Estimation of characterized source model of the mainshock in the 2016 Kumamoto earthquakes using the stochastic Green’s function method

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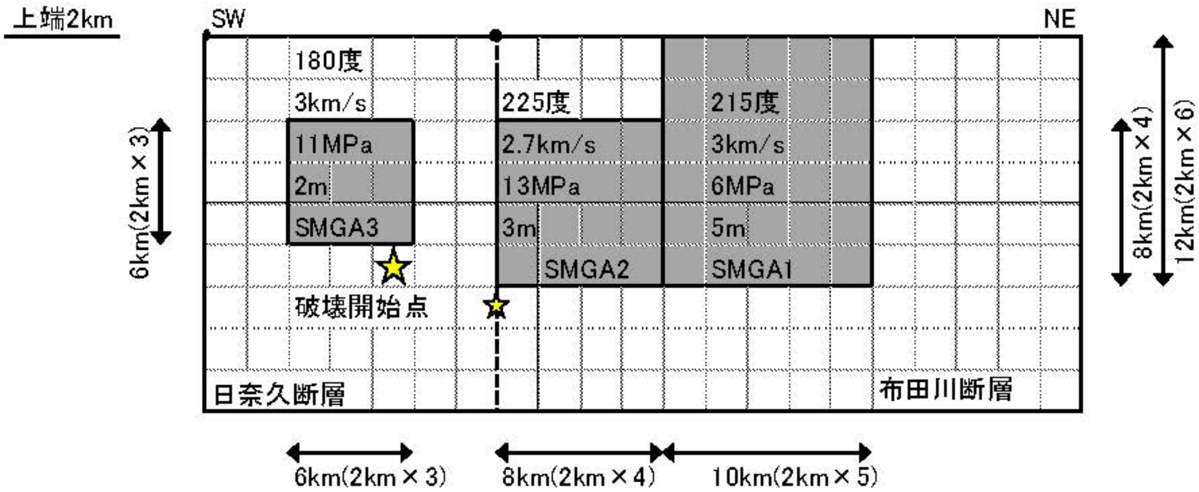
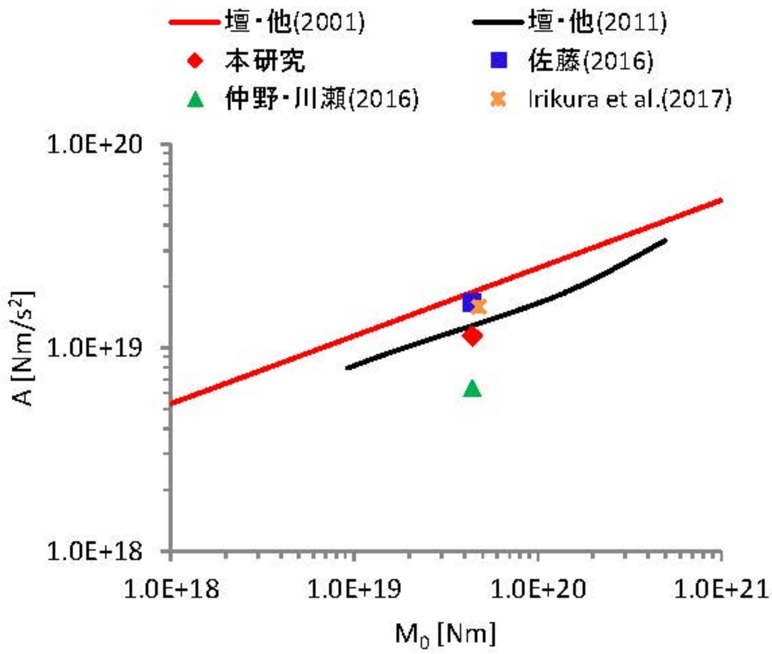
We estimated a characterized source model for the mainshock in the 2016 Kumamoto earthquakes using the stochastic Green’s function method, in preparation for strong motion prediction at points where no observation records were obtained.
Records of the seven KiK-net observation stations, including KMMH16 (Mashiki), were targets of this study. First, the strong motions on the engineering bedrock were estimated in order to remove the site effects of the shallow soil from the observation records. In concrete, the soil models were identified so that the transfer functions between the surface records and the borehole records could be reproduced for less 5 Hz. Then, the strong motions on the engineering bedrock were calculated by the multiple reflection theory using the identified soil models and the borehole records. The NS and EW components were calculated separately, because it was difficult to invert both of them back to the motions on the engineering bedrock using the common identical soil model.
Next, one-dimensional velocity structure models from the seismic bedrock to the engineering bedrock were assumed based on the Japan integrated velocity structure model (Koketsu et al., 2012), then those models were adjusted so that the dominant frequencies of the models corresponded to those of the H/V spectral ratios of the small aftershock records.
The stochastic Green’s functions were generated using the stochastic amplitude model and the envelope function model (Boore, 1983), especially for the area close to the fault. Then, the waves that had bell-shape forms were selected based on Kagawa (2004). The cutoff frequency f_{max} was assumed to be 4 Hz. The Q-value was $62f^{0.87}$ (for f less than 1 Hz) taken from Satoh (2016). The source model was assumed as an SMGA (Strong Motion Generation Areas) model. The location and area of SMGA were set by trial and error, inside the region of the source inversion of Asano and Iwata (2016). The slip of each SMGA was determined with reference to the slip distribution of source inversion (e.g., Asano and Iwata, 2016; Hikima, 2016), and at the same time, so that the displacements and the velocity response spectra in long period range of our simulation agreed with the observed ones. The stress drop of each SMGA was determined so that the accelerations, velocities, and velocity response spectra in short period range of our simulation agreed with the observed ones. The location of the rupture initiation point of Hinagu fault was the same as that by JMA (2016), and that of Futagawa fault was slightly deeper than Hinagu one and located at the southern edge of the fault. The rupture velocity of the small SMGA in Futagawa fault was 2.7 km/s, and that of the large SMGA in Futagawa fault and that of Hinagu fault were 3 km/s.
The obtained source model had a short-period level of 1.14×10^{19} Nm/s^2, which was smaller than Satoh (2016) and Irikura et al. (2017) and larger than Nakano and Kawase (2016). Furthermore, the short-period level was smaller than the empirical relationship between the seismic moment and short-period level of crustal earthquakes proposed by Dan et al. (2001), and was slightly smaller than the empirical relationship of crustal earthquakes caused by strike-slip faults proposed by Dan et al. (2011). The averaged response spectral ratio between the observation records and the simulation results became almost 1 in the period range of 0.2-5 s. However, the ratio was smaller than 1 in the period range longer

than 5 s. This is because the seismic moment of the obtained SMGA model was about 60 % of that of the whole fault (e.g., F-net, 2016). While the duration of simulation results in the area close to the fault trace corresponded well to the observed ones, those of the simulation results in the area far from the fault trace were shorter than the observed ones. This attributes to a problem for setting the amplitude and the envelope function of the Green's function in the area far from the fault trace.

Keywords: 2016 Kumamoto earthquake, Stochastic Green's function method, Characterized source model



（数値：すべり角[度]、破壊伝播速度[km/s]、応力降下量[MPa]、すべり量[m]）



※本研究、佐藤(2016)、仲野・川瀬(2016)の地震モーメント M_0 は F-net の 4.42×10^{19} Nm とした。佐藤(2016)と Irikura et al. (2017)の短周期レベル A は、SMGA の応力降下量と面積を用いて算出した。

