Evaluation on successive occurrence of Tonankai and Nankai earthquakes by 3-D simulation

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Along the Nankai Trough from Kumano-nada through south-off Shikoku, great earthquakes tend to occur sequentially, where the order of occurrence seems to be predetermined as the Tonankai earthquakes preceded the Nankai earthquakes in the past. We study what underlies this succession and how stable the mechanism is by using a simulation model of plate subduction.

We try to reproduce the sequential occurrence by using a 3-D simulation model with a rate- and state-dependent friction law. In the model, the time evolution of a dislocation field in an elastic half-space is governed by a quasi-static interaction induced by the dislocation field itself as well as by a rate- and state-dependent friction law acting on the plate interface. Configuration of the plate interface is estimated from the hypocentral distribution of micro-earthquakes in the slab. The Philippine Sea plate is taken to subduct toward the NW direction. We set the relative plate velocity to be 4cm/year everywhere. We make use of the overshooting method employed in Tse and Rice (1986) to describe the moment release during earthquakes.

We assume two asperities, one in the Tonankai region and the other in the Nankai region, which are provisionally called the Tonankai asperity and the Nankai asperity, respectively. We also assume three buffer zones with stable sliding: two zones 20km wide on both sides of the model region of 500km wide, and a zone 40km wide that separates the two asperities.

On the asperities, the friction parameter a-b is negative to cause unstable slips. The friction parameter L is taken to be 10cm, 10cm and 5cm in the side buffer zones, the separating buffer zone, and the rest of the model region, respectively. In this study we allot 0.001 to the a value at every depth in the whole model region including the buffer zones, and 0 to the b value at the depths of 0 and 60 km. Then, at first we set the b value to be 0.00115 and 0.001115 at the depth of 15km and 25km, respectively, and interpolate linearly between those depths, on both the Tonankai and Nankai asperityies. The result is that a great earthquake first occurs in the Nankai region, followed by another in the Tokai region at an interval of 2 to 50 years. The occurrence period of a pair of earthquake in both regions is about 120 years. This result does not accord to the fact that the Tonankai earthquake preceded the Nankai earthquake in historical cases.

Therefore, we assigned next a larger b value to the Nankai asperity, expecting that it would make the Tonankai earthquake occur earlier than the Nankai earthquake, because the change means increase of the strength of the plate coupling on the Nankai asperity. When we set a 2.6% larger b value to the Nankai asperity than that to the Tonankai asperity, we got a result that the Tonankai earthquake occurred earlier than the Nankai earthquake except the first two pair of earthquakes. The interval between them was about 0.6 years and the occurrence period of the pair earthquakes was about 140 years. When the b value on the Nankai asperity is only 0.9% larger than that on the Tonankai asperity, the Nankai earthquake occurs earlier than the Tonankai earthquake. In that case, the interval of the pair earthquakes is 2 to 9 years and the occurrence period of a pair of earthquakes is about 130 years. If the b value on the Nankai asperity is 1.2% larger than that on the Tonankai asperity, the occurrence order of the Tonankai and Nankai earthquakes alternate.