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Detailed velocity structure along the Nankai trough, off the Kii Peninsula, obtained from DONET data

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Along the Nankai trough off southwestern Japan, the Philippine Sea (PHS) plate is subducting to the northwest below the Eurasian plate. Historically, mega-thrust earthquakes have occurred repeatedly along the Nankai trough (e.g., Ando, 1975). Future great earthquakes will cause serious and widespread damage in central and western Japan. The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) installed a network of permanent ocean-bottom observation stations off the Kii Peninsula above the source region of the expected great earthquakes. This is known as the Dense Oceanfloor Network System for Earthquakes and Tsunamis (DONET). Previous studies (e.g. Nakano et al., 2014) revealed that the present seismic activity well overlaps the aftershock region of the sequence of 2004 off the Kii Peninsula earthquakes (M_{JMA} = 7.1, 7.4, and 6.5). The focal mechanisms of the earthquakes show that the axis of compressive stress in the PHS plate is oriented N?S, almost perpendicular to the direction of plate convergence, indicating a complex tectonic regime in this region. In this study, we investigate detailed seismic velocity structure in this region.

In this region, P-wave velocity (Vp) structure is well developed based on repeated seismic surveys, but S-wave velocity (Vs) structure is not well known. Therefore, we start from an initial layered velocity structure assuming Vs, and update it to well explain the travel-time of earthquakes, then obtain three-dimensional velocity structure described below.

1. Estimate average layered structure below the study area.

1.1. An initial layered structure of Vp is constructed referring to the result of seismic surveys. The Vp/Vs ratio of each layer is assumed considering oceanic structures. Using this structure, we determine the hypocenter distribution.

1.2. Using the travel-time and initial hypocenters, 3D velocity structure is computed by using the tomoDD program (Zhang and Thurber, 2003).

1.3. The 1D velocity structure is updated by averaging the velocity at each depth.

1.4. Hypocenters are re-calculated based on the updated velocity structure, and the procedures 1.2.-1.4. are repeated until the 1D velocity structure converges.

2. Construction of 3D velocity structure.

2.1. Initial 3D velocity structure representing the subducting plate and oceanic sedimentary layers is constructed based on the study of Nakamura et al. (2011). Vp is from the result in 1.

2.2. The Vp/Vs ratio of each layer is obtained by a grid search method, in which minimizes the residual between observed and calculated travel time.

2.3. Site correction is obtained for the best model.

3. Computation of detailed 3D velocity structure.

3.1 Using the velocity structure and hypocenter distribution obtained in 2. as the input, detailed 3D velocity structure is obtained by using tomoDD program. In the computation of travel time, the site correction obtained in 2.3. is included.

The obtained velocity structure shows that the velocity anomaly along the trough anomaly well corresponds to the earthquake distribution. In the oceanic crust, seismic activity corresponds to a region of low-velocity anomaly, while earthquake distribution corresponds to a high-velocity anomaly in the mantle. The obtained structure may help to understand the detailed structure in this region. However, since the used data is from earthquakes immediately below DONET, the resolution of tomography may not be good. We will investigate the resolution and dependence on the initial velocity structures in the future study.

Keywords: Nankai trough, Ocean-bottom seismic observations