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应用动态复合震源模型模拟汶川M_W7.9地震强地面运动

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Near-fault strong ground motion simulation of the May 12, 2008, M_W7.9 Wenchuan Earthquake by dynamical composite source model

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摘要 2008年5月12日中国汶川地区发生M_W7.9地震,震中位置103.4° E,31.0° N.主要发震断层空间展布长达300多公里,由南西方向到北东方向呈现明显的分段性,汶川—映秀段逆冲为主兼有少量的右旋走滑分量;安县—北川段为逆冲-右旋走滑的断层错动;青川段以右旋走滑为主兼有少量逆冲分量.采用改进后的复合震源强地面运动预测模型,建立了长为320 km,宽为20 km的断层破裂运动学模型,实现了断层分段、空间倾角、滑动方向连续变化的动态设定.数值模拟结果给出了近断层两侧(上、下盘)的地面加速度的分布特征,并同卧龙、郫县走石山及绵竹清平强震观测记录进行了对比分析.模拟加速度时程曲线无论在波形、持续时间、频率分量、峰值大小同观测记录都具有较好的相似性.利用现有83个已知经纬度台站的强震实测数据及数值模拟的结果同Boore等的新一代衰减关系(NGA)进行比较,对比模拟与实际观测水平峰值加速度的一致程度.近断层峰值加速度分布特征则进一步显示了在汶川、北川和青川附近明显的高值分布区域,同野外地质调查相一致.进一步的分析结果也表明,汶川—映秀段逆冲为主的断层上盘的运动量远大于断层下盘,在距离断层地表出露位置5 km处,峰值加速度N-S、E-W及UP方向分量的比值分别为1.72∶1、2.5∶1及1.77∶1.本文中给出的动态复合震源模型和近断层区域强震模拟的计算方法,对大震强地面运动的预测及实现近实时强地面运动分布特征的圈定(Shaking Map)有着重要的实际意义.

关键词: 汶川地震 断层分段 复合震源模型 强地面运动 NGA 峰值加速度 Shaking Map

Abstract: The great Wenchuan Earthquake of May 12, 2008, M_W7.9 occurred in Sichuan province of western China with the epicenter at longitude 103.4° E and latitude 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 significant fault segmentation 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 strike-slipping 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 developed to simulate near-fault strong ground motion with associated fault rupture properties from a kinematic point of view. For the Wenchuan event, a specific finite fault model with a length of 320 km and a width of 20 km 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 that the numerical technique of current source model could reproduce the main characteristics of strong ground motion for the Wenchuan Earthquake. In addition, the near-fault peak ground acceleration (PGA) distributions resulted from current simulation show much higher PGA values in the areas of Wenchuan, Beichuan and Qingchuan than other places, which is consistent with recent field observation and reports. The map of PGA distribution also indicates that, compared with other two segments of earthquake faulting, the ground motion

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caused by Wenchuan-Yingxiu thrusting is much stronger on the hanging wall than on the footwall, for example, the PGA ratios of the hanging wall to footwall could reach 1.72∶1, 2.5∶1 and 1.77∶1 for N-S, E-W and UP components, respectively, at a given distance of 5 km from the fault trace on both sides of the fault. 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 Fault segmentation Composite source model Strong ground motion NGA Peak ground acceleration Shaking Map

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