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American Geophysical Union Fall Meeting, San Francisco, California, USA, 11-15 Dicembre 2006
Vilotte J., Festa G., Ampuero J.
Abstract

Numerical simulation of rupture dynamics and wave radiation is of major importance in seismology to bridge the gap between earthquake source physics and observations, as well as to guide seismic hazard analysis. The dynamics of earthquake rupture is mainly control by the energy dissipation within the fault zone, often described in terms of an effective friction and the fault geometry. Numerical simulations must resolve the different space and time scales involved in the rupture nucleation, the rupture front propagation and short waves radiation, and the rupture termination together with taking into account complexity in fault geometry, material properties and initial conditions. This is clearly a challenging task. Lately Spectral Element Method (SEM) has become a reference method for seismic wave propagation in complex heterogeneous geological media. SEM is based on a high-order variational formulation of the elastodynamics equations in space. The method combines the geometrical flexibility of Finite Element Methods and the precision of spectral methods, and has been shown to model very accurately surface and body waves propagation in heterogeneous media at both regional and global scales. Combined with explicit time stepping, the SEM approximation leads to a very efficient matrix-free method that can be easily parallelized on large distributed memory architectures. Extensions of the Spectral Element Method to handle non-smooth rupture dynamics and non regular friction laws with the context of earthquake rupturing will be discussed here. The accuracy of the non-smooth SEM is analyzed through different canonical examples of planar and non planar rupture propagation. Capabilities of non smooth Spectral Element Methods will be illustrated by recent numerical results on the sub-to-supershear transition of earthquake dynamic rupture and high-frequency wave radiations induced by complex fault geometries. Finally, we shall discuss some challenging issues in the numerical simulation of rupture dynamics and dynamic fault-zone dissipation.