10-minute slow slip subevents and atmospheric modulation: Assessing fault zone processes

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Here we assess the fault zone processes that could create slow slip by considering two features: the range of observed slip events and the response of slow slip to long-period (2 to 10-day) loading. First, we consider that slow slip events and tremor appear to form a spectrum, with durations that range from 0.2 seconds to several months and slip rates that range from about 10^{-8} to 10^{-3} m/s (Ide et al, 2007). But that spectrum has gaps, with fewer events with durations between 1 and 10 seconds and 2 and 20 minutes. Here we partially fill the second gap. We precisely map tremor in Cascadia using a phase coherence-based technique (Hawthorne and Ampuero, 2017), building off the low frequency earthquake templates identified by Bostock et al. (2012). We compare these templates with seismic data from the PNSN, Polaris, and Earthscope networks and identify local bursts of tremor that last between 1 and 20 minutes. The bursts migrate at rates of 3 to 20 m/s, with shorter tremor bursts migrating more quickly. The bursts fit in the spectrum of slow earthquakes reasonably well.

The potentially wide-ranging spectrum of slow earthquakes is intriguing because it requires a single fault zone process that acts on a wide range of length scales and which allows slip rate to depend on fault size. Two plausible processes are shear-induced dilatancy, where slip rate depends on the fault zone width, and brittle-viscous shear, where slip rate depends on the concentration of brittle asperities. To help distinguish between these processes, we examine the modulation of tremor in Cascadia due to the shear and normal stresses produced by atmospheric pressure and ocean loading. One might expect slip rate to respond only to shear stress in a viscous model, but dilatancy should also give a response to normal stress at long timescales. So far we have identified modulation of the tremor identified by Wech et al. (2007) in response to atmospheric loads, but the timing of the atmospheric loads cannot distinguish the response to shear and normal stresses. So currently we are examining the response of tremor to 2- to 10-day ocean loading.