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A hybrid method for the computation of quasi-3D seismograms.

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The development of powerful computer clusters and efficient numerical computation methods, such as the Spectral Element Method (SEM) made possible the computation of seismic wave propagation in a heterogeneous 3D earth. However, the cost of theses computations is still problematic for global scale tomography that requires hundreds of such simulations. Part of the ongoing research effort is dedicated to the development of faster modeling methods based on the spectral element method. Capdeville et al. (2002) proposed to couple SEM simulations with normal modes calculation (C-SEM). Nissen-Meyer et al. (2007) used 2D SEM simulations to compute 3D seismograms in a 1D earth model. Thanks to these developments, and for the first time, Lekic et al. (2011) developed a 3D global model of the upper mantle using SEM simulations. At the local and continental scale, adjoint tomography that is using a lot of SEM simulation can be implemented on current computers (Tape, Liu et al. 2009). Due to their smaller size, these models offer higher resolution. They provide us with images of the crust and the upper part of the mantle. In an attempt to teleport such local adjoint tomographic inversions into the deep earth, we are developing a hybrid method where SEM computation are limited to a region of interest within the earth. That region can have an arbitrary shape and size. Outside this region, the seismic wavefield is extrapolated to obtain synthetic data at the Earth's surface. A key feature of the method is the use of a time reversal mirror to inject the wavefield induced by distant seismic source into the region of interest (Robertsson and Chapman 2000). We compute synthetic seismograms as follow: Inside the region of interest, we are using regional spectral element software RegSEM to compute wave propagation in 3D. Outside this region, the wavefield is extrapolated to the surface by convolution with the Green's functions from the mirror to the seismic stations. For now, these Green's functions are computed using 2D SEM simulation in a 1D Earth model. Such seismograms account for the 3D structure inside the region of interest in a quasi-exact manner. Later we plan to extrapolate the misfit function computed from such seismograms at the stations back into the SEM region in order to compute local adjoint kernels. This opens a new path toward regional adjoint tomography into the deep Earth.

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