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Reducing non-uniqueness in finite source inversion using rotational ground motions

Moritz Bernauer (1), Andreas Fichtner (2), and Heiner Igel (1)
(1) LMU Munich, Germany (moritz.bernauer@geophysik.uni-muenchen.de), (2) ETH Zurich, Switzerland

In a synthetic source inversion experiment, we succeeded to substantially reduce the non-uniqueness in kinematic finite fault rupture models by inverting strong translational and rotational ground motions with a Bayesian inverse approach.
Finite source inversions are critical for realistic ground motion simulations especially in the near-field of seismic events. While being highly relevant, e.g. in seismic hazard assessment, the kinematic description of finite fault rupture is complicated by many aspects. Physics of earthquake rupture, the inherent lack of data, the trade-offs between model parameters and the non-linear relationship between model parameters and observations render earthquake source imaging an ill-posed problem with multiple solutions. To reduce the non-uniqueness in finite source studies we propose to include rotational ground motion measurements in addition to conventional strong translational ground motion data. This means we consider a seismic array providing three component velocity and three component rotation rate seismograms at individual stations. In a synthetic test based on the geometry of the Tottori 2000 earthquake we aim to recover the slip amplitudes, the rupture velocity and the rise time. Applying a Bayesian, i.e. probabilistic, inversion approach allows us to naturally combine the two distinct data types and facilitates the quantitative analysis of the results. Performing a global search of the model space with a Metropolis-Hastings algorithm we show that test cases including both, translational and rotational ground motions provide significantly more information on the model parameters compared to test cases exclusively based on velocity seismograms.