A Predictive Simulation Model for Earthquake Generation at Plate Boundaries in and around Japan

Mitsuhiro Matsu'ura[1]; Chihiro Hashimoto[2]; Eiichi Fukuyama[3]

[1] Dept. of Earth & Planetary Science, Univ. of Tokyo; [2] IFREE,JAMSTEC; [3] NIED

In general, the entire process of earthquake generation consists of tectonic loading due to relative plate motion, quasi-static rupture nucleation, dynamic rupture propagation and stop, and restoration of fault strength. This process can be completely described by a coupled nonlinear system, which consists of an elastic/viscoelastic slip-response function that relates fault slip to shear stress change and a fault constitutive law that prescribes change in shear strength with fault slip and contact time. The shear stress and the shear strength are related with each other through boundary conditions on the fault. The driving force of this system is observed relative plate motion. In such a conceptual framework we developed a physics-based predictive simulation model for the entire process of earthquake generation at plate boundaries in and around Japan, where the four plates of Pacific, North American, Philippine Sea and Eurasian are interacting with each other in a very complicated way. The complexity in practical modeling mainly comes from complexity in structure of the real earth. The total simulation system consists of a crust-mantle structure model, a tectonic loading model and a dynamic rupture model. First, we constructed a realistic 3D standard model of plate interfaces in and around Japan by applying an inversion technique to ISC hypocenter distribution data, and computed viscoelastic slip-response functions for this structure model. Second, we introduced the slip- and time-dependent fault constitutive law with an inherent strength-restoration mechanism as a basic equation governing the entire process of earthquake generation. Third, combining all these elements, we developed a simulation model for quasi-static stress accumulation due to relative plate motion. Fourth, we also developed a simulation model for dynamic rupture propagation on a 3D curved fault surface by applying BIEM. Finally, we connected the quasi-static stress accumulation model and the dynamic rupture propagation model to simulate the entire process of earth quake generation. Outputs of this simulation system are crustal deformation, internal stress changes and seismic wave radiation associated with seismic and/or aseismic slip at the plate interfaces. From comparison of these simulation outputs and observed data, we can extract useful information to estimate the past slip history and the present stress state at the plate interfaces by using an inversion technique. Given the past slip history and the present stress state, we can predict the next step fault slip and stress changes through computer simulation.