Determination of coseismic frictional properties on the megathrust during the 2012 M7.6 Nicoya earthquake

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Frictional properties on seismogenic faults are critical to understand earthquake rupture physics. Most frictional data are obtained from laboratory friction experiments, and it remains difficult to conduct in-situ measurements since the areas where ruptures occur are usually unreachable. Here, we conduct numerical modeling to robustly determine the frictional properties on the megathrust where the 2012 Nicoya M7.6 earthquake occurred, based on constraints of surface displacements, velocities and kinematic source models. The finite-element domain is constructed in a cube (190*180*70 km), and the fault geometry was defined according to a seismic reflection profile (Christeson et al., 1999). The material properties are defined by a one-dimensional depth dependent velocity model (Audet and Schwartz, 2013). We derived the static stress drop of the 2012 earthquake from kinematic models and then estimated the initial stress before the earthquake using a constant dynamic friction coefficient. Effective normal stress was taken as a constant, assuming near-lithostatic pore pressure on the megathrust. In our model, we used three free parameters: C, B and S, to represent the critical slip-weakening distance, the initial stress level, and the yield strength. Then we conducted a large number of dynamic simulations to search for the best solutions for C, B, and S, using constraints from near-field surface measurements. Modeling results shows that frictional properties play a critical role in rupture propagation, final slip distribution and ground shaking, even under identical initial stress condition. These well determined frictional properties can be combined with interseismic locking models to improve the reliability of future rupture scenarios, which can be used in assessment of regional tsunami and seismic hazard.