Spatiotemporal Distributions of Interplate Coupling and Aseismic Slips Prior to the 2011 Tohoku-Oki Earthquake Inferred From GNSS Data

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We obtained horizontal and vertical tectonic crustal deformations in the Tohoku district, Japan, by analyzing time series of the GEONET data for 15 years prior to the 2011 Tohoku-Oki earthquake (M9.0). We expressed tectonic crustal deformations, using the Chebyshev polynomials, and determined their optimal order, by minimizing AIC. After correcting offsets caused by coseismic crustal deformations of large earthquakes and antenna exchange in the time series, we obtained tectonic crustal deformations with respect to the average of three GNSS stations in Niigata prefecture, by excluding annual and semi-annual components, common-mode errors, and postseismic crustal deformations for the 2003 Tokachi-Oki (M8.0), the 2005 Miyagi-Oki (M7.2), and the 2008 Iwate-Miyagi nairiku earthquakes.

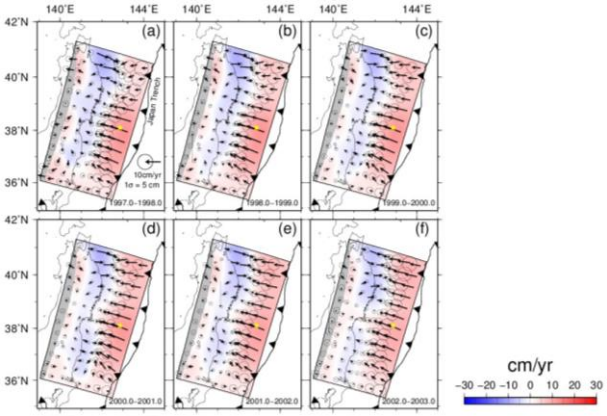

Figure 1. Spatiotemporal distributions of interplate locking and aseismic slips whose direction and magnitude are expressed by black arrows. The circles at the tip of the arrows represent estimation errors (1σ). Red and blue areas denote interplate locking and aseismic slips, respectively. The yellow star indicates the epicenter of the 2011 Tohoku-Oki earthquake.

Then, we performed an inversion analysis for the tectonic crustal deformations with a time interval of one year, and estimated spatiotemporal distributions of interplate coupling and aseismic slips on the plate boundary between the Pacific and the North American plates. We employed the inversion analysis which includes the 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 distributions of locking and aseismic slips are smooth to some extent [Yoshioka et al., 2015]. Optimal values of the hyper-parameters were determined objectively and uniquely, by minimizing ABIC [Akaike, 1980].

The results of our inversion analysis revealed locking of approximately 9 cm/year at the offshore of Miyagi prefecture throughout the analyzed period, indicating strong interplate coupling (Figure 1). In the southern part of the Sanriku region, compared the coupling distribution in 2009 with that in 2010, the coupling in the latter was found to be weaker by 4 cm/yr than the former. The obtained coupling distributions during the period from 1997 to 2003 were almost similar to those of Ikuta et al. [2012], which were obtained by an annual inversion analysis. Accelerated displacements at the GNSS stations in the Tohoku district shown by Mavrommatis et al. [2014] were also identified.