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Various properties of the interplate slip estimated from slow earthquake phenomena in subduction zones

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In southwest Japan, deep slow earthquakes frequently occur at the interface between the subducting Philippine Sea plate and overlying plate at depths of 20 - 30km. These slow earthquakes reflecting the subduction process are composed of some phenomena having different characteristic time. The long-term slow slip event (SSE) and short-term SSE are crustal deformation with time duration of years and several days, respectively. The short-term SSE usually occurs associated with very low frequency earthquake with a predominant period of 20 seconds and low frequency tremor with dominant frequency of a few Hz. The long-term SSE occurs between the short-term SSE region and the locked zone. These SSEs reflect the different slip properties on the plate interface.
The low frequency tremors are distributed along the strike of the subducting Philippine Sea plate at the deeper side of the megathrust seismogenic zone. The belt-like tremor distribution is separated into some segments. In each segment, the tremor occurs at a certain recurrence interval and migrates during each active stage. Sometimes, the migration of tremors reaches to the neighbor segment. If the tremor is triggered by the occurrence of the short-term SSE, the tremor is considered as an effective monitor tool for the space-time evolution of slip. Recently, we developed a hybrid method based on the envelope correlation considering spatial distribution of amplitude. Then, we constructed the new tremor catalog extracting the centroid location from 1-hour tremor distribution by the hybrid method. As a result, the spatial resolution of tremor activity has been improved especially in the dip direction of the slab. The tremors are concentrated along two parallel lines at the deeper and upper sides of the transition zone in western Shikoku and northeastern Kii area. The shallow alignment becomes active during major episodes accompanied by the short-term SSE. On the other hand, the deeper tremor activity is rather stable and minor tremor frequently occurs. Because the deeper side from the tremor source area is the stable sliding zone, the deep tremor activity might be a boundary between the stable sliding zone and the short-term SSE zone, which is the weak stick-slip zone.
Around the Bungo channel area, the width of the double tremor alignments becomes narrower from Shikoku to Kyushu. Around this area, the long-term SSE occurred in 1996-97 and 2003. During the 2003 episode, the short-term SSE occurred at three month interval although it usually occurs every six months. Moreover, minor tremor activity continued for two months in the Bungo channel area. Reanalyzing the tremor activity based on the new catalog, the activated tremor was concentrated at the shallower part of the tremor zone. On the other hand, the tremor activity in the deeper part was stable. The shallow alignment of the tremor is well consistent with the deeper limit of the slip area of the 1996-97 long-term SSE estimated by Yagi and Kikuchi (2003). This suggests that the shallower tremor alignment is the boundary between the long-term SSE and short-term SSE regions.
Such variation of slip property is expected to be caused by the difference of the underground structure. Based on the seismic exploration in the Tokai area including both regions of long-term and short-term SSE, the reflection intensity from the tremor and short-term SSE region is stronger than that from the long-term SSE region. Based on the tomography analysis, the upper part of the

plate interface is characterized by high Vp/Vs ratio for both regions of long-term and short-term SSE. Taking into account the P wave velocity, the upper part of the long-term SSE region is the lower crust including fluid and the upper part of short-term SSE region corresponds to the surpentinized mantle wedge. The material difference on the plate interface may control the slip property.

Keywords: subduction zone, slow earthquake, low-frequency tremor, very-low-frequency earthquake, slow slips event