Source models for the 2016 Kumamoto earthquakes of April 14 (M_{JMA}6.5) and April 16 (M_{JMA} 7.3) estimated by the empirical Green's function method

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Two large inland crustal earthquakes, which occurred in the Kumamoto prefecture, Japan, excited the strong ground motions with seismic intensity 7 (upper limit value) of Japan Meteorological Agency scale. One of them occurred at 21:26 (JST=UT+9) on April 14, 2016, with M_{JMA} 6.5 (hereafter we call "the largest foreshock") and the other occurred at 1:25 on April 16, 2016, with M_{JMA} 7.3 (hereafter we call "mainshock"). The large ground motions from these events were densely observed by K-NET and KiK-net stations in and around the epicentral areas. In particular, extremely large ground motions with peak ground acceleration greater than 1000 cm/s^2 were observed at KiK-net KMMH16 (Mashiki) during both the largest foreshock and mainshock. For understanding the physical mechanisms of strong motion generation processes during these events, reliable source models to explain the observed strong motion records need to be constructed.
In this study, we estimate the source models composed of strong motion generation areas (SMGA) by the broadband strong motion simulations (0.3-10 Hz) using the empirical Green's function method. For an objective estimation of corner frequencies for the target and element events, we apply the Source Spectral Ratio Fitting Method (Miyake *et al.*, 1999). From the obtained corner frequencies, scaling parameters N and C, which required for the empirical Green's function method of Irikura (1986), are determined. Then, the parameters of each SMGA (e.g., the size, rupture starting point, rise time, rupture velocity, and relative location from the hypocenter) are estimated by trial and error method.
For the largest foreshock, 16 stations of K-NET and KiK-net (downhole) in Kumamoto prefecture are the target in the strong motion simulation. The observed ground motion records of M_w 4.4 event (element event) occurring at 7:46 on April 15, 2016, are used as the empirical Green's functions. The obtained source model is composed of two SMGAs with same size of 16 km^2. The stress drop of SMGA is estimated to be 13.3 MPa. The rupture within SMGA1 mainly propagates northeastward from the hypocenter. The rupture of SMGA2 located northeast of the SMGA1 also propagates in northeast direction. The obtained source model simulates the observed acceleration, velocity, and displacement waveforms fairly well. The each forward directivity effect by SMGA1 and SMGA2 contribute to the two pulsive wave packets observed in the northeast area along the source fault (e.g., KMM005, KMMH16).
For the mainshock, we also use the same 16 stations as in the case of the largest foreshock. The observed ground motion records of M_w 5.4 event occurring at 22:07 on April 14, 2016, are used as the empirical Green's functions. The obtained source model is composed of one SMGA of 100 km^2 located on the northeast from the hypocenter. The stress drop of SMGA is estimated to be 19.8 MPa. The main characteristics of observations near the source area could be simulated by the obtained source model, although some discrepancies between the observation and simulation still remain. In order to improve the reproducibility of observed ground motions, the parameters of SMGA for the mainshock need to be examined in more detail.

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