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Wavelet domain inversion of the 2000 Western Tottori earthquake for broadband seismic wave radiation process

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In order to discuss the broadband strong motion radiation process from the earthquake fault, we develop a new source inversion method to estimate the frequency-dependent source processes by treating waveform synthesis, model parameters, and target to evaluate the fitness in a unified way. The source inversion developed in this study has two new features. One new feature is to apply the wavelet domain inversion to the high-frequency range. Ji et al. (2002) proposed the wavelet domain inversion which evaluates the fitness of the observed and synthetic records using the wavelet coefficients of waveforms. The wavelet domain inversion enables to evaluate the fitness depending on the frequency-dependent property of seismic waves. The fitness for the low-frequency range (lower than 1 Hz) is evaluated by the norm of the wavelet coefficients while the fitness is calculated from the square of the wavelet coefficients, called 'scalogram', for the high-frequency range (higher than 1 Hz), where the sign of the coefficient rapidly changes. The other new feature is to introduce the hybrid Green's function into the source inversion. For the broadband waveform synthesis, we construct the hybrid Green's function which consists of the theoretical and empirical Green's functions for the low- and high-frequency ranges, respectively.

We estimate source processes of the 2000 Western Tottori earthquake for three frequency ranges. First, the distribution of the low-frequency (0.0625-1 Hz) wave radiation intensity and rupture time is obtained. In this low-frequency inversion, we take the multi-scale approach which estimates the model parameters in some stages by increasing the number of model parameters and higher limit of analyzed frequency range. Then, the high-frequency wave radiation intensity is mapped for the frequency ranges of 1-2 Hz and 2-4 Hz with the fixed rupture time distribution to that obtained from the low-frequency inversion.

Synthetic test is performed to confirm the applicability and resolution of the wavelet domain inversion. Multi-scale inversion for the low-frequency range can retrieve the assumed model parameters for the case of variable rupture velocity, while single-scale inversion which inverts minute distribution at once cannot retrieve the assumed model. The wavelet domain inversion works satisfactorily for the high-frequency range although reproduction of the area stretching along depth direction is not good for some cases.

Multi-scale inversion of the real data shows that the area of the large low-frequency (0.0625-1 Hz) wave radiation intensity (asperity) stretches to the southeast of and above the hypocenter. The rupture toward the southeast asperity is faster than upward. Multi-scale inversion can well resolve this complex rupture propagation. The 1-2 Hz wave is intensely radiated from the area around rupture starting point of the southeast asperity. On the other hand, the strongest radiation intensity of 2-4 Hz wave is observed at the edge of the southeast asperity. These results indicate the possibility that the frequency-dependent strong motions are generated in relation to the growth and termination of asperity rupture. The high-frequency waves (1-4 Hz) seem to be radiated from the localized area in and around the asperities although there is also possibility that the estimated area is smaller than the actual one because of less resolution on the depth direction for high-frequency inversion as observed in synthetic test.

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