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The occupation of a box as a toy model for the seismic cycle of a fault

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A simple stochastic model is introduced, as a sketch of the loading of elastic energy in a seismic fault. This model and previous ones are used here as renewal functions to fit the series of earthquakes with a magnitude of around 6, which happened at the Parkfield segment of the San Andreas fault (California) and to estimate the time-dependent probability of the next large earthquake.

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The model proposed here idealizes the loading of elastic energy in a fault with the stochastic filling of a box. The emptying of the box after its complete filling is analogous to the generation of a large earthquake, in which the fault relaxes after having been loaded to its failure threshold. The duration of that filling process is thus equivalent to the seismic cycle in the fault, i.e. the period elapsed between two successive large earthquakes in that fault.

The simplicity of this model enables us to characterize the statistical distribution of the duration of its seismic cycle, its mean, standard deviation and aperiodicity. In order to compare the results with actual data, we use this distribution as a renewal model to fit the series of characteristic earthquakes, with a magnitude of around 6, which occurred at the Parkfield segment of the San Andreas fault in California. The last of these events took place on September 28th, 2004.

For this data series, the quality of different fits is similar: with the Box Model, the Brownian Passage Time Model, the Minimalist Model, and the lognormal, gamma and Weibull distributions. All these fits can be considered together to give reasonable upper and lower bounds to the annual probability of occurrence at Parkfield: between 8.5% and 10% after 25 yr since the last earthquake (i.e., after one mean cycle length), and between 11% and 17% after 37 yr (i.e., after 1.5 mean cycle lengths).

Finally, a simple forecasting strategy is introduced, and its effectiveness is shown by means of an error diagram.