Two effects of slow earthquakes on large megathrust earthquakes: Triggering and facilitating of coseismic slip

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We propose that slow earthquakes may have two effects on ordinary megathrust earthquakes, especially in the shallow subduction zone. The first effect is triggering of coseimic rupture by slow slip events; this is well modeled in previous work. The second is facilitation of coseismic slip on a fault which is experiencing slow slip. The fault hosting ongoing slow slip may be more easily induced to slip coseismically if a dynamic rupture from a large earthquake propagates onto the fault.
Before the 2011 Tohoku-Oki earthquake, two shallow episodic tremor and slip events (ETS) were observed in the same area of the 2011 mainshock near the Japan Trench, where the huge coseismic slip exceeding 30 m occurred. The first ETS event occurred over a week in November 2008 and included a slow slip event that exhibited an equivalent moment magnitude of 6.8. Shortly prior to termination of the slow slip, a M6 earthquake was induced by the slow slip event at the down-dip edge of the slow slip rupture area. The second ETS event was observed from the end of January 2011 until just before the 2011 Tohoku-Oki earthquake and exhibited an equivalent moment magnitude of 7.0. This slow slip event induced the largest foreshock (M7.3 on March 9) and probably triggered the March 11 mainshock of the 2011 Tohoku-Oki earthquake. Both of the ETSs clearly trigger interplate earthquakes on the plate interface.
The difference between 2008 and 2011 ETSs is whether they continued or ceased before they induced large interplate earthquakes. To investigate the effect of ETS on coseismic slip occurring on the same fault, we performed laboratory friction experiments on simulated fault gouges. We observed that increases in sliding velocity could induce slip-weakening behavior, which overwhelms the velocity dependence resulting in large overall weakening. Therefore, a fault which is experiencing a transient slip or slow earthquakes may be more easily induced to slip coseismically if a dynamic rupture from large earthquake propagates onto the fault.

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