Geophysical Research Abstracts
Vol. 18, EGU2016-11380-1, 2016
EGU General Assembly 2016

Simulated precursory large aseismic slip at the deeper extension of the seismic region along the Nankai Trough, SW Japan

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At the subduction zone along the Nankai Trough, SW Japan, large earthquakes around M8 had occurred repeatedly. Their intervals (around 100—200 years) have been identified precisely from old historical documents combined with geological surveys (*Sangawa*, 2011). The most recent events occurred in 1944 (the Showa To-Nankai EQ.) and 1946 (the Showa Nankai EQ.) when modern satellite geodetic networks had not been developed yet.

The existence of short-term aseismic processes before the 1944 and 1946 events has been inferred from the leveling or interview records. Two-times level difference measurements showed the displacement of north down before the 1944 event (*Mogi*, 1986), and the water level of some wells were reported to have dropped before the 1946 event (*Sato*, 1982). These phenomena were observed within several days before the earthquakes, and each could have been caused by 2 m slip on the plate interface at the deeper extension of the seismic region before each event (*Linde and Sacks*, 2002).

In this study, we simulate the cycle of large earthquakes in a quasi-dynamic 2D model to investigate aseismic slip acceleration in the deeper extension of seismic fault. We consider a flat plate interface with a shallow dipping angle of 15° for the depth 0—60 km mimicking the Nankai Trough. Following *Nakatani and Scholz* (2006) and *Yoshida et al.* (2013), we introduce an intrinsic cut-off time for healing into the state evolution law of the rate-and-state friction. The intrinsic time leads to a corresponding cut-off velocity (V_{cx}) beyond which velocity strengthening occurs. We assume that V_{cx} is depth dependent (1—10^{-9}m/s). We show that this depth variation in V_{cx} can possibly produce large aseismic slip.

In our simulation, the bottom part of the fault below the deeper extension exhibits a constant slip rate loaded by a subducting plate velocity (4.5 cm/year). This bottom slip drives the adjacent deeper locked part and aseismic slip starts to accelerate. Because of the introduction of low V_{cx} there, the slip cannot monotonously accelerate to seismic slip at the same depth. Instead, the aseismic slip propagates to the shallower part where the slip accelerates following the increasingly higher V_{cx} at the depth, and finally reaches to seismic slip at the shallow part with the large V_{cx}. The seismic slip starting at shallow part then propagates bilaterally to the shallower and deeper parts, and develops into a large earthquake. For example, the point at 20 km depth starts to slip aseismically 5.4 days before the earthquake and 54% of the slip occurs as the precursory aseismic slip. The deeper part produces the longer-lasting aseismic slip with the smaller velocity.

This simulated aseismic slip may correspond to the several-days precursors of the 1944/1946 events. Our results also suggest that the observed short-term aseismic slip acceleration is a part of the longer-term aseismic slip that has started at deeper parts, which may be detected at the next To-nankai/Nankai earthquakes with the help of recently installed modern observation networks (Do-Net, Hi-Net, and GEONET) around the Nankai region.