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Finite-frequency measurements of conventional and core-diffracted P-waves (P and Pdiff) for waveform tomography

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In its lowermost 200-300 km, the mantle has a complex structure resulting from accumulations of downwellings (subducted slabs), upwellings (LLSVPs and plumes), and probably phase transitions; seismic velocities and density show large variations but are not tightly constrained.

Core-diffracted body waves are the seismic phases that sample the lowermost mantle extensively and are prime candidates to be used in tomography for enhancing resolution in this depth range. Since they are diffracted along the core-mantle boundary, their behavior is highly dispersive and cannot be modeled satisfactory using ray theory, nor early versions of finite-frequency modeling. Hence they have rarely been used for tomography so far, and where they have been, large imaging blur can be expected.

We present a processing scheme to measure finite-frequency travel-time anomalies of arbitrary seismic body-wave phases in a fully automated way, with an initial focus on core-diffracted P waves. The aim is to extract a maximum of information from observed broadband seismograms using multi-frequency techniques.

Using a matched-filtering approach, predicted and observed waveforms are compared in a cross-correlation sense in eight overlapping frequency passbands, with dominant periods ranging between 30 and 2.7sec. This method was applied to a global data set of ≈2000 teleseismic events in our waveform archive, which resulted in 1,616,184 P and 536,190 Pdiff usable multi-frequency measurements of high cross-correlation coefficient (≥ 0.8). The measurements are analyzed statistically in terms of goodness of fit, effects of epicentral distance, and frequency-dependent behavior of P and Pdiff phases. The results for Pdiff waves are displayed by projecting the measured travel time anomalies onto the phase's nominal grazing segments along the core-mantle boundary.