AGU FALL MEETING
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S51D-13 - A Volumetric, Visco-Elastic Damage Model to Explain Transient Slow Deformation within Active Faults

Friday, 17 December 2021

15:39 - 15:42

Convention Center - eLightning Theater VI

Abstract

The development of seismological and geodetic observations over the last 20 years has led to a better understanding of the seismo-tectonic cycle on major faults associated with plate boundaries such as subduction zones. In particular, the discovery of slow earthquakes that associate transient accelerations of the relative plate slip with weak seismic radiations known as tectonic tremors poses a significant challenge to the physics of tectonic faults, which has traditionally been based on the rate-and-state (RaS) interface rheology. While many studies continue to use the RaS formalism to model the slow earthquake cycle, it remains an empirical formulation derived from friction experiments that does not offer a strong physical interpretation from which laboratory-scale experiments can be extrapolated at the temporal and spatial scales of faults. It also presents a limit to which it can be enriched to include the relevant steady-state relaxation, chemical, mineralogical and hydro-mechanical processes. In this context, we are therefore developing a new continuum, volumetric and physically-based model that aims at improving the current understanding of the seismic-aseismic, brittle-ductile transition within major faults.

The framework is based on a visco-elastic Maxwell constitutive equation, in which the elastic modulus and effective viscosity are allowed to evolve in both space and time via a coupling to the level of fracturing at the sub-grid scale, which is represented by a scalar damage variable, and to sealing processes.

We run two-dimensional simulations representing a boundary between two sliding plates, which reproduce a localized but finite-width shearing zone concentrating the deformation. This zone evolves in time and space through a competition between damaging, stress redistribution, and healing that naturally generates the spatial heterogeneity and lead to transient accelerations of the intra-plate sliding akin to observation of slow-slip events. While our model is quasi static and does not reproduce seismic waves, the evolution of the scalar damage variable can be used as a proxy of tremor source energy. With this approach, we reproduce the close association between the slow-slip events and tremors observed in many subduction zones.

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