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Earthquake energy balance

R. Madariaga

Laboratoire de Géologie, Ecole Normale Supérieure, Paris, France (madariag@geologie.ens.fr)

Earthquake energy balance has been the subject of a lively discussion in recent years, in particular whether energy balance is global or whether it can be localized on the fault. We examine in detail the energy balance both antiplane cracks (mode III) and slip-pulse models of earthquakes. For flat crack models we demonstrate that energy balance is local and entirely determined by rupture velocity and its variations in space and time. All rupture speeds up to the shear wave speed are possible. For slip pulse models it is not possible to localize energy balance because healing reduces available energy transferring it from the bulk into a region located around the fault. For pulses of finite width, rupture speeds can not reach the shear wave speed because there is not enough time to transfer energy from the bulk into the trailing edge of the slip pulse. Slip pulses are thus unstable. For models with fault discontinuities, each of these geometrical features radiate accelerations that have all the properties of white noise in a finite frequency range explaining the ubiquitous omega-squared model of seismic radiation. If these geometries are not included explicitly into the energy balance they produce an increase in the apparent energy release rate that is no longer a property of friction, but of friction plus geometry. We examine the possibility that energy release rate scales with fault size in this model. These results can be extended to in-plane faulting under certain assumptions about the behavior of geometrical discontinuities that will be discussed. These results also apply to 3D rupture fronts under the condition that the radius of curvature of the wave front is much longer than the length scales related to slip weakening.