Implications of dynamic rupture models for the Santa Barbara-Ventura Area

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What can dynamic rupture models tell us about fault geometries in the Santa Barbara-Ventura area?

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Or: So you've found yourself in a geologist fight...

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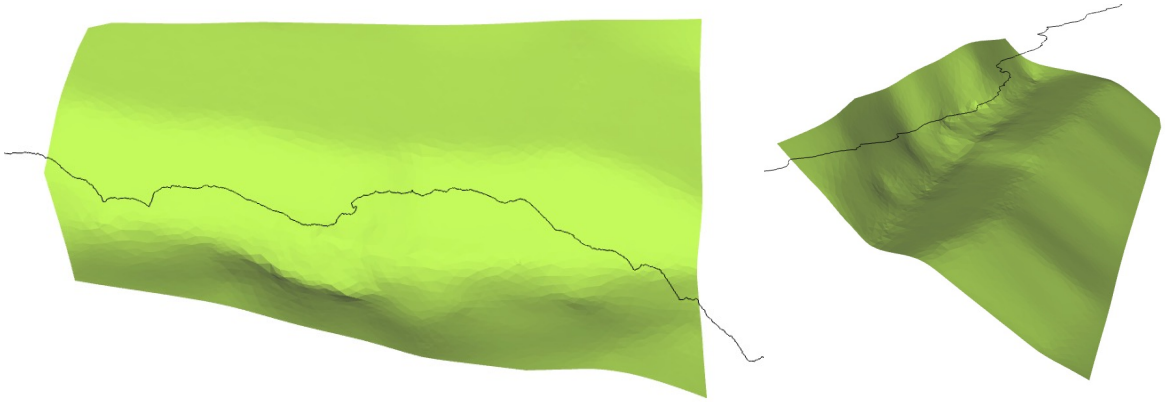
There is some debate over the geometry of the Pitas Point Fault.

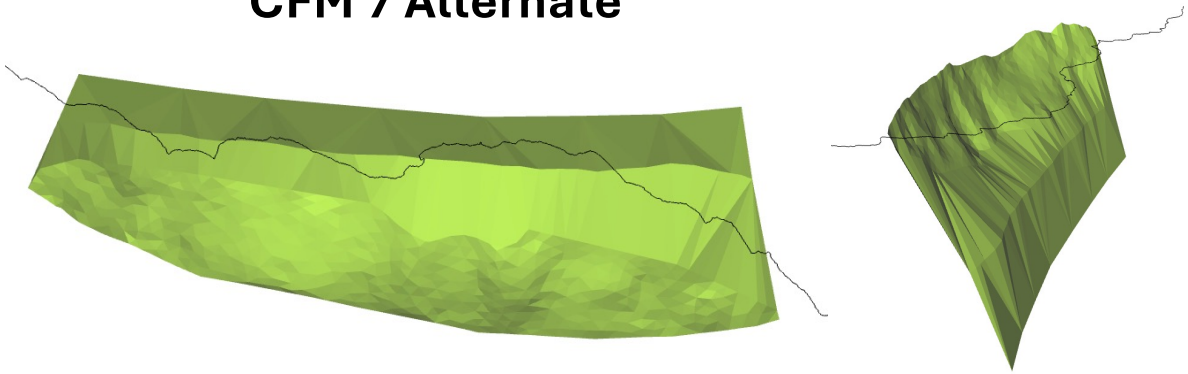
The CFM has two geometries. **Which one is most consistent with observations?**

CFM 7 Preferred



- Average dip: 29° N
- Flat ramp in the middle.
- Basal depth: 10 to 16 km
- Emergent at easternmost end.

CFM 7 Alternate

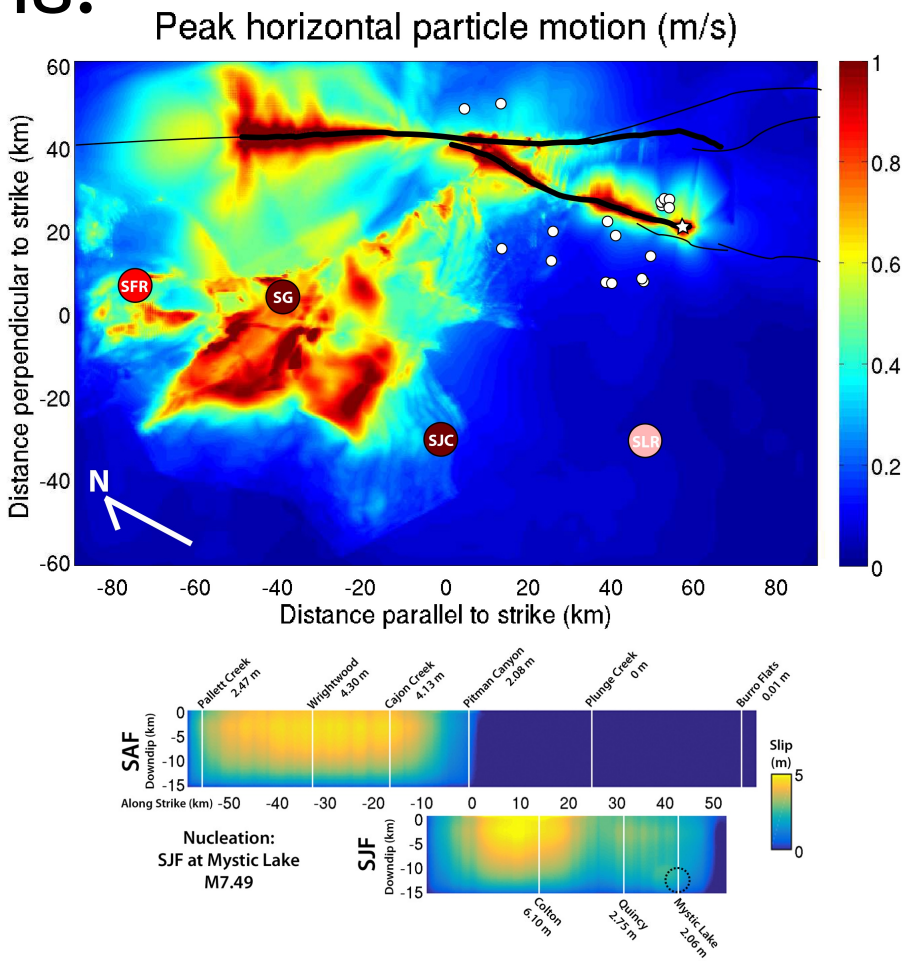


- Average dip: 50° N
- No ramp.
- Basal depth:
- Completely buried.

Dynamic rupture modeling is a great tool for addressing these questions!

- Can use observations to inform inputs and constrain outputs.
- Requires no a priori assumptions about the rupture.

- I compared dynamic rupture simulations to paleoseismic and precarious rock data to study the 1812 Wrightwood earthquake!
- I can take a similar approach for the Pitas Point!



Model Setup

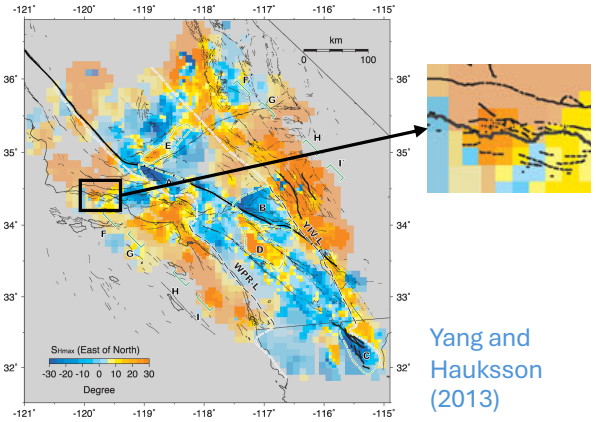
- 3D finite element method (FaultMod; Barall, 2009)
- Fault geometry: SCEC CFM
  - Meshed faults with Coreform Cubit
- Velocity structure: SCEC CVM
- Linear slip-weakening friction
- Stress: tapered with depth (more detail on the next slide)

Output Comparisons

- Displacement at Pitas Point
- Cluster of precariously balanced rocks in the Santa Ynez Mountains
- Mountains up and basins down
- Stress drop?

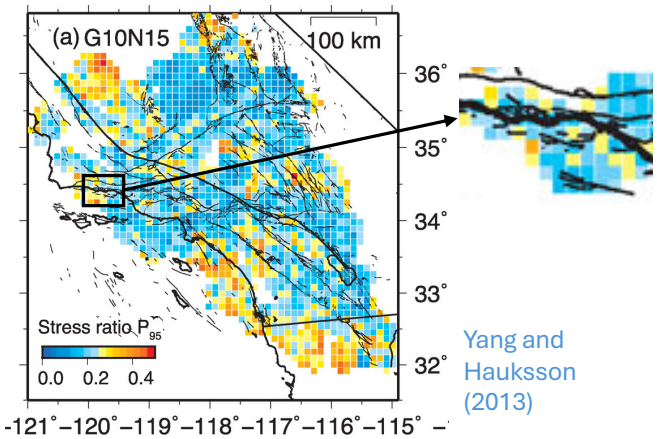
Observations help constrain initial stresses.

S_{Hmax} orientation:
~N20°E



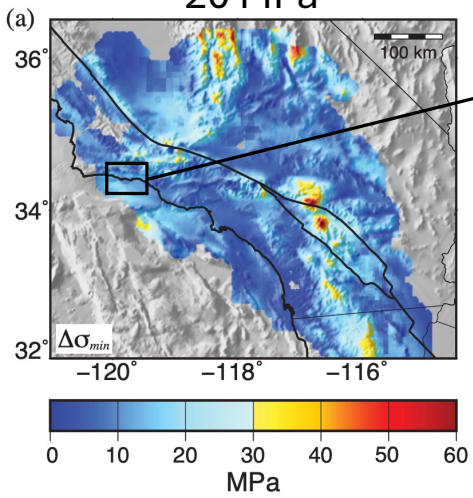
Yang and Hauksson (2013)

Stress ratio (σ1-σ2/σ1-σ3):
~0.225



Yang and Hauksson (2013)

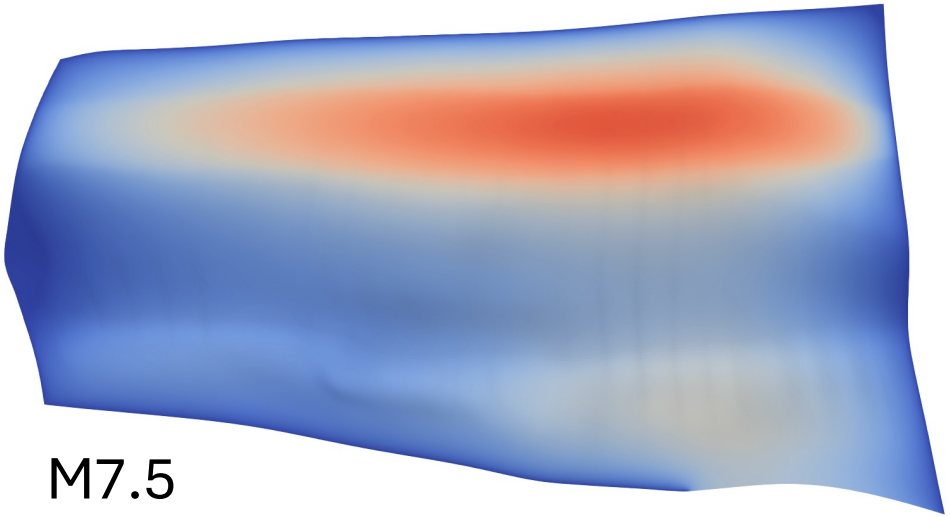
Minimum differential stress:
20 MPa



Luttrell and Smith-Konter (2017)

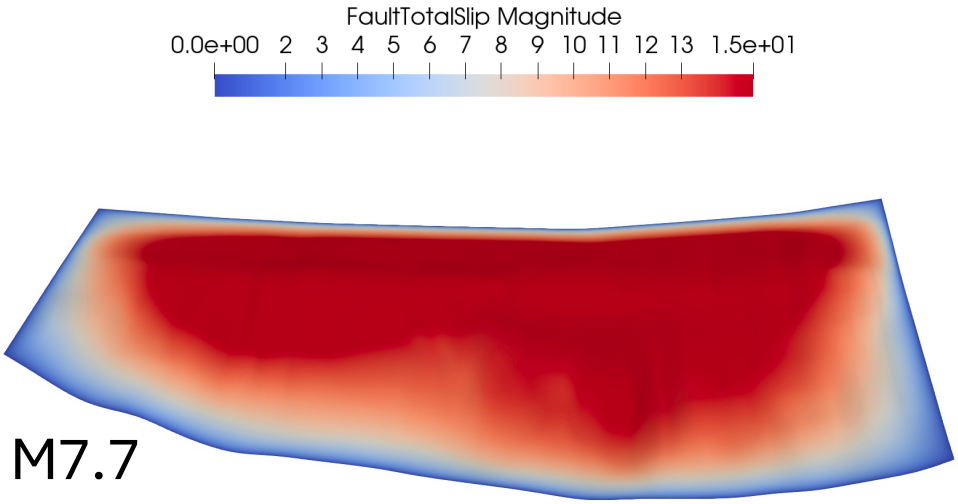
- These constraints still allow a wide range of stress levels.
- The right stress state should produce a relatively low stress drop (Goebel et al., 2016).
- I have tested a few cases, but here, I am mostly showing results with σ_{NS} = 60 MPa, σ_{EW} = 35.5 MPa, σ_v = 40 MPa

Within the same regional stress field, the steeper geometry produces a larger earthquake.



M7.5

Average $\Delta\sigma$ = 5.2 MPa

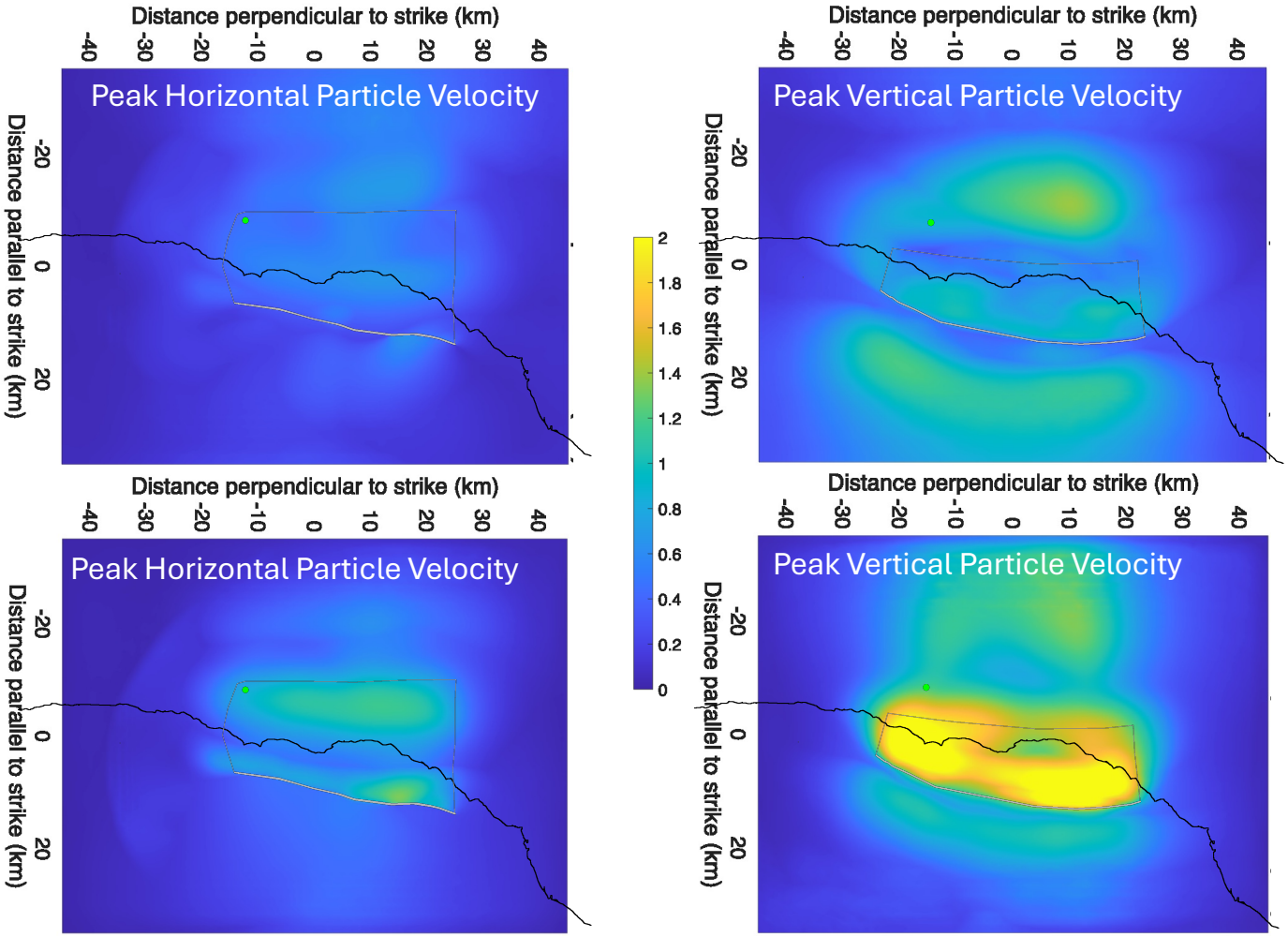


M7.7

Average $\Delta\sigma$ = 14.5 MPa

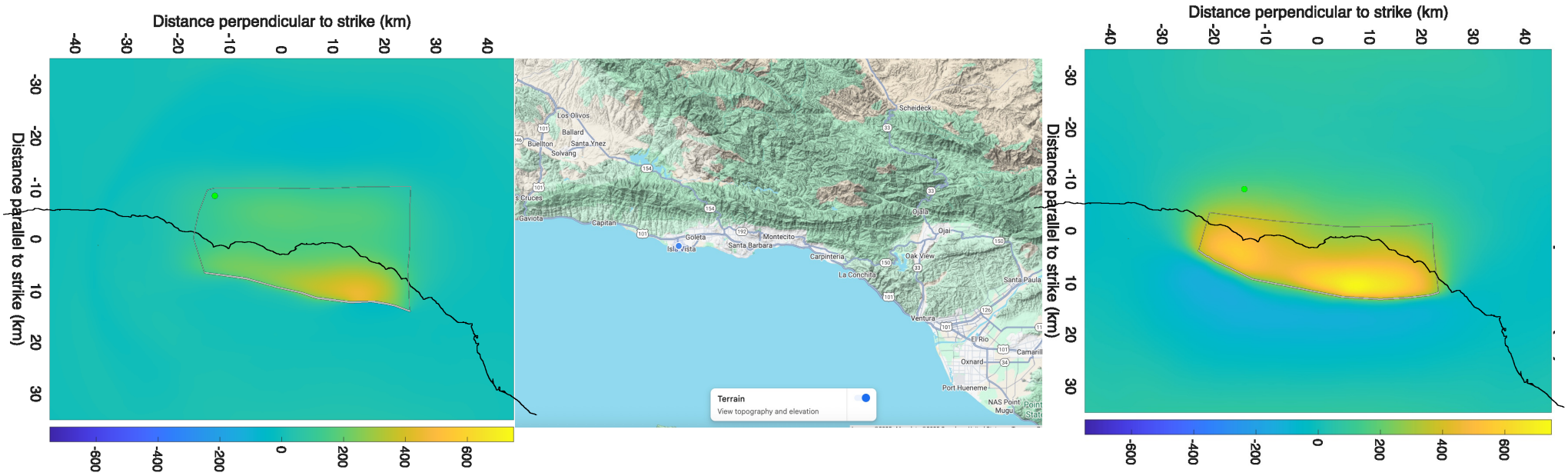
- The steeper geometry cuts deeper into areas of higher stress.
- The ramp breaks directivity.

The steeper geometry causes stronger ground motion.



- Largely due to the same factors as the magnitude/slip difference.
- Cluster of precarious rocks experiences similar PGV in both cases.

The steeper geometry causes larger displacement.



- Both have largest displacement offshore.
- Steeper geometry has more displacement at Pitas Point.
- Lower-angle geometry has more displacement under on-shore mountains.

Initial stress state will affect some of these differences.

- I could run a steeper dip model with lower stress drop.
  - The slip would also be lower.
  - The ground motion and displacement patterns would not change qualitatively.

- I could run a lower-angle model with higher displacement.
  - The stress drop would go up.
  - The ground motion and displacement patterns would not change qualitatively.

Not so much conclusions as thoughts…

- I should probably have more than one fault in this model.
  - Certainly at least the different parameterizations of the Padre Juan.
  - May need a multi-fault event to explain Pitas Point uplift.

- I need to keep looking for the right stress state.
  - The CSM would be a good next place to look.

- Finding more PBRs would be more helpful!

- The lower-angle (CSM preferred) geometry does fit topography better so far.