Investigation on various generation modes of short-term silent slip events at the deeper subduction interface

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Recent high-resolution observations of crustal movements have revealed short-term silent slip events (SSEs) with propagation velocities of around 10-15 km/day and with intervals of 3-14 months along the deeper parts of the Cascadia and Nankai subduction zones. Shibazaki and Shimamoto (2007) developed a model of these short-interval SSEs by considering the frictional behaviour that was experimentally confirmed by Shimamoto (1987) using halite for the unstable-stable transition regime. Recently, Ito et al. (2006) found that very-low-frequency earthquakes are accompanied by and migrates with the activity of deep low-frequency tremors and short-interval SSEs. The present study investigates the scaling relation between the physical parameters controlling the occurrence of these short-interval SSEs and discusses their various generation modes. Furthermore, considering a nonuniform frictional properties along the transition zone, the generation processes of very-low-frequency earthquakes are investigated.

Shibazaki and Shimamoto (2007) have modelled silent slip events considering a rate- and state-dependent friction law with a small cut-off velocity to an evolution effect. When the cut-off velocity to the evolution effect is significantly smaller than that to a direct effect, the steady-state friction exhibits velocity weakening at low slip velocity and velocity strengthening at high slip velocity. By setting the effective stress and critical displacement to be 1 MPa and 0.8 mm, respectively, short-interval SSEs with a propagation velocity of 4-8 km/day and a recurrence interval of 14 months are reproduced. Recurrence intervals of short-interval SSEs along the Nankai subduction zone are 3-6 months. By assuming the smaller value for the effective stress and critical displacement, we can reproduce short-interval SSEs with a recurrence interval of 3-6 months.

Next, we try to model very-low-frequency earthquakes observed by Ito et al. (2006) that are accompanied by short-interval SSEs. A possible scenario for the occurrence of these very-low-frequency earthquakes, as proposed by Ito et al. (2006), is that stronger coupled patches of very-low-frequency earthquakes are surrounded by a region of short-interval SSEs. At the propagation front of a short-interval SSE, the shear stress increases at the patches of very-low-frequency earthquakes, and these patches eventually rupture at a high slip velocity after the shear stress reaches the critical stress level. To model low-frequency earthquakes, we consider a locally unstable zone where the steady-state friction exhibits velocity weakening at even high slip velocity in the unstable-stable region. We confirm that high-speed slips occur in the region of a locally strongly coupled region. We report on whether we can reproduce low-frequency earthquakes by changing the constitutive law parameters.