

- Providing continuous updates and maintenance to the present SBAS InSAR processing chains available on the GEP, thus including on-demand and systematic processing of InSAR data (primarily Sentinel-1). User support will also be provided;
- Exploiting the systematic SBAS InSAR processing chain for volcano monitoring at large scale (beyond the GEP Pilot);
- Investigating the possibility to implement new automatic tools for the generation of value-added products after major seismic events (e.g. fault source models from InSAR maps);
- Facilitating the interaction of the Geohazards Lab with the EPOS community which is not directly related to the risk management but can provide fundamental inputs (in terms of data and tools) for natural hazards study and mitigation;
- Participating to the discussions on InSAR and EO-derived products standardization (capitalizing the experience gained within EPOS);
- Promoting the use of the tools available within the Geohazards Lab by also giving training courses and demo sessions;
- Providing InSAR based products during seismic emergency (at best effort).

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 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 pre-processing 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:

- 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.

<u>Contribution from DRM experts to exploit the capability beyond the CEOS pilots:</u>
The Geohazards Lab intends to collaborate with other CEOS activities, in particular from the WG Disasters (see Appendix: Proposition - The Geohazards Lab Initiative, provided in a separate document).

Capacity building and outreach activities:

As far as systematic *data exploitation* is concerned, the pilot will:

- *Develop communities*: pro-actively develop and manage the international community of geohazard users. Conduct outreach and capacity development concerning EO based techniques within user communities (geoscience centres, observatories, end users);
- *Conduct e-science:* accelerate the science use of satellite EO & promote research through new mechanisms using the web;
- *Integration and use of tools in an e-collaboration platform*: The added value of CEOS DRM will be to reinforce the capacity of the CEOS pilots, CEOS follow-on activities, the RO, the GSNL and GEODARMA with the functionalities of federated platform (for instance data storage, on-line processing, scientific animation, etc.).

Suggested evaluation criteria:

1. Number of EO processing chains available to the users by the end of the activity (at least 15 chains)
2. Type of EO data available through the Geohazards Lab's on-line platforms (at least 3 SAR and 1 VHR Optical data sources)
3. Volume of EO data available through the Geohazards Lab's on-line platforms (at least 100 scenes per data source)
4. Number and quality of products generated on-line (at least 30 products per year)
5. Number of users and practitioners using the Geohazards Lab (at least 30 users)
6. Number and quality of peer reviewed papers based on the work accomplished by the Geohazards Lab (at least 5 papers per year)
7. Success in raising awareness within the scientific community and the end users/decision makers (when these are recipients of information products and reports based on the interpretation of Geohazards Lab's products)

Geohazards Lab Contributors (as of 29 September 2017):

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