Geophysical Research Abstracts
Vol. 17, EGU2015-12401, 2015
EGU General Assembly 2015

Biases in velocity and Q estimates from 3D density structure

Agnieszka Płonka (1) and Andreas Fichtner (2)

(1) Utrecht University, Department of Earth Sciences, Faculty of Geosciences, Utrecht, Netherlands (a.i.plonka@uu.nl), (2) ETH Zurich, Department of Earth Sciences, Zurich, Switzerland

We propose to develop a seismic tomography technique that directly inverts for density, using complete seismograms rather than arrival times of certain waves only. The first task in this challenge is to systematically study the imprints of density on synthetic seismograms.
To compute the full seismic wavefield in a 3D heterogeneous medium without making significant approximations, we use numerical wave propagation based on a spectral-element discretization of the seismic wave equation. We consider a 2000 by 1000 km wide and 500 km deep spherical section, with the 1D Earth model PREM (with 40 km crust thickness) as a background. Onto this (in the uppermost 40 km) we superimpose 3D randomly generated velocity and density heterogeneities of various magnitudes and correlation lengths. We use different random realizations of heterogeneity distribution.
We compare the synthetic seismograms for 3D velocity and density structure with 3D velocity structure and with the 1D background, calculating relative amplitude differences and timeshifts as functions of time and frequency.
For 3D density variations of 7 % relative to PREM, the biggest time shifts reach 2.5 s, and the biggest relative amplitude differences approach 90 %. Based on the experimental changes in arrival times and amplitudes, we quantify the biases introduced in velocity and Q estimates when 3D density is not taken into account. For real data the effects may be more severe, given that commonly observed crustal velocity variations of 10-20 % suggest density variations of around 15 % in the upper crust.

Our analyses indicate that reasonably sized density variations within the crust can leave a strong imprint on both traveltimes and amplitudes. While this can produce significant biases in velocity and Q estimates, the positive conclusion is that seismic waveform inversion for density may become feasible.