Simultaneous Estimation of Fault Slip and Asthenosphere Viscosity Using Large Scale Finite Element Simulation of Postseismic Deformation

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In the field of geodetic inversion, estimation of the coseismic/postseismic slip using postseismic deformation observation data is an important topic. Such estimation is expected to be improved by an inverse analysis method using numerical simulation (e.g. finite element (FE) method) of viscoelastic deformation, whose model is of high-fidelity to the available high-resolution crustal data. The authors had been developing a large-scale simulation method using such FE high-fidelity models (HFM), assuming use of a large scale computation environment such as the K computer in Japan. In this study, we developed an inverse analysis method incorporating HFM, in which fault slip and asthenosphere viscosity are estimated simultaneously, since the value of viscosity in the simulation is not trivial.We carried out numerical experiments using synthetic crustal deformation data. We constructed an HFM in the domain of 2048x1536x850 km, which includes the Tohoku region in northeast Japan based on Ichimura et al. (2013). We used the model geometry data set of JTOPO30 (2003), Koketsu et al. (2008) and CAMP standard model (Hashimoto et al. 2004). The HFM is currently in 2km resolution, resulting in 1.4 billion degrees-of-freedom. Coseimic slip based on Suzuki et al. (2011) and afterslips originally set by the authors based on Yamagiwa et al. (2014) were used as the inputted fault slips. Synthetic crustal deformation data of one and a half years after an earthquake in the location of GEONET, GPS/A observation points, and S-net were used. Inverse analysis was formulated as minimization of L2 norm of the difference between the FE simulation results and the observation data with respect to viscosity and fault slip, combining the quasi-Newton algorithm with the adjoint method. Use of this combination decreases the necessary number of forward analyses in the optimization calculation. As a result, we are now able to finish the estimation using 1/20 of entire resource of the K computer for 10 hours and a few. In the future, we would like to apply the method to the actual data.

Keywords: finite element method, adjoint method, inverse analysis, crustal deformation, viscosity estimation, fault slip estimation

