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Dynamic Source Rupture Process of the 2016 Kumamoto, Japan, earthquake

Xiangwei Yu and Wenbo Zhang
College of Earth Science, University of Chinese Academy of Sciences, China (yuxw@ucas.ac.cn)

The 2016 Kumamoto earthquakes are a series of earthquakes occurred in the Kumamoto Prefecture in Kyushu Region of Japan, including a magnitude 7.0 mainshock which struck at 01:25 JST on April 16, 2016 beneath Kumamoto City, at a depth of about 10 km, and a foreshock earthquake with a magnitude 6.2 at 21:26 JST on April 14, 2016, at a depth of about 11 km. This series earthquake killed at least 50 people and injured about 3,000 others in total. Severe damage occurred in Kumamoto and Oita Prefectures, with numerous structures collapsing and catching fire. More than 44,000 people were evacuated from their homes due to the disaster. Kumamoto Prefecture lies at the southern end of the Japan Median Tectonic Line, Japan's longest, where a system of active faults forks in two directions at the Beppu-Haneyama Fault Zone. Specifically, the series of quakes ruptured the 81-km-long Hinagu Fault and 64-km-long Futagawa Fault to its north, as well as lesser but discernable interaction with the farther flung Beppu-Haneyama Fault Zone. A 27-km section of the Futagawa Fault Zone slid 3.5 meters. The earthquakes are occurring along the Beppu–Shimabara graben, with epicenters moving from west to east over time.

In this study, we analyze the dynamic rupture process of this earthquake. Our analyzing procedure is as follows, 1) Obtain the spatial-temporal stress distribution on the fault surface from the kinematic source model inverted from strong motion data (Zhang & Zhen, the abstract of this meeting, No. EGU2017ASC20162770). Estimate the strength excess (yielding stress) and the frictional stress level for each subfault; 2) Estimate the critical slip-weakening distance Dc for each subfault assuming a simple slip-weakening law and according to the method of Mikumo et al. (2003); 3) Reconstruct the dynamic source rupture process using those dynamic source parameters with the slip-weakening friction law; and 4) Simultaneously, simulate the near source ground motions based on the obtained dynamic source model.

Our result shows that in general large stress drop occurred around areas with a large slip except the shallow part around the hypocenter. Although kinematic source model shows that this area has a large slip, the stress drop is not so large comparing with the deep areas that has a similar amount of slip. The estimated strength excess is generally small and that suggests the tectonic shear stress has reached near the level of the fault strength before the main shock. Usually, the area with a large strength excess on the fault surface will delay the rupture propagation. Thus, the rupture propagation becomes slow down at these areas. Faster rupture is observed at the main asperity area whereas slower rupture at the northwestern deep part is shown in the dynamic source model. Based on the dynamic source model, near-source ground motions are simulated. Generally, the synthetic waveforms show well the observed record characteristics. This shows that our dynamic source model reproduces the main features of the long period ground motions in this earthquake.