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Near-Fault Strong Ground Motion Simulation of the Mw7.9 Wenchuan Earthquake by Dynamic Composite Source Model

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The great Wenchuan Earthquake of the May 12, 2008, M_w7.9 occurred in Sichuan province of the Western Interior China with an epicenter located at the longitude of 103.4°E and latitude of 31.0°N. The main fault ruptured more than 300 km in length with a striking direction from southwest toward northeast along the Longmenshan Central Fault. The geological and geophysical investigations also revealed the significant fault segmentation existed during the earthquake faulting. The Wenchuan-Yingxiu segment of the fault is dominated by pure thrusting with a dip angle about 40°,while the Beichuan-Anxian segment of the fault in the central part of the main fault underwent both thrusting and striking with a dip angle of 70°,and the remained segment of the fault, a part of the Qingchuan fault, underwent an almost pure strike slip motion with a dip angle of 80°.In this study, a modified composite source model, named as dynamical composite source model (DCSM), has been constructed to simulate near-fault strong ground motion with associated fault rupture properties from a kinematic point of view. In addition to the moment conservation used in the source description, we also derived a new scaling relation between the apparent stress and static stress to constrain the near fault particle motions from seismic radiation conservation principle given by Rivera and Kanamori (2005). For the Wenchuan event, a specific finite fault model with the size of 320 km and 20 km both in length and width, respectively, is constructed for simulation purpose. Moreover, the fault model consists of three major segments in which each segment could has a specific geometry related to the dip angle and strike direction. In addition, the rakes related to the slip direction on the fault plane of each segment could be assigned dynamically based on the focal mechanism solution. For comparing purpose, we conduct broadband ground motion predictions for three typical near-fault strong motion stations of Wolong, Pixian-Zoushishan and Mianzhu-Qingping. In general, the synthetic seismograms produced for these stations have good agreement with the observations in time histories, waveforms, peak values and frequency contents, which indicate the numerical technique of current source model could be capable of reproducing the main characteristics of strong ground motion for the Wenchuan earthquake. In addition, we give the comparison of recorded PGA on 83 stations and the simulations on the same stations with the attenuation relationship which is given by Boore. The comparison indicates the consistency of the recorded and simulated PGA in the field nearer the fault line. In fact, the numerical modeling developed in this study has the great potential application in the ground motion estimation/prediction for the earthquake engineering purpose. Furthermore, the numerical algorithm could also be used to generate the near-real-time shaking map in the implementation level if incorporated current finite fault inverse technique.

Keywords: Wenchuan Earthquake, Dynamic composite source model, Strong ground motion simulation