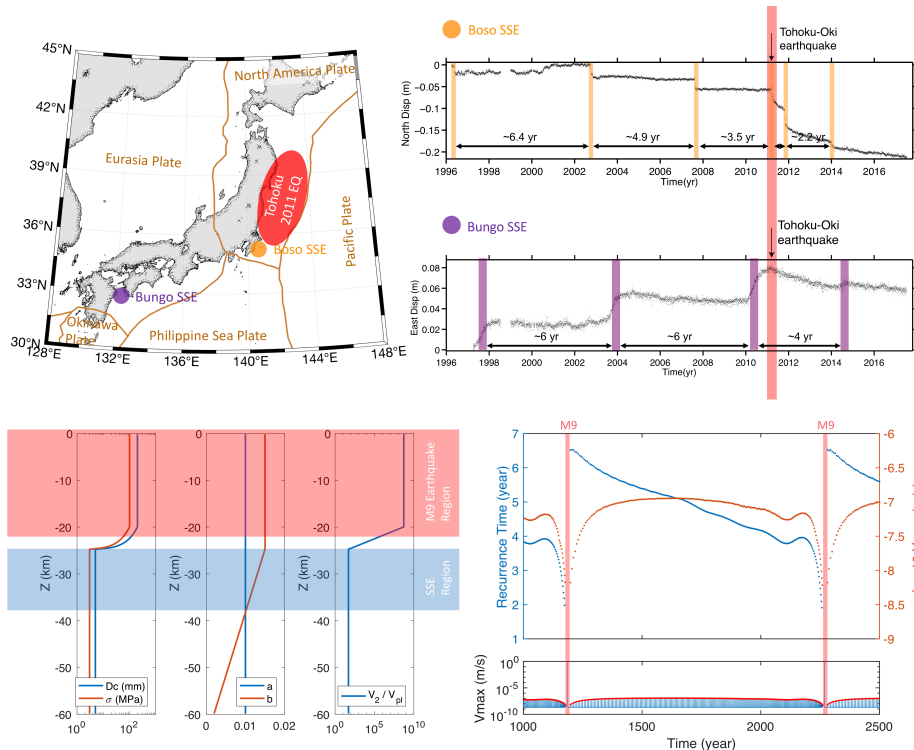


# Slip transient pattern changes: external perturbation or intrinsic interaction with earthquakes

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## Abstract

Advances in geodetic techniques enable us to detect slow-slip events (SSE) and shallow fault creeping events (part of shallow SSE) with improving accuracy and coverage. Recent observations reveal intriguing changes of SSE behavior before and/or after earthquakes. However, the physics behind these observations remain largely unknown. How does SSE pattern change during an earthquake cycle? How do SSEs respond to “external” stress perturbations? Can SSE pattern changes shed light on the onset of a large earthquake? To address these questions, we employ laboratory-based rate-and-state frictional law on faults with realistic frictional properties incorporating earthquake and SSE regions. In the first set of models we consider subduction zone setting with deep SSE interacting with megathrust earthquakes. In the second set of models we consider strike slip fault settings with shallow SSEs interacting with strike slip earthquakes. We conduct both 2D and 3D quasi-dynamic earthquake cycle simulations to study the “intrinsic” SSE pattern changes as how it evolves at different stages of the earthquake cycle, versus the changes in SSE pattern responding to external stress perturbations. Our results suggest that, despite both intrinsic and perturbation models are capable to introduce large variability in SSE pattern, there are considerably observable characteristics that can be used to differentiate these two scenarios. On one hand, without external perturbation the SSE patterns can change intrinsically during an earthquake cycle. The recurrence interval of SSEs decreases significantly right before megathrust earthquake and could be used as a potential warning sign. On the other hand SSE patterns can vary significantly when perturbed by an earthquake or other tectonic/non-tectonic sources. Recurring SSEs can be advanced or delayed by external perturbations, and multiple SSEs can be affected if perturbation is long lasting.



**Figure caption:**  
**Change of Slow-Slip Event (SSE) Intervals before Megathrust Earthquakes.**

**Upper panel:** GPS time series of Boso and Bungo SSEs before and after the 2011 M9 Tohoku megathrust earthquake. The Boso SSEs, located adjacent to the rupture zone of the Tohoku earthquake, shows consistent shortening of its recurrence intervals before the earthquake. **Lower panel:** rate-and-state model of subduction zone fault with megathrust earthquake and SSE regions shows change of SSE recurrence intervals throughout the earthquake cycle, including shortening of intervals before earthquake.