Detection of 2000 large and small creep events along the San Andreas Fault

Daniel Gittins & Jessica Hawthorne
Email: daniel.gittins@earth.ox.ac.uk
Twitter: @Tees_Seis

EGU21-7452

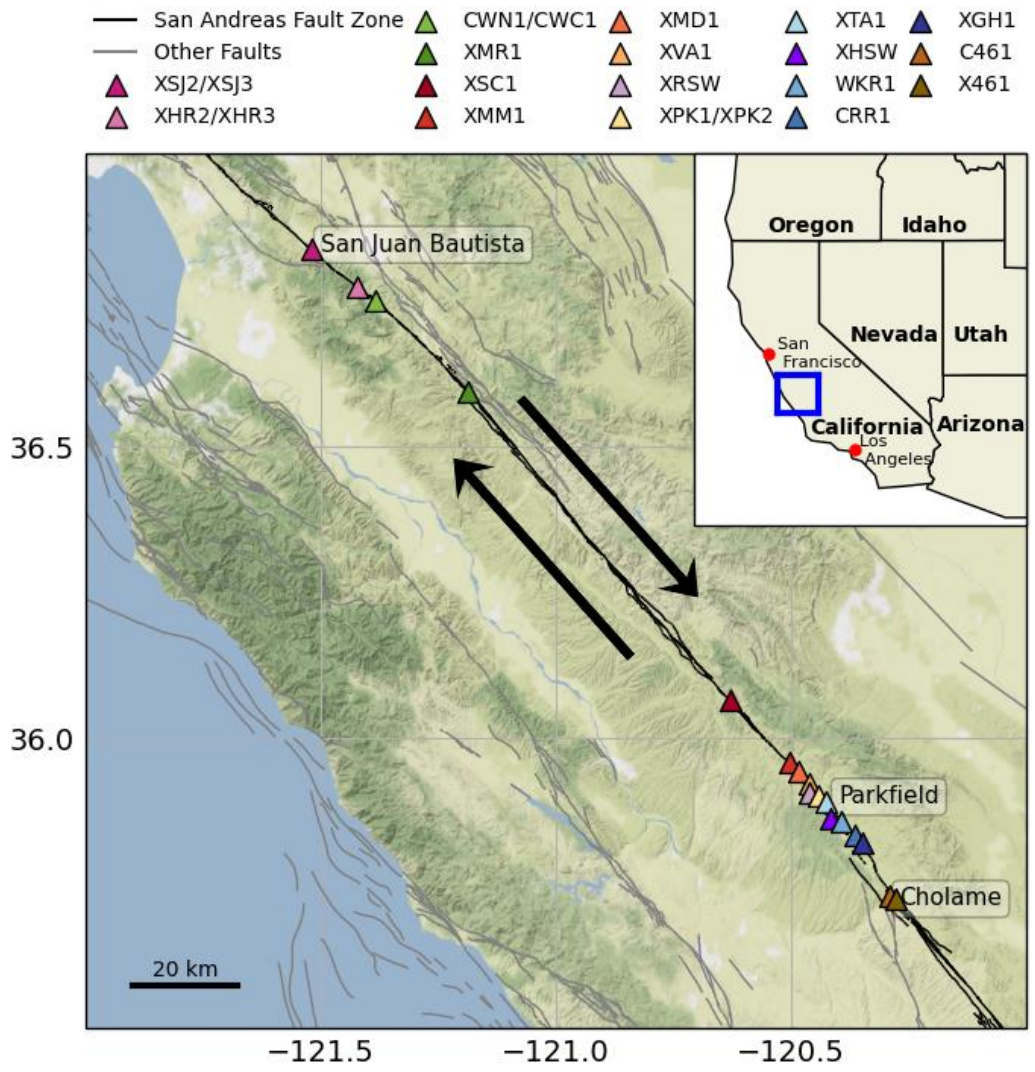
EGU General Assembly

UKRI Natural Environment Research Council

University of Oxford

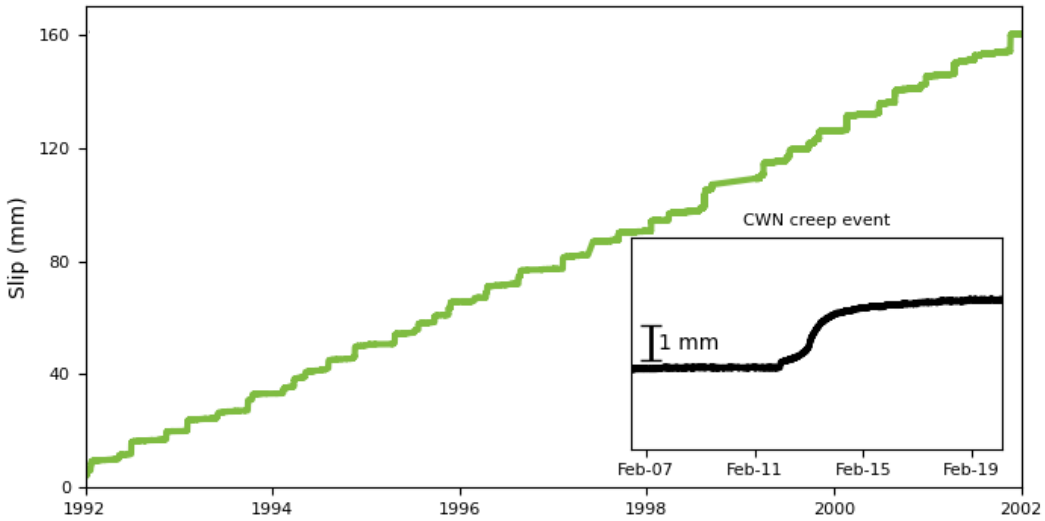
Creepmeters

- San Andreas Fault (black) is creeping along a 175 km long section between San Juan Bautista and Cholame in Central California.
- We use 18 USGS creepmeters (coloured triangles) to investigate the behaviour of the creeping section of the San Andreas Fault.
- Each creepmeter operated for at least 9 years between 1985-2020.

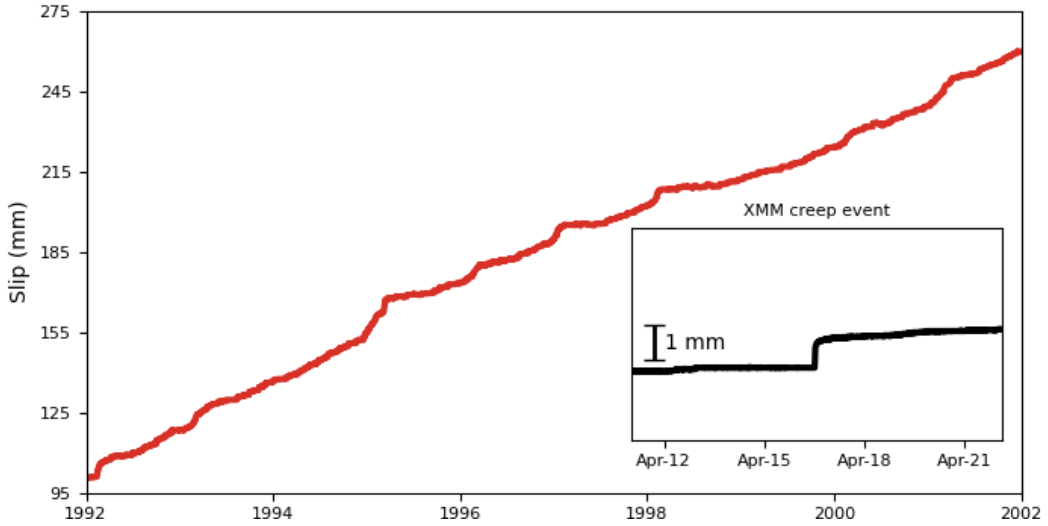


Creep events

Creep on the San Andreas Fault accumulates at both a steady background rate as well as in bursts of slip known as creep events.

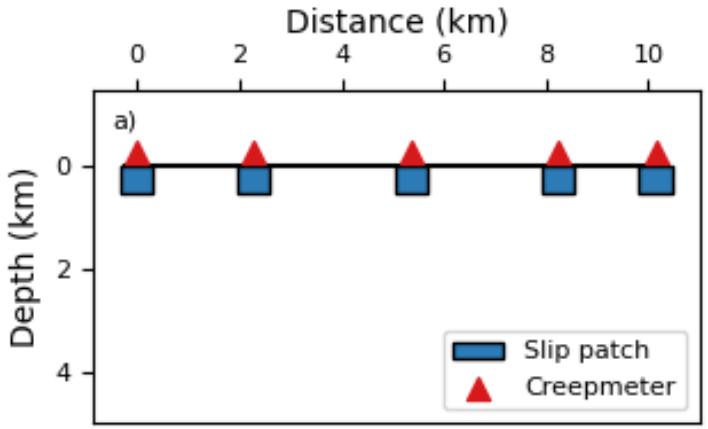


- 10-year creepmeter record from Cienega Winery. Here creep events occur every few months.

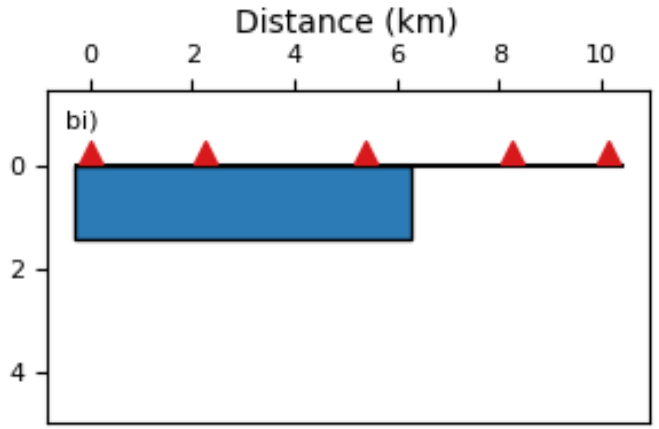


- 10-year creepmeter record from Middle Mountain. Here creep events occur every few weeks

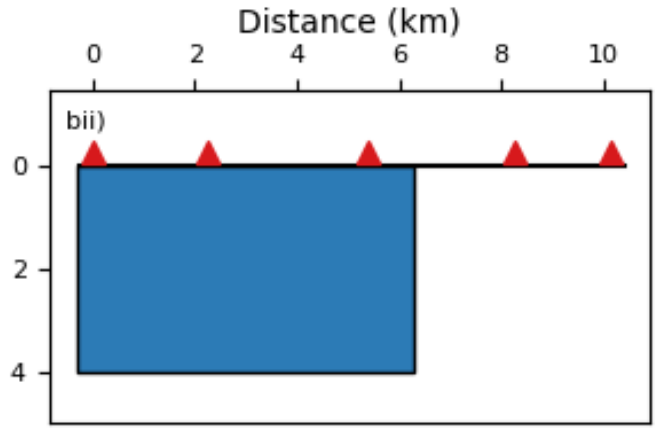
Creep event scenarios



Small, shallow events (Gladwin et al., 1994; Goulty & Gilman, 1978).



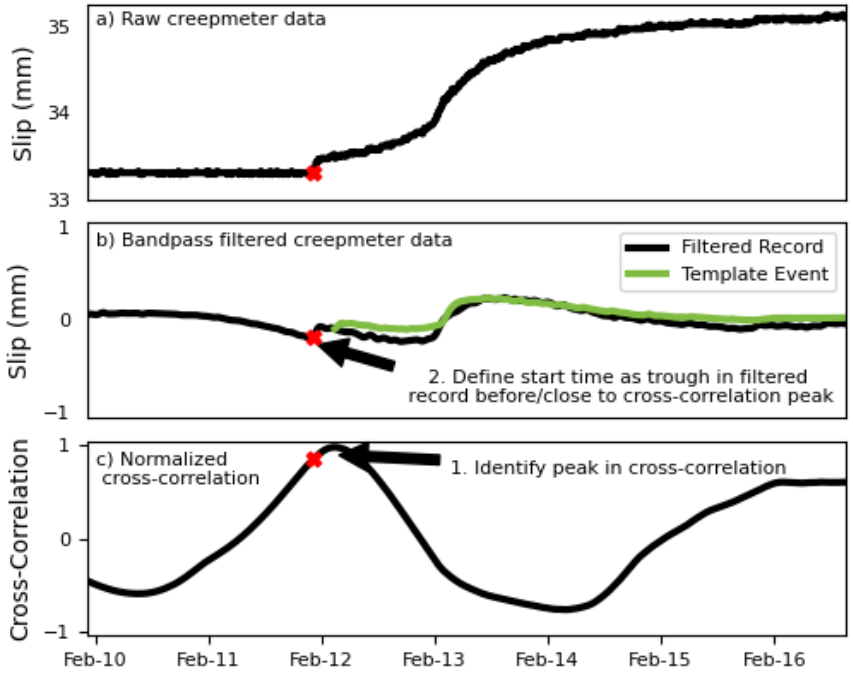
Long but shallow events (Evans et al., 1981; King et al., 1973).



Large and deep events, reaching depths of 4km and rupturing to the surface (Bilham et al., 2016).

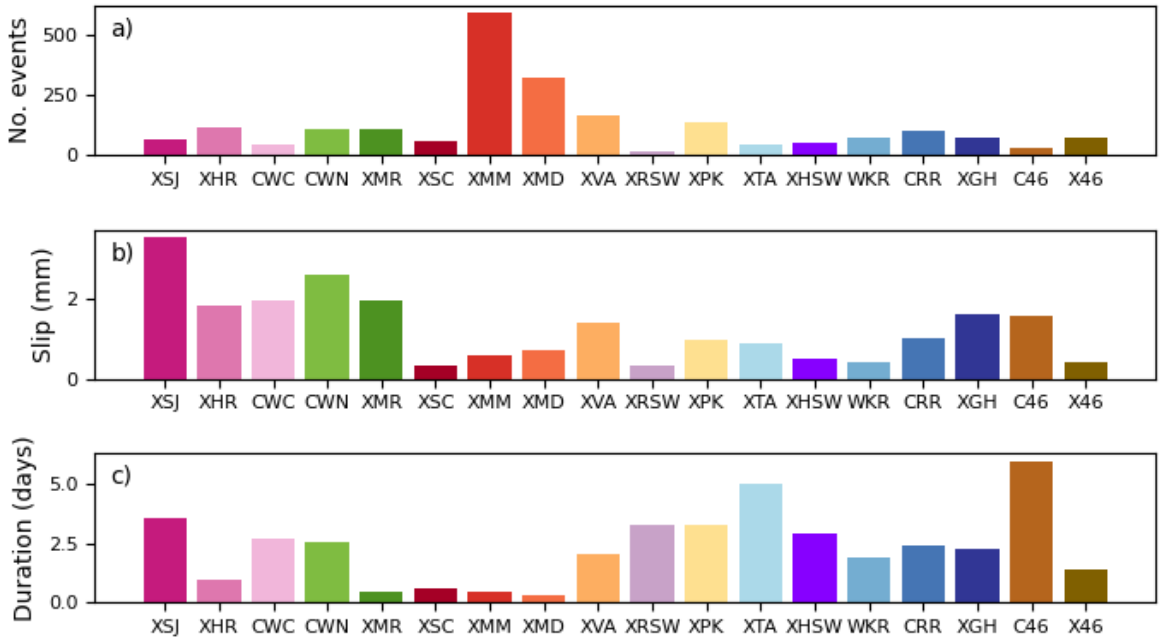
Automated detections

Methods



- We have identified creep events in creepmeter records using cross-correlation.
- Identified times of similarity to template that also have significant slip.

Results



- We identified 2120 creep events across 18 creepmeters.
- The number of creep events is anti-correlated with the amount of slip in /duration of each event.

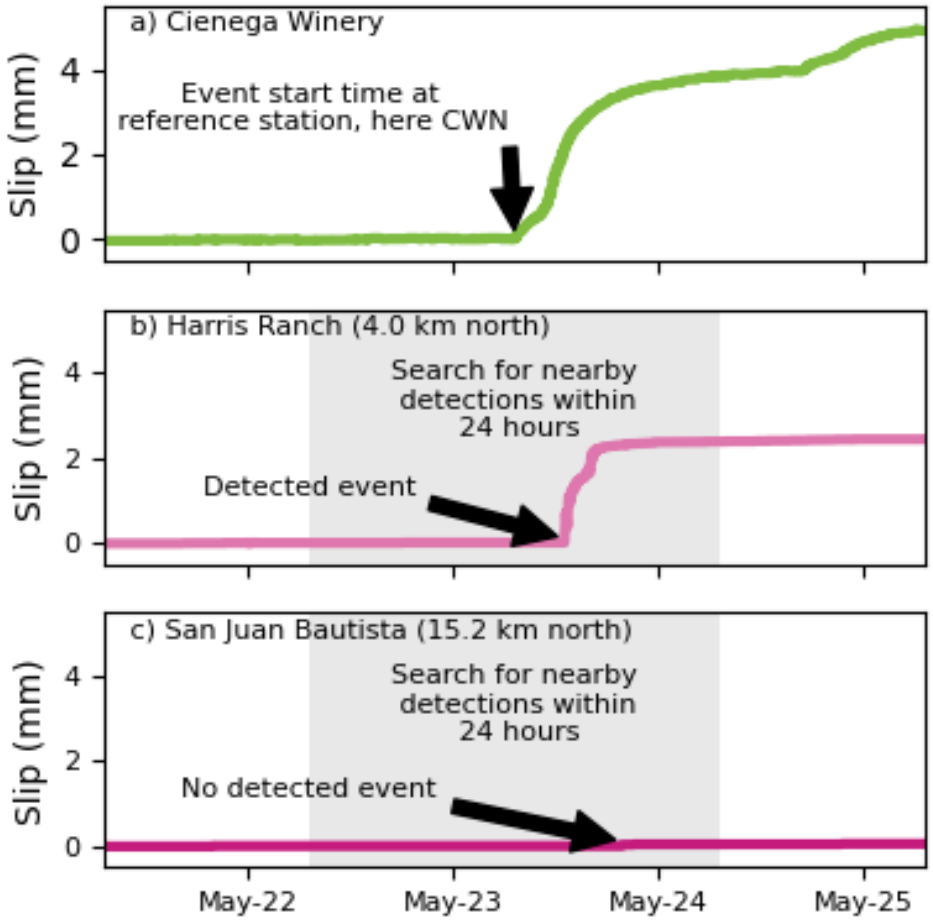
EGU General Assembly

UKRI Natural Environment Research Council

University of Oxford

Identifying correlated events between creepmeters

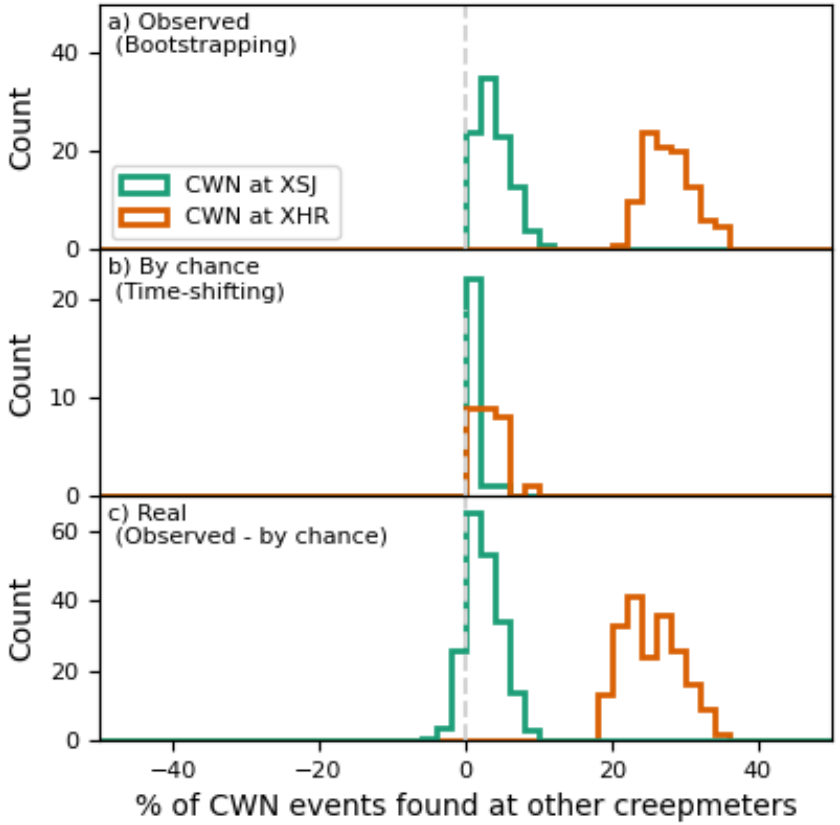
- We have identified the coincident timing of creep events leading to the detection of 306 possible larger creep events recorded at two or more creepmeters.
- Systematically search for/ and calculate percentage of events at other creepmeters within 24hrs of an event at the ‘main’ creepmeter.



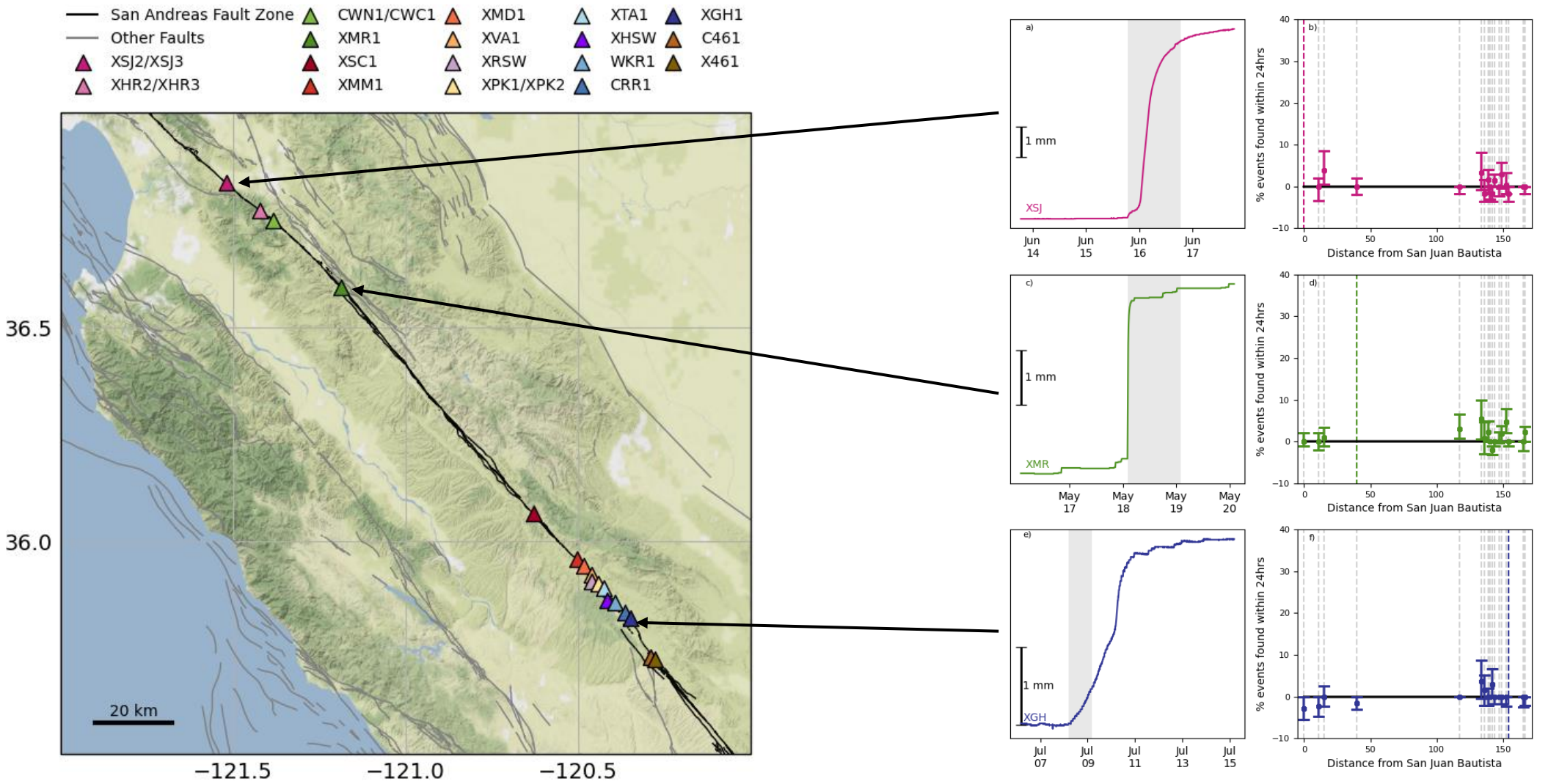
Estimating the frequency of multi-creepmeter ruptures

a) Bootstrapped to get uncertainty on the percentages of correlated events.
b) Randomly time-shifted creep events to understand if they are coincidently timed by chance.
c) Subtracted b) from a) to determine the percentage of truly connected events.

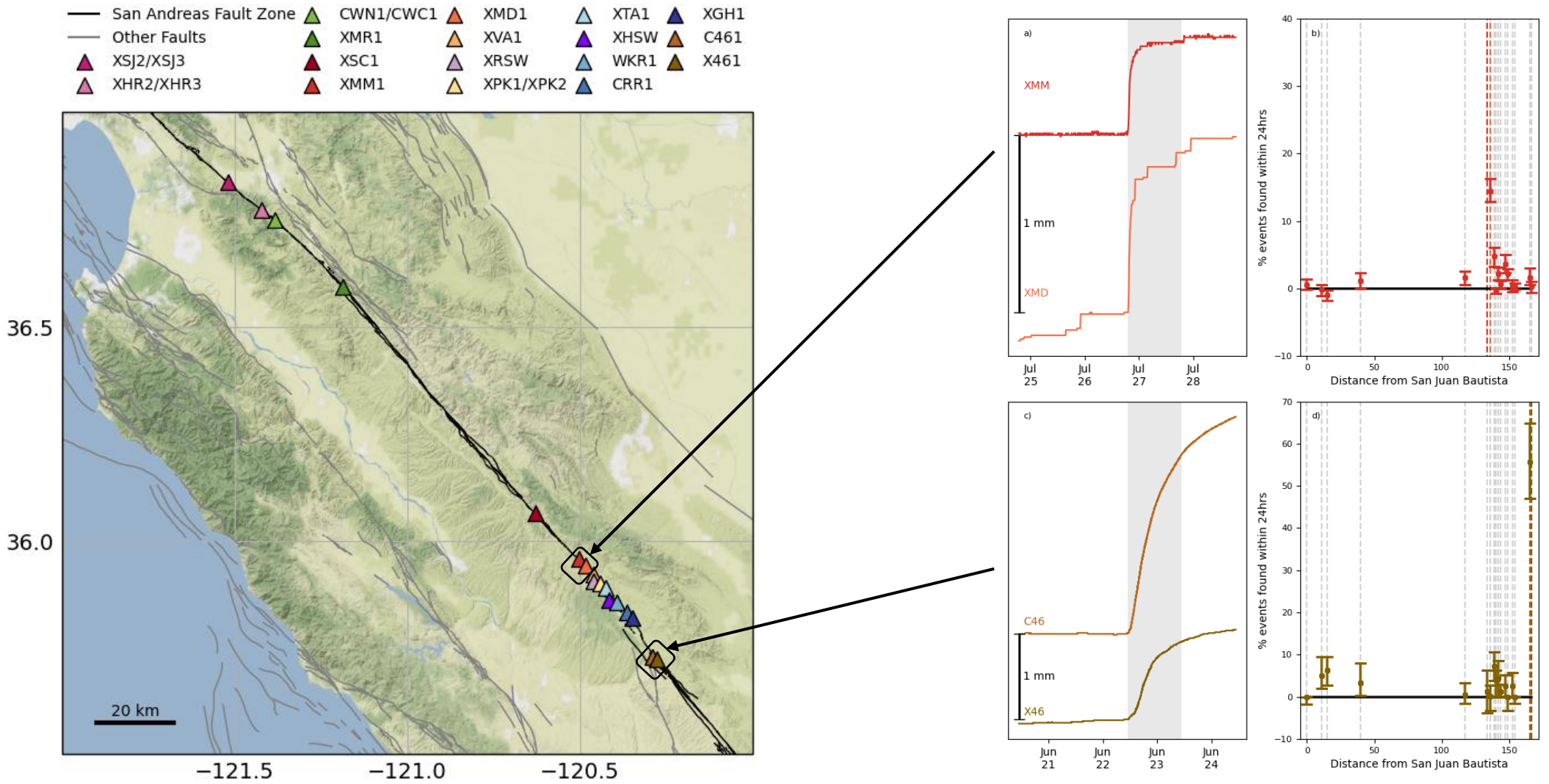
- The percentage of CWN-XSJ events is around zero so coincident events are likely to be **unrelated**.
- The percentage of CWN-XHR events is around 25, meaning that coincident events are **related**.



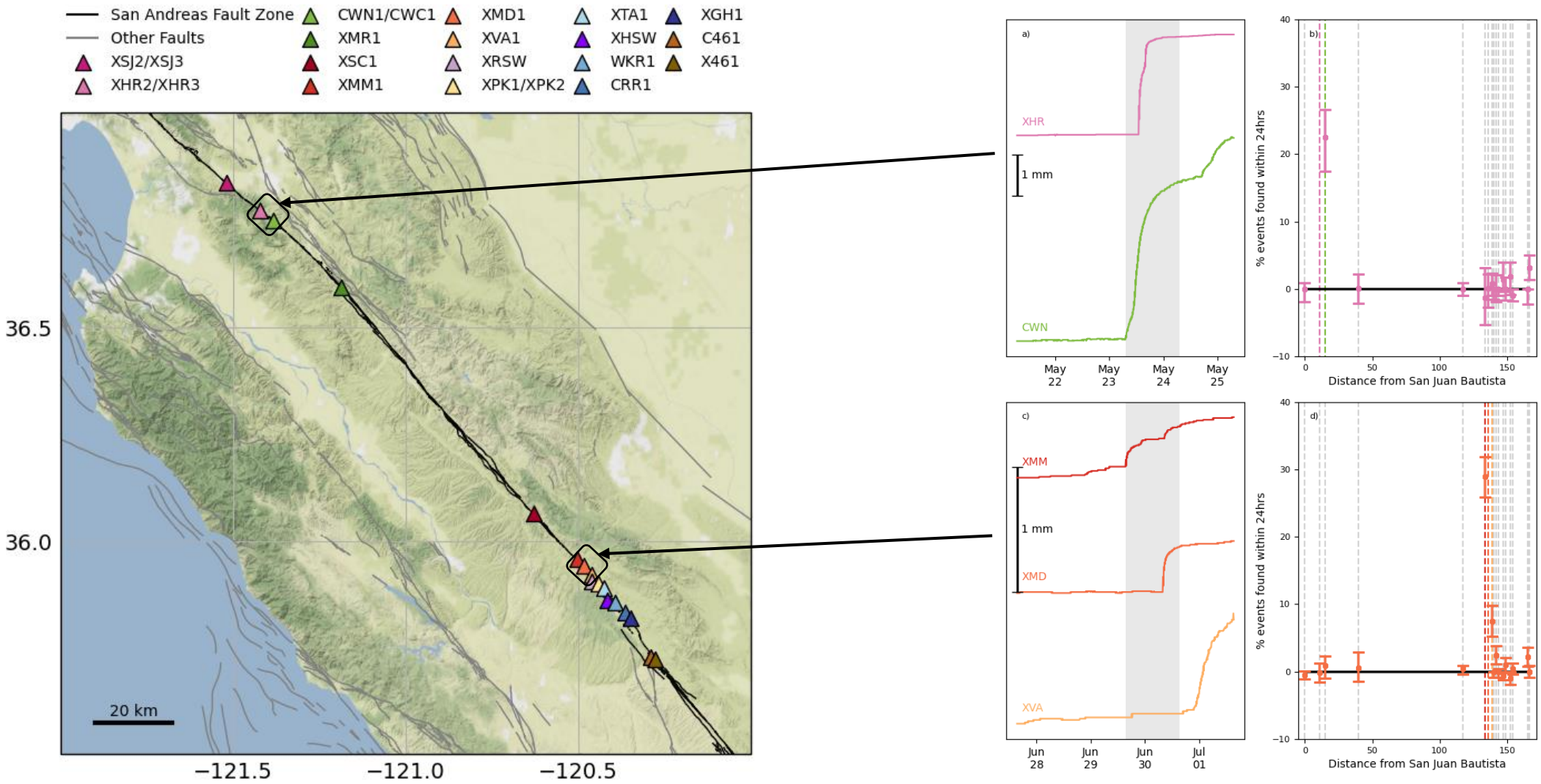
Behaviour 1: Isolated events



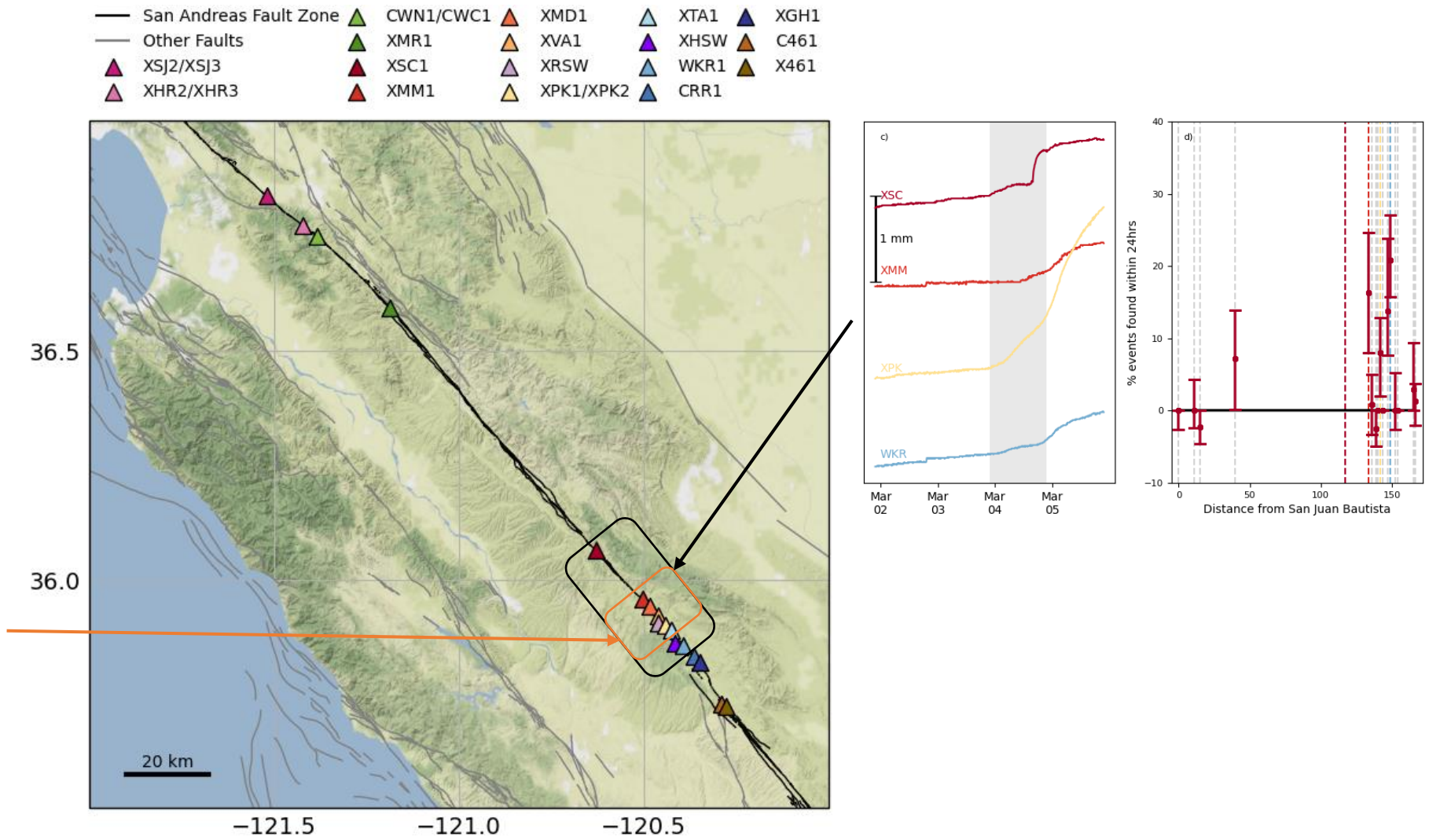
Behaviour 2: Small events (2km or less)



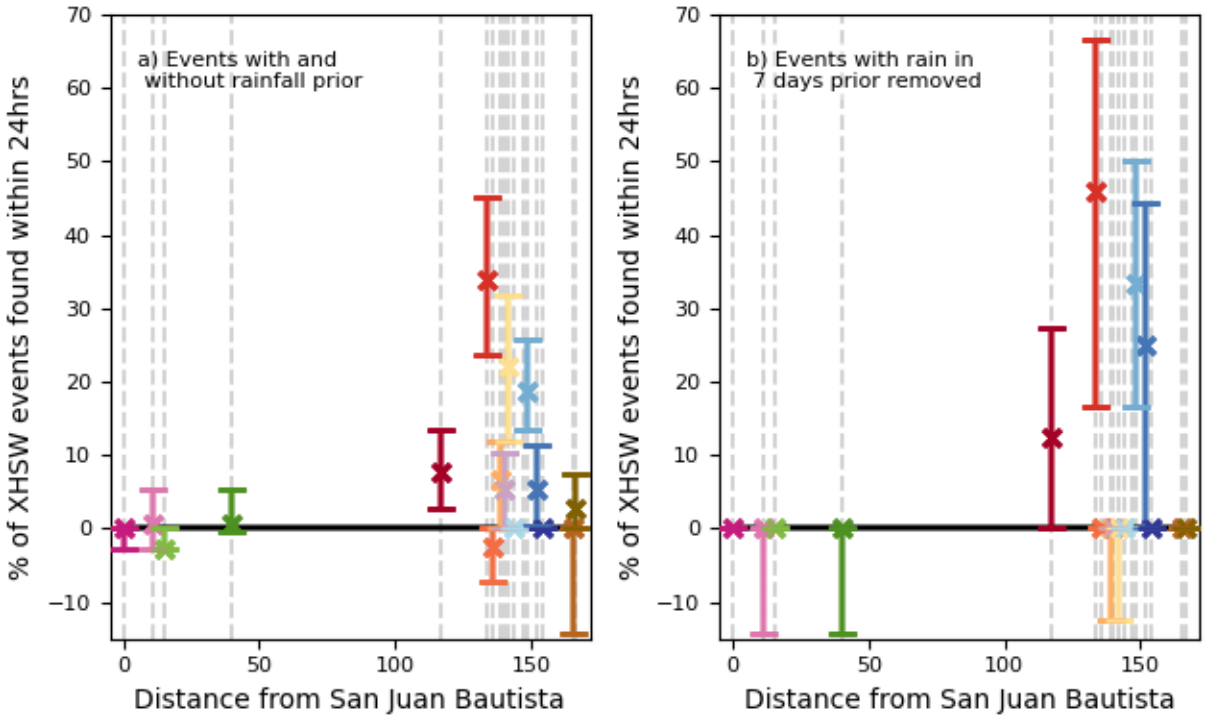
Behaviour 3: Medium-sized events (3-6 km)

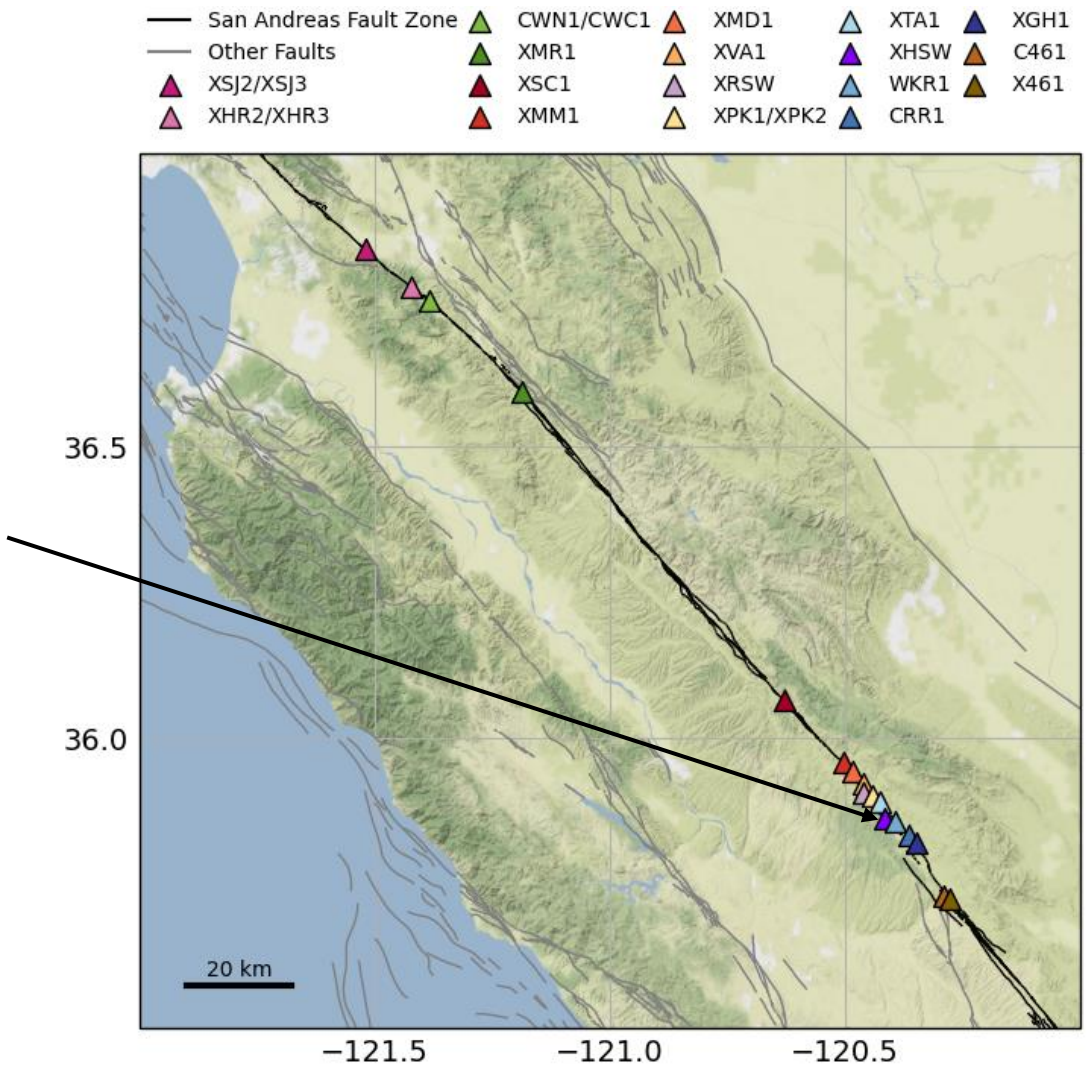


Behaviour 4: Large events (10 km or more)



Behaviour 5: Multi-strand ruptures





Removing short-term rainfall effects

- Repeat the previous analysis, removing events that have rainfall in the previous 7 of 14 days.

a) Affected by rainfall.

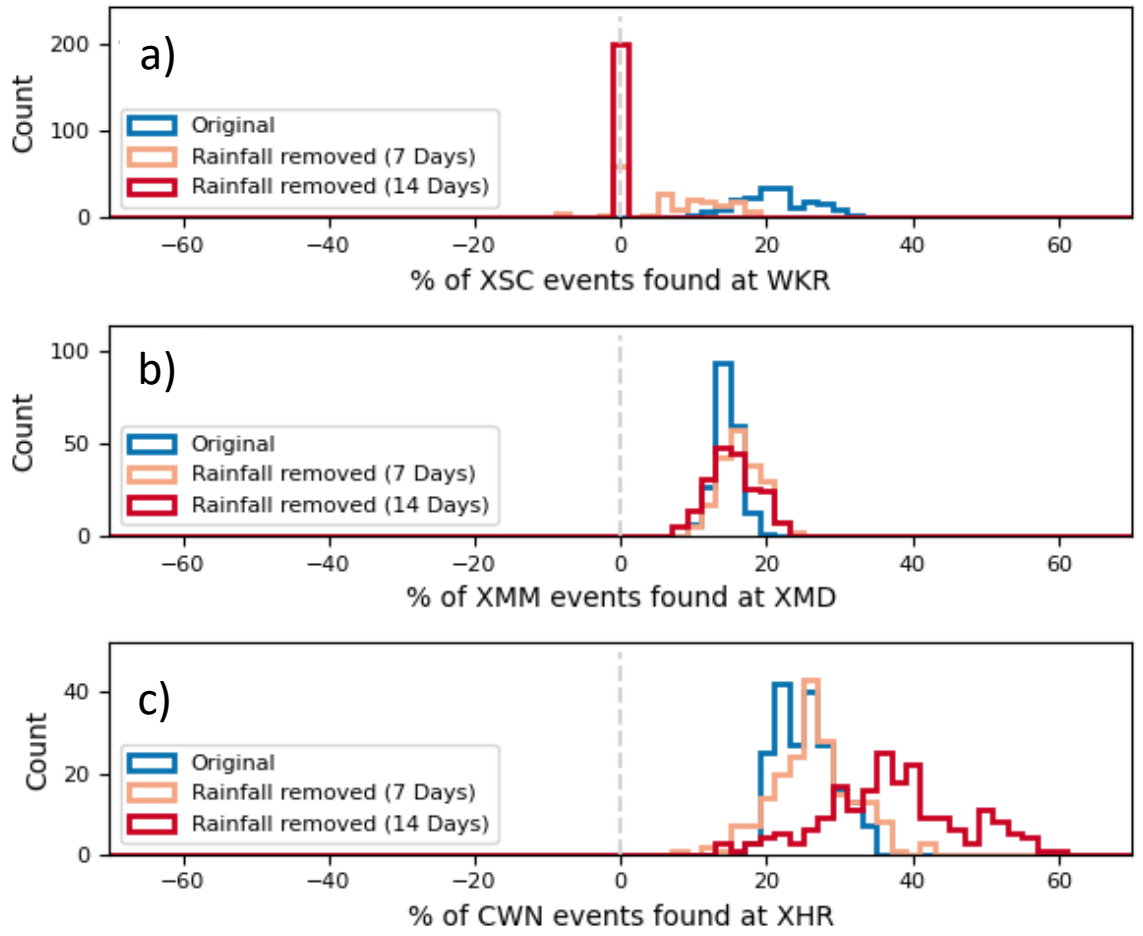
- Expect closely timed events to coincide due to rainfall rather than a larger creep event connects the creepmeters.

b) Unaffected by rainfall.

- Lack of change in closely spaced events implies that creep events respond minimally to rainfall.

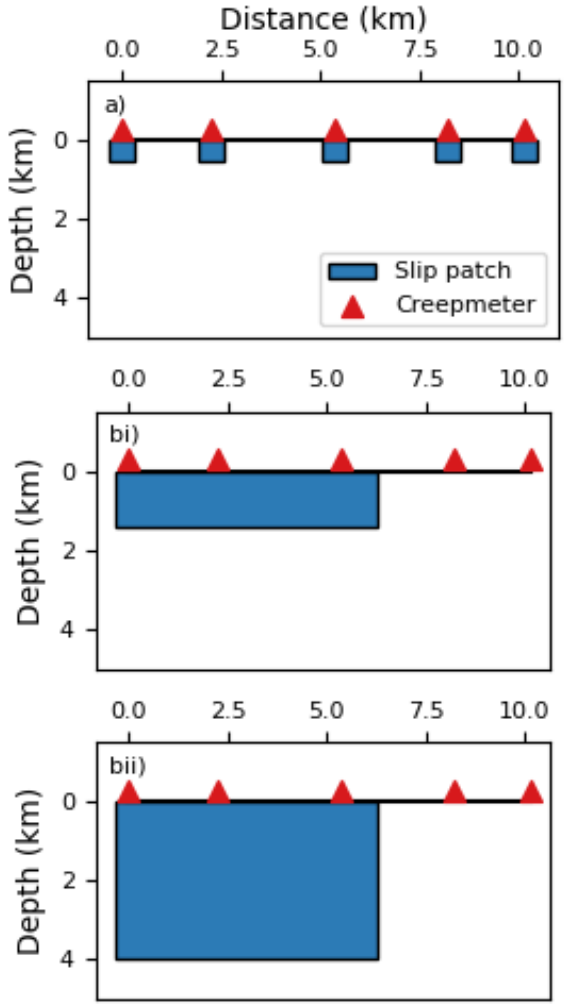
c) Percentage increase when rainfall removed.

- Small shallow events at XHR and CWN are triggered by rainfall.
- Removing rainy intervals leaving only deeper large creep events that span both creepmeters.



Discussion

- Both small and large creep events occur along the San Andreas Fault.
- We have found creep events that have along-strike lengths of 2-10 km which are not driven by rainfall (scenarios bi) & bii)).
- If these creep events are much deeper (i.e. bii)), then they **will play a much larger role in the slip dynamics of the San Andreas Fault.**



Increasing amount of slip accommodated

Summary

- We have detected 2120 creep events on the creeping section of the San Andreas Fault between 1985-2020 using cross-correlation techniques.
- We have found evidence for the coincident timing of creep events at two or more creepmeters giving rise to events of varying lengths.
- We have determined that most of the creep events we observe are unaffected by rainfall, with only our largest event losing significance when rainfall is accounted for.

Email: daniel.gittins@earth.ox.ac.uk | Twitter: @Tees_Seis