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A new interpretation of the slow slip event in the Tokai region

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In the Tokai region, central Japan, anomalous displacements had been detected by GEONET during the period from mid-2000 to mid-2005 and they seem to have been caused by a slow slip event (SSE) beneath the Lake Hamana and have been called as “Tokai SSE”. Previous studies introduced the Tokai SSE by the inversion of data which is the difference between the observed displacements and the displacements due to the continuous plate coupling. However, this model has no physical meaning. The present study claims that the combined effects of the slow slip events (or forward slip) and the plate coupling (or so-called back slip) should represent the state of the plate interface. In addition, the temporal change of the plate coupling has not been taken into account in the previous studies. In this study, we estimated the state of the plate interface by the geodetic inversion method without the assumption of the steady state coupling in order to estimate the temporal change of the coupling and slip process on the plate interface.

The data used in this study are the GPS data taken from the GEONET and the leveling data published by GSI for the period from July 1996 to June 2009. In order to examine the temporal change, we divided the entire period into 12 epochs. The duration of each epoch is two years and the neighboring two epochs overlap one year. The two-year averaged rate of crustal deformation are derived from the GPS data and the leveling data separately and are taken into the geodetic inversion simultaneously.

The estimated distributions of the strain accumulating and releasing areas, by which “strain accumulating area” indicates a area of slip deficit and accumulates in the continental wedge and vice versa, suggested that the whole period was able to be divided into three sub-periods depending on the emergence of the strain releasing area. The strain releasing area emerged in the period from 2000 to 2005, which is consistent with the duration of the Tokai SSE in the previous studies. The maximum value of the strain releasing was about 20 mm/yr and the depth was around 30-40 km, while the maximum value of the Tokai SSE was about 35-50 mm/yr in the previous studies. Compared with the previous studies, the present study showed that only the deeper portion of the Tokai SSE really released the strain. The total amount of the released strain was equivalent to the seismic moment of Mw ˜ 6.6, while the Tokai SSE was equivalent to Mw ˜ 7.0 to 7.1. Therefore the previous studies overestimated the released strain.

The spatial distribution of the interplate coupling also changed temporally, whereas the coupling of the area had been assumed to be time invariant in the previous studies. It had extended along the plate interface to a point beneath the Lake Hamana before the emergence of the strain releasing area, and then became narrower with the emergence of the strain releasing area, and then had not recover the original distribution after the end of strain releasing process. Although the distribution of coupling changed with time, the maximum value of the interplate coupling did not change; 35 mm/yr through the entire period from July 1996 to June 2009. The maximum value estimated in this study were almost the same as the maximum coupling estimated by the previous studies.

The results also revealed that the distribution of the strain releasing area well coincide with the hypocenters of the low frequency events which occurred repeatedly near the plate boundary. The previous studies inferred that the distribution of the Tokai SSE is shallower than that of the strain releasing area in the present study.

Therefore the Tokai slow slip and the low frequency events were thought to be spatially segregated. The results of present study may require a change of the view about the relationship between these two sorts of strain releasing processes, which may be important for the study of background physics.