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A simple method to improve automatic CMT solutions based on a feature of long-period seismic wavefields

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A correct and rapid centroid moment tensor (CMT) estimation of an earthquake is essential to a prompt response of the earthquake and tsunami disaster. Broadband seismograph networks were deployed for the earthquake and tsunami warning in the Philippines and Indonesia, and the long-period (50?100 s) seismic records from that networks are routinely analyzed by the waveform inversion method of SWIFT (Nakano et al., GJI, 2008) to automatically determine CMT solutions. Non-seismic long-period noisy waveforms occasionally appear in the seismic records when seismic waves arrive at stations. These noisy waveforms have relatively larger amplitudes than the seismic waveforms of each event and affect the automatic CMT solutions. However, there is no established way to correct or avoid the noisy waveforms. In this study, we developed a simple and rapid method to detect the noisy waveforms for automatic CMT inversion analysis.

We used the source amplitude defined as the maximum amplitude of an earthquake at each seismograph station corrected for the geometrical spreading and medium attenuation assuming a surface wave. We compared the source amplitudes with the moment magnitudes (Mw) of the CMT solutions to distinguish noisy waveforms from seismic waveforms. We carried out numerical tests using synthesized seismograms to investigate the cause of the relationship between source amplitudes and Mw. In the tests, we used two different source mechanisms and synthesized seismograms at broadband seismic stations in the Philippines as well as grid positions with about 55 km intervals.

We compared the source amplitudes with Mw in the manual solutions of earthquake that occurred around the Philippines and Indonesia. Although the source amplitudes varied due to the radiation pattern, we found that the variations of source amplitudes fell within a constant band against the change of Mw in the manual solutions. We calculated the ratios of the individual source amplitudes to the minimum source amplitude in each event. We found that the ratios were less than 10 for most of these events. Therefore, we introduced a threshold in the ratios (R) around 10 to detect pulse-like waveforms, and performed the waveform inversion without such waveforms for 25 events with inappropriate automatic solutions. We found that the source locations assuming R=11 best matched with those of the manual solutions and Mw and source mechanisms also greatly improved. The numerical test results showed that the variations of source amplitudes become larger as the angles between stations and node directions are smaller. This relation may appear if the station density is higher. Therefore, we investigated the variations of source amplitudes and their ratios in the Japan broadband seismograph network (F-net), which is denser than the Philippine network. We found that the variations of source amplitudes fell within a constant band against the change of Mw and the ratios were less than 10 for most of events with Mw in the range from 4 to 8.

Our method may be useful to detect noisy waveforms and avoid them in automatic CMT inversion analysis to improve the accuracy of automatic solutions. The ratios were less than 10 in the observation data from the Philippines and Indonesia networks and F-net, of which the station densities are different. This result indicates that the variations of source amplitudes are independent of the density of the stations, and implies that the radiation pattern may be distorted by source complexity and structural inhomogeneity in the long-period seismic wavefields.

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