# Seismic and aseismic fault slip during the interseismic period: *observations from the Marmara region*

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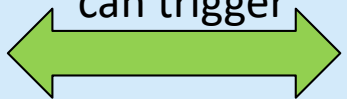
# The interplay between seismic and slow deformation

Faults can slip dynamically (earthquakes) or slow and aseismic (creep)

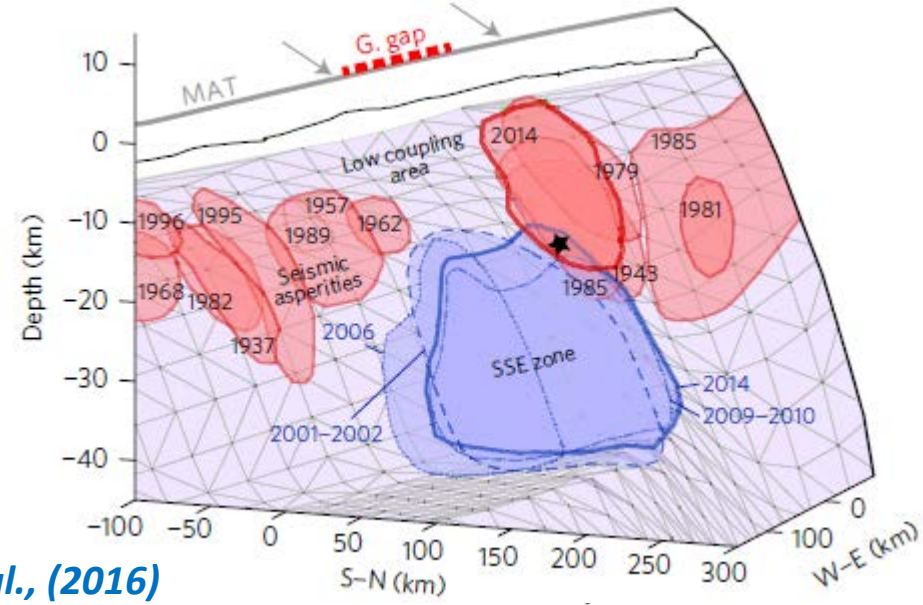
Earthquakes  Slow slip



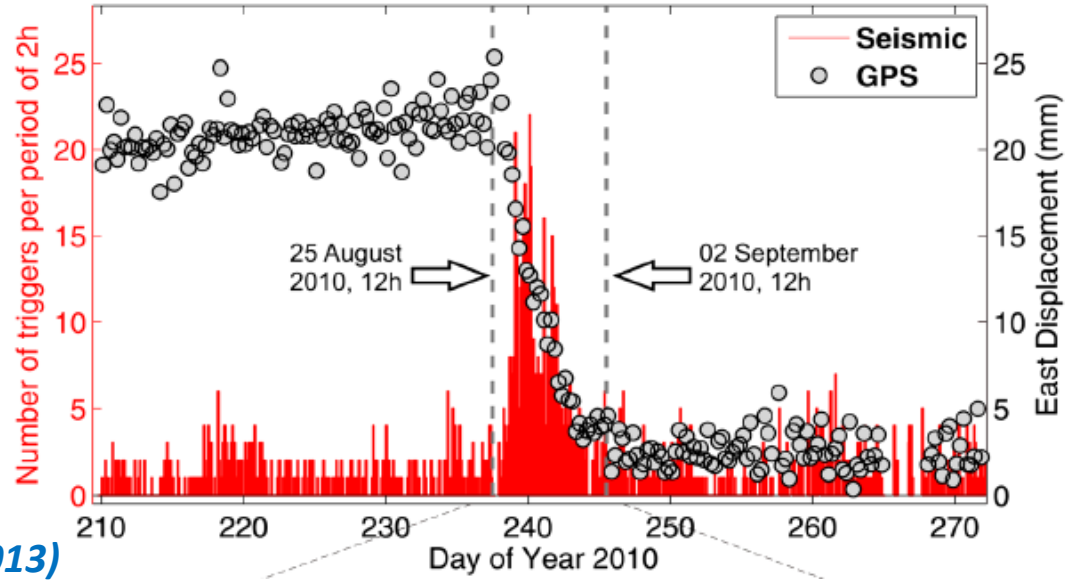
Different factors may govern the different slip modes, including $P^{eff}, T, V_S^L$, structure, material, geometrical complexities

**How does the fault seismic coupling vary in the Marmara region ?**

**How is the slow slip release affecting the nucleation of future large earthquakes ?**




*Radiguet et al., (2016)*

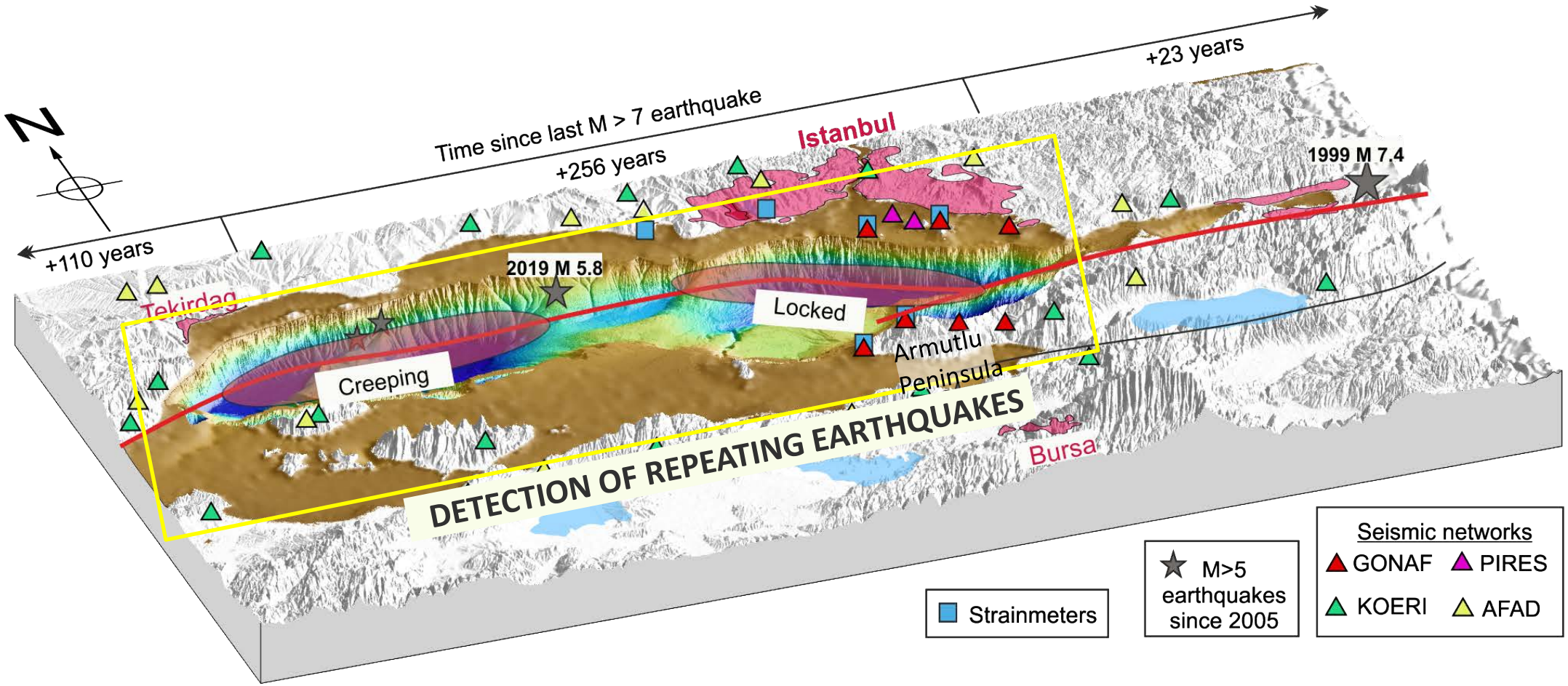



*Valleé et al., (2013)*

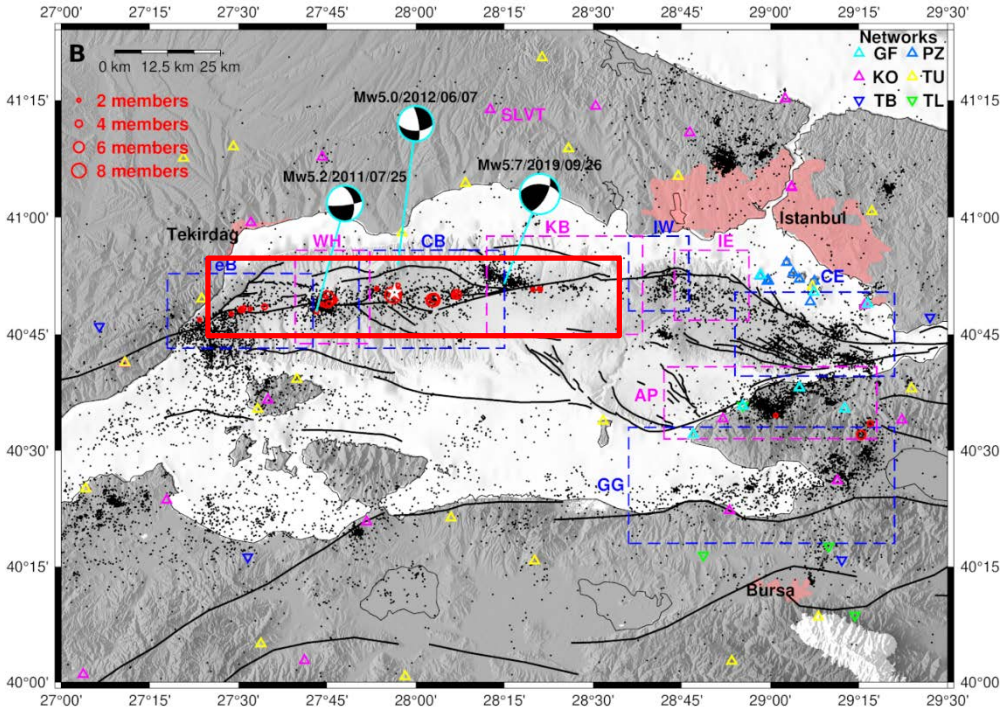
# Locked and creeping segments in the Sea of Marmara region

The Marmara Sea contains a ~250 km long fault segment that is late in its seismic cycle

The Main Marmara Fault contains locked and partially creeping fault segments



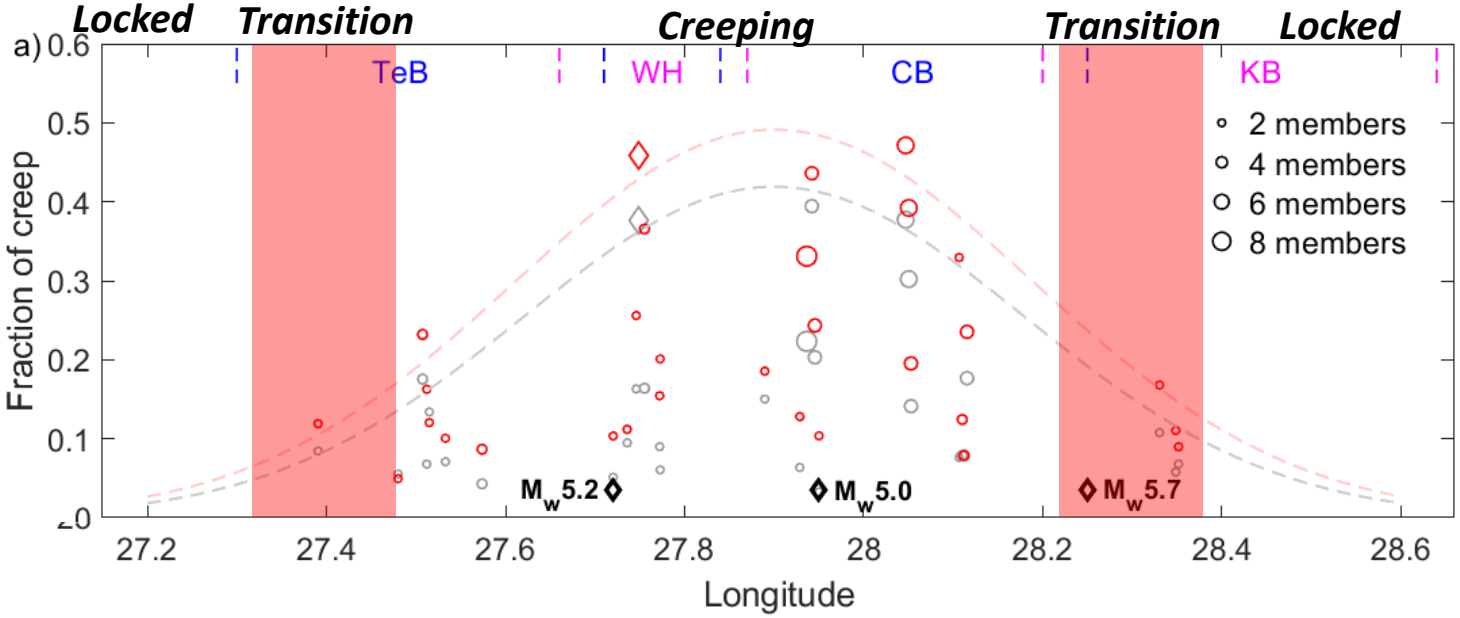
# Quantifying creep along the Marmara fault from repeating earthquakes




Seismicity catalog 2006-2020 (13.800 events)

30 repeater sequences, all in western Marmara

Proportion of creep peaking at WH,CB decreasing towards both sides



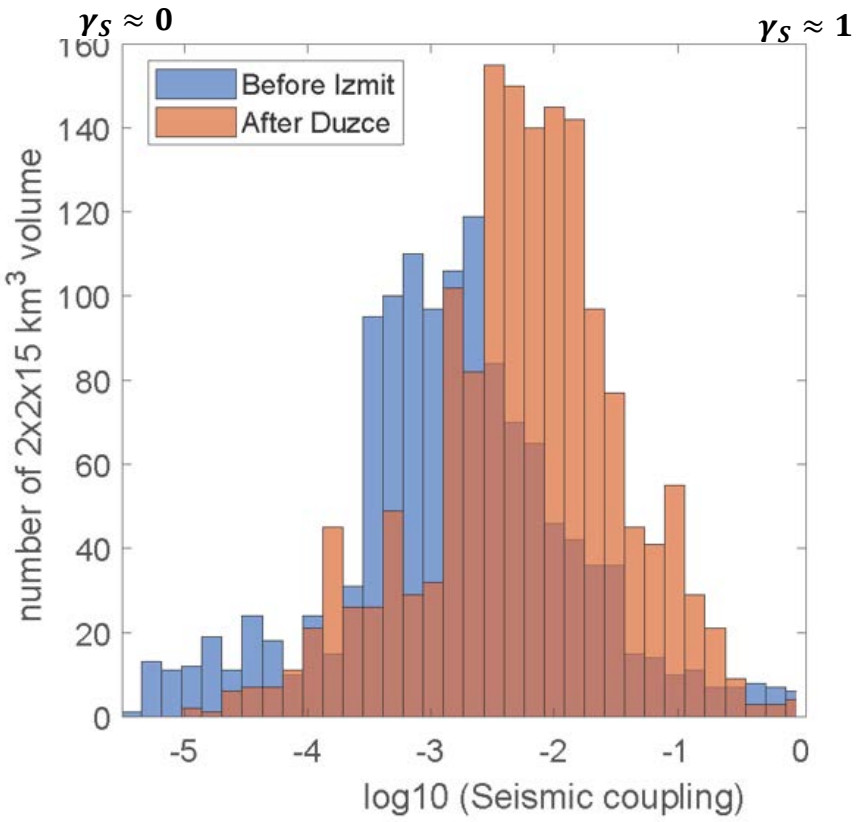

*Becker et al., (in prep)* ***EGU Session TS: 4.1 on May 25th at 16:16 CEST***

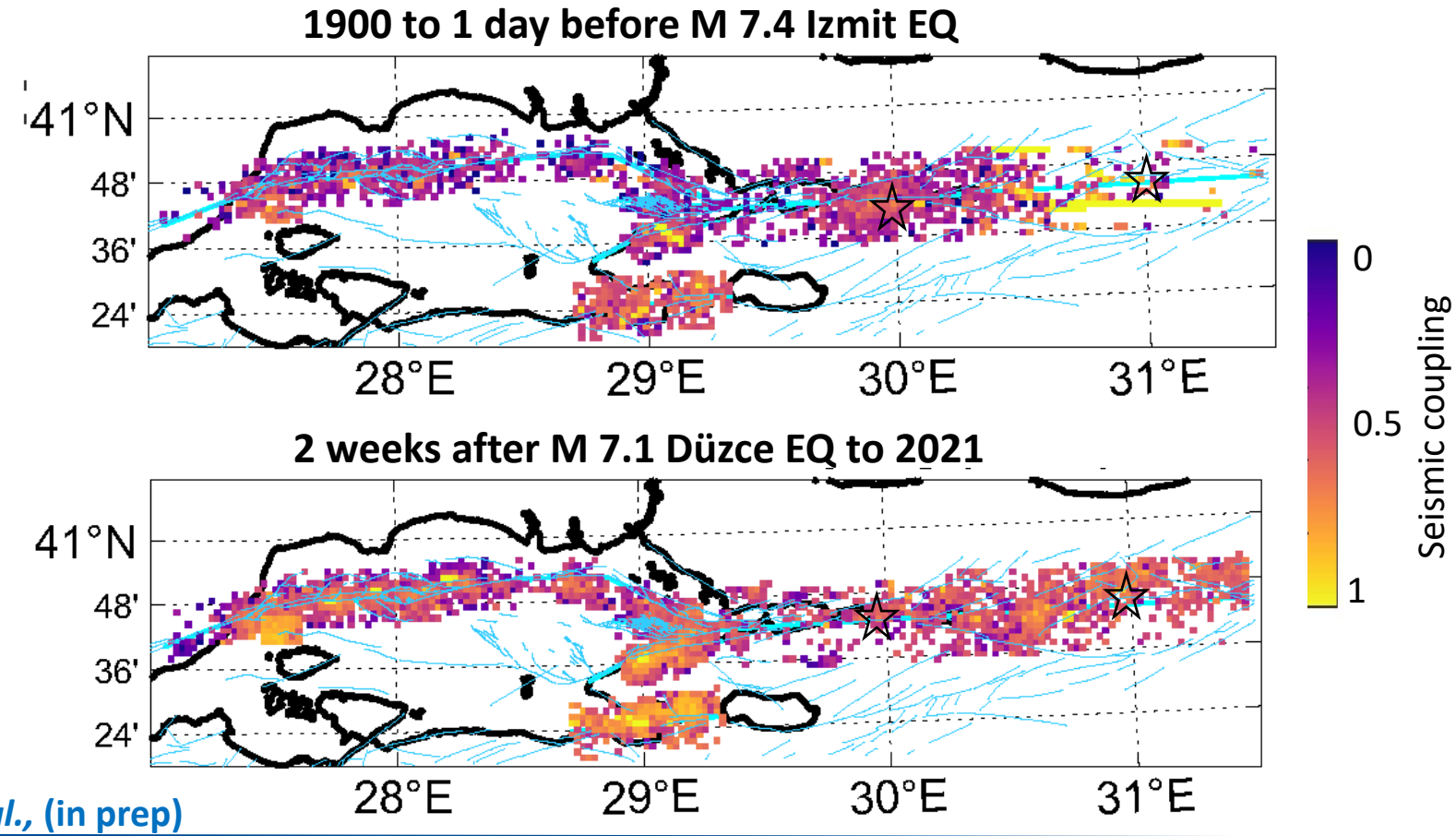
# Temporal variations in the seismic coupling during the interseismic period

Seismic (Kostrov's strain) and tectonic strain rates

Seismic coupling increases after 1999 Izmit and Düzce earthquakes

**Seismic coupling** $\gamma_S = \frac{\dot{\varepsilon}_S}{\dot{\varepsilon}_T}$



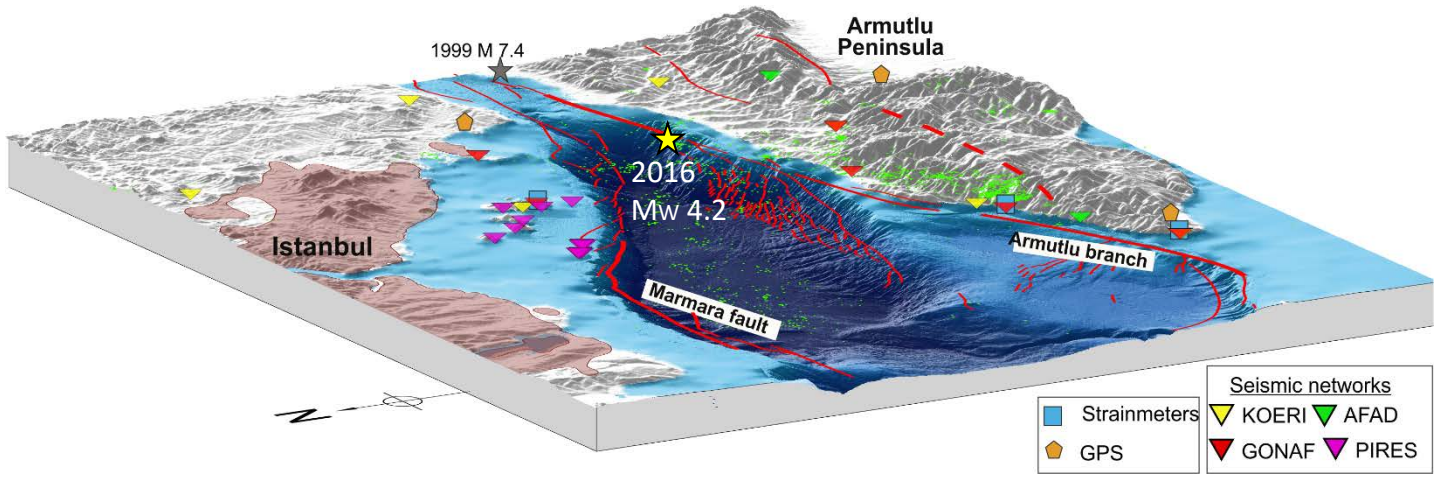



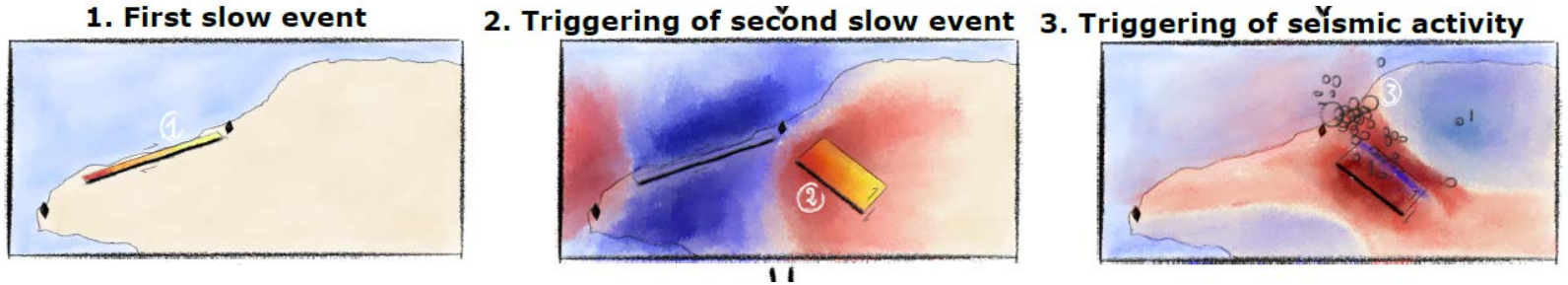

***Amemoutou et al.*, (in prep)**

# The evolution of slow slip event in the Armutlu Peninsula

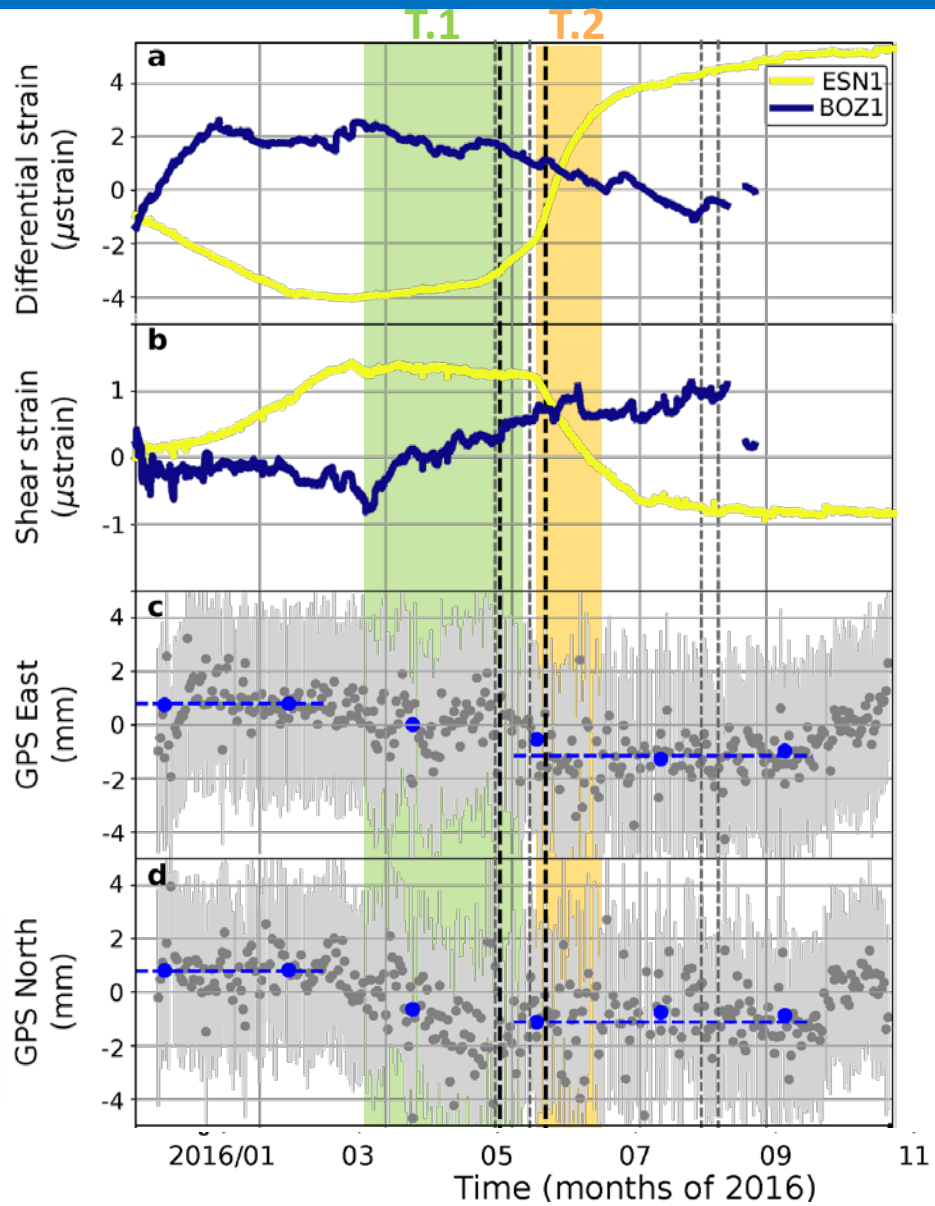
Seismicity, strainmeters and geodetic data to analyze a 50+day slow slip

Two sub-events: 1- Armutlu branch, 2- Perpendicular normal fault



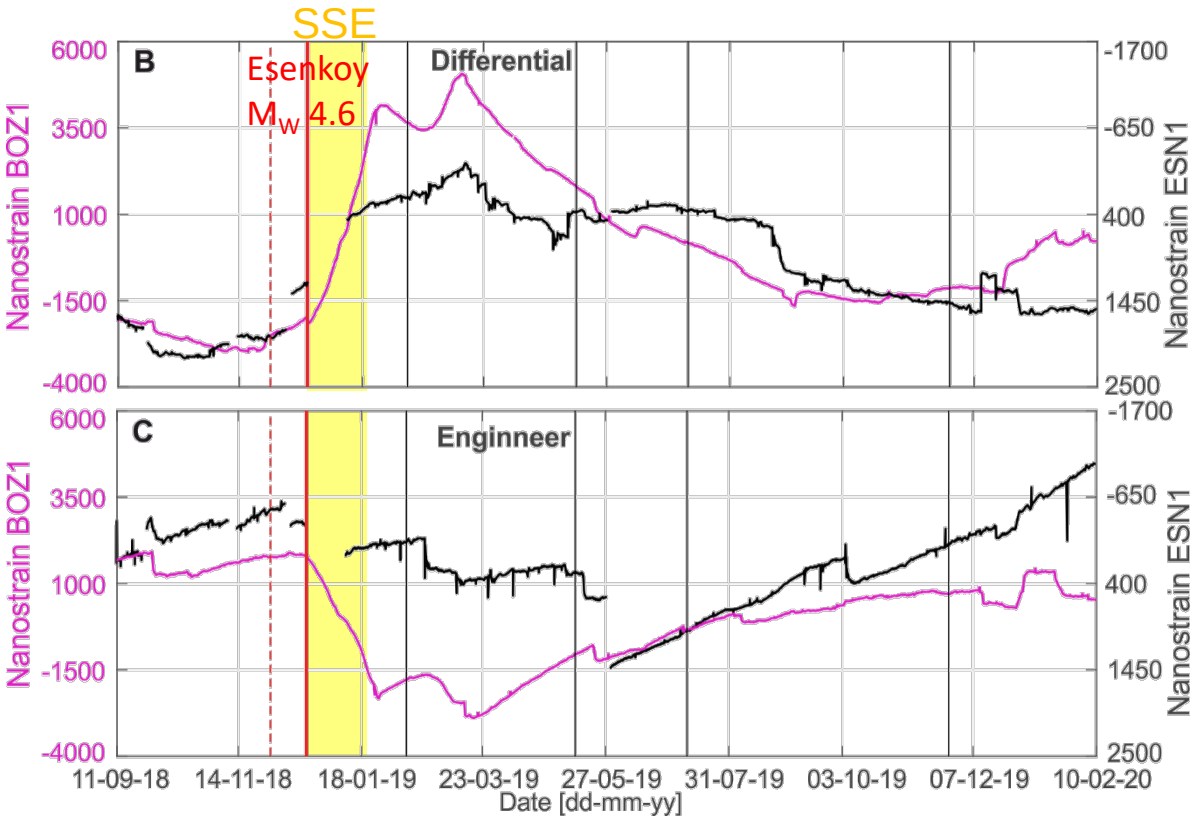

*(Martínez-Garzón et al., 2019; Durand et al., in review)*



# A second slow slip transient following the 2018 Mw 4.6 earthquake

SSE observed at two strainmeters after the 2018 Esenkoy $M_W$ 4.6, coming from same fault but different depth

The fault remained seismically active the entire year

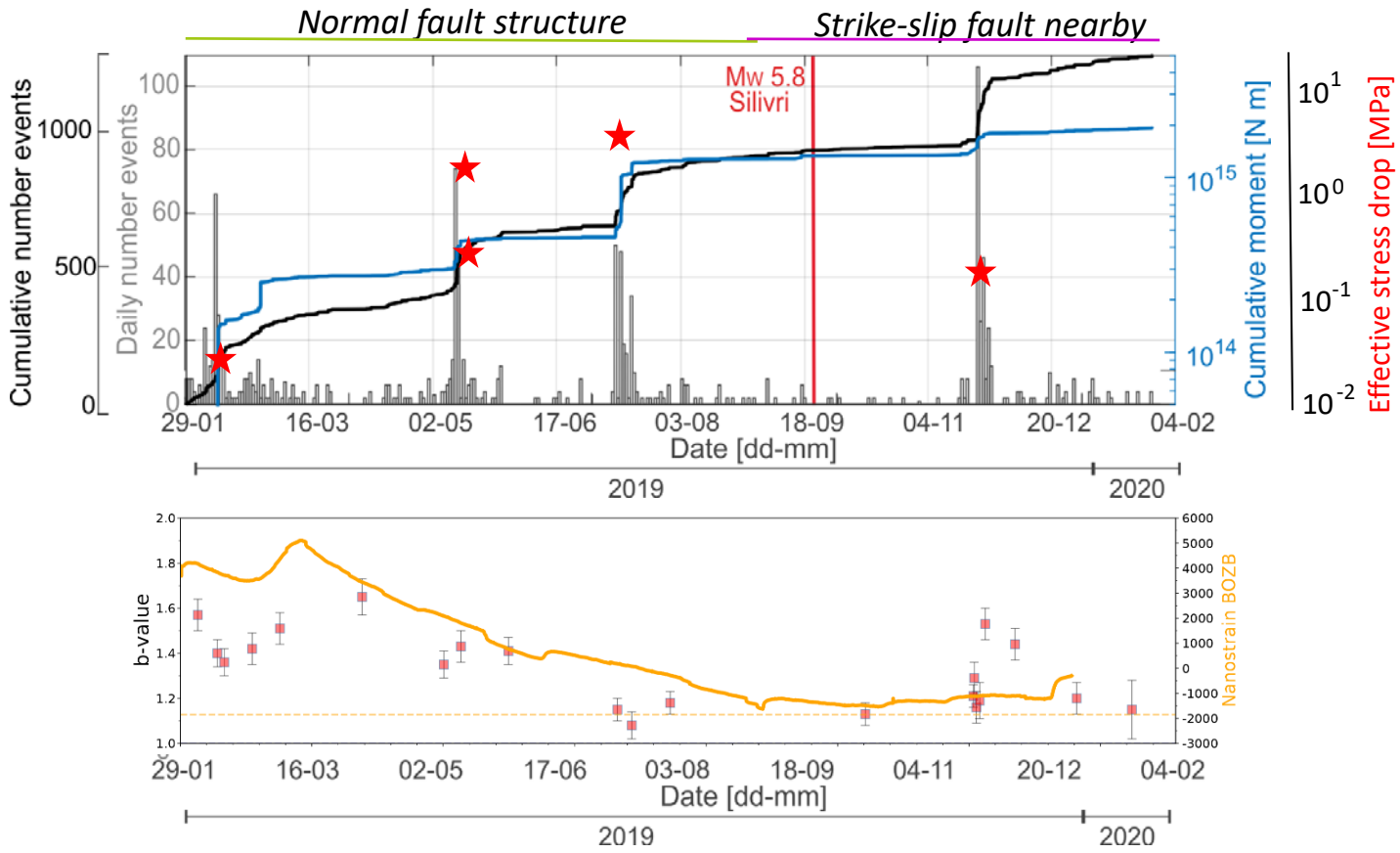



*(Martínez-Garzón et al., 2021; Bocchini et al., in review)*

***EGU Session SM: 6.1 on May 23rd 2022 at 13:34 CEST***

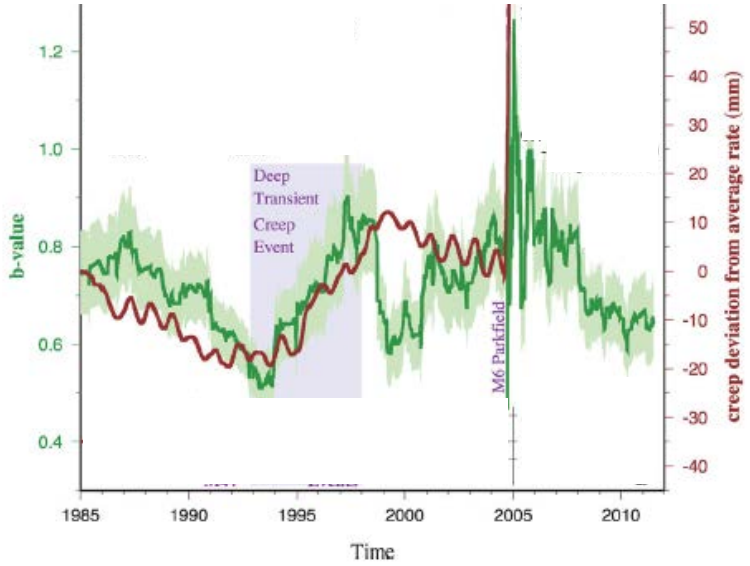
# Magnitude frequency distribution modulated by slow slip

*b*-value follows slow slip evolution: High b-value during largest strain, decreases as strain drops back to background
Change in effective stress drop from lower (0.01 MPa) to higher (~ 1 MPa) with time




(Bocchini et al., in review)

## The Parkfield observation




(Tormann et al., 2013)

**EGU Session SM: 6.1 23 May 2022, 13:34 CEST**

# Summary and Conclusions

## Spatial and temporal variations of seismic coupling along the Main Marmara fault

- Repeating earthquakes revealed a segment of about 100 km releasing up to 40% of tectonic strain through creep
- Seismic strain rate estimations from seismicity catalogs reflect and increase in the seismic coupling for the 20 years after 1999 M > 7 Izmit and Düzce earthquakes

## Slow slip episodically occurs in the Armutlu Peninsula, following M4+ earthquakes

- Evidence from two slow slip events (June 2016, Dec 2018) recorded with strainmeters and geodetic stations
- The shallow portion of the Armutlu Fault and a local normal fault structure could be the main fault structures hosting slow slip

## Slow slip also promotes micro-seismicity

- Enhanced seismicity M < 3.5 for 1+ year following the slow slip event exhibiting strong spatio-temporal clustering: One of few well-documented cases of seismicity driven by slow slip
- Magnitude-frequency distribution of seismicity modulated by the slow slip transient: Seismic hazard is temporally affected by slow slip

# Thank you for your attention !

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## *Related published work:*

**Martínez-Garzón, P.** et al. (2019). Slow strain release along the eastern Marmara region offshore Istanbul in conjunction with enhanced local seismic moment release. *Earth and Planetary Science Letters*, *510*, 209–218. https://doi.org/10.1016/j.epsl.2019.01.001

**Martínez-Garzón, P.** et al. (2021). Near-Fault Monitoring Reveals Combined Seismic and Slow Activation of a Fault Branch within the Istanbul–Marmara Seismic Gap in Northwest Turkey. *Seismological Research Letters*, *92*(6), 3743–3756. https://doi.org/10.1785/0220210047

## *Related EGU contributions:*

***Becker, Dirk et al:*** *Systematic variations of fault creep along the Marmara seismic gap, north-western Turkey, based on the observation of earthquake repeaters obtained from a high-resolution regional earthquake catalogue* (Session TS: 4.1)

***Bocchini, Gian Maria et al:*** Spatio-temporal distribution of seismicity in the northern Armutlu Peninsula, northwest Turkey (Session SM: 6.1)