Geohazard Supersites and Natural Laboratories (GEO-GSNL)

Stefano Salvi (Chair of GEO-GSNL initiative)

WG Disasters 18, Nice

4, 5, 6 October 2022

CE**O**S

Committee on Earth Observation Satellites
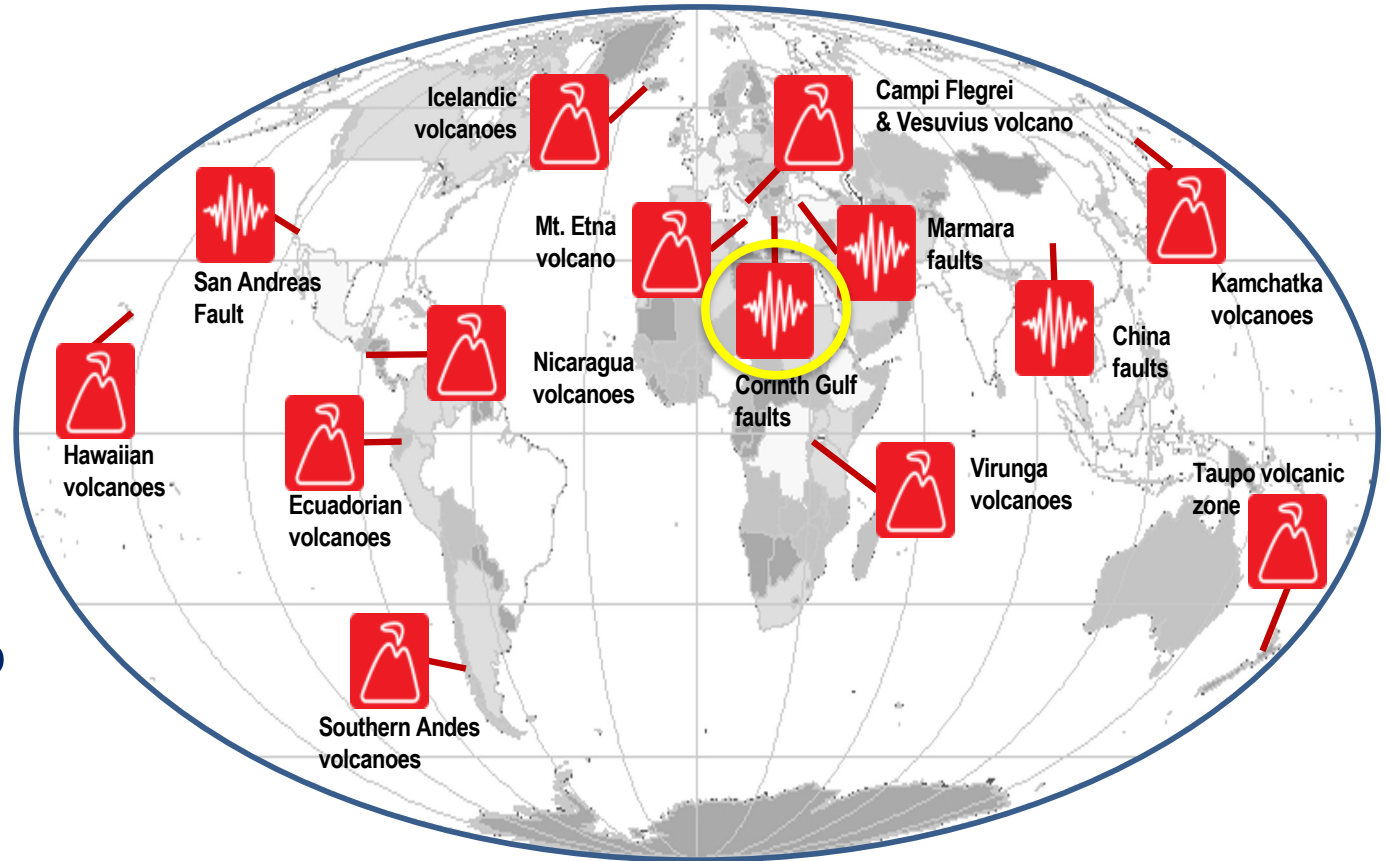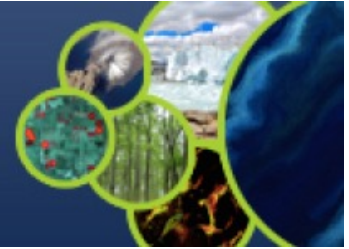
Status of Supersites
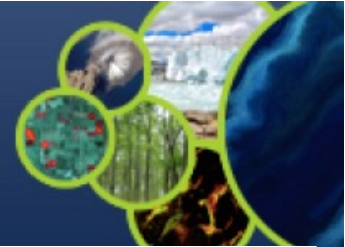
GSNL is presently a network of 14 Supersites

13 are supported by CEOS

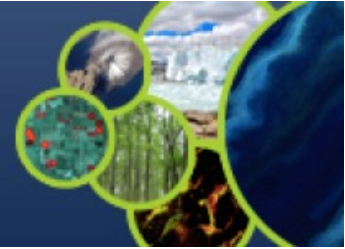Support to Enceladus Supersite withdrawn in April 2021 due to supersite inactivity (no use of image quotas).

Icelandic volcanoes

Campi Flegrei & Vesuvius volcano

San Andreas Fault

Mt. Etna volcano

Marmara faults

Kamchatka volcanoes

China faults

Nicaragua volcanoes

Corinth Gulf faults

Hawaiian volcanoes

Ecuadorian volcanoes

Virunga volcanoes

Taupo volcanic zone

Southern Andes volcanoes

EO data

- CSK and TSX data continue to be important SAR assets, although Sentinel 1 is the most widely used for ground deformation monitoring

- Pleiades data are also much requested for HR DEMs and geomorphological analysis

- SAOCOM L-band data are now part of the Supersite image quotas.

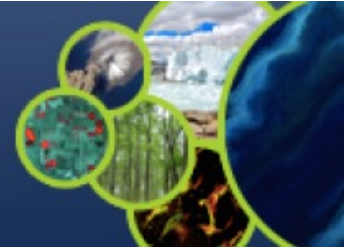We are very grateful to all the Agencies and the people who are making this happen

- There is a 62 ± 15% probability of strong shaking during the next 30 years for a M> 7 earthquake in Istanbul (32 ± 12% during the next decade).

- The population is becoming increasingly aware of the high risk affecting the area.

- The Supersite scientists continue to disseminate their results to the public through interviews and participation to national media events, as well as social media.
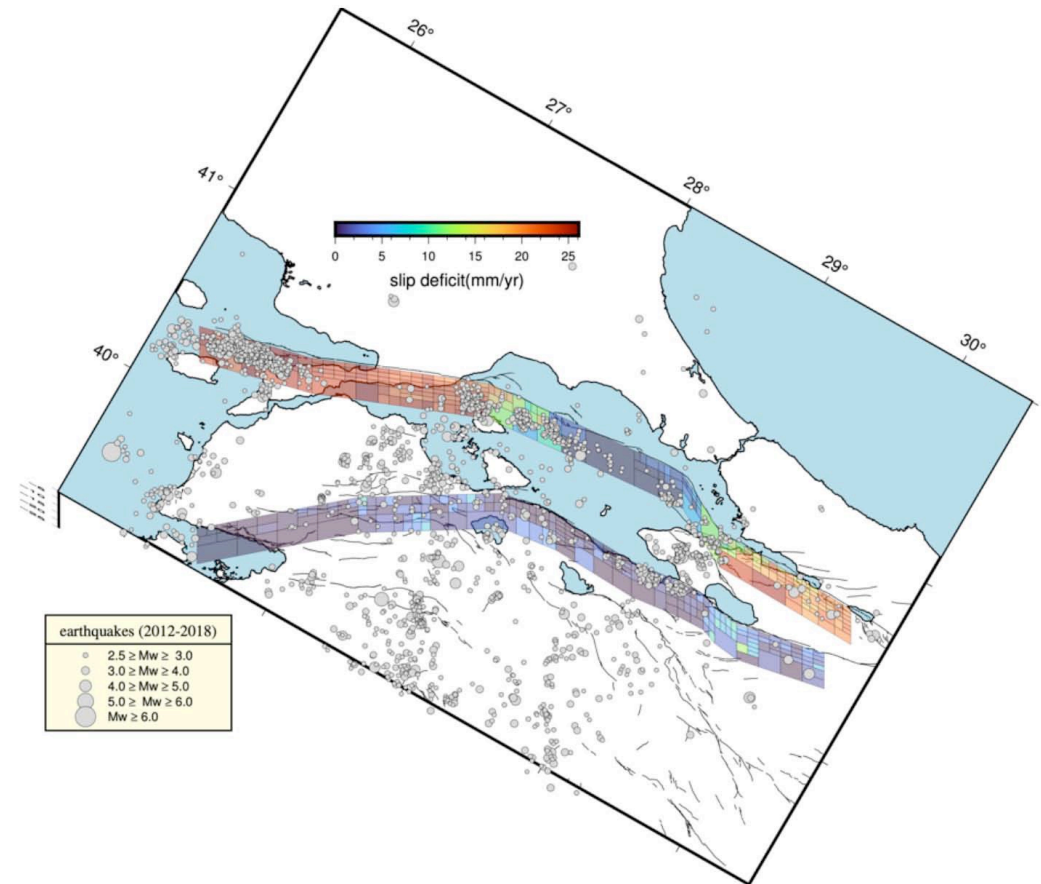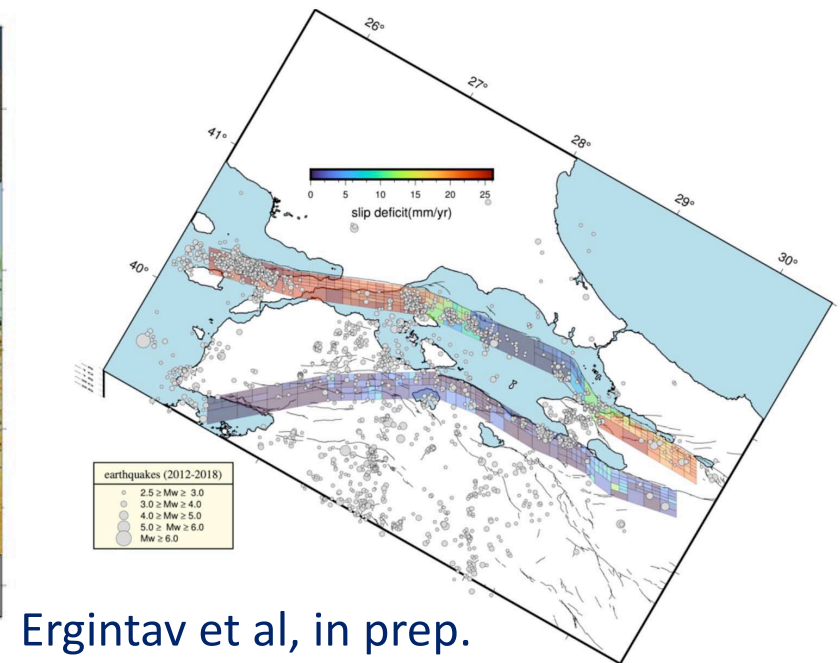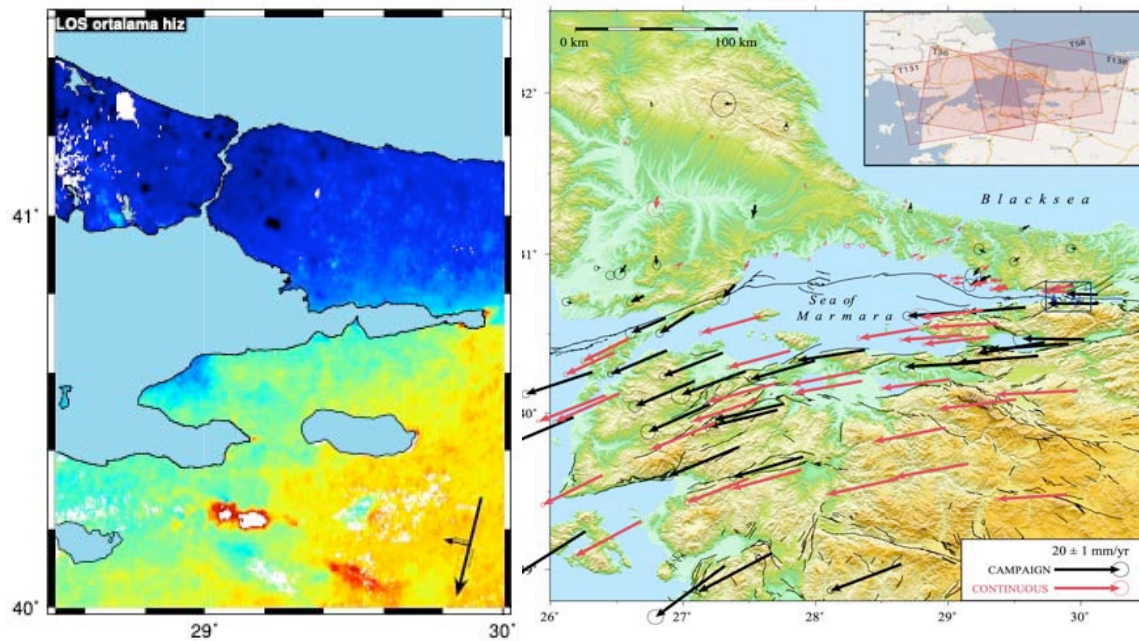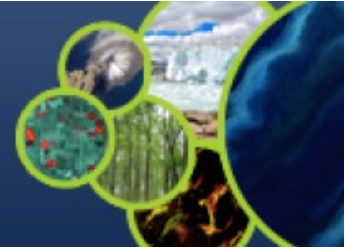
Marmara Fault Supersite

All available InSAR and GNSS data are used to generate a slip deficit model on the Marmara Fault which provides important information for the seismic hazard assessment.
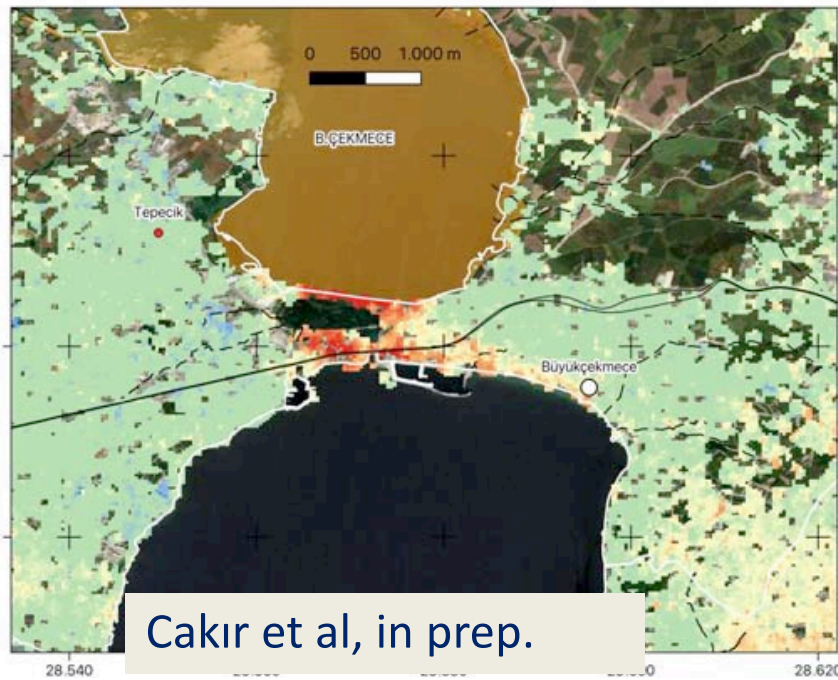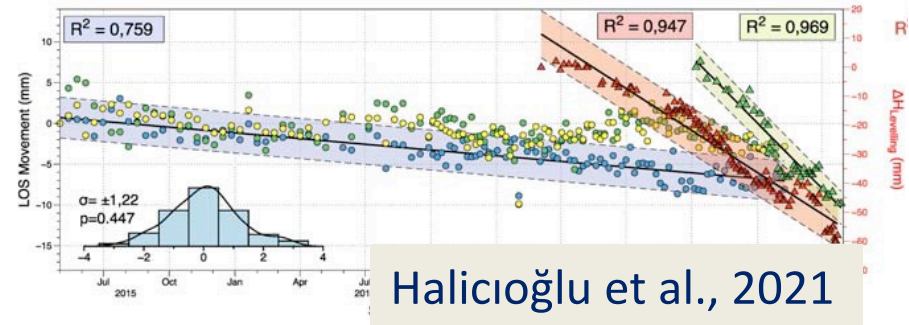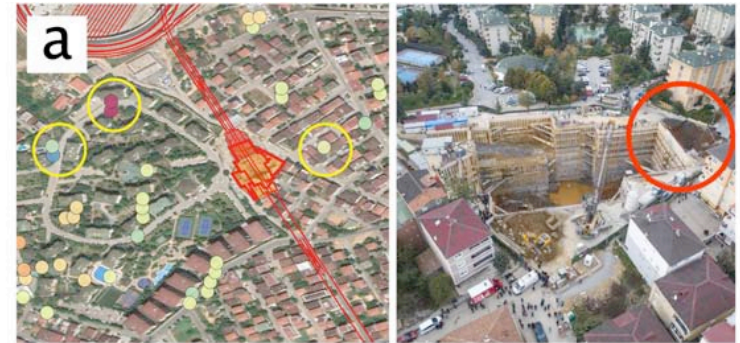

Ergintav et al, in prep.

InSAR is also used to investigate and monitor the stability of Istanbul critical infrastructures, as the Büyükçekmece dam and some metro stations.
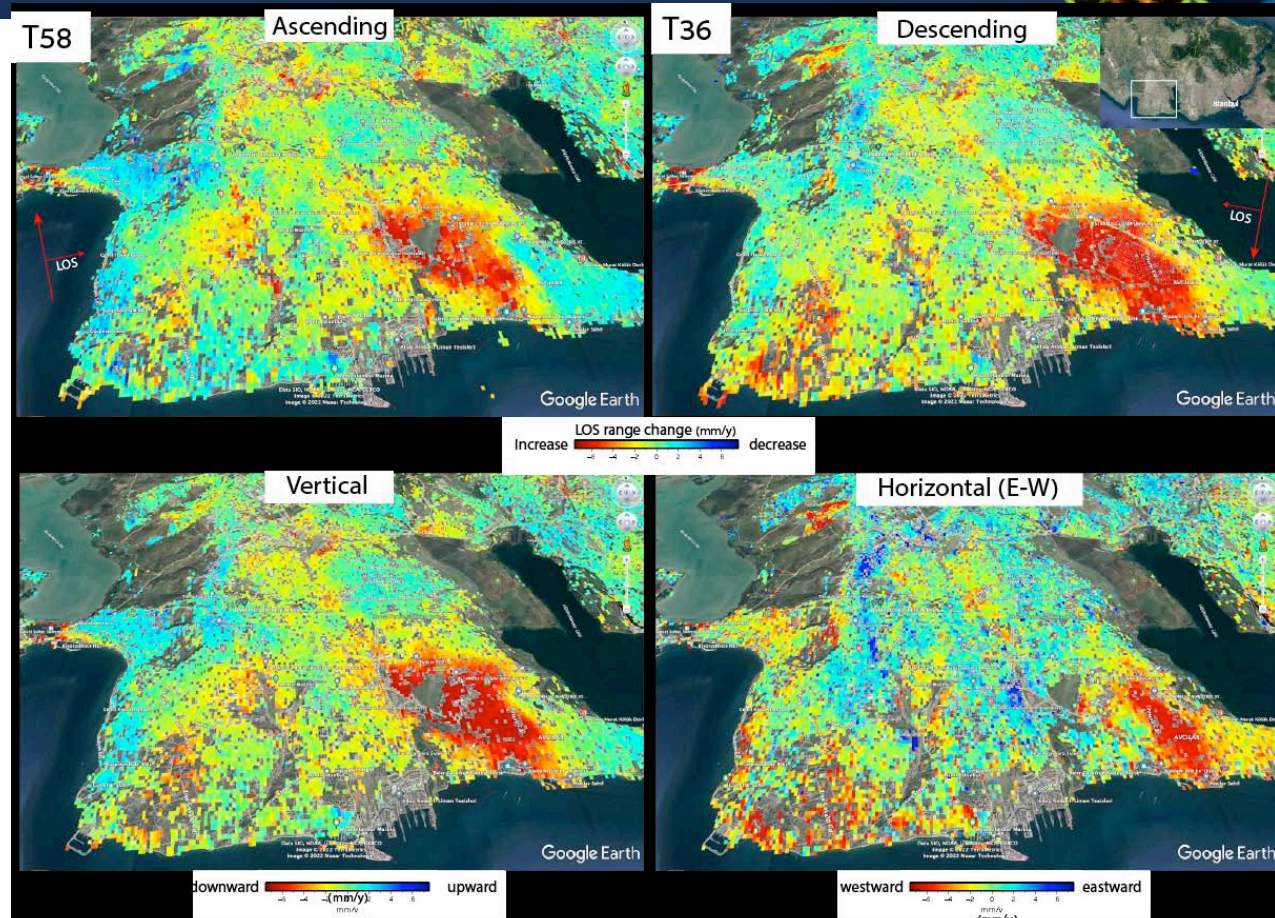

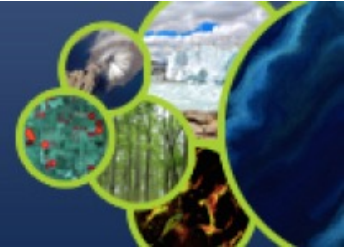
Cakır et al, in prep.

Halıcıoğlu et al., 2021

CEOS

A large landslide in western Istanbul is also monitored through Sentinel 1 data.

Cakır et al, in prep.

Marmara Fault Supersite

The Supersite coordinator informs the decision-makers at every appropriate opportunity.

The main end users are:

• The Istanbul Metropolitan Municipality (IBB)

• The Disaster and Emergency Management Authority of Turkey (AFAD)

In 2021 they started a project with the IBB to increase the public awareness about the seismic hazard and to improve the related risk plans. The project is based on the systematic analysis of PSInSAR deformation time series for Istanbul.

Kamchatka volcano Supersite
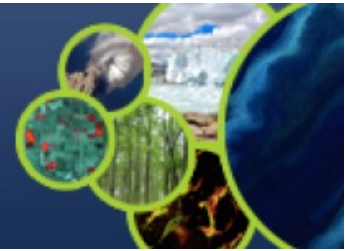
- The Supersite activities are suffering from the consequences of the war in Ukraine on travel to and from Russia.

- Access to new in situ data is more difficult, but the capacity to use satellite data for volcano monitoring is being increased.

- The main results so far were obtained on the Shiveluc volcano using Pleiades data for HR DEM generation.

- The image quota consumption is consistent only for Pleiades, but the Coordinator has plans for improvements.
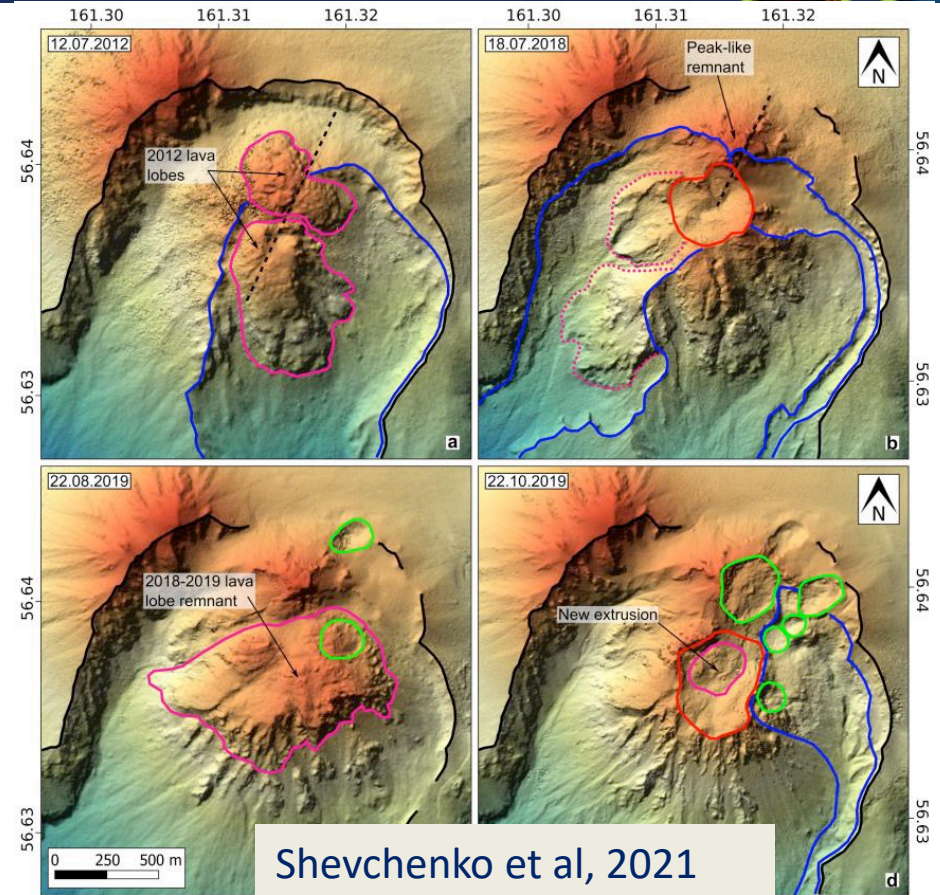
Kamchatka volcano Supersite
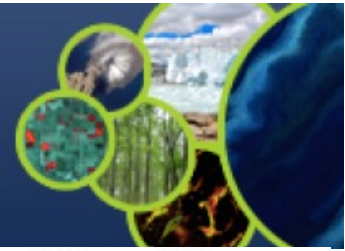
Topographic maps of the Shiveluch volcano dome during its complex evolution between 2012 and 2019.
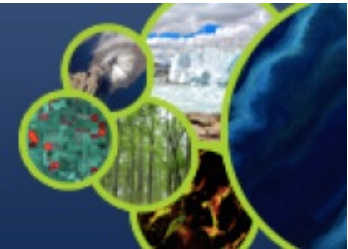
The DEMs were derived from aerial and Pleiades data, locally complemented by TDX data (not provided through the Supersite).

The maps allow to follow the construction and destruction of the new central craters (red circles) and of short-lived explosion craters (green circles).

———	1964 collapse amphitheater rim
———	Recent collapse scar rims
———	Recent extrusions
··········	Remnants of lava bodies exposed by collapses
- - - - -	Fracture
———	Central craters
———	Explosion craters

Shevchenko et al, 2021
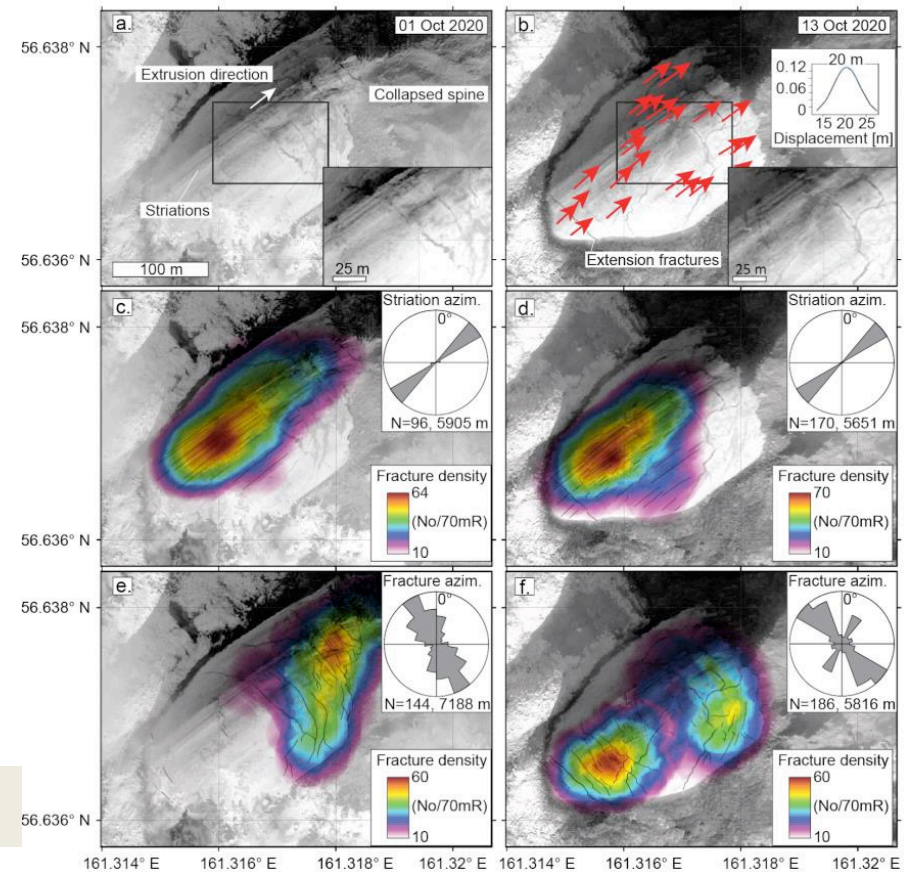
Kamchatka volcano Supersite

Fracture analysis of the 2020 Shiveluch magma spine, shown by two Pleiades orthophotos (October 1 and 13, 2020).

The colors in the images below show the fracture densities for different fracture orientations. The fracturing evolves with time and concentrates near the spine collapse region at higher elevations.
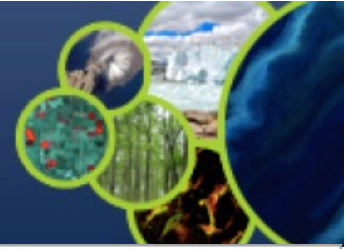
These results are relevant for understanding the growth and collapse hazards of spines and provide unique insights into the magma-conduit architecture.
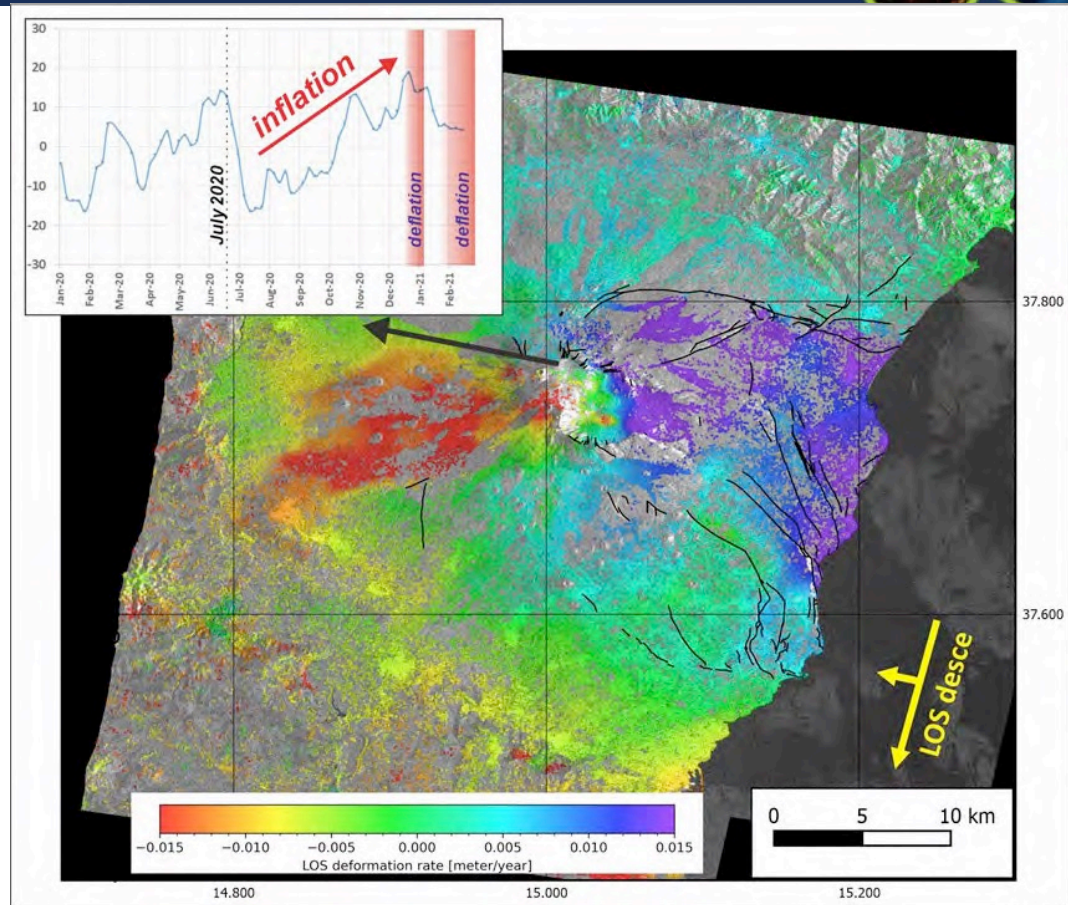
Walter et al, under review

Etna Volcano Supersite

Constant Sentinel 1 InSAR data processing is used to monitor the volcano, to identify eruption preparatory processes.

This recent ground displacement time series (2020-2021), shows the inflation phase of the volcano edifice, followed from deflation episodes associated to the 2021 paroxysms.

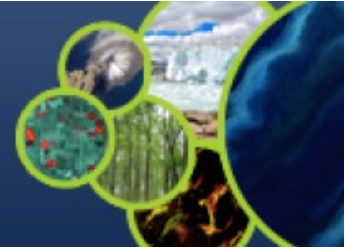Puglisi et al.

Etna Volcano Supersite

GNSS and MODIS were used for the tomography of the wet refractivity index , to calculate the tropospheric delays affecting InSAR measurements of ground motions.

Maximum tropospheric delays of 10 cm were observed and corrected in the Sentinel-1 interferograms, improving the accuracy of the ground deformation estimates.
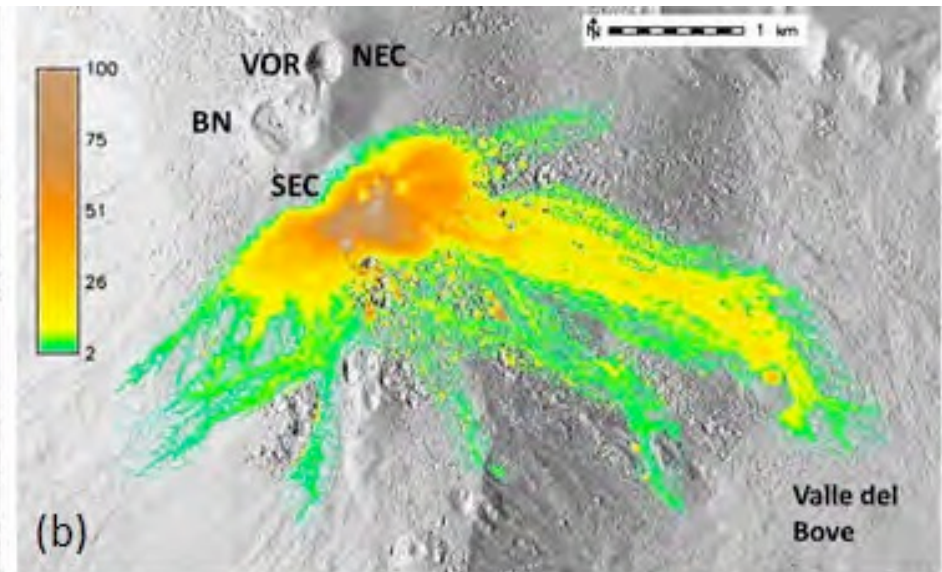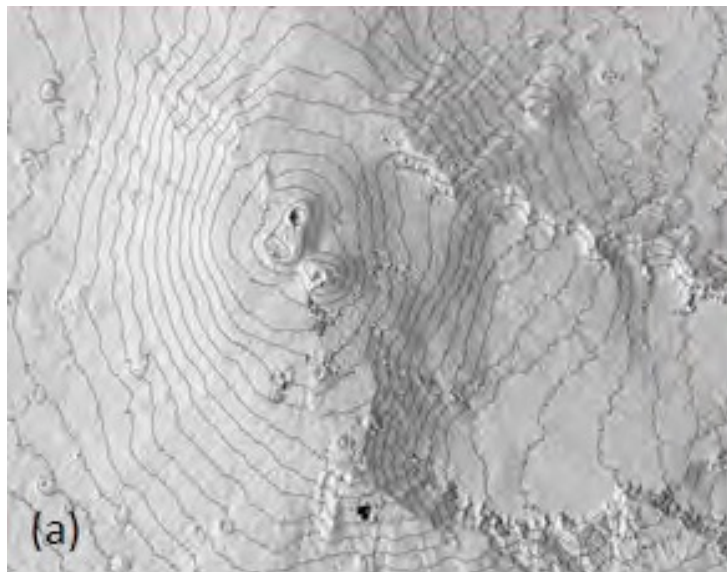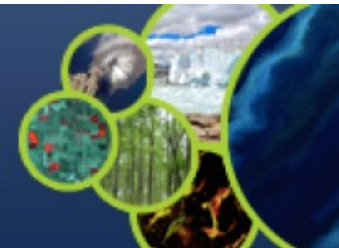

Puglisi et al.
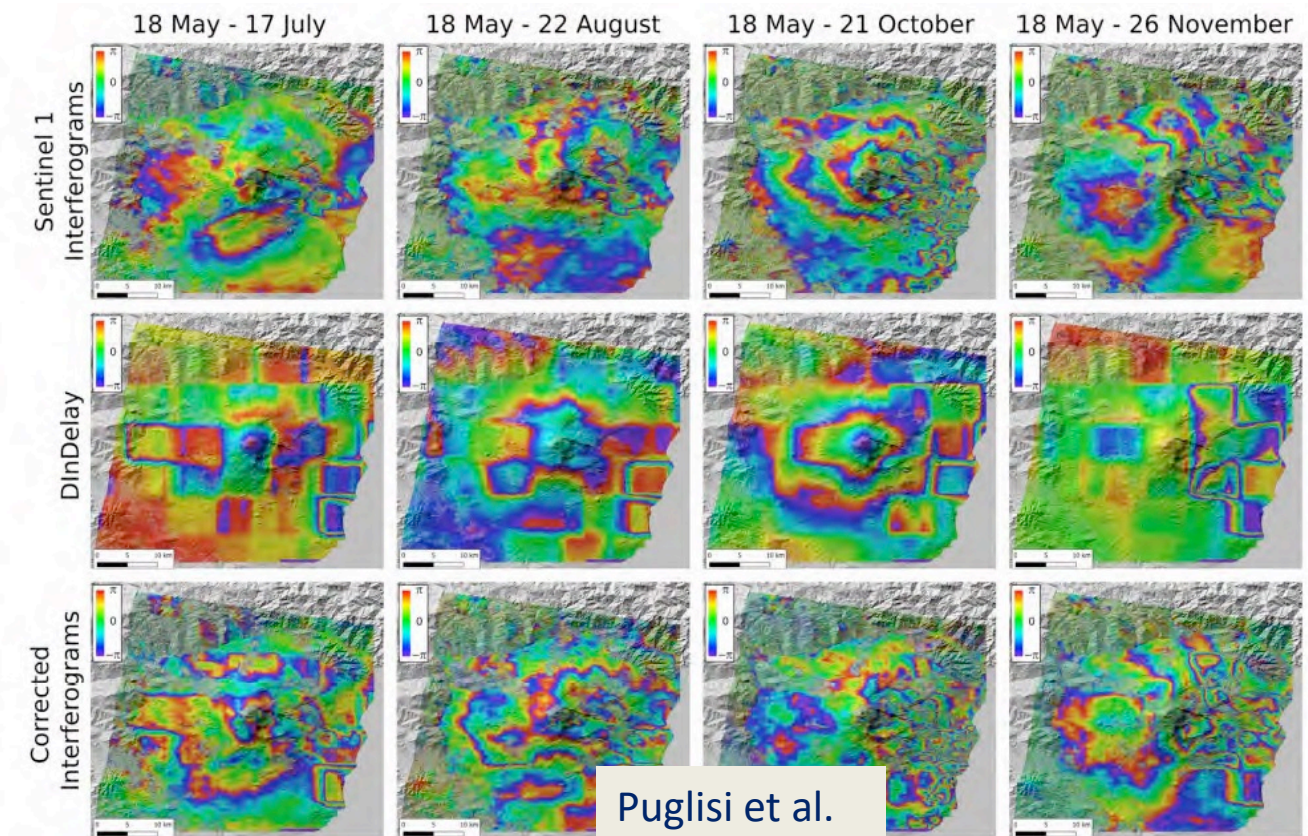
Etna Volcano Supersite

Comparison of DSMs obtained from Pleiades tri-stereo data from different dates is used to estimate the thickness of erupted products, providing important information for the effusion rate and ultimately for volcanic hazard assessment.
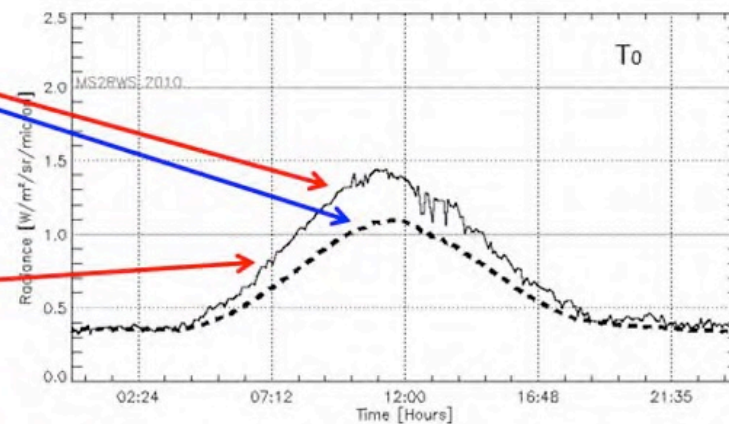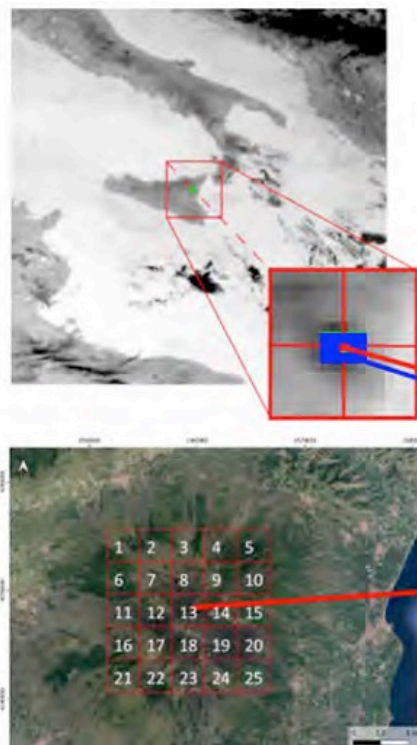
Ganci et al.

Etna Volcano Supersite

MSG - SEVIRI is routinely used on Etna to identify volcanic hot spots in the MIR spectral region.
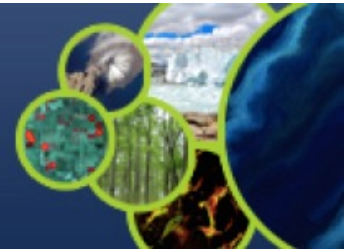
Despite its spatial resolution (4x5 km at mid latitudes), the presence of a high temperature source, even affecting only a small portion of the pixel, causes an easily detectable increase of the emitted MIR radiance.

Musacchio et al.
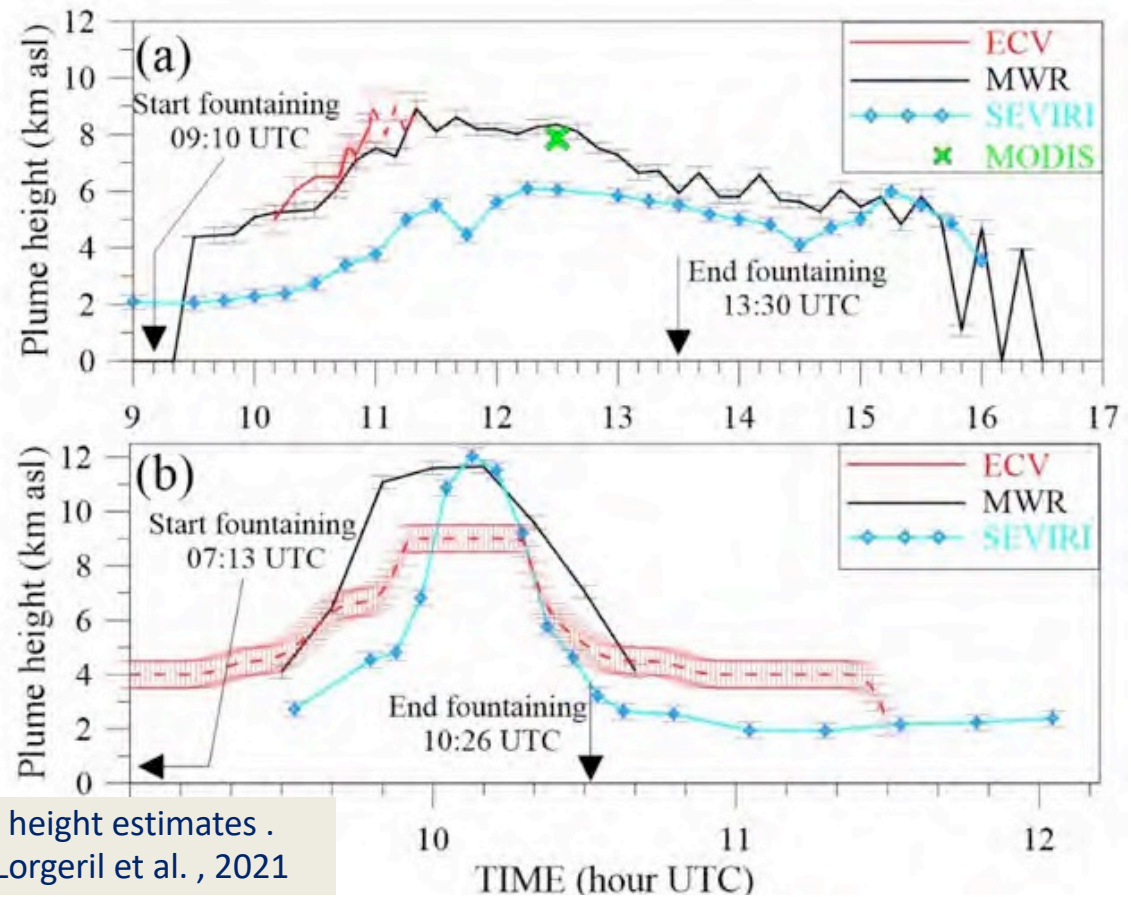
A multi-sensor experiment demonstrated the capacity to estimate event duration, plume heights, total erupted mass, mass eruption rate and total grain-size distribution of volcanic particles.

Data from Doppler radars, MODIS, MSG-SEVIRI, infrasound array, visible and thermal cameras, tephra fallout deposits, were used for the study.
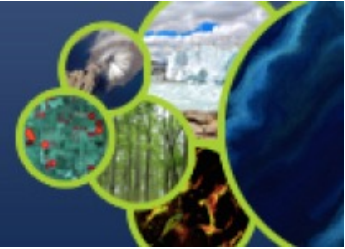

Plume height estimates .
Feret-Lorgeril et al. , 2021

Etna Volcano Supersite

The Supersite infrastructure for data sharing will eventually (2023) be absorbed by the EPOS European Research Infrastructure data portal.

Three new EU projects will contribute to Supersite activities:

IMPROVEMENT - Five Early Stage Researchers (ESRs) will carry out their projects on Mt. Etna to investigate the volcanic phenomena in the range of frequencies between the seismic and quasi-static deformations, by integrating ground-based and satellite data.

Geo-INQUIRE – Project aimed at improving the offer of scientific data and foster the advanced use of the research infrastructure.

DT-GEO - Mt Etna will be the volcano test site of a project aiming to design and experiment the concept of "Digital Twins" in different contexts.

Vesuvius – Campi Flegrei volcano Supersite
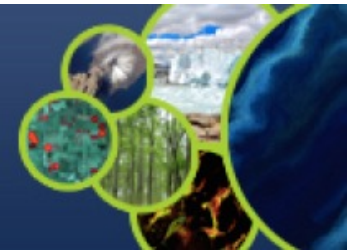
Vertical and E-W ground motion components obtained by composition of ascending and descending Sentinel-1 mean velocity maps.

Left column graphs: vertical displacement time series at three selected points.

Right column graphs: E-W displacement time series at the same points.
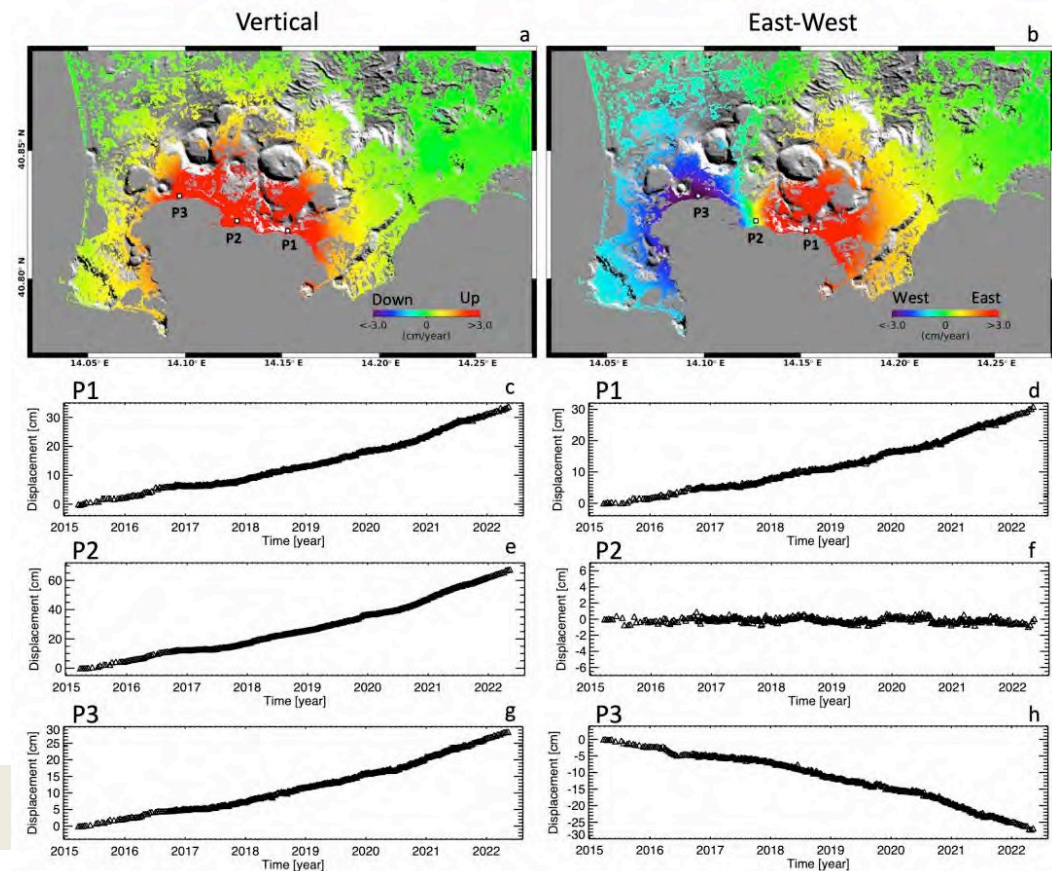
IREA-CNR

Vesuvius – Campi Flegrei volcano Supersite

Mean ground velocity map along the ascending LoS for COSMO-SkyMed data (2021/01/10 – 2022/06/30)

INGV-OV

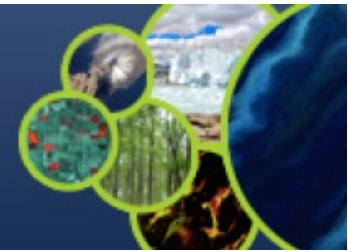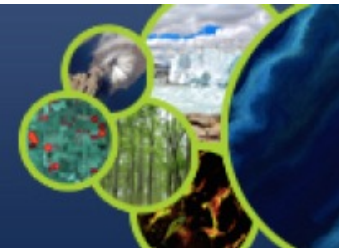# Vesuvius – Campi Flegrei volcano Supersite

- InSAR data from S-1, CSK and TSX are constantly used for ground deformation monitoring over the two volcanoes.

- The Campi Flegrei area is currently at the attention (yellow) level according to the Emergency Plan issued by the Italian Department for Civil Protection, considering the steady uplift ongoing since 2011 (90 cm).

- The Supersite infrastructure for data sharing will eventually (2023) be absorbed by the EPOS European Research Infrastructure data portal.

Iceland volcano Supersite

- EO data were crucial for the monitoring of a new dike intrusion in the Reykjanes peninsula, occurring in July-August 2022

- Following the March 2021 fissure eruption at Fagradalsfjall volcano, located 30 km SW of Reykjavik, on 30 July 2022 the seismicity and the GNSS observations were suggesting a new dike intrusion was occurring.
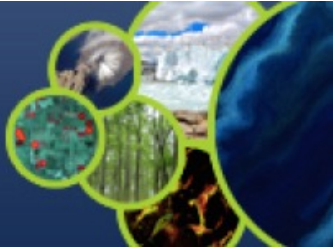
Two days after, a Sentinel-1 interferogram (spanning 20 July-1 August 2022) allowed to clearly see, and measure, the ground deformation pattern due to the magma intrusion.

Processed by Michelle Parks (IMO)

The model based on the S-1 ground displacement was generated on the same day

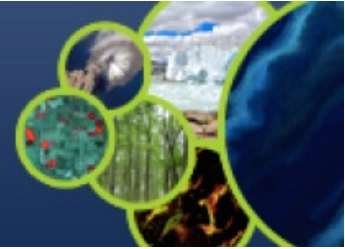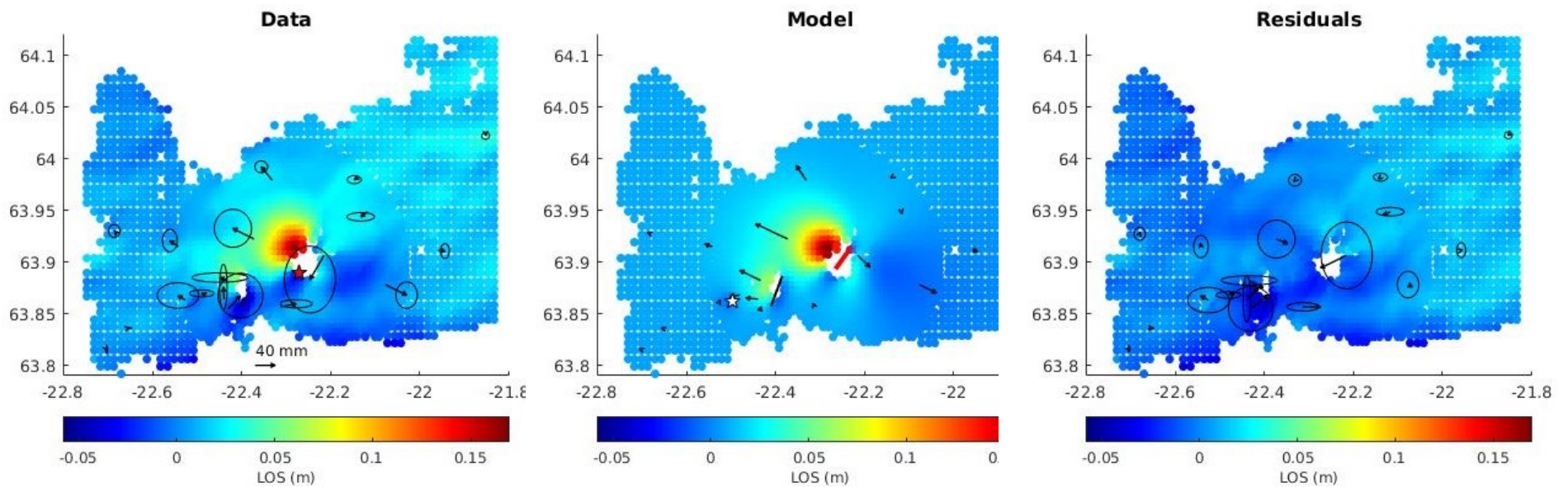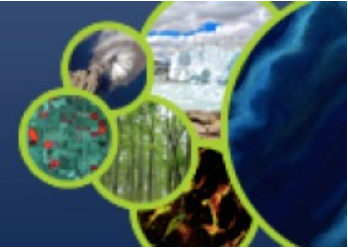# Reykjanes event:
timeline of activity and response

Date/time	Activity
2 August, early morning	Sentinel-1 interferogram is generated, ground deformation is mapped
2 August	The geodetic model reveals that the top depth of the dike is shallow (~ 1 km) and the magma inflow rate is high (~ 50 m3/sec). A decline in seismicity is also suggesting an impending eruption.
2 August, 15:00	The results are presented at a meeting with the Civil Protection.
2 August, 17:49	IMO issues a warning that the likelihood of a new eruption in the coming days is high. This is reported on the IMO website, in local media and also on the evening news.
3 August, 13:30	The eruption starts, with a 375 m-long fissure opening within 49 m of the modelled dike location.

Reykjanes event: location of modelled dike and eruptive fissure

Modelled dike

Eruptive fissure

Gossprungan er 375 m að lengd (ljósrauð lína), mæld frá loftmyndinni

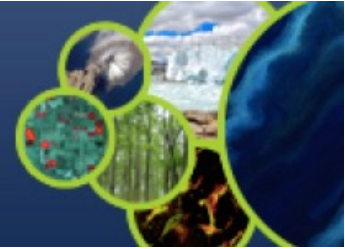Dökkrauða línan sýnir líkan af kvikuganginum sem var gert fyrir gos af Michelle Parks (VÍ)

Loftmyndin er tekin af Joaquin Belart, hæðarlíkanið er frá LMÍ

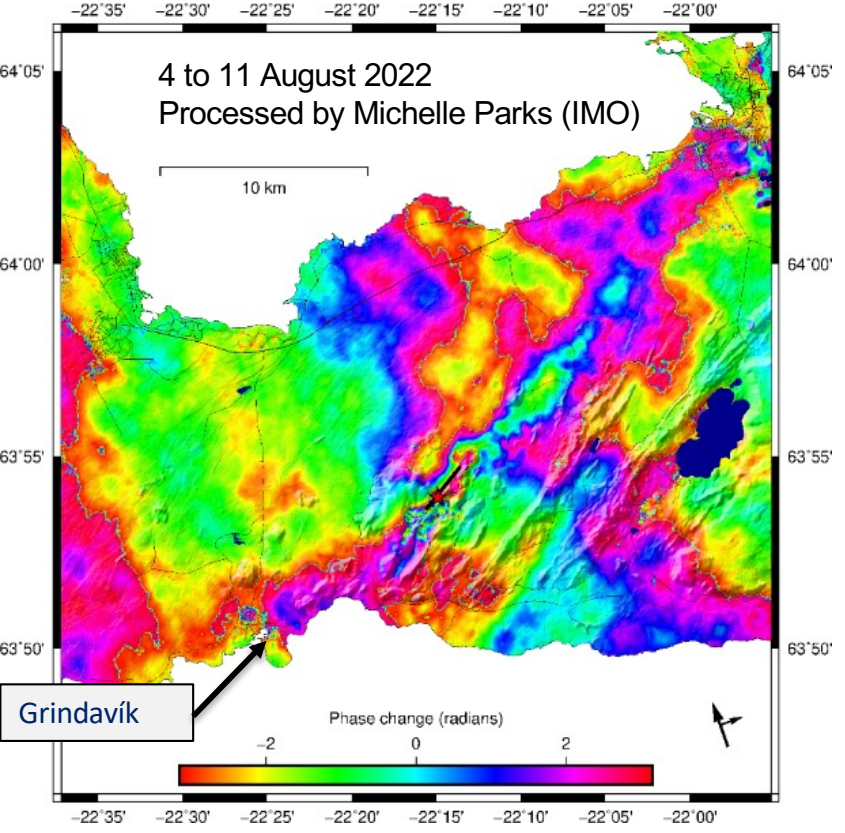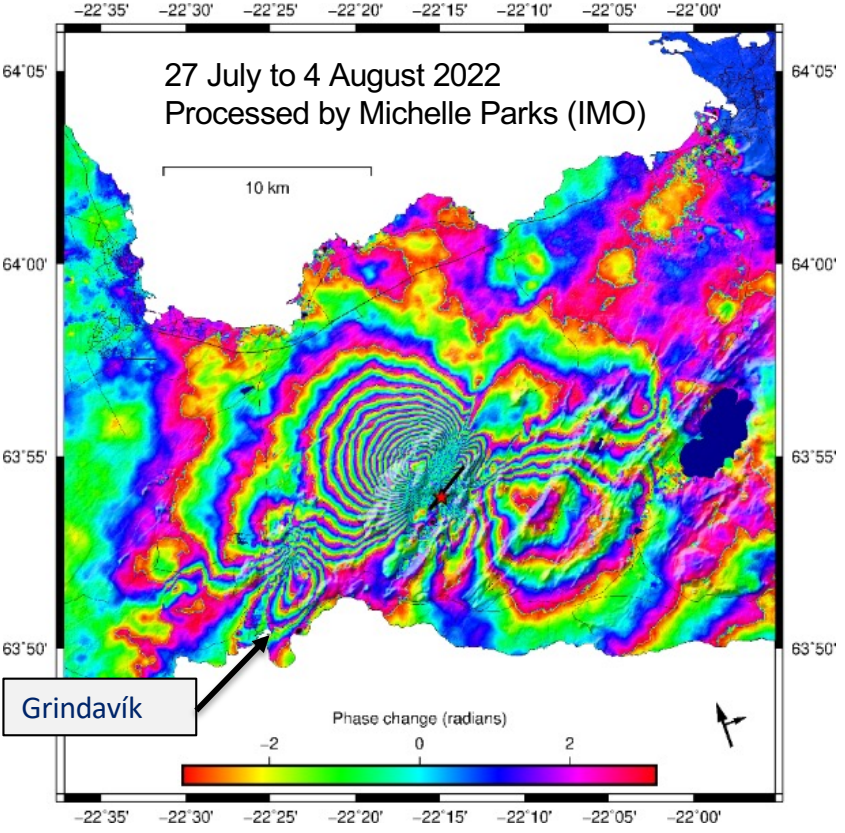Kortagerð og kortlagning: Ásta Rut Hjartardóttir (Jarðvísindastofnun HÍ)
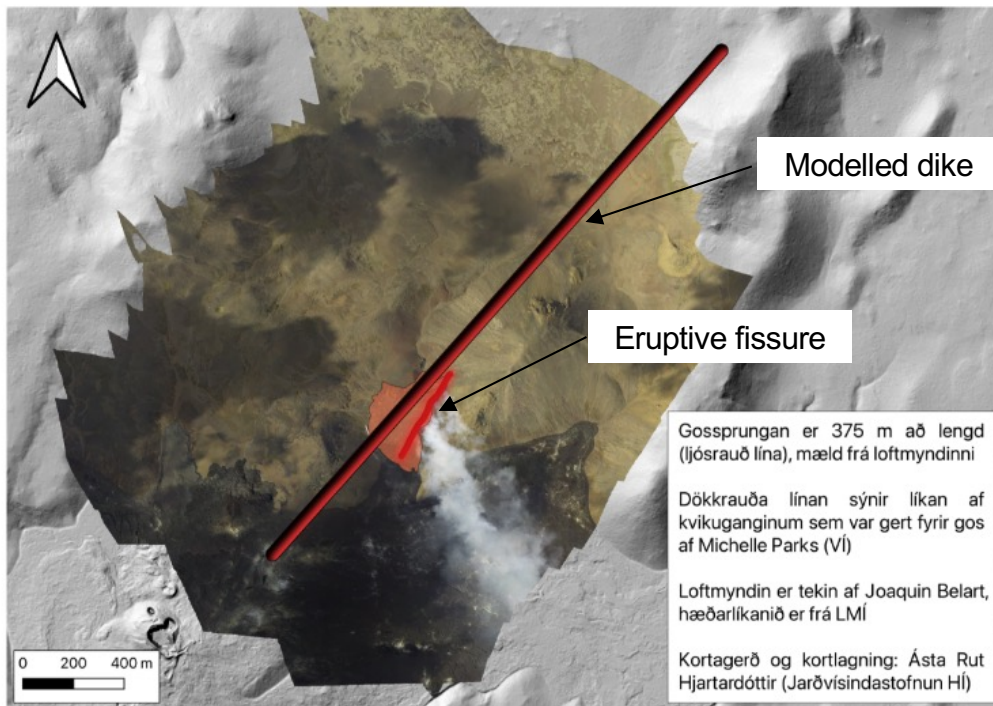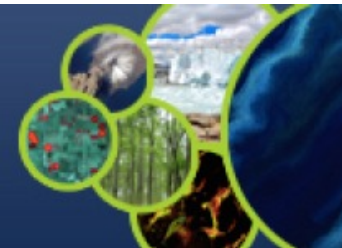
Reykjanes event:
additional benefit of Supersite data

- In the following days large fractures were observed close to the town of Grindavík and there was a concern of magma migration in this area

- A CSK interferogram was produced and used in additional geodetic modelling, which indicated fractures were likely produced during a M5.3 earthquake that occurred on 31 July 2022, whilst the dike was still propagating

- An additional CSK interferogram displayed no deformation in the vicinity of Grindvík, demonstrating no intrusive activity in this area

- The Fagradalsfjall eruption lasted until 21 August 2022 and produced a lava field with a volume of approximately 11 million cubic meters

27 July to 4 August 2022
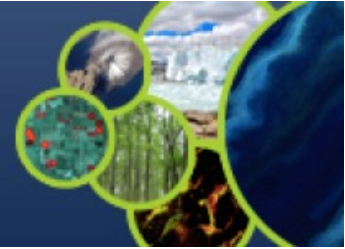Processed by Michelle Parks (IMO)

4 to 11 August 2022
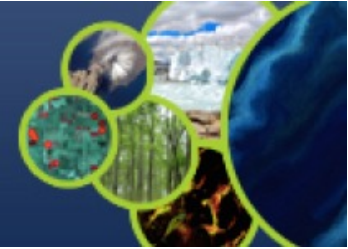Processed by Michelle Parks (IMO)

Grindavík

Grindavík

Enceladus Supersite situation

- The CEOS data provision was suspended in April 2021 due to a lack of use of the image quotas for over 3 years.

- At the last meeting of the WGD we decided to ask for re-submission of the proposal, with a re-evaluation of the image requests and a clear explanation on how the previous issues on data usage will be solved.

- The Coordinator in mid-September declared the intention to re-submit a proposal. The deadline is the end of November, date of the planned Supersite Biennial Report.

- The Coordinator was informed that if the new proposal is not submitted, the Supersite will be canceled permanently.
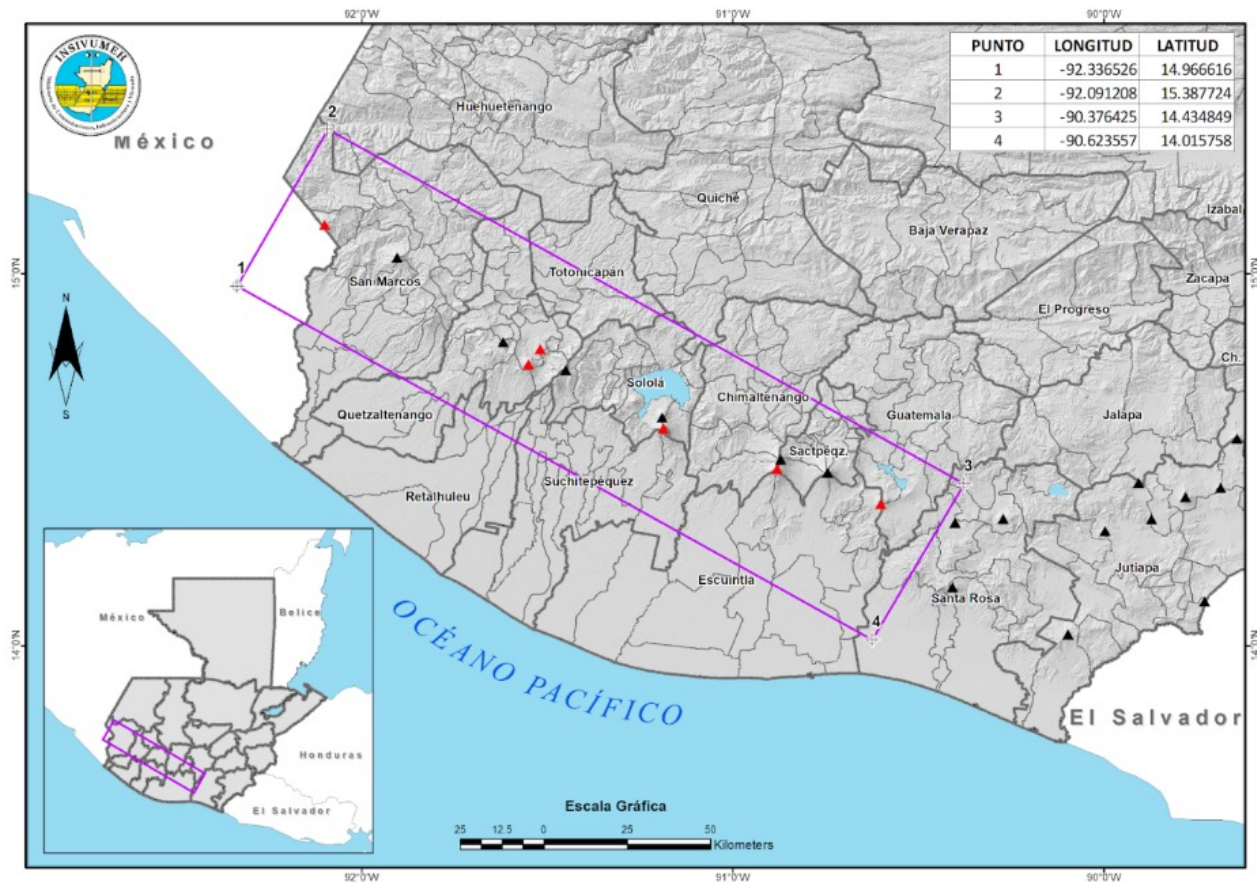
We received a Supersite proposal for an area including six active volcanoes in Guatemala.
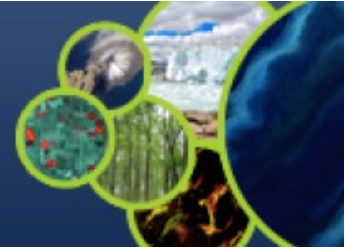
40% of the population in Guatemala lives around an active volcano, and the local capacities for monitoring are limited.

Satellite data are expected to contribute strongly to Hazard assessment and risk prevention.

PUNTO	LONGITUD	LATITUD
1	-92.336526	14.966616
2	-92.091208	15.387724
3	-90.376425	14.434849
4	-90.623557	14.015758

The proposal is submitted by:

- Dept. of Research and Geophysical Services of the National Institute of Seismology, Volcanology, Meteorology, and Hydrology -INSIVUMEH-,
- Volcano Prevention Unit -U.P.V. of the National Coordinator for the Reduction of Natural and Provoked Disasters -CONRED,
- Dept. of Geographic Information Systems –SIG of the CONRED

Guatemala Supersite proposal

EO data requested include:

    CSK: about 180 images per year
    TSX: 150 images per year
    SAOCOM: 150 images per year
    Pleiadès: 2200 sq km per year

In situ data made available by the team:
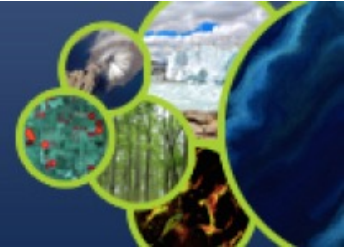
    Seismic station data
    Data from acoustic sensors
    Data from local cameras
   Meteorological data.

Further updates

- GSNL 2023-2025 Implementation Plan was approved by the GEO Program Board in early September.

- The Ecuador Supersite Coordinator was requested by GEOSec to provide material for a use case in EO Risk Toolkit, demonstrating the use of EO data for decision making during the Sangay eruption.

- An INGV researcher in the team of the Italian Supersites provided training on volcano source modeling during a course in Quito, focused on methods and practice of volcano geodesy.

- GSNL donates 5 GNSS stations to the Goma Volcano Observatory for the improvement of the in-situ monitoring capacities at the Virunga Supersite. This is part of a larger cooperation with USGS-VDAP and other international institutes.
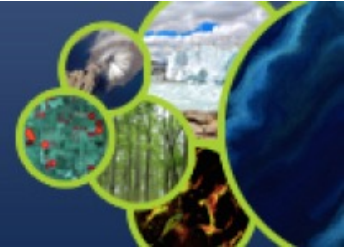
Assessment of 2020-2022 biennial reports of:

- Etna Supersite
- Campi Flegrei Supersite