Ground-motion prediction based on the scattering theory by incorporating the effects of random velocity inhomogeneities in the crust

*Kazuo Yoshimoto[1], Shunsuke Takemura[2], Manabu Kobayashi[1]

1.Yokohama City Univ., 2.NIED

Introduction

It has been reported for the ground motions of local crustal earthquakes that, for frequencies higher than approximately 1 Hz, the azimuthal distributions of maximum amplitudes (hereafter “apparent radiation pattern”) and amplitude fluctuations are characterized by the seismic scattering due to random velocity inhomogeneities in the crust (e.g., Kobayshi et al., 2015; Yoshimoto et al., 2015). In recent years, to investigate the properties of these seismic phenomena, a number of pioneering studies on seismic scattering have been conducted (e.g., Sawazaki et al., 2011). In this study, on the basis of the scattering theory, we propose a new method for predicting the ground motions of local earthquakes by incorporating the frequency and distance changes in the apparent radiation pattern and amplitude fluctuations.

Ground-motion prediction method

In our ground-motion prediction for small to moderately sized local crustal earthquakes, for simplicity, only the effects of scattering due to random velocity inhomogeneities in the crust are considered, whereas the effects of anelastic attenuation (intrinsic attenuation) and local site amplification are not considered. We assume a spatial uniformity for the crustal inhomogeneity and its spatial autocorrelation can be stochastically characterized by using an exponential function. We adopt a double-couple point source as a source model and assume that the maximum amplitude is generated by a certain frequency component of S waves.

We suppose that the spatial distribution of maximum amplitudes can be evaluated by the following two calculation steps: (1) Evaluation of apparent radiation pattern from mean square (MS) seismogram envelopes, and (2) Estimation of amplitude fluctuation and superposition of its value on the MS envelope amplitude. For the calculation in Step 1, we utilize a numerical method developed by Sawazaki et al. (2011) to synthesize seismogram envelopes for a double-couple point source by way of the stochastic raypath technique using the Markov approximation for the parabolic wave equation. For the estimation procedure in Step 2, we adopt a scattering theory (Yoshimoto et al., 2015) for the evaluation of amplitude fluctuations of acoustic waves radiated isotropically from a point source in random inhomogeneous media.

Discussion

The above-stated method, which is based on the scattering theory, has a potential to evaluate the frequency and distance changes in the apparent radiation pattern and amplitude fluctuations for crustal earthquakes. For example, as for the increase in hypocentral distance, our method predicts both the dissipation of the non-uniform azimuthal distribution in apparent radiation pattern and the increase in amplitude fluctuations. The simultaneous appearance of these phenomena results in that, even at large hypocentral distances, the maximum amplitudes at different receivers are not equalized, but differ from receiver to receiver, with up to ten-times difference between the largest and smallest as found in seismic observations.

In our presentation, we will show numerical evaluation results in the frequency and distance changes in apparent radiation pattern and amplitude fluctuations and will discuss their physical relations between random velocity inhomogeneities in the crust. As for our group study on observed characteristics of P- and S-wave amplitude fluctuations during local crustal earthquakes, please see Kobayashi et al. (2016, JpGU) in the same session.

Keywords: Seismic scattering, Apparent radiation pattern, Amplitude fluctuation, Ground-motion prediction, Random velocity heterogeneity

