Estimation of the strong motion generation area (SMGA) during the 2018 Hokkaido eastern Iburi earthquake

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On 6 September 2018, an Mw 6.6 earthquake occurred in Hokkaido Eastern Iburi, Japan. Strong ground motion with a maximum 7 on Japan Meteorological Agency (JMA) seismic-intensity scale struck Atsuma in Eastern Iburi and south-east Hokkaido, causing 42 death, about 462 collapsed houses and about 1570 partially destroyed houses (Fire and Disaster Management Agency, 2018). The hypocenter of this earthquake determined by the JMA is located as deep as 37km beneath the western part of the Hidaka Collision Zone where an arc–arc collision system in Hokkaido Island is placed. The characteristics of strong ground motions from this earthquake occurring in deep crust are needed to compare with those from shallow crustal earthquake in other regions in Japan.

The K-NET and KiK-net strong-motion observation networks operated by Japan’s National Research Institute for Earth Science and Disaster Prevention (NIED) recorded strong ground motions at 473 stations during the 2018 Hokkaido Eastern Iburi earthquake. The peak ground acceleration of 1796.4 gal and 1504.8 gal (absolute values calculated from the three components) were measured at K-NET stations HKD127 (Oiwake) and KiK-net stations IBUH01 (Oiwake), respectively, with almost the same hypocentral distance of 44.9km. Figure 1 shows a map view of aftershock distribution and the locations of observed stations and observed records.

The strong motion generation area (SMGA) source model during the 2018 Hokkaido eastern Iburi earthquake (Mw6.6, depth: 37km) was estimated by the empirical Green’s function method (EGFM) using strong motion data in 0.5-10Hz. First, a source fault model of the mainshock was assumed with three segments from aftershock distribution and observed waveforms consisting of three wavepackets. A rupture starting point of each SMGA was determined from the onset of each wavepacket seen in the observed records assuming the source fault plane. Second, two aftershocks (EGF events) are used as the empirical Green’s functions. One is for SMGA1 and SMGA3 the other is for SMGA2 because source mechanisms are different between SMGA1 and SMGA3, although almost the same between SMGA2. The stress parameters and area of the EGF events were estimated from corner frequencies calculated by the source spectral ratios of the mainshock to the EGF events. Third, the synthetic motions from the mainshock are estimated for assumed SMGA models using the EGFM. The best-fit SMGA source model was obtained to minimize the residuals between the observed and synthetic waveforms.

As a result, the best-fit SMGA source model consists of three SMGAs (SMGA1-3) located in the northern segment, the southern segment and the central segment, respectively. The stress parameter of each SMGA is 20-25MPa and slightly higher than those of general crustal earthquakes. The combined area of SMGAs is 68km^2 and deviates a bit smaller from the relationship between the combined area of asperities and seismic moment by Miyakoshi et al. (2019) standing for a higher stress parameter. Finally, we estimated the stress parameters of 35 aftershocks (Mw3.5-Mw4.9) occurring in and around the source area of the mainshock using their corner frequencies from the source spectral ratio method. The stress parameter of the mainshock is slightly higher than those of the aftershocks. The stress parameters of the aftershocks were not particularly high, although they occurred deeper than the other crustal earthquakes.

Keywords: The 2018 Hokkaido eastern Iburi earthquake, strong motion generation area, empirical Green’s function method