Discrimination between silent slip events and nucleation: the future of the Tokai silent slip event

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To investigate the mechanism of recently observed silent slip events such as the Tokai silent slip events, we simulated earthquake preparation processes using the Dieterich/Ruina rate- and state-dependent friction law. To ensure realistic modeling of the unstable-stable transition, we considered small cut-off velocity to an evolution effect in the friction law for the transition zone. 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. This kind of frictional behavior was experimentally and theoretically confirmed for the transition zone. The results of our numerical simulations show that silent slips of which velocity is higher than the velocity of relative plate motion, eventually propagates horizontally along the unstable-stable transition over a period of several years. Silent slip events can be interpreted as being caused by the transitional behavior of the fault constitutive law.

The geographical survey of Japan (2002) examined cumulative moment for the Tokai silent slip event with time. We can see that the cumulative moment increases linearly with time. We assume the slip velocity state at a certain time to be stationary and compute the non-stationary cumulative moment release associated with the slow event. The computed moment function increases almost linearly with time during the propagation of the slow event. The linearly increasing moment rate function means that the silent slip event is the migration of the high-slip velocity region and the moment release rate is almost constant. This result is consistent with observation. The maximum propagation velocity of a silent slip event reaches 8 km/year, which is very close to the observational value for the silent slip event in the Tokai region (Ozawa et al., 2002). In the case of the nucleation processes, on the other hand, the cumulative moment increases exponentially with time. This means that, in the case of nucleation process, slip is accelerated continuously at the same place. If the Tokai silent slip continues to migrate with the linearly increasing moment rate function, the Tokai slow event is expected to terminate when it reaches the eastern end of the fault area.