# Simulation using the empirical Green's tensor spatial derivatives method: case of the 2001 Hyogo-ken Hokubu earthquake

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1. Background

The empirical Green's tensor spatial derivatives (EGTD) method was originally proposed by Plicka and Zahradnik (1998). The EGTD method inverts the Green's tensor derivatives instead of the moment tensor elements using waveform data from five or more events with the same focal zone and makes it possible to synthesize the strong ground motion with an arbitrary source mechanism. In this process, the fault mechanisms of targeted events must be well known. The EGTD method has the potential to provide accurate results in simulating strong motion. However, the number of its application has been limited so far. The limited use of the EGTD method may arise from the lack of records, that is, the EGTD method requires a number of waveform data from the same focal zone.

2. Purpose

Recently, in Japan, the strong motion observation networks, K-NET and KiK-net have been operated by the National Research Institute for Earth Science and Disaster Prevention and have accumulated a large amount of strong motion data. Therefore, we consider that we will enhance opportunities to apply the EGTD method to the simulation of the strong ground motion. In this study, we used the EGTD method to simulate the near-filed strong motion records obtained from the 2001 Hyogo-ken Hokubu earthquake (MJ5.4).

3. Used Data

One of the K-NET station, HYG004 was chosen as a target station because it was located at the closest epicentral distance (6 to 10 km) from the fault zone whose range extended to 4 km in the east-west direction and to 5 km in north-south direction. The observed acceleration records at HYG004 from for a mainshock and 15 aftershocks (MJ 3.1 to 4.4) were integrated into the velocity waveform data with a bandpass-filter between 1 to 10 s.

4. Estimation of Source Parameters

First, we estimated the strike, dip, and rake of a double-couple point source by applying a grid search technique. The smoothed ramp function with a rise time of 0.3 s was used for the source time function. We inverted data of 5 s including the P-wave arrival and the S-wave portion. The searching ranges of these parameters were set within 20 deg. from the solutions of the F-net. Second, fixing the fault mechanism obtained by the grid search, we determined the seismic moments and the source time function. The seismic moments released by five sequential slips were estimated by the least-square method with non-negative constraints [Lawson and Hansen (1974)].

5. Estimation of EGTD

Based on 11 aftershock waveform data and estimated source parameters, we estimated the EGTD. Prior to the inversion, the data was corrected in the source time function and adjusted in time considering the arrival time of the mainshock. We performed the inversion independently for each component. The station azimuth of the HYG004 from each epicenter was rotated to be 90 deg. measured clockwise from the north direction, so that the number of unknown elements to be solved was reduced to 3 in radial and vertical components and 2 in transverse component. As a result, the EGTD were successfully estimated.

6. Simulation Results for the Mainshock

Using the EGTD and the source parameters, we simulated the strong motion records for the mainshock. The agreement between the observed and the calculated waveforms is satisfactory for the long duration as well as the amplitude.

7. Conclusion

Through this study, we confirmed that the EGTD method is applicable to the simulation of the near-field strong motion based on the data from aftershocks within a spreading fault zone.

8. Acknowledgement

We used the strong motion data of the K-NET and KiK-net and the focal mechanism solutions of the F-net, operated and opened by the National Research Institute of Earth Science and Disaster Prevention.