Estimating the earthquake source mechanism using full waveform inversion

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An immediate understanding of the source mechanism of an earthquake after the occurrence is an important task for disaster mitigation to realize a safe society. One of the most important tasks for considering the mechanism of an earthquake is estimating the earthquake source mechanism. Due to the lack of seismic data and computational requirements, the centroid-moment tensor (CMT) solution has been widely used to estimate the focal mechanism until recent years. However, long term observation of the spatial distribution of aftershocks is required to identify the nodal plane that caused the fault motion. Since the earthquake waveform caused by a nodal plane becomes different from that caused by the other conjugate nodal plane, the analysis of full-waveform could be utilized to identify which nodal plane has caused the fault motion so that the focal mechanism of the earthquake could be estimated before the observation of aftershocks. Although some numerical experiments revealed that the possibility of FWI to inversion of earthquake source mechanism, the sensitivity of each fault parameter to full-waveforms has not been fully investigated yet.

In this study, we investigate the applicability of full-waveform inversion (FWI) to determine focal mechanism using numerical experiments. In FWI, L2-norm error function is often used as an objective function to be minimized. We evaluate the effect of some fault parameters (strike, dip, and rake) on the difference of recorded waveforms.

We make a three-dimensional numerical model with an earthquake source, and simulate elastic wave propagation using the finite-difference method. The seismic waves are recorded by receivers located on the ground surface. Subsequently, we slightly change the fault parameters, and then, simulate elastic wave propagation. We calculate the residuals between two recorded waveforms. This procedure enables us to investigate the sensitivity of the parameters on the L2-norm error function. Our numerical results indicate that rake has poor sensitivity whereas the change of strike and dip has a large effect on the recorded waveforms.

Keywords: Full-Waveform Inversion (FWI), Earthquake Source Mechanism, Numerical Experiment

