2020 SOURCES: Coupling between the Southern and Northern Central San Andreas Fault

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Abstract

The central San Andreas fault (cSAF) between San Juan Bautista and Parkfield fails in episodic, aseismic creep events which are still poorly understood. Interactions between creep events and earthquakes at the regional scale may produce feedbacks in earthquake and faulting cycles and have implications for coupling between the northern and southern ends of the SAF. We find delayed creep triggering in the northern cSAF following the 2003 San Simeon and 2004 Parkfield earthquakes of Mw 6.5 and 6.0 respectively.

Questions:

- **Do the northern and southern San Andreas Fault act as independent or coupled systems?**
- **How do major regional earthquakes trigger creep rate changes?**

Data and Methodology

We use data from the USGS creepmeters in the northern central San Andreas Fault and the SJT borehole strainmeter from GTSM Technologies to relate shallow surface ground creep to deeper fault activity. We used BAYTAP-08 (Tamura et al., 1991; Tamura & Agnew, 2008) with NOAA sea-level pressure data from Salinas Airport to estimate and remove tidal and atmospheric components from the SJT time series data.

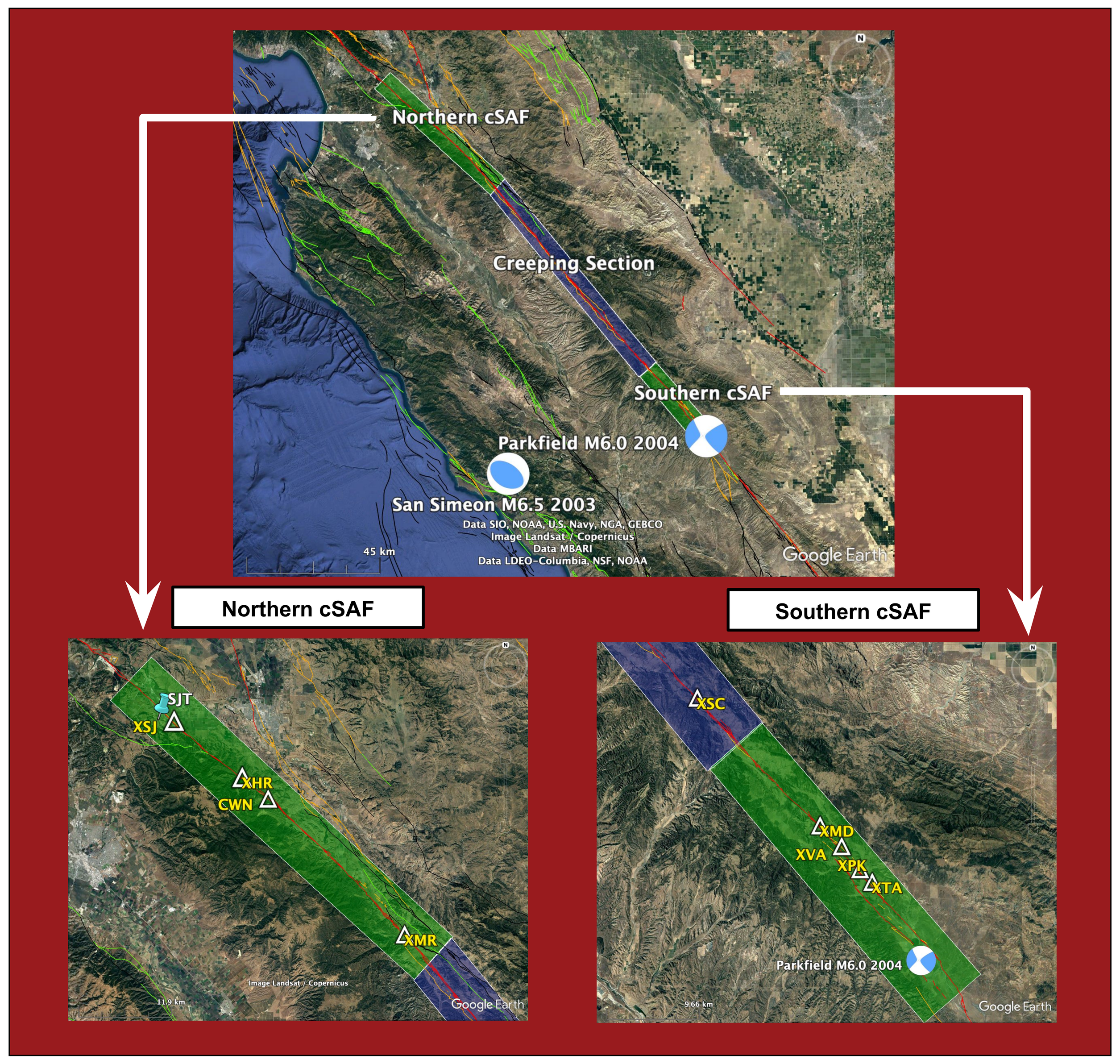
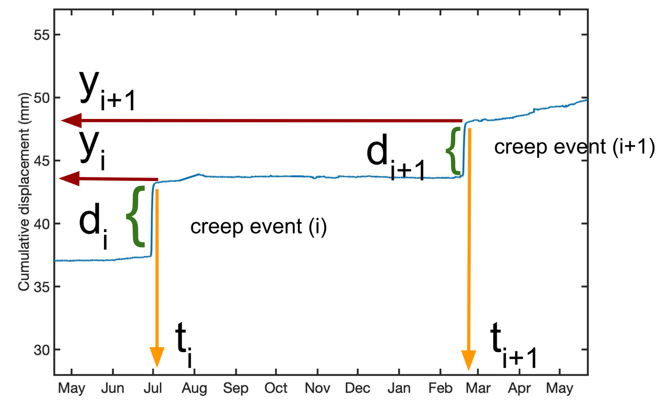


Figure 1: Central San Andreas fault with locations of creepmeters (white triangles), borehole strainmeters (blue pin), and regional earthquake epicenters.

We define the "**creep ratio**" **Φ** to describe the relative amount of cumulative displacement d_i accommodated by i'th creep event over total displacement y_i at the end of every i'th creep event.

$$\Phi_i = \frac{\sum_1^i d_i}{y_i}$$



Result 1: Creep rate changes

We find a secular creep rate change at XSJ that begins with the 2003 San Simeon M6.5 and ends around the 2004 Parkfield M6.0. The recurrence intervals between these two earthquakes at XSJ are shorter than average, around this time.

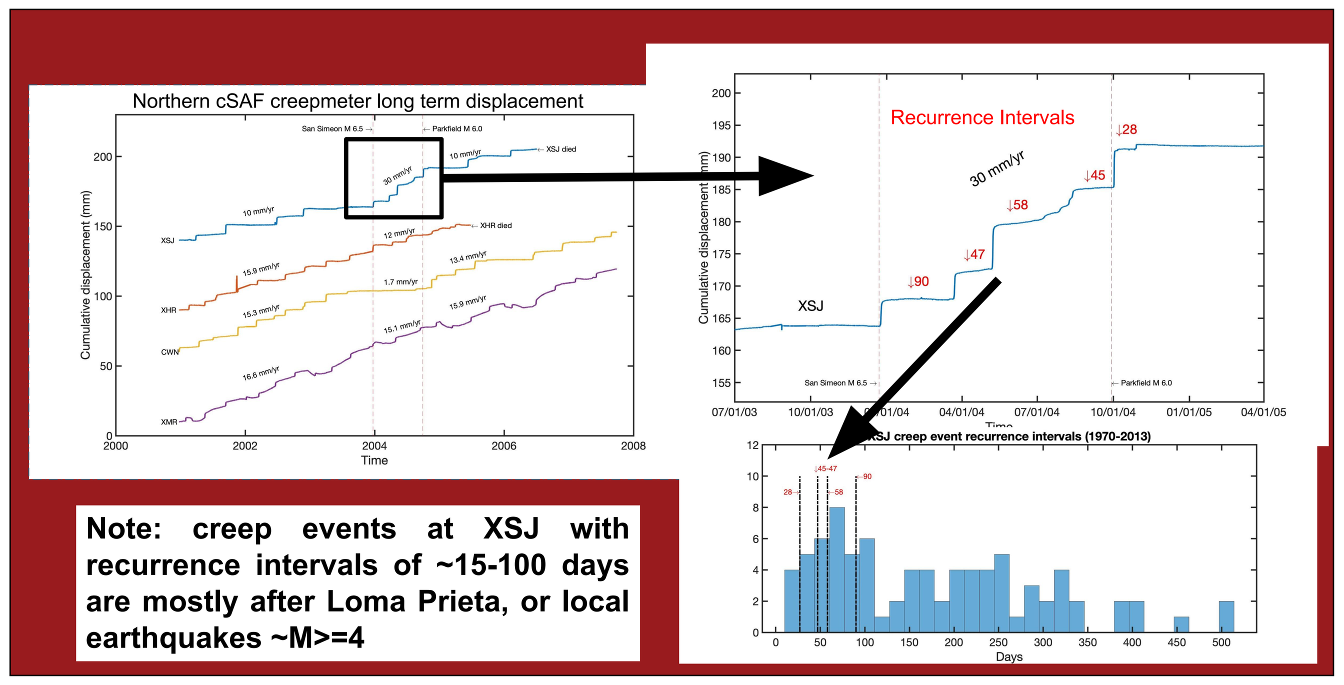


Figure 2: Northern cSAF creepmeter displacement, with secular rate. Creep triggered in southern cSAF is already documented.

Result 2: Triggered creep events

The San Simeon and Parkfield earthquakes triggered instantaneous creep events to within the 10-minute sampling rate. Delayed creep events at creepmeter XSJ triggered by both San Simeon and Parkfield earthquakes are accompanied by precursory strain transients recorded at the SJT borehole strainmeter (~1.5 km west of XSJ).

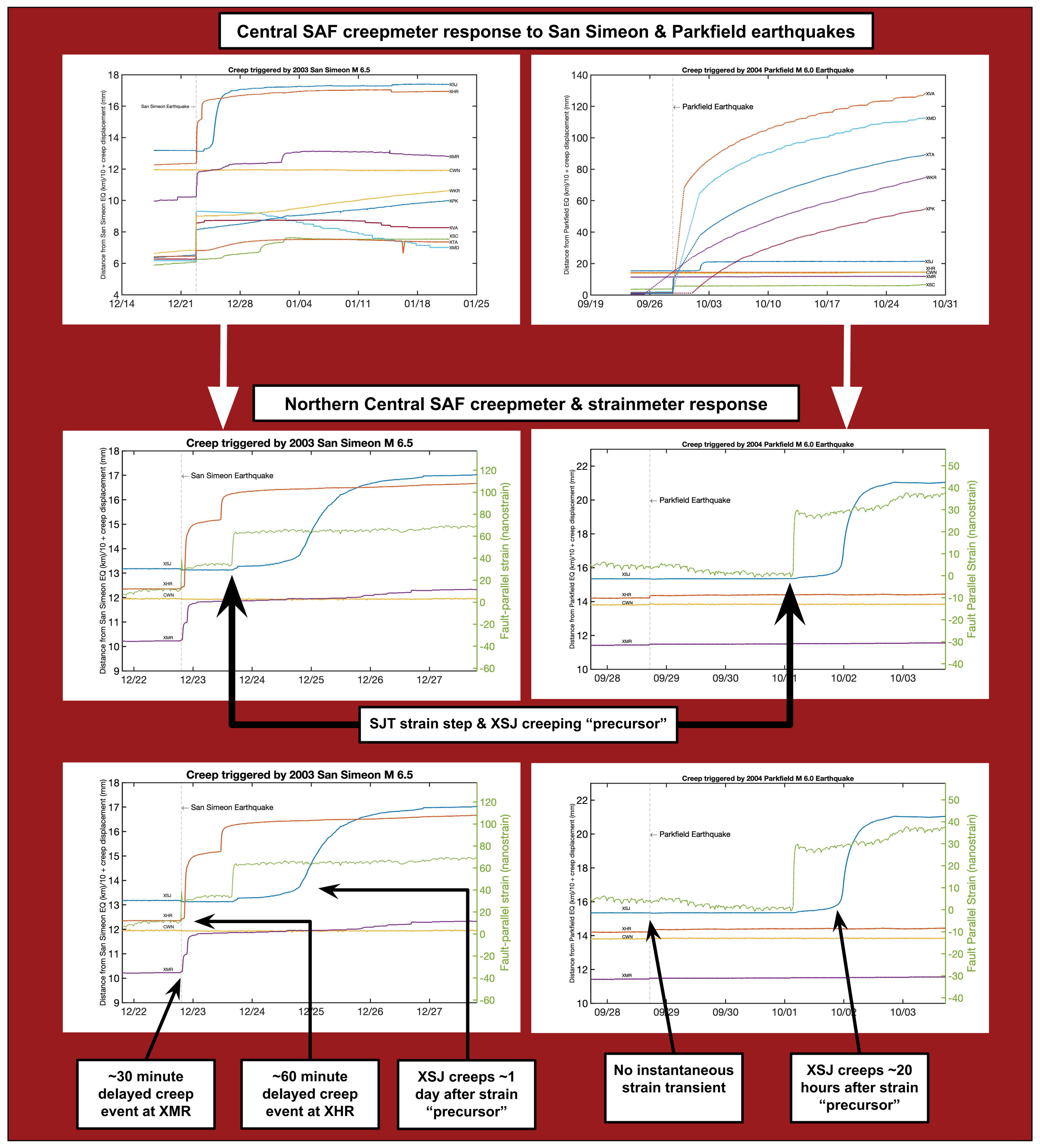
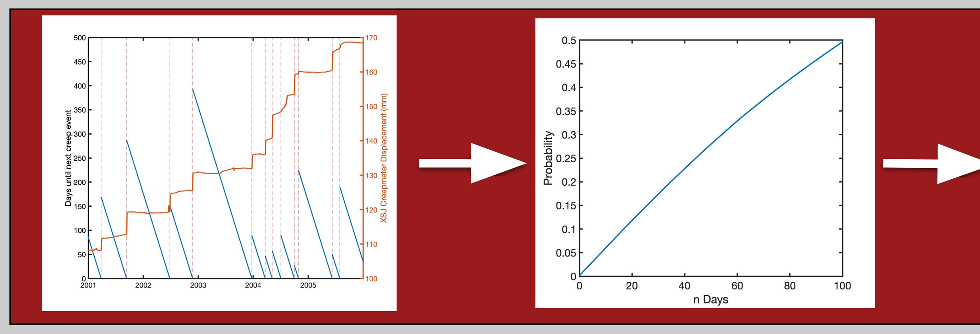


Figure 3: Creepmeter sampling rate is 10 minutes. SJT sampling rate is 18 minutes. Dashed lines indicate data gap. We use the fault parallel gage. Extension is positive.

Aside: Are the triggered creep events statistically significant?

We calculate the probability of having a creep event after any given day, within n days. This is done by:

1) Making an evenly spaced array of times on every day between the beginning and end of the XSJ creepmeter time series.
2) Calculating the time difference between each day, and the following creep event
3) Generating a CDF of all time differences (all values on blue line on left plot)



n Days	Probability
1	0.007
2	0.013
5	0.030
20	0.120

Figure 4: Note that these calculations were based on creep events spanning the entire XSJ time series (1970-2013)

Creep events within 2 days after any given day have a probability of 0.013. Therefore, they are statistically significant.

Result 3: Creep Ratio Φ Increases sharply after earthquakes

The creep ratio increased with creep events triggered by the San Simeon Earthquake, i.e., the SAF slips more in creep events after a large earthquake.

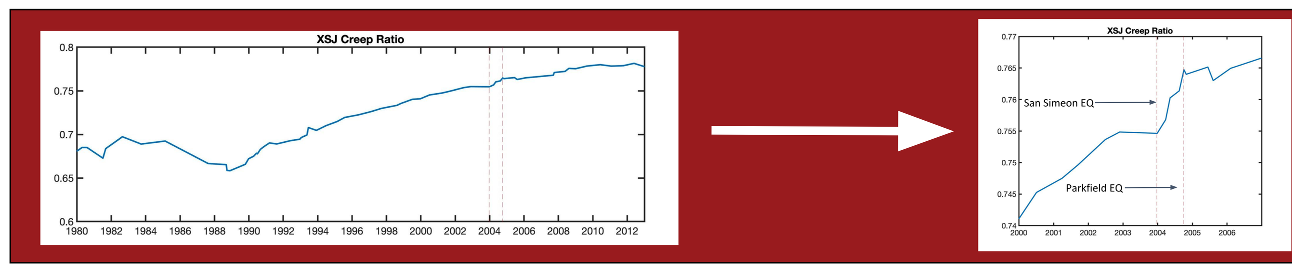


Figure 5: The creep ratio **Φ** describes the amount of displacement accommodated by creep events, normalized by total displacement (see left side of poster).

Conclusion

Delayed creep events on the northern creeping section following the Parkfield and San Simeon earthquakes may suggest a slow rupture process beneath the San Juan Bautista area that can be triggered by perturbations from a remote source. The data show interactions that couple the northern San Andreas Fault to both the southern locked section and other regional faults.

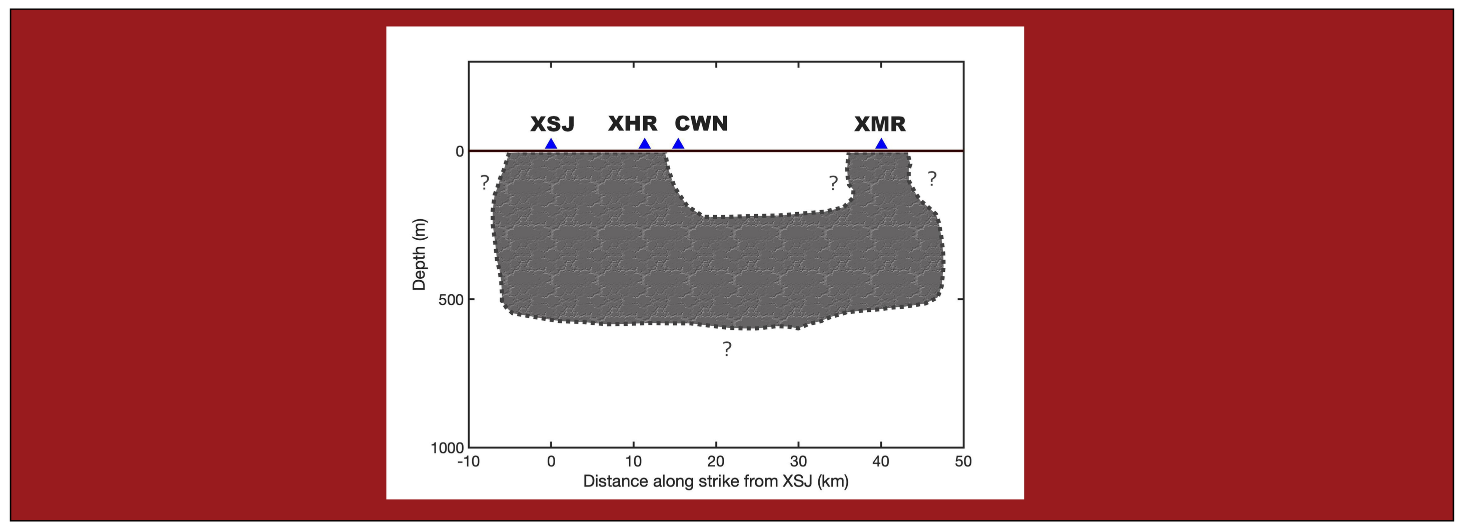


Figure 6: Slow, shallow rupture patch triggered by the 2003 San Simeon earthquake (see Figure 3). Inspired by shallow rupture patch from Gladwin et al., (1994).

References

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