CATS CENTRE FOR THE ANALYSIS OF TIME SERIES

"Predictability, Probability(s) and Physical Insight: Probability for weather and climate"

AGU Conference, San Fransisco, 9-13 December 2013

Professor Leonard A. Smith

Abstract

Over the last 60 years, the availability of large-scale electronic computers has stimulated rapid and significant advances both in meteorology and in our understanding of the Earth System as a whole. The speed of these advances was due, in large part, to the sudden ability to explore nonlinear systems of equations. The computer allows the meteorologist to carry a physical argument to its conclusion; the time scales of weather phenomena then allow the refinement of physical theory, numerical approximation or both in light of new observations. Prior to this extension, as Charney noted, the practicing meteorologist could ignore the results of theory with good conscience. Today, neither the practicing meteorologist nor the practicing climatologist can do so, but to what extent, and in what contexts, should they place the insights of theory above quantitative simulation? And in what circumstances can one confidently estimate the probability of events in the world from model-based simulations?

Despite solid advances of theory and insight made possible by the computer, the fidelity of our models of climate differs in kind from the fidelity of models of weather. While all prediction is extrapolation in time, weather resembles interpolation in state space, while climate change is fundamentally an extrapolation. The trichotomy of simulation, observation and theory which has proven essential in meteorology will remain incomplete in climate science. Operationally, the roles of probability, indeed the kinds of probability one has access too, are different in operational weather forecasting and climate services.

Significant barriers to forming probability forecasts (which can be used rationally as probabilities) are identified. Monte Carlo ensembles can explore sensitivity, diversity, and (sometimes) the likely impact of measurement uncertainty and structural model error. The aims of different ensemble strategies, and fundamental differences in ensemble design to support of decision making versus advance science, are noted. It is argued that, just as no point forecast is complete without an estimate of its accuracy, no model-based probability forecast is complete without an estimate of its own irrelevance.

The same nonlinearities that made the electronic computer so valuable links the selection and assimilation of observations, the formation of ensembles, the evolution of models, the casting of model simulations back into observables, and the presentation of this information to those who use it to take action or to advance science. Timescales of interest exceed the lifetime of a climate model and the career of a climate scientist, disarming the trichotomy that lead to swift advances in weather forecasting. Providing credible, informative climate services is a more difficult task. In this context, the value of comparing the forecasts of simulation models not only with each other but also with the performance of simple empirical models, whenever possible, is stressed.

The credibility of meteorology is based on its ability to forecast and explain the weather. The credibility of climatology will always be based on flimsier stuff. Solid insights of climate science may be obscured if the severe limits on our ability to see the details of the future even probabilistically are not communicated clearly.

LSE