Exploring complex normal faulting systems through physics-based dynamic modeling.

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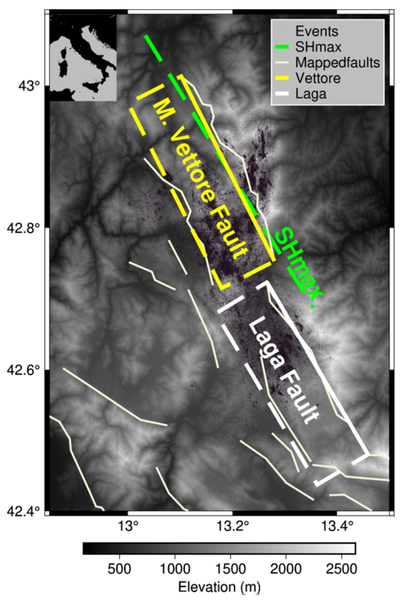
1. Introduction

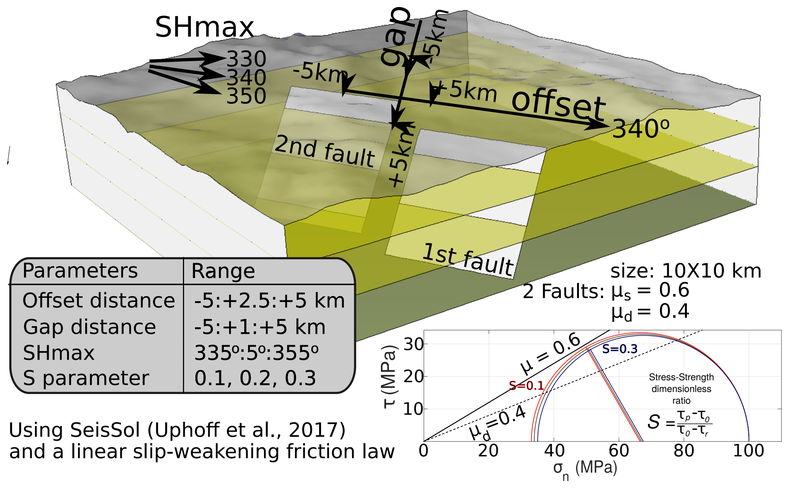


Geological context:

The Apennine seismic belt in Italy is an extensional province characterized by multi-fault normal-faulting seismic activity. Earthquakes and/or seismic sequences ocurring across multi-fault segments during a single event (e.g. 1980 Ms 6.9 Irpinia Bernard & Zollo (1989)) or sequences spanning a period of days (e.g. 2009 Mw 6.1 L'Aquila Valoroso et al (2013)) to months (e.g. 2016 Amatrice-Visso-Norcia Improta et al. (2019)), are controlled by the physical complexities of the active normal fault system. Understanding rupture propagation across step-overs, breaking multiple fault segments during a single earthquake, is crucial to enhance the current SHA Bai and Ampuero (2017).

Goal: Explore dynamic rupture parameters to better understand the physical condition promoting rupture jumps in normal faulting systems

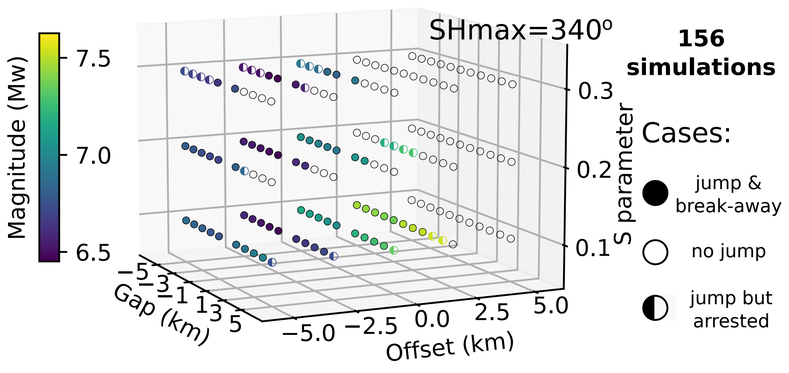
2. Geometry-Settings



Parameters	Range
Offset distance	-5:+2.5:+5 km
Gap distance	-5:+1:+5 km
SHmax	335°:5°:355°
S parameter	0.1, 0.2, 0.3

Using SeisSol (Uphoff et al., 2017) and a linear slip-weakening friction law

3. Simulation-Results



Some cases did not break the second fault, due to the distance between faults (large offsets and gaps), effect enhanced by prestress state (large S, small stress). Overlap (Offset<0) promotes the jump.

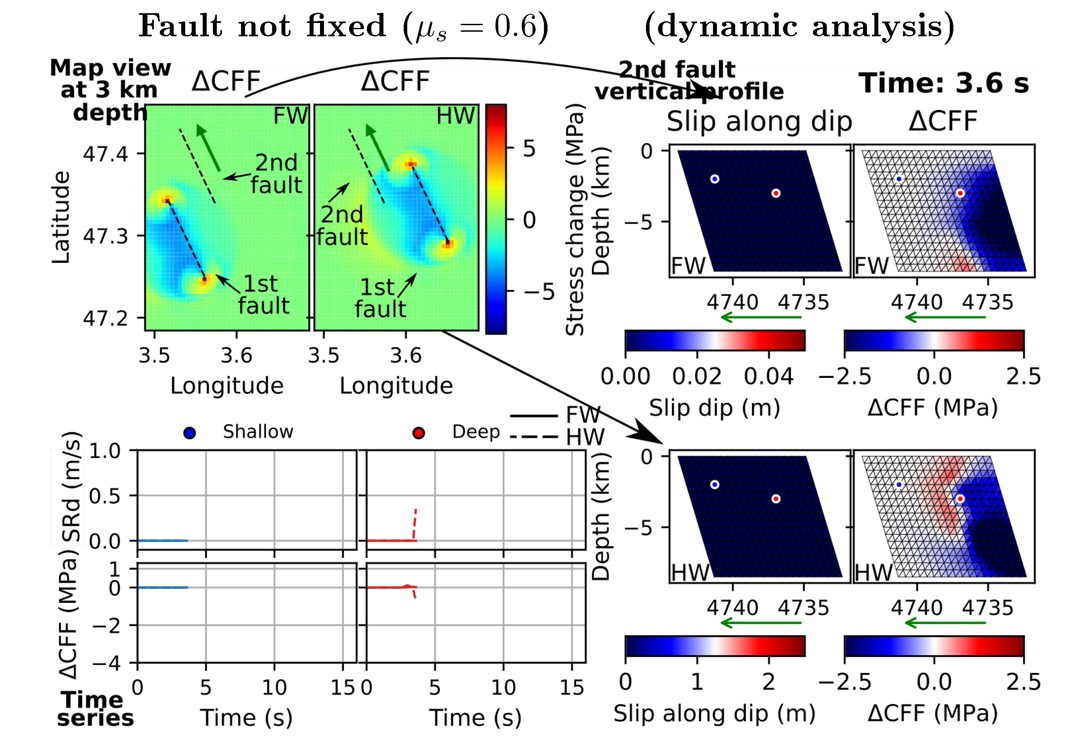
Hanging/foot wall asymmetry:

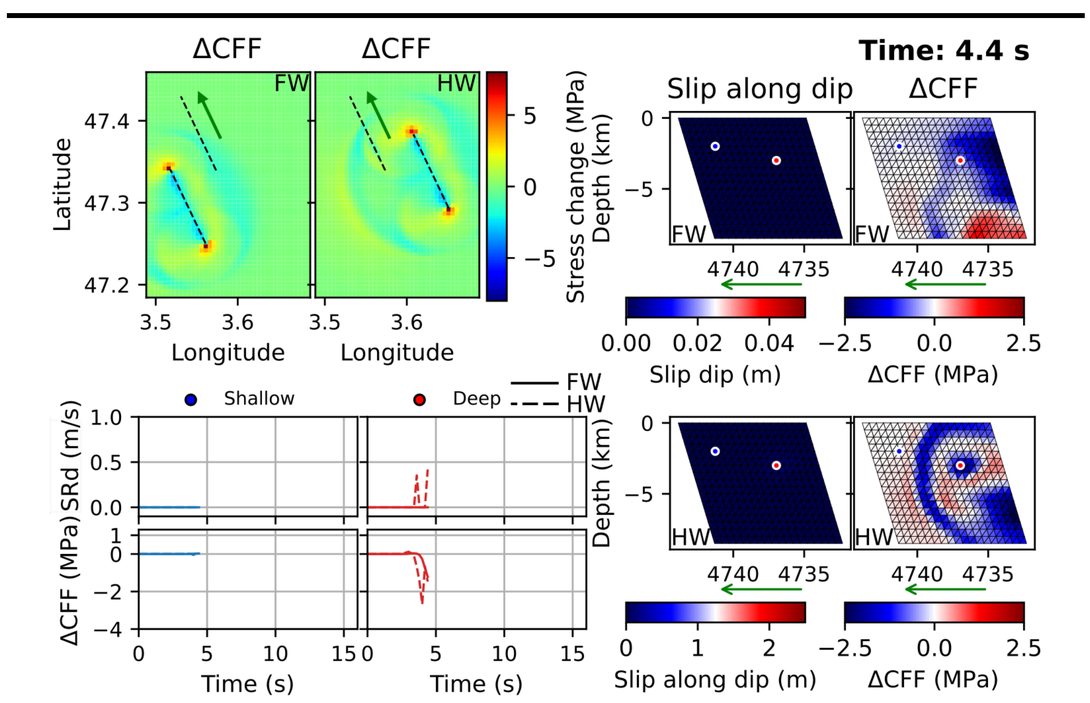
Regarding the second fault location with respect to the main fault (hanging or foot wall), when the second fault is on the hanging wall (Gap<0), the dynamically triggered rupture is more likely to be triggered and sustainable.

Stress shadow:

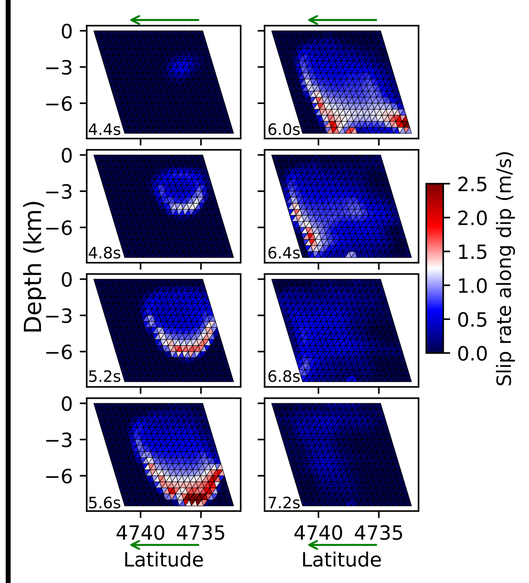
The final energy released (M_w) increases/decreases according to the distance between faults (offset & gap). Although the overlap increases the triggering effect, the stress shadow due to the fault proximity inhibits a large stress drop on the 2nd fault.

4. Jump ? How ? When ? Why ?

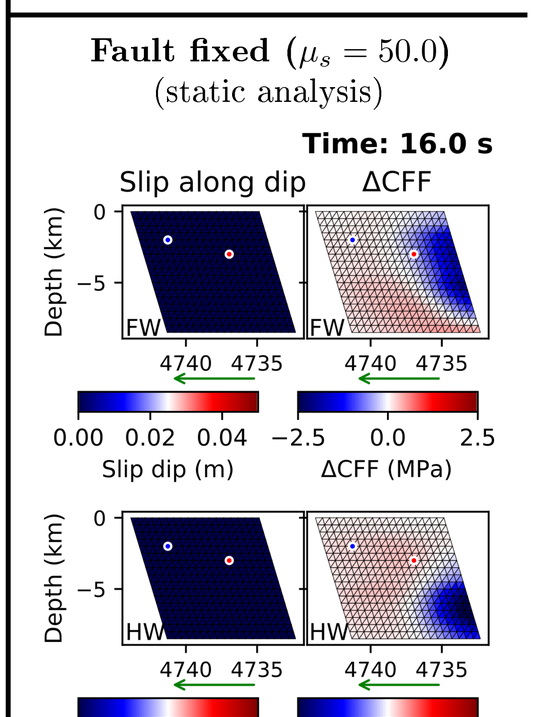




Slip rate snapshots
fault not fixed &
break-away behavior



Fault fixed ($\mu_s = 50.0$)
(static analysis)



5. Conclusion & Discusion

☞ A static analysis seems insuficient to determine a **"break-away"** behavior across step-over jumps.

☞ A maximum **5 km** step-over distance can still be crossed and promote **break-away ruptures** when pre-stress levels are high enough ($S = 0.1$) and no obstacles (geometry, SHmax direction, friction properties, etc.) are present.

☞ **Break-away** ruptures on the 2nd fault seem to be triggered by two S waves arriving simultaneously to the 2nd fault from the northern and bottom ends of the 1st fault.

☞ A positive ΔCFF area on the 2nd fault is insuficient to determine if the rupture will be triggered.

☞ Triggered by coinciding arrival of several waves?

References

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