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On the use and applicability of the modified Omori law

Ilaria Spassiani and Warner Marzocchi
Istituto Nazionale di Geofisica e Vulcanologia (INGV), Roma 1, Rome, Italy

The Omori-Utsu law, or Modified Omori law (MOL), is often used to describe the temporal decay of the aftershocks in a seismic sequence. It has been proposed in its first version by Omori to describe all the aftershocks following the 1981 Great Nobi earthquake of magnitude 8. Since then, MOL has been embedded in the Epidemic Type Aftershock Sequence (ETAS) models – which are the most reliable earthquake forecasting models in the short-term – to model the temporal correlation of the first generation of aftershocks. We argue that these two applications of MOL are mathematically incoherent. In particular, if $\pi(\cdot)$ is the law of the first generation shocks, the distribution $\lambda(\cdot)$ of the whole sequence of aftershocks starting from a fixed background event is given by the convolution power series of π, i.e., $\lambda(t) = \sum_{i=0}^{\infty} \pi^{*i}(t)$, where $(\cdot)^{*i}$ is the $i - fold$ convolution power; interestingly, if $\pi(\cdot)$ is the modified Omori law as in the ETAS models, nothing ensures that the $\lambda(\cdot)$ is again a MOL. Here we analyze the problem in two directions. First we impose $\pi(\cdot)$ to be a MOL and search for the resulting $\lambda(\cdot)$ that should describe the whole sequence. Second, we impose that $\lambda(\cdot)$ is a MOL, and look for a suitable $\pi(\cdot)$. Finally, the theoretical calculations are compared with the magnitude distribution of high quality seismic catalogs.