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Complex splay fault rupture and its effect on seafloor displacements

Iris van Zelst (1), Stephanie Wollherr (2), Alice-Agnes Gabriel (2), and Ylona van Dinther (3)

(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, (3) Department of Earth Sciences, Utrecht University, Utrecht, The Netherlands

Studying splay fault activation and its effect on seafloor displacements is crucial for understanding the overall tsunamigenic potential of subduction zones. It has been suggested that splays play an important role in tsunamigenesis, because they could potentially accommodate large vertical displacements (Fukao, 1979). This is typically due to their steep angles compared to the relatively shallow dipping megathrust.

In previous models, we coupled a geodynamic seismic cycling (SC) model (Gerya & Yuen 2007; van Dinther et al. 2013a, b, 2014). to a dynamic rupture (DR) model to better constrain initial conditions of the latter, because the natural fault stresses and strengths are difficult to quantify directly (Van Zelst et al, EGU abstract, 2018). In these models, we focused on a megathrust rupture, but the SC model also reveals possible splay fault geometries in the accretionary wedge in the form of localised, high strain rates. However, according to our slip rate criterion for rupture (slip rate > $5 \cdot 10e\text{-}9$ m/s), these splay faults do not rupture in the SC model. The physically consistent stress, strength and geometry provided by the SC model can shed light on splay fault activation in subduction settings with a complicated network of splay faults. Dynamic rupture models that include off-fault plasticity already show that the splay fault geometries of the SC model can accommodate deformation in the DR model (Wollherr et al., EGU abstract, 2018). By explicitly meshing all possible splay geometries in the DR model, we further investigate whether these splays are activated by the dynamic effects of the emitted seismic waves during coseismic rupture.

We use the software package SeisSol (Dumbser & Käser 2006; de la Puente et al. 2009; Pelties et al. 2014), which allows us to study coseismic frictional failure on complex geometries in subduction zones. We systematically test different configurations allowing all or some splays to spontaneously rupture to analyse splay fault activation and its effect on the vertical seafloor uplift and the corresponding tsunami hazard. By running both models with and without off-fault plasticity, we can evaluate the effect of large-scale yielding in the accretionary wedge, in particular along the splay faults. We also quantify the effect of the location and angle of the splay faults on the seafloor displacements and discuss which splay geometries have the largest tsunamigenic potential.