The when and where of shallow creep events: producing the first global catalog

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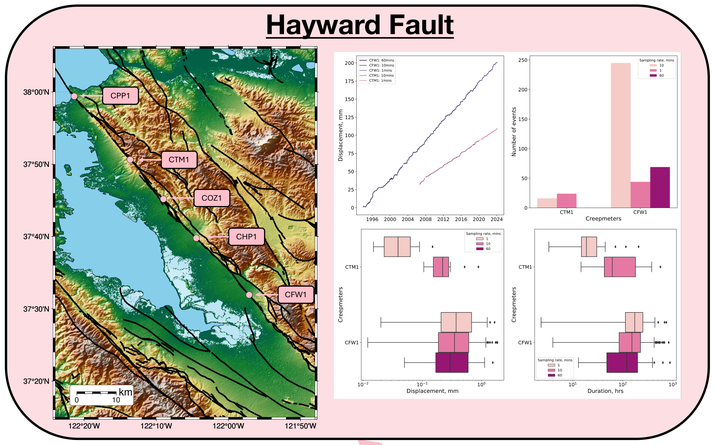
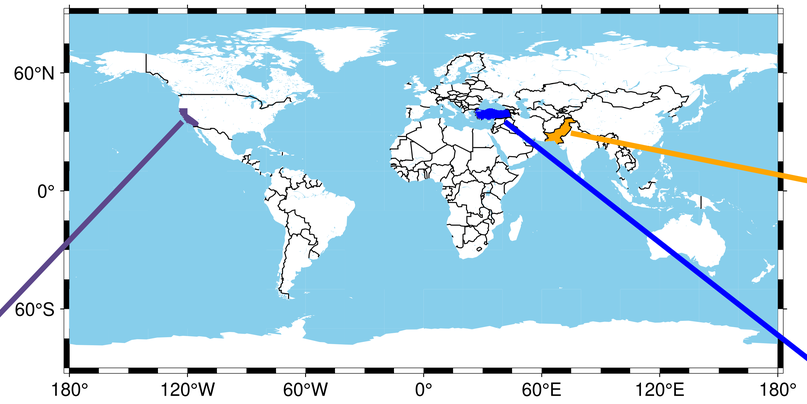
Abstract

The aseismic movement of shallow faults does not always occur as a steady process but instead can occur as a steady process interrupted by bursts of slip known as creep events. We have known about creep events for over half a century (e.g., Schulz et al., 1976; Tocher, 1960) due to creepmeters, a specialized instrument for monitoring fault creep. These creepmeters have been recording creep events in California since the 1970s (Duffield & Burford, 1973; Langbein et al., 2024; S Schulz & Burford, 1978; Schulz et al., 1976; Schulz, 1989), providing one of the longest continual geodetic time series in existence. Creepmeters have also been deployed in Turkey on the North and East Anatolian Faults and the Chaman Fault in Pakistan. However, despite having over 37 creepmeter data sets available and knowing the existence of creep events for over 50 years, we do not have a global catalog of creep events similar to those used to study earthquakes. Recent attempts to produce a catalog of creep events by Gittins & Hawthorne, 2022, have identified creep events on less than half of the creepmeters available, focusing only on those along the Creeping Section of the San Andreas Fault. Here, we present an effort to produce a global creep event catalog for the first time.

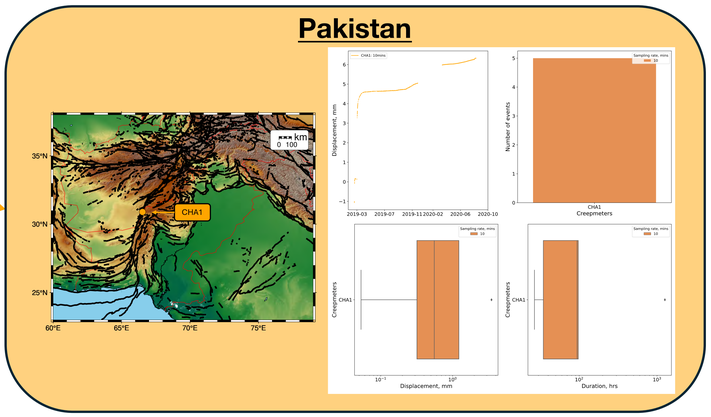
We manually picked creep events across 37 creepmeters globally and have identified over 4,500 creep sub-events (smaller events within larger creep events made up of multiple bursts of slip), producing the most comprehensive catalog of creep events to date, with more data to be processed. Further work on this catalog is ongoing. We aim to use this new catalog to perform statistics on a catalog of creep events for the first time. Examples of future analysis include determining if creep events follow a Gutenberg-Richter type distribution, identifying if there is a slip-duration scaling for creep events akin to the moment-duration scaling for earthquakes and slow slip events (e.g., Ide et al., 2007), or if creep events have a common temporal evolution related to a driving rheology. A comprehensive catalog would also allow us to compare the timing of creep events to other natural phenomena, such as local and distant earthquakes or rainfall.

Hayward Fault

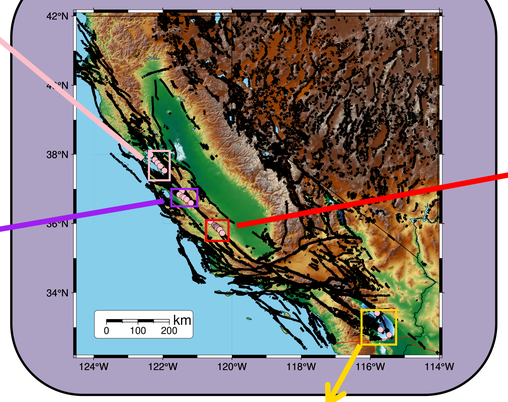




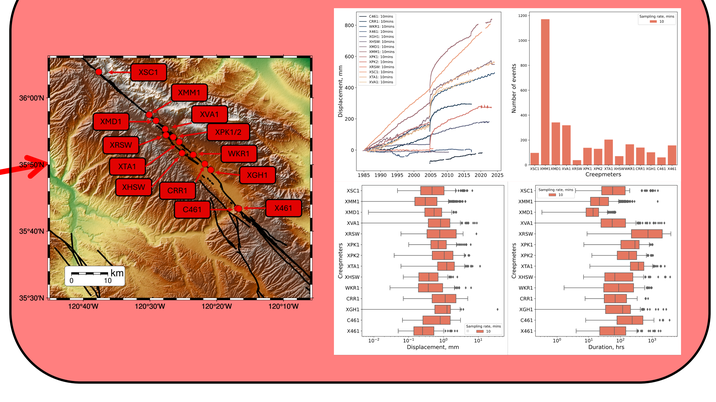
Pakistan



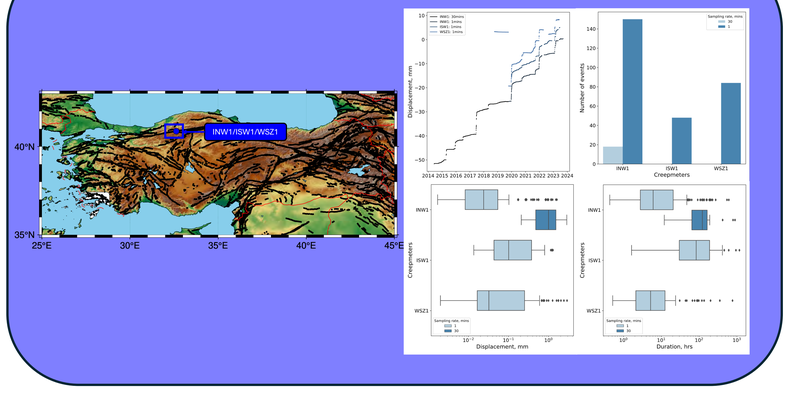
California



Parkfield

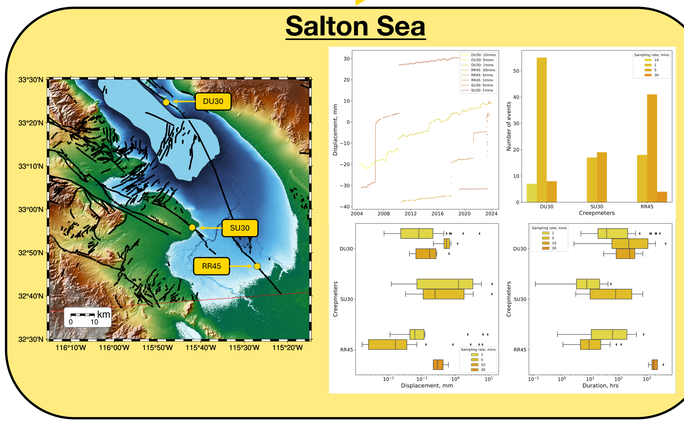


Turkey



Hollister

Salton Sea



Future Work/Questions

1. Can we produce a taxonomy of creep (sub)events based on their amplitude and duration?
2. Is there an association between creep (sub)events and rainfall, atmospheric pressure or local and teleseismic earthquakes?
3. Do creep (sub)events follow a Gutenberg-Richter distribution?
4. Does the displacement in a creep (sub)event scale with their duration?
5. Is this scaling linear so that $T \propto \delta$ or is the scaling like that of slow slip events $T \propto \delta^{\frac{1}{3}}$?
6. Do all creep (sub)events have the same temporal evolution?
7. Does the temporal evolution of creep (sub)events tell us something about the rheology of the fault driving these events?

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