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Local anomaly of crustal deformation associated with the 2011 Pacific coast off Tohoku earthquake in the Echigo plain

Takuya NISHIMURA[1*], Hisashi Suito[1], Tomokazu Kobayashi[1], DONG, Qinxi[2], SHIBAYAMA, Takashi[3]

[1]Geospatial Information Authority of Japan, [2]Eduscience Research Institute, [3]Research Center of Computational Mechanics, Inc

Geospatial Information Authority of Japan constructed a dense GNSS array across the Echigo plain in the Niigata-Kobe tectonic zone in 2010. We conducted campaign GNSS measurements every fall. Strain distribution based on GNSS data acquired in 2010 and 2011 campaigns suggests that extensional strain of the 2011 Tohoku-oki earthquake is large in the Echigo plain, which is concordant with the analysis of Ohzono et al. (2013) using the GEONET data. Ozawa et al. (2013) pointed out local subsidence around active volcanoes of northeastern Japan using InSAR data and suggested that local deformation was attributed to soft medium beneath the volcanoes. We present detailed strain distribution measured by three GNSS campaigns and that calculated using finite element model (FEM) in and around the Echigo plain.

Strain and displacement distribution from October 2010 to October 2011 in a direction of N105^{o}E shows 6.2 ppm (15.4 cm in a 25-km-long baseline) of extension west of Niitsu hill and 3.8 ppm (6.2 cm in a 16-km-long baseline) of extension east of Niitsu hill, whereas the area east of the hill is close to the source area of the 2011 Tohoku-oki earthquake. It disagreed with our expectation that strain east of the hill should be larger than that west of the hill. Large strain west of the hill may be related with thick soft sediments layers in the Echigo plain. We made a FEM analysis with the rectangular fault model of Nishimura et al. (2011) and a heterogeneous elastic medium approximating the J-SHIS subsurface structure model developed by National Research Institute for Earth Science and Disaster Prevention. Calculated strain distribution shows EW extensional strain in a central part of the Echigo plain is about twice as large as that in the surrounding region. Calculated extensions are 6.1 and 3.4 ppm for western and eastern regions of Niitsu hill, respectively, which is concordant with the observation. It is generally difficult to distinguish heterogeneous strain distribution due to a fault mechanism and variable slip on the fault from that due to elastic heterogeneous medium using observed near-field deformation. However, a large slip of the 2011 Tohoku-oki earthquake far from the observation area enables us to distinguish them clearly. Our result suggests that incorporating inhomogeneous medium is important in the modeling of crustal deformation for not only the 2011 Tohoku-oki earthquake but also a general case.

Keywords: Crustal deformation, the 2011 Tohoku-oki earthquake, Finite Element Model, GNSS