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Maximum entropy production in earthquake dynamics: origin of spatial order and temporal unpredictability in a complex system

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The concept of maximum entropy production (MEP) is a corollary of the maximum entropy principle in statistical mechanics for some problems in nonlinear, complex, far-from equilibrium systems, including the latitude dependence of Earth's temperature field. Here we examine the extent to which MEP drives earthquake population dynamics. Specifically we derive an analytical expression for entropy production rate for earthquake populations based on the conceptual Burridge-Knopoff model. The result implies that MEP is achieved by maximising the elastic strain, i.e. by evolving to and then keeping the Earth in a marginally stable state with broadband scale-invariance and a large correlation length. This state, i.e. one of self-organised criticality, implies limited temporal predictability. In contrast MEP is achieved by minimising the local strain fluctuations, resulting at the same time in the creation of correlated 'domains', with fluctuations confined predominantly to their boundaries. Such spatial order may be the origin of segmented faults on a hierarchy of scales in the Earth, with implications for the creation of spatially characteristic earthquakes. In contrast MEP would require a Gutenberg-Richter b-value of 3/2, in contradiction to the universal observation $b \sim 1$. This implies the b-value is a relatively fixed parameter, as a consequence of its geometric origin in the space-filling properties of source rupture area.