



ISTITUTO NAZIONALE
DI GEOFISICA E VULCANOLOGIA

Damage proxy map of the 2023 Mw 7.8 Turkey earthquake by SAR data

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Outline

Motivation

Methodology

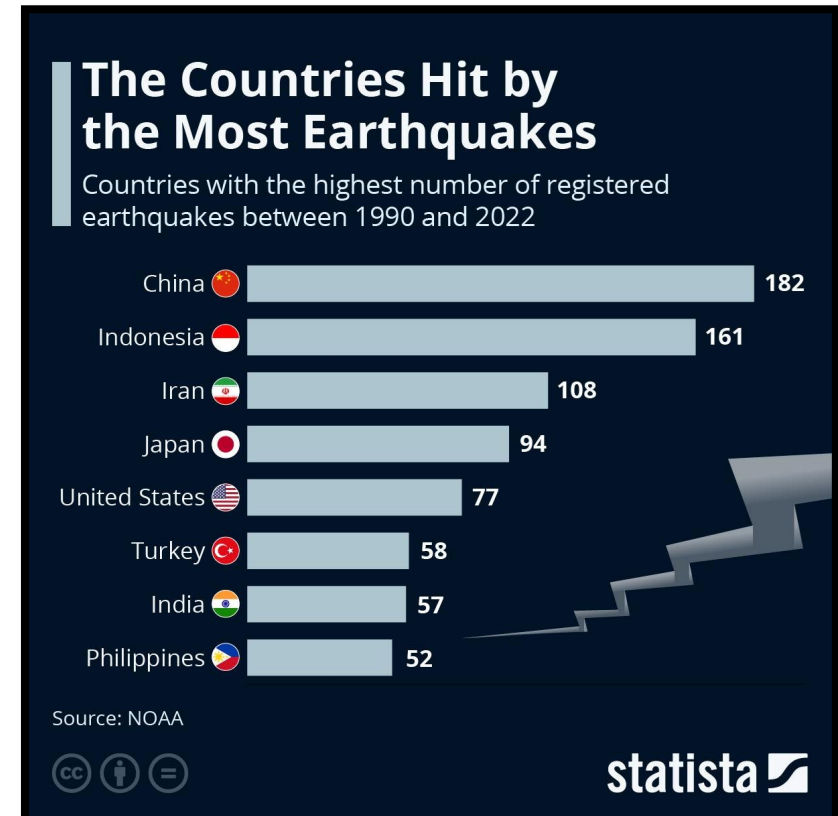
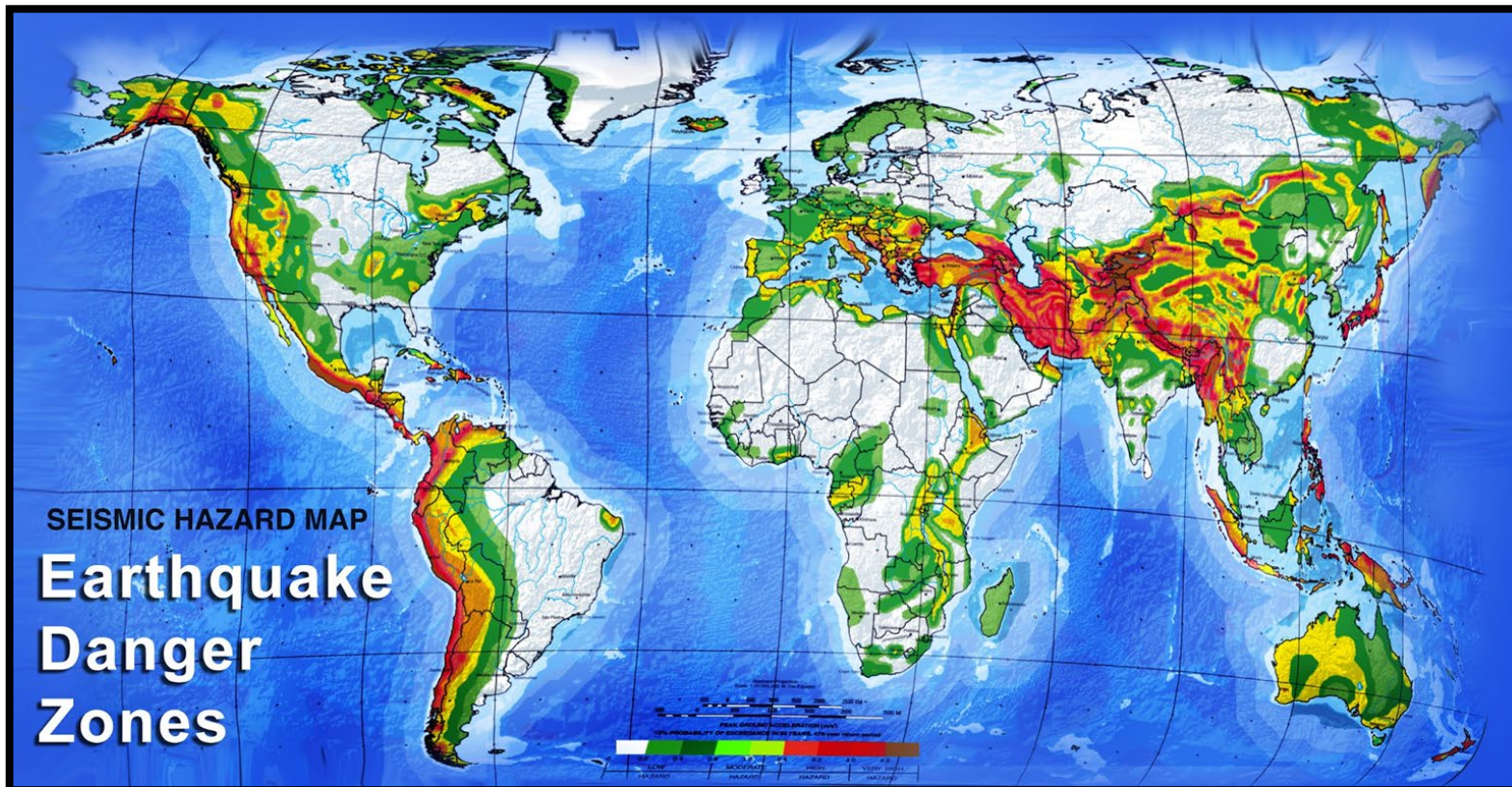
Results

Summary and future works



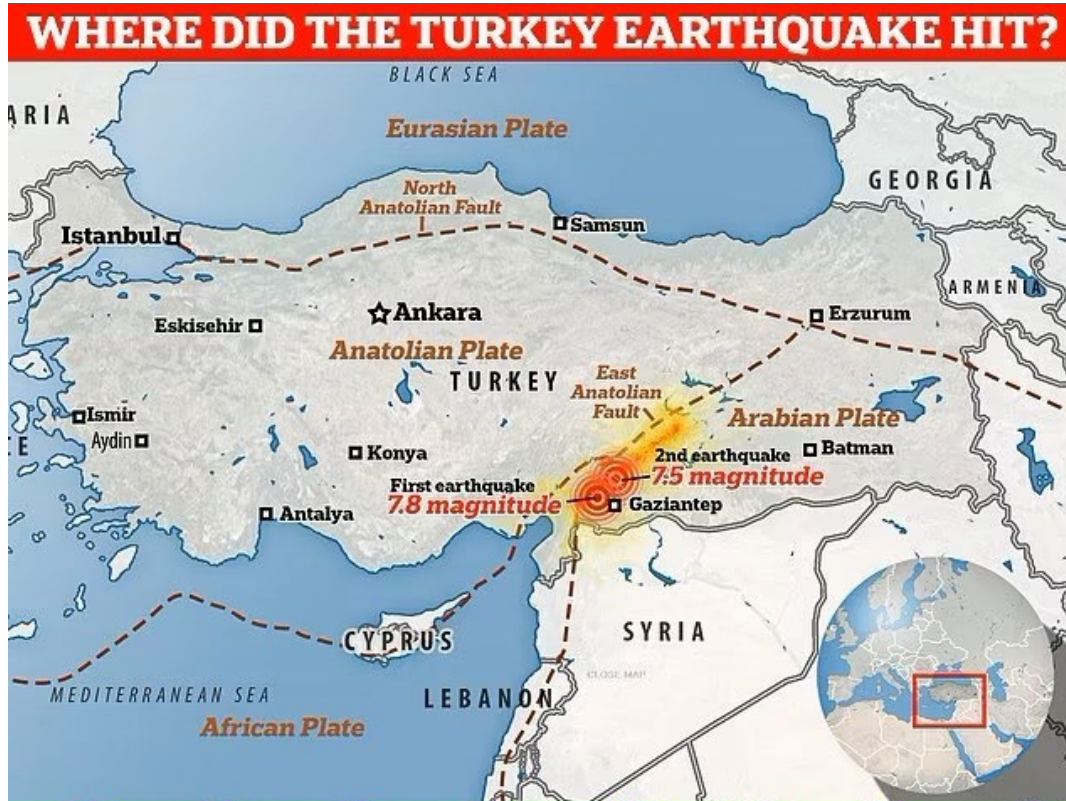
Motivation

- Satellite remote sensing plays an important role to observe changes induced by earthquakes.
- Fast assessment of damage is a vital step to post-disaster emergency response and to reduce the impact of the disaster (e.g., reconstruction activities)
- We quantify buildings damage occurred in Turkey (06 February 2023)



Motivation

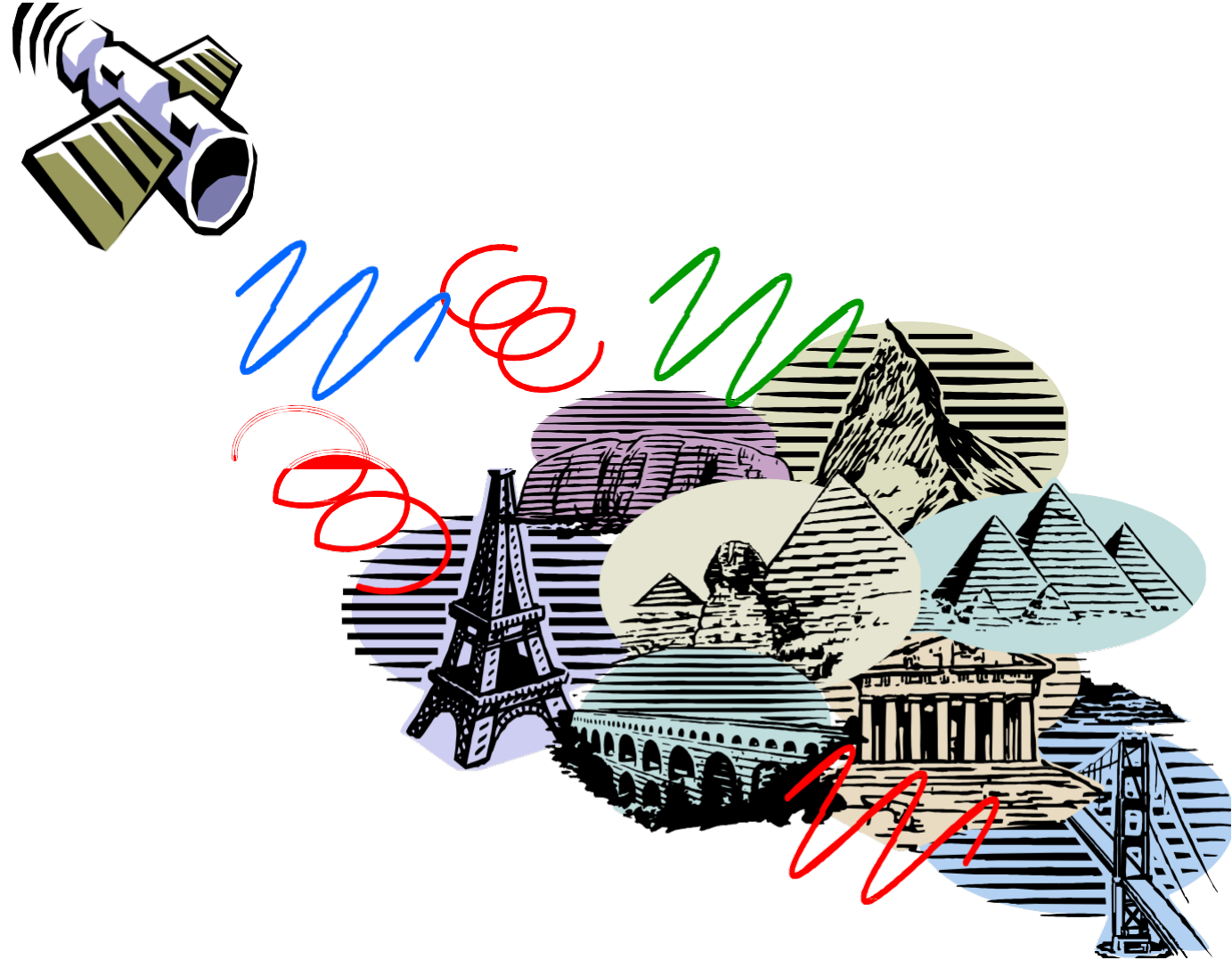
- On February 6th, 2023, a 7.8 magnitude earthquake hit the southern and central regions of Turkey, as well as the northern and western regions of Syria.
- This earthquake was *one of the largest earthquakes* ever recorded causing extensive damage to the buildings and infrastructure in the affected regions and more than 50000 casualties.
- The disaster management authorities have been struggling to assess the damages and prioritize rescue and relief operations due to the widespread nature of the damages.



Methodology

Microwave Remote Sensing

- All-day acquisitions
- Almost all-weather acquisitions
- Fine spatial resolution (SAR)



Methodology

Damage in urban areas mapped from SAR

The change detector index we used as damage proxy, is the Intensity Correlation Difference (ICD).

It analyses the spatial distribution of scatterers, and their SAR intensity value, within a user-defined window:

$$ICD = R_{COS} - R_{PRE}$$

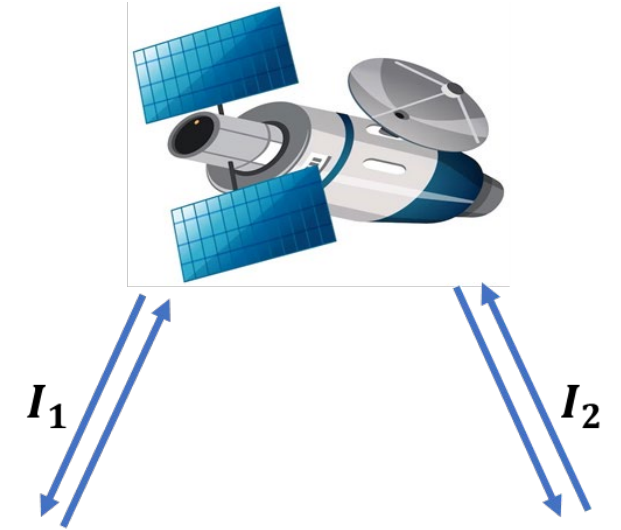
R_{COS} is the intensity correlation values obtained from a co-seismic images pair; while R_{PRE} is the correlation obtained from two images acquired before the earthquake:

$$R_I = \frac{E(I_1 I_2)}{\sqrt{E(I_1^2) E(I_2^2)}}$$

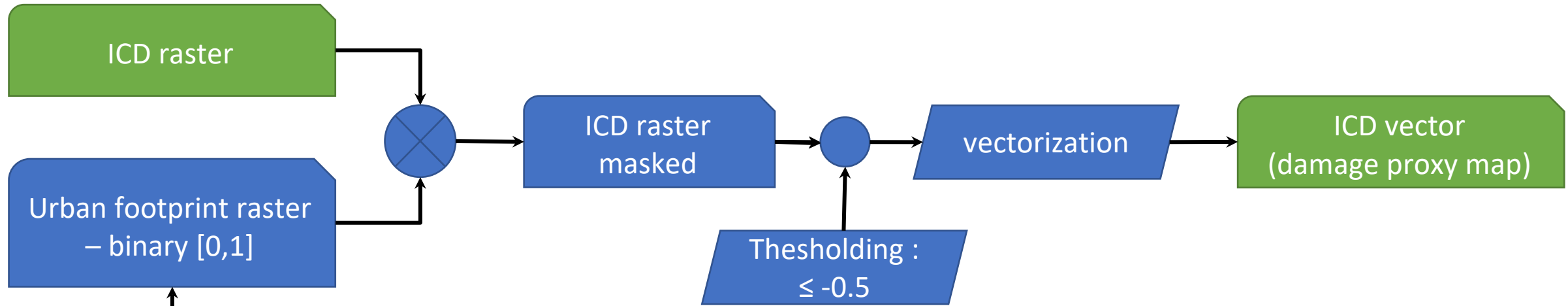
where I_1 and I_2 are two imagery collected at different time.

R_{COS} is expected to decrease because of damage

SAR phase coherence did not provide good results à large spatial baseline of SAR images



Methodology



Vectorization in QGIS

- 1) Raster to vector function
- 2) Selection of elements with DN=1 and export of selected elements to new shapefile

Results

Dataset

Sensor: Cosmo-SKYMed Second Generation

Frequency: X-band (9.6 GHz)

Acquisition dates:

Gaziantep

18 January 2023 (Pre event)

3 February 2023 (Pre event)

11 February 2023 (Post event)

Kahramanmaraş

19 January 2023 (Pre event)

4 February 2023 (Pre event)

12 February 2023 (Post event)

Acquisition pass: Ascending

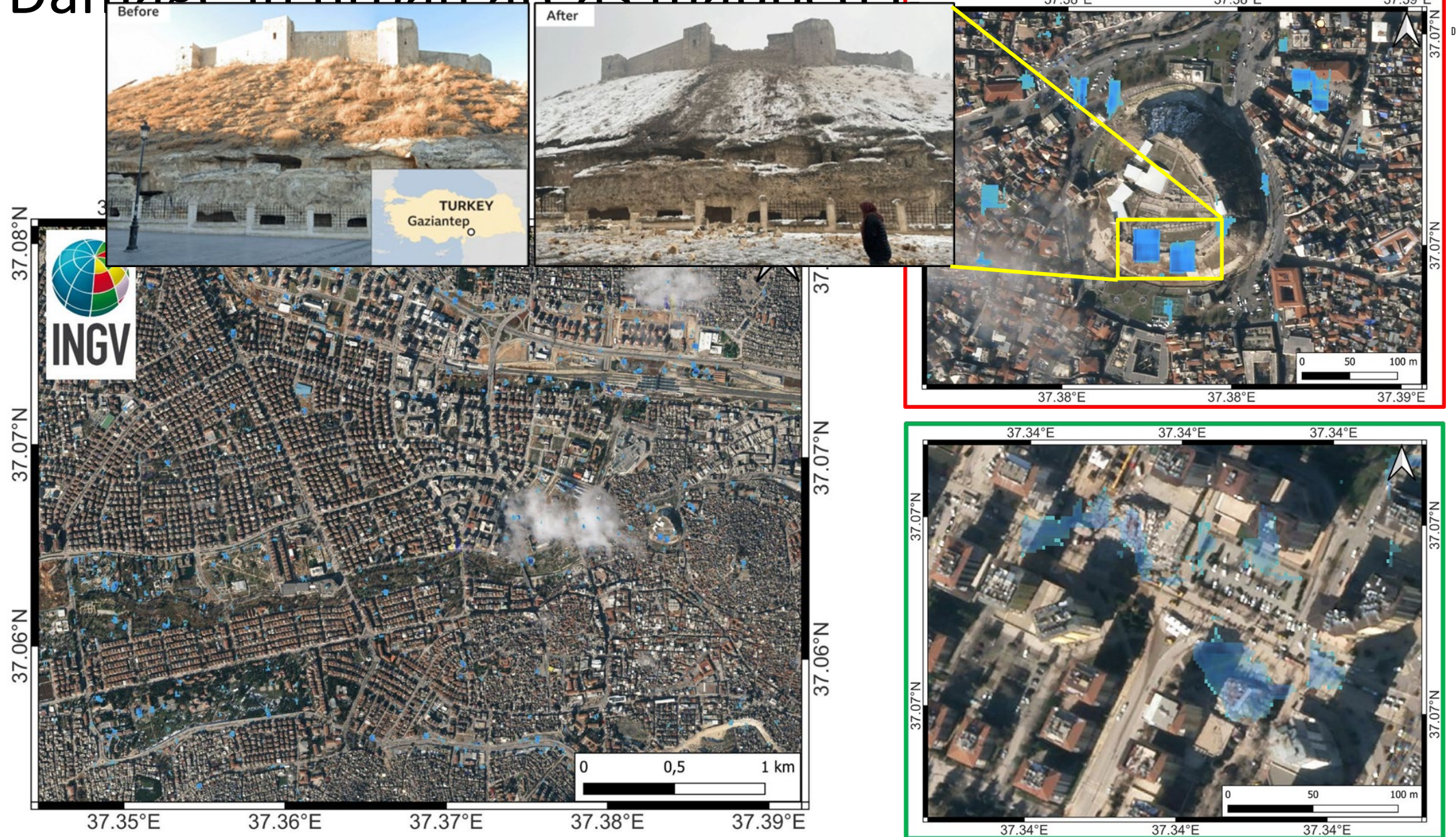
Acquisition mode: Stripmap

Pixel spacing: 2.25m x 2.25m (range x azimuth)

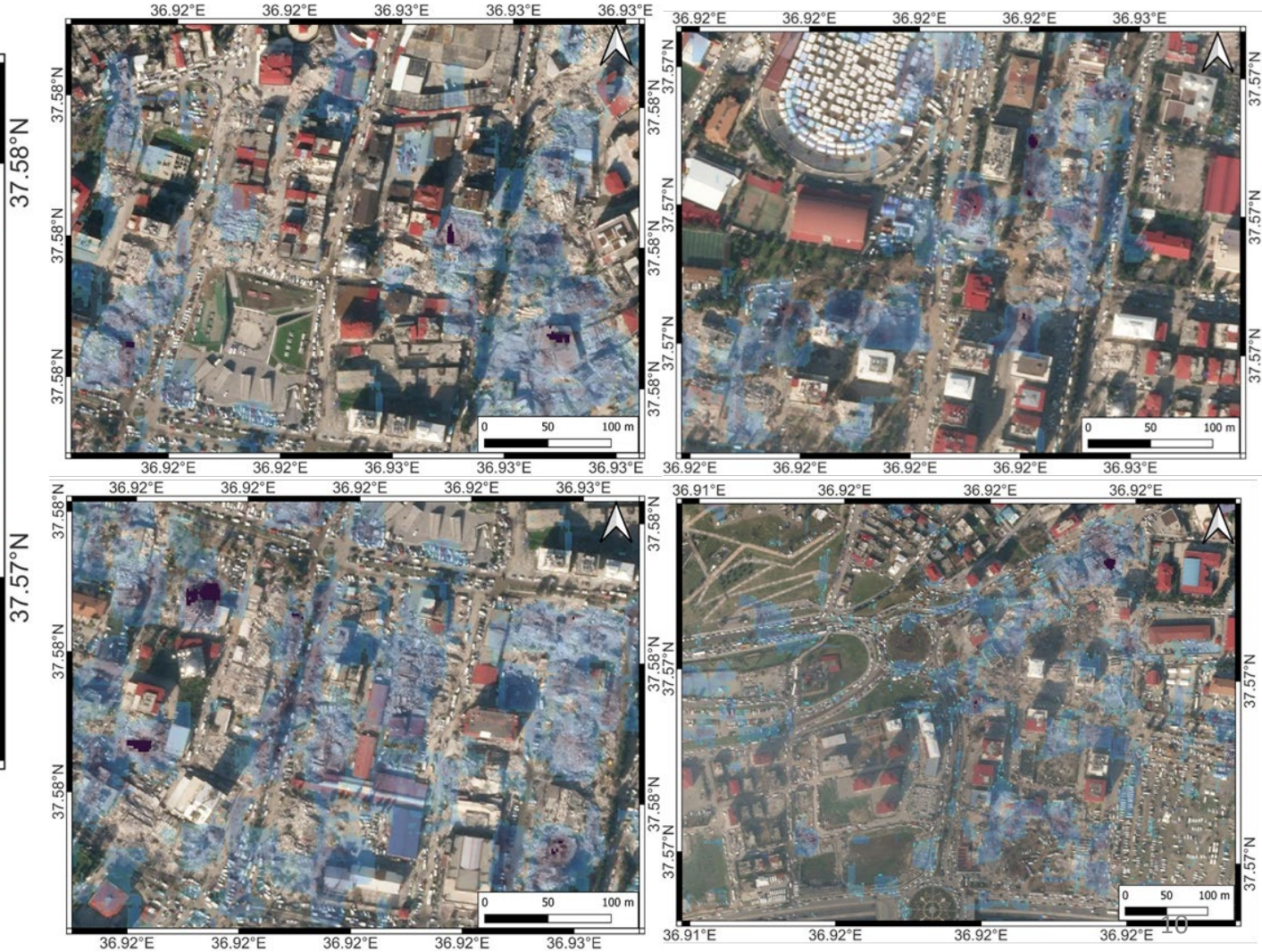
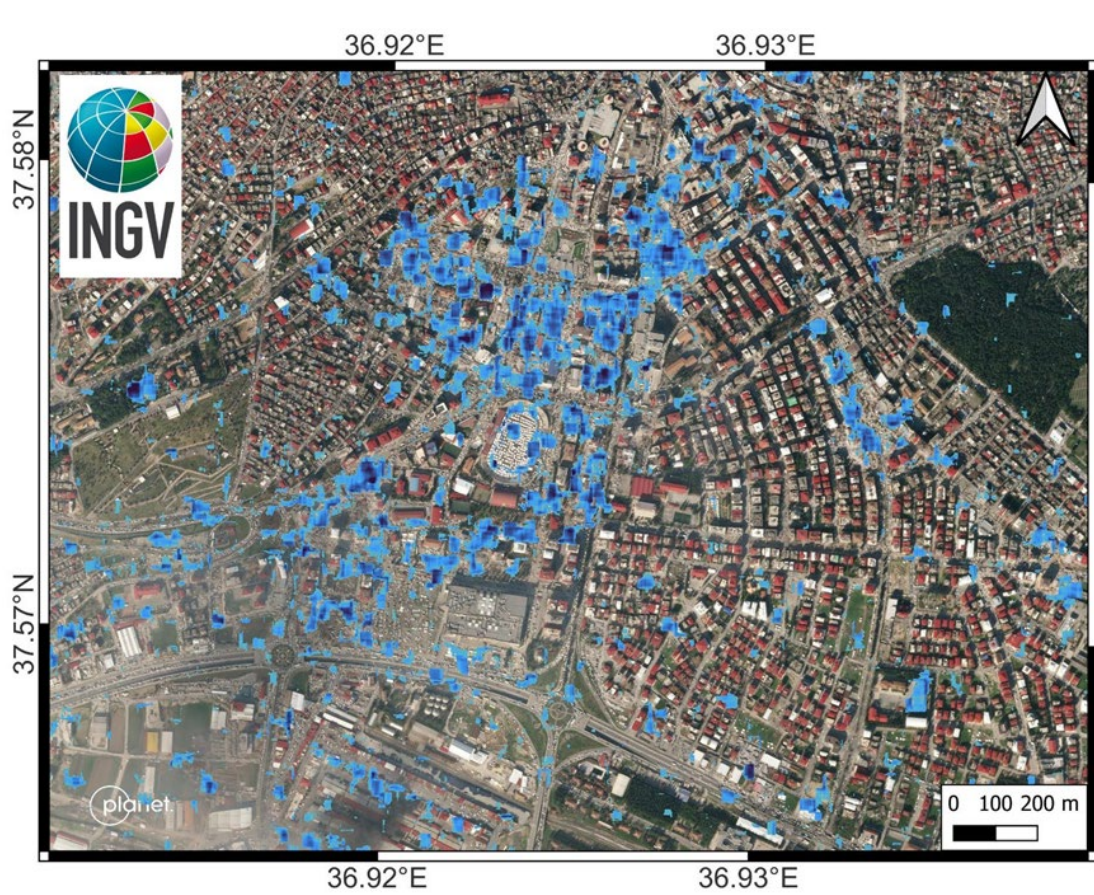


Cosmo-SKYMed Second Generation, ASI©

Damage in urban areas mapped from SAR: Gaziantep



Damage in urban areas mapped from SAR:Kahramanmaraş



Damage in urban areas mapped from Dual-Pol SAR: Kahramanmaraş

Methodology

$$C_{CD} = C_{post} - C_{pre} \longrightarrow \lambda = |\lambda_1| + |\lambda_2|$$

where λ_1 and λ_2 are the two eigenvalues obtained from the covariance matrix difference C_{CD} . λ is used to detect the levels of damage.

Dataset

Sensor: Sentinel-1

Frequency: C-band (5.4 GHz)

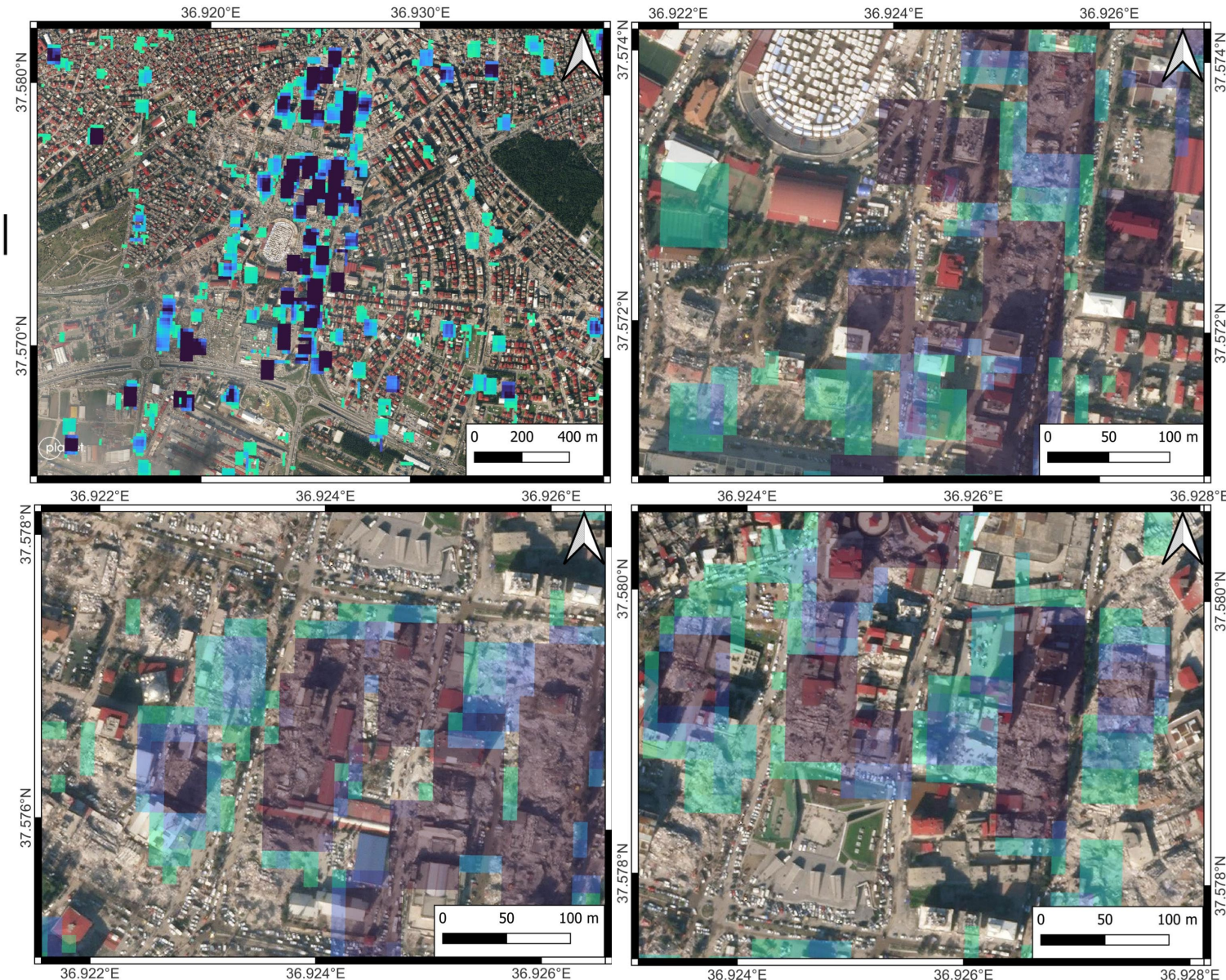
Acquisition dates:

29/01/2023 (Pre-event)

10/02/2023 (Post-event)

Acquisition pass: Descending

Pixel spacing: 2.3 x 13.9m (range x azimuth)



Conclusions

- We have investigated the buildings damage due to the M7.8 earthquake occurred along a wide sector of the EAF considered a “seismic gap” till 2023, and a second earthquake, M 7.6, that took place in a further seismic structure toward NW.
- We carried on a damage analysis in the cities of Gaziantep and Kahramanmaraş by means of CosmoSkyMed Second Generation and Sentinel-1 images.
- Intensity Correlation Difference (ICD) allowed computing a change detection map at medium resolution (2.5m pixel) showing a large number of collapsed and heavily damaged manufactures.
- DP change detector allows obtaining a damage map using only two images (pre- and post-event).
- SAR change detection methods provide a powerful tool for detecting damages in the aftermath of the 2023 Turkey earthquake.
- Future works deal with:
 - SAR Polarimetric features
 - Data fusion of SAR and Optical data
 - Neural network features



Thank you

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