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Co-seismic displacements from SAR data - application to the earthquakes with Mw 6 for the Balkan Peninsula

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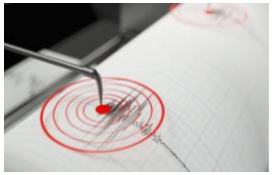
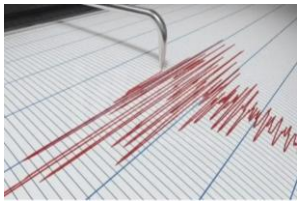
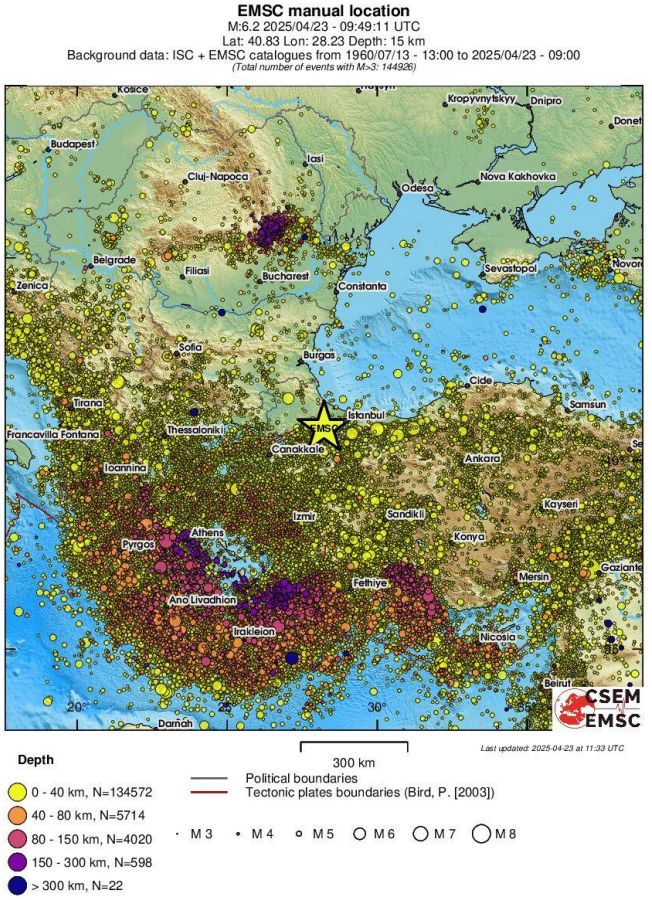
1. Introduction

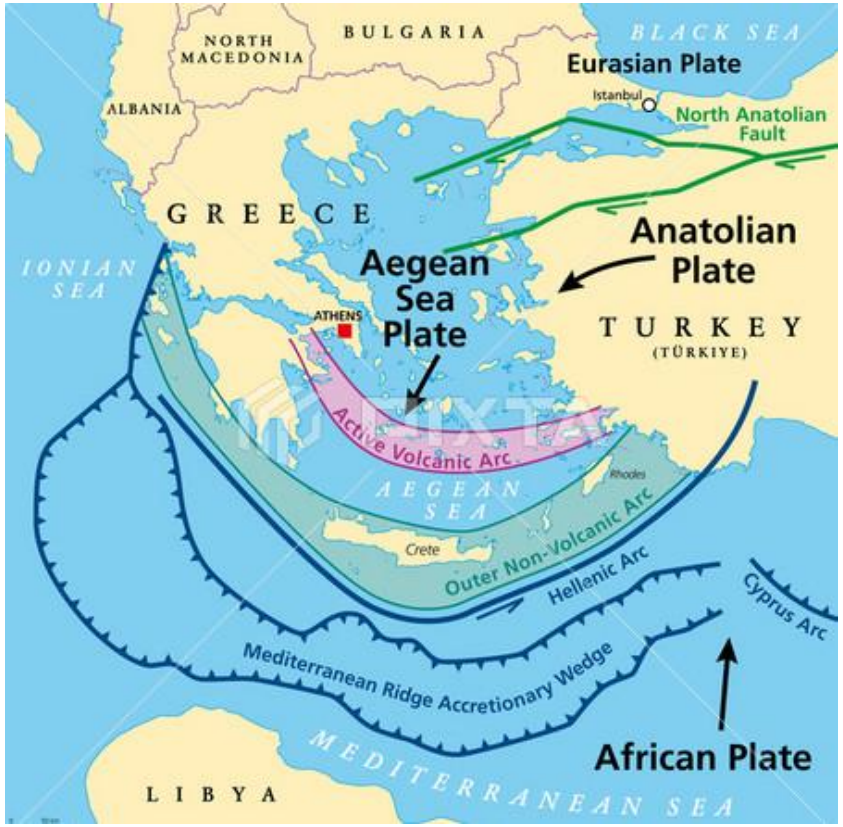
- The current study is focused on one of the significant challenges for our society - registration, monitoring and improvement of post-earthquake prevention.
- A contemporary method that has proven its place in this type of research is the Differential interferometry (DInSAR) method, which uses as output data values for the intensity and phase of the radio signal reflected by natural and anthropogenic objects.
- The Balkans is one of the most seismically active areas in the Europe.







1. Motivation



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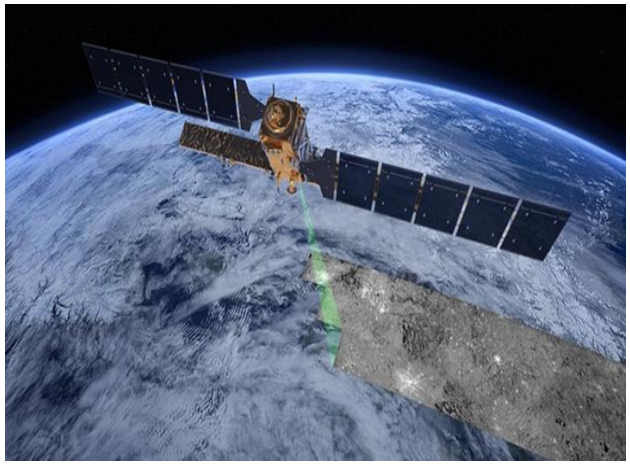
Tectonic setting and seismicity

- project "Study of coseismic deformations of the earth's crust for the territory of the Balkan Peninsula using satellite data" which was launched in December 2023.
- The main task of this project is to demonstrate operational readiness for determining the magnitude of deformations of the earth's surface, the size of the affected area and preparation of maps of surface displacements that occurred after a seismic event.

3. Data and Methods

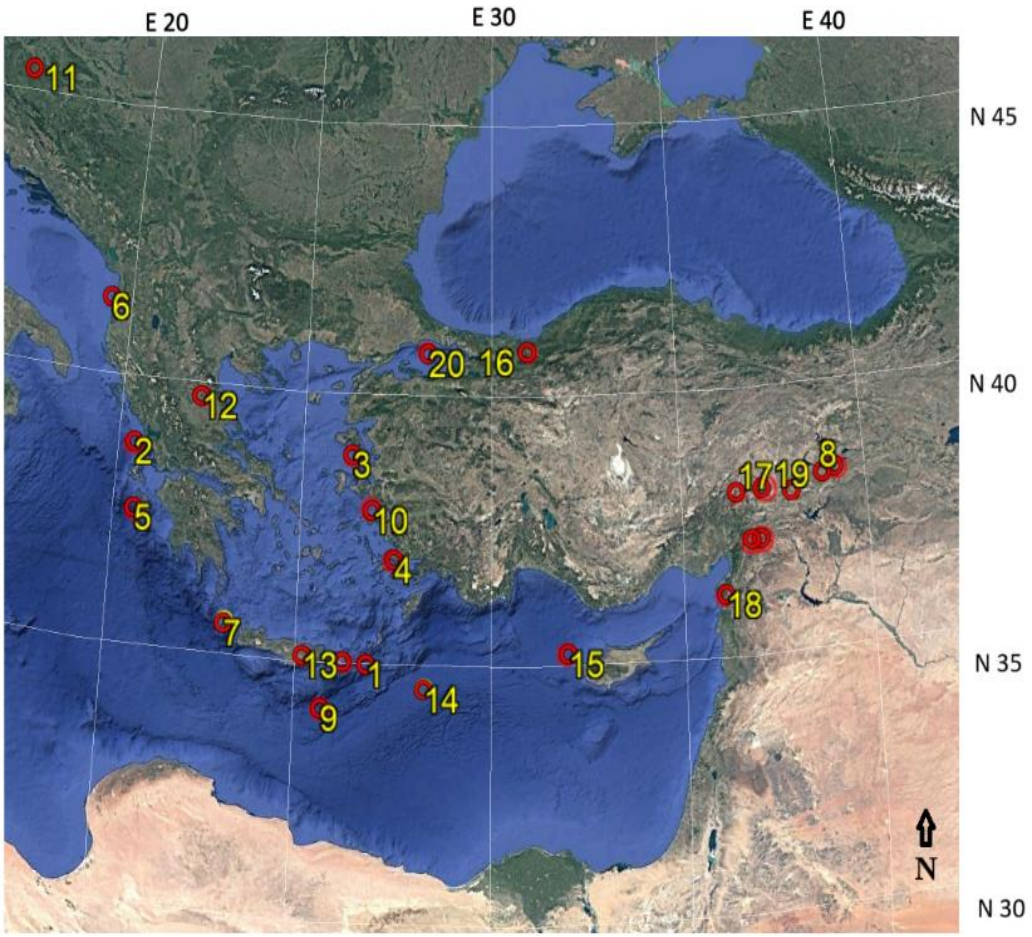


- Methods
- Coseismic deformations of the Earth's crust occur during a strong seismic event with a magnitude above 5.0 and have manifestations on the Earth's surface at points close to the epicenter of the event.
- Coseismic displacements are determined mainly by satellite observation methods that use both GNSS data and DinSAR technology - a combination that has been applied very successfully in recent years

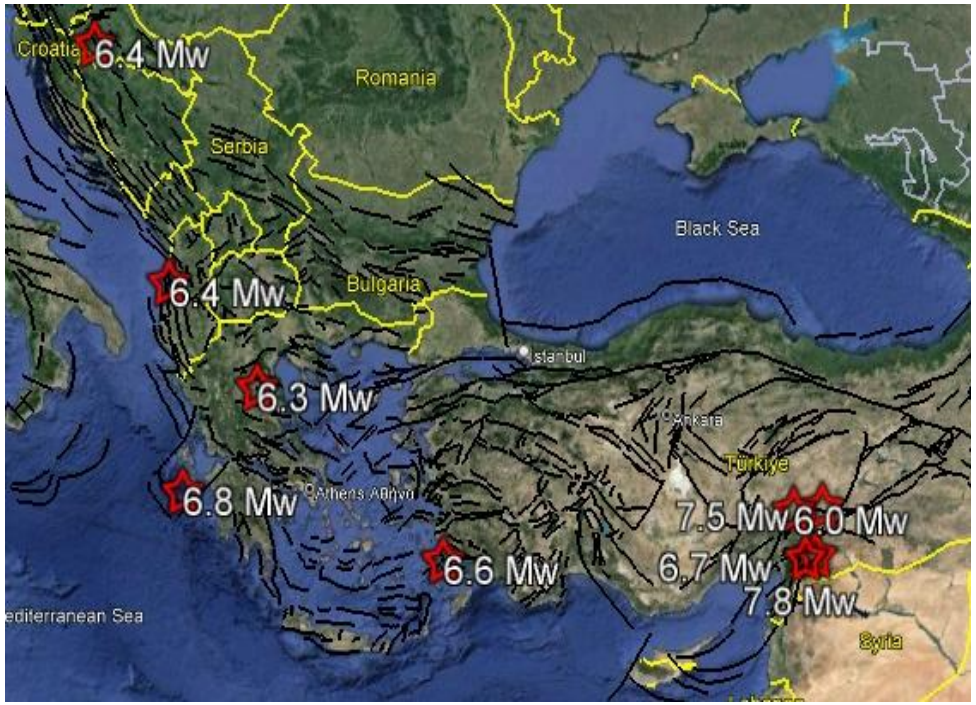
- Data
- The spatial distribution of the earthquakes, the time interval to have occurred after 2015 and the magnitude of the event to be greater than Mw 6.0 are the limitations set in our research activity, since the main method for observing the deformations of the Earth's crust used in this study is the InSAR technology. The data used to achieve the objectives of the study are the SLC products from the Sentinel 1 A and B mission, which are available after 2015.

4. Location of the earthquakes (Mw=6.0) after 2015 for the Balkans (EMSC)

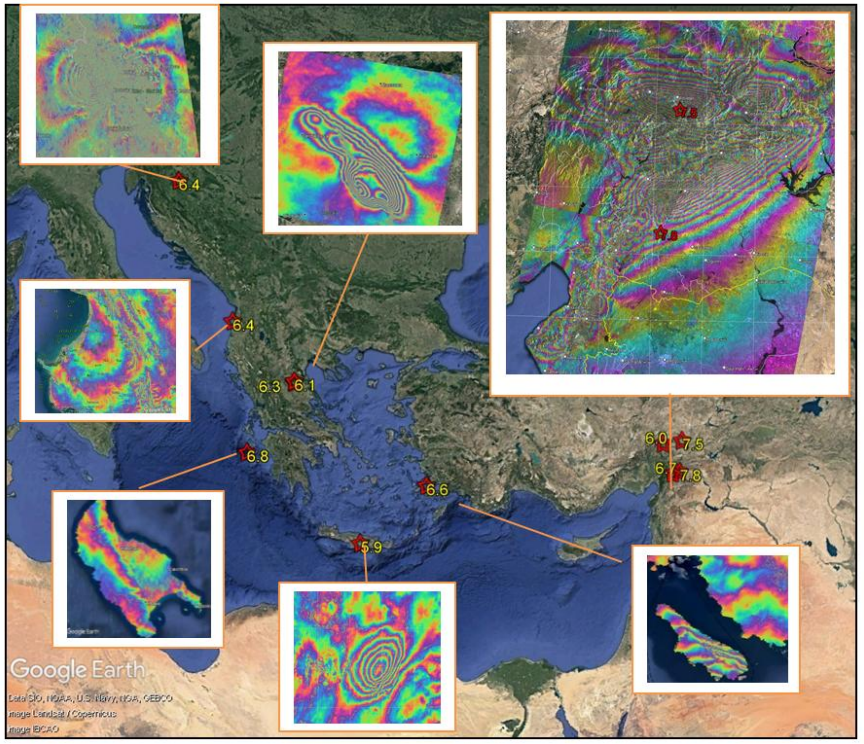
	Date	Lat	Long	Region	M
20	23.04.2025	40.83	28.22	Western Turkey	6.2
19	16.10.2024	38.30	38.82	Eastern Turkey	6
18	20.02.2023	36.16	36.02	Turkey-Syria	6.3
17	06.02.2023	38.07	36.47	Central Turkey	6
	06.02.2023	38.03	37.96		6
	06.02.2023	38.11	37.24		7.5
	06.02.2023	37.13	36.81		6.7
	06.02.2023	37.17	37.08		7.8
16	23.11.2022	40.82	30.99	Western Turkey	6.1
15	11.01.2022	35.24	31.93	Cyprus Region	6.6
14	19.10.2021	34.6	28.3	Eastern Medi sea	6
13	12.10.2021	35.04	26.27	Crete	6.4
	27.09.2021	35.11	25.22		6
12	03.03.2021	39.76	22.21	Greece-Larisa	6.3
11	29.12.2020	45.42	16.21	Croatia-Petrinja	6.4
10	30.10.2020	37.91	26.84	Samos Is Greece	7
9	02.05.2020	34.14	25.7	Crete, Greece	6.6
8	24.01.2020	38.37	39.22	Eastern Turkey	6.8
7	27.11.2019	35.66	23.16	Crete, Greece	6
6	26.11.2019	41.38	19.47	Albania	6.4
5	25.10.2018	37.53	20.62	Zakynthos	6.8
4	20.07.2017	36.96	27.45	Kos-Bodrum	6.6
3	12.06.2017	38.85	26.31	Western Turkey	6.3
2	17.11.2015	38.76	20.45	Greece	6.5
1	16.04.2015	35.03	26.81	Crete, Greece	6.1



5. Location of the studied earthquakes (Mw=6.0) for the Balkans based on DinSAR metod

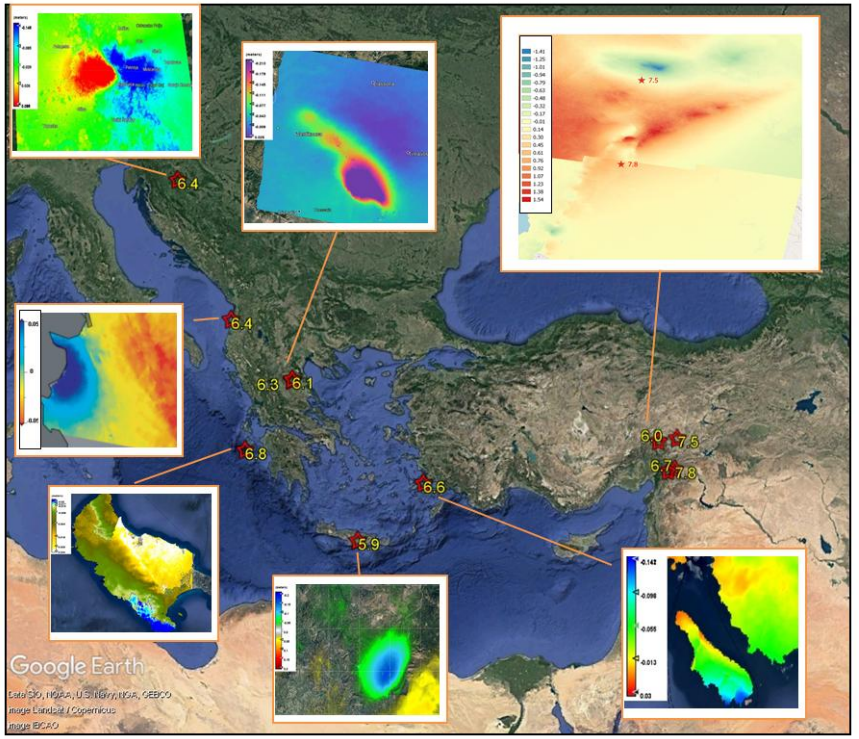


5. Application of SAR data to determine the coseismic displacements

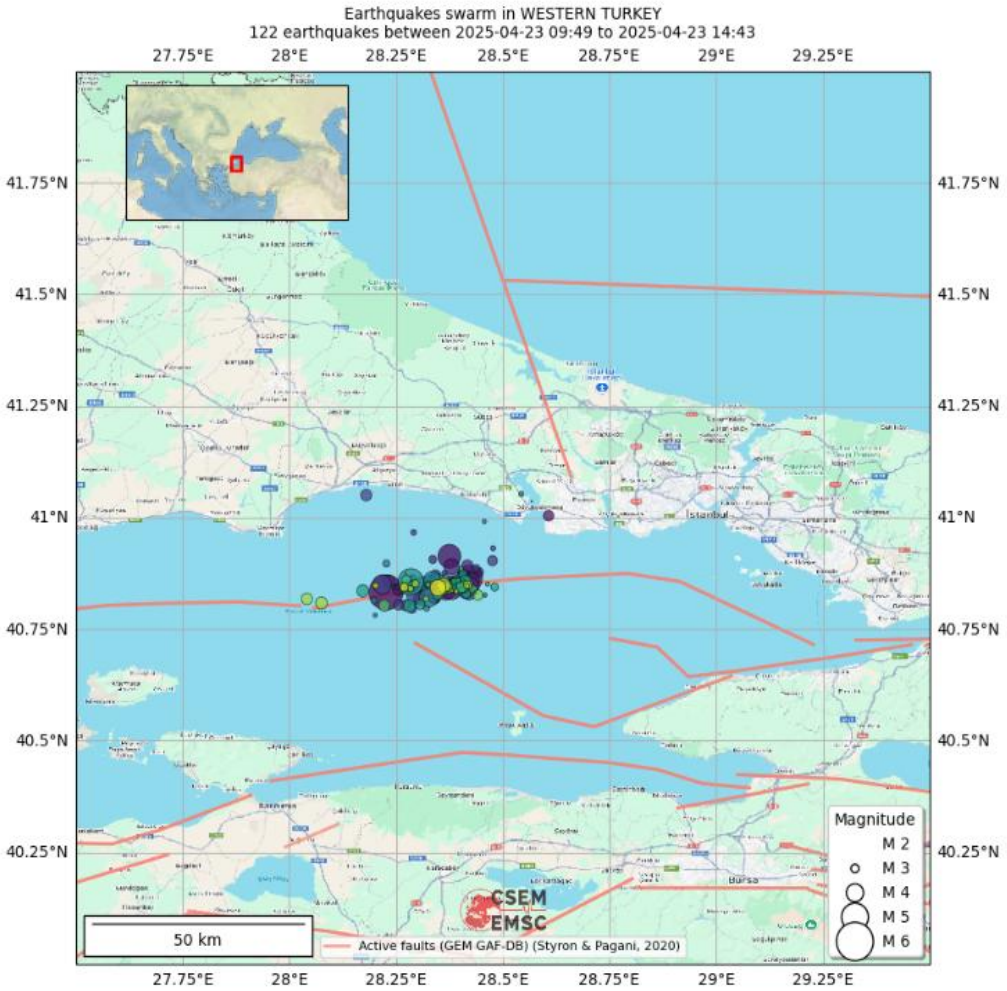


interferograms

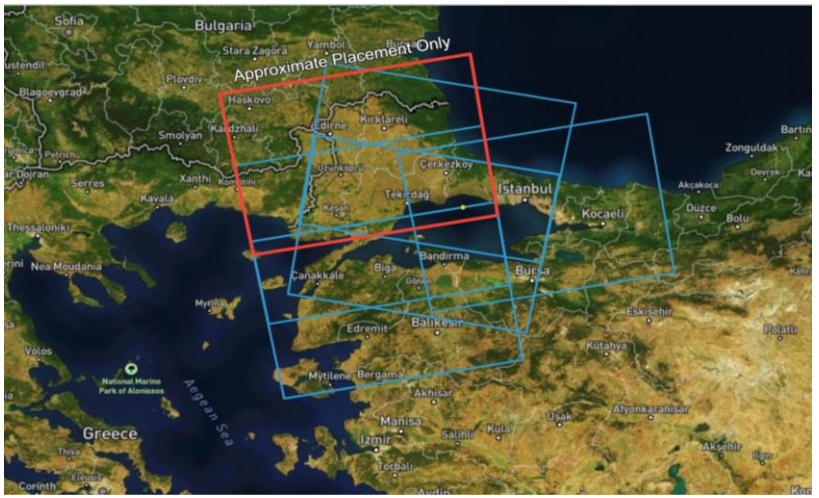
coseismic displacement



6. Earthquake with Mw 6.2 on April 23-th 2025 Western Turkey

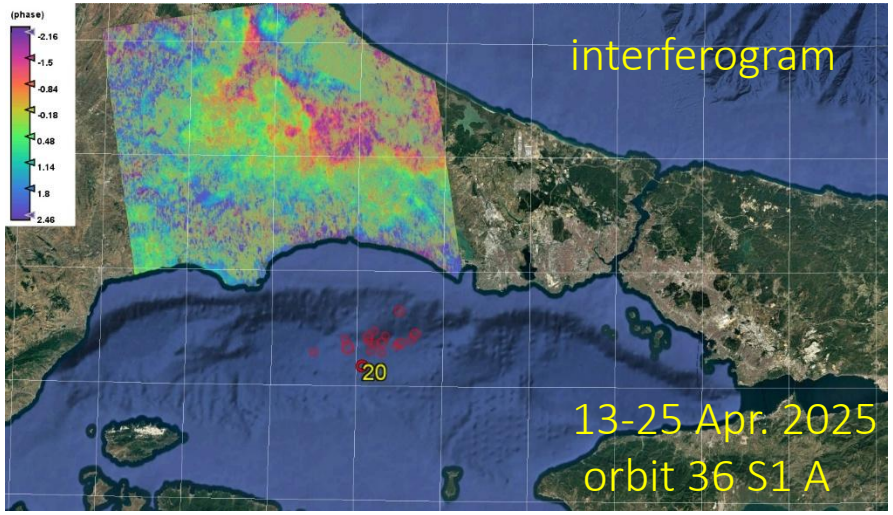


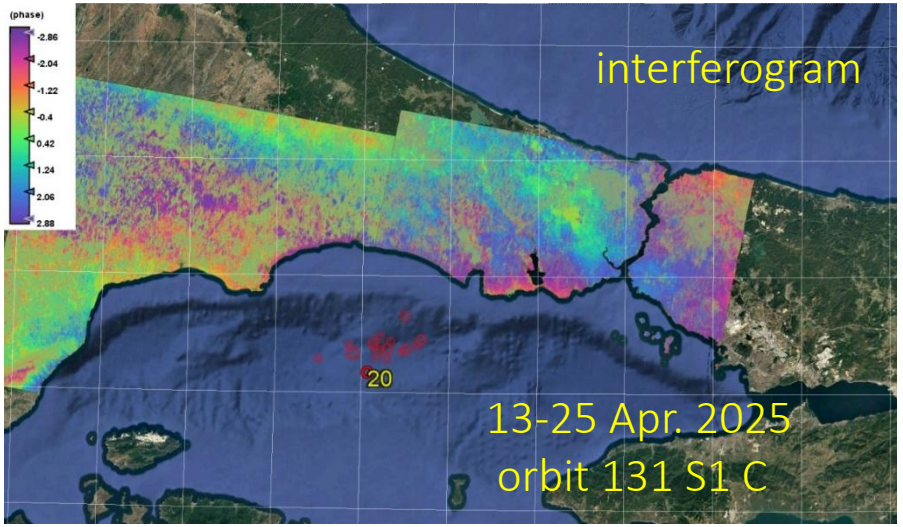
Last strong earthquake is registered in 23.04.2025 09:49:11 Western Turkey Mw 6.2 and was felt on the territory of Bulgaria.

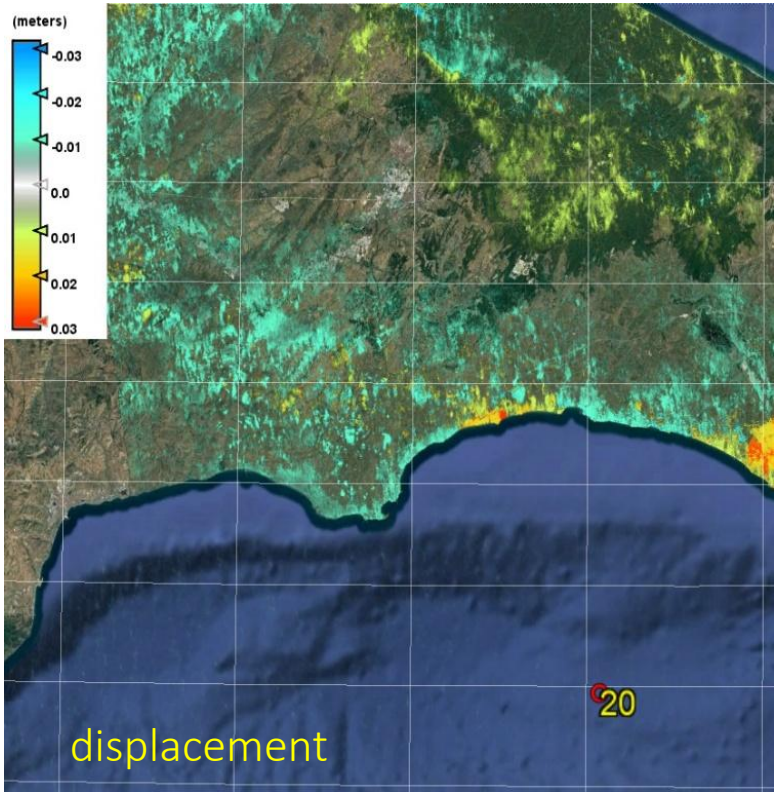


SAR data type SLC, obtained in IW
S-1C ascending orbit 131, 13 - 25 April 2025
S-1A descending orbit 36, 13 - 25 April 2025
S-1A descending orbit 58, 14 - 26 April 2025

6. Earthquake with Mw 6.2 on 23 April 2025 Western Turkey







7. Discussion

From the presented results after processing the SAR data by the InSAR method, it can be concluded that they are an additional source of information on the deformations of the earth's crust that occurred as a result of earthquakes.

The good correspondence between the InSAR maps and regional tectonics shows that the SAR method is a reliable and very useful source of information. Its advantage is that this information is obtained for large areas and in a relatively short time after the event, which helps in the preparation of maps for overcoming its consequences and updating plans for preparing for future strong events in the same area.

The processing methodology applied made it possible to obtain interferograms that visually represent the displacements around the epicenters. SAR data were used to obtain information indicating the actual surface displacements.

InSAR data has proven to be a useful tool in seismology for detecting the actual deformation of the Earth's surface caused by a seismic event, and thus supports the determination of the general location of ruptures and the constraining of fault geometry.

8. Conclusions

- The main objective is to demonstrate the possibility of determining the degree of deformation of the Earth's surface and to prepare displacement maps that can be used by a large number of experts.
- The applied processing methodology used by the author successfully generates interferometric images that visually depict displacements around the epicenters.
- The presented examples demonstrate the application of Earth observation satellite technologies, such as InSAR, for the study and monitoring of the seismogenic zones of the Balkan Peninsula, emphasizing their importance and advantages in establishing regularities in the movements in these zones.
- The interpretation of the spatial distribution and coseismic deformations caused by large earthquakes also provides insight into geodynamic and tectonic processes.

Thank you!

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project: "Study of co-seismic deformations of the earth's crust for the territory of the Balkan Peninsula based on satellite data", financed by “Competition for financial support of basic research projects – 2023” of Bulgaria. Contract No. KP-06-N74/2 from 14.12.2023г