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A Coupled Earthquake-Tsunami Simulation Framework Applied to the Sumatra 2004 Event

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Large earthquakes along subduction zone interfaces have generated destructive tsunamis near Chile in 1960, Sumatra in 2004, and northeast Japan in 2011. In order to better understand these extreme events, we have developed tools for physics-based, coupled earthquake-tsunami simulations. This simulation framework is applied to the 2004 Indian Ocean M 9.1-9.3 earthquake and tsunami, a devastating event that resulted in the loss of more than 230,000 lives.

The earthquake rupture simulation is performed using an ADER discontinuous Galerkin discretization on an unstructured tetrahedral mesh with the software SeisSol. Advantages of this approach include accurate representation of complex fault and sea floor geometries and a parallelized and efficient workflow in high-performance computing environments. Accurate and efficient representation of the tsunami evolution and inundation at the coast is achieved with an adaptive mesh discretizing the shallow water equations with a second-order Runge-Kutta discontinuous Galerkin (RKDG) scheme.

With the application of the framework to this historic event, we aim to better understand the involved mechanisms between the dynamic earthquake within the earth's crust, the resulting tsunami wave within the ocean, and the final coastal inundation process. Earthquake model results are constrained by GPS surface displacements and tsunami model results are compared with buoy and inundation data.

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