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Three-dimensional Seismic Wave Propagation Simulations in the southern Korean Peninsula using Pseudo-dynamic Rupture Models

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Key Points

- We simulated seismic wave propagation in the 3-D Korean Peninsula model for pseudo-dynamic rupture scenarios.
- Surface wave radiation, rupture directivity, and 3-D amplification effects were accurately modeled.
- The physics-based simulations provide constraints on seismic hazard characterization in the Korean peninsula.

Declaration of Competing Interests

The authors acknowledge there are no conflicts of interest recorded.

Abstract

Accurate and practical ground motion predictions for potential large earthquakes are crucial for seismic hazard analysis of areas with insufficient instrumental data. Studies on historical earthquake records of the Korean peninsula suggest that damaging earthquakes are possible in the southeastern region. Yet classical ground motion prediction methods are limited in considering the physical rupture process and its effects on ground motion in complex velocity structures. In this study, we performed ground motion simulations based on rigorous physics through pseudo-dynamic source modeling and wave propagation simulations in a three-dimensional (3-D) seismic velocity model. Ensembles of earthquake scenarios were generated by emulating the 1- and 2-point statistics of earthquake source parameters derived from a series of dynamic rupture models. The synthetic seismograms and the distributions of simulated peak ground velocities were compared with the observations of the 2016 M_W 5.4 Gyeongju earthquake in the Korean Peninsula. The effects of surface-wave radiation, rupture directivity, and both local and regional amplifications from the 3-D wave propagation were reproduced accurately in the spatial distribution of simulated peak ground velocities, in agreement with the observations from dense seismic networks by mean log-residuals of -0.28 and standard deviations of 0.78. Amplifications in ground motions were found in regions having low crustal velocities and in regions of constructive interference from the crustal shear wave phases associated with post-critical reflections from the Moho discontinuity. We extended the established approach to earthquake scenarios of M_W 6.0, 6.5, and 7.0, at the same location, to provide the distribution of ground motions from potential large earthquakes in the area. Although we demonstrate the value of these simulations, improvements in the accuracy of the 3-D seismic velocity model and the

scaling relationship of the source models would be necessary for a more accurate estimation of near-source ground motions.