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Modeling off-Boso slow slip events: toward the evaluation of the occurrence of large earthquakes

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Recent high-resolution observations of crustal movements have revealed the occurrence of slow-slip events (SSEs) in various subduction zones. Because SSEs occur in areas surrounding the source regions of large earthquakes, SSE activity may change during a cycle of large earthquakes (Matsuzawa et al., 2010). Detecting SSEs will be also useful to find the coupled regions where strain is accumulated. SSEs in the eastern part of the Boso peninsula (Boso SSEs) are located on the east side of the source region of the Kanto earthquake. Therefore, monitoring and modeling Boso SSEs will be useful for the evaluation of the occurrence of the next Kanto earthquake. In the present study, we discuss possible mechanisms of Boso SSEs, the possibility of dynamic rupture in the Boso SSE region with the next Kanto earthquake, and point out expectations of the Kanto asperity project from the viewpoint of numerical modeling.

Boso SSEs occur at an interval of approximately 6 years (Ozawa et al., 2003; Sagiya, 2004). The duration of the main event is around a week (e.g. Hirose et al., 2008), but slips continued for a few months for the 2002 event (e.g. Ozawa et al., 2003). Boso SSEs occur at the brittle zone on the east side of the source region of the Kanto earthquake. Possible mechanisms causing the SSEs are 1) velocity strengthening at high slip velocity (transitional property in friction) and 2) an unstable slow slip under nearly stable conditions. In the present study, we model Boso SSEs on the basis of the observational study by Hirose et al. (2008), using the rate- and state-dependent friction law under the nearly stable conditions. In the case where the effective normal stress and critical displacement are around 8 MPa and 1 cm, respectively, our simulation reproduces SSEs at intervals of 5 to 6 years. Because the effective stress is low in the regions of Boso SSEs, the pore pressure is high, or the normal stress is low. Another possible mechanism is that a fault material in which velocity weakening rate in friction exists. Interaction between the Kanto asperity and Boso SSEs is an important problem. If slips occur in the area surrounding the coupled region when a Kanto earthquake is approaching, SSE activity may change because of changes in the loading rate. Also, dynamic rupture may extend to the SSE region when a Kanto earthquake occurs. This depends on the frictional property in the SSE region. In the case where no velocity strengthening occurs at high slip velocity, ruptures easily propagate to the Boso SSE region. In our presentation, we will discuss these problems using numerical simulation results.

To model Boso SSEs, it is necessary to investigate the mechanisms of the SSEs. Therefore, it is necessary to conduct seismological surveys to find whether the pore-fluid pressure is high or if serpentines exist. It is also necessary to investigate the SSE region and details of spatio-temporal development of the SSEs by intensive observations. In particular, we need to investigate the slip behavior at the regions near the source region of the Kanto earthquake and at the east side of the SSE region. We also need to investigate earthquake swarms associated with the SSEs. To predict the occurrence of Kanto earthquakes, long-term monitoring of the SSEs will be necessary. Furthermore, data assimilation using models with various friction laws will be necessary.

Keywords: Slow slip event, off-Boso, Kanto Asperity Project, Modeling