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Global measurements of the mantle transition zone discontinuities by receiver functions

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Upper mantle discontinuities at depths around 410 and 660 km are global structures and have great importance in understanding the mantle convection mode. The 410 and 660 km seismic discontinuities define the mantle transition zone that separates the upper and lower mantle. The discontinuities are generally accepted to be phase changes in mantle mineralogy due to pressure and temperature variations in the Earth's interior. The equilibrium depth positions may be altered by temperature variations, and are often related to tectonic features at shallower depths. We use receiver function technique to study the mantle discontinuities by identifying P-to-S converted phases produced by the discontinuities. Here we show new receiver functions calculated for 250 global permanent seismic stations, together with earlier results of 130 stations. Most of the stations are located on continents. Results revealed significant variations in the arrival times of the 410 and 660 km discontinuity phases and a good correlation between them. The variations in the timing of the discontinuity phases may be caused both by the variations in the upper mantle P and S wave velocities and by the topography of the discontinuities. The mantle transition zone thickness, measured by differential times of the 410 and 660 km discontinuity phases, deviates by -35 km to +20 km from that predicted by the IASP91 model and changes according to mantle temperature, e.g., the transition zone is thick in subduction zones and thin within mantle plumes. The correlation of the arrival times of the 410 and 660 km discontinuity phases are closely related to the upper mantle velocities above them, therefore, reflecting the tectonic features in the upper mantle. We found a good correlation between the arrival times of the 410 km discontinuity phase and the thickness of the lithosphere, derived by surface wave inversion. This may indicate that the variation of the lithospheric thickness is the most significant heterogeneity in the upper mantle.