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

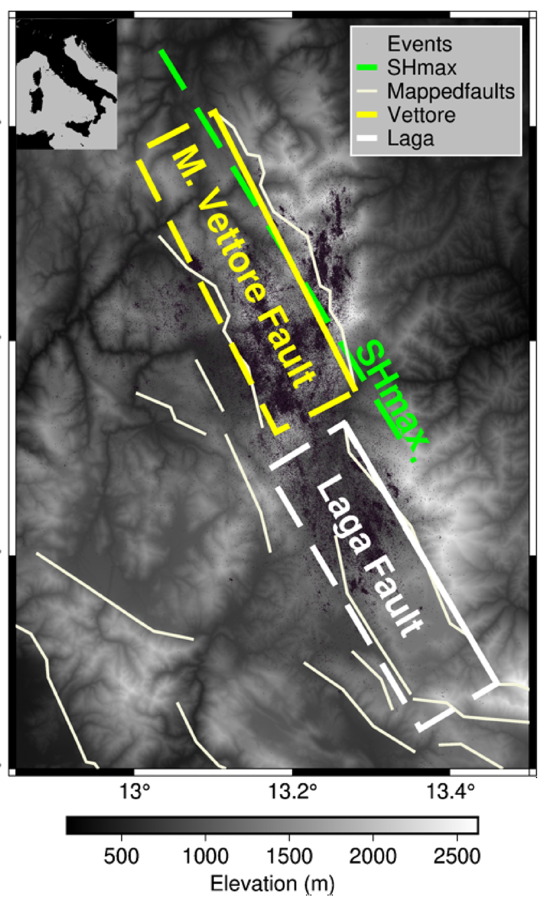
H.-S. Sánchez-Reyes[1], O. Scotti[1], S. Hok[1], A.-A. Gabriel[2] and T. Taufiqurrahman[2]

Bureau d'Évaluation des Risques Sismiques pour la Sûreté des Installations, IRSN, 92260 Fontenay-aux-Roses, France

Department of Earth and Environmental Sciences, Ludwig-Maximilians-Universitat, 80333 Munchen, Germany

hugo.sanchez-reyes@univ-grenoble-alpes.fr

1. Introduction

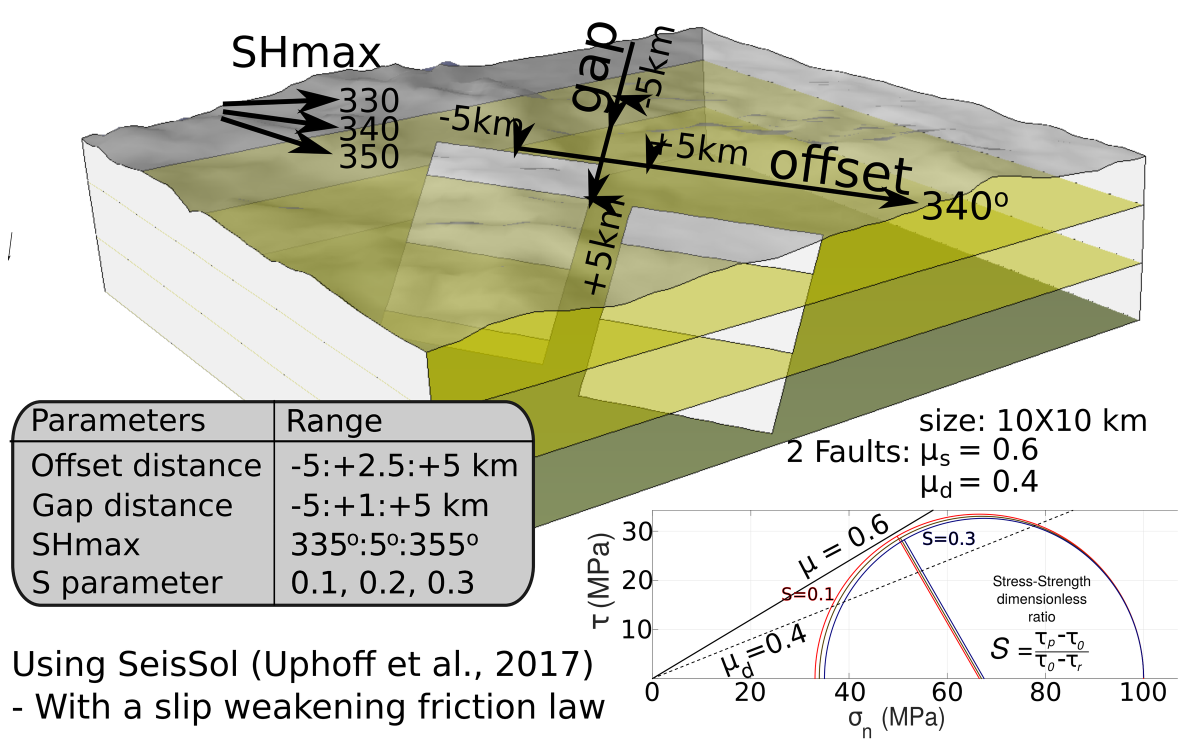


Geological context:

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 Bernnard & 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 Amatri-ce-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

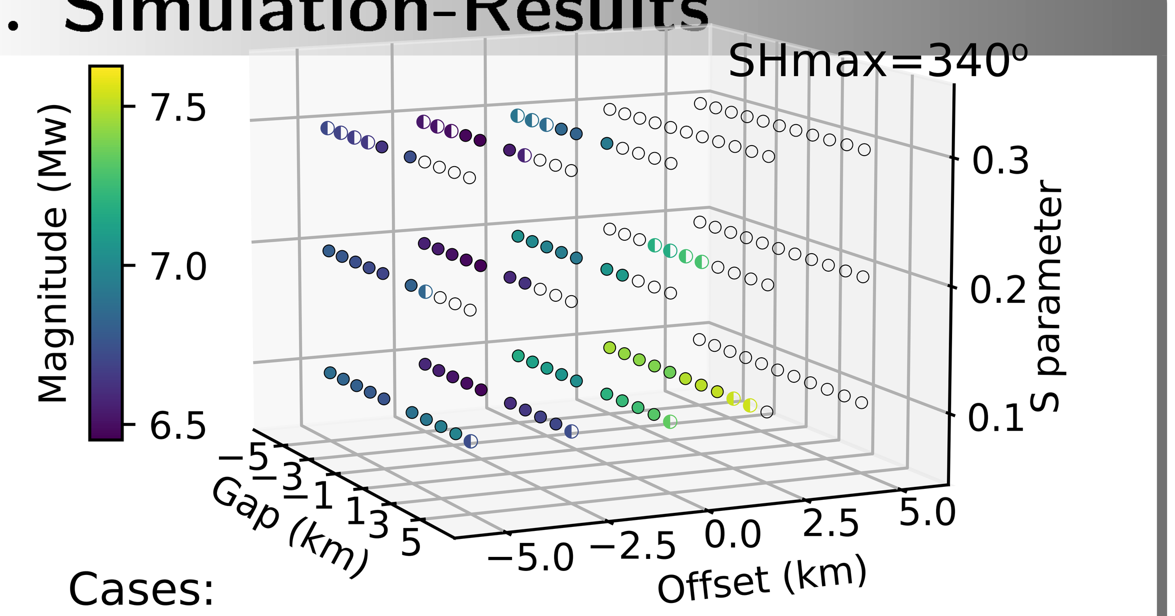
2. Geometry-Settings



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)
- With a slip weakening friction law

3. Simulation-Results



Cases:
- jump & break-away
- no jump
- jump but arrested

156 Simulations using this configuration, S depends on the stress level, not on μ_s or μ_d. Some cases did not break both faults, mainly due to prestress state.

Hanging/foot wall asymmetry:

A small asymmetry regarding the triggering potential of the secondary fault related to its location with respect to the main fault (hanging or foot wall) is observed. When the secondary fault is on the hanging wall, the dynamically triggered rupture is more likely to be self-sustainable.

Stress shadow:

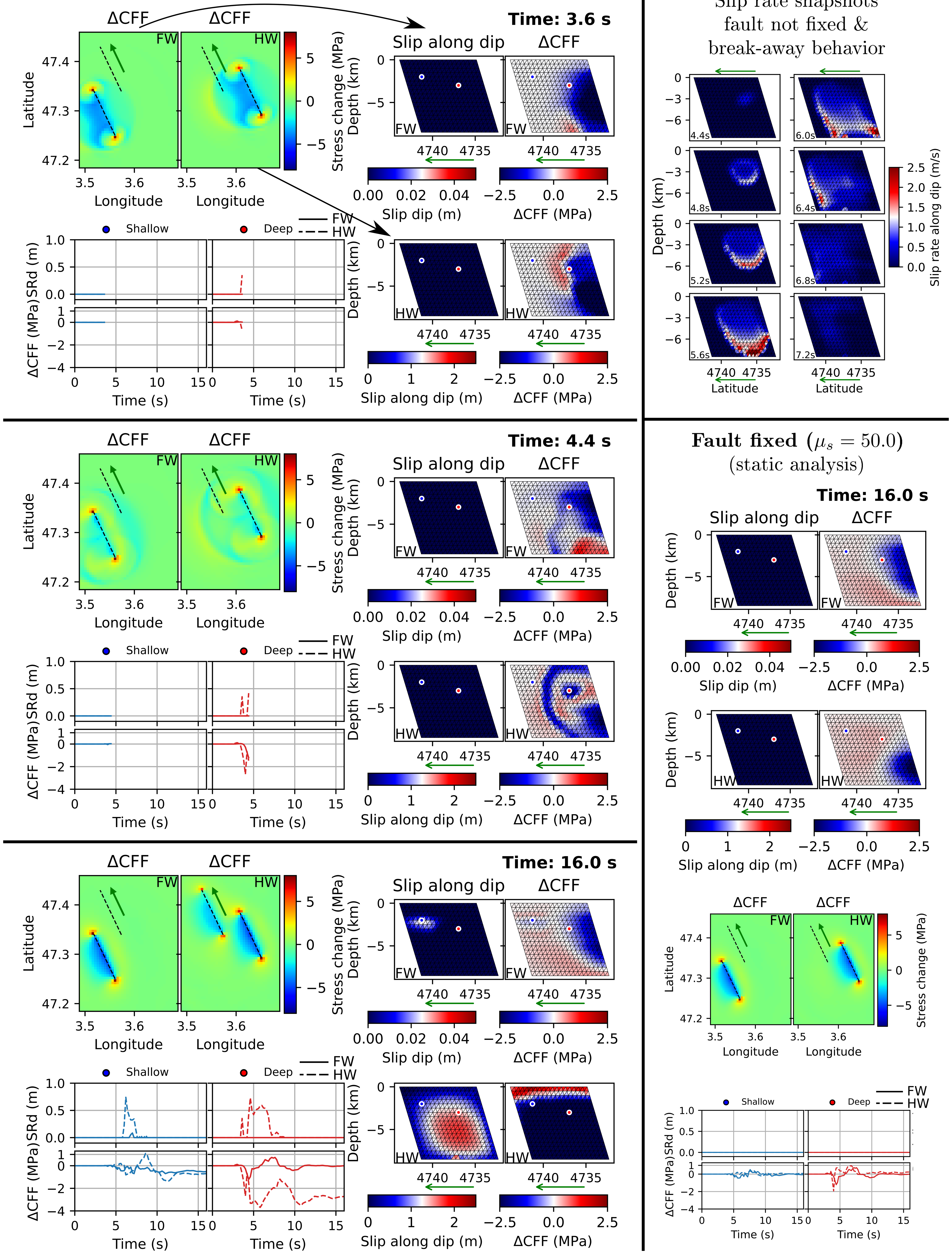
The final energy released (estimated magnitude) increases/decreases according to the distance between faults (i.e. offset and gap). Although the overlap increases the triggering effect, the stress shadow, due to the fault proximity, inhibits a large stress drop on the secondary fault.

4. Jump ? How ? When ? Why ?

Fault not fixed ($\mu_s = 0.6$) (dynamic analysis)

Slip rate snapshots fault not fixed & break-away behavior

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



5. Conclusion & Discusion

Under our configuration and assumptions:

☞ 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 other obstacles (geometry, SHmax directions, friction properties, etc.) are present.

☞ The **break-away** rupture on the 2nd fault seems to be triggered by two S waves arriving simultaneously to the 2nd fault from the northern and bottom ends of the 1st fault.

References

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