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Megathrust kinematics along the Chilean Subduction Margin constrained by GNSS displacement time series

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With over two decades of continuous GNSS monitoring of subduction zones and the gradual densification of these natural observatories, it is increasingly apparent that in-between large earthquakes, to first order, the megathrust creeps in some places while remaining stuck in others. The second order behavior consists of postseismic relaxation processes (either on the megathrust or in the mantle) and episodes of creep that are sometimes accompanied by seismic tremor. Thus, the question is: What controls the lateral differences and range in kinematic behavior on the plate interface? Various hypotheses exist over the controlling factors. For example roughness and topology of incoming plate (e.g. seamounts or fracture zones), forearc basin geology, effect of fluid lubrication on the megathrust, local thermal controls, varying deformation modes in the downgoing slab, and the critical taper theory are all candidate explanations for explaining the variation in observed kinematics. Crucial to tackling this question is our reliance on the accurately modeled relative motions of plates whereby GNSS time series are used to constrain dislocation and mantle flow. Recent advances in efficient signal separation routines, such as matrix factorization and advanced linear regression methods, mean that transient features, across a wide range of spatial and temporal scales, can be better isolated from hydrological surface loading and common-mode noise. These more detailed transient extraction routines translate into a superior spatiotemporal resolution at the plate interface after the application of appropriate kinematic modeling techniques.

In our presentation, we will show the plate interface kinematics modeled from over ten years of transient motion captured by the continuous GNSS time series in Chile. Transient motions are extracted with the Greedy Automatic Signal Decomposition routine (GrAtSiD; Bedford & Bevis 2018). We find that interseismic velocities vary considerably over space and time meaning that the assumption of a steady-state interseismic velocity is no longer appropriate. The extracted transient motions are modeled by dislocation on the subduction plate interface in a 3D spherical coordinate system spanning the length of Chile. The Green's functions are calculated using the finite elements method on a mesh and block structure that represent realistic plate interface and lithospheric geometries and elastic parameters. We see that there exist several asperities with varying sizes along the subduction margin, many of which are coincident with portions of the coseismic slip regions at recent large megathrust events (such as Maule Mw 8.8 2010, Iquique Mw 8.1 2014, Illapel Mw 8.3 2015, Melinka Mw 7.6 2016). We also describe the transient afterslip and creep episodes that occur at various locations along the Chilean Coast. Finally, we compare the kinematics to existing seismic catalogs with a view to refining the aforementioned hypotheses for kinematic differences along the margin.