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Geometrical Constraints on World Deep Tremor
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Deep tectonic tremor has been discovered in many places in the world, but little was known about control factors of the activity. A standardized analysis of tremor in four tremor zones enables to compare regional characteristics of tremor activity. Here I show that tremor duration and sensitivity to tidal stress are controlled by the width tremor zone in the subduction direction. Local structures such as striations may act as the size yielding the variety of tremor activity.

The study areas are the Nankai subduction zone (SZ) in southwestern Japan, the Cascadia SZ in western Canada and USA, the Jalisco-Colima-Michoacan SZ in northern Mexico, and the Chile triple junction. The data are from Hi-net of NIED Japan (Nankai), the Canadian National Data Centre, POLARIS broadband seismic stations, University of Washington, University of Oregon, UC Berkeley, Plate Boundary Observatory and USArray of EarthScope Program (Cascadia), Mapping the Riviera Subduction Zone Project (Mexico), and Chile Ridge Subduction Project (Chile).

A modified version of envelope correlation method was applied to these data. This method divides continuous records of velocity envelope into a set of half overlapping 300 s time windows, detects a seismic source in each window, and determines the source locations as well as the event duration as a half value width of the stacked envelope. Although the method does not automatically distinguish tremor sources from ordinary earthquakes, by extracting events longer than 10 s, we can eliminate most of ordinary earthquakes.

In western Shikoku, the western end of the Nankai tremor zone, the duration is anti-correlated with the sensitivity to tidal stress, which is also observed in other SZs. The sensitivity to tidal stress measured by the Fourier amplitude at semi-diurnal lunar period for delta-function sequences, each of which corresponds to the tremor origin time, shows similar negative correlation. Moreover, we observe regional difference of typical duration: Cascadia tremor is the longest and Mexican tremor is the shortest. This duration correlates with the width of tremor zone in the subduction direction. The width is up to about 65, 45, 40, and 30 km for Cascadia, Nankai, Chile, and Mexico. In the very narrow (< 20 km) tremor zone near the northern end of Mexico, tremor is very sensitive to tidal stress. On the other hand, long-distance migration of tremor sources is often observed for very long tremor in the wide tremor zone of Cascadia SZ, which is consistent with the observation in western Shikoku.

The observation in these SZs suggests the idea that the geometry of tremor zone constrains tremor behavior. The characteristic size of tremor zone has been introduced to tremor models that consider random processes, where the size corresponds to the change point in the scaling law of slow earthquakes, from short diffusive migration to long migration at a constant velocity. Below the width extent in the subduction direction, there may be diffrent kind of characteristic size, such as the width of striations identified in western Shikoku and also visible. In western Shikoku fast (~10 m/s) tremor migration along a narrow striation has been detected, where the typical duration is very short.

A dense structural survey illustrated a mechanism to produce tremor zone, which is formed in the wedge mantle near the Mohorovicic discontinuity by water dehydrated from the subducting slab. If such a mechanism is working everywhere, the total amount of water transported by plate subduction, or simply the amount of subducted materials may control the size of tremor zone and tremor behavior. A long subduction history is also reflected in large accretionary prism along the trench. Therefore, it must not just coincidence that the SZs with large accretionary prism like Cascadia, Nankai, and Chile have thick tremor zones and megathrust earthquakes as large as magnitude 9.