Upper mantle structure beneath the Indonesia archipelago from surface wave tomography

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The tectonic setting of the Indonesian archipelago is very complex, which is characterized by several oceanic basins and complicated subduction zones. A key to the understanding of such complexity of this area was grossly detected by its seismic velocity structure of the mantle as reported by Okabe et al. (2004, PEPI). The main objective of this study is to obtain a three-dimensional S-wave velocity model of the upper mantle beneath the Indonesia archipelago from surface wave analysis, which should reflect the tectonic process of this region. We investigate the lithospheric structure of the Indonesia archipelago by using the multimode surface tomography method (Yoshizawa & Kennet, 2004). The effects of strong heterogeneity of the region resulting in large off-great circle propagation and scattering of surface waves can be considered by incorporating ray tracing and influece zone for finite-frequency surace waves.

Seismic data are collected from the JISNET (Japan-Indonesia Seismic NETwork) and IRIS (Incorporated Research Institutions for Seismology) networks in Southeast Asia. Three-component broad-band seismograms data from the JISNET from 1998 to 2003 and the IRIS from 1995 to 2006 are used for seismic events with magnitude greater than 6.0. The initial data comprise 192 events for 23 JISNET stations, and 470 events for 53 IRIS stations. Locations and origin times of the earthquakes are taken from the NEIC catalogue. Centroid moment-tensor solutions from the Global CMT catalogue are used for our waveform inversions.

The observed waveforms were processed by applying the three-stage inversion technique (Yoshizawa & Kennett 2004, JGR), which comprises three independent steps; (1) estimation of a path-specific multi-mode phase velocities from a fully non-linear waveform inversion, (2) construction of phase velocity maps as a function of frequency and mode, incorporating the effects of finite frequency as well as off-great-circle propagation, and (3) construction of a 3-D shear wave velocity model from the phase velocity maps.

We obtained two sets of 3-D shear wave speed models, one from the IRIS data only and the other from combination of the IRIS and JISNET data, using the fundamental-mode Rayleigh waves in a period range from 40 to 150 seconds. A large-scale high velocity anomaly can be seen in all the tomography maps, which is associated with the subducting Australian plate in the south and Philippine Sea plate in the north. The fast velocity anomaly of the younger Philippine Sea plate is rather moderate compared to the older Australian plate. In the South China Sea, a high velocity anomaly, which may be associated with the oceanic lithosphere of the South China Sea Basin, are observed at about 50-70 km depth. Meanwhile, a conspicuous low velocity anomaly was observed in the north-western part of Borneo Island at 50-100 km depth. Such a feature can also be seen in the S-wave model by Lebedev and Nolet (2003). The volcanic zones of Sumatra, Java, Banda arcs, Sangihe, and Philippine arcs are dominated by low velocity anomalies in the depth range from 50 to 75 km.