3D passive-source reverse-time migration imaging of mantle discontinuities

*Yang Shen[1], Jiahang Li[1], Hitoshi Kawakatsu[2]

1. Graduate School of Oceanography, University of Rhode Island, USA, 2. Earthquake Research Institute, University of Tokyo

With the advance of computational power and deployment of dense seismic networks, wave-equation-based imaging methods, which account for wave multi-pathing, scattering and focusing/defocusing, have become increasingly practical and advantageous for imaging complex crustal and mantle discontinuity structures. Over the past few years, we have developed a 3D passive-source reverse-time migration (3D PS-RTM) method using scattered and converted earthquake arrivals to image mantle discontinuities. Here we present results of its first applications in two different tectonic regions with different receiver settings and thus different applicable wave frequencies: The western U.S. centered on the Yellowstone and southwest Japan. Data processing involves selection of quality teleseismic events with epicentral distances of 28-98 degrees, calculation of vertical-, radial- and transverse-component receiver functions with an iterative deconvolution method, suppression of random noise using principle component analysis, and interpolation of wavefields recorded at stations onto numerical grids of the model surface. The P arrival and its coda, which contains the converted and scattered waves, are time reversed and back-propagated separately into the model via a finite-difference method. The back-propagated wavefields are decomposed into the P and S modes and their imaging condition reflects the convergence of the two modes at velocity interfaces or scatters. In the western U.S., the ~70 km station spacing of the USArray stations dictates that only intermediate- and long-period (>10 s) wavefields of teleseismic body-wave arrivals can be reliably reconstructed on the surface. Our RTM results show remarkably clear images of the 410-, 520- and 660-km discontinuities. The mantle transition zone is ~20 km thinner than the average of the transition zone beneath the western U.S. and the global average, an anomaly comparable to that beneath Iceland. The anomaly is centered ~100 km northwest of the Yellowstone hotspot in a 200 km by 300 km area, supporting the notion of a tilted mantle plume between the surface hotspot and the high temperature thermal anomaly in the transition zone. In contrast, we observe a ~40-km depression of the 660-km discontinuity, an indication of substantially lower mantle temperatures, beneath Nevada, where tomographic models reveal the presence of a subducted slab. In southwest Japan, the combined seismic stations from the Hi-net and other networks have a station spacing of 10-20 km, making it possible to reconstruct teleseismic body-wave wavefields on the surface at periods down to 2-3 s and thus achieve potentially much higher resolution than in Yellowstone. Teleseismic P waves for earthquakes with magnitude greater than 5.6 between 2004-2018 were collected from the Hi-net, F-net, JMA, and several university networks. Data processing and imaging are ongoing and preliminary results for southwest Japan will be presented at the meeting.

Keywords: passive-source reverse-time migration, mantle transition zone, receiver function, Yellowstone, Japan subduction zone, 3D wave simulation

