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Earthquakes, asperities, and forest-fire models

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The earthquake size-frequency distribution of individual seismic faults commonly differs from the Gutenberg-Richter law of regional seismicity by the presence of an excess of large earthquakes. Here we simulate the different size-frequency regimes by means of a modification of the forest-fire model. The model describe a fault plane as a two-dimensional array of cells where each cell can be a normal site or an asperity site. Only asperity sites can trigger earthquakes, and the topology of this subset of sites controls the way the fault relaxes during large earthquakes. We study the effect that the type of asperity, the size of the system and the aspect ratio of the fault have on the size-frequency distribution, the aperiodicity of the characteristic earthquakes, and their inter-event time distribution. Small compact asperities tend to produce a characteristic earthquake distribution, whereas large and/or distributed asperities tend to produce Gutenberg-Richter-like distributions. We also show, by means of the aperiodicity of the time series of large earthquakes, that the system is quasi-periodic, with aperiodicities greater than zero (periodic systems) and smaller than 1 (Poissonian systems), as palaeoseismological studies on specific fault segments show.