



GROUP ON  
EARTH OBSERVATIONS

Geohazard Supersites  
& Natural Laboratories

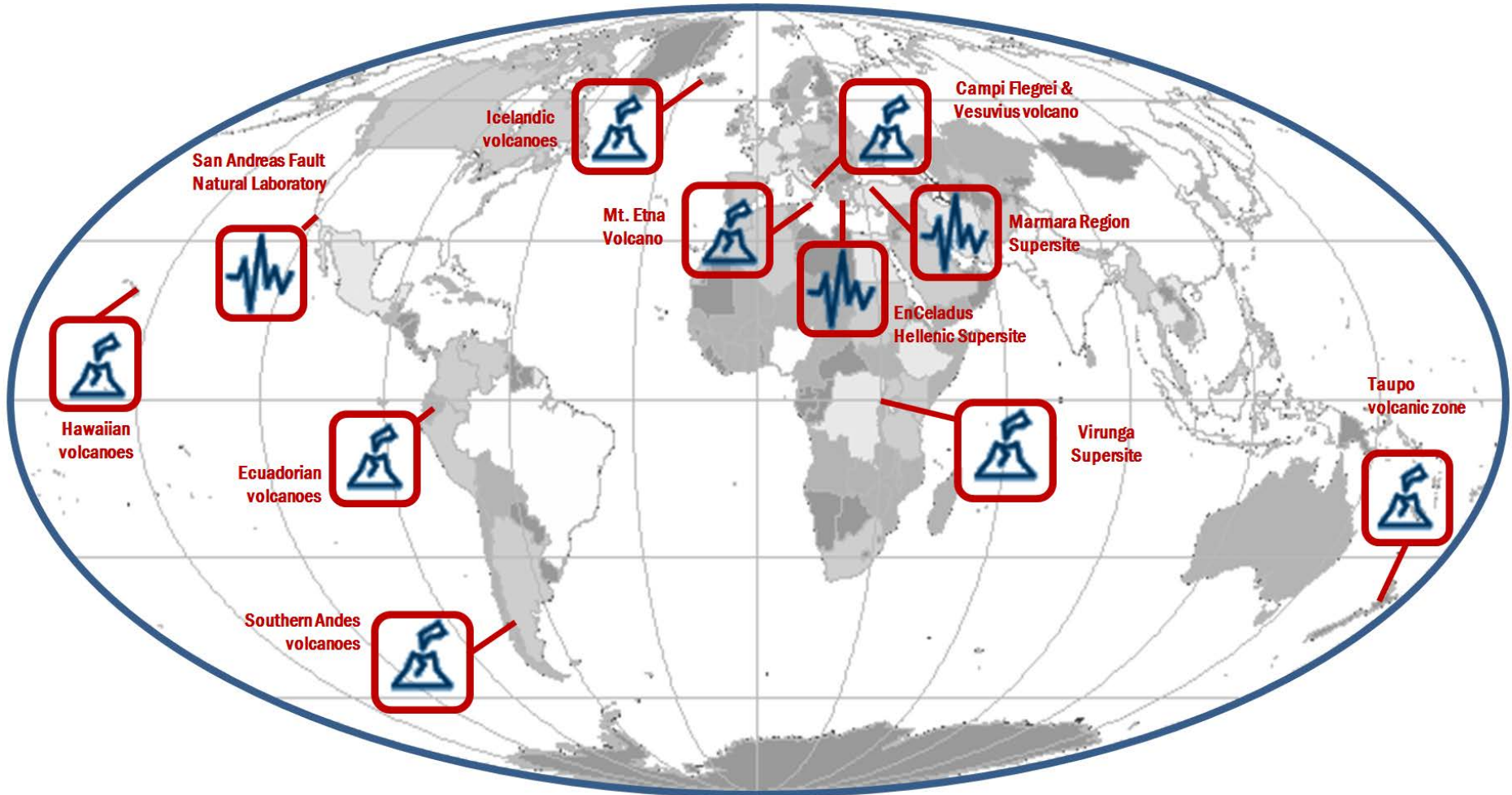
# Status of the GEO-GSNL initiative

Stefano Salvi

Chair of the Supersites Advisory Committee

CEOS WG Disasters meeting #9, Brussels, March 2018

# The Supersite network in 2018



# Permanent Supersites

	<b>Supersite</b>	<b>Status</b>	<b>Next Biennial report</b>
1	Hawaiian volcanoes	Renewed at SIT 32	25-Oct-18 (3rd)
2	Icelandic volcanoes	To be renewed at SIT 33	5-Nov-17 (2nd)
3	Etna volcano	Renewed at Plenary 30	9-Apr-18 (2nd)
4	Campi Flegrei/Vesuvius volcano	Renewed at Plenary 30	9-Apr-18 (2nd)
5	Western North Anatolian Fault	Renewed at Plenary 30	9-Apr-18 (2nd)
6	Taupo Volcano	To be renewed at Plenary 31	29-Oct-18 (2nd)
7	Ecuador volcanoes	To be renewed at Plenary 31	29-Oct-18 (2nd)
8	Corinth Gulf/Ionian Islands	1st year of activity	8-Nov-18 (1st)
9	San Andreas Fault NL	Approved at SIT 32	27-Apr-19 (1st)
10	Southern Andes volcanoes	Approved at Plenary 31	19-Oct-19 (1st)
11	Virunga volcanoes	Approved at Plenary 31	19-Oct-19 (1st)

# Event Supersites

	<b>Supersite</b>	<b>Supporting agencies</b>	<b>Status</b>
1	Sinabung volcano (Indonesia)	DLR	ongoing



## Outstanding issues

The 2015-2017 Biennial Report of the Iceland volcano Supersite was submitted to DCT and should be approved at SIT 33.

Some agencies still have not expressed renewed support.

Questions/issues?

We need to update the EO data access procedures for CSK.

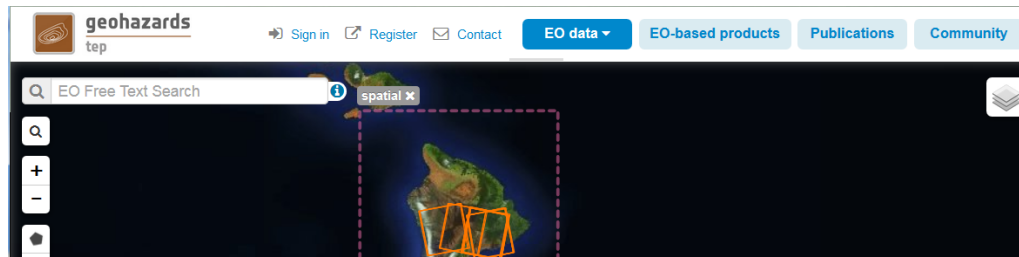
## Progress with EO data sharing

The COSMO-SkyMed data for Supersites (and pilots ?) are now made accessible through the ESA-GEP. The data are sent to the Supersite coordinator and the GEP at the same time. This makes external access through webservices easy .

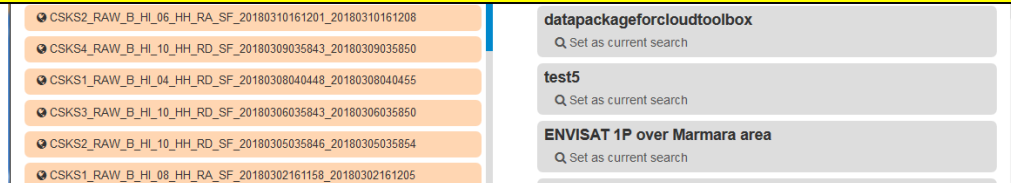
Browsing is open for all but for download the users need to sign the CSK license. This process is managed by Supersite Coordinator and SAC Chair.

Bulk download of data stacks is going to be implemented soon.

We will soon repatriate all old CSK data.



Thanks to ESA and ASI !!



## Issues with EO data sharing

Some Supersites found the DLR portal interface not easy to navigate. It is not possible to understand which data belong to where (from the data lists), and the map browser is not intuitive.

Maybe we can have an interaction with DLR to make it more user friendly. An alternative is to use the GEP for access to DLR data too.

DLR Download Services for Geohazard Supersites

Supersites Data map opensearch

Supersites > EO Data Gateway > Browse > geohazards > Ecuador

Welcome Stefano Salvi Logout

Dataset (232 products)

..	
TSX_20111008T110701.752_Ecuador_C144_0051_D_R_SM004_SSC.tar.gz	1.17 GB
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mapshup Search / Add a layer url O S S R M ?

CATALOG#98 WIKIPEDIA

500 km 500 mi

Google STREETVIEW

Immagini ©2018 NASA, TerraMetrics Termini e condizioni d'uso



## Proposal for coordinated EO data access

We propose to place also Radarsat and Pleiadés data on the GEP.

Having all EO data accessible from one single platform would be an extremely positive step forward for the CEOS.

It would make it easier also for other platforms, including GEOSS, to harvest the metadata and disseminate the information on data existence to a larger audience.



## In situ data issues

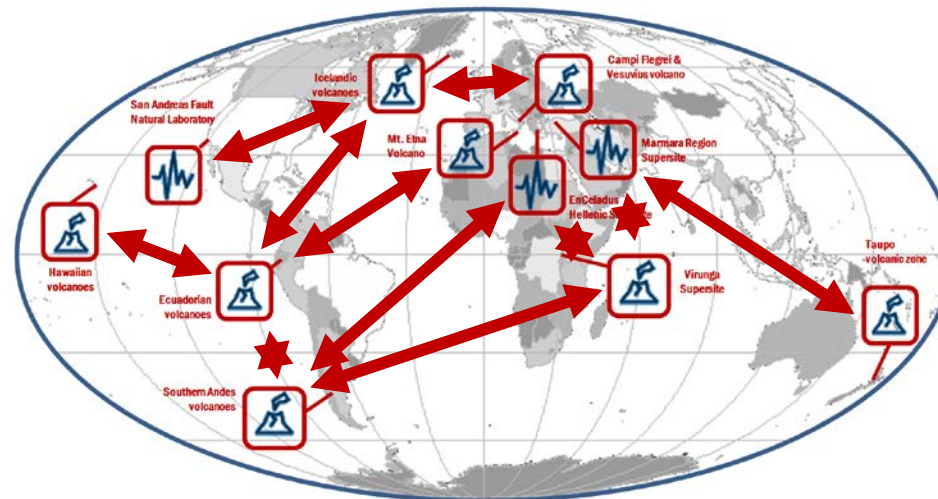
- Organized in situ data sharing is slow to improve.  
Some data types are presently only accessible through papers or reports, since there is no usable infrastructure. One of the problems is that for some data there is no standard metadata structure.  
However developments are under way (e.g. EPOS, Earthcube).
- Few Supersite data are presently accessible from GEOSS, due to the above problem.
- For some Supersites there is also a capacity issue (e.g. Virunga).

## Issues from the Supersites

- The start of data ordering is slow for the new Supersites. There are no written procedures for each space agency.
- There is a strong need for capacity building on satellite remote sensing methods (more later).
- Access to automatically processed products (e.g. deformation maps) would be desirable in the short term, at least for first order investigation/monitoring.

## GSNL is becoming a network

- We work to implement the Sendai Framework, so the network approach is important for capacity building in Less Developed Countries.
- The network approach will stimulate the sharing of knowledge and capacities rather than only data.
- Technological developments will support the network.





## The network approach requires resources

- Coordination with national/international capacity building initiatives (e.g. USGS, NASA, UN, etc.)
- Cooperation with infrastructures (EPOS, GEP, EVER-EST, etc.), consortia (UNAVCO, IRIS, etc.), initiatives (WGCapDD, GEODARMA, UN, GPSTAR, etc.), able to support focused capacity development in the Supersites
- Seek appropriate funding for the sharing of personnel , laboratory resource, processing capacities, etc.

**Suggestions and offers for support are welcome !**

## The EVER-EST virtual research platform for GSNL

- EVER-EST is a collaborative platform developed in a H2020 project led by ESA. One of the supported communities is the Supersites one
- EVER-EST provides a variety of services, the most important being management of Research Objects and processing services for image analysis and modeling
- We are now training scientists from the Supersites (or not) on its use
- There are sustainability issue, to be addressed with ESA and EPOS.

VRE

The screenshot shows the EVER-EST VRE interface. On the left, there is a 3D map of Iceland. On the right, a 'Data Dictionary' panel is visible. Below the map, the 'Icelandic Volcanoes Permanent Supersite' is detailed with its coordinator (Freysteinn Sigurðsson) and scientific objectives, such as understanding magma transfer and storage between volcanoes.

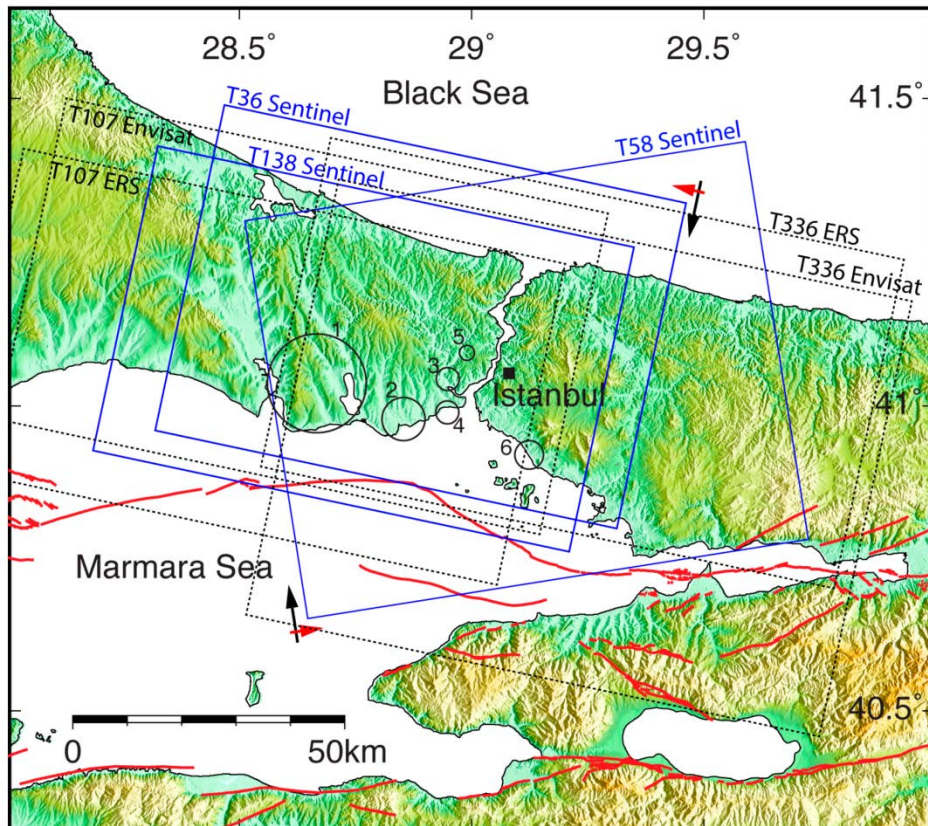
RO

The screenshot shows the EVER-EST RO interface. It displays a detailed view of a Research Object titled 'Method and application of VRE (Vertical) with potential magnetic source'. The description states that the RO contains the results of the geodetic monitoring of the 1991-92 eruption of the VRE. A 3D visualization of the volcanic structure is shown at the bottom.

## Results from the Supersites

- Marmara
- Ecuador
- Campi Flegrei
- Taupo, NZ
- Iceland
- Virunga

# Results from Marmara Supersite



PS-InSAR time series analysis of C-band satellites for the period 1992- 2017.

A collaboration among:

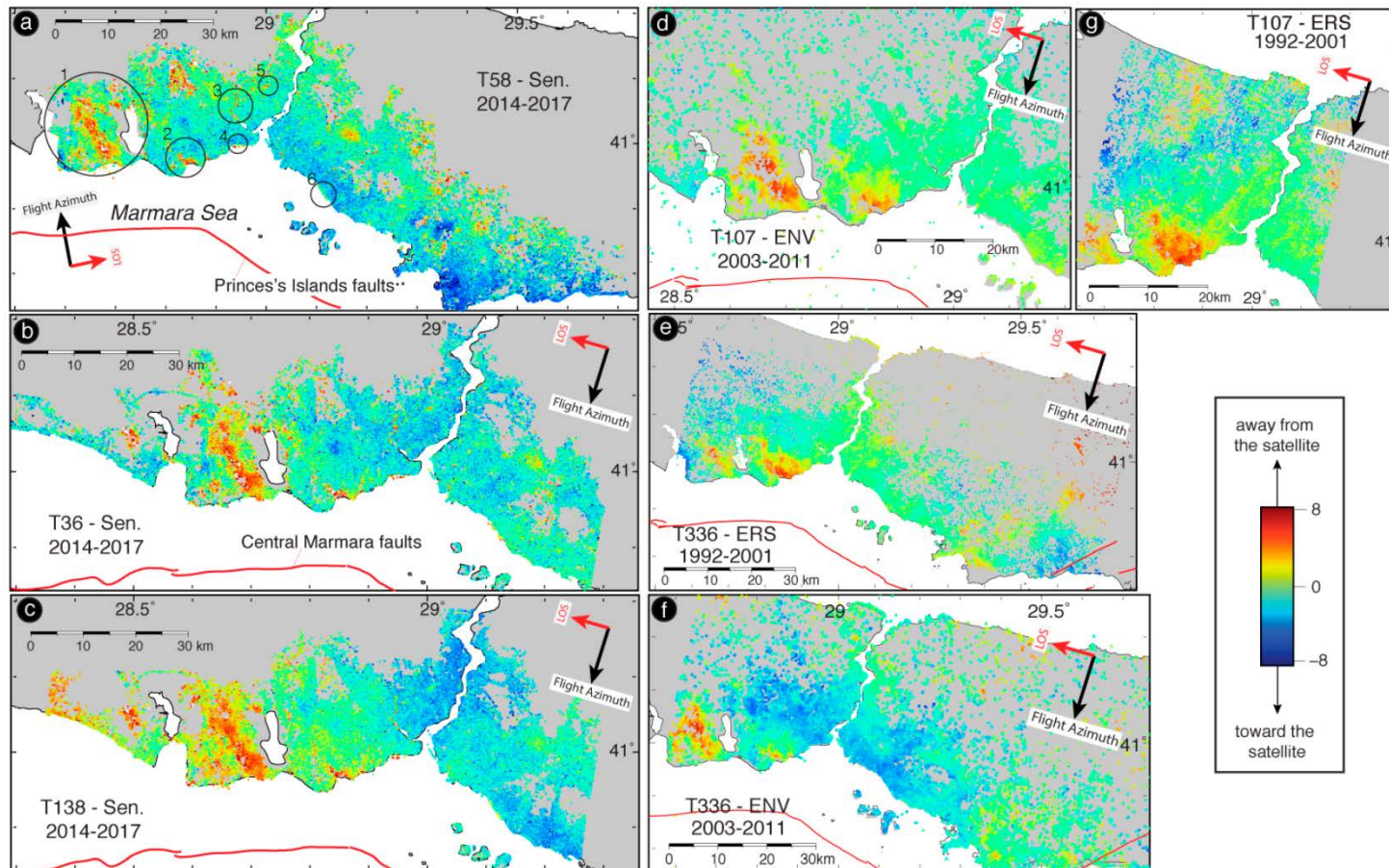
- Université Grenoble-Alpes,
- Eurasia Institute of Earth Sciences, Istanbul
- Istanbul Technical University,
- Kandilli Observatory and Earthquake Research Institute (KOERI), Istanbul
- Université de Lyon
- The NJORD Centre, Department of Geosciences, Oslo, Norway

Aslan et al., 2018, Analysis of Secular Ground Motions in Istanbul from a Long-Term InSAR Time-Series (1992–2017), *Remote Sensing* **2018**, 10(3), 408; doi:[10.3390/rs10030408](https://doi.org/10.3390/rs10030408)



# Results from Marmara Supersite

They identify vertical ground subsidence at rates from 5 to 15 mm/yr in the metropolitan area of Istanbul. They also investigated the causes of the subsidence (essentially water table overexploitation and land reclamation along the coast).





# Results from Ecuador Supersite - Cotopaxi

They analysed COSMO-SkyMed data for the 2014-2016 period, and identified inflation of few cm before the late 2015 eruptions.

The deformation was modeled and suggests that there was a magma ascent from 12 to 5 km depth.

It showed that Cotopaxi eruptions can be predicted using satellite monitoring.

Collaboration among:

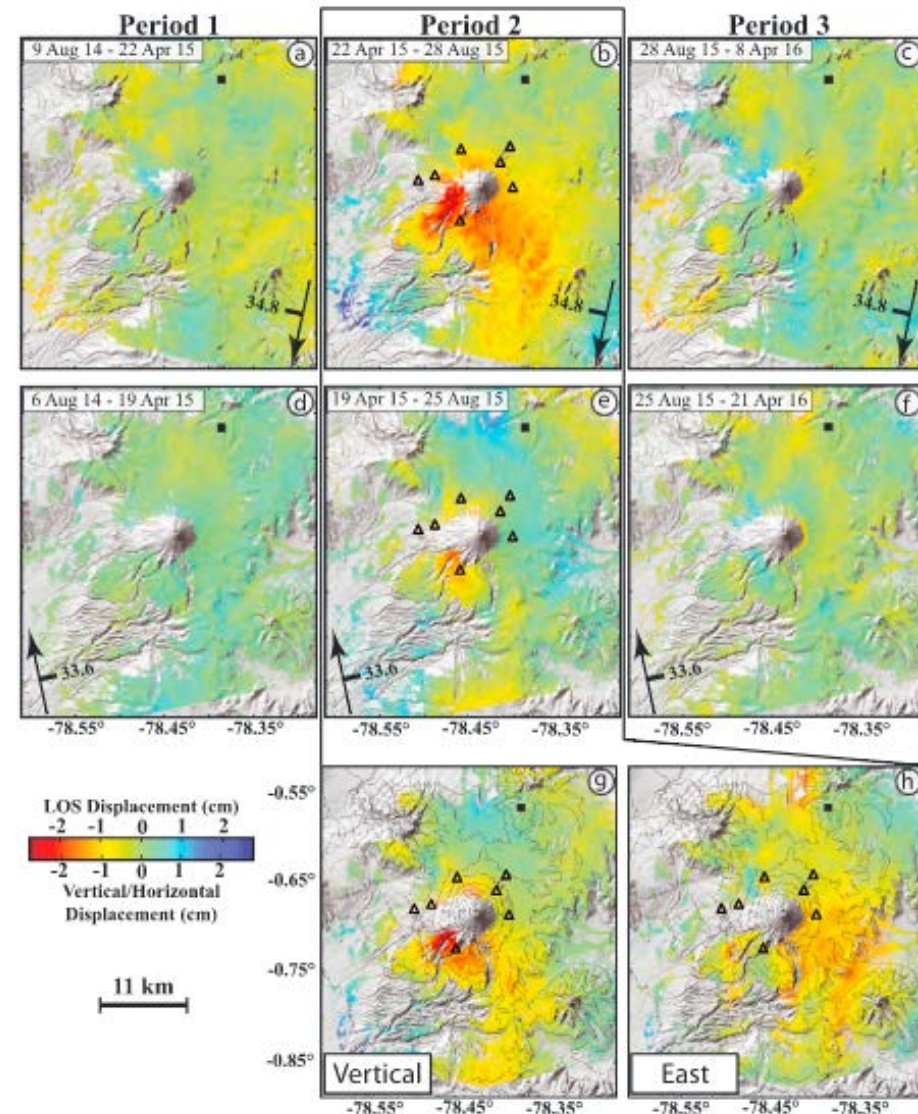
Int. Geofisico Ecuador

Univ. of Miami

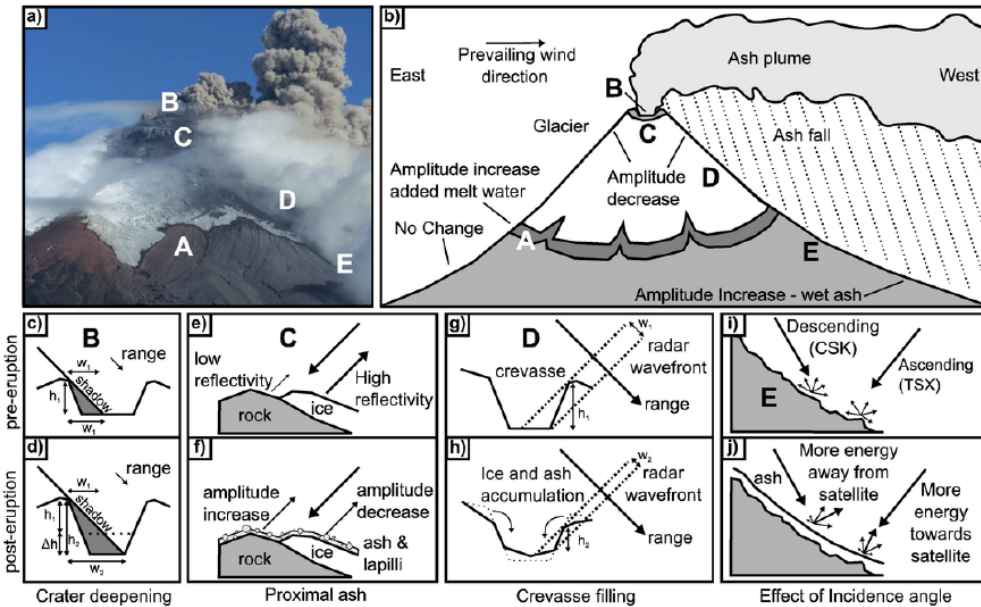
Pusan Univ., South Korea

Geoazur, France

Morales Rivera, A. M., F. Amelung, P. Mothes, S.-H. Hong, J.-M. Nocquet, and P. Jarrin (2017), Ground deformation before the 2015 eruptions of Cotopaxi volcano detected by InSAR, *Geophys. Res. Lett.*, 44, 6607–6615, doi:[10.1002/2017GL073720](https://doi.org/10.1002/2017GL073720).

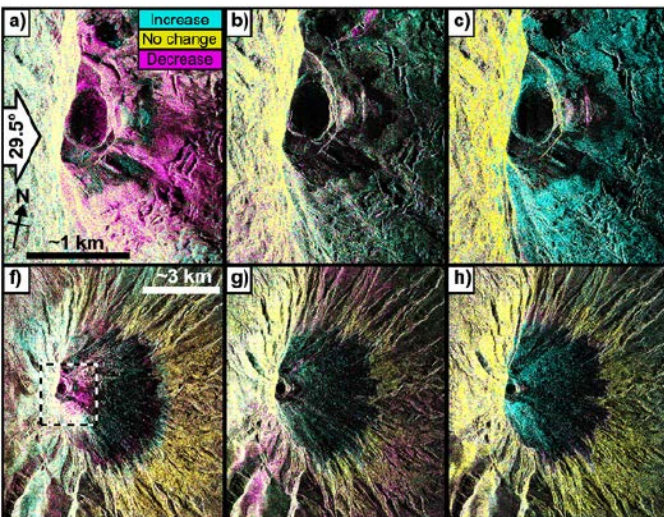


# Results from Ecuador Supersite - Cotopaxi



They use COSMO-SkyMed and TerraSAR X amplitude data to map spatial extent and dynamics of volcanic deposits and landforms.

Important to demonstrate how radar data can provide information normally extracted from optical data. Useful for volcano monitoring in regions of dense cloud coverage.



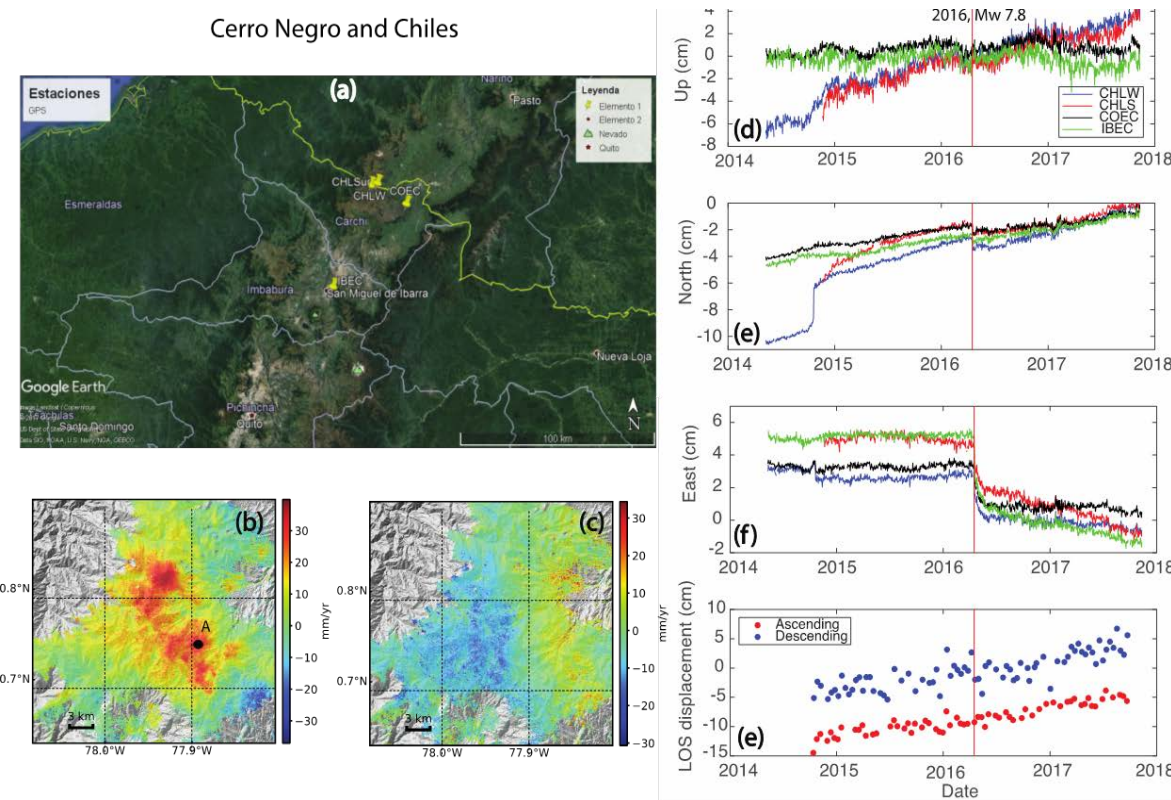
Collaboration among:  
 Int. Geofisico Ecuador  
 Univ. of Bristol  
 Univ. of Reading

Arnold et al., 2018 Using satellite radar amplitude imaging for monitoring syn-eruptive changes in surface morphology at an ice-capped stratovolcano, Rem. Sens. of Environment



# Results from Ecuador Supersite Chiles-Cerro Negro volcanoes

Cerro Negro and Chiles

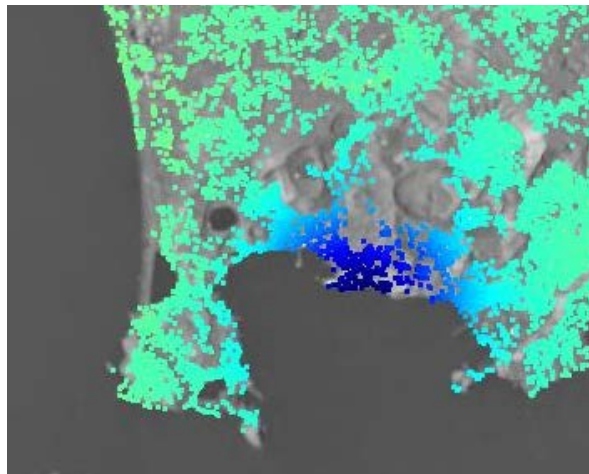


Analysis of GPS and Sentinel 1 data shows the ground deformation occurred during the 2016 earthquake. The earthquake was initially thought to be a precursor for an eruption but thanks to the deformation data and modeling was later interpreted as a tectonic earthquake.

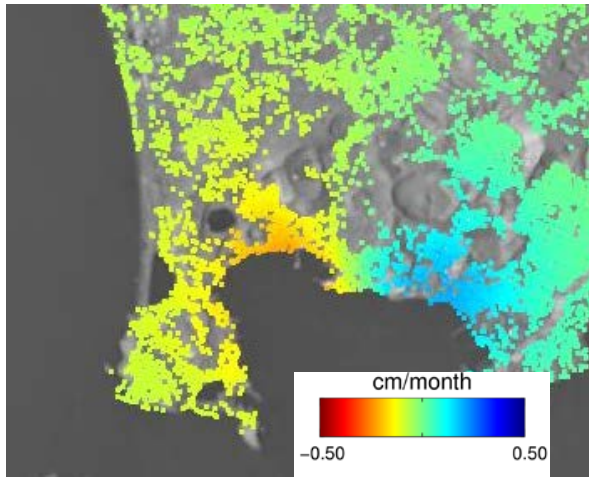
Collaboration among:  
 Int. Geofisico Ecuador  
 Univ. of Miami

# Results from Campi Flegrei Supersite

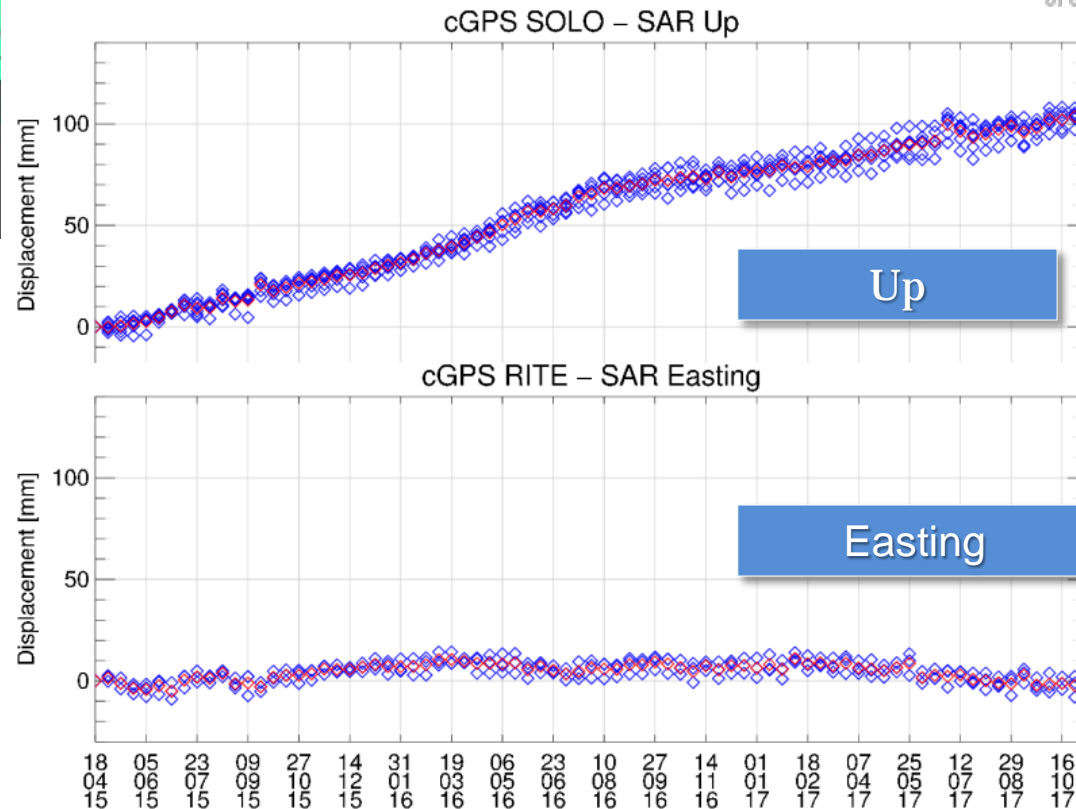
Vertical velocity



East-West velocity



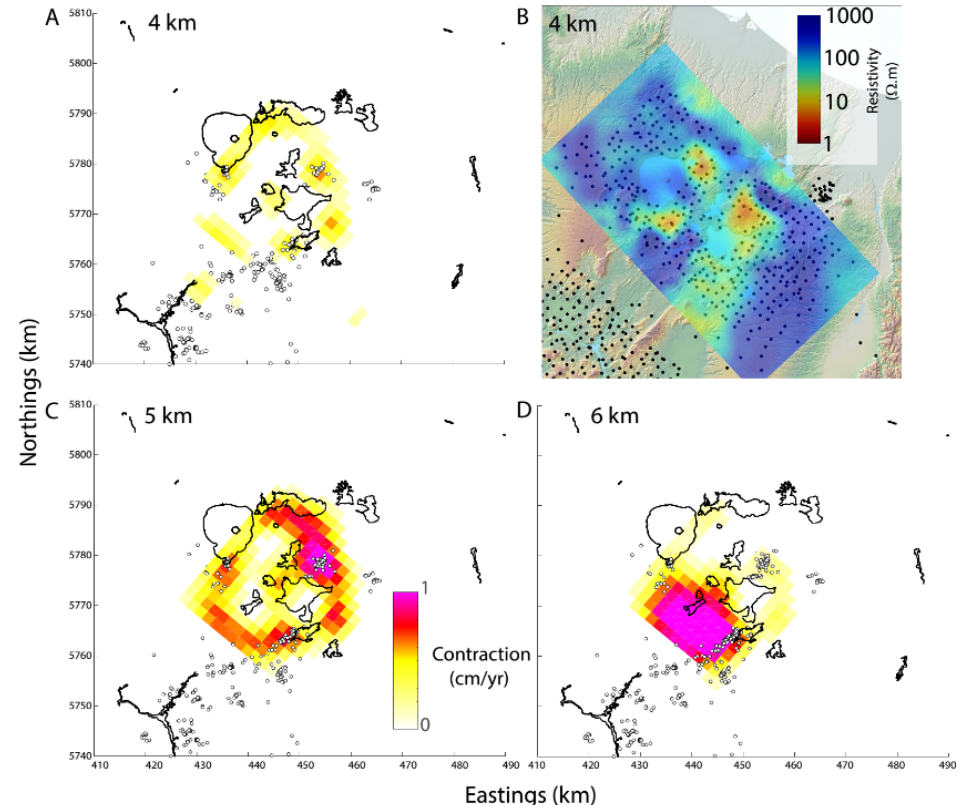
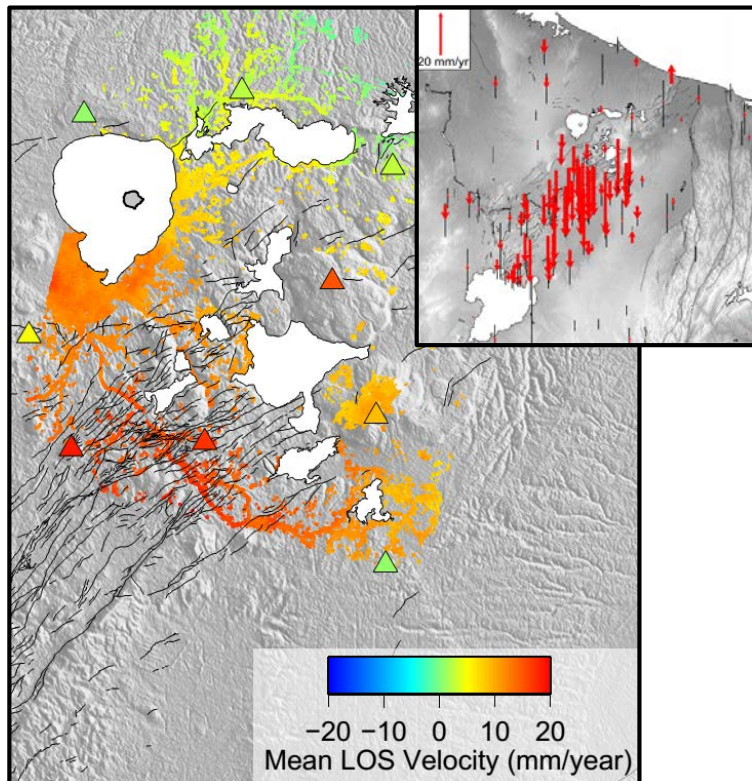
Analysis of GPS and Sentinel 1 data (50 passes, from Oct. 2014 to Sept. 2017) show the ground deformation in the caldera. Results of the INSARAP project in the framework of the SEOM program. Participants: INGV, ESA, DLR



# Results from Taupo Supersite (NZ)

At the Okataina caldera, they are trying to integrate geodetic observations of subsidence with magnetotelluric data to better image the subsurface magmatic system.

Early models are suggesting a layered system with largest present day contraction occurring at 5-6 km depth.

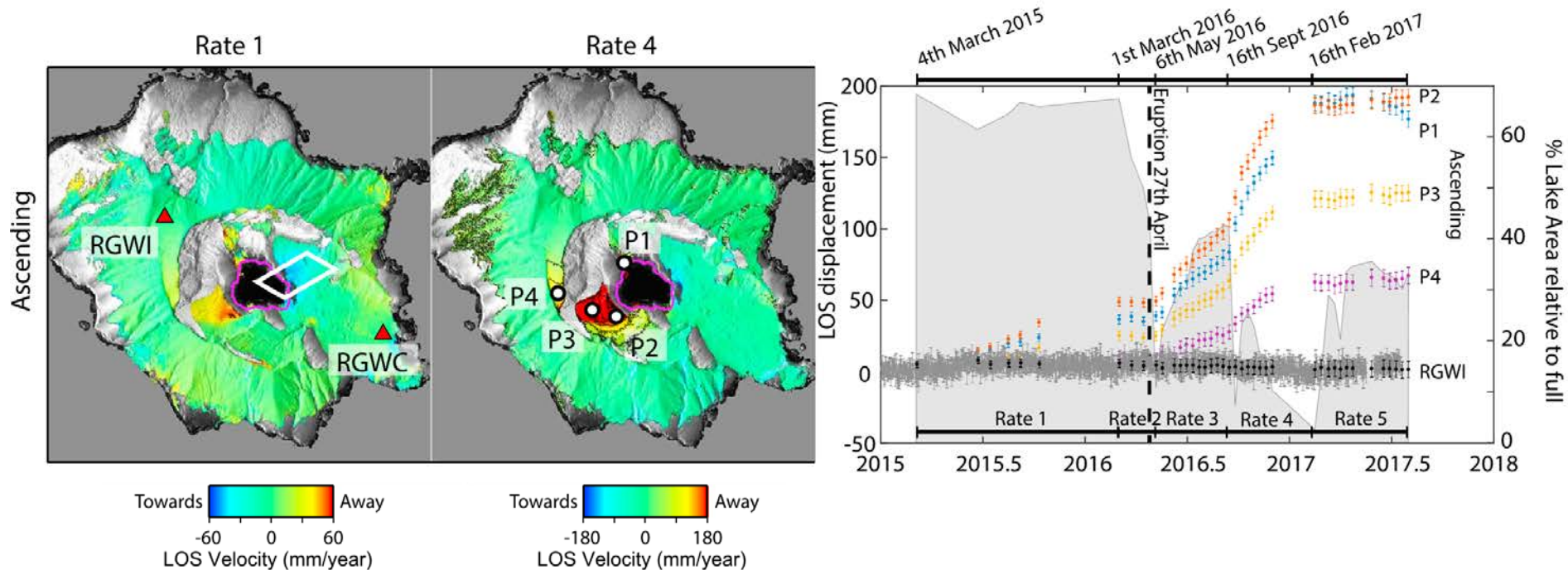




# Results from Taupo Supersite (NZ)

White Island: TSX data indicates rapid slope movements of up to 200 mm/yr following an eruption on 2016. Without SAR data it would not have been detectable with existing observation methods.

Although the eruption in 2016 led to rapid slope movement, extending the timeseries into 2018 indicates that the slope also has a seasonal signal.



## Results from Iceland Supersite

They used Radarsat 2, COSMO-SkyMed and TerraSAR X to monitor the following volcanoes and geothermal areas:

- Öræfajökull
- Bárðarbunga
- Holuhraun
- Hekla
- Eyjafjallajökull
- Askja
- Krafla
- Reykjanes
- Hengill

Results are provided to the Iceland Civil Protection in case of eruptions.

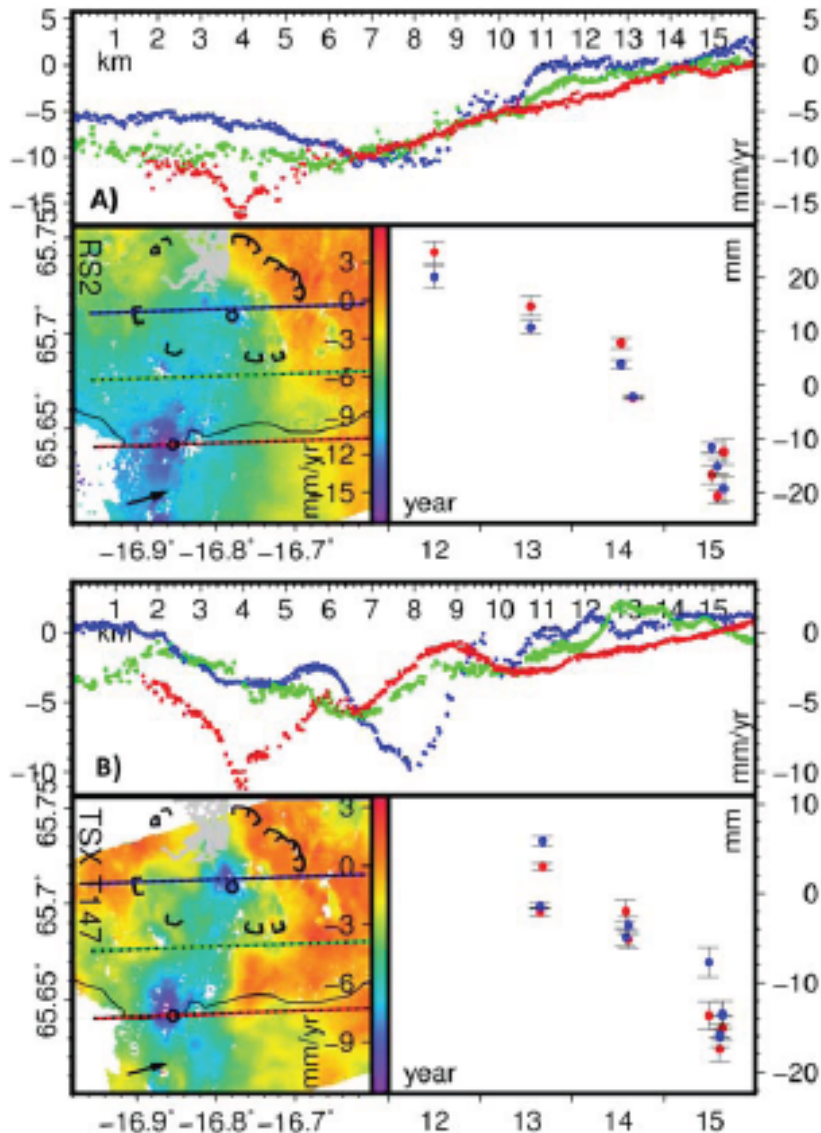
# Results from Iceland Supersite

These are the latest publications (from the biennial report):

- Spaans, K., Hooper, A. (2018), Insights into the stress field around Bardarbunga Volcano from the 2014/2015 Holuhraun rifting event, *J. Geophys. Res. Solid Earth*
- Parks, M., Sigmundsson, F., Sigurðsson, Ó., Hooper, A. (2018) Deformation due to geothermal exploitation at Reykjanes, Iceland, 2003 to 2016: InSAR time series analysis, *J. Volc. Geotherm. Res.*
- Parks, et al. (2017) Evolution of deformation and stress changes during the caldera collapse and dyking at Bárðarbunga, 2014–2015: Implication for triggering of seismicity at nearby Tungnafellsjökull volcano, *Earth Planet Sci. Lett.*, 262, 212-223.
- Pedersen et al., (2017), Lava field evolution and emplacement dynamics of the 2014–2015 basaltic fissure eruption at Holuhraun, Iceland, *J. Volc. Geotherm. Res.*, 40, 155–169.
- Gudmundsson, et al., (2016) Gradual caldera collapse at Bárðarbunga volcano, Iceland, regulated by lateral magma outflow, *Science* 353 (6296)
- Ruch, et al., Oblique rift opening revealed by reoccurring magma injection in central Iceland, *Nature Communications*, 7:12352
- Drouin, et al., (2017) Deformation at Krafla and Bjarnarflag geothermal areas, Northern Volcanic Zone of Iceland, 1993–2015, *J. Volc. Geotherm. Res*
- Wittmann, et al., (2017) Postemplacement cooling and contraction of lava flows: InSAR observations and a thermal model for lava fields at Hekla volcano, Iceland, *J. Geophys. Res. Solid Earth*, 122



# Results from Iceland Supersite



Krafla volcano: Radarsat 2 and TSX time series show subsidence connected to geothermal power plants.

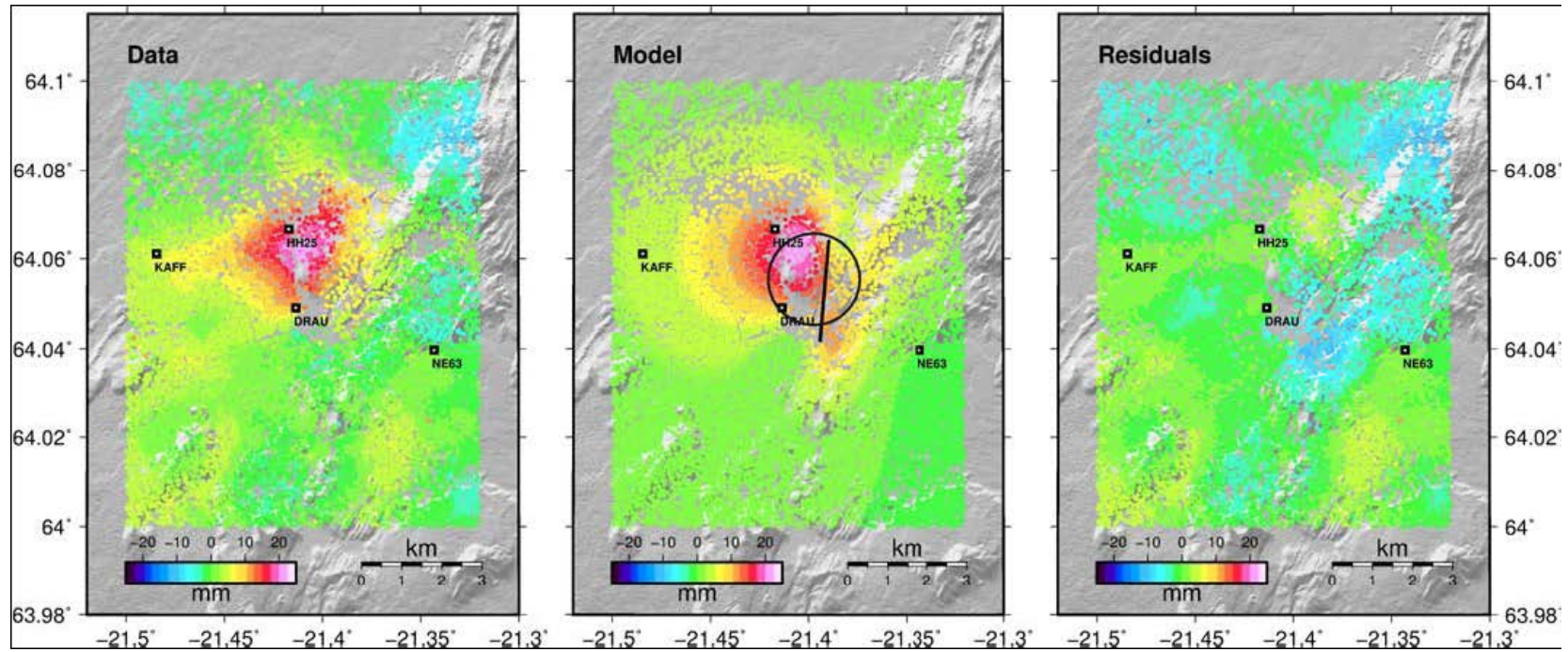
Modelling based on this deformation data suggest that thermal contraction within the geothermal reservoirs can explain the observed subsidence. The deformation data also shows that subsidence caused by a nearby magma source decayed exponentially in the 1990s until 2000.

Research by Univ. of Iceland

# Results from Iceland Supersite

They analyzed ground deformation related to fluid injection and induced seismicity at the Hellisheidi geothermal field. Around  $\sim 20$  mm of expansive ground deformation was linked to fluid injection, which, in turn, could be linked to induced seismicity in the area. The study is a rare example where significant ground deformation can be linked to induced seismicity related to the injection of fluids into the crust.

Research by Univ. of Iceland



## Results from the Virunga Supersite

Thanks to info from Francoise Villette the Coordinator activated the Risk and Recovery mapping from Copernicus EMS.



**Service Request Form (SRF)** **Copernicus EMS Risk and Recovery Mapping**

To be sent to the ERCC (Mon-Fri 9-17h)

Email: [echo-ercc@ec.europa.eu](mailto:echo-ercc@ec.europa.eu)  
Tel: +32-2-29-21112

Please provide the information requested in the areas marked in **blue**.  
For more information on the service and a printable/editable version of this form, please refer to <http://emergency.copernicus.eu>.



### Activation details

#### Activating institution

National Focal Point       EC Services       EEAS

Organisation Name: Goma Volcano Observatory

Contact Person: Dr Charles Balagizi

# Results from the Virunga Supersite

They requested a Volcanic Hazard map and a VHR DEM to model the impact of lava flows descending from the volcano flanks.

## Detailed description

*Please provide in the following text field more details on the product(s) you need., e.g. a list of maps you require (map name, size, scale), spatial and thematic detail you need, coordinate system, etc.*

We need the following:

- Volcanic Hazards map: WGS84 Geographic system  
1:1,000 scale

- Generate a VHR DEM of the area that will be used for computer based simulations of lava flow pathways for eruptions of Nyiragongo, and thus predict the level (low, middle or high) susceptibility to future invasion for each part of Goma city. Preferred resolutions: spatial 1-2 m, height <1 m.

## Risk information

*Please select the information you need and possibly provide further details.*

- Hazard: Volcanic, mainly lava flows pathways
- Exposure: population of Goma, Gisenyi and surroundings (estimated at least 1.5 million inhabitants in 2012 and 2013)
- Exposure: assets private and public buildings (schools, hospitals, government, etc.), airport, commercial activities, lifelines, essential infrastructures, agricultural activities
- Risk: Risk scenarios providing economic, environmental, social impact estimates
- Consequences (e.g. delineation of the event impact area and damage grading):

Other, please specify:

## R & R mapping for the Virunga Supersite

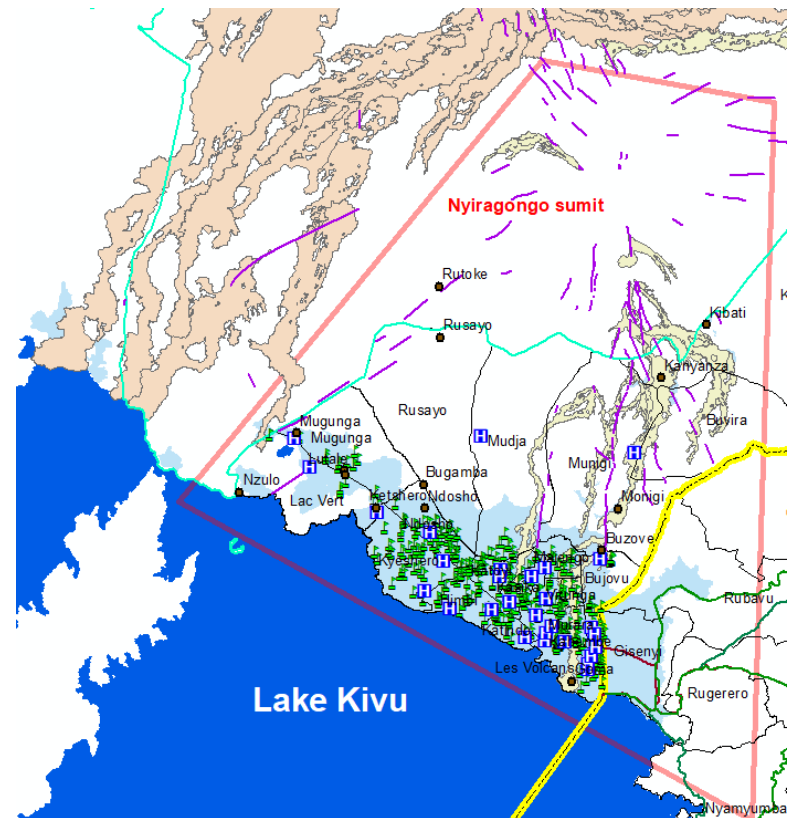
- ❖ The Service Request Form was sent on May 10, 2017
- ❖ The process started on August 30, 2017
- ❖ The SAR data to produce the DEM was acquired on February 23, 2018
- ❖ The DEM is under production
- ❖ Other maps will follow

# Local data acquired for the R & R mapping Virunga Supersite

- Nyiragongo and Nyamulagira historical (1938 to present) lava flows shapefiles
- Nyiragongo and Nyamulagira eruptive fissures
- Nyiragongo 1977 and 2002 eruptions eruptive vents
- Road Network for both Goma (DR Congo) and Gisenyi (Rwanda) cities and surroundings
- Urban area shapefiles for both Goma and Gisenyi cities and surroundings villages
- Hydrographic Network in the study area
- Hospitals location in both Goma and Gisenyi cities
- Schools (primary, secondary and university) location in both Goma and Gisenyi cities



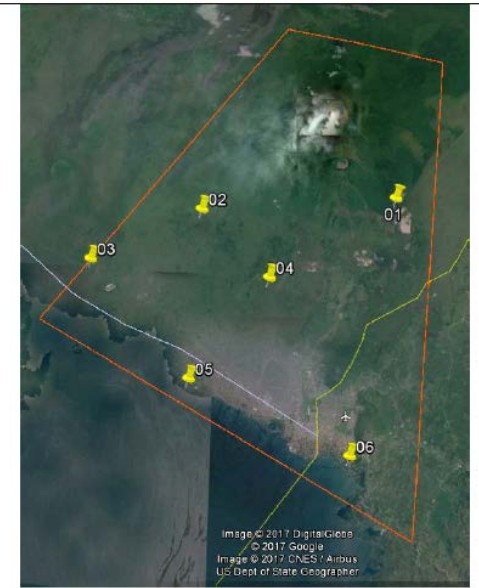
# Local data acquired for the R & R mapping Virunga Supersite



Overview of the five (5) Differential GCPs



Overview of the six (6) extra GCPs



## Future Supersites ?

**Proposal for a permanent Supersite in Peru** – There has been a lot of work done by three large scientific institutes: INGEMMET, IGP and INAIGEM. They have prepared a proposal but last week we met in Lima and I requested some further integrations. The final proposal should be submitted very soon (a description follows)

**Discussions on a permanent Supersite in Colombia** – The Colombia Geological Survey has expressed the intention to propose a Supersite, area still TBD

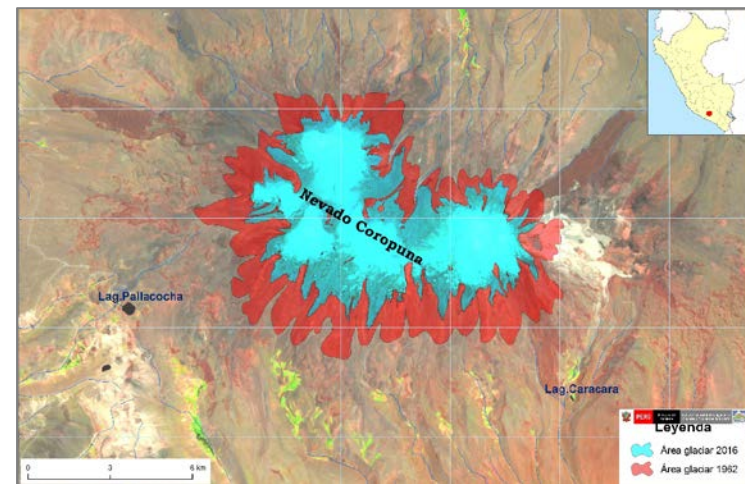
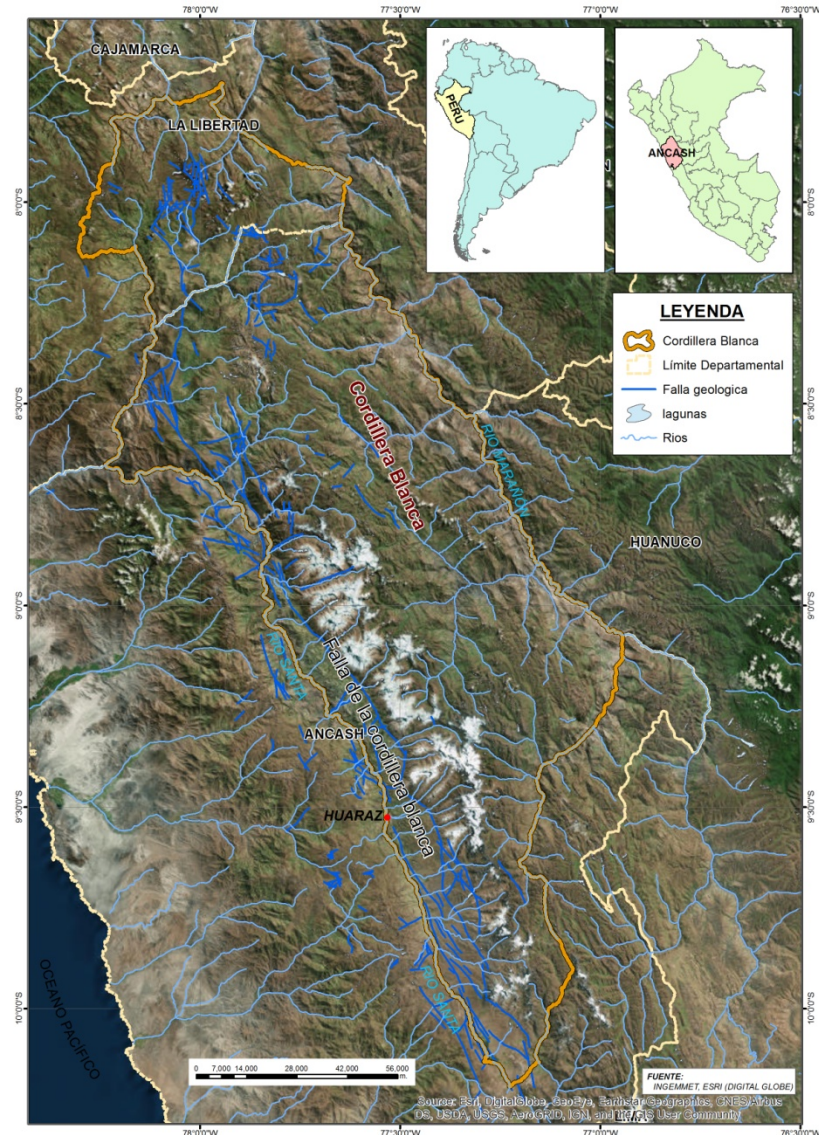
**Discussion on a permanent Supersite in the Philippines** – PHIVOLCS and the Univ. of Phil. have expressed interest but there must be more discussion.



## Peru Supersite proposal

The proposal includes two areas:

- the Cordillera Blanca, a 200-km long mountain range with elevations up to 5500 m, including several volcanoes with summit glaciers;
- the Nevado Coropuna (6733 m), hosting a large glacier and deep canyons dissecting the edifice



## Peru Supersite proposal

High geohazard levels: strong earthquakes, eruptions, landslides, avalanches and glacial lake outburst flood (GLOF) occur every few tens of years, sometimes triggered by earthquakes. The most important were:

- 1941 - Palcacocha GLOF on the city of Huaraz, destroying a third of the city (about 4000 deaths);
- 1962 - avalanche of the Nevado Huascarán Norte (6654 MASL) destroying Ranrahirca (>4000 deaths);
- 1970, earthquake-triggered avalanche and GLOF over the cities of Yungay and Ranrahirca completely erasing them (>18000 deaths). The earthquake caused > 70000 deaths in total;



*City of Yungay, Peru: Before and after the earthquake of May 31, 1970.*



# Peru Supersite proposal

The 1970 earthquake-triggered glacial outburst flood which destroyed Yungay



## Peru Supersite proposal

The specific objectives of the Supersite are the following:

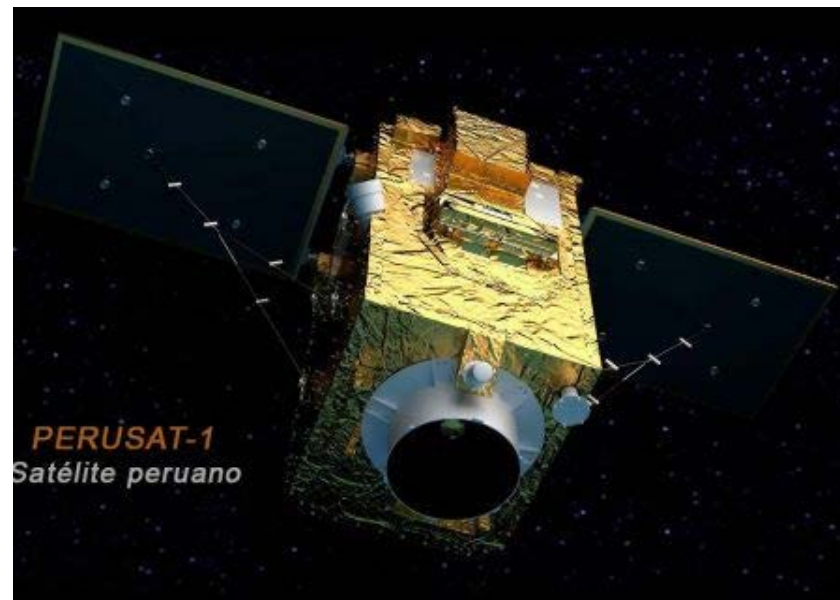
- Improve the monitoring capacity of seismicity/deformation and evaluate their influence on the stability of the hanging glaciers;
- Improve scientific research in glacial areas related to internal and external geodynamics;
- Establish a regional geological model of the Fault Tectonics;
- Have technical-scientific information in near real time to generate detailed maps of avalanche and other external geodynamic flows;
- Establish and integrate with EO data an Early Warning System for Avalanches in the sub-basins of glacial origin

## Peru satellite: PeruSat-1

Peru has a great optical satellite (70 cm spatial resolution), built by Airbus for CONIDA.

CONIDA is already providing imagery to the institutes proposing the Supersite and has expressed the intention of supporting other Supersites.

They should be part of the CEOS and of the WG Disasters.





## GSNL ethical rules (TBD in the SAC)

The Supersite scientific community will be invited to respect some **ethical rules**:

- Research must be collaborative, pursuing the active involvement of local scientists such that there is a **transfer of knowledge and capacities**.
- Research results should be digitally shared within the community, **ensuring protection of intellectual property rights (IPRs)**.
- The top priority during an emergency is to **generate data and research to support the Response activities**, not to aim for scientific publications.





## Supersite concept extended to other scientific goals ?

- Lately we have seen more requests to include in GSNL other geohazards, as landslides, glacial outbursts, basin overflows, ground subsidence.
- Moreover, the success of the Geohazard Supersites has stimulated other communities to think about the same concept in different disciplines (biology, ecology, etc.).
- What is the CEOS WG Disaster feeling on this ?

## CEOS & GEO-GSNL

- Add CEOS logo to our banner?
- Add CEOS logo to each Supersite webpages ?
- Place GEO-GSNL logo somewhere on the CEOS website
  
- Cooperate for capacity building