# Synthetic Tests of the Focal Mechanism Estimation using High Frequency Seismic Waveform

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Moment tensor of medium to large earthquakes and its spatiotemporal distribution provides us important information about the fault plane where the rupture occurs and kinematic process of seismic rupture on the fault. Long-period (> 10 s) seismic waveform is often used for this purpose because they are less sensitive to three-dimensional and small-scale seismic velocity heterogeneities, where our knowledge is usually incomplete. Furthermore, high frequency seismic waveforms mostly loose source information due to the seismic scattering (summarized in Sato et al., 2012). However, revealing high frequency behavior of seismic slip is also important to understand the dynamic behavior of fault rupture.

This study tries to develop the method for moment tensor estimation in high frequency band using synthetic waveforms, which considers three-dimensional large- and small-scale heterogeneities. As a first step of this development, we develop grid-search focal mechanism estimation method, assuming double-couple source, by fitting seismogram envelope of target events, which is expected to be applicable for higher frequencies rather than fitting raw waveform. Before analyzing observed data, we conduct a series of synthetic tests to confirm the applicability of the method and resolutions of the estimation.

The synthetic waveform is calculated using the parallel finite difference code developed by Takemura et al. (2015). The seismic source is set in Kii Peninsula as representing low frequency earthquakes. The three-dimensional background velocity structure is the JIVSM (Koketsu et al., 2012), including large-scale seismic velocity heterogeneity and topography. The small-scale random velocity heterogeneity model of Takemura et al. (2017) is embedded over the continental crust of the JIVSM. Target seismic waveform is filtered in four frequency bands (0.2-1 Hz / 1-2 Hz / 2-4 Hz / 4-8 Hz), and its focal mechanism is estimated by grid search in (strike, dip, rake) space by fitting its envelope with the synthetic stacked envelope waveforms in 5 s time windows around S-wave arrival.

Our synthetic tests reveals following points. (I) When the seismic structure is correct, envelope-fitting focal mechanism estimation is well applicable up to 2-4 Hz, and could be applicable to 4-8 Hz. When one-dimensional structure of F-net (Kubo et al., 2002) is used, the estimated focal mechanism is significantly biased even in lower frequency band and not constrained in higher frequency band. There is strong trade-off in the focal mechanism estimation between strike and rake. (II) The focal mechanism estimation is highly sensitive to the assumed hypocentral location. When the assumed epicenter is 0.1º shifted from the true position in each direction, the fitting residual becomes significantly worse. When the assumed depth is shifted from the true position at the plate interface by a few kilometers, shallower shift makes fitting residual worse and biased. (III) The difference in the source time duration from 0.1 s to 1.0 s or the shape of source time function does not vary the fitting significantly. (IV) Isotropic components as non double-couple components of target events do not influence the fitting much because we use only S-wave time window. On the other hand, the contamination of a few tens percent of second double

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couple component affects the fitting results. (V) The analysis can be applicable to the contamination of random noise with the amplitude up to about one-thirds of signal amplitude.

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