Committee on Earth Observation Satellites

WGDisasters Seismic Hazards Demonstrator

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WGDisasters-15 Meeting

Virtual Meeting

9 – 11 March 2021

Overview and objectives

Aims to provide satellite data to generate EO based scientific information to be shared with decision makers for seismic hazard assessment

Objectives (not on an emergency basis)

- Pursue **global tectonics mapping** in the long term
- Expand **active fault mapping from regional to global coverage primarily using VHR optical data** supporting supporting geomorphological and morpho-tectonics studies

Objectives (on an emergency basis)

- Exploit EO data to derive **advanced research products for earthquake response**: expand to target of at least 10-12 EQ per year
- **Articulate with EO disaster response capabilities** e.g. the Charter to make sure users are aware of and use it.

Data - Yearly quota available and requests

Agency	ASI	CNES	DLR	ESA
	Cosmo-SkyMed	Pleiades	TerraSAR-X	Sentinel-1 & 2
Quota per year	650 images	20000 sq. km.	Upon request	Open

Request no.	Request status	Prime Investigator Affiliation	Data requested	AOI	Number of images requested
2019-R02	**Approved**	University of Leeds	Pleiades	Central Asia	**2322 sq. km. in Central Asia**
2019-R03	**Approved**	University of Leeds	Pleiades	Indonesia	**316 sq.km. in Indonesia**
2019-R04	**Approved**	University of Leeds	Pleiades	Ecuador	approx. 3000 sq. km. in Ecuador
2019-R05	**Approved**	University of Leeds	Pleiades	Nepal	approx. 3000 sq. km. in Nepal
2019-R06	Not received	University of Leeds	Pleiades	Turkey	approx. 3000 sq. km. in Turkey
2019-R07	**Approved**	University of Leeds	Pleiades	Kenya	approx. 3000 sq. km. in Kenya
2019-R08	Not received	HUA	TerraSAR-X, Cosmo-SkyMed, Pleiades	Greece	N/A in Greece
2019-R09	Not received	HUA	TerraSAR-X, Cosmo-SkyMed, Pleiades	Iran	N/A in Iran
2019-R10	**Approved**	University of Oxford	Pleiades	Turkmenistan	3,648 (tri-stereo total)
2019-R11	**Approved**	Argans c/ESA	Cosmo-SkyMed	Durres (Albania)	
2020-R12	**Approved**	University of Leeds	Pleiades	Elazig (Turkey)	
2020-R13	*Rejected by DLR*	INGV	TanDEM-X	North Zanjan fault (Iran)	

Data - Yearly quota available and requests (2)

Request no.	Request status	Prime Investigator Affiliation	Data requested	AOI	Number of images requested
2020-R14	**Approved**	University of Oxford	Pleiades	Dushanbe (Tajikistan)	1,500 sq. km. (tri-stereo total)
2020-R15	**Approved**	NOA, AUTH, DUTH	Pleiades	Samos island (Greece)	824 sq. km. (tri-stereo total)
2020-R16	**Approved**	University of Oxford	Pleiades	Dushanbe (Tajikistan)	1,856 sq. km. (stereo total)
2021-R17	**Approved**	University of Oxford	Pleiades	Almaty (Kazakhstan)	4,227 sq. km. (tri-stereo total)
2021-R18	*Awaiting approval*	University of Tehran	Cosmo-SkyMed	Tehran	400 images
2021-R19	*Awaiting approval*	INGV, NOA, AUTH	Cosmo-SkyMed and CSK Second Generation	Tirnavos, Thessaly (Greece)	19 images per satellite per orbit

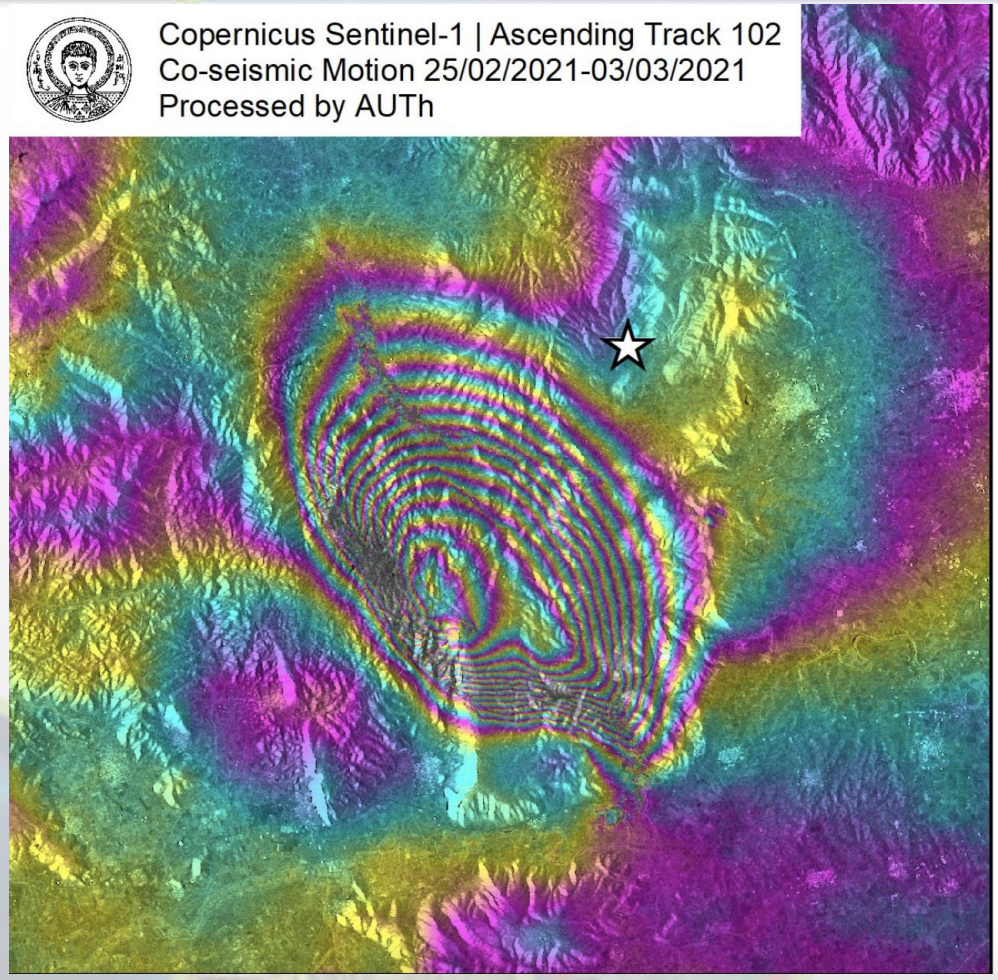
- Updated **Data Requests spreadsheet** uploaded on www.ceos.org under Document Managament

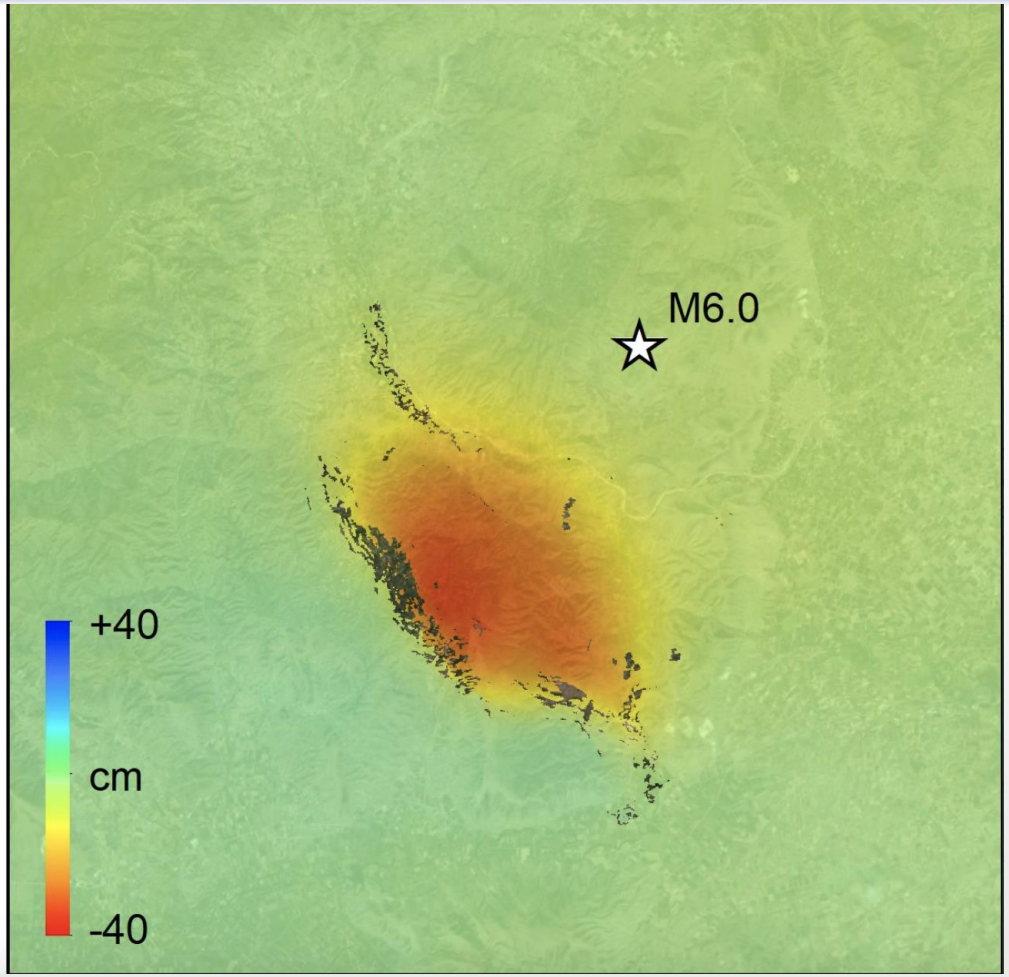
Status of activities (1)

Advanced research products for earthquake response

- ✓ Thessaly (Greece) earthquake – March 2021
  - Identify the seismic source and assess the stress changes in the area and the increase of stress on nearby active faults (INGV, NOA), work using CSK and CSG products (*request awaiting approval*)
  - Ground motion products using Sentinel-1
- ✓ Samos island (Greece) earthquake – October 2020 (NOA, AUTH), ground motion products using Sentinel-1
- ✓ Philippines - August 2020 (CRL/NOA), products using Sentinel-1

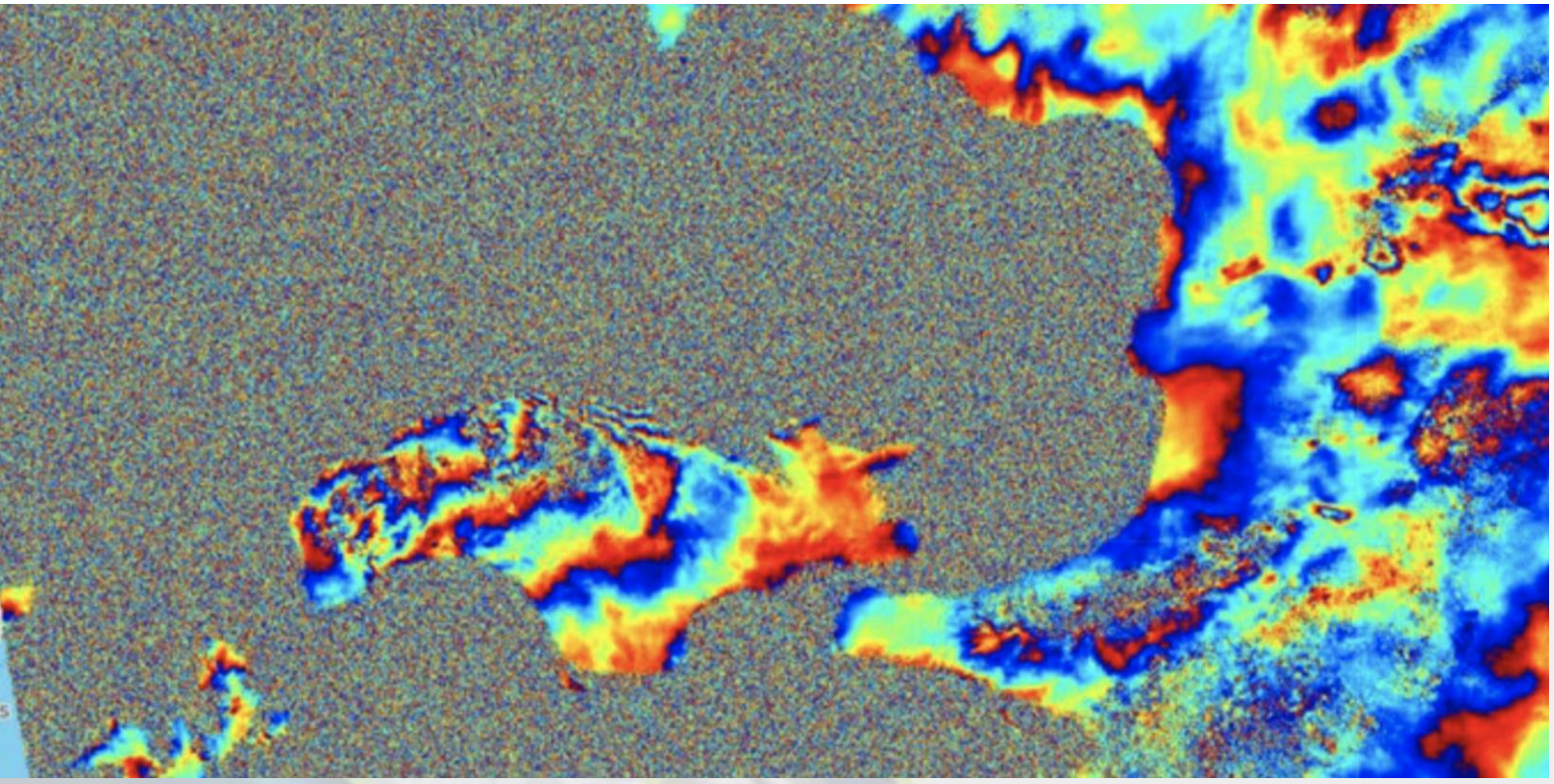
Thessaly, Greece earthquake (AUTH)





Co-seismic interferogram & ground motion of the **Tirnavos (Greece) M6.0 earthquake on 03/03/2021** using Copernicus Sentinel-1 data. **Maximum LoS displacement at -38 cm. No rupture reached the surface.** Processed on GEP by Aristoteleion University of Thessaloniki.

Samos Island, Greece earthquake (AUTH)



Co-seismic differential interferogram (wrapped phase) using **Sentinel-1** images acquired before (24/10/2020) and approx. 4 hrs after the seismic event (30/10/2020 at 16:07 GMT); processed using CNES DIAPASON DInSAR online service on the GEP. Contains modified Copernicus Sentinel data (2020), processed by AUTh.

More results available by AUTH, HUA and NOA.

M7.0 earthquake felt as far away as Athens and Istanbul - struck at a depth of ~10-15km. Uplift (over 10 cm) observed in W-NW of Samos island, corresponding to a large local fault slip (> 0.5-1 meter on the fault rupture surface).

- Interpretation of the earthquake activity, combining seismological data and EO data was prepared and communicated to Greek authorities (EPPO, etc.).

Status of activities (2)

On-going studies on active fault mapping with SAR and VHR optical imagery

- ✓ Support the GSRF Hubs : Aiming to derive models of multi-hazard risk to inform urban development planning for four major capital cities Quito (Ecuador), Istanbul (turkey), Nairobi (Kenya) and Kathmandu (Nepal) by the University of Leeds
- ✓ Active faulting in Dushanbe (Tajikistan) and Almaty (Kazakhstan) by the University of Oxford
- ✓ Mapping the effects of the Samos earthquake on both the physical and the building environment by NOA, AUTH, DUTH
- ✓ Mapping interseismic strain accumulation over the urban area of Tehran by the University of Tehran (*request awaiting approval*)

❖ *Short presentations on these activities to be given just after the Seimsic Hazards Demonstrator presentation.*

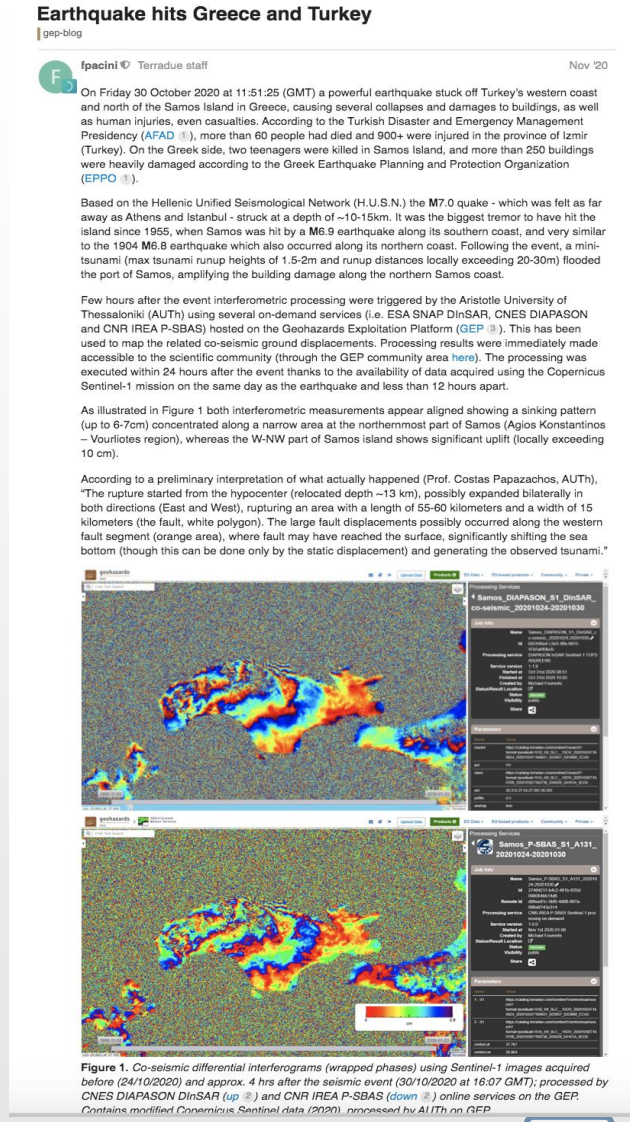
Promotion and publications

Papers, Presentations, Posters:

- Paper: **Contrasting seismic risk for Santiago, Chile, from near-field and distant earthquake sources** (University of Leeds)
- Paper: **Magnitude of the 1920 Haiyuan Earthquake Reestimated Using Seismological and Geomorphological Methods** (University of Leeds and University of Oxford)
- Paper in review (American Geophysical Journal): **Significant Seismic Risk Potential from Buried Faults Beneath Almaty City, Kazakhstan, revealed from high-resolution satellite DEMs** (Ruth M.J. Amey, John R. Elliott, Ekbal Hussain, Richard Walker, MarcoPagani, Vitor Silva, Kanatbek E. Abdrakhmatov, C. Scott Watson)

Web articles and Twitter:

- https://eo4society.esa.int/2019/07/30/mapping-the-faults-of-2019-california-earthquakes-with-sentinel-1-2
- https://discuss.terradue.com/t/earthquake-hits-greece-and-turkey/950
- Several tweets published



Earthquake hits Greece and Turkey

gep-blog

fpacini · Terradue staff · Nov '20

On Friday 30 October 2020 at 11:51:25 (GMT) a powerful earthquake stuck off Turkey's western coast and north of the Samos Island in Greece, causing several collapses and damages to buildings, as well as human injuries, even casualties. According to the Turkish Disaster and Emergency Management Presidency (AFAD), more than 60 people had died and 900+ were injured in the province of Izmir (Turkey). On the Greek side, two teenagers were killed in Samos Island, and more than 250 buildings were heavily damaged according to the Greek Earthquake Planning and Protection Organization (EPPO).

Based on the Hellenic Unified Seismological Network (H.U.S.N.) the M7.0 quake - which was felt as far away as Athens and Istanbul - struck at a depth of ~10-15km. It was the biggest tremor to have hit the island since 1955, when Samos was hit by a M6.9 earthquake along its southern coast, and very similar to the 1904 M6.8 earthquake which also occurred along its northern coast. Following the event, a mini-tsunami (max tsunami runup heights of 1.5-2m and runup distances locally exceeding 20-30m) flooded the port of Samos, amplifying the building damage along the northern Samos coast.

Few hours after the event interferometric processing were triggered by the Aristotle University of Thessaloniki (AUTh) using several on-demand services (i.e. ESA SNAP DInSAR, CNES DIAPASON and CNR IREA P-SBAS) hosted on the Geohazards Exploitation Platform (GEP). This has been used to map the related co-seismic ground displacements. Processing results were immediately made accessible to the scientific community (through the GEP community area here). The processing was executed within 24 hours after the event thanks to the availability of data acquired using the Copernicus Sentinel-1 mission on the same day as the earthquake and less than 12 hours apart.

As illustrated in Figure 1 both interferometric measurements appear aligned showing a sinking pattern (up to 6-7cm) concentrated along a narrow area at the northernmost part of Samos (Agios Konstantinos – Vourliotes region), whereas the W-NW part of Samos island shows significant uplift (locally exceeding 10 cm).

According to a preliminary interpretation of what actually happened (Prof. Costas Papazachos, AUTh), "The rupture started from the hypocenter (relocated depth ~13 km), possibly expanded bilaterally in both directions (East and West), rupturing an area with a length of 55-60 kilometers and a width of 15 kilometers (the fault, white polygon). The large fault displacements possibly occurred along the western fault segment (orange area), where fault may have reached the surface, significantly shifting the sea bottom (though this can be done only by the static displacement) and generating the observed tsunami."

Figure 1. *Co-seismic differential interferograms (wrapped phases) using Sentinel-1 images acquired before (24/10/2020) and approx. 4 hrs after the seismic event (30/10/2020 at 16:07 GMT); processed by CNES DIAPASON DInSAR (up) and CNR IREA P-SBAS (down) online services on the GEP. Contains modified Copernicus Sentinel data (2020), processed by AUTh on GEP.*

Seismic Demonstrator needs

Based on our experience in the Demonstrator since 2018, the activity (as well as a potential follow-on activity) needs:

- ✓ **To continue VHR data provision.** Since 2018, the most used data are VHR data (Pleiades imagery).
- ✓ **L-band SAR alternative solutions**. A few requests have been received (and finally rejected) for ALOS-2 (L-band) data.
- ✓ **To define a semi-automated data request procedure** (e.g. online data request form submission, notification to each WGD lead and evaluation by each CEOS agency concerned)
- ✓ **To have a link on the CEOS WGD webpages explaining the procedure and allowing online access to the necessary data request forms** for submission (at first it can be done separately for each Pilot activity and then once semi-automated it can be centralized)
- ✓ **To promote that CEOS WGD data can be requested from the broader EO seismic community.** The Demonstrator supports EO studies focusing on regions spread worldwide, although requests come from a small group of partners.

Next steps

As Demonstrator activity shall be concluded in end of 2021 it is important to:

- Make sure there is **no interruption in data provision** for on-going projects
- Understand **how user needs have changed** and **how EO data requirements have evolved** (do they still need data? What data are missing? Should we provide more than data?)
  - The Review Process of the Santorini Report could help in this
- Depending on the needs, **re-shape** the Demonstrator activity **to better address the user/community needs**

Thank you

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