# Co-seismic and Early Post-seismic Deformation Associated with the 6 February 2023 Southeast Turkey Earthquake Doublet

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Porter School of the Environment and Earth Sciences

The Raymond and Beverly Sackler Faculty of Exact Sciences
Tel Aviv University

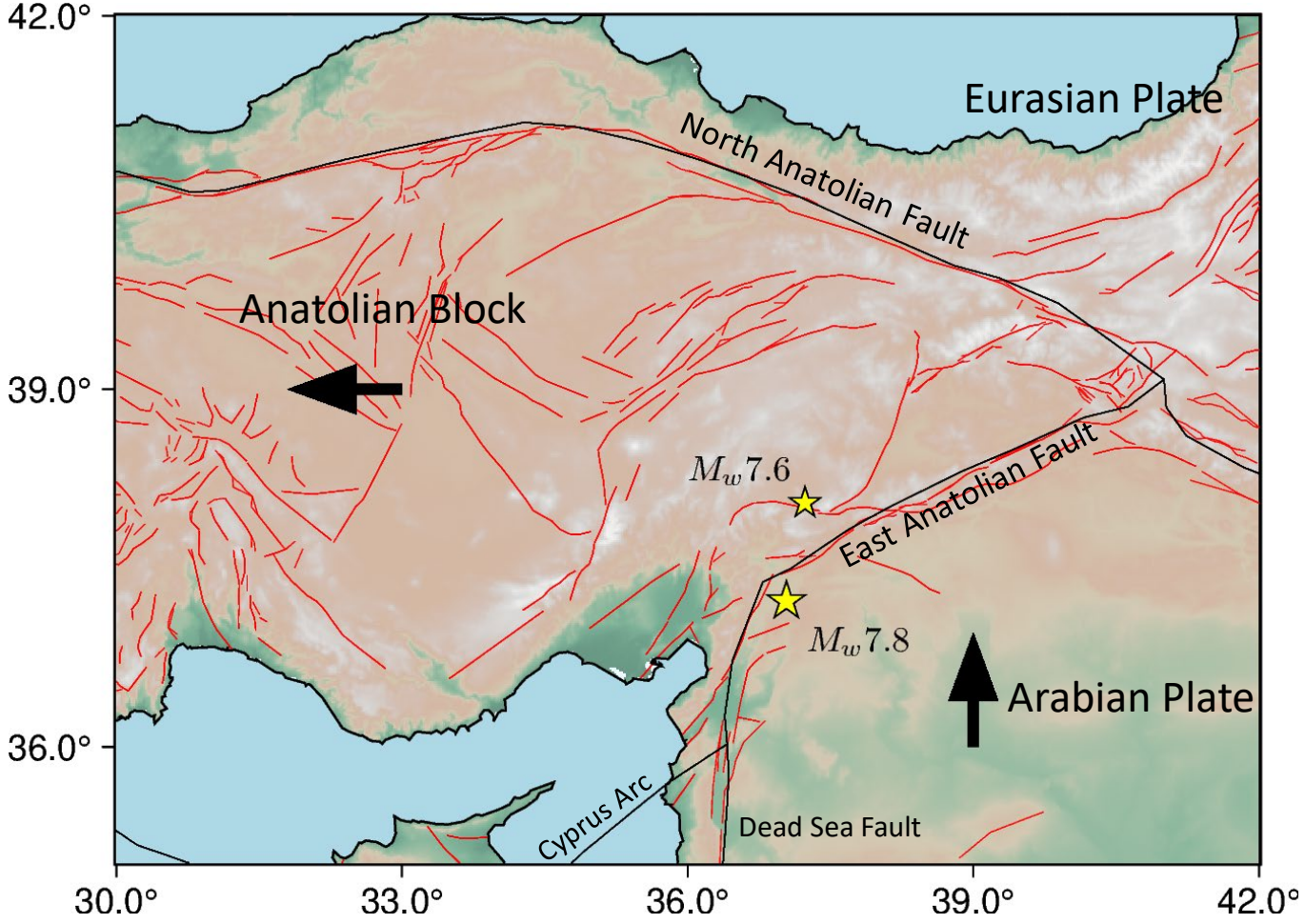
הפקולטה למדעים מדויקים ע"ש ריימונד ובברלי סאקלר
אוניברסיטת תל אביב

בית הספר לסביבה ולמדעי כדור הארץ על שם פורטר

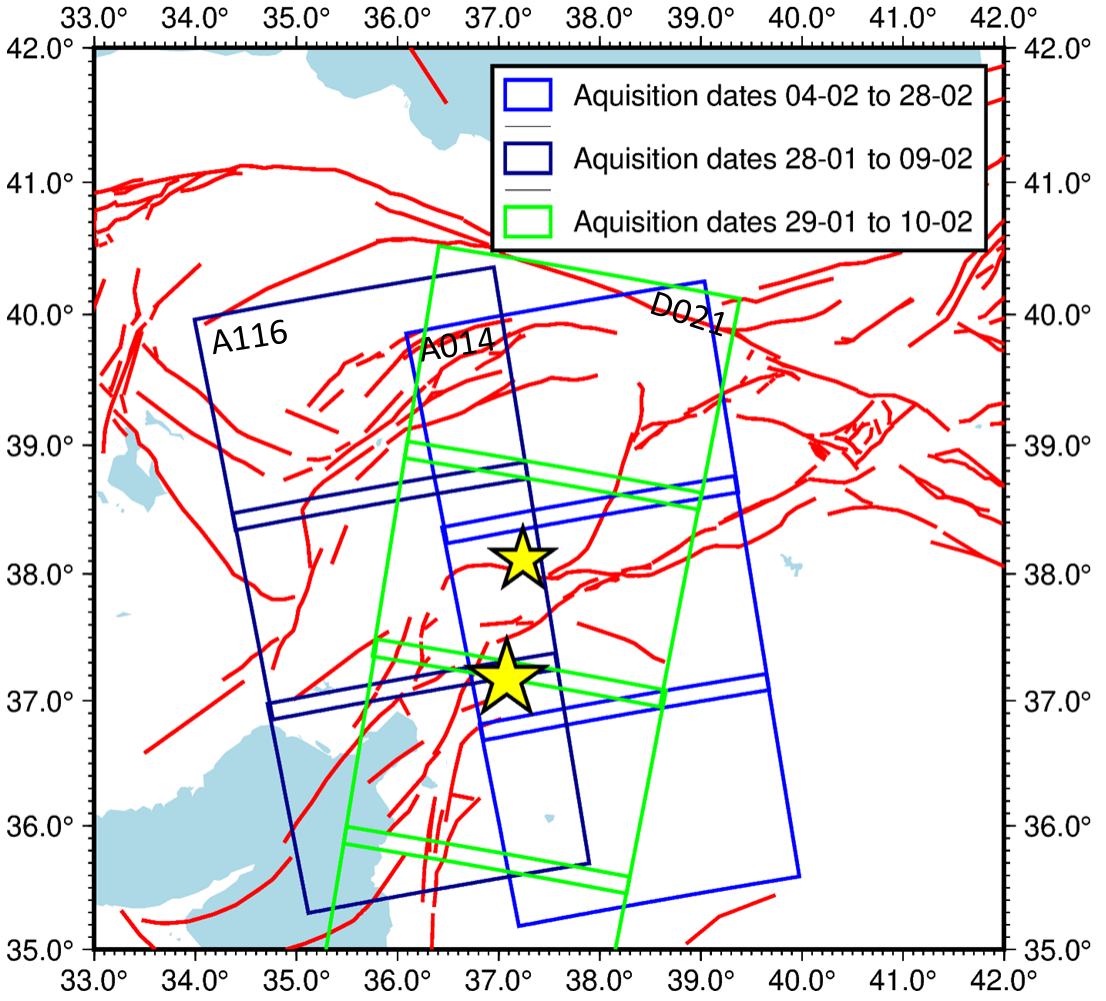
המכון הגיאולוגי
GEOLOGICAL SURVEY OF ISRAEL
ESTABLISHED 1949

# The $M_w$7.8 and $M_w$7.5 6-02-2023 southern Turkey earthquake doublet

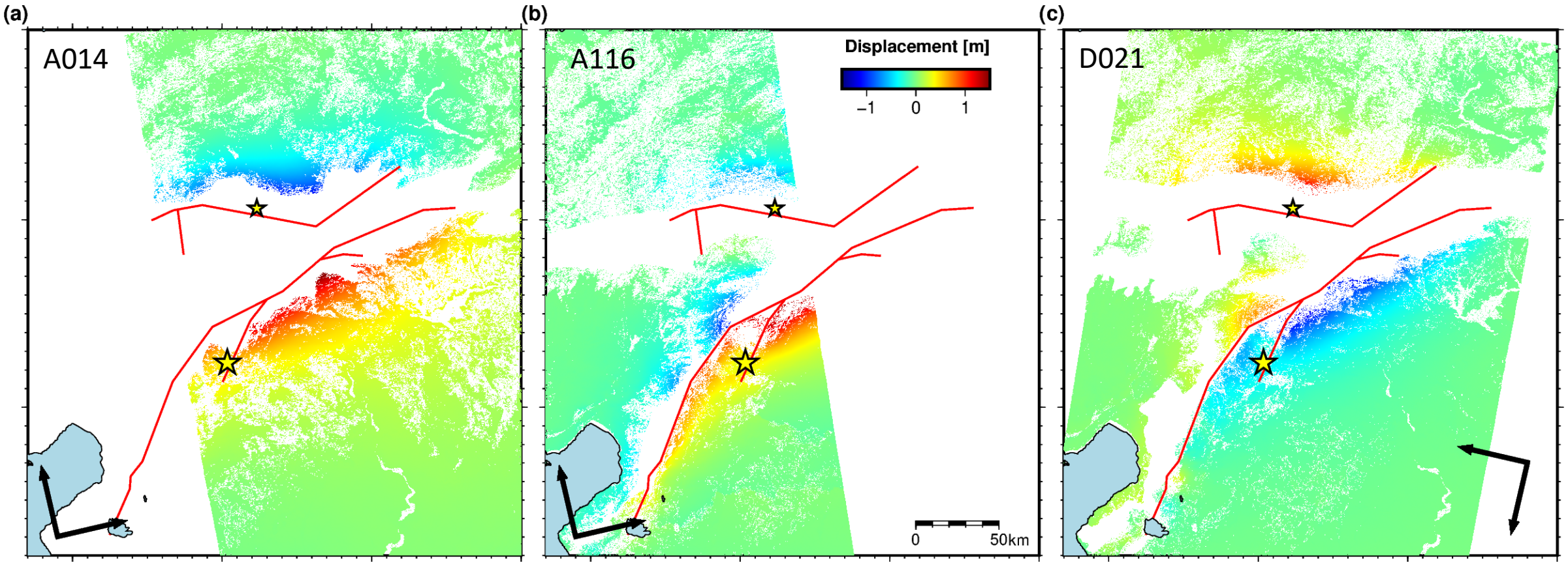
Tectonic framework



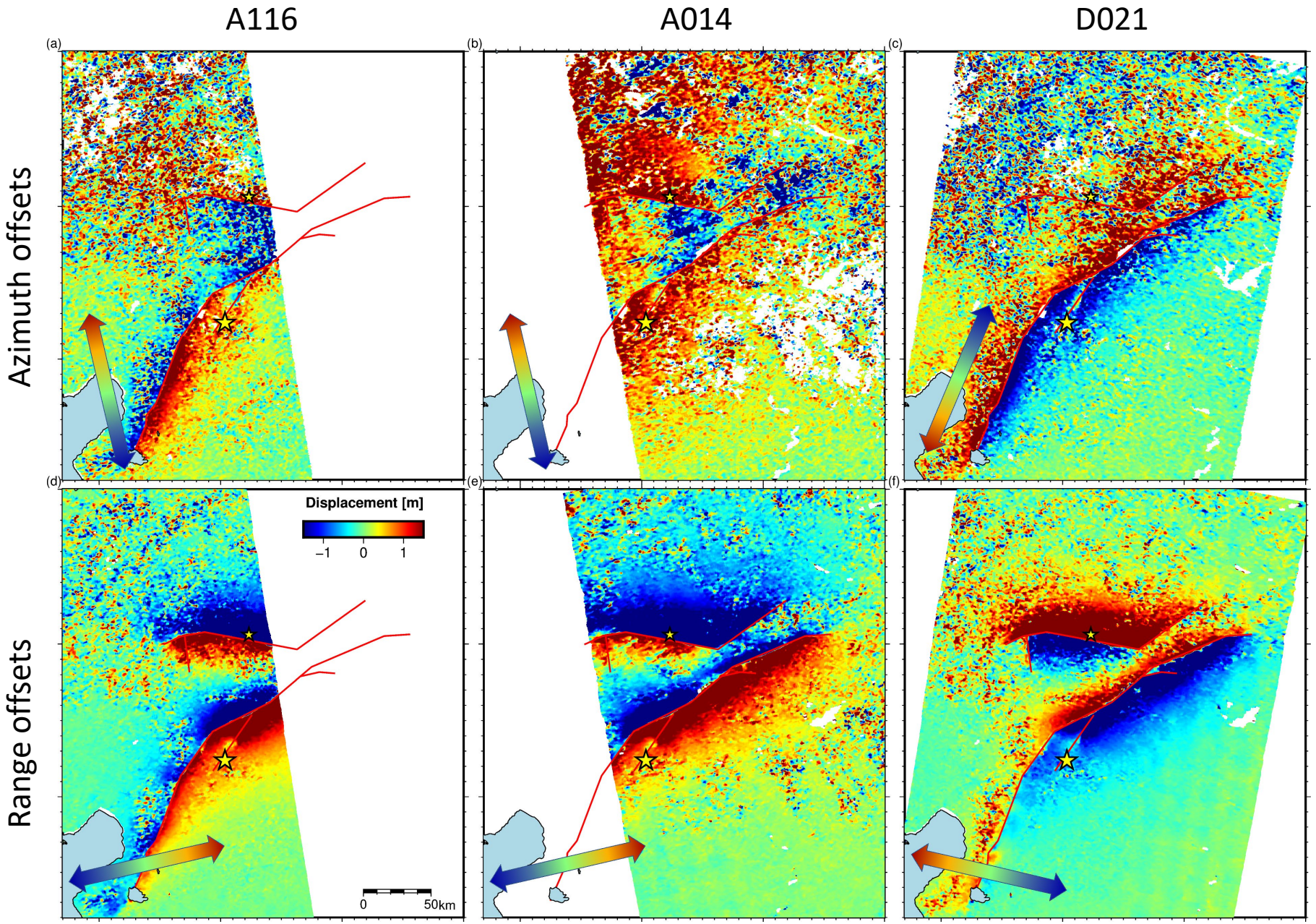

Sentinel 1



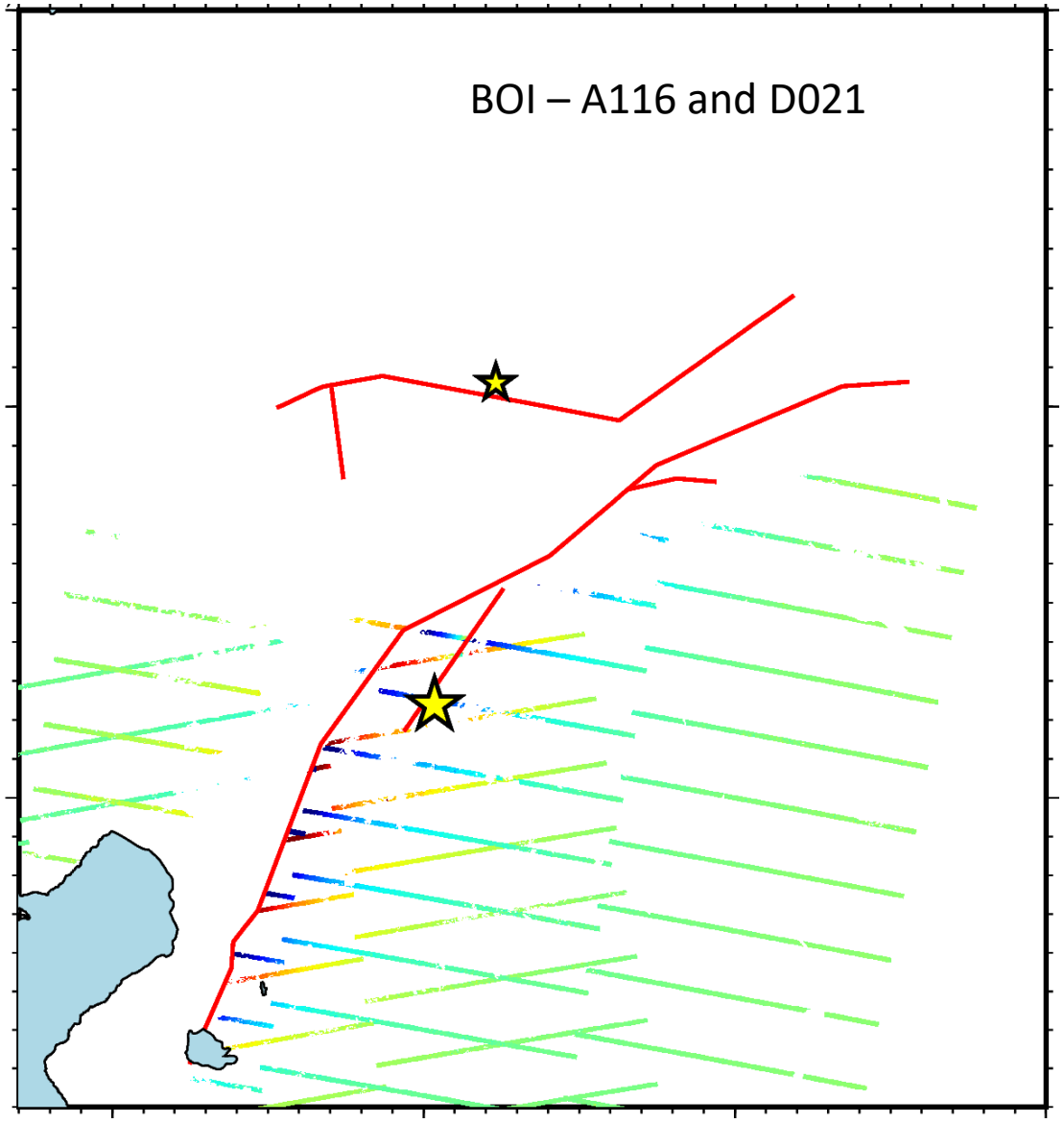
# Sentinel 1
# Line of Sight Interferometry



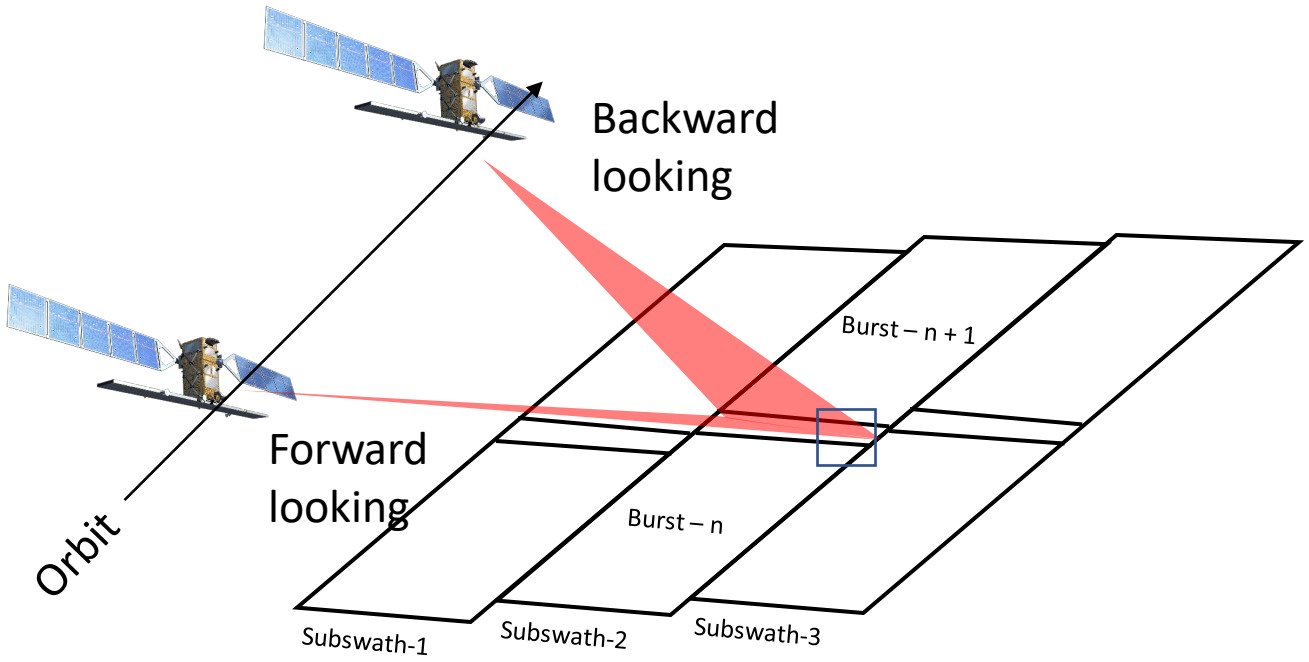
# SAR pixel offset tracking



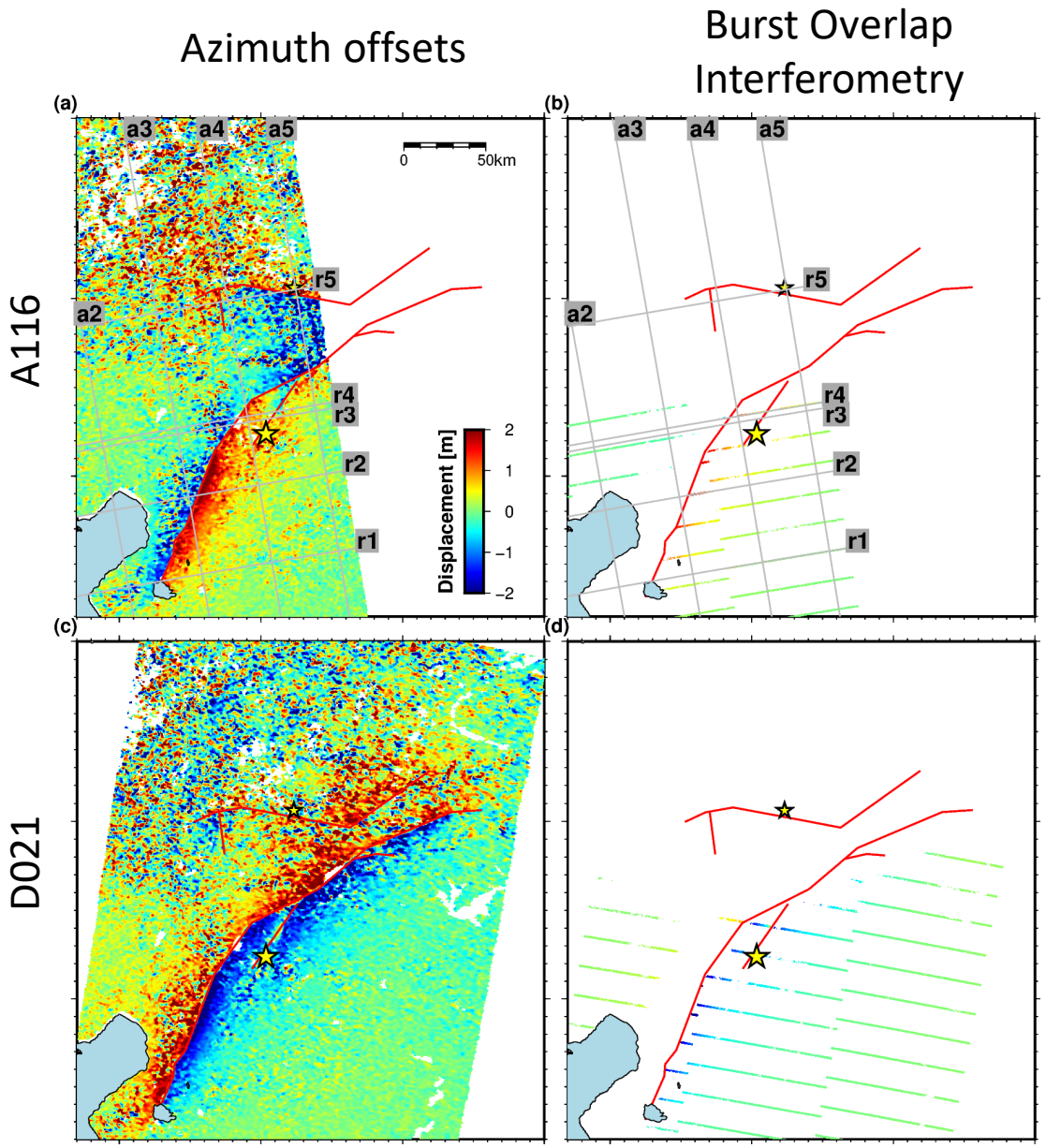
# Sentinel 1
# Burst overlap Interferometry

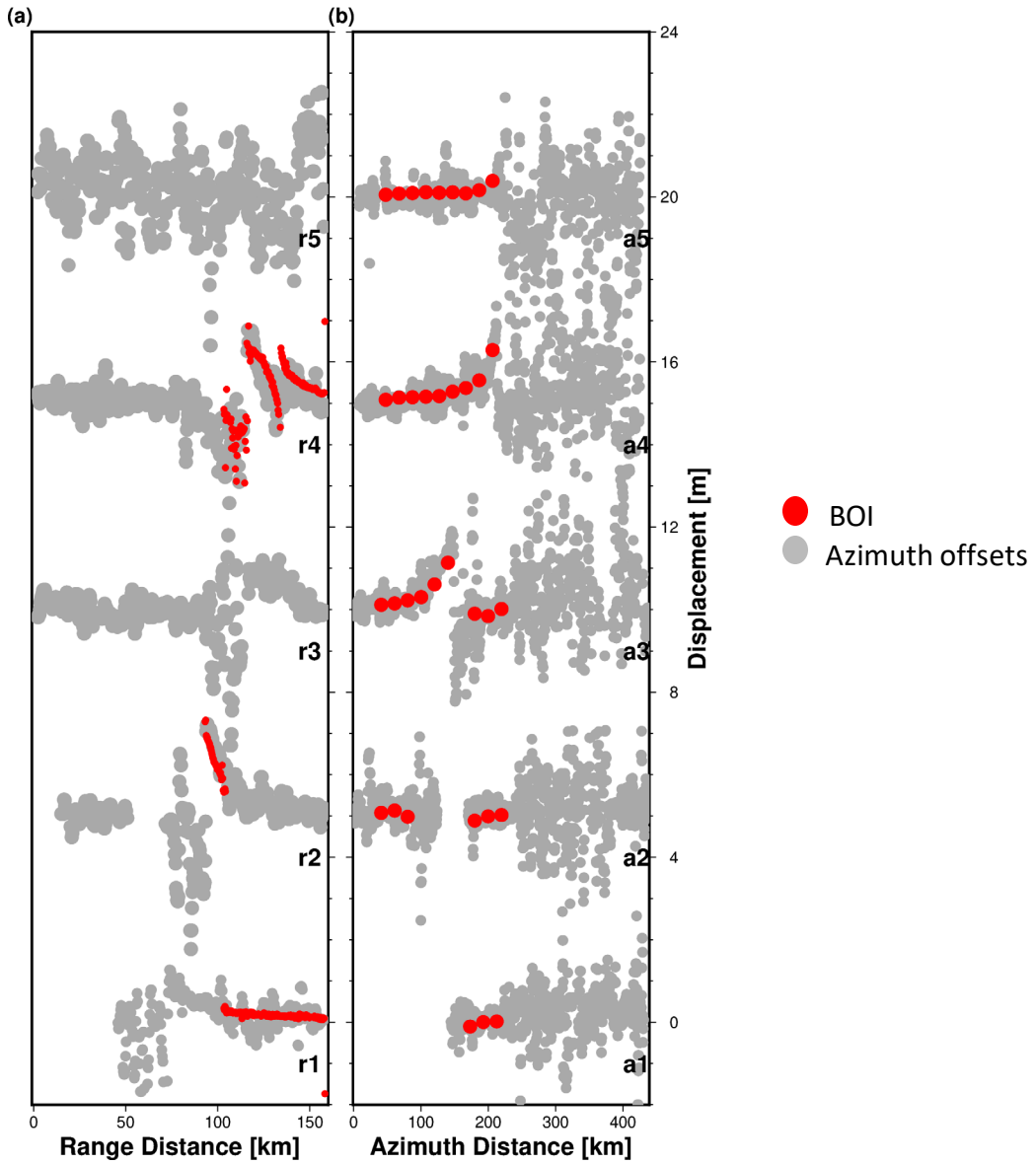



Sentinel-1 TOPS observation mode



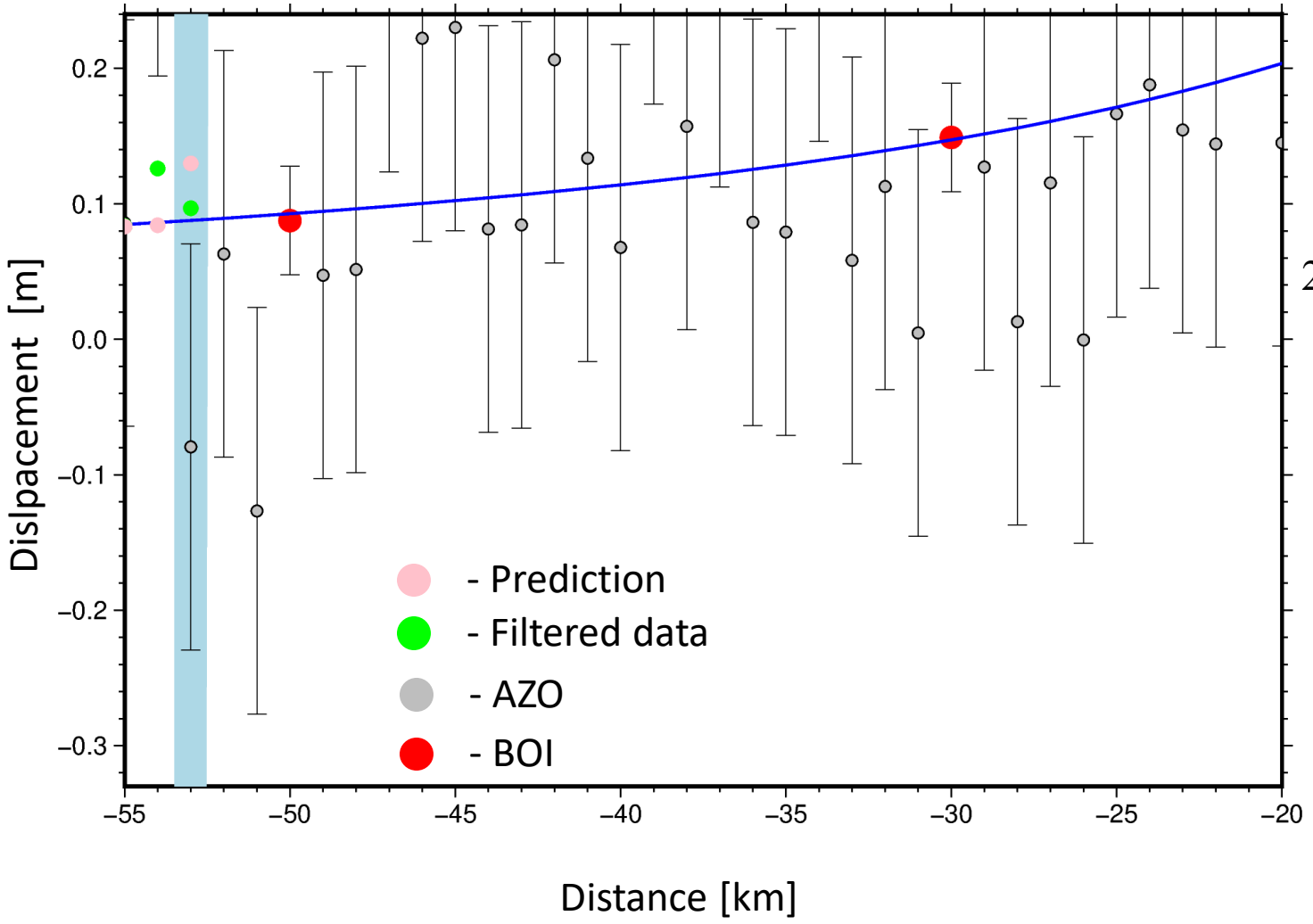
# Azimuth offset BOI comparison



# Azimuth offset BOI integration

Synthetic example of fusing dense and precise noise measurements (AZO) with sparse and accurate measurements (BOI) using the Kalman filter.

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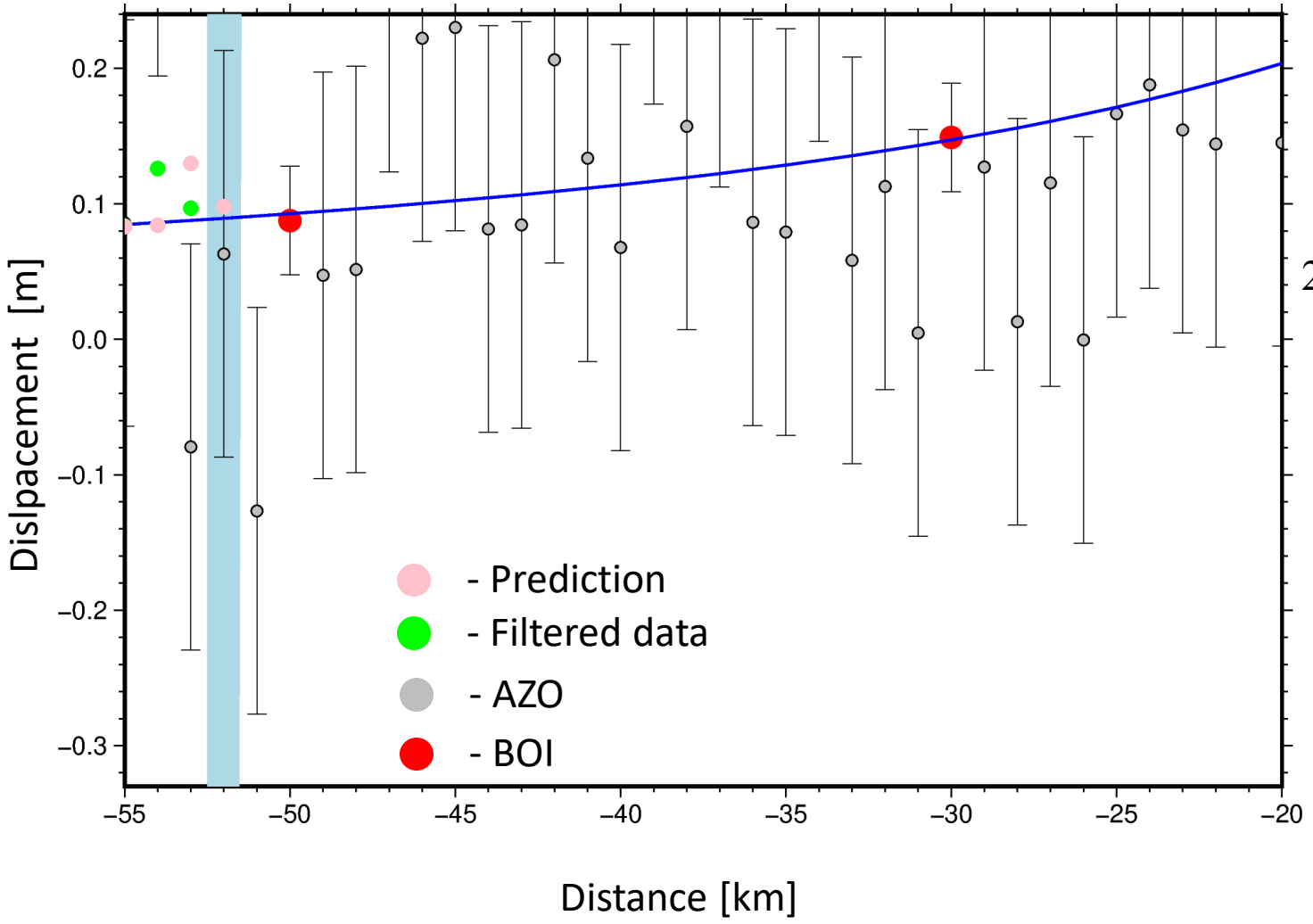


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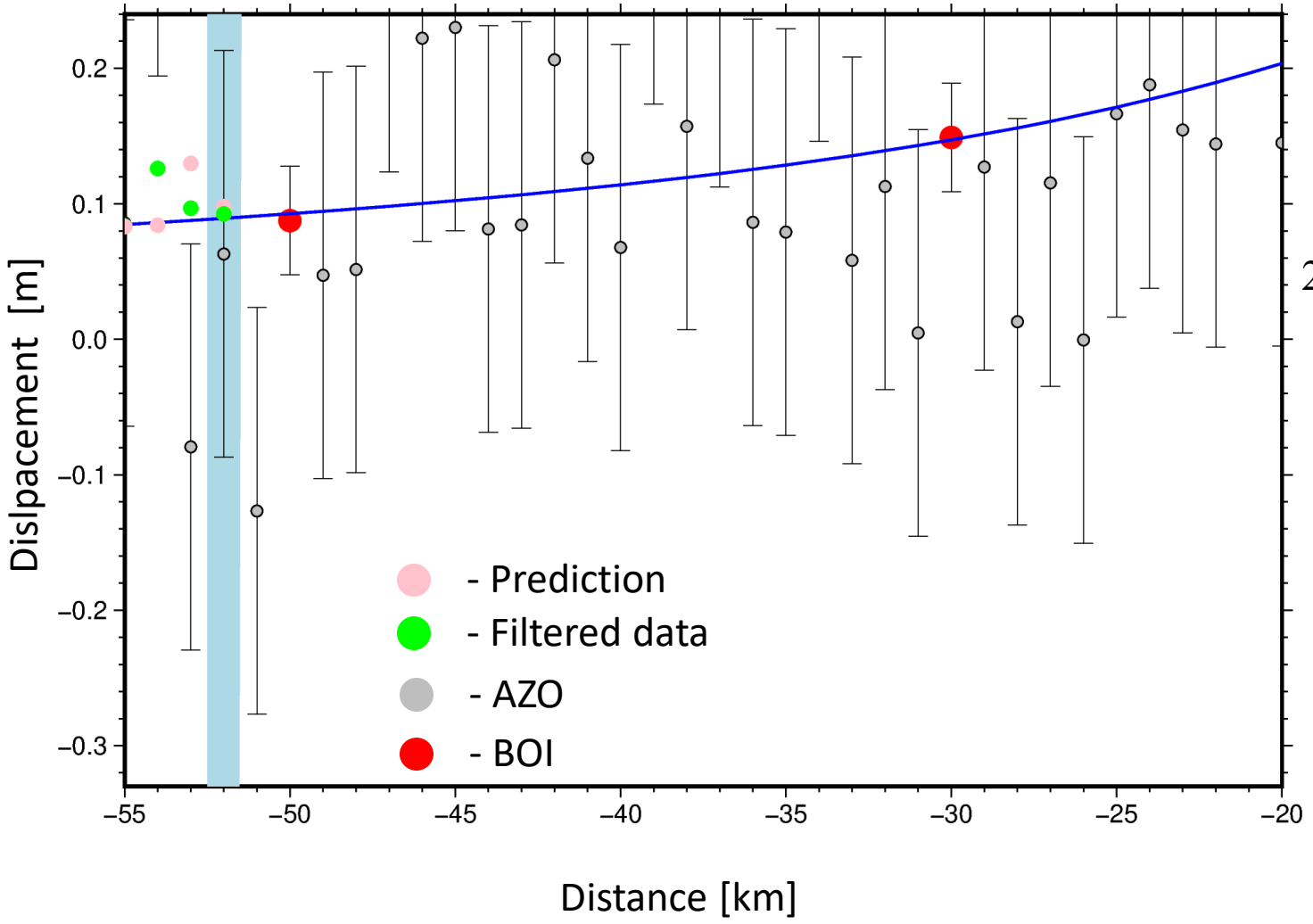


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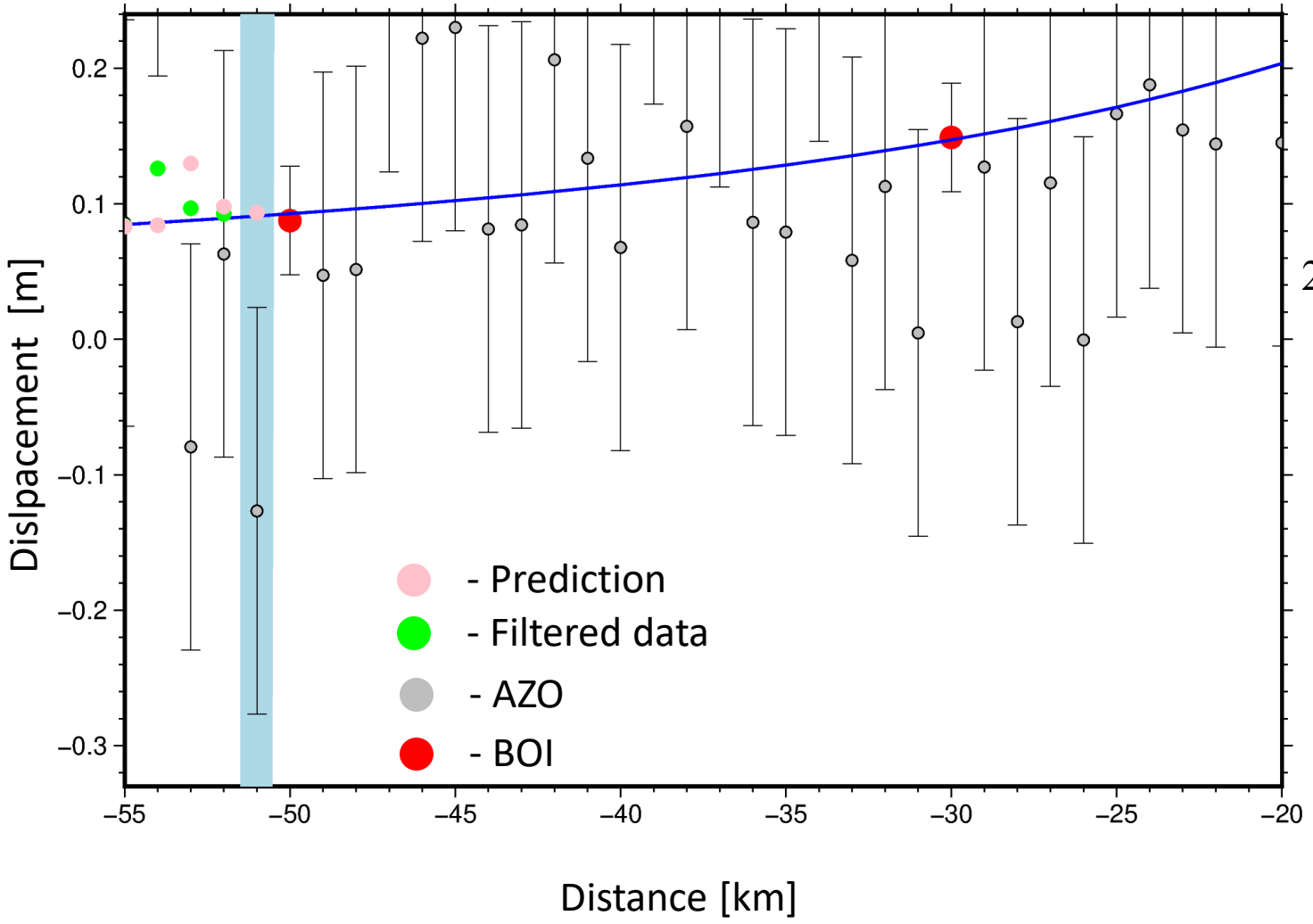


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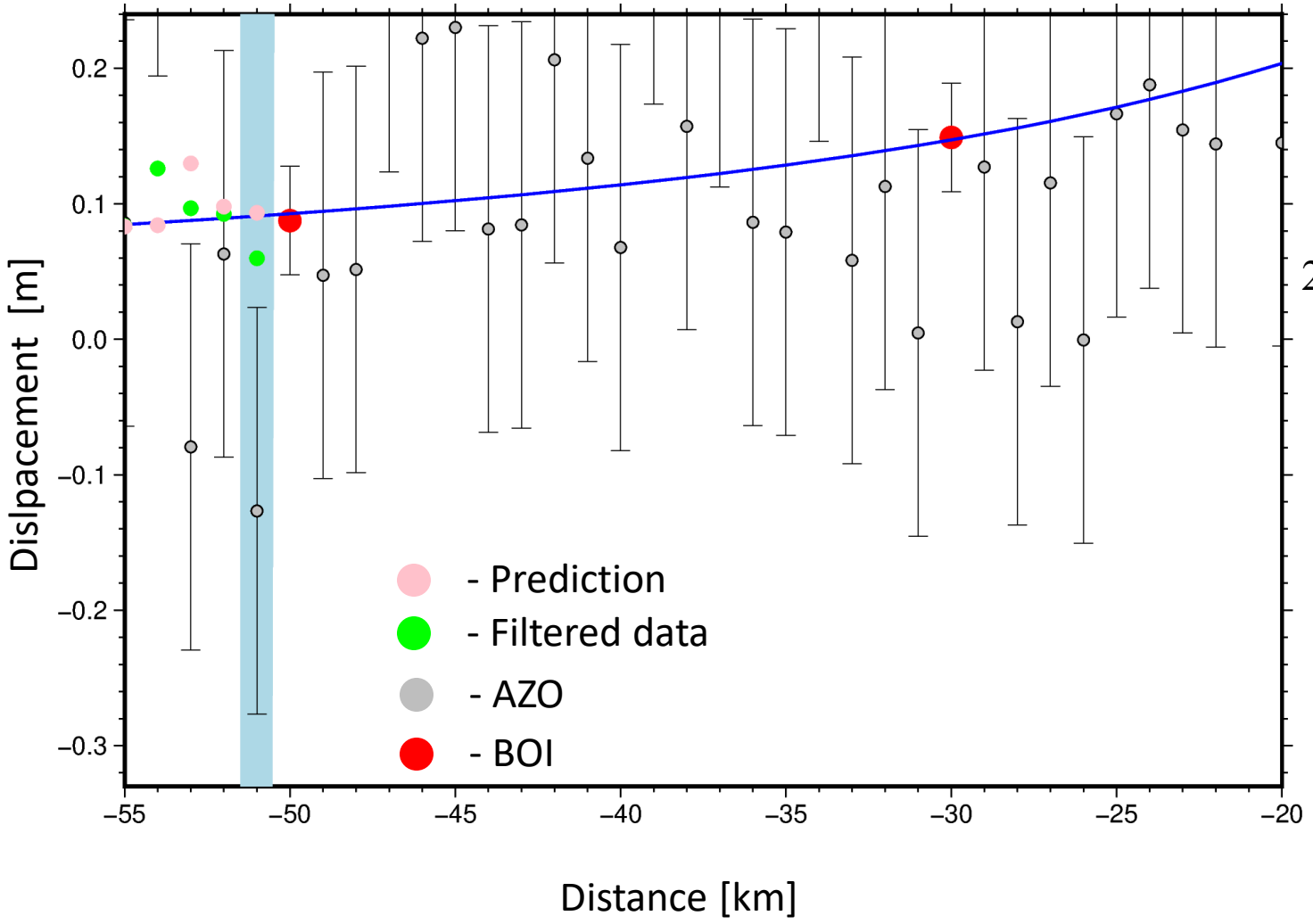


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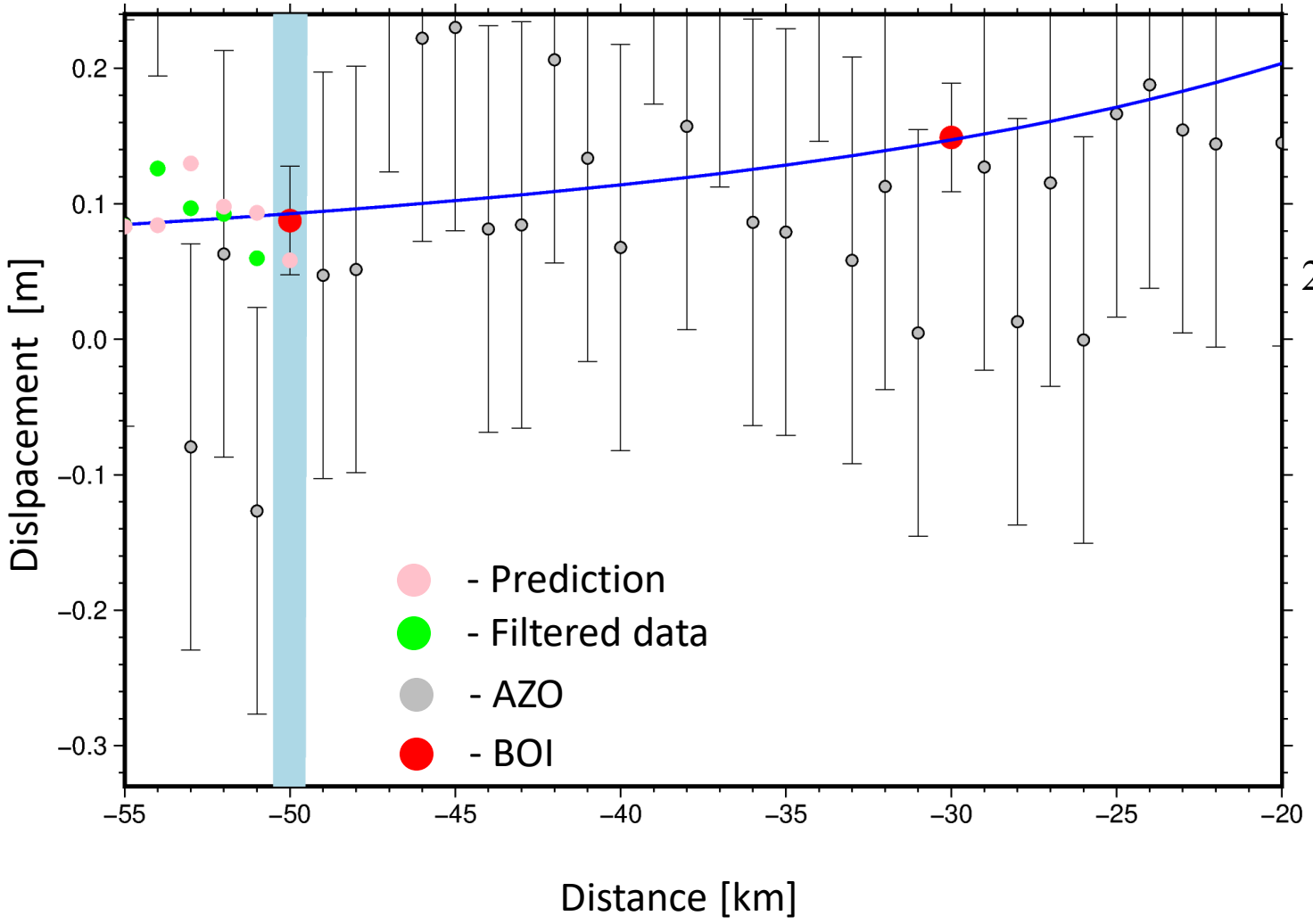


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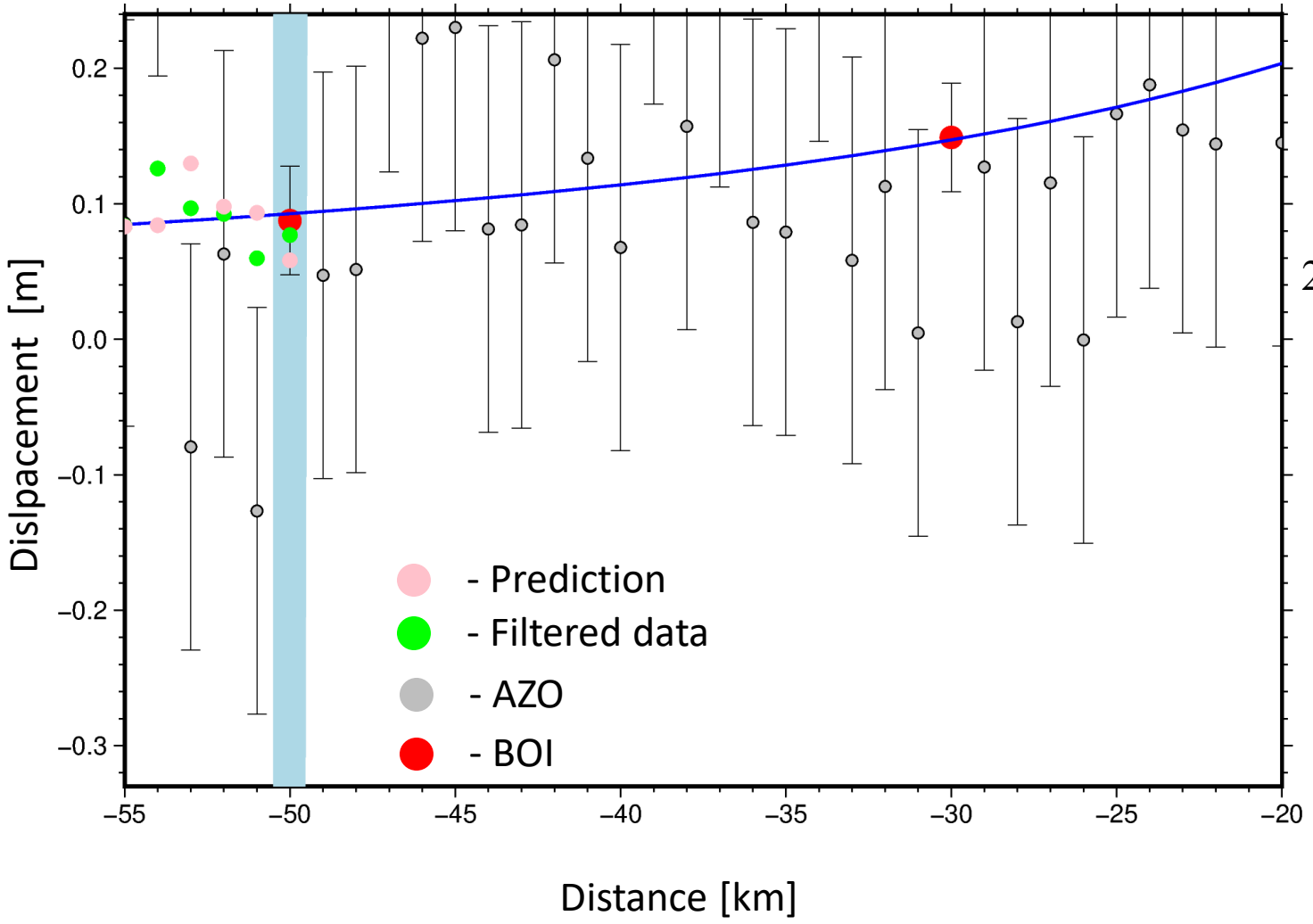


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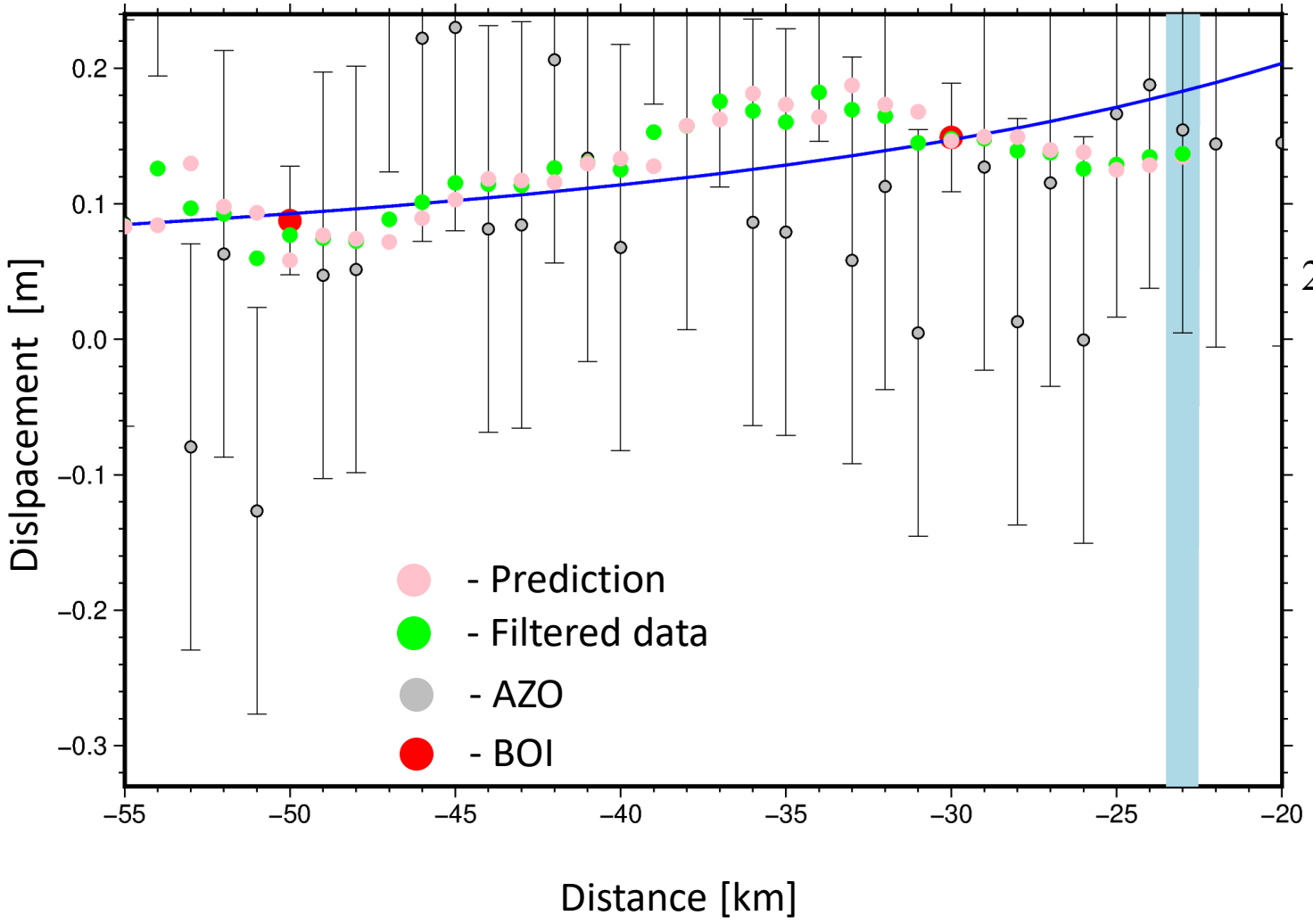


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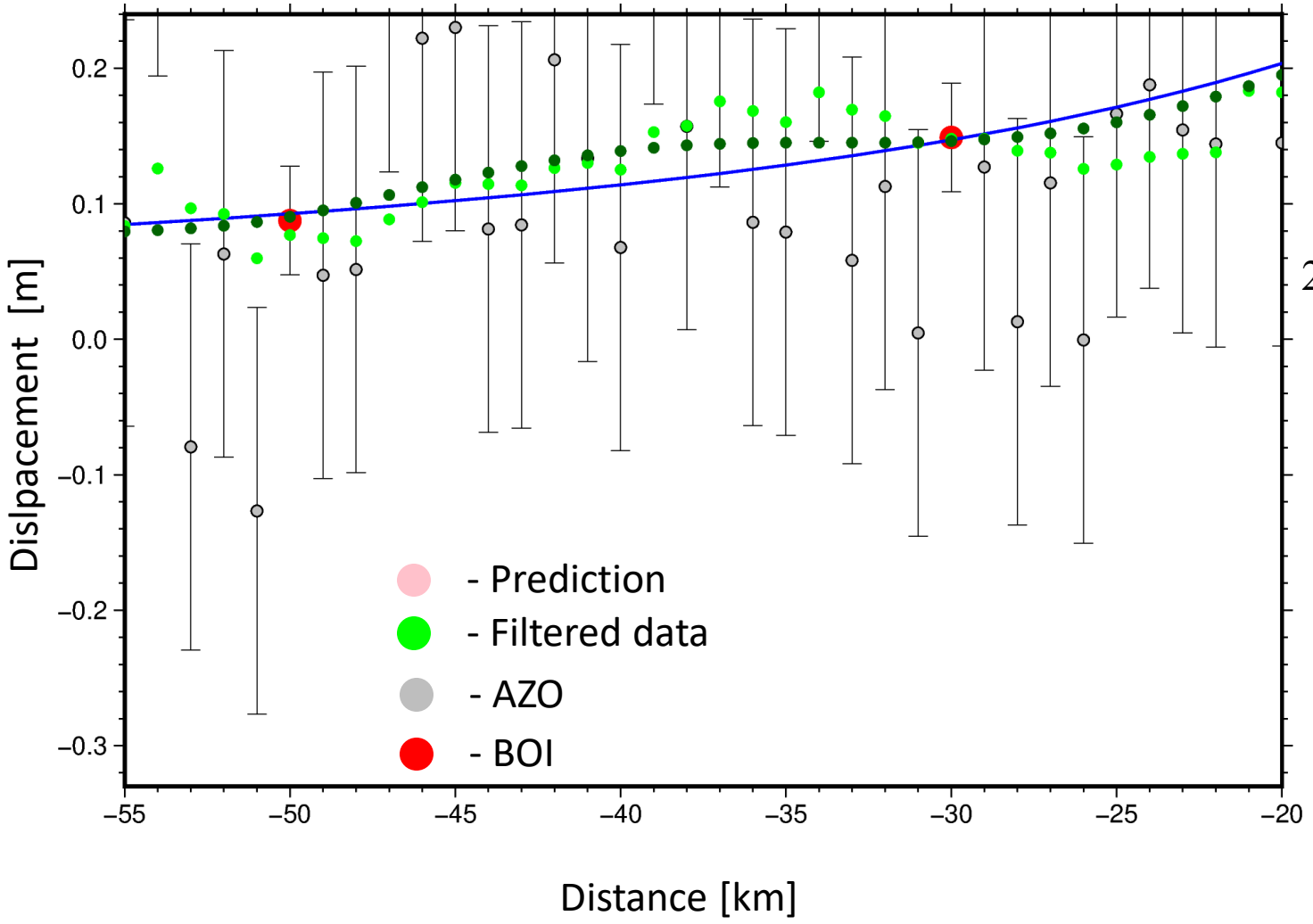


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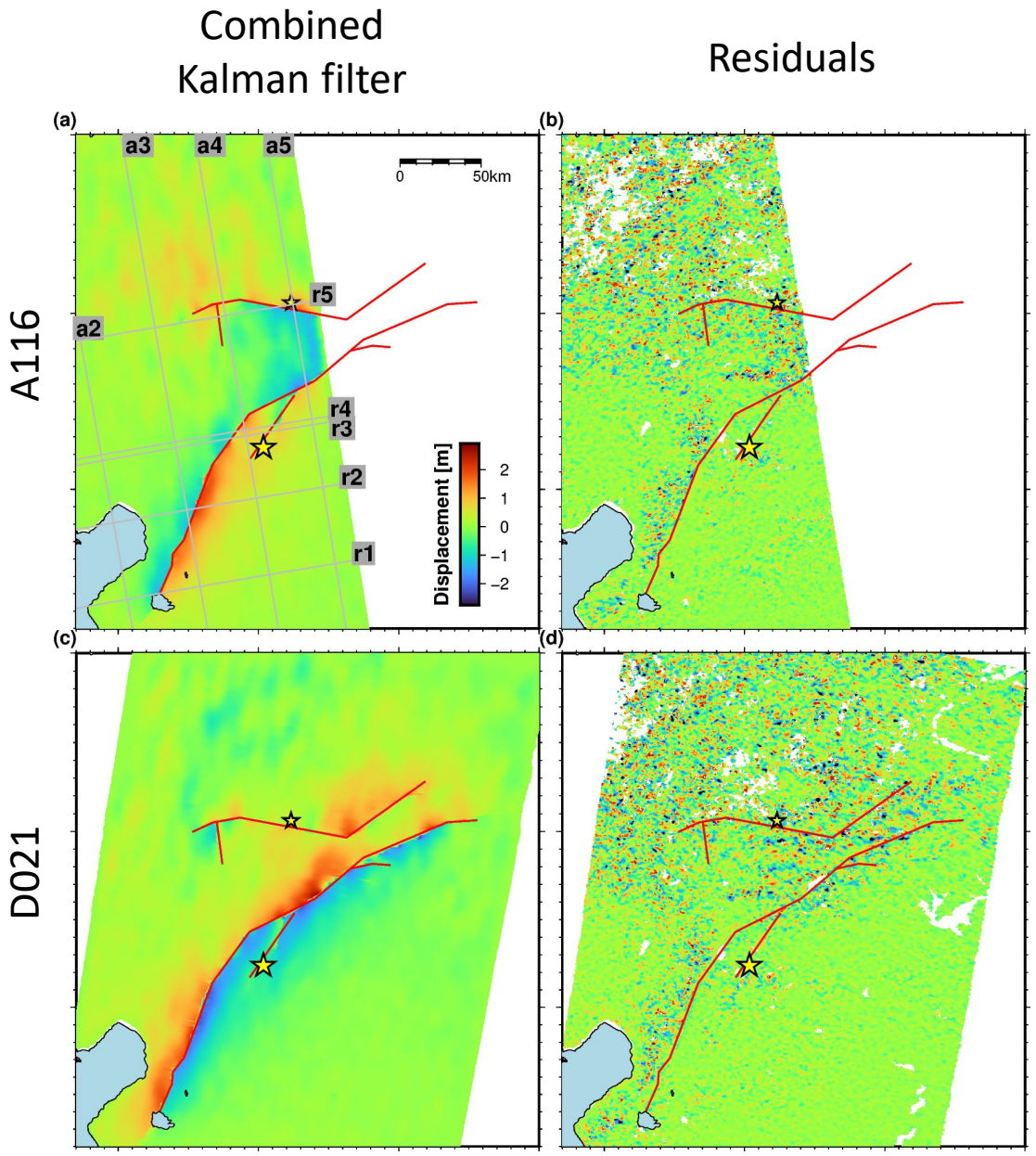
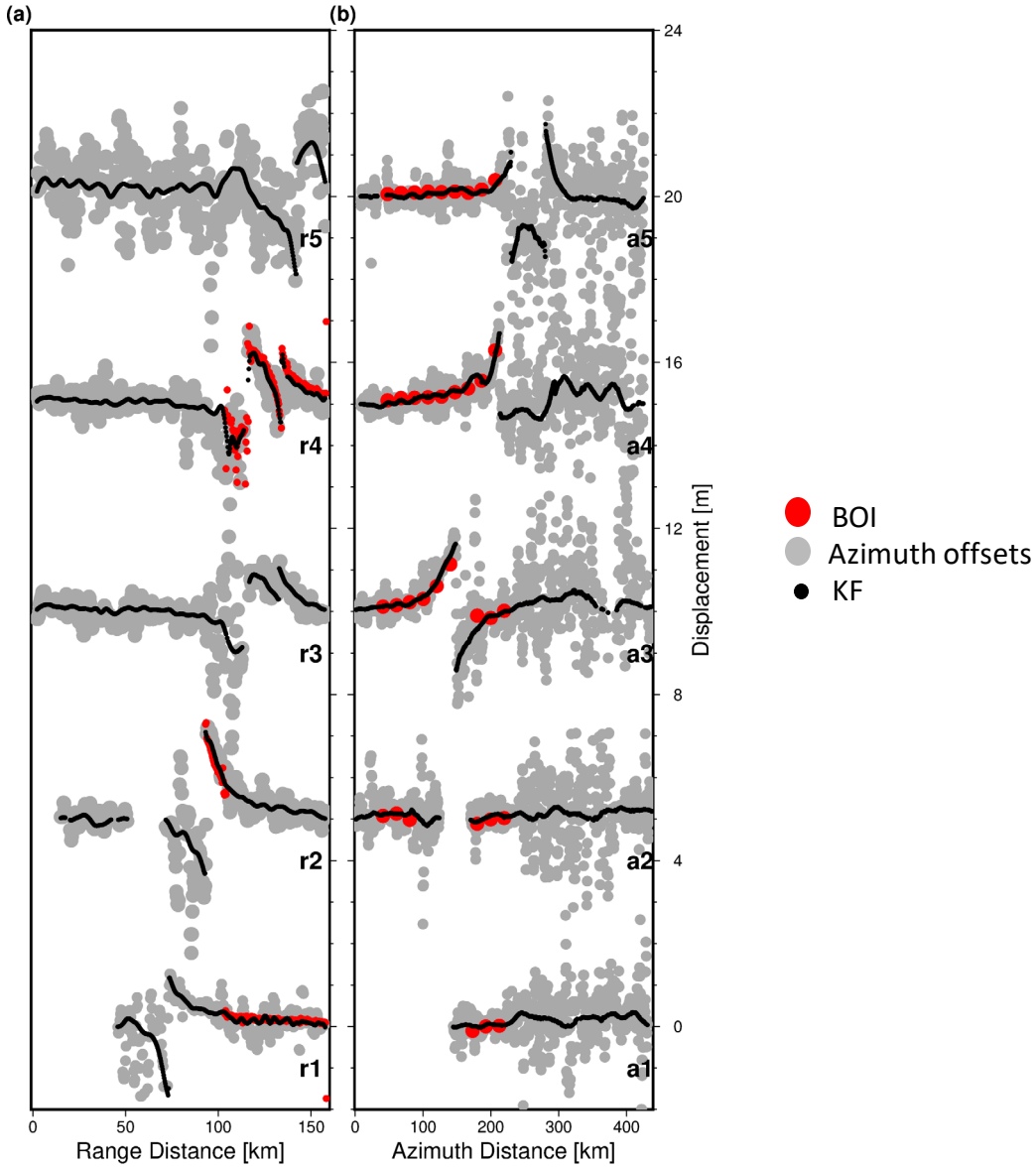
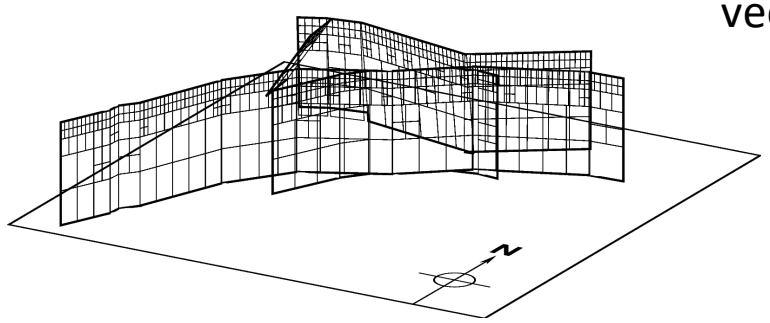
# Azimuth offset BOI integration results



# Inversion for slip distribution

3D view



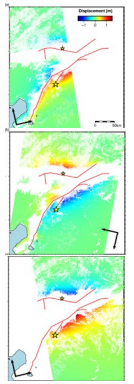
Slip vector

Data vector

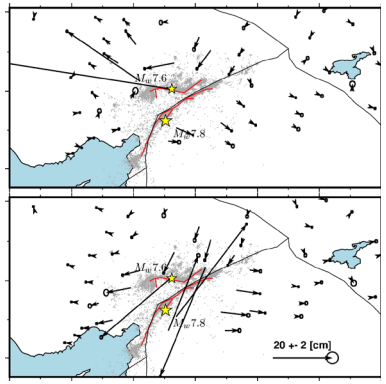
$$Am = d$$

$$\|Am - d\|_2 + \beta\|\nabla m\|_2 \rightarrow 0$$

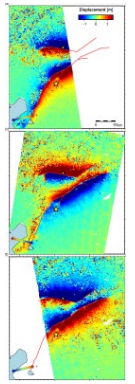
InSAR



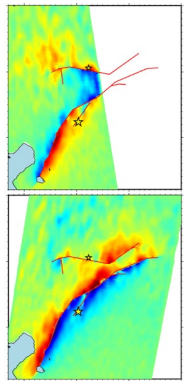
GNSS



Range offsets

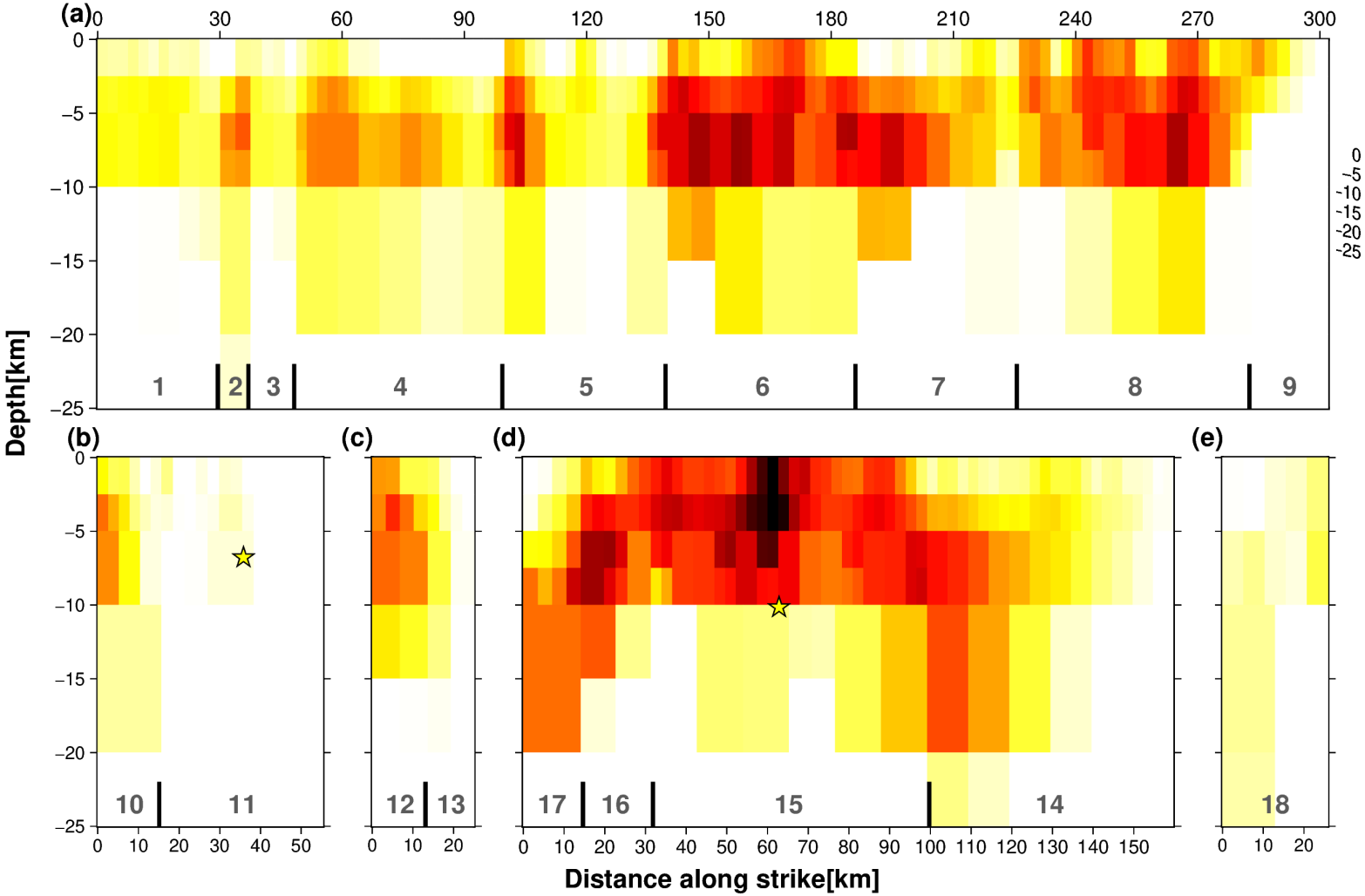


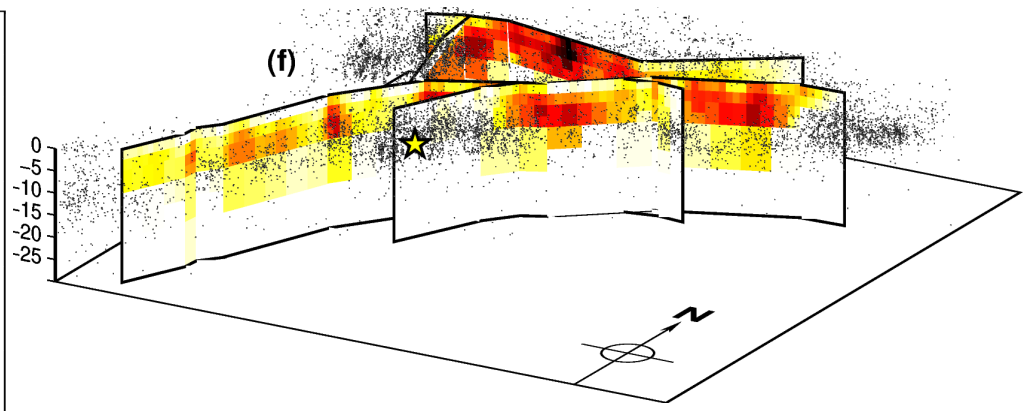
Azimuth offsets – BOI KF

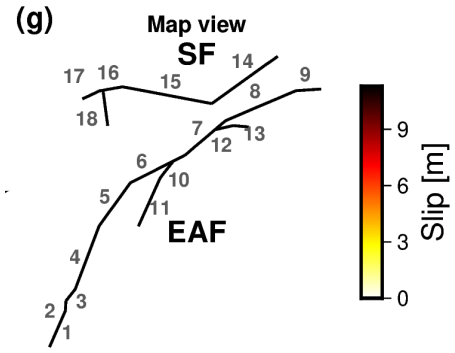


# Fault slip distribution

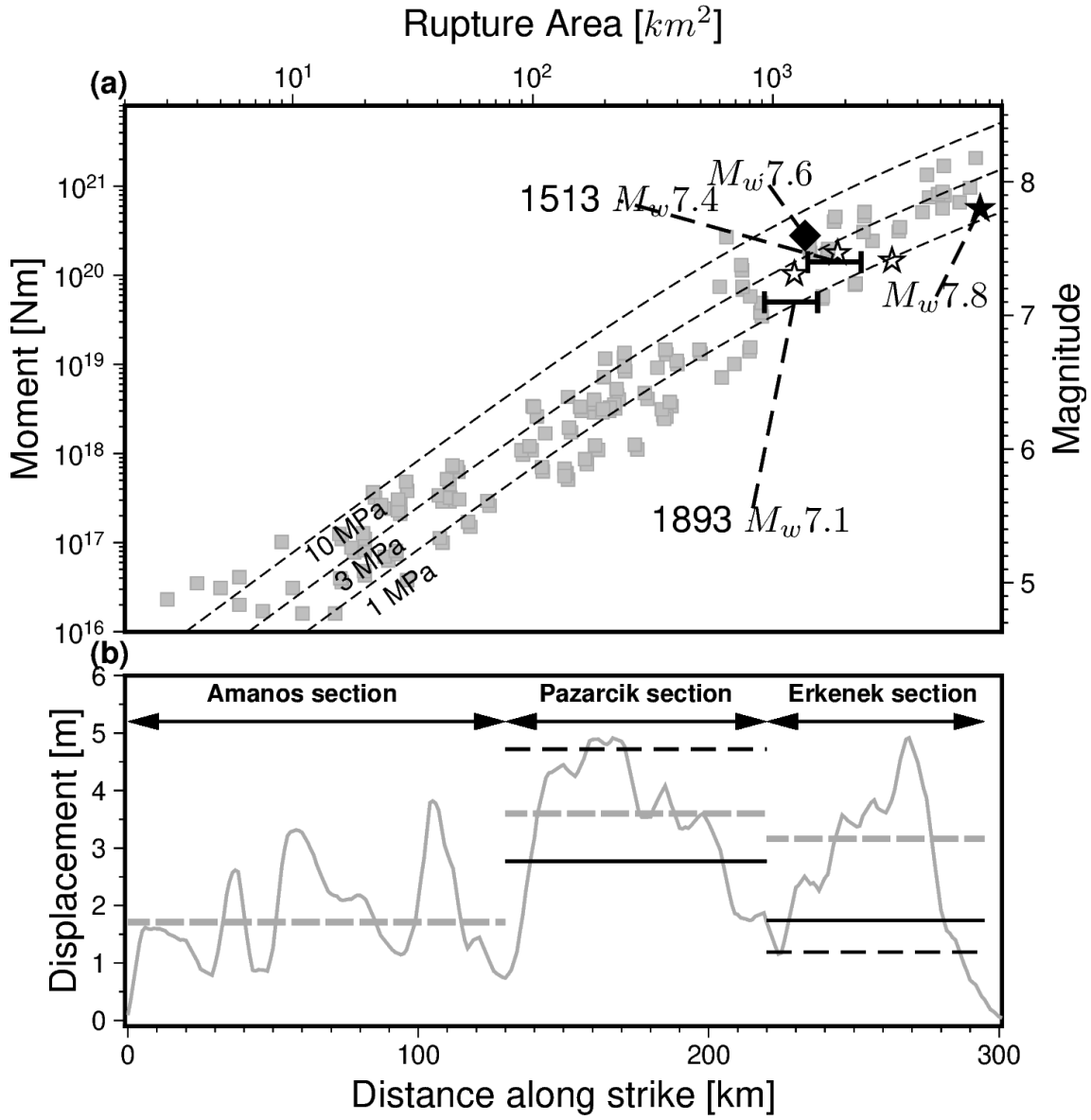
- The $M_w$7.8 earthquake on the EAF had patchy slip concentrated in 3 asperities
- The $M_w$7.6 earthquake on the SF had more regular slip distribution with peak slip of 12m
- Total geodetic moment is 10-20% higher than seismological, likely due to postseismic deformation during the SAR acquisition period.



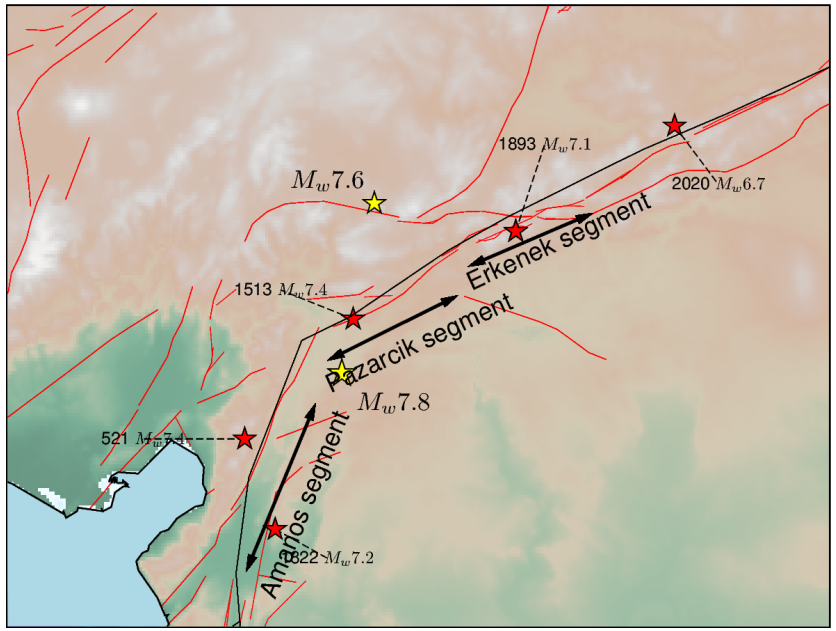



# Stress drops and a historic earthquake

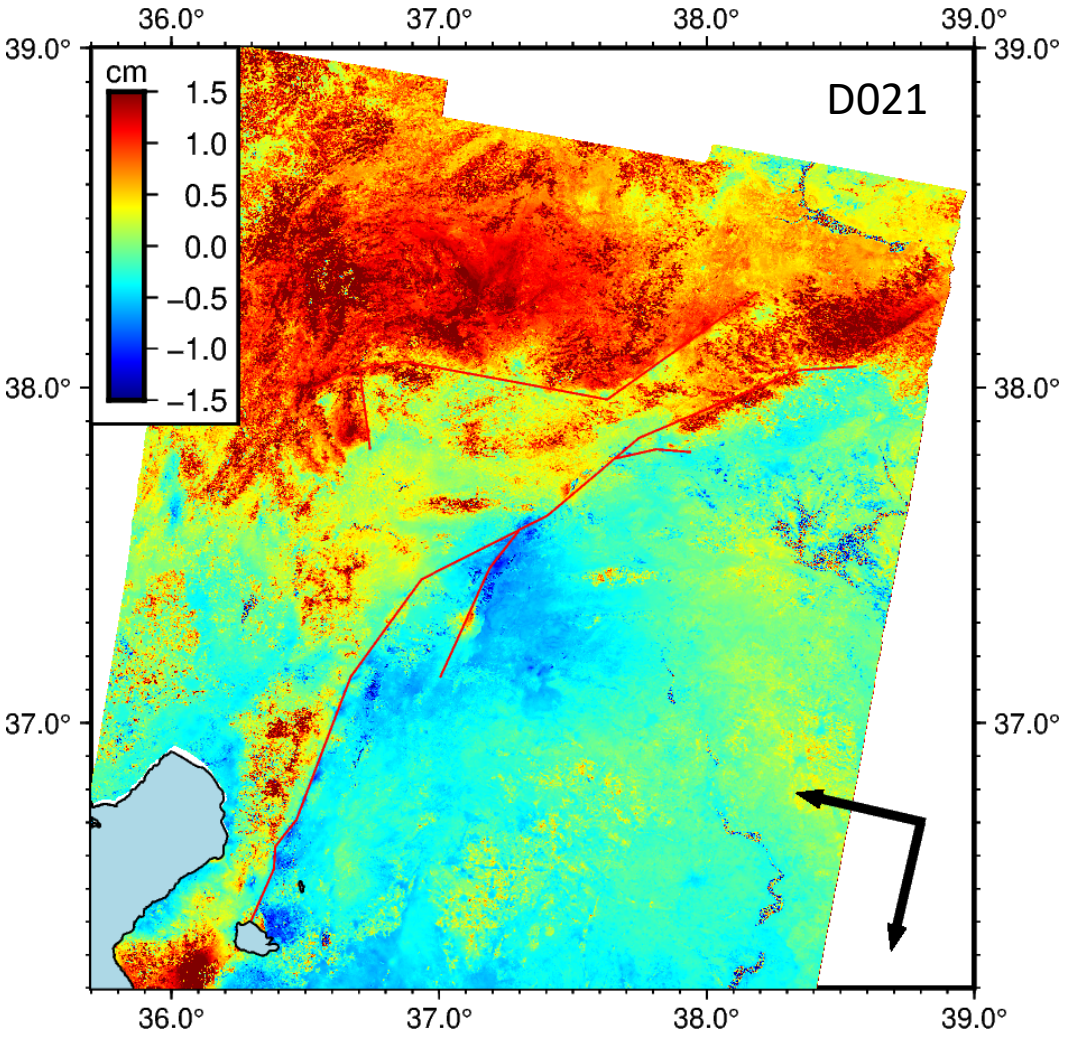


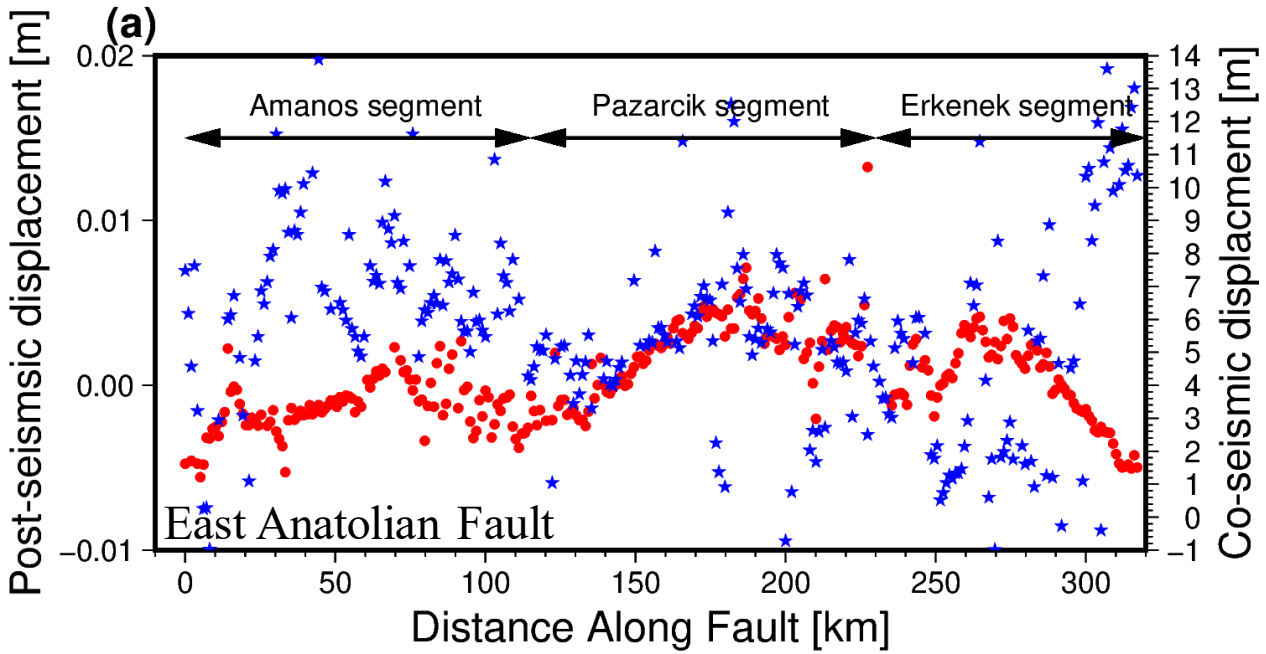

- $M_w$7.6 earthquake has 4x bigger stress drop than $M_w$7.8 earthquake.
- Previous $M_w$>7 EAF earthquakes also shows smaller stress drops.
- Likely due to longer intervals between the earthquake along the SF, aiding frictional healing.



# Post-seismic deformation

Feburary 10, 2023 – May, 5 2023




★ - Post-seismic

● - Co-seismic

# Summary

- The $M_w$7.8 southeast Turkey earthquake ruptured multiple fault segments of the East Anatolian Fault Zone over ~300 km rupture. The $M_w$7.6 earthquake ruptured the Sürgü Fault over ~160 km rupture.
- A new Kalman filter approach is introduced to merge AZO and BOI data to improve displacement precision along the satellite path direction.
- Joint inversion reveals patchy $M_w$7.8 slip distribution with 3 large asperities, and more uniform $M_w$7.6 slip with higher peak slip indicating larger stress drop.
- Moment released on the $M_w$7.8 fault segments is 2-4 times larger than historical earthquakes on individual segments, suggesting underestimation of hazard by simple seismic moment summation.
- Post-seismic deformation follows co-seismic and geological segmentation patterns