Spatial variation of slip deficit at the Nankai Trough estimated from three-dimensional GPS velocities

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The Philippine Sea plate has subducted beneath Southwest Japan at the Nankai Trough causing large earthquake repeatedly. The subduction process shows lateral variations such as a bending of the plate interface beneath the Kii Peninsula and rapid changes of strike and dip of the plate interface west of off Shikoku. In this study, we invert three-dimensional GPS velocities using ABIC geodetic inversion technique (Yabuki and Matsu'ura, 1992) to estimate slip deficit distribution on the Nankai Trough plate interface. The studied area is from the Kii peninsula to eastern Kyushu (131.5-137E, 31-35N).

In the ABIC geodetic inversion some constrains were needed to stabilize solutions such that fault slip at the edge of the region was set to zero. In some cases, however, these constraints produced unrealistic estimates in the margin of the region. In this study we adopt iterative inversion technique that repeats inversions laterally shifting target area (Tsuka and Tabei, 2006). This method doesn't adopt low-reliable estimates obtained in the margin but make averaging using high-reliable estimates from the internal region. As a result effect of constraints is minimized and final estimates are stabilized regardless the setting of the region.

Horizontal and vertical velocities were derived from long time series (1998.0-2007.5) of the final F2 solutions of GEONET. We used velocities at 241 sites distributed form Kii peninsula to northern Kyushu. The time series sometimes included offsets due to antenna change and earthquake occurrence. We correct them and calculate linear velocities. For those stations which were affected by the 2003 slow slip event beneath the Bungo Channel and the 2004 off Kii Peninsula earthquake, velocities were calculated from shorter length time series before the events. This is because it was difficult to quantify total amount of transient movements and delete their effects. Calculated horizontal velocities were then converted to the Amurian plate fixed frmae using REVEL (Sella et al., 2002). We used new plate boundary configuration that was renewed from hypocenter distribution and structural exploration in Southwest Japan (Yoshioka and Murakami, 2007).

Distribution of estimated slip deficit is in accordance with the plate boundary configuration. Plate coupling that is defined as a ratio of the estimated slip deficit to the relative plate velocity is 90-100% at 10-25 km in depth and 40-80% at 25-35 km. It is notable that the region of the maximum plate coupling off Sikoku and Kii peninsula nearly overlaps with the region of the maximum slip at the 1946 Nankai earthquake. Estimated slip deficit vectors are generally parallel to the direction of plate convergence. In more detail, however, vectors are oriented more westerly by about 10 degrees in the east and west of the maximum coupling region. This is considered as an effect of non-recoverable slip motion of the Nankai forearc block. In addition, westerly-oriented velocities are recognized in the eastern part of the studied area. This can be interpreted as an effect of collision between the Northeast and Southwest Japan arcs. In a future study, we need to take into consideration lateral slip motion of the forearc block and arc-arc collision.