Simulation of strong ground motions for the 1995 Kobe earthquake based on the pseudo point-source model

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In our country, the characterized source model, which is composed of rectangular subevents generating strong ground motions, have extensively been used for the purpose of predicting strong ground motions (e.g., Kamae and Irikura, 1997). On the other hand, the author (Nozu, 2012) proposed a new source model, namely, the pseudo point-source model. In the model, the spaciotemporal distribution of slip within a subevent is not modeled. Instead, the source spectrum associated with the rupture of a subevent is modeled and it is assumed to follow the omega-square model (Aki, 1967). The source model consists of only six parameters for each subevent, namely, the longitude, latitude, depth, rupture time, seismic moment and corner frequency of the subevent. The model involves much less model parameters than the conventional characterized source model. Once the model parameters are given, by multiplying the source spectrum with the path effect and the site amplification factor, the Fourier amplitude at the site of interest can be obtained. Then, combining it with the Fourier phase of a smaller event, the time history of strong ground motions from the subevent can be calculated. Finally, by summing up contributions from the subevents, strong ground motions from the entire rupture can be obtained.
According to the results of past studies, the model can explain strong ground motions from a mega-thrust earthquake (Nozu, 2012) and an intraslub earthquake (Nagasaka et al., 2014), sometimes better than the conventional characterized source models. Its applicability to short distances, however, could be restricted, because it is expressing the subevent with a point. In addition, the current version of the pseudo point-source model does not consider directivity effects. Therefore, its applicability to shallow crustal earthquakes should carefully be examined by using observed records.
In this study, a pseudo point-source model with three subevents was developed for the Kobe earthquake and strong ground motions were simulated based on the model. According to the results, the pseudo point-source model can explain strong ground motions at KBU and MOT located in Kobe fairly well.
It is well known that strong ground motions in Kobe during the Kobe earthquake were affected by forward directivity (e.g., Kamae and Irikura, 1997). Then the question is why a pseudo point-source model, which does not consider rupture propagation explicitly, can explain strong motions in Kobe. To understand the reason, both Fourier amplitude and phase characteristics of the synthetic ground motions have to be considered. In terms of the Fourier amplitude, rupture propagation theoretically causes a shift in the corner frequency; the corner frequency is increased when the site is affected by forward directivity. In the present pseudo point-source model for the 1995 event, the corner frequencies were determined to be consistent with the observations and, as a result, the selected values of corner frequencies involve any effect of forward directivity. This should be one reason why the model can explain strong ground motions in Kobe. In terms of the Fourier phase, in general, the observed Fourier phase is the sum of the source, path and site effects. In the pseudo point-source model, because the Fourier phase of a small event is used, only the path and site effects are considered. This is equivalent to assuming that the source time function of each subevent is a delta function. Therefore, as long as the Fourier phase is concerned, the pseudo point-source model is actually suitable for the forward sites where the apparent source time function approaches to a delta function. It means that discrepancy is anticipated for the backward

sites. This point should be further studied using records from other crustal earthquakes with better azimuthal coverage.
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Keywords: pseudo point-source model, the 1995 Kobe earthquake, strong ground motion

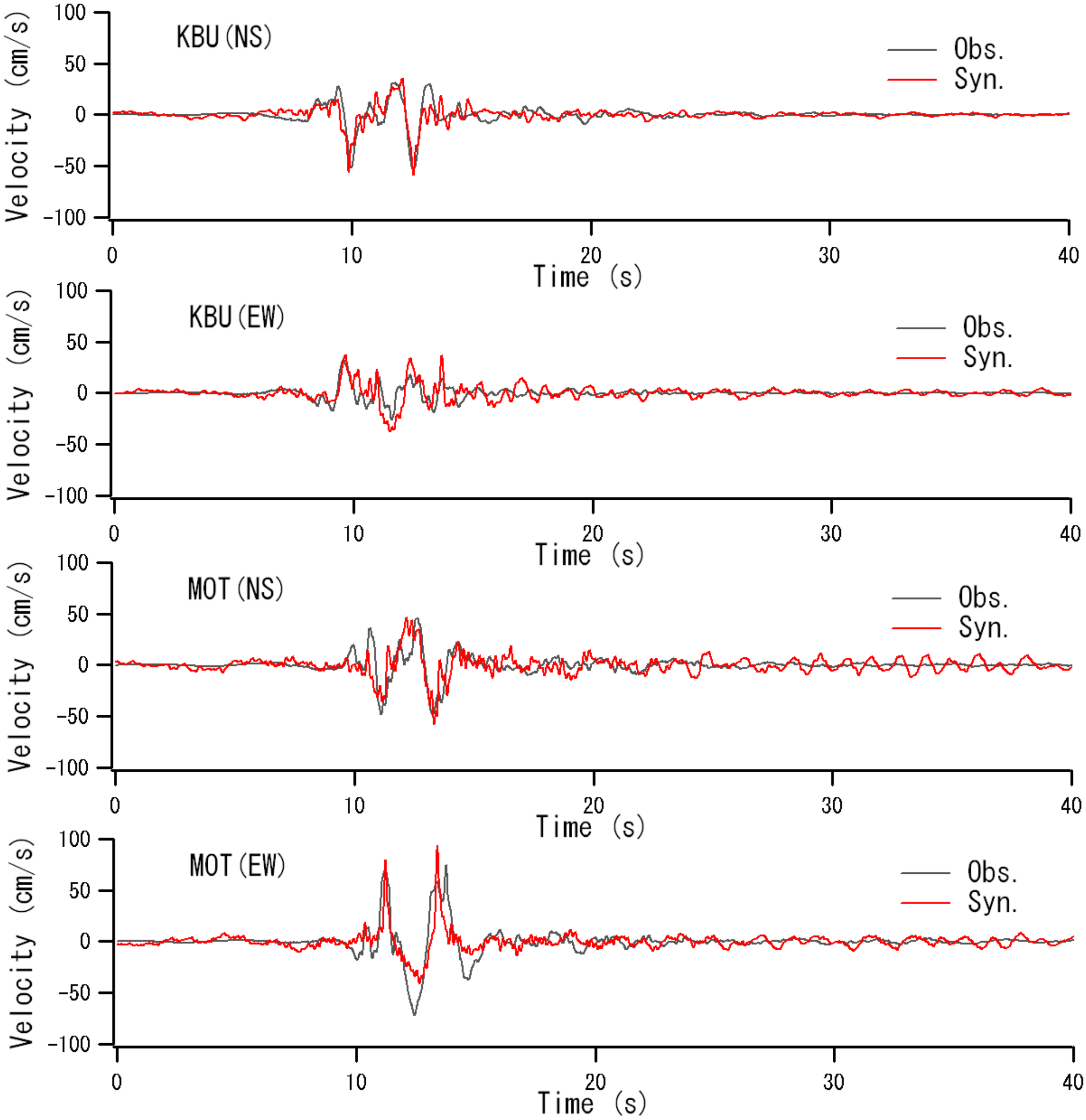

Figure 1 Observed and synthetic velocity waveforms at KBU and MOT

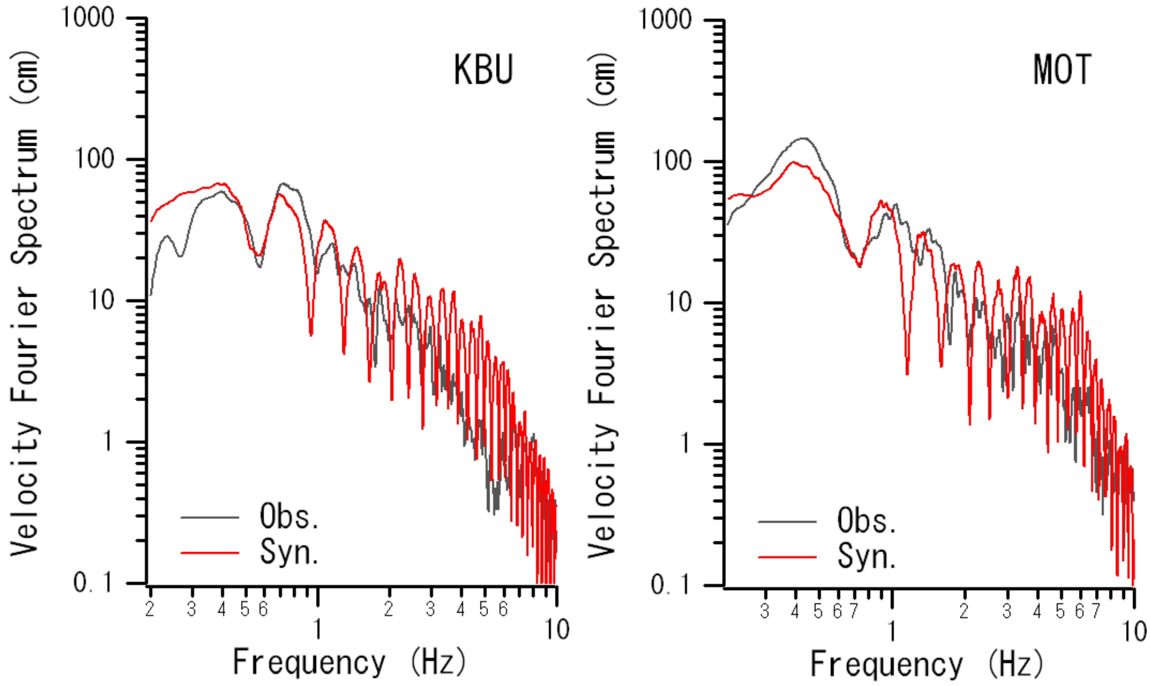

Figure 2 Observed and synthetic Fourier spectra at KBU and MOT
(composition for two horizontal components, parzen window 0.05Hz)