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Earthquake cycles on the bumpy plate interface assuming subducting ridge chain : generation of SSE

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Recently the seismic and the geodetic observation networks have observed the slip events on the plate interface in subduction zones, in multiple scales in time and space. These slip events are densely distributed on the plate interface, and considered to interact to each other. And then, their interactions with large earthquakes are now starting to be investigated, using ECSs (Earthquake Cycls Simulations) (Ariyoshi et al., 2014; Matsuzawa et al., 2013).

When we consider the actual large earthquakes, the fault system such as the topography of the plate interface plays an important role on the occurrence of the earthquakes. However, the previous studies consider only the relatively large scale of the topography for the plate interface (e.g., Hirose and Maeda, 2013). In this study, we focus on the subducting ridge chains in Tokai regions, as the fault topography in the smaller scale. The ridge chain subducts under the Tokai region, central Japan. We can detect them in the bathymetry data (Hirose and Maeda, 2013). From the survey of velocity structure, we can also observe the ridges subduct with the oceanic plate (Kodaira et al., 2004). In the Tokai region, the next Tokai earthquake is anticipated to occur in the first half of this century. In the deeper part of the Tokai region, there have been observed also long-term slow slip events (SSEs) just beneath the Lake Hamana (Tokai SSEs). In this study, we set the bumpy plate interface assuming subducting ridge chain, and examined the slip cycles on the plate interface.

For ECSs, we often use the boundary integral elemental method and the quasi-dynamic scheme, which have smaller computational amount. Such ECSs always consider only the shear stress change but not the normal stress change due to the slip. However, the normal stress changes due to the slip on the fault interface when the fault interface is not flat but has topography. Therefore, in this study, we introduced the static normal stress change to the quasi-dynamic ECSs in BIEM, and examined the slip behaviors on the bumpy plate interface.

Now, as the fault, we set the flat plate interface of 200 km $\times$ 240 km for strike and dip directions, which subducts with the steady subducting velocity of 3.25 cm/year and the subducting angle of 15 degrees. We also set the bumpy plate interface as the fault, which has three bumps with the height of 5 km on the above flat plate interface. And then, we compare the earthquake cycles on the two plate interfaces to investigate the effect of the fault topography. We assume the laboratory derived rate- and state-friction law with the normal stress change (Linker and Dieterich, 1992). We set the uniform initial shear and normal stresses. The frictional parameters are set to be uniform at the region shallower than the depth of 40 km.

Then, even with the frictional condition that produces repeated normal earthquakes, the bumpy fault interface produced repeated slow slips and the earthquakes. A series of the tops and valleys of the ridges exhibit the increase and decrease in the normal stress during the interseismic period. This striped normal stress change can be the cause for recurring slow slip events around the valley of the ridge chain, because the change in the normal stress leads to the change in the friction. The Tokai SSEs are observed at the valley of the ridges. This study shows that the fault geometry can be one of the mechanism of generating the Tokai SSEs, in addition to the existence of high pore pressure.

Keywords: earthquake cycle simulation, normal stress, ridge chain, Tokai SSE