Geophysical Research Abstracts
Vol. 21, EGU2019-15214-1, 2019
EGU General Assembly 2019

Dynamic rupture and ground motion modeling of the 2016 Mw 6.2 Amatrice, Italy, earthquake constrained by Bayesian dynamic finite-fault inversion

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Seismic hazard assessment for specific regions is required to anticipate ground motions due to a future earthquake. Concurrently, proper understanding of geophysical processes controlling earthquake rupture propagation is a key point in earthquake hazard mitigation. We here explore data-driven progress in earthquake source physics and physics-based seismic hazard assessment.

The 2016 Mw 6.2 Amatrice event caused about 300 casualties and was recorded by a uniquely dense network of seismic stations. Our starting point is a novel Bayesian dynamic source inversion procedure, which directly infers the fault friction parameters and stress conditions that controlled the 2016 Amatrice earthquake rupture (Gallovic et al., EGU 2018). Assuming a planar dipping fault, near-field accelerometric data are fitted combining prior information on the nucleation area with a starting model based on a purely kinematic slip inversion. The posterior probability density function is sampled using Parallel Tempering Monte Carlo algorithm.

We extend the preferred dynamic source inversion result assuming different representations of realistic earthquake source and strong motion complexities, such as non-planar fault geometry, modern friction laws and topography. For instance, the Amatrice fault may be characterized by a listric geometry as inferred from InSAR data and high-precision seismicity relocation(e.g., Tung and Masterlark, 2018; Falcucci et al., 2018), which cannot be accounted for in the highly efficient dynamic source inversion approach. Here we utilize the SeisSol software package (www.seissol.org), which is based on the discontinuous Galerkin method on unstructured tetrahedral meshes. SeisSol incorporates many aspects of realistic source physics, as e.g. geometrically complex fault setups, fault roughness, various modern friction laws and off-fault plasticity, in the framework of efficient HPC computation.

The complex dynamic rupture models have to be modified from the planar inversion model to ensure waveform and earthquake characteristics. We investigate the impact of realistic dynamic rupture modeling ingredients on the inferred dynamic parameters as well as on the observed waveforms. The required adjustments will shed light on the relevance and dominance of dynamic source parameters for capturing the effects of, e.g., non-planar fault geometries. Maps of the most commonly used ground motion attributes to express intensity and damage potential such as peak ground velocity (PGV) and spectral acceleration (SA) of the synthetic seismograms are compared to quantify the effects.