A Support-Operator Method for Dynamic Earthquake Rupture Simulation

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We present a numerical method to simulate spontaneous shear crack propagation within a heterogeneous, three-dimensional, viscoelastic medium. The implementation is highly scalable, enabling large scale, multi-processors calculations. Wave motions are computed on a logically rectangular hexahedral mesh, using the generalized finite difference method of Support Operators. This approach enables the modeling on non-planar boundaries, as well as non-planar ruptures. Computations are second-order in space and time. Stiffness and viscous hourglass corrections are employed to suppress zero-energy grid oscillation modes. Model boundaries may be reflective or absorbing, where absorbing boundaries are handled using the method of perfectly matched layers (PML).

Three well-known test problems are used to verify and validate various aspects of the numerical method: wave propagation in a layered medium; surface amplification due to a semi-cylindrical canyon; and spontaneous rupture of a rectangular fault. Tests are repeated with varying levels of simple shear deformation of the mesh. We find that the simulations retain adequate accuracy even for severely sheared meshes. These results indicate that applications to modeling thrust faults with highly sheared, yet logically rectangular meshes will be possible.