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Postseismic deformation of the 11 April 2011 Fukushima Hamadori (Mw=6.6) earthquake inferred from GPS observations

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The 2011 Fukushima Hamadori earthquake (Mw=6.6) is one of aftershocks of the 2011 Tohoku-oki earthquake (Mw=9.0). While the coseismic deformation field due to the Fukushima Hamadori earthquake is derived from InSAR measurements, leading to detailed slip distribution (Kobayashi et al., 2012; Fukushima et al., 2013), SAR data is not available to decipher postseismic deformation because the ALOS satellite terminated its operation right after the Fukushima Hamadori earthquake. GPS observations are thus the only way to delineate postseismic displacements of the earthquake. Here we try to detect the postseismic deformation of the Fukushima Hamadori earthquake and investigate the mechanism of it.

We assumed that the observed displacements are a combination of 1) rigid plate motion, 2) postseismic deformation of the Tohoku-oki earthquake, and 3) the triggered afterslip of the Fukushima Hamadori earthquake that results from fault creeps around the hypocenter of the mainshock, all of which are simultaneously estimated by solving an inverse problem. Because the postseismic deformation of the Tohoku-oki earthquake has prominent long-wavelength features compared with the spatial scale of this study, we approximated the deformation by either linear, quadratic, cubic, or quartic function. A statistical assessment indicates that the postseismic deformation of the Tohoku-oki earthquake is most appropriately represented by a cubic polynomial.

Our results indicate that, in the first six month, the afterslip is concentrated at the deeper and horizontal extension of the mainshock rupture and the shallowest part of the mainshock rupture. Of these, location of the slips in the horizontal extension of the mainshock rupture depends on the size of the fault we assume probably because of insufficient coverage of GPS sites.

We found that the observed displacement field during the first 12 months is inconsistent with the afterslip, invoking the need for assessing a contribution of viscoelastic relaxation. A preliminary analysis with a viscoelastic halfspace overlaid by a 25-km thick elastic layer indicates that a viscosity of 1×10^{18} Pa s, a very low value for a upper mantle viscosity, seems to be consistent with the observed postseismic displacements.

Keywords: Crustal deformation, GPS, Postseismic deformation, Normal faulting earthquake