# Bayesian trans-dimensional reflection full waveform inversion: synthetic and field data application

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Seismic full waveform inversion (FWI) is a state-of-the-art technique for estimating subsurface physical models from recorded seismic waveform, but its application requires care because of high non-linearity and non-uniqueness. The conventional FWI is an linearised process, with local gradient information to iteratively update the model; the global convergence relies on an informative starting model. Bayesian inference using Markov chain Monte Carlo (MCMC) sampling is able to remove such dependence, by an extensive direct search of the model space. We use a Bayesian trans-dimensional MCMC seismic FWI method with a parsimonious dipping layer parameterization [2], to invert for subsurface velocity models from prestack seismic common-source gathers. For the synthetic study, we use a simple four-layer model and a modified Marmousi model. A recently collected multi-channel offshore seismic reflection dataset, from the Lord Howe Rise (LHR) in the east of Australia, is used for the field data test.

The trans-dimensional FWI method is able to provide model ensembles for describing the posterior distribution, when the dipping-layer model assumption satisfies the observed data. The model assumption requires narrow models, thus only near-offset data to be used. We use model stitching with lateral and depth constraints to create larger 2D models from many adjacent overlapping sub-model inversions.

The inverted 2D velocity model from the Bayesian inference is then used as a starting model for the gradient-based FWI, from which we are able to obtain high-resolution subsurface velocity models, as demonstrated using the synthetic data. However, lacking far-offset data limits the constraints for the low-wavenumber part of the velocity model, making the inversion highly non-unique. We found it challenging to apply the dipping-layer based Bayesian FWI to the field data. The approximations in the source wavelet and forward modeling physics increase the multi-modality of the posterior distribution; the sampled velocity models clearly show the tradeoff between interface depth and velocity. Numerical examples using the synthetic and field data indicate that trans-dimensional FWI has the potential for inverting earth models from reflection waveform. However, a sparse model parameterization and far offset constraints are required, especially for field application.

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References

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