P02

Attempts to improve understanding and forecasts of slow and fast earthquakes

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1. Introduction

Slow earthquakes are episodic slow fault slips. They form a fundamental component of interplate deformation processes, along with fast, regular earthquakes. Although slow earthquakes have been studied intensively over the past two decades, much remains unclear about them (e.g., their activity, physical mechanisms, relation to fast earthquakes, and predictability). In this poster, we introduce our three recent efforts to improve understanding and forecasts of slow and fast earthquakes: the elucidation of the detailed megathrust slip behavior along the Japan Trench, the construction of a statistical model for fast earthquakes that incorporates fast-earthquake-triggering effects of slow earthquakes, and the construction of a statistical model for slow earthquakes.

2. Elucidation of the detailed megathrust slip behavior along the Japan Trench

Recent seismological and geodetic observations have revealed detailed slow earthquake activity along the Japan Trench—the subduction zone where the March 11, 2011 moment magnitude (M_w) 9.0 Tohoku-Oki earthquake occurred (e.g., Nishikawa et al., 2019; Baba et al., 2020; Nishimura, 2021). We thoroughly reviewed studies on slow earthquakes along the Japan Trench and their research history (Nishikawa et al., 2023). By compiling the observations of slow earthquakes (e.g., tectonic tremors, very-low-frequency earthquakes, and slow slip events) and related fault slip phenomena (e.g., small repeating earthquakes, earthquake swarms, and foreshocks of large interplate earthquakes), we revealed the detailed megathrust slip behavior of the Japan Trench (Figs. 1 and 2). The integrated distribution of slow and fast earthquakes (Fig. 1) provides a firm basis for future earthquake research in the Japan Trench.

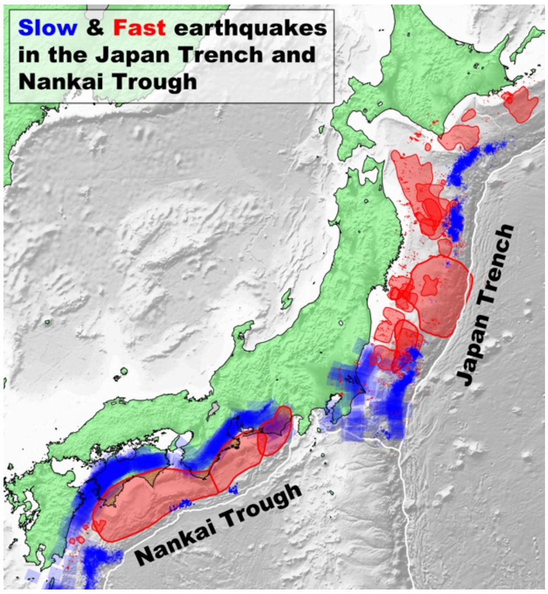

Figure 1. Integrated distribution of slow and fast earthquakes in the Japan Trench and Nankai Trough. Blue and red symbols indicate areas where slow and fast earthquakes occur, respectively.

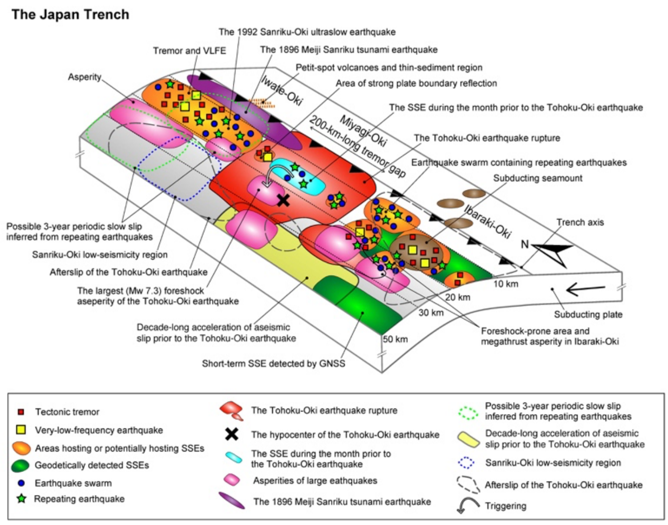

Figure 2. Schematic of the megathrust slip behavior of the Japan Trench.

3. Construction of a statistical model for fast earthquakes considering fast-earthquake-triggering effects of slow earthquakes

Slow earthquakes, especially slow slip events (SSEs), sometimes trigger earthquake swarms and megathrust earthquakes, and the causal relationship between SSEs and fast earthquakes has been studied worldwide. However, the epidemic-type aftershock-sequence (ETAS) model, which is a standard statistical model of fast earthquake activity, has not explicitly considered the fast-earthquake-triggering effect of SSEs. Therefore, if an SSE occurs at a plate boundary, probabilistic earthquake forecasts based on the ETAS model fail to predict observed fast earthquake activity.

With the above background, we constructed a new statistical model by incorporating SSE moment rates estimated from global navigation satellite system observation data into the original ETAS model (Nishikawa & Nishimura, 2023, in prep.). This model assumes a linear or power relation between SSE moment rates and seismicity rates and estimates its proportionality constant as a new ETAS parameter.

We applied our new model to three SSEs and *M* 2.5 or greater earthquakes in the shallow part of the Hikurangi Trench, New Zealand. The results show that our model is better than the original ETAS model, with a significant reduction in the Akaike information criterion. In addition, we examined function forms (e.g., lag time and power exponent) of the equation relating the moment rate of SSEs and the seismicity rate. The results implied that besides SSE-induced stress changes, crustal fluid migration may be related to the SSE-induced seismicity. We also examined the influence of SSEs on aftershock productivity. Our model can improve short-term forecasts of seismicity associated with SSEs and is useful for quantifying its characteristics.

4. Construction of a statistical model for slow earthquakes

Numerical simulations of megathrust earthquake cycles (e.g., Matsuzawa et al., 2010) suggest that characteristics of slow earthquake activity may change before megathrust earthquakes. Therefore, understanding and forecasting slow earthquake activity are important for improving forecasts of megathrust earthquakes. However, there is no standard model to describe and forecast slow earthquake activity. With this background, we aim to construct a new statistical model to forecast and quantify slow earthquake activity by utilizing slow earthquake observations accumulated in the Nankai Trough over the past two decades.

In this poster, we present our preliminary attempts. We followed the formulation of the ETAS model (Ogata, 1988) and constructed a new statistical model for slow earthquakes, especially for low-frequency earthquakes (LFEs). In our preliminary model, the occurrence rate of LFEs is determined by (1) the effect of random LFE occurrence at a constant rate, (2) the effect of LFE clustering, (3) the effect of SSEs randomly triggering LFEs, (4) the effect of SSEs enhancing LFE clustering. We used comprehensive catalogs of LFEs and SSEs in the Nankai Trough (Kato & Nakagawa, 2020; Okada et al., 2021) and examined the performance of our new model. Furthermore, we evaluated the magnitudes of effects (1) to (4) and found that SSEs increase the rate of random LFE occurrence and the effect of LFE clustering by more than tens of times and several times, respectively.