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A Benchmarking setup for Coupled Earthquake Cycle - Dynamic Rupture - Tsunami Simulations

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We developed a simulation framework for coupled physics-based earthquake rupture generation with tsunami propagation and inundation on a simplified subduction zone system for the project "Advanced Simulation of Coupled Earthquake and Tsunami Events" (ASCETE, funded by the Volkswagen Foundation). Here, we present a benchmarking setup that can be used for complex rupture models.

The workflow begins with a 2D seismo-thermo-mechanical earthquake cycle model representing long term deformation along a planar, shallowly dipping subduction zone interface. Slip instabilities that approximate earthquakes arise spontaneously along the subduction zone interface in this model. The absolute stress field and material properties for a single slip event are used as initial conditions for a dynamic earthquake rupture model.The rupture simulation is performed with SeisSol, which uses an ADER discontinuous Galerkin discretization scheme with an unstructured tetrahedral mesh. The seafloor displacements resulting from this rupture are transferred to the tsunami model with a simple coastal run-up profile. An adaptive mesh discretizing the shallow water equations with a Runge-Kutta discontinuous Galerkin (RKDG) scheme subsequently allows for an accurate and efficient representation of the tsunami evolution and inundation at the coast.

This workflow allows for evaluation of how the rupture behavior affects the hydrodynamic wave propagation and coastal inundation. We present coupled results for differing earthquake scenarios. Examples include megathrust only ruptures versus ruptures with splay fault branching off the megathrust near the surface. Coupling to the tsunami simulation component is performed either dynamically (time dependent) or statically, resulting in differing tsunami wave and inundation behavior. The simplified topographical setup allows for systematic parameter studies and reproducible physical studies.