# Improvement of spatial resolution and evaluation of uncertainty for the coseismic slip distribution of the 2011 Tohoku-oki Earthquake

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Due to the 2011Tohoku-oki earthquake, a large coseismic deformation was detected not only by the onland geodetic observational network but also by the seafloor geodetic observations (GNSS-Acoustic observations, ocean bottom pressure observations and differential bathymetry observations). These observations revealed that large coseismic slip reached to the Japan trench off Miyagi [e.g., Iinuma et al., 2012, JGR; Sun et al., 2016, Nat. Comm.]. However, southern and northern extent of the large coseismic slip along the trench was not well constrained due to low spatial resolution in the northern and southern areas because the seafloor geodetic observation sites mainly located in the central part (off-Miyagi region). Meanwhile, it is essential to evaluate uncertainties of the slip parameters to discuss the extent of the large coseismic slip. Although the linear slip inversion methods generally assume Gaussian distribution for the unknown parameters, this assumption was not necessarily right. Here, we examined the following two approaches: 1) Constraining the coseismic slip distribution by postseismic geodetic observational data via a viscoelastic inversion [Tomita et al., 2020, EPS], 2) Evaluating the uncertainties of the slip parameters by introducing a MCMC technique.

Introduction of the viscoelastic inversion: Viscoelastic relaxation, which is a transient deformation after the large earthquake, is caused by stress changes due to coseismic slips. Thus, postseismic geodetic observational data have information of the coseismic slip via the viscoelastic relaxation. Then, we tried to constrain the coseismic slip distribution from the postseismic geodetic observational data by simultaneously estimating the co- and post-seismic slip distribution via viscoelastic Green functions. We calculated the viscoelastic Green functions assuming a simple horizontally stratified viscoelastic structure [Fukahata & Matsu’ ura, 2005; 2006, GJI]. As a result, the spatial resolution of the coseismic slip distribution can be improved using the seafloor geodetic observational data in the postseismic period (Tomita et al., 2017, Sci. Adv.). The conventional elastic inversion method showed that large coseismic rupture area was concentrated in the narrow region where the spatial resolution was high. By contrast, in the viscoelastic inversion method, the high spatial resolution region was relatively wide along the trench, and the large coseismic slip area was also extended. The northern and southern limits of the large coseismic slip (over 20 m) area were estimated as ~39.2°N and ~37.0°N, respectively.

Introduction of the MCMC technique: Using the MCMC technique, posterior probability density function (PDF) following a non-Gaussian distribution can be estimated by sampling unknown parameters. In this study, we divided the fault space using Voronoi cells and estimated number of the unknown parameters (number of the Voronoi cells) by a reversible-jump MCMC (rj-MCMC) technique to perform the slip inversion without using any spatial smoothing constraints. Note that we conducted the rj-MCMC analysis only using the coseismic geodetic data and investigated the performance of the rj-MCMC method. As a result, we successfully obtained the posterior PDFs following the non-Gaussian distributions for the slip parameters and found the region where large coseismic slip might occur in a low probability.

Through above two approaches, we successfully improved the inversion methods of the coseismic slip

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distribution of the 2011 Tohoku-oki earthquake in terms of the spatial resolution and evaluation of uncertainties. We plan to perform the viscoelastic inversion assuming a realistic viscoelastic structure and to apply the rj-MCMC technique to the viscoelastic inversion method in the future.

Keywords: The 2011 Tohoku Earthquake, Viscoelastic relaxation, Reversible-jump MCMC technique, Seafloor geodesy

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