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Full waveform inversion schemes for 3D density structure

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We develop full waveform inversion schemes for density, based on numerical wave propagation, adjoint techniques and various non-seismological constraints to enhance resolution.

Density variations drive convection in the Earth and serve as a discriminator between thermal and compositional heterogeneities. However, classical seismological observables and gravity provide only weak constraints, with strong trade-offs. To put additional constraints on density structure, we develop full waveform inversion schemes that exploit the complete seismic waveform for the benefit of improved density resolution.

Our inversion scheme is intended to incorporate any information that can help to constrain 3D density structure. This includes non-seismological information, such as gravity and mineral physical constraints on maximum density heterogeneities (assuming reasonable variations in temperature and composition). As a trial case, we compare the results of current tomographic models to such constraints.

In a series of initial synthetic inversion experiments, we aim to construct efficient optimisation schemes that allow us to assimilate all the available types of information. For this, we use 2D numerical wave propagation combined with adjoint techniques for the computation of sensitivity kernels. With these kernels, we drive gradient-based optimisation schemes that incorporate our non-seismological constraints. Specifically, we assess the usefulness of two different inversion strategies: (i) optimising a single augmented objective functional that incorporates all the constraints we have, and (ii) using an objective functional based on the seismological data only, and using the additional information as hard constraints to project the solution onto an allowed range.