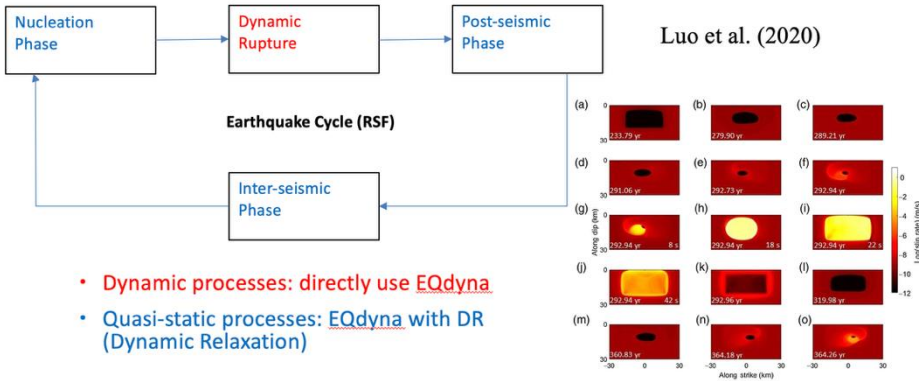
Using a **Dynamic Earthquake (EQ) Simulator** to explore complex fault slip over EQ cycles

- Current ways to model fault slip behaviors, in particular EQ rupture
  - Dynamic rupture modeling: rupture physics; single-event w/ assumed initial stress condition
  - Quasi-static EQ cycle modeling: earlier days; some EQ simulators
  - Quasi-dynamic EQ cycle modeling: major way currently, radiation damping for coseismic process
  - Fully dynamic EQ cycle modeling
  - Earthquake simulators: most quasi-static? **RSQsim: Quasi-dynamic**
  - SEAS: quasi-dynamic or fully dynamic
  - …

- Our group's focus: **FEM**-based dynamic EQ cycle simulations with **real complexity in geometry and CVM and as many physics** as possible - **EQdyna**

EQdyna-based Dynamic Earthquake Simulator



Using a Dynamic Earthquake (EQ) Simulator to explore **complex fault slip over EQ cycles**

- **Complex fault geometry:** an example

Comparing Dynamic Rupture Behavior of the Southern San Andreas Fault over Multiple Earthquake Cycles between CFM5.3 and CFM7 with a 3D Fully Dynamic Earthquake Simulator

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INTRODUCTION

Earthquake rupture behavior is strongly influenced by fault geometry. The Mojave segment of the southern San Andreas Fault often acts as a rupture barrier, even though it has a straight surface trace (e.g., 1812, 1857 events). Recent paleoseismic studies suggest lower earthquake frequency in the middle Mojave compared to adjacent sections. Bemis et al., (2021) proposed that this may be related to the non-vertical subsurface geometry of the SSAF.

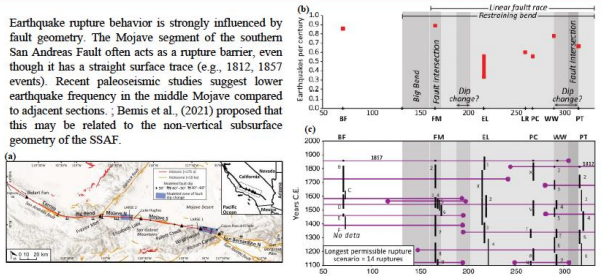
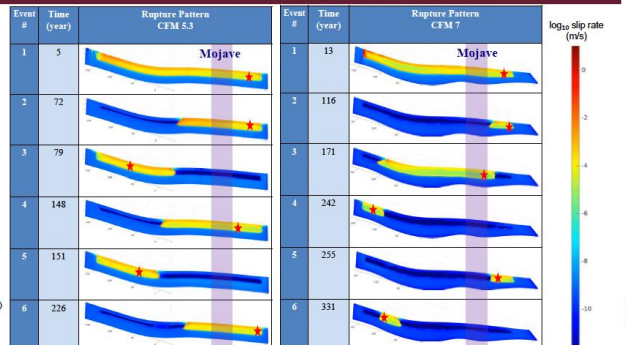


Figure 1. (a) Map of the southern San Andreas Fault (SSAF) system showing paleoseismic sites (black triangles) and dipping fault geometry. (b) Earthquake frequency distribution along the SSAF inferred from paleoseismic observations. (c) A plausible earthquake rupture scenario. (Bemis et al., 2021)

MAIN GOAL

RUPTURE PATTERNS



MAXIMUM SLIP RATE

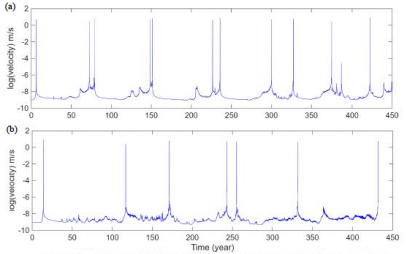


Figure 7 MaMaximum fault slip rate through time for (a) CFM5.3 and (b) CFM7. Peaks mark dynamic earthquakes; intervals between peaks represent interseismic periods.

CONCLUSIONS

- Spatially variable loading weakens the Big Bend barrier.

- **Complex interactions: e.g., SSE & megathrust along subduction zone? (Meng & Duan, 2022, SRL)**
- **More physics: e.g., Fluid effects – Dilatant hardening in 3D permeability structure (Tang and Duan, in preparation)**