Detailed structure of the subducting Pacific slab beneath the Japan Islands and Japan Sea

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Although many tomographic studies have been made to image the subducting Pacific slab in and around the Japan Islands, details of the slab structure (such as the slab thickness and its seismic velocity perturbation as well as the depth variations of these factors) are still unclear. In this study, we have addressed this issue by using arrival times of intermediate-depth and deep earthquakes recorded by the dense seismic network on the Japan Islands. We adopt a forward-modeling approach using a 3-D ray-tracing technique (Zhao et al., 1992, 2004) and 3-D P-wave velocity models obtained by tomographic inversions. Our results show that the thickness of the Pacific slab beneath Japan is 90.0 km. Then assuming different values of velocity perturbation in the slab from 1.5% to 8% relative to surrounding upper mantle, we calculate the root-mean-square (RMS) residuals between the observed travel times and the calculated ones. The velocity perturbation that results in the minimal RMS travel-time residual is considered as the optimal one. We used 130,227 P-wave arrival times from 4532 local and regional events with focal depths greater than 40 km. These events are divided into 7 groups with the following depth ranges: 40-100, 100-150, 150-200, 200-300, 300-400, 400-500, and 500-700 km. The average velocity perturbations (in %) of the slab in these 7 ranges are 6.5, 4.0, 8.0, 4.0, 3.0, 3.0, and 6.0, respectively. The result for the depth range of 150-200 km is very different from others. Therefore this range is further divided into two parts with depth ranges of 150-175 km and 175-200 km. The data at seismic stations in three latitude ranges (30-37 [deg], 37-42 [deg] and 42-46[deg]) are examined separately. After these investigations, we found that the large velocity perturbation of the Pacific slab (8.0%) was caused by a very anomalous structure of the slab beneath Hokkaido. The slab geometry seems to be poorly constrained for that part of the slab perhaps due to the poorly located deep seismicity there. Except for that, the velocity perturbation of the Pacific slab generally decreases gradually with depth from 40 to 500 km, while it increases to 6.0% from 500 to 700 km depth, which may be also affected by the large uncertainty in the hypocenter locations of the very deep events under the East Asia continent margin.