Spaceborne and airborne DInSAR products generation and analysis to support Civil Protection activities in volcanic and seismic regions

Fernando Monterroso[1]

Francesco Casu[1], Paolo Berardino[1], Manuela Bonano[1], Sabatino Buonanno[1], Federica Casamento[1,2], Federica Cotugno[1,3], Claudio De Luca[1], Alessandro Di Vincenzo[1,2], Carmen Esposito[1], Marianna Franzese[1], Adele Fusco[1], Michele Manunta[1], Antonio Natale[1], Giovanni Onorato[1], Stefano Perna[2], Yenni Lorena Belen Roa[1], Pasquale Striano[1], Muhammad Yasir[1,2], Giovanni Zeni[1], Ivana Zinno[1], Riccardo Lanari[1]
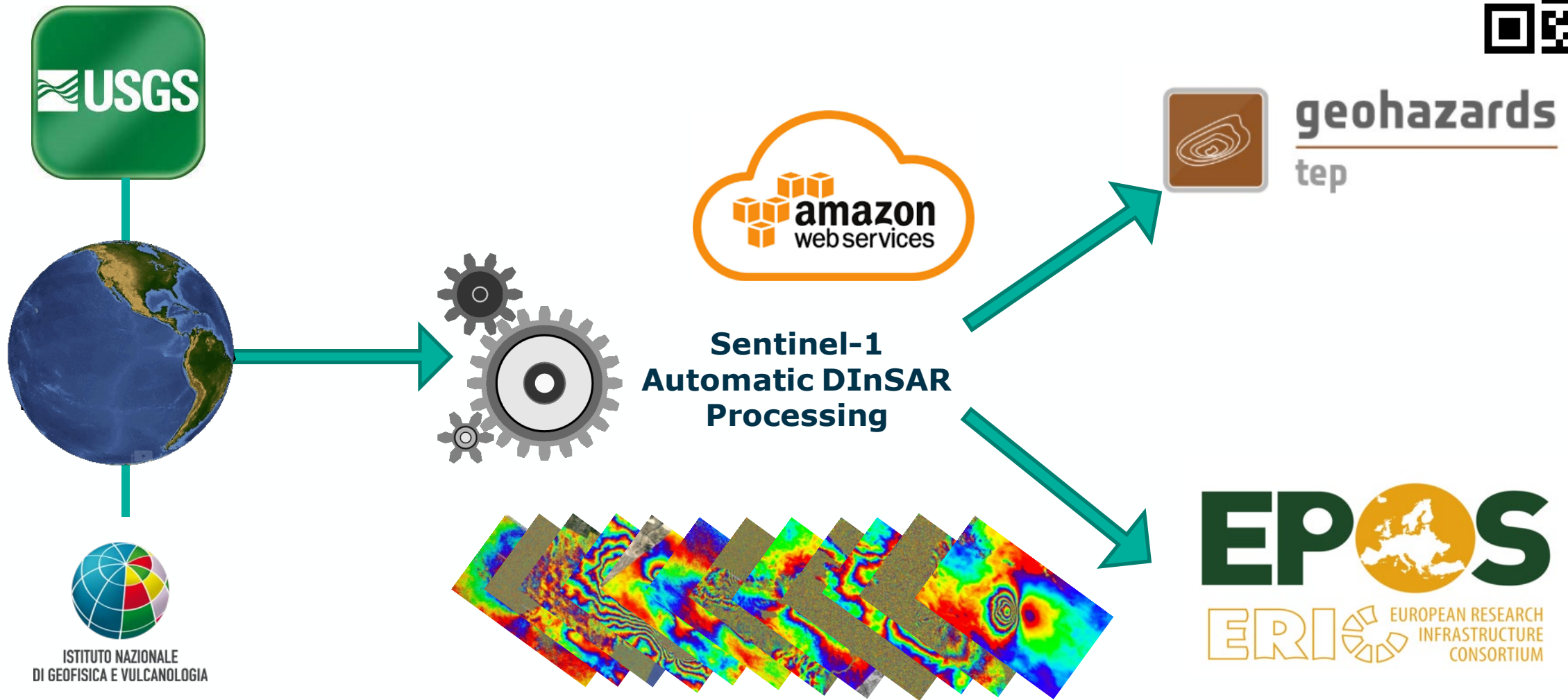
[1] CNR-IREA, Italy
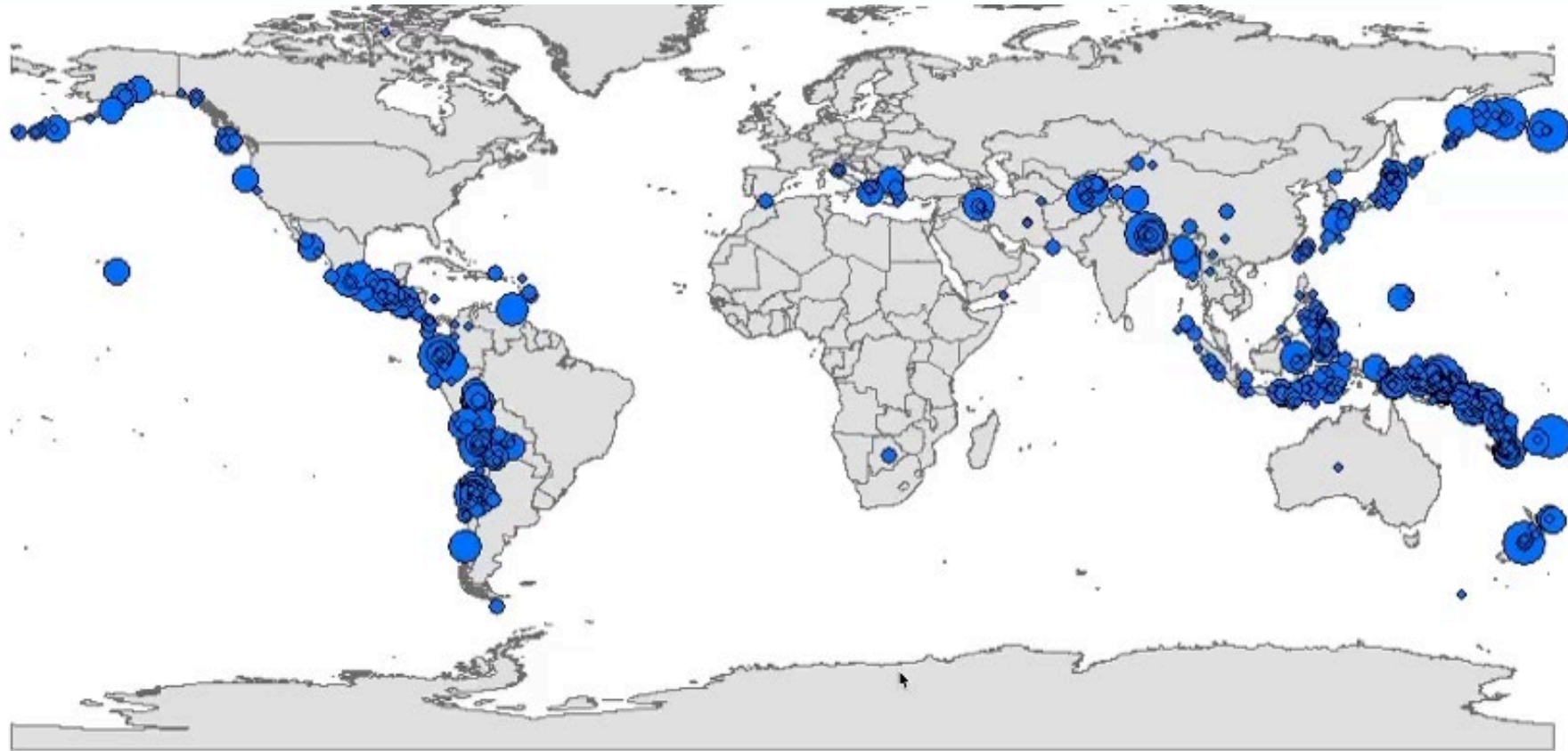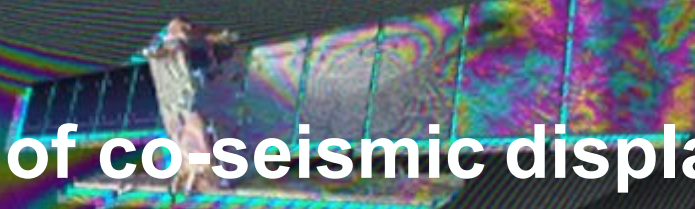[2] Università degli studi di Napoli "Parthenope", Italy
[3] Università degli studi di Napoli Federico II, Italy

FRINGE 2023
University of Leeds, UK | 11 - 15 September 2023.

→ THE EUROPEAN SPACE AGENCY

Operational services EPOSAR: Automatic generation of co-seismic displacement maps

USGS

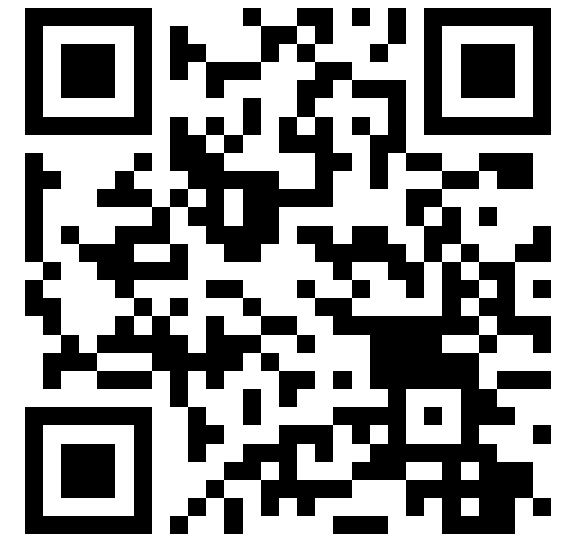ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

amazon web services

Sentinel-1 Automatic DInSAR Processing

geohazards tep

EPOS ERIC — EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM

Operational services
EPOSAR: Automatic generation of co-seismic displacement

606 Earthquakes (Sept 10, 2023)

45000 products

Interferograms,
LOS Displacement maps
Coherence maps

Standardized products available in the EPOS data portal

https://www.ics-c.epos-eu.org

→ THE EUROPEAN SPACE AGENCY

Operational services
EPOSAR: Automatic generation of co-seismic displacement maps

Data availability: European Plate Observing System (EPOS) data portal

https://www.ics-c.epos-eu.org/

Operational services
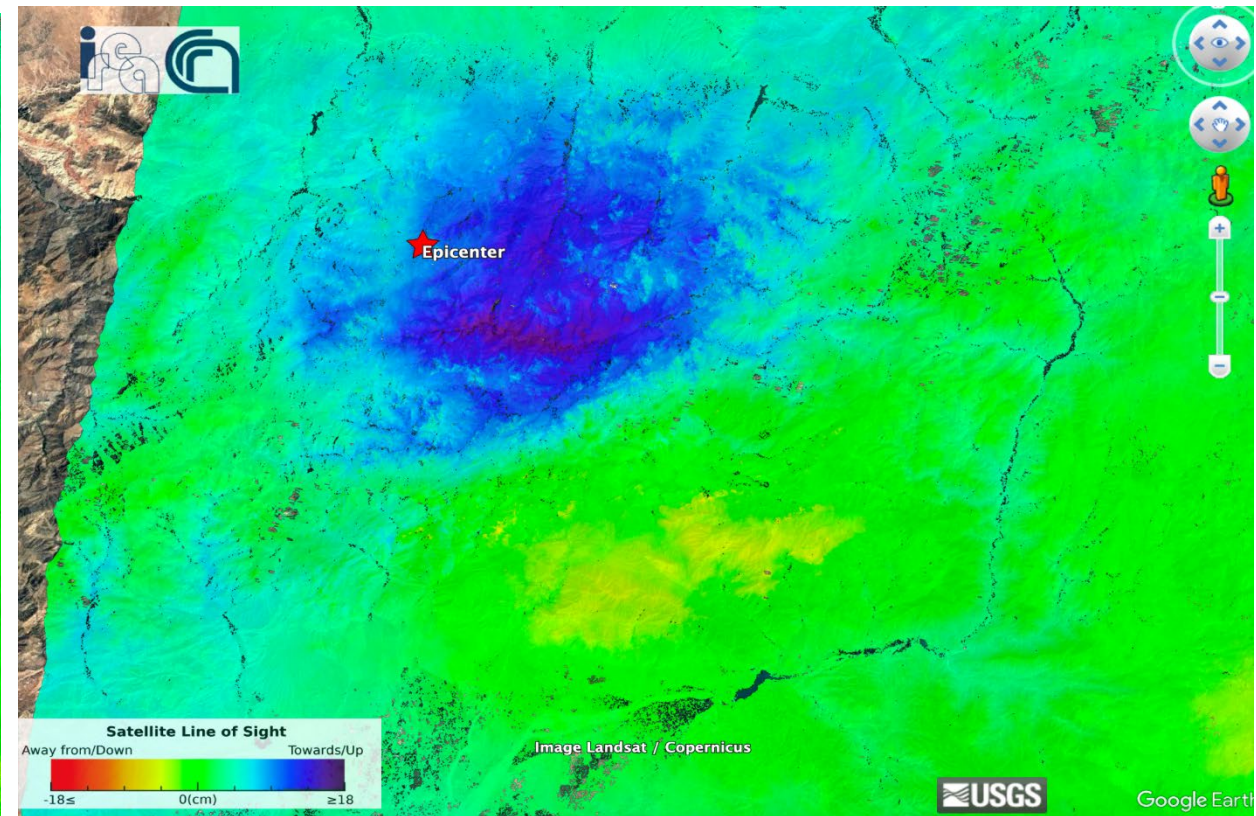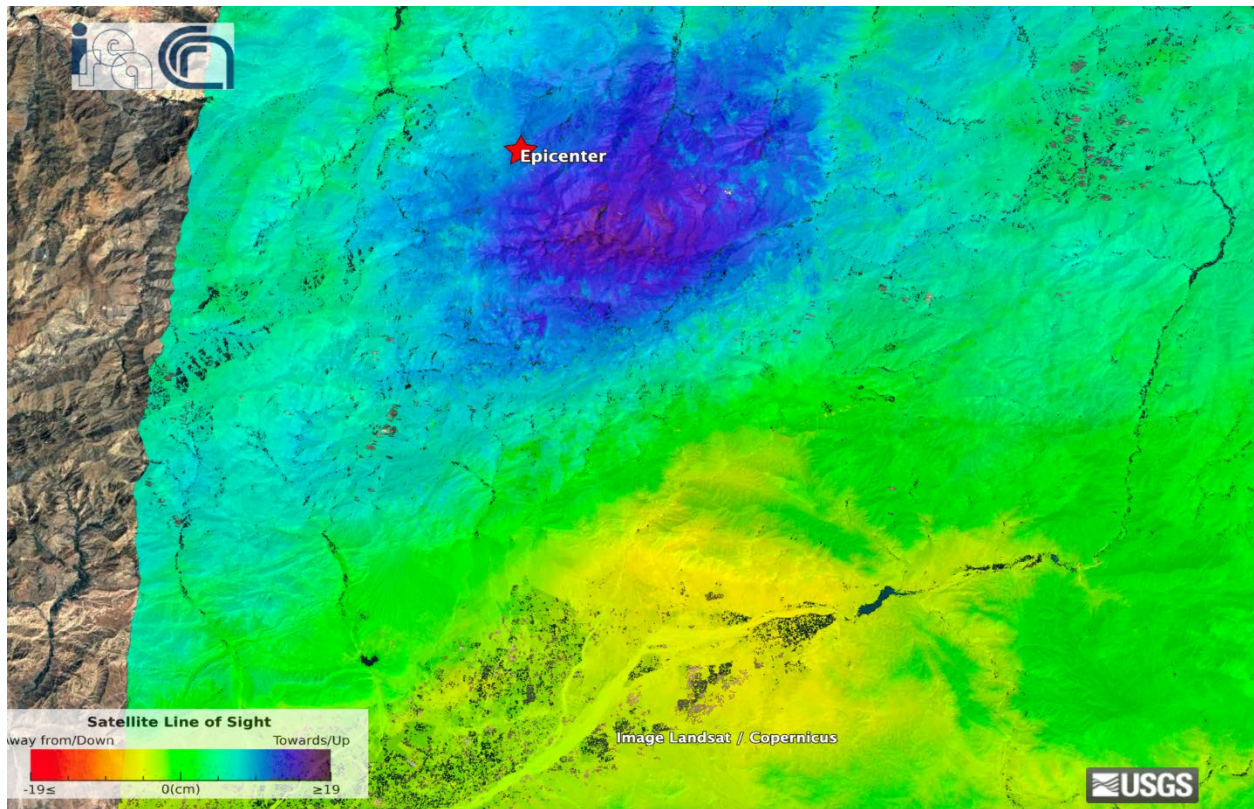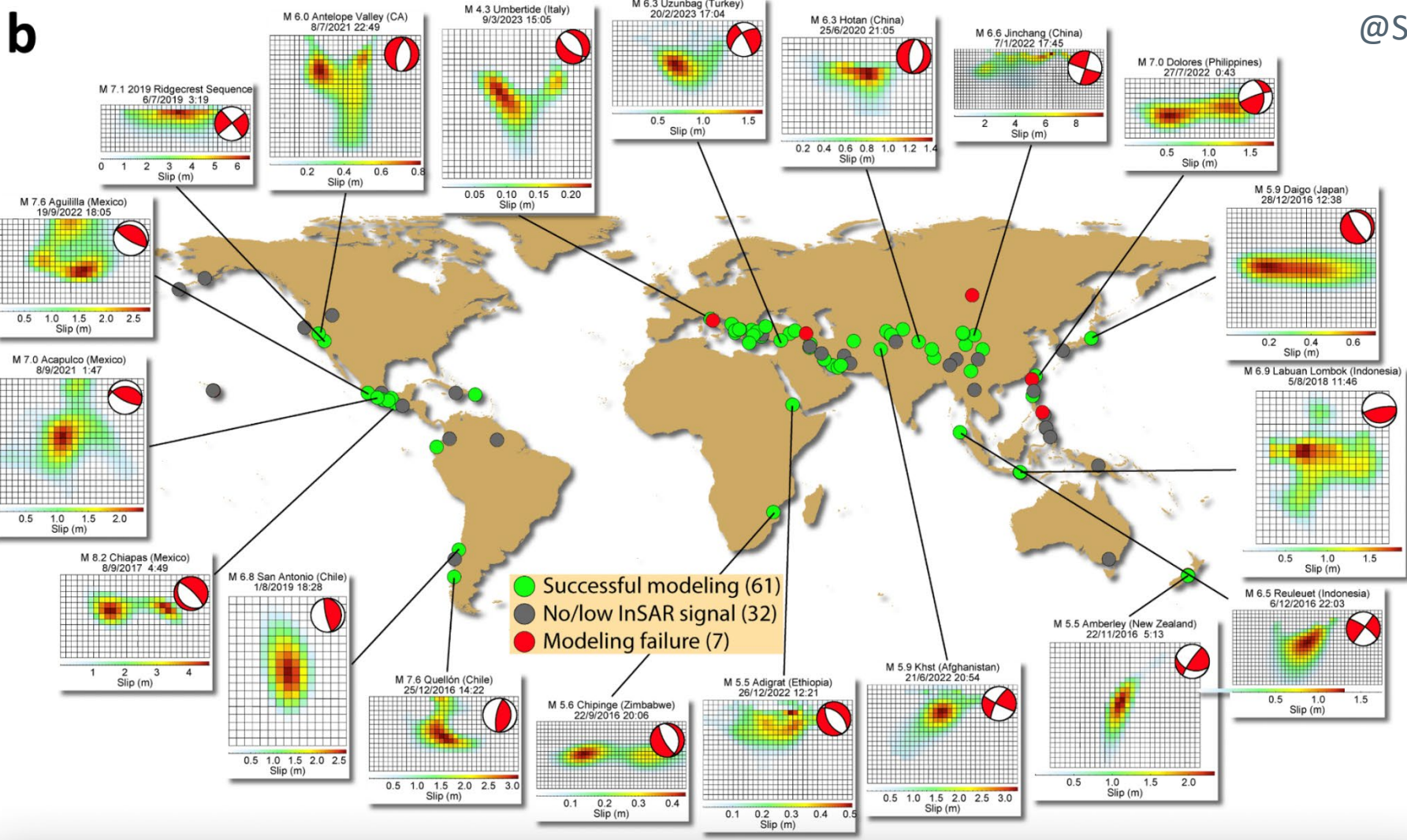EPOSAR: Automatic generation of co-seismic displacement maps

Coseismic interferograms and displacement maps of the 09/09/23 Morocco Earthquake (Descending Orbit 154)

18082023S1A-11092023S1A   30082023S1A-11092023S1A

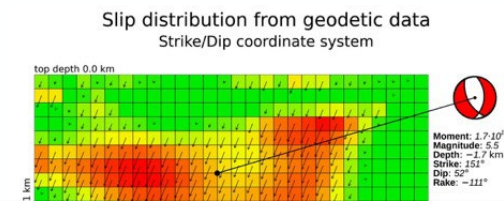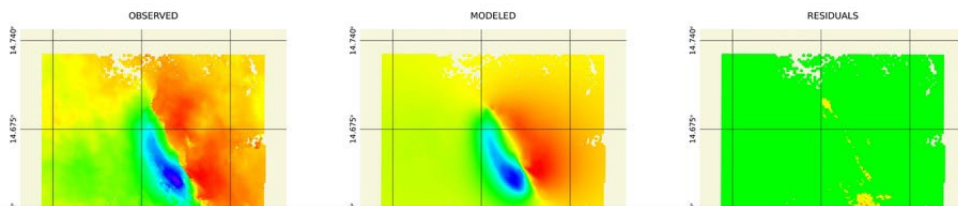# Pre-Operational: Automatic Source Models by using EPOSAR products

@SimoneAtzori73

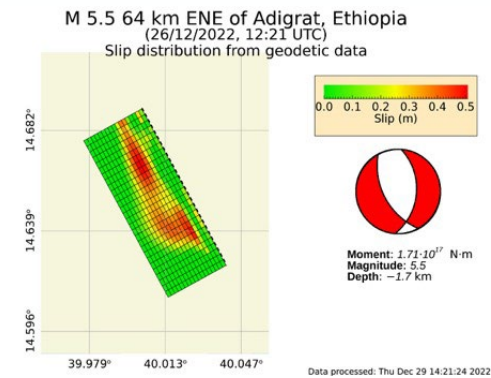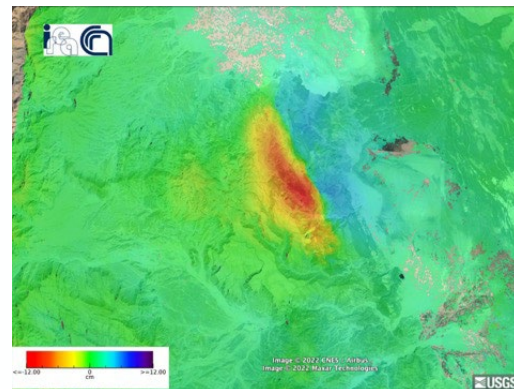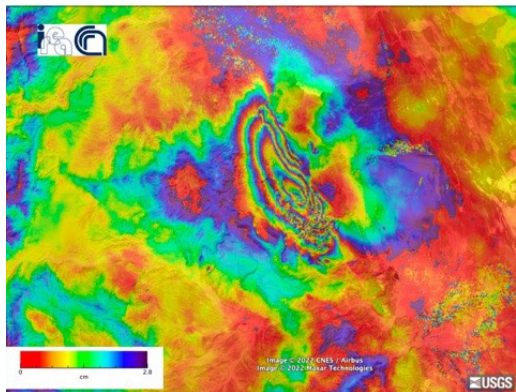**4.02.a: Earthquake and Tectonics 2**
Time: 14/Sept/2023: 11:10am-12:50pm · Location: Auditorium I
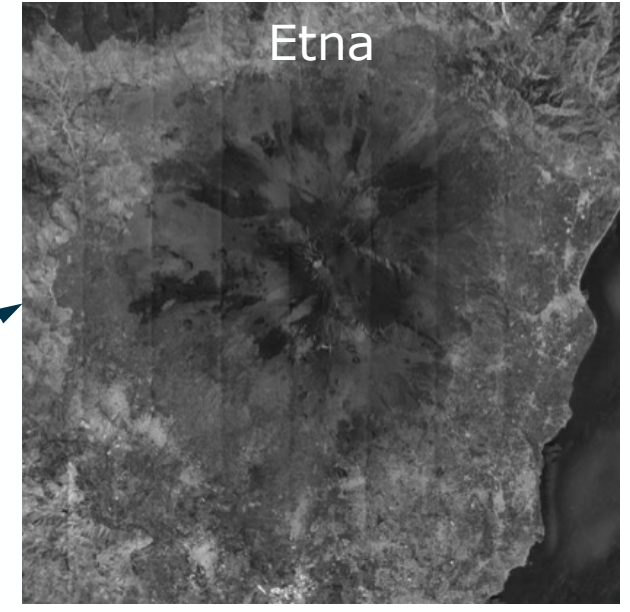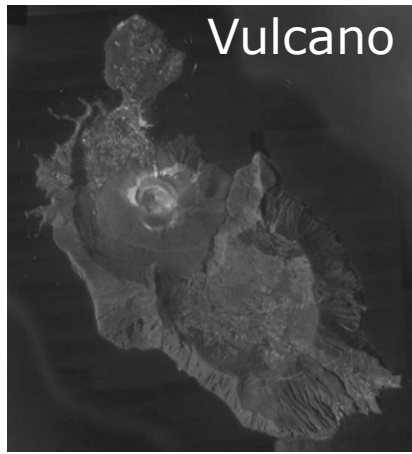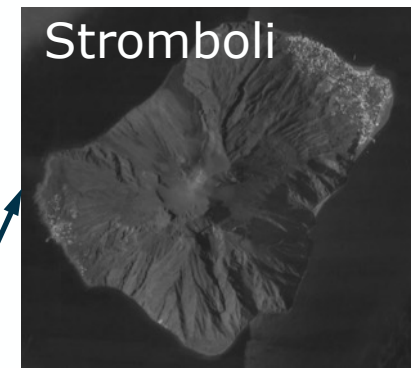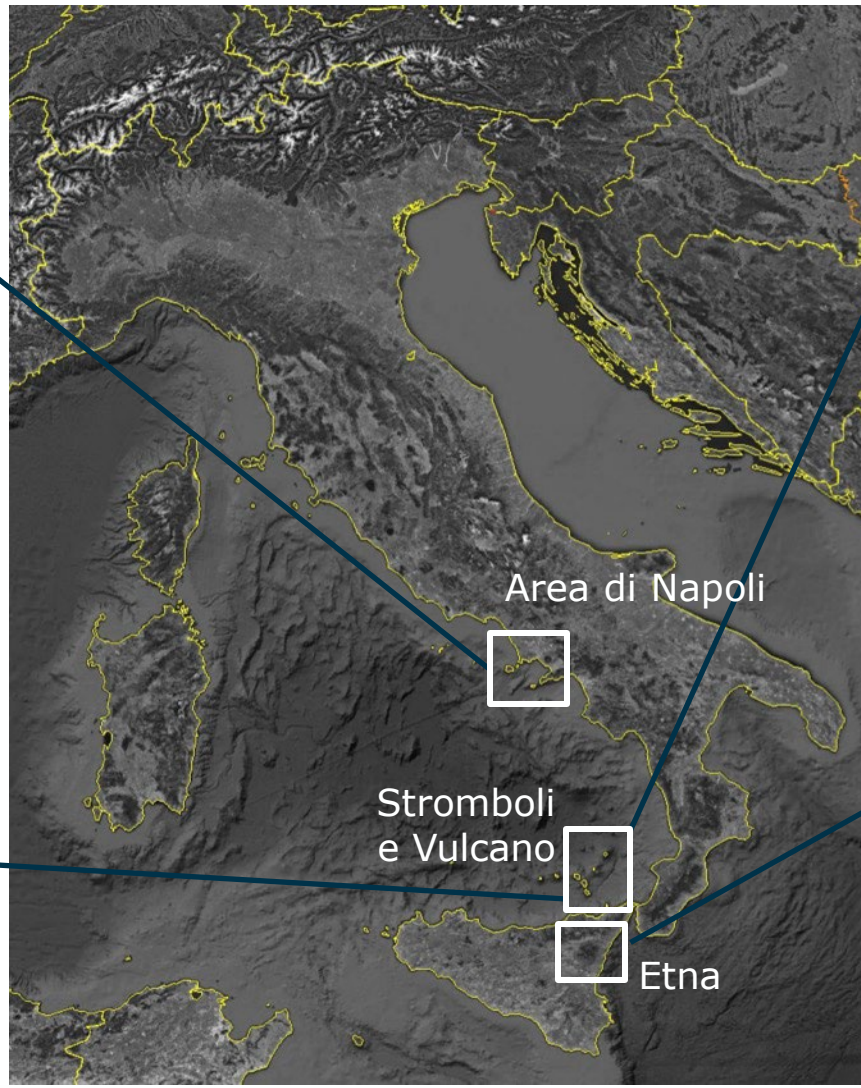
12:30pm - 12:50pm
Oral_20

Automatic Seismic Source Model Retrieval By Exploiting The Sentinel-1 DInSAR Co-seismic Displacement Maps Available Through The EPOSAR Service

Fernando Monterroso[1], Simone Atzori[2], Andrea Antonioli[2], Claudio De Luca[1], Nikos Svigkas[2], Michele Manunta[1], Matteo Quintiliani[2], Riccardo Lanari[1], Francesco Casu[3]
[1]IREA-CNR, Naples, Italy; [2]INGV, Rome, Italy; [3]IREA-CNR, Milan, Italy
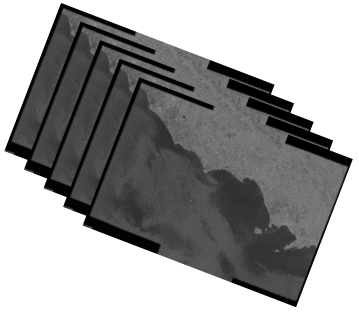
→ THE EUROPEAN SPACE AGENCY

Operational services: ground deformation monitoring of Italian volcanic areas

Campi Flegrei

Vesuvio

Ischia

Stromboli

Vulcano

Etna

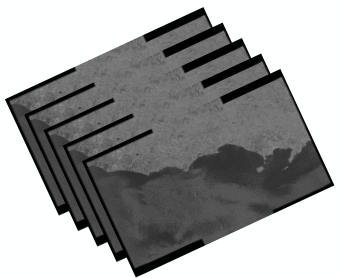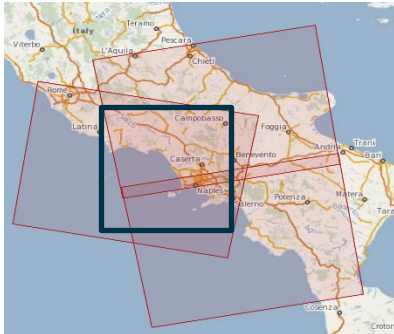Area di Napoli

Stromboli e Vulcano

Etna

Workflow Operational services: ground deformation monitoring of Italian volcanic areas

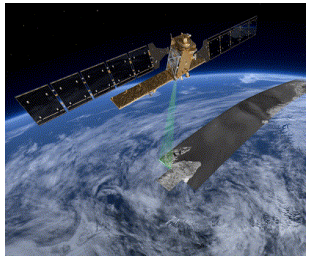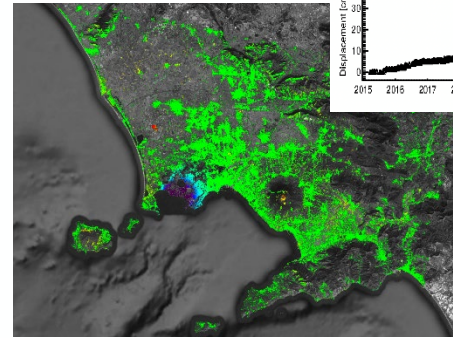Descending Orbit

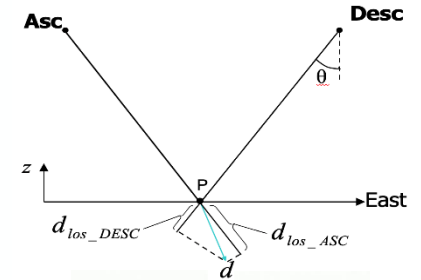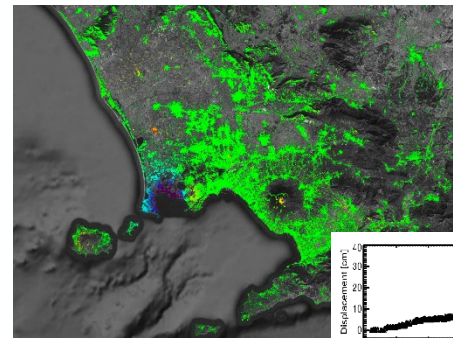P-SBAS
Parallel - Small BAseline Subset

The Parallel SBAS Approach for Sentinel-1 Interferometric Wide Swath Deformation Time-Series Generation: Algorithm Description and Products Quality Assessment
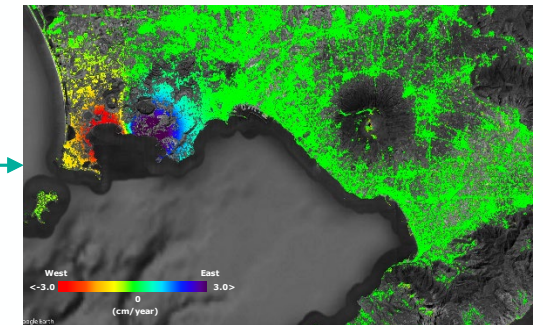
Manunta et al., 2019, IEEE TGRS
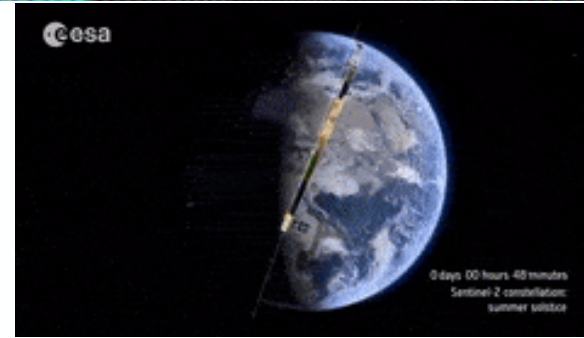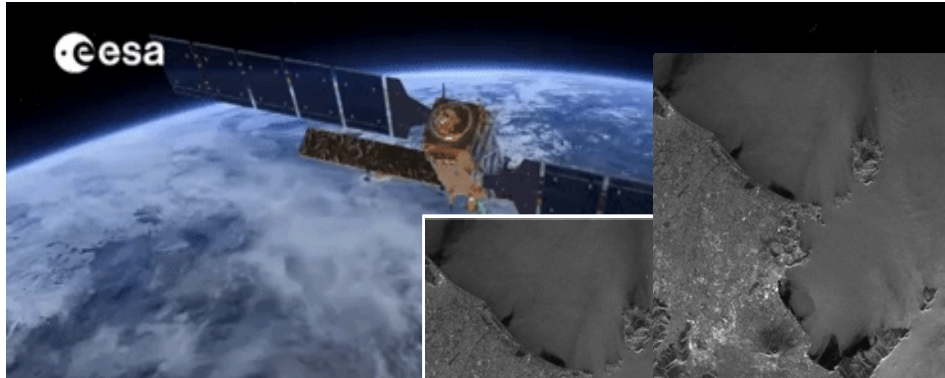
P-SBAS
Parallel - Small BAseline Subset

Ascending Orbit

Vertical Displacement

Horizontal Displacement

https://doi.org/10.1130/GES01225.1
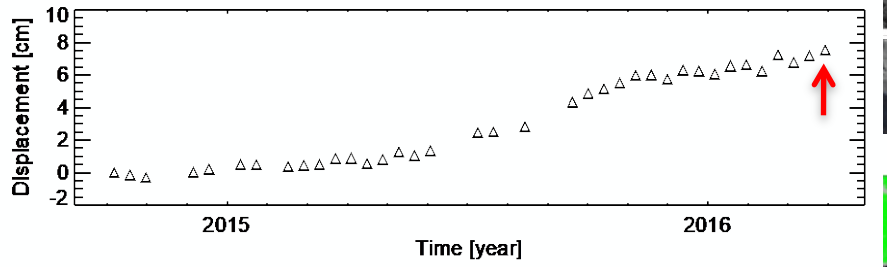
9

Operational services: ground deformation monitoring in volcanic areas

Sentinel-1 revisit time **12 days**

P-SBAS

Parallel - Small BAseline Subset
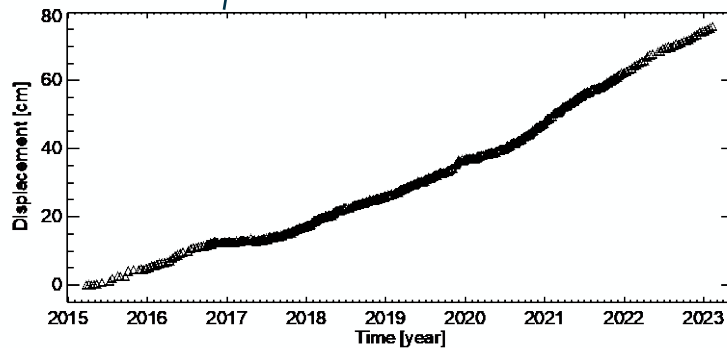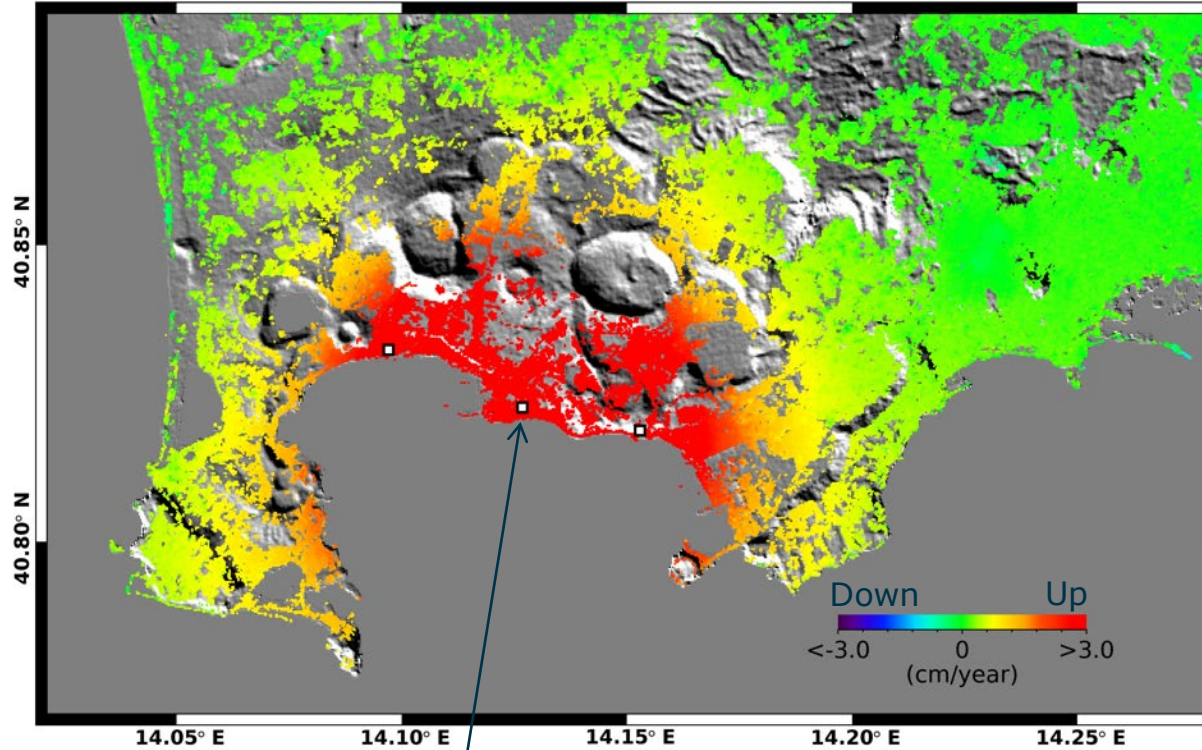
Monthly report to define the volcano "status"

Campi Flegrei

[cm/year]

<-6   >6
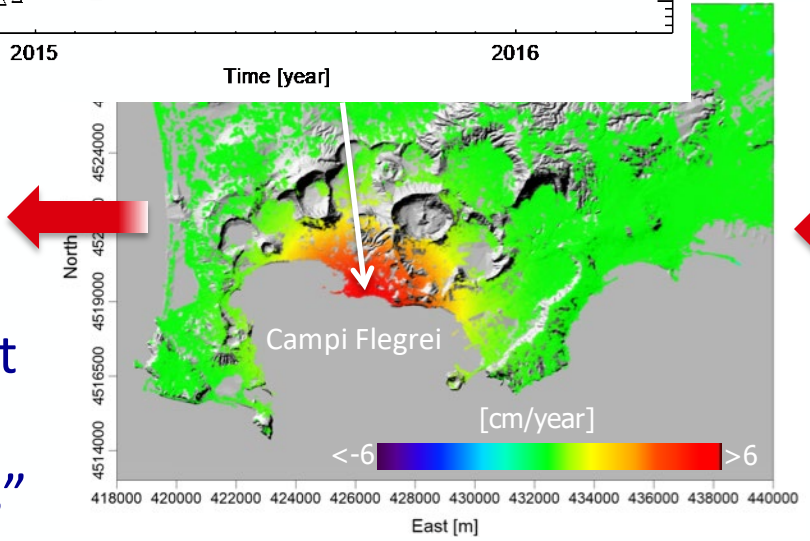
Casu et al., 2014, IEEE JSTARS
Manunta et al., 2019, IEEE TGRS

Operational services: ground deformation monitoring of Italian volcanic areas

Vertical Mean Velocity (Up – Down)

Campi Flegrei Caldera

407 SAR images to generate 1183 interferometric pairs (Descending Track 22).

408 SAR images to generate 1187 interferometric pairs (Ascending Track 44).

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Operational services: ground deformation monitoring of Italian volcanic areas

Vertical Mean Velocity (Up – Down)
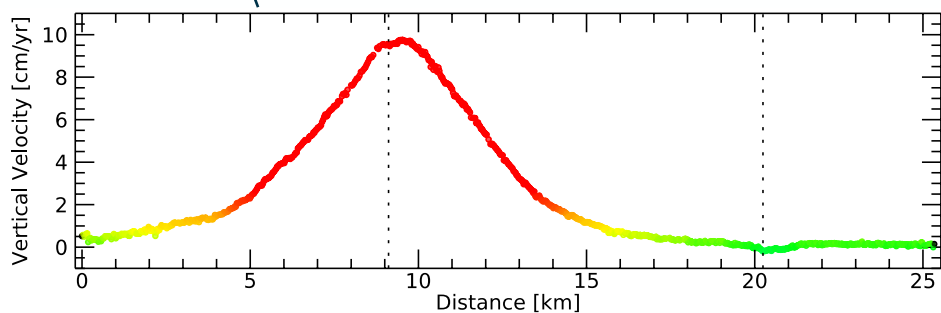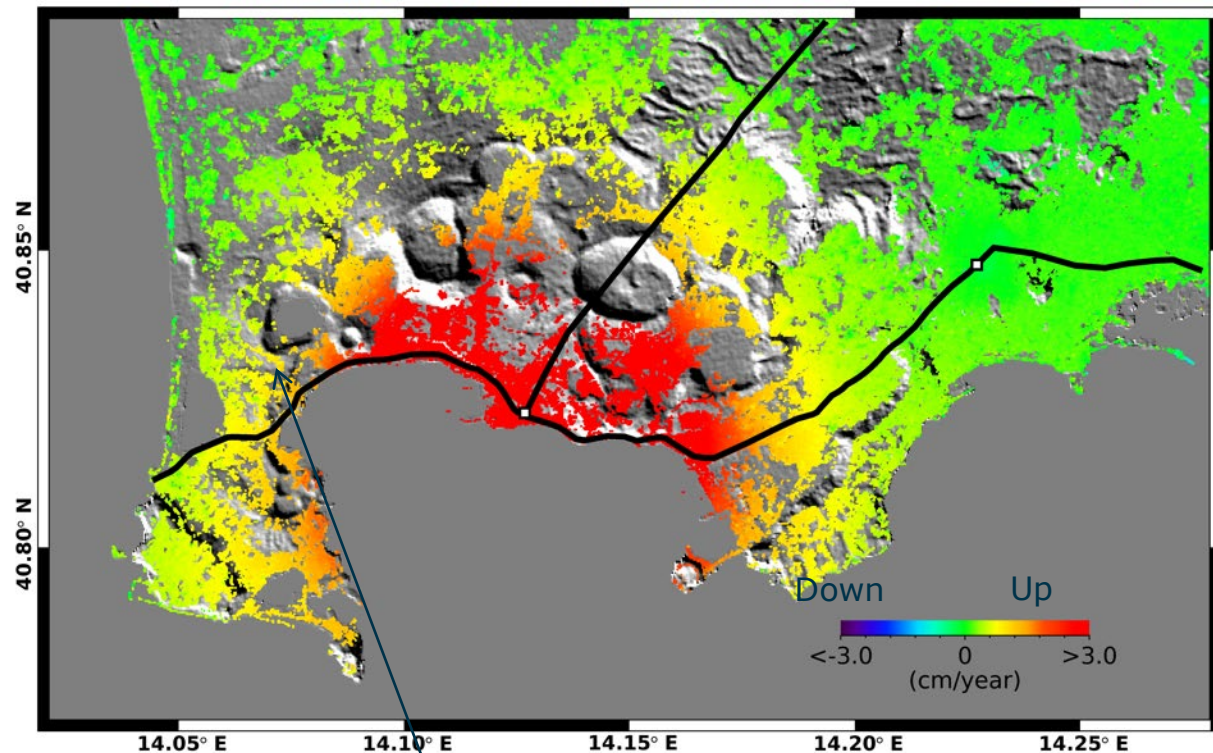

Campi Flegrei Caldera

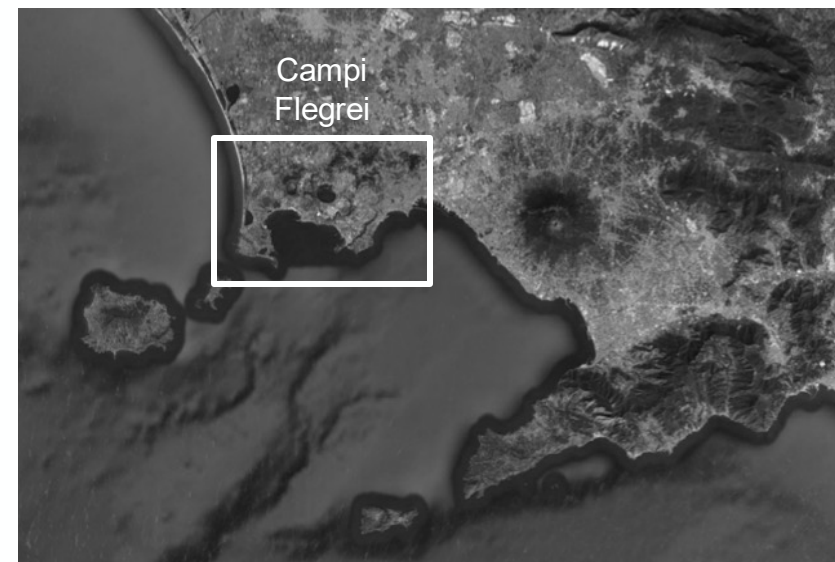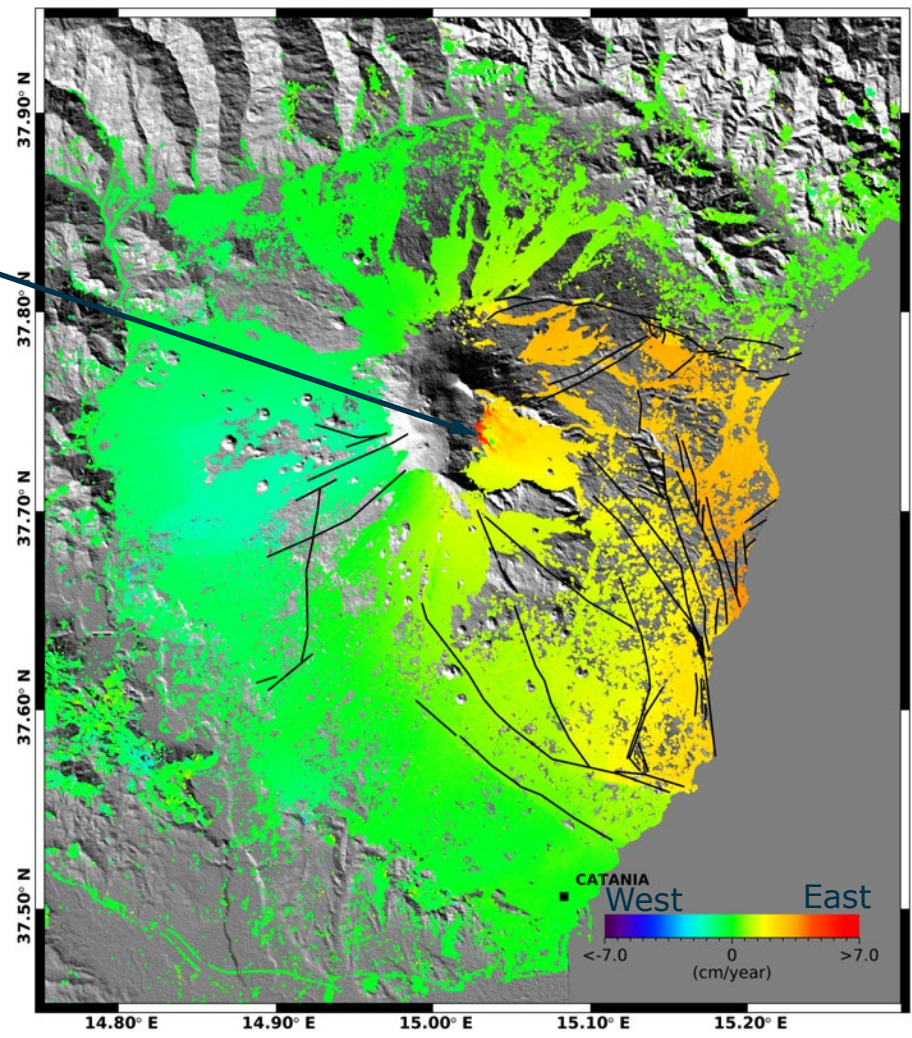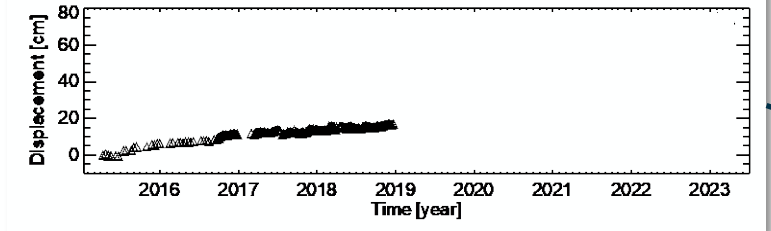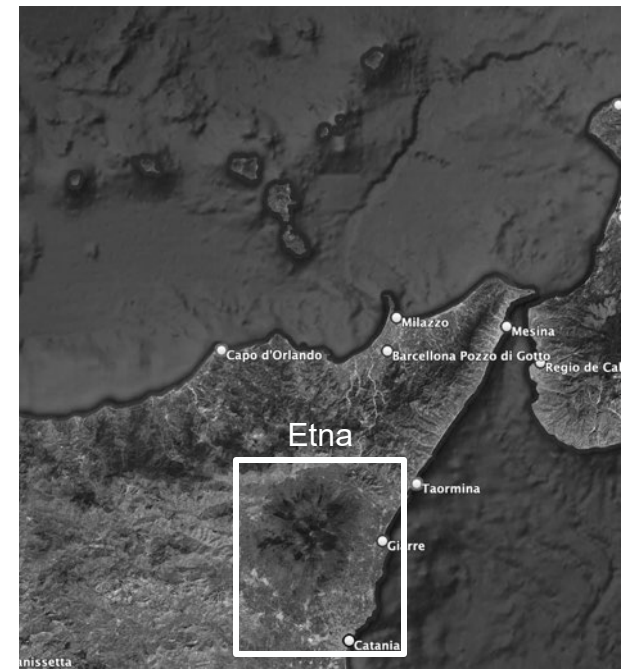407 SAR images to generate 1183 interferometric pairs (Descending Track 22).

408 SAR images to generate 1187 interferometric pairs (Ascending Track 44).

→ THE EUROPEAN SPACE AGENCY

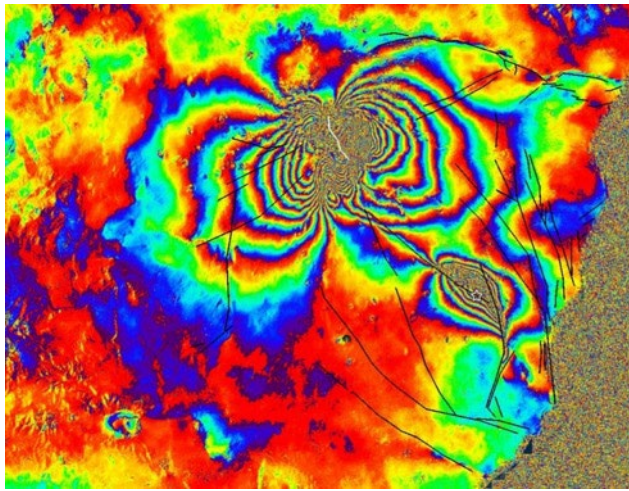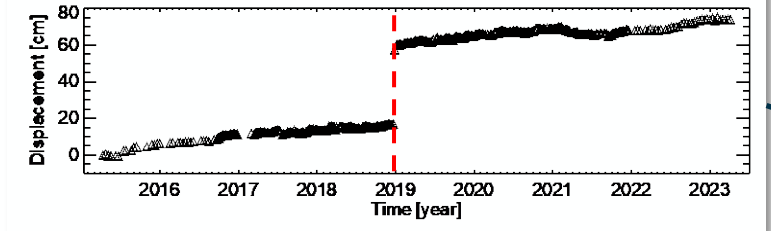# Operational services: ground deformation monitoring of Italian volcanic areas

387 SAR images to generate 1082 interferometric pairs (Descending Track 124).

394 SAR images to generate 1098 interferometric pairs (Ascending Track 44).

Apr 2015 – Dec 2018 Horizontal Mean Velocity (East – West)

Etna Volcano

→ THE EUROPEAN SPACE AGENCY

Operational services: ground deformation monitoring of Italian volcanic areas

24.12.2018: Eruptive event
26.12.2018: Fiandaca EQ – M_L 4.8

V. De Novellis et al (2019)
https://doi.org/10.1029/2019GL082467

Jan 2019 – Apr 2023 Horizontal Mean Velocity (East – West)

Etna Volcano

→ THE EUROPEAN SPACE AGENCY

Operational services: ground deformation monitoring of Italian volcanic areas

Vertical Mean Velocity (Up – Down)

Horizontal Mean Velocity (East – West)

403 SAR images to generate 1178 interferometric pairs (Descending Track 124)

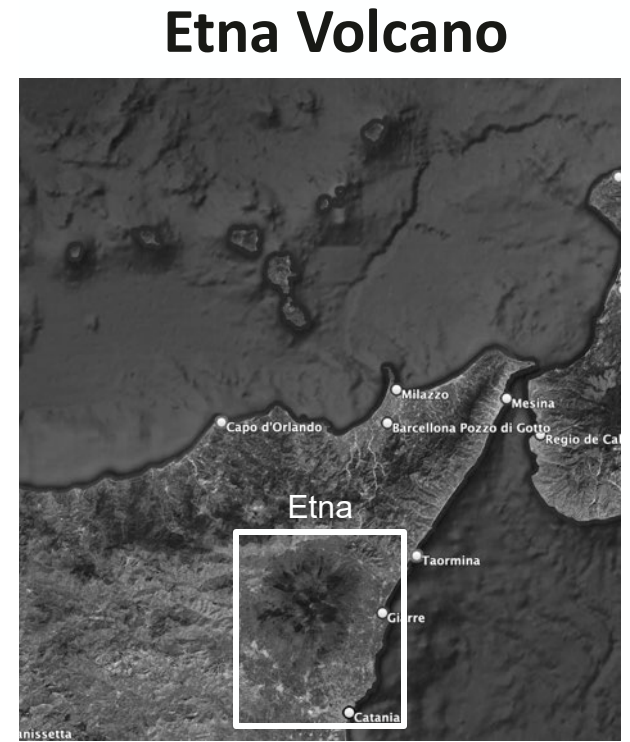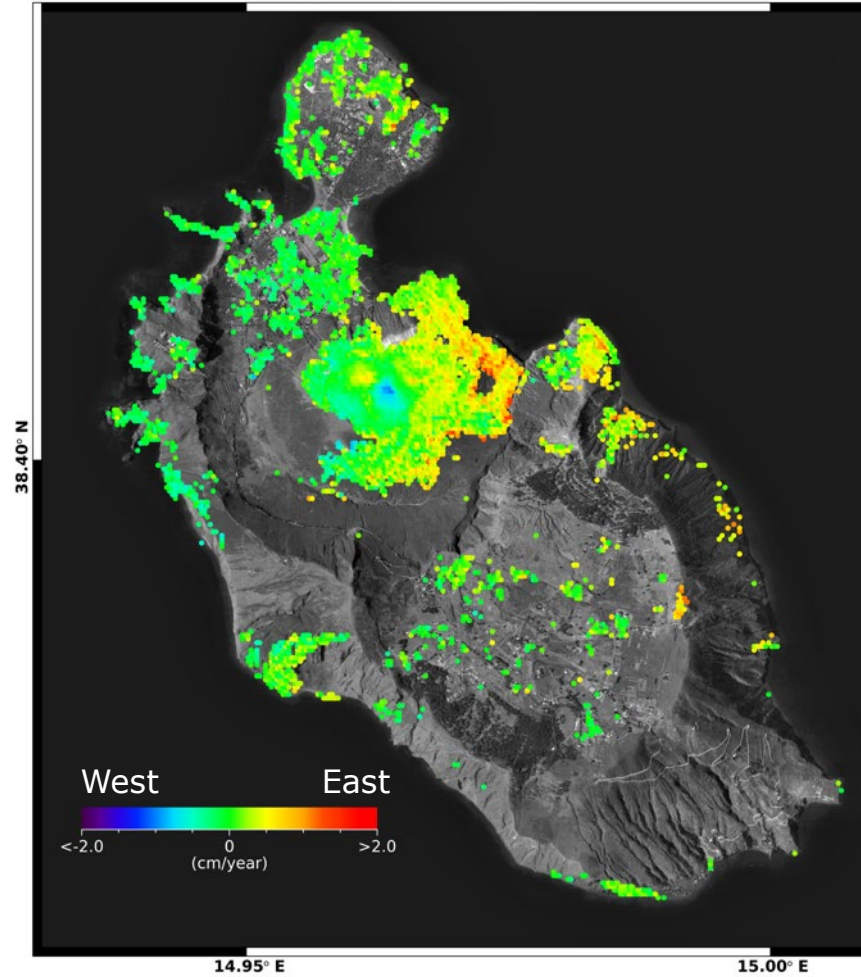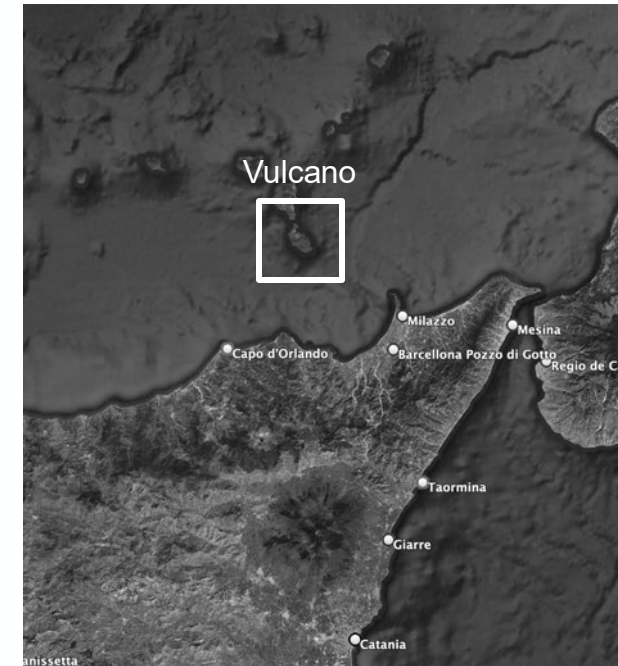401 SAR images to generate 1118 interferometric pairs (Ascending Track 44)

Vulcano Island

Sep-Nov 2021 Vertical Displacement
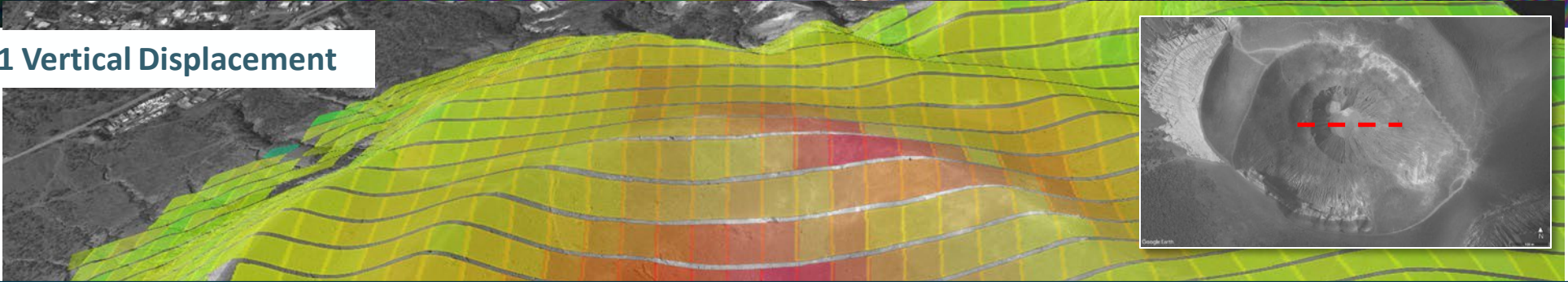
Multi-Temporal InSAR, GNSS and Seismic Measurements Reveal the Origin of the 2021 Vulcano Island (Italy) Unrest, Di Traglia et al (2023), *submmited*

Down   Up
-5<   cm   >5
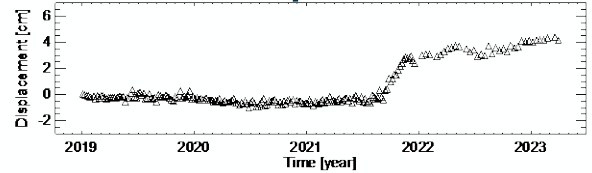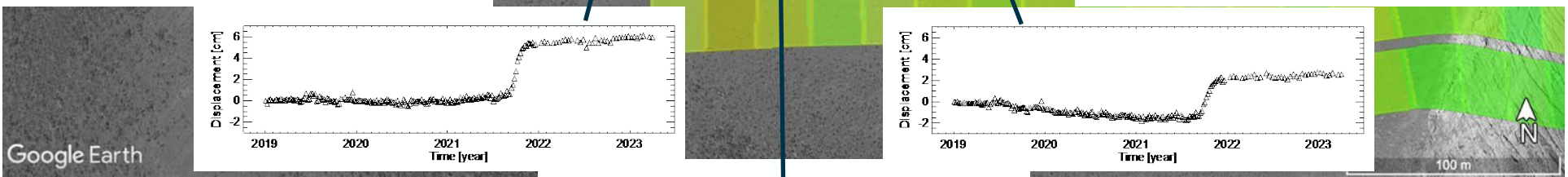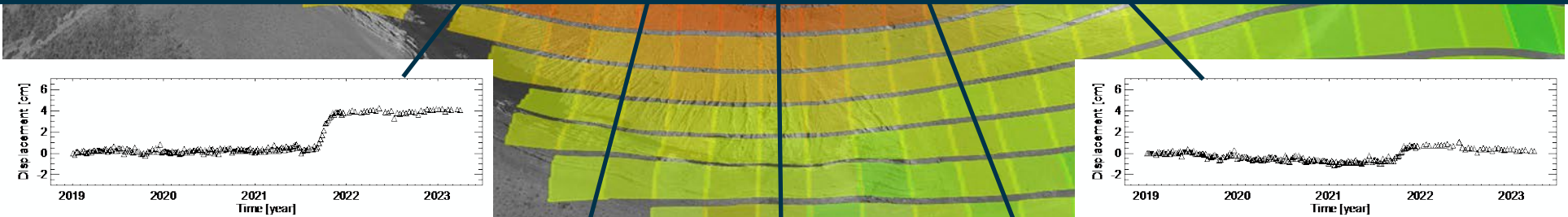
Operational services: ground deformation monitoring of Italian volcanic areas
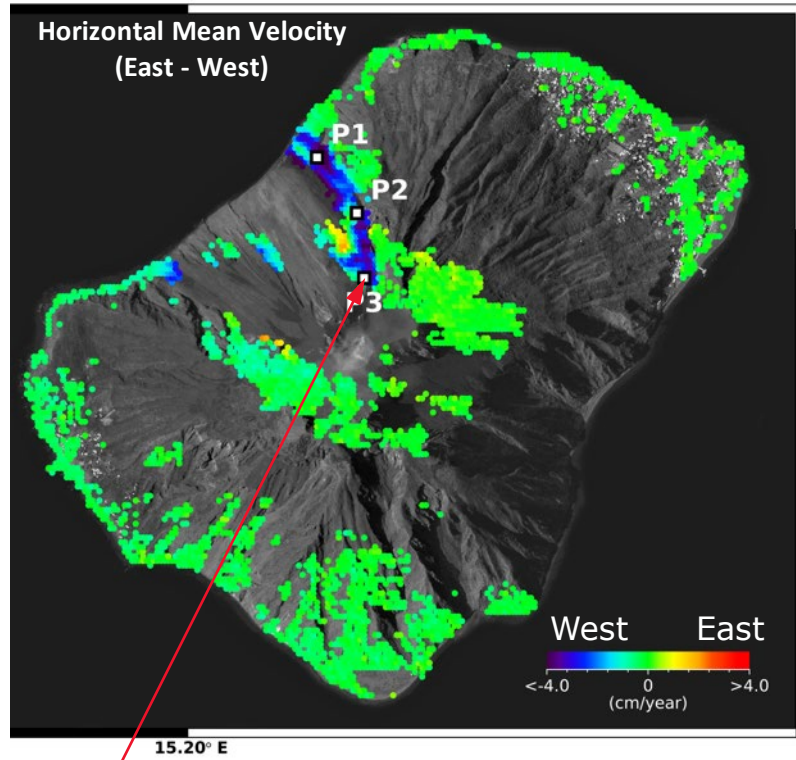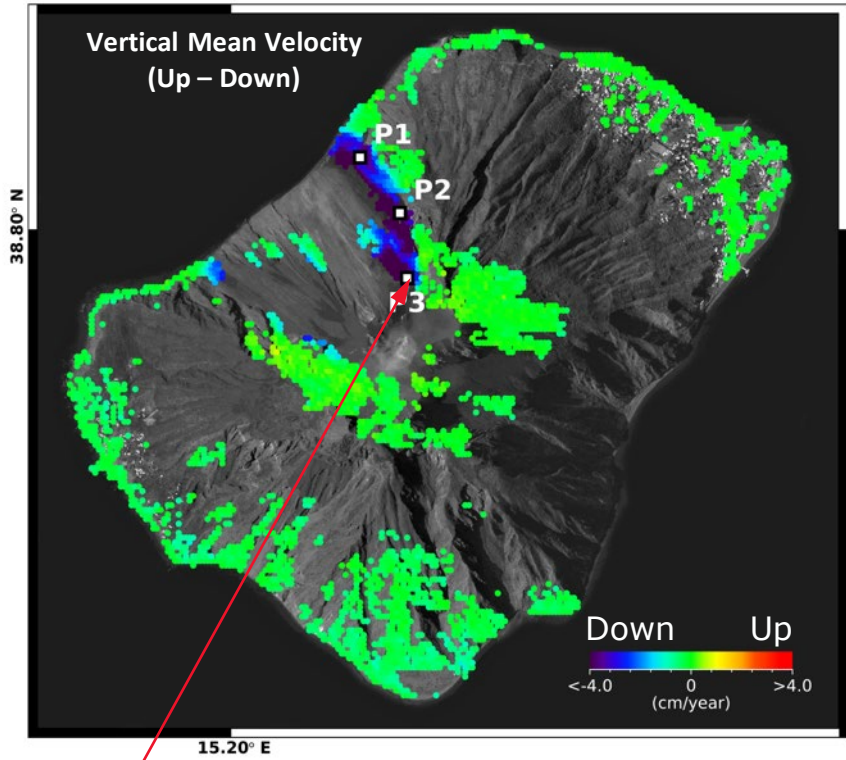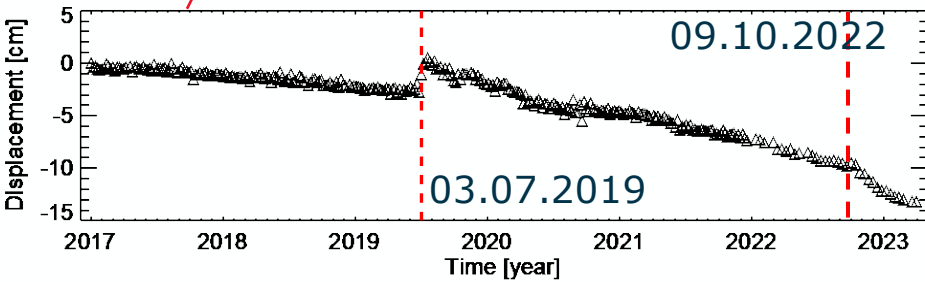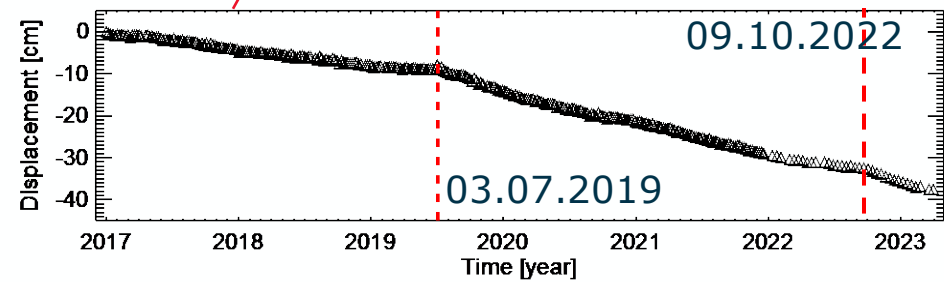

Stromboli
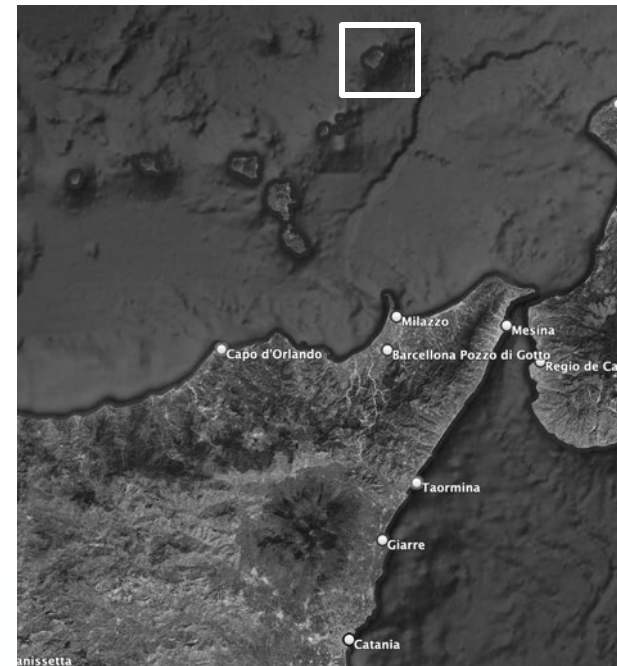
Pre-Operational services: Airborne SAR system Airborne X-Band Interferometric SAR AXIS)

Stromboli: 9 October 2022 event

Mapping elevation changes
Campaigns: 12.09.2022 and 17-18.10.2022

A' – – – – – A

Sciara del Fuoco

Google Earth

Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus

300 m

< -50 erosion | m | > 50 accumulation

Differenza di Quota 12/09/2022 - 17/10/2022

A ... A'

Lunghezza [m]

Conclusion and Future perspectives

- Earthquakes
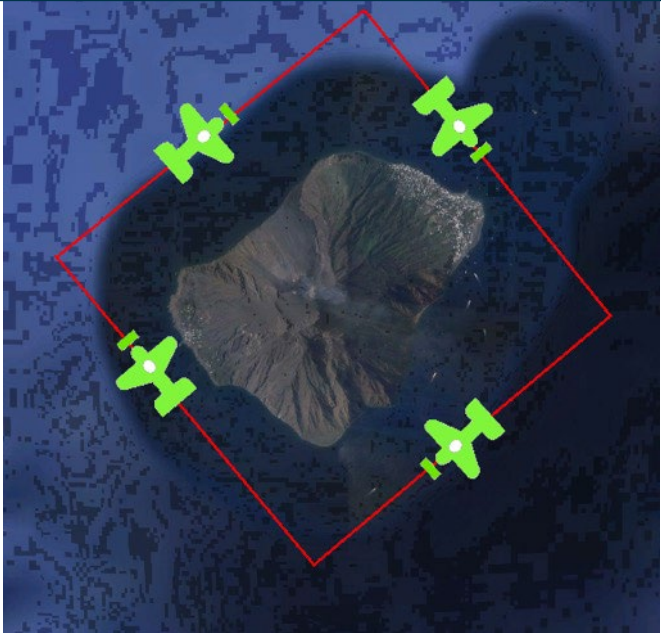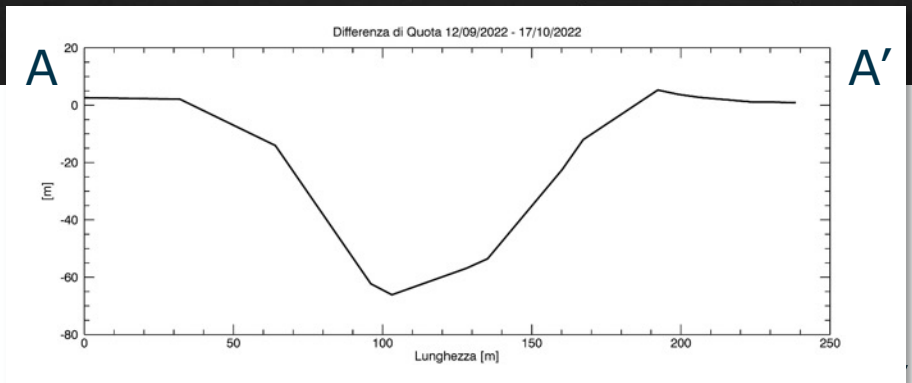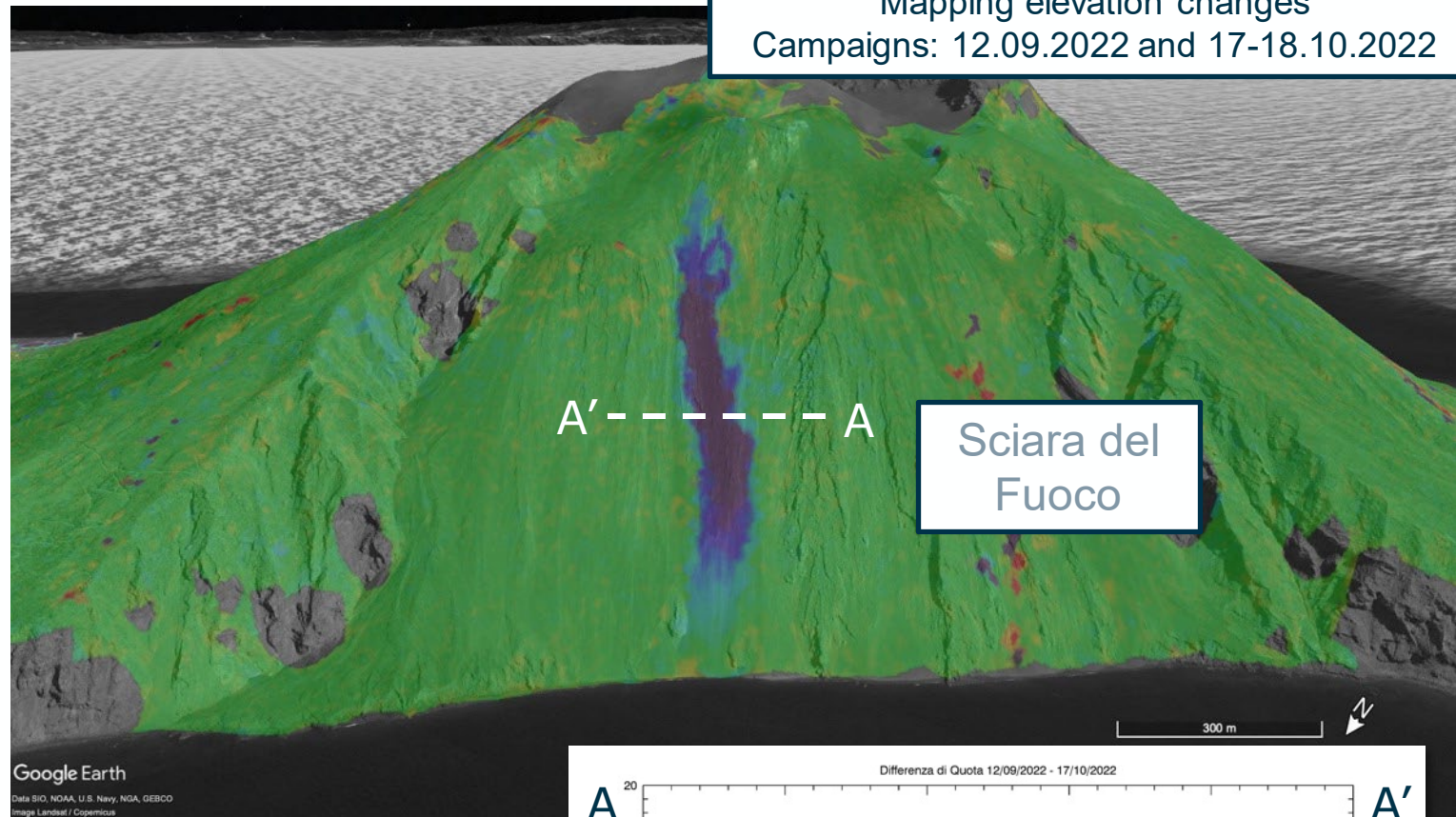 - Operational **EPOSAR** service (standardized products available through EPOS RI)
  - Support DPC during seismic crisis
  - Pre-operational **Automatic Seismic Source Model** generation (a quick and reliable automatic fault model solution)
- Volcano monitoring:
  - Satellite: **operational**
  - Airborne**: pre-operational**
  - Continuous Support to DPC (during and in between crisis)
- New challenges:
  - **Analysis and interpretation of measurements**
    - Develop **AI** techniques to **interpret** and **analyze** the available amount of data
    - Deformation areas **identification**
  - Move **airborne** system to **operational** phase

Thank you!

𝕏 @maferp_13, @FraxInSAR

monterroso.f@irea.cnr.it, casu.f@irea.cnr.it