Geophysical Research Abstracts, Vol. 9, 02425, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-02425

Pseudo-dynamic modeling of large strike-slip earthquakes

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Accurate prediction of the intensity and variability of strong ground motion for future large earthquakes depends on our ability to simulate realistic earthquake source models. Guatteri et al. (2004) developed a "pseudo- dynamic" source modeling method to generate physically self-consistent kinematic source models based on dynamic source parameters (i.e., stress drop and fracture energy). Pseudo-dynamic models are constructed by first generating a slip distribution as a realization of a spatial random field that is consistent in its scaling and spatial variability with slip distributions of past earthquakes. The corresponding static stress drop is computed from the given slip distribution and fracture energy is obtained using scaling relations with stress intensity factor (Mai et al., 2006). The model is completed by estimating the temporal evolution of slip through a set of empirical relationships, derived from the analysis of spontaneous rupture models, between the dynamic source parameters and kinematic motions. However, their method was originally developed for strike-slip earthquakes with a magnitude range of $M < 7.2$ and, its application to larger earthquakes ($M > 7.2$) requires a new procedure updated and validated for larger magnitudes. We have constructed 15 spontaneous dynamic rupture models with different slip realizations and hypocenter locations for large, Mw 7.5, strike-slip earthquakes that have a very long and narrow rupture dimension (150 km long and 15 km wide). Our regression analysis of these constructed models suggests that the previous pseudo-dynamic relationships break down for earthquakes larger than originally designed, particularly for the rise time. This is due to the critical role that fault width plays in controlling rupture behavior in a long narrow faulting (Day, 1982). We are using the dynamic rupture models to develop a next generation of the pseudo-dynamic modeling scheme that applies to large strike-slip earthquakes and can be used for strong motion simulations.