Ensuring the best science-based predictions of climate change

LSE researchers have challenged the validity of current models used to predict climate change and pressed for credible science-based policymaking

What was the problem?

Climate change is arguably the greatest threat that humans face in this century. Scientists from many disciplines are involved in defining the exact nature of this threat, evaluating its magnitude and identifying the most effective ways to respond to it.

An important aspect of this work is producing models that simulate possible future scenarios and assess their probabilities. Such scenarios enable policymakers and planners to explore and make decisions on the nature and timing of individual and collective responses.

Unfortunately, the mathematical models on which such decisions have been based are imperfect. Interpreting the outputs of models in each particular case requires estimating the extent to which one can interpret the simulations as high fidelity reflections of the future.

Given multiple factors that interact with one another in highly dynamic ways, the future state of the climate system is expected to evolve in a non-linear fashion and reach states that are qualitatively different from what we have experienced to date. At stake is how we adapt to and plan for climate change. Over-interpreting projections of climate probabilities can produce poor policy choices and leave us vulnerable to more intense and devastating forms of change.

Also at stake is the credibility of science-based policymaking.

What did we do?

Climate simulation research within LSE has taken place within a broader research programme on nonlinear dynamical systems carried out by the Centre for Analysis of Time Series (CATS) over the last decade.

This research has challenged the fidelity of current climate-change models and their projections of future climate states. The research has been led by Professor Leonard Smith and Dr David Stainforth, aided by graduate researchers E. R. Tredger, Ana Lopez and Erica Thompson.

Mathematical research in 2004 by Smith and CATS Visiting Fellow Kevin Judd had identified the consequences of model imperfections when forecasting probabilities from 'noisy' observations and models of chaotic systems.

These findings were then applied specifically in the context of climate models. In 2005 CATS researchers sought to interpret the largest ensemble of relevant climate simulations generated by climateprediction.net, a project co-founded by Stainforth for which Smith was co-investigator and a key player in its conceptual design.

Their work explored a wider range of variety of model behaviour than ever seen before, demonstrated that simple, reasonable looking statistical approximations failed in practice, and also suggested that model-based probability distributions have limited fidelity in terms of their predictive value extrapolating into the far future. Each generation of models has a limited range after which the information and numbers they generate are not expected to reflect the future. Any 'probabilities' produced by the models beyond that range are of highly limited relevance for cost-benefit analyses of policy options, and may well prove maladaptive.

What happened?

Since 2002 Smith's research has stimulated and informed policy debate both nationally and internationally. CATS' conclusions have been noted by the world's leading scientific body on climate change, the United Nations Intergovernmental Panel on Climate Change. The Panel's Fourth Assessment Report cites Smith as the authority in terms of noting the significant impact of model inadequacy on its 'probability' distributions.

Within the UK, Smith and Stainforth's improved interpretation of climate-model simulations has contributed to changes in the way climate projections are presented and has influenced government policy on climate change more generally. More specifically, their work affected the government's first Climate Change Risk Assessment of 2012, prepared in response to the Climate Change Act 2008, which committed the government to significant reductions in greenhouse gas emissions.

> "Professor Smith understands better than most climate scientists what the limitations of the science are and how to use statistical and physical analysis to draw robust conclusions for policy makers"
>
> **Dr James Baker, co-lead author of the Harvard Report for the Central Intelligence Agency, *Climate Extremes: Recent Trends with Implications for National Security* (2013)**

Smith and Stainforth remain vocal and engaged consultants regarding the interpretation and use of climate projections, particularly the UK Climate Projections 2009 (UKCP09), which are still current. These contain projections of future changes to the UK climate until the end of the century at very very high resolution.

At the request of the Department for Environment, Food and Rural Affairs, Smith and Stainforth were present at the initial meeting called to agree the methodology for the Assessment. They objected strongly to the intense pressure to over-interpret the output of climate models.

National meteorological services often wish to avoid known defects of probabilities-based approaches. For example, Smith and Stainforth worked with the Dutch meteorological office and Dutch government scientists in their successful efforts to introduce an alternative approach to climate risk management. More recently, the Dutch government invited members of CATS to a closed-door meeting on the presentation of uncertainty in the 2013 report of the UN Intergovernmental Panel on Climate Change.

Smith and Stainforth, together with Roman Frigg of the Philosophy Department and a co-director of CATS, continue to engage with government departments and the now independent UK Climate Impact Programme to improve the quality and coherence of information relating to climate change.

Commerce and industry have also turned to CATS for help and have modified their approaches to climate risk management as a direct result of understanding CATS' research. Retained by major companies in the energy sector, Professor Smith has reviewed UK Meteorological Office commercial projects targeting the energy infrastructure under future climate change as a representative of the energy sector. His continued engagement with insurance industry partners such as Munich Re and Lloyd's of London has also enabled these companies to interpret climate information more effectively.

Internationally, Professor Smith was a key participant in a series of meetings and reviews that produced the Harvard Report, *Climate Extremes: Recent Trends with Implications for National Security* (2013). Funded by the US Central Intelligence Agency, the study explored the forces driving extreme weather events and their impacts over the next decade, concentrating on their implications for national security plans. Smith's contribution focused on the extent to which the risks of climate change can be quantified, and he is named as one of the report's major reviewers. He has also regularly engaged on climate-change issues with the offices of individual US Senators and Congressmen and with US scientific associations such as the American Statistical Association.

Professor Leonard Smith is Director of the Centre for the Analysis of Time Series (CATS) at the London School of Economics and Political Science. Since 1992 he has been a Senior Research Fellow (mathematics) at Pembroke College and Research Associate, Mathematics Institute, University of Oxford, (UK). Professor Smith was active in the formation of strategy for THORPEX and the original experimental design(s) of climateprediction.net. In recognition of his contributions to mathematically-coherent user-relevant developments in meteorology, the Royal Meteorological Society awarded Professor Smith its Fitzroy Prize in 2003. Professor Smith is currently a member of the ASA Advisory Committee on Climate Change Policy (ACCCP) and a member of the Smith Institute's Scientific Committee.

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