Numerical simulation of earthquake cycles along the Nankai trough: Where does rupture start?

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In southwest Japan, the Philippine sea plate is subducting with complex geometry. Recent seismic surveys reveal the subduction of seamounts and ridges in this region. Such deep structures may affect the earthquake generation process here, especially for great interplate earthquakes such as 1944 Tonankai and 1946 Nankai earthquakes. The complex deep structures should cause laterally heterogeneous distribution of frictional properties which are basically depth-dependent. To investigate how it affects the occurrence of great earthquakes, we demonstrate numerical simulation of earthquake cycles based on a laboratory derived friction law.

The plate boundary is represented by a plane fault in 3D homogeneous elastic half space. The friction on the fault obeys the rate- and state-dependent law. Frictional parameters and normal stress are assumed to be depth-dependent. These values are evaluated according to the complex geometry of plate boundary and then mapped on the plane fault. The relative plate velocity decreases in the east of Kii peninsula based on the results of Heki & Miyazaki (2001). The fault is divided into 1.2km x 1.2km subfaults. The time evolution of slip velocity on each subfault is calculated using Runge-Kutta method.

The results show that slow slip starts and is accelerated to seismic slip below the Kii peninsula and the high velocity slip propagates both eastward and westward. One great earthquake breaks the whole fault region from Tokai to Shikoku and its recurrence interval is almost constant (about 145 years). The slow slip occurs early below the Kii peninsula probably because the width of unstable region (seismogenic zone) is narrower. The width of seismogenic zone is dependent on the dip angle of the plate boundary. Thus the position of preslip or rupture initiation of great interplate earthquake may depend on the plate geometry. In fact, the hypocenter of the 1944 Tonankai earthquake is also below the Kii peninsula.

This study is done as a collaboration project in Earth Simulator Center (project title: Simulation of Earthquake Generation Process in a Complex System of Faults, leader: Kazuro Hirahara) and all the simulations are run on Earth Simulator.