Large Scale Simulations of Dynamic Rupture Propagation to Investigate the Fault Behavior of Mega-Thrust Earthquakes

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The investigation of dynamic rupture propagation is very important to understand the seismic behavior of mega-thrust earthquakes such as the 2011 Tohoku earthquake. The shallow parts of the fault (near the trench) hosted large slip and long period seismic wave radiation, whereas the deep parts of the rupture (near the coast) hosted smaller slip and strong radiation of short period seismic waves. Understanding such depth-dependent feature of the rupture process of the Tohoku earthquake is necessary as it may occur during future mega-thrust earthquakes in this and other regions, such as the Nankai Trough. In order to achieve such understanding, dynamic rupture modeling is an important tool (e.g., Galvez *et al.,* 2014).
In this study, we have simulated the dynamic rupture propagation for models of the Tohoku earthquake. Our large-scale simulations used the 3D spectral element method on unstructured grids (Galvez *et al.,* 2014) with performance tuning for the Earth Simulator at JAMSTEC. The number of elements in the mesh is 4,300,000 with 2 km size and polynomial order 4. The simulation takes around 10 hours of wall-clock time on 512 cores. The effective period for the simulation is longer than 1.2 sec.
Our model reproduced the depth-dependency of the rupture process of the Tohoku earthquake. We also examine the sensitivity of the results to model parameters and assumptions, for instance to the value of the slip weakening distance (Dc). We find that the value of Dc does not affect the final slip distribution, as long as it is small enough to allow the rupture to develop and propagate to the trench. A long Dc (order of 10 m) is reasonable in terms of fracture energy and promotes the generation of long period seismic waves on the shallow part of the fault.

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