Persistence and Burn-in in Solar Coronal Magnetic Field Simulations

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Simulations of solar phenomena play a vital role in space weather prediction. A critical computational question for automating research workflows in the context of data-driven solar coronal magnetic field simulations is quantifying a simulation's burn-in time, after which a solar quantity has evolved away from an arbitrary initial condition to a physically more realistic state. A challenge to quantifying simulation burn-in is that underlying solar processes and data, like many physical phenomena, are non-Markovian and exhibit long memory or persistence, and, therefore, their analysis evades standard statistical approaches. We provide evidence of long memory in the non-periodic variations of solar quantities (including over timescales significantly shorter than previously identified) and demonstrate that magnetofrictional simulations capture the memory structure present in magnetogram data. We also provide an algorithm for the quantitative assessment of simulation burn-in time that can be applied to nonstationary time series with long memory. Our approach is based on time-delayed mutual information, an information-theoretic quantity, and includes a small-sample bias correction.

This is joint work with Karen Meyer (University of Dundee) and Anthony Yeates (Durham University).