Predictability, Probability and Insight: The Case of Physical Simulation of Large Dynamic Systems

Leonard Smith

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Abstract

It is common to extract probability forecasts for models of macroscopic physical systems including the weather, the climate, tropical storm formation, the temperature at London Heathrow Airport, laboratory experiments, or each NFL game in the 2018/2019 season. I argue that for basic, longstanding mathematical reasons, these so-called probabilities cannot (reasonably) be used as such. The basic framework was laid by I.J. Good in the second half of the previous century, and extended slightly in work by Smith, Judd and Du in this century. In short, structural model inadequacy combined with Smale's work in the 1960's on (the general lack of) structural stability implies we cannot expect to put a reliable (accountable) probability density reflecting the current state of a system best represented by nonlinear models. The talk is not as negative as that sounds at first.

We face a dilemma: we can waste time arguing that these results do not apply to your particular case (often they merely apply with probability one). Or we can let go of the perfect model model of macroscopic physical science. Letting go frees us to do really interesting things, of value in application, with our good but imperfect models. I aim to illustrate these ideals on predictability with actual (nontrivial) cases of energy demand and anticipatory disaster risk reduction; and issues of probability with the 2018/19 NFL season and decision support for the insurance sector.

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