Similutanious estimation of amplitude and travel time variation in the transfer function with ACROSS

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Summary

We developed a method for simultaneous estimation of deviation of the amplitude and the travel time of the transfer functions obtained by an artificial seismic source, ACROSS.

Background

Variation of the amplitude is important information for monitoring the strength of the fault plane (e.g. Nagata et al, 2008). However, studies on the variation of propagation properties were mainly discussing the deviation of the travel time (e.g. Ikuta et al., 2002; Hobiger et al., 2016). The conventional method using the signal envelope is affected by the noise level, which is the shortcoming of the method. Thus, we developed a new method to make a simultaneous estimation of the deviation of both the amplitude and travel time.

Method

The simultaneous estimation method is basically a maximum likelihood estimation using a least square method. We adopt the least square method for deviation functions which are obtained by dividing each transfer function by averaged transfer function on the complex plane in the frequency domain. This is incontrast to the cross-spectrum method which was commonly used for calculation of the deviation of the travel time. In our method, the amplitudes as well as the deviation of travel time is calculated similarly to the cross-spectrum method. We estimated the deviation of the amplitudes and travel times as a nonlinear model fitting problem. We made a model of the deviation function with an assumption that the deviation of the amplitude and travel time is independent of frequency. We searched for the best fitting parameters so that minimizing the sum of the square lengths on the complex plane by grid search. As a result, we could estimate the deviations for smaller SNR data. We also could estimate the errors of the obtained deviations.

Results

We applied the method to High Sensitivity Seismograph Network Japan (Hi-net) stations around an ACROSS seismic source which is deployed at Toki City, the middle part of Honshu Island, Japan. The estimated deviation of the travel time with this method generally coincides with the results with the conventional cross spectrum method. When the data has low SNR, the average of the deviation of the amplitude did not become one due to averaging in the complex domain. This is because the least square fitting is made on the complex plane which does not mathematically guarantee the averaging of amplitude.

Keywords: Deviation of the amplitude, Deviation of the tarvel time, velocity change, Artificial seismic source, ACROSS

