Time dependent block fault modeling of Japan

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Abstract
We developed a time dependent block fault modeling program and applied it to the GNSS data in Japan. The results based on the data before the 2011 Tohoku earthquake shows afterslips of the 2003 Tokachi-oki earthquake, weakening and restoration of coupling off Miyagi area afther the 2005 Miyagi-oki earthquake, weakening of coupling off Ibaraki and Fukushima after the 2008 off Ibaraki and Fukushima earthquakes, which continued just before the 2011 Tohoku earthquake. The analysis of the GNSS data after the 2011 Tohoku earthquake shows Bungo slow slips, east coast Kyushu slow slips, Kii channel slow slips.

Introduction
It is very important to estimate interplate coupling in subduction zones to assess the source region and magnitudes of the expected subduction earthquakes in Japan. In particular, the probabilities of the anticipated Tokai and Nankai earthquakes are estimated to be high within 30 years period. Under this circumstance, many studies to estimate interplate coupling were conducted. However, those studies did not take into consideration temporal changes. In this study, we developed a time dependent block fault modeling program and applied it to the nationwide GNSS data.

Analytical Method
Hashimoto et al. (2000) conducted a block fault modeling of Japan based on GNSS data. We used the geometry of the block fault model of Japan adopted by Hashimoto et al. (2000). In inland area, we modeled boundaries of the microplates of Japan by rectangular faults and used parametric spline surfaces in subduction zones along the Japan trench, Sagami trough, and Suruga and Nankai troughs. Base on the adopted block fault model of Japan, we estimated interplate coupling on the plate interface by employing the time dependent inversion program which was developed by this study. We used east-west, north-south, and up-down position time series of GNSS data at approximately 1200 GNSS sites in Japan for the periods between 1997-2011 before the 2011 Tohoku earthquake and between 2013-2015 after the Tohoku earthquake.

Results and discussion
The result shows afterslip of the 2003 Tokachi-oki earthquake (M_w8.0) on the plate interface between the Pacific plate and the continental plate. The afterslip was observed in source regions of the 2003 Tokachi-oki earthquake and the afterslip area moved to northeast over time. The weakening and restoration of interplate coupling after the 2005 Miyagi earthquake (M_w6.8) was observed for the period between 2005 and 2007. Weakening of the coupling off Ibaraki and Fukushima was observed after the 2008 Fukushima (M_w7.0) and Ibaraki earthquakes (M_w6.9). This weakening continued just before the 2011 Tohoku earthquake. With regard to the Philippine Sea plate, our result shows Bungo slow slip in 1997, 2003, and 2010 in the Bungo channel area between Shikoku and Kyushu Islands. In addition, interplate coupling was weakened in 2002 and 2005 in the Pacific coastal area of Kyushu Island, indicating slow slips in this region. For the data set after the Tohoku earthquake, we detected the Bungo slow slip in 2013 and 2016, and the Pacific coastal area slow slips of Kyushu Island, and Kii channel slow slip. These result were derived without detrending of position time series, suggesting the effectiveness of

the developed time dependent block fault modeling.

Keywords: block fault modelong, interplate coupling, slow slip

