

Understanding Natural Recurrence of Earthquakes and Slip over Time (UNREST) Technical Activity Group

Mike Oskin, Sally McGill, Kim Blisniuk, Alba Rodriguez Padilla, Sinan Akciz, Tom Rockwell, Ramon Arrowsmith, Kate Scharer (TAG Leadership Roles)

+ Tim Dawson, Belle Philibosian, Ian Pierce, Gordan Seitz, Lisa Grant-Ludwig, Genya Ishigaki (TAG Collaborator Roles)

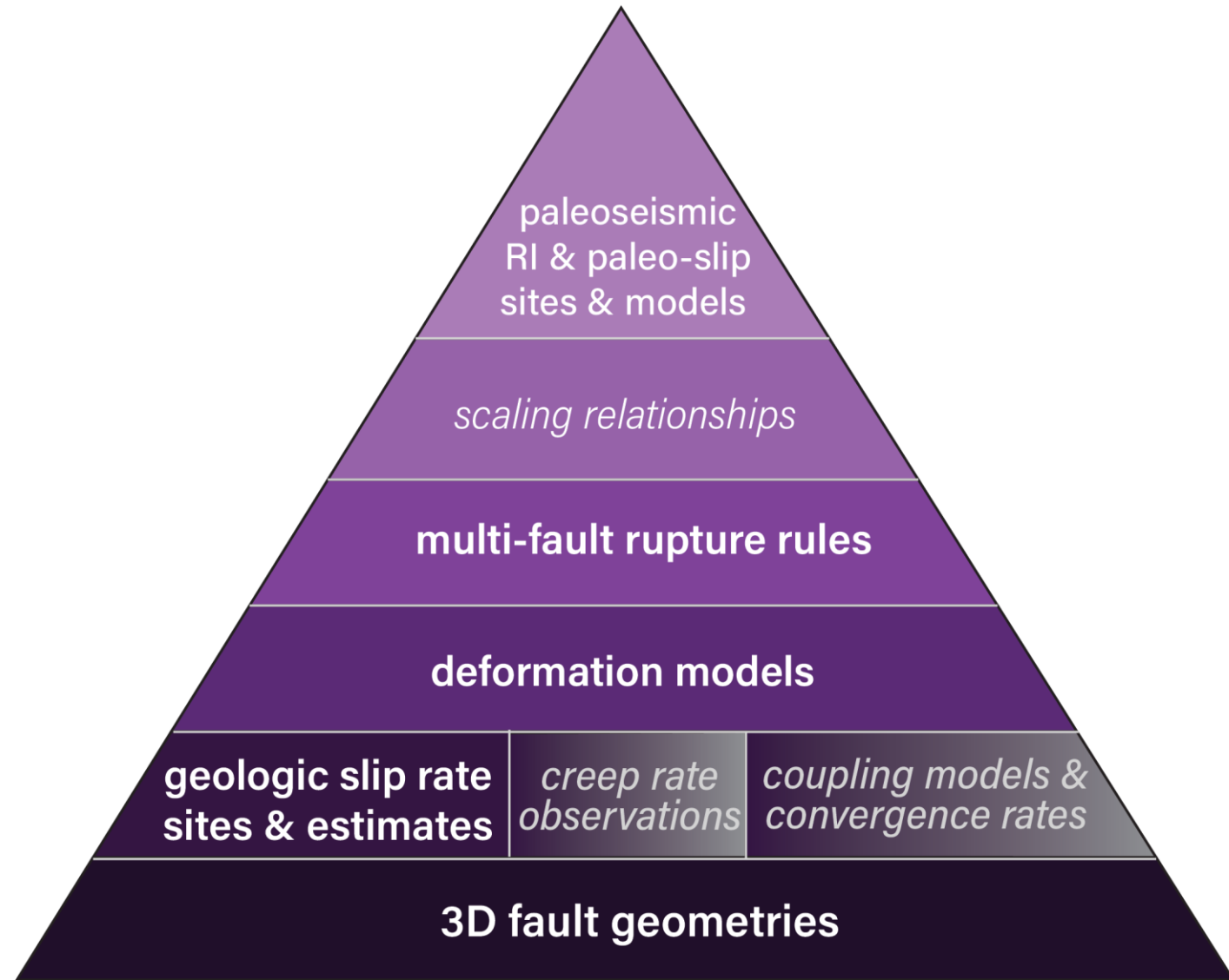
+ Erik Perkins, Sophia Esquenet, Brian Ducharme (Students)

+ Any of you!

Poster #121

The Problem:

- Most geologic data are site measurements, but earthquake ruptures span 10s to 100s of kilometers.
- Connecting site measurements (a.k.a. stringing pearls) is non-unique.
- Natural earthquake recurrence and event-to-event variation are much more complex than models predict.

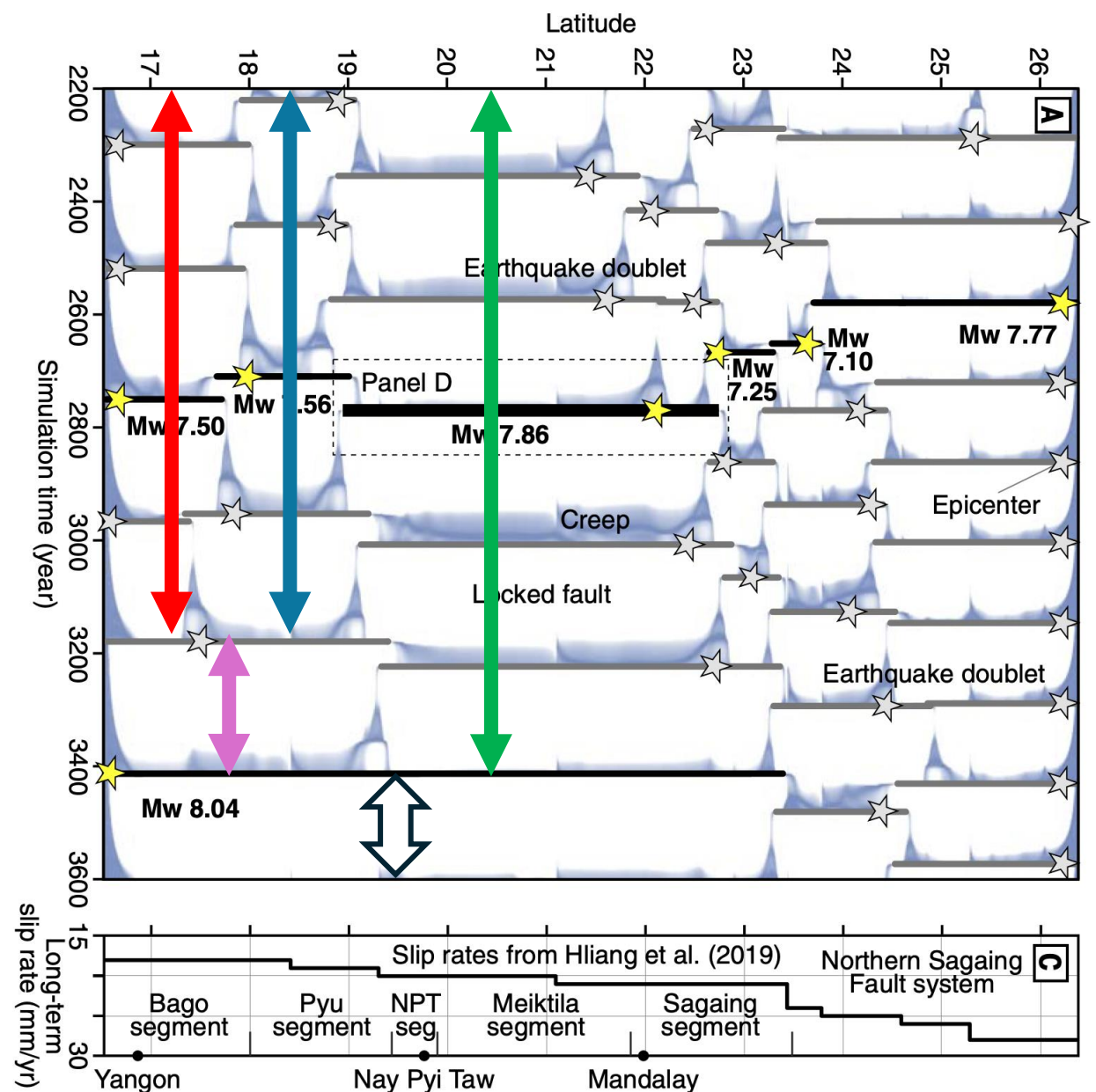


Hierarchy of NSHM Data & Model Inputs

Figure from Alex Hatem

The Problem:

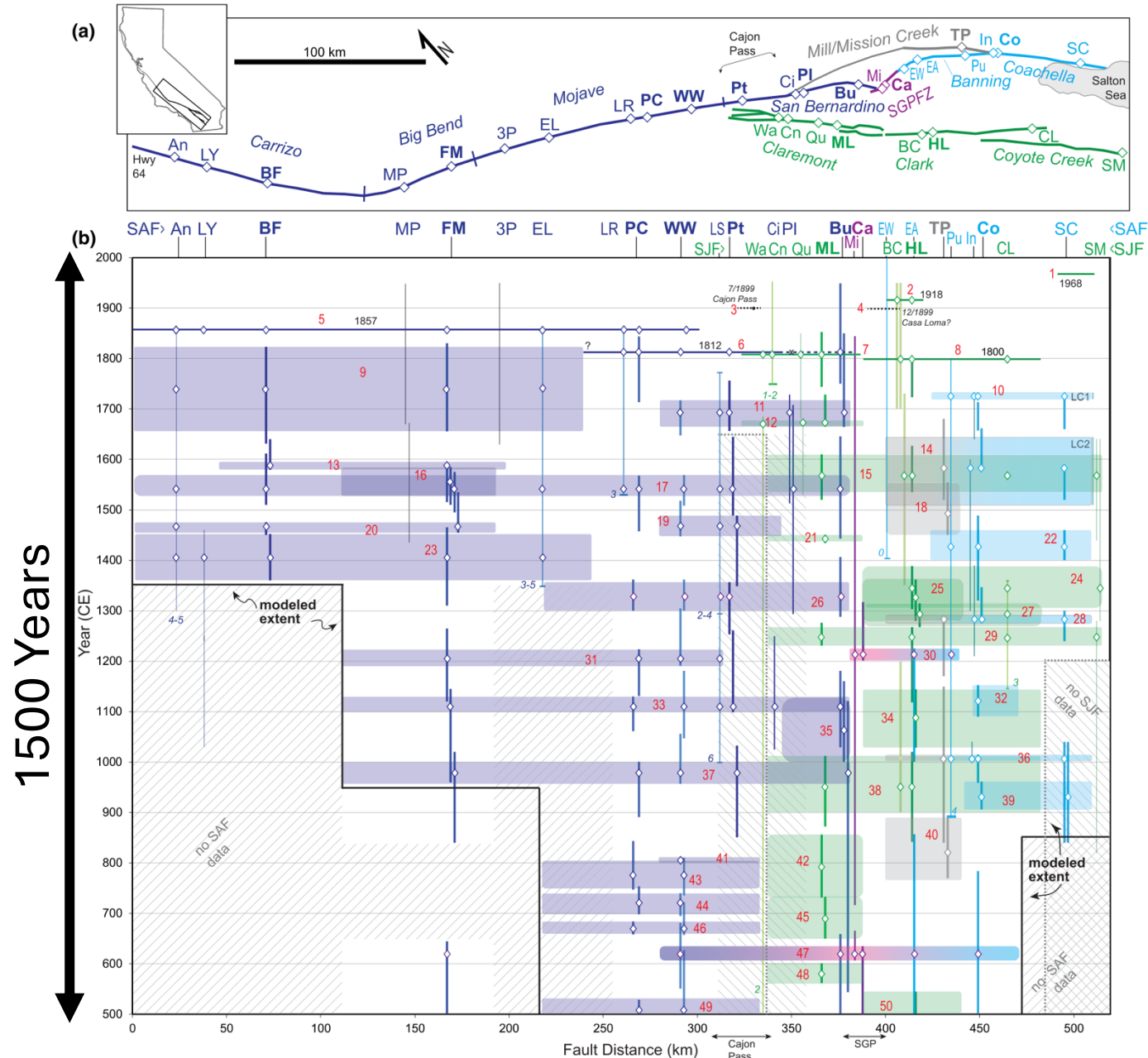
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- Connecting site measurements (a.k.a. stringing pearls) is non-unique.
- Natural earthquake recurrence and event-to-event variation are much more complex than models predict.
- Natural seismic cycles are irregular in space *and time*.



Seismic Cycle Model of Sagaing Fault

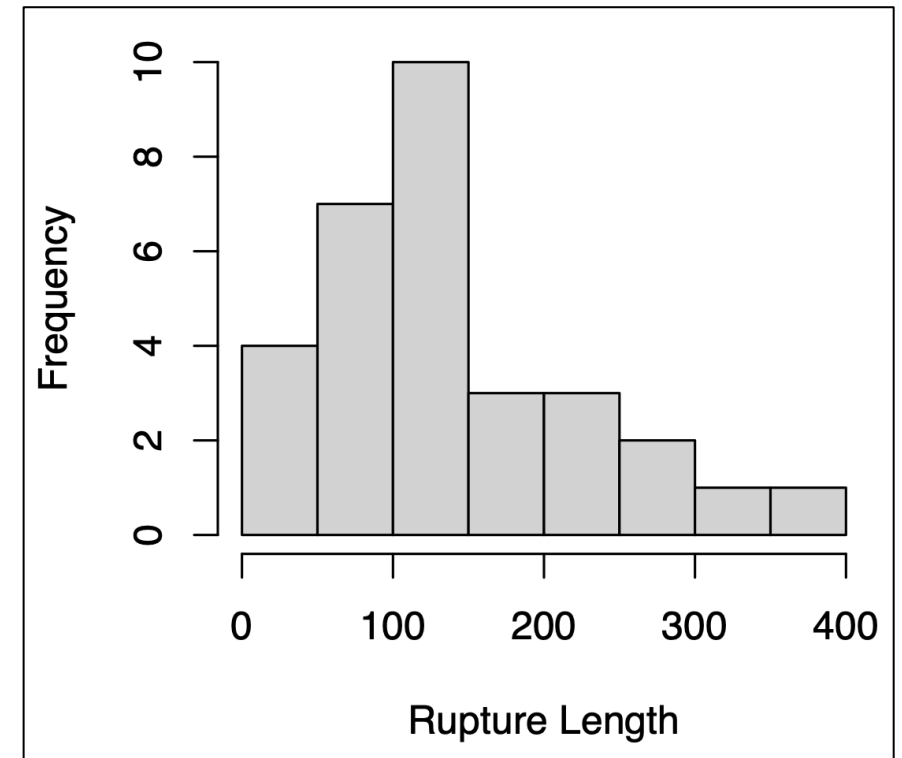
Liu et al., *Science*, 2026

The Solution: Rapid Scenario Modeling

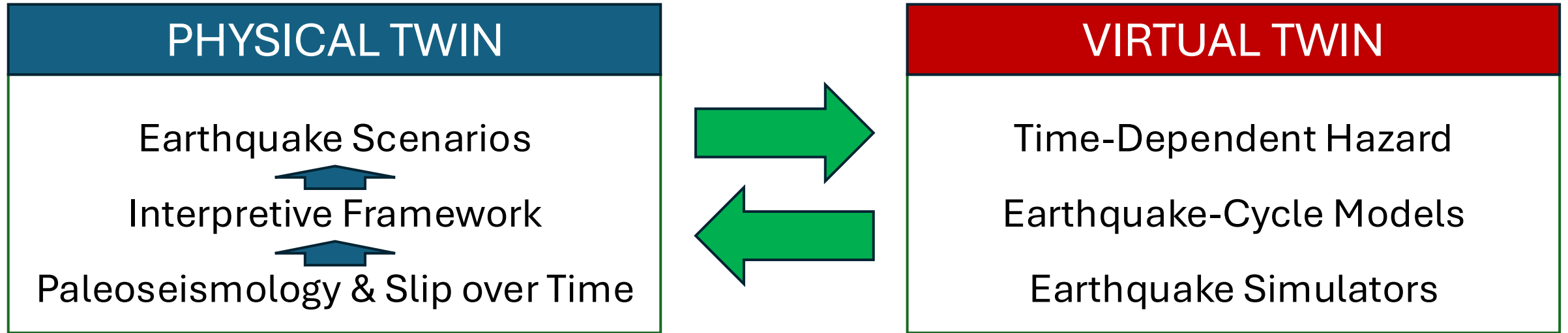


Southern San Andreas Scenario Scharer & Yule (2020)

n = 36 in 1500 years
System Recurrence $\approx$ 40 yrs
Only 2/36 exceed 1857 length



UNREST *vision: Digital Twin Fault System*



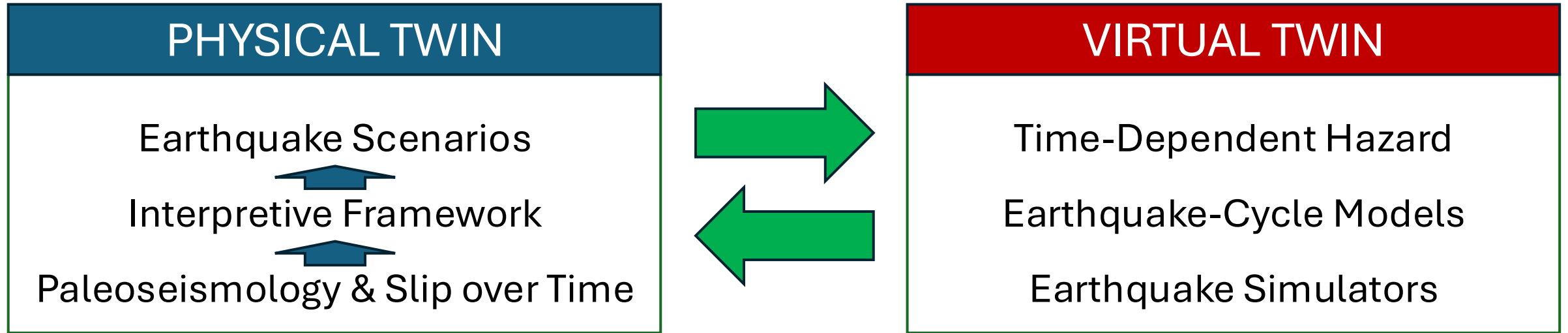
The ***Physical Twin*** is constructed from point observations along a fault, e.g.,

- Paleoseismic event sequences, slip per event proxy (trench data)
- Slip over time (within sequence) & long-term slip rates
- Fault geometrical controls on rupture length

The *Interpretive Framework* correlates point observations to build *Earthquake Scenario Models* of the natural earthquake cycle.

(stringing pearls with linear programming – see poster #123)

UNREST *vision: Digital Twin Fault System*

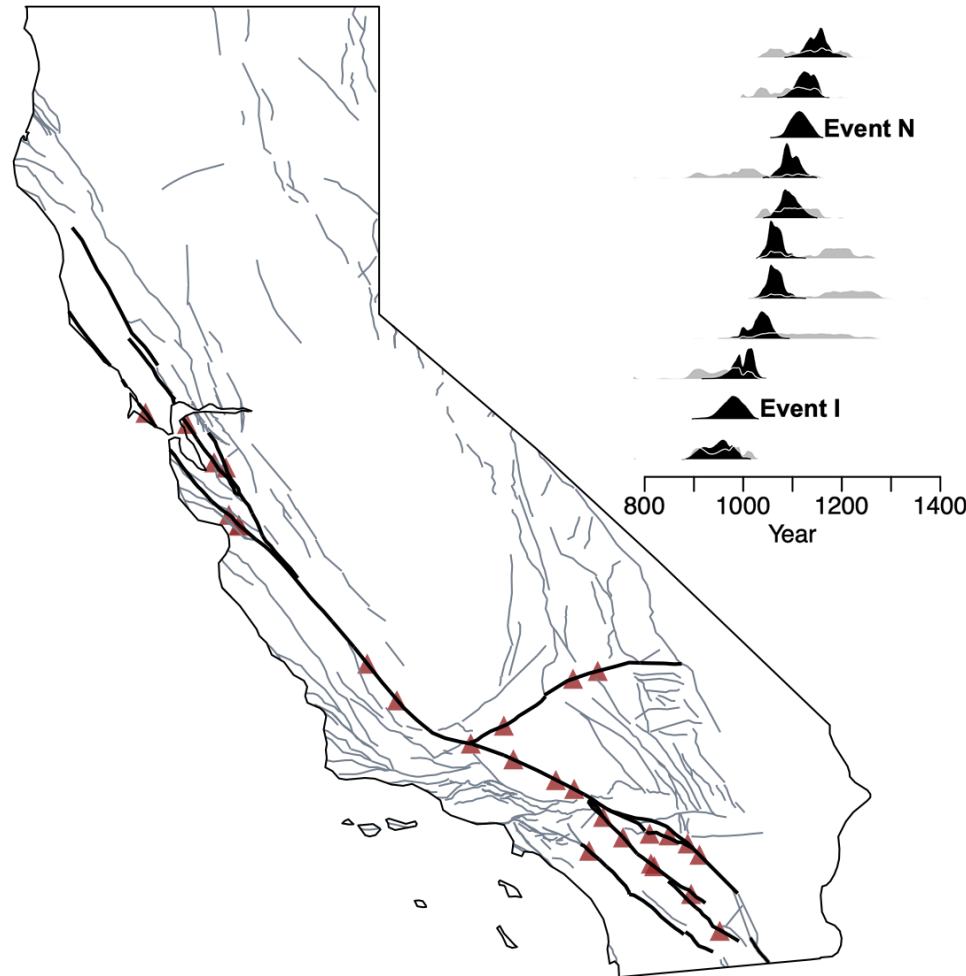


The ***Virtual Twin*** is a container for earthquake-cycle models , e.g.,

- Statistical Models (BPT, Weibull, Long-Term Fault Memory, etc.)
- Earthquake Cycle Models (full physics basis with evolving stress conditions)
- Earthquake Simulators (reduced physics basis with complex fault network)

The ***Digital Twin Feedback Loop*** allows for *model-derived insight* to influence the physical twin through the interpretive framework layer. Scenarios and models are iteratively revised and improved.

Project scope: Primary plate-boundary transform faults (slip rate ≥ 5 mm/yr, sum to $\geq 70\%$ plate motion)

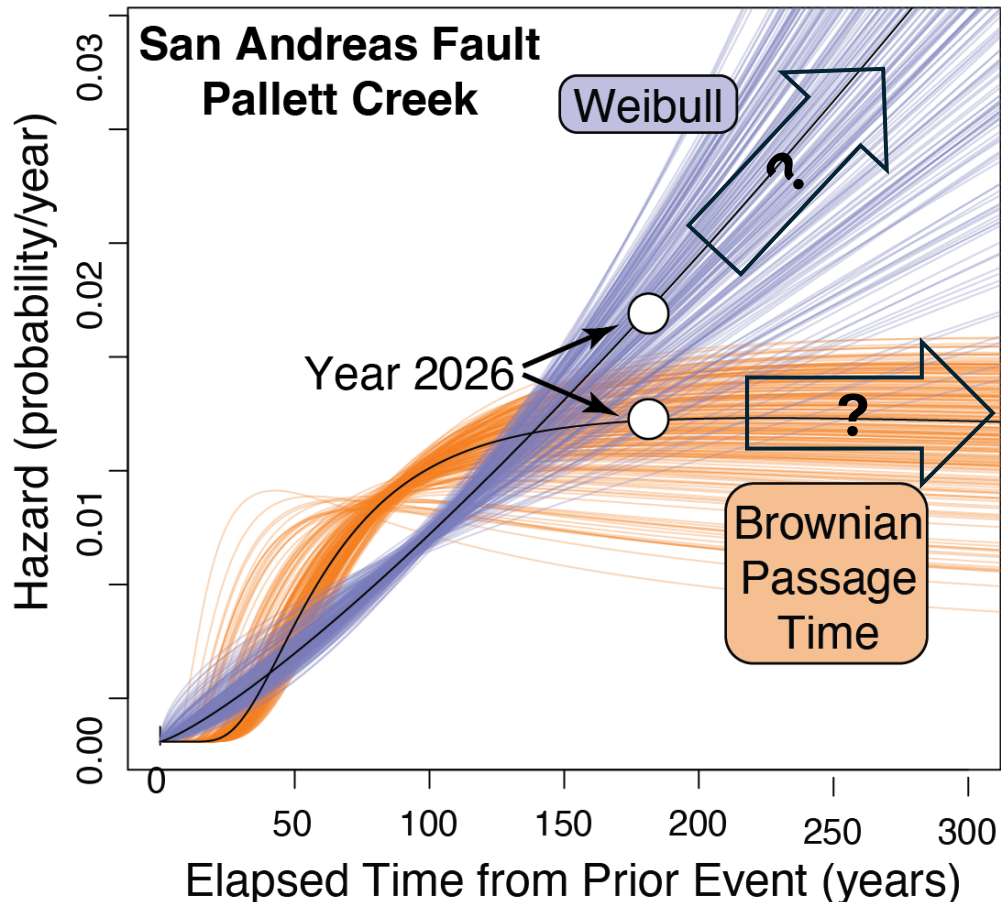


- Northern California:
 - Northern San Andreas
 - Calaveras-Hayward-Rodgers Creek-Maacama
- Southern California
 - Southern San Andreas
 - Garlock
 - San Jacinto
 - Elsinore
 - Imperial

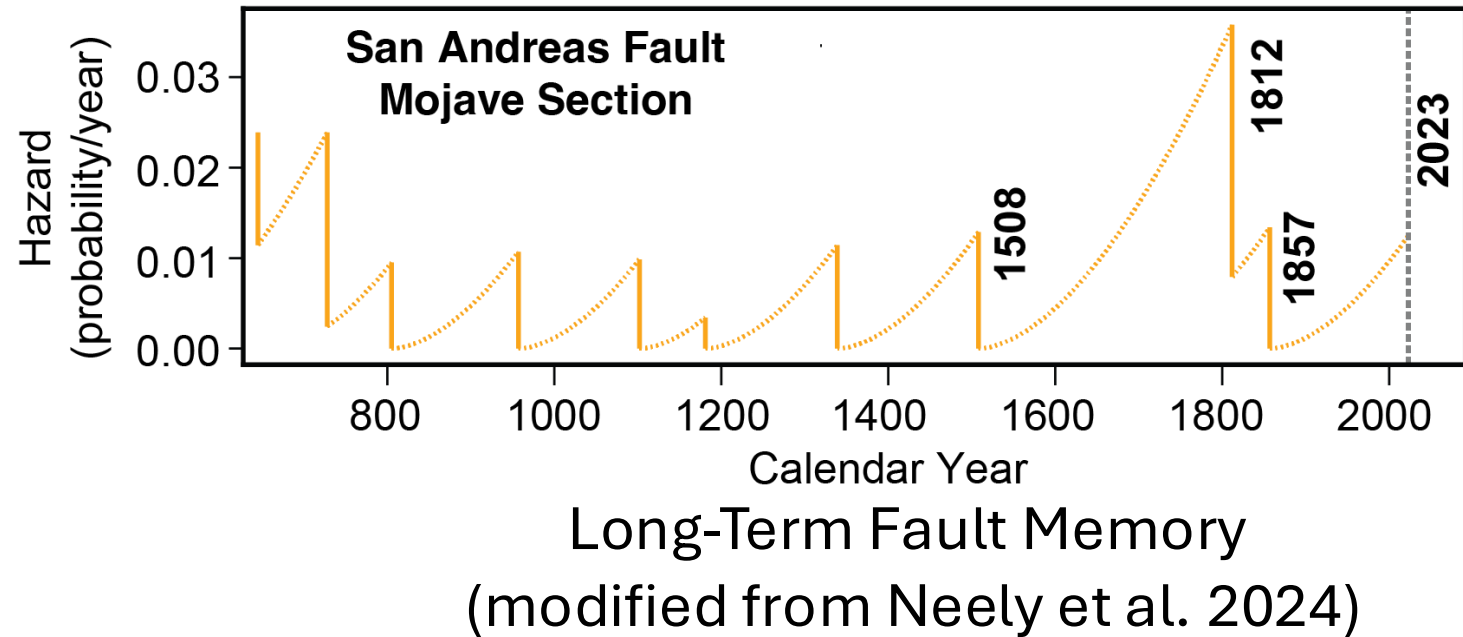
▲ Primary Oaxcal Event Sequences
(more to be added -- see poster #84)

Science-to-Practice: Time-Dependent Hazard

What is the appropriate time-dependent hazard function?



How much does present hazard depend on the timing and size of past events?



Hazard functions from fits to paleoseismic record. (Oskin et al., in review)

Check out the UNREST TAG in the posters:

- **Poster 84:** Development of a SCEC Paleoseismic Database
- **Poster 121:** Understanding Natural Recurrence of Earthquakes and Slip over Time (UNREST) TAG
- **Poster 123:** Exploring the Paleoseismic Solution Space: An Optimization-Based Event Correlation Technique

