Spatio-temporal variation of the postseismic deformation of the 2011 Tohoku Earthquake based on terrestrial and seafloor observations

*Takeshi Iinuma[1], Yusaku Ohta[2], Satoshi Miura[2,4], Jun Muto[3,4], Fumiaki Tomita[2], Motoyuki Kido[4,2], Ryota Hino[2,4]

1. Japan Agency for Marine-Earth Science and Technology, 2. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 3. Department of Earth Science, Graduate School of Science, Tohoku University, 4. International Research Institute of Disaster Science, Tohoku University

Introduction

On March 11, 2011, the 2011 Tohoku Earthquake (M 9.0) occurred on the plate boundary between the subducting Pacific and overriding continental plates. Clear postseismic deformations are still being detected in terrestrial and seafloor geodetic observations on and around the Japanese Islands, although almost six years have passed since the event.

Sun *et al.* [2014] constructed a viscoelastic structure model based on a horizontal displacement time series from terrestrial and seafloor stations from April to December, 2011 (Period A) by means of the Finite Element Method (FEM). Iinuma *et al.* [2016] applied the FEM model to exclude the effect of viscoelastic relaxation from the observed displacement time series in order to estimate the distribution of postseismic slip on the plate interface.

Recently, Tomita *et al.* [2017, in Review] reported displacement rates at seafloor stations that were newly installed in 2012. They concluded that there is a strong trench-parallel variation in the postseismic displacement rates derived from the difference between dominant postseismic deformation factors. For instance, viscoelastic relaxation is primarily around the main rupture area of the Tohoku Earthquake, while the postseismic slip strongly affects areas south of the main rupture. In this study, we investigated the postseismic deformation field using displacement rates at the seafloor and terrestrial geodetic stations.

Data

We estimated displacement rates based on the daily coordinates at the GNSS continuous stations at the Geospatial Information Authority of Japan and Tohoku University during the period from September 2012 to May 2016 (Period B). The same period in which Tomita *et al.* [2017] estimated displacement rates at the seafloor stations. The displacement rates at the terrestrial GNSS stations were estimated by taking differences between the monthly average positions in May 2016 and September 2012.

Results and Discussion

The difference between the horizontal displacement rate fields in Periods A and B are not initially apparent. Taking a trench-normal profile that runs through the main rupture area of the Tohoku Earthquake, in the forearc region, the trench-normal displacement rates during Period B were as large as one fourth of those in Period A. The B:A ratio increases nearly monotonically, to one third, with distance from the Pacific coast. In contrast, the differences between the vertical components in Periods A and B are very clear. The large local subsidence around the Ou Backbone Range observed in Period A had almost vanished in Period B, while the uplift rates in Period B were more than half those in Period A. The low viscosity beneath the Ou Backbone Range hypothesized by Muto *et al.* [2016] to account for the large local subsidence, also accounts for the rapid decay of local deformation.

As described, the inland rheological heterogeneity strongly affects the vertical displacement rate field, while large spatial scale deformations dominate the horizontal displacement rate field. These observations suggest that viscous flow in the mantle wedge and beneath the oceanic lithosphere is the main factor controlling the horizontal displacement field.

Therefore, we estimated the distribution of interplate coupling and postseismic slip based on horizontal displacement rates and applying Sun *et al.* [2014]' s model to exclude the effects of viscoelastic relaxation. Preliminary results indicate that postseismic slip occurred at the shallow plate interface off the Fukushima and Ibaraki Prefectures and at the deep portion beneath the Pacific coast of the Iwate Prefecture during Period B, the same as Period A. Estimated back-slip in the main rupture areas of the 2011 Tohoku Earthquake indicates interplate coupling at the main rupture area has already recovered.

Keywords: The 2011 Tohoku Earthquake, Postseismic deformation, Seafloor geodesy, GNSS, Postseismic Slip, Viscoelastic relaxation