Title: Record-Breaking Events in Non-linear Threshold Systems

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Abstract:

Record-breaking avalanches generated by the dynamics of several driven non-linear threshold models are studied. Such systems are characterized by intermittent behavior, where a slow buildup of energy is punctuated by an abrupt release of energy through avalanche events, which usually follow scale-invariant statistics. From the simulations of these systems it is possible to extract sequences of record-breaking avalanches, where each subsequent record-breaking event is larger in magnitude than all previous events.

Sequences of record-breaking events can be extracted for various natural phenomena where records of the variability of different measurements exist. The best known example is weather, where daily observations of temperatures are documented and new record-breaking temperatures are often reported. Monitoring such record-breaking temperatures can be used to infer possible trends in the weather variability. Other natural phenomena for which record-breaking events play an important role include earthquakes, floods, forest-fires, volcanic eruptions, and solar flare events, to name only a few.

In the work, several cellular automata are analyzed, among them the sandpile model, the Manna model, the Olami-Feder-Christensen (OFC) model, and the forest-fire model to investigate the record-breaking statistics of model avalanches that exhibit temporal and spatial correlations. Several statistical measures of record-breaking events are derived analytically and confirmed through numerical simulations. It is found that the statistics of record-breaking avalanches for the above cellular automata exhibit behavior different from that observed for i.i.d. random variables, which in turn can be used to characterize complex spatiotemporal dynamics. The most pronounced deviations are observed in the case of the OFC model with a strong dependence on the conservation parameter of the model. This indicates that avalanches in the OFC model are not independent and exhibit spatio-temporal correlations.

The OFC model can be considered as a simplification of a single fault system to simulate earthquake occurrences. The avalanches in the model reproduce some important aspects of statistics of earthquakes such as a power-law frequency-magnitude distribution. Therefore, the analysis of correlations in the OFC model can shed light on the dynamics and triggering mechanisms of real earthquakes. The obtained results concerning the record-breaking avalanches in the OFC model can be used to constrain the effects of correlation and self-organization in seismogenic zones.