Localizing hypocenters of induced earthquakes using a Hamiltonian Monte Carlo scheme

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Probabilistic earthquake source localization can be tedious and computationally expensive with conventional schemes such as a simple grid search or Metropolis-Hasting. To reduce these costs, in this study, we use the hamiltonian monte carlo (HMC) scheme to sample the posterior. The scheme is known to have better sampling density and faster convergence which results in less iterations and well-distributed posteriors. We apply the scheme to a 2D Groningen velocity model which is known for its induced seismic events. Synthetic travel times are computed by means of the fast marching method and we perform ray tracing to the model that gives the travel time and wavepaths from an artificial source location to the receivers. Applying the HMC scheme to the synthetic data involves iterative evaluation of the travel-time misfit (or likelihood) associated with different source locations. Importantly, contrary to conventional Metropolis-Hastings' schemes, the posterior is not probed randomly, but the sampling is guided by the gradient of the posterior. Consequently, we need less iterations to obtain a good estimate of the probability density of the source locations.