A comparison between Green's functions in coseismic fault slip inversions for the 2011 earthquake off the Pacific coast of Tohoku

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Several Green's functions have been proposed to calculate coseismic crustal deformations caused by earthquakes. In geodetic inversions to estimate coseismic fault slip, the Green's function introduced by Okada (1992), which assumes a semi-infinite medium (hereafter referred to as "semi-infinite model"), has been widely used. The semi-infinite model can accurately approximate crustal deformations with smaller spatial scales. However, when the crustal deformation occurs over a wider area, the effects of vertical inhomogeneities in density and elastic constants, the curvature of the Earth, and self-gravitation may not be negligible.

In this study, we calculated the Green's function for a self-gravitating and layered sphere with the internal structure of PREM, using the method of Tanaka et al. (2014) (hereafter referred to as “spherical model”). We applied the calculated Green's function to a fault slip inversion for the 2011 M9 Tohoku earthquake and compared results with those obtained with the semi-infinite model. In the inversion, we used GNSS data from the Geospatial Information Authority of Japan (GSI) and seafloor crustal deformation data from the Japan Coast Guard. The plate interface was approximated with rectangular subfaults and smoothing was considered based on the method of Yabuki & Matsu'ura (1992).

The result shows that the minimum ABIC value is smaller for the spherical model than that of the semi-infinite model. The ABIC value depends on the number of model parameters. In this analysis, the number of the model parameters is the same for the semi-infinite and spherical models. This indicates that the slip distribution obtained with the spherical model is better than that with the semi-infinite model. In addition, the spherical model significantly improved the agreement between the observed and calculated surface displacements. The spherical model gave a deeper slip distribution off the coast of Fukushima Prefecture (around 38 degrees north latitude) than the semi-infinite model. The maximum slip for the semi-infinite model was 47 m, while that for the spherical model was 39 m. The peak positions were not much different between the two models. These results indicate that the difference in Green's functions should be considered when discussing the uncertainty of the coseismic slip distribution for the M9 event.

Keywords: Fault slip inversion, Green's function, The 2011 earthquake off the Pacific coast of Tohoku

