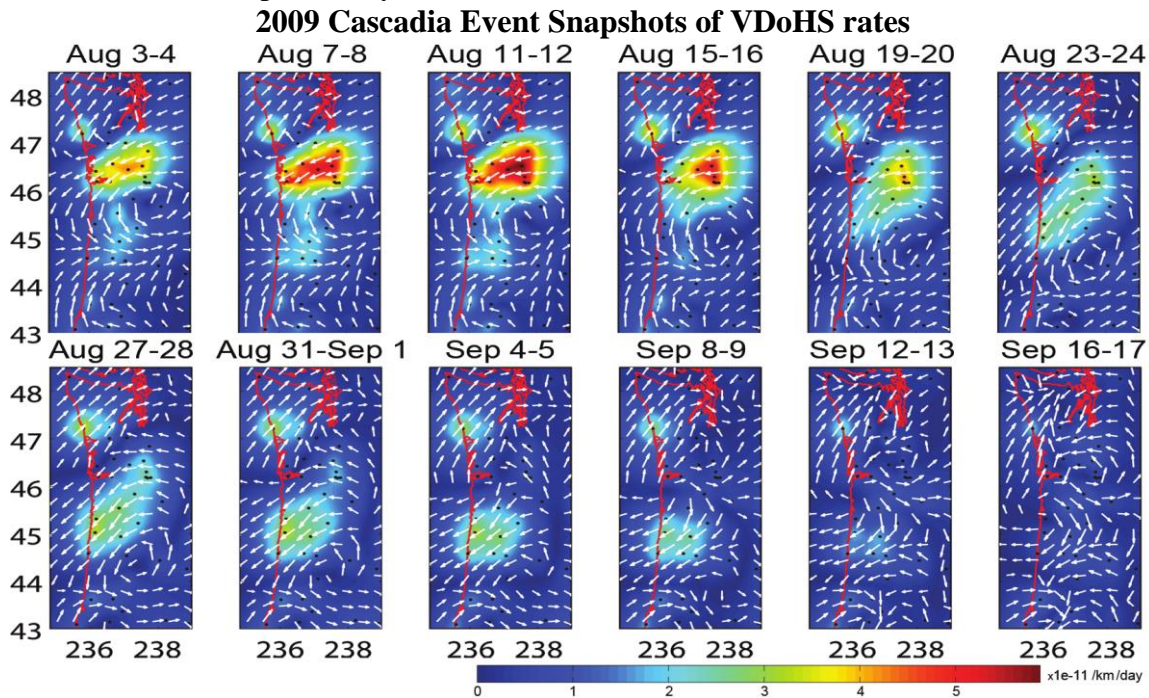


Slow slip events (SSEs) in Cascadia occur at ~30-50 km depth, every 10-19 months, and typically involve slip of a few cm, producing surface displacements on the order of a few mm up to ~1cm. There is a well-known association between tremor and SSEs; however, there are more frequent tremor episodes that are not clearly associated with geodetically detected SSEs (Wech and Creager, 2011). This motivates the question: Are there smaller SSE signals that we are currently not recognizing geodetically? Most existing methods to investigate transient deformation with continuous GPS (cGPS) data employ kinematic, smoothed approaches to fit the cGPS data, limiting SSE identification and characterization.

Recently, Haines et al (2015) showed that Vertical Derivatives of Horizontal Stress (VDoHS) rates, calculated from GPS data by solving the force balance equations at the Earth's surface, represent the most inclusive and spatially compact surface expressions of subsurface deformation sources: VDoHS rate vectors are tightly localized above the sources and point in the direction of push or pull. We adapt this approach to daily cGPS time series from Cascadia and compare our results with those from the Network Inversion Filter (NIF) for 2009 (Bartlow et al., 2011). In both NIF and VDoHS rate inversions, the main 2009 SSE pulse reaches a peak slip value and splits into northern and southern sections. However, our inversion shows that the SSE started prior to July 27-28, compared to August 6-7 from the NIF results. Furthermore, we detect a smaller (~1 mm surface displacement) event from June 29-July 7 in southern Cascadia, which had not been identified previously. We also show results from 2010 and 2011 events.



VDoHS rates also reveal the boundaries between the locked and unlocked portions of the megathrust, and we can track how this varies throughout the SSE cycle. Above the locked interface, the pull of the subducted plate generates shear tractions in the overlying plate in the direction of subduction, while above the creeping section shear tractions are in the opposite direction, which is reflected in the VDoHS rates. We show that sections of the Cascadia megathrust unlock prior to some SSEs and lock thereafter, with the locked zone propagating downdip and eastward after the SSEs over weeks to months.

Movies of the events are freely available for educational and public outreach purposes at <http://www.ig.utexas.edu/people/staff/lada/SSEs/cascadia2009.htm>