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Dispersion of seismic waves in isotropic elastic mantle heterogeneity derived from a geodynamic model

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Recently, we developed a new joint forward modeling approach to test geodynamic hypotheses directly against seismic data: Seismic heterogeneity is predicted by converting the temperature field of a high-resolution 3-D mantle circulation model into seismic velocities using thermodynamic models of mantle mineralogy. 3-D global wave propagation in the synthetic elastic structures is then simulated using a spectral element method. Being based on forward modelling only, this approach allows us to generate synthetic wavefields and seismograms independently of seismic observations. This way, the danger of circular reasoning is minimized, which may pose problems when using tomographic mantle models in seismic forward calculations. In addition, our approach avoids the problems of limited resolution and non-uniqueness inherent in tomographic inversions while taking all possible finite-frequency effects into account.

So far, we focused on direct body waves and measured traveltime variations of the synthetic P- and S-waves at a single dominant period (15 seconds) using an automated cross-correlation technique. However, capturing the correct physics of wave propagation in mantle models that exhibit a realistic power spectrum of seismic heterogeneity provides us with a unique tool to study the effects of focusing/defocusing and diffraction. In particular, using our approach we are now able to analyse seismic dispersion in isotropic, purely elastic structures in a consistent manner. This can provide important information on the relative contributions of inherent (i.e. related to dissipation of seismic energy) and structural dispersion and may, for example, help in improving our understanding of seismic attenuation. To this end, we extend our recent work and measure P- and S-wave delay times now in four different frequency bands. This way, we create a synthetic finite-frequency traveltime dataset that can be compared to the existing global datasets derived from seismic observations.