Introducing the Cajon Pass Earthquake Gate Area

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A Modern Chaconne: A Structural and Harmonic Analysis of "Hotel California"

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SCEC Annual Meeting • Palm Springs, California • 12 September 2017

The Earthquake of December 8th, 1812: A Case for the Cajon Pass Earthquake Gate Area

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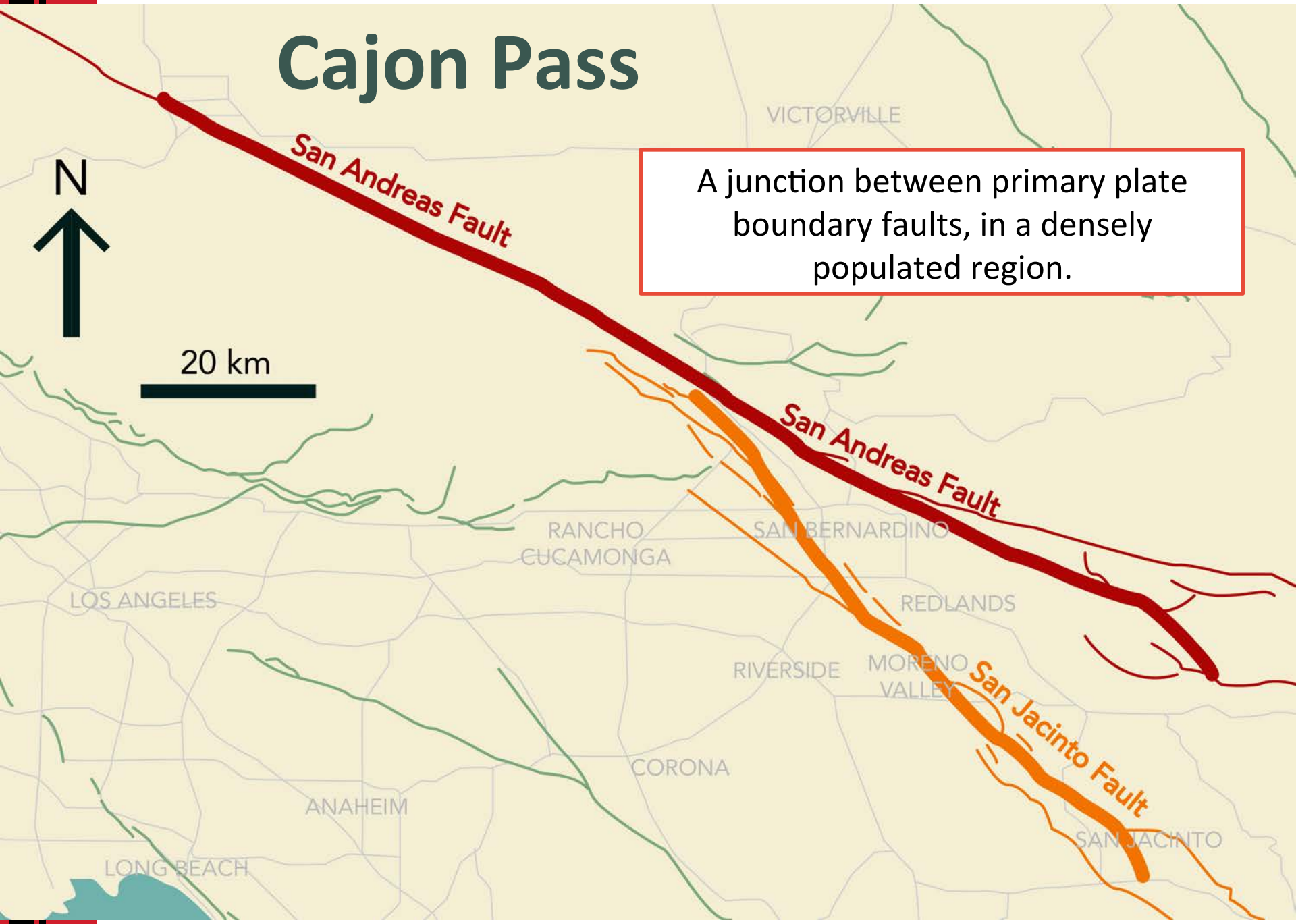
Earthquake Gates

- Critical point in a fault system that may (or may not) stop rupture or may control which way a rupture goes.
- Do gates swing the same way every time?

Cajon Pass



A junction between primary plate boundary faults, in a densely populated region.

Some Key Questions

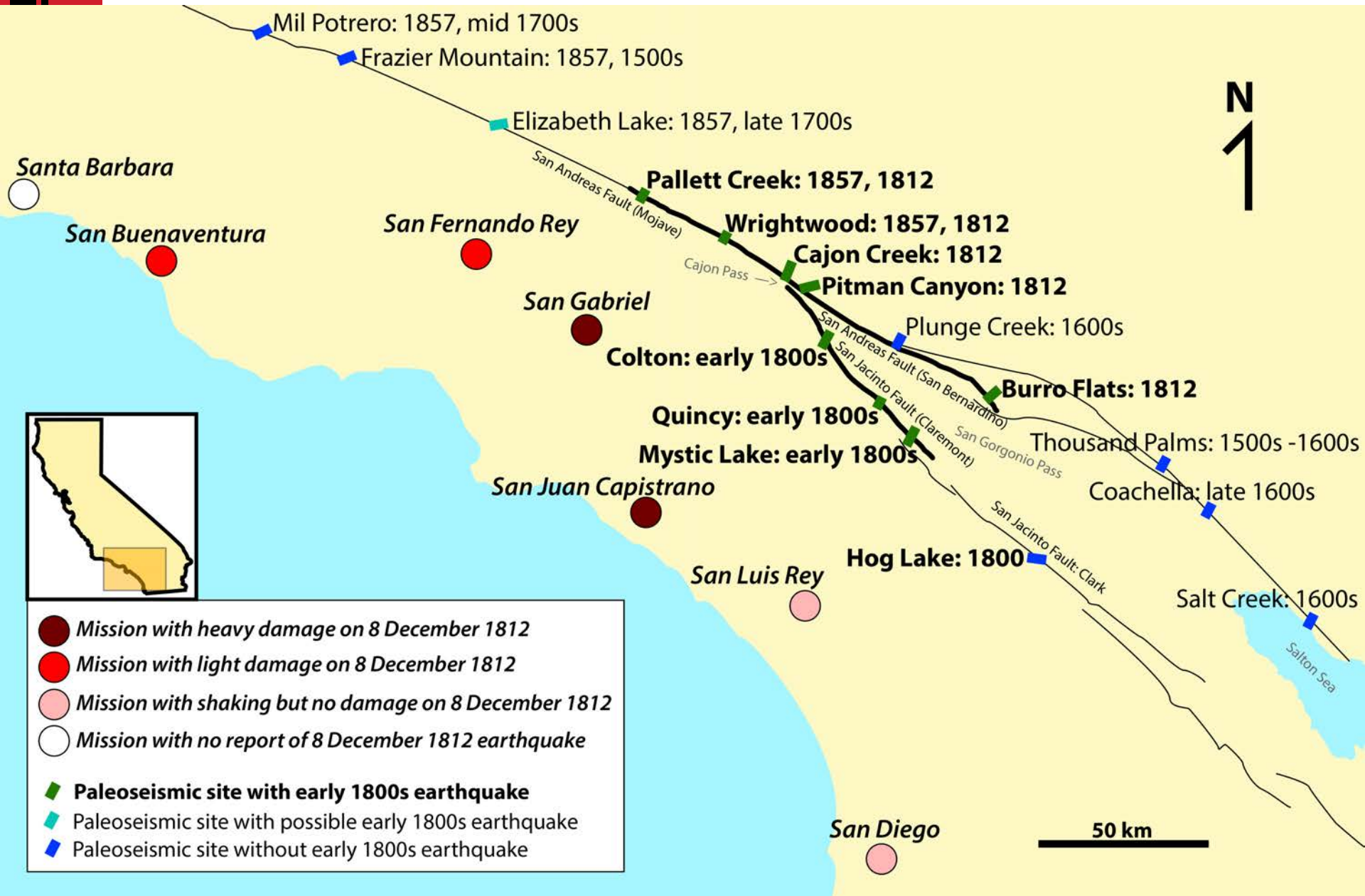
- How do fault interactions affect the probability of through-going earthquakes?
- How much does the geometry of the component faults modulate this?
- How do previous ruptures affect future rupture paths and probabilities?
- Does the current stress field represent recent rupture history?

The Earthquake of December 8th, 1812

- Heavy damage at Mission San Gabriel, 40 deaths at Mission San Juan Capistrano.
- Initially considered a Newport-Inglewood event.
- Reassigned to the San Andreas based on tree ring evidence.
- Since identified in many San Andreas paleoseismic trenches.

I cannot definitively prove anything here.

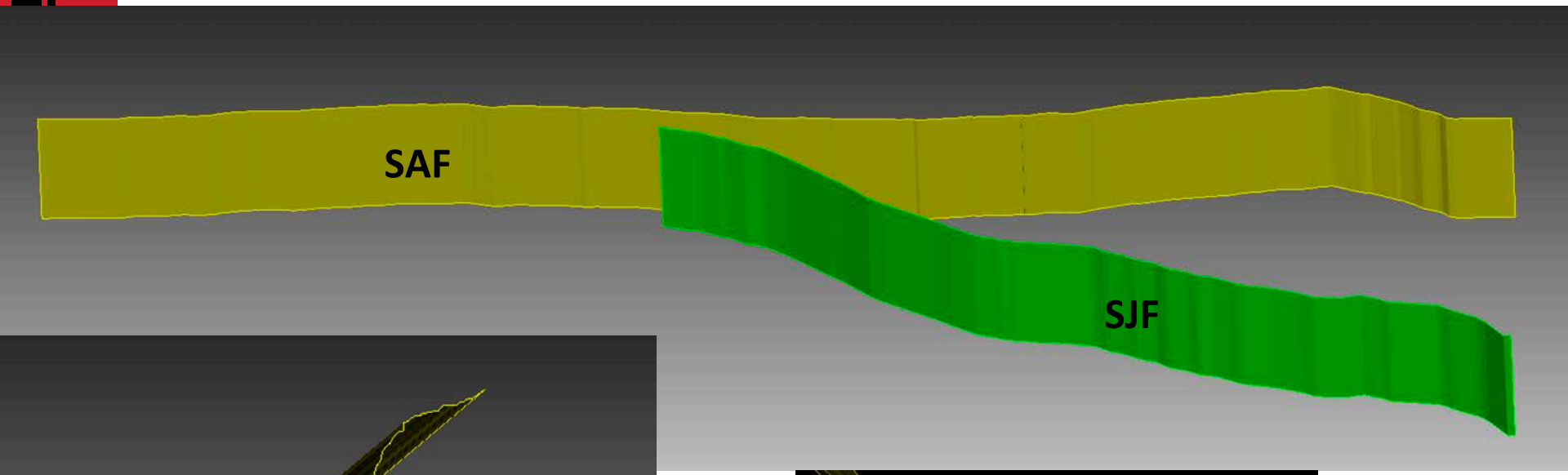
Historic and Paleoseismic Records

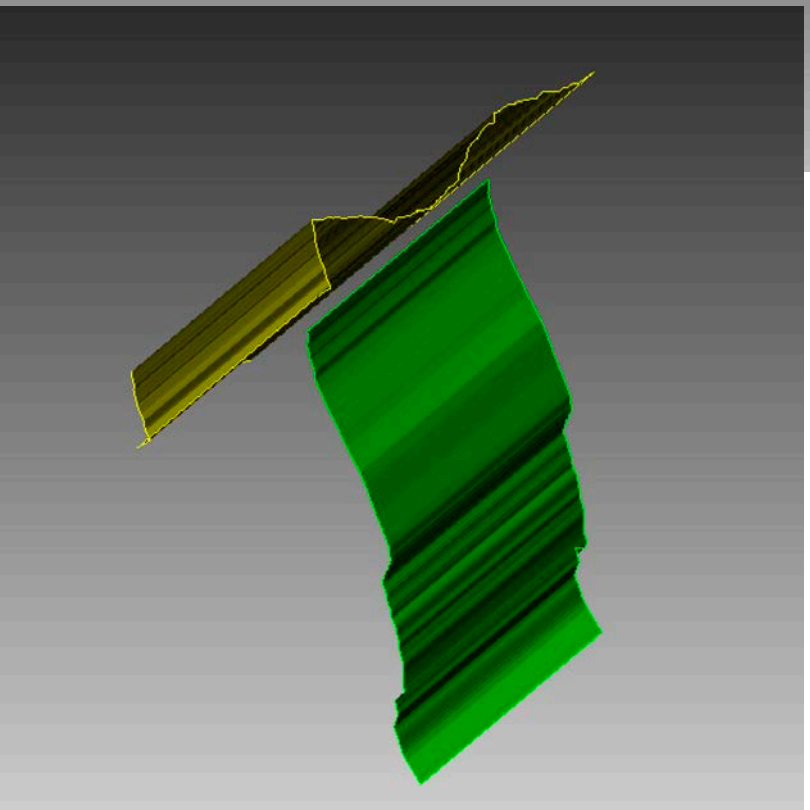


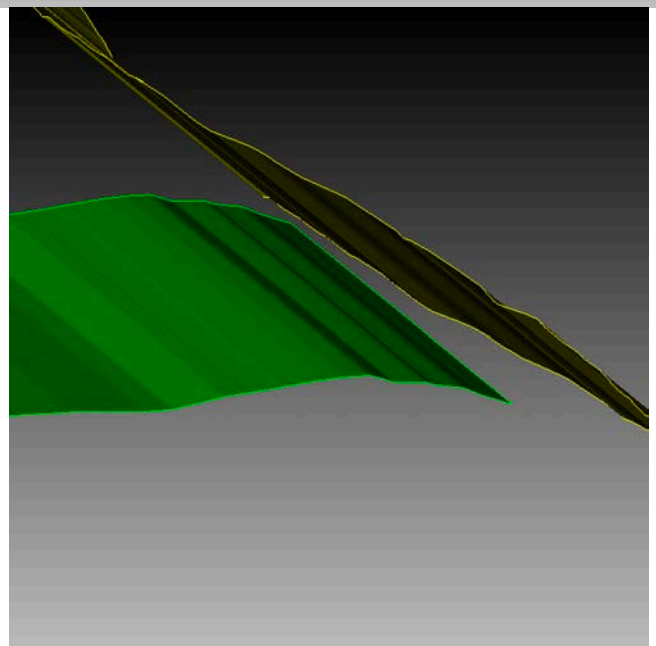
Modeling Approach

- 3D fully dynamic rupture modeling.
  - Finite element method (FaultMod, Barall, 2009).
- Realistic initial conditions:
  - Fault mesh with complex geometry.
  - Complex regional velocity structure (SCEC CVM).
  - Regional stress field from seismicity studies.
- Vary initial stress amplitudes until models produce slip consistent with paleoseismic records.

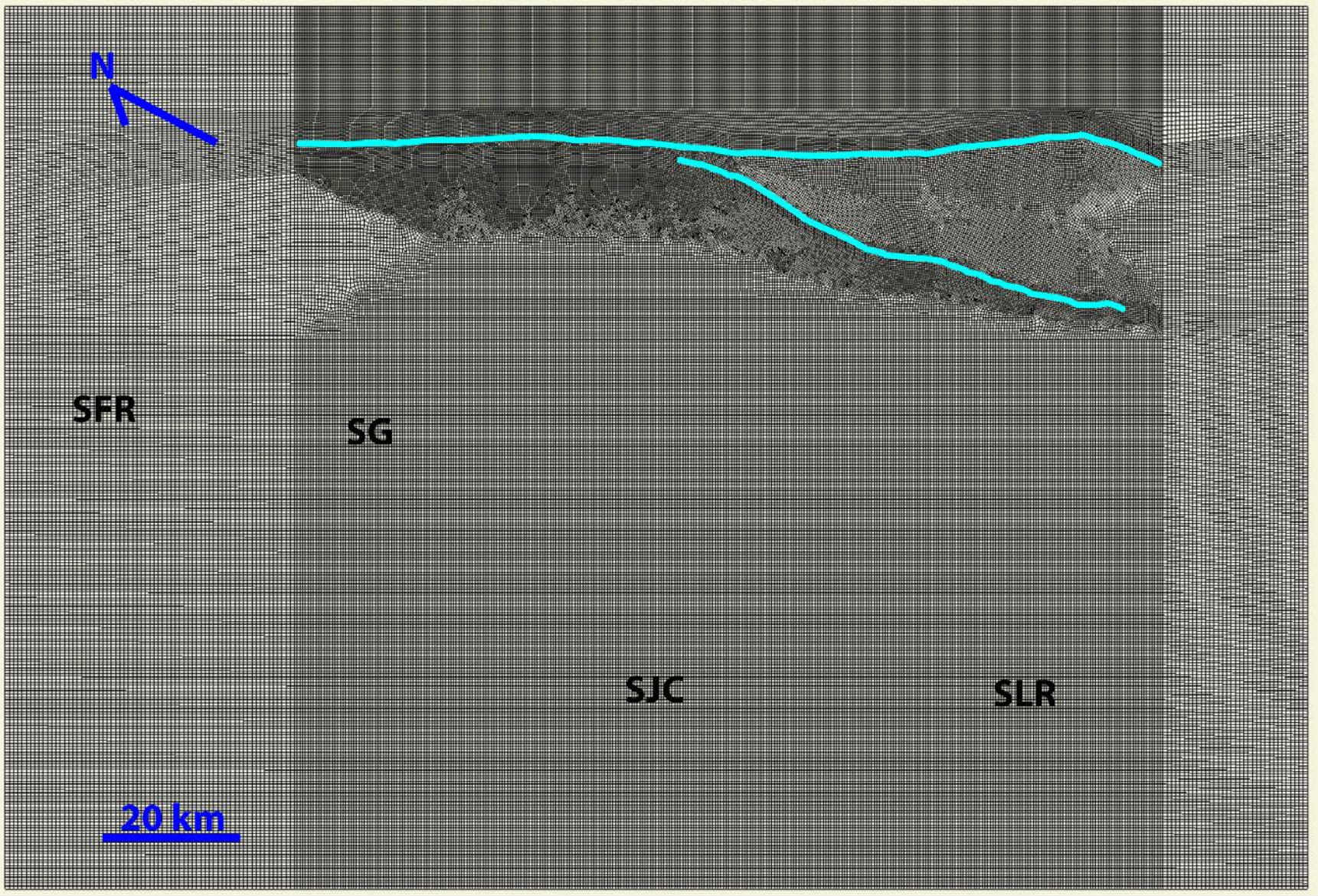
Model Geometry



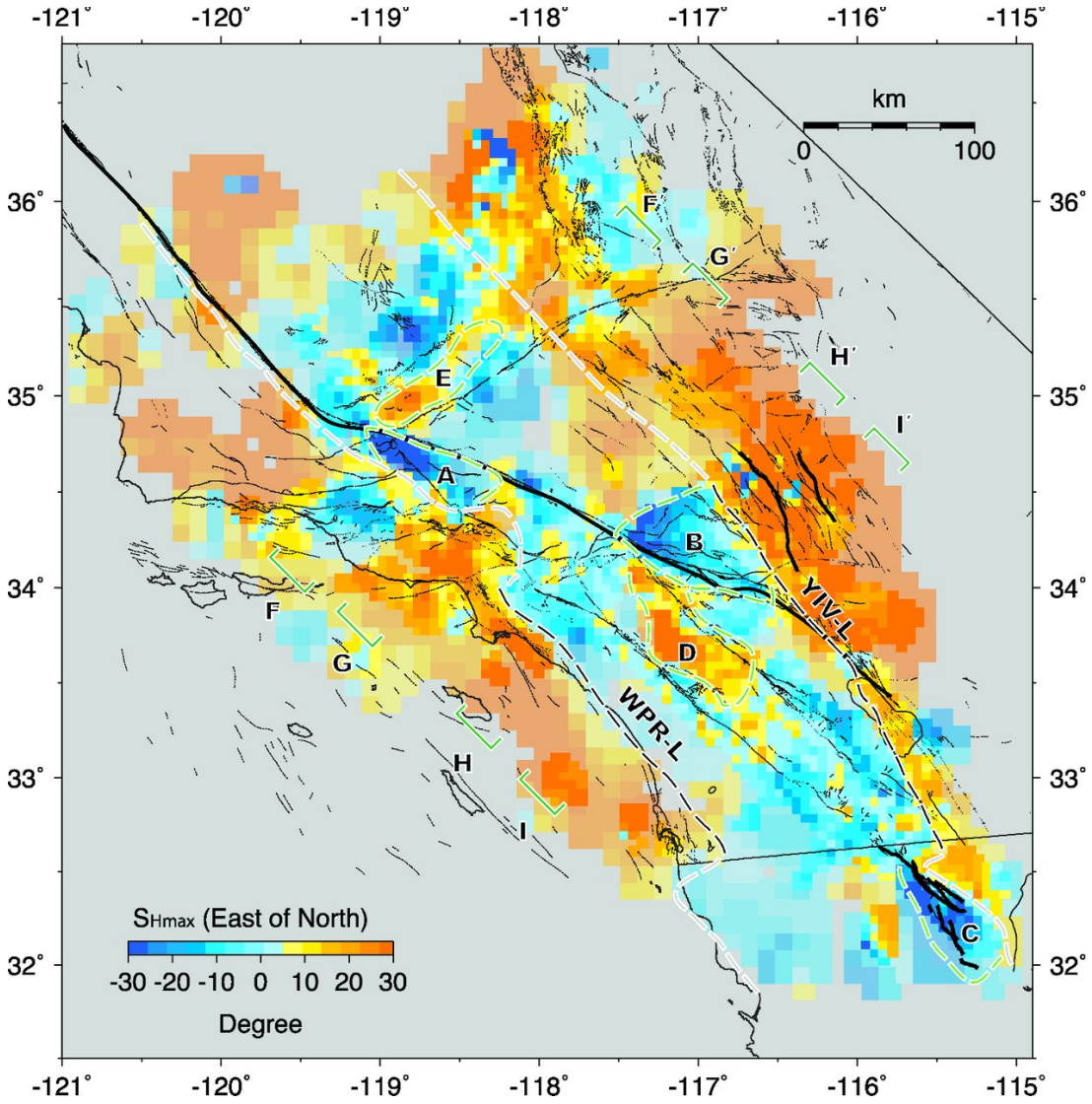




Model Geometry



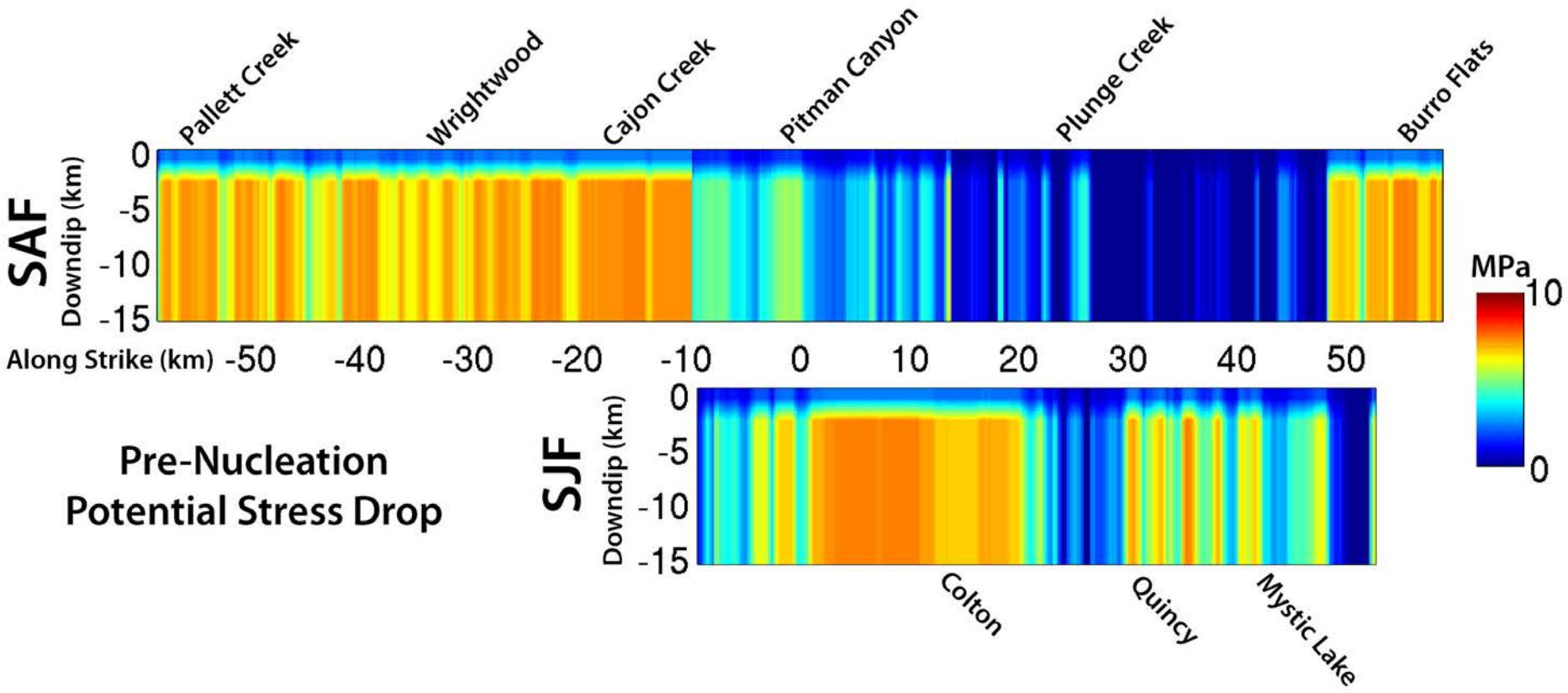
Regional Stresses



Maximum horizontal compressive stress orientation in southern California

Yang and Hauksson, 2013

On-Fault Stresses

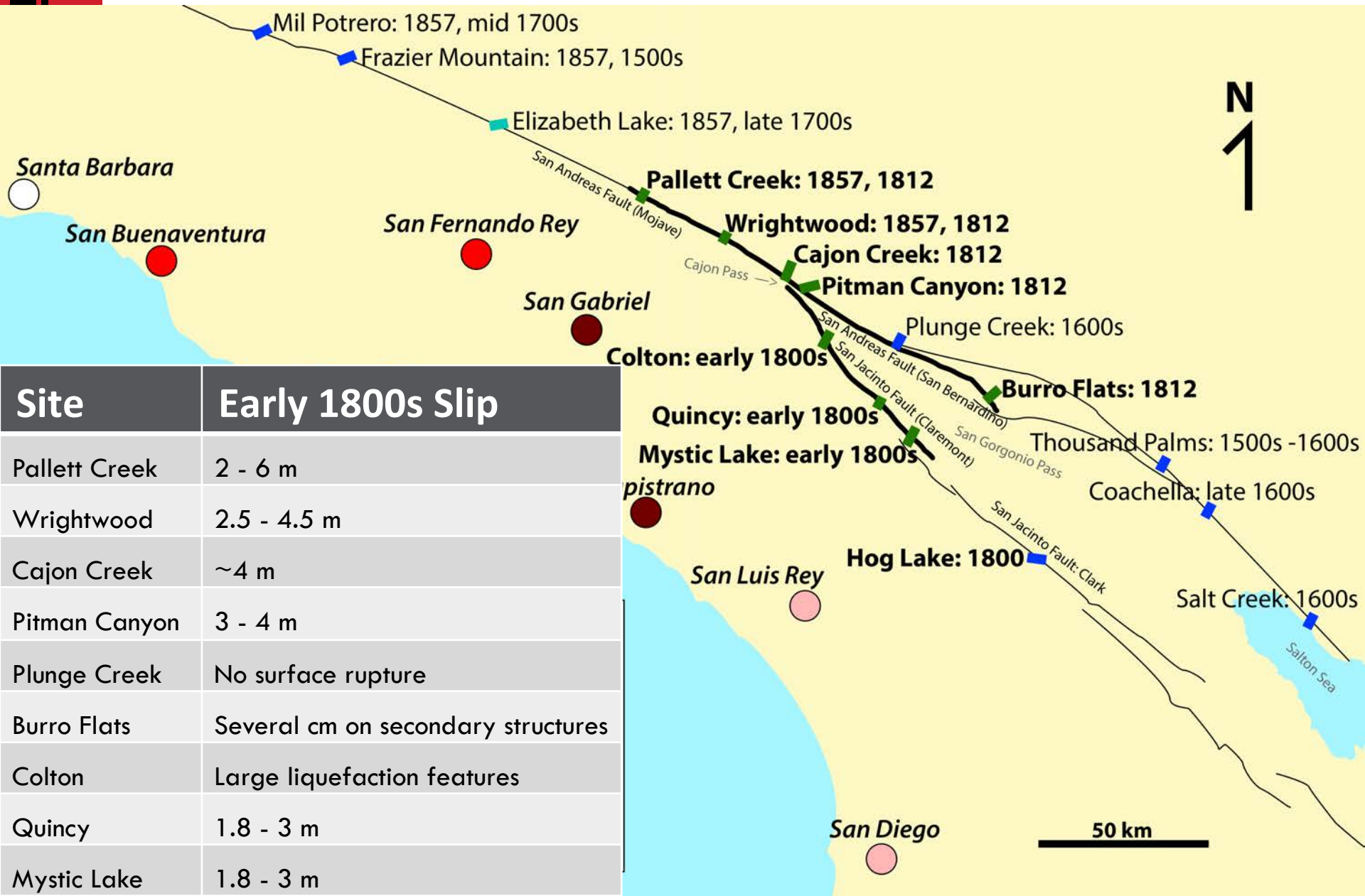


- Additional heterogeneity from fault geometry.

Physical and Computational Parameters

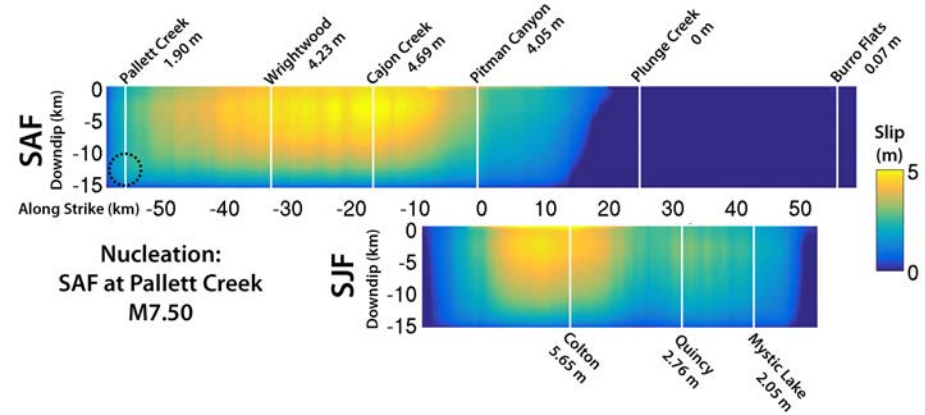
V_p	From SCEC CVM
V_s	From SCEC CVM
Density	From SCEC CVM
μ_{static}	0.6
$\mu_{dynamic}$	0.2
d_0	0.4 m
Principal stresses	Variable (Best fit: σ_V = 30 MPa, σ_{NS}= 36 MPa, σ_{EW} = 12 MPa)
Stress orientation	**SAF**: N5E north of junction, N15W south of junction; **SJF**: N12E
Element size	200 m in near field, 400 m in far field
Nucleation radius	3000 m

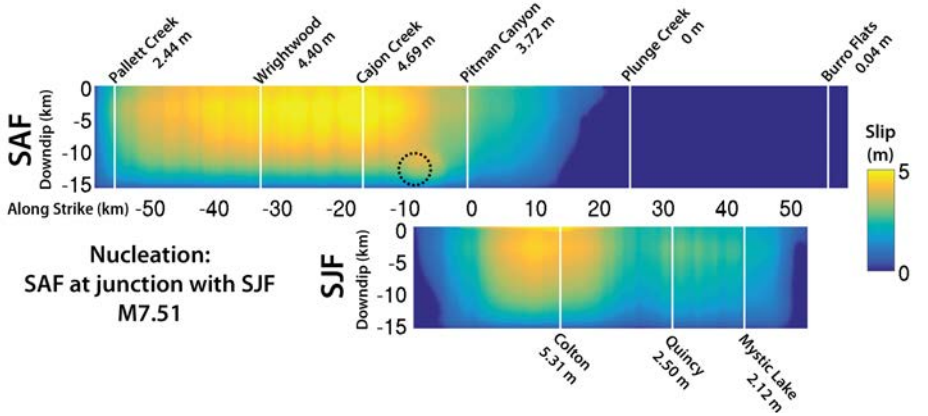
Slip in the Early 1800s

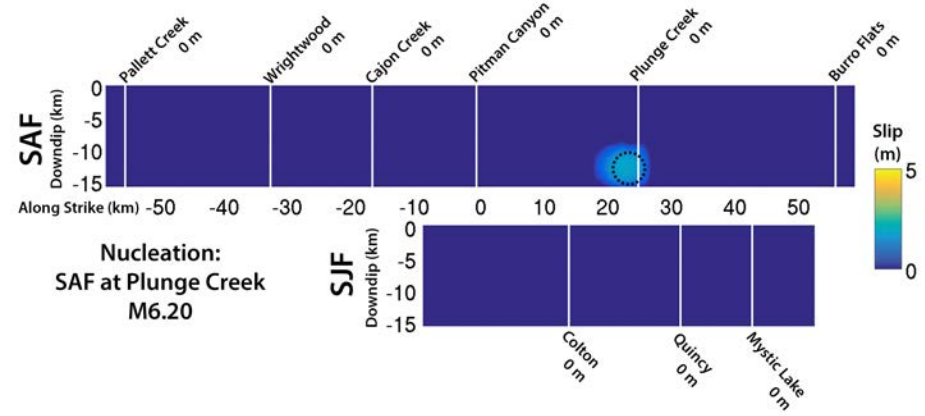


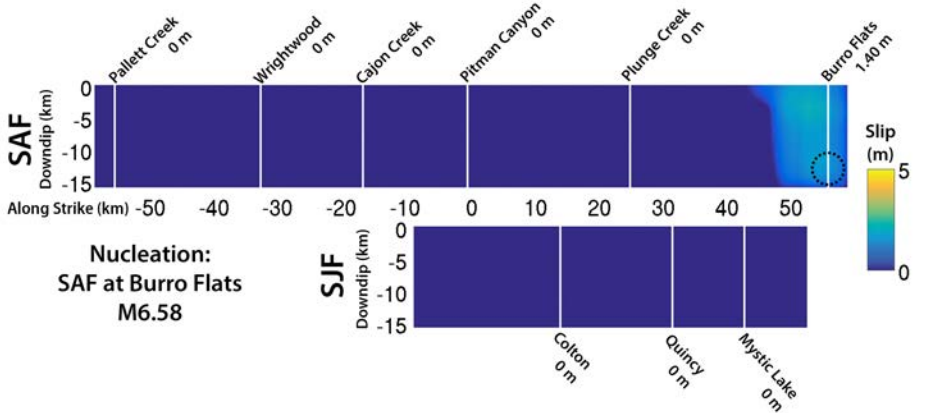
Site	Early 1800s Slip
Pallett Creek	2 - 6 m
Wrightwood	2.5 - 4.5 m
Cajon Creek	~4 m
Pitman Canyon	3 - 4 m
Plunge Creek	No surface rupture
Burro Flats	Several cm on secondary structures
Colton	Large liquefaction features
Quincy	1.8 - 3 m
Mystic Lake	1.8 - 3 m

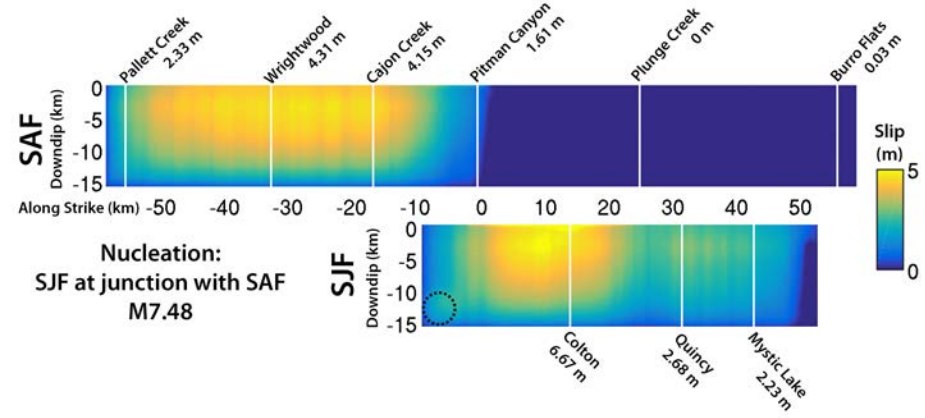
Model Slip Distributions

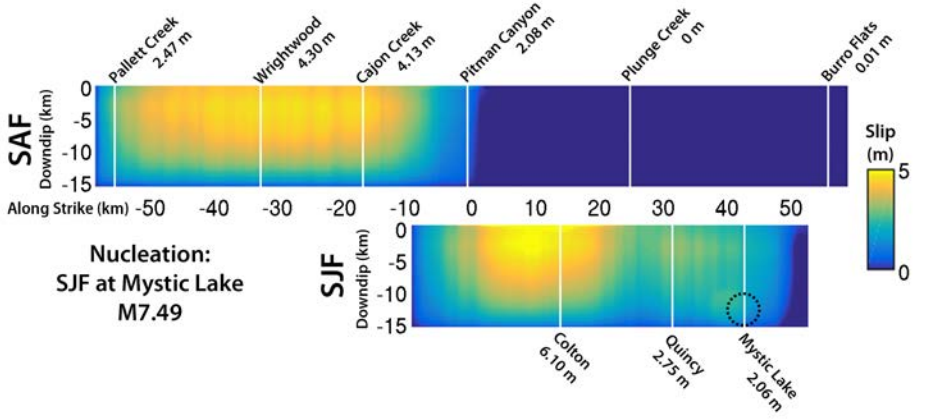




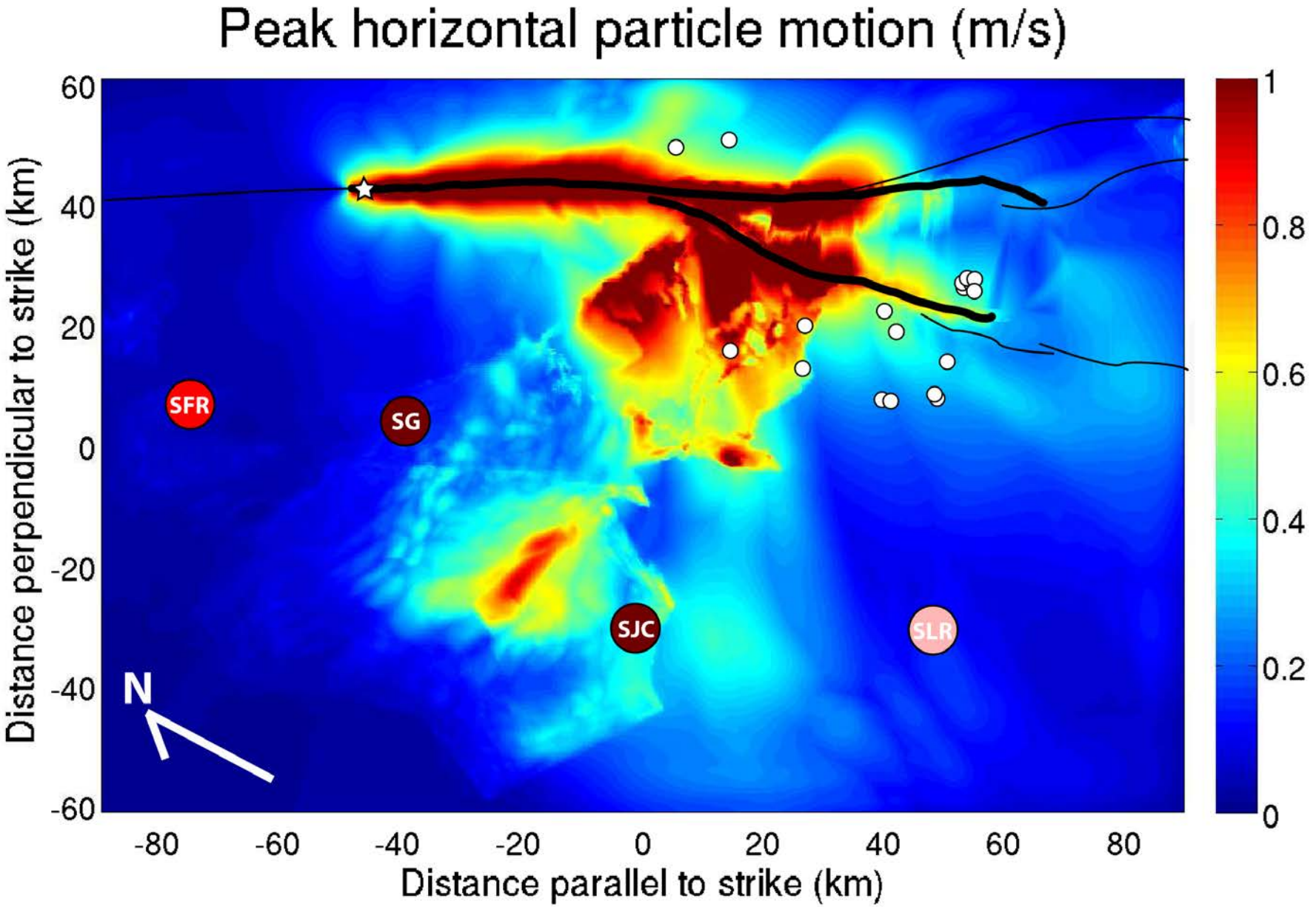




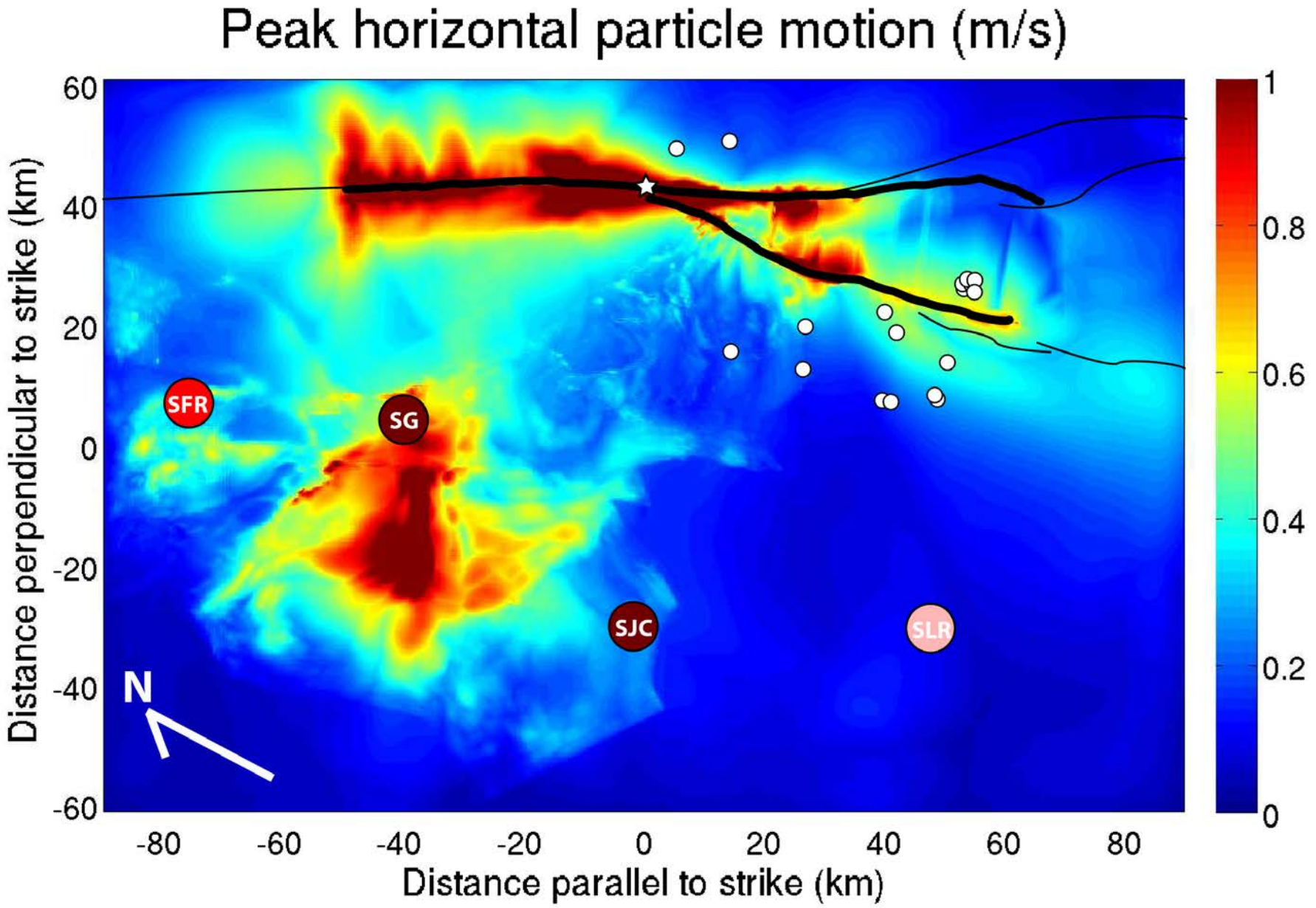




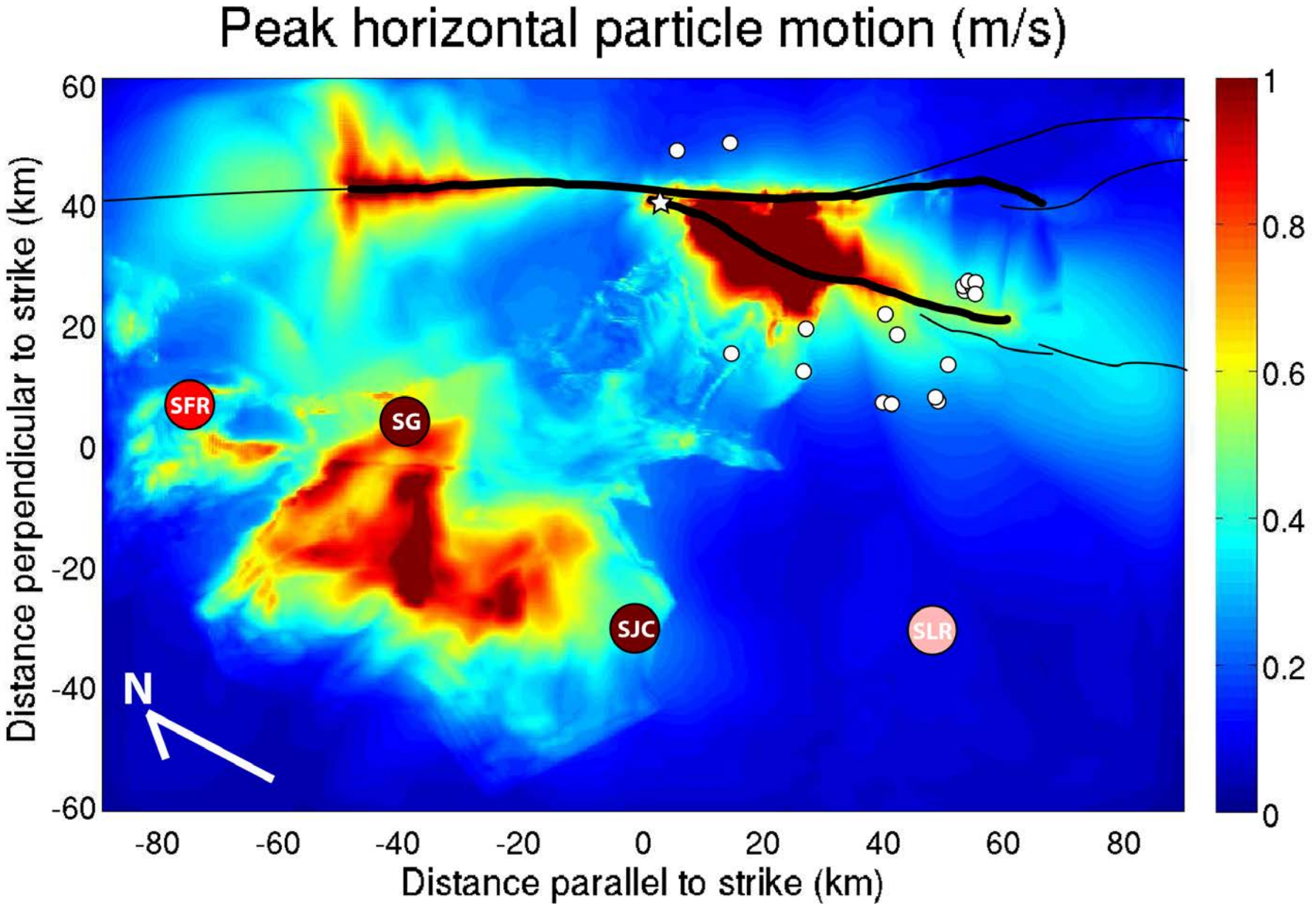
Ground Motion: SAF north



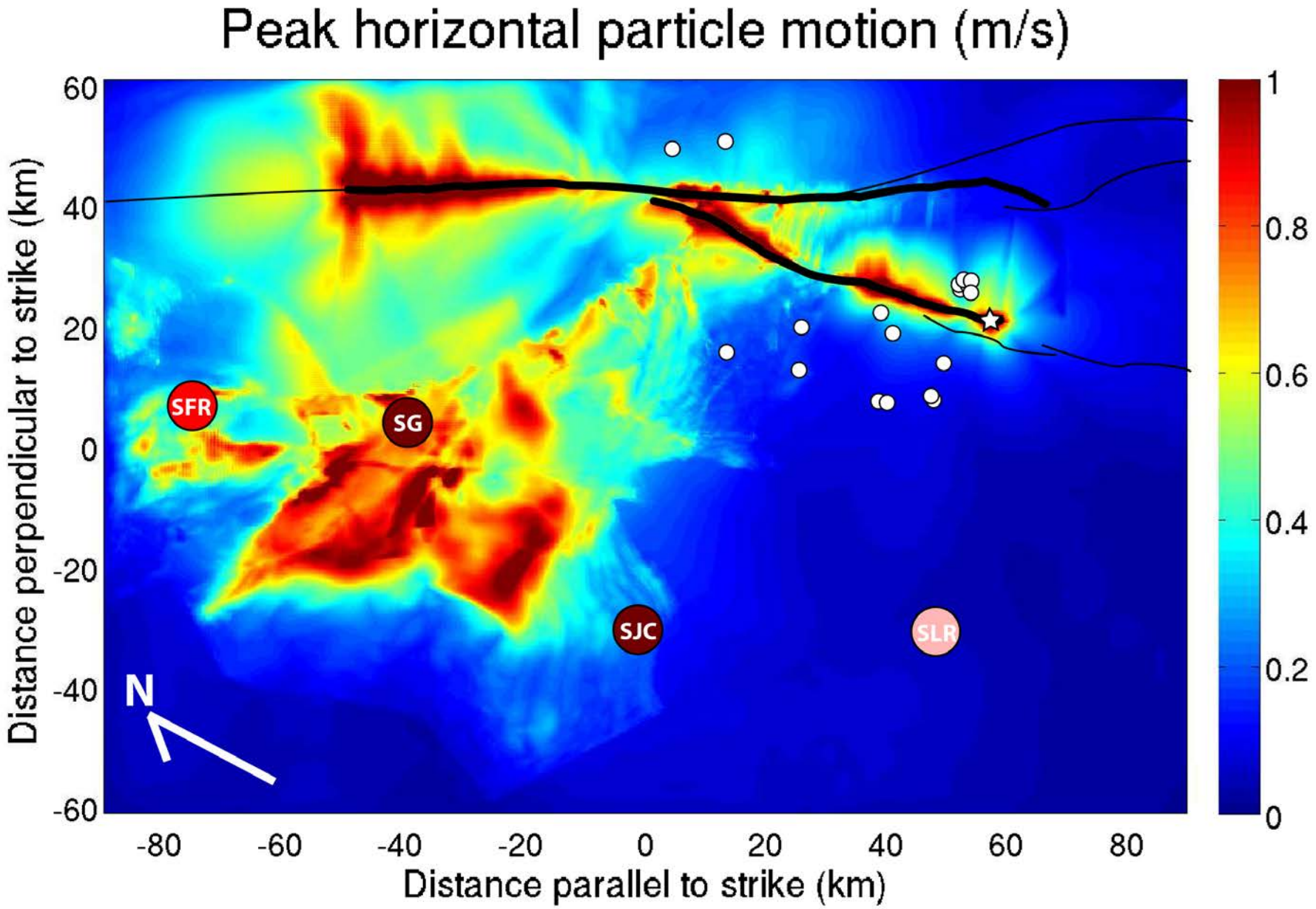
Ground Motion: SAF at junction



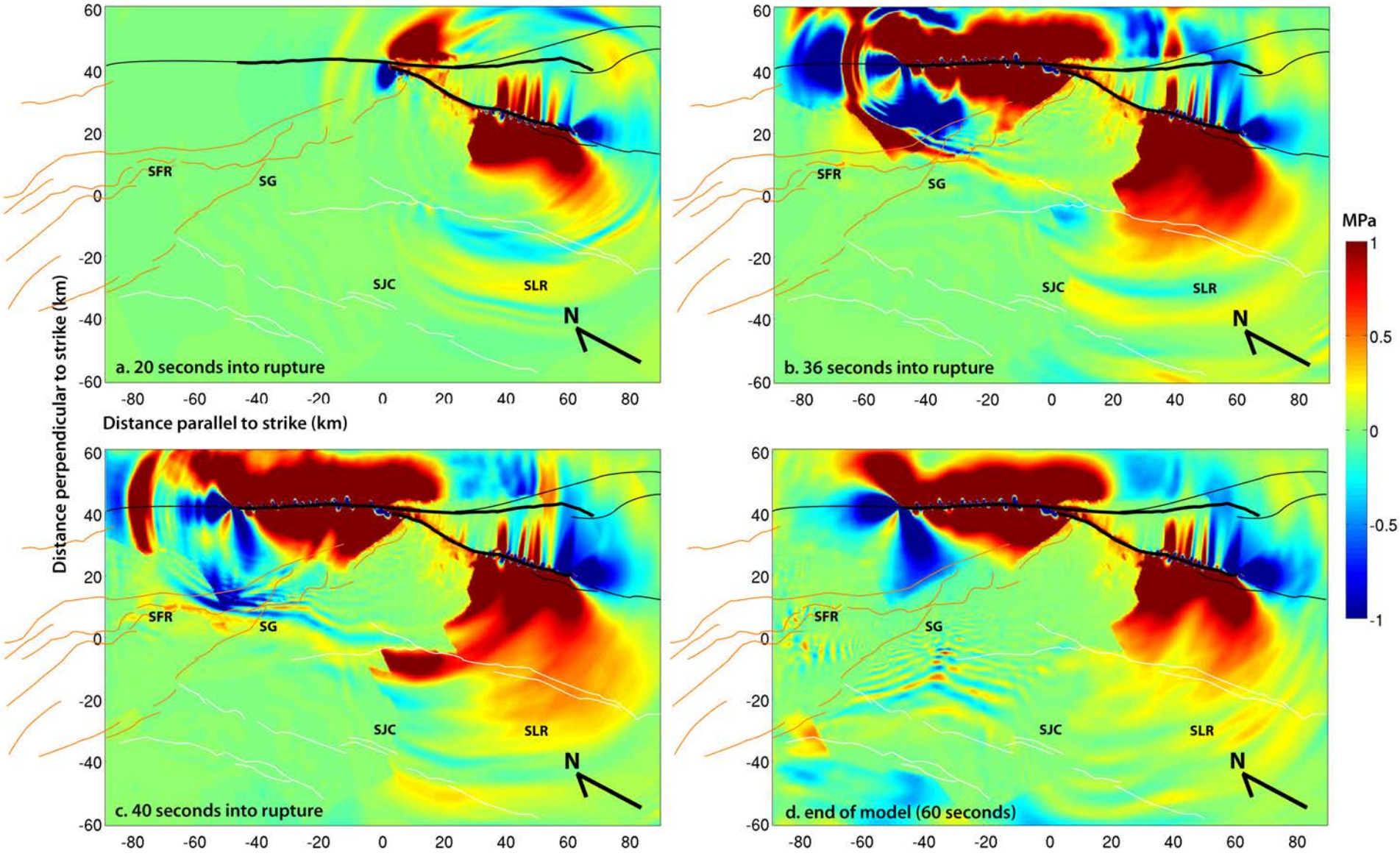
Ground Motion: SJF at junction



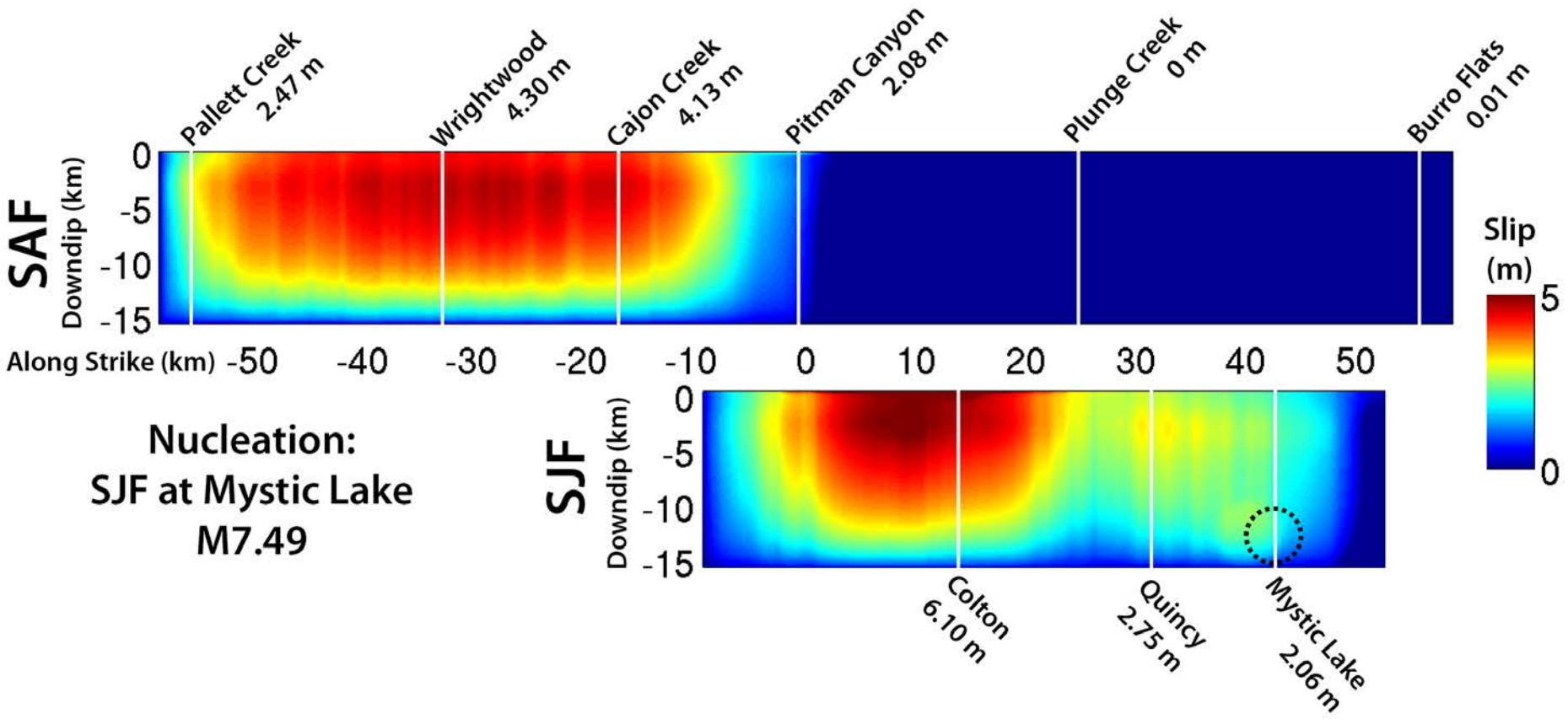
Ground Motion: SJF south



Coulomb Stress: SJF south

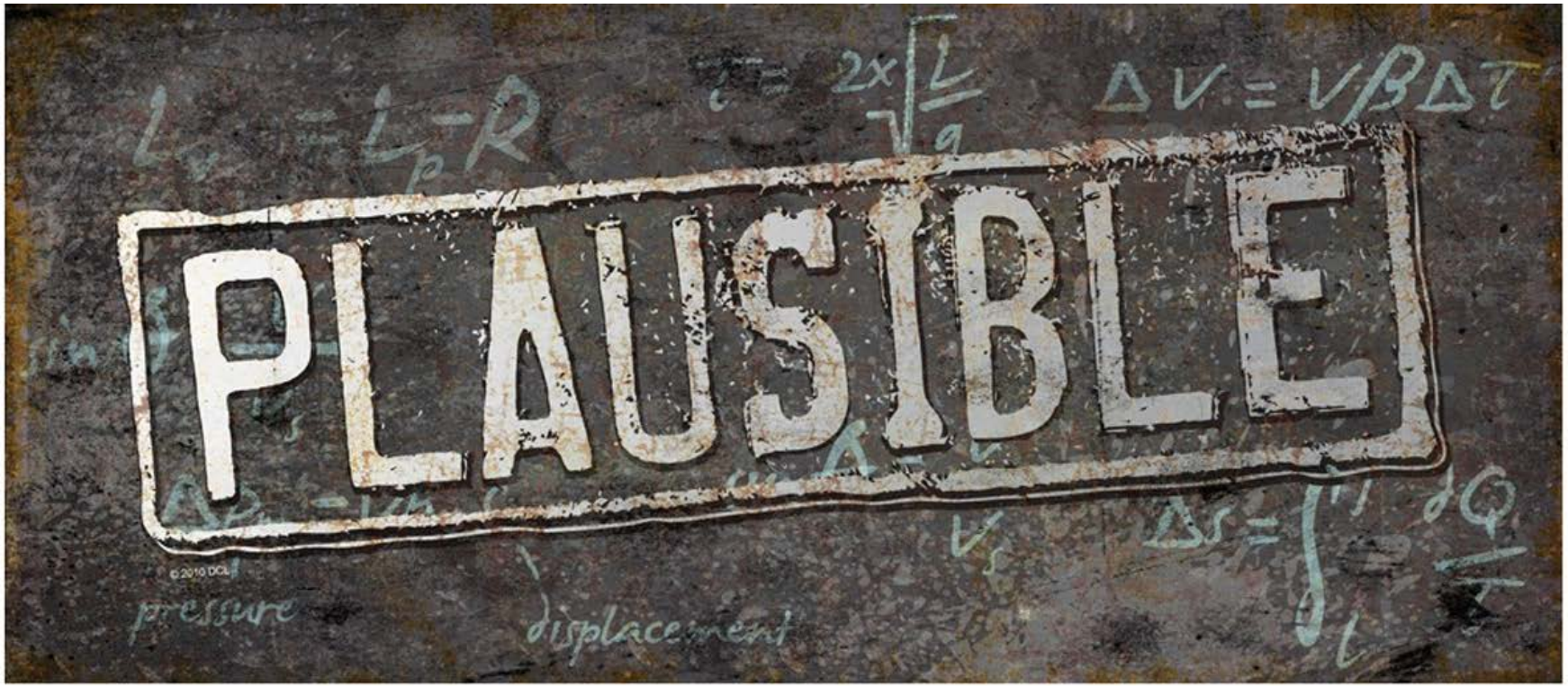


Preferred Model



- Ground motions consistent both with Mission records and with PBRs.
- Stress changes consistent with northward-propagating EQ sequence.

Implications for 1812



Implications for SAF-SJF Interactions

- The San Andreas and San Jacinto can rupture together.
  - Even if they didn't in 1812, it's physically plausible under current conditions.
  - Corroborated by paleoseismoloy and PBRs.
- How loaded is the San Andreas Fault south of its junction with the San Jacinto Fault?
- Does this change the most likely Really Big One for southern California?
- **How often does this happen? Is this a usual pattern?**

Now, we want to add more detail, clarity, and length to the Cajon Pass story.

Some Key Questions

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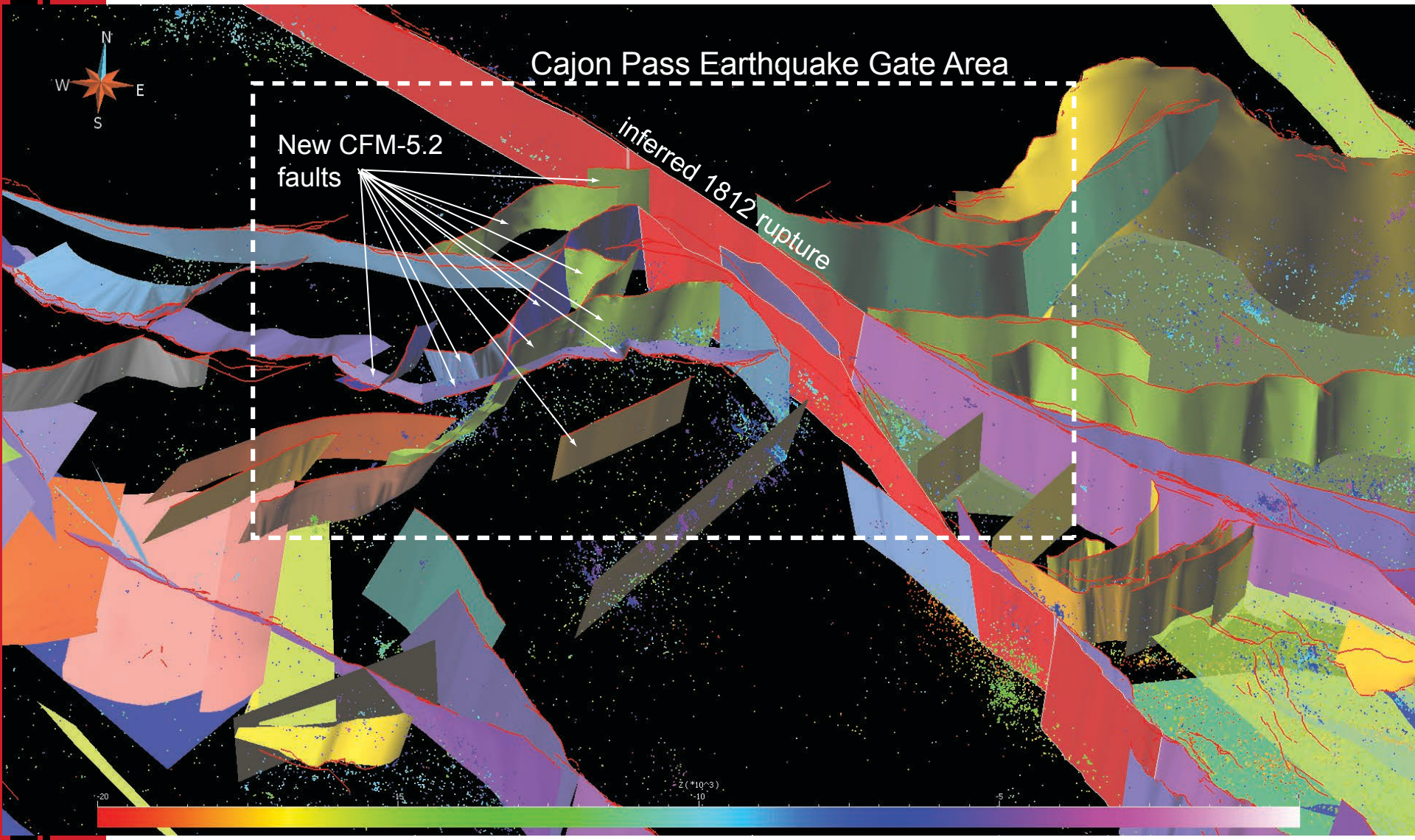
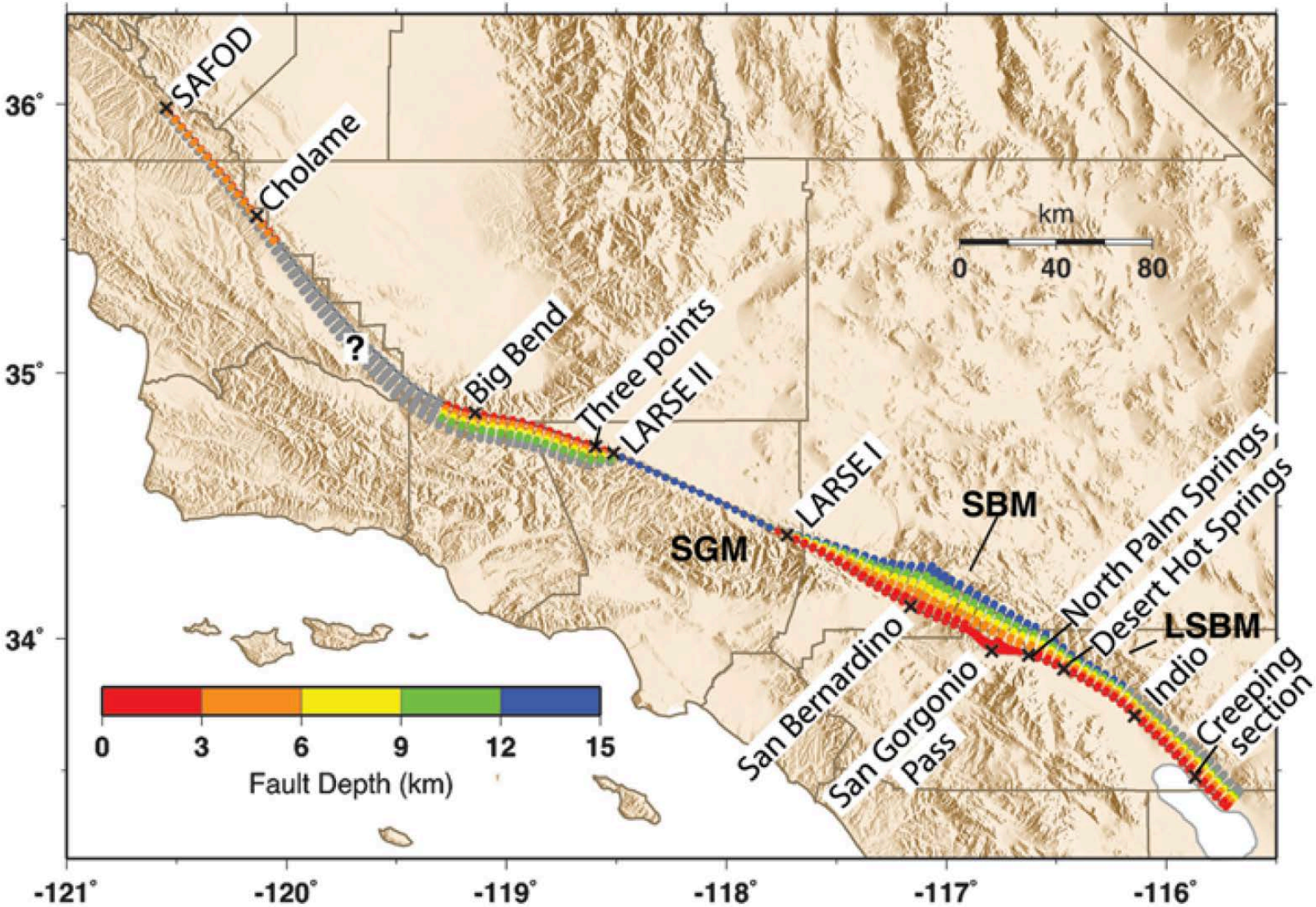
Cajon Pass Fault Geometry



Nicholson et al., 2017

Dip on the Southern San Andreas



Fuis et al., 2012

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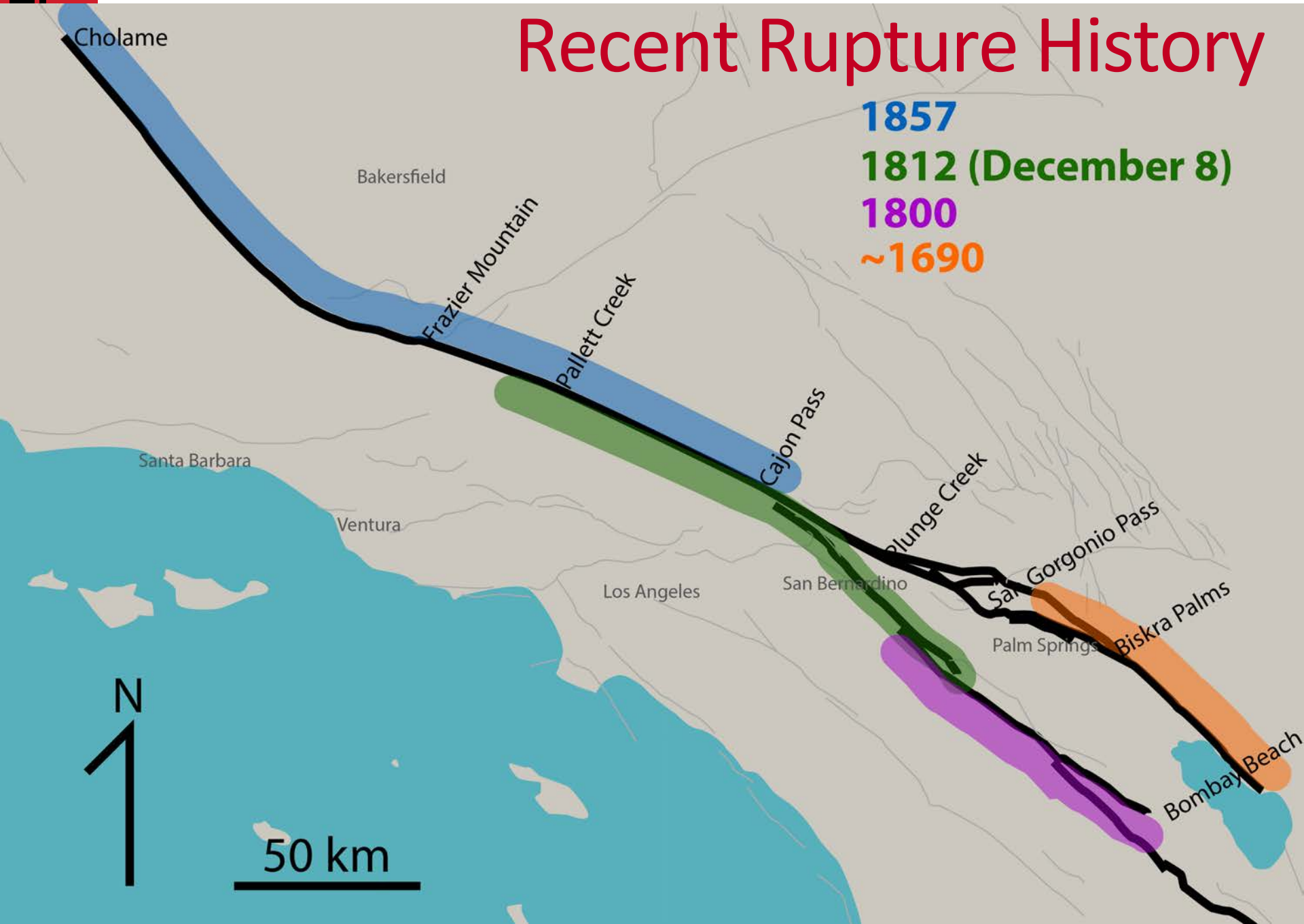
Recent Rupture History



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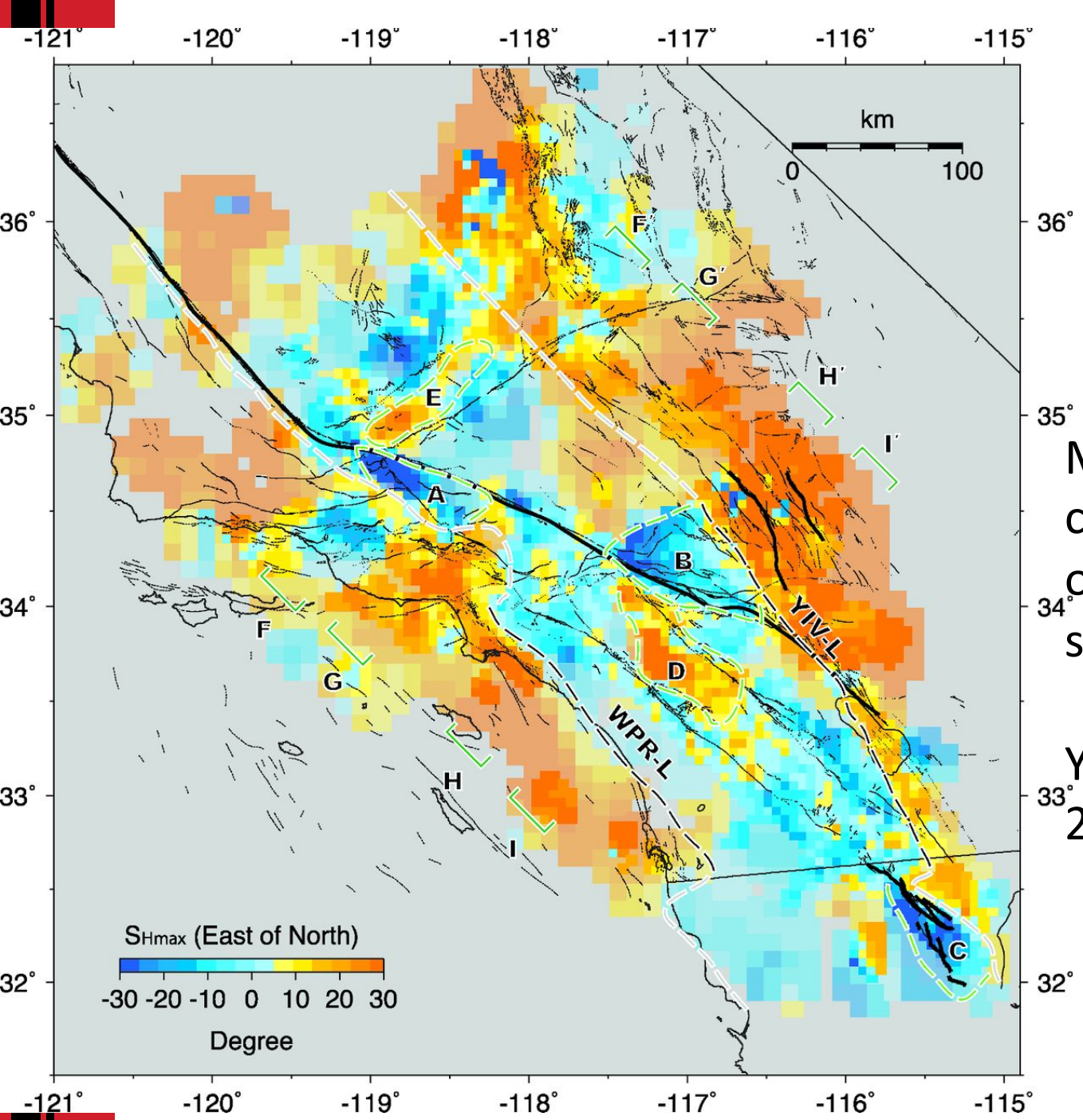

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Yang and Hauksson, 2013

Cajon Pass Panel Discussion

3 - 4 PM today, in this room.