Kinematic and dynamic source models of the 2016 Mj6.4 Kumamoto third large earthquake

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We make a kinematic source model of the 2016 Mj6.4 earthquake (2016 Apr. 15, 00:03 JST) which is a third large event during the 2016 Kumamoto earthquake sequence and dynamic source models based on the result of the kinematic model.

The kinematic model is made by inverting the strong-motion data obtained from K-NET, KiK-net, JMA and local government were used. The data were windowed for 18 s, starting at P-wave arrival time, and band-pass-filtered between 0.05 to 1.0 Hz (periods of 1-20 s) for waveform inversion. The accelerograms were integrated into ground velocities. Theoretical Green's functions are calculated using the discrete wavenumber method (Bouchon, 1981) and the Reflection/Transmission coefficient matrix method (Kennett and Kerry, 1979) using a stratified medium. We assumed individual one-dimensional velocity structure model for each station by using waveform modelling with small earthquake records (Yoshida et al., 2017). The event locations were relocated using double-difference method by Uchide et al. (2016). We used multi-time-window linear waveform inversion procedure (e.g., Hartzell and Heaton, 1983) in which the moment-release distribution is discretized in both space and time. The length and width of the fault plane was assumed to be 12 km and 10.5 km, respectively. The fault plane is divided into subfaults of 1.5 km ×1.5 km. The moment function of each subfault was represented by a series of six smoothed ramp functions in the 0.4 second interval. The first time-window triggering velocity (V_{FT}) was determined as 2.4 km/s, which was searched between 2.0 and 2.6 km/s based on residual of the waveform fits.

The estimated source model indicated 1.2 $\times 10^{18}$ Nm (Mw6.0) of the total moment release and 0.3 m average slip. One rectangular asperity and a high slip/moment rate area (HRA, Yoshida et al., 2017) patches with the average slip of 0.7 m were identified on the shallow part of the fault plane. The slip of the background area is 0.1 m.

We attempt to make dynamic rupture models based on the kinematic model. Stress drop distribution of the kinematic model was calculated (Okada, 1992). The average static stress drops were 3.9 MPa (asperity) or 4.9 MPa (HRA) and 1.0 MPa for the background. Effective stress was taken from the stress parameters estimated from SMGA (Kurahashi et al., 2017). The effective stresses were adjusted as 5.1 MPa (Asperity) or 6.3 MPa (HRA) to rupture over the entire fault. We conducted dynamic rupture simulations using the patched stress drop distribution obtained from the kinematic model (Figure left-bottom). We assumed slip-weakening law with uniform critical distances of 0.1 m, based on Dc’’ (Fukuyama and Mikumo, 2007) of about 0.15 m at KMMH14. The simulation results show that the final slips and total moments well agree with the ones of the kinematic model. Nevertheless, small slips and high slip rate on the top margin of the patches, and supershear rupture propagation on the further of the patch were found. We expect examination of some dynamic parameters, such as critical slip distances, to improve simulation results.

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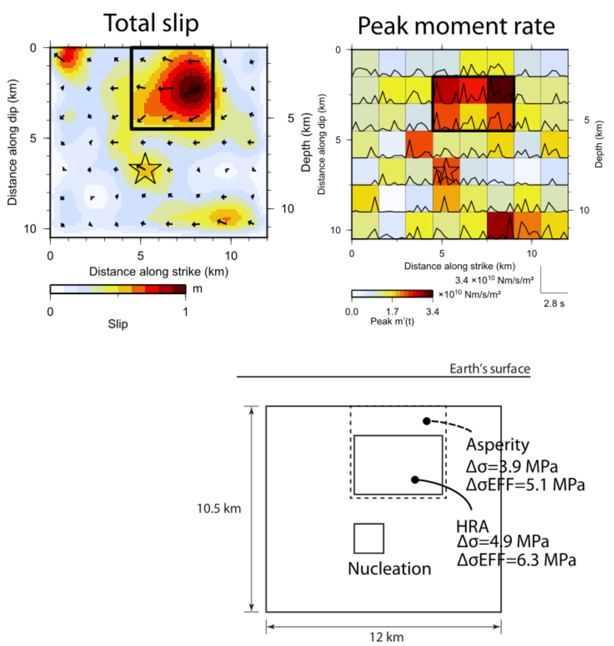
Keywords: 2016 Kumamoto earthquake, source process, dynamic simulation

Kinematic model



Dynamic simulation