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# Sensitivity kernels of PP precursor traveltimes and their limitations for imaging topography of discontinuities

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In this paper we present an analysis of the sensitivity of *PP* precursor traveltimes. By using spectral-element, exact synthetic seismograms in a 1-D background, we isolate the predicted arrivals of these phases and their exact Fréchet sensitivity kernels are calculated using the adjoint method.

Similarly to SS precursors, *PP* precursors can, in principle, help us to understand the lateral depth variations of the 410 and 660 km discontinuities. Seismologists usually interpreted their traveltimes in terms of topographic variations within a linearised ray theory framework. Information about lateral depth variations can be connected to thermal and chemical variations along the global discontinuities.

Many studies have been devoted to the analysis of these phases and used their traveltimes for imaging the discontinuities, i.e. topographic variations, velocity jumps and sharpness of depth undulations. However, using *PP* precursors has not led to converging results. There are some problematic aspects regarding the employment of *PP* precursors that necessitate further investigation. Their inconsistent detectability and often the absence of the *P660P* phase as well as the weak *P410P* data do not agree with seismological predictions or mineral physics modelling in which these phases are shown to be global features.

Exact Fréchet derivatives of the *PP* precursors traveltimes are calculated with respect to the 410 and 660 boundary topography and to structural parameters, namely compressional and shear wavespeed. Our results indicate that the boundary sensitivity of the *PP* precursors is rather weak, especially compared to *SS* precursors, and these phases are not coherently seen even in noise-free, exact synthetics. We find strong sensitivity both to shear and compressional wave speeds, indicating that wave interference and *P-to-S* wave energy conversions are dominant and can only be taken into account in a full-waveform inversion.

We reach the conclusion that the *PP* precursors traveltimes are unlikely sources of valuable insight into discontinuity topography, since they are more sensitive to structural parameters than to the boundaries. Interpreting their traveltimes as a result of topography of discontinuities therefore demands extreme caution.