Trans-dimensional imaging or random inhomogeneities at northern Ryukyu arc with a non-diagonal covariance matrix

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Crust and uppermost mantle at subduction zones have various structural inhomogeneities over a broad scale range due to accumulations of various tectonic processes such as deformation, faulting, and volcanism. Randomly fluctuating components of velocity inhomogeneity are essential for describing scattered seismic waves at high frequencies (>1 Hz). This study estimated a 3-D spatial variation of random velocity inhomogeneity at northern Ryukyu arc by applying the peak delay time analysis (Takahashi et al. 2013). Study area is off east of Tanegashima and Tokara islands. Seismic waveform data was acquired by a passive survey with 43 short-period ocean bottom seismographs (OBSs) and 4 temporal onshore stations (Yamamoto et al. 2020, EPSL). We measured the delay times of S-wave from rms envelopes of velocity seismograms at 4-8 Hz, 8-16 Hz and 16-32 Hz, and estimated power spectral density of inhomogeneity by assuming the von Karman type function. For a precise imaging of random inhomogeneity, we revised the covariance matrix of likelihood function. The original method uses a diagonal covariance matrix for residuals at all frequency bands. In our revised method, the covariance matrix has non-zero off-diagonal components to make adequate correlations of residuals among different frequencies for each raypath. These non-diagonal terms are quite effective to estimate the exponent of the von Karman type power spectral density function.

Preliminary analysis with a part of observed data imaged weak random inhomogeneity at most of the study area. These weak inhomogeneities commonly have steep spectral gradient. One of strongly inhomogeneous areas was imaged beneath the Tokara islands. Spectral gradient in this area is gentle as with those beneath the Quaternary volcanoes at northeast Japan (Takahashi et al. 2009). Other strongly inhomogeneous areas were found in the forearc side at 10-30 km depth. These anomalies show linear distributions parallel to the Ryukyu trench. Distances from the trench axis are about 80km and 110 km. Vertical extents of these anomalies have large uncertainties due to insufficient data, but it seems to be certain that the former one locates at low seismicity area of regular earthquakes. Correlation with shallow low frequency tremors (e.g., Yamashita et al. 2015) is not clear, then this strong inhomogeneity probably represents structural anomalies of subducting plate rather than those at the plate boundary.

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