Committee on Earth Observation Satellites

WGDisasters Geohazards Lab

Michael Foumelis (AUTh)

Philippe Bally (ESA)

Theodora Papadopoulou (ARGANS Ltd. c/ ESA)

WGDisasters-16 Meeting

Virtual Meeting

21-23 September 2021

GeoHazards Lab Initiative

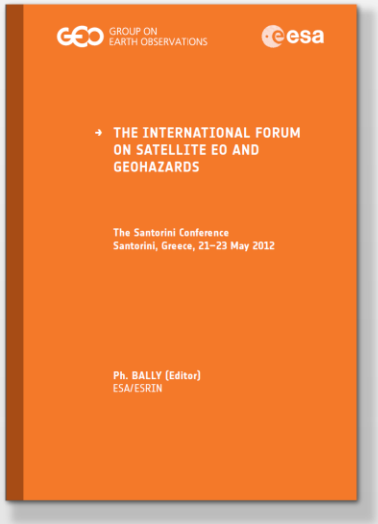
A platform with federated resources to provide **data access and an online processing and e-collaboration environment** to exploit EO data to assess geohazards and their impact

- ✓ Supports and complements the CEOS WG Disasters thematic activities, GSNL and users from the broader geohazards community
- ✓ Maximize use of EO techniques and cloud processing by the EO expert community
- ✓ Achieve acceptance of EO products by the non-expert EO scientific community, non-EO downstream users and decision makers

Geohazards Exploitation Platform - GEP

The GEP is a cloud-based environment providing a set of EO processing services that allow mapping hazard prone land surfaces and monitoring terrain motion.

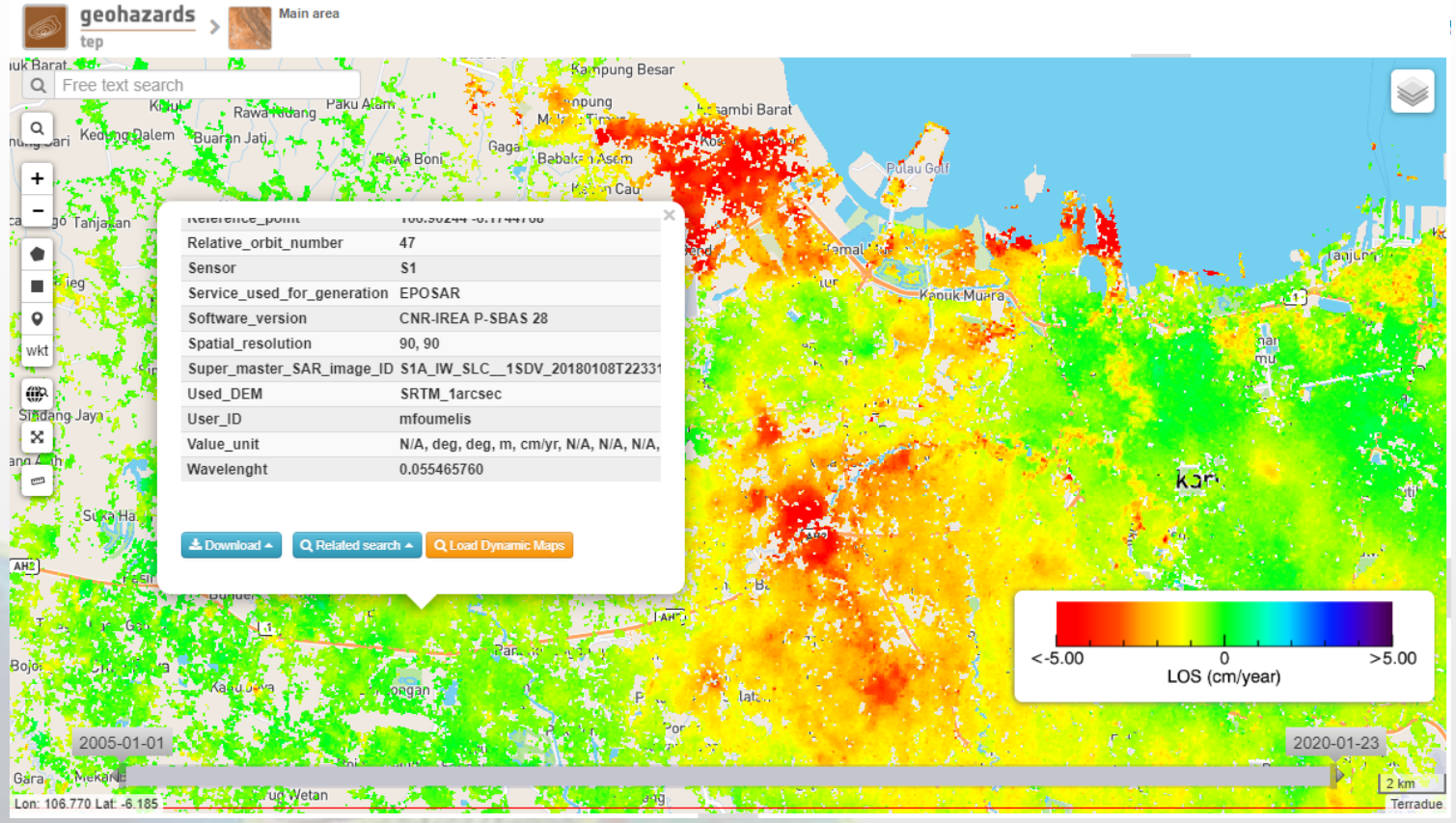
International Forum on Satellite EO and Geohazards organized by ESA and GEO in Santorini in 2012 (140+ participants)



tep
thematic exploitation platform
https://tep.eo.esa.int

geohazards tep | polar tep | coastal tep
hydrology tep | urban tep | forestry tep

GEP P-SBAS On-demand Service



https://geohazards-tep.eu

Will be supported by EGI BELNET-BEGRID (Belgium)

ONDA

CNR-IREA P-SBAS Sentinel-1 processing on-demand

P-SBAS stands for Parallel Small BAseline Subset and it is a DInSAR processing chain for the generation of Earth deformation time series and mean velocity maps. Input: SLC (Level-1) Sentinel-1 data.

GEP SNAPPING PSI service

SNAPPING
SURFACE MOTION MAPPING

SNAPPING | Surface motioN mAPPING is a multi-temporal interferometric service developed by AUTh (GR), MJaen (ES), with the support of Terradue (IT), that produces measurements of surface displacements based on open source ESA SNAP and StaMPS software packages.

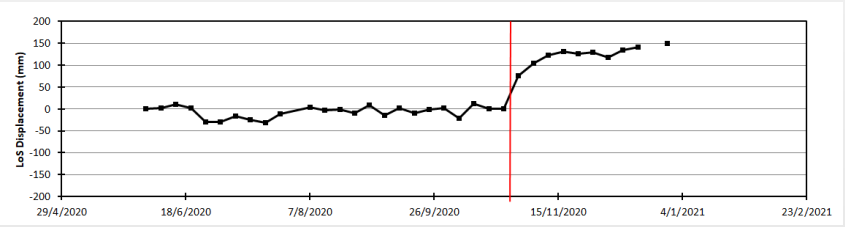
SNAPPING IFG

First step consists in setting-up **SNAPPING IFG** processing pipeline to generate the interferogram stack.

SNAPPING PSI

Second step the interferogram stack is channeled to the **SNAPPING PSI** pipeline for time series analysis0

Samos (Greece) **M**7.0 2020 Earthquake
S1 20200602-20210104 (76 acquisitions, ~7 months)



Challenges in data access tackled making the service more resilient.

Following successful testing and performance optimization it is now in operations in view of making it available to GEP users.

geohazards tep

EO.Lab Earth Observation & Geospatial Applications Lab

Universidad de Jaén

TERRADUE Advancing Earth Science

GLab Activities
Overview

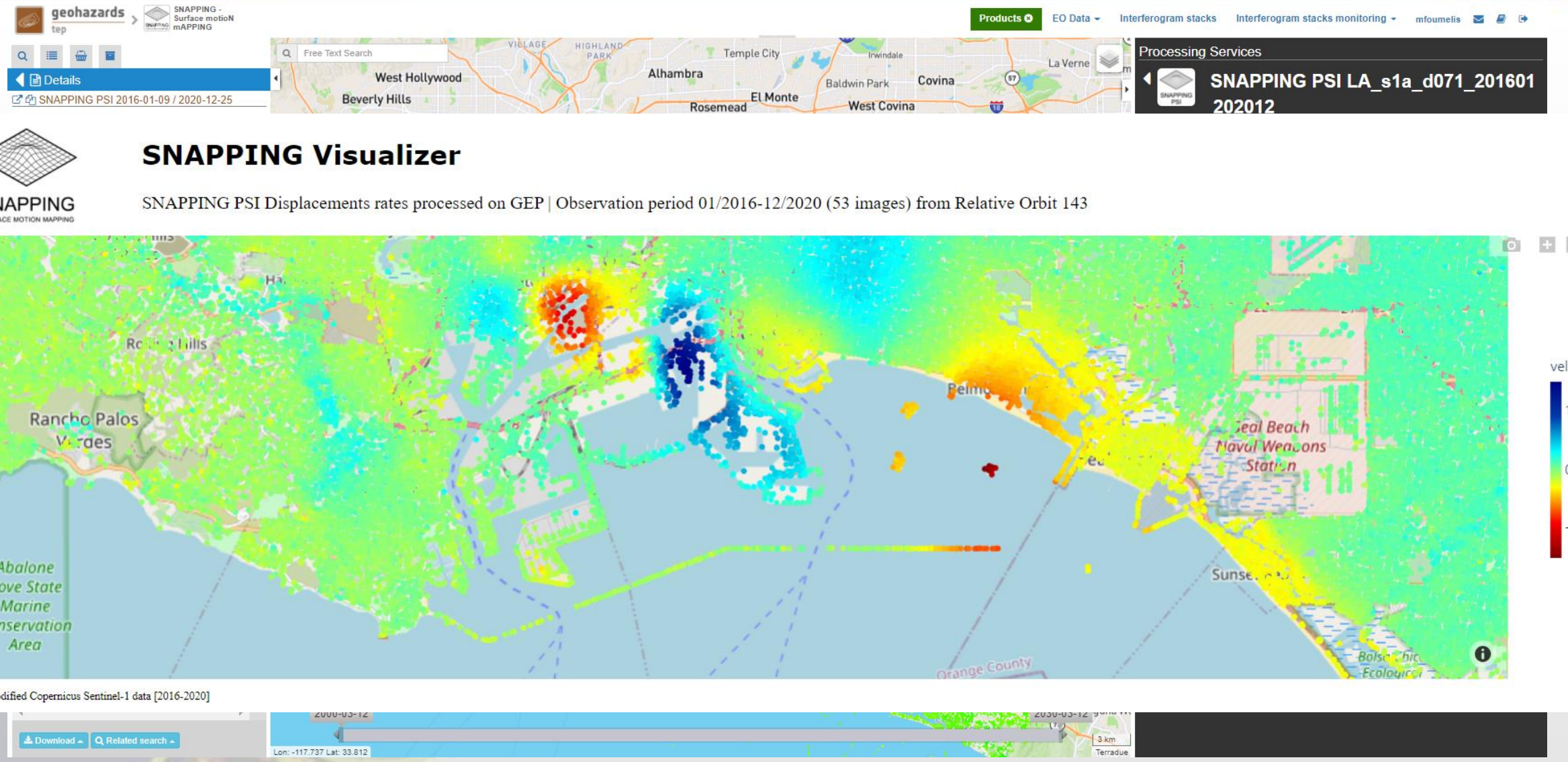
Overview of GLab activities 1/2

- Response to WB stakeholders → Service delivery for Mexico City (wide area processing)
- Utilization of GEP services in International Development projects (EO-AID GDA and ADB)
- Systematic acquisition of CSK data (Tirnavos Eq. 03/2021) under Seismic Pilot and collaboration between INGV (IT) & AUTh (GR) for investigation of post-seismic evolution
- First time request to used EO/InSAR measurements in Greek court..!

Overview of GLab activities 2/2

- Demo processing over US sites for promotion to WB
- Efforts to improve resilience of GEP services to data access issues (inlc. auxiliary products such as DEM/DSMs and orbits)
- Inter-verification of advance GEP InSAR services (P-SBAS & SNAPPING)
- Moving forward with GEP governance

GEP GeoBrowser | Los Angeles



Overview of GLab activities

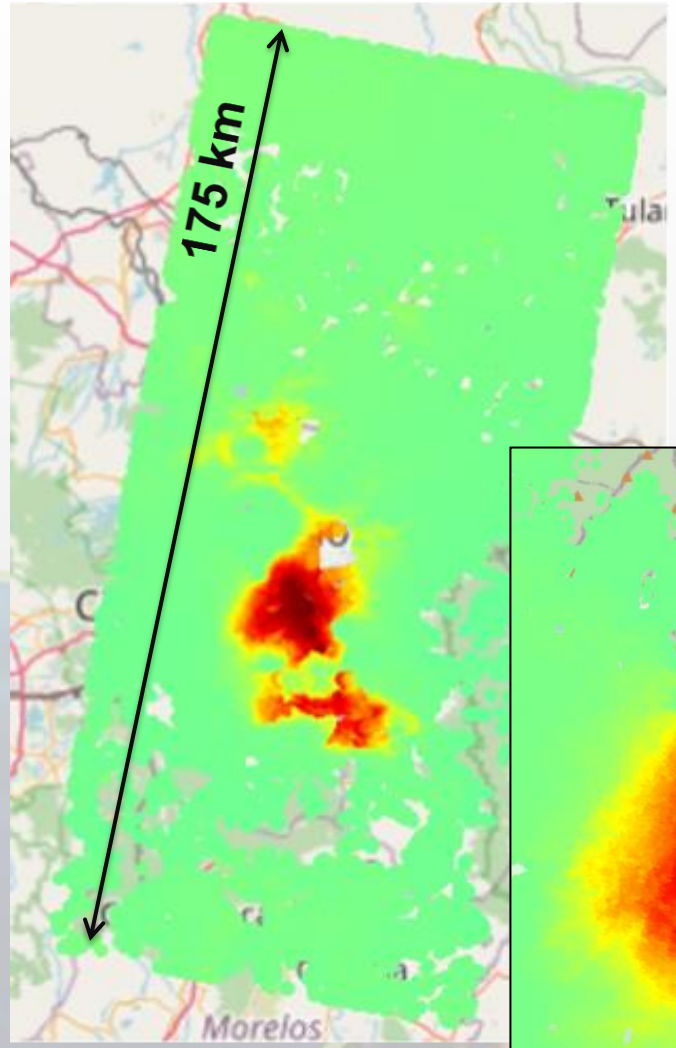
SNAPPING
SURFACE MOTION MAPPING

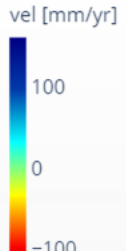
SNAPPING Visualizer

SNAPPING PSI Displacements rates processed on GEP | Observation period 01/2016-12/2020 (148 images) from Relative Orbit 115

© Contains modified Copernicus Sentinel-1 data [2016-2020]

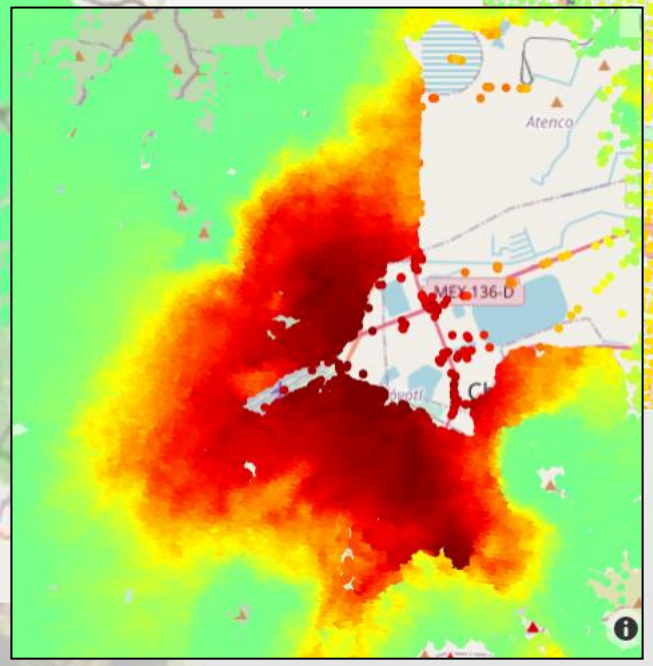
World Bank Mexico service

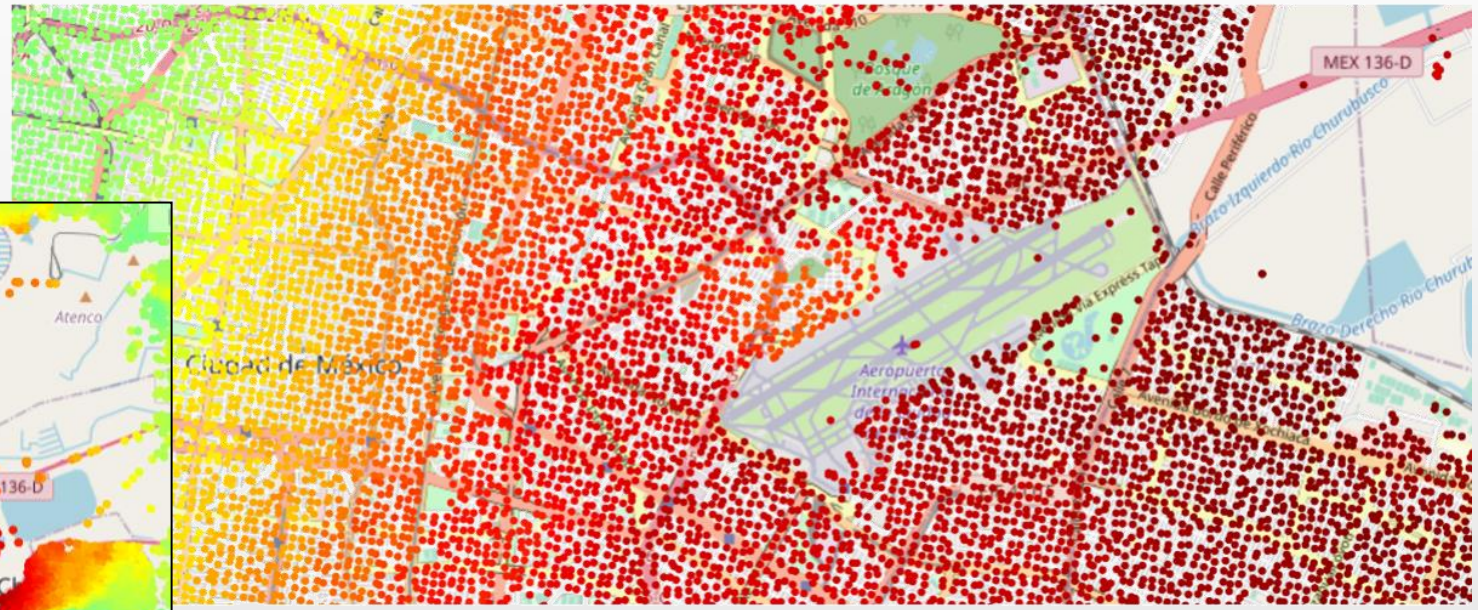




SNAPPING PSI Displacements rates processed on GEP

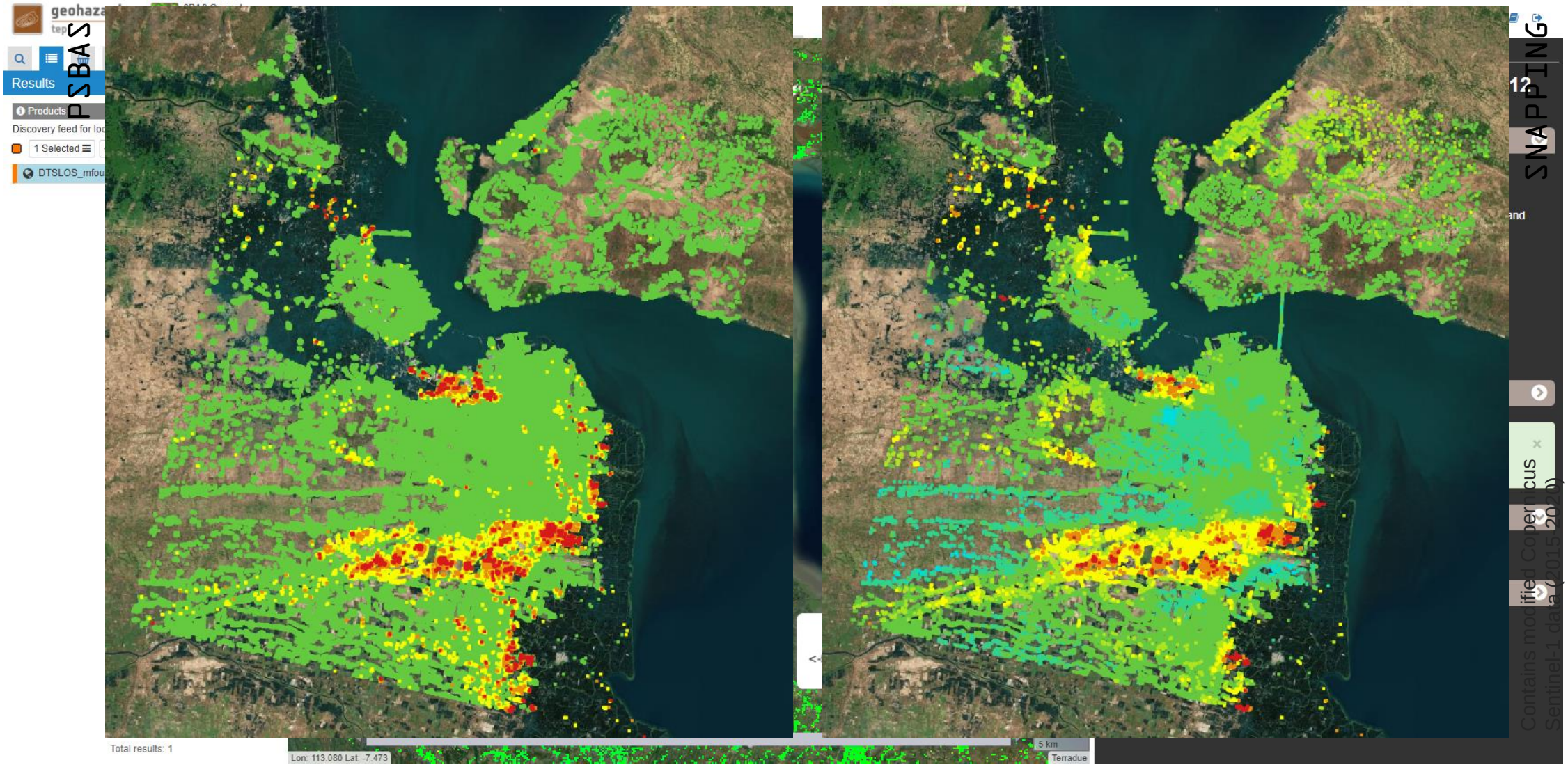
Observation period 04/2015-12/2020 (205 images) from Relative Orbit 143





A total number of ~245k point measurements

Surabaya Terrain Motion | GEP On-Demand InSAR Services

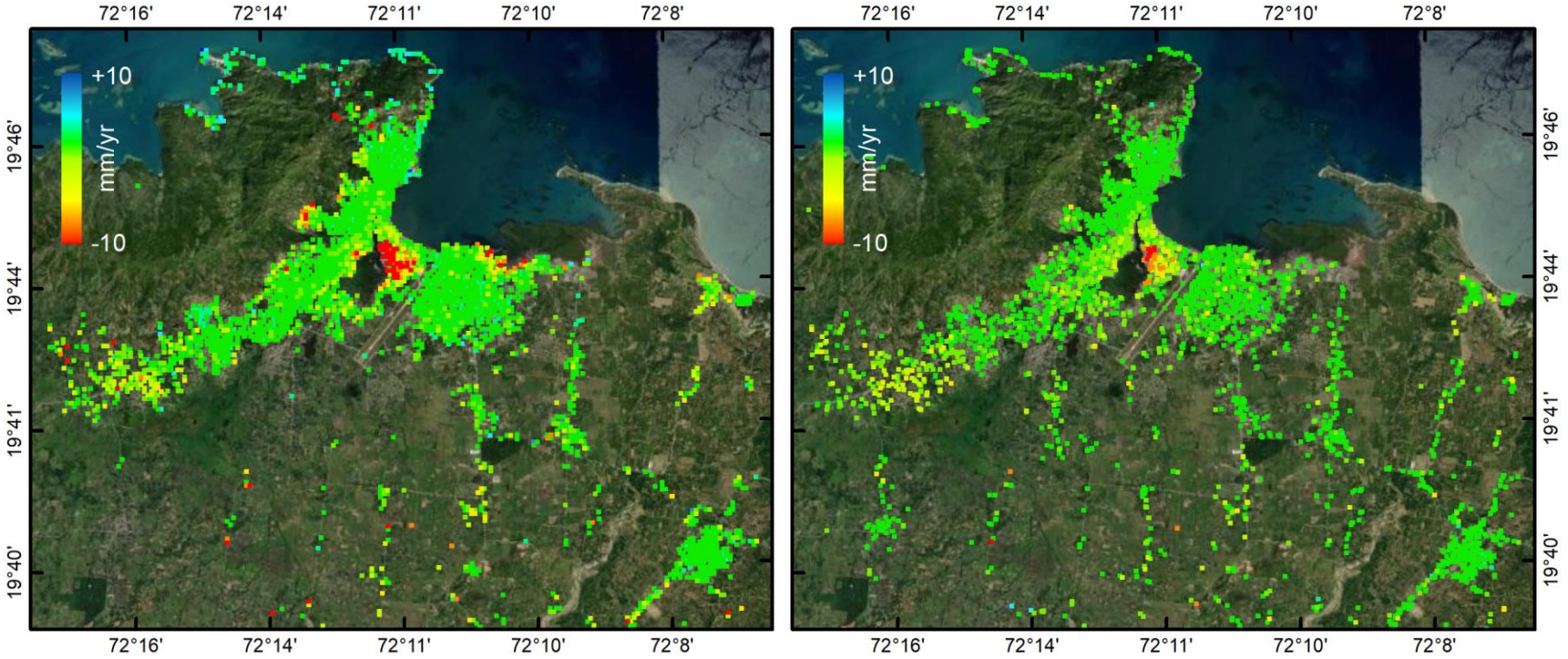


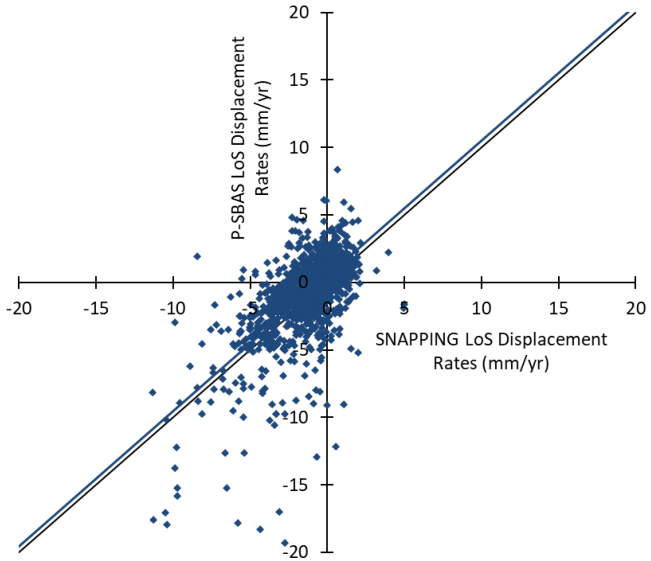
Inter-Verification of EO-Based Measurements

Inter-verification of Sentinel-1 terrain motion measurements using different operational services on GEP. Example over **Cap-Haïtien** by P-SBAS & SNAPPING services.

CNR-IREA P-SBAS

SNAPPING (AUTh, MJaen & T2)





Contains modified Copernicus Sentinel-1 data (2015-2020)

Outreach and Capacity Building

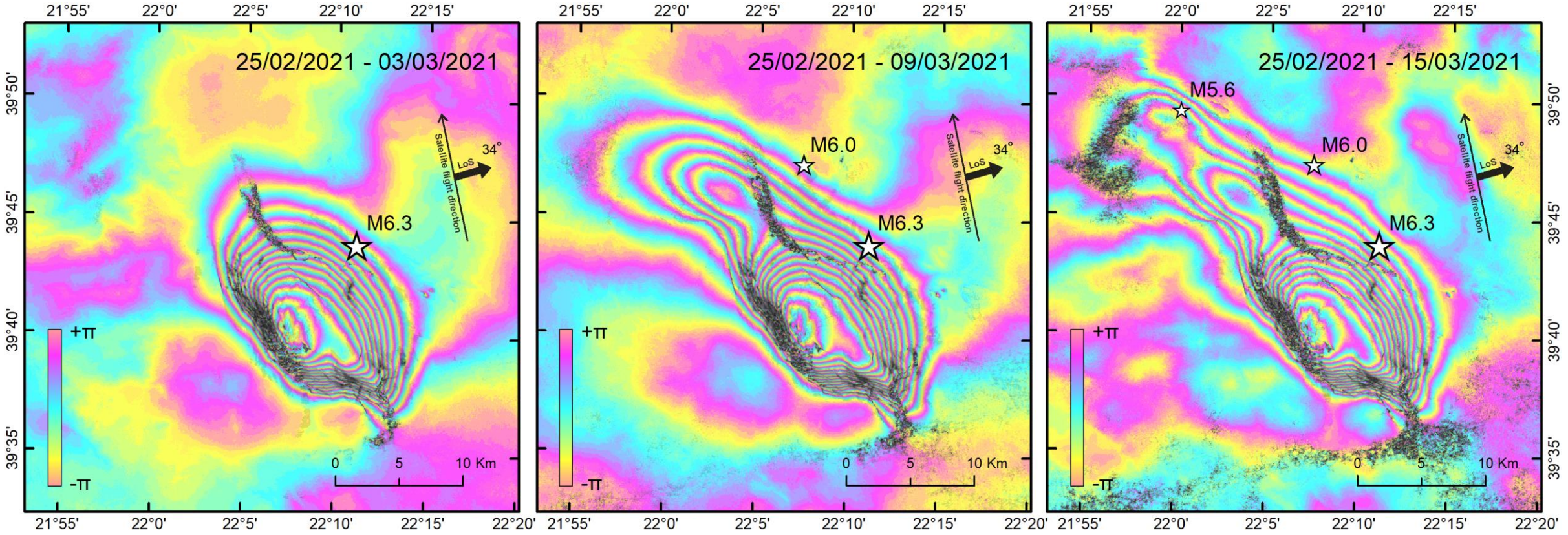
Q2 – Q3 2021

- Several communications to social media (mainly blog posts and twitter)
- Publishing in scientific journals and participation to international conference and workshops (Fringe 2021; IGARSS 2021)
- Basic training with AIT (May 2021) followed by more advanced capacity building activity (Sept. 2021) for adoption of platform-based solution in operational contexts.
- Capacity building with WP stakeholders in Mexico and Univ. of Cincinnati (US) for the proper exploitation of GEP services' outputs (June 2021)

Contribution to Fringe 2021 - ESA Opening Presentation (Plenary Session)

Tirnavos (Greece) Seismic Sequence by Copernicus Sentinel-1

Sentinel-1 6-days differential interferograms (ascending track 102) of time spans comprising major seismic events of the Tirnavos 2021 sequence. The systematic coverage of Sentinel-1 mission, apart from facilitating the rapid mapping of the affected area, also allowed the investigation, separately, of the major events of the seismic sequence.



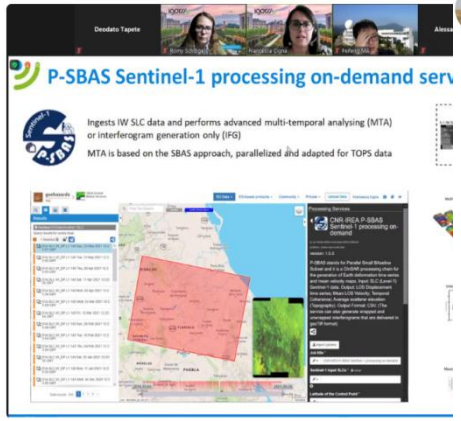
Contains modified Copernicus Sentinel data [2020], processed by AUTh

EO.Lab
Earth Observation
& Geospatial Applications Lab

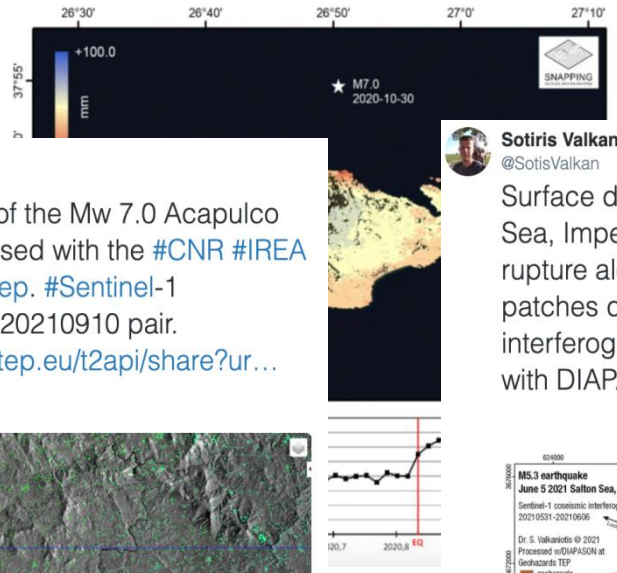
Animate & Communicate Scientific Results

Deodato Tapete
@DeodatoTapete
Replying to @DeodatoTapete
It is now @CnrIsac @FraCigna's turn with#Monitoring natural & anthropogenic #geohazards with #SAR #BigData

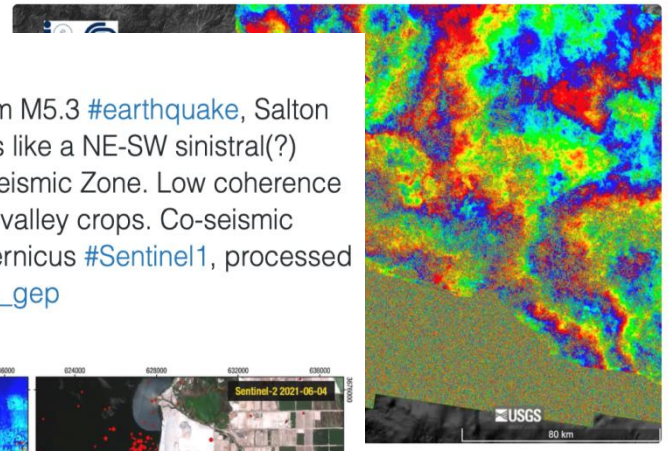
Successful experiences with @esa_gep using @CNRsocial_ #CNR_IREA #PSBAS #Sentinel1 service@Igarss2021 #IGARSS2021



Geohazards Exploitation Platform
@esa_gep
The PSI service "SNAPPING" has been opened to expert users on GEP for a test phase.
discuss.terradue.com/t/1020

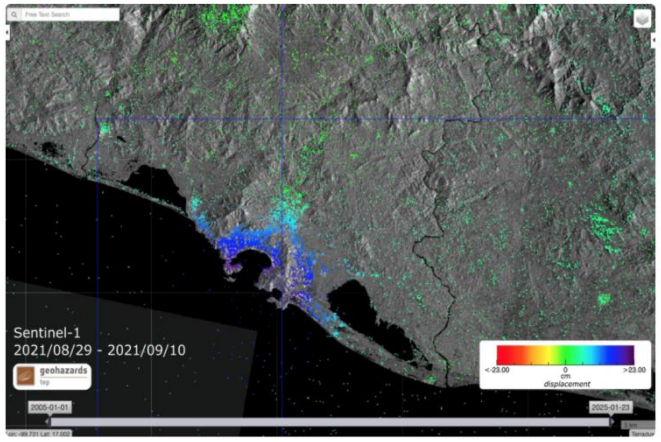


Fernando Monterroso
@maferp_13
Automatic @CopernicusEU #Sentinel1 processing of co-seismic interferogram for the Mw 7.0 Acapulco Earthquake, Mexico. Path 143 (02092021 - 08092021) #IREA #CNR @FraxInSAR @SimoneAtzori73 @claudiodeluca @dott109 available in @EPOSeu and @esa_gep



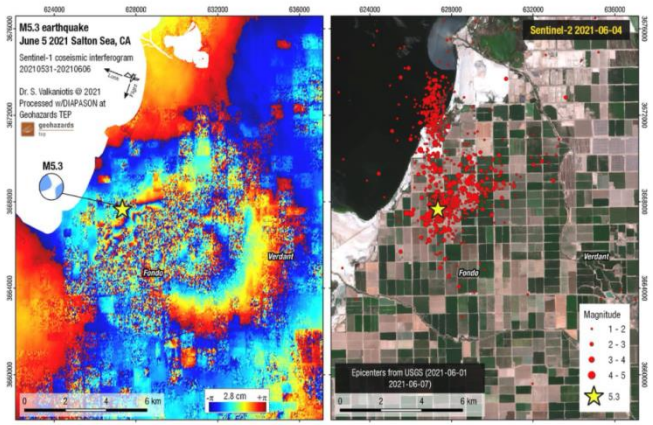
Sep 8, 2021

Floriane Provost
@FlorianeProvost
Surface displacement map of the Mw 7.0 Acapulco Earthquake, Mexico. Processed with the #CNR #IREA P-SBAS service on @ESA_gep. #Sentinel-1 ascending track, 20210829-20210910 pair. accessible on: geohazards-tep.eu/t2api/share?ur…



Sep 14, 2021

Sotiris Valkaniotis
@SotisValkan
Surface deformation from M5.3 #earthquake, Salton Sea, Imperial, CA. Looks like a NE-SW sinistral(?) rupture along Brawley Seismic Zone. Low coherence patches due to Imperial valley crops. Co-seismic interferogram from Copernicus #Sentinel1, processed with DIAPASON at @esa_gep



Jun 6, 2021

Scientific Publications

EO4SD DISASTER RISK REDUCTION TERRAIN MOTION PRODUCTS IN SUPPORT OF THE CITY RESILIENCE PROGRAM

Michael Foumelis[1,2], Alberto Lorenzo-Alonso[3], Ross Eisenberg[4], Ángel Utanda González[3], Christoph Aubrecht[5], Philippe Bally[3], Jan Kolomaznik[6], Vincenzo Massimi[7], Steven Rubinyi[4], Francisco Cano Gonzalez[3], María Encina Aulló-Maestro[3], Francesco Casu[8], Fabrizio Pacini[9]

[1] BRGM -
[2] Aristotle University of Thessalo
Thessalon
[3] Indra, Earth
[4] The World Bank, Urban, Di
[5] Euro
[6] C
[8] Institute for the Electromagnetic

ABSTRACT

An effort is made herein to demonstrate motion products obtained via o interferometric services running on Exploitation Platform to support the W Resilience Program. The objective is validity of medium resolution terrain mo the provision of systematic terrain mo operational teams, allowing for the prompt potential hazardous phenomena over challenge is to inform the City Resilienc connected operational teams about urban manner in order to capably guide their in resilience. Such services, combined with building activities, pave the way for the u based InSAR solution directly by EO prac users for the purpose of monitoring ci various concerns. The introduction of onl and scales the skills of technical staff of lo relevant agencies while increasing their ac Observation and its solutions.

Index Terms — Terrain motion processing, Geohazards Exploitation P DRR, City Resilience Program

SNAPPING FOR SENTINEL-1 MISSION ON GEOHAZARDS EXPLOITATION PLATFORM: AN ONLINE MEDIUM RESOLUTION SURFACE MOTION MAPPING SERVICE

Michael Foumelis[1], Jose Manuel Delgado Blasco[2], Fabrice Brito[3], Fabrizio Pacini[3], Panteha Pishehvar[3]

[1] Aristotle University of Thessaloniki (AUTh), Department of Physical and Environmental Geography, 54124 Thessaloniki, Greece, e-mail: mfoumelis@geo.auth.gr
[2] Grupo de investigación Microgeodesia Jaén, Universidad de Jaén, Spain
[3] Terradue s.r.l., Rome, Italy

ABSTRACT

We are communicating recent integration of the SNAPPING surface motion mapping service for Sentinel-1 mission on the GEP platform in support to the scientific community as well as EO practitioners. The service is built on ESA SNAP and StaMPS packages that have already demonstrated numerous successful investigations of geohazard phenomena. SNAPPING is well-tailored in terms of EO data manipulation and parallelization on cloud resources, enabling users to respond to the ever increasing volume of satellite data and high computational requirements. The service generates average motion rate maps and full displacement time series at reduced spatial resolution, making it suitable not only for various research application domains, but also when rapid and low cost inspection of an area is of interest.

Index Terms — Copernicus Sentinel-1, Persistent Scatterers Interferometry, online processing, Geohazards Exploitation Platform, SNAPPING service

1. INTRODUCTION

The ability of the Interferometric SAR (InSAR) technique for measuring surface displacements has been well demonstrated in the early 1990s. Over the past years, the technique has gone through several performance and validation activities. Moreover, numerous algorithms have been proposed to extract not only displacement maps but also displacement time series by multi-temporal analysis of large data stacks of SAR imagery [1-2] and references therein). Currently, InSAR measurements are being routinely used to assess geohazards, including the detection of earthquake-induced ground displacements [3-4], mapping and monitoring of landslides [5-6], instabilities at active mining sites [7], land subsidence [8-9] and volcano monitoring purposes [10]. Given its maturity, the need to further improve their acceptance and usage in operational disaster risk management schemes has been underlined [11].Copernicus is the most ambitious Earth observation programme to date. The Sentinel missions perform a systematic data acquisition, which is based upon a pre-defined and conflict-free acquisition plan. The Sentinel-1 mission acquires systematically and provides routinely a large volume of C-band SAR data to the global scientific and operational user community. The scientific communities as well as EO practitioners were thus given the means to extend the use of spaceborne SAR data to land applications.

With the multitude of SAR missions available, especially the Copernicus Sentinels, it is now possible to obtain national-wide [12-13], and continental coverage [14] InSAR results. At the same time, platform-based solutions offer access to data and algorithms for massive InSAR processing [15], whereas others also provide thematic exploitation and e-collaboration capabilities [16].

The ever increasing volume of satellite data –Sentinel-1 being a very characteristic case of large-volume data– as well as the outcome of discussions during the International Forum on Satellite EO for Geohazards [17], revealed the need for cloud-based processing solutions to address difficulties for both storage and processing capacity.

In the current work we present a newly integrated surface motion mapping service on a cloud platform for interferometric processing of Sentinel-1 mission data. Our objective is to contribute to the optimal use of Copernicus data by simplifying extraction of InSAR-based displacement measurements to allow focusing efforts on post analysis and interpretation of EO observation for improving our understanding of geohazard phenomena.

BGSG Volume 58

Research Paper

Correspondence to: *Vasileios Karakostas* vkarak@geo.auth.gr

DOI number: http://dx.doi.org/10.12681/bgsg.27237

Keywords: seismic sequence; finite–fault slip model; seismological geodesy; stress transfer and triggering

Citation: Karakostas, V., Papazachos, C., Papadimitriou, E., Foumelis, M., Kiratzi, A., Pikridas, C., Kostoglou, A., Kkallas, C., Chatzis, N., Bitharis, S., Chatzipetros, A., et al. (2021), The March 2021 Tyrnavos, Central Greece, Doublet (M_w6.3 and M_w6.0): Aftershock Relocation, Faulting Details, Coseismic Slip and Deformation. Bulletin Geological Society of Greece, 58, 131-178.

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The Editor wishes to thank two anonymous reviewers for their work with the scientific reviewing of the manuscript and Ms Emmanouela Konstantakopoulou for editorial assistance.

Geological Society of Greece

THE MARCH 2021 TYRNAVOS, CENTRAL GREECE, DOUBLET (M_w6.3 and M_w6.0): AFTERSHOCK RELOCATION, FAULTING DETAILS, COSEISMIC SLIP and DEFORMATION

Vasileios Karakostas[1], Constantinos Papazachos[1], Eleftheria Papadimitriou[1], Michael Foumelis[2], Anastasia Kiratzi[1], Christos Pikridas[3], Anastasios Kostoglou[1], Charalambos Kkallas[1], Nikolaos Chatzis[1], Stylianos Bitharis[3], Alexandros Chatzipetros[4], Aris
Karagianni[1], Pavlos Bonatis[1], Chris
Emmanouil Scordilis[1], Domenikos
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[4]Department of Geology, School of Geo
ac

On 3 March 2021, the M_w6.3 Tyrnavos
leading to extensive damage in many
The first main shock was followed
"equivalent" main shock with M_w6.0
largest earthquakes to strike the north

The northern Thessaly strong earthquakes of March 3 and 4, 2021, and their neotectonic setting

Chatzipetros A.[1], Pavlides S.[1], Foumelis M.[1], Sboras S.[2], Galanakis D.[2], Pikridas Ch.[3], Bitharis S.[3], Kremastas E.[1], Chatziioannou A.[1], Papaioannou I.[4]

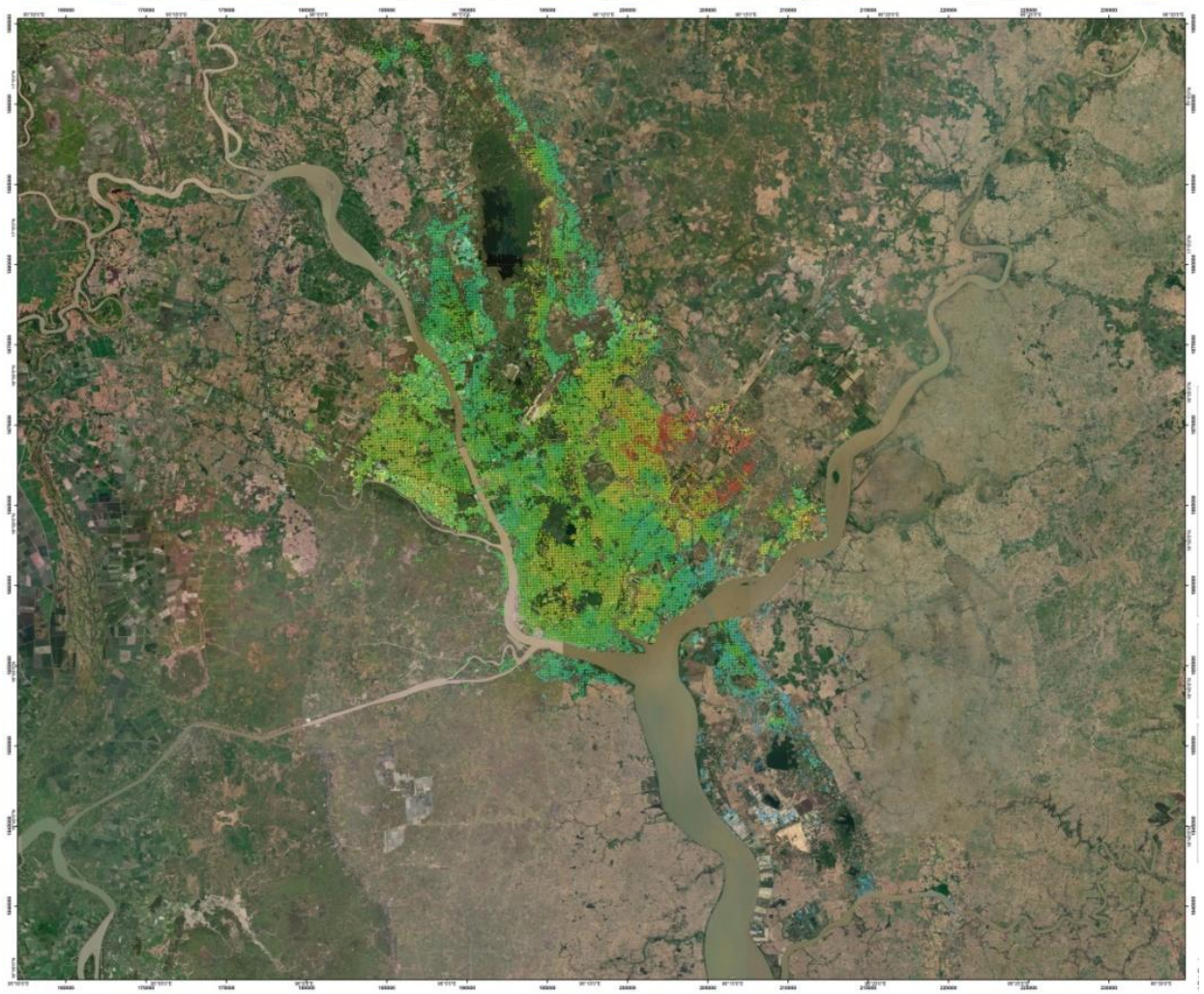
1. *Department of Geology, School of Geology, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece*
2. *H.S.G.M.E., Hellenic Survey of Geology and Mineral Exploration of Greece, Athens*
3. *Department of Geodesy and Surveying, School of Rural and Surveying Engineering, Aristotle University of Thessaloniki, 54124, Thessaloniki, Greece*
4. *Historian, Larissa, Greece*

Abstract

A sequence of earthquakes occurred on March 3rd and 4th in Northern Thessaly, northern Greece, associated with normal unknown hidden faults within the crystalline Paleozoic basement of the Pelagonian geotectonic zone. Surficial ground deformation, such as liquefaction phenomena in fluvial plains, as well as soil fissures and rock falls, have been mapped. Evidence of characteristic geological indications of the unmapped seismic fault has been identified through fieldwork, within the bedrock. Based on geological indications, the main fault projection to the surface could be considered a 15 km NW-SE trending structure and average dip of 45° - 50° to the NE. The seismic fault (seismic source) of the main shock was modelled, and the Coulomb static stress changes are calculated for receiver faults. The determination of the active tectonic regime of the region by geodetic data and the well-known faults of NE Thessaly plain are also presented, as well as the revised historical seismicity. This earthquake raises new concerns and challenges, revising some established views, such as the status of active stress trends, the direction of active tectonic structures, the existence of a seismogenic fault in a mountainous volume of crystalline rocks without typical geomorphological expression and the role of blind faults to Seismic Hazard Assessment.

Keywords: earthquake geology, Thessaly, interferometry, modelling, active faults

WB CRP | Terrain Deformation Analysis via GEP



Contains modified Copernicus Sentinel-1 data (2015-2020), processed by BRGM via GEP

Banjul (The Gambia)

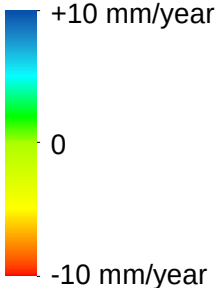
Beira (Mozambique)

Cap-Haitien (Haiti)

Paramaribo (Suriname)

Vinh Long (Vietnam)

Yangon (Myanmar)

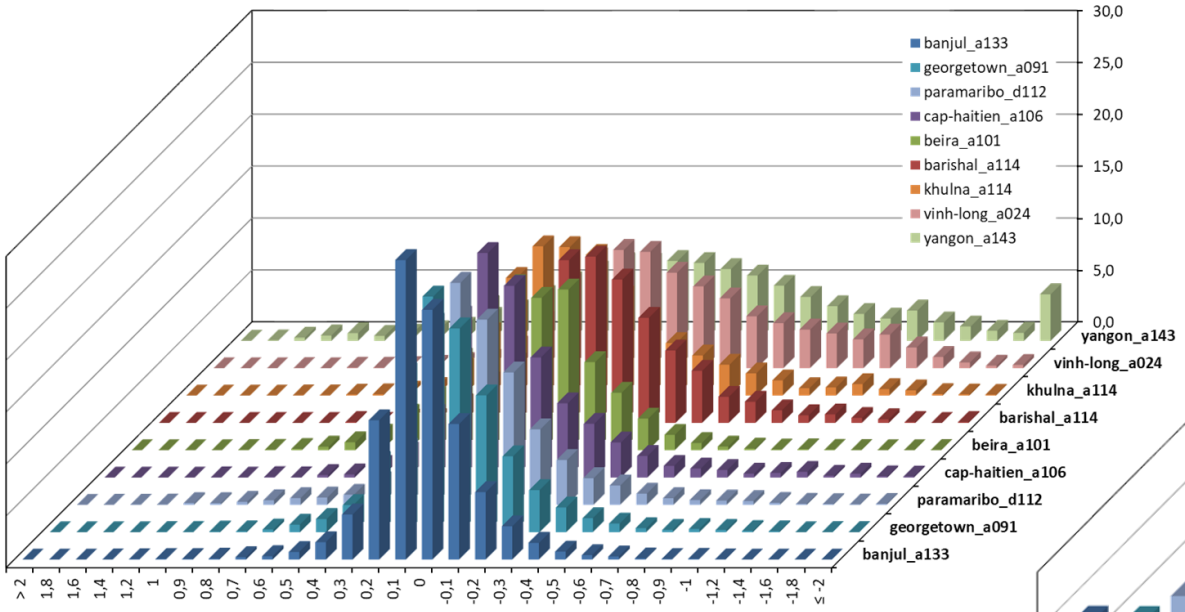


Spatial resolution
90x90m

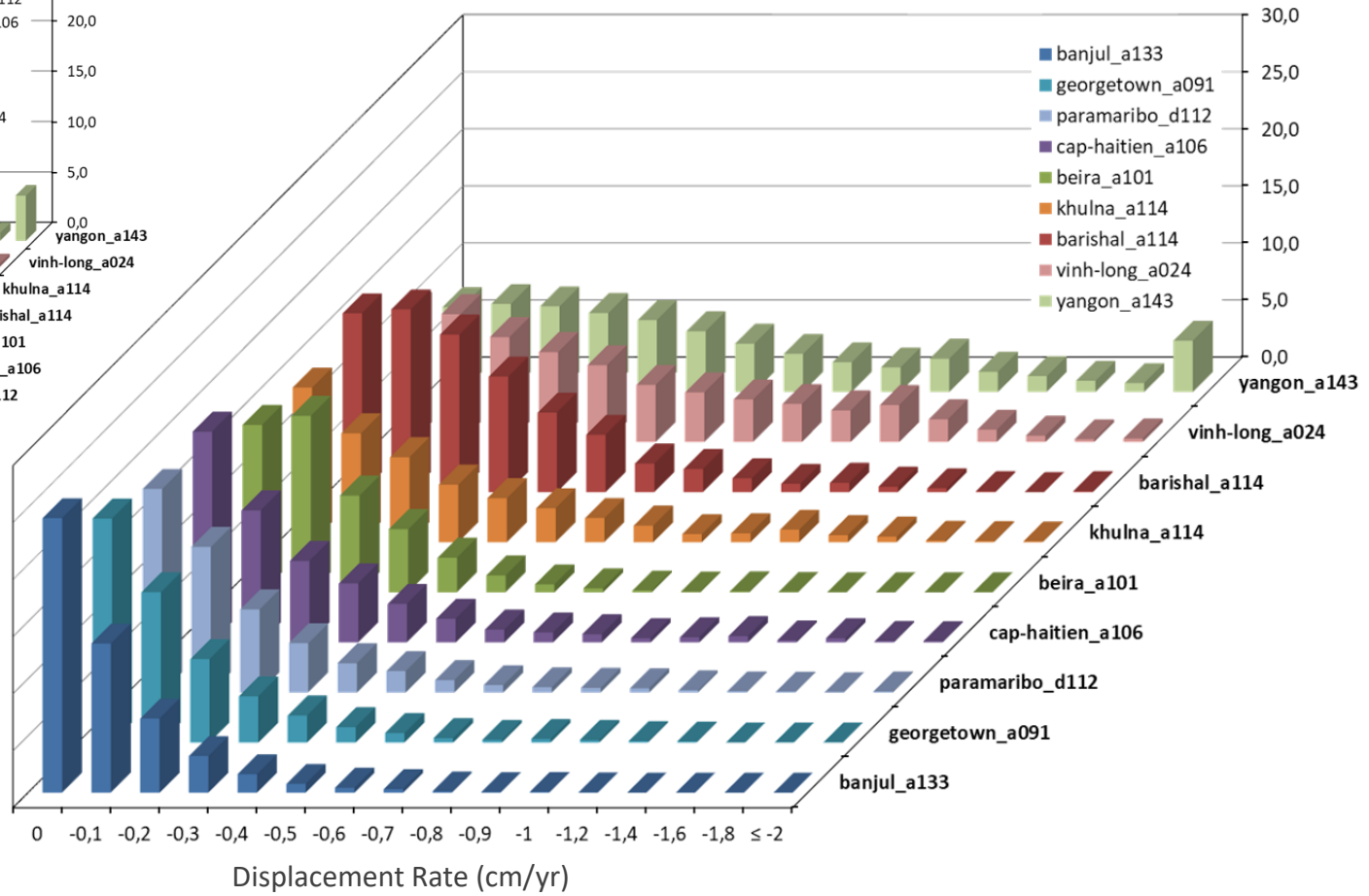
Total number of measurements
81147 points

Maximum observed displacement
~7 cm/yr

GEP 4 WB CRP | Distribution of Terrain Deformation



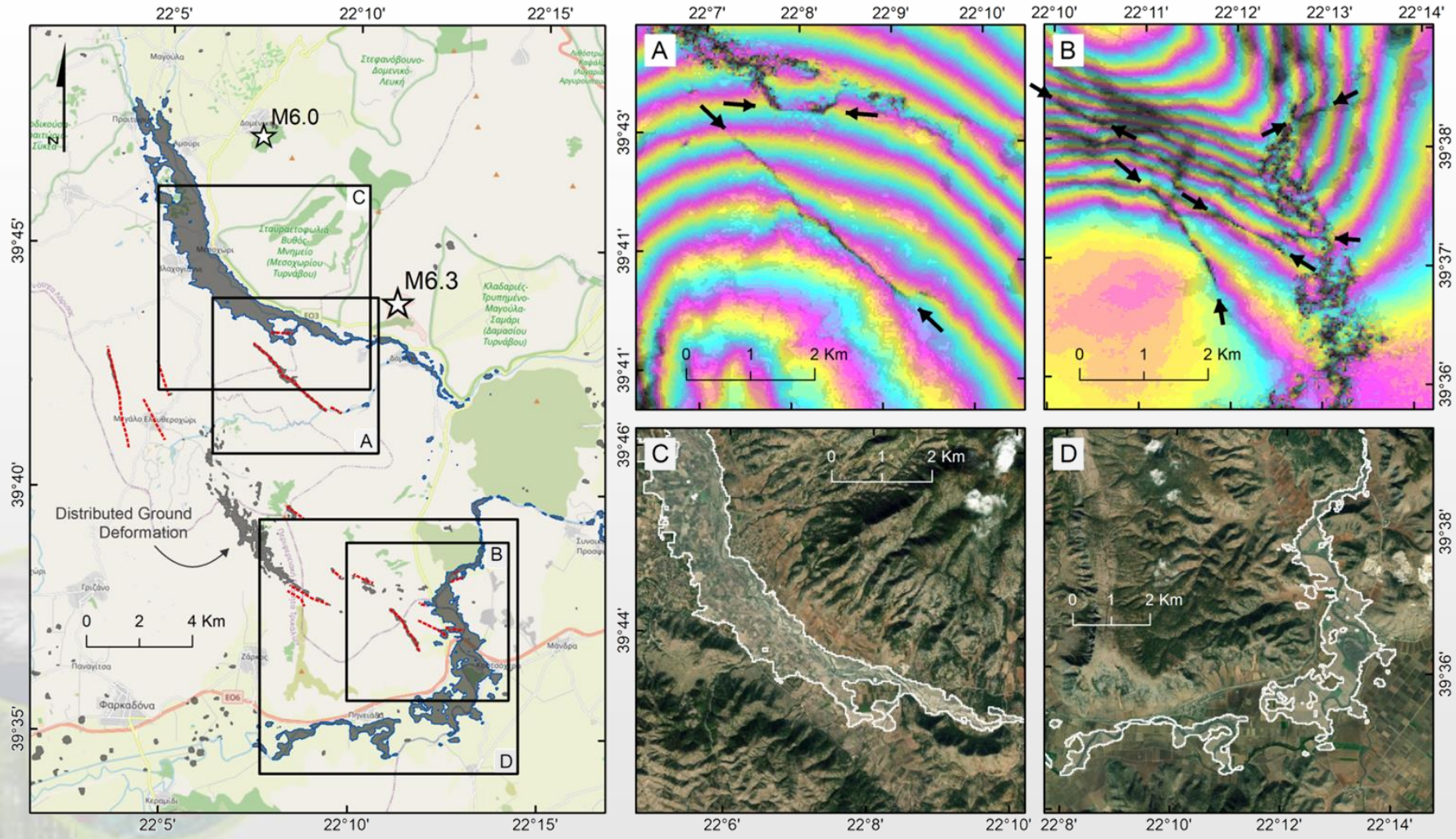
Histograms showing the distribution of terrain deformation among the various examined cities (up) and the part of the histogram referring to subsidence (negative values) for the period 2017-2019 (left).



Tirnavos Earthquake Secondary Phenomena

Tirnavos (Greece) M_w6.3 earthquake of March 2021

Composite map of decorrelated areas as derived by analysis of co-seismic interferometric coherence and surface ruptures by visual interpretation of fringes' spatial discontinuities Regions suffered extended liquefactions collocate with riverbeds.



Contains modified Copernicus Sentinel-1 data (2015-2020), processed by AUTh

The Way Forward

- Collocating data and processing is still challenging (incl. archive cost)
- Various Data Sources on the platform (link to Euro Data Cube, PlanetScope as DaaS, Spot World Heritage (SWH) etc.)
- Improve service resilience to data access issues
- Build chains that utilize other missions (apart from Copernicus Sentinel)
- Well-defined platform governance (incl. service providers)

Thank you

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Michael Foumelis (AUTh) mfoumelis@geo.auth.gr
Theodora Papadopoulou (ARGANS Ltd. c/ ESA) tpapadopoulou@argans.co.uk