Solar Flares: extreme event predictions using SOC models

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Abstract:

Solar flares are the most powerful bursting phenomena in the solar corona and there is no doubt that they are at the origin of space weather phenomena and its consequences. Thus, the interest in understanding and forecasting (at least large flares) remains in the top list of solar physics research efforts (Barnes et al, 2016 and Leka et al, 2019). In the last 30 years several avalanche models of solar flares have been successful in reproducing the main statistical observational features of solar flares and, lately, they have been explored as a useful way to forecast extreme events (Strugarek & Charbonneau, 2014).Waiting times statistics of solar flares could provide crucial information regarding the existing (or not) long range connections underlying flare generation. Observations of solar flares waiting times have provided discordant results: power law distribution, simple Poisson or time-dependent Poisson distributions (see a review of observations in Aschwanden and McTiernan, 2010). More or less the same dispersion in results have been found in avalanche models for flares (Charbonneau et al. 2001, Aschwanden and McTiernan, 2010). Additionally, the study of numerical models of sandpiles (which are at the base of all avalanche models) hinted at the variability of waiting time statistics conditioned by the very definition of what is the waiting time. In this work we have undertaken the study of three alternative definitions of waiting time and applied them to the classic Lu & Hamilton model (1991) avalanche model for flares. Our results suggest that the statistical behaviour is not independent of the waiting time definition which could imply that forecasting methods should take into account the lapse between one flaring event and the other. We have also studied the waiting time distribution of extreme events, defined by whether the peak of energy release from an avalanche is greater than a given threshold. By applying the different definitions of waiting time it was found that the classical definition of waiting time remained the same, while the alternative definitions changed and were well fitted by a lognormal distribution. This result indicates a certain correlation between the variables that describe avalanches and the different definitions of waiting time distributions, and could also point to the predictability of extreme events.

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