Modeling dynamic rupture process of the 1999 Chi-Chi earthquake and near source strong ground motion simulation

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Earthquake source dynamics provides key elements for the prediction of strong ground motion and for understanding the physics of earthquake processes. This research addresses the characteristics of dynamic source rupture process of a large earthquake by using a 3D finite difference method with variable grid spacing. A new algorithm is proposed to deal with a non-planar fault model. We apply this approach to the 1999 Chi-Chi earthquake with a curved fault surface and rebuild the dynamic source rupture process for this larger earthquake.

For the dynamic rupture process, our result reveals the rupture propagation jumping phenomenon which is difficult to be simulated in kinematic modeling. That is when the propagation front encountered a zone with a high strength excess, the rupture would pause to accumulate more energy to break it. Meanwhile, if there are low strength excess zones around the barrier, the propagation front would jump over the barrier to break the low strength excess zones and leave the high strength barrier unbroken. Such phenomenon of the high strength excess barriers intend to delay the propagation front can be seen clearly in the dynamic model. So, the distribution of the rupture starting time is much more inhomogeneous than that of the kinematic model. Using a thick fault zone model, the dynamic model discovers that the slip on the hanging-wall side is larger than that on the food-wall side.

Based on the dynamic source rupture model, the strong ground motions near the fault surface breaks are simulated in frequency range of 0.05 to 0.5 Hz. In general, the synthetic velocity waveforms agree well with the observed records for most stations. The dynamic source model successfully simulates the distinctive velocity pulse for the stations in the forward rupture direction. Also our dynamic source model successfully reproduced the waveforms as well as the distinctive velocity pulses for the station nearby or on the fault surface breaks. These results demonstrate that our dynamic source model can reproduce the main features of long period ground motions; hence, lead us to a better understanding on the source rupture process of the Chi-Chi earthquake.