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Seismic wave propagation damage caused by the 1999 Chi-Chi, Taiwan earthquake: II. FDM simulation of the repeating earth

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Three quasi-periodic M 3.8˜ 4.6 repeating earthquake sequences occurred in eastern Taiwan from 1991 to 2007 reveals a unique temporal and spatial variation in seismic wave character associated with the 1999 Mw 7.6 Chi-Chi earthquakes in central Taiwan. The repeating events occurred after the time of Chi-Chi event reveal late-arriving phases and notable change in seismic wave character of S-wave coda as demonstrated by Chen et al. (2011).

To understand the behavior of low velocity anomaly induced by 1999 M7.6 Chi-Chi earthquake, we compute the postseismic changes in wavefield using a 2-D finite-difference method for seismic waves simulation. The simulation model covers a 200x100 km2 area and is discritized by small grid of 50 m, with a seismic source radiating seismic wave of frequency up to 8 Hz. The P- and S-wave velocity structure model is followed by studies of reflection experiments, gravity anomaly and travel-time tomography. The effect of slightly different location and focal mechanism on waveform cross-correlation coefficient (ccc) was first examined. The subtle change in source location, dip angle, and rake produce the ccc drop over the whole seismograms and in all frequencies, which is not consistent with the observed predominance of ccc reduction in high-frequency energy and in S-wave coda. The effects of near-surface damage and fault zone damage with varying depth are next examined, to compare with the spatial extent and magnitude of ccc reduction. The computed change in scattering properties correlates with the spatial extent of such influence zone only if the near-surface, low-velocity anomaly is placed in a ˜50 km wide area, or if the fault zone damage is set at 10-20 km depth. The snapshots of differential wavefield (i.e., substituting reference wavefield from the target) clearly illustrate the newborn P-to-S and S-to-S converted waves by the Chi-Chi earthquake fault. In contrast, the surface break model explains the Chi-Chi effect at the stations on the hanging wall, where the change appears at late S-wave coda. The differential wavefield illustrates strong scattering of the S wave from near surface low-velocity layer, overlapping the S-wave coda in later time. The correlation between the observation and simulation explored here point to not only pervasive damage near the surface but also the deep, along-fault damage at the time of the Chi-Chi earthquake.

Keywords: repeating earthquake, Taiwan Chi-Chi earthquake, FDM simulation