Geophysical Research Abstracts
Vol. 20, EGU2018-15363, 2018
EGU General Assembly 2018

Extreme scale multi-physics simulations of the tsunamigenic 2004 Sumatra megathrust earthquake

Alice-Agnes Gabriel (1), Thomas Ulrich (1), Betsy Madden (1), Stephanie Wollherr (1), Carsten Uphoff (2), Sebastian Rettenberger (2), and Michael Bader (2)

(1) Department of Earth and Environmental Sciences, LMU Munich, Germany (gabriel@geophysik.uni-muenchen.de), (2) Institut für Informatik, Technische Universität München, Garching, Germany,

SeisSol (www.seissol.org) is an open-source software package based on an arbitrary high-order derivative Discontinuous Galerkin method (ADER-DG). It solves spontaneous dynamic rupture propagation on pre-existing fault interfaces according to non-linear friction laws, coupled to seismic wave propagation with high-order accuracy in space and time (minimal dispersion errors). SeisSol exploits unstructured meshes to account for complex geometries, e.g. high resolution topography and bathymetry, 3D subsurface structure, and fault networks.

We present the up-to-date largest (1500 km of faults) and longest (500 s) dynamic rupture simulation modeling the 2004 Sumatra-Andaman earthquake. We demonstrate the need for end-to-end-optimization and petascale performance of scientific software to realize realistic simulations on the extreme scales of subduction zone earthquakes: Considering the full complexity of subduction zone geometries leads inevitably to huge differences in element sizes. In particular, the dynamic rupture calculations pose, despite the low contribution to the overall computational load, a major bottleneck for realistic earthquake geometries. Earthquake scenarios consisting of up to 221 million elements and 111 billion degrees of freedom are here enabled by a cache-aware wave propagation scheme and optimizations of the dynamic rupture kernels using code generation. In addition, a novel clustered local-time-stepping scheme for dynamic rupture has been established. Finally, asynchronous output has been implemented to overlap I/O and compute time. Detailed scaling tests reveal a speed-up 13.6 compared to the previous implementation and a speed-up of 6.8 compared to an optimized global time stepping implementation.

We resolve the frictional sliding process on the curved mega-thrust and a system of splay faults, as well as the seismic wave field and seafloor displacement with frequency content up to 2.2 Hz. The model includes high-resolution bathymetry and 3D layered subsurface. We validate the scenario by geodetic, seismological and tsunami observations. The resulting rupture dynamics shed new light on the activation and importance of splay faults and serves as time-dependent sea-floor initial conditions to study tsunami generation and propagation.