Geophysical Research Abstracts
Vol. 17, EGU2015-11726, 2015
EGU General Assembly 2015

Dynamic rupture simulations on complex fault zone structures with off-fault plasticity using the ADER-DG method

Stephanie Wollherr, Alice-Agnes Gabriel, and Heiner Igel
Department of Earth and Environmental Sciences, Ludwig-Maximilians-Universität, Munich, Germany
(wollherr@geophysik.uni-muenchen.de)

In dynamic rupture models, high stress concentrations at rupture fronts have to to be accommodated by off-fault inelastic processes such as plastic deformation. As presented in (Roten et al., 2014), incorporating plastic yielding can significantly reduce earlier predictions of ground motions in the Los Angeles Basin. Further, an inelastic response of materials surrounding a fault potentially has a strong impact on surface displacement and is therefore a key aspect in understanding the triggering of tsunamis through floor uplifting.

We present an implementation of off-fault-plasticity and its verification for the software package SeisSol, an arbitrary high-order derivative discontinuous Galerkin (ADER-DG) method. The software recently reached multi-petaflop/s performance on some of the largest supercomputers worldwide and was a Gordon Bell prize finalist application in 2014 (Heinecke et al., 2014). For the nonelastic calculations we impose a Drucker-Prager yield criterion in shear stress with a viscous regularization following (Andrews, 2005). It permits the smooth relaxation of high stress concentrations induced in the dynamic rupture process. We verify the implementation by comparison to the SCEC/USGS Spontaneous Rupture Code Verification Benchmarks. The results of test problem TPV13 with a 60-degree dipping normal fault show that SeisSol is in good accordance with other codes. Additionally we aim to explore the numerical characteristics of the off-fault plasticity implementation by performing convergence tests for the 2D code.

The ADER-DG method is especially suited for complex geometries by using unstructured tetrahedral meshes. Local adaptation of the mesh resolution enables a fine sampling of the cohesive zone on the fault while simultaneously satisfying the dispersion requirements of wave propagation away from the fault. In this context we will investigate the influence of off-fault-plasticity on geometrically complex fault zone structures like subduction zones or branched faults. Studying the interplay of stress conditions and angle dependence of neighbouring branches including inelastic material behaviour and its effects on rupture jumps and seismic activation helps to advance our understanding of earthquake source processes.

An application is the simulation of a real large-scale subduction zone scenario including plasticity to validate the coupling of our dynamic rupture calculations to a tsunami model in the framework of the ASCETE project (http://www.ascete.de/).

Andrews, D. J. (2005): Rupture dynamics with energy loss outside the slip zone, J. Geophys. Res., 110, B01307.

Heinecke, A. (2014), A. Breuer, S. Rettenberger, M. Bader, A.-A. Gabriel, C. Pelties, A. Bode, W. Barth, K. Vaidyanathan, M. Smelyanskiy and P. Dubey: Petascale High Order Dynamic Rupture Earthquake Simulations on Heterogeneous Supercomputers. In Supercomputing 2014, The International Conference for High Performance Computing, Networking, Storage and Analysis. IEEE, New Orleans, LA, USA, November 2014.

Roten, D. (2014), K. B. Olsen, S.M. Day, Y. Cui, and D. Fäh: Expected seismic shaking in Los Angeles reduced by San Andreas fault zone plasticity, Geophys. Res. Lett., 41, 2769–2777.