

Strong ground motion simulation of the main shock of the 2016 Kumamoto Earthquake using the pseudo point-source model and its improvement

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Many near-fault strong motion records were obtained during the main shock of the Kumamoto, Japan, earthquake on April 16th, 2016. In general, observed records of such a large earthquake reflect the finiteness of the fault, that is, directivity effect. On the other hand, strong motion simulations using simple point sources and empirical site amplification and phase characteristics have well reproduced observed strong motions of large earthquakes such as the 1995 Kobe and 2011 Tohoku Great earthquakes (for example, Nozu, 2016). Investigating the applicability of the point source model to large earthquakes is important to understand the mechanism of strong motion generation. In this study, then, we constructed a pseudo point-source model (Nozu, 2012) for the main shock of the Kumamoto earthquake and the simulation results were compared with the observed records.

In the pseudo point-source model, the source spectrum is combined with the path effect, empirical site amplification factors, and empirical phase characteristics from small earthquakes to synthesize strong motions. Source parameters include the location of the point sources, corner frequencies, and seismic moments. In our model for the main shock of the 2016 Kumamoto earthquake, three subevents were placed on the fault plane along Futagawa fault: two of them were placed below Mashiki Town, about 5 km northeast from the epicenter, and the other was placed below Nishihara Village, about 15 km northeast from the epicenter. Two subevents were placed around Mashiki town to reproduce the characteristic velocity pulses and the trough in the observed Fourier spectrum at Mashiki, which was considered due to the interference of the seismic waves from two different sources. The observed and synthetic velocity waveforms (0.2-2Hz) and acceleration Fourier spectra were compared. The synthetic results generally reproduced the main features of the observed records, however, discrepancies were also observed. One of them is the underestimation in the frequency range below 0.6 Hz, which was considered due to the contribution from shallow slip including near-field and intermediate-field terms, because the effect of shallow slip were not considered in the point source models. Large permanent displacements could be due to the near-field and intermediate-field terms. We need to incorporate the effect of shallow slip including these terms if they contribute to near-fault ground motions around 0.6 Hz, because ground motions in this frequency range contribute to damage to structures. Another discrepancy found in the point-source model is the underestimation at the stations northeast of the epicenter, around Aso Caldera. This is presumably due to the fact that the point source models cannot capture the directivity effect, whereas the actual rupture proceeded northeast and caused significant forward directivity effect at stations located northeast of the fault.

We need to model not only the deep subevents but also the shallow slip in order to adequately conduct strong motion simulation for the 2016 Kumamoto earthquake. We will use an ordinary point source model for the deeper part, and incorporate the effect of shallow slip including near and intermediate-field terms. The original model was intended to explain whole strong motions without considering the shallow slip. In the new model, by incorporating the effect of the shallow slip, the parameters for the deeper point source will also be affected. The new model will be presented in the meeting.

Keywords: The 2016 Kumamoto earthquake, strong ground motion simulation, pseudo point-source model