Comparison of goodness-of-fits of seismograms for earthquake CMT solutions

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The Centroid Moment Tensor (CMT) solution has been used as one of the focal mechanisms of an earthquake. We can find the CMT solution based on the goodness-of-fit between the synthetic waveform and the observed waveform at the centroid position of the point source. Although the estimation of moment tensor component upon an assumption of the centroid location is straightforward, the proper estimation of the centroid location is time-consuming. Previous studies have searched for the centroid position by means of a goodness-of-fit which represents fit between the synthetic and the observed waveforms among many virtual seismic sources in three-dimensional space. In this study, we set virtual seismic sources around the true source and compute the goodness-of-fit for each virtual source. We investigate the effect of the goodness-of-fit and its spatial distribution on the evaluation of the CMT solution. We estimate the CMT solution by using waveforms simulated in three-dimensional heterogeneous or one-dimensional structures as pseudo-observed waveforms and Green’ s function, respectively.

There are several methods to compute the goodness-of-fit of a waveform. One approach calculates goodness-of-fit by the residual sum of squares of the two waveforms. The other is calculation methods based on cross-correlation. Since the goodness-of-fit value obtained by each method is different, the reliability of the CMT solution may vary depending on the goodness-of-fit index. We compared the goodness-of-fit of waveform estimated by each index by considering the seismic source computed by numerical simulations as the true source. We investigated the region from 138.00E to 140.00E, from 39.40N to 41.40N, and in depth from 0.5 to 50.0 km. A 3-D grid is set with a grid size of 0.05° by 0.05° in horizontal and 0.5 km in depth. The true source is located in the inland crust off the coast of Akita Prefecture. The total number of virtual sources in the grid is approximately 170,000. We first solved a linear inverse problem to minimize the residual sum of squares of the synthetic and observed waveforms at each source. We then calculated the goodness-of-fit of waveforms by each index. Finally, we discussed the values of goodness-of-fit and its spatial distribution.

The results of comparing several goodness-of-fit indices showed that the properties of goodness-of-fit indices were different. For example, the minimum goodness-of-fit value was about -100 % when using the index based on the cross-correlation, while it was sometimes less than -10000 % when using the index based on the residuals. This may be related to the fact that only formulas based on residuals normalize the values. We also found that the goodness-of-fit varied depending on whether the synthetic or observed waveform was normalized. When computing the CMT solution, it is necessary to use different goodness-of-fit indices depending on the purpose.

Keywords: CMT solution, Goodness-of-Fit, Residual, Cross-correlation

