An estimation of SMGA of M6 class earthquakes based on strong motion records near the source regions

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High amplitude earthquake motions exceeding 1 G have been observed when M6 class earthquakes occurred for a couple of decades. In the 2004 Rumoi earthquake (M6.1), two SMGAs in the vicinity of the strong motion station caused high amplitude earthquake motions (Maeda and Sasatani , 2008, Motoki et al., 2015). For M6 class earthquakes, which are difficult to set up fault models to be used for strong ground motion prediction, we thought that accumulating information such as stress drop and area of SMGA gave useful information for setting ground motion level for future earthquakes. In this report, we inverted SMGA for the 2011 Ibaraki-ken Hokubu earthquake.

We used empirical Green's function method (EGF) to invert SMGA. Unknown parameters in this inversion were the location of SMGA trigger point, stress drop ratio c, the number of superposition N, length of SMGA, rupture velocity in SMGA, starting rupture time of SMGA, rise time, and random numbers giving the rupture fluctuation to weaken artificial periodicity. For inverse analysis of SMGA, we used a hybrid heuristic method (Yamanaka, 2007), which could solve nonlinear problems and did not require an initial model.

For an inversion of SMGA, we selected 4 stations (IBRH13, IBRH14, IBR001 and FKS014) where the influence of nonlinearity in subsurface soil during the main shock might be small based on degree of nonlinear site response proposed by Noguchi and Sasatani (2011). We also selected 7 earthquakes as element earthquakes for empirical Green’s function. We performed 7 inversion analyses using each element earthquake record.

Corner frequencies of the element earthquakes were evaluated by means of genetic algorithm so as to minimize the sum of residuals between the observed source spectral ratio and the source spectrum ratio function assumed ω-square model in the frequency domain. We set the search range for an inversion of SMGA, by referring to the previous source model (JMA, 2017) and c and N expected from the observed source spectral ratio. In this inversion M_0 and A, which means radiant amplitude in a short period range, were constrained not to exceed the value estimated by F-net and the value obtained from the source spectral ratio, respectively. The acceleration envelope shapes, the displacement waveform, and the Fourier amplitude were used as the objective function for an inversion.

Assuming one SMGA, the inverted SMGA could explain the earthquake motions near the source region. The SMGA location were good agreement with the large slip area in the previous models (JMA, 2017 and Hikima, 2017), which were used long period motions for their inversions.

Furthermore, in order to confirm the validity of the inverted SMGA from a theoretical aspect, we performed numerical simulation for the down-hall station at IBRH13 using the theoretical Green’s function analysis (Hisada and Bielak, 2003). The simulated motions successfully reproduced the pulse wave and the response spectra of the observed motions.

We compared the area of SMGA estimated in this study with the relation of M_0 –area of SMGA according

to Miyake et al. (2003). The result of this study is smaller than that of relation by Miyake et al. One factor that caused this difference is thought to be due to the difference in idea of modeling. As mentioned above, M_0 of the SMGA in this study corresponded to a third of M_0 evaluated by F-net. Meanwhile, the SMGA of Miyake et al. (2003) had set the SMGA to include all of the M_0. It can be consider that the larger M_0 of SMGA has the larger area of SMGA. On this issue, we think that it is important to apply other earthquakes and accumulate data, and we will analyze SMGA of the 2013 Tochigi-ken Hokubu earthquake.

Keywords: Strong motion generation area, M6 class earthquake, Inversion, Empirical Green's function method

