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Modeling short-interval silent slip events considering frictional properties at the unstable-stable transition zone

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Recent high-resolution observations of crustal movements have revealed occurrences of silent slip events with propagation velocities of around 10-15 km/day and with intervals of 3-14 months along the deeper part of the Cascadia and Nankai subduction zones. This study develops 2D and 3D models of these short-interval silent slip events considering frictional behavior that was confirmed experimentally by Shimamoto (1986) for the unstable-stable transition regime. A small cut-off velocity to an evolution effect is introduced in a rate- and state-dependent friction law to represent this frictional behavior. When the cut-off velocity to the evolution effect is significantly smaller than that of a direct effect, steady state friction behaves as velocity weakening at low slip velocity and velocity strengthening at high slip velocity. At deeper subduction interfaces, pore pressure is inferred to be high because of dehydration of materials in the descending plate. In conditions where pore-fluid pressure is nearly equal to the lithostatic pressure and the critical displacement is very small in proportion to the effective normal stress, short-interval silent slip events can be reproduced. By setting model parameters, the effective normal stress, critical displacement, and cut-off velocity as 1.12 MPa, 0.75 mm, and, 1.0E-6.5 m/s, respectively, silent slip events with a propagation velocity of 4-8 km/day and a slip velocity of 2.0-4.0E-7 m/s are reproduced. We investigate relationship between the maximum slip velocity at the tip of silent slip event and the propagation velocity of silent slip event. It is founded that the propagation velocity of silent slip events is in proportion to the slip velocity. Numerical results also show that, during the nucleation process of large earthquakes, occurrence of silent slip events becomes irregular because of the accelerated slips that occur at the bottom of seismogenic zone. Our numerical results suggest that monitoring of silent slip events is very important for forecasting main earthquakes.