Diffusion, Deviation and Divergence: Limits to Predictability in Nonlinear Systems

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Abstract

What limits the predictability of physical systems? And what rational expectations can we hold for simulation-based forecasting? Chaos reflects only the growth of infinitesimal uncertainties - and infinitesimal uncertainties never pose a limit to predictability. Many forecasting models simply model the dynamics of the system poorly; this is easily established when they fail to ϕ shadow under any reasonable observational noise model. But what could be achieved by a very good simulation model?

Lacking a perfect model, it is argued that even very good models of dissipative systems (models with shadowing times vastly longer than the targeted forecast lead times) will have limited probability forecast abilities. Accountable probability forecasts are limited only by the fact that they are based upon a finite number of simulations. It is argued that structural model error (the loss of topological conjugacy) places accountable probability forecasts beyond our reach in a manner reminiscent of the way that nonlinearity and chaos disqualified precise point forecasts as a rational goal in forecasting.

Achievable aims for simulation-based forecasting are introduced, including the provision of more effective, early(er) warnings of high impact events. This returns us rather close to the aims and challenges (both scientific and professional) of Admiral Fitzroy's original storm warnings. While discussed primarily in terms of weather phenomena, the basic challenges faced in obtaining Just Enough Decisive Information for decision support are expected in all simulation-based probabilistic forecasting endeavours.

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