Simulation of earthquake cycles with heterogeneous frictional properties related to the deep structures along the Nankai trough

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A numerical simulation is demonstrated for earthquake cycles in subduction zone to investigate the seismic cycles along the Nankai trough, southwest Japan. In this region, great interplate earthquakes occurred repeatedly with 100-200 years interval, although their rupture patterns are different with each other. Sometimes earthquakes occurred separately in the eastern and western areas along the Nankai trough with different time intervals. On the other hand, one great earthquake occurred whole along the Nankai trough in 1707.

We consider that these variable source processes in seismic cycles can be basically explained by an asperity model. Recent source analyses of the latest earthquakes in the 1940's and seismic structural surveys along the Nankai trough show that slip distribution seems to be controlled by the deep structures such as subducting seamount, ridge or bending of the slab. Subduction of these structures cause significantly heterogeneous normal stress distribution. So they may act as asperities which break with large slip in every seismic cycle or break only in every second or more cycles.

To examine the above hypothesis, we demonstrate numerical simulations of earthquake cycles based on a three-dimensional model in elastic half space with a rate- and state-dependent friction law. A subducting plate is modeled by a dipping flat plane. Frictional parameters, which is dependent on the depth of plate boundary with realistic complex geometry, are mapped on that plane. This makes the heterogeneous distribution of frictional parameters. The results show that there are two large segments in the eastern and western areas along the Nankai trough. Furthermore, normal stress anomalies in a few hundred MPa are put where the deep structures are found by the recent seismic surveys. The results show that these anomalies behave as asperities and divide the above two segments into smaller ones. The smaller segments sometimes rupture sequentially. Thus our simulation results indicate that heterogeneous distribution of frictional properties related to the deep structures may control the segmentation of source region and other characteristics of rupture patterns along the Nankai trough.