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Waveform Sensitivity Kernels for 3D Elastic Background Media

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We investigate waveform sensitivity kernels in frequency domain based on spectral-element simulations using the SPECFEM3D GLOBE package. Born scattering theory provides an integral relation between absolute changes of the wavefield caused by absolute changes of the material parameters. For unit material perturbations, the Born integrand is identical to the waveform sensitivity kernel for the considered source-receiver configuration. Its evaluation requires the calculation of Green functions for single forces at the receiver positions and displacement fields originating at the seismic source.

The kernels shall be used to relate model perturbations and differences between data and synthetics in a full waveform inversion procedure. Incorporating waveform sensitivity kernels into such a procedure has several advantages. Firstly we expect better convergence properties compared with strategies that calculate gradients of a misfit function. As the kernels may be calculated completely independent of the data, this will allow for subsequent model regularization and flexible choice of (components of) receivers that are used for the inversion. Furthermore, in total only one time-reversed simulation per (component of) receiver plus one simulation per seismic event are required for one iteration step of the inversion. One disadvantage of the method is, that in order to calculate the kernels in the volume of interest, wavefields and strains have to be stored throughout that volume. This typically demands a large amount of storage capacity. On the other hand, the stored kernels may be reused for different data, whereby the amount of permanent storage can be reduced by integrating the kernels over small subvolumes.

In order to produce Green functions, single force sources have been integrated into the SPECFEM3D GLOBE routines. Also all necessary processing of the time series and Fourier transformation are done on the fly before the spectra are written to file.