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A complementary approach to provide realistic long-term stress conditions for a dynamic rupture model of a megathrust earthquake

Iris van Zelst (1), Ylona van Dinther (1), Alice-Agnes Gabriel (2), Stephanie Wollherr (2), and Elizabeth H Madden (2)

(1) ETH Zürich, Institute of Geophysics, Department of Earth Sciences, Zürich, Switzerland (iris.vanzelst@erdw.ethz.ch), (2) Department of Earth and Environmental Sciences, Geophysics, LMU Munich, Munich, Germany

Our geodynamic seismic cycle (SC) model solves for earthquake cycles in a self-consistent manner with regard to the stress history, strength, and fault geometry (STM method; van Dinther et al., 2013). However, it lacks a high enough spatial and temporal resolution necessary to resolve co-seismic processes.
The high-performance computing software package SeisSol (de la Puente, 2009) uses dynamic rupture (DR) simulations that are able to solve for frictional failure at co-seismic timescales in conjunction with seismic wave propagation. However, it is hard to constrain the initial stress, strength, and geometry of the dynamic rupture models self-consistently.
Here, we couple the output of a geodynamic seismic cycle model to a dynamic rupture model to exploit the advantages of both methods and resolve one earthquake from geodynamic timescales up to co-seismic timescales. We first pick the fault geometry for a representative earthquake in a Southern Chilean setup from the continuum formulation of the SC model to provide a finite fault for the DR model based on the highest strain rate during the rupture. To couple the failure criterions of SC and DR, we need to take into account how the pore-fluid pressure in the SC model affects the frictional parameters and realistic long-term stresses that we use as input for the DR model. We demonstrate that the effective stresses differ depending on where in the equations the pore-fluid pressure enters.
The coupled reference event shows a similar rupture process in both simulations: both events rupture mainly updip and have similar stress drops. In the DR model, we see a spontaneous (i.e. not forced) nucleation at the same location as in the SC model. Besides that, the rupture stops spontaneously at the downdip end of the fault in the DR model due to the low stress in the ductile regime of the SC model. As expected, only the DR model is able to capture the complex interplay between emitted seismic waves and the free surface, and the subsequent rupture re-activation due to reflected waves. These reflections cause large stress changes that are absent in the SC model. To further investigate the source and influence of the reflections on the ensuing earthquake, we also run DR models without a free surface and without compositional layering to eliminate any impedance contrasts in the model.

References

de la Puente, Josep, J-P. Ampuero, and M. Käser. "Dynamic rupture modeling on unstructured meshes using a discontinuous Galerkin method." Journal of Geophysical Research: Solid Earth 114.B10 (2009).
Dinther, Ylona van, et al. "The seismic cycle at subduction thrusts: Insights from seismo-thermo-mechanical models." Journal of Geophysical Research: Solid Earth 118.12 (2013): 6183-6202.