Ramification et vitesse supershear de la rupture du séisme de Kahramanmaras, 2023, M7.8, Turquie

J. P. Ampuero (Geoazur, IRD / UniCA)

+ Bertrand Delouis, Y. Xie, J. Premus, M. van den Ende (Geoazur)
+ Shiqing Xu & team (SUSTech, China)
+ Lingsen Meng & team (UCLA, USA)

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COMMENT

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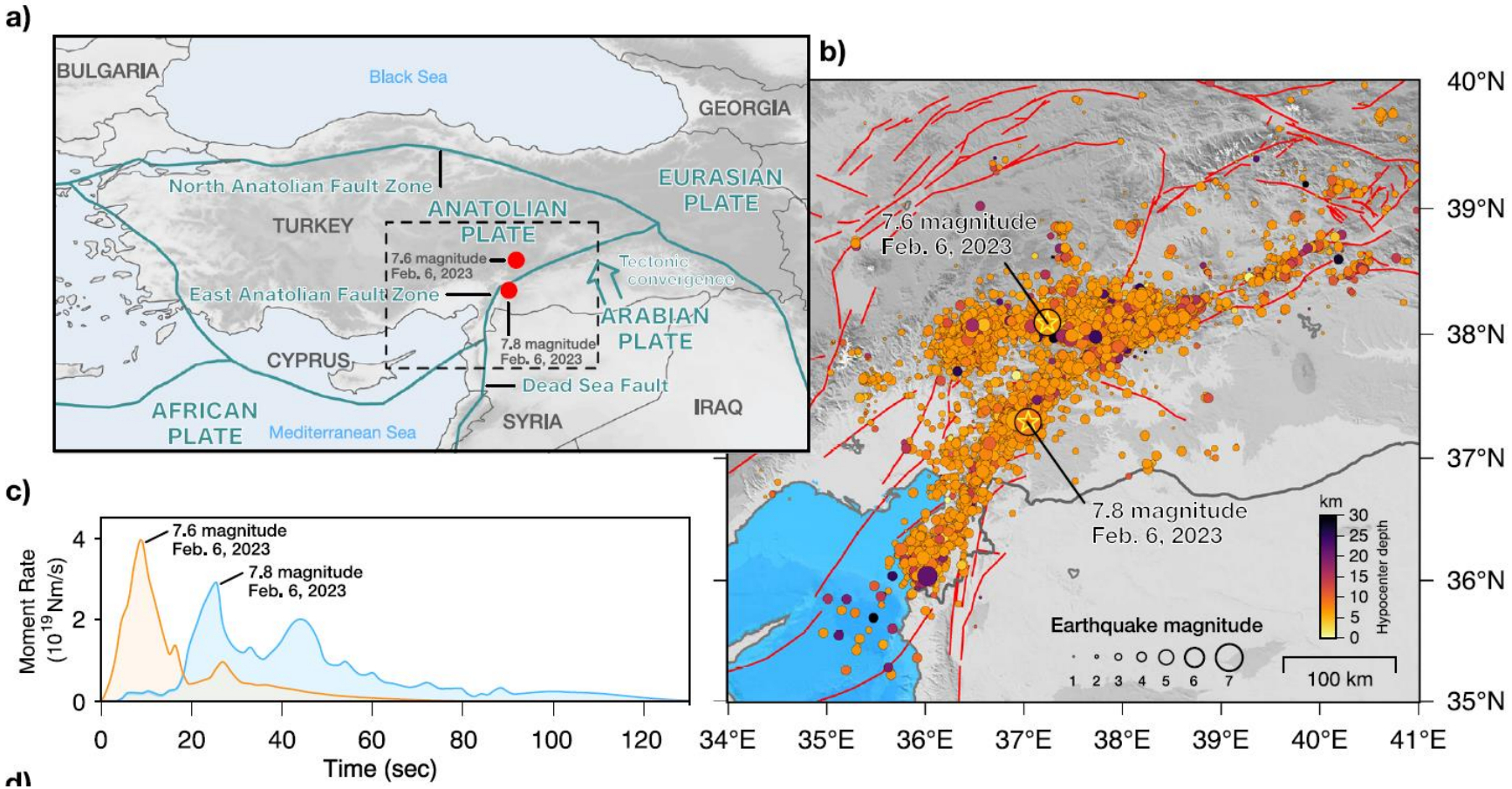
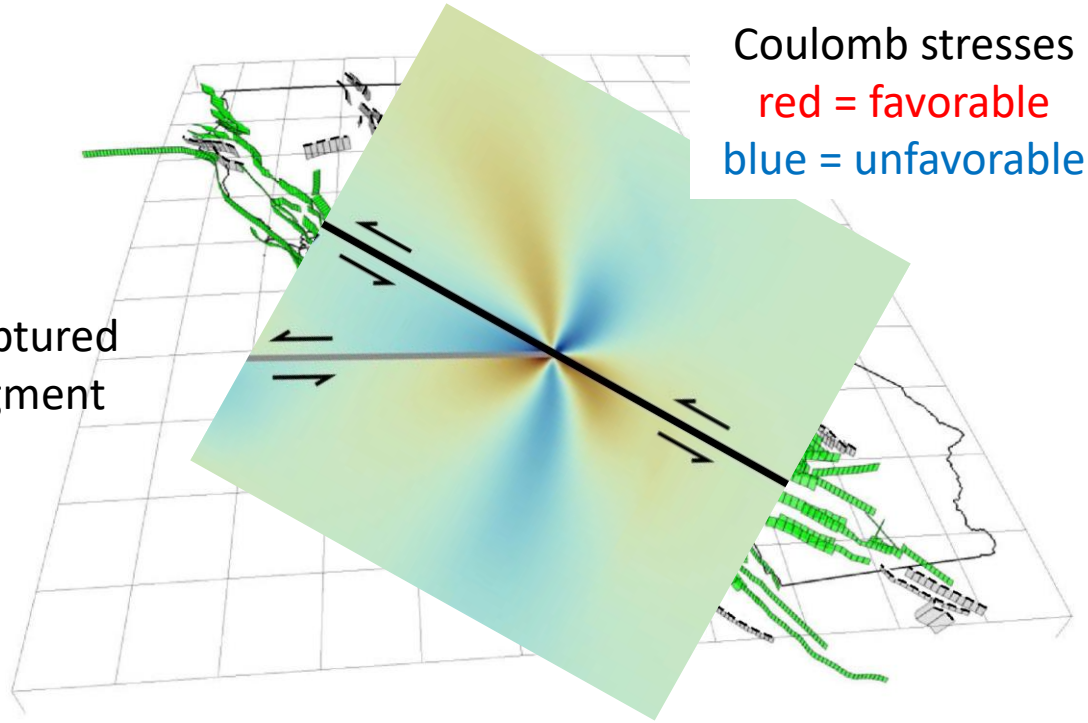
Earthquake doublet in Turkey and Syria

Luca Dal Zilio[1]✉ & Jean-Paul Ampuero[2]

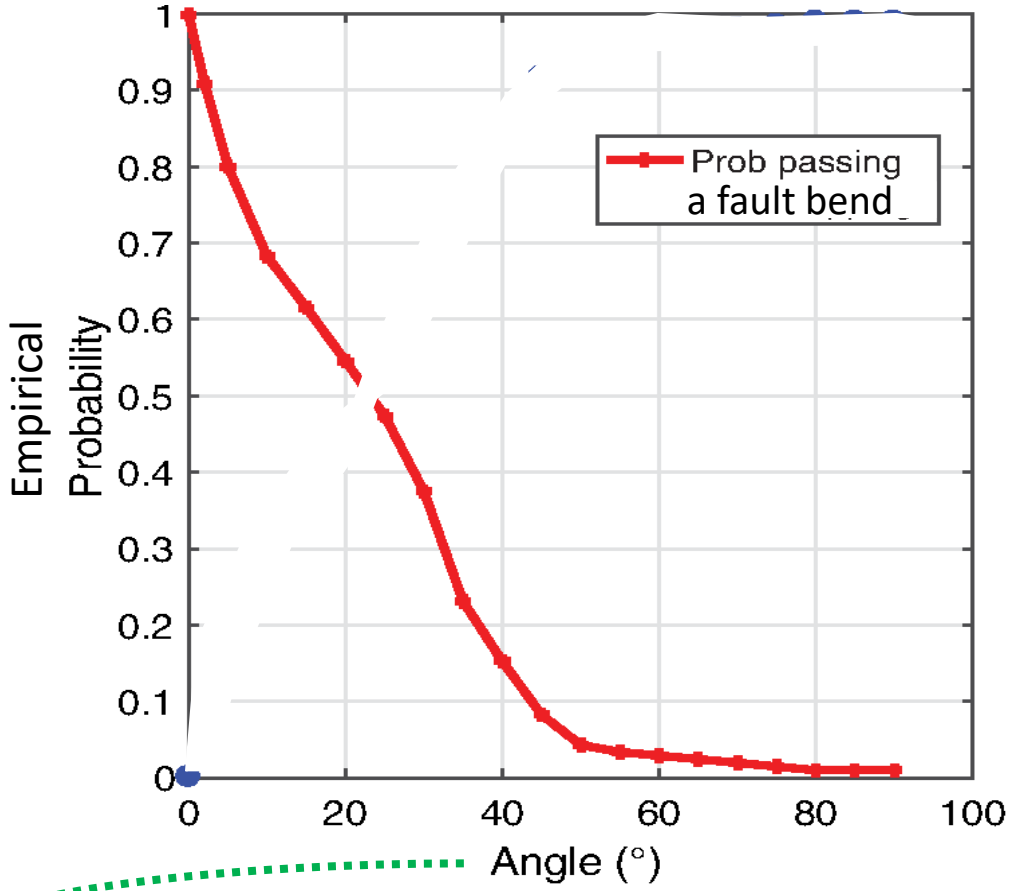


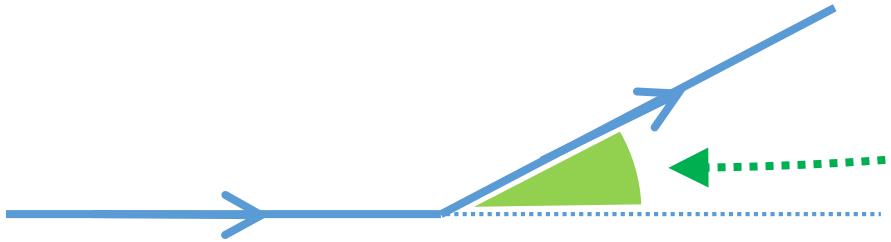
Multi-fault ruptures



Coulomb stresses
red = favorable
blue = unfavorable

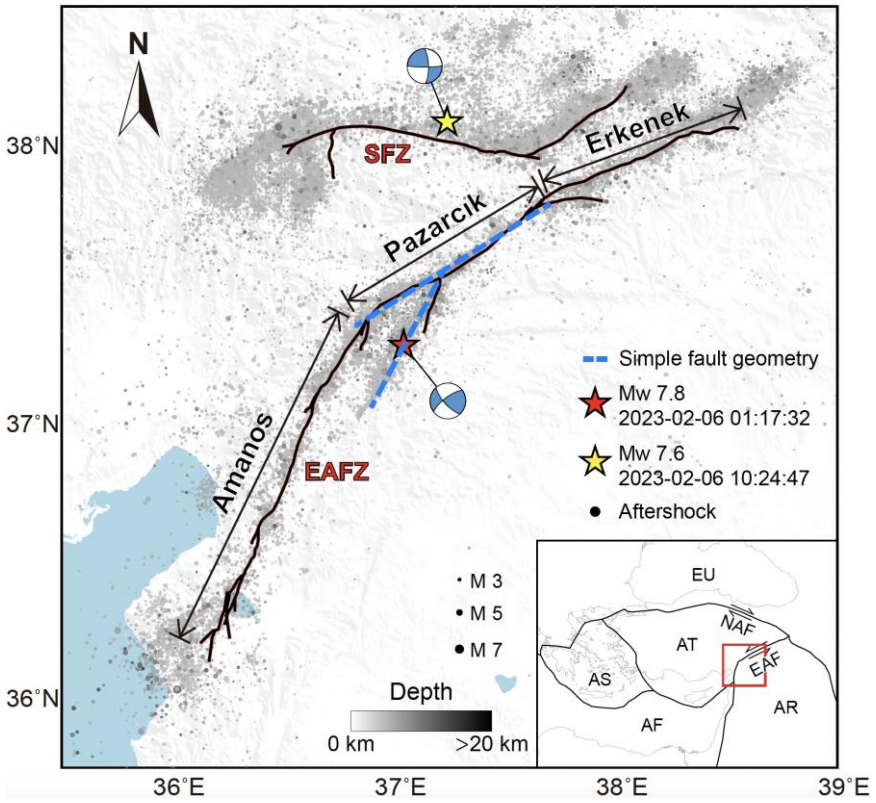
Ruptured segment

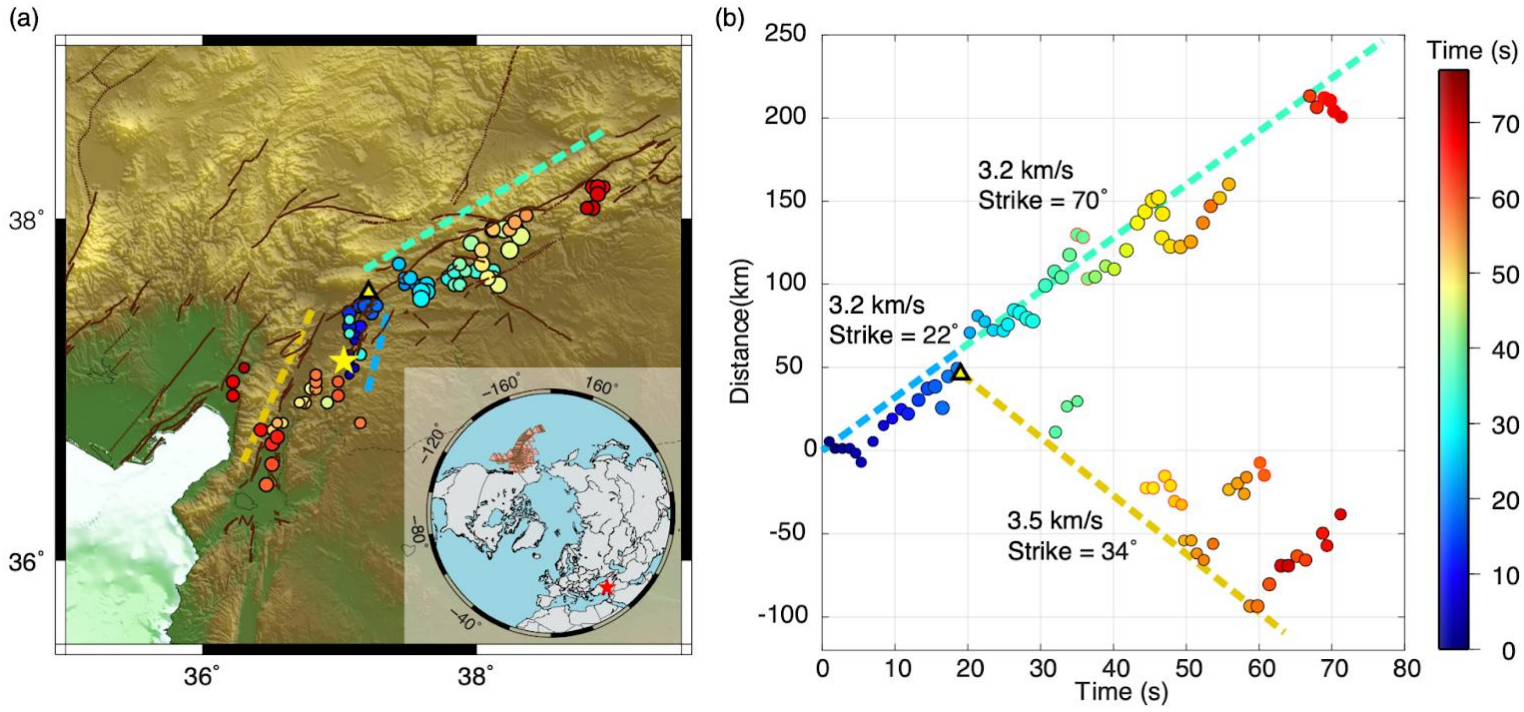




Biasi & Wesnousky (2021)

2023 Mw7.8 Kahramanmaraş, Turkey earthquake

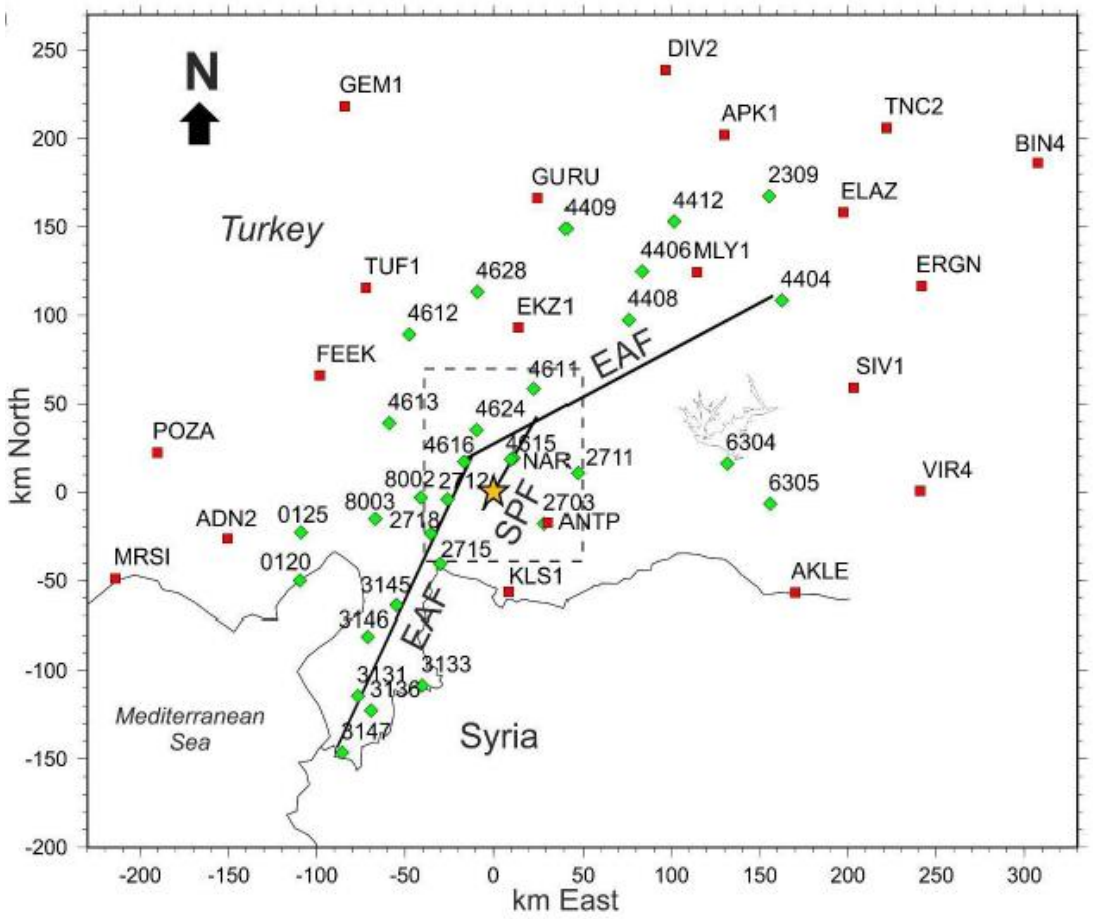


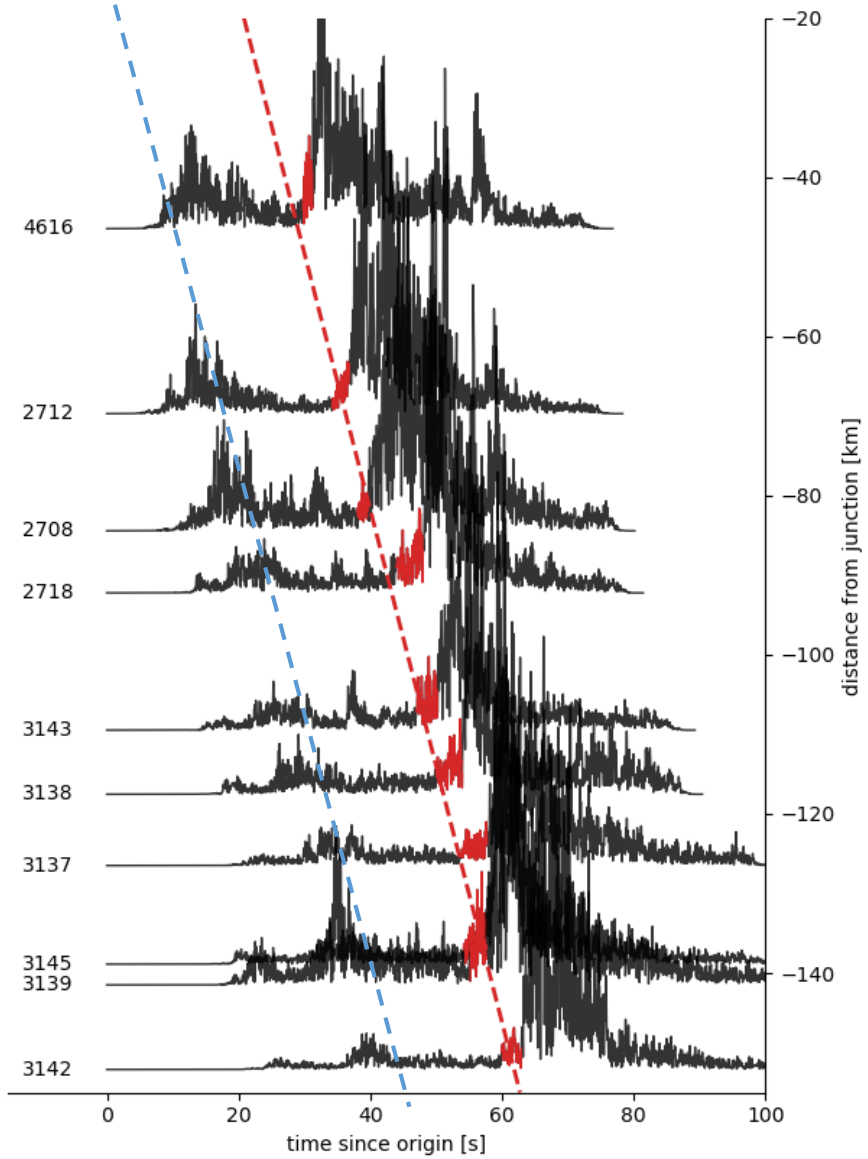


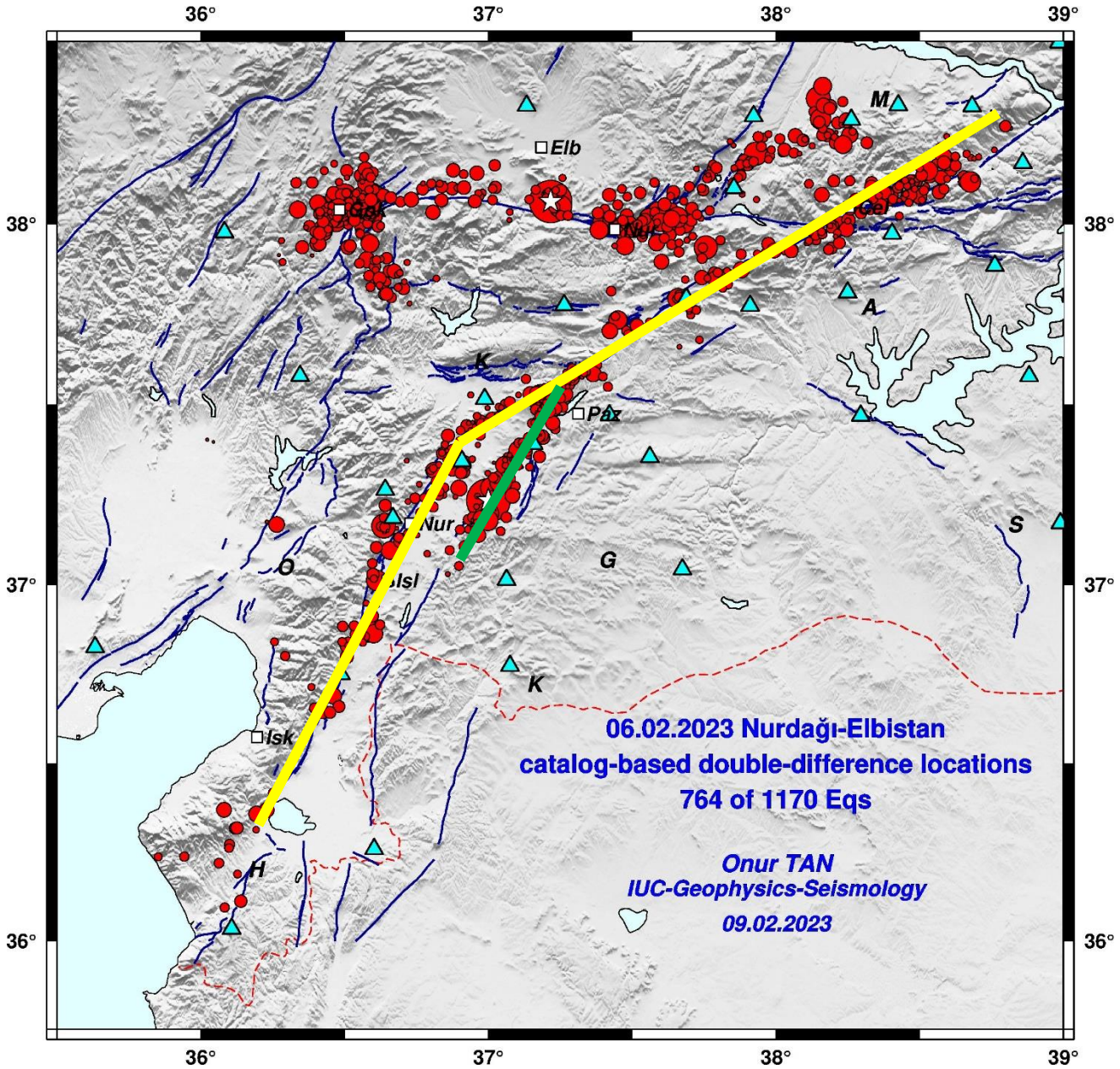
Teleseismic back-projection by Yuqing Xie (Geoazur)

Ding et al (2023)
https://doi.org/10.48550/arXiv.2307.06051

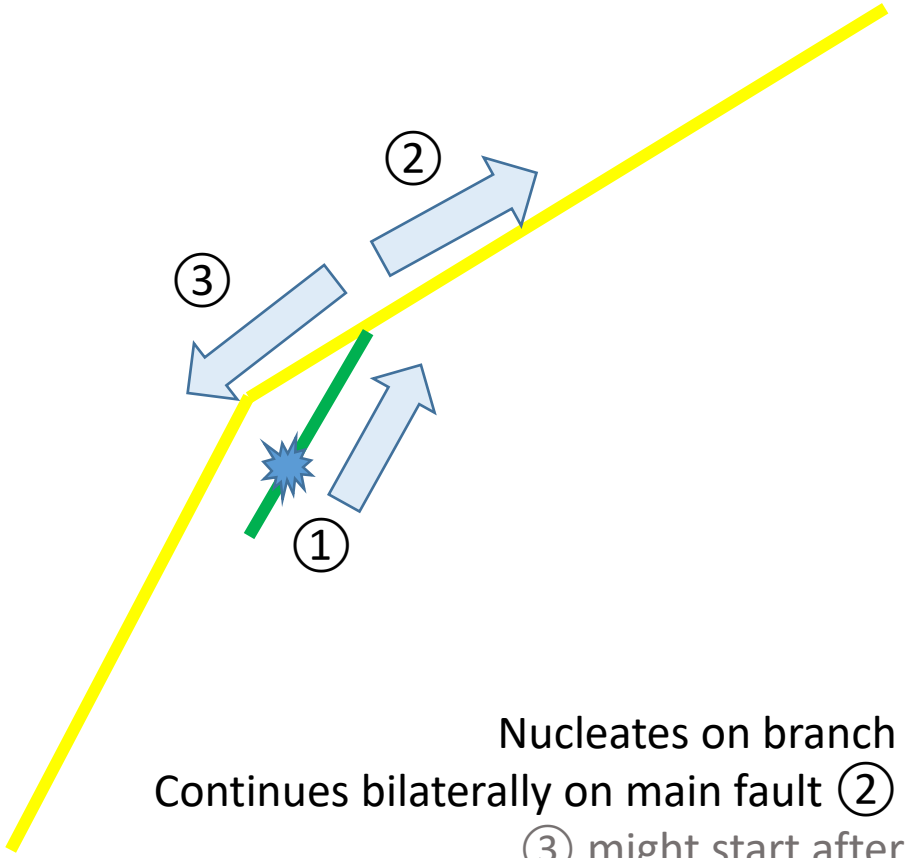
Local strong-motion data (AFAD)







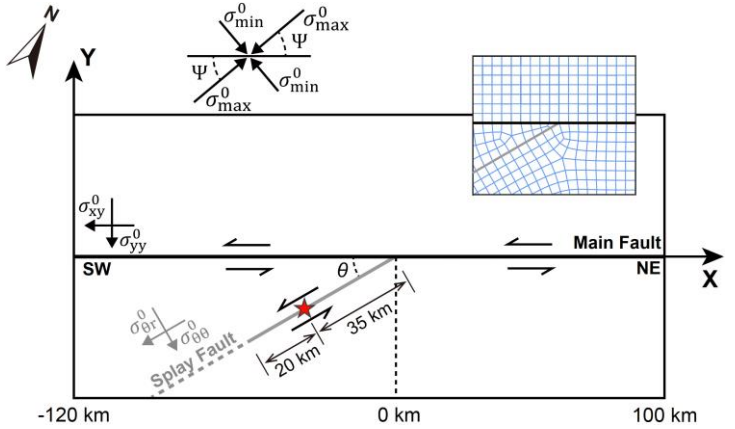
Left-lateral strike-slip faults
Main (yellow) and branch (green)

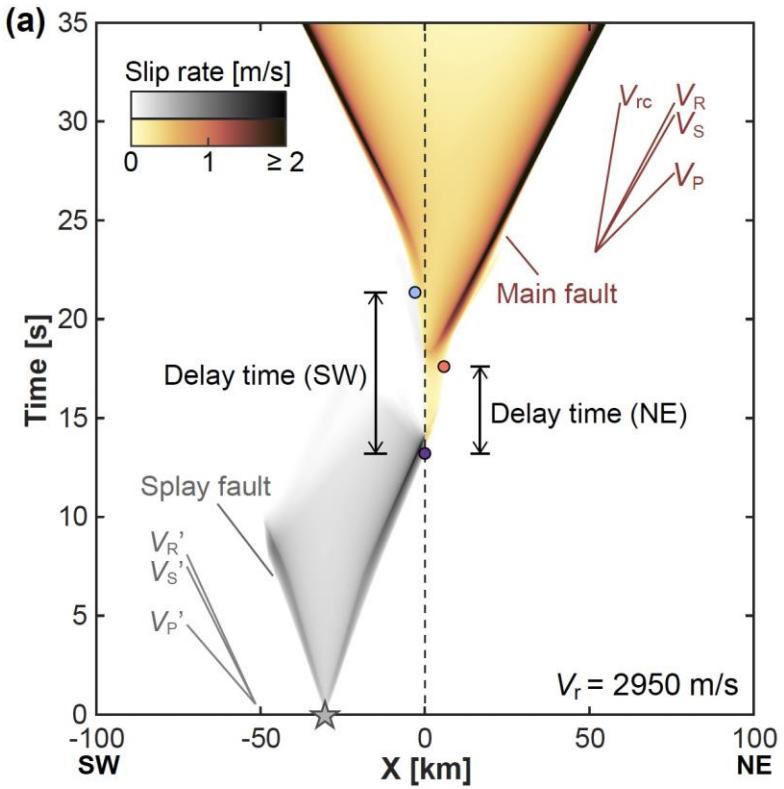


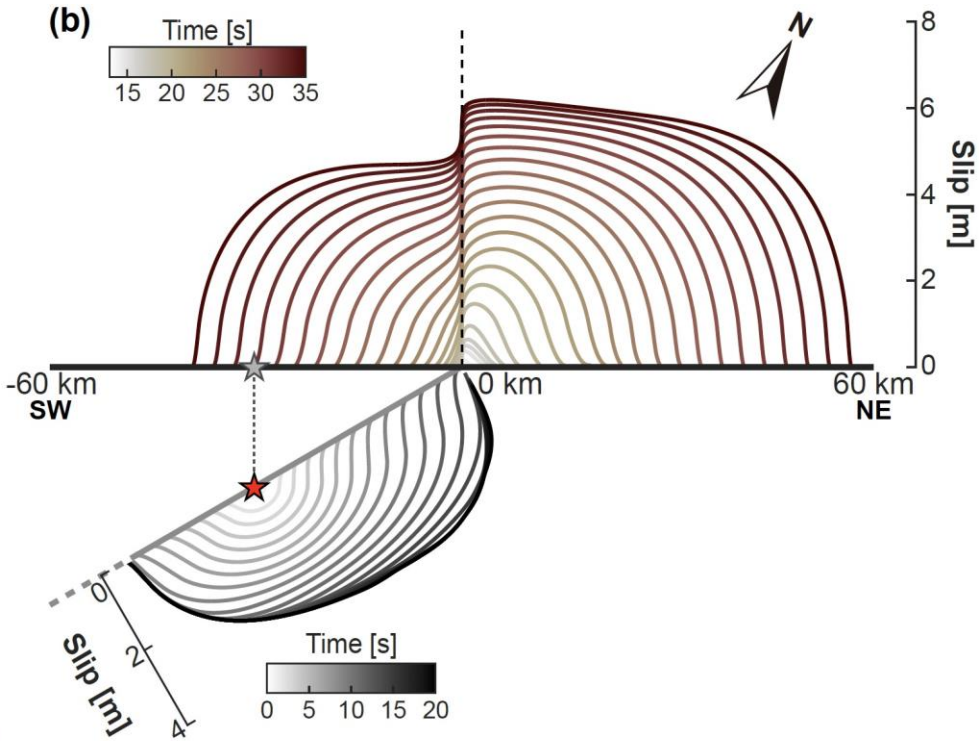
Nucleates on branch ①
Continues bilaterally on main fault ② ③
③ might start after ②

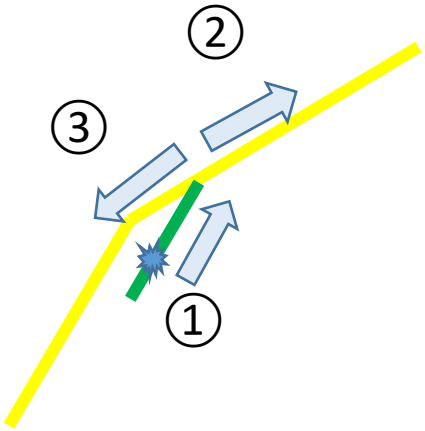
Dynamic rupture modeling

2.5D spectral elements
SEM2DPACK software
Shiqing Xu & team (SUSTech, China)



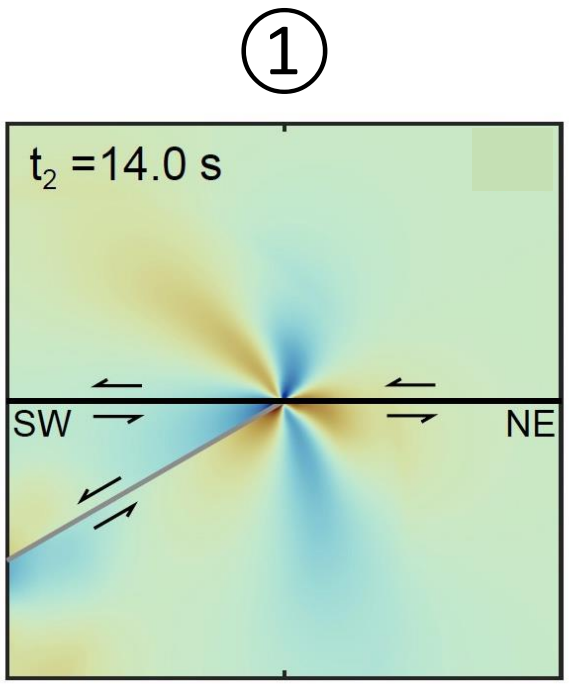


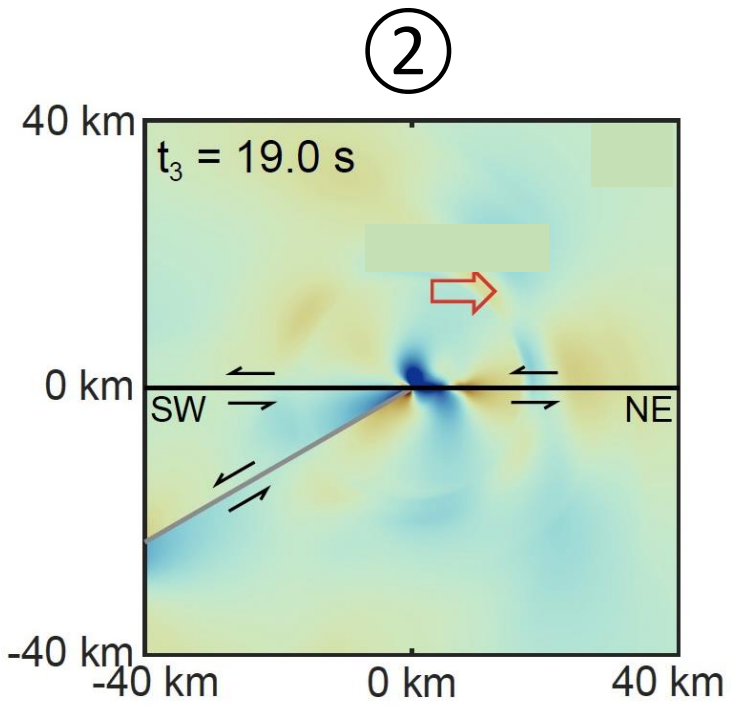


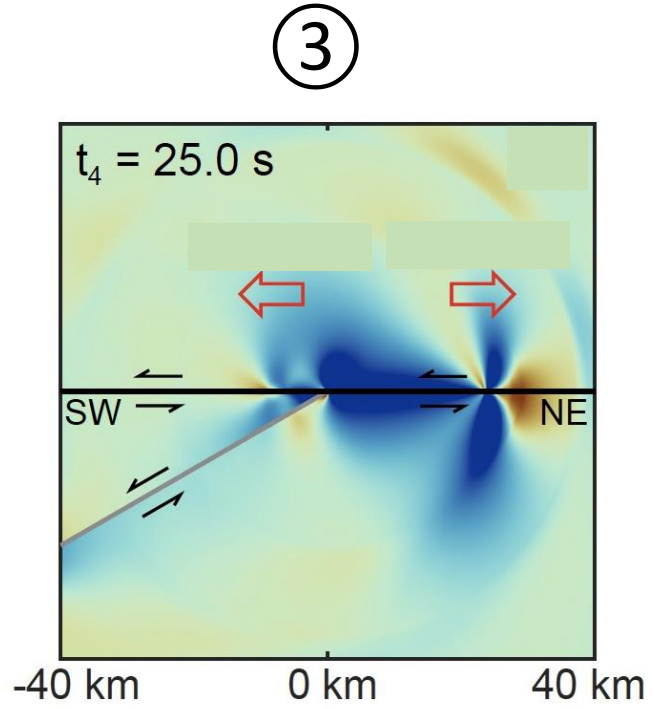


Dynamic rupture modeling

SW rupture ③ is not triggered by the splay ①,
but by the NE rupture ②

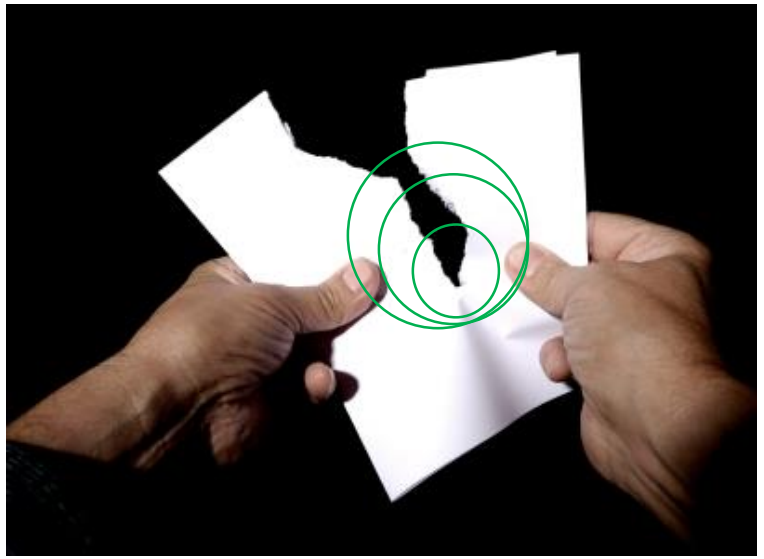




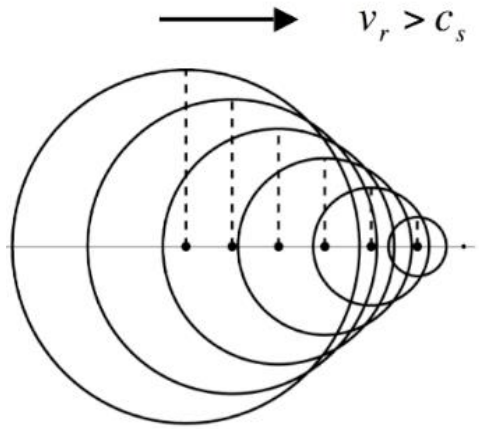


Earthquake rupture speed

Moving source



Supershear sources



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Article

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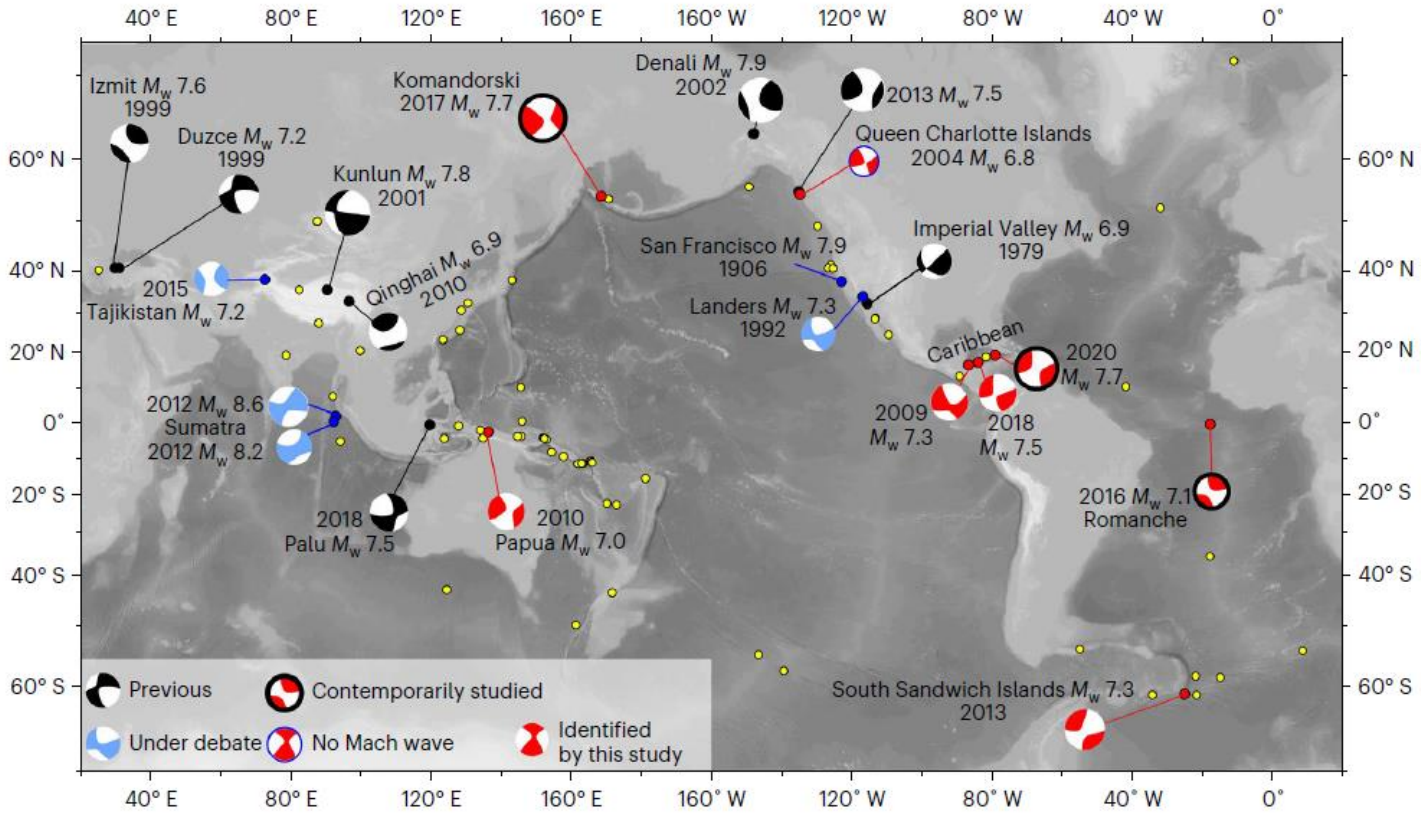
Global frequency of oceanic and continental supershear earthquakes

Received: 28 December 2021

Accepted: 20 September 2022

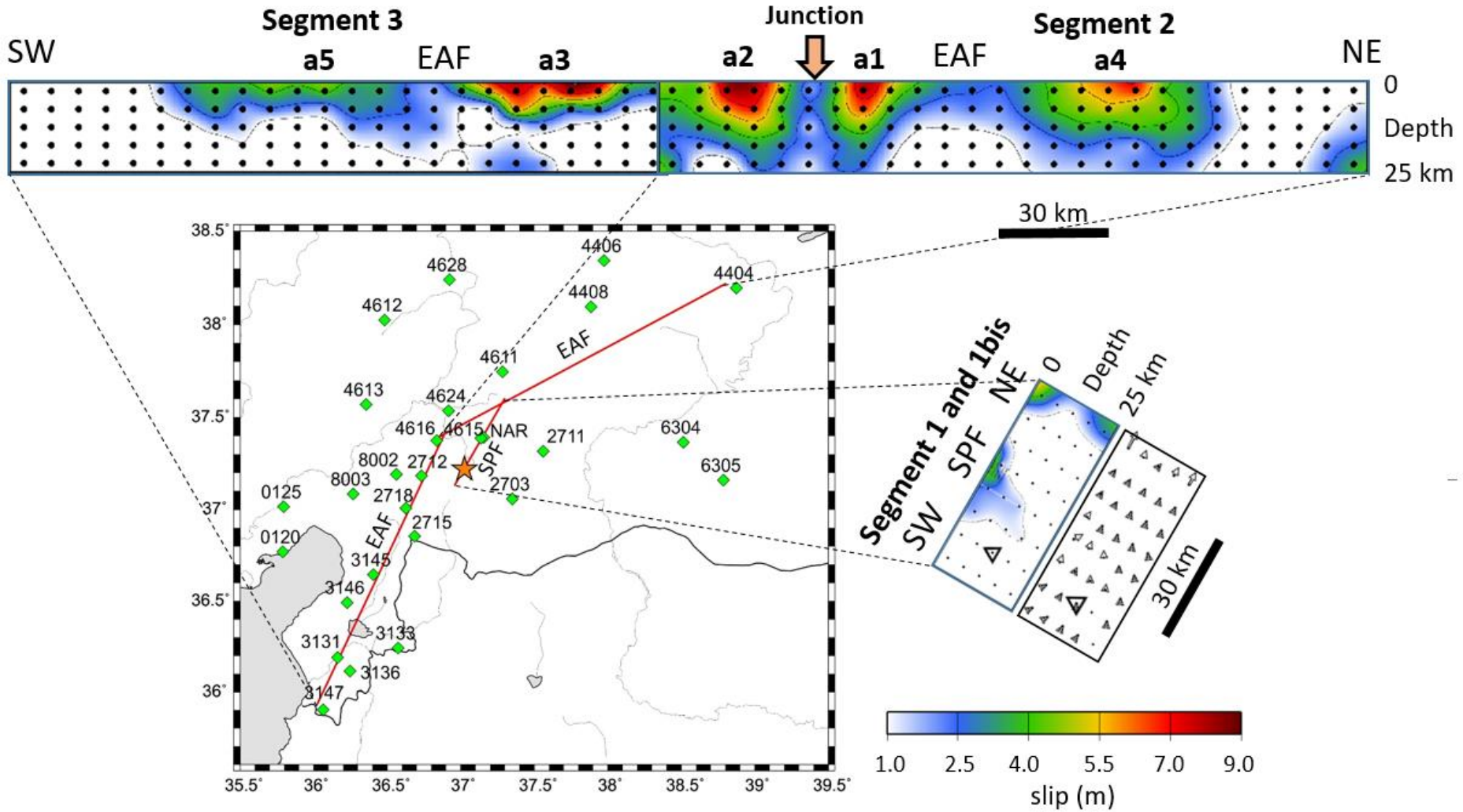
Han Bao[1,4], Liuwei Xu[1,4], Lingsen Meng[1] ✉, Jean-Paul Ampuero[2], Lei Gao[3] and Haijiang Zhang[3]



Global survey of large strike-slip earthquakes 2000-2020 using teleseismic back-projection and surface Mach waves

→ **At least 15% are supershear**

(M6.7+, depth<70 km, dip angles > 70°)

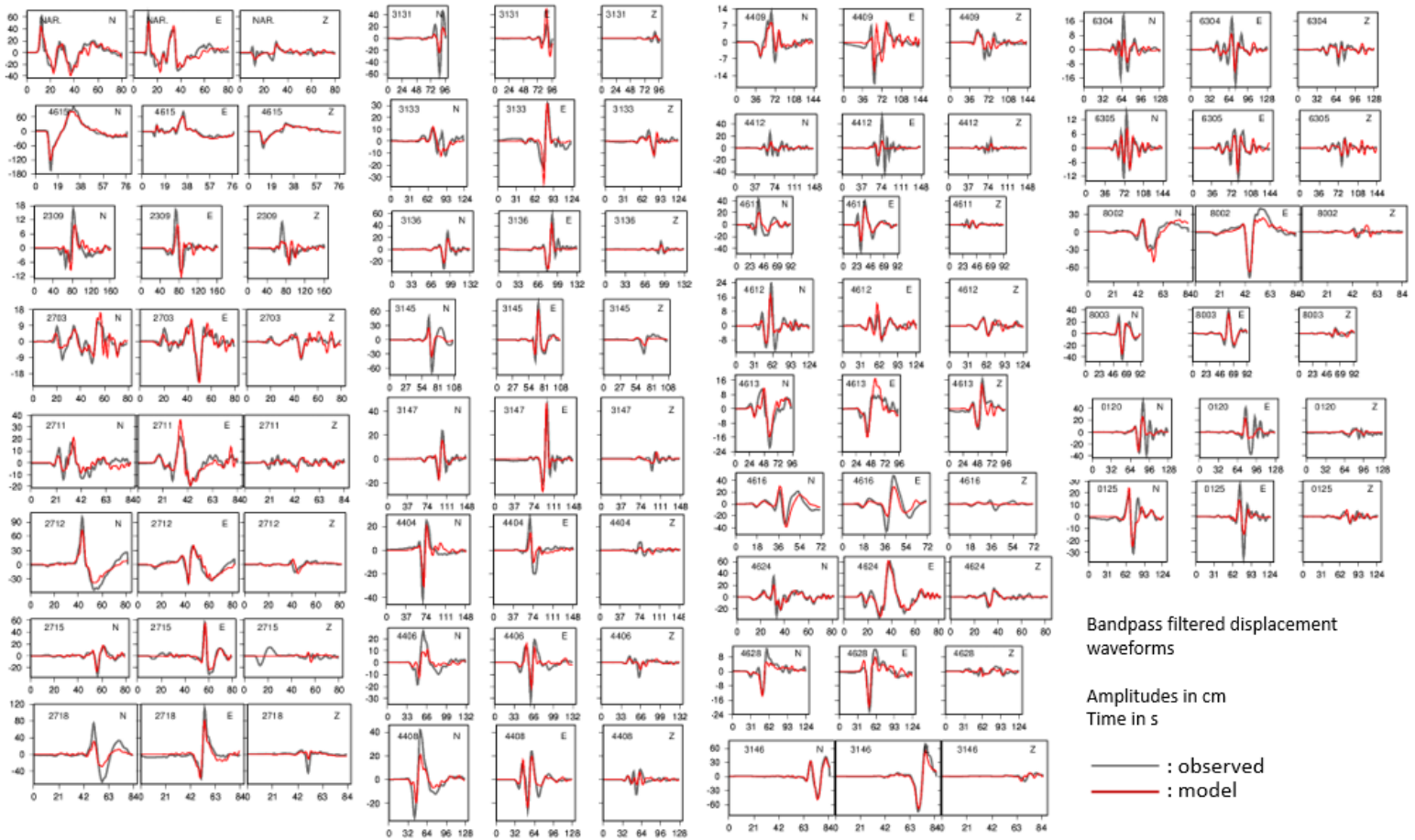


Finite source inversion. Strong motion data (AFAD) + GPS.

With Bertrand Delouis and Martijn van den Ende

Delouis et al (BSSA 2023)

Fit to strong motion data

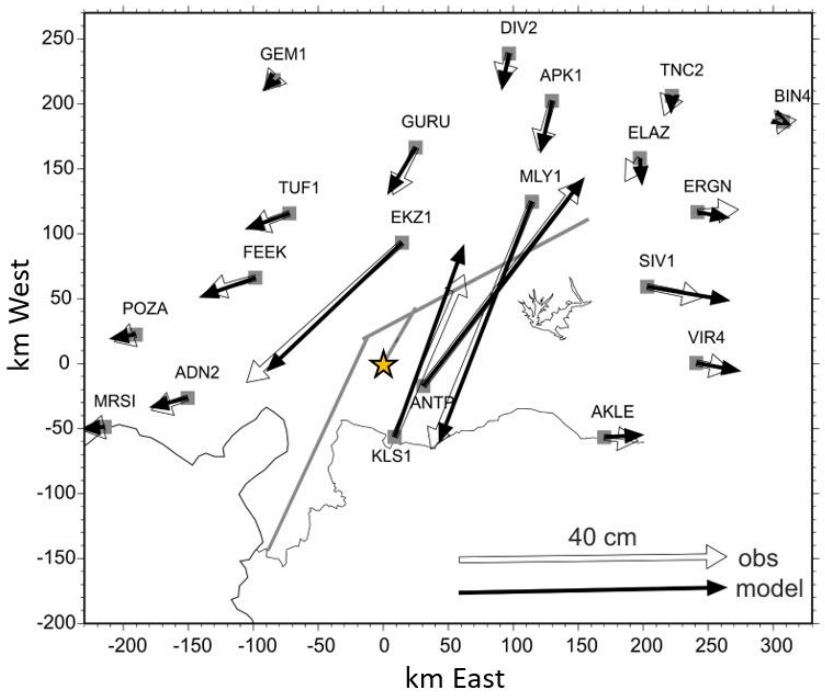


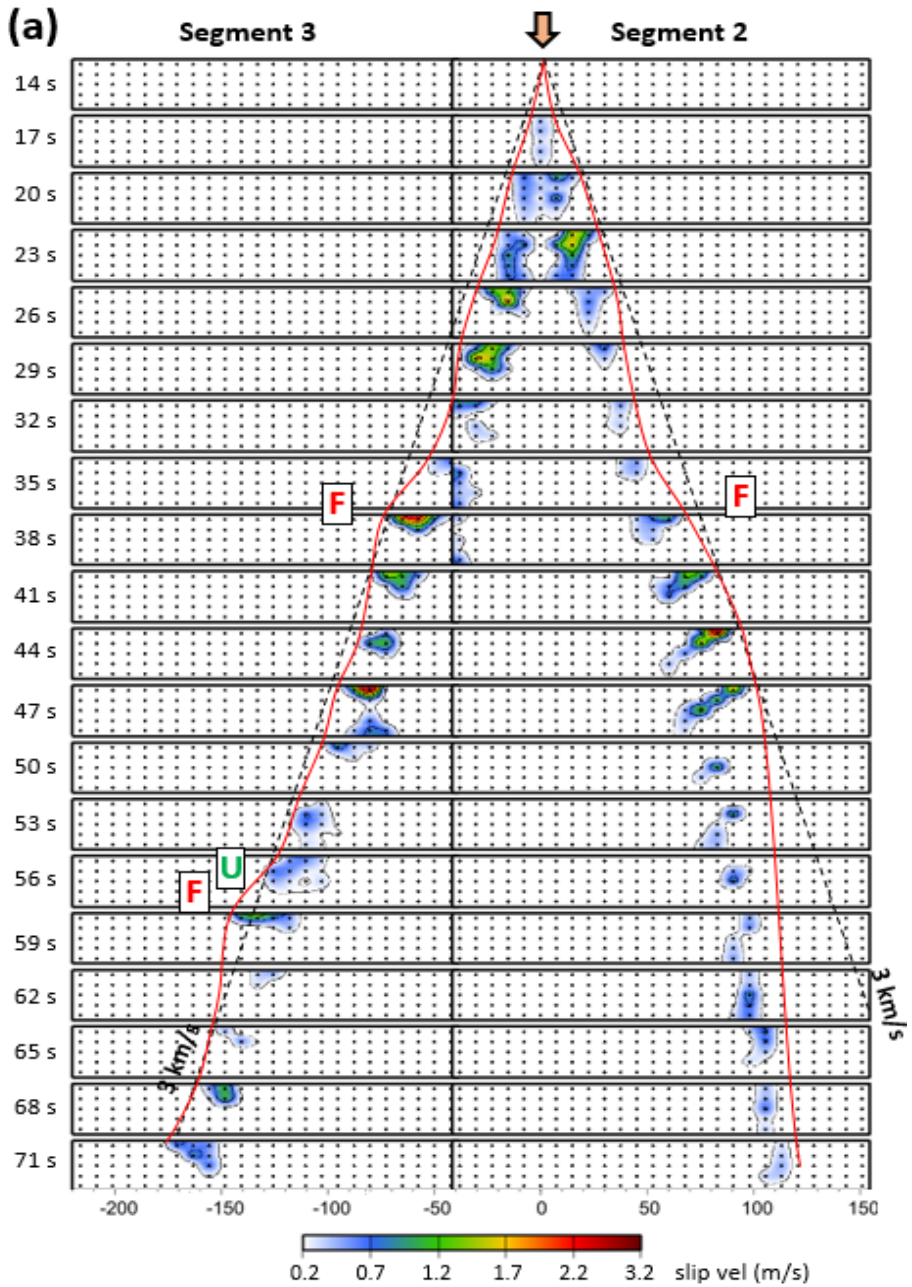
Bandpass filtered displacement waveforms

Amplitudes in cm
Time in s

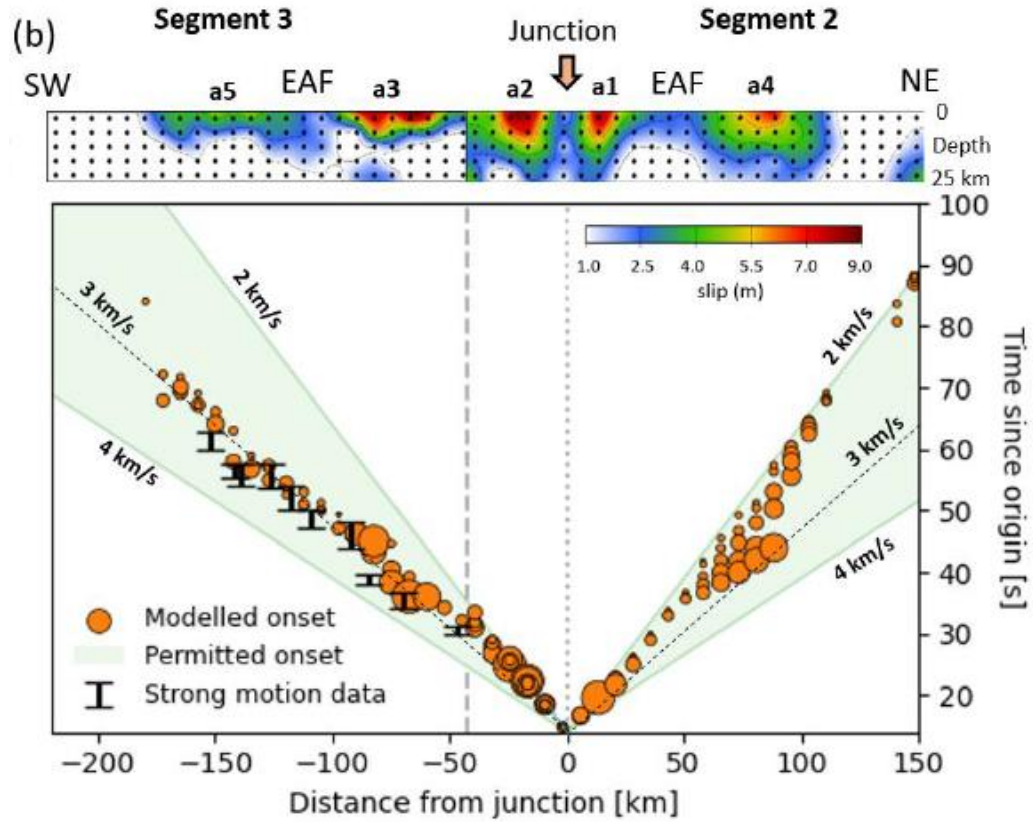
: observed
: model

Fit to GPS data





Finite source inversion. Strong motion data (AFAD) + GPS.
Delouis et al (BSSA 2023)



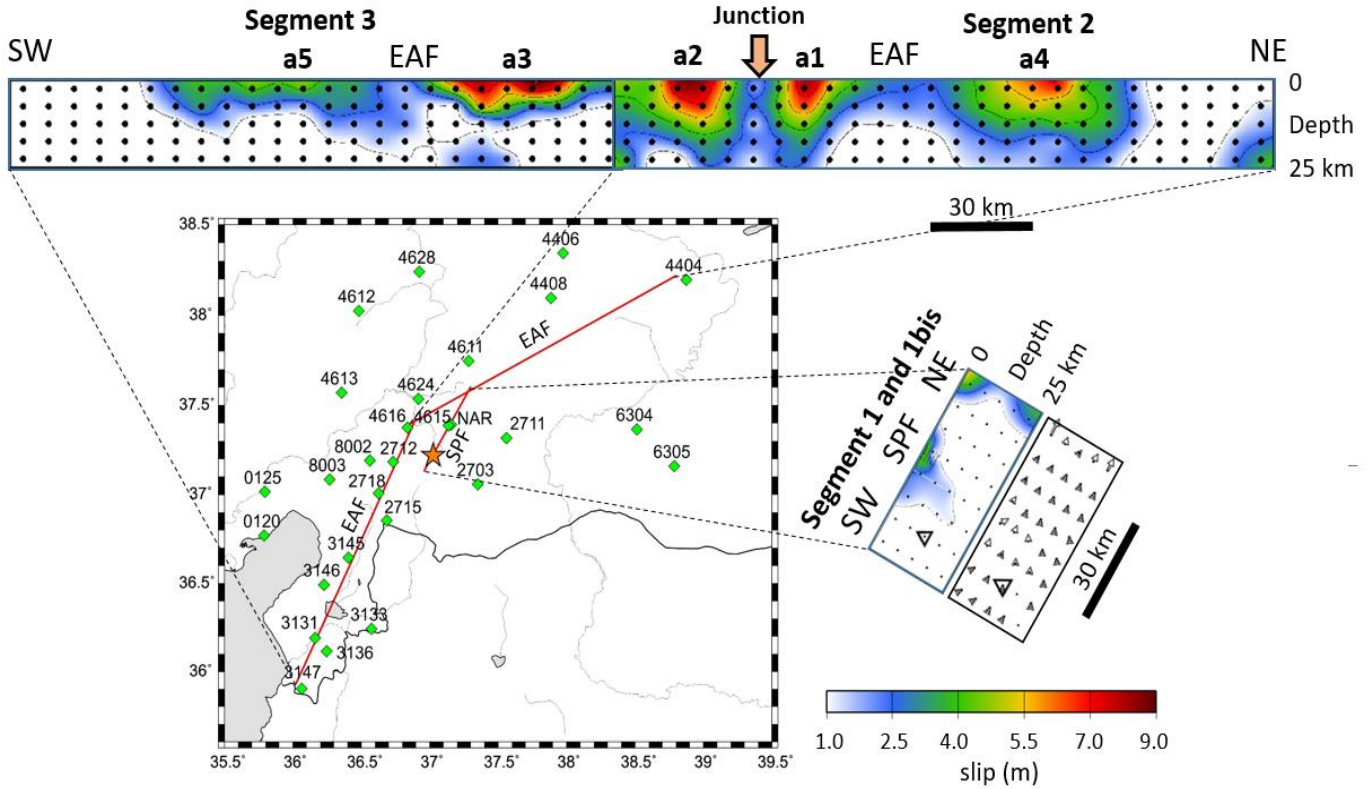
Intermittent supershear rupture

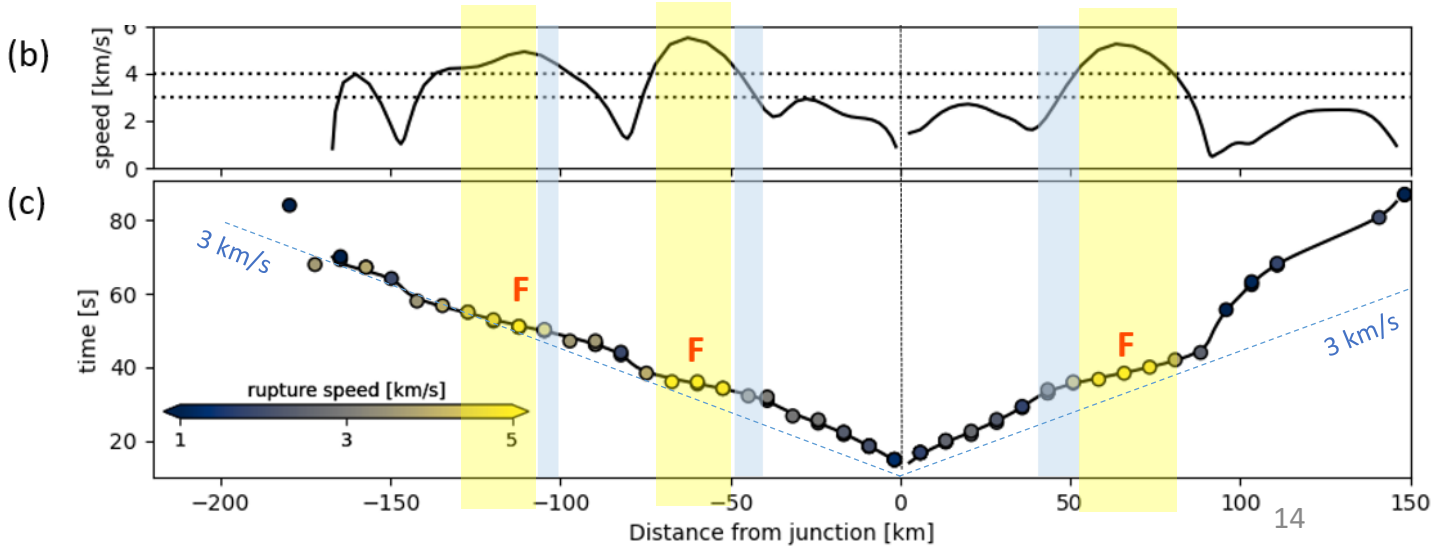
Delouis et al (2023)

Source inversion with a large set of near-source strong motion records + GNSS reveals the rupture process with high resolution

The rupture speed was subshear on average, but locally supershear on three ~20 km-long portions of the East Anatolian Fault.

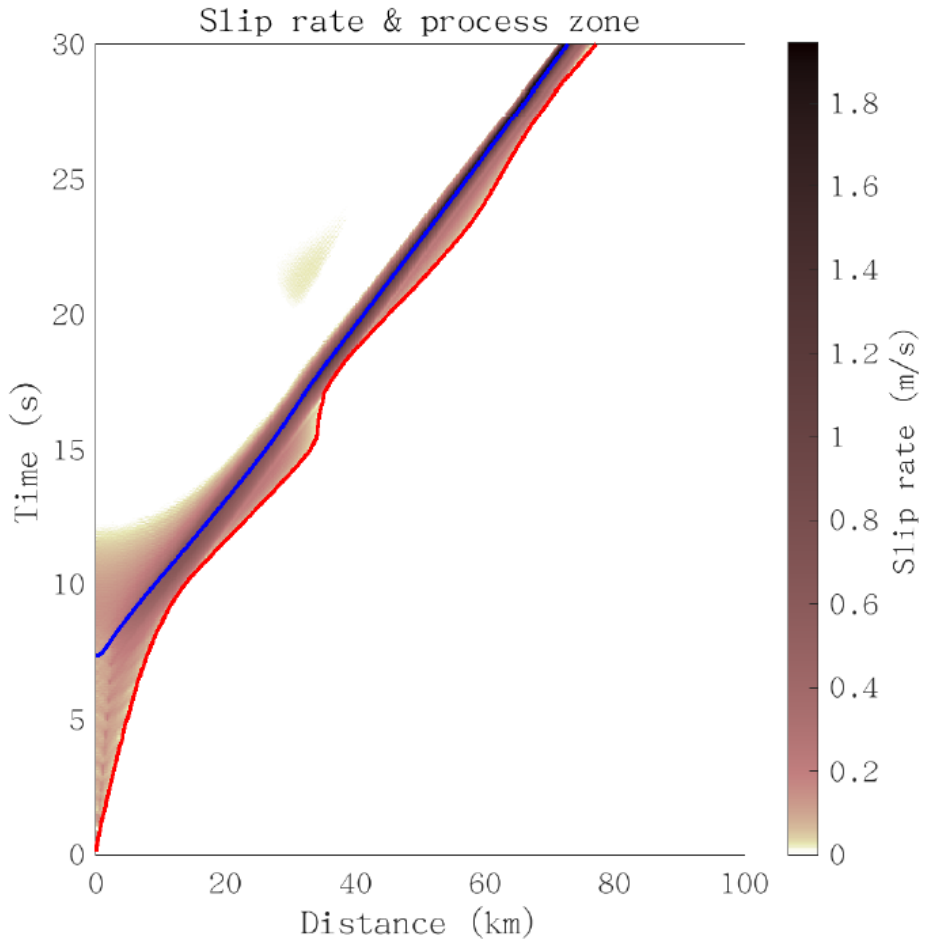
Supershear speeds do not correlate systematically with slip, fault geometry, aftershock density.

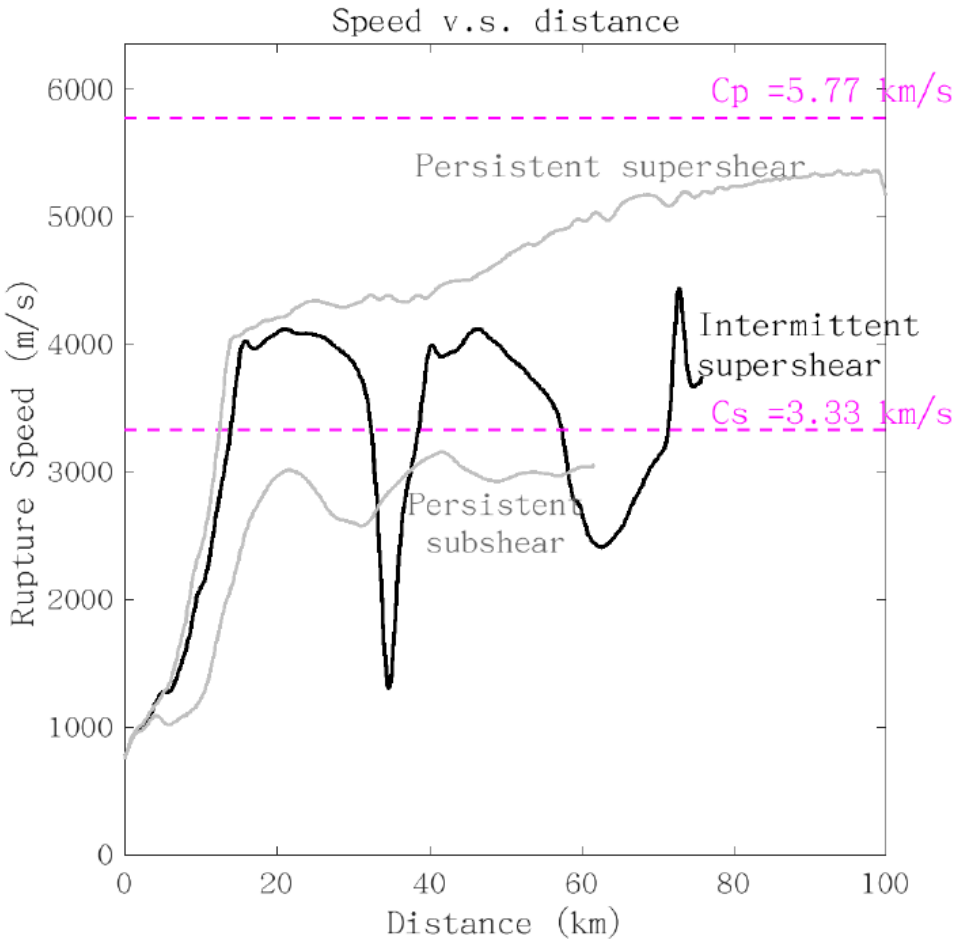




Intermittent supershear in a dynamic rupture model on a homogeneous fault

By Liuwei Xu (UCLA)





Conclusions

The 2023 Turkey M7.8 earthquake:
a uniquely dense dataset, provides new insights on rupture processes

1. Rupture branching despite acute angle
2. Intermittent supershear rupture

These surprising features
might be more usual than we think (limited observations)
and should be incorporated in hazard assessment

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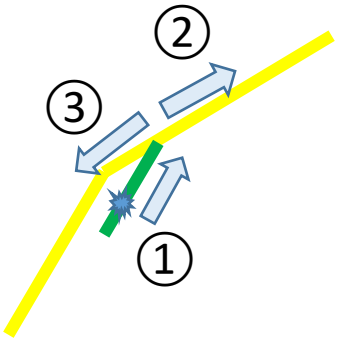
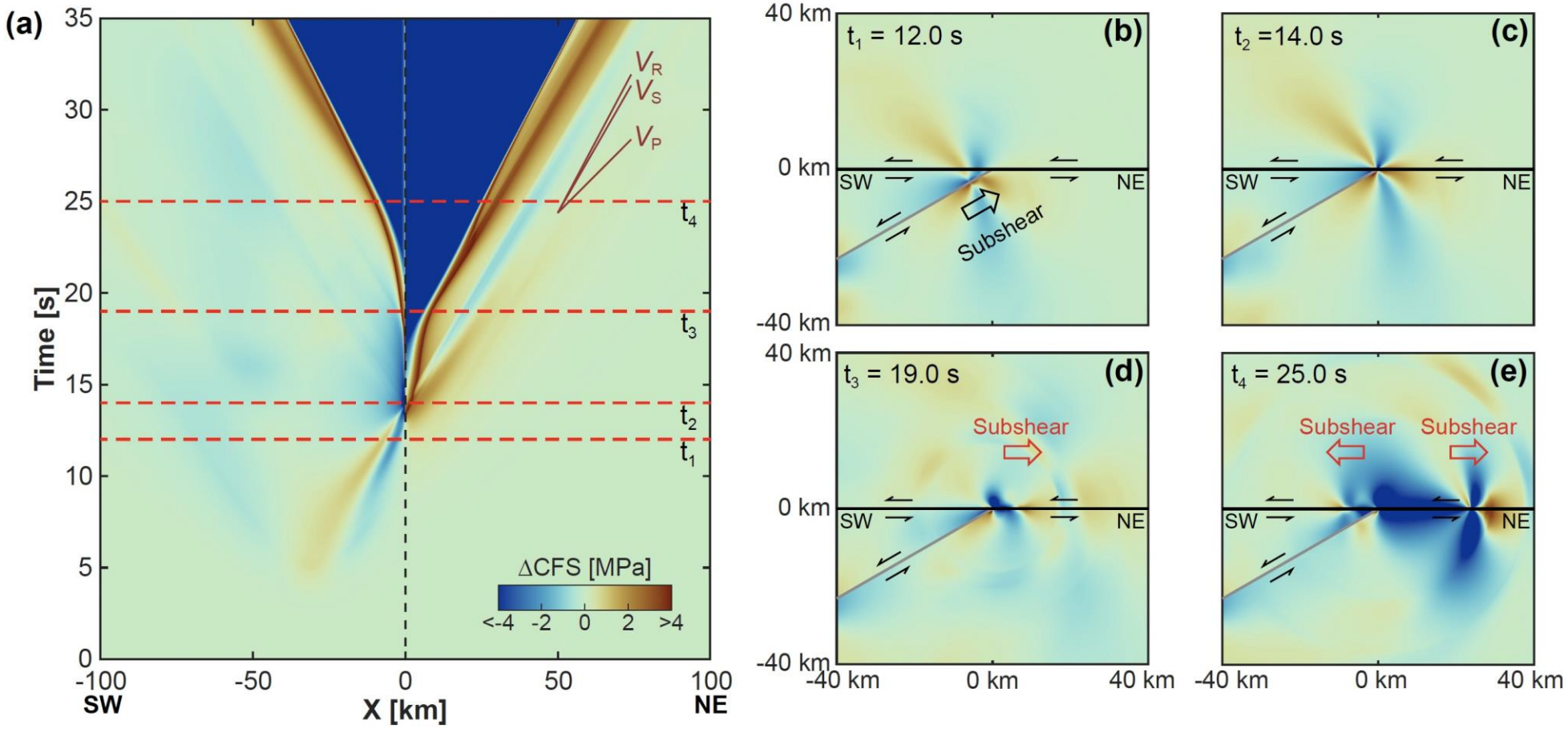
Dynamic rupture modeling

SW rupture ③ is not triggered by the splay ①, but by the NE rupture ②



SW NE



Another scenario:
SW rupture ③ is triggered by the splay ①,
and the NE rupture ② starts later

This scenario is unlikely:
it only happens for very high initial stress on the EAF