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有限要素法に基づく 2011 年東北地方太平洋沖地震による地殻内変形
Finite element analysis for modeling the crustal deformation caused by the 2011 Tohoku-Oki earthquake

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We performed a finite element analysis for constructing a two-dimensional model of the deformation due to the 2011 Tohoku-Oki earthquake, taking into account the realistic subsurface structure and topography. We used a finite element code developed using GeoFEM. The two-dimensional cross section considered in the finite element analysis was perpendicular to the Japan Trench. This profile also transects an area of huge coseismic slip with the slip magnitude exceeding 60 m. Two-dimensional model of the crust, mantle wedge structures, and subducting slab geometry were developed on the basis of a offshore seismic reflection survey (Ito et al., 2005) and high-precision seismic tomography profile of the crust, mantle wedge structures, and subducting slab in this region (Nakajima et al., 2009). Rock density in each mesh is calculated from the P-wave velocity using the laboratory measurements of P-wave velocity and density reported by Ludwing et al. (1970). Assuming Vp/Vs ratios of 2.20, 1.90, 1.73, and 1.76 in the frontal prism, oceanic crust, continental crust, and mantle, respectively, we calculated their Poisson ratio and Young's modulus. First, we calculate the crustal deformation assuming an uniform slip model, following Ito et al. (2011). In this model, the updip of the fault reached the trench and the downdip was 80 km away from the trench; the slip magnitude was 80 m uniformly. The numerical results show an uplift of 8 m and a displacement of 75 m at a point 20 km away from the trench; however, the observed values of the uplift and displacement at this point were 5 m and 60 m, respectively. One of reasons of this discrepancy was the difference between fault geometries; Ito et al. (2011) considered simple fault geometry with a constant slope angle of 3^o, while our model adopts realistic curved fault geometry, taking into consideration the upper surface of the subducting plate. The other reason is the difference between the elasticity values of the frontal wedge and subducting plate; the vertical displacement increases by 10 percents near the trench if we assume homogeneous elasticity within the whole region. In future, we will develop a suitable model that can simulate crustal deformation consistent with the displacement as obtained by ocean-bottom as well as on-shore observations.

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