Elastic Full-waveform inversion using Hamiltonian Monte Carlo approach for imaging the Moho transition zone

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Full-waveform inversion (FWI) is a high-resolution seismic imaging technique which uses waveform from the entire seismic data including phase, amplitude and travel-time for determining the physical parameters of the subsurface. The inversion remains local owning to the fact that it requires a reasonably accurate initial model so that it can converge to the correct model using either gradient or Newton-based optimization methods. The inversions use adjoint-state theory for computation of gradients to update the model. However, while inverting for the Moho-transition zone, things start becoming complex as the amplitude, and phase variation for the critically reflected arrivals no longer remains linear. This results in poor inversion of the Moho-transition zone as the gradients computed for model update and the adjoint-state theory are based on linear approximations.

We surmise that the Hamiltonian Monte Carlo (HMC), similar to Bayesian Markov Chain Monte Carlo (MCMC) approaches and takes the gradients into account for updating the model might be the key to resolve this problem. Bayesian approaches can remove our dependence on the initial models. Our goal is to use MCMC approach with Metropolis-Hasting acceptance criterion to prove the feasibility of the Bayesian approaches in inverting active seismic data and quantify the uncertainty. Our further goal is to show that HMC can provide good results for inversion of active seismic data with a dense acquisition geometry. We present a theoretical proof of FWI with HMC algorithm for imaging the Moho-transition zones.

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