Earthquake Radiated Energy and Apparent stress, constraints for dynamic models of the rupture

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The energy radiated as seismic waves strongly depends on how the fracture propagates during the earthquake. We calculated the radiated energy, and apparent stress, from the known slip history, resulting from a kinematic inversion. Since we know the evolution in time of the slip, we can then obtain the relationship between the slip and the apparent stress for every subfault.

We applied the above methodology to the Hyogoken-nanbu earthquake, obtaining similar values of Dc to those obtained by Bouchon (1998). So far the results obtained, show a clear dependence of the Dc value to the final slip distribution in the fault plane. The present method could be a straightforward way of defining a constitute law consistent with the slip distribution to be use in the calculation of dynamic models.

The energy radiated as seismic waves from an earthquake depends mainly on two factors: the first one is determined only by static quantities, that is the final slip and static stress drop and does not directly depend on the rupture process. On the other hand the second factor contains the traction rate on the fault and strongly depends on how the fracture propagates during the earthquake (Rudnicki and Freund 1981, Kostrov B. and Das. S. 1988). The observation so far obtained suggests the possibility of obtaining information about the dynamic parameters of the source directly from the temporal evolution of the radiated energy in the fault plane.

The basic idea is the calculation of the radiated energy from the known slip history, resulting from a kinematic model, following (Rudnicki and Freund 1981). The radiated energy from the source up to some time t, is proportional to the integral between the rupture starting time and t, of the squared value of the derivative of the moment rate, obtained from the kinematic source inversion. For calculating the apparent stress we should first obtain the cumulative moment (namely cumulative slip) until some time t, and then the apparent stress at t is calculated from the ratio between the energy and the cumulative moment times the rigidity.

The information we actually obtain from the above calculation represents the evolution of the apparent stress in time for every subfault in the fault plane. If we go one step further, since we already know the evolution in time of the slip, we can then obtain the relationship between the slip and the apparent stress for every subfault.

We applied the above methodology to the Hyogoken-nanbu earthquake, and obtained the relationship slip vs apparent stress for every subfault. The relationship here obtained showed in general a shape corresponding to a typical slip-weakening constitutive law. Moreover we compared our results to the results obtained by Bouchon 1998, and we found that the values we obtained for the slip weakening distance Dc, are in the same range (0.2 to 1.0 m).

The relationship between the apparent stress and the actual stress field in the fault plane is not clear yet, but the results suggest that from the radiated energy it is possible to obtain a fundamental dynamic parameter such as the slip weakening distance. If this result comes to be true, it would be a straightforward way of obtaining the Dc value, and then proposing a constitutive law that is consistent to the distribution of the slip in the fault plane, namely the location of asperities. So far the results obtained from the Hyogoken-nanbu earthquake and the Tauramena (Colombia 1/191995) earthquake, show a clear dependence of the Dc value to the final slip distribution in the fault plane.

References

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