Extension of characterized source model for long-period strong motions near surface-rupture-earthquakes

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Introduction: Strong ground motions from the 2016 Kumamoto earthquake (Japan) were well simulated based on the characterized source model consisting of strong-motion-generation-areas (SMGAs) with high stress drop and a background area with low stress drop except very-near fault stations (Irikura et al., 2017). Strong ground motions observed at very-near-fault stations less than 3 km away from the surface traces along the Futagawa fault zone have specific long-period motions including maximum permanent displacements beyond 2 m. To reproduce long-period ground motions at those very-near-fault stations, we need not only to put SMGAs but also to add long-period motion generation areas (LMGAs) in surface layers from fault surface to a certain depth above the seismogenic zone. During the 2010 Mw7.1 Darfield earthquake (New Zealand), surface breaks caused by the mainshock were found associated with active faults by field surveys. Strong ground motions from the 2010 Darfield earthquake were also simulated well using the conventional characterized source model except ground motions at very-near fault stations. Reproduction of very-near-fault motions with permanent components for the 2010 Darfield earthquake are also needed to take into account LMGAs in surface layers. The same phenomena have been observed in the 2011 Nagano-ken Hokubu earthquake (Mw 6.2), the 1999 Chi-Chi earthquake (Mw 7.6), and other surface-rupture earthquakes as long-period motions and permanent displacements seen in the 2016 Kumamoto and 2010 Darfield earthquakes Then, we propose the extension of the characterized source model adding long-period motion generation areas (LMGAs) from fault surface to a certain depth above the seismogenic zone. The parameters for SMGAs are given following the recipe by Irikura and Miyake (2010). The parameters of LMGAs are discussed in relation to scaling relationships of surface-rupture earthquakes.

Extension of characterized source model: Long-period motions with permanent displacements at the very-near-fault stations during the 2016 Kumamoto earthquake are not well simulated based on the conventional characterized source model. SMGAs in the conventional characterized model were determined inside the seismogenic zone deeper than 3 km. To generate long-period motions near the fault traces, long-period motion generation areas (LMGAs) are deployed in surface layers from fault traces down to a certain depth. Similar studies have been made by several authors (e.g. Ikutama et al. 2017; Tanaka et al., 2018; Satoh, 2018; Iwaki et al., 2018). Ground motions more than 2 s observed at very-near-fault-distance stations such as 93048 (Nishihara Village Hall), 93051 (Mashiki Town Hall), KMMH16 (Mashiki-KiK-net station) in the 2016 Kumamoto earthquake are well reproduced adding long-period motion generation areas (LMGAs). During the 2010 Mw7.1 Darfield (New Zealand), surface breaks caused by the mainshock were found associated with active faults by field surveys. Strong ground motions from the 2010 Darfield earthquake were also simulated well using the conventional characterized source model except ground motions at very-near fault stations. Reproduction of very-near-fault motions with permanent components for the 2010 Darfield earthquake are also needed to take into account LMGAs in surface layers. To determine the extended characterized source model for strong motion prediction of target earthquakes, first the procedures for estimating the outer and inner fault parameters are preserved for the SMGAs. Next, to set LMGAs for the target earthquake, L_b (Length of LMGA), W_b (Width of LMGA), D_b (Maximum slip of LMGA), T_b (rise time of slip velocity time, function) are systematically given, following scaling relationships for surface-rupture earthquakes.

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Keywords: strong ground motions, characterized source model, strong-motion generation area, long-period motion generation area

