Interseismic Crustal Deformation in Southwest Japan: Oblique Plate Convergence and Forearc Block Motion

*Masahiko Shiomi[1], Takao Tabei[2], Takeo Ito[3]

1.Graduate School of Science, Kochi Univ., 2.Faculty of Science, Kochi Univ., 3.Earthquake and Volcano Research Center, Nagoya Univ.

The Median Tectonic Line (MTL) is the longest arc-parallel strike-slip fault in southwest Japan, whose right-lateral motion originates from oblique subduction of the Philippine Sea plate (PHS) at the Nankai trough. MTL separates the forearc block from the rest of the overriding southwest Japan arc. Rate of relative block motion between them is estimated small enough compared with the dominant crustal shortening in the direction of PHS convergence since the interseismic coupling on the plate interface is generally strong. Nevertheless strain accumulation on the MTL fault plane is very important because it is capable of producing a major inland earthquake in the future. In this study, we simultaneously deal with elastic deformation due to strong coupling on the PHS interface, forearc block motion relative to the southwest Japan arc, and small shear deformation due to partial locking of the shallower part of the MTL fault plane.
We use horizontal and vertical displacement rates derived from GEONET final coordinate time series at 291 sites from Kyushu to Kinki regions during the period of 2004-2009. In addition we incorporate horizontal displacement rates from dense GPS campaign observations at 37 sites deployed along two traverse lines across the MTL. The PHS interface is reproduced by more than 1000 triangular elements from 5 to 60 km in depth. Similarly MTL is divided into four segments from east to west and each segment is modeled by a uniform rectangular plane with a dip angle of 50 degrees. Also the MTL fault plane is assumed to be partially locked from the surface to the depth of 15 km. We introduce Markov Chain Monte Carlo method (MCMC) for simultaneous estimation of parameters. The MCMC derives posterior probability density functions of unknown parameters from enormous forward calculations. These calculations are executed by random value sampling which are generated by Monte Carlo method based on Markov chain algorithm. Even in a case of the model with a large number of unknowns, we can estimate parameter values and confirm their validities. In our modeling, new constrains are introduced that forearc block motion relative to the southwest Japan arc is inherently parallel to the strike of MTL and slip-deficit rate on the MTL fault plane does not exceed the rate of the relative block motion across the MTL.
The results shows that distribution of interseismic slip deficit rates on the PHS interface is very similar to those obtained in several previous studies. The strongest-locked region (> 60 mm/yr) exists at the depth of 15-25 km under Tosa Bay just south of Shikoku, which nearly overlaps the main rupture zone at the last megathrust event in 1946. The rate of the forearc block motion relative to the southwest Japan arc is estimated as about 4 mm/yr westward. Locking of the shallow MTL fault plane shows slight lateral variation from east to west. We find that the eastern segment is nearly fully locked, then the locking weakens toward the west. It is interesting whether the results are related to the difference of strain accumulation rate and recurrence interval between the segments.

Keywords: Markov Chain Monte Carlo method, Median Tectonic Line, Southwest Japan, GPS observation

