Inversion method for seismic rupture process using simulated annealing with empirical Green's function

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1. Introduction

In the previous study (Shiba, 2002) we proposed a heuristic search technique to investigate the seismic rupture process from the observed strong motion data, using the empirical Green's function. Spatial variation in the microscopic source parameters such as the local stress drop and the released seismic moment density on the fault plane of the target event is searched independently. The very fast simulated annealing (VFSA, Ingber, 1989) is adopted for the heuristic search that is suitable for the combinatorial optimization. The developed method is applied to the strong motion data observed during the moderate event of MJMA 5.7 occurred at east off Izu Peninsula, Japan in 1997. In this study we propose the improved method in order to reduce the computational times and to select the suitable cost functions and annealing schedule. Finally the proposed method is applied to the 1987 Off-Fukushima earthquake sequence, which occurred in the subduction zone.

2. Improvement of Method

In the simulated annealing the cost functions are calculated whenever one parameter is changed. So the time reduction for the total calculation is expected by reducing the calculation time of the synthesizing waves by the empirical Green's function method. The algorithm is improved so that only the element waves on the sub-fault, where the source parameter is changed, is replaced. By this improvement the total computational time becomes about 40 % in comparison with the old method.

The sensitivities of the searched source parameters to the cost functions are also evaluated. As a result the sensitivity of the amplitude of the correction function that represents stress drop is about ten times higher than that of duration time that indicates the rise time. The re-annealing, which rescales the annealing schedule of the insensitive parameters, shows no remarkable effect to the result in our case. On the other hand weighting the displacement waves, which have the longest dominant period among the cost functions, may improve the sensitivity of the rise time.

3. Application to Earthquakes in a subduction zone

It is difficult to apply a waveform inversion to earthquakes occurred in a subduction zone due to one-sided strong motion observatories and strong lateral heterogeneity of a propagating medium. By using empirical Green's function we are able to avoid the difficulty by calculating the theoretical Green's function for lateral-heterogeneous medium. During the 1987 Off-Fukushima earthquake swarm many strong motion data are observed at the several stations installed on the coastal area. We inverted the source process of earthquakes of M larger than 6.5. Smaller earthquakes are used as the element events for the synthesis assuming their source spectra obey the homogeneous source model. The corner frequencies and the seismic moments of the element events are determined by the Andrews' objective method (Andrews, 1986). In a preliminary analysis the amplitude levels and duration times of the observed waves are reproduced well. The synthesized source spectra will be compared with observed ones hereafter.