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The onset of the power law aftershock decay rate in South California

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We analyse the aftershock decay rate in South California in order to investigate the onset of the power law regime during the first day of the aftershock sequence.

A common measure of the power law aftershock decay rate is the parameter p of the modified Omori law (MOL),

$$\Lambda(t) \sim 1/(c+t)^p,$$

where c is a time constant essential to define a finite aftershock frequency at $t = 0$. Nevertheless, the question of the aftershock frequency immediately after an earthquake remains open, essentially because, over short times, the counting of the aftershocks is incomplete due to the overlappings of seismograms. In a limited power law model (LPL),

$$\Lambda(t) \sim \frac{(\gamma(q, \lambda_2 t) - \gamma(q, \lambda_1 t))}{t^q},$$

the power law decay is limited in time by two characteristic rate constants ($\lambda_1 < \lambda_2$). Over long times ($t > 1/\lambda_1$), an exponential decay dominates while over short times ($t < 1/\lambda_2$), a linear decay dominates. Ultimately, the power law regime is delayed according to a decreasing magnitude of an upper limit of the overload distribution, a function which combines the state of stress and the state of strength in the aftershock zone just after the mainshock.

For the comparison with real data from South California, we stack sequences in time without those of large main shocks to minimize the effect of incomplete catalogues. We show that, in a vast majority of cases, the LPL provides a better fit than the MOL.

In addition, we observe that c-value and $(1/\lambda_2)$-value are not constant, but evolve, influenced by the seismicity. Major earthquakes prolong an initial regime before the onset of the power law aftershock decay rate, while during periods of low seismic activity this delay tends to shorten. As a result, temporal patterns of seismic strain release are correlated with temporal patterns of c and $1/\lambda_2$. These results suggest long range interactions of loading and release of energy in active seismic zones. They also indicate that statistical properties of aftershock decay rate may be used to develop meaningful strategies for dealing with extreme seismic events.