Mapping intrinsic and scattering attenuation parameters in 3D space: a case for southwestern part of Japan

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Estimating heterogeneous attenuation structure is important for not only study of Earth structure but also strong ground motion prediction. In this study, we propose a new method to estimate 3D heterogeneity of intrinsic and scattering attenuation parameters. Proposed method consists of two steps. We assumed isotropic scattering and 1D velocity structure.

The first step is to calculate synthetic envelopes based on Eulenfeld and Wegler (2016, GJI). Observed envelope was modeled by multiplication of source term, site amplification term, Green’ s function of envelopes and intrinsic attenuation term. Green’ s function were calculated using Monte Carlo simulation of the radiative transfer theory. Estimated intrinsic attenuation factor and scattering coefficient of each earthquake show that the earthquakes occurred in and around Kyushu region affected strong attenuation from both intrinsic and scattering.

For the second step, we try to map the attenuation parameters estimated in the step 1 to 3D space. In this step, we utilize the sensitivity kernels derived by Takeuchi (2016). We selected initial structural parameters from the results of step 1, then we modified the structure sequentially based on the sensitivity kernels and ART-type Bayesian reconstruction technique. In this step, we utilize synthesized envelopes in the step 1 as the observation. This feature enabled us to exploit full information of the observed envelope to modify the initial structure even though we assumed isotropic scattering, leading to avoid trade-off between intrinsic and scattering attenuation.

We applied the proposed method to estimate attenuation structure of the western part of Japan. Used stations and earthquakes were 238 and 422, respectively. After bandpass filtering of 1-2 Hz, we calculated seismogram envelopes by taking vector summation. Distribution of intrinsic attenuation and scattering coefficient for each earthquake in the step 1 indicates strong intrinsic and scattering attenuation in the Kyushu region. These characteristics were reproduced after the step 2. We verified the reconstructed structure of the step 2 by the checkerboard resolution test. We validated that the reconstructed structure was reliable to the depth of 30 km beneath the land area.

Strong intrinsic attenuation at the shallowest layer seems to correlate with the low velocity region at shallow depth estimated by Nishida et al., (2008). Sedimentary rocks would cause this attenuation. On the other hand, scattering coefficients around active volcanoes seem to be large, indicating existence of heterogeneity such as hydrothermal system or magma chamber.

In this study, we assumed isotropic scattering, however, both the formulation of Eulenfeld and Wegler (2016) and Takeuchi (2016) would hold in the non-isotropic scattering case. Non-isotropic scattering are required to synthesize the whole seismogram envelope (e.g. Sato et al., 2012). We will work to extend the proposed method to include non-isotropic scattering, which will lead the estimated attenuation structure more reliable.

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