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A statistical kinematic source inversion approach based on the QUESO library for uncertainty quantification and prediction

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Seismic, often augmented with geodetic data, are frequently used to invert for the spatio-temporal evolution of slip along a rupture plane. The resulting images of the slip evolution for a single event, inferred by different research teams, often vary distinctly, depending on the adopted inversion approach and rupture model parameterization. This observation raises the question, which of the provided kinematic source inversion solutions is most reliable and most robust, and — more generally — how accurate are fault parameterization and solution predictions? These issues are not included in “standard” source inversion approaches.
Here, we present a statistical inversion approach to constrain kinematic rupture parameters from teleseismic body waves. The approach is based a) on a forward-modeling scheme that computes synthetic (body-)waves for a given kinematic rupture model, and b) on the QUESO (Quantification of Uncertainty for Estimation, Simulation, and Optimization) library that uses MCMC algorithms and Bayes theorem for sample selection. We present Bayesian inversions for rupture parameters in synthetic earthquakes (i.e. for which the exact rupture history is known) in an attempt to identify the cross-over at which further model discretization (spatial and temporal resolution of the parameter space) is no longer attributed to a decreasing misfit. Identification of this cross-over is of importance as it reveals the resolution power of the studied data set (i.e. teleseismic body waves), enabling one to constrain kinematic earthquake rupture histories of real earthquakes at a resolution that is supported by data. In addition, the Bayesian approach allows for mapping complete posterior probability density functions of the desired kinematic source parameters, thus enabling us to rigorously assess the uncertainties in earthquake source inversions.