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Imaging Resolution of 410-km and 660-km Discontinuities

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Seismic discontinuities in the mantle transition zone at depths of about 410 and 660 km are associated with olivine phase transformations. The depths of the discontinuities provide important constraints on the thermal structure of the mid mantle. Teleseismic receiver functions as well as PP and SS precursors have been widely used in imaging topographic variations of the 410 and 660 discontinuities. Ray-theory based migration and stacking methods are often used to enhance signals of the converted and reflected waves, assuming that the effects of 3-D structure in wavespeed can be averaged out. In this study, we investigate the resolution of traditional methods in imaging the 410-km and 660-km discontinuity topography based on wave propagation simulations using the Spectral Element Method (SEM). We calculate synthetic seismograms in laterally heterogeneous wavespeed models with lateral variations in the 410-km and 660-km discontinuity depths. The SEM synthetics are processed following standard migration and stacking techniques to image the discontinuities. We show that 3-D wave speed structure beneath seismic stations can introduce significant artifacts in transition zone discontinuity topography. We also investigate finite-frequency effects of P-to-S converted waves as well as PP and SS precursors in imaging the discontinuities by varying the length scale of depth variations in the 410-km and 660-km discontinuities in SEM simulations, and show that wave front healing effects depend on the length scale of the depth variation as well as epicentral distances. Finally we compare receiver function delay times with calculations based on finite frequency sensitivity and show that wave front healing effects can be properly accounted for.