Extraction of inelastic deformation in the Tohoku region by analyzing spatio-temporal changes of horizontal/vertical GNSS velocities

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In northeast Japan, significant crustal deformation has been observed by the continuous GNSS network (GEONET) and its pattern has changed drastically before and after the 2011 Tohoku-oki earthquake. These spatio-temporal variations of the crustal deformation reflect various processes such as locking or slipping on the plate subduction interface, activities of inland active faults and volcanoes, and the mechanical properties of the island arc crust. Meneses-Gutierrez and Sagiya (2016) demonstrated that crustal deformation in the northern Niigata-Kobe tectonic zone contains significant contribution of inelastic deformation. However, detailed characteristics of the inelastic behavior are still under investigation. In this study, in order to separate elastic and inelastic deformation in the northeast Japan, we analyze temporal change of spatial distribution of horizontal as well as vertical velocities at the GNSS stations located in the Tohoku region. We divide preseismic and postseismic periods of the 2011 Tohoku-oki earthquake into multiple periods every two years, and calculate horizontal and vertical displacement rates of GEONET stations located in the Tohoku region for each period. Spatial distribution of these velocities is examined using three longitudinal profiles in the northern, the central, and the southern part. During the preseismic periods, E-W convergence and the subsidence along the Pacific coast is evident, mainly reflecting elastic deformation due the plate coupling. On the other hand, a localized contraction can be identified along the Ou Backbone Range and at the Oga Peninsula, indicating localized inelastic deformation in the crust. In the postseismic periods, the horizontal and vertical velocities show contrasting behaviors. Vertical velocities in the northern and the central profiles show a rapid (10~20 mm/yr) localized subsidence of the Ou Backbone Range. Also, while the horizontal velocity rapidly decrease over time, the vertical velocity pattern looks pretty persistent throughout the postseismic period. If we consider deformation of an elastic medium due to external fixed sources, horizontal and vertical displacement components should be in proportion each other. The observation suggests that the vertical velocity pattern reflects an effect of localized inelastic deformation source.

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