In-situ frictional properties on seismogenic faults inferred from near-field observations and numerical simulations

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Frictional strength and slip weakening distance are crucial for earthquake generation and rupture propagation, and may significantly impact ground shaking intensities and tsunami potential during megathrust earthquakes. However, in-situ frictional properties remain elusive on natural faults. Even after earthquakes, determination of in-situ frictional properties is challenging and is mostly obtained from indirect estimation. Previous approaches are either limited by the lack of near-field observational data, or suffer from strong trade-off between strength drop and the critical slip weakening distance ($D_0$). Here we constrain the frictional parameters along the megathrust that was ruptured during the 2012 $M_w$ 7.6 Nicoya earthquake, which was well recorded by a local dense network. We conduct spontaneous rupture simulations with constraint from kinematic source models and near-field GPS records. The trade-off between strength drop and $D_0$ is removed by constraints from near-field displacements and velocities recorded by low- and high-rate GPS, respectively. Our preferred dynamic model indicates a relative low fracture energy: $0.4 \times 10^6$ J/m$^2$, with the $D_0 \sim 0.2$m and the strength drop $\sim 4.0$ MPa. The determined frictional parameters can be applied in deriving future rupture scenarios and thus serve for hazard assessment from physics-based simulations.