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Pronounced sP Depth Phases Recorded in Southwestern Japan: Modeling and Implications

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In southwestern Japan, sP phases are clearly observed at epicentral distances of 60 km or further while the phases are less visible in other regions of Japan. The amplitudes of sP phases are sometimes larger than those of direct S-waves, especially at a distance of 130 km or further. We found that subsurface sedimentary layers are critical for SV-P conversion at the ground surface and subsequent propagation to observation stations. The strong sP phase arrivals in southwestern Japan can be explained by the shallow crustal structure of the Chugoku area. We used sP phases to help refine the slab and crustal velocity models in this region.
We first calculated synthetic waveforms (up to 1 Hz) using a frequency-wavenumber (F-K) integration code (Saikia, 1994) for 1D and a staggered-grid finite difference (FD) code for wave propagation [E3D by Larsen and Schultz (1995)] using existing velocity models. We used the 1D model of Asano et al. (1986) and 3D models derived from P-wave tomography (Nakajima and Hasegawa, 2007) and receiver function images (Shiomi et al., 2006; Ueno et al., 2008). The agreement of the recorded waveforms and synthetic seismograms calculated with the existing 1D model is reasonable. The P-wave arrival times estimated from the 3D model also fit the observations reasonable well. However, the agreement between the synthetics and the data is not satisfactory for the sP phase amplitudes and the travel times of the sP- and S-waves at many of the stations. The travel times of sP- and S-waves in the synthetics are somewhat slower than those of the observed data at many of the stations. We developed new 1D models which match the observed waveform data better at some stations. The improved 1D models show a tendency for significant variations in Moho depth and indicate deeper Moho (32-35 km) beneath the central and southern parts of the Chugoku region, which is in good agreement with the recent receiver function images, For stations where the travel times calculated with 1D model still show large discrepancies, we constructed a modified 2D/3D model considering the configuration of the slab and variations of the velocity discontinuity depths. The synthetics calculated with the 2D/3D models account for the travel times of sP- and S-waves well. The improvements of the velocity structure model beneath SW Japan contribute to better estimation of strong ground motions for large earthquakes in the region.

Keywords: southwestern Japan, sP phase, crustal structure, waveform modeling