Spatio-temporal evolution of inter-plate coupling during 2002-2007 beneath Tohoku district estimated from GPS data

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1. Introduction

Subduction of the Pacific plate beneath the Tohoku district, NE Japan, causes several large earthquakes that repeatedly occur at the coupling zone of the plate interface between subducting oceanic and the landside continental plates. An M7.5 class earthquake in the Miyagi-Oki region, *Miyagi-Oki Earthquake*, especially has been expected to occur with the about 40 years of recurrence interval, and the probability of the occurrence of next earthquake in this 30 years is estimated about 100 %. On 16 August 2005, an M7.2 earthquake occurred in the Miyagi-Oki region and broke a part of the rupture area of the last Miyagi-Oki Earthquake in 1978. The event in 2005 caused postseismic slip on the plate boundary, and the analysis with respect to the postseismic slip indicated that the unbroken part of the rupture area of the last event is still coupled. The result, however, also pointed that we need eliminate the crustal movement due to the deformation around the Miyagi-Oki region to estimate the interplate coupling in the Miyagi-Oki region in detail.

We estimated distributions of the coupling distributions based on the surface displacement rate obtained from GPS data. We had already reported the results at fall meeting of the Seismological Society of Japan in 2007, but several errors of the analysis procedures were unveiled after the presentation. Especially, the calculation of ABIC (Akaike's Bayesian Information Criterion) under the assumption that the slip deficit is not negative was not appropriate. Thus, we reconstructed the procedures to estimate long-term trend of the displacement at each GPS site and to optimize the weight of constraint conditions, and we applied the procedures to GPS data obtained from 2002 to 2007 in Tohoku district. Here, we introduce the analysis procedures and the estimated distributions of plate coupling.

2. Data and analysis

We used data that are observed by continuous GPS sites of Tohoku University and the Geographical Survey Institute of Japan to estimate the time series of the site displacement. We extracted displacement rate field from the site displacement time series by fitting the function that consists of long-term trend(s), annual and biannual trigonometric curve, and steps due to the earthquakes and antenna replacements. The long-term trend are estimated for the periods of every year, before and after the event in 2005, and throughout 7 years from 2002 to 2007, and we obtained the displacement rate field from these long-term trend for each period.

Fukuda and Johnson (2008) claimed that usage of non-negative least square algorithm makes the inversion method of Yabuki and Matsu'ura (1992) inconsistent because of the fault of ABIC calculation under the non-negativity constraint. They suggested alternative method to overcome the problem. However, we doubt that their treatment of the Laplacian operator for the spatial smoothing is sufficient. They included boundary condition in the Laplacian operator matrix in order to prevent the rank deficient for a plane fault (Fukuda, 2008, personal communication), but the weight between the boundary and smoothness constraint conditions are not optimized. We constructed the method in which the weights of the three constraint conditions about spatial smoothing, boundary value, and dumping to the initial value are optimized by minimizing ABIC.

3. Result

Estimated slip deficit distributions generally consist with the ones reported in 2007. The results indicate that the coupling at the rupture area of the 1994 Sanriku-Haruka-Oki Earthquake has already recovered, strong coupling does not exist beyond the western limit of the low-angle thrust earthquakes and small repeating earthquakes, and plate interface beneath the back bone range are weakly coupled. Especially, the weak coupling in the deeper portion might vanish after the event in 2005, while it had been observed before the event occurred.