In the past decade, scientists have recognized slower forms of fault motion, termed slow slip events. These events are found primarily in subduction zones, and occur when the plate interface slips over the course of days to years, often releasing seismic moment equivalent to a large ($M_W > 6$) earthquake [Peng and Gomberg, 2010, Schwartz and Rokosky, 2007]. These slow slip events generate surface displacements recorded by GPS networks. Slow slip events are often accompanied by non-impulsive, low-frequency seismic signals, termed non-volcanic or tectonic tremor. The phenomenon of repeating slow slip with accompanying tremor is referred to as episodic tremor and slip (ETS) [Rogers and Dragert, 2003]. The precise physical relationship between slip and tremor during ETS has not been established. Multiple hypotheses have been suggested, one of which states that tremor represents slip on small locked asperities within the ETS region driven to instability by creep on the surrounding fault. To test this hypothesis, we invert Plate Boundary Observatory (PBO) GPS data from the August 2009 ETS event in central Cascadia using the Network Inversion Filter. We obtain a history of daily solutions of both slip and slip rate on the plate interface for the duration of the event, and compare to a tremor catalog provided by Aaron Wech. The tremor locations are determined using the WECC method [Wech and Creager, 2008], and the catalog can be viewed at pnsn.org/tremor [Wech, 2010].

For this event, we find that slip is concentrated between 35 and 50 km depth, with a maximum slip of approximately 5 cm. We find a cumulative moment of $1.65 \times 10^{19}$ N-m, assuming a shear modulus of $3 \times 10^{10}$ Pa, which is equivalent to a moment magnitude of 6.8. The final slip distribution and tremor epicenters for the event correlate very well (Figure 1). This inversion fits the data very well, with fits to the static offsets shown in Figure 2 and time dependent fits for selected stations shown in Figure 3. When we examine the slip rate as a function of time, we find an excellent correlation between tremor epicenters and the instantaneous position of high fault slip-rate (Figure 4), consistent with the stated hypothesis. This correlation is especially remarkable given that tremor hypocenters and slip are obtained from completely independent data.
2. References


![Figure 1. Estimated cumulative slip on the plate interface for the August 2009 ETS event. Left panel: Slip at final epoch. Right panel: Same as left, with tremor epicenters for the time interval 08/02/2009 - 09/22/2009 plotted in black.](image-url)
Figure 2. Observed and predicted cumulative GPS displacements during the 2009 ETS event. Data and 1σ error ellipses shown in blue; model fit shown in red. Labeled stations refer to time series fits in Figure 3.
Figure 3. Time series fits to GPS data for selected stations (locations shown in Figure 2). Blue dots represent east displacements with model fit in red continuous line; Pink dots represents north displacements with model fit in green. North component offset by 1 cm for clarity.
Figure 4. Slip rate on the plate interface, averaged over two day intervals. Tremor hypocenters are plotted in black for the same two-day intervals. The plate interface mesh is shown between 10 and 60 km depth. Note that not all of the modeled days are shown.