"Forecasting, monitoring, controlling: Dealing with a dynamic world"

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Abstracts

1. Talk: Leonard A. Smith

‘On the Use and Abuse (and rational interpretation) of Probability Forecasts’

Von Neumann prophesied famously that we would learn to predict stable systems and to control those too unstable to predict. The Earth's weather and its climate provide the classic showcases for attempts to forecast, monitor, and indeed control complicated dynamical systems. Consideration of the climate is more complicated than that of the weather, of course, as the climate is evolving in an interesting and somewhat controllable way, while weather can often be considered as merely dynamic.
Prediction, control and indeed monitoring each hinge on the quantification of uncertainty, usually in terms of probability distributions. This paper discusses the various kinds of probability, their role in prediction and control, and the extent to which we have access to those kinds that are of most value. While focusing on actual weather forecasts, seasonal forecasts and climate forecasts, financial probability forecasts of the Bank of England will also be touched on to provide a more complete picture of the challenges of probability forecasting.
Von Neumann also remarked that there is no sense in being precise when you don't even know what you're talking about. There are different kinds of probability, and it is important to know which kind we are talking about. IJ Good noted several kinds of probability. There are also at least two kinds of dealings with a dynamic world: weather-like and climate-like. Rational use of probability forecasts requires access to the right kind of probability for the particular dealing at hand. Absent this, there is no persuasive argument for using "a probability forecast" at all: no rational interpretation of "a probability forecast" need exist. The implications this conclusion holds for applying Bayesian methods, amongst others, both in the context of weather and in the context of climate will be discussed, and two alternatives to traditional probability-based decision making will be suggested.

2. Talk: Erica L. Thompson and Leonard A. Smith

'The Hawkmoth Effect in Forecasting, Monitoring and Controlling Complex Dynamic Systems'

The Butterfly Effect is a well-known constraint on the predictability of certain types of nonlinear systems, describing a sensitive dependence on initial conditions such that the "flap of a butterfly's wing" can have profound long term effects on the evolution of the system. Less well known but at least as pernicious is the Hawkmoth Effect, which also constrains predictability of dynamical systems. In this instance, the problem is our understanding of the system itself, and our necessarily imperfect numerical representation of the physical processes involved in a complex physical system. We will present some simple demonstrations which show the key features, and then give some examples of the potential importance of the effect for modelling real-world systems such as climate, ecosystems, and economics. The importance of understanding the limits to predictability in these areas cannot be overstated, since the real-world impact of over-reliance on inadequate models is poor or maladaptive decision-making: consider the effects of reliance on mathematical models in precipitating the ongoing financial crises, or the magnitude of decisions about mitigation and adaptation to climate change. An understanding of the Hawkmoth Effect motivates greater humility in the construction and interpretation of mathematical models, and a more open epistemic attitude towards uncertainty in model output. Some aspects of uncertainty in forecasting can be quantified; others require a qualitative understanding of the system itself and ultimately a subjective judgement about the likelihood of model failure, which cannot be quantified within the realm of the model itself, even given a large amount of calibration data. Finally, we will discuss more general implications of the Hawkmoth Effect for forecasting, monitoring and controlling complex systems, suggesting heuristics for interpretation of model results and for working with any system where nonlinearities and feedback effects are known or thought likely to be significant.

3. Poster: Leonard A. Smith, Emma B. Suckling and Erica L. Thompson

Dealing with big dynamic models of a dynamic world

Large simulation models can always be used to make engaging pictures of the future, but to what extent do their quantitative outputs reflect their scientific foundations as opposed to their use of state of the art graphics packages? We consider the use of General Circulation Models for forecasting, and perhaps influencing, the Earth Climate System. Surrogate models, simple empirical models with no explicit "physics", are used to make probability forecasts, in particular decadal forecasts of global mean temperatures, initiated every year since 1960. The skill of these forecasts is then contrasted with that of today's state of the art climate models. There is little doubt that *ideal* physics-based models can realistically simulate and more accurately predict the climate system than empirical models; the question is whether or not *today's* physics-based models can.