On the friction laws revealed fromwaveform inversions

Changjiang Wu[1], Minoru Takeo[2]

[1] Earth and Planetary Sci., Univ. of Tokyo, [2] ERI, Univ. Tokyo

There are two apparently different friction laws widely applied to explain earthquake phenomena, namely the rate and state friction law and the slip weakening law. Kinematic source models obtained from waveform inversions have been used to extract the friction laws (e.g. Ide and Takeo, 1997; Guatteri et al., 2001). Before applying these two laws to dynamic ruptures, however, we need examine the extend to which the stress obtained from kinematic parameters by FDM or other ways agrees with the definition of friction. We propose that instead of focusing on the critical parameters of these two conventional friction laws we should pay more attention to energy balance during dynamic rupture.

Taking into consider kinetic energy consumed by the rupture zone or the process zone, we find overshoot can not be safely neglected when the width of the rupture zone reaches an order of kilometers. It seems that earthquakes with surface rupture trace probably experience overshoot. The 1999 Taiwan earthquake ruptured the surface ground and took a shape of horsetail in the north fault. It suggested that overshoot should be taken into account in this case. Meanwhile, a larger width of the fault zone means larger rupture energy. The so-called critical weakening distance losts its physical meaning when overshoot is included.

Moreover, considering the asymmetry of displacement distribution on the two sides of the sliding fault plane in the case of a reverse faulting, work done against the gravity cannot be neglected, especially in the hanging wall. It means that the energy carried by the seismic waves above the hanging wall is smaller than that of strike slip faulting even with the same slip distribution.

Finally, when we apply the finite difference method to simulate the dynamic rupture or to obtain the stress-slip functions, a considerably large magnitude of the width of the fault zone is implicit in this method. However, overshoots have always been neglected, partly due to calculation difficulties.