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Recurrent large earthquakes in a fault region: What can be inferred from small and intermediate events?

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We present a renewal model for the recurrence of large earthquakes in a fault zone consisting of a major fault and surrounding smaller faults with Gutenberg-Richter type seismicity represented by seismic moment release drawn from a truncated power-law distribution. The recurrence times of characteristic earthquakes for the major fault are explored. It is continuously loaded (plate motion) and undergoes positive and negative fluctuations due to adjacent smaller faults, with a large number N_{eq} of such changes between two major earthquakes. Since the distribution has a finite variance, in the limit $N_{eq} \rightarrow \infty$ the central limit theorem implies that the recurrence times follow a Brownian passage-time (BPT) distribution. This allows to calculate individual recurrence time distributions for specific fault zones without tuning free parameters: the mean recurrence time can be estimated from geological or paleoseismic data, and the standard deviation is determined from the frequency-size distribution, namely the Richter b value, of an earthquake catalog. The approach is demonstrated for the Parkfield segment of the San Andreas fault in California as well as for a long simulation of a numerical fault model. Assuming power-law distributed earthquake magnitudes up to the size of the recurrent Parkfield event ($M = 6$), we find a coefficient of variation that is higher than the value obtained by a direct fit of the BPT distribution to seven large earthquakes. Finally we show that uncertainties in the earthquake magnitudes, e.g. from magnitude grouping, can cause a significant bias in the results. A method to correct for the bias as well as a Baysian technique to account for evolving data are provided.