INGV

GSNL
GEO Geohazards Supersites and Natural Laboratories

Integration between space- and ground-based observations in areas prone to volcanic hazard: the experience of Mt. Etna Supersite

Puglisi G. [(1)], *Bonforte A.* [(1)], *Buongiorno M.F.* [(2)], *Cacciola L.* [(1)], *Guglielmino F.* [(1)], *Ganci G.* [(1)], *Musacchio M.* [(2)], *Scollo S.* [(1)], *Reitano D.* [(1)], *Silvestri M.* [(2)], *Spampinato L.* [(1)]

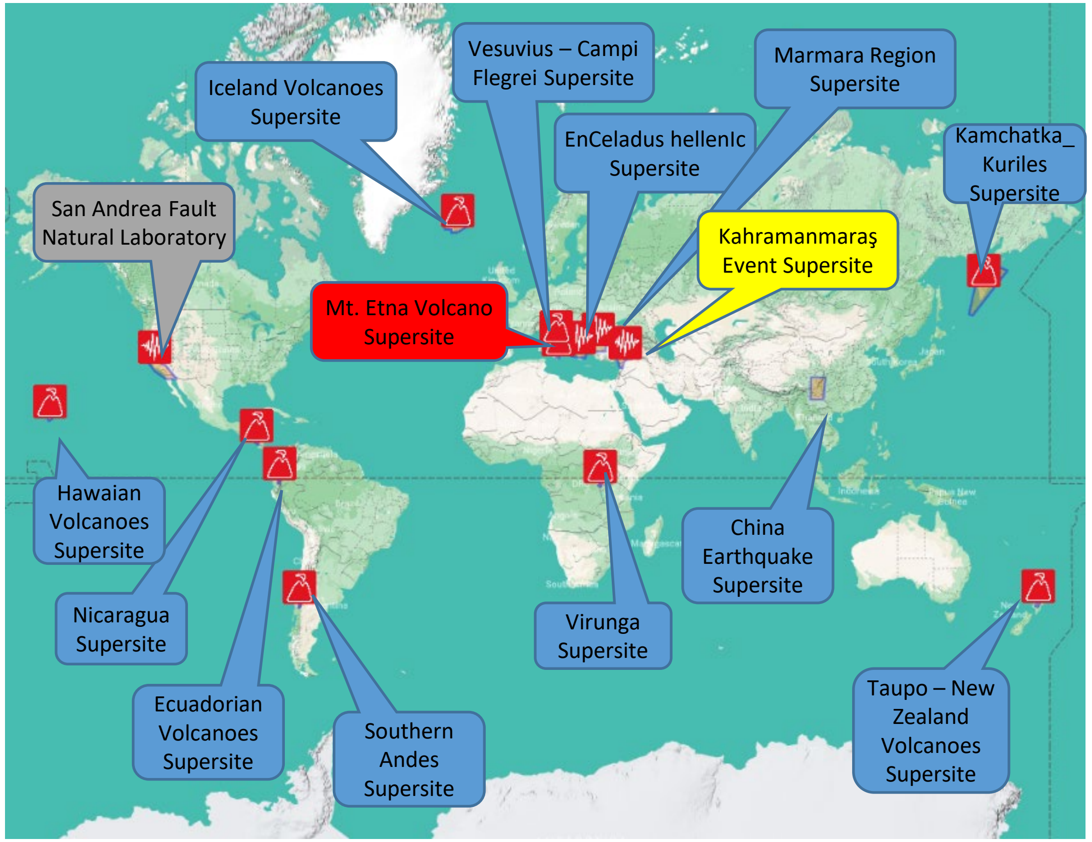
1) Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Etneo, Catania, Italy

2) Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Nazionale Terremoti, Roma, Italy

EGU General Assembly 2023 Vienna, Austria & Online | 23–28 April 2023

The GEOhazard Supersite and Natural Laboratories initiative (GSNL): an overview

The Supersites' network



Objectives:

- **To enable the global scientific community offering open, full and easy access** to a variety of space and ground-based data, over selected high-risk areas of the world;
- **To promote** the conditions by which **state of the art geohazard science** is generated by the global community over the selected sites;
- **To communicate scientific results useful for the geohazard assessment** to authoritative bodies and other stakeholders, supporting informed decision making in Disaster Risk Management activities at the selected sites;
- **To promote innovation** in the development and testing of technologies, processes and communication models, to enhance data sharing, global scientific collaboration, knowledge transfer and capacity building in geohazard science and application

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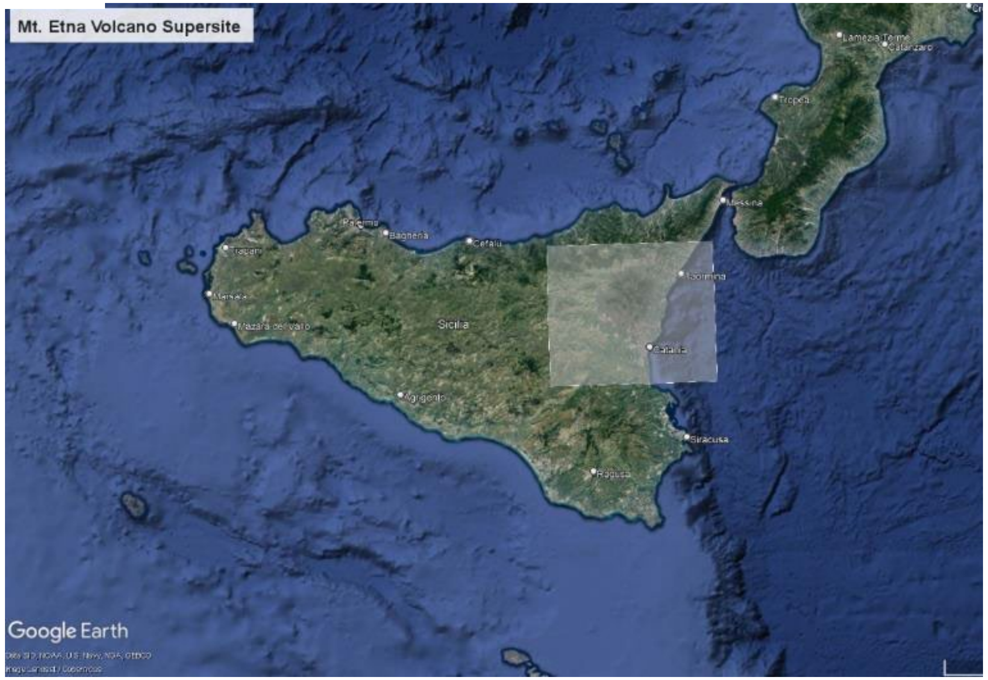
Mt. Etna Volcano Supersite: an overview

Permanent Supersite since 2014

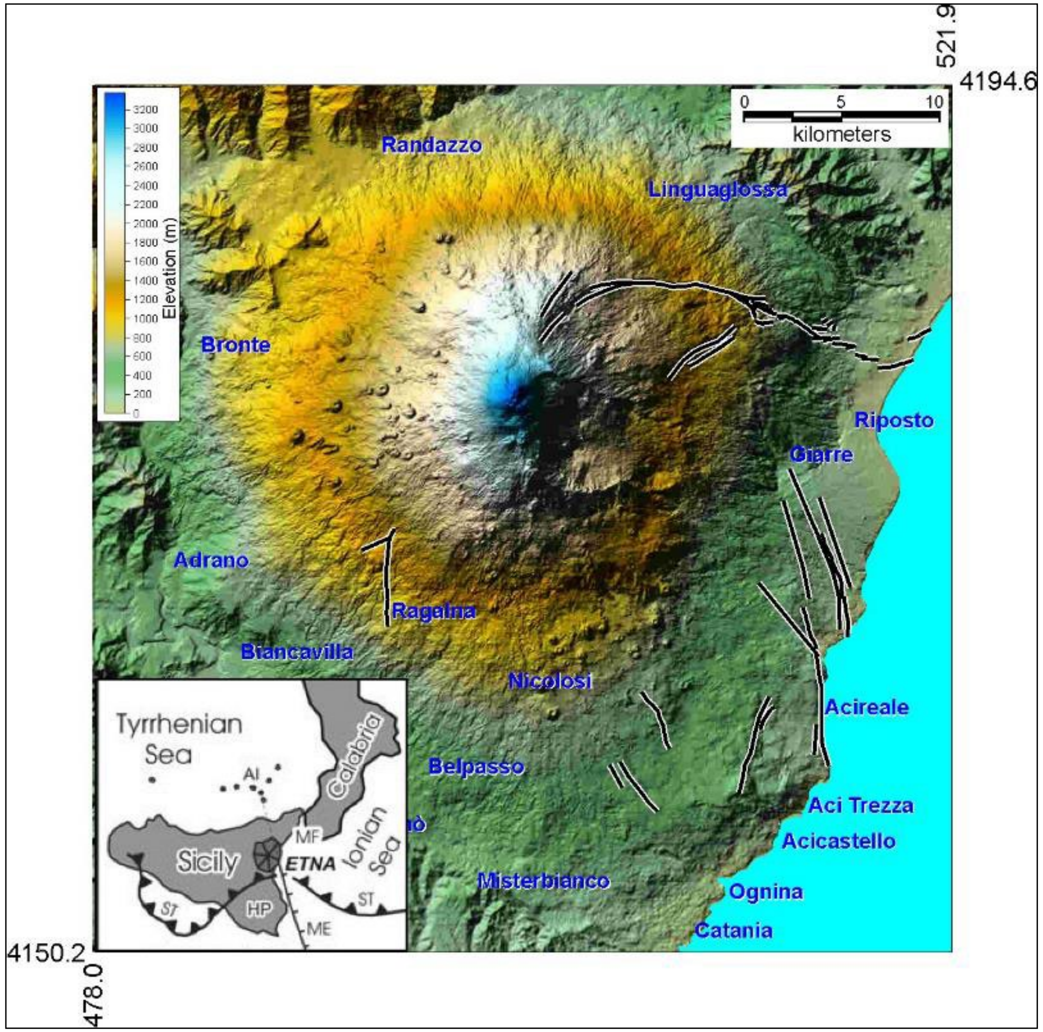


Implemented by the MED-SUV EC FP7 project (2013-2016)

MEDiterranean SUpersite Volcanoes
MED-SUV

Supporting projects:

- EUROVOLC (EC)
- FISR (INGV)
- e-Shape (EC)
- IMPACT (INGV)
- ATTEMPT (INGV)
- IMPROVE (INGV)
- Geo-INQUIRE (EC)
- SAFARI (INGV)



43 institutions exploiting the EO and in-situ data

Objectives:

- **To increase the capability to interpret the clues of a volcanic unrest** by exploiting SAR and optical data together with in-situ data;
- **To deepen the knowledge of volcanic processes** by measuring deformation produced by either deep magma storage or flank dynamics, mapping of volcanic plume dispersion, lava flow fields emplacements, etc. integrating groud-OE observations
- **To improve the short- and long-term hazard assessment of a specific volcanic area**

Mt. Etna Volcano Supersite: data provision

The in-situ data

Type of data	Data provider	How to access	Type of access
Seismic waveform	INGV	Link to Network Italian Seismic Network Web Service through the Gateway Portal and EPOS Data Portal	Public
Seismic events	INGV	Link to Network Italian Seismic Network Web Service. A dedicated catalogue on Mt. Etna is provided through the Gateway Portal and EPOS Data Portal	Public
GPS data	INGV	GSAC server is not available at the moment. A migration into a GLASS server is planned in the framework of Geo-INQUIRE project to be compliant with EPOS	Public
GPS data survey (1994- 2013)	INGV	provided through the Gateway Portal	Public
GPS coordinates / displacement vectors	INGV	Not available at the moment. A migration into a GLASS server is planned in the framework of Geo-INQUIRE project to be compliant with EPOS	Limited to registered users
Hydrophone / OBS waveform	INGV	Not available at the moment	Limited to registered users
Thermal cameras	INGV	Not available at the moment. Implementation is ongoing in the frame of EPOS	Limited to registered users
Tilt	INGV	Under testing	Public
Geochemical Bulk Rock Data	INGV	provided through the Gateway Portal and EPOS Data Portal	Public

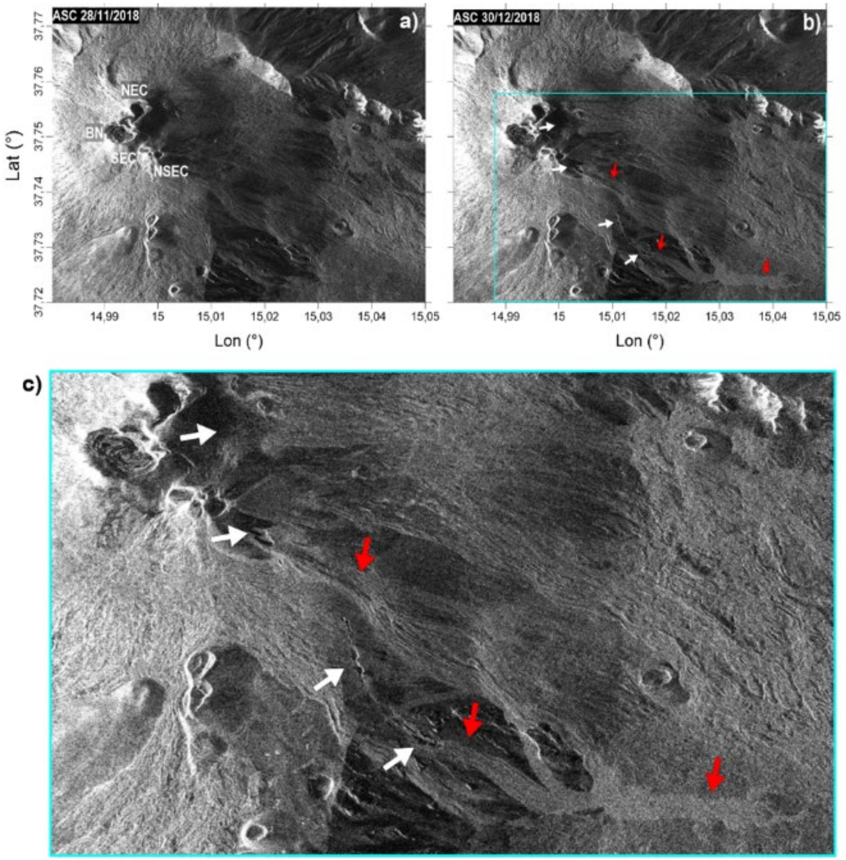
The EO data

Type of data	Data provider	How to access	Type of access
ERS-1/ERS-2	ESA	Direct link to https://earth.esa.int/eogateway/missions/ers/data	Registered public
ENVISAT	ESA	Direct link to https://earth.esa.int/eogateway/missions/envisat	Registered public
Sentinel	ESA	Direct link to https://sentinels.copernicus.eu/web/sentinel	Registered public
TerraSAR-X	DLR	Direct link to https://supersites.eoc.dlr.de	GSNL scientists
COSMO-SkyMed	ASI/ESA	https://earth.esa.int/eogateway/missions/cosmo-skymed	GSNL scientists
PLEIADES	CNRS	PoC requests access from CNRS for individual users;	GSNL scientists
Landsat 8	USGS	Direct link https://earth.esa.int/eogateway/missions/landsat-8	Registered public
AVHRR	NOAA	Direct link to http://earthexplorer.usgs.gov	Registered public
MODIS	NASA	Direct link to http://modis.gsfc.nasa.gov/data/	Open

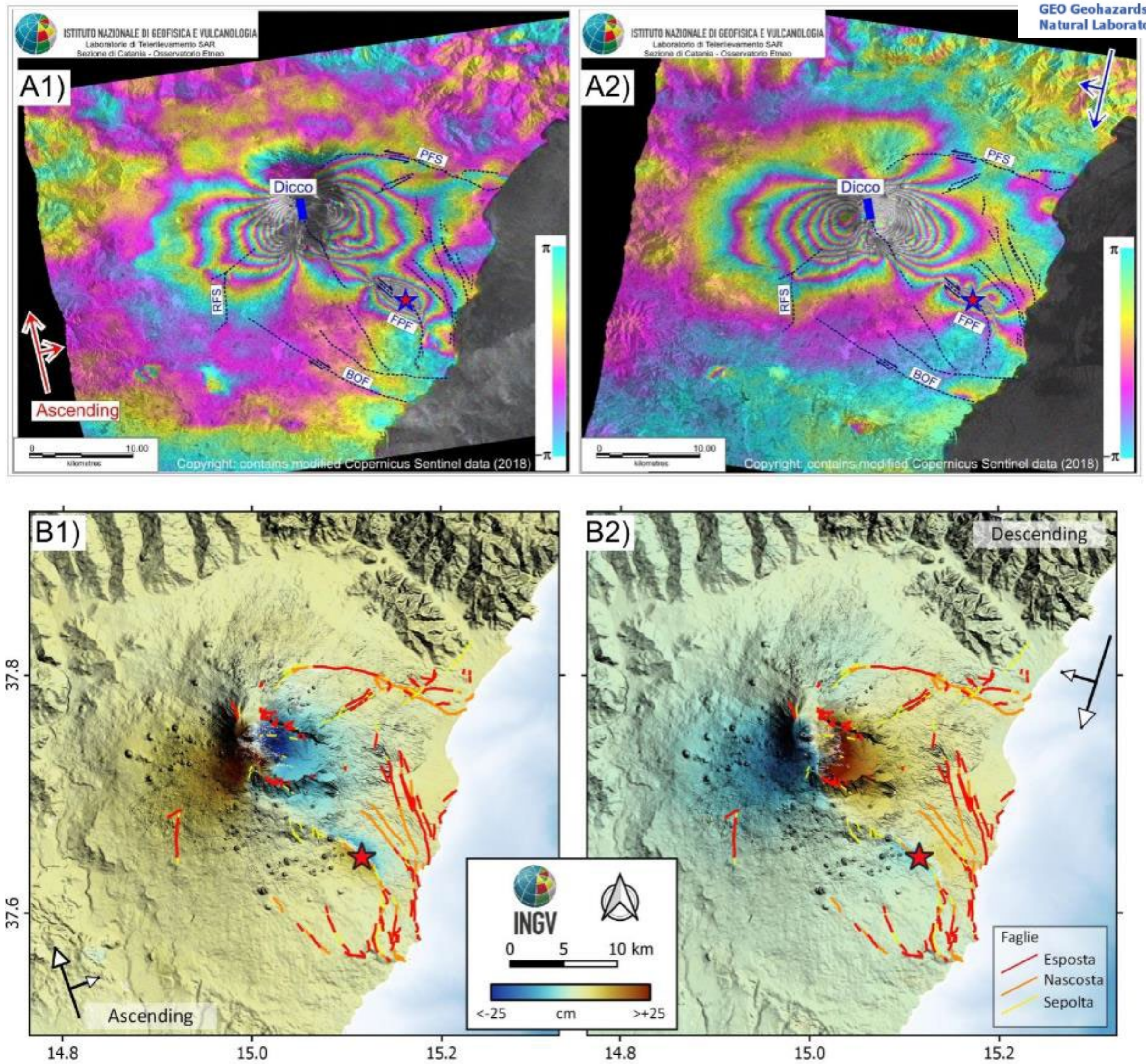
Examples of exploitation of EO & in-situ data

- 2018 Eruption (SAR IF and amplitude, SEVIRI)
- 2021 lava fountains (SAR and Seviri)
- 2021 VdB eruption
- Volcanic Plume detection and modelling
- SAR time series portal

2018 Eruption

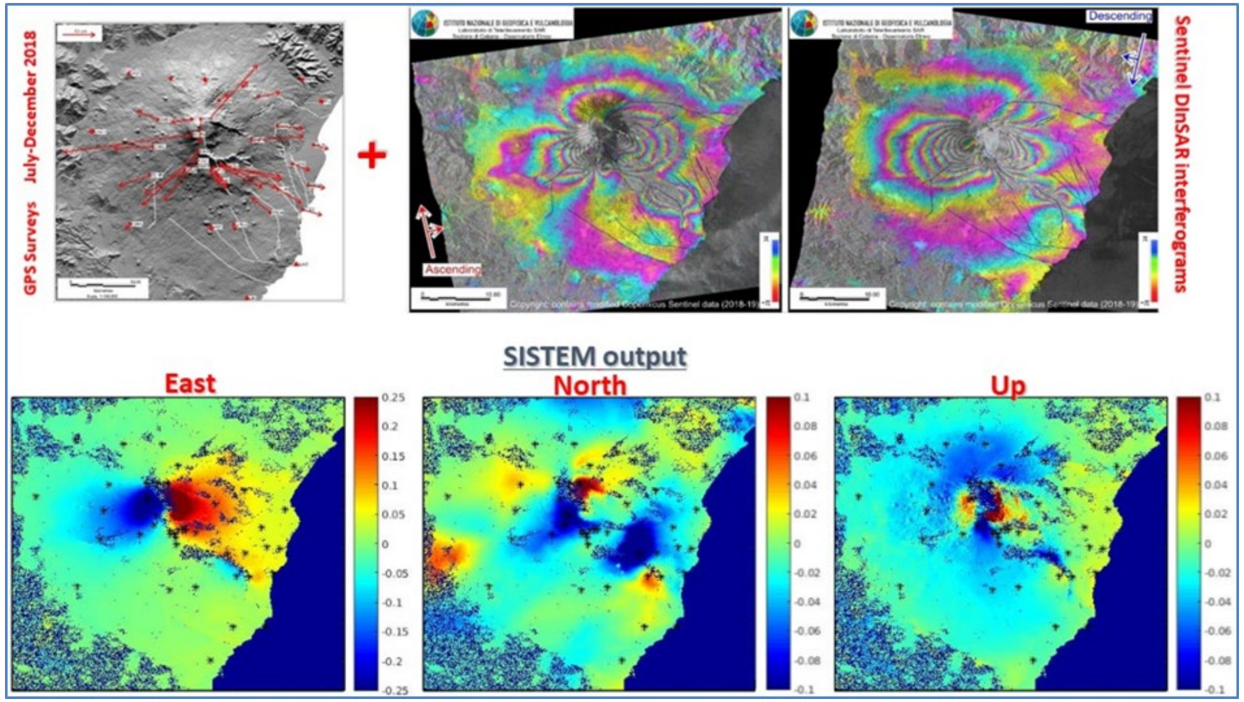


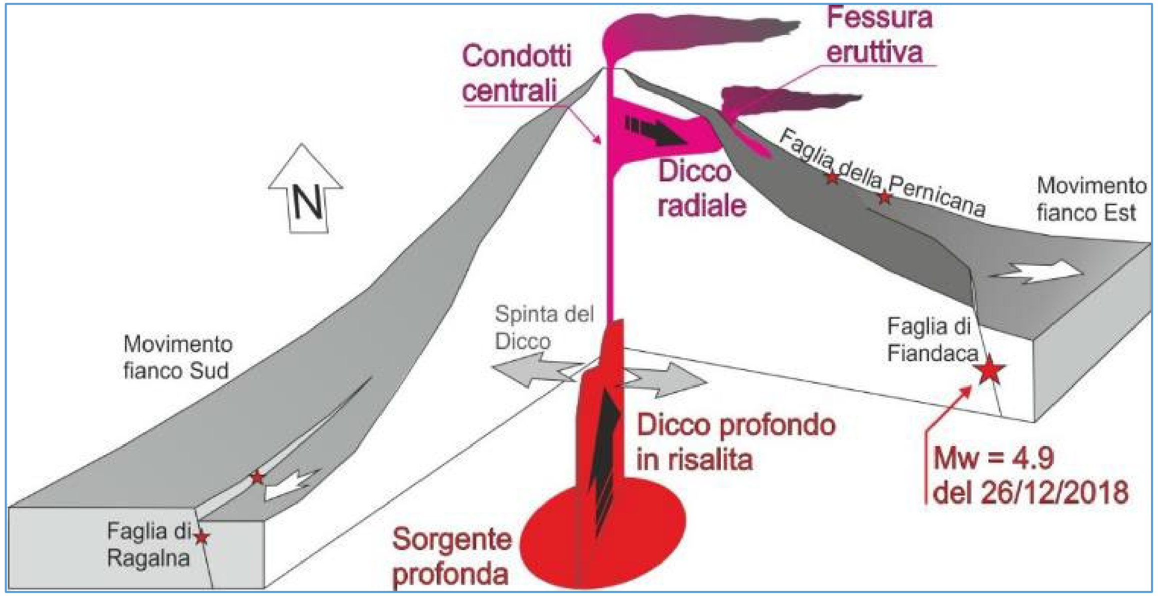
Geomorphological evidences of the EE2018. a) pre- (28 November 2018) and b) post- (30 December 2018) eruption COSMO-SkyMed ascending SAR amplitude images. These SAR images allowed us to identify a 2800 m long fissures, which start from the base of the NSEC and propagate southwards within the VdB depression (see red arrows). These fissures were also responsible for the 24 December lava emission (see white arrows). c) This is the zoom area of panel b) where the eruptive fissures and lava field are represented. . [from De Novellis el al. 2019]. NSEC: New South-East Crater; NEC: North-East Crater; SEC: South-East Crater; BN: Bocca Nuova Crater;



Ascending and descending Sentinel 1 interferogram (phase) and corresponding LOS deformation maps in cm. Into (A1) and (A2) the ascending and descending Sentinel 1 interferograms relevant to 22122018 – 28122018 time spanning are reported; (B1) and (B2) LOS deformation maps corresponding to interferograms. [Comunicato CNR-IREA & INGV]

2018 Eruption

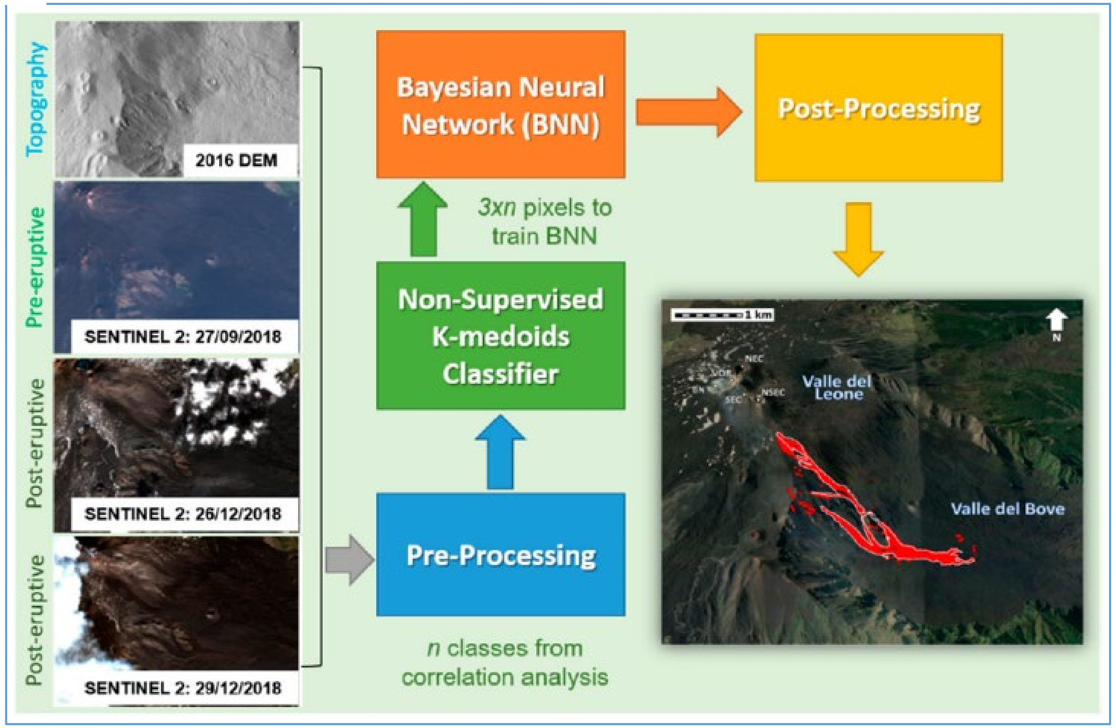




3d sketch model of the Dicembre 2018 eruption [from Blog INGV-Vulcani, https://ingvvulcani.com/2019/05/13/sulle-ali-della-farfalla-delletna-cosa-e-avvenuto-durante-leruzione-del-natale-2018/]

Integration go InSAR and GNSS data relevant to 2018 eruption: SISTEM input/output

2018 Eruption



The workflow adopted to map lava flows using the MSI Sentinel-2 data and DEM information. The input data are firstly pre-processed and given as input to the k-medoids unsupervised clustering; then n pixels for each class are used to train the BNN. The output of the BNN is post-processed by opening the resulting image providing the areal extent of lava flow. [From Corradino et al., (2019)]

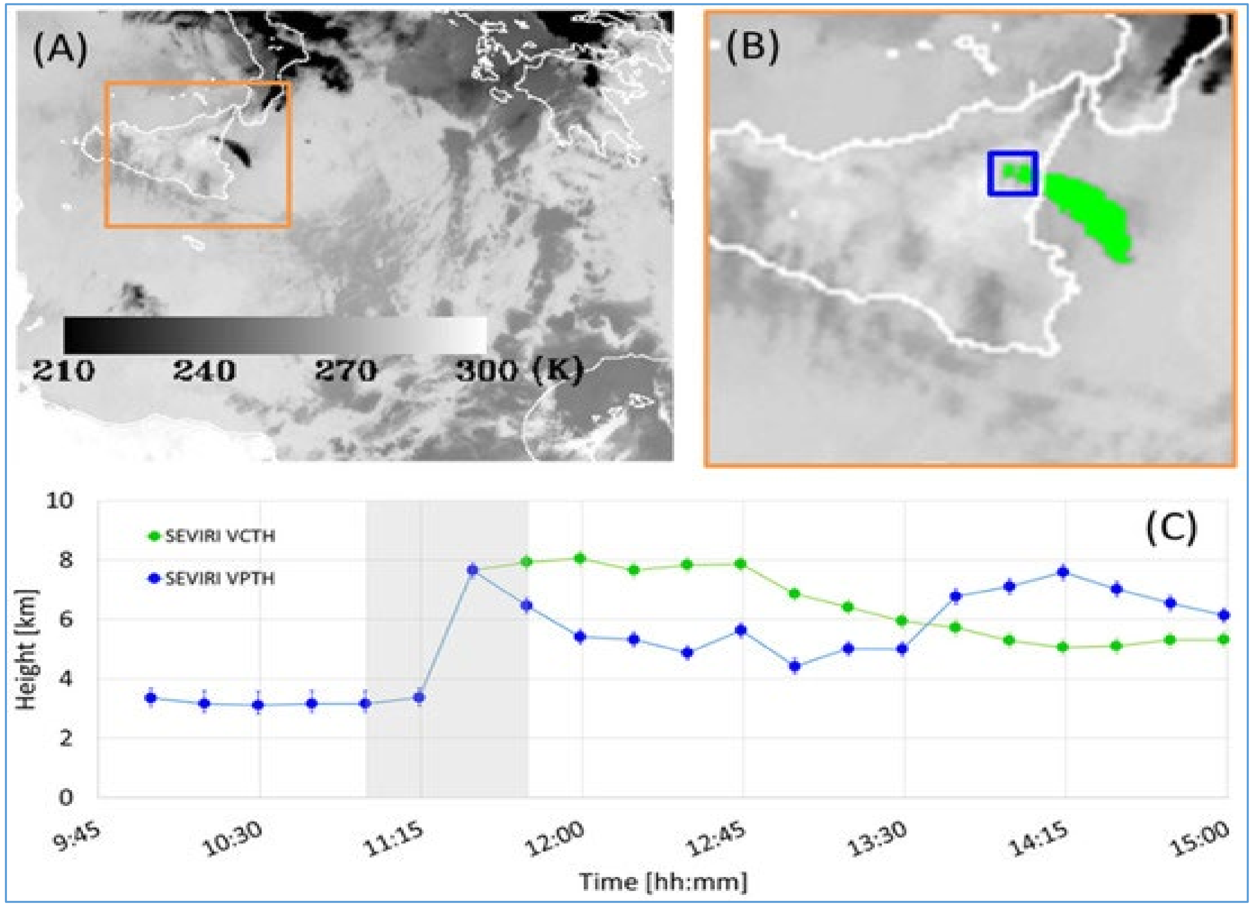
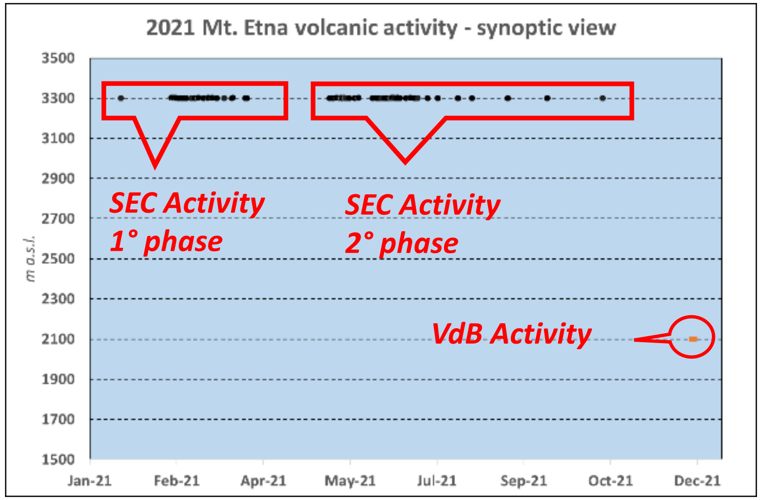
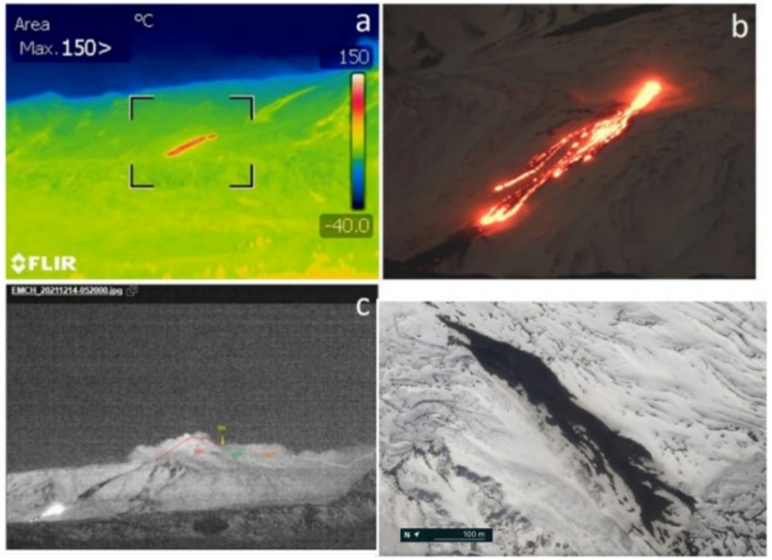


Figure 8. Brightness temperature at 10.8 μm considering the SEVIRI image collected on 24 December 2018 at 12:00. (B) Image of Sicily with the blue square area and the green area used for the Volcanic Plume Top Height (VPTH) and Volcanic Cloud Top Height (VCTH) computation, respectively. (C) Plot of VPTH (blue points-line) and VCTH (green points-line) time series obtained from SEVIRI data collected every 15 min on 24 December 2018. The green and blue vertical bars represent the VCTH and VPTH SEVIRI retrieval uncertainties, respectively. [From Corradini et al., (2020)]

2021 Eruptions

February – June
Lava fountains episodes
At South-East Crater





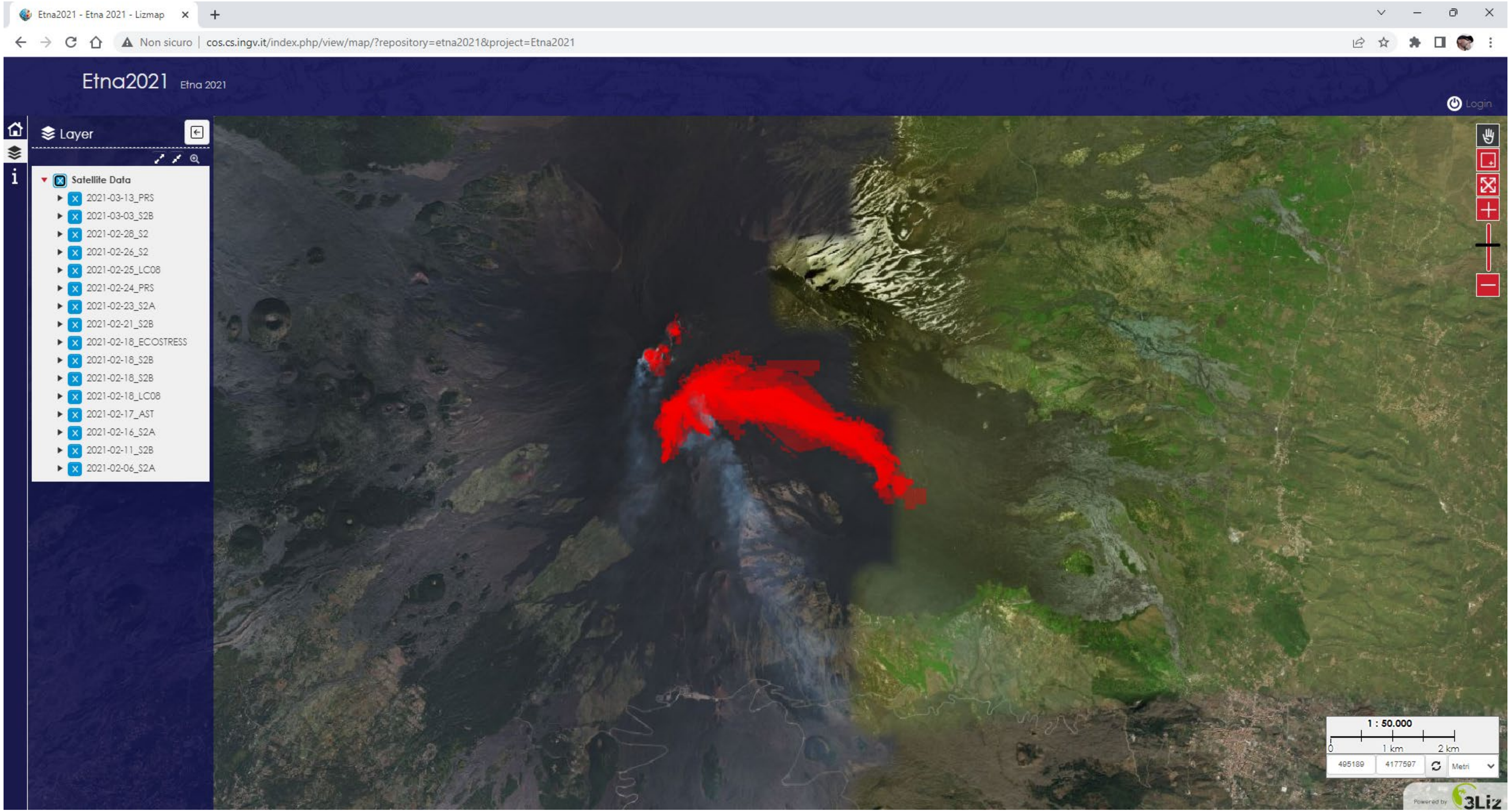
13 December
Lava flow in Valle del Bove

2021 Eruptions – SEC paroxysms (lava fountain and lava flows) 1st phase

Feb-Mar 2021

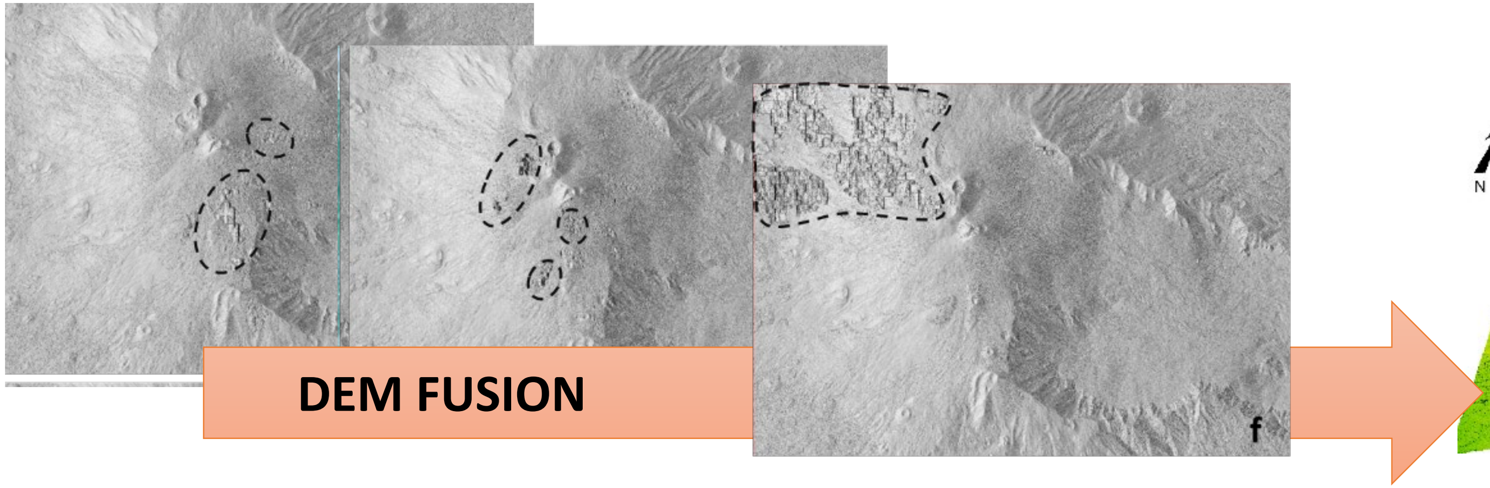
Thermal anomalies from multiple sensors:

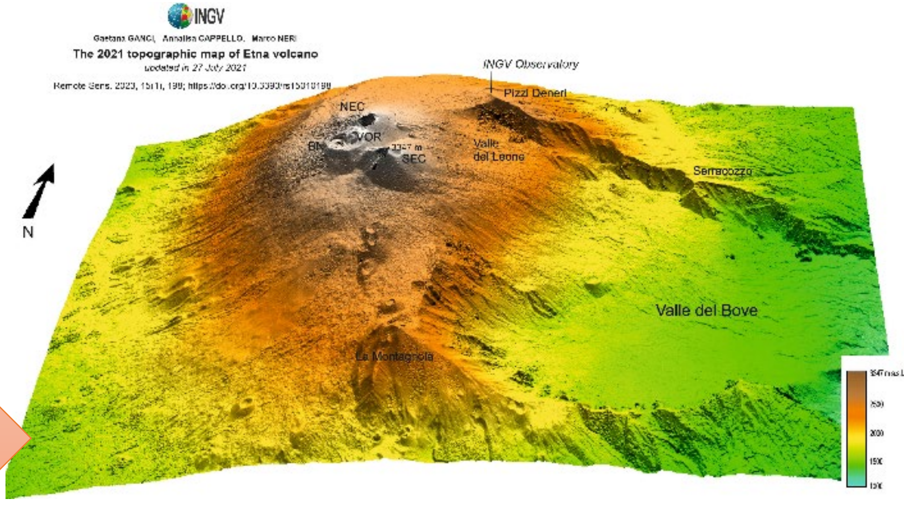
- **Sentinel 2**
- **ASTER**
- **LANDSAT 8**
- ECOSTRESS
- PRISMA

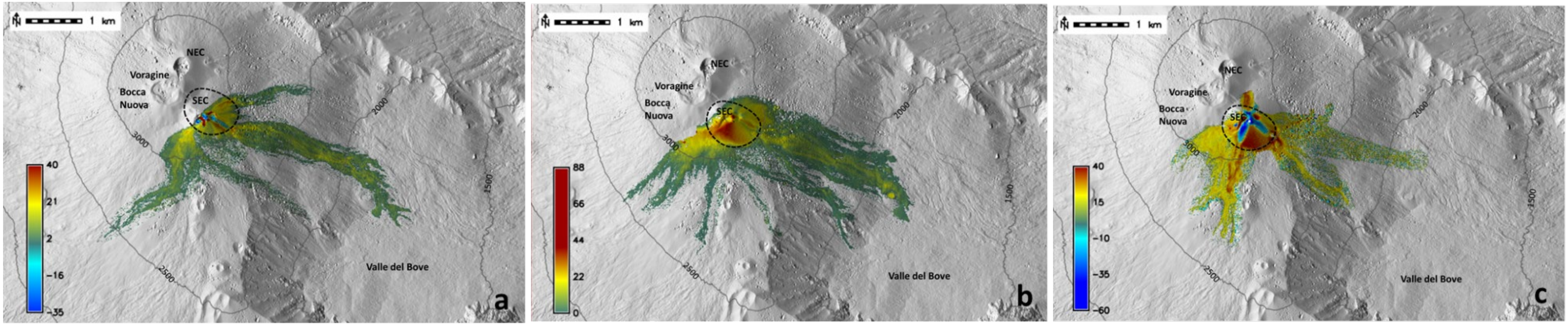


2021 Eruptions – SEC paroxysms (lava fountain and lava flows)

Pleiades data

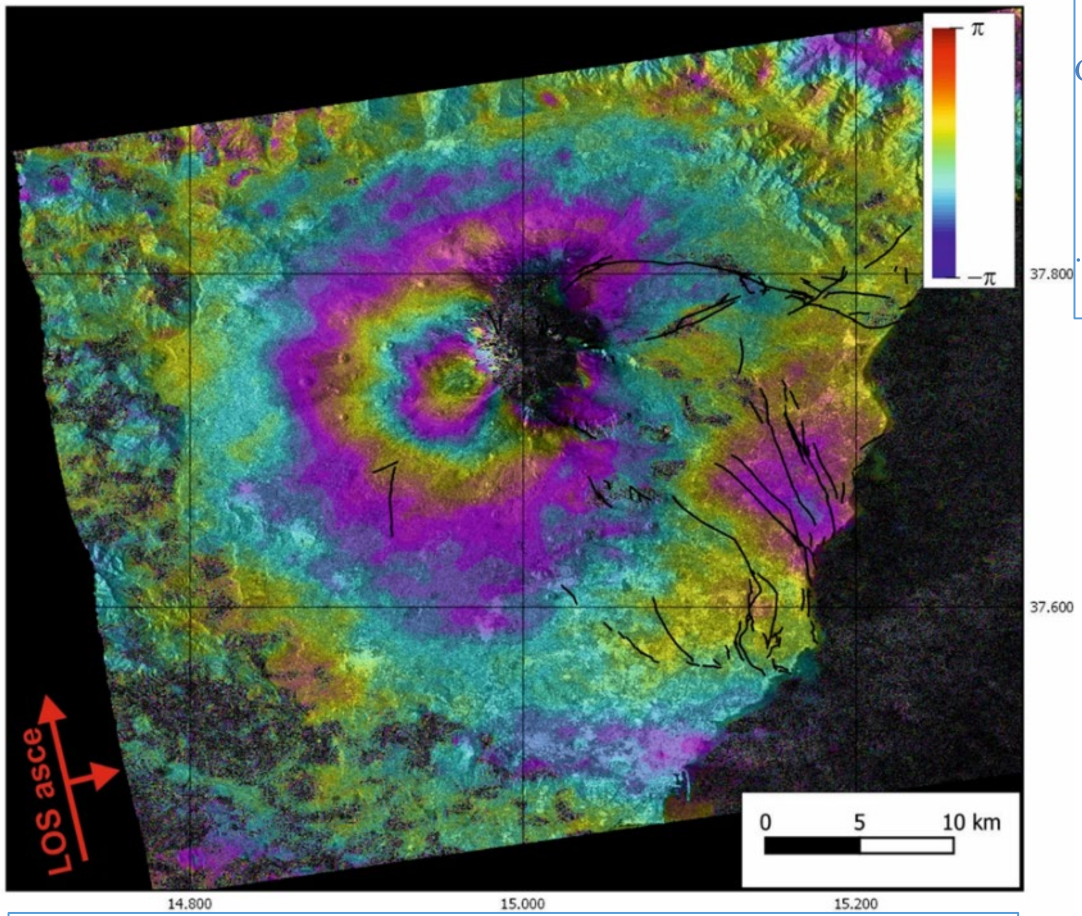






Topographic changes due to the volcanic deposits emplaced from 22 August 2020 to 26 February 2021 (a), from 26 February to 27 July 2021 (b) and from 27 July 2021 to 29 June 2022 (c). The colors indicate the flow thickness in meters. The dotted black circle defines the area of the SEC cone.

2021 Lava fountains



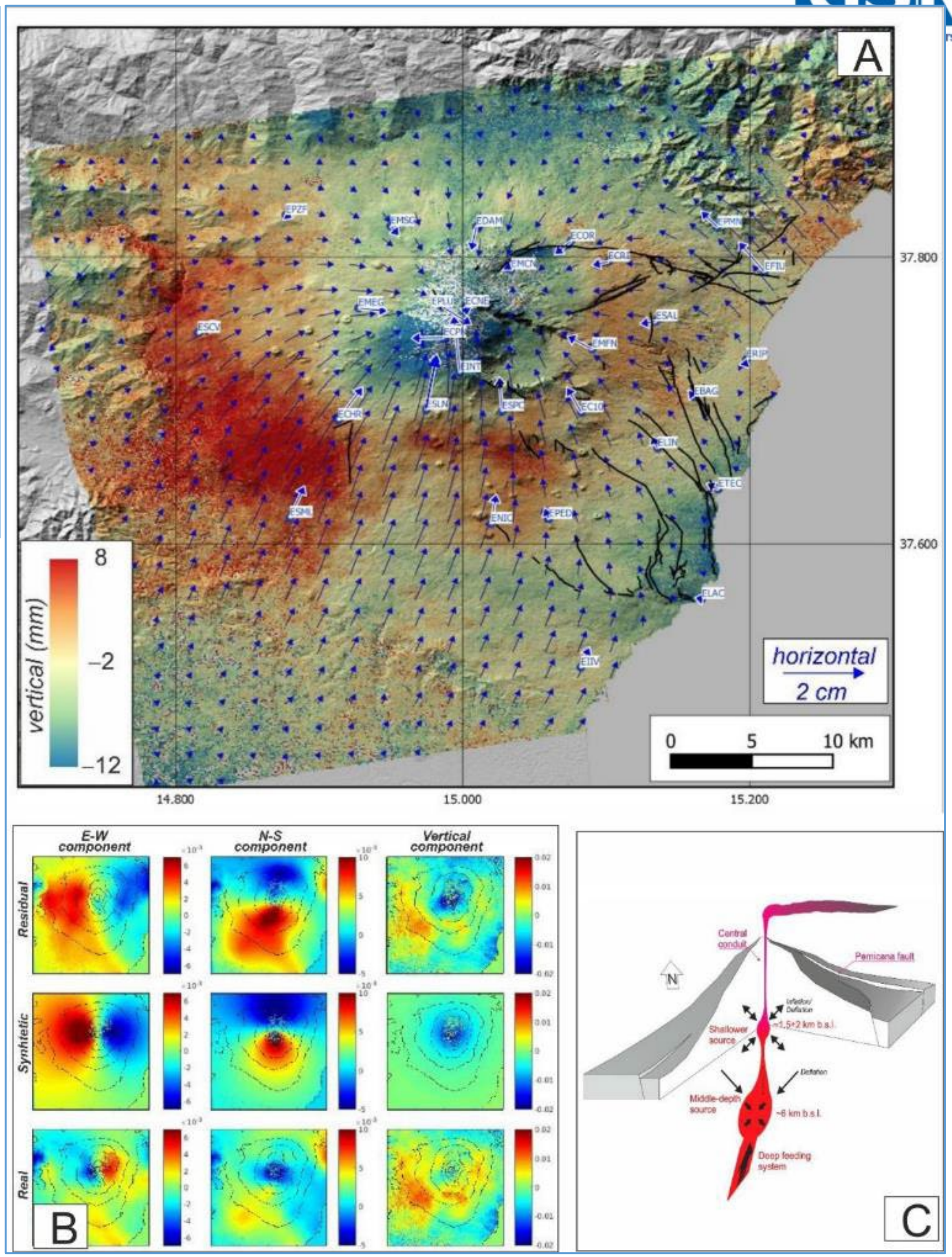
Sentinel 1 A/B ascending phase interferogram relative to December 23th 2020 –March 29th 2021. The volcanic edifice is affected by a diffuse deflation of about 2 fringes.

A) 3D displacement map obtained by SISTEM algorithm over the 2015 Dec 2 to 14 -

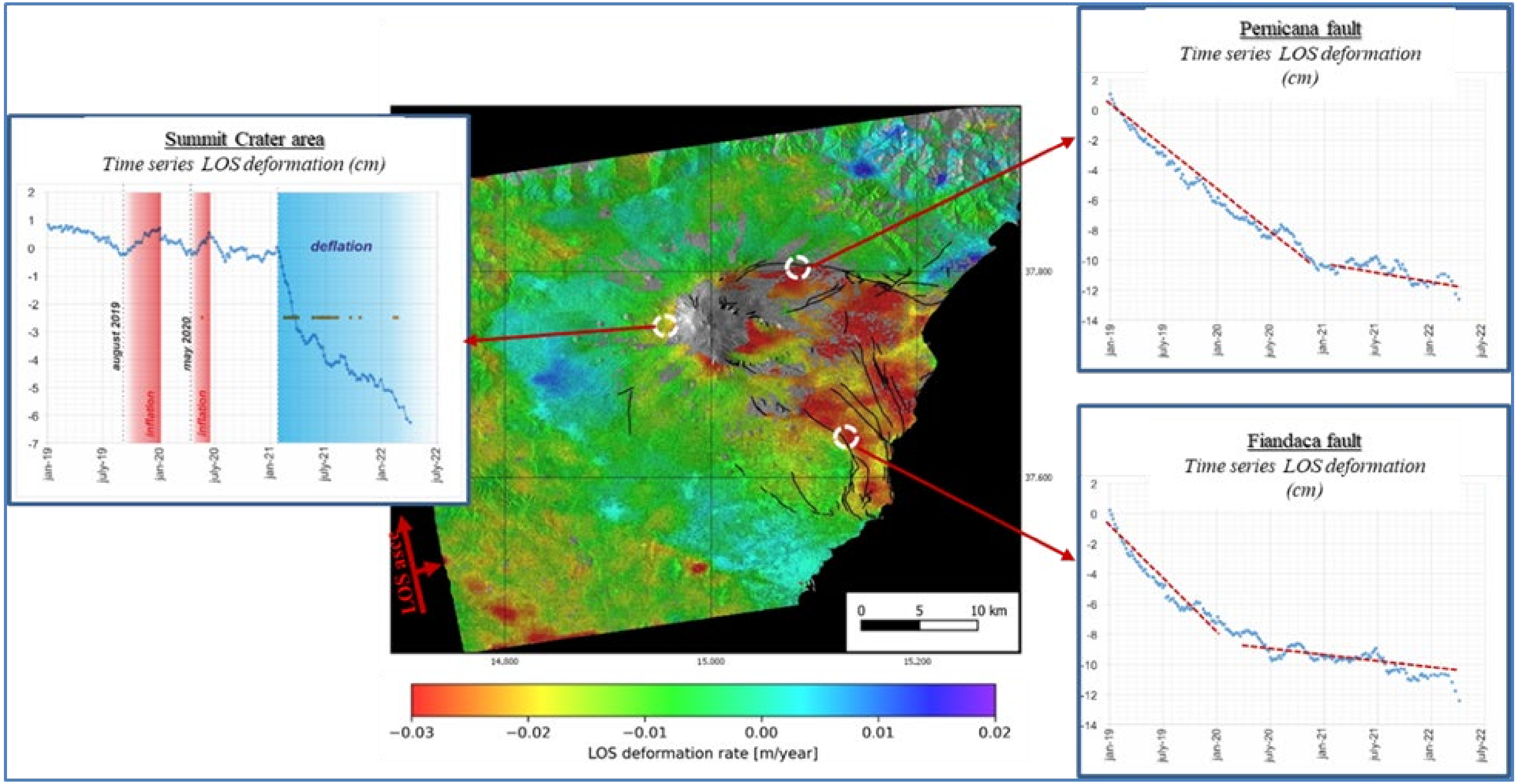
B) SISTEM inversion results;

C) C) Sketch of the feeding system resulting from High Rate data and SISTEM modelling

.Bonforte et al. 2021.

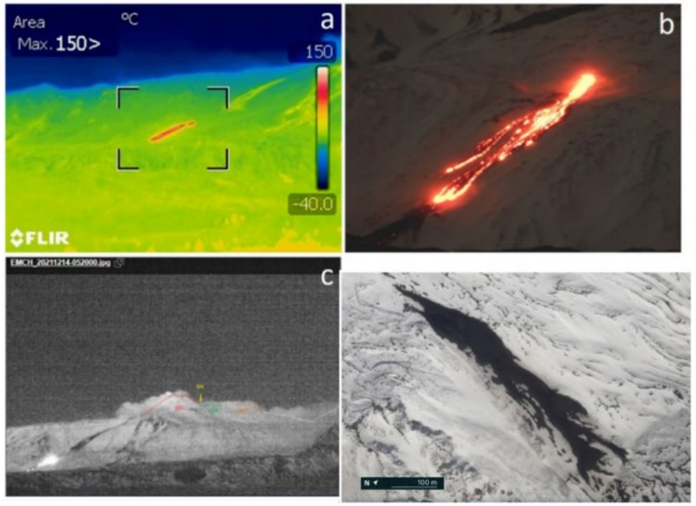


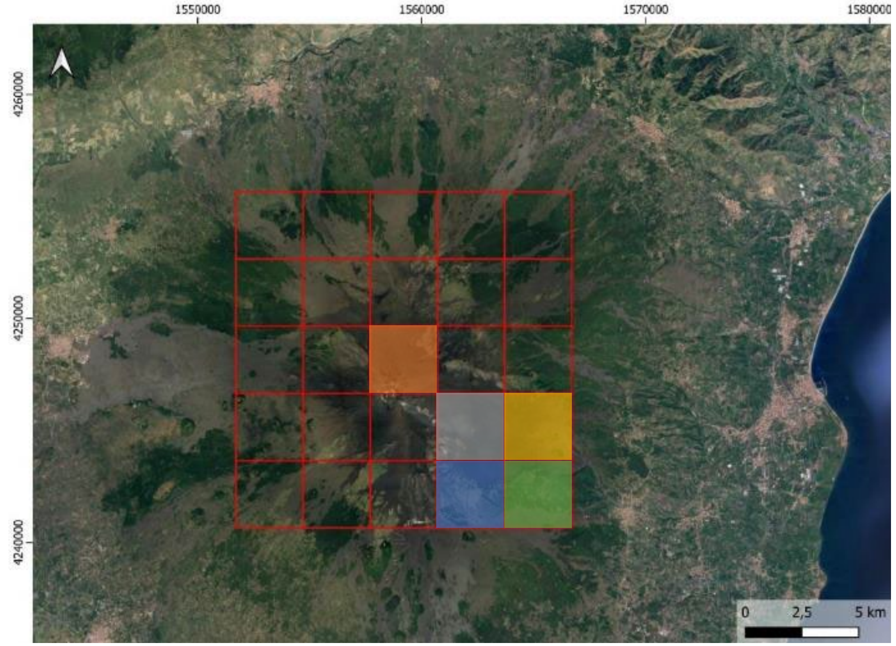
2021 Lava fountains



A-DInSAR analysis 2019-2022. Ascending mean LOS velocity and time series of LOS displacement of selected points.

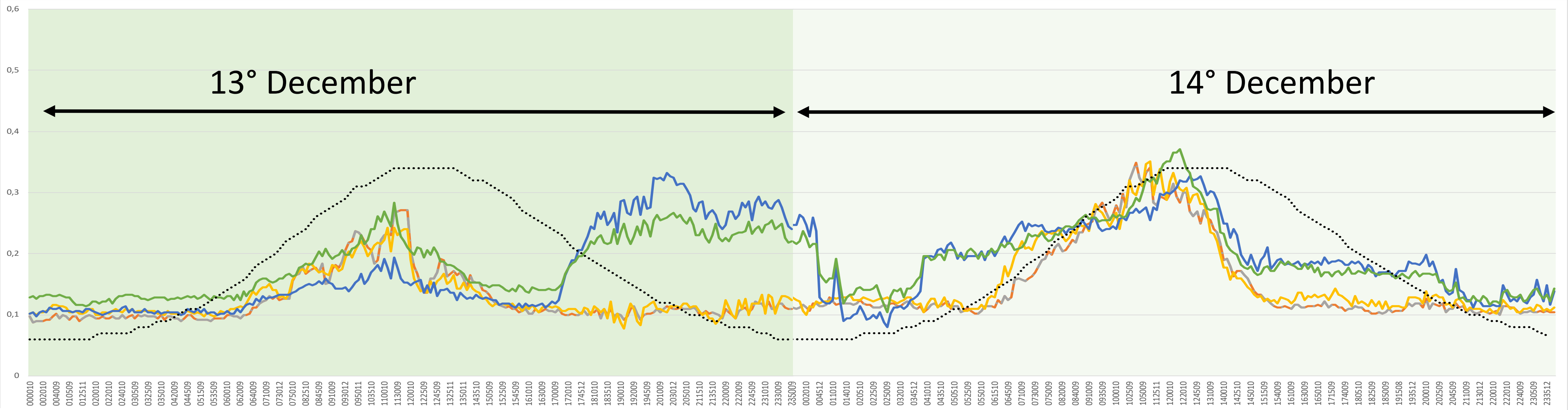
2021 31 Dec. eruption





Pixel 13 Pixel 19 Pixel 20

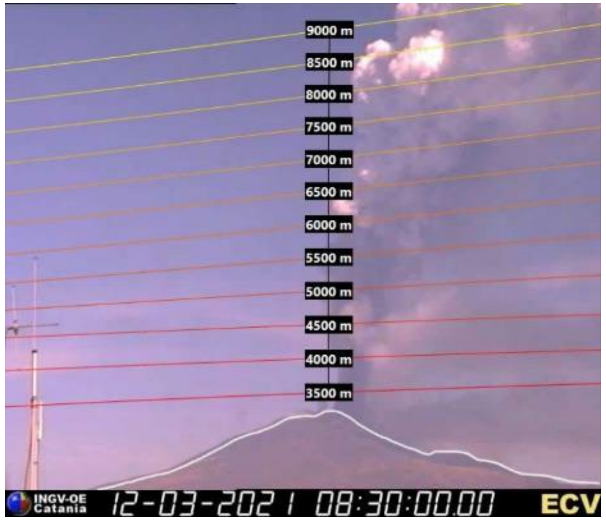
Pixel 24 Pixel 25 Threshold



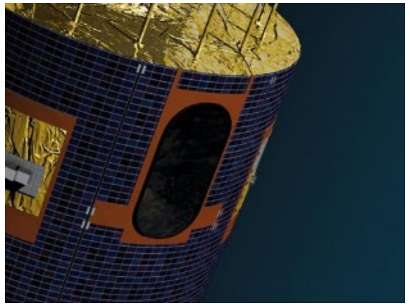
Volcanic Plume

Pilot 6.1 | EO4D_ASH - EO Data for Detection, Discrimination & Distribution (4D) of Volcanic ash

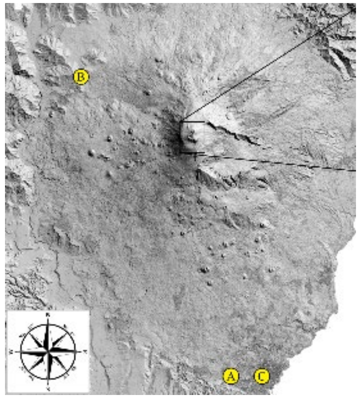
- At Etna Volcano Observatory different instruments (e.g. cameras, satellite, LIDAR) are operative.
- Data are very useful to have information in near real time during an eruptive event.
- These information are used to send the Volcano Observatory Notice to Aviation (VONA) to the Volcanic Ash Advisory Centres (VAAC)
- VAAC also activates the Pilot 6.1 in **e-shape Project**, based on Etna Supersite
- Here we show an example of data available in real time during the lava fountain event of 12 March 2021 (Scollo et al., 2019; Corradini et al., 2018). Those data are used as input parameters for volcanic ash dispersal models.



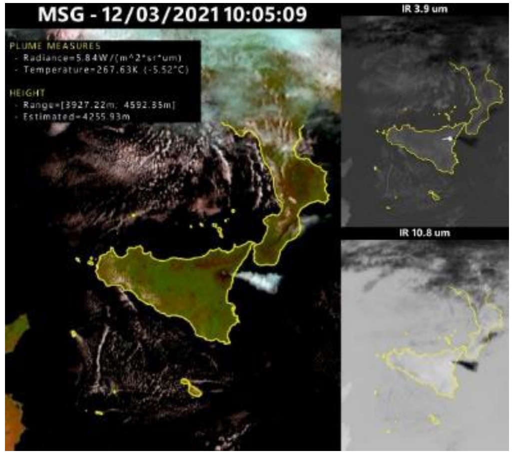
Lidar: < 100 μm (atmosphere)

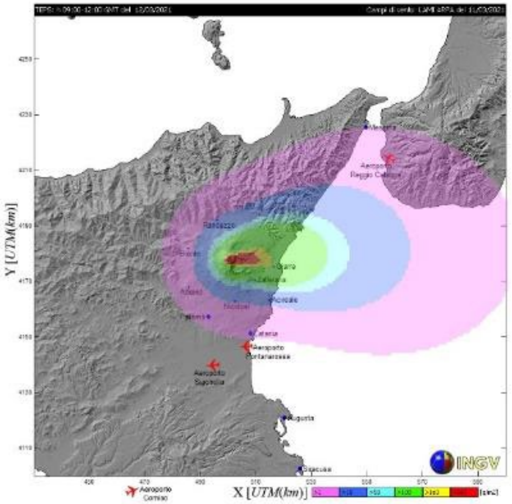


Seviri satellite: < 10 μm (atmosphere)

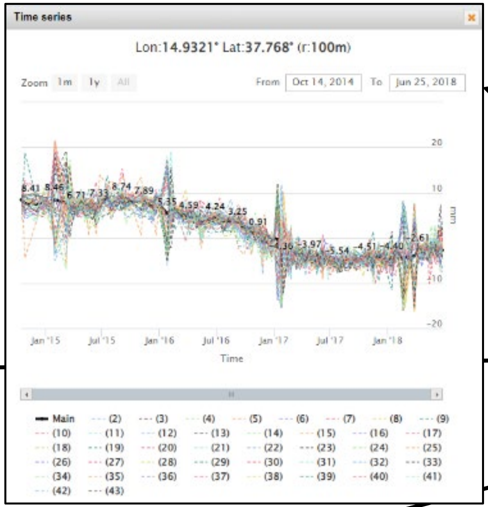


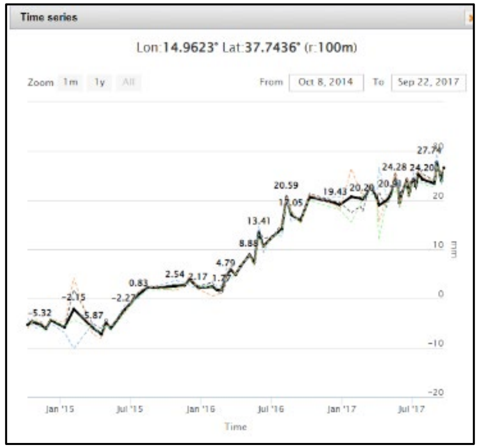
Camera location from Scollo et al. 2019

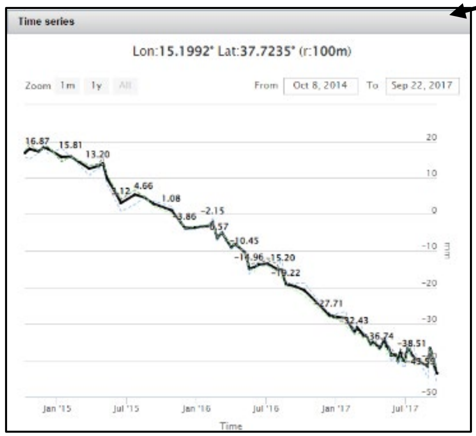


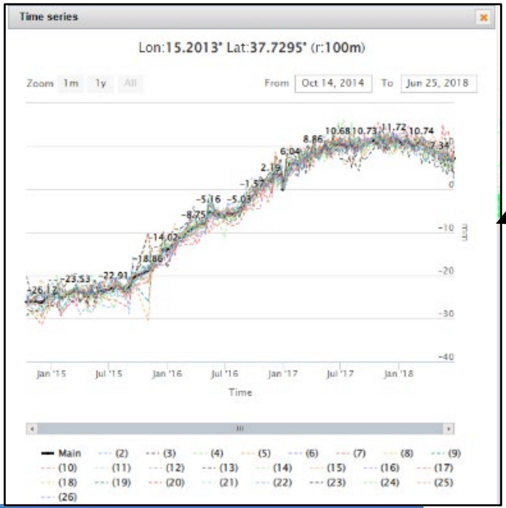


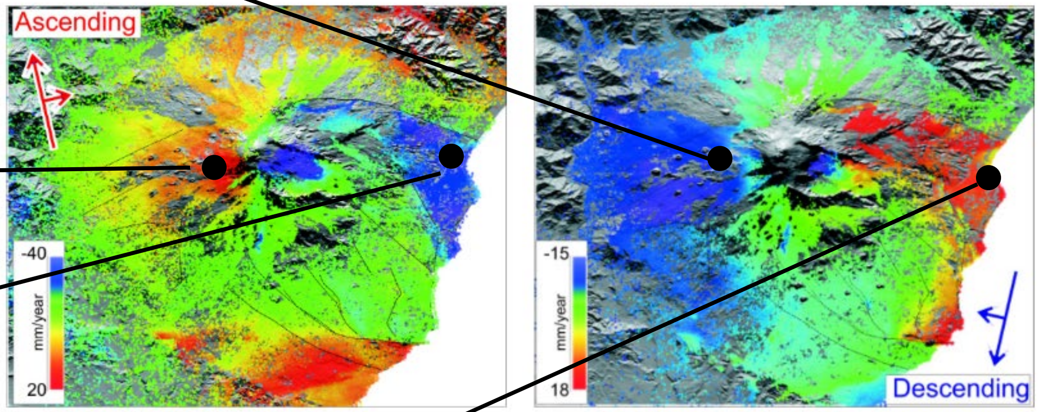
SAR time series portal











ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

Mt. Etna SAR

Sentinel-1A/1B

BETA Version

About this map

This interactive map provides access to EU Copernicus Sentinel-1 A-DInSAR products made by INGV-OE Remote Sensing Lab. SENTINEL 1 TOPSAR data are provided by ESA to Mt. Etna Volcano Supersite, in the frame of GEO-GSNL initiative. Data were processed by the GAMMA software, using a spectral diversity method and a procedure able to co-register the TOPSAR SLC pairs with extremely high precision (< 0.01 pixel). The DInSAR results are analysed and successively used as input for the time series analysis using the StaMPS package (Hooper, 2008). In order to optimize the time processing, a new software architecture based on the hypervisor virtualization technology for the x64 versions of Windows has been implemented.

All Sentinel-1 results that are available for download are Derived Works of Copernicus data (2015-2016), subject to the following use conditions: "Terms and conditions for the use and distribution of sentinel data and service information".

Credit

This service has been implemented in the frame of INGV-FISR project (Sale Operative integrate e Reti di Monitoraggio del futuro: l'INGV 2.0)

Please cite the following publication if you use data from this service:

Guglielmino, Francesco; Bonforte, Alessandro; D'Agostino, Marcello; Puglisi, Giuseppe (2016). **Mt. Etna Ground deformation imaged by SISTEM approach using GPS data and SENTINEL-1A TOPSAR data.** ESA Living planet symposium, Prague, 2016, HAZA-113 Poster Session

Contact Us

For any question please contact:
carmelo.cassisi@ingv.it
francesco.guglielmino@ingv.it

Update Ascending (2019-2022)

Update Descending (2020-2021)

Update Ascending (2018-2019)

Type of product	Product provider	How to access	Type of access
Ground Deformation Time series	*Francesco Gugliemino (INGV)*	http://tsd.ct.ingv.it/tsdws/sar	*public*

Scientific products

1. Aranzulla, M., Puglisi, G. (2015) GPS tomography tests for DInSAR applications on Mt. Etna, Annals of Geophysics, Vol. 58, Issue 3 , Italy.
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Institutions exploiting the data

1. British Geological Survey, Keyworth, Nottingham NG12 5CG, United Kingdom.
2. Center of Excellence Telesensing of Environment and Model Prediction of Severe events (CETEMPS), 67100 L'Aquila, Italy.
3. CNR - Institute of Atmospheric Pollution Research, Florence, Italy.
4. CNR - Istituto per il Rilevamento Elettromagnetico dell'Ambiente, Naples, Italy.
5. CNR - Istituto di Metodologie per l'Analisi Ambientale, Potenza, Italy.
6. Conservatoire National des Arts et Métiers, Laboratoire Modélisation Mathématique et Numérique, 75003 Paris, France.
7. Deutschen Zentrums fur Luft- und Raumfahrt, Cologne, Germany.
8. Dipartimento della Protezione Civile, Rome, Italy.
9. Dipartimento di Scienze della Terra e Geoambientali, via Orabona 4, 70125 Bari, Italy.
10. École Normale Supérieure, Laboratoire de Géologie de, Paris, France.
11. European Commission - Joint Research Centre, Ispra, Italy.
12. Georgia State University, Department of Computer Science, 25 Park Place SE, Atlanta, GA 30303, USA.
13. INGV – Sezione di Catania - Osservatorio Etneo, Catania, Italy
14. INGV – Osservatorio Vesuviano, Napoli, Italy
15. INGV – Osservatorio Nazionale Terremoti, Roma, Italy
16. INGV – Sezione di Pisa, Pisa, Italy.
17. Ludwig-Maximilians-Universität (LMU) München, Department of Earth and Environmental Sciences, Theresienstr. 41/III, 80333 Munich, Germany.
18. Institute of Geosciences (CSIC-UCM), Madrid, Spain.
19. Instituto Andaluz de Geofisica, Universidad de Granada, Campus de Cartuja, C/Profesor Clavera 12, E-18071 Granada, Spain.
20. Institut de Physique du Globe, CNRS UMR-7154, Sorbonne Paris-Cité, Univ. Paris Diderot, F-75005 Paris, France.
21. Institut de Physique de Globe de Strasbourg, Équipe de Géophysique Expérimentale, 5 rue René Descartes, 67084 Strasbourg cedex, France.
22. Institut de Physique du Globe de Paris, Sorbonne Paris Cité, Observatoire Volcanologique du Piton de la Fournaise, Univ. Paris Diderot, UMR 7154 CNRS, F-97418 La plaine des Cafres, France.
23. Institut Pierre Simon Laplace, Laboratoire de Météorologie Dynamique, Paris, France.
24. Semeion Research Center of Sciences of Communication, Via Sersale, Roma, Italy.
25. Sapienza University of Rome Department of Information, Electronics and Telecommunications,
26. Scuola Normale Superiore di Pisa, Pisa, Italy.
27. SurveyLab, Spinoff of La Sapienza, via Eudossiana 18, Rome 00198, Italy.
28. Technische Universität München, Lehrstuhl für Ingenieurgeologie, Arcisstr. 21, 80333 Munich, Germany;
29. USGS, California Volcano Observatory, Menlo Park, CA, USA.
30. USGS, Cascades Volcano Observatory, 1300 SE Cardinal Ct., Suite 100, Vancouver, WA 98683, USA.
31. Universidad de Las Palmas de Gran Canaria, GEOVOL, 35017 Las Palmas de Gran Canaria, Spain.
32. Università di Catania, Dipartimento di Scienze Biologiche, Geologiche e Ambientali, Sezione di Scienze della Terra, Catania, Italy.
33. Università di Firenze, Dipartimento di Scienze della Terra, 50124 Firenze, Italy.
34. Università di Roma "La Sapienza", Dipartimento di Ingegneria dell'Informazione, Elettronica e Telecomunicazioni, 00184 Rome, Italy.
35. Università di Roma La Sapienza, Dipartimento di Ingegneria Civile Edile ed Ambientale, via Eudossiana 18, Rome 00198, Italy.
36. Università di Pisa, Dipartimento di Ingegneria Civile e Industriale, Pisa, Italy.


Thanks
Questions?