Geophysical Research Abstracts
Vol. 21, EGU2019-6381, 2019
EGU General Assembly 2019

An application of source stacking followed by cross-correlations for global waveform tomography using the Spectral Element Method

Li-Wei Chen (1) and Barbara Romanowicz (1,2,3)

(1) Berkeley Seismological Laboratory, UC Berkeley, CA, United States, (2) Collège de France, Paris, France, (3) Institut de Physique du Globe, Paris, France

The spectral element method (SEM) is widely used for computing accurate synthetic seismic wavefields for the construction of 3D earth models by seismic waveform tomography and has been shown to help improve resolution, in particular of mantle plumes. However, the heavy computational costs represent a challenge for further resolution improvements. Capdeville et al. (2005) first proposed a source stacking method, in which multiple earthquake sources are simultaneously triggered in only one teleseismic SEM simulation, thus potentially reducing the computational costs by several orders of magnitude. One issue with this approach is that the summed wavefield is dominated by the large amplitude fundamental mode surface waves, while windowing and weighting schemes used in conventional waveform tomography cannot be applied.

Romanowicz et al. (2013) suggested including an additional step which consists in cross-correlating the summed wavefield between pairs of stations before each inversion iteration. By doing so, similarly to Ambient Noise Tomography (ANT), time windows with large energy arrivals corresponding to fundamental mode surface waves can be isolated, and weighting schemes designed to bring out the contribution of overtones and body waves sensitive to deeper earth structure. Contrary to ANT, even though the source distribution is not uniform so that the Green's function's emergence is not perfect, it is possible to apply the same processing to data and synthetics, since the source locations are known. Also, because we use normal mode perturbation theory to compute the gradient and Hessian rather than an adjoint approach, cross-talk in the inversion step is not an issue.

We first tested this approach on a synthetic global long period (400-60s) 3-component waveform dataset constructed for a toy 3D radially anisotropic upper mantle model containing shear wave anomalies at different scales (Romanowicz et al., 2018), demonstrating the effectiveness of this approach to document uncertainties in tomographic models such as those due to noise and sampling biases, as well as trade-offs between different parameters, that are practically unattainable using conventional SEM-based waveform tomography. Here we show the first preliminary results of application to real data at the global scale, including first and second orbit surface waves down to 60s period, starting with a 1D model. We compare the resulting radially anisotropic 3D shear velocity model to other existing models constructed using conventional approaches and discuss further developments and limitations.