An evaluation on the successive occurrence of the Tonankai and Tokai earthquakes by using a 3-D simulation (A preliminary report)

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Along the Suruga-Nankai trough, great earthquakes adjacent to one another tend to occur successively, 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. Because of difference in tectonics, we deal with two cases separately:1) the Tonankai and the Tokai regions in this lecture and 2) the Nankai and the Tonankai regions in Takayama's lecture.

We reproduced earthquake cycles in the Tokai region by using a 3-D simulation model with a rate- and state-dependent friction law, and studied quantitatively the properties of slow slips around Lake Hamana and of preslips just before the anticipated Tokai earthquake (Kuroki et al., 2001, 2002, 2003). In this study, we discuss the successive occurrence of the Tonankai and Tokai earthquakes by extending the model region of the previous studies.

In the present 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 almost the NW direction. Following Heki and Miyazaki (2001), we set the relative plate velocity to be 2, 2.5, 4, 7cm/year on suitably chosen 4 blocks from east to west. 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 Tokai region, which are provisionally called the Tonankai asperity and the Tokai asperity, respectively. We also assume three buffer zones with stable sliding: two zones 20km wide on both sides of the model region, and a zone 50km 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, 12cm and 5cm in the buffer zones on both sides, the separating buffer zone, and the rest of the model region, respectively.

The result is that a great earthquake first occurs in the Tonankai region, which is followed by another in the Tokai region at an interval of about one year. The occurrence period of a pair of earthquakes in both regions is about 80 years. The moment magnitudes of the earthquakes in the Tonankai and the Tokai regions are 8.2 and 7.9, respectively. The difference in magnitude is caused by the tectonic condition that relative velocity of plate subduction in the Tonankai region is larger than that in the Tokai region; slip amount during the earthquake naturally becomes large where the velocity of plate subduction is large and which is especially small in the Suruga Bay area. Location of the nucleation point for earthquakes in the Tonankai region is different from cycle to cycle, while that for earthquakes in the Tokai region is always at a site near the boundary between the separating buffer zone and the Tokai asperity.

Occurrence of the earthquake in the Tonankai region increases shear stress in the buffer zone between the two asperities. The shear stress, however, has dissolved just before the occurrence of the earthquake in the Tokai region, while that in the western boundary of the Tokai asperity has increased considerably; we thus recognize propagation of stresses through the separating buffer zone.

The results are dependent on the plate configuration, regional change in the relative plate velocity and the distribution of friction parameters. These determine the strength of the asperities and the effects of the buffer zones, by which the occurrence of the earthquakes is strongly influenced. We will study these problems in detail in the near future.