Timing of Earthquakes on Major Intraplate Active Faults Subjected to Semi-Periodic Stress Perturbation due to Seismic Cycle on a Subduction Interface

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Great earthquakes take place every about 100 to 200 years along the Nankai Trough megathrust. Previous studies [e.g., Utsu, 1974, Hori and Oike, 1996] pointed out that intra-plate large earthquakes in Southwest Japan are concentrated between 50 years before and 10 years after the megathrust earthquakes and discussed that these active periods of intraplate earthquakes are conceivably produced by semi-periodic stress perturbation associated with the megathrust earthquake cycles. In Northeast Japan, the recurrence interval of dominant megathrust events such as the 2011 Mw 9.0 Tohoku-oki earthquake is estimated as between 500 and 800 years on a basis of analysis of tsunami deposit (e.g., Sawai et al., 2015), which is longer than that in Southwest Japan by a factor of 2.5 to 8. How the length of the active period is scaled by the interval of the dominant megathrust events is an important question in considering hazard mitigation in a longer time scale than tens of years.

In the present study, the effect of stress perturbation to a numerical model of a strike-slip fault with a ductile shear zone below a seismogenic layer [Shimamoto and Noda, 2014] is investigated. The unperturbed model has 100 m quartzite shear zone, and the maximum effective normal stress of 50 MPa, rate-and-state parameters $a = 0.016$ and $b = 0.02$ in the brittle regime, long-term slip rate of 10^{-11} m/s, and recurrence interval of 6000 years. When shear stress perturbation of sawtooth wave function, a proxy of effect of cycles of megathrust earthquakes, with 1 MPa amplitude and various period T_{cyc} (100 to 1000 years) is added, it is observed that the earthquakes tend to take place in the later half of the megathrust earthquake cycles (Figure 1). Interestingly, the distribution of timing of the intraplate earthquakes depends modestly on T_{cyc} indicating that the length of the active period is scaled by T_{cyc} if the amplitude is fixed.

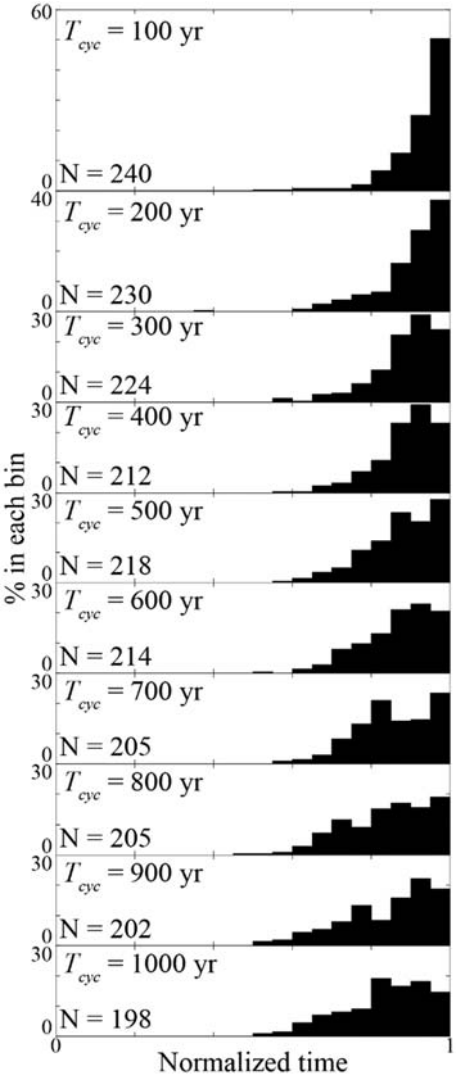

Figure 1. Histograms of modelled intraplate earthquakes as functions of normalized time between megathrust earthquakes.

The amplitude of 1 MPa is minor compared with stress drop of modeled earthquakes or the loading due to stable slip of the ductile shear zone. If the amplitude of the perturbation is zero, uniform distribution of intraplate earthquakes is obtained. Therefore, faults with similar recurrence intervals can have different probability of earthquake as a function of time according to the amplitude of ΔCFF due to megathrust earthquake cycle.