Modeling of high-frequency seismic wave propagation via observed waveform and numerical simulations using 3D heterogeneous model

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To achieve precise modeling of high-frequency (>1 Hz) seismic wave propagation, small-scale heterogeneities, which have characteristics scales less than several kilometers, should be required (e.g., Sato, 1984, 1989; Kumagai et al., 2011; Takemura et al., 2015). In this study, to investigate the effects of small-scale velocity heterogeneity and surface topography on seismic wave propagation, we conducted finite-difference method simulation of seismic wave propagation for shallow moderate earthquake.
We conducted FDM simulations of shallow moderate (Mw 4.4) earthquake occurred in the Shimane-Hiroshima boarder on 25 November, 2011. The model covers a volume of 384×384×128 km^3, which is discretized by an uniform grid size of 0.1 km. Technical details are same as in Takemura et al. (2015). The background velocity structure is referred from the Japan Integrated Velocity Structure Model (JIVSM; Koketsu et al., 2012). Small-scale velocity heterogeneity model of Kobayashi et al. (2015) is embedded over the crust of the JIVSM. Intrinsic attenuations of the crust for *P* and *S* waves is represented by a single-relaxation Zener body with $Q_S^{-1} = Q_P^{-1} = 4.0\times10^{-3}$ and reference frequency f_0 = 1 Hz (Takemura et al., 2017). We assume a double-couple point source referred from the F-net MT catalog.
We also conducted FDM simulation using the JIVSM without small-scale velocity heterogeneity (original JIVSM), as a reference. Our simulations well reproduced observed PGV and characteristics of seismic wave propagation for frequencies of 0.1-4 Hz. However, in the original JIVSM, coda waves are excited due to topographic scattering but its envelope shapes doesn’t show smooth-time decay. By introducing small-scale velocity heterogeneity, simulated coda envelopes well agree with observed smooth coda envelopes.
The effects of small-scale velocity heterogeneity dominate in higher frequencies. Simulated PGVs of JIVSM are widely fluctuated due to the source radiation pattern but this fluctuation is suppressed by homogenizing azimuthal variation of PGVs due to small-scale velocity heterogeneity.

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We used the Hi-net/F-net data and F-net MT solution. The computations were conducted on the Earth Simulator at the Japan Marine Science and Technology (JAMSTEC).

Keywords: Seismic wave propagation, Small-scale velocity heterogeneity, Irregular topography, High-frequency seismic waves, Numerical modeling

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