BOOKS & ARTS

Embracing an uncertain future

A history of climate modelling shows that forecasts that acknowledge uncertainty will be the way forward, argues **Myles Allen**.

A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming
by Paul N. Edwards
MIT Press: 2010. 528 pp.
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Storms can't be predicted a month ahead, and climate models too are limited by chaotic variability.

Many people find climate models puzzling. As some of the most complex computer codes ever written, necessarily riddled with approximations and errors but also uniquely tested, these 'surrogate Earths' occupy a strange limbo between direct observations and conceptual tools. *A Vast Machine* traces how the development of these models has shaped both the way climate scientists think, and the institutions in which they work. A thorough and dispassionate analysis by a historian of science and technology, Paul Edwards' book is well timed. Although written before the University of East Anglia e-mail leak, it anticipates many of the issues raised by the 'climategate' affair.

A Vast Machine describes how the disciplines of statistical climatology, weather forecasting and theoretical meteorology evolved into modern physical climate science. Rather than centring on observations and ice-core records, which many others have discussed, the book focuses on computer modelling. More than a history, it explores the nature of climate simulations and controversies over inconsistencies between models and observations. To those who favour 'hard' data over simulations, Edwards points out that there is no such thing as a model-free observation. Every piece of data rests upon some theoretical model of the measurement system, and the assumptions that underlie models can be as important as the accuracy of the data.

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The key question Edwards poses is whether climate forecasting will become reliable enough to "disappear beneath the surface of everyday life", as weather forecasting has done. He suggests two ways in which this might happen. By incorporating ever-higher resolution and more detailed representation of processes, uncertainty arising from model specification will eventually be eliminated, leaving only observational uncertainty and chaotic variability to limit the skill of a climate forecast. Alternatively, different models will continue to project a range of possible future climates even when constrained by the same observations.

Many climate scientists think they are on the first of these paths; but it is fraught with risk. We can never be sure that the model we converge on is the right one, rather than one that has merely been tuned to fit the data from previous decades. But modellers are uncomfortable with Edwards' second path, because uncertainty feels like failure.

In the 1950s, Edward Lorenz, the meteorologist and pioneer of chaos theory, realized that chaos sets a hard limit in weather forecasting: we must accept that we are unable to predict the timing of storms a month ahead. Yet the current limitations of climate models are much less clear — most of their uncertainty arises from missing information, such as poorly known drivers of climate change. Whereas some uncertainties, such as the timing of volcanic eruptions, are irreducible, many of these unknowns will respond to more data, better models and a stronger signal of emerging climate change. Improvements are possible, but intrinsic uncertainties will always remain. This is why Edwards' second path is the only realistic way forward.

Over the coming decade, systems for forecasting climate that treat uncertainty as an additional prognostic variable will become the norm. The notion of a single 'flagship' climate model, which for a given set of initial conditions simulates a single climate trajectory, will look increasingly anachronistic. Forecasts may converge, but only on the same range of uncertainty, which users will still have to live with. Our aim in climate modelling should be to convert unknown unknowns into known unknowns, not to pretend that we can eliminate them altogether.

The popular myth that the 'climategate' e-mails revealed a conspiracy to suppress uncertainties about climate change could hardly be further from the truth. Instead they revealed a scientific community obsessed by uncertainty, in stark contrast to the mysterious confidence of many of its critics. One of the first lessons of climate research is not to read too much into a single event. *A Vast Machine* puts the whole affair into historical context and should be compulsory reading for anyone who now feels empowered to pontificate on how climate science should be done. ■

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