Localized deformation in Mid-Niigata as observed by dense GPS network before and after the 2011 Tohoku-oki earthquake

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The Niigata-Kobe Tectonic Zone (NKTZ) is a deformation zone along the east coast of Japan Sea, with localized geodetic contraction (10^{-7}/yr, Sagiya et al. 2000), one order of magnitude larger than the long-term deformation rates in the area (10^{-8}/yr, Wesnousky et al., 1982). Meneses-Gutierrez and Sagiya (2016) studied strain rate distributions based on GPS sites from the GEONET array in central Japan before and after the Tohoku-oki earthquake and found a persistent localized contraction (4~10x$10^{-8/}$yr), in northern NKTZ, showing that the concentrated contraction is mainly inelastic in the form of aseismic fault slip. However, a complete scale characterization of the deformation source was not possible due to limited spatial resolution of the GPS data.
In December 2010, the Association for the Development of Earthquake Prediction (ADEP), in collaboration with Nagoya University, constructed 20 continuous GPS sites in Mid-Niigata, for the purpose of monitoring crustal activity around the Western Nagaoka Basin fault, one of major active faults in this area. Analysis of this network with GEONET allows a better characterization of the deformation source in the area.
We evaluate the response of Mid-Niigata during the preseismic (2008/3-2011/2) and postseismic period (20013/3-2016/2) of the Tohoku-oki earthquake. We calculate horizontal strain rate distributions from the displacement rate data using the method developed by Shen et al. (1996), with a distance decay constant of 15 km. Then, we decomposed the E-W strain rate with respect to its wavelength following Meneses-Gutierrez and Sagiya (2016). We found a persistent localized contraction in the short wavelength component within 40 km before and after the Tohoku-oki earthquake. However, differences in the amplitude and horizontal location of the localized deformation suggested that elastic heterogeneities of the crust, acting in different sense before and after the earthquake, might affect the deformation in Mid-Niigata. Localized deformation in the preseismic and postseismic period was modeled across a longitudinal profilie considering an aseismic east dipping fault and an elastic heterogeneity as the source of deformation. We found that the data is better explained by faults cutting the lower crust and part of the upper crust with a dipping angle of 30-40º with a slip rate larger than 10 mm/yr and an elastic heterogeneity with a horizontal width of 50km located above the fault. Although our model is simple, it is effective in showing that the contribution from both, elastic heterogeneities within the upper crust and aseismic fault slip on the lower crust and part of the upper crust, are necessary to explain the deformation in the Niigata region. Such discussion was not possible before due to the lack of spatial resolution in the area.

Keywords: Crustal deformation, GPS, Niigata-Kobe Tectonic Zone