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Modeling the activity of shallow very-low-frequency earthquakes in the region off Tokachi

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Recent observations reveal that very-low-frequency (VLF) earthquakes occur in the shallow subduction zones in the Nankai trough, Hyuganada, and off the coast of Tokachi, Japan (Obara and Ito, 2005; Ito and Obara, 2006; Asano et al., 2008; Obana and Kodaira, 2009; Sugioka et al., 2010; Okamoto et al., 2010). Asano et al. (2010) investigated the details of the shallow VLF earthquake activity in the region off Tokachi and found that the sequences of VLF earthquakes repeat with intervals of a few years before the 2003 off Tokachi earthquake and that the activity became very high just after the 2003 off Tokachi earthquake and then intervals between sequences of VLF earthquakes become longer gradually. They also found that the migration speed of VLF earthquakes is from 10 to 50km/day.

We perform 2D quasi-dynamic modeling of the sequential occurrence of VLF earthquakes in the region off Tokachi in an elastic half-space using a rate- and state-dependent friction law. Tsutsumi and Ujiie (2011) examined frictional properties of clay-rich fault materials collected from a major splay fault within the Nankai accretionary complex under water saturated condition. Their experimental results reveal that there are both velocity-weakening and velocity-strengthening fault materials for slip velocities from 0.026 to 26 mm/s. Their results suggest that both velocity weakening and strengthening regions are comingled in the shallow subduction zones. Since no experiments have been conducted using the fault materials in the subduction zone, NE Japan, we refer to the experimental results by Tsutsumi and Ujiie (2011). We consider several unstable patches of a few km in the stable zone to simulate VLF earthquakes. We set the effective normal stress to be on the order of 1.0 MPa. When we set the intervals between patches to be in a certain range, VLF earthquakes occur sequentially. We can also reproduce the migration speed (10-50km/day) of VLF earthquakes in a certain range of constitutive law parameters. After large earthquakes occur activity of VLF earthquakes is very high due to afterslips but the recurrence intervals between sequences of VLF earthquakes become longer gradually with time. We report the range of constitutive law parameters which explain the activity of VLF earthquakes in the region off Tokachi.

Keywords: modeling, rate- and state-dependent friction law, shallow very-low-frequency earthquake, subduction zone, the region off Tokachi