Geophysical Research Abstracts
Vol. 19, EGU2017-14062, 2017
EGU General Assembly 2017

Dynamic rupture scenarios from Sumatra to Iceland - High-resolution earthquake source physics on natural fault systems

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Capturing the observed complexity of earthquake sources in dynamic rupture simulations may require: non-linear fault friction, thermal and fluid effects, heterogeneous fault stress and fault strength initial conditions, fault curvature and roughness, on- and off-fault non-elastic failure. All of these factors have been independently shown to alter dynamic rupture behavior and thus possibly influence the degree of realism attainable via simulated ground motions.

In this presentation we will show examples of high-resolution earthquake scenarios, e.g. based on the 2004 Sumatra-Andaman Earthquake, the 1994 Northridge earthquake and a potential rupture of the Husavik-Flatey fault system in Northern Iceland. The simulations combine a multitude of representations of source complexity at the necessary spatio-temporal resolution enabled by excellent scalability on modern HPC systems. Such simulations allow an analysis of the dominant factors impacting earthquake source physics and ground motions given distinct tectonic settings or distinct focuses of seismic hazard assessment. Across all simulations, we find that fault geometry concurrently with the regional background stress state provide a first order influence on source dynamics and the emanated seismic wave field.

The dynamic rupture models are performed with SeisSol, a software package based on an ADER-Discontinuous Galerkin scheme for solving the spontaneous dynamic earthquake rupture problem with high-order accuracy in space and time. Use of unstructured tetrahedral meshes allows for a realistic representation of the non-planar fault geometry, subsurface structure and bathymetry.

The results presented highlight the fact that modern numerical methods are essential to further our understanding of earthquake source physics and complement both physic-based ground motion research and empirical approaches in seismic hazard analysis.