Numerical modeling of long- and shallow slow slip events including shallow region in Hyuganada and western Nankai, Japan

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Recent studies reported deep long-term slow slip events (SSEs) in the Hyuganada and western Nankai region (e.g., Kobayashi, 2014; Takagi et al., 2016; Ozawa. 2017). Shallow SSEs are also recently reported with low-frequency tremor and very low-frequency earthquakes (e.g., Araki et al., 2017; Nakano et al., 2018). In our previous study, we have numerically reproduced recurring deep long- and short-term SSEs in the Shikoku region (Matsuzawa et al., 2013), considering the actual distribution of slow earthquakes and configuration of the subducting Philippine Sea plate. We aim to reproduce deep long- and short-term SSEs and shallow SSEs in a single numerical model applying a similar approach in Matsuzawa et al. (2013).

We adopt a rate- and state-dependent friction law (RS-law) with cutoff velocities. We assume that (a-b) value in the RS-law is negative within the deep short-term SSE region, and positive outside that region. The deep short-term SSE region is modeled based on the actual distribution of deep low frequency tremor. Deep long-term SSE region is assumed based on the geodetic observation (Hirose et al., 2011). To focus on the Hyuganada and western Nankai region, we assume stable sliding region with positive (a-b) in the south of the Kyushu-Palau ridge. We also assume low cutoff velocity at the depth shallower than 9 km to reproduce shallow SSEs. Low effective normal stress is assumed at the depth of SSEs. Temporal evolution of slip velocity is numerically simulated, introducing elastic response and realistic configuration of the plate interface.

In terms of deep long-term SSEs in Hyuganada, a simple extension of the long-term SSE region in the Bungo Channel cannot reproduce the segments of observed SSEs. Narrowed long-term SSE region in the dip direction between Bungo and southern Hyuganada can reproduce three observed segments of SSEs, i.e., Bungo, northern Hyuganada, and southern Hyuganada. In addition, recurring shallow SSEs along trench in Hyuganada and off Ashizuri are reproduced in our result. Megathrust earthquakes are divided into two regions; off Shikoku and Hyuganada in our result. The segments of these large earthquakes may be attributed to the long-term SSE region in the Bungo Channel. Our model comprehensively reproduces various SSEs and megathrust earthquakes, including newly found long-term SSEs.

Keywords: Slow Earthquake, Slow Slip Event, Hyuganada

