Comment on "Coexistence of Self-Organized Criticality and Intermittent Turbulence in the Solar Corona"

In their recent Letter [1] Uritsky *et al.* (U07) claimed direct observational evidence for the coexistence of self-organized criticality (SOC) and intermittent turbulence (IT) in the magnetized plasma of the solar corona. By analyzing two dimensional (2D) extreme ultraviolet snapshots (typically 3-4000) of the solar corona, U07 found coexisting power law avalanche statistics and multiscaling of the structure functions. These properties were taken to be robust signatures of SOC and IT, respectively, and their coexistence to imply new physics with elements of both SOC and IT. In this Comment we show that in one dimension (1D) a standard multifractal model of IT, Meneveau and Srinivasan's p-model, straightforwardly generates U07's restricted range IT and SOC signatures simultaneously. Thus SOC need not have been invoked. In Fig. 1 we show the scaling exponents $\zeta(q)$, obtained from the generalized structure functions $S_q = \langle |x(t+\tau) - x(t)|^q \rangle \sim \tau^{\zeta(q)}$, of order 0–6, using a sequence of 131 072 data points. Extended self similarity (ESS) is often used, as it was by U07, to improve the scaling range from which the $\zeta(q)$ are obtained. ESS yields only the ratios of $\zeta(q)$ so that one would need to fix $\zeta(3) = 1$ in order to make a comparison with phenomenological theories of turbulence, as done by U07. Figure 1 then shows $\zeta(q)/\zeta(3)$ versus q compared with the monofractal Kolmogorov 1941 model. The concave dependence of $\zeta(q)/\zeta(3)$ on q clearly illustrates the known multiscaling nature of the p model. In Fig. 2 we plot the distributions of avalanche size for the same time series. The size of an avalanche is defined in the usual way, also used by U07, as the area between the curve $x(t)$ and a fixed threshold $x = x_T$, for each segment of the curve where $x(t) > x_T$. One can obtain finite range power law regions in the statistics in avalanche burst size (and duration, not shown), as U07 did. Finally, we do recognize that U07 performed detailed and extensive analyses of snapshots of 2D fields to identify time evolving patches of activity, observed contiguously over a sequence of snapshots, with distinct avalanche events, needed to obtain both spatial and temporal avalanche distributions. Our main intent here is to point out that the (rolled off) power laws claimed by U07 in lifetime, peak area and emission flux over about 2.5, 2.5 and 3 orders, respectively, (Fig. 2, U07) may simply have arisen from intermittent turbulence. We used the p model as an illustrative simple 1D prototype of IT. The distinction here is between *exhibiting* the SOC mechanism itself, and *mimicking*, over a finite range, a necessary signature of SOC. If turbulence, or indeed any other multiplicative process, can do the latter, Occam's razor suggests SOC need not be additionally invoked.

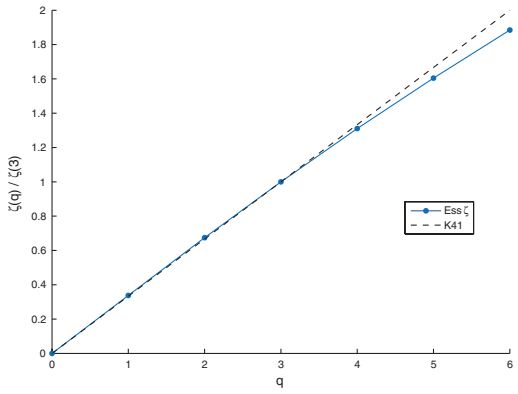

FIG. 1 (color). IT diagnostics for the p-model time series. Here p is 0.45, and the spectral filter exponent is -1.2. We used Venema's implementation [2].

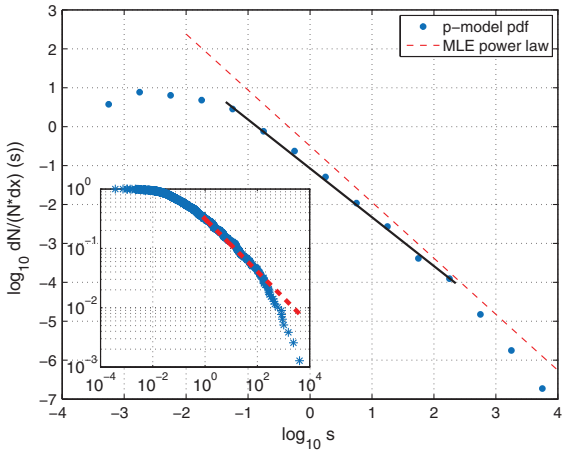

FIG. 2 (color). The main SOC diagnostic applied to the p-model time series. Plotted are the probability density function (pdf) and (inset) cumulative distribution function of burst size; and (displaced for clarity) the power law, with a pdf exponent of 1.44, which would be identified using the maximum likelihood algorithms of [3]. An "eyeball" power law region (black line) might be inferred over about 3 decades.

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[1] V. M. Uritsky *et al.*, Phys. Rev. Lett. **99**, 025001 (2007).
[2] http://www.meteo.uni-bonn.de/mitarbeiter/venema/themes/surrogates/pmodel/
[3] A. Clauset *et al.*, arXiv:0706.1062v2.

