Integrated predictive simulation system for earthquake and tsunami disaster: I. Predictive simulation for earthquake generation

Matsu'ura, M[(1)], Fukuyama, E[(2)] and Hashimoto, C[(3)]

(1) Institute of Statistical Mathematics, Tachikawa, Tokyo 190-8562, Japan
ph. +81-50-5533-8445 ; email mat-lab@ism.ac.jp

(2) National Research Institute for Earth Science and Disaster Prevention, Tsukuba, Japan

(3) Graduate School of Environmental Studies, Nagoya University, Nagoya, Japan

We can regard the occurrence of earthquakes as release of tectonically accumulated stress through dynamic fault rupture. Given this, the entire process of earthquake generation consists of tectonic loading, quasi-static rupture nucleation, dynamic rupture propagation and stop, and fault strength recovery. The entire earthquake generation process can be quantitatively described by coupled nonlinear equations, consisting of a slip-response function, a fault constitutive law, and relative plate motion as driving force. On the basis of such an idea, we developed a computer simulation model for earthquake generation at plate interfaces by combining two basic simulation models for quasi-static tectonic loading and dynamic rupture propagation constructed on a common structure model [Hashimoto et al., GJI, 2010]. In order to predict earthquake generation with this computer simulation model, we need to incorporate various sorts of information extracted from observations into theoretical computation. For this purpose we developed an inversion method to estimate the spatiotemporal variation of interplate coupling from GPS data [Matsuura et al., GJI, 2007]. Applying the inversion method 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 slip-deficit peaks almost completely coincide with the source regions of large interplate earthquakes occurred along the Kuril-Japan trench in the last century [Hashimoto et al., Nature Geoscience, 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 [Fukuyama et al., BSSA, 2009]. With the same inversion method, we estimated slip-deficit rate distribution on the Eurasian-Philippine Sea plate interface in southwest Japan, and revealed that a high slip-deficit rate belt extends from Suruga Bay to Bungo Channel along the Nankai trough. Incorporating the inversion results into the computer simulation, we examined the dynamic rupture propagation of hypothetical Nankai trough earthquakes. The development of the dynamic rupture strongly depends on the strength distribution as well as the initial stress distribution.