The French CIEST² Initiative: Results From The 2023 Turkey-Syria Earthquakes Sequence

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ISDeform

Français

WELCOME

Objectives

The main objective of the National Service of Observation ***ISDeform*** is to propose the monitoring of ground deformation due to different natural processes (e.g., external forcing, hydrology, geothermal), focusing in particular on telluric hazards: earthquakes, landslides, volcanic activity, using optical and radar satellite imagery. ISDeform aims to support observatories, the French scientific community and its partners in the South in the use of these satellite data. Its main mission is to provide databases/products (interferograms, time series, Digital Terrain Models) on targets of high scientific interest as well as systematic and on-demand processing services. The SNO is also developing interactions with the "continental surface" community (e.g., the SNOs Glacioclim and H+) in order to provide complementary observations or adapted services

ForM@Ter

CELLULE D'INTERVENTION ET D'EXPERTISE SCIENTIFIQUE ET TECHNIQUE NOUVELLE GÉNÉRATION : CIEST²

Synergie de la communauté française MDIS (Mesure des Déformations par Imagerie Spatiale) de ForM@Ter pour l'interprétation et la compréhension des phénomènes géophysiques à partir de données spatiales : répondre rapidement lors d'une catastrophe naturelle.

La **Cellule d'Intervention d'Expertise Scientifique et Technique** (CIEST) avait été créée en France en 2005 via une convention entre six organismes nationaux (BRGM, CEA, INSU, IPGP, IRD, UCBL). L'objectif était d'étendre l'utilisation des moyens spatiaux, et en particulier les images SPOT acquises dans le cadre de la Charte Internationale « Espace et Catastrophes Majeures », pour la compréhension et l'étude des aléas géologiques.

En 2019, une trentaine de scientifiques français se sont déclaré intéressés par la réactivation de cette initiative sur la base de données Pléiades stéréo. Nous appelons ce revival CIEST² : CIEST nouvelle génération, qui se place désormais dans le cadre du pôle national de données et de services dédié à la Terre Solide ForM@Ter.

Cette synergie doit stimuler le partage et la diffusion des résultats pour l'interprétation géophysique multi-discipline et inter-établissement.

Principles

The activation of the CIEST² can be requested following an activation of the **Chart** or **if an interest for a geophysical event is expressed by a scientist** from a French laboratory and **member of the CIEST²**.

CNES will then trigger Pleiades programming for DMS generation or multitemporal monitoring. The community can use **specific** or common **tools** via the ForM@Ter optical services or the PEPS and GEP platforms, for **Sentinel 1-2** processing in addition to Pleiades.

Essential point: this synergy must stimulate the sharing and dissemination of results for multidisciplinary and inter-institutional geophysical interpretation.

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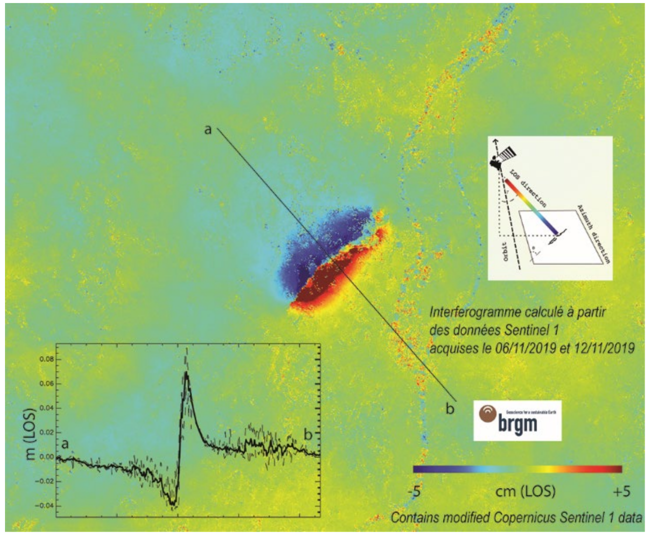
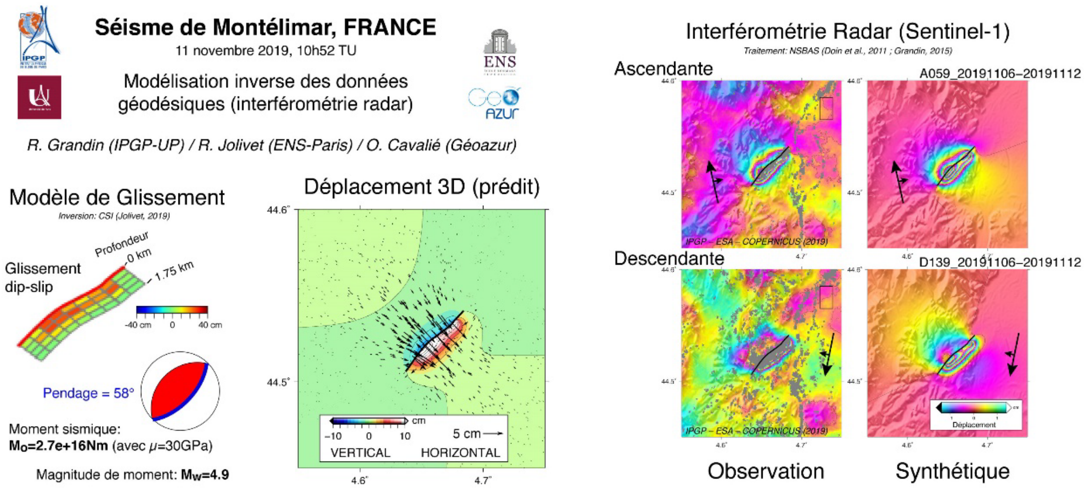
Example of 'rapid' response to geohazards in seismotectonics :
Le Teil Earthquake (France, 19 nov 2019, ML 5.2) – IPGP – ENS- GEOAZUR-BRGM

Contribution from BRGM (Sentinel 1)



Contribution from Raphael Grandin (IPGP) Romain Jolivet (ENS) Olivier Cavalié (UNIV. GEOAzur): (pers. comm.)



https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel1/French_earthquake_fault_mapped

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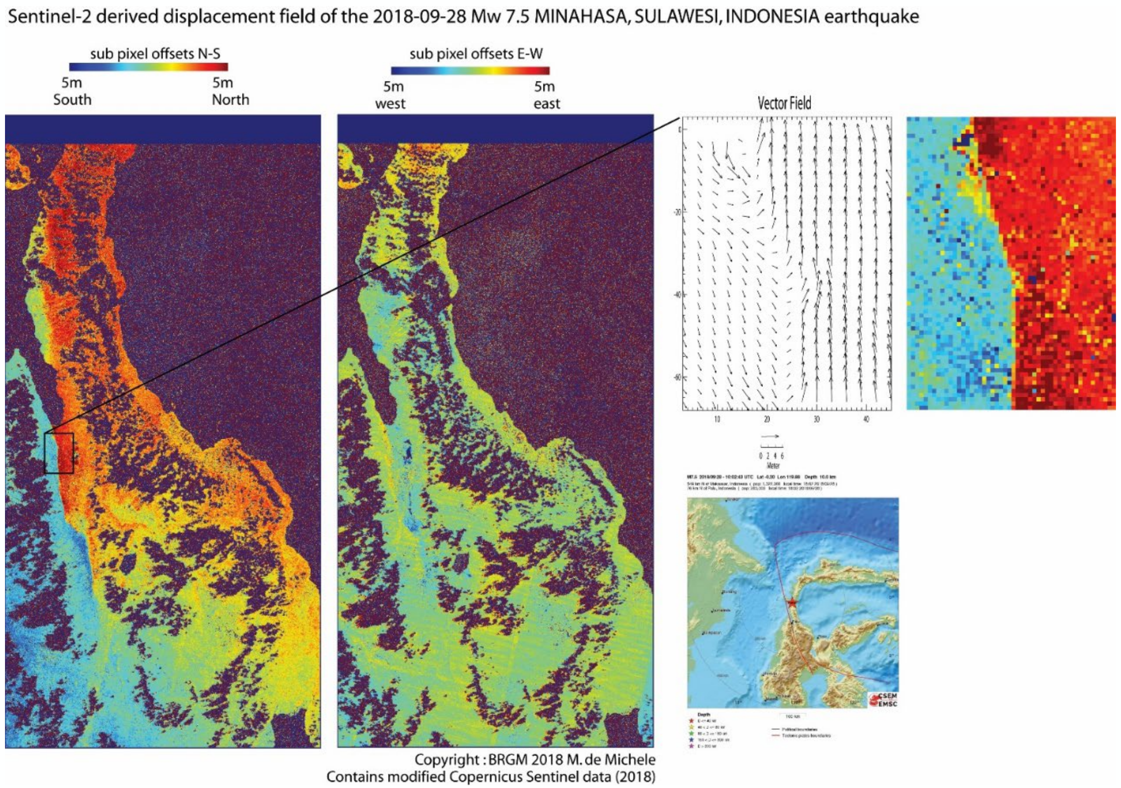
Example of rapid response to geohazards in seismotectonics : Soulawesi Earthquake (28 Sept. 2018, Mw 7,5) –UCA-BRGM

Sentinel 2



https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-2/Sentinel-2_maps_Indonesia_earthquake

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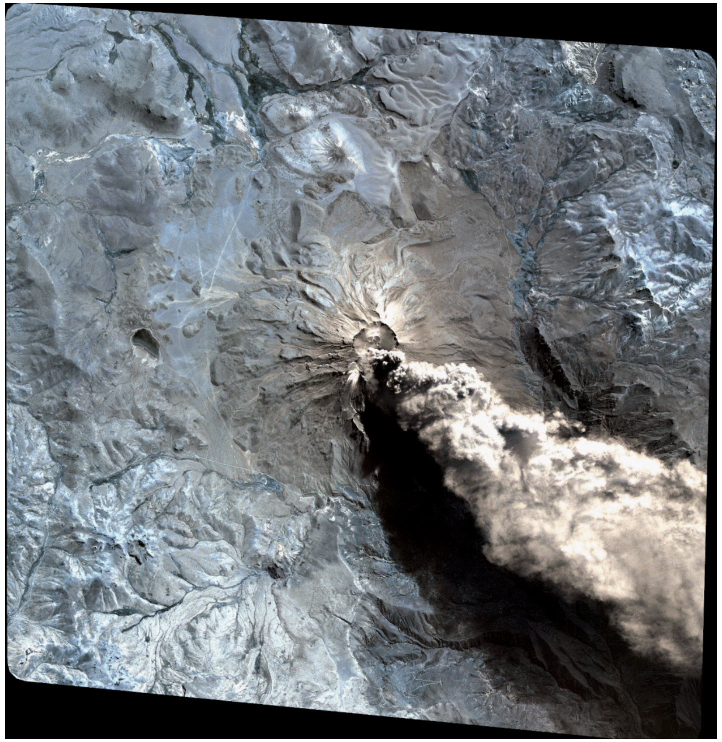
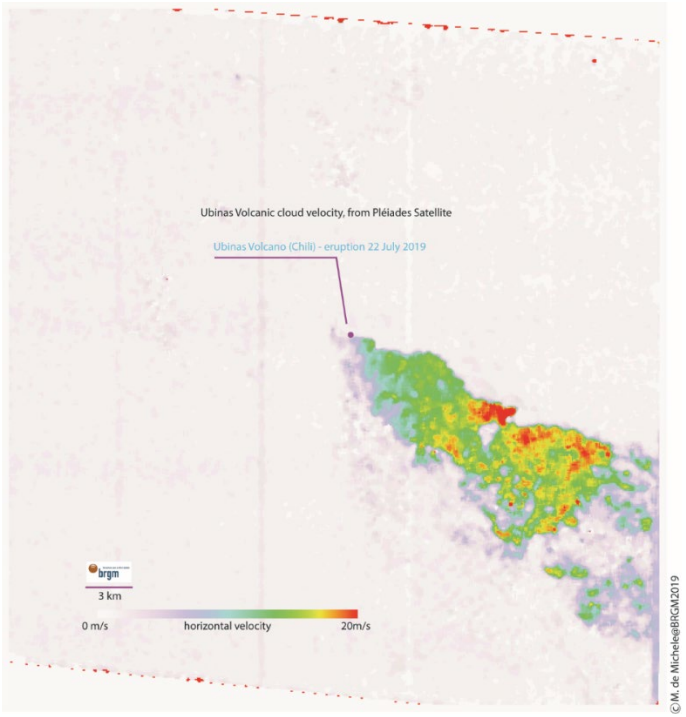
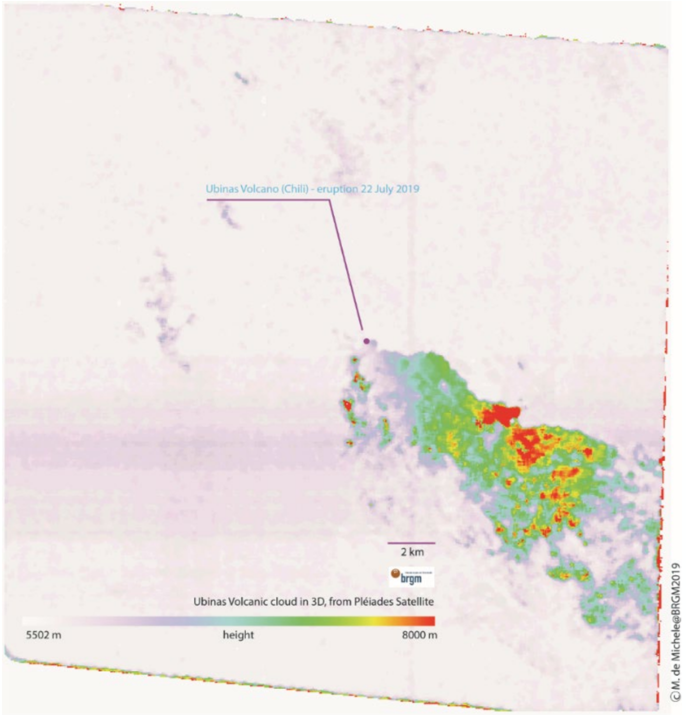
Example of rapid response to geohazards in seismotectonics : Ubinas volcano eruption (July 2019) –BRGM-CNES



1) velocity of the volcanic ash cloud



2) Elevation of the volcanic ash cloud



Objectif: utiliser Pléiades pour mesurer la vitesse et la hauteur de nuages de cendres pendant une éruption volcanique (deux paramètres cruciaux en volcanologie)

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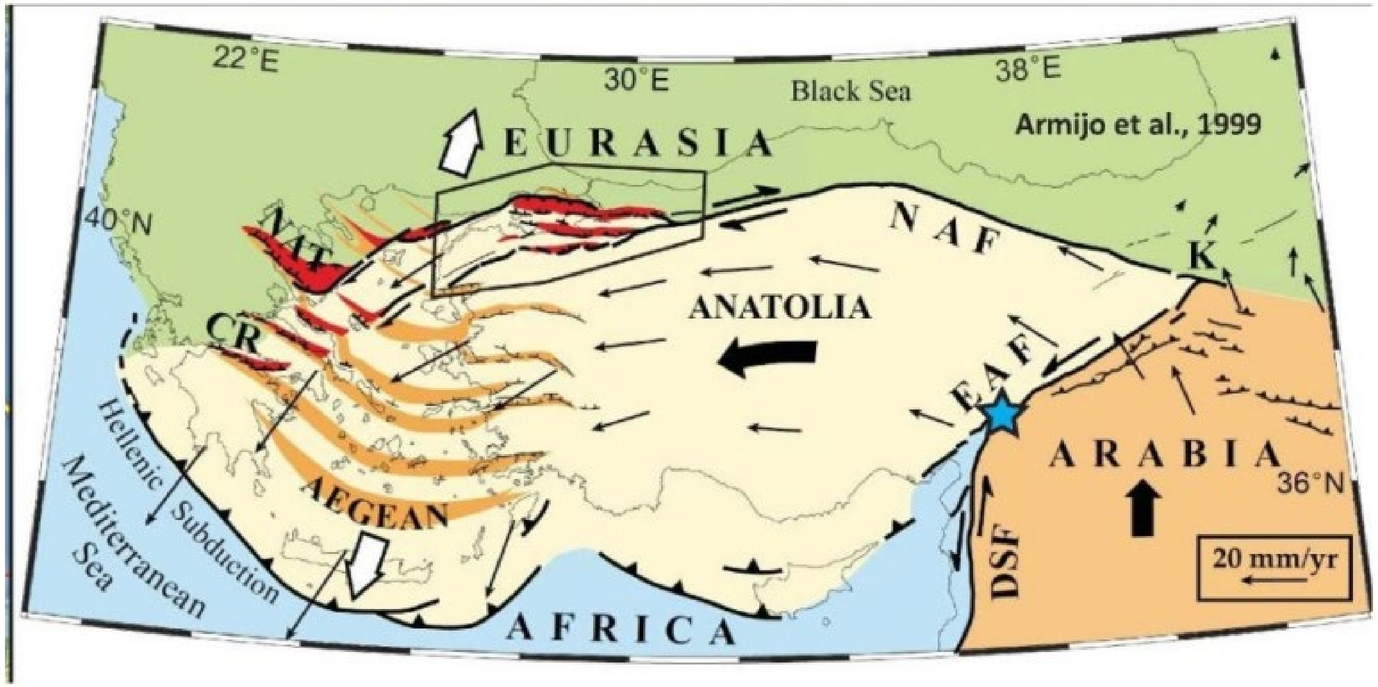
On the night of February 5 to 6, 2023, an earthquake Mw 7.8 struck Turkey and Syria at 4:17 a.m. (local time). The latter, whose epicenter is located near Gaziantep in the southeast of Turkey, was followed by a second of magnitude Mw 7.5 at 1:24 p.m. local time whose epicenter was near Ekinözü. Hundreds of aftershocks were also felt in the days that followed, some as far away as Lebanon and Cyprus.

Turkey, corresponding mainly to the Anatolian plate, is located between three tectonic plates: the Eurasian plate, the African plate, and the Arabian plate. It is bounded to the east by the main East Anatolian fault (EAF) and to the north by the main North Anatolian fault (NAF) which ruptured over more than 900 km by a series of earthquakes cascading from east to west between 1939 and 1999.



Armijo et al. , 1999

Map of the Anatolian plate, the blue star represents the epicenter of the main earthquake of February 6, 2023. ©Armijo et al., 1999 www.poleterresolide.fr

Pre-earthquake context: tectonic loading rate maps

The FLATSIM service makes it possible to systematically produce interferograms from Sentinel-1 data, as well as surface displacement time series, over large geographical areas. The objective is to measure deformations of the Earth's surface on a continental scale, and thus ensure the spatio-temporal monitoring of critical regions (e.g. large active fault zones and magmatic systems, landslides on a continental scale). It operates on Call for Ideas (AI); Turkey is one of the target sites of the first AI. Time series of ground displacement from 2014 to 2021 (therefore prior to the Turkish earthquakes of 2023) were thus calculated and made it possible to extract average spvelocity maps (linear trend, separated from seasonal terms), showing the relative movement of the tectonic plates in the study region and elastic loading across faults in the pre-earthquake period.

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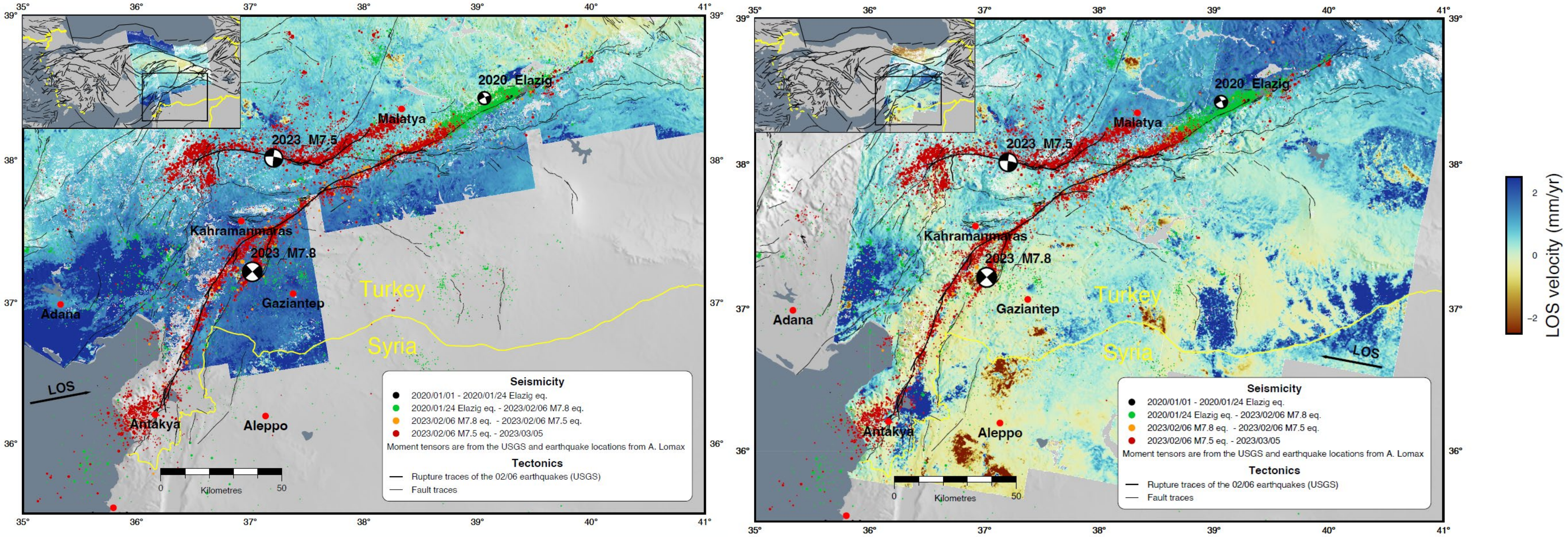

Map of average LOS velocity across the East Anatolian fault system (in mm/year) over the period 2014-2021, ascending and descending orbits. Credit: P. Derand (LG-ENS Paris).

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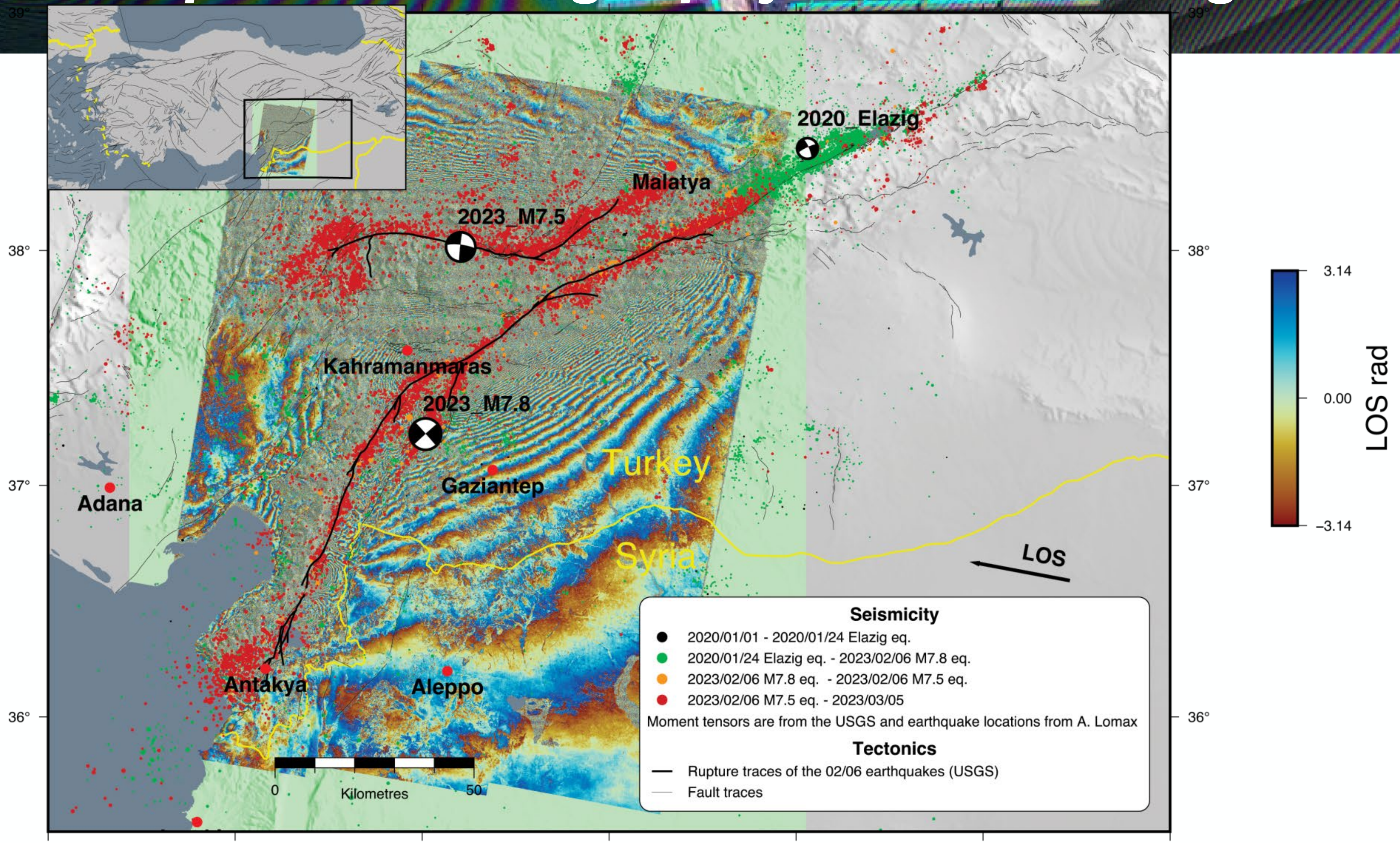

Co-seismic interferogram (descending orbit D21, 01/29/2023-02/10/2023) including the two main earthquakes of Mw 7.5 and 7.8. Credit: L. Pousse-Beltran (ISTerre).

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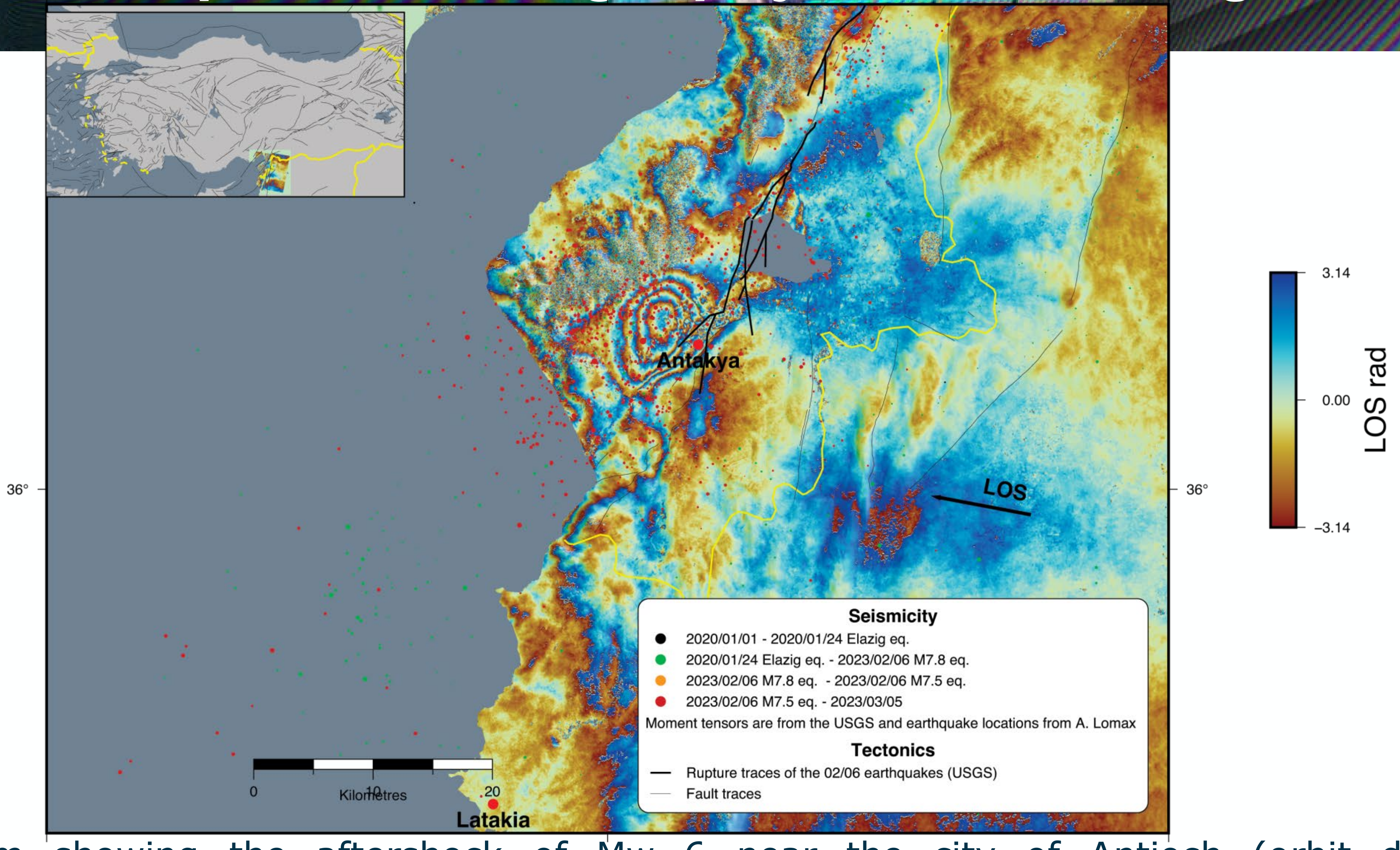

Interferogram showing the aftershock of Mw 6 near the city of Antioch (orbit descending D21,02/10/2023-02/22/2023). Credit: L. Pousse-Beltran (ISTerre).

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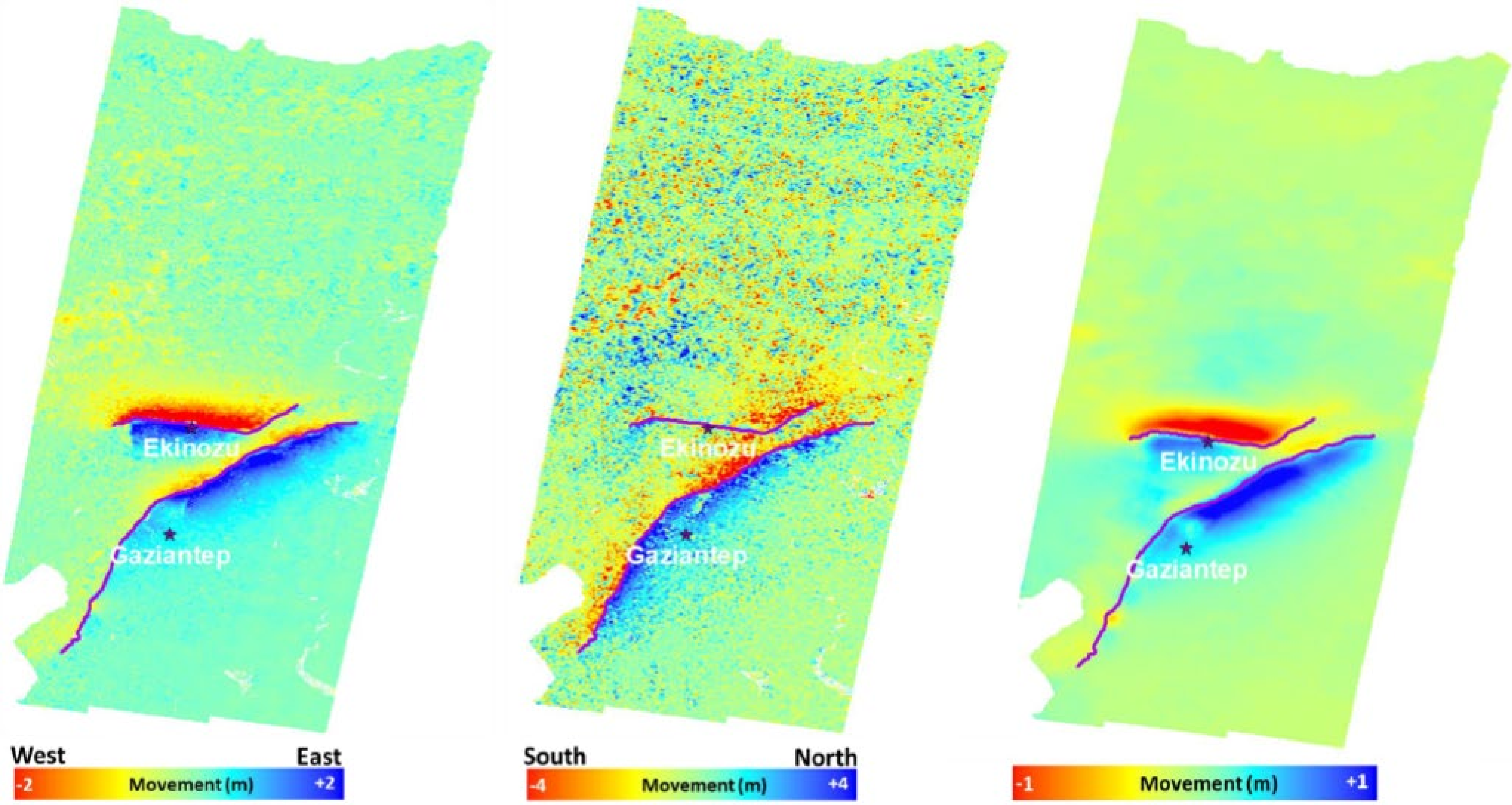
offset Tracking on S1 data.

By Dinh Ho-Tong-Minh



Pixel offset tracking (POT) is a technique used in SAR for motion estimation in earthquake studies. It involves tracking the displacement of scatterers on the ground between two SAR images acquired at different times to estimate the motion caused by an earthquake. Differential InSAR (DInSAR) is a technique used to map ground motion with even greater precision than traditional POT. DInSAR involves comparing the phase difference between two or more SAR images.

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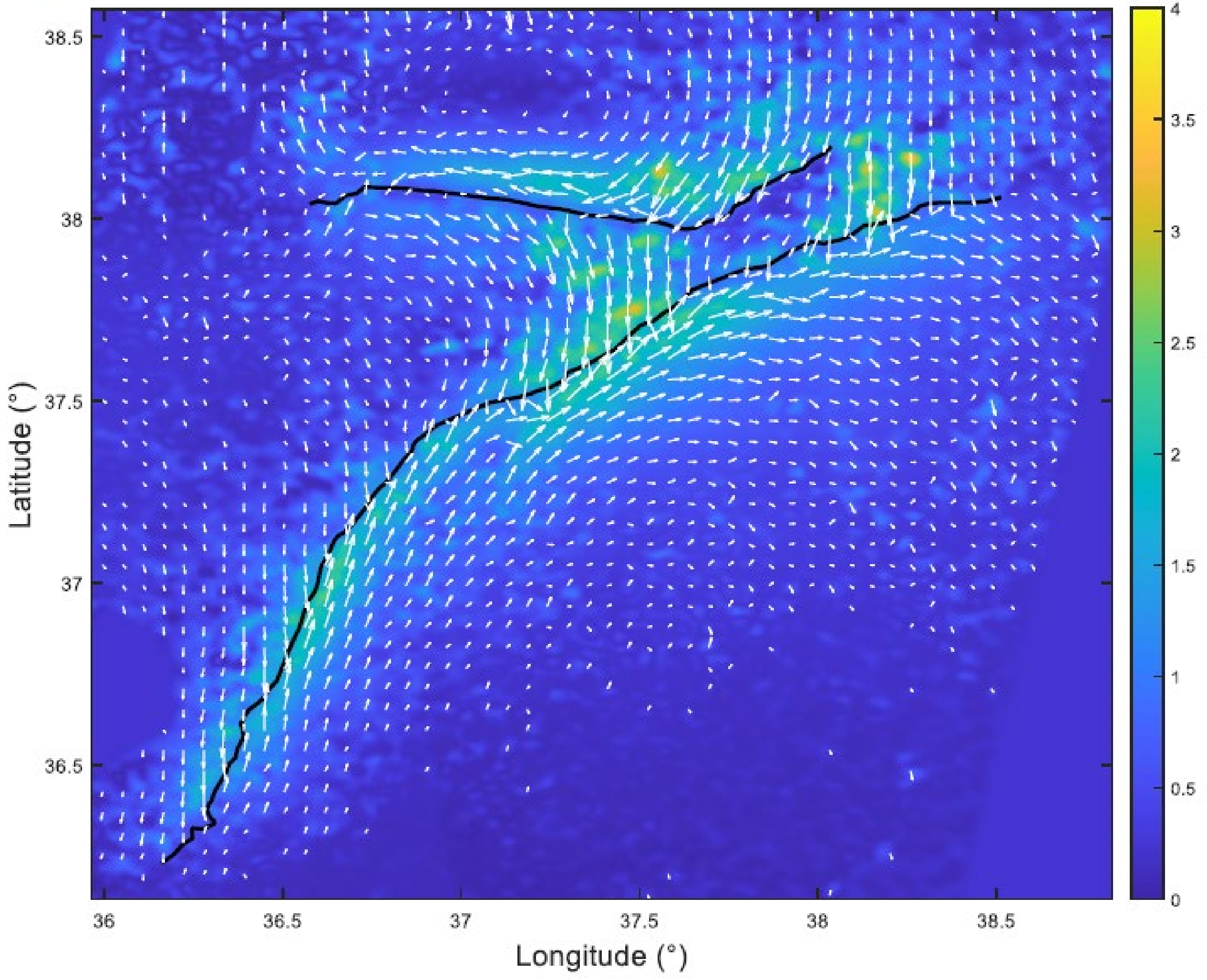
The 3D displacement (including East, North and Up components) estimation constitutes an important subject in SAR displacement measurements exploration for both, offset tracking and SAR interferometry.



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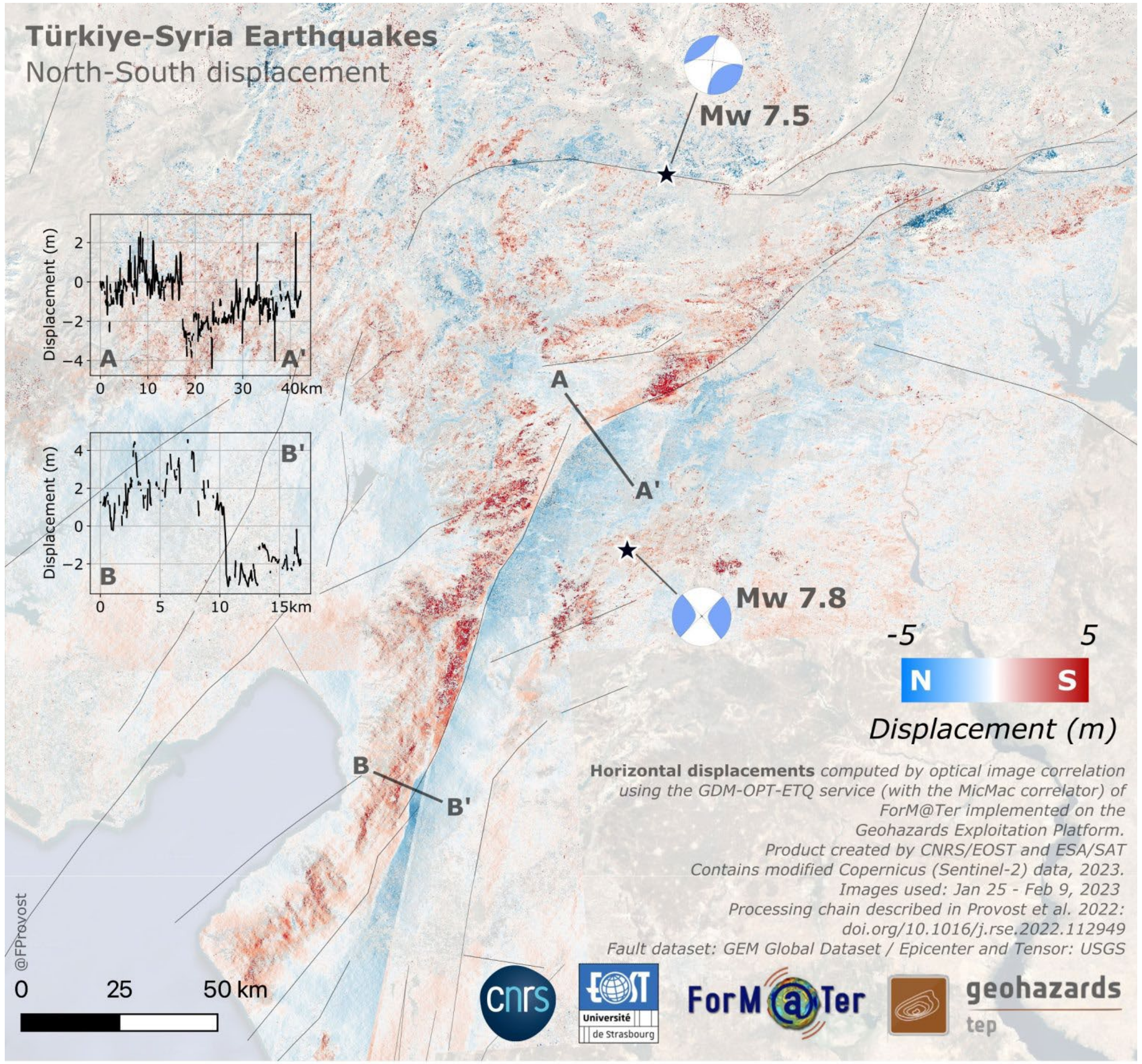
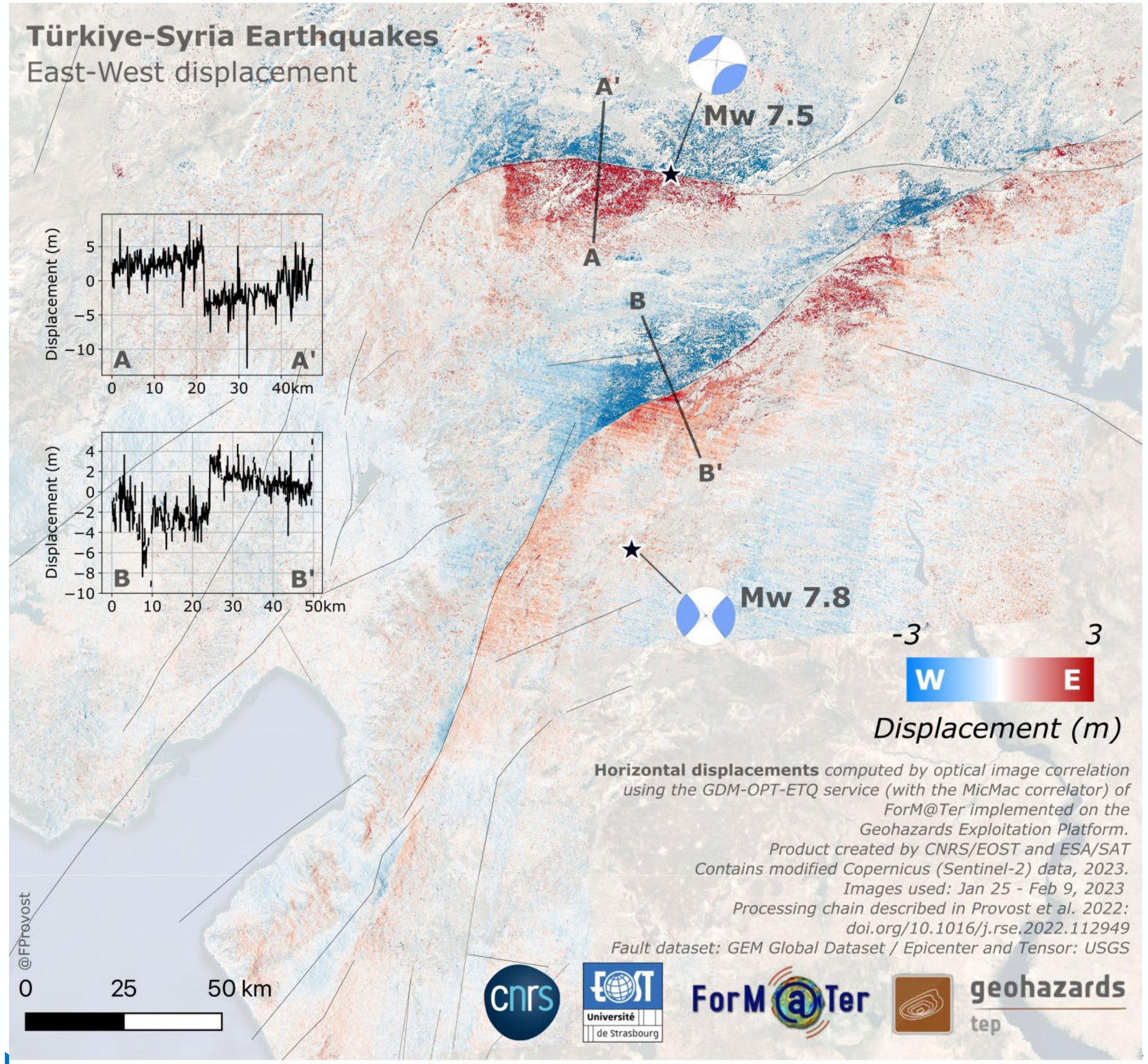
Sentinel 2 💪





Some conclusions, perspectives

To do list :

Integrate Pleiades data for near fault displacement mapping

Perform Offset Tracking on L Band SAR

Modeling and interpretation