Estimation of fault models by MCMC method

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Summary

The Geospatial Information Authority of Japan estimates the fault parameters by using observed coseismic displacement caused by large earthquakes. The fault models are indispensable to evaluate the surface displacement of the whole area, as well as the seismic activities near the source faults. However, we frequently face a difficulty in estimating the fault parameters uniquely due to non-linear dependency of the model parameters and to restriction of the available observation data. In this paper, we show the results of the fault model estimation for some large earthquakes by using Markov Chain Monte Carlo (MCMC) method in order to evaluate the fault parameters probabilistically.

Calculation method

We calculated the surface displacement by rectangular faults with a uniform slip in an elastic half space (Okada 1985). The coseismic displacement data is derived from the F3 solutions of the GEONET sites. We used Metropolis–Hastings algorithm for MCMC calculation to estimate the fault parameters. Parallel tempering (e.g. Sambridge 2013) is also applied to improve the efficiency of the MCMC sampling. All fault parameters are estimated in our analysis while many previous studies constrained some parameters such as fault direction (e.g., Ito et al. 2016, Ohno and Ohta 2018).

Results

In the estimation of the fault parameters of the 2011 off the Pacific coast of Tohoku Earthquake, we used two sectioned faults since single fault model shows systematic difference between the observed and calculated displacement. We found that marginal posterior probability density of the fault parameters show clearly peaked distribution. The calculated displacements by using the averaged values of the estimated parameters can well explain the observed data.

For the earthquake offshore Yamagata prefecture on June 18, 2019, we simultaneously estimate the parameters of two conjugate faults with two different strike angles. The result shows that it is difficult to determine the fault direction only by the GEONET data used in our analysis.

Keywords: Crustal Deformation, Inversion

