Simulation of ground strain and tilt changes in the source area of the 2008 Iwate-Miyagi Nairiku earthquake

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Ground strain and tilt changes associated with fault displacements and tectonic deformations at large earthquakes could cause damages to civil structures, systems, and components located near the source faults. At the 2008 Iwate-Miyagi Nairiku earthquake (Mw 6.9), the ICNS station operated by Tohoku University and the KiK-net IWTH25 station by National Research Institute for Earth Science and Disaster Resilience (NIED) recorded large static displacements of approximately 1.5 m in the vertical component (Ohta et al., 2008; Aoi and Morikawa, 2009; Matsu’ura and Kase, 2010). The IWTH25 station also recorded a large static tilt of 1/5,000 in a tiltmeter (Fukuyama, 2015), which is under the indication value of 1/2,000 described in the design recommendation for buildings published by Architectural Institute of Japan (AIJ) but may not be a significantly small value compared with the indication. The investigation and prediction of such strain and tilt changes for large earthquakes would contribute to assessing seismic hazards and safeties of important structures and facilities located near source faults. In this study, we investigated the spatial distribution of ground strain and tilt changes in the source area of the 2008 earthquake based on 3D numerical simulations.

We employed the finite-difference method (Nakamura et al., 2012) for the simulations and used the slip distribution models of the 2008 earthquake investigated by Suzuki et al. (2010) and Asano and Iwata (2011). We used the three-dimensional (3D) sediment layer model from the Japan Seismic Hazard Information Station (J-SHIS) (Fujiwara et al., 2012) and the 50 m mesh topography data by the Geospatial Information Authority of Japan (GSI). We employed the slip rate function proposed by Liu et al. (2006) and its rise time by Graves and Pitarka (2010) at each point source on the fault plane.

Our simulation results show that the main features of the distribution of the static strain and tilt are consistent with those estimated by the elasticity theory assuming a half-space structure (Okada, 1992). In the area above the top of the source fault, large strains and tilts of more than 1/2,000 are found. We confirm wider areas with the large values as the fault location is shifted in shallower depths. For dynamic components in the frequency band of less than the calculation accuracy (1.5Hz), we also confirm the distribution of large values in the northeastern part of the source area where shallow slips are resolved in the source model. We are also going to present the effects of subsurface structures and slip distributions on the distribution at the surface.

Keywords: Iwate-Miyagi Nairiku earthquake, strain, tilt change, finite-difference method

