Development of crustal block motion model, including elastic plate coupling based on MCMC method.

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Introduction

Large earthquakes have been occurred along plate interface due to the subducting oceanic plate. It is necessary to consider the relative plate motion for evaluation of earthquake potential. Hashimoto and Jackson (1993) defined the small plates as crustal blocks and estimated the crustal block motion in and around Japanese islands using the trilateration and triangulation data. Owing to the introducing of inland GNSS observation(GEONET), inland relative block motion has been clarified more accurately. And then, it was estimated that spatial interplate coupling distribution along crustal block boundary, such as the plate convergence zone, too. In addition, development of seafloor geodetic observation technology will reveal crustal deformation near the trench. In order to more accurately estimation of coupling along plate interface, it is necessary to consider the interaction between crustal block motion and coupling at simultaneously. In this study, we developed a new crustal block motion model to estimate the crustal relative block motion with the interplate coupling effect.

Previous crustal block motion analysis

In many previous studies, DEF-NODE (McCaffrey., 1995) can analyze the crustal block motion. It employed rectangular plane faults along crustal block boundary. It estimates the crustal block motion, internal strain of block, and the coupling along crustal block boundary based on nonlinear estimation (e.g., Wallace et al., 2005).

Loveless and Maede (2010), on the other hand, divided in and around Japanese islands into 20 crustal blocks, and estimated the plate motion, slip vectors on the crustal block boundary, and coupling along plate interface, using inland GNSS observation data, based on least squares estimation. However, these methods cannot obtain the covariance of the estimated unknown parameters.

Crustal block motion analysis in this study

The relative block motion(Bv_{ij}) along the two crustal blocks boundary (Br_{ij}) can be described as $Bv_{ij} = Br_{ij} \times (\omega_i - \omega_j)$ using the Euler poles(ω) of the two crustal blocks. Since the interaction between the crustal blocks, we set triangular faults along the block boundary based on a back slip model. First, the slip deficit (χ_{ij}) between the two crustal blocks can be expressed as $\chi_{ij} = C_{ij} Bv_{ij}$ (C_{ij}: coupling coefficient). The elastic response(ve) can be expressed as $ve = G\chi$ (G: elastic response function). The coupling coefficient is a magnitude of slip deficit normalized by crustal relative block motion. Observed crustal deformation(d) is the result of elastic response due to coupling between the crustal blocks and the crustal block motion. It is expressed by $d = ve + Bv = G\, C_{ij}\, (Br_{ij} \times (\omega_i - \omega_j)) + r \times \omega$, meaning that nonlinear equation. Then, crustal block model is constructed by combining these equations, considering the relationship between crustal blocks.

In this study, the coupling between the crustal blocks is estimated using the Markov Chain Monte Carlo method (MCMC). MCMC can evaluate the covariance between estimation parameters. This advantage is possible to evaluate the correlation between the slip deficit at the deep plate boundary and the crustal block motion at inland.

We make new source code for this problem. In this program, it is easy to set up configurations. Thus, it is possible to trial and error with various models. Furthermore, we will implement the elastic response

function derived from finite element method(FEM).
We make a crustal block motion model that is consist of 11 blocks in southwest Japan (see figure). This model consider to plate interface shape and relationship to each blocks.

Future plans
We will use this model to estimate the interplate coupling throughout Japan. As a further step, we will compute spatial coupling distribution on plate interface using FEM.

Keywords: Crustal block motion model, Block relative motion, interplate coupling, Markov Chain Monte Carlo method, GNSS