The Geohazard Supersites and Natural Laboratories GEO initiative

Stefano Salvi, Chair of the GEO-GSNL initiative

GSNL

GEO GROUP ON EARTH OBSERVATIONS

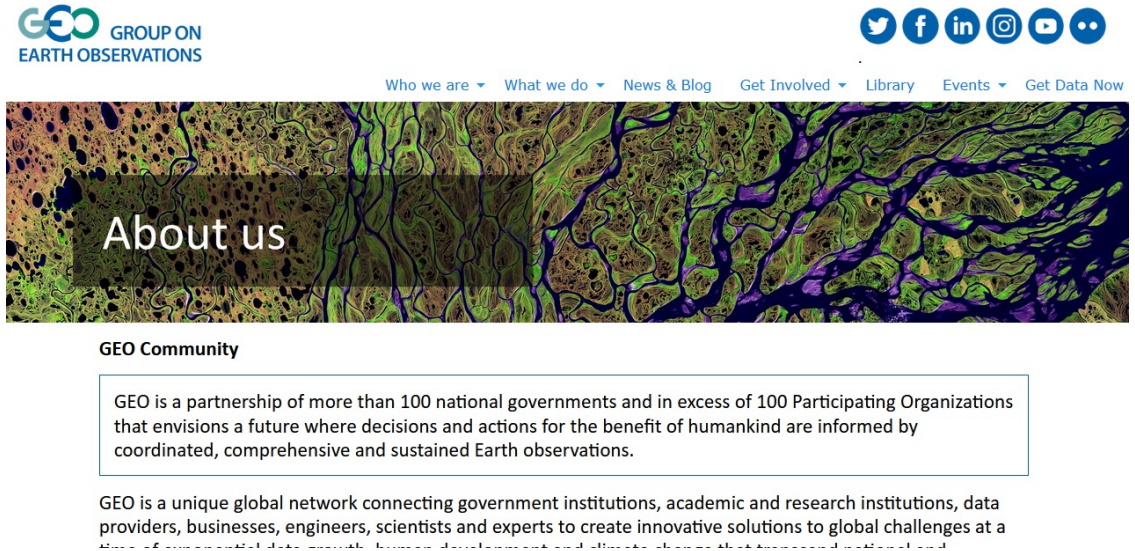
EPOS EUROPEANPLATEOBSERVINGSYSTEM

The EPOS SP project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 871121

GROUP ON EARTH OBSERVATIONS

The Group on Earth Observations is an intergovernmental partnership aiming to **improve international collaboration in environmental monitoring**.

GEO provides a framework for projects and initiatives to **stimulate wider data access and more rapid societal benefits** of science.



http://www.earthobservations.org

EPOS EUROPEAN PLATE OBSERVING SYSTEM

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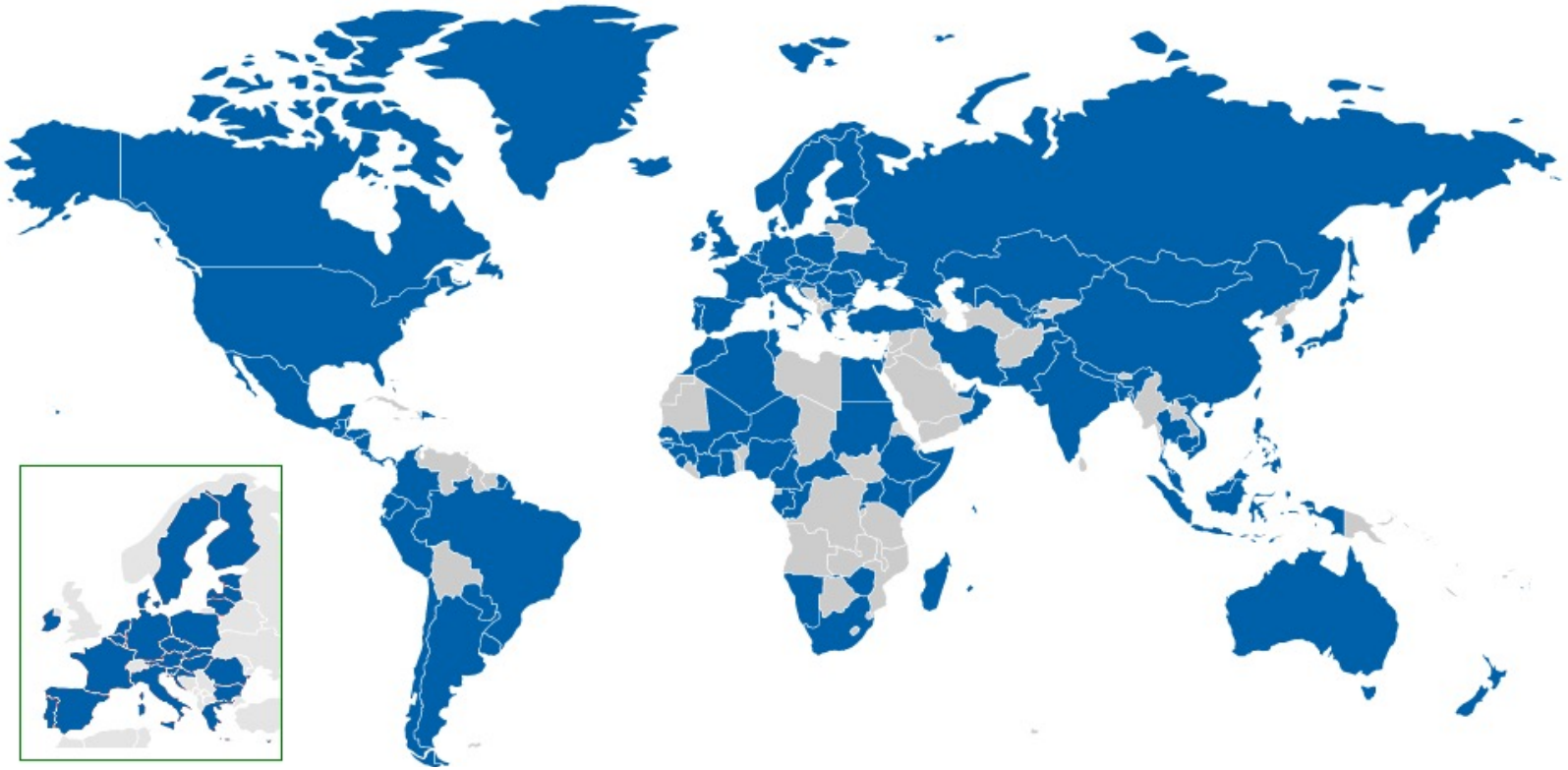
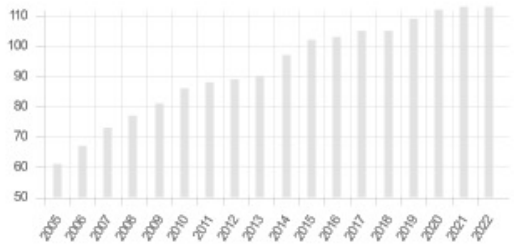
GROUP ON EARTH OBSERVATIONS : 110+ member countries



Number of Members (2022)

Africa:	30
Americas:	20
Asia/Oceania:	22
C.I.S.:	6
Europe:	35
Total:	113

Number of Members by year



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GEO: over 140 Participating International Organizations

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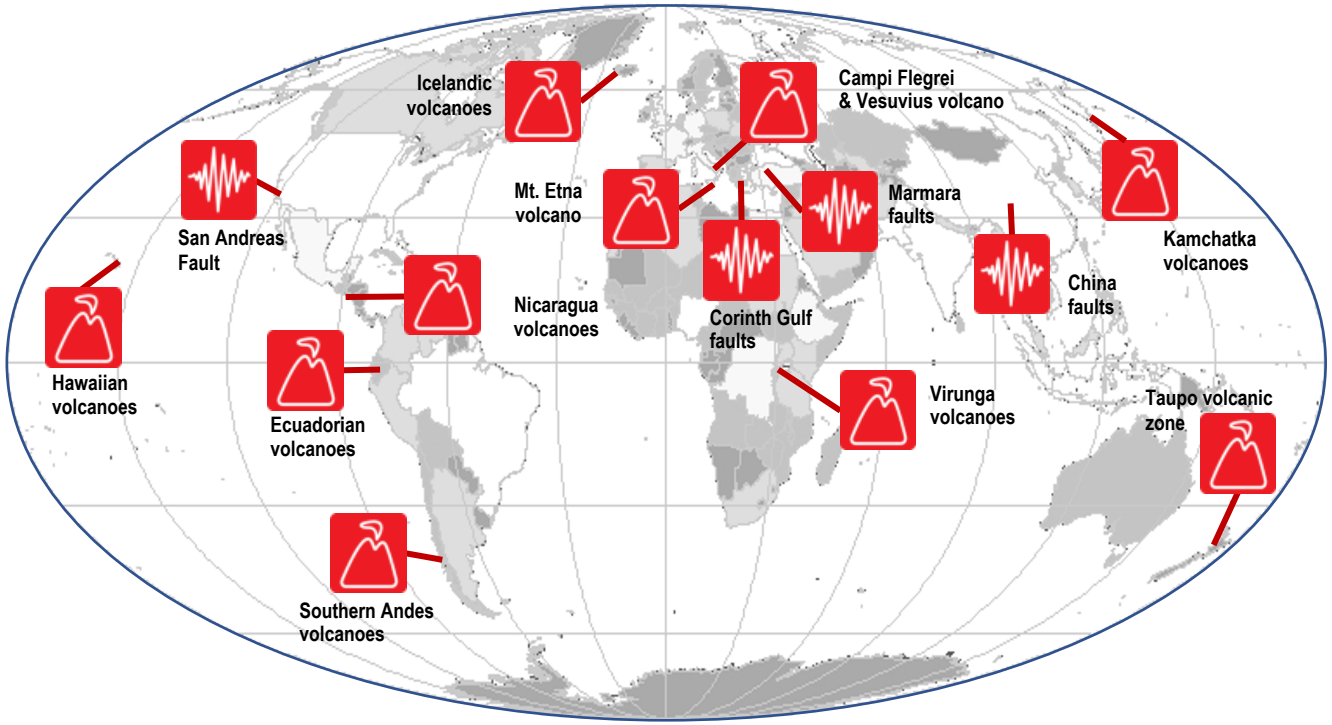
The GEO-GSNL initiative

Established in GEO in 2011, GSNL aims to improve **monitoring and research** on seismic and volcanic hazards, to stimulate better information support for **Risk Prevention and Emergency Response** by local governments**.**

We do so by promoting **international collaboration** and **Open Science.**

We now include 14 Geohazard Supersites and one Natural Laboratory worldwide:



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The GSNL partnership

- **Satellite data providers** (Space Agencies)

- **In situ data providers:** The Supersite Coordinators belong to the local hazard monitoring Institutes

- **The Supersite scientific community**, including over 150 scientists worldwide

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Supersite coordinators

Supersites are coordinated by scientific institutes which have a national mandate to provide scientific support to government agencies for DRM

			Institution
1			USGS-HVO, USA
2			Univ. of Iceland - IMO
3			INGV - Italy
4	***Campi Flegrei / Vesuvius***	S. Borgstrom	INGV - Italy
5	***Western North Anatolian Fault***	S. Ergintav,	KOERI, Turkey
6	***Taupo Volcano***	I. Hamling	GNS Science, NZ
7	***Ecuador volcanoes***	P. Mothes	Inst. Geofísico, Ecuador
8	***Corinth Gulf / Ionian Islands***	S. Lalechos	EPPO-OASP, Greece
9	***San Andreas Fault Nat. Lab.***	C. Wicks	USGS, USA
10	***Southern Andes volcanoes***	L. Lara	SERNAGEOMIN, Chile
11	***Virunga volcanoes***	C. Balagizi	GVO, DR Congo
12	***Kamchatka volcanoes***	A. Shevchenko	IVS, Kamchatka - Russia
13	***China faults***	Y. Shao	AIR - CAS, China
14	***Nicaragua volcanoes***	I. Cruz Martínez	INETER-Nicaragua

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The UN Sendai Framework for Disaster Risk Reduction

Priority 1: "DRR should be based on the knowledge of all risk components (science-based decision-making)"

Actions:

- Generate new data and strengthen scientific capacities
- Open access to data and risk information
- Conduct risk-related research at all scales
- Capacity building of local communities and decision-makers
- Promote dialogue and cooperation among scientists, practitioners and decision-makers

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Specific objectives of the GEO-GSNL initiative

1. To empower the Supersite scientific communities with **open and easy access to space- and ground data, knowledge, capacities and resources**;
2. to demonstrate how **Open Science** and international collaboration can improve the generation of actionable geohazard information;
3. to establish the conditions by which **decision makers can use high quality scientific information** for risk management and reduction;
4. to promote **innovation in technologies, processes and communication models**, fostering data sharing, global scientific collaboration, knowledge transfer and capacity development.

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GSNL promotes Open Science

1. **Open access to satellite and in-situ data.** For in-situ data we acknowledge that scientific communities in less developed countries could be damaged by a fully open data policy, and we allow specific data policy conditions to be implemented (e..g.; embargo period, involvement of local researchers).
2. **Use of Research Infrastructures** to access and share data and scientific knowledge according to the FAIR principles, and for data analysis/processing.

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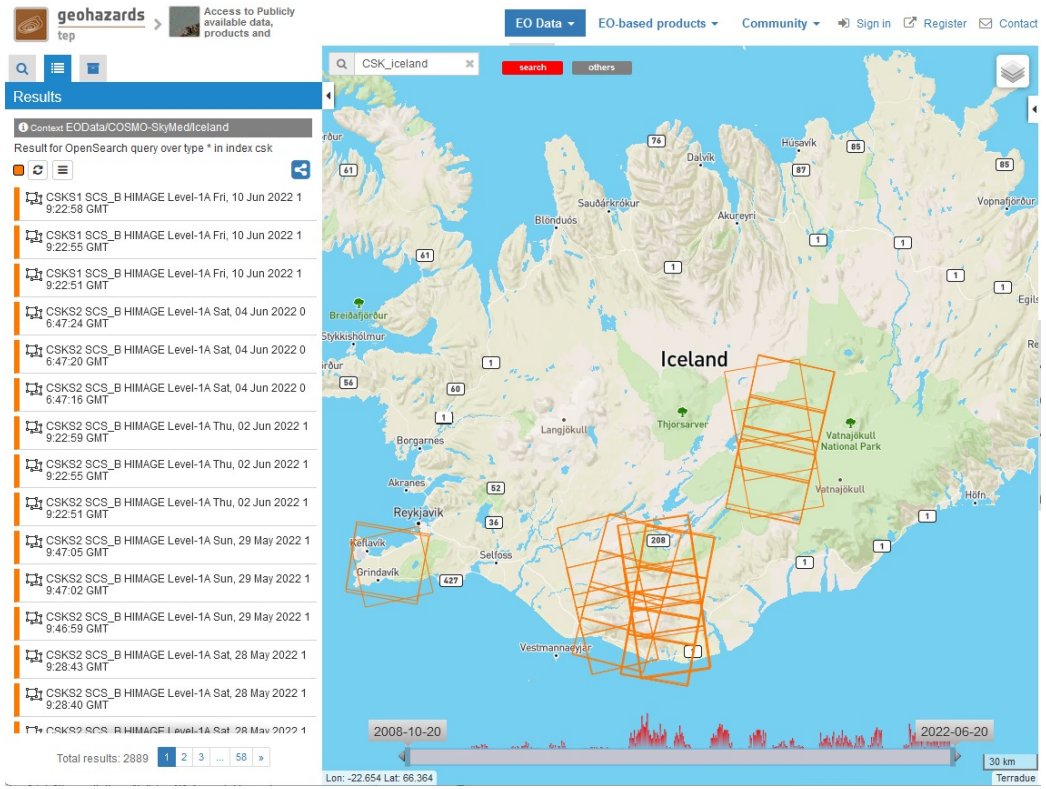
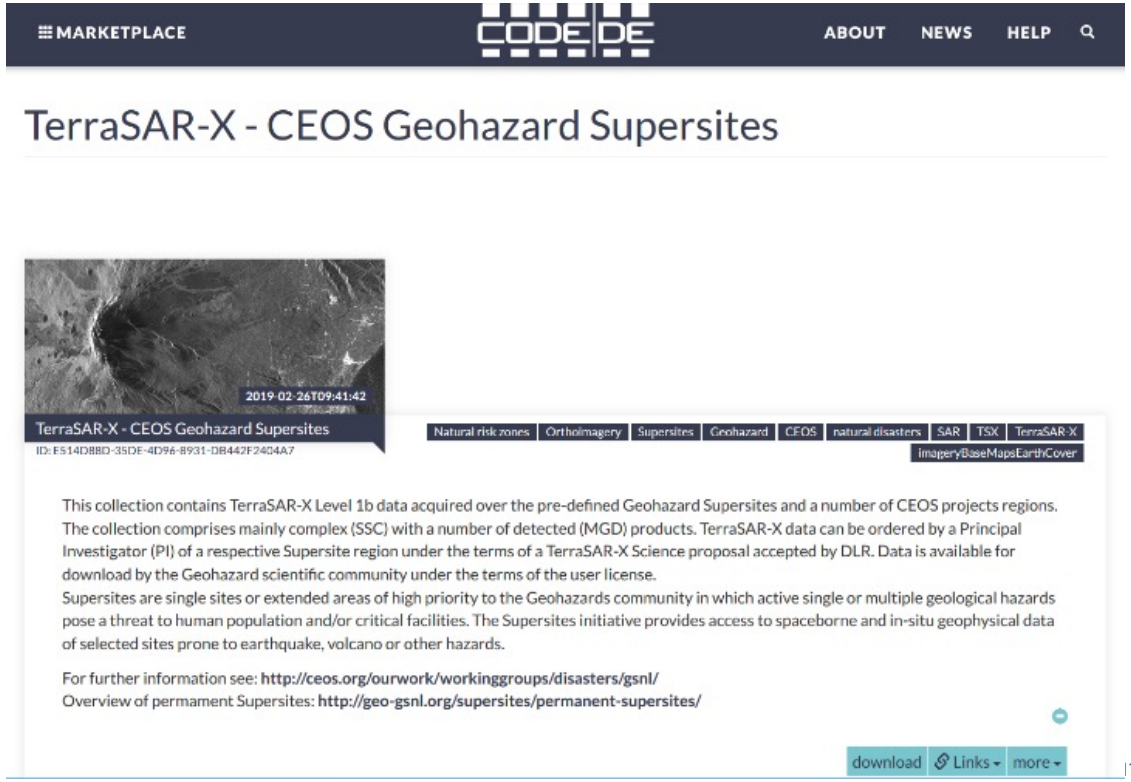
Open satellite Earth Observation data

- CEOS space agencies provide access to hundreds (3-500) of satellite images per year at each Supersite, for a total monetary value in excess of 7 M$/year.
- Data and results are made accessible through community portals: GEP, DLR's CODE-DE, UNAVCO-SSARA, EPOS ICS.





Annual image quota per Supersite

Supersite	COSMO-SkyMed	TerraSAR X	SAOCOM	Pléiades
Hawaii	250	70	tbd	1200 km²
Iceland	700	250	tbd	5000 km²
Etna	200	-	tbd	1200 km²
Vesuvio	200	130	tbd	1200 km²
Marmara	200	250	200	1200 km²
Ecuador	200	130	tbd	Not requested
New Zealand	200	130	tbd	Not requested
Corinth Gulf	120	120	tbd	400 km²
San Andreas Fault	1600	320	tbd	Not requested
Southern Andes	400	150	tbd	10000 km²
Virunga	450	-	tbd	11000 km²
Nicaragua	200	135	tbd	4000 km²

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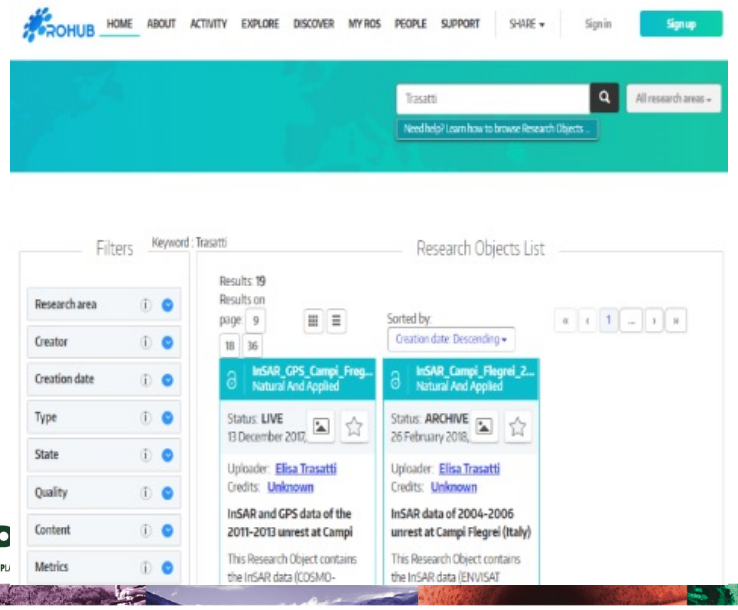
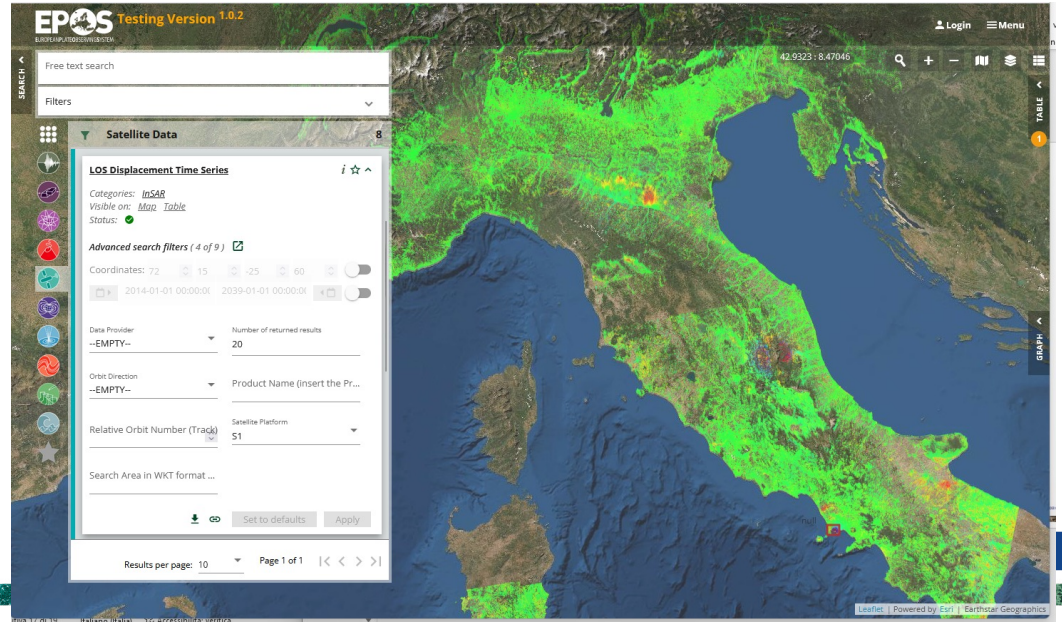
Community research infrastructures

- The **Geohazard Exploitation Platform** (https://geohazards-tep.eu) is used to access and process satellite data. Processing is not free but can be sponsored by ESA.
- Services provided by **UNAVCO** (www.unavco.org) can be used to access EO and GNSS data and process them.
- The Research Object HUB (https://reliance.rohub.org) can be used to exchange knowledge.
- Services from the **EPOS** research infrastructure can be used to access satellite and in-situ data and research products. In the future also for data processing.





Training and capacity development

- We try to support Supersites where local scientists are in need of training and capacity development.
- We do this by mobilizing resources from other Supersites and project funding.
- At present we provide training on SAR data analysis and volcano/earthquake source modeling. We can organize further training courses on request.
- For temporary mid-term needs (up to 2-3 years) we can provide to local Supersite scientists cloud computing resources including state of the art processing software.
- Opportunities for post-graduate education abroad can be identified with the help of the Supersite communities.
- In case of need we can help to identify resources for equipment, e.g. through donations or permanent loans.

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GSNL resources

- GSNL is mainly functioning on in kind resources provided by the partners
- Several million Euro per year is the value of in-kind resources, made available as data, labour, infrastructures.
- Direct funding is normally obtained by the participants from national and international competitive calls. E.g., the EC has directly funded development of three European Supersites (18 M€), a Virtual Research Environment (6 M€), trans-national laboratory access (2 M€), Supersite Research Object development.
- Development funding is sought for Supersites in less developed countries with support from GEO.

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GSNL promotes fair and ethical research

We promote fair and ethical collaboration, which means that:

- Especially in less developed countries, international scientists requesting access to data should pursue the active involvement of local scientists, such that there is a **transfer of knowledge** and **development of local capacities**.
- To join the community, everyone should embrace Open Science, accepting to share his/her data and knowledge. If necessary, a specific **Supersite Data Policy** can be negotiated.
- **During a seismic/volcanic crisis** the international scientific community is invited to collaborate with the local scientists to produce data and research able **to support the local Response activities**, not to aim for rapid scientific publication. Direct sharing of information with the media by the international scientists is discouraged, public release of scientific information should be coordinated by the local scientists, acknowledging the authorship.

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Science-based decision making

- Open Science and international collaboration eventually result in a better understanding of hazard sources and characteristics.
- The new scientific results can support better decision-making processes for risk prevention and response.
- It is the responsibility of the Supersite managing institutions to provide scientific information to decision makers. The Supersite Coordinator is expected to coordinate the support from the international Supersite scientific community.

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Supersite End-Users

Supersite	Official end-users
Hawaiian volcanoes	Hawaii County Civil Defense, Hawaii Volcanoes National Park
Icelandic volcanoes	Icelandic Police – Dept. of Civil Protection, Environmental Agency, Directorate of Health
Mt.Etna volcano	National Department of Civil Protection, Regional Civil Defense
Campi Flegrei/Vesuvius volc.	National Department of Civil Protection, Regional Civil Defense
Marmara Fault	Istanbul municipality
Ecuadorian volcanoes	Secretariat for Risk Management, Regional governments, Municipalities
Taupo volcanic zone	Ministry of Civil Defence and Emergency Management, Department of Conservation, Regional councils, MetService
Gulf of Corinth- Ionian Islands	Greek Civil Defence
Southern Andes volcanoes	ONEMI, Ministry of Interior and Public Safety of Chile
San Andreas Fault	California Office of Emergency Services, FEMA, local users
Virunga volcanoes	D.R. Congo and Rwanda Civil Defense Agencies
Kamchatka volcanoes	The Russian Civil Defence
China faults	China Earthquake Administration
Nicaragua volcanoes	SINAPRED, UNAN

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A few examples

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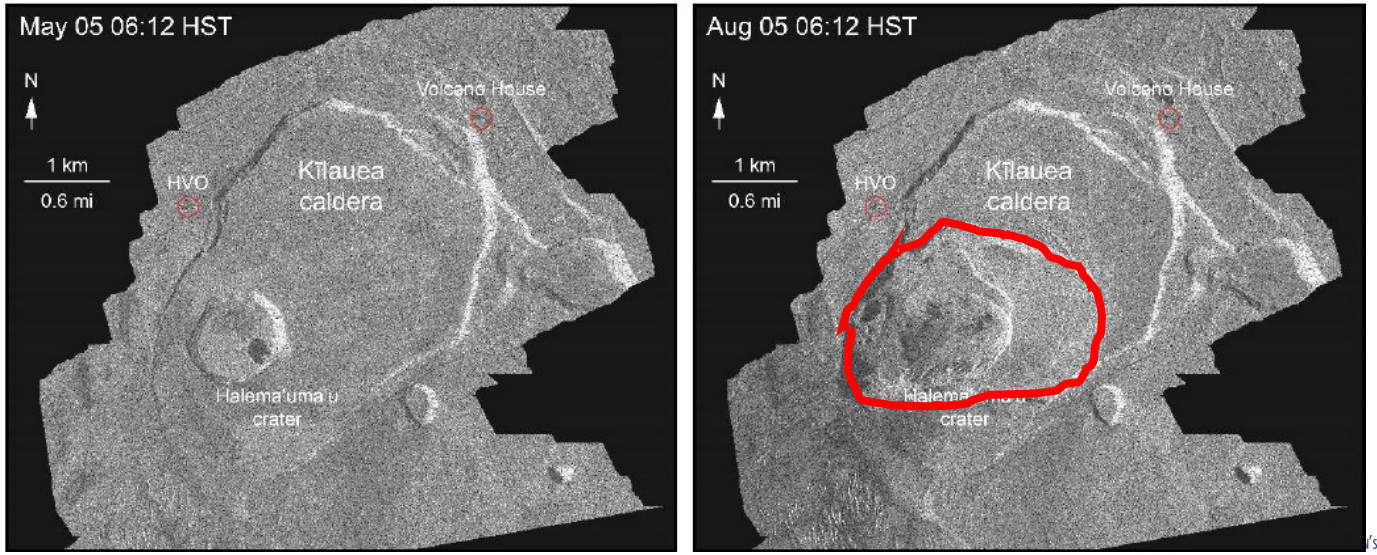
The 2018 Kilauea eruption

A new caldera formed in a 4-month period inside Kilauea, with ground displacements reaching 400 m at places. USGS followed in NRT the evolution of the eruption using the Supersite satellite data.

To monitor the caldera formation, repeated DEMs from 0.5 m resolution optical satellite data (Pleiades) were used.

High resolution InSAR monitoring with COSMO-SkyMed and TerraSAR X images has been critical for understanding how the subsidence was evolving over time.

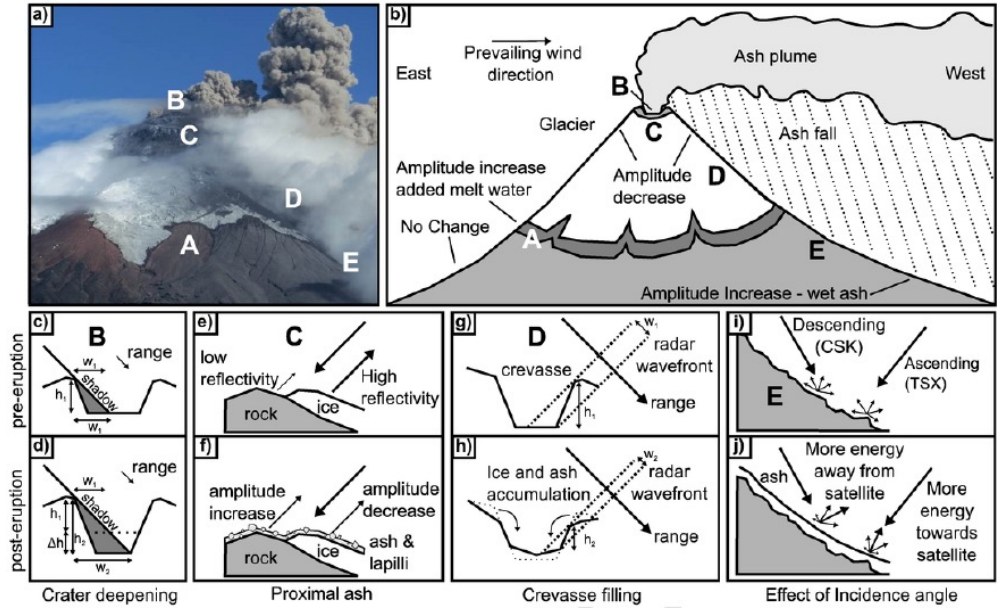
This information has been of crucial importance to the Hawai'i County Civil Defense, which is responsible for emergency response operations (including evacuations).

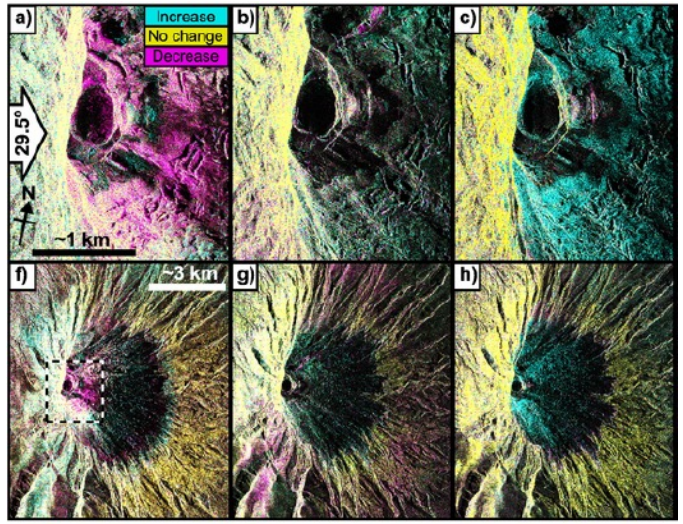


Images by HVO-USGS, 2018

's Horizon 2020 research and innovation programme under grant agreement N° 871121

Ecuador Supersite - Cotopaxi





COSMO-SkyMed and TerraSAR-X data were used to map volcanic deposits and landforms.

Important information for volcanic hazard assessment. Radar provides all-weather imaging capabilities, irrespective of clouds and volcanic plumes.

A collaboration among:

- *Instituto Geofisico EPN, Ecuador*
- *University of Bristol*
- *University of Reading*

Arnold et al., 2018

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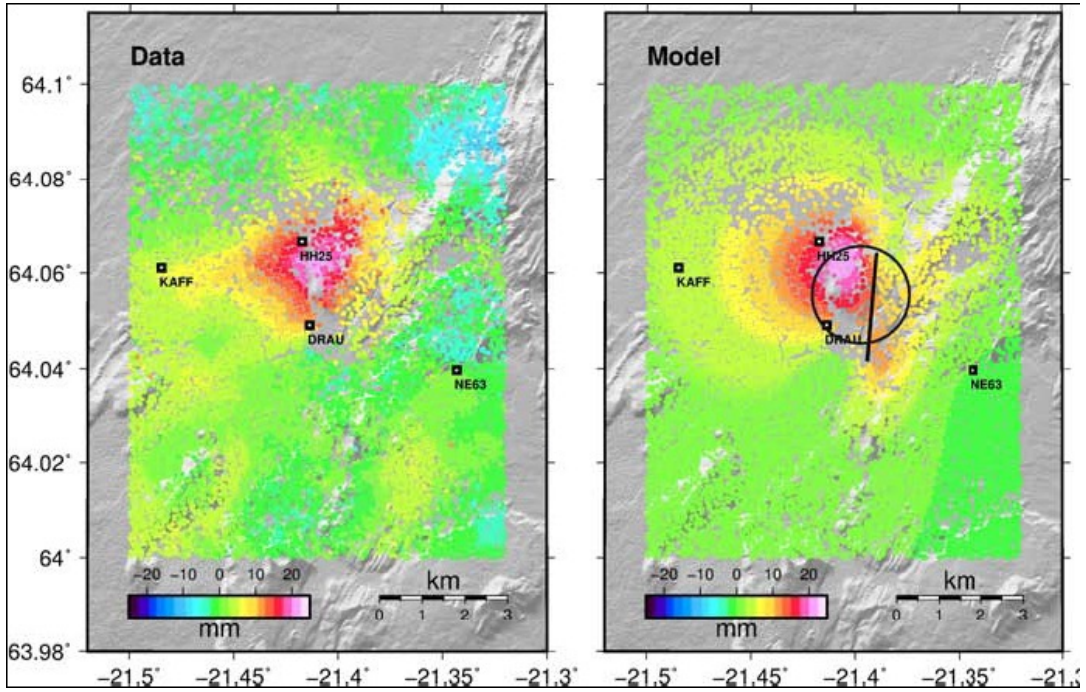
Induced seismicity in Iceland

Analysis of ground deformation from TerraSAR X InSAR time series data suggests that the local seismicity is induced by fluid injections by a geothermal power plants.

The information is used to identify the local seismic source, supporting the hazard assessment.



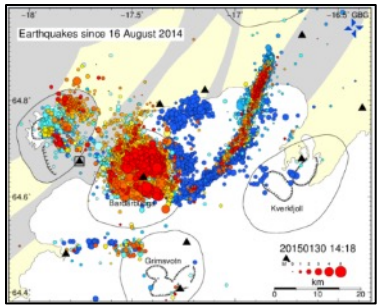
A collaboration among:

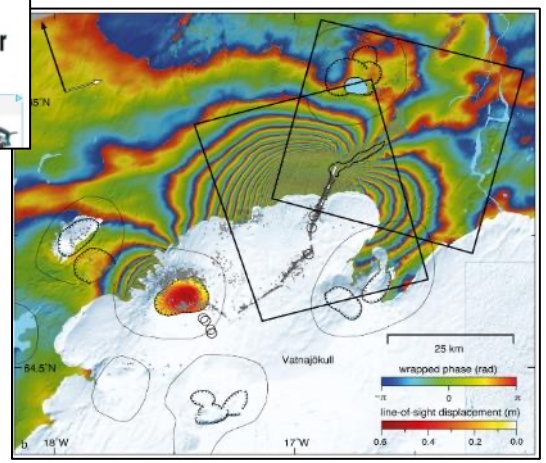
- *University of Iceland*
- *Icelandic Meteorological Office*
- *University of Leeds, UK*

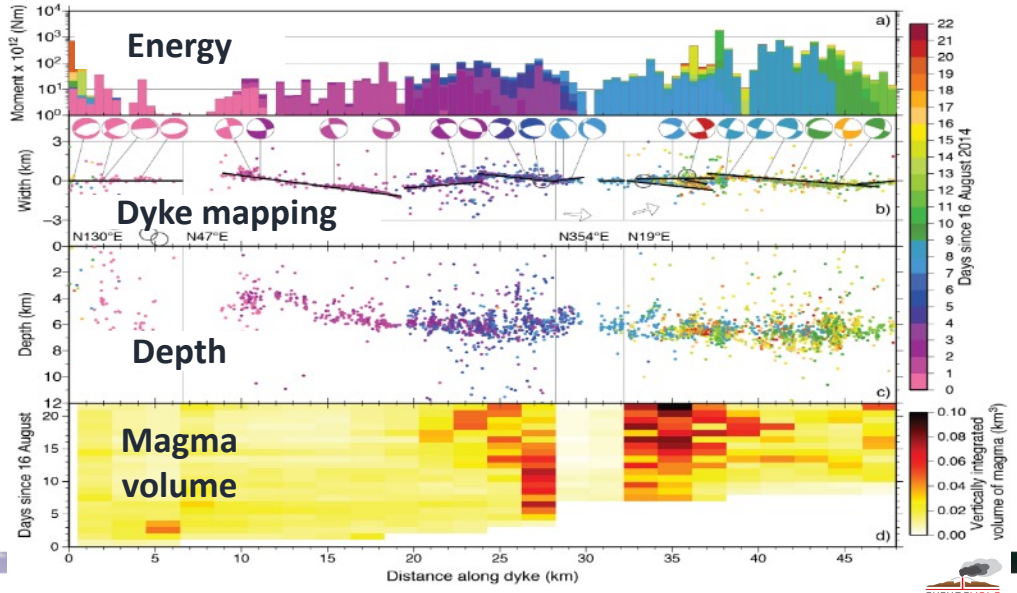
Junco et al., 2018

THE EPOS-SP PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT N° 871121

Bardabunga eruption, Iceland Supersite







Seismic, geodetic, InSAR, and field data were shared and jointly analysed.

A large team of researchers interpreted the results to provide evolutionary models for the eruption.

Scientific support helped decision makers (Civil Protection) to take important decisions as lowering the alert level for the aviation industry.

Research by:

- *University of Iceland, IS*
- *Iceland Meteorological Office, IS*
- *University of Cambridge, UK*
- *University of Leeds, UK*
- *University of Dublin, IR*
- *University of Gothenburg, SWE*
- *University of Arizona, USA*
- *Canada Centre for Mapping and Earth Observation, CAN*

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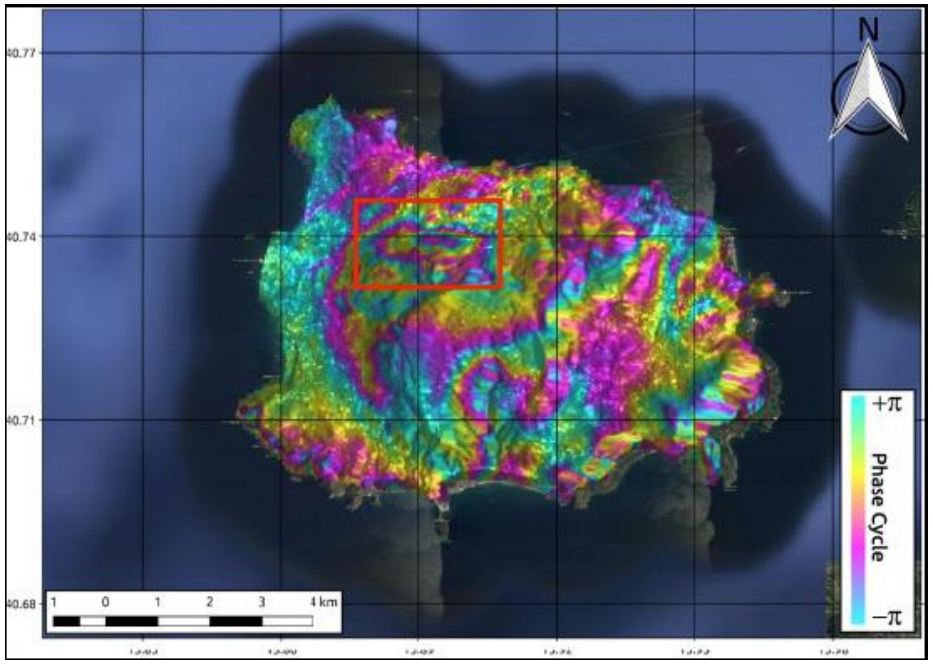
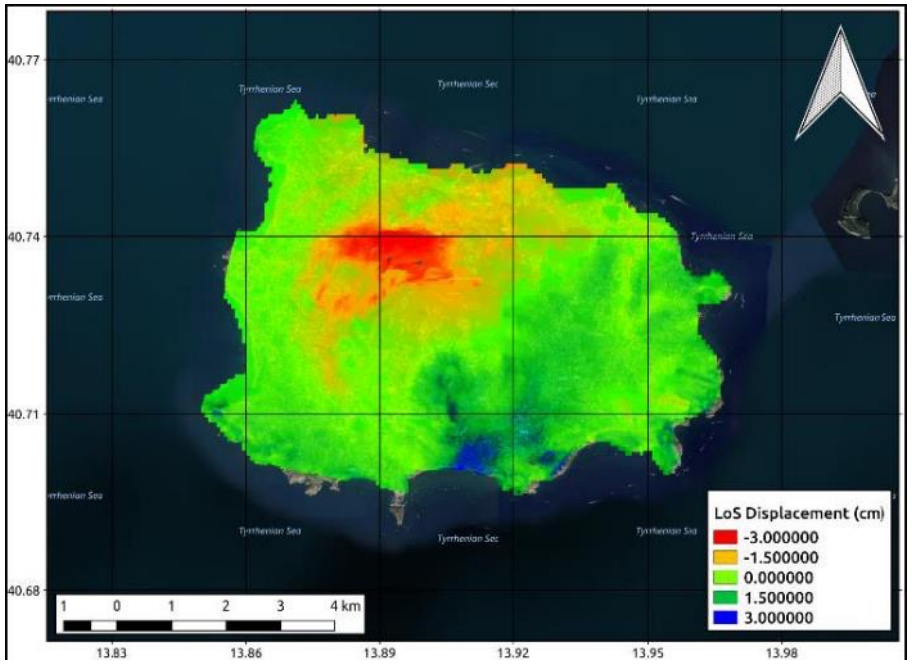
2017 Ischia earthquake - Campi Flegrei Supersite

Using CSK and S1 data INGV mapped the ground deformation caused by a shallow Mw 3.9 earthquake which caused 2 casualties.
Using a geotechnical model they find that the observed ground displacement is due to both fault slip and shallow gravitational sliding, the latter well correlated with strongly damaged areas.

The identification of the sources is a crucial component of local hazard assessment.





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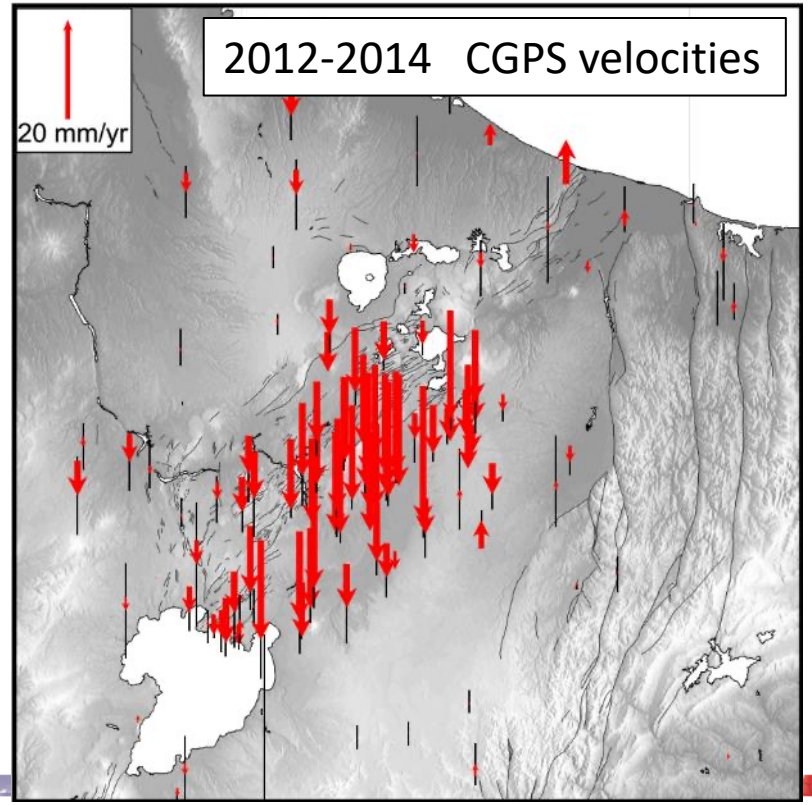
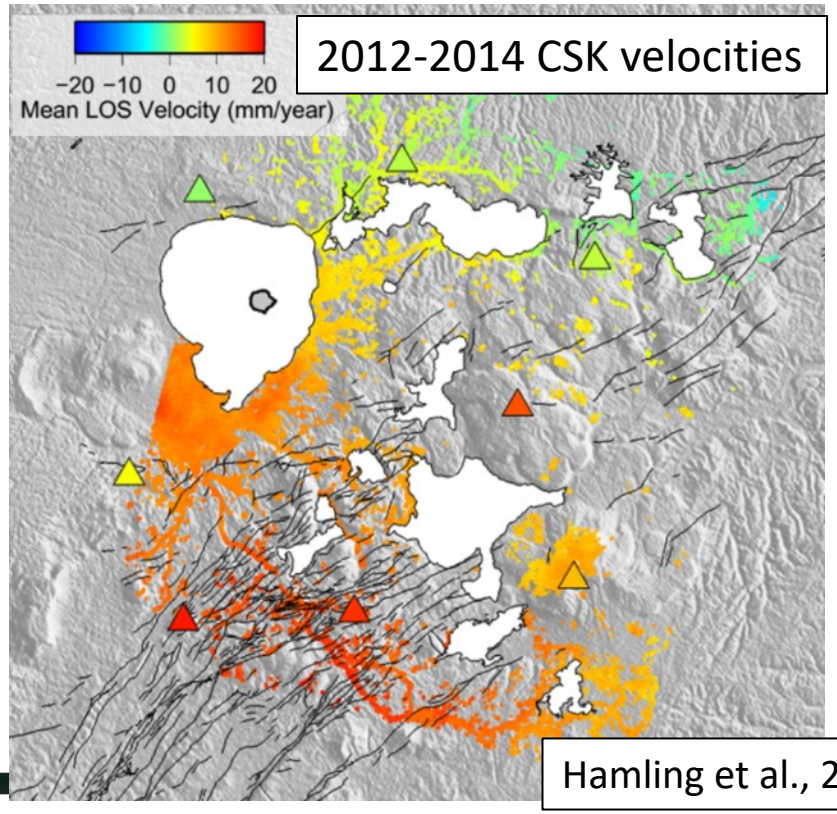
Albano et al, 2018, Geosciences

Okataina caldera - Taupo Supersite

Ground deformation is studied by GNS Science using S1, CSK InSAR data and GPS, and analysed jointly with seismological and magnetotelluric data to image the distribution of melt at depth.

Constraining the inversion of geodetic data with the crustal resistivity, proides an improved estimate of depth of the magma sources, contributing to volcanic hazard assessment.



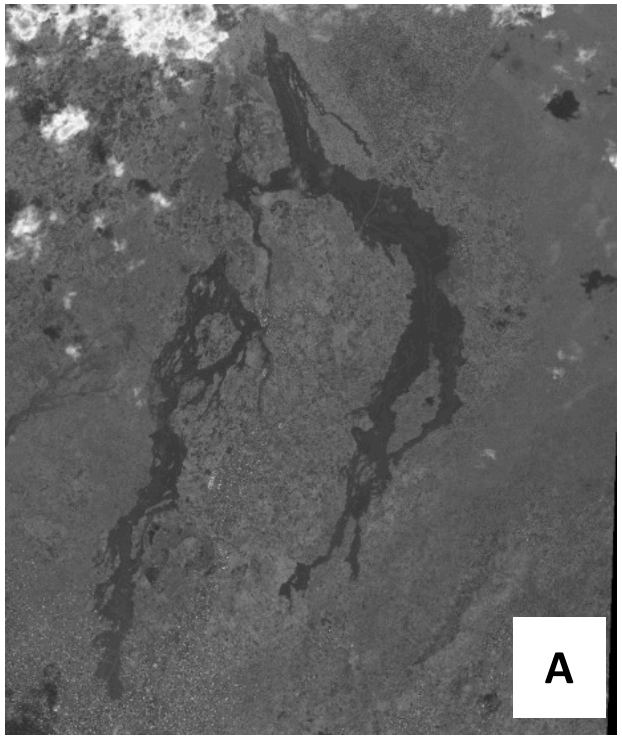


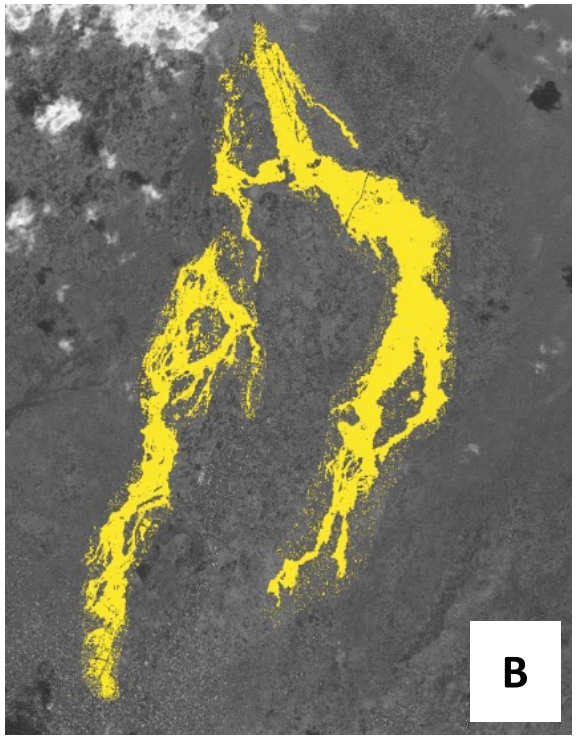
Hamling et al., 2018

AMME UNDER GRANT AGREEMENT N° 871121

Lava flow mapping during the 2021 Nyiragongo eruption

Comparing pre- and post-eruption Pléiades satellite images, the lava flow progress could be followed.
A: image acquired on 12 November 2021
B: lava flow field emplaced in May 2021 (yellow area from digital classification).





Results by G. Ganci, INGV, provided to the local scientific response team.

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Supersite numbers

- Over **8000 satellite images** per year are provided by CEOS to the Supersites
- Over **150 scientists** participate to the Supersite initiative
- The Virunga Supersite is the **first in a UN Least Developed Country**
- **18 M€** was the direct funding obtained by the European Supersites
- **7 M€/year** is the value of commercial satellite data contributed by the CEOS agencies to GSNL

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For more information

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