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Sampling the mantle transition zone beneath North America with regional P-waves from the USArray

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The mantle transition zone (MTZ) is crucial for understanding the evolution of the whole mantle of the earth. Here, we report preliminary results on the lower MTZ obtained from USArray waveform data.
Phenomena like slab stagnation, or undulation of the top and bottom boundaries of the MTZ have been visualized by seismic tomography, but can yet not be brought into accordance with mineral physics observations. Recent results of high-pressure experiments highlight the importance of water on the behaviour of the mineral phases in the MTZ: Lower-mantle mineral phases are unable to hold as much water as the MTZ phases, so that water has to be released from the crystal structure at the ringwoodite-to-perovskite phase transition near the 660 km discontinuity. This water release would strongly alter the phase behaviour and could lead to localised low velocity zones of hydrous phases directly above the 660 discontinuity.

Studies using receiver function and SS-precursor data have shown that the depth of the discontinuities varies by tens of kilometres globally. However, the resolution of these approaches is limited by the low signal-to-noise ratios of the seismic phases used.
We investigate triplicated P-waves recorded at epicentral distances between 16 and 28 degrees. The seismograms of those waves consist of three phases: one from the upper medium, one reflected at the boundary, and one refracted into the lower medium. As all three phases arrive within a short time window, they overlap, and the resulting waveform is strongly sensitive to the depth, thickness and velocity contrast of the boundary. Using deep focus events, these waves have been shown to resolve the lower MTZ for highly active subduction zones such as the Japanese.
Usage of recent dense continental arrays like the USArray or the European networks organized by ORFEUS allows us to determine source parameters robustly and thus include shallow earthquakes, which are more abundant than deep events.

Using 10 shallow events offshore the northern American and Mexican west coast, we compared the P-waveforms with synthetic seismograms calculated from layered models. The comparison was done for the broadband data and on narrowly filtered passbands. For waveforms filtered around 5s central period, the correlation coefficient between data and synthetics varied azimuthally between 0.9 and 0.6 over a few degrees. We conclude that lateral variations in the lower MTZ occur within tens of kilometres under the western United states.

Since the correlation coefficient and the travel-time difference calculated with a matched-filter analysis is shown to be frequency dependent, our final goal is to include this dataset into a finite-frequency tomography of Northern America and Europe, using sensitivity kernels calculated with a SEM code in a spherically symmetric reference model. These kernels can be calculated either for volumetric velocity changes, or for topography undulations of the discontinuity itself.