GROUP ON EARTH OBSERVATIONS

Geohazard Supersites & Natural Laboratories

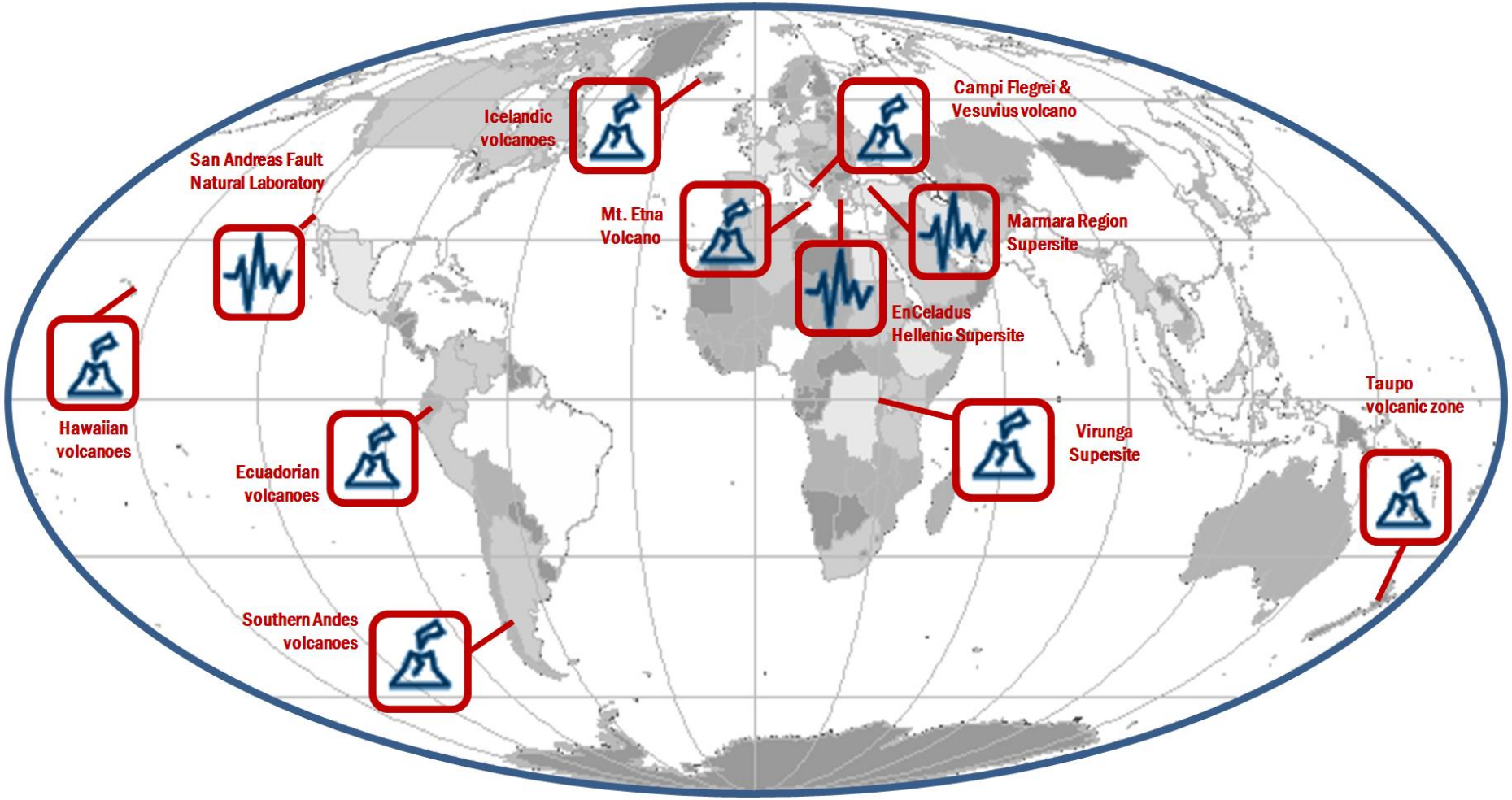
Status of the GEO-GSNL initiative

Stefano Salvi

Chair of the Supersites Advisory Committee

CEOS WG Disasters meeting #12, Reykjavik, 24 September 2019

The Supersite network in 2019 – 11 sites



	Supersite	Next Biennial report	Use of CEOS data in 2019
1	Hawaiian volcanoes	25-Oct-20(4th)	Very good use of CEOS data
2	Icelandic volcanoes	5-Nov-19 (3rd)	Good use of CEOS data
3	Etna volcano	9-Apr-20 (3rd)	Good use of CEOS data
4	Campi Flegrei/Vesuvius volcano	9-Apr-20 (3rd)	Good use of CEOS data
5	Marmara Fault	9-Apr-20 (3rd)	Good use of CEOS data
6	Taupo volcano	15-Apr-21 (4th)	Good use of CEOS data
7	Ecuador volcanoes	15-Apr-21 (4th)	Good use of CEOS data
8	Corinth Gulf/Ionian Islands	8-Nov-20 (2nd)	Limited use of CEOS data
9	San Andreas Fault NL	27-Apr-21 (2nd)	Limited use of CEOS data
10	Southern Andes volcanoes	19-Oct-19 (1st)	Limited use of CEOS data
11	Virunga volcanoes	19-Oct-19 (1st)	Limited use of CEOS data

Event Supersites

	Supersite	Supporting agencies	Use of CEOS data in 2019
1	Azgeleh earthquake, Iran-Iraq	ASI, CNES	InSAR data processed and nearly published, optical data under acquisition

New Supersite proposals (more later)

	Proposal	Coordinator	Data requested
1	China faults	Prof. Yun Shao, Aerospace Information Research Institute Chinese Academy of Sciences	CSK, TSX, ALOS 2 and Sentinel 1 at 6-day repeat pass
2	Kamchakta/Kuriles volcanoes	Dr. Alina Viktorovna, Institute of Volcanology and Seismology / GFZ German Research Centre for Geosciences	CSK, TSX, RSAT 2, Pleiades, ALOS 2

EO data provision issues

- At the moment Pleiades data are still distributed to the community by the Supersite coordinators. It would be advisable to use a digital platform to improve access and thus usage.

CSK data in the GEP

Supersite	CSK data available In the GEP	Data uploaded since the start of ASI-ESA agreement, Feb. 1st 2018
Hawaii volcanoes	1090	245
Iceland volcanoes	1924	315
Marmara fault	563	302
Etna volcano	0	0
Campi Flegrei-Vesuvius volcano	524	212
Ecuador volcanoes	27	27
Corinth Gulf/Ionian Islands	0	0
Taupo volcano	246	246
Southern Andes volcanoes	702	703
San Andreas Fault	446	452
Virunga volcanoes	885	885
Azgeleh eq. Event Supersite	116	116

EO data usage

- All recent Supersites have started to order EO data, although data processing may not have started yet.
- While data are constantly acquired, data processing is carried out irregularly, following the evolution of the seismic and volcanic phenomena.
- Since Supersite Coordinators are members of the local disaster prevention frameworks, scientific results are directly fed into the decision-making chain.
- Scientific publication rate may be slow in some cases due to inadequate capacities or computing resources at local scale. Also, during events the priority is to support the crisis management, and publications are put in low priority.

Data processing resources

Supersite computing resources have been supported by the ESA-GEP and the EVER-EST project:

- **The GEP provides** InSAR data processing capacities using 4 different softwares. It also provides optical data processing tools for DEM extraction and deformation mapping. The services are available to several Supersite users.
- **The EVER-EST project** provides access to powerful virtual machines including commercial software for high performance computing of InSAR and optical data. The VMs are reserved to the Supersite coordinators.

Improving Supersite capacities

- **Ecuador Supersite**: two scientists were trained at a school organised by USGS in Peru (1 week), and then at INGV for a month. The Coordinating institution (IGEPN) is now able to process and interpret/model InSAR data locally.
- **Chile Supersite**: one scientist was trained at a school organised by USGS in Peru (1 week), then she has been invited to INGV for extended training in InSAR.
- **Virunga Supersite**: one scientist has visited at INGV for training in volcano geochemistry (1 month). Two others will be trained in GNSS in late 2019.
- In the framework of the EUROVOLC EC project, **European volcano Supersites** are allowing scientists to access their local resources and laboratories, remotely and on site.

GSNL community meeting @ IUGG 2019 -1

- **Relations to GEO:** some members believe that being a GEO initiative is not providing an added value to GSNL. Reasons are that we do not get much support from GEOSec, the GEO WP is requesting initiatives to involve the private sector (which is nearly impossible for GSNL), the new GEOSec director believes that the impact from voluntary initiatives has reached a limit, and aims to promote less scientific initiatives. Also local governments, international organisations, development funds, do not seem to regard GSNL with more attention because it is a GEO initiative.
  At the end of the discussion the audience concluded that for now it is still important that GSNL be part of GEO, but GEOSec should improve its support to the initiative.
- **Community resources**: the Supersites should exchange resources and use open infrastructures for data hosting (especially EO data, but in some cases also in situ). To be verified if Earthcube (USA) can host data and products for foreign Supersites.

GSNL community meeting @ IUGG 2019 -2

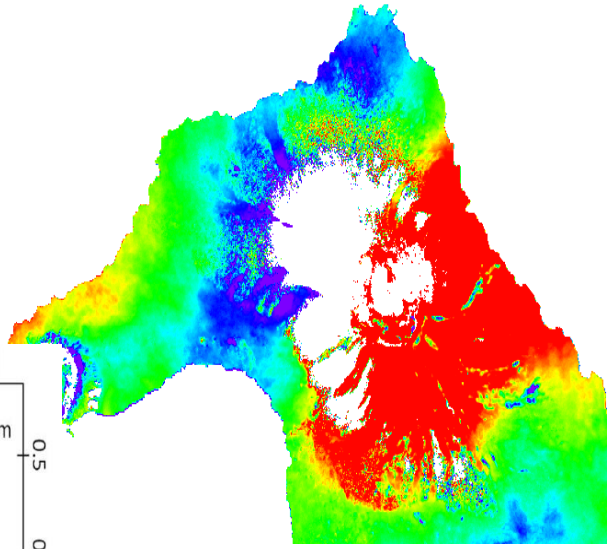
- **Sendai Framework contribution:** not clear how to demonstrate GSNL practical contribution towards reaching the (very wide) SF targets. As a minimum, we can try to identify and contact the reference persons for SF reporting in each country, to be able to contribute to the national reports.
- **Communications**: we need to improve communications with GEOSec and with our community.

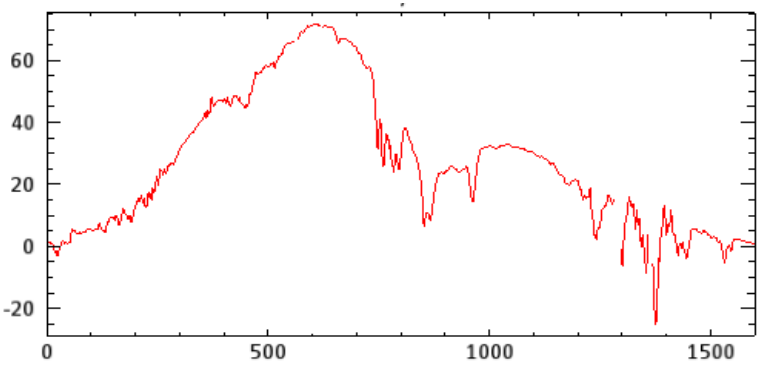
Results from the Supersites

- Ecuador
- Etna
- Taupo
- Campi Flegrei/Vesuvius
- Virunga

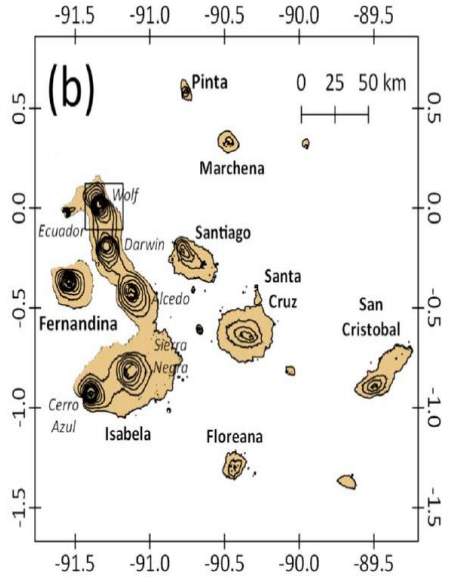
Deformation at Wolf volcano, Galapagos

There are not GPS or tiltmeters in the volcano, so InSAR is the only tool to monitor patterns of deformation. Sentinel 1 data. Inflation up to 70 mm between December 2016 and August 2019 is visible in the caldera.





Displacement in LOS interferogram in the Wolf volcano between December 2016 and August 2019 (S. Aguaiza – IGEPN).



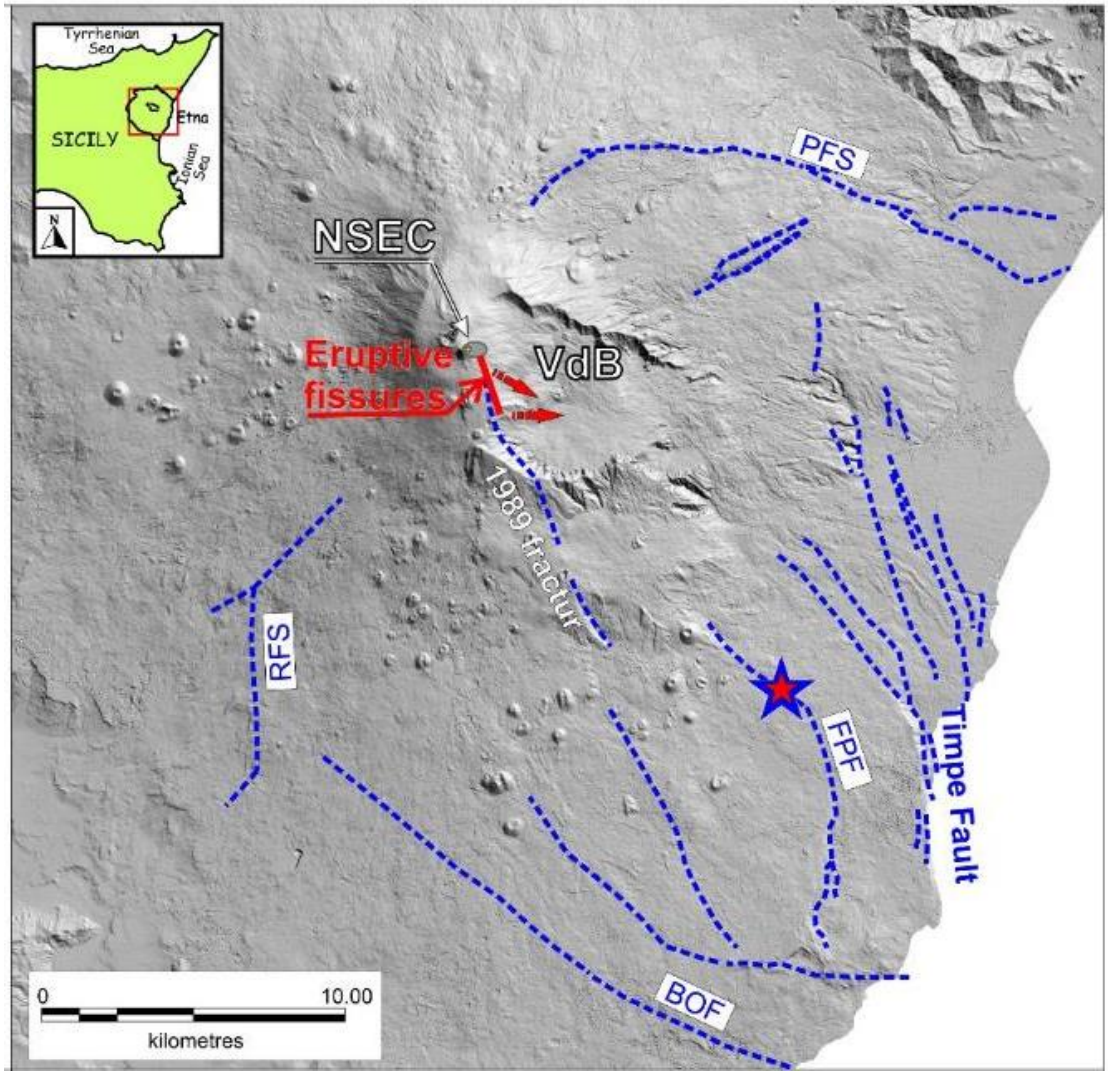
Not a Supersite volcano, but first local processing of InSAR data at IGEPN

Volcanic and seismic activity at Mt. Etna, December 2018

On 24/12/18, an eruptive fissure propagated from the South-East Crater into the Valle del Bove, for a length of about 2 kilometers. Explosive phenomena accompanied the first phase of the eruption, but ended after just a few hours. The lava flow was fed until December 27.

F. Guglielmino, 2019

The seismic swarm

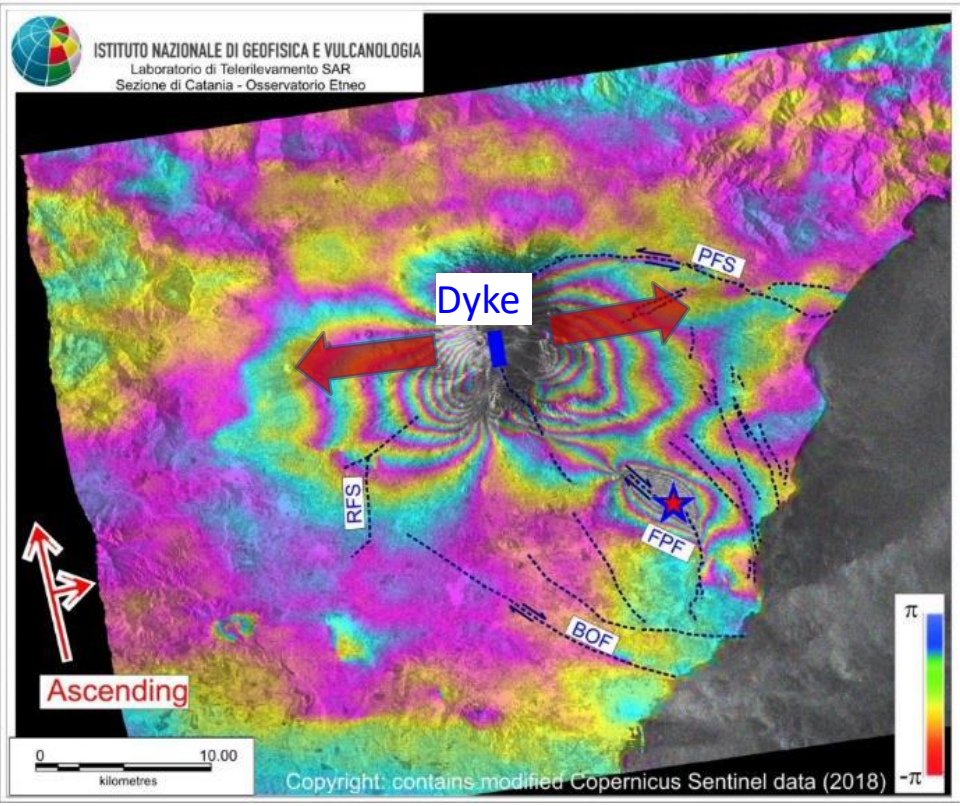


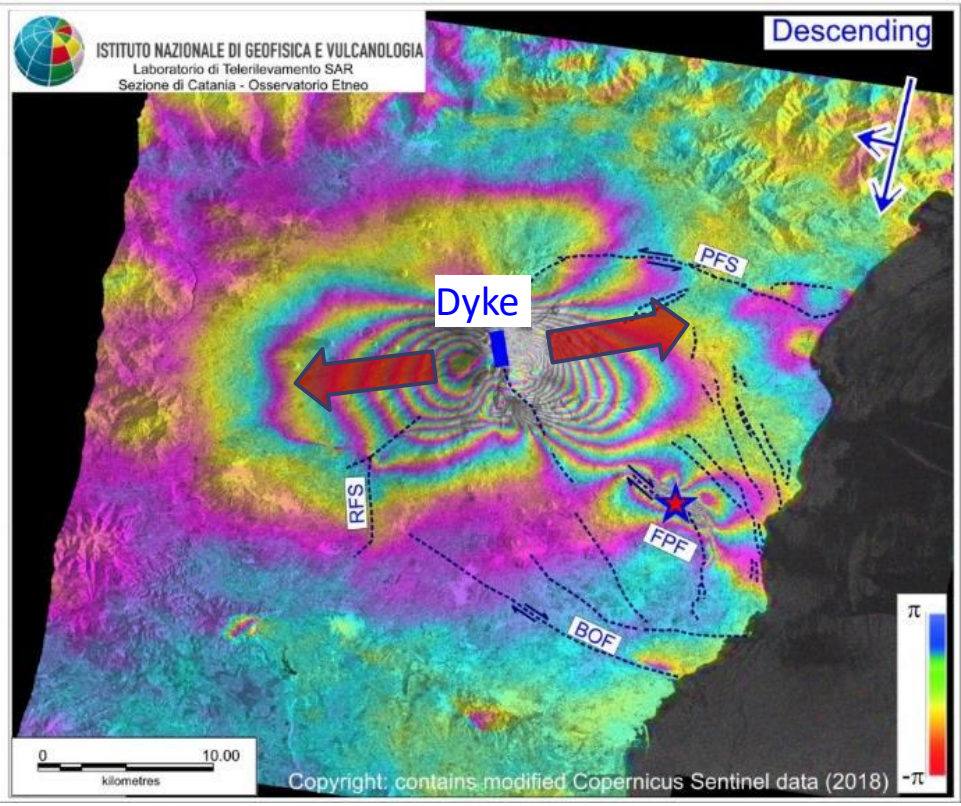
Thousands of earthquakes occurred along many of the known active faults. The highest energy one was a Mw 4.9 event recorded along the Fiandaca-Pennisi fault. Due to its very shallow depth (3 km) the quake created widespread damage in the villages of the lower southeast flank of Etna.

Bonforte, et al., 2019,. *Terra Nova*

22-28 December Sentinel 1 interferogram

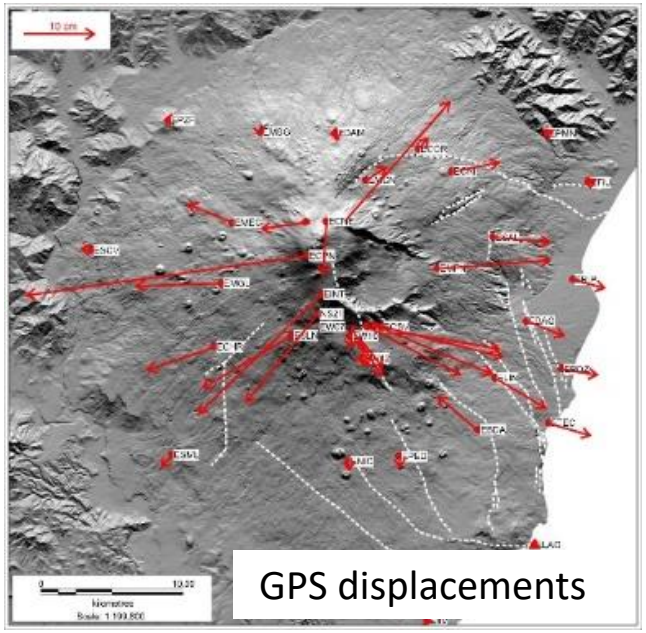
The InSAR results show extension along a N-S dyke located near the summit.
Co-seismic deformation due to the Mw 4.9 is also visible in the lower right.



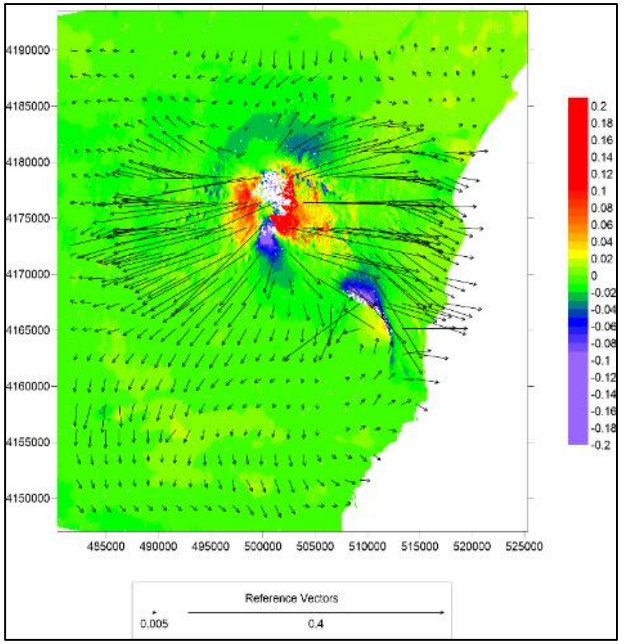


Bonforte, et al., 2019,. *Terra Nova*

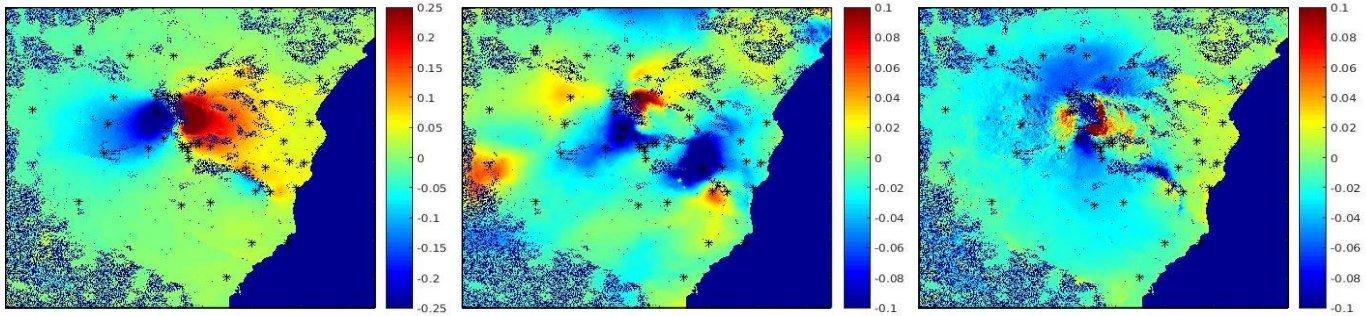
GPS & SAR data integration using the SISTEM 3D algorithm



GPS vector displacements have been combined with the LoS InSAR diplacements to obtain a continuous representation of the 3D deformation field in the area.

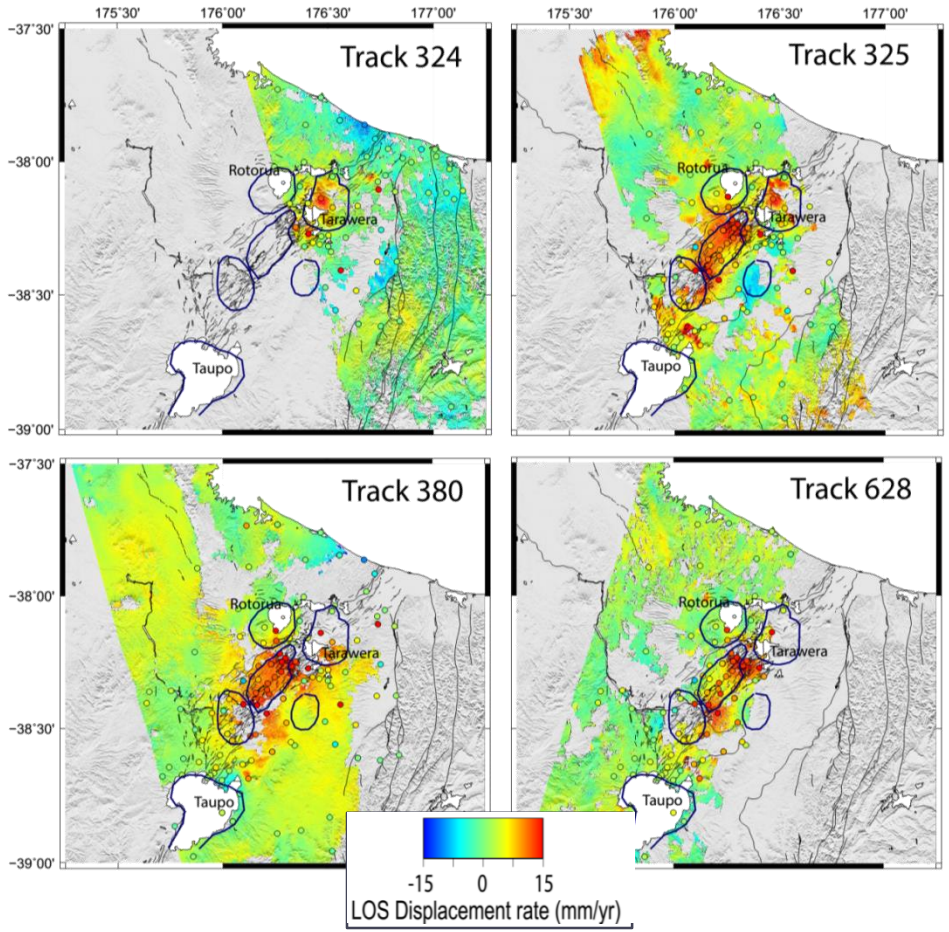


East **North** **Up**

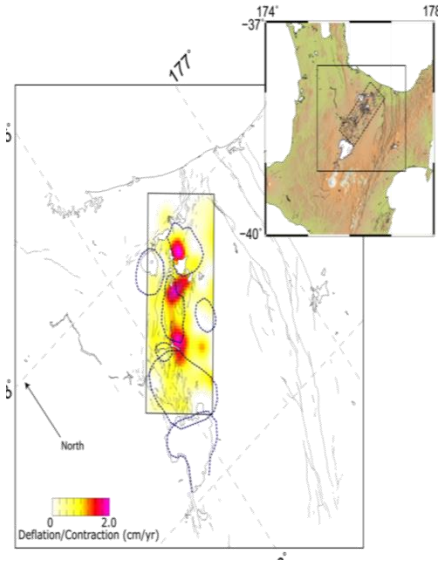


Taupo Supersite: deformation along the TVZ

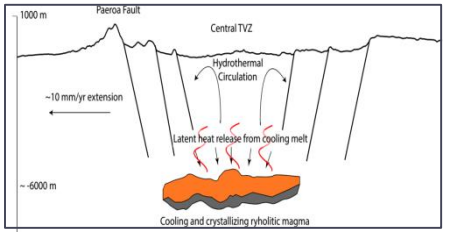
Archive Envisat, ALOS data and GPS show up to 20 mm/yr of subsidence along the length of the TVZ between 2003 and 2011.



Large scale subsidence has been explained as due to cooling of magma at ~8 km depth and is consistent with magnetotelluric data



Annual volume loss = 0.016 km^3



I. Hamling, 2019

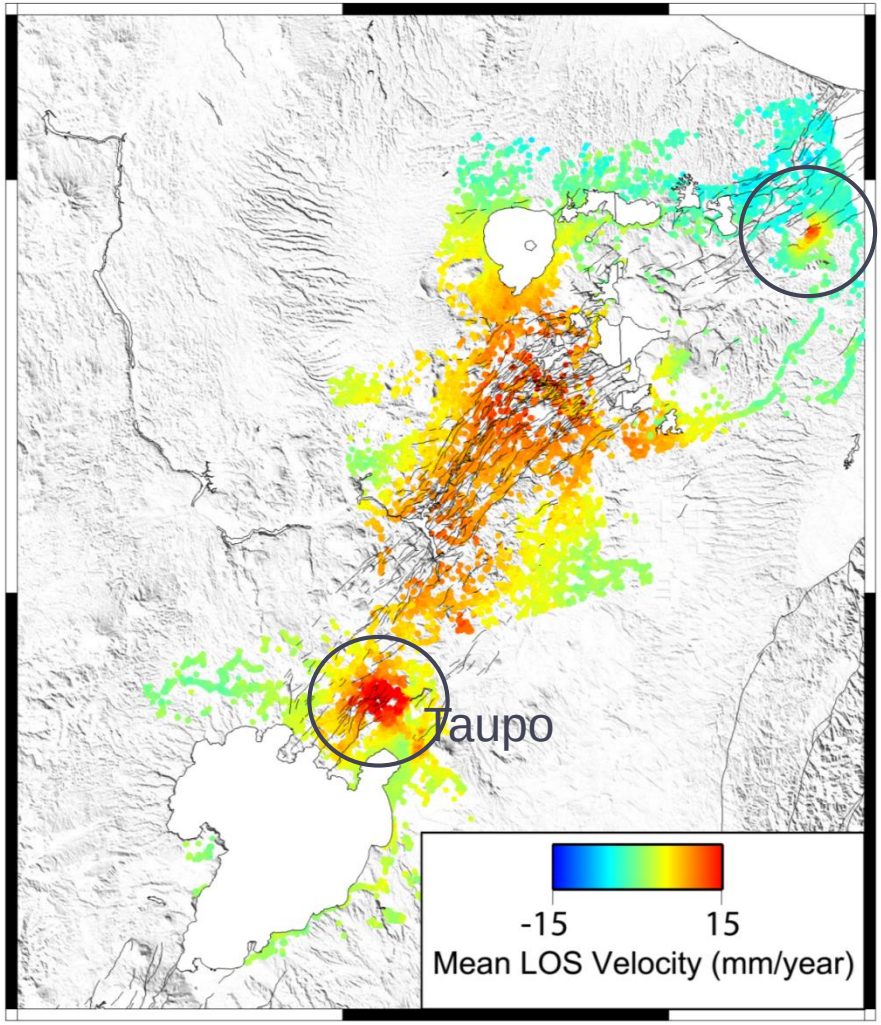
Deformation along the TVZ updated by CSK 2015-2019

CSK data provide updated information on the current state of deformation.

Despite challenges with coherence, PS-InSAR is able to highligh the continued subsidence along the length of the TVZ.

The map, derived from 4 CSK frames between 2015 and 2019, shows LOS rates of ~10-15 mm/yr over a ~1500 km^2 region.

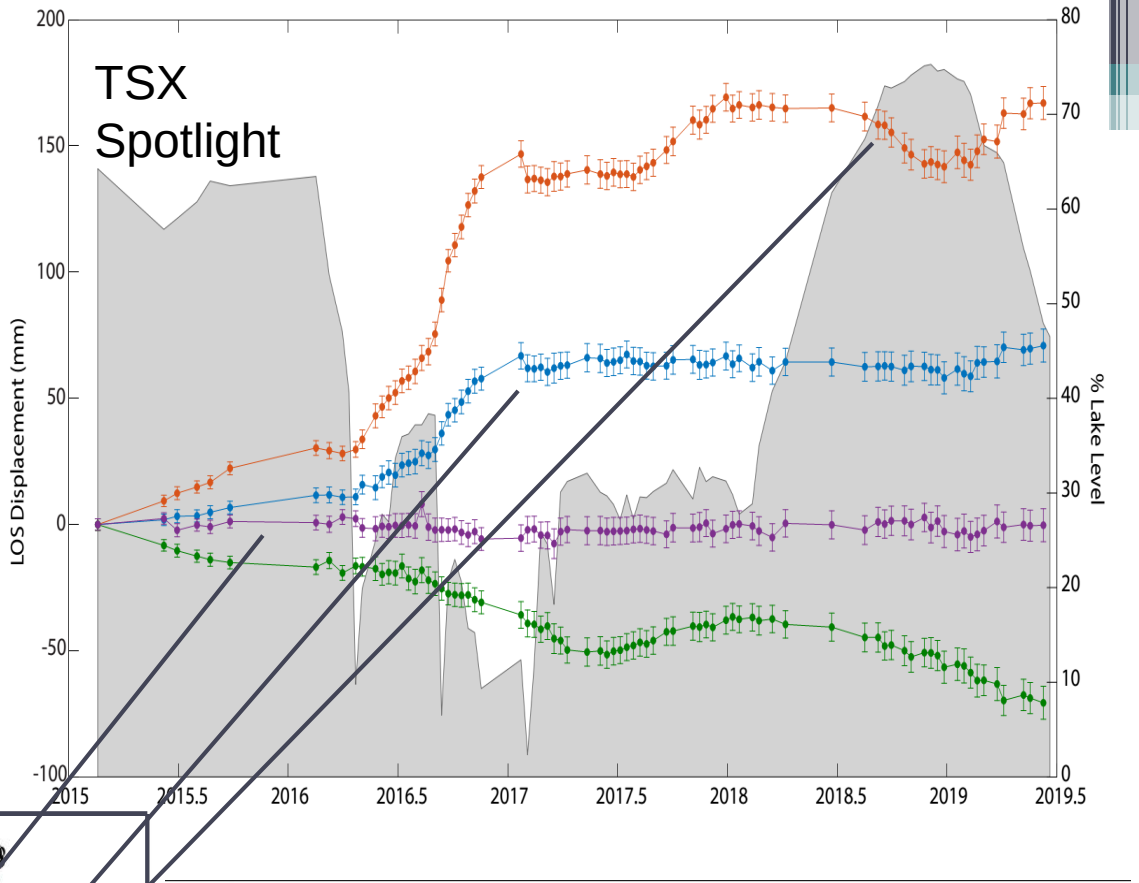
Displacement rates up to ~ 50 mm/yr are observed over geothermal plants, such as Wairakei north of Taupo as well as Kawerau in the North (circles).

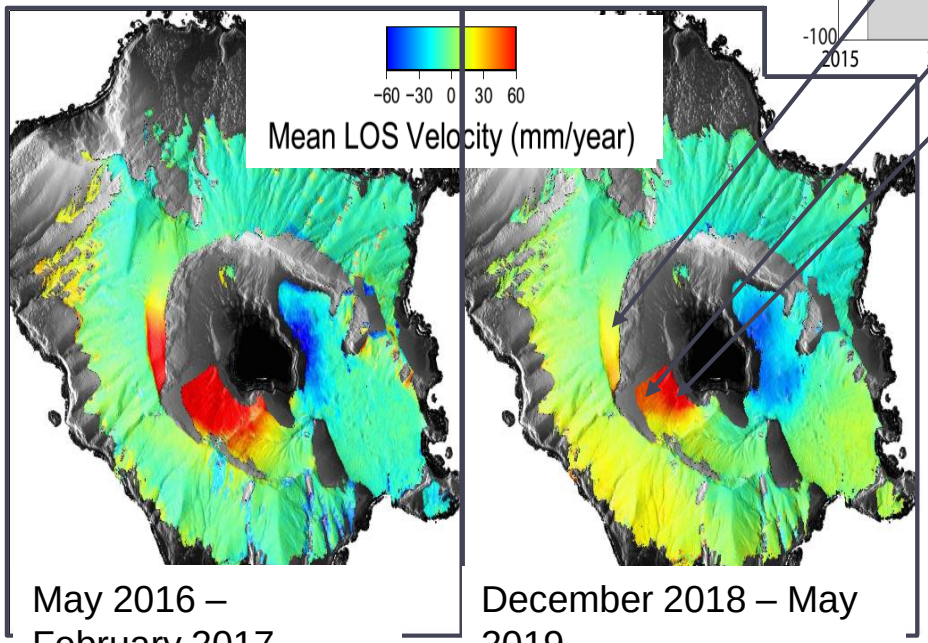


I. Hamling, 2019

Deformation along the TVZ: White Island

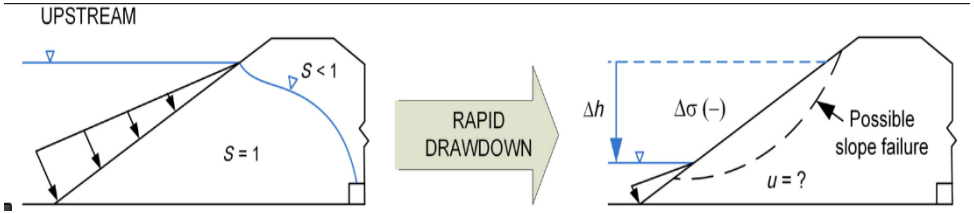
Slope motion is a result of the rapid removal of the crater lake. The rate of deformation peaks during periods of dropping water level in the lake.





May 2016 – February 2017

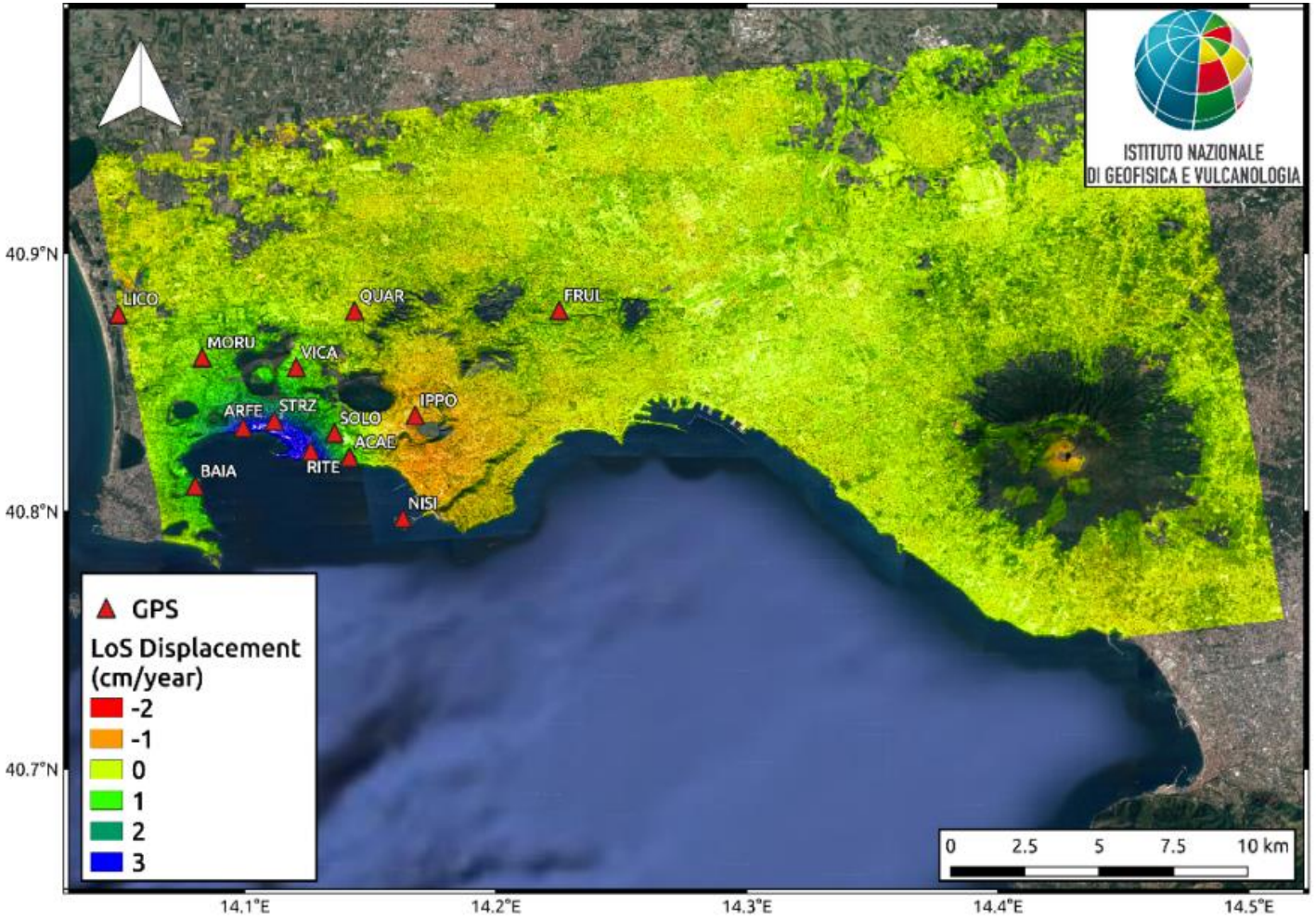
December 2018 – May 2019



Changes in pore pressure within the hydrothermal system modulates the rate of motion along the slope.

I. Hamling, 2019

Deformation in the Campi Flegrei Supersite

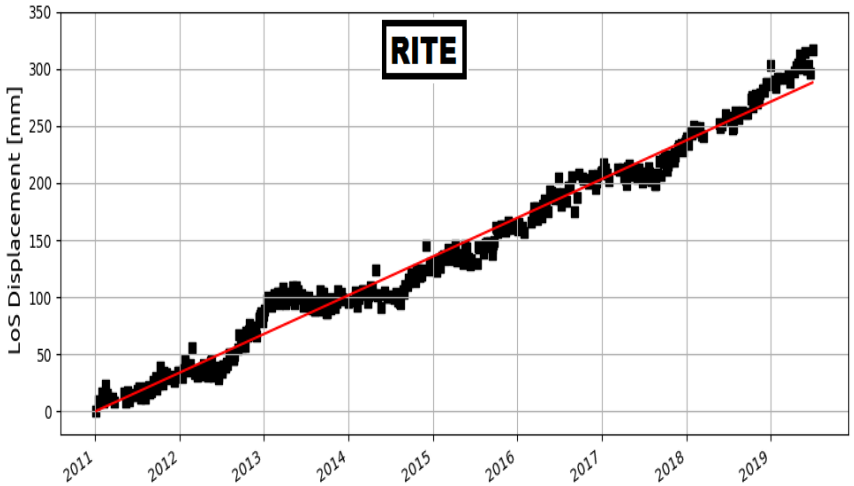


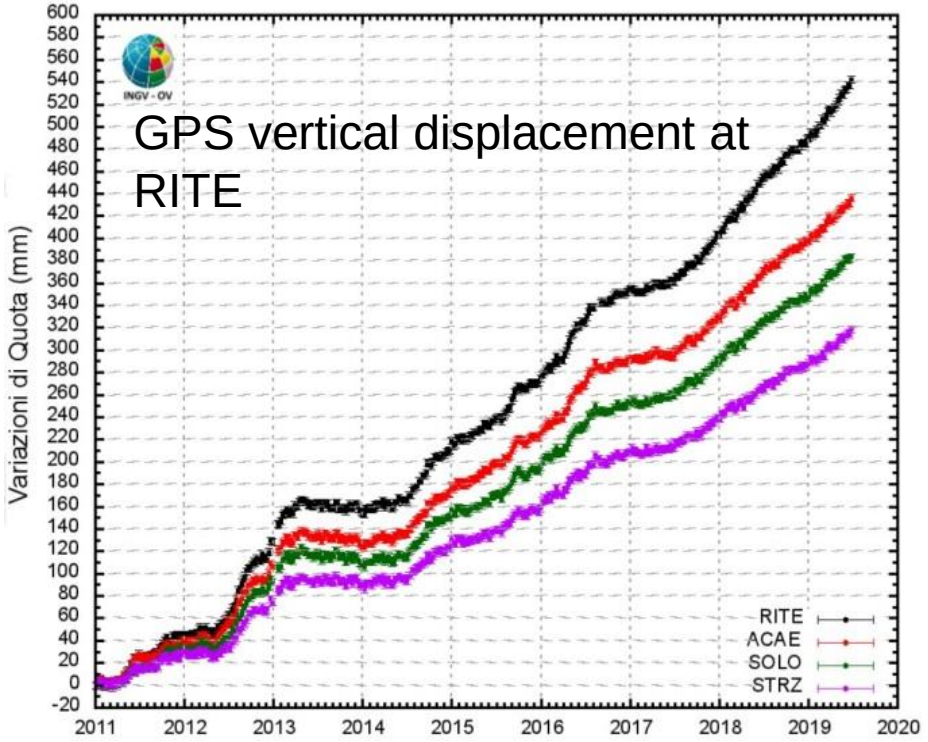
Mean LoS velocity map on the Vesuvius-Campi Flegrei Supersite
COSMO-SkyMed data, ascending track, 2011.01-2019.06

M. Polcari, INGV-ONT

Deformation in the Campi Flegrei Supersite

CSK 2011-2019 LoS ground displacement time-series at the RITE CGPS site



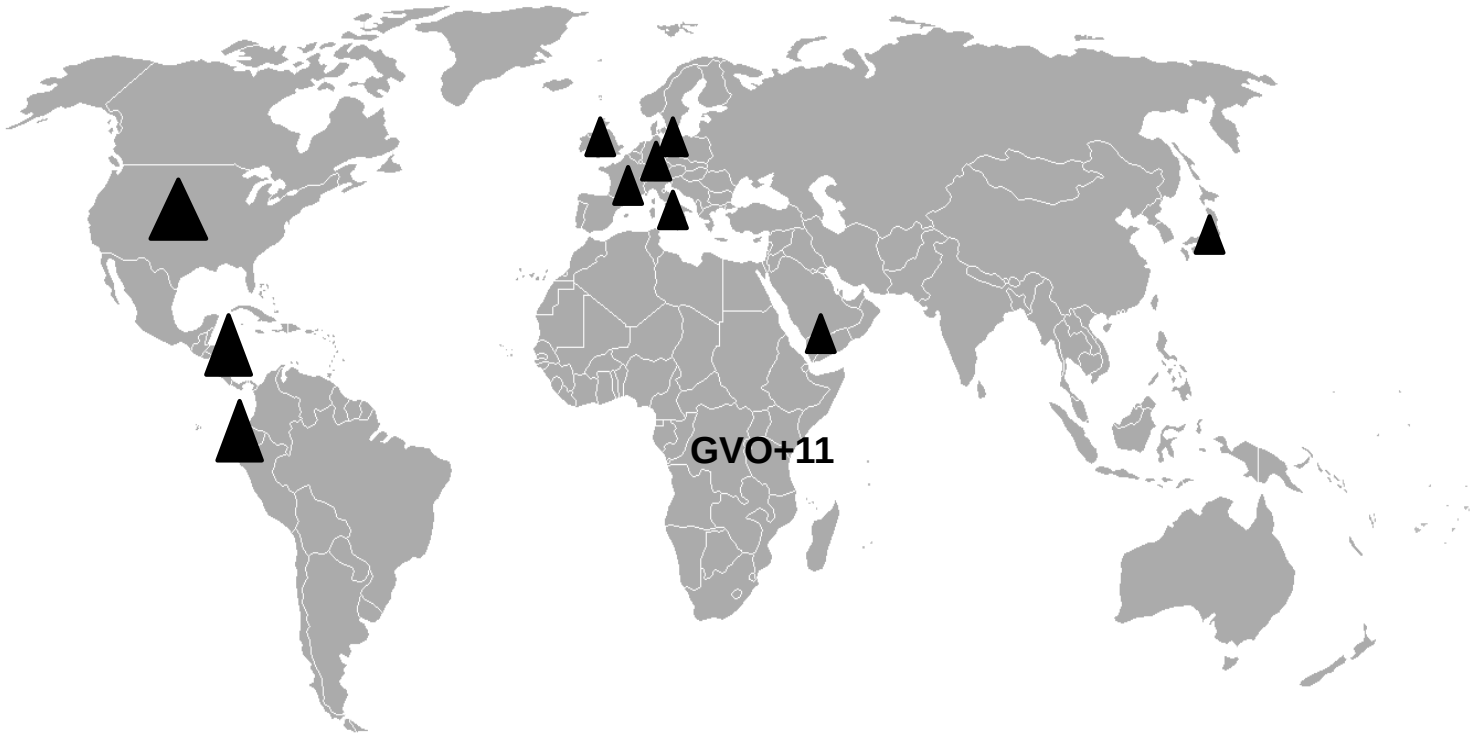


Total vertical displacement ≈ LoS/cosΘ ≈ 33/cos49° ≈ **51 cm**

InSAR and GPS time series are in very good agreement

M. Polcari, INGV-ONT - P. De Martino, INGV-OV

International collaborations at Virunga Supersite



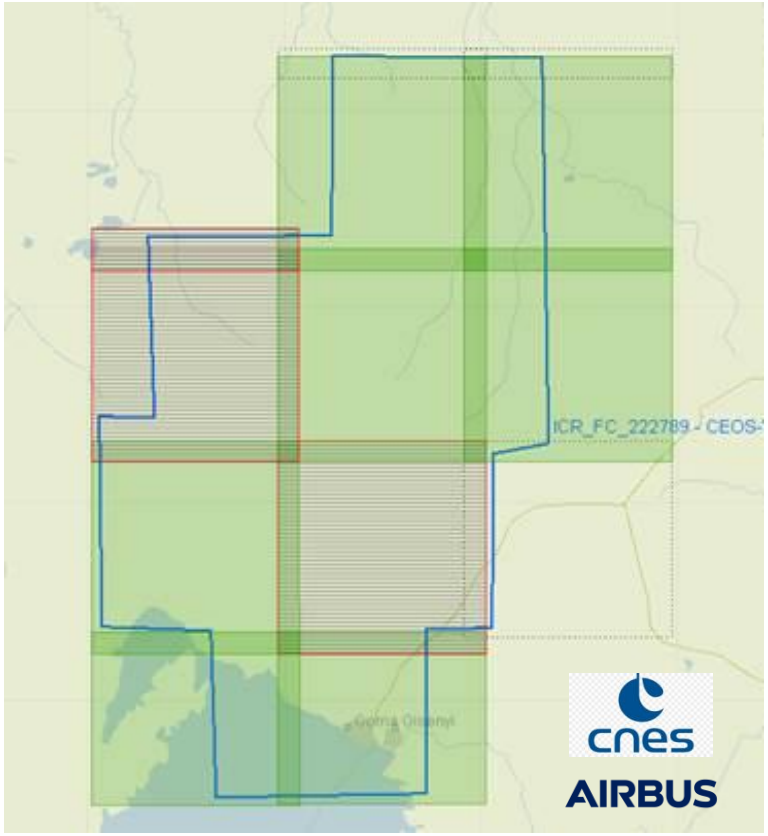
The Virunga Supersite has allowed GVO to obtain more international support and visibility, and is now an international network of scientists and agencies.

More active partnership with:

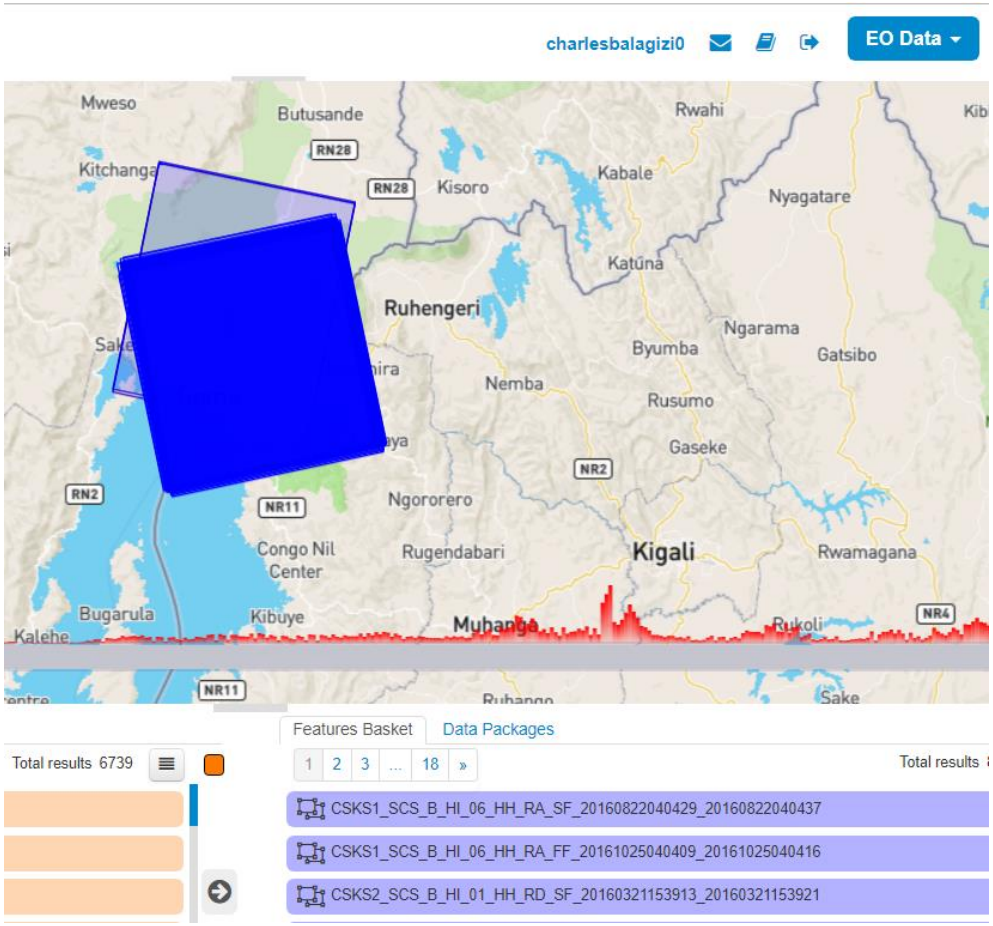
- USGS and the Volcano Disaster Assistance Program, USA
- INGV, Italy

C. Balagizi, 2019

CEOS support to Virunga Supersite



Pléiades acquisition plan nearly completed



COSMO-SkyMed SAR data are available through the ESA-GEP

C. Balagizi, 2019

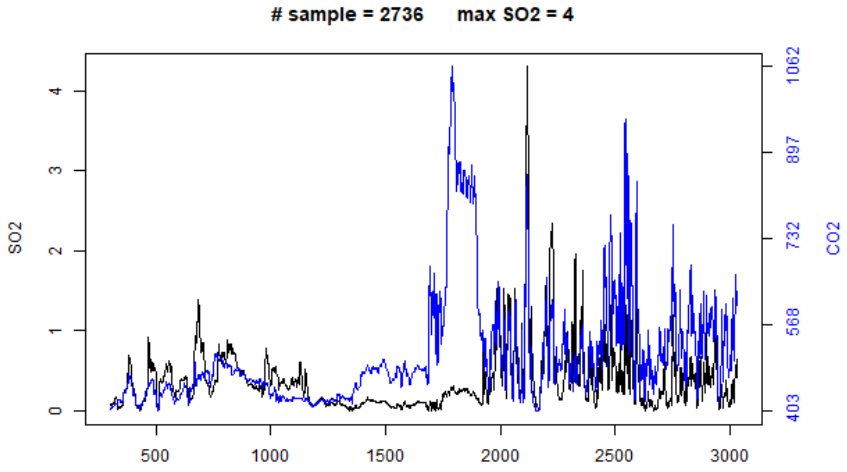
Virunga S: GVO scientists trained by VDAP

MultiGas training in the lab, Washington-USA

Training in the field, Lassen National Park-USA

Instrument deployed at Nyiragongo Volcano

Preliminary results from the MultiGas Nyiragongo Volcano



Further international collaborations

- Collaboration with IREA-CNR, Italy, for time series InSAR data processing. First results will be shown in the biennial report.
- Two INGV researchers were planned to visit GVO in September for training on GPS data analysis, but the news of an Ebola outbreak in Goma forced them to postpone the mission.

New Supersite proposals

	Proposal	Coordinator	Data requested
1	China faults	Prof. Yun Shao, Aerospace Information Research Institute Chinese Academy of Sciences	CSK, TSX, ALOS 2 and Sentinel 1 at 6-day repeat pass
2	Kamchakta/Kuriles volcanoes	Dr. Alina Viktorovna, Institute of Volcanology and Seismology / GFZ German Research Centre for Geosciences	CSK, TSX, RSAT 2, Pleiades, ALOS 2

China proposal objectives

Objective 1: Imaging of new earthquakes. Acquire multi-sensor SAR imagery for all significant earthquakes in China to study co-seismic and post-seismic deformation.

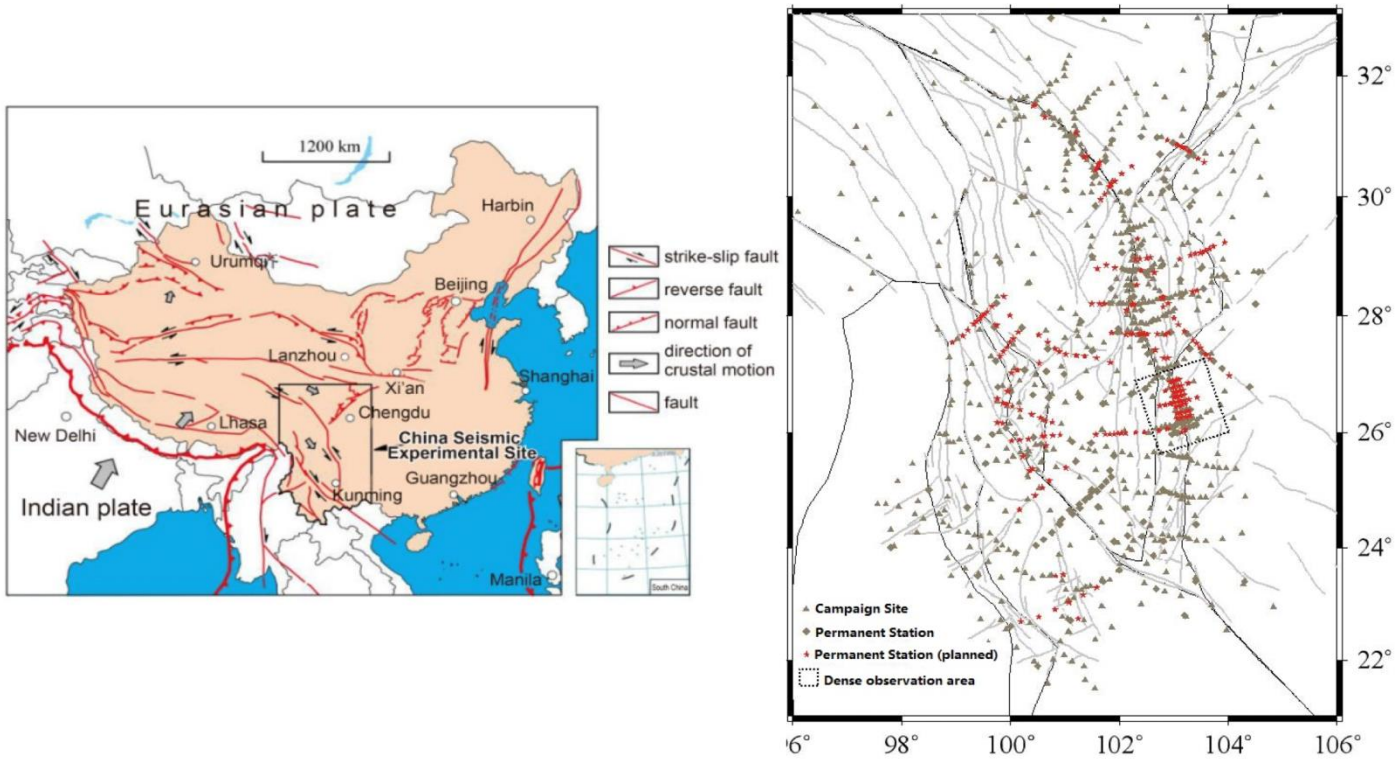
Objective 2: Longmenshan Fault post-seismic deformation. Acquire 6-day Sentinel-1 data on the 2008 Sichuan eq region to resolve post-seismic deformation and understand how it affects nearby faults.

Objective 3: Haiyuan Fault interseismic deformation. Acquire high-resolution imagery of selected sections of the Haiyuan fault to study the interseismic deformation and aseismic creep.

Objective 4: Support the China Seismic Experimental Site (CSES). Acquire 6-day Sentinel-1 imagery and ALOS2 PALSAR2 imagery at CSES sites to map the interseismic deformation.

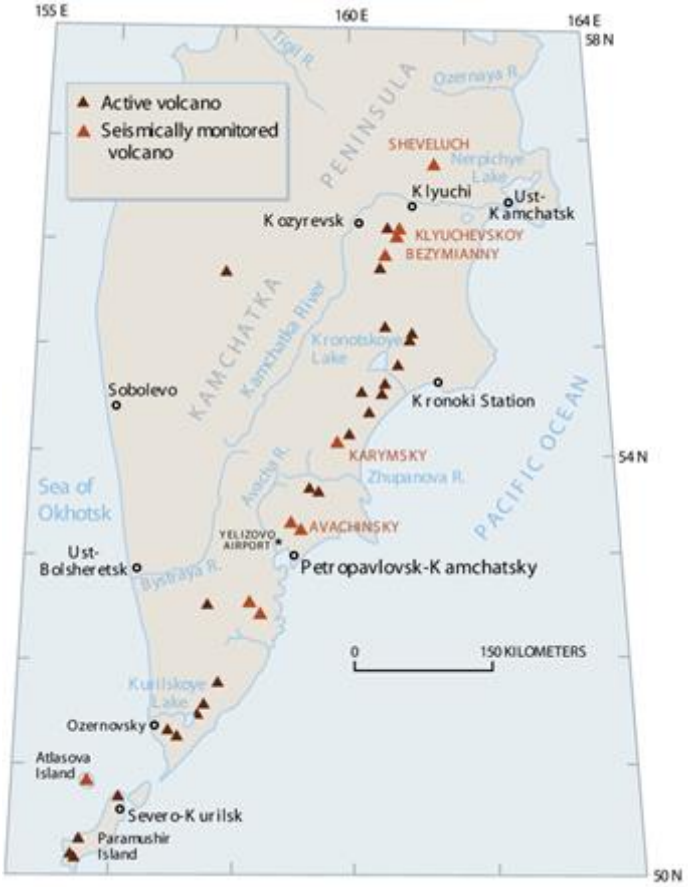
Objective 5: Data sharing. Advance data sharing in China (GNSS, Seismic, InSAR). Promote the GEO data sharing principles and the GEO objectives. Promote international collaboration and participation of China in the GSNL initiative (with two L-band satellites to be launched in 2021, China could become an important data provider).

The China Seismic Experimental Site (CSES).



The China Seismic Experimental Site (CSES) was launched in 2018 at the 10year anniversary of the 2008 Wenchuan earthquake. CSES follows international initiatives such as the Southern California Earthquake Center (SCEC) and has open data policy.

The Kamchatka/Kuriles proposal



The Kamchatka/Kuriles region. By combining ground truth (geophysical and geochemical instrumentations) with satellite remote sensing, the proposal aims at the scientific monitoring of all large Holocene volcanoes.

Kamchatka/Kuriles proposal objectives

1. To collect space-borne data for active volcanoes in the area for hazard mapping and rapid response actions at volcanoes under red alert level.
2. To establish regional source models mostly based on ongoing research at Kamchatka Institute of Volcanology and Seismology.
3. To develop a strategy for deformation monitoring based on InSAR and optical (Pleiades) data processing.
4. To develop an early warning system for volcanic unrest integrating seismicity with deformation and gas measurements.
5. To improve the capability to track effusion/emission rates based on optical and radar image products.
6. To improve the capability to generate high resolution hazards maps for lahars and other debris flows.
7. To develop new products and services based on collaborations within GSNL, for first responders, civil and scientific communities.

Status of new proposals

The proposals have been received in the last week and are now under review by the GSNL SAC.

They will be sent to the DCT Chair when the SAC has completed the evaluation.

On TSX data use

Action T24/8:
Raise awareness of different TSX acquisition modes within GSNL community.

Coordinators are aware that TSX data can be used with initial orbits, however they raised two other issues.

1. The procedure to order data is not straightforward as for CSK. New acquisitions must be ordered in small quantities and the user cannot place an order for a long period of time as for CSK or Pleiades.
2. Moreover all the data which are part of an order are delivered only when the last image of the order has been acquired, and this causes delays.

Users would love to use TSX, given the very controlled baseline, but apparently these issues discourage them from using TSX in a more massive way.

On GSNL sustainability

The sustainability must be analised with respect to the Supersite objectives. As stated in geo-gsnl.org/supersites/permanent-supersites/, Supersites:

- are areas where focused scientific investigations can increase the scientific understanding of the general geological and geophysical processes causing the hazards, allowing to reduce the uncertainty in hazard and risk assessment,
- make data from all disciplines and sensors from both in-situ and satellite systems, openly available through easy-to-access data infrastructures,
- support collaborative research activities of a broad international research community, favouring Open Science as the best approach to reduce the geohazard risks,
- should promote testing and adoption of innovative technologies for geophysical monitoring, data sharing, scientific collaboration, and communication to the stakeholders (including the public),
- promote the development of a community of generous and altruistic scientists and geohazard experts, who want to contribute to reduce the effects of earthquakes and volcanic eruptions,
- are part to the GSNL network, in which they may be asked to contribute expertise, capacities, infrastructures, training, to support the needs of other Supersites,
- are coordinated by local scientific institutes which have an official mandate for supporting the national risk and emergency management agencies with monitoring and scientific data and products,
- are not limited in time and will normally exist during the lifetime of the related activities or organizations, subject to a periodic review of their objectives.

Supersite sustainability and development

It may be argued that at least some Supersites can reach their objectives using their existing resources (obtained from governments, national and international funding agencies, CEOS data support). However, even where the Supersite operation is sustainable, **further development is advisable** to increase the level of the accomplishments.

Moreover, some Supersites at present are not able to reach all the objectives, even in their general form, and they **would not be sustainable in the long term if specific development activities are not carried out**.

In GSNL some activities can in part be supported by the partnership (e.g. data hosting, processing capacities) but others require direct funding, as in ground network development, stakeholder communications, etc.

We need a strategy for developing Supersite capacities and raise their level of sustainability.

Development and sustainability strategy

1. A specific Supersite plan is prepared, including short term and long term activities for development and operations. The entire Supersite partnership is involved in this process.

2. If the Supersite country is part of GEO, the plan is submitted to the national GEO Principal to verify national support for development and coordinate with international funding agencies. GEO Secretariat support will be requested.

3. Part of the activities in the plan may become the subject of research projects which are submitted to the local funding agencies in a coordinated way.

4. All the partners, including the CEOS agencies, promote the Supersite development plan at the national and international scale.

Action M10/15: *Draft a table of contents (…)* of the development plan

1. Introduction
2. Volcanic (seismic) risk reduction in the xxx Supersite
    1. The risk components (main focus on hazards)
    2. Disaster scenarios
    3. Impacts
3. Observational requirements
    1. In situ observations
    2. Earth observations
4. Development plan
    1. Objectives
    2. Priorities and schedule
    3. Funding scheme (in kind, direct)
    4. Management and risks
5. Sustainability plan
    1. Requirements for long term operations
    2. Funding scheme