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Deep tremors response to tidal stress in western Japan: Analysis by Schuster's test

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In Japan, many deep tectonic tremors occur in the Nankai subduction zone from the center of Honshu to western Shikoku. Each tremor is a tiny shear slip that reflects local plate motion. Thus the physical conditions that enhance tremor activity would also control plate motion to some extent. For example, in a small tremor cluster beneath south Okayama, tremor rate is extremely well correlated with tidal level [Ide & Tanaka, 2014]. Here, we calculate ocean and solid earth tidal stress on the plate interface and quantitatively evaluate the degree of tidal triggering of tremors in the Shikoku region using the Schuster's test [e.g., Tsuruoka et al.,1995].

In the Shikoku region, we calculate normal and shear stresses at each reference point located at 0.1^o interval at 30 km depth, assuming a low-angle thrust fault based on global subducting plate motion. We compute the spatial distribution of theoretical ocean height using NAO.99b [Matsumoto et al., 2000] and convolve it with Green's function [Okubo & Tsuji, 2000] to obtain an ocean tidal stress tensor. We also calculate a stress tensor by solid earth tide using tide-generating potential of Tamura [1987]. The tremor catalog is of Idehara et al. [2014], for the nine years period from April 1, 2004 to March 31, 2013. We use tremors within $\pm 0.1^o$ in latitude and longitude, respectively, from each reference point.

In the Schuster's test, a phase angle of 0^o is assigned to the maximum stress peak nearest to the tremor occurrence time and $\pm 180^o$ to the following and preceding minima respectively. Based on the phase angles of all tremors, we calculate the significance level p for rejecting the null hypothesis that tremors occur randomly, regardless of stress. In general, small p means large statistical significance, and p less than 1% is considered significant in many previous studies.

We found some spatial variation in tremors response to tide. For example, in Kagawa, we found that two tremor clusters of similar sizes separated by 20km differently respond to tidal stress. The western cluster shows a strong tidal dependency (p=7.6e-44%), while eastern cluster has two peaks in phase angle and its tidal dependency is obscure. By changing fault parameters for the east cluster, we found that a low p (=0.7%) and a single peak in phase angle are obtained with some mechanisms similar to strike slip. This result implies that fault structure in Eastern Shikoku is complex and that tremor occurring mechanism changes locally.

Keywords: deep tectonic tremors, tide, Schuster's test, Nankai Trough, Shikoku