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A new statistical time-dependent model of earthquake occurrence: failure processes driven by a self-correcting model

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The long-term recurrence of strong earthquakes is often modelled by the stationary Poisson process for the sake of simplicity, although renewal and self-correcting point processes (with non-decreasing hazard functions) are more appropriate. Short-term models mainly fit earthquake clusters due to the tendency of an earthquake to trigger other earthquakes; in this case, self-exciting point processes with non-increasing hazard are especially suitable.
In order to provide a unified framework for analyzing earthquake catalogs, Schoenberg and Bolt proposed the SELC (Short-term Exciting Long-term Correcting) model (BSSA, 2000) and Varini employed a state-space model for estimating the different phases of a seismic cycle (PhD Thesis, 2005). Both attempts are combinations of long- and short-term models, but results are not completely satisfactory, due to the different scales at which these models appear to operate.
In this study, we split a seismic sequence in two groups: the leader events, whose magnitude exceeds a threshold magnitude, and the remaining ones considered as subordinate events. The leader events are assumed to follow a well-known self-correcting point process named stress release model (Vere-Jones, J. Phys. Earth, 1978; Bebbington & Harte, GJI, 2003, Varini & Rotondi, Env. Ecol. Stat., 2015). In the interval between two subsequent leader events, subordinate events are expected to cluster at the beginning (aftershocks) and at the end (foreshocks) of that interval; hence, they are modeled by a failure processes that allows bathtub-shaped hazard function. In particular, we have examined the generalized Weibull distributions, a large family that contains distributions with different bathtub-shaped hazard as well as the standard Weibull distribution (Lai, Springer, 2014). The model is fitted to a dataset of Italian historical earthquakes and the results of Bayesian inference are shown.