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Time behavior of aftershock series simulated by using a modified version of the Dynamic Fiber Bundle (FBM) model

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The Fiber Bundle Model (FBM) has been frequently used to analyze the rupture process in heterogeneous materials. The FBM is a simple discrete stochastic fracture model suitable to either close analytical or fast numerical solutions. The dynamic version of the FBM simulates the failure of materials due to different kind of phenomena like static fatigue, delayed-rupture, stress-rupture or creep-rupture. Three basic components are common to all FBM: a discrete set of N elements located at the sites of a d-dimensional lattice; a probability distribution for the failure of individual elements, where the most common is the Weibull distribution; and, a load-transfer rule which determines how the load carried by a failed element is distributed among the surviving elements. The time behavior of three series of aftershocks in Southern California, associated with the main shocks of Landers (M_w = 7.3, 1992), Northridge (M_w = 6.7, 1994) and Hector Mine (M_w = 7.1, 1999) is simulated using a modified version of the dynamic FBM. This version makes use of a property of the static FBM that allows establishing a threshold value, σ_{th}, for the stress that each elemental fiber can hold without failure. Given that an aftershock sequence is a stress relaxation process, a dissipative term is introduced. The local load sharing (LLS) is chosen as load-transfer rule. The starting stress values for the set of fibers are assumed to follow a uniform probability distribution. After the failure of an elemental fiber, the load is transferred to the adjacent fibers, and the increase of stress can lead one or more fibers to overcome a threshold stress σ_{th}, generating an avalanche event. The avalanche ends when all the surviving fibers have a stress value below σ_{th}. The avalanche-like events are related to local stress accumulations, which lead to shorter inter-event times and a sudden stress release. These accelerations are embedded in the general trend of stress relaxation, which is in agreement with the time behavior observed in the three seismic aftershock sequences. The numerical simulations are controlled by three parameters: the Weibull exponent, ρ, the dissipative ratio, π, and the number of fibers, N. A large number of numerical simulations have been carried out to find the set of parameters (ρ, π, N) best reproducing the fundamental characteristics of the three empirical aftershock series, such as the parameters of the modified Omori law and the time evolution of the generation rate and the number of aftershocks within the episodes of sudden stress release.