Spatio-temporal evolution of after-slip following the 2003 Tokachi-oki earthquake estimated by GPS

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Introduction

An interplate thrust earthquake with M8.0 occurred off Tokachi, Hokkaido, Northern Japan on September 26, 2003. GPS measurements conducted by the Geographical Survey Institute (GSI) revealed clear co- and post-seismic crustal deformations due to this event. This type of large earthquake releases stress built up due to interplate coupling, and thus it is important to evaluate the variation of postseiemic slip in space and time. There occurred another interplate thrust event with M7.1 off Nemuro, about 100 km northeast of the rupture area of the M8.0 event on November 29, 2004. This drives us to the question whether the co- and post-seismic slip of the M8.0 event might affect the occurrence of the M7.1 event. In this study, we investigate the spatio-temporal evolution of postseismic slip on the plate boundary using deformation data derived by GPS.

Analysis

We utilized a geodetic inversion technique devised by Yagi and Kikuchi (GRL, 2003). The geometry of the plate boundary was assumed from the iso-depth contours derived by Hasegawa et al. (JGR, 1994). We put a model fault on the plate boundary and divide it into 13 by 10 sub-faults. The slip-rate function at each sub-fault is represented by a series of isosceles triangles. Slip angle was constrained in the range of –90 +/-45 degree (normal slip) or +90 +/- 45 degree (reverse slip).

The precise point positioning technique of GIPSY software (Zumberge et al., JGR, 1997) was used to obtain the horizontal displacements at 122 GEONET stations. The preseismic trend, annual and semi-annual constituents were estimated using displacement data at each station for the period from January 1, 1999 to September 25, 2003, and then they were extracted for the inversion.

Result

Spatio-temporal distribution of the postseismic slip for 400 days after the M8.0 event was estimated by the inversion. The area of the dominant postseismic slip grew at the south of the coseismic rupture area, extending to the northeast, say, the direction of the forthcoming M7.1 event. There is a minor local maximum of forward slip of about 40 cm beneath the area between Obihiro and Kushiro at a depth of about 100 km. The cumulative seismic moment in the whole study area amounts to about 9.7E+20 Nm, which is equivalent to Mw 7.9. The after-slip distribution estimated by this study is complementary to the coseismic rupture area estimated by waveform inversions (e.g. Yagi, EPS, 2004). This characteristic has already been pointed out for the cases of the 1996 Hyuga-nada events (Yagi and Kikuchi, GRL, 2003) and the 1994 Sanriku-Haruka-Oki earthquake (Yagi et al., GRL, 2003). The quasi-static slip distribution estimated by Uchida et al. (this meeting) using repeating earthquakes coincides with the area of 60 cm slip or more estimated by the geodetic inversion. Comparing the time evolution of slip obtained by the two different methods, the slip amount estimated by GPS exceeds that by repeating earthquakes in general. In the best case, however, the quasi-static slip by repeating earthquakes amounts to about 70 to 80 % of geodetic estimation in regions demonstrating the major postseismic slip. This suggests that the scaling law used to convert magnitudes of repeating earthquakes to the quasi-static slip (Igarashi et al., JGR, 2003) is plausible.