3-D Spontaneous Rupture Simulations of the 2016 Kumamoto, Japan, Earthquake

Yumi Urata (1), Keisuke Yoshida (2), and Eiichi Fukuyama (1)

(1) National Research Institute for Earth Science and Disaster Resilience (NIED), Tsukuba, Japan, (2) Tohoku University, Sendai, Japan

We investigated the M7.3 Kumamoto, Japan, earthquake to illuminate why and how the rupture of the main shock propagated successfully by 3-D dynamic rupture simulations, assuming a complicated fault geometry estimated based on the distributions of aftershocks. The M7.3 main shock occurred along the Futagawa and Hinagu faults. A few days before, three M6-class foreshocks occurred. Their hypocenters were located along by the Hinagu and Futagawa faults and their focal mechanisms were similar to those of the main shock; therefore, an extensive stress shadow can have been generated on the fault plane of the main shock. First, we estimated the geometry of the fault planes of the three foreshocks as well as that of the main shock based on the temporal evolution of relocated aftershock hypocenters. Then, we evaluated static stress changes on the main shock fault plane due to the occurrence of the three foreshocks assuming elliptical cracks with constant stress drops on the estimated fault planes. The obtained static stress change distribution indicated that the hypocenter of the main shock is located on the region with positive Coulomb failure stress change (ΔCFS) while ΔCFS in the shallow region above the hypocenter was negative. Therefore, these foreshocks could encourage the initiation of the main shock rupture and could hinder the rupture propagating toward the shallow region. Finally, we conducted 3-D dynamic rupture simulations of the main shock using the initial stress distribution, which was the sum of the static stress changes by these foreshocks and the regional stress field. Assuming a slip-weakening law with uniform friction parameters, we conducted 3-D dynamic rupture simulations by varying the friction parameters and the values of the principal stresses. We obtained feasible parameter ranges to reproduce the rupture propagation of the main shock consistent with those revealed by seismic waveform analyses. We also demonstrated that the free surface encouraged the slip evolution of the main shock.