Modeling short-term slow slip events and the associated very-low-frequency earthquakes in southwest Japan subduction zone

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Recent observational studies have revealed the detailed activities of short-term SSEs and low-frequency earthquakes in western Japan (e.g. Ito et al., 2006; Obara et al, 2007). To understand the loading processes for megathrusts along the Nankai subduction zone, it will be important to model these short-term SSEs considering a realistic 3D geometry of the subduction interface. Based on the study by Shibazaki and Shimamoto (2007), we have developed a 3D model of short-term SSEs on the 3D subduction interface beneath Shikoku, western Japan considering a rate- and state-dependent friction law with a small cutoff velocity to an evolution effect. We assume that the pore-fluid pressure is nearly equal to the lithostatic pressure and the critical weakening displacement is very small at the generation zone of SSEs. The occurrence of SSEs is very complex: the generation zone of SSEs is divided into several segments in the horizontal direction. The mode of segmentation depends on the width of the generation zone. When the width of the generation zone is sufficiently small, significant segmentation occurs. On the other hand, when the width of the generation zone is large, multisegment events can occur that extend horizontally over the entire region. From the epicentral distribution of deep, low-frequency tremors, we set the width of the generation zone of SSEs where it is wider beneath the western part of Shikoku than the eastern part of Shikoku. We can reproduce events with longer lengths in the horizontal direction beneath the western part of Shikoku with longer recurrence times. The numerical results are consistent with the observation by Obara (2007) that the events at longer segments have longer recurrence intervals.

We have also attempted to model the very-low-frequency earthquakes observed by Ito et al. (2006) that are accompanied by short-interval SSEs. The scaling relationship between the moment and the duration of slow eartquakes, as proposed by Ide et al. (2007), suggests that the rupture velocity of slow earthquakes increases with the decrease in the size of the events. Therefore, to reproduce the low-frequency earthquakes, a nonuniform fault zone structure in which the local rupture with a high rupture velocity occurs along with the propagation of short-interval SSEs must be considered. We consider a local patch where the critical displacement is extremely small. We then confirm that high-speed multiple slips occur in the local patch with a small critical displacement with the occurrence of short-interval SSEs. For the modeling of low-frequency earthquakes with the propagation of SSEs, it will be necessary to consider the scaling property such that the critical weakening displacement is proportional to the size of the patch.