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Characteristics of high-frequency seismic waves during relatively deep event at Kanto region

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Observed Characteristics of high-frequency seismic waves

Observed records during Mw 5.0 earthquake occurring at depth of 53 km at southwestern Ibaraki, central part of Japan, demonstrated various features depending on the station location. Especially, the waveforms with 2-4 Hz at central and southern part of Chiba are showing strong peak delay and spindle shape of S wave, while weak peak delay appears at other area in Kanto region. In the high frequency ($f > 1$ Hz), seismic waves are strongly affected by the effect of seismic wave scattering due to small-scale velocity fluctuation along propagation path (e.g. Sato, 1989). The spatial distribution of small-scale velocity fluctuation in the subsurface structure of Kanto area may be cause of strong peak delay (e.g., Takahashi et al., 2007).

2-D FDM simulation

We conduct FDM simulation of seismic wave propagation in the 2-D heterogeneous structure to clarify the cause of strong peak delay. Our 2-D simulation model is covering the zone 245 by 123 km, which has been discretized with grid size 0.015 km. We assume the layered background velocity structure base on the model proposed by Koketsu et al. (2008). The model is including basin structure, crust, mantle and subducting oceanic plate.

In order to introduce the effect of seismic wave scattering, we assume stochastic random velocity fluctuation in each layer. Random velocity fluctuations are characterized by exponential-type auto-correlation function (ACF) with correlation distance a = 3 km and strength of fluctuation e = 0.05 in the upper crust, a = 3 km and e = 0.07 in the lower crust, a = 10 km and e = 0.02 in the mantle (e.g., Takemura and Furumura, 2013). In the subducting plate, we assume anisotropic random velocity fluctuation characterized by exponential-type ACF with a_H = 10 km in horizontal direction, a_Z = 0.5 km in vertical direction and e = 0.02 (Furumura and Kennett, 2005). In the low velocity layer, basin structure, we assume random velocity fluctuation model characterized by exponential-type ACF with a = 1 km in vertical direction and e = 0.07.

In addition, we assume the low-velocity zone at northeastern part of Chiba with depth of 30 km (Matsubara et al., 2004). In the low-velocity zone, random velocity fluctuation characterized by Gaussian-type ACF with a = 0.5 km and e = 0.10 is superposed on exponential-type ACF with a = 3 km and e = 0.07. Strong seismic scattering would occur in the low-velocity zone of simulation model and affect peak delay time at Chiba.

Simulation results

Simulated waveforms with 2-4 Hz are showing spindle shape due to scattering and energy trap in the basin structure. Strong peak delay also appears at central and southern part of Chiba. Simulation result demonstrated that strong scatters in the low velocity zone play important role in peak delay time and waveform shape.

Low-velocity zone at northeastern Chiba is considered as a result of dehydrated water from oceanic crust of subducted Philippine Sea plate. Therefore strong small-scale velocity fluctuation in the low-velocity zone may be related with dehydrated water.

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Keywords: seismic wave, numerical simulation, seismic wave scattering, heterogeneous subsurface structure