Simulation of earthquake generation process in complex fault systems

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In these 5 years, our group has developed a module of earthquake cycle simulation in a parallel FEM code, GeoFEM, cooperating with RIST under a program in MEXT. In 2002, we apply a proposal to use Earth Simulator for simulation of earthquake generation process in complex fault systems. We aim at constructing regional realistic 3-D models of earthquake generation cycle in northeast and southwest Japan. We show our present group activity and the future plan in the simulation on Earth Simulator.

GeoFEM has the following features; 1) a parallel FEM code for large-scale problems; 2) the viscoelastic medium can be included; 3) dislocation is implemented for representing fault slips or kinematic plate subduction, 4) contact analysis based on master-slave method can be executed for simulating slip evolution on a plate boundary or faults. At present, only simple friction law can be used. Efficient method of solving rate and state friction law is now being developed for simulating quasi-static earthquake cycle.

In 2002, we installed GeoFEM in Earth Simulator and tuned the vectorilaztion and parallelization. We achieved 99.8% parallel ratio and 98.3% vector one. For testing, we use a simple 3-D model of northeast Japan. There, the detailed feature of asperities or locked-unlocked states along the Japan trench has been elucidated from source inversion of seismic waveforms and from GPS observations. Simple models including three asperities with higher frictions comparing with those in surrounding regions is constructed to simulate earthquake cycles cased by plate subduction with a 100-year recurrence time, where we drop 1% friction and cause an earthquake for a asperity. And dynamic propagation of fracture on a fault is simulated using a slip dependent friction law. For these two simulations using a flat plain, we confirmed the contact analysis well works. For southwest Japan where the Philippine Sea plate is subducting with a 3-D complex configuration along the Nankai trough, we construct a preliminary model and test in Earth Simulator. However, the configuration is too rough to execute the stable contact analysis. Accordingly, we are now reconstructing the model.

In parallel with GeoFEM development, we develop the extended 3-D version HH02 (Hirose and Hirahara, 2002) from 2-D earthquake cycle simulation KH97 (Kato and Hirasawa,1997). Before implementing rate and state friction low in GeoFEM, we use HH02 to simulate the earthquake cycle in northeast Japan where there are asperities with higher negative a-b values than those in the surrounding regions. And for southwest Japan, we simply examine segment interaction using HH02 on Earth Simulator.