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Slip deficit rate distribution and its temporal changes along the Japan islands

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The Japan islands are located along several plate boundaries, where the oceanic plates are subducting beneath the continental plates. Due to this subduction, slip deficits are being generated and strain is being accumulated in coupled zones of the plate boundary so that many large earthquakes have occurred. Therefore, in order to reveal the generation mechanism of large earthquakes at the plate boundaries, it is necessary to clarify slip deficit rate distributions. In addition, as seen in long-term slow slip events, there are significant temporal changes in the slip deficit rate distributions. In this study, we determined the slip deficit rate distribution along the whole Japan islands for each year from 1996 to 2010 (the observation period of GEONET operated by GSI before the 2011 Tohoku earthquake) using the inversion method, and compared each other to investigate their temporal changes.

For calculating the deformation fields in Japan, we used the daily coordinates of F3 solutions. We obtained daily time series data considering the movements of the continental plates against reference frame and removing the offsets and postseismic effects due to nearby earthquakes. We then derived horizontal rate fields in Japan for each year by least-squares fittings. For reflecting the geometry of the plate boundaries, we used the plate model (Baba et al., 2005) incorporated in JIVSM (Koketsu et al., 2012). The Green's functions were calculated using the frequency-wavenumber method (Zhu and Rivera, 2002). We performed slip deficit inversions using the method of Yoshida et al. (1996).

The slip deficit rate distributions derived from the inversions were consistent with the previous study and the plate convergence rates. In addition, known long-term slow slip events were found in the temporal changes of the slip deficit rate distributions. Furthermore, we can see the temporal changes in the Hokkaido and Kanto regions, which suggest variations of plate coupling in these regions. The zones of large slip deficit rate in the distributions look corresponding to the source regions of past megathrust earthquakes. These correspondences are significant not only in Earth science but also in seismic hazard assessments.

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Keywords: the Japan islands, crustal deformation, GPS, slip deficit, megathrust earthquake