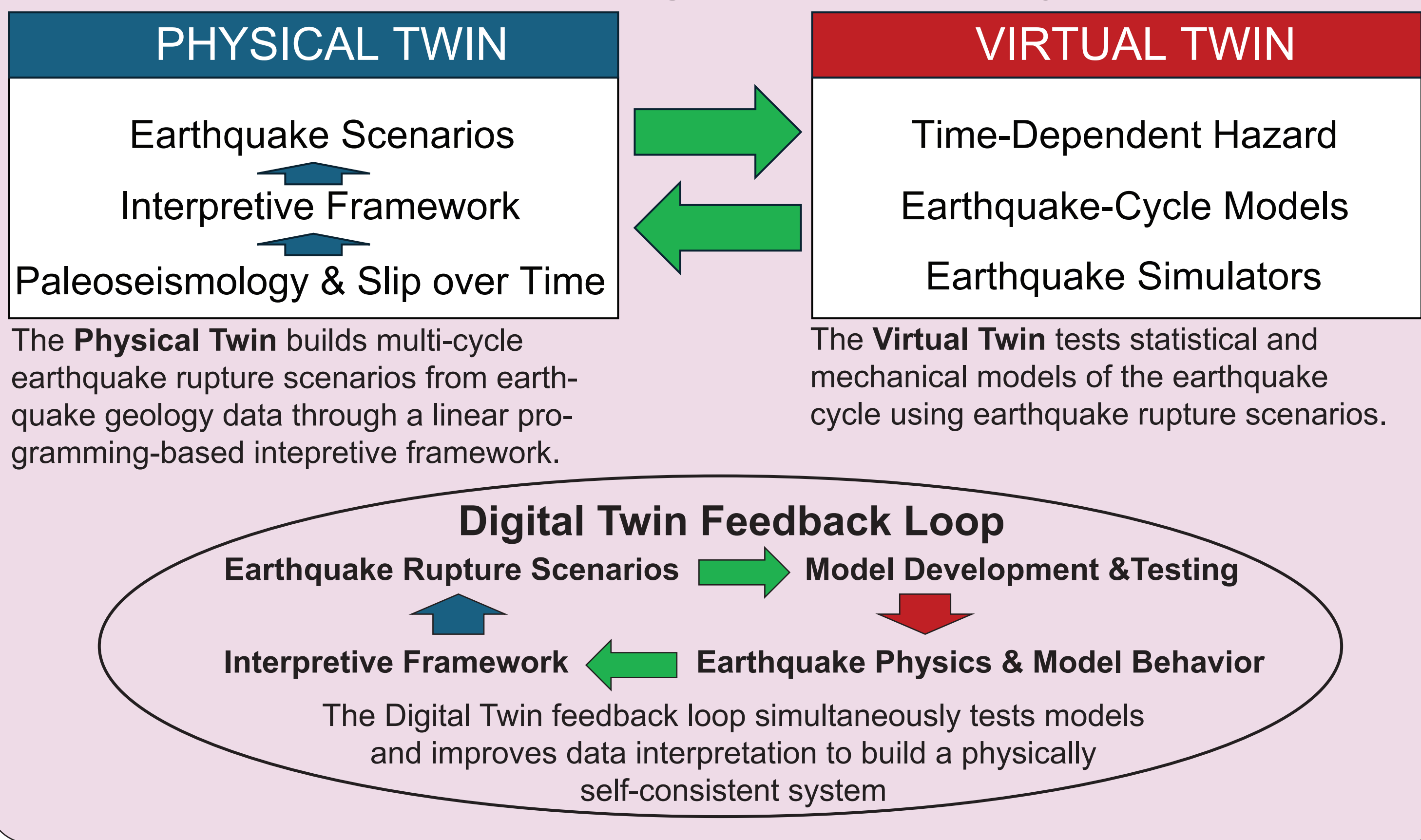


Understanding Natural Recurrence of Earthquakes and Slip over Time (UNREST)

Technical Activity Group

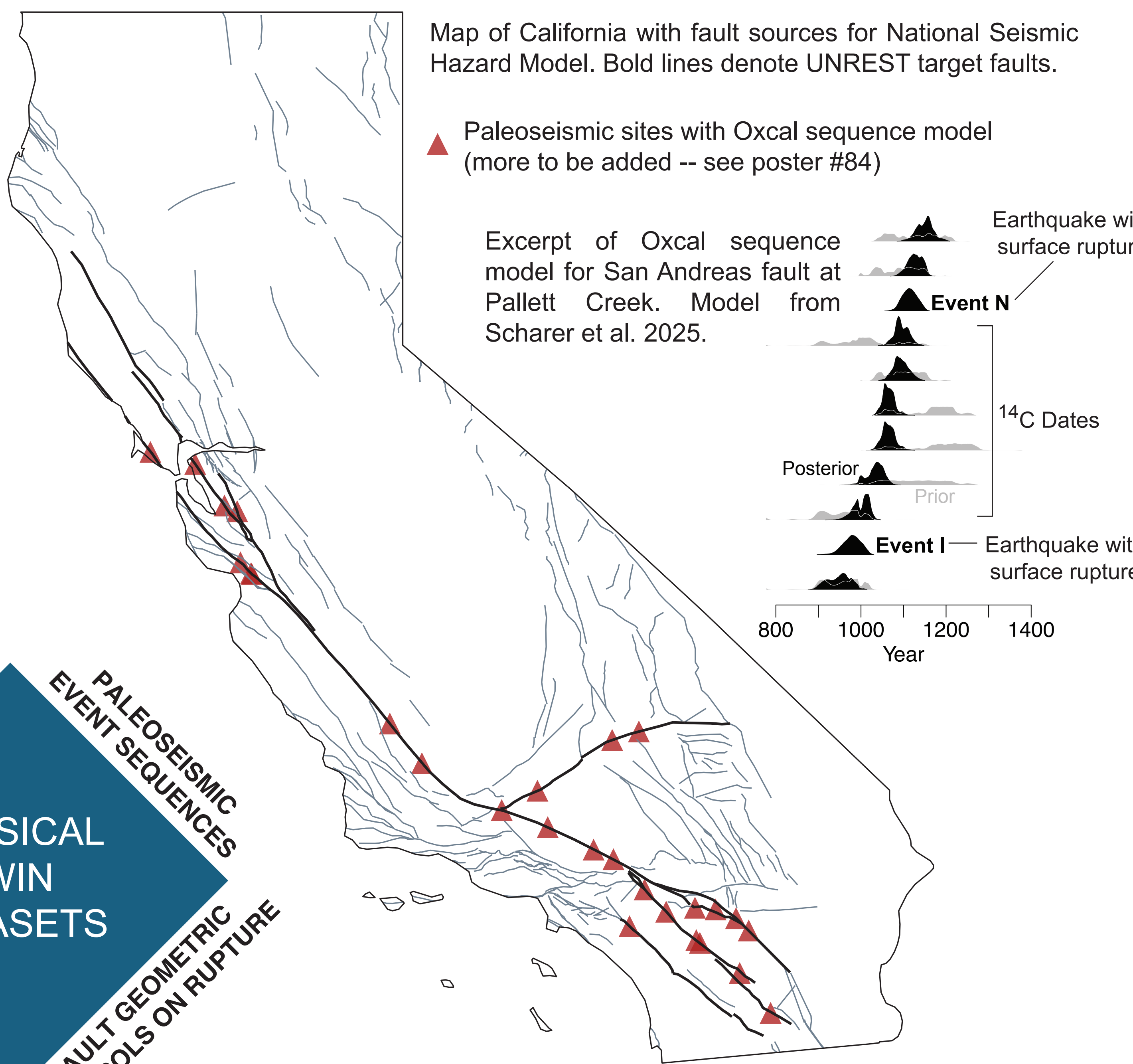
Poster #121

UNREST Vision: Digital Twin Fault System



Paleoseismology of Primary Plate-Boundary Strike-Slip Faults

Faults with slip rate ≥ 5 mm/yr collectively carry $\geq 70\%$ of plate motion



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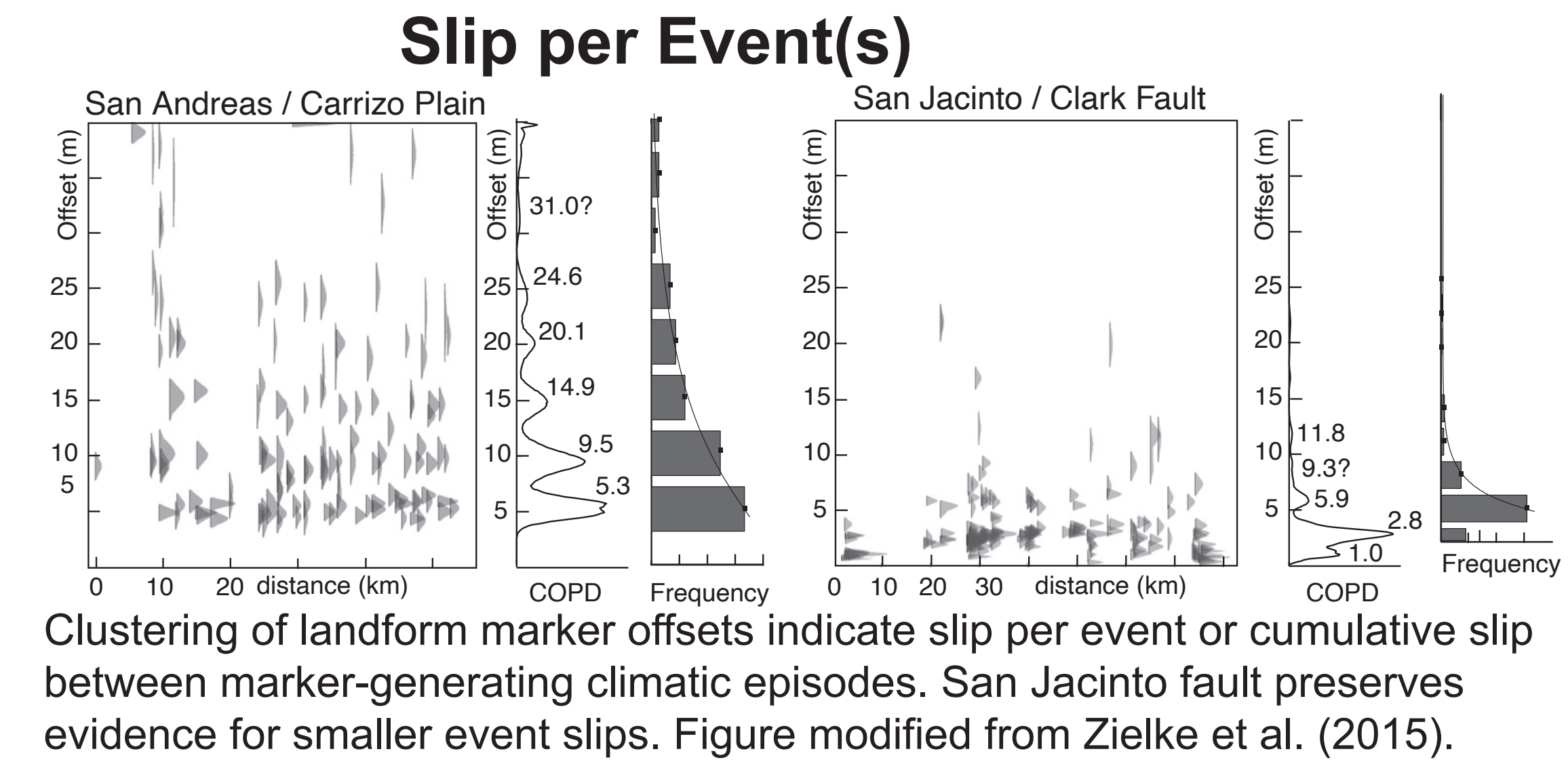
Brian Ducharme, California State University, Fullerton

<Your Name Here>, <Your Institution Here>

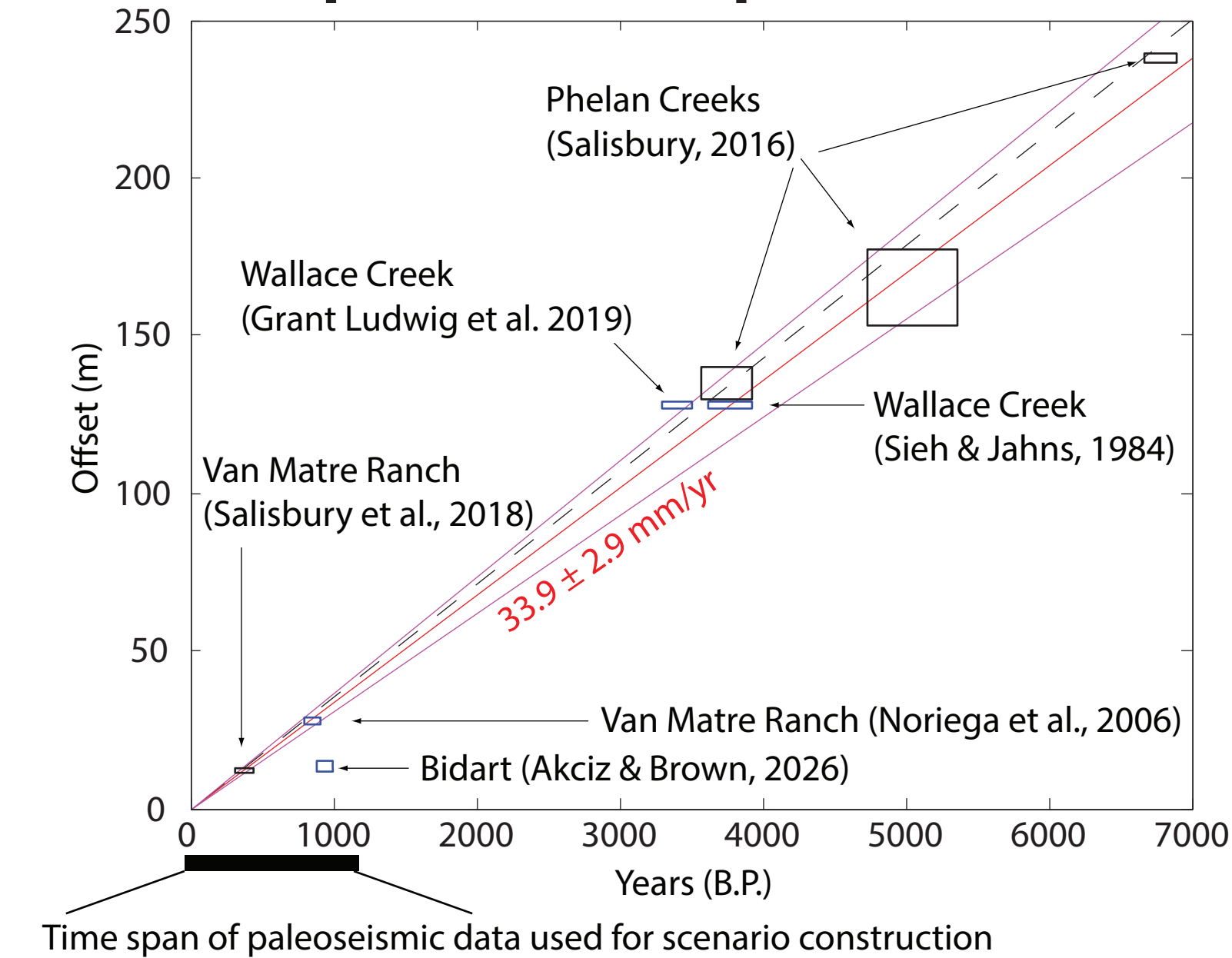
Abstract

The UNREST TAG leads a community effort to develop an AI/ML-ready Digital Twin Fault System to test earthquake-cycle models against the observed paleoseismic record, refine data interpretation, and improve time-dependent rupture forecasts. The Physical Twin will consist of mutable, paleoseismically derived multi-cycle earthquake rupture scenarios for the past 1200 years and slip rates along the major plate-boundary transform faults of northern and southern California. These scenarios are built from primary paleoseismic, slip over time, and long-term slip rate datasets, and further refined by incorporating fault geometry, event-quality and event-size proxy measurements. A computational interpretive framework, based on integer linear programming, will be developed to objectively correlate paleoseismic site records to produce rupture scenarios optimized by cumulative slip and other data- or model-informed criteria. The Virtual Twin will be developed to act as a container for computational and statistical models of the earthquake system. One of the major goals for this first year is to compile the necessary paleoseismic, slip-rate, and fault geometry datasets, including developing new earthquake-sequence models for older paleoseismic sites, and to develop the interpretive framework to build Physical Twin scenario models. These products will have immediate utility to the earthquake science community and hazard-modeling practitioners. By the end of this first year, we will demonstrate the potential for hypothesis-testing with our proposed digital twin fault system through comparison of scenario models with statistical earthquake rupture forecasts based on the Brownian Passage time, Weibull and Long-Term Fault Memory models. Future efforts will be coordinated with allied TAGs seeking to foster development of earthquake simulators and earthquake-cycle models using this digital twin approach.

Information on references cited available upon request

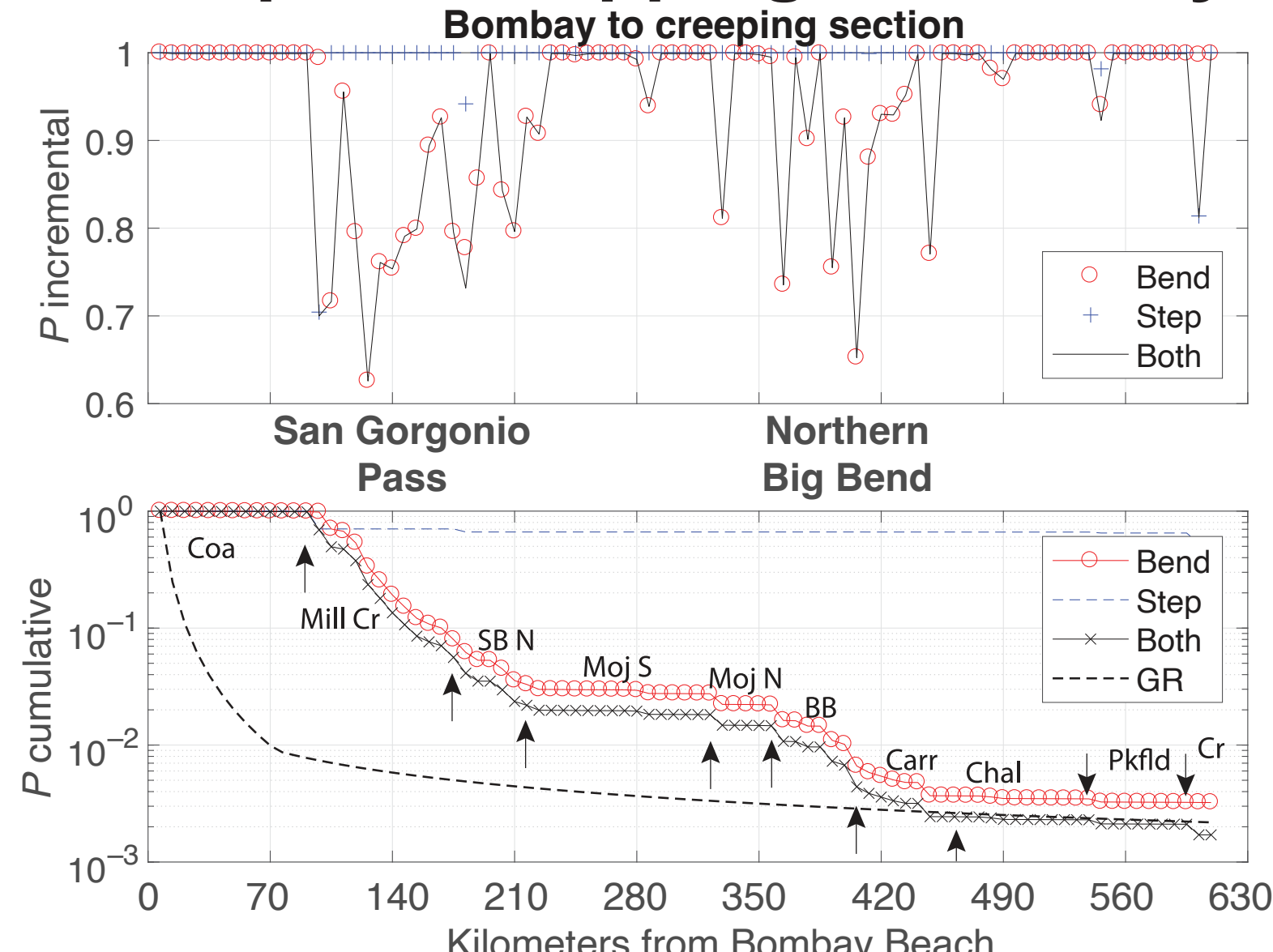


Slip Rate & Slip over Time



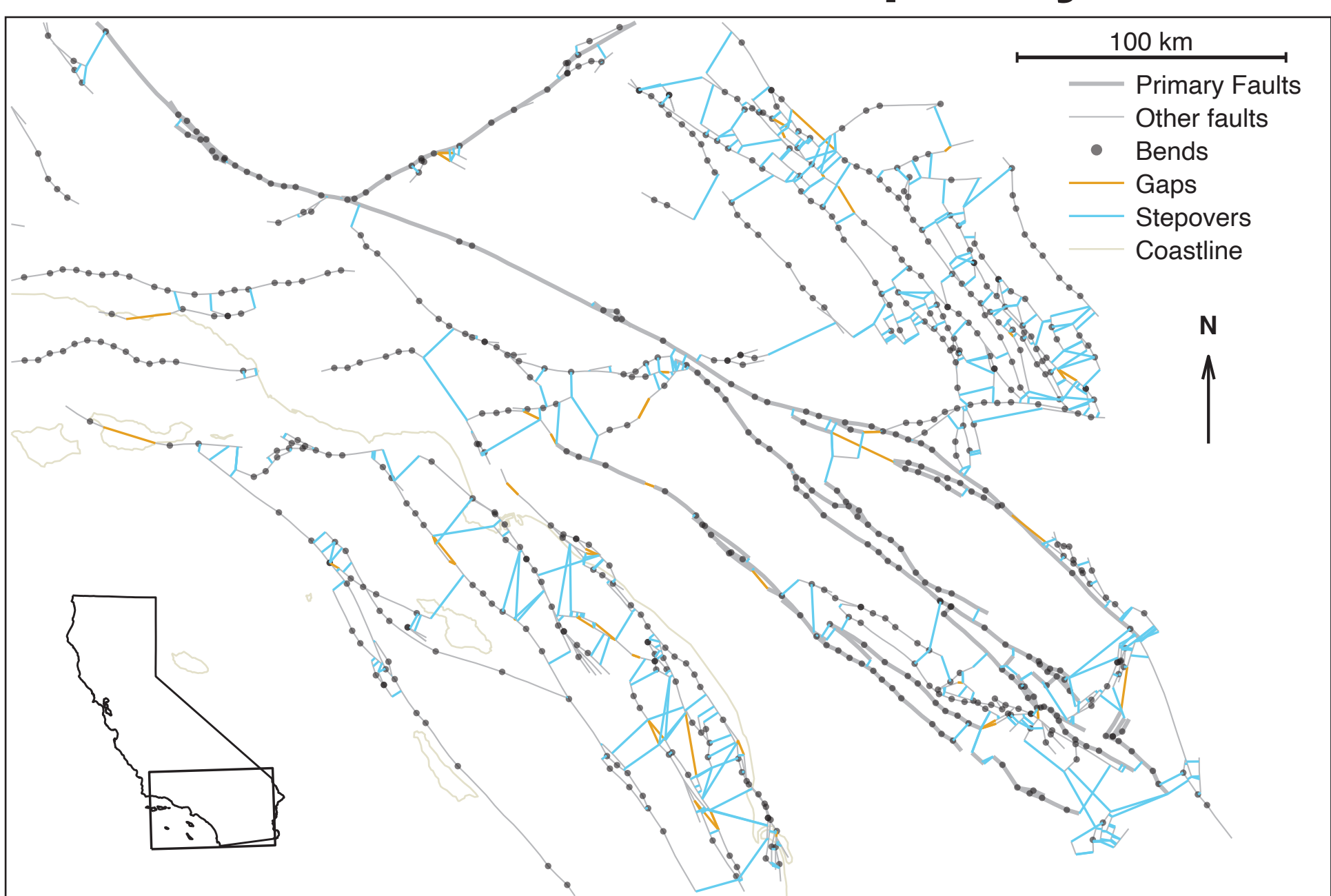
Marker displacement as a function of marker age for San Andreas fault at sites in the northern Carrizo Plain. Long term **slip rate** from several sites yields values of 34 ± 3 mm/yr consistent with geodesy. **Slip over time** describes marker offsets within span of paleoseismic data used for scenario construction. Figure modified from Salisbury (2016).

Rupture Stopping Probability



Probability per 7 km section and cumulative probability of rupture termination for San Andreas fault, reckoned northward from initiation at Bombay Beach, shows significant barriers at San Gorgonio Pass and northern Big Bend. Figure modified from Biasi and Wesnousky (2021)

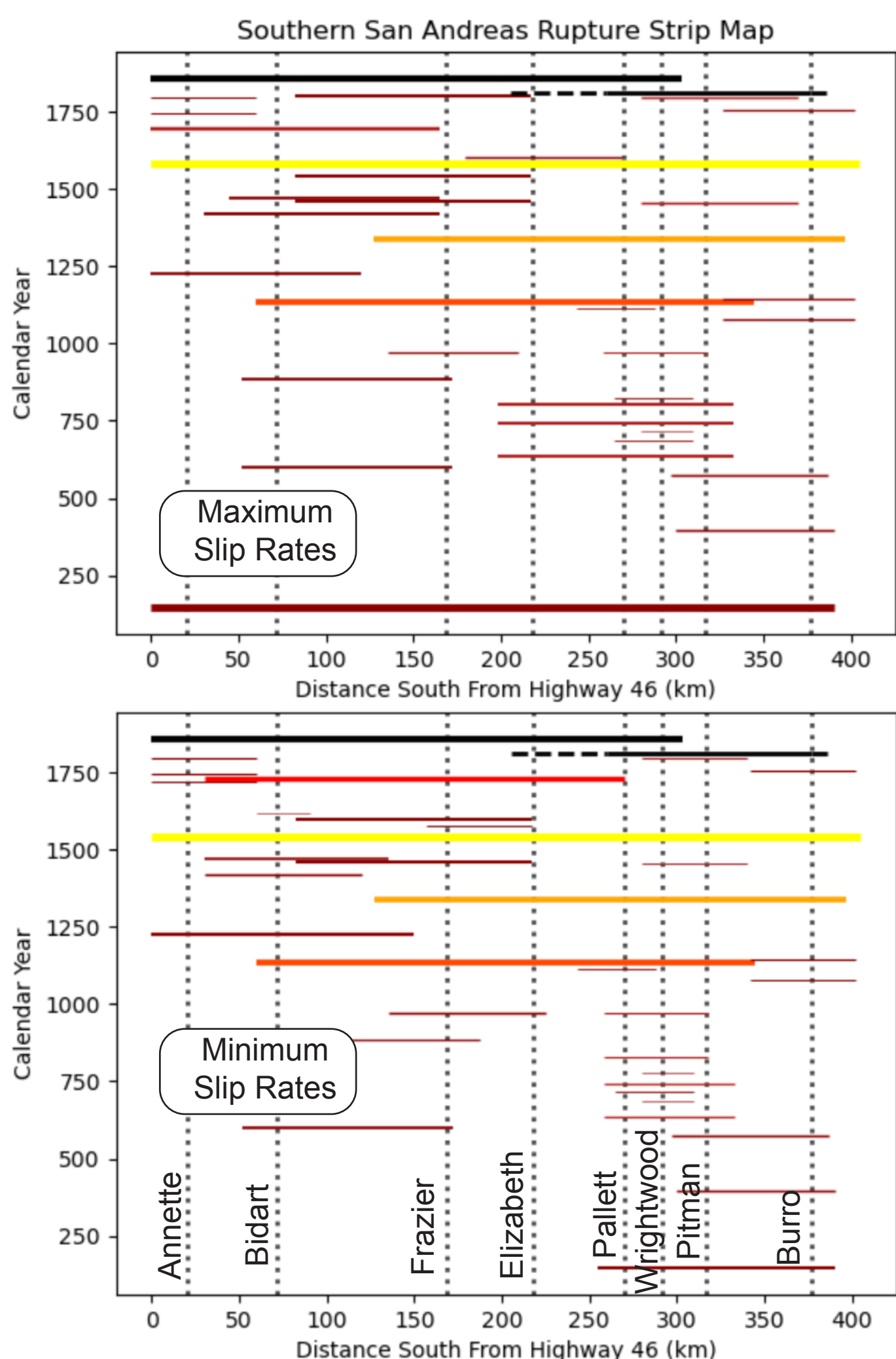
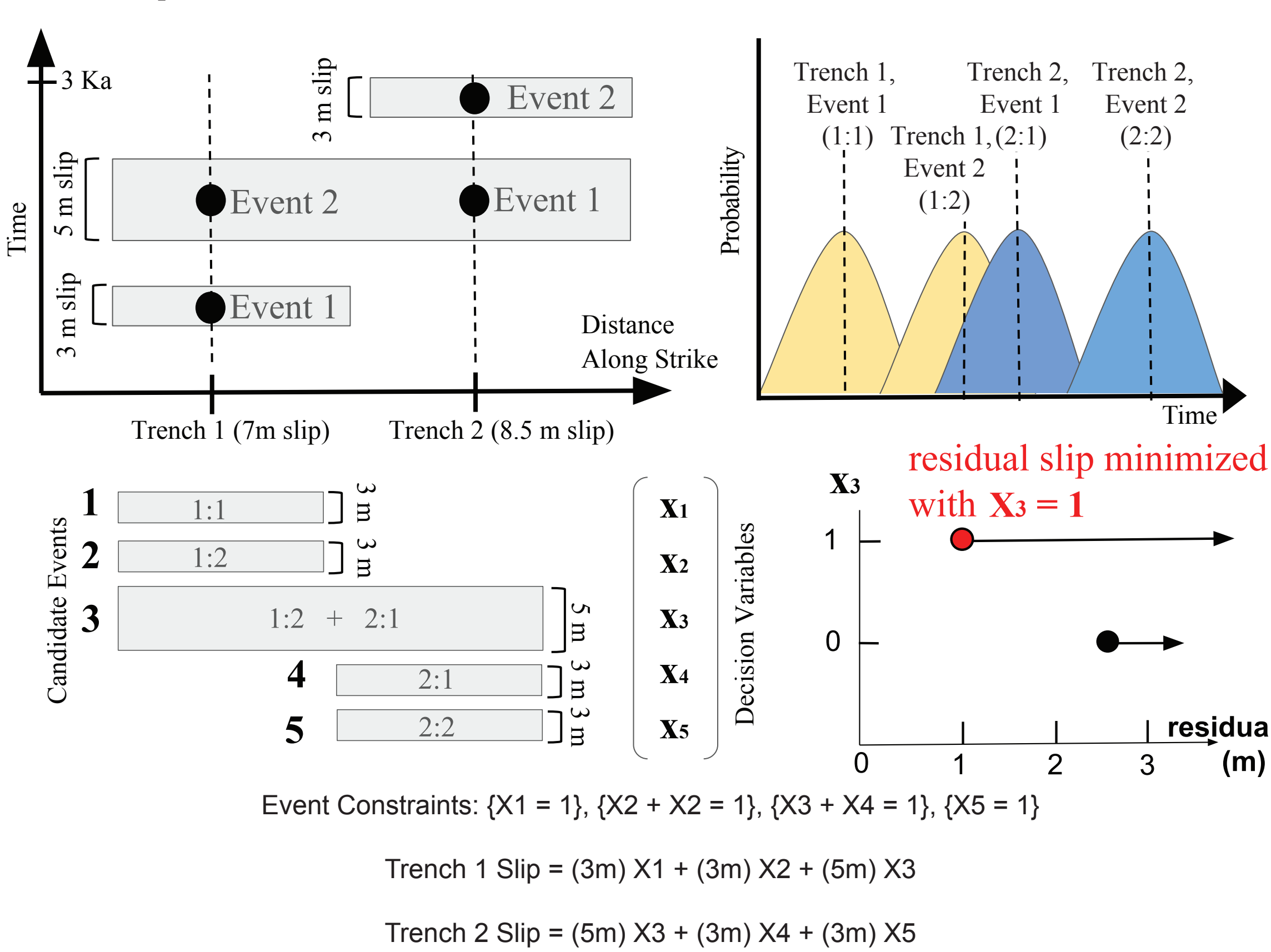
Fault Geometric Complexity



Results from automated mapping of fault geometrical complexities for southern California. Fault traces simplified into 5 km long segments and then bends, gaps, and step-overs are identified across the fault network. Figure from unpublished work in progress by Esquenet and Rodriguez Padilla.

INTERPRETIVE FRAMEWORK & SCENARIO MODELS

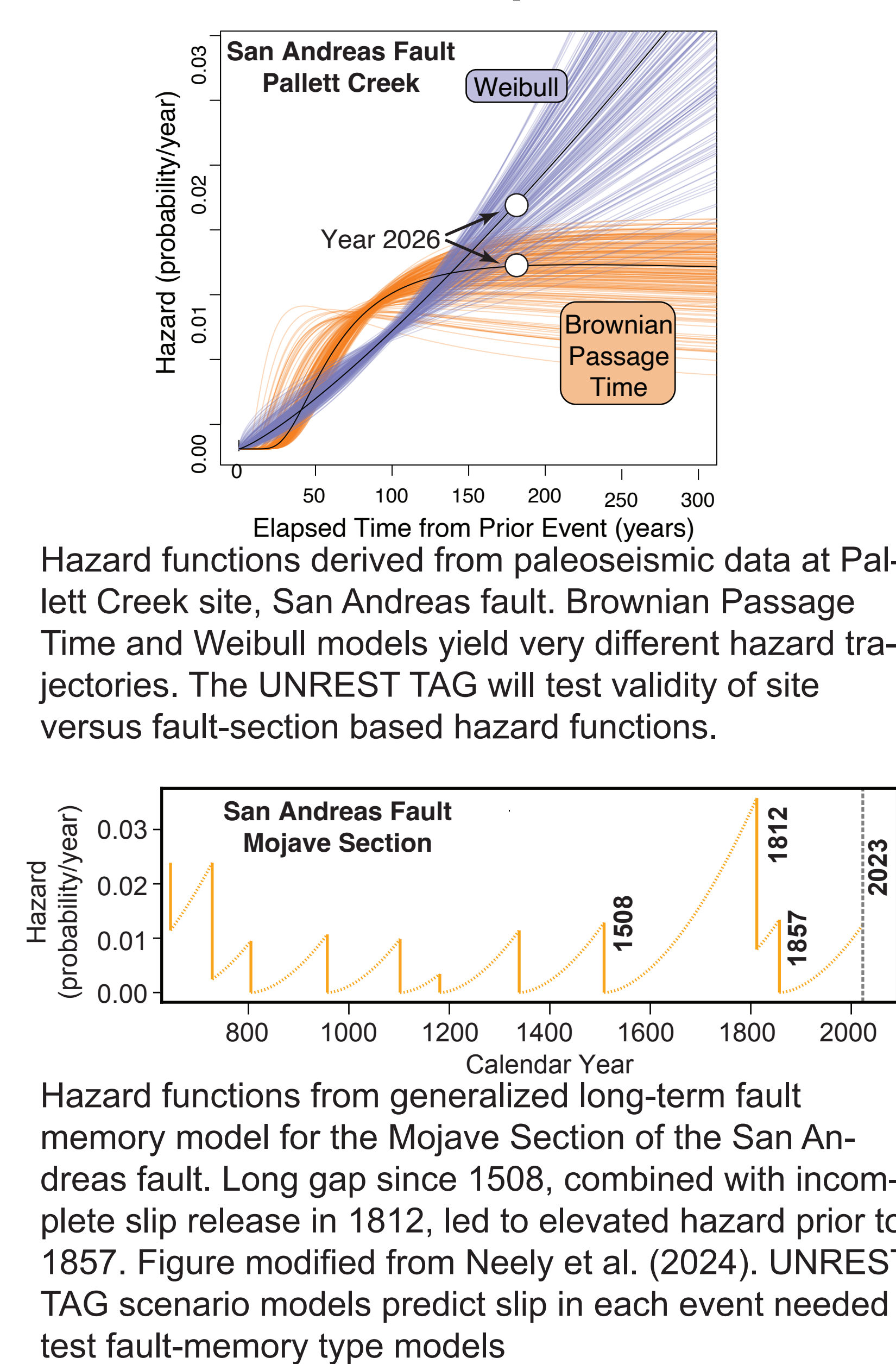
Optimal Paleoseismic Event Correlation



Two example scenario models for the southern San Andreas fault based on correlation of eight paleoseismic sites and fit to minimum and maximum slip rate measurements. Rupture end points also optimized to produce best-fitting slip. Incomplete records limit events prior to 1000 A.D. for northern half of fault.

VIRTUAL TWIN MODEL EXAMPLES

Statistical Time-Dependent Hazard



Physics-Based Seismic Cycle Simulation

