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Integrated Predictive Simulation System for Earthquake and Tsunami Disaster: Nankai Trough Earthquakes

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Since October 2005, we have urged a JST (Japan Science and Technology Agency) CREST (Core Research for Evolution Science and Technology) project "Integrated Predictive Simulation System for Earthquake and Tsunami Disaster." The aim of this research project is to develop an integrated simulation system for predicting earthquake and tsunami disasters, which covers the multi-scale and multi-physics processes related to earthquakes, such as tectonic stress accumulation due to relative plate motion, earthquake generation, seismic wave/tsunami propagation, and artificial structure oscillation. In the first phase (2005-2007), by integrating related basic simulation models, we developed three subsystems for earthquake generation, strong ground motion and tsunami propagation, and artificial structure oscillation. In the second phase (2 008-2010), we tested the validity of the three subsystems, and developed the inversion methods of seismic and geodetic data to incorporate observed data into computer simulation. We also performed a tentative simulation for the generation of interplate earthquakes along the Nankai trough by combining the subsystem for earthquake generation with that for strong ground motion and tsunami propagation. In 2010 (the last year of the project), we will integrate the three subsystems into a unified total system, and perform predictive simulations for earthquake and tsunami disasters in realistic scenarios by incorporating observed data into theoretical computation. In this talk, we present the current simulation results for the generation of Nankai trough earthquakes. In 2008, by applying a unified inversion method (Matsu'ura et al., 2007) to GPS data in the Hokkaido-Tohoku region, we estimated the slip-deficit rate distribution on the North American-Pacific plate interface, and revealed that the inverted five slip-deficit peaks almost completely coincide with the source regions of 10 large interplate earthquakes occurred along the Kuril-Japan trench in the last century (Hashimoto et al., 2009). In 2009, on the basis of the inversion results, we performed a joint simulation of quasi-static stress accumulation, dynamic rupture expansion, and seismic wave propagation for the 2003 Tokachi-oki earthquake, and demonstrated that strong ground motions produced by potential interplate earthquakes can be quantitatively evaluated through the physics-based computer simulation of earthquake generation cycles (Fukuyama et al., 2009). Recently, by applying the inversion method to the GPS data in southwest Japan, we estimated the slip-deficit rate distribution on the Eurasian-Philippine Sea plate interface, and revealed that a high slip-deficit rate belt extends from Suruga Bay to Bungo Channel in the depth range of 5-20 km. On the basis of the inversion results, we computed stress accumulation rates in and around the seismogenic regions, and performed a tentative simulation for the dynamic rupture propagation of hypothetical Nankai trough earthquakes by using the boundary integral equation method. The development of the dynamic rupture strongly depends on the strength distribution (the distributions of peak strength and critical slip distance) as well as the initial stress distribution. Therefore, in order to predict the point of rupture initiation and the extent of high-speed rupture, we need to set the strength distribution of the plate interface properly.

Keywords: Nankai trough, inversion analysis, numerical simulation, stress accumulation, earthquake rupture