



Türkiye's Recent Earthquakes, and What They Can Teach Us About Preparation and Response Here



**Eric Sandvol¹, Ekrem Zor², Mehmet Ergin², Oguzhan Yalvac¹,
Mustafa Cengiz Tapirdamaz², Phuc Mach³, Chang Ding³, Adil
Tarancioglu², Fatih Sevim², and Zhigang Peng³**

¹University of Missouri, Columbia, Missouri, USA

**²TUBITAK, The Scientific and Technological Research Council of Türkiye,
Marmara Research Center, Earth and Marine Sciences Institute, Türkiye**

³Georgia Institute of Technology, Atlanta GA USA

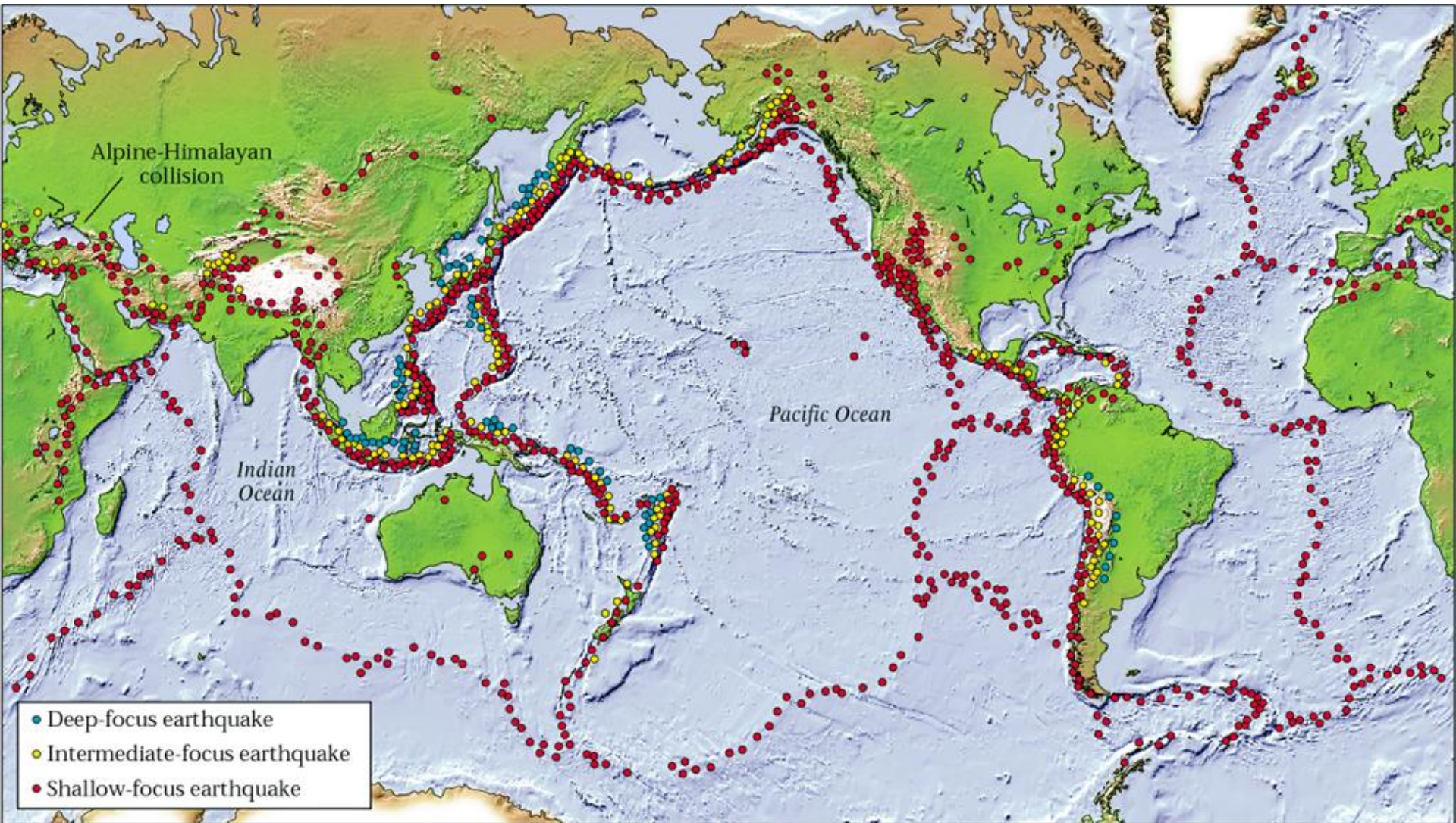


Outline

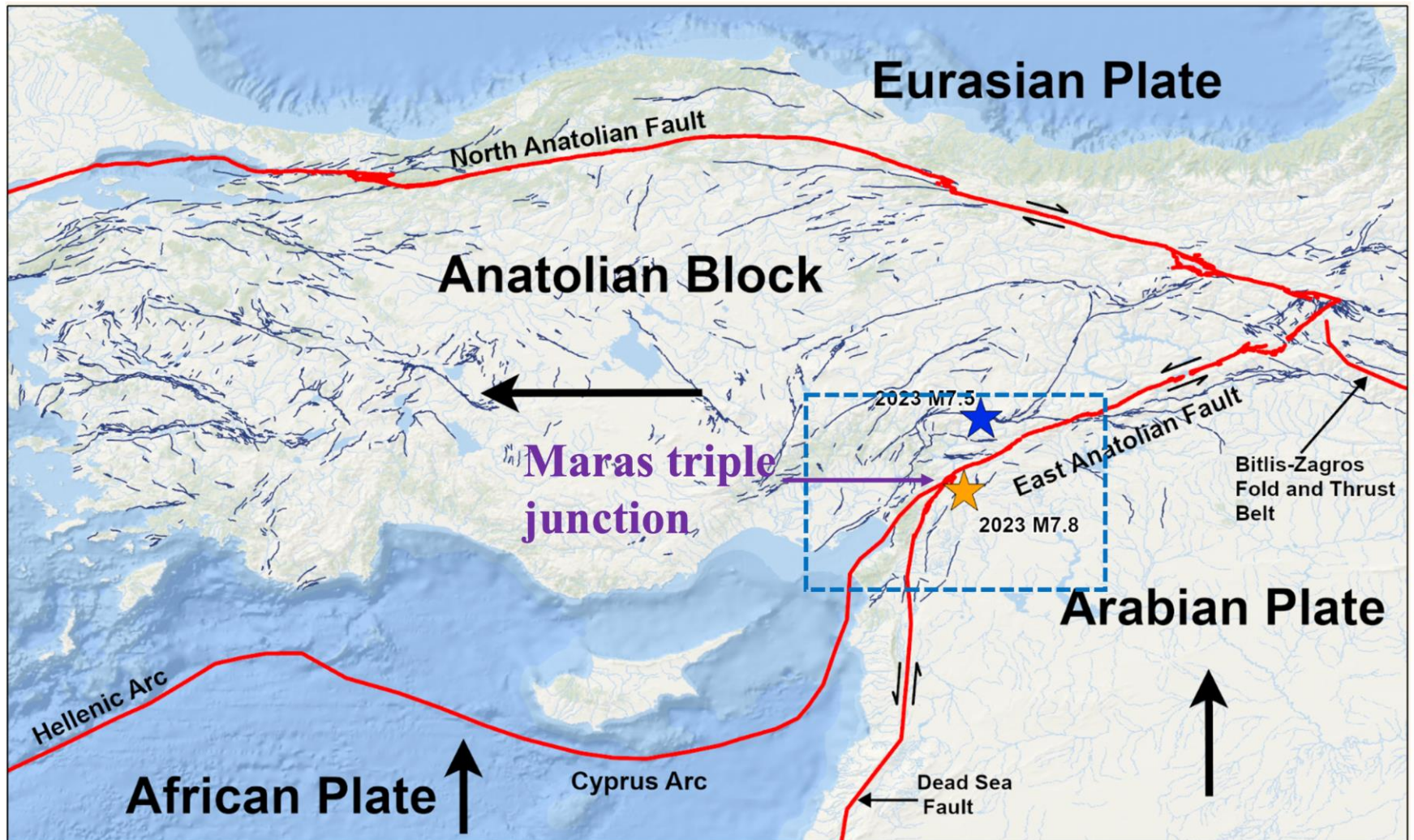
- I. Introduction to the Kahramanmaras Earthquakes
- II. Some Comparisons of the New Madrid and Kahramanmaras Earthquakes
 - A. Earthquake Sequences and stress triggering
 - B. Ground motions in the Amik Basin and Mississippi Embayment
- III. 2023 Rapid Aftershock Deployment



Earthquake Locations:

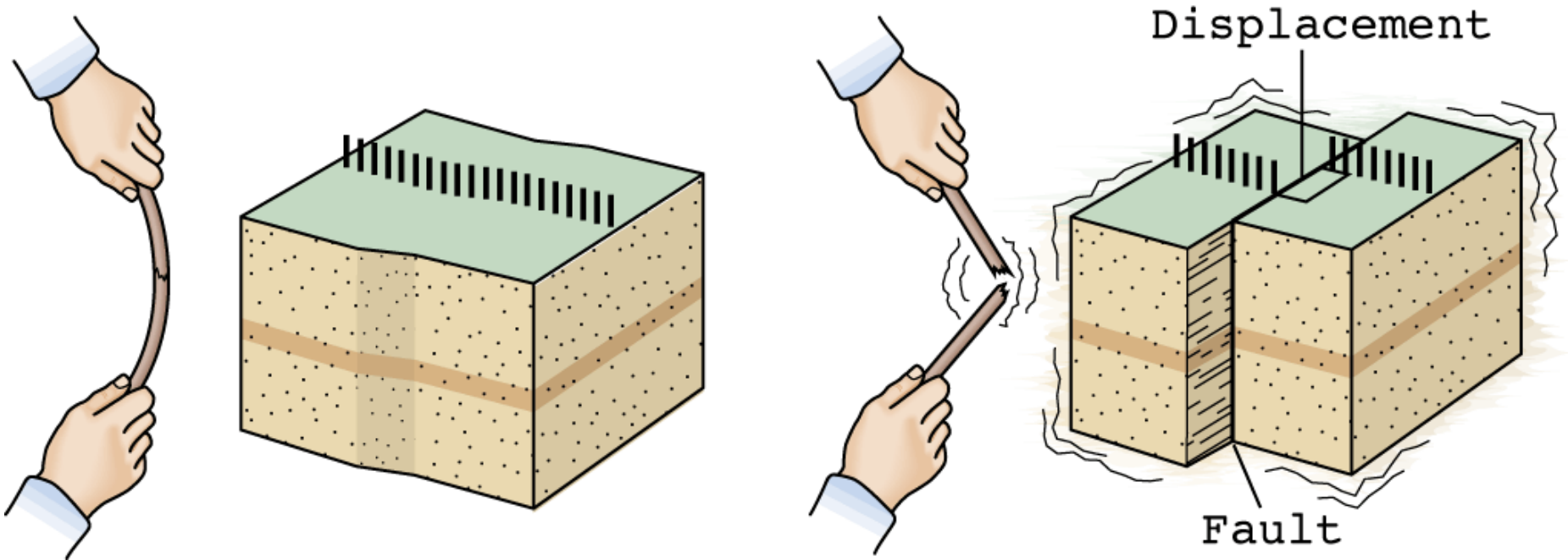


Differences between the NMSZ and EAFZ



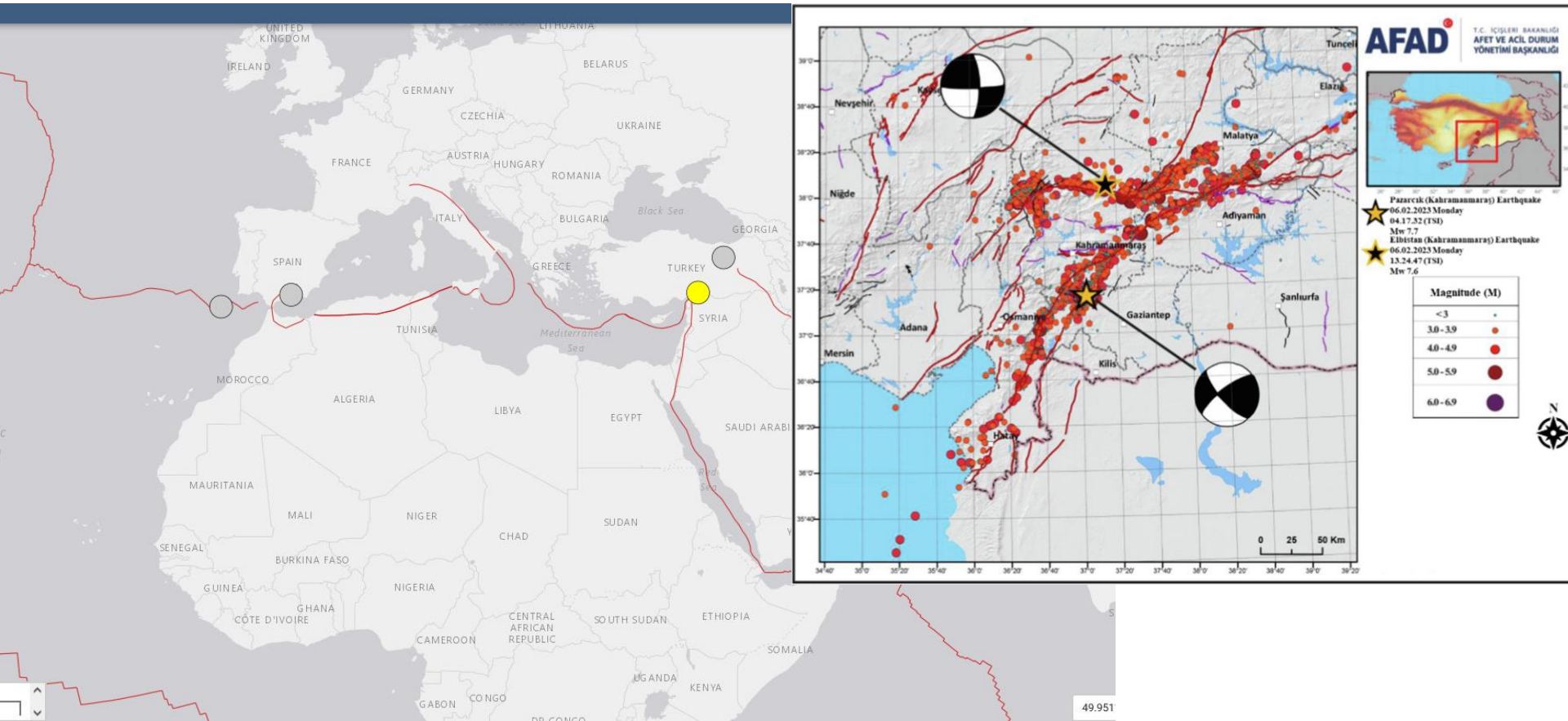
What is an Earthquake?

Earthquakes occur when the earth's crust
“breaks” along a fault

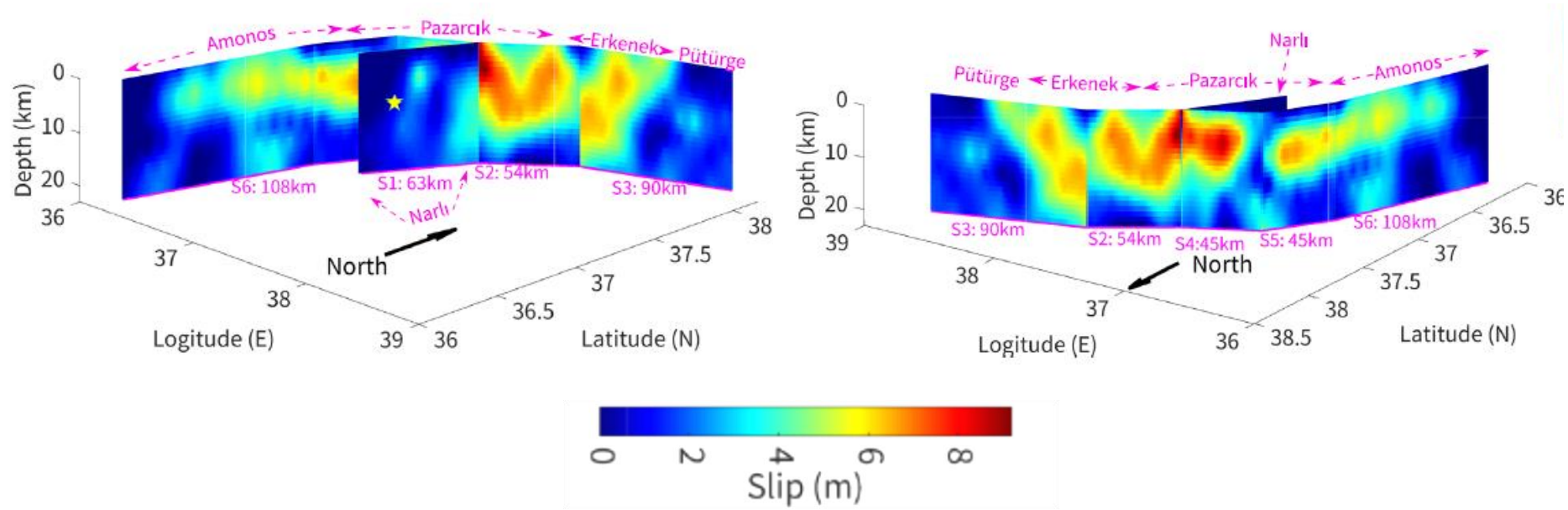
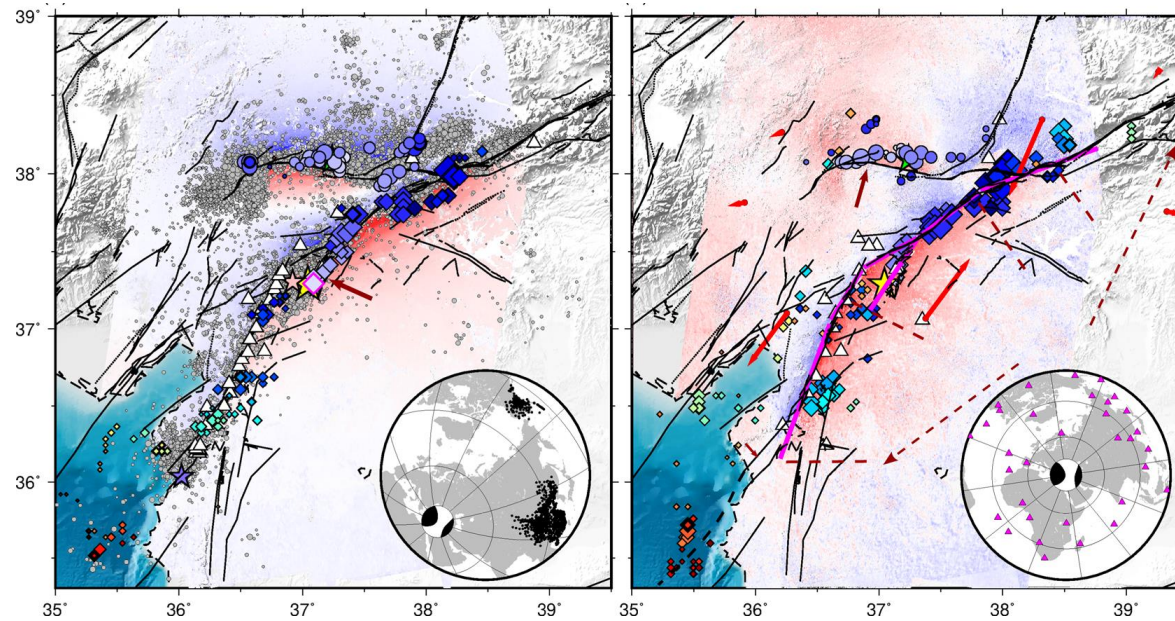


This process generates waves that travel through
the earth called seismic waves

February 6th, 2023 Kahramanmaraş Earthquake Sequence







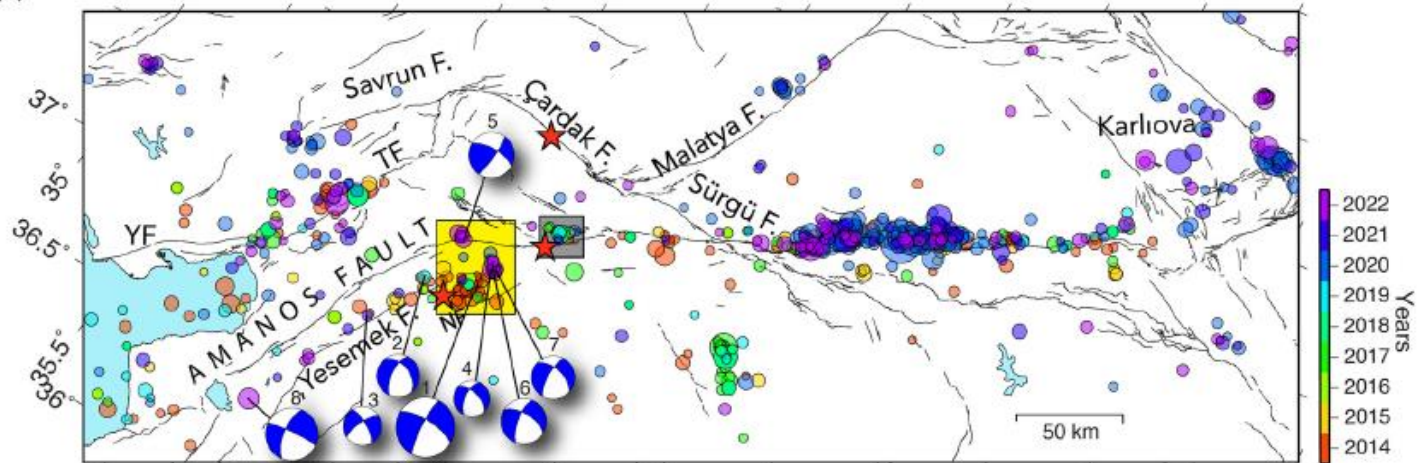
Xu et al., 2023



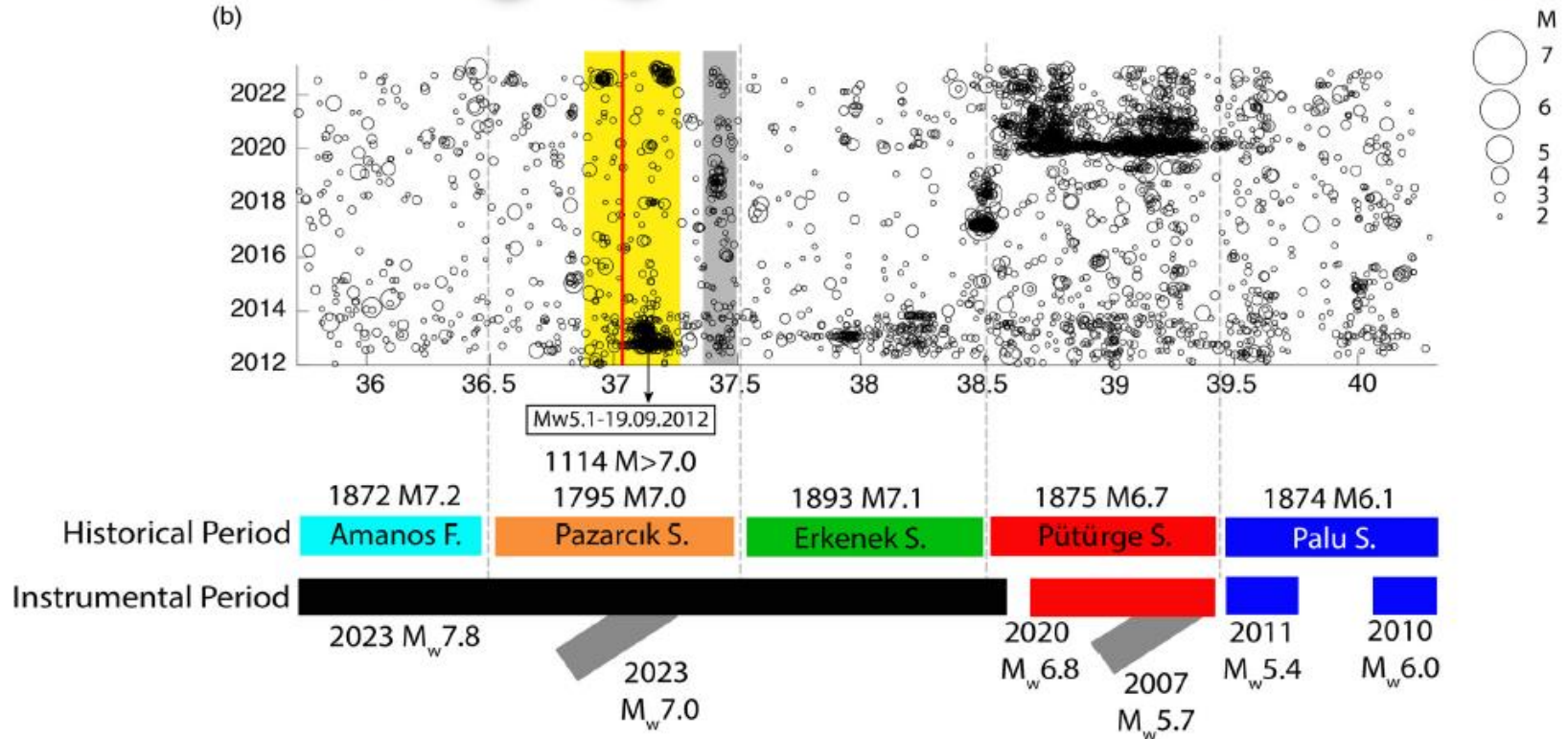


Historical Seismicity Along the EAFZ

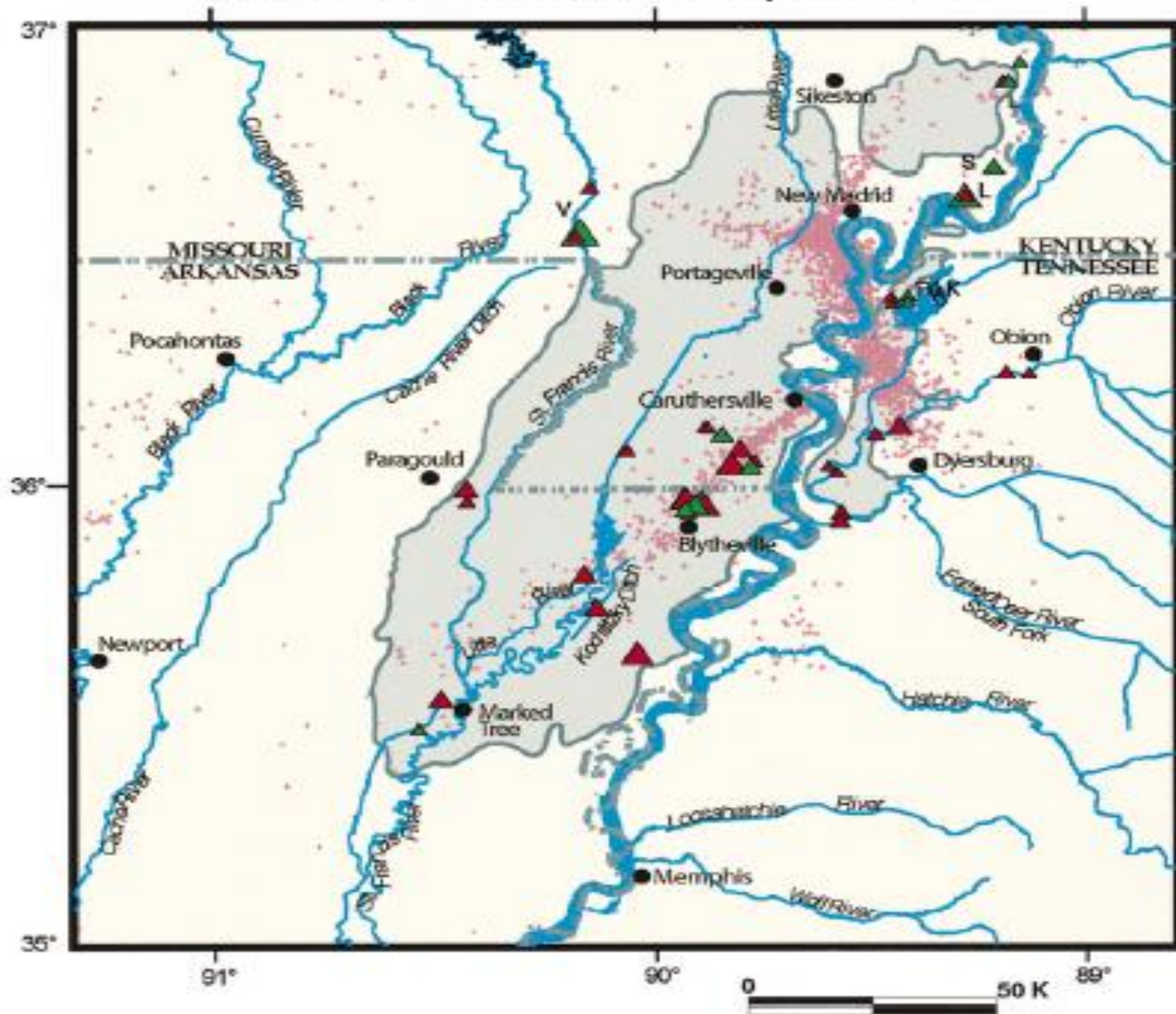
(a)

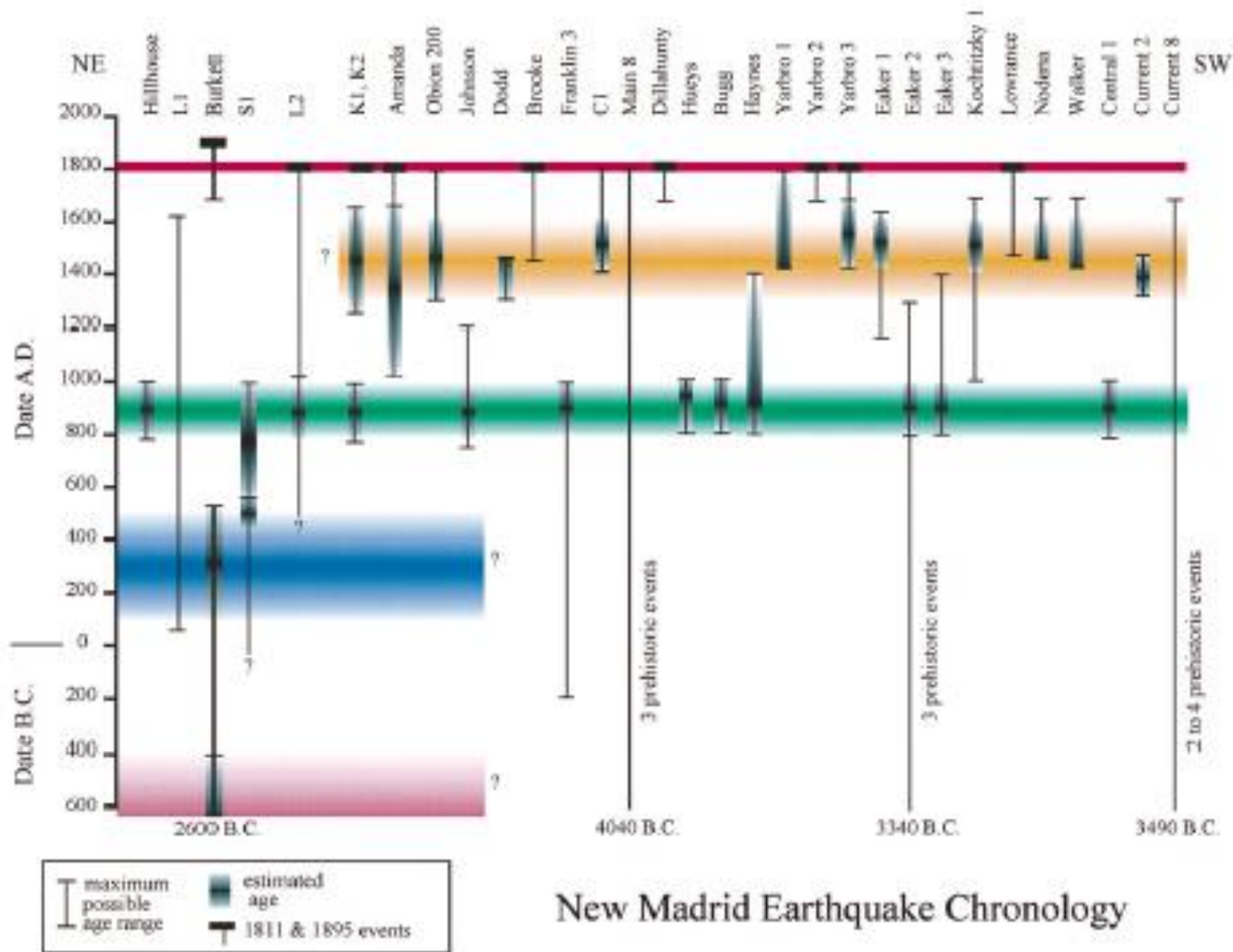


(b)



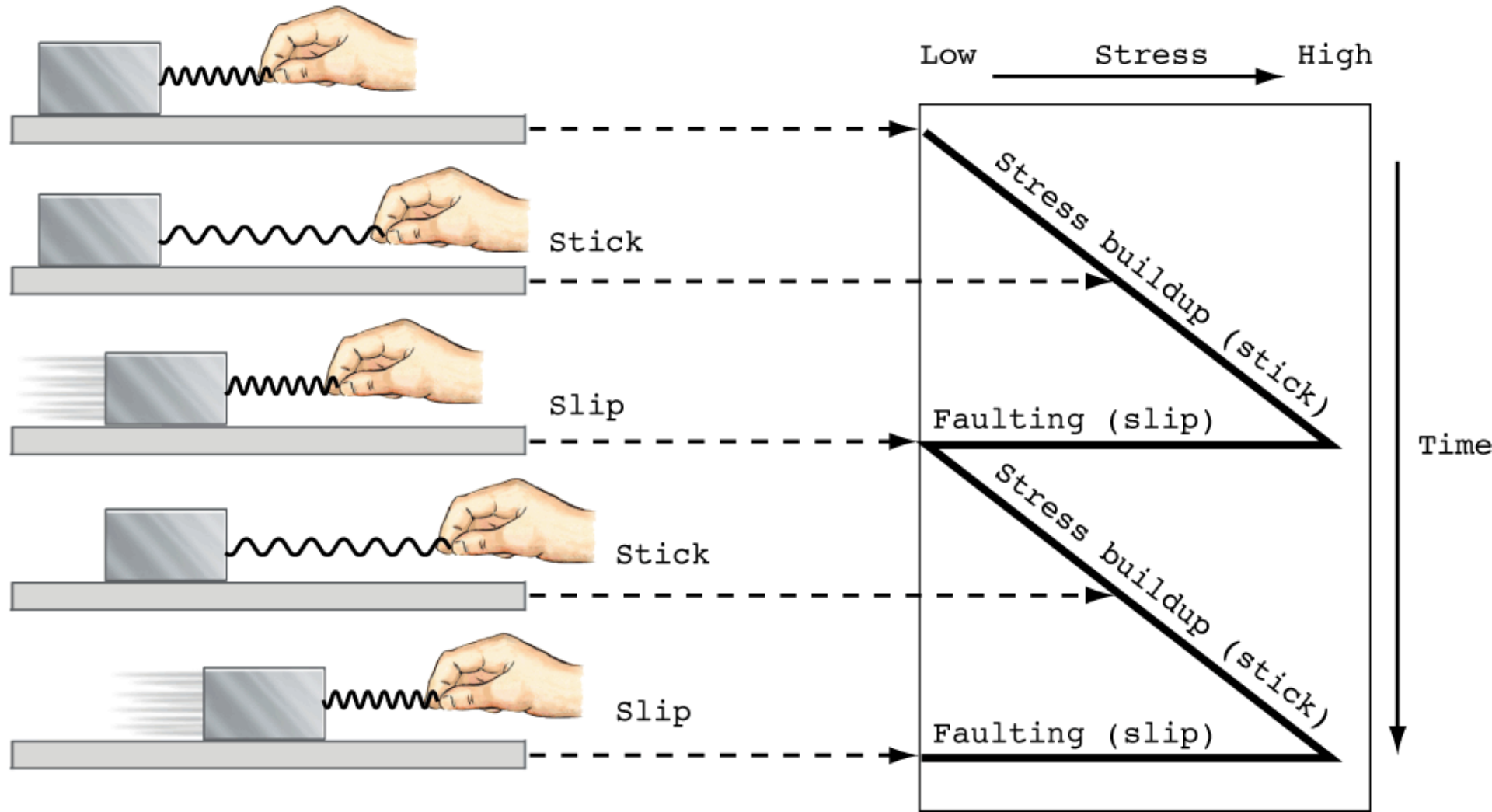
A.D. 900 and 1811-1812 Earthquake Features



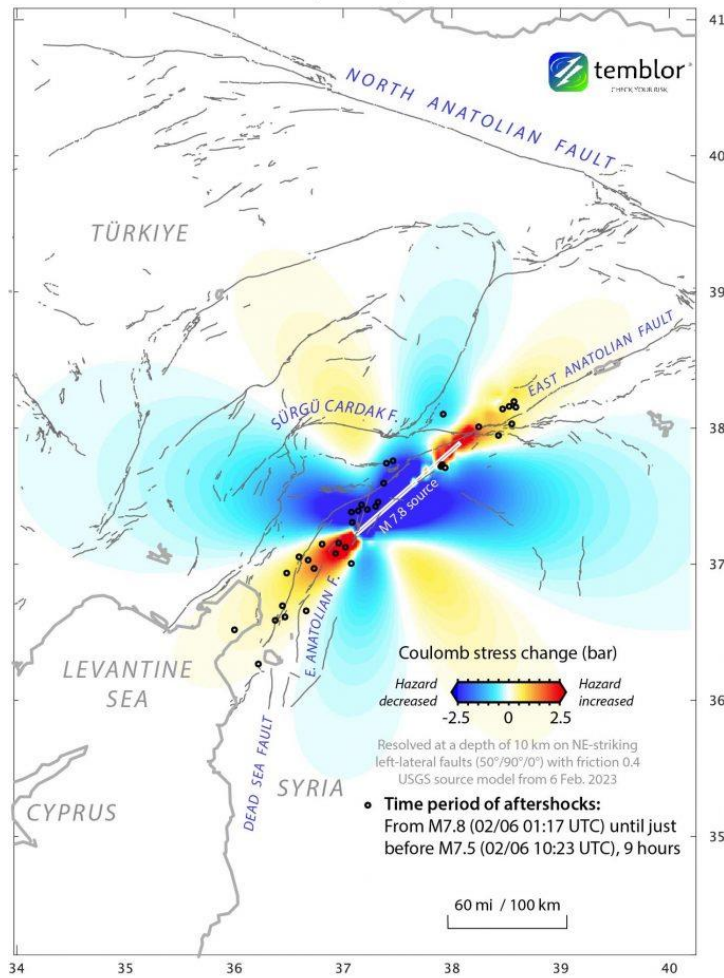


Tuttle et al., 2002 SSB

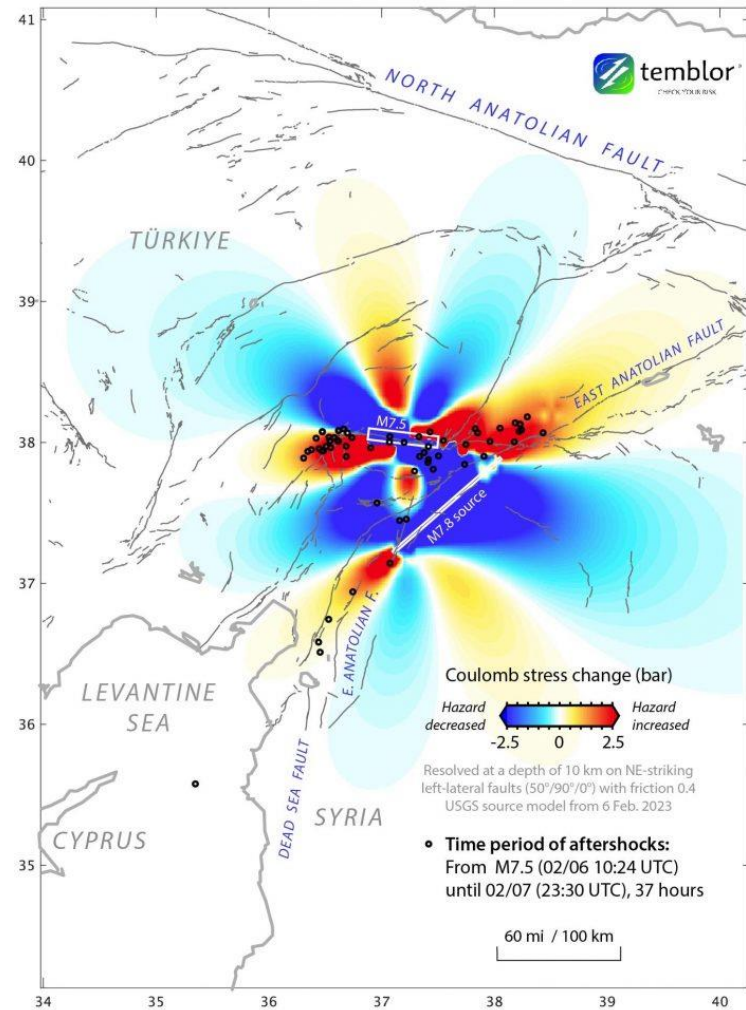
Forecasting Earthquakes: The Earthquake Cycle



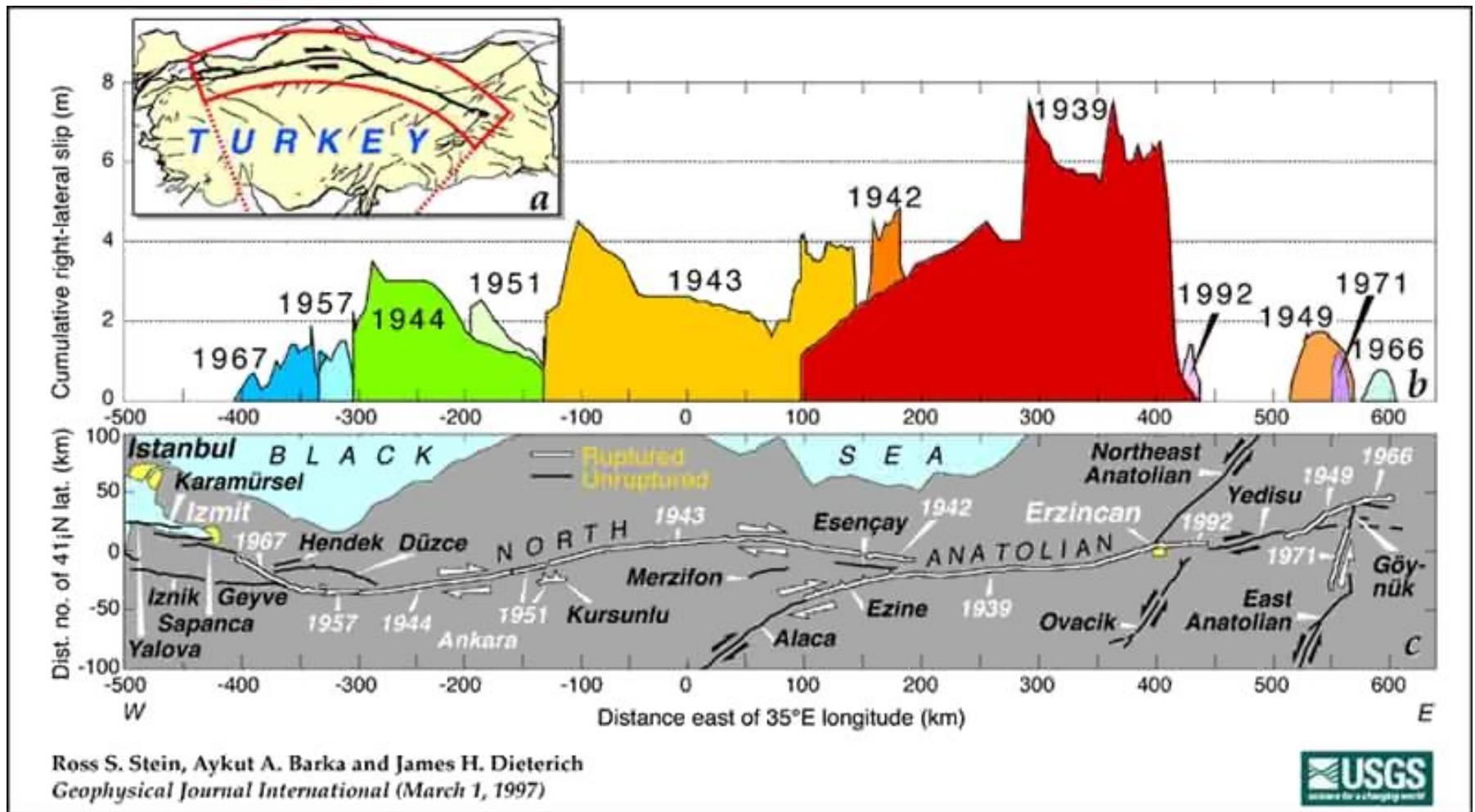
Calculated stress imparted by M 7.8 mainshock



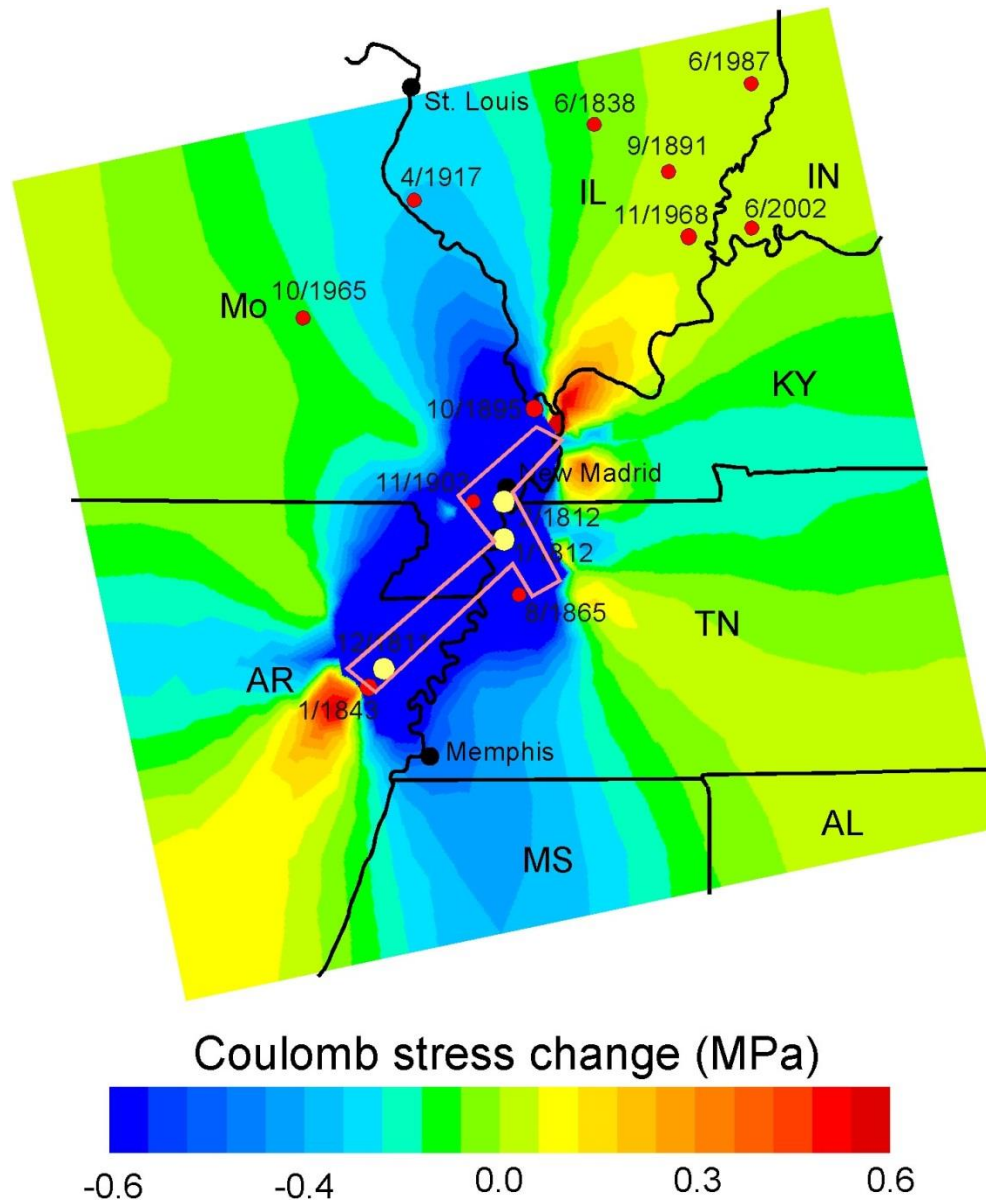
Calculated stress imparted by M 7.8 and M 7.5 shocks



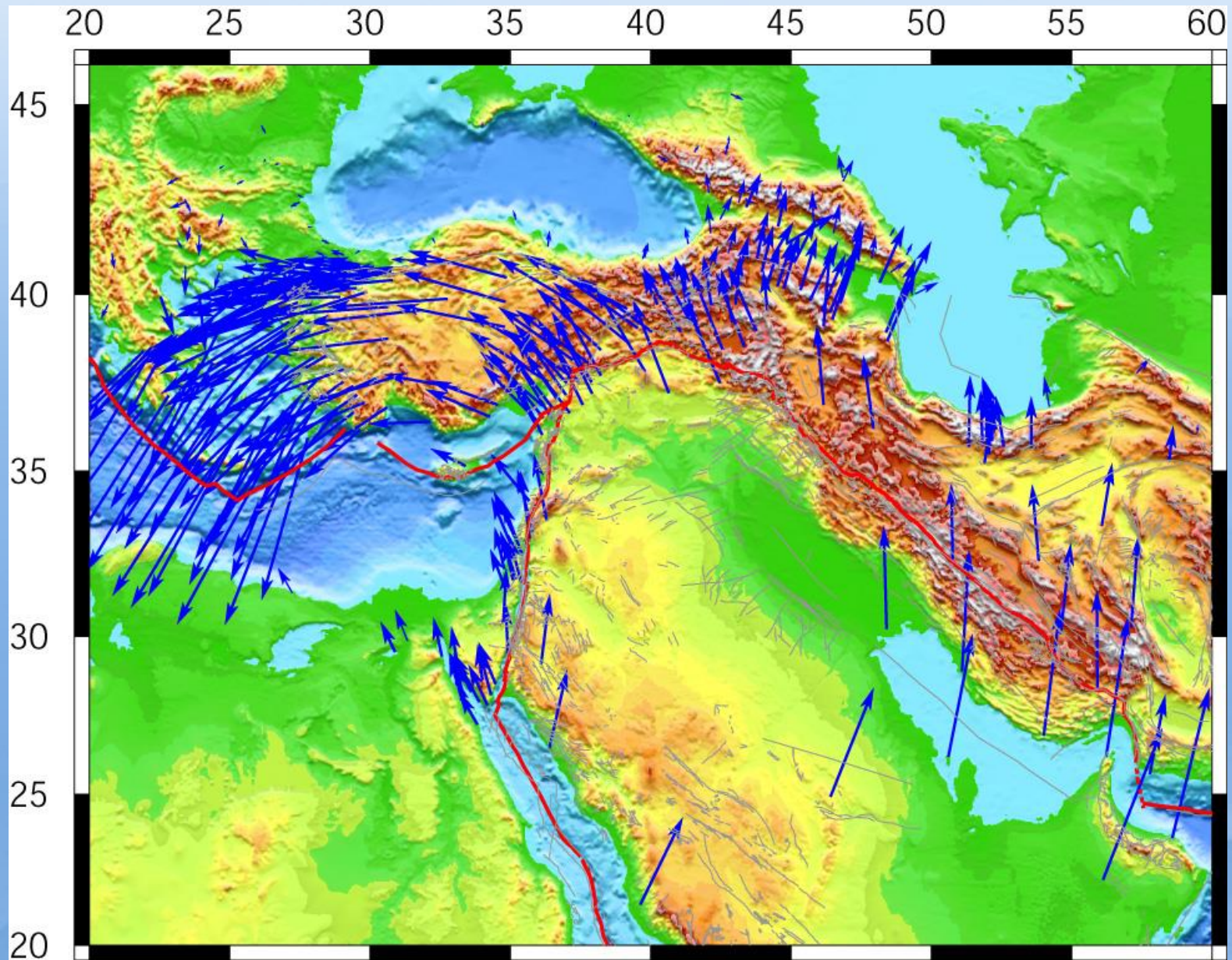
An analog for these events and a window into the future?



Predicted change of Coulomb stress change 200 year after the 1811-1812 events

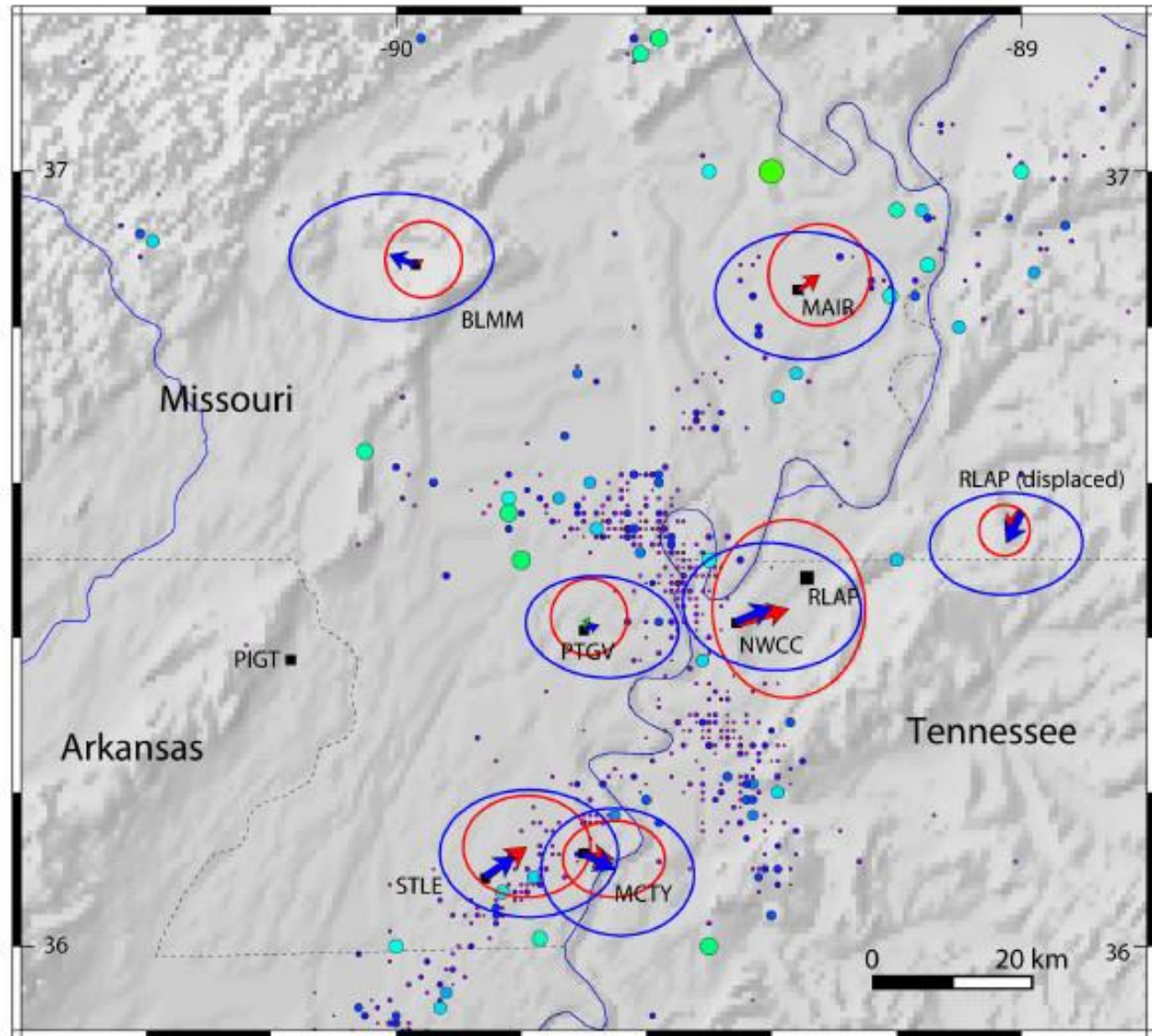


GPS Vectors (Reilinger et al., 2006)

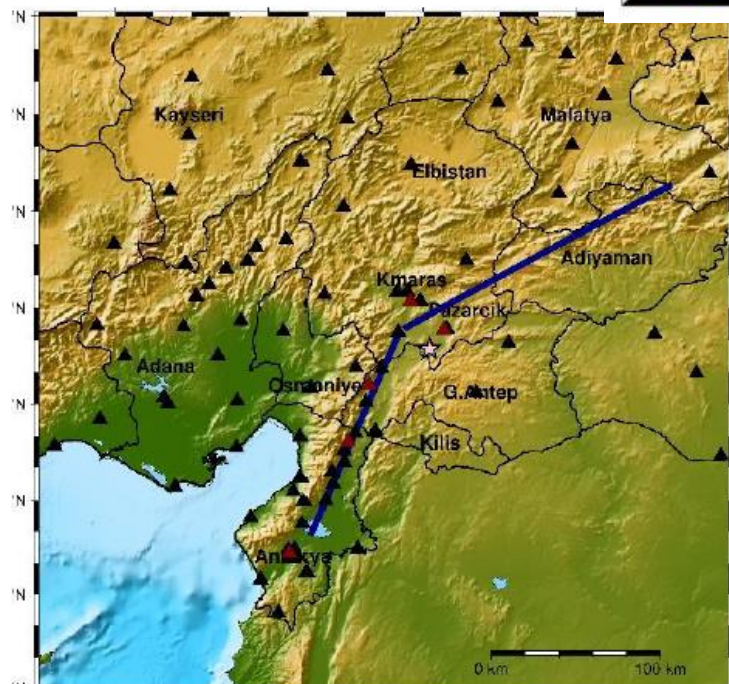
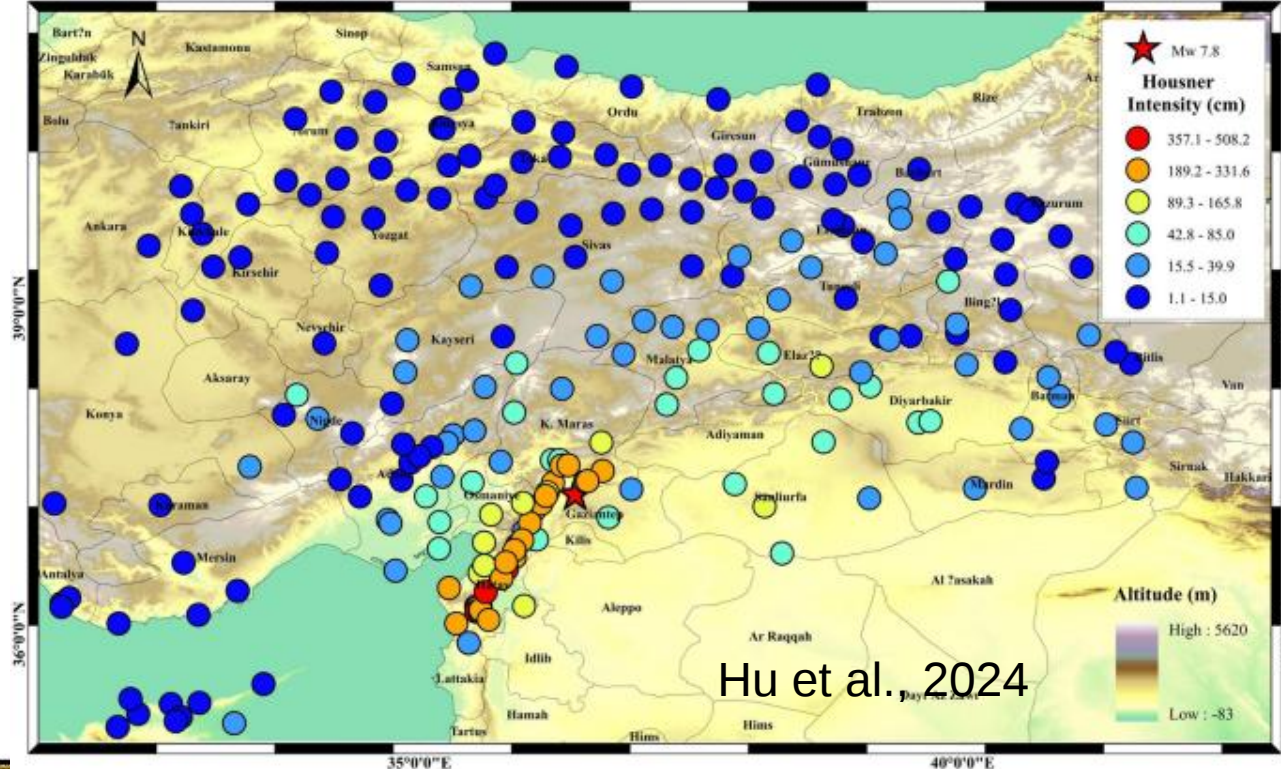


NMSZ Strain Accumulation?

Calais et al., 2005

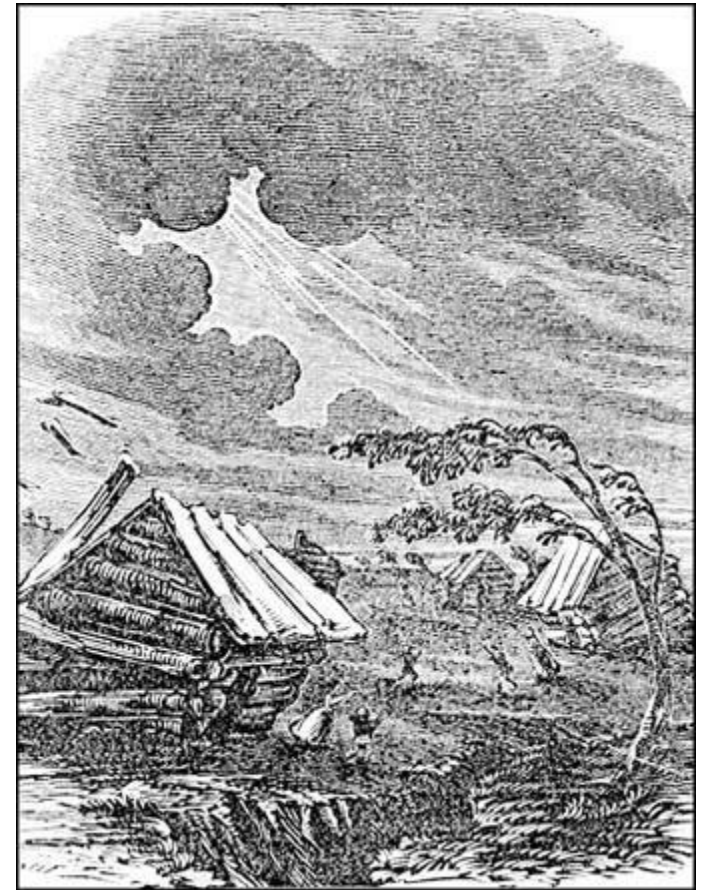
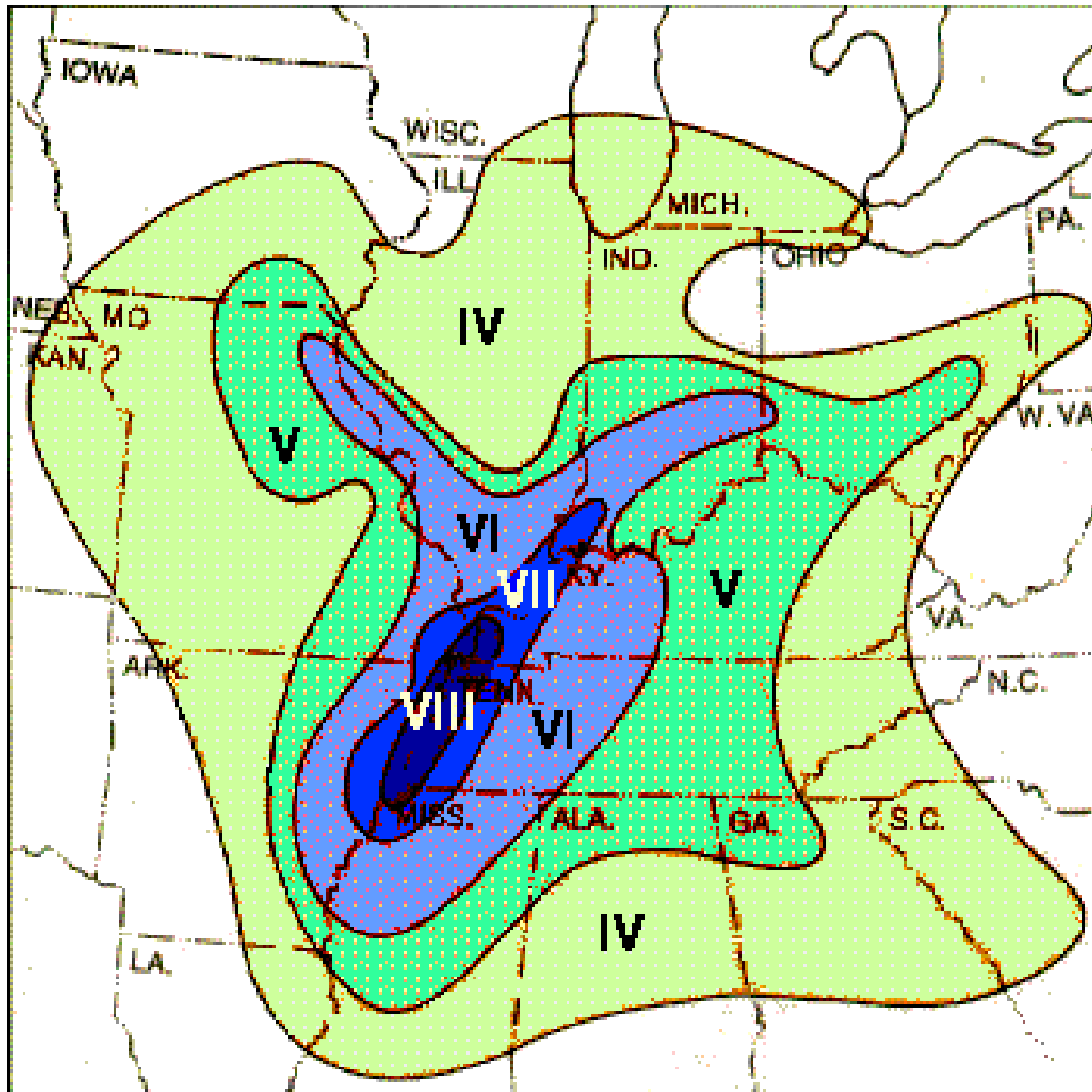


Ground Motions



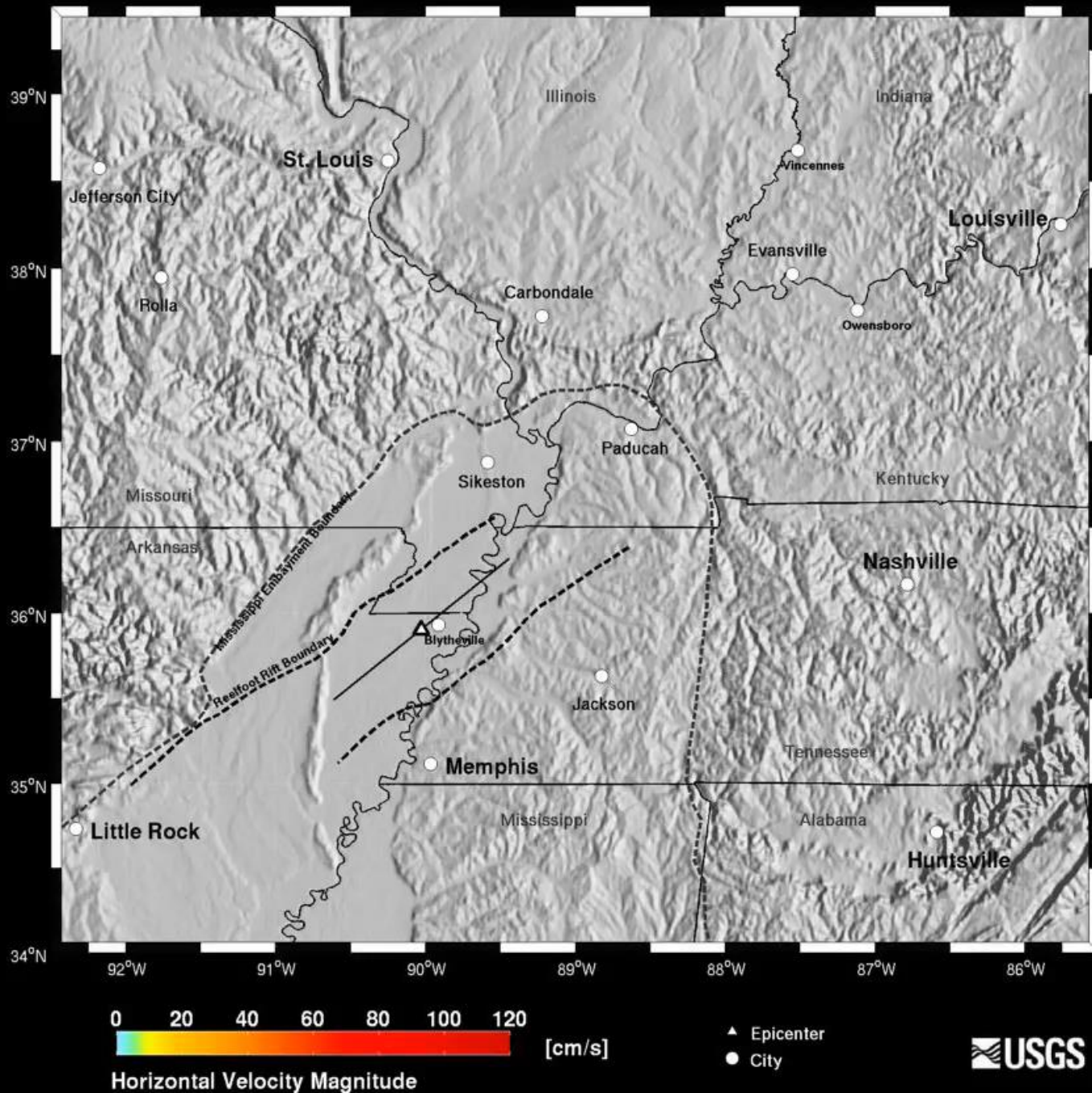


New Madrid Ground Motions

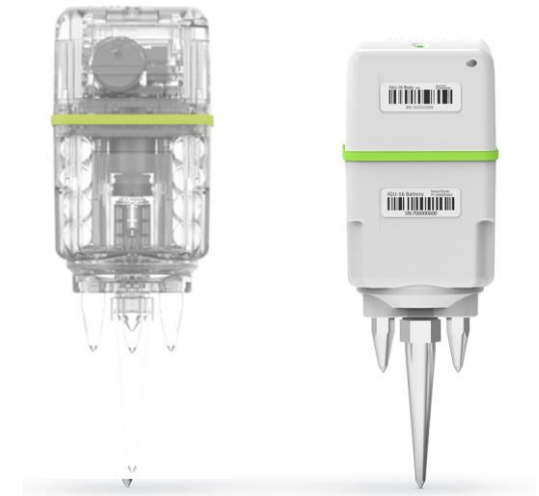
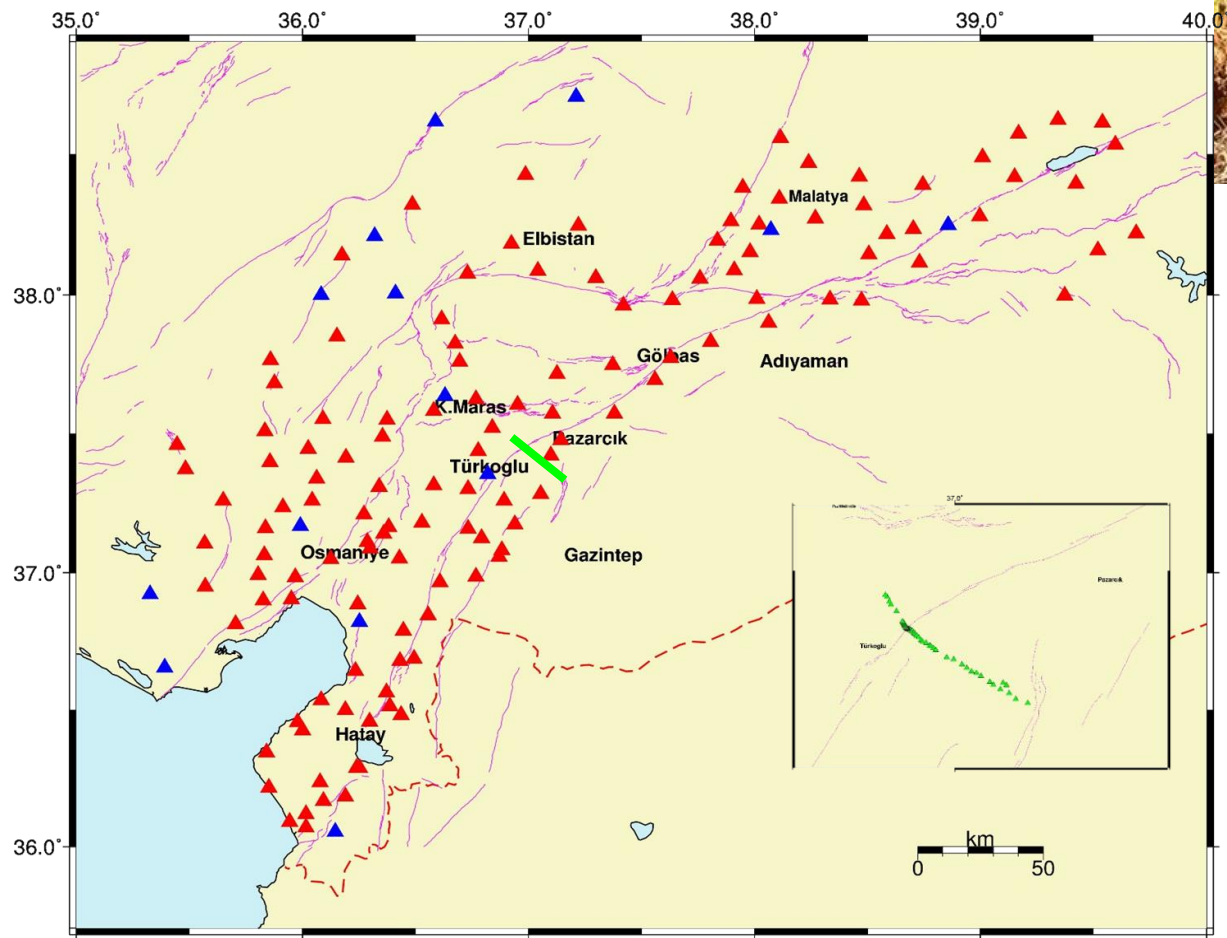


Woodcut by Henry Howe, from Historical Collections of the Great West (Cincinnati, 1854, p.239)

Magnitude 7.7 Earthquake Simulation in the New Madrid Seismic Zone.
Time since earthquake started t=0.40 seconds



EAFZ Seismic Network



(Adapted from SmartSolo website)

Seismic Velocity: *Rate at which seismic wave propagates through a given material. The seismic velocity is proportional to the *rigidity* of a material. The harder or more rigid a rock is, the faster a seismic wave will travel through it:*

$$V_s = [\mu / \rho]^{1/2};$$

$$V_p = [(\mu + 4/3\kappa) / \rho]^{1/2}$$

Examples:

Water:

1400-1600 m/s

Clay:

200-2500 m/s

Soil:

300-600 m/s

Alluvium:

1000-3000 m/s

Limestone (unweathered):

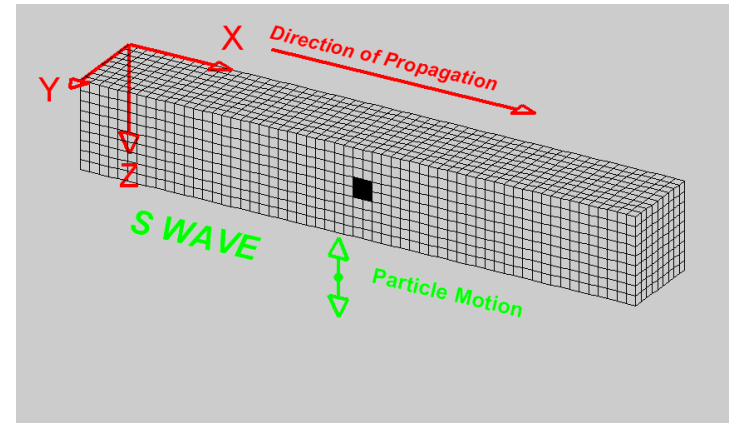
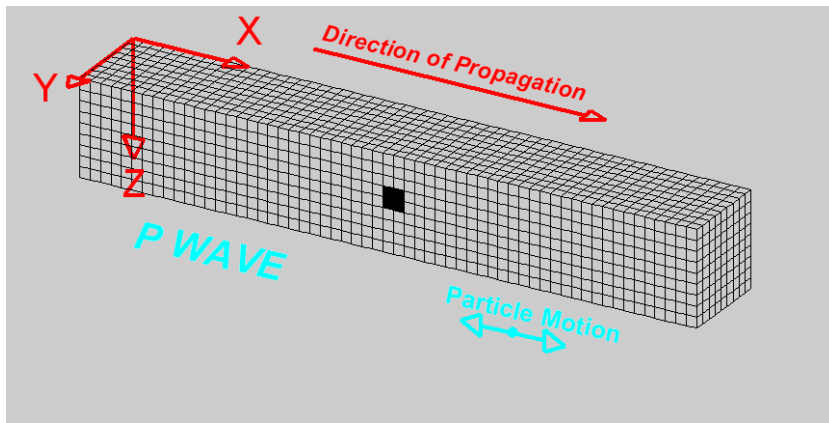
2000-5000 m/s

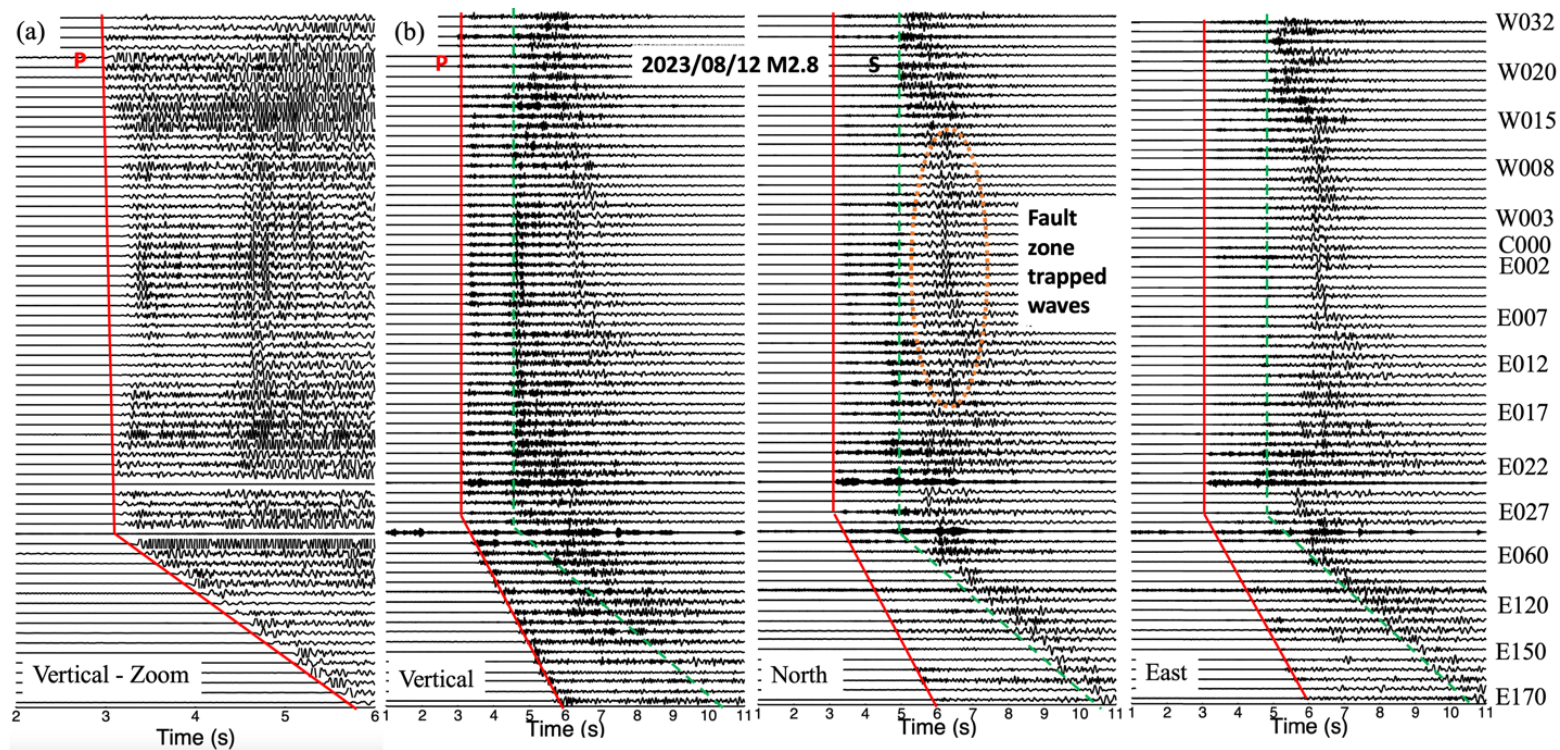
Granite (unweathered):

5000-6000 m/s

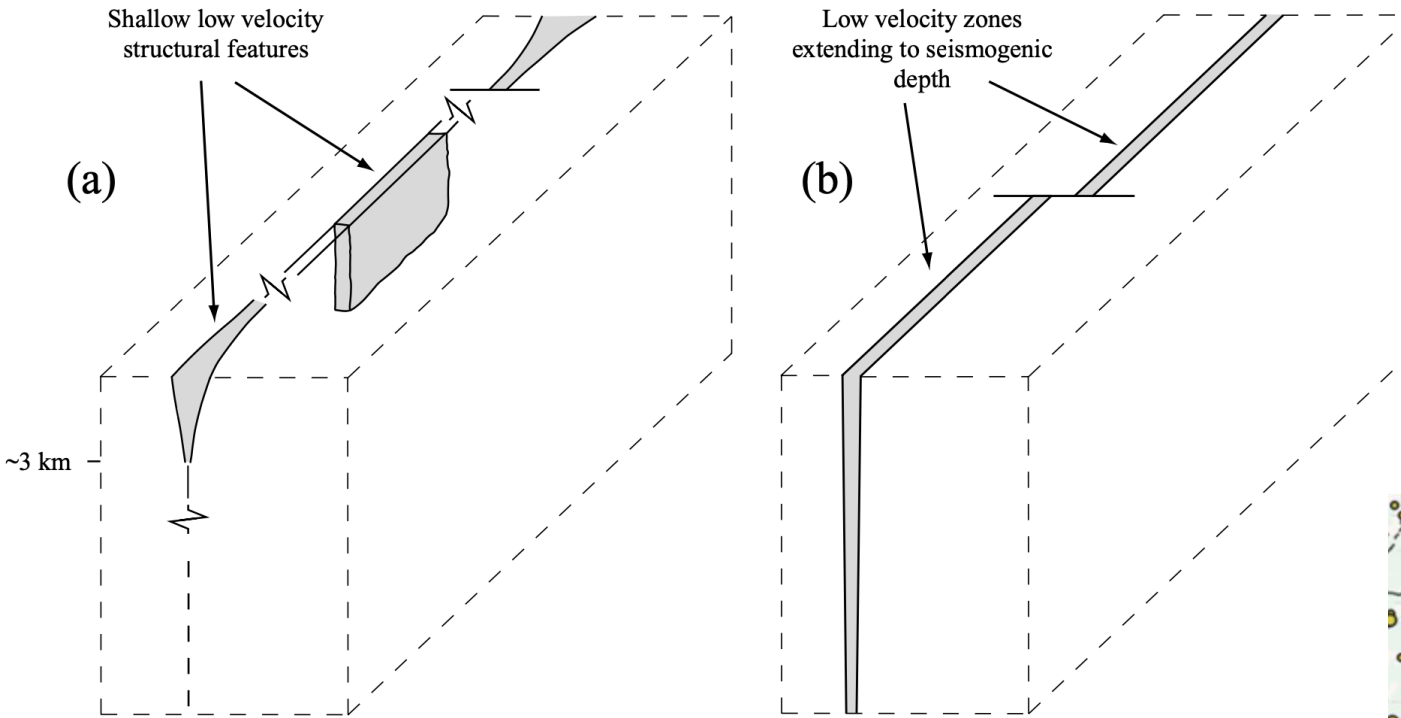
Sandstone (weathered):

2500-4500 m/s



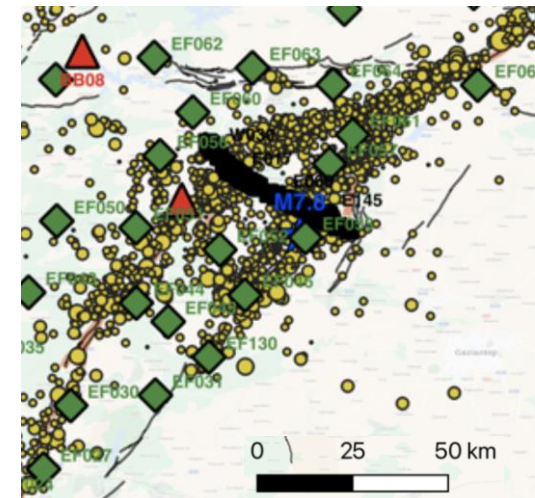


Testing shallow versus deep low-velocity fault zone structures with ultra-long dense array and two parallel rupture zones



Different fault zone trapped waves are expected for these models from on and off-fault seismicity.

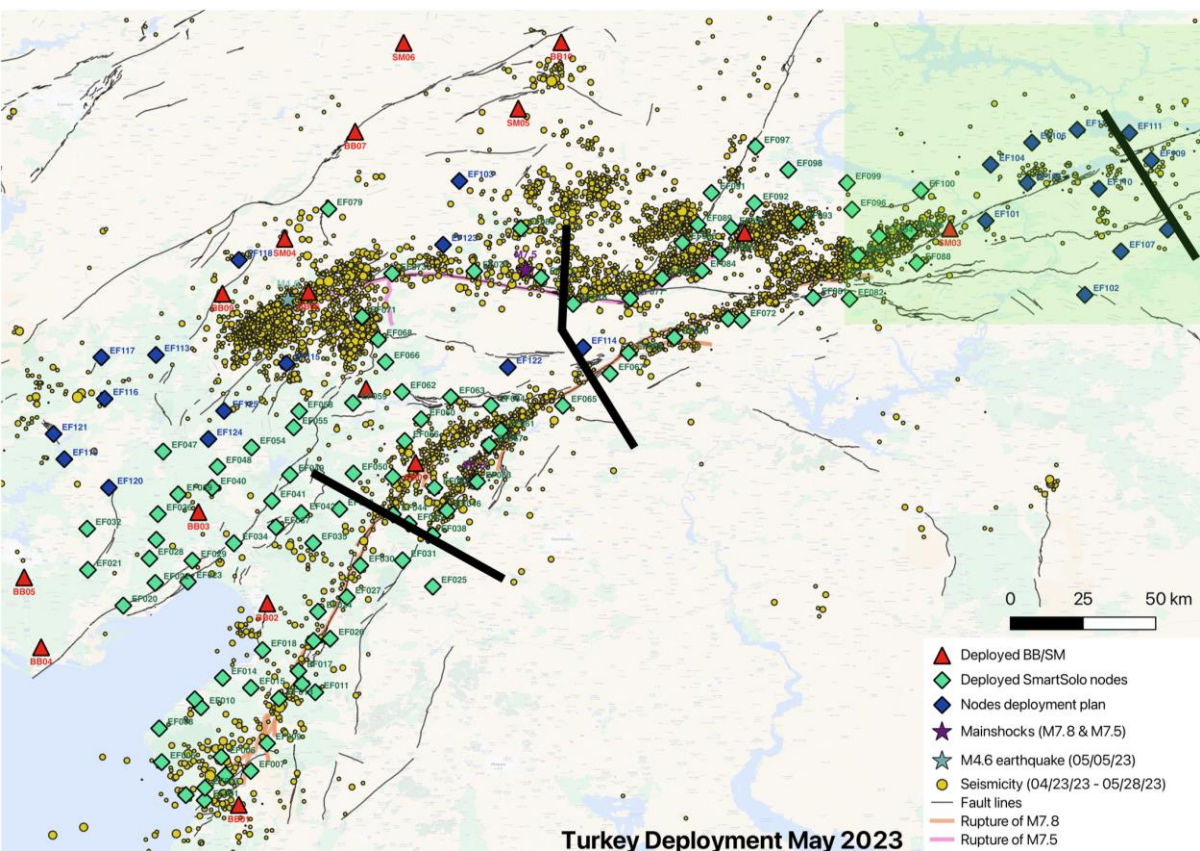
Ben-Zion et al. (GJI, 2003) for the 1999 Izmit/Duzce earthquake sequence



Things we can learn from the Turkiye earthquakes:

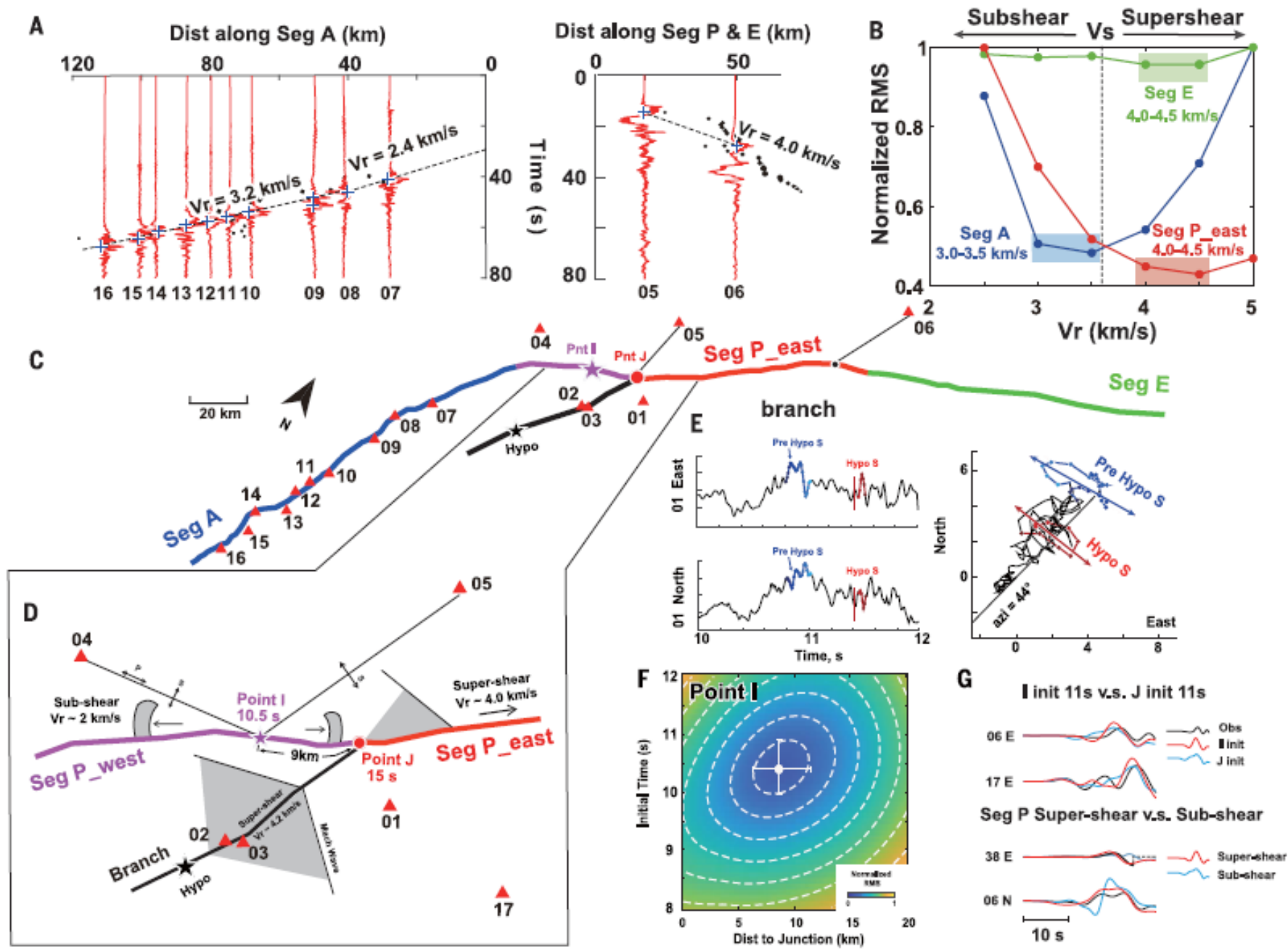
- We can expect a sequence of earthquakes rather than just one event (similar to what happened in 1811-812)
- Strongest ground motions and liquefaction will occur primarily in the Mississippi embayment (i.e. the effect of shallow, young, water saturated sediments)
- Recovery time will likely be years rather than days

QUESTIONS?

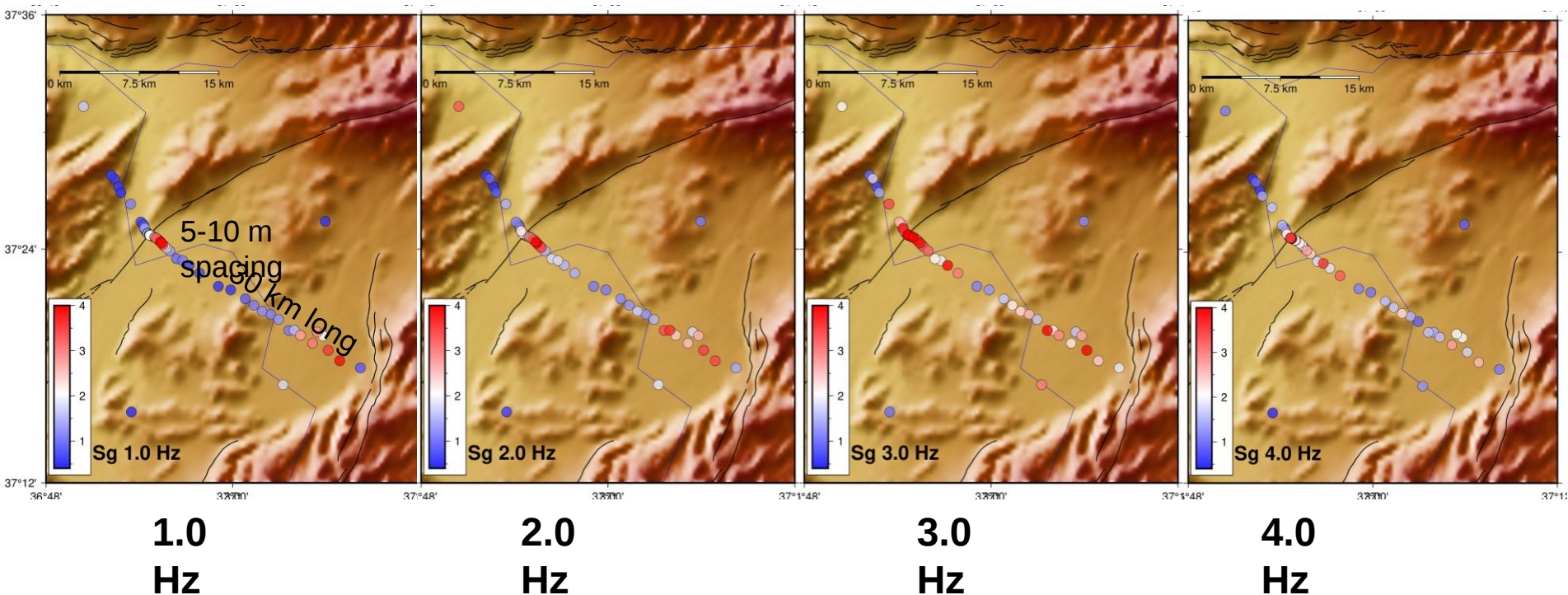


This deployment would not have been possible without support from the United States National Science Foundation's Geophysics Program (**RAPID EAR-2322461**). Thanks to SmartSolo Inc. for providing 150 nodes.

Ren et al., Science, 2024



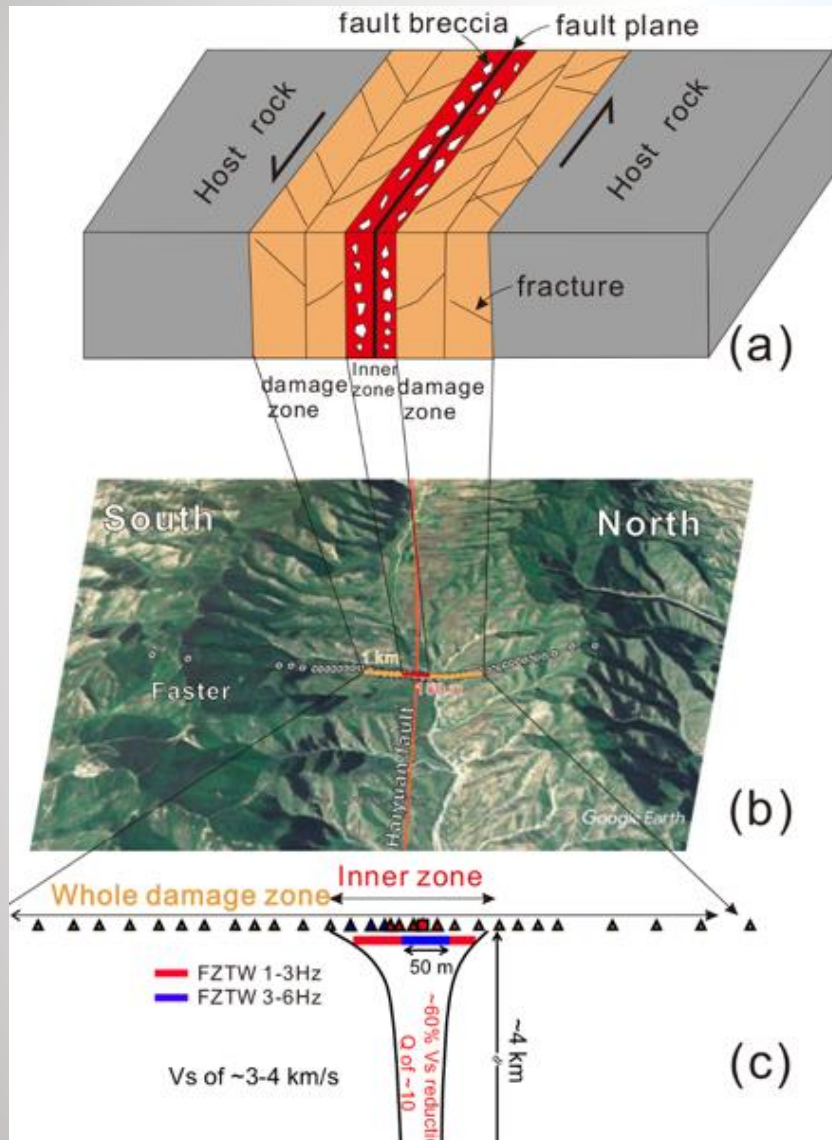
Ground Motions Along the August Profile:

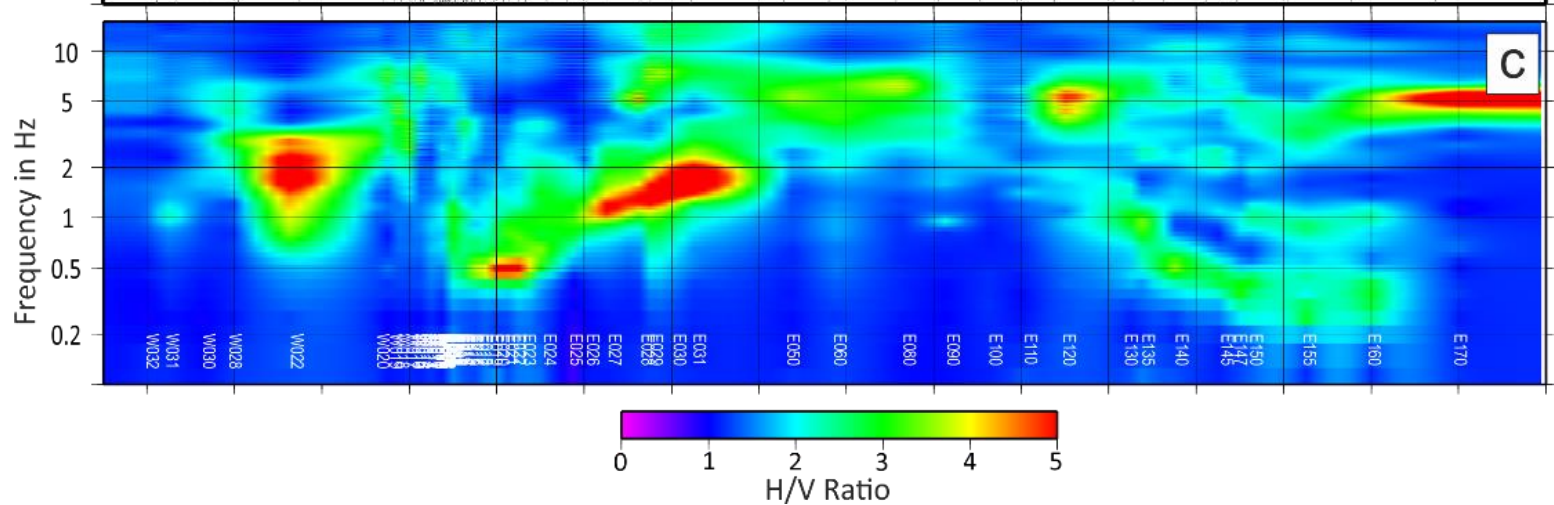
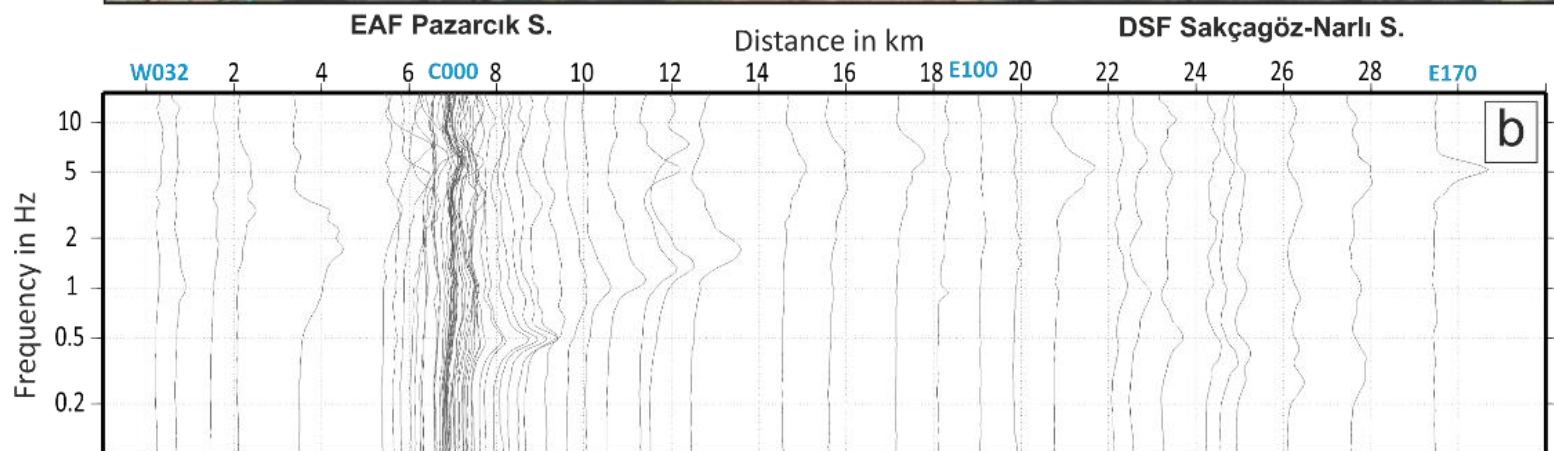
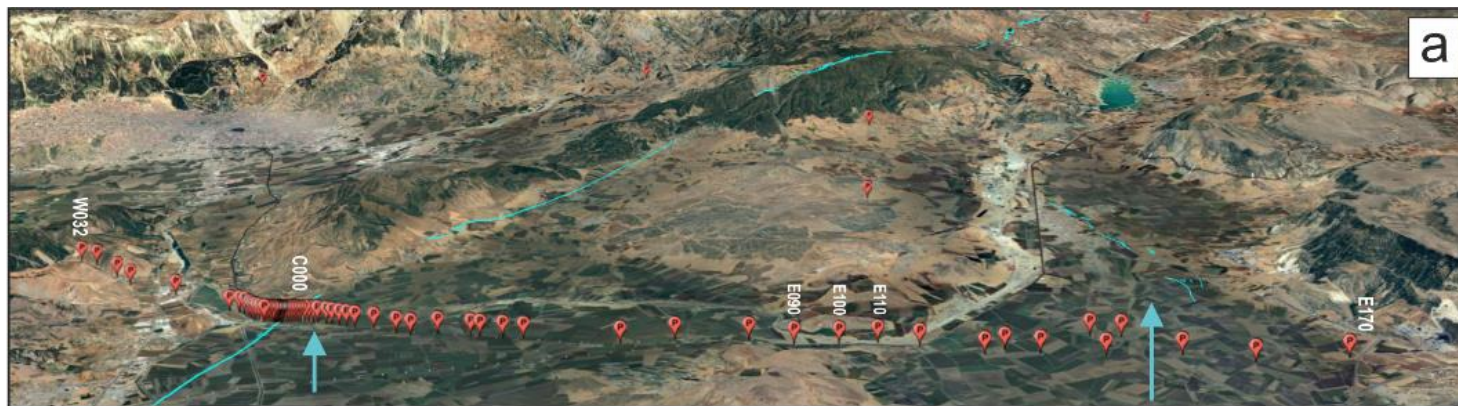


$$A_j^i(\omega) = S_j(\omega, \theta) I^i(\omega) E_j(\omega) G_j^i(\Delta) \exp \left[-\frac{\pi f \Delta_j^i}{v Q(f)} \right]$$

Proposed Array Objectives

- Create comprehensive EQ catalog with detection thresholds near zero
- Use the catalog to image detailed 3D structural images of the active faults zones with an emphasis on bends, fault intersections, and step-overs
- Construct frequency dependent model of site amplification across EQ zone
- Detailed images of upper crustal seismic anisotropy



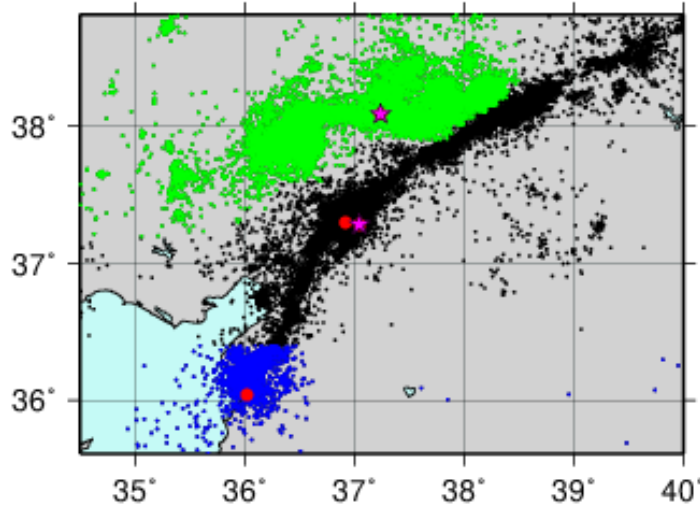
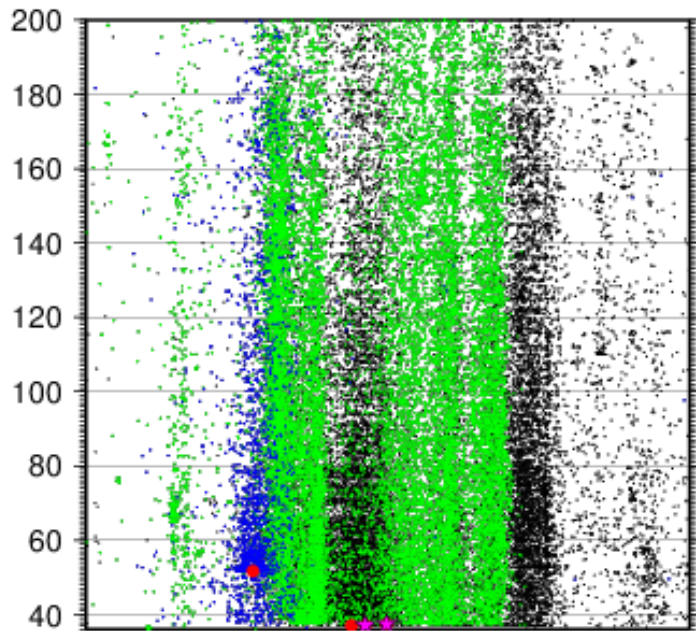


Spatial-Temporal Variations in Seismicity

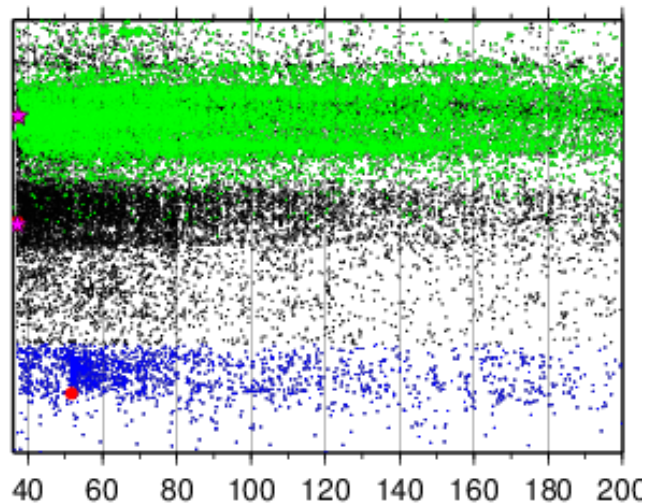
Earthquake Epicenters taken from the combined TUBITAK and AFAD catalog.

The EAFZ aftershock Networks had nodes deployed between Julian day 120 and 237

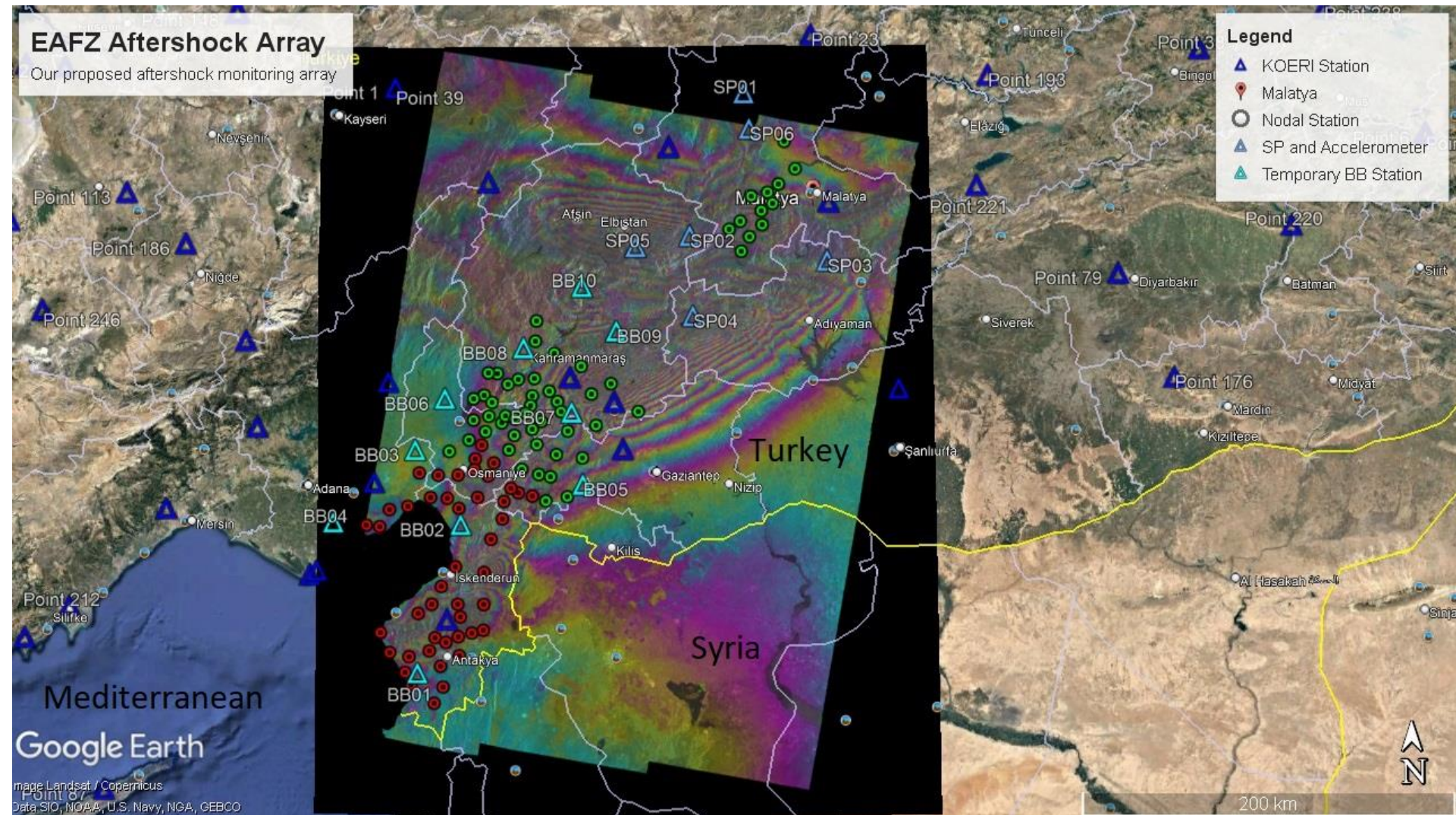
2023 Julian Days



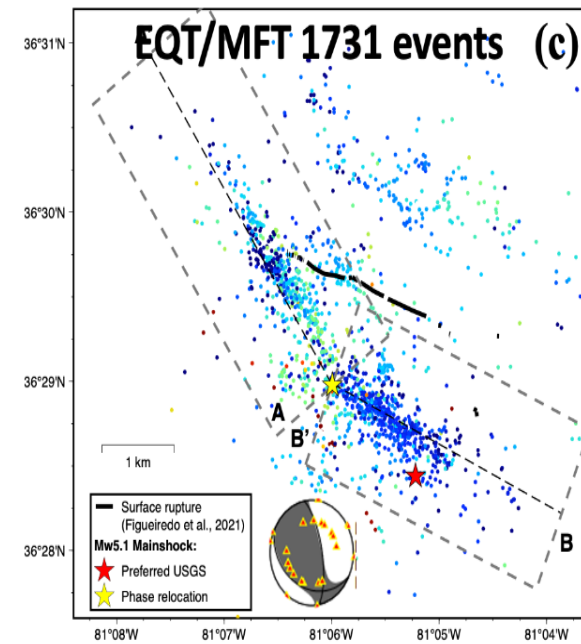
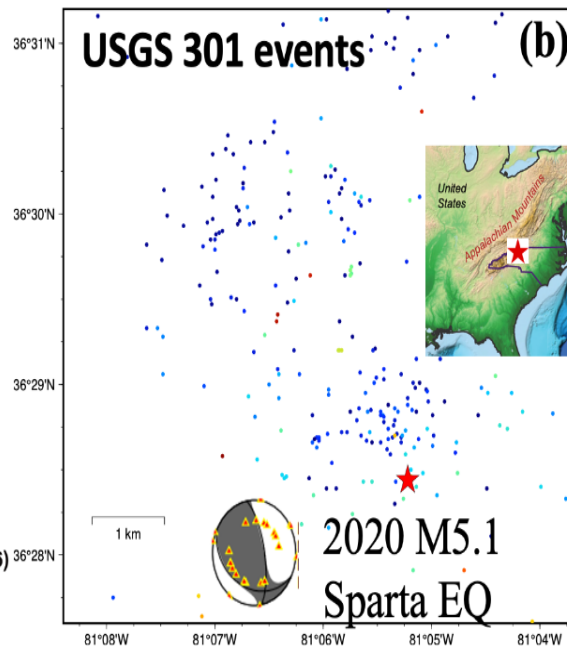
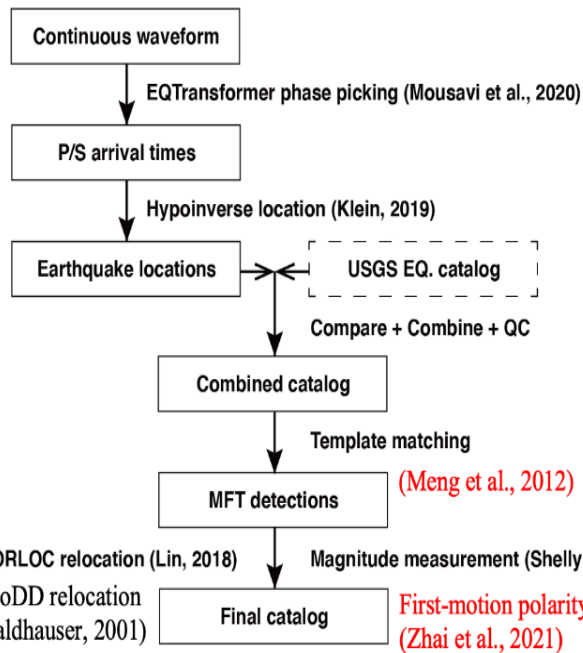
2023 Julian Days



Array Deployed in April 2023

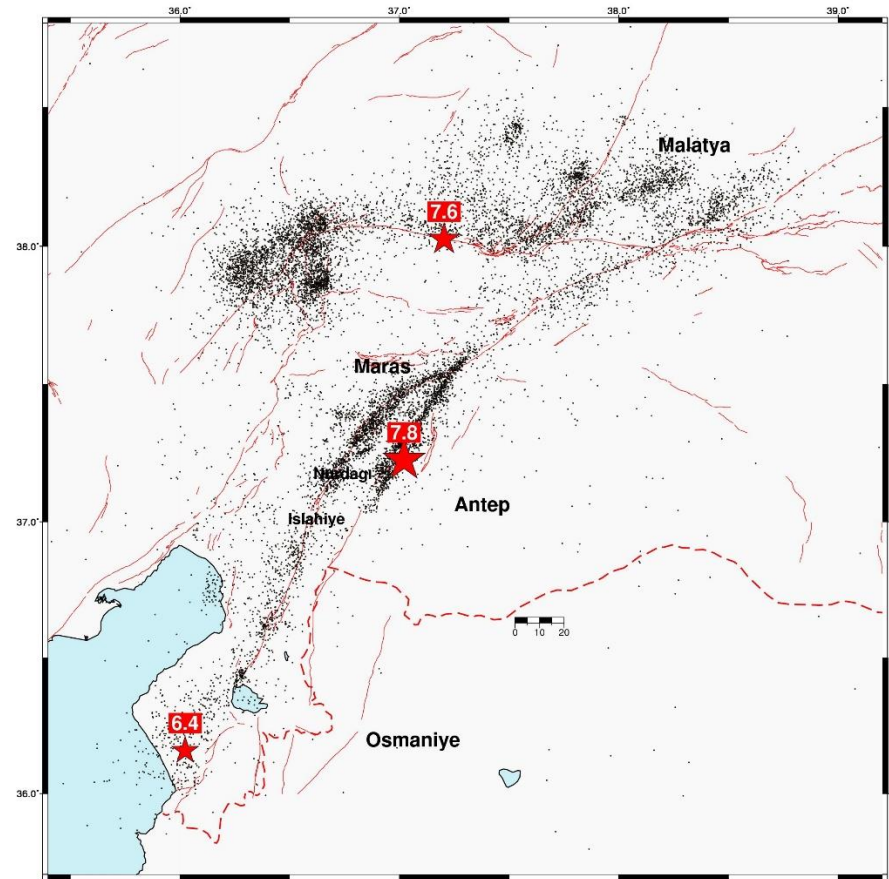
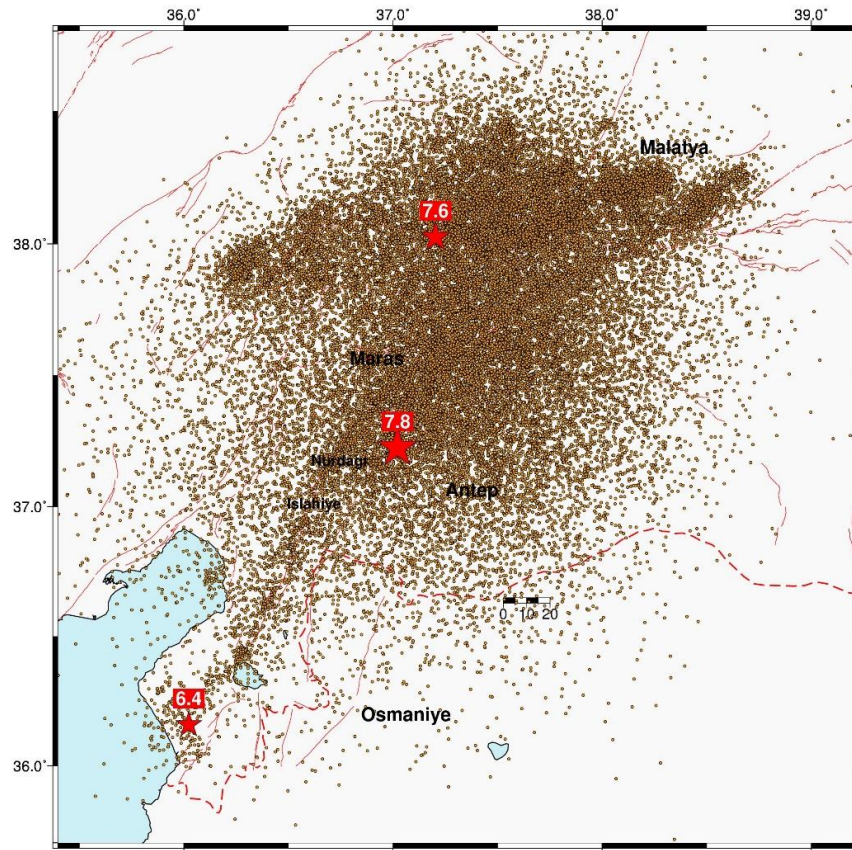


Planned Analysis

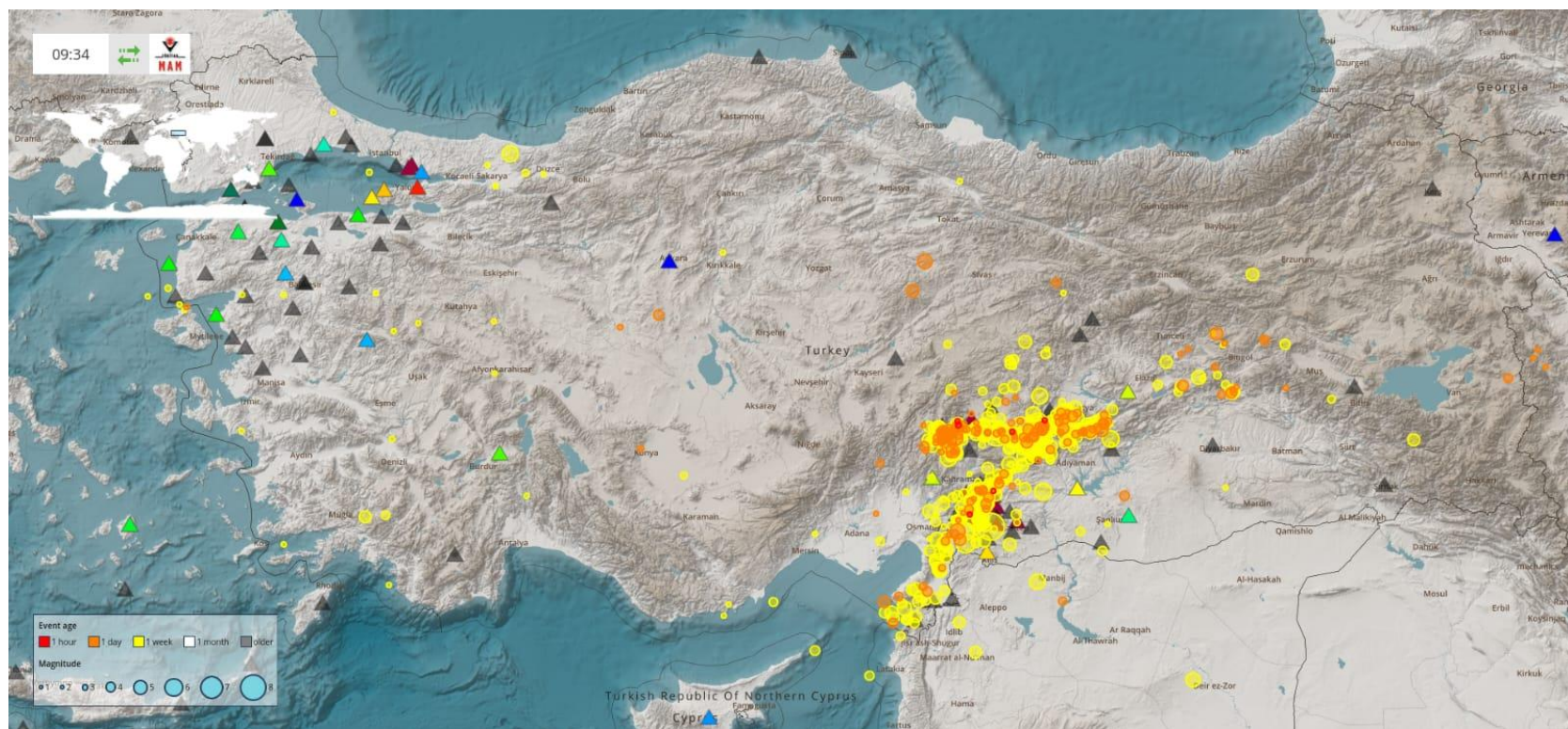


Preliminary EAFZ Nodal Earthquake Locations from May 1st- June 12th

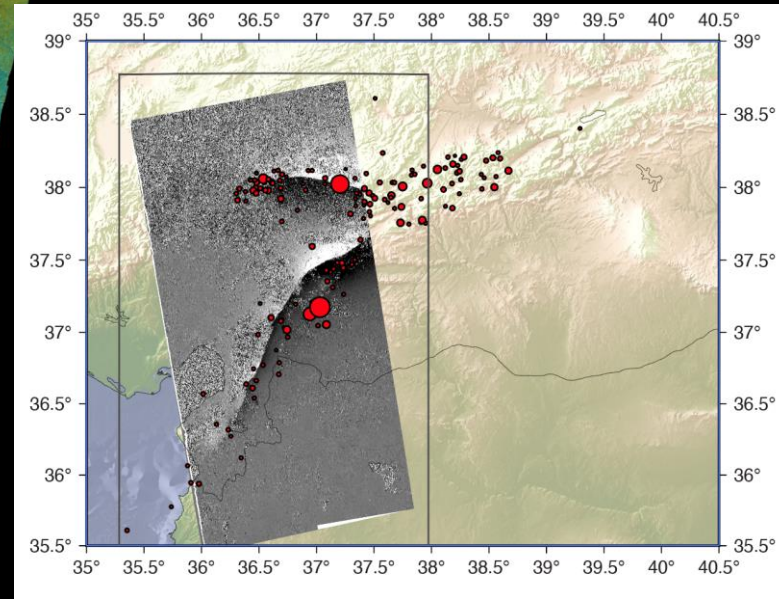
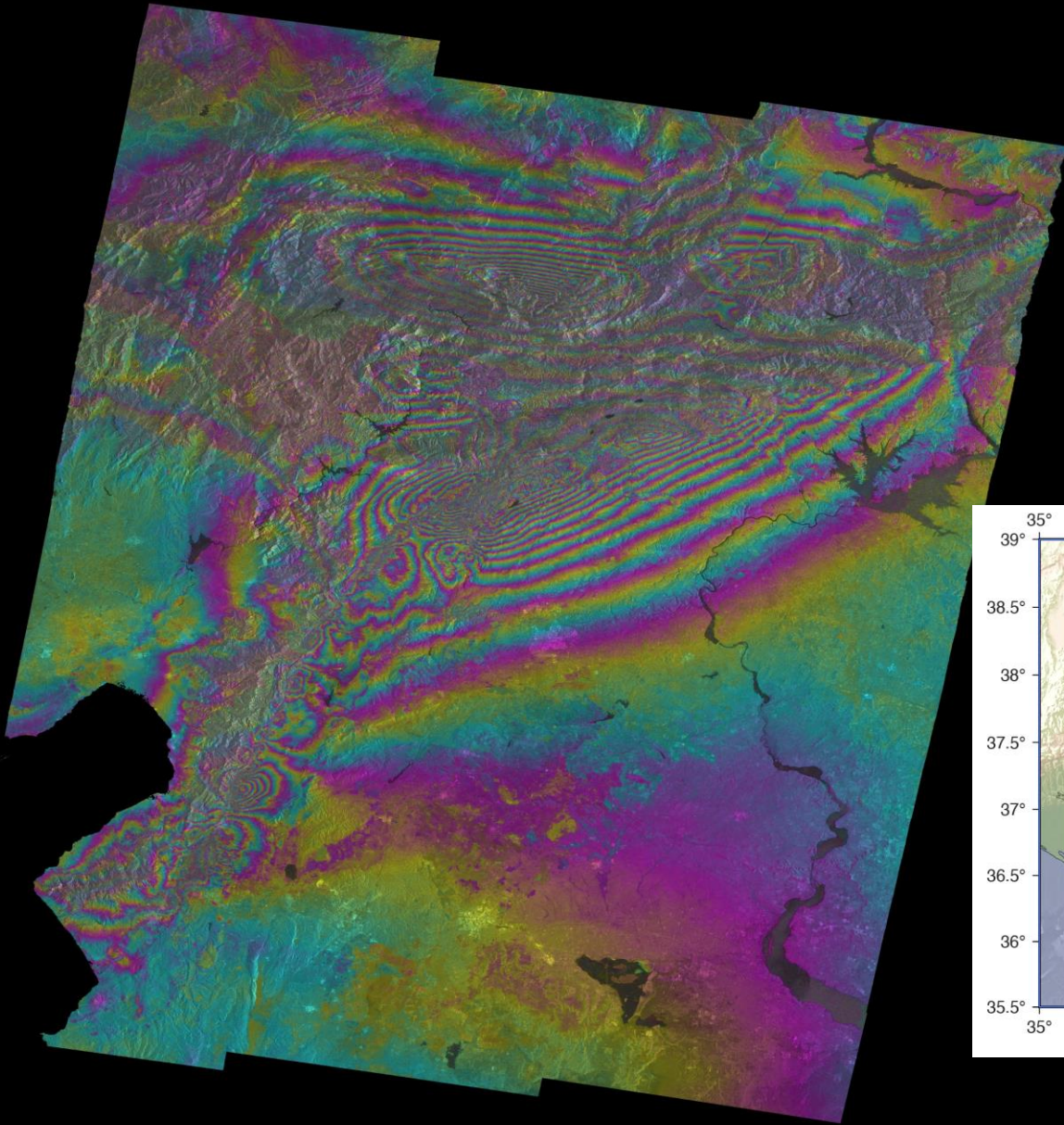
EQTransformer (Mousavi et al., 2020)



Latest Aftershock map from our collaborators at TUBITAK:



Interferogram

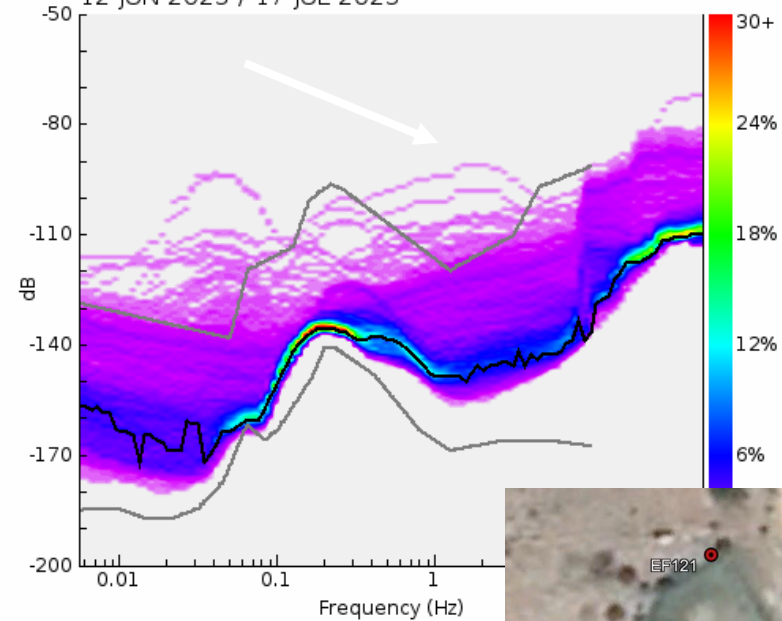






Broadband vs Nodal

TB.AKO.--.BHZ : 1610 PSDs
12-JUN-2023 / 17-JUL-2023



TB.EF121.--.SHZ : 1592 PSDs
12-JUN-2023 / 17-JUL-2023

