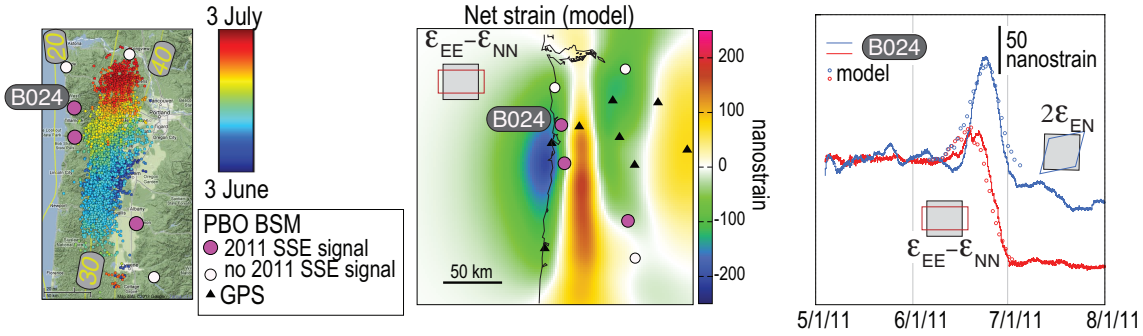
Observing Cascadia Slow Slip Events with Plate Boundary Observatory Borehole Strainmeters: The Value of Coastal Stations for Earthquake Hazard Applications

Evelyn Roeloffs, U.S. Geological Survey, Vancouver WA

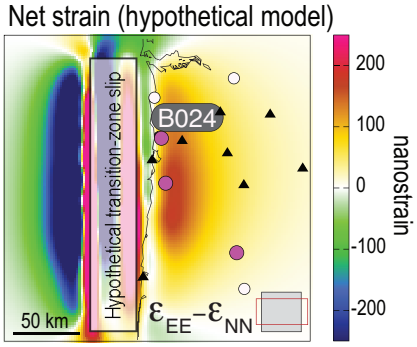
Plate Boundary Observatory (PBO) GPS and borehole strainmeter (BSM) networks have detected numerous SSEs since 2003 in the Cascadia subduction zone, which, although seismically quiet, is capable of a M9 megathrust earthquake. Here I illustrate how PBO BSMs close to the coast can identify features of SSEs with significance for earthquake hazards.

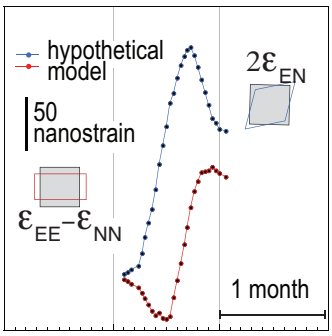
First, coastal BSMs can constrain the up-dip limit of slip during SSEs, which is plausibly related to the down-dip limit of potential seismic rupture during a future megathrust earthquake. The down-dip limit of seismic rupture strongly controls expected seismic ground motions in densely-populated areas such as Portland and Seattle.



In June-July 2011, tremor epicenters propagated 240 km along-strike in northern Oregon (pnsn.org/tremor). A forward model that matches coastal GPS offsets and the strain record at PBO BSM B024 was constructed by superimposing rectangular dislocations surrounding each day's tremor epicenters (assumed on the plate interface); each rectangle slips 2 mm RL and 4 mm thrust. This model includes no slip up-dip of the tremor zone to avoid violating the observed net negative $\varepsilon_{EE}-\varepsilon_{NN}$.

Second, BSMs along the coast have some ability to detect slip in the shallower, partially-locked transition zone that lies mostly offshore. In all conceptual models, an SSE with shallower up-dip extent is more able to destabilize a locked zone, and the SSEs before the 1944 and 1946 Nankai M8, the 1960 M9 Chile, and the 2011 M9 Tohoku earthquakes all occurred adjacent to hypocentral areas. Transition-zone slip propagating much more slowly or less coherently than known Cascadia SSEs could be undetectable with BSMs, and tremor may not be a proxy for slip under transition-zone conditions. However, the figures below illustrate that hypothetical offshore slip could produce observable strain.





For this example, the dislocations of the 2011 SSE model were moved updip to the shaded rectangle, keeping the amount of slip and time dependence the same. Strain at BSM B024 would be similar in size to that of the 2011 slip event. Net positive $\varepsilon_{EE}-\varepsilon_{NN}$ *together with coastal GPS offsets could diagnose the offshore location.*