

Spatiotemporal interplate locking and aseismic slip distributions estimated by tectonic crustal deformation prior to the 2011 Tohoku-Oki earthquake

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We obtained the horizontal and vertical tectonic crustal deformation in the Tohoku district, by analyzing time series of the GEONET data. We investigated GEONET data for seven years just prior to the 2011 Tohoku-Oki earthquake (M9.0). We set the average displacement rate of three GNSS stations, namely, Murakami, Kurokawa, and Shibata in Niigata prefecture as a reference. Chebyshev polynomials enabled high-precision estimation of the tectonic crustal deformation. We determined an optimal order of the polynomials, by minimizing AIC. After correcting offsets caused by coseismic crustal deformation and antenna exchange in the time series, we fitted logarithmic curve to horizontal data to eliminate the effects of postseismic crustal deformations of the following four large earthquakes: the 2003 Tokachi-Oki (M8.0), the 2004 Kushiro-Oki (M7.1), the 2005 Miyagi-Oki (M7.2), and the 2008 Iwate-Miyagi nairiku earthquakes. Then, we obtained the tectonic crustal deformation, by subtracting common-mode errors calculated by using all the used GNSS stations and the annual and semi-annual periodic signals from the time series. During the analyzed period, the westward horizontal displacement rates of approximately 2 cm/year were identified in Iwate and Miyagi prefecture on the Pacific Ocean side. We also found that the westward horizontal displacement rates became gradually smaller in Fukushima prefecture on the Pacific Ocean side during the period from 2008.0 to 2011.0 Then, we performed the inversion analyses for the tectonic crustal deformation with a time interval of one year, and estimated spatiotemporal interplate locking and aseismic slip distributions. We used the geometry model of the Pacific plate by Nakajima and Hasegawa (2006). We employed an inversion analysis which includes the following three prior constraints: the spatial slip distribution is smooth to some extent, slip directions are mostly oriented in the direction of plate convergence, and the temporal change in locking and slip distributions was smooth to some extent (Yoshioka et al., 2015). Optimal values of the hyper-parameters were determined objectively and uniquely, using ABIC minimization method (Akaike, 1980). The results of our inversion analyses revealed locking of approximately 10 cm/year at the offshore of Miyagi prefecture during the period from 2004 to 2010, indicating strong interplate coupling. We also found that locking was 2 cm/year at the middle of offshore Sanriku in 2004, and it became gradually smaller and almost disappeared in 2010.

Keywords: GNSS, plate motion