Dynamic rupture modeling with non-planar faults and generation of strong motion

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Recently, Aochi and Fukuyama (2001) investigated the 1992 Landers earthquake and found that using a rotating stress field together with a laterally homogeneous depth dependent friction law can produce a convincing model that explains the characteristic feature of its dynamic rupture. In this paper, we show how the initial conditions given in the modeling produces differences in rupture history and how we can constrain the fault properties by comparing various alternative models with that obtained by Aochi and Fukuyama (2001). Moreover, by introducing lateral heterogeneity as well as the normal stress effect in Coulomb's friction law, we discuss the possibility of modeling the dynamic rupture process taking into account the fault geometry, fault property and initial distribution of stress.

Recently, Aochi and Fukuyama (2001) investigated the rupture process of the 1992 Landers earthquake using BIEM on a non-planar fault model. They found that rotating the stress field and using a laterally homogeneous depth dependent friction law can produce a convincing rupture model that explains most of the features of the dynamic rupture of this event. These results suggest a more general discussion on the relation between fault structure and earthquake generation process through the dynamic simulation of spontaneous rupture. In this paper, we show how the initial conditions given in the modeling produces differences in the rupture history and how we can constrain the fault properties by comparing various alternative models with the model obtained by Aochi and Fukuyama (2001).

In order to reproduce the large observed slip distribution near the surface that did not appear in Aochi and Fukuyama (2001), the simulation requires that we introduce a non-zero cohesive force in the depth-dependent friction law. This cohesive stress should be close to 10MPa as used by Payrat et al. (2001). These values are required in order to fit the observed waveforms at the Yermo station situated toward the forward direction of the rupture. Moreover, the fault selection mechanism during the rupture cannot be explained without a heterogeneous stress distribution and/or heterogeneous distribution of fault parameters in the friction law. These two features become very critical when we consider the strong motion generation near the fault. As shown by Aochi and Fukuyama (2001), the fault geometry, the distribution of frictional parameters as well as the initial stress condition let us predict the dynamic rupture of the large earthquake, which in tern determine the generation of strong motion.

Under uniform external loading, we had to assume strong heterogeneity on both main fault and its branches, whereas for the rotational stress field under uniform friction we could explain the characteristic feature of the observation [Aochi and Fukuyama, 2001]. When we used the Coulomb friction law in order to produce stress/strength heterogeneity on the fault taking into account the normal stress, more heterogeneity was still required to reproduce the observations. This should exist as a lateral heterogeneity of materials. However, although we did not obtain an effective way to introduce heterogeneity yet, we hope this methodology will eventually lead us to make a reasonable modeling of earthquake rupture and generation of strong motions. Because in our method, unfavorable fault orientation with respect to external loading direction requires very weak fault property, however, fault strength might be difficult to change drastically in the horizontal direction.