Crustal deformation in the San-in Shear Zone as observed by a dense GNSS network

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The San-in Shear Zone (SSZ) is a right-lateral shear zone in southwest Japan with a 30-50 km width, where active seismicity and high strain rates have been observed. No major active fault is identified in the SSZ, however, deformation in the area can be modeled by assuming a 5 mm/yr deep creep on a vertical fault with right lateral motion and conjugate Riedel shears within the shear zone can reconcile the seismotectonics in the area (Nishimura and Takada, 2017). A model having a deep creep on a vertical fault plane well explains observed GNSS velocity, yet it does not provide how wide aseismic motion is confined below a seismogenic depth. Thus, we evaluate the width of the shear zone beneath the SSZ using GNSS data available in the area.

We analyzed daily coordinates from 100 continuous GNSS stations around the SSZ in the postseismic period of the 2011 M_w9.0 Tohoku-oki earthquake (1 January 2014 to 1 April 2018). The network consists of 87 GEONET stations and original stations in the SSZ operated by Kyoto University since 2014 near the source regions the 2000 Western Tottori (M_w6.6) and the 2016 Central Tottori (M_w 6.2) earthquakes. Horizontal displacement rates are calculated for all stations using linear regression with respect to site 0344 (35.09ºN, 134.59ºE). During the analyzed period two major events affected the crustal deformation in the area: the 2016 Kumamoto earthquakes (M_w 7.0) and the 2016 Central Tottori earthquake. Coseismic and postseismic corrections were applied for the perturbed stations. Viscous relaxation associated with the 2011 Tohoku-oki earthquake is expected to affect the SSZ. This effect was removed employing the 3-dimensional viscosity model by Suito (2017).

The SSZ is characterized by strike-slip motion in the N80ºE direction, thus, we focus on deformation in that component. We evaluate deformation along two profiles, one corresponding to eastern Tottori, where the 2000 Western Tottori earthquake took place, and another considering Central and Eastern Tottori. In order to evaluate the width of the shear zone, we assumed multiple vertical faults located every 0.5 km across the region and optimized the slip rate by minimizing the sum of squares residuals. We fixed the depth of the dislocations to 13 km based on microseismicity studies (Omuralieva et al., 2012).

We found the best fitting models with a different width (i.e., 60 km and 21.5 km) for Western and Central-Eastern Tottori, respectively. They suggest that ductile flow in the lower crust is distributed in a channel beneath the SSZ. However, models with a single vertical fault in the middle of the shear zone are also within the confidence interval. GNSS data alone cannot constrain the width of the shear zone in the lower crust.

Keywords: San-in Shear Zone, GNSS data, The 2011 Tohoku-oki earthquake

