Q and A with David Stainforth on Predicting Our Climate Future: What We Know, What We Don’t Know, and What We Can’t Know

We speak to **David Stainforth** *about his new book,* **Predicting Our Climate Future: What We Know, What We Don’t Know, and What We Can’t Know**, *which argues for a re-evaluation of how we go about the study of climate change in the physical sciences, the social sciences, economics and policy.*

You can watch a public LSE event with David Stainforth to launch the book from October 2023 on YouTube here.

Predicting Our Climate Future: What We Know, What We Don’t Know, and What We Can’t Know. David Stainforth. Oxford University Press. 2023.

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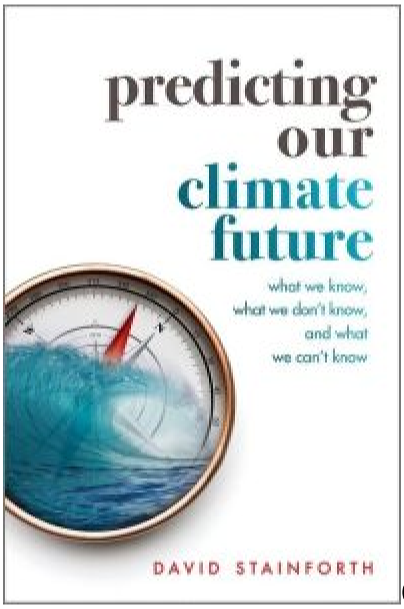

Q: Where did the idea for the book come from and what

were you setting out to do in writing it?

Between 2000 and 2015, I became aware that my perspective on what we should be trying to do in climate change science wasn't at all reflected in the practice of research in research institutions. It seemed to me important to write something that would engage people with all the fascinating challenges that exist in understanding the problems of climate change. Doing so, I hoped, would help make clear the separation between what we know and what we don't know.

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If I was a sixth-former now, I would certainly see climate change as an important issue for society, but I'm not sure I would be passionate about trying to understand it. That's because it appears that we already understand it, although in fact we don't. Many big, fundamental, questions – philosophical, mathematical, physical, and economic questions – about climate change tend not to be examined, probably because of the urgency for society to act. My book addresses these questions. I would love for my book to stimulate high-school students and undergraduates across diverse disciplines to say, actually, there's something really fascinating to get my teeth into here; something that humanity hasn't yet understood.

Of course, none of this undermines the importance and urgency of acting on climate change, but acting and understanding need to go hand in hand.

Q: What are the limitations of scientists' understanding of the climate system? How do these affect our ability to predict how the climate will change?

The central issue is complexity and there are two aspects of complexity that create a barrier to predicting what the climate future will look like.

The climate system is made up of many components – the atmosphere, the oceans, land ecosystems, ocean ecosystems, biogeochemical systems, the cryosphere etc. Many of these can be broken down further into subsystems, and all of this is before you get into the social aspects. The first aspect of complexity is simply how these many disparate components interact.

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The second aspect of complexity is more mathematical. Certain types of system, like the climate system, have real barriers to predictability because what happens in the future can be very sensitive to the state of the system today. This is what’s meant by the “butterfly effect”. At the same time, the relationship between our models and reality is unclear: how close does a model have to be to reality for it to be able to tell us something about how reality will behave? That’s a difficult question to answer; it might be that our models could represent reality very closely, but still provide unreliable predictions. This is something that Erica Thompson has named the “hawkmoth effect”; it’s something we haven’t really begun to study.

These types of complexity affect how we should be designing our climate models and what sort of experiments we should run with them.

Q: What do Global Climate Models (GCMs) do and what are their limitations?

Global Climate Models break down the atmosphere and ocean into grid points and at each grid point they solve the equations of motion to tell us how things change over time. This is what’s known as a reductionist approach to modelling, and it allows us to work out what the state of the atmosphere or ocean system might be at some point in the future. Solving the equations on a computer can typically only tell us how things will change over about 10 minutes, so you’ve got to repeat the process millions of times to get information for 100 years ahead.

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But there are lots of elements of the climate system that can’t be modelled that way, either because we don’t know what the fundamental equations are or because the processes take place on scales that are far too small to include in the models. Examples include how ecosystems absorb and release carbon dioxide and how clouds and rainfall form. For these components there are various different ways to approximate the processes at play, but it's not easy to know how reliable these approximations are. And because all aspects of the climate system affect all the other aspects of the climate system, this means that the model predictions can't simply be taken as predictions of reality.

Q: Why do we rely so heavily on GCMs for climate prediction and policy development today? Is there a danger in relying too heavily on these models?

When we study climate change, we don't have multiple climates to examine. The time scales and the system are defined: it's our real-world climate system that we're interested in, and how it will change through the 21st century. We are doing an experiment on the real climate system through humanity's emissions of greenhouse gases, but we'll only ever get one result, and that will come too late to be of much use to us. The models enable us to study what we can't study in reality – for instance, multiple possible scenarios of future greenhouse gas emissions. But we need to always remember that we're studying a model, not reality. The power, the detail and the ubiquity of the models encourages us to avoid asking the big questions about how the model predictions relate to reality – whether what they're telling us is actually what we think will happen.

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Research on climate, particularly with models, has grown out of work on weather forecasting. The reliability of weather forecasts over the last 20 to 30 years has massively improved, principally because of these models. But in the shift from weather forecasting to climate forecasting, we are dealing with a fundamentally different problem. In weather forecasting, we don't need to get the whole of the climate system right: it's mainly just about simulating the atmosphere. Furthermore, we repeat the weather forecasting process three or four times a day, so we can compare the model's predictions against what happens in reality. That means we can test whether our models are doing a good job in a way that is impossible for climate predictions

With climate, you need to bring in many other elements of the climate system, including oceans and ecosystems, and we don't have the same possibility to verify the results. This puts us in a very different domain, but the problem is that it doesn't feel that way. It feels as though weather forecasting and climate predictions are very similar because they use similar, related models. This represents a barrier to using the models effectively to help us provide reliable information about future climate.

Q: Why do you argue that greater diversity of climate models rather than greater "realism" of climate models should be the goal for better climate prediction?

Aiming for realism tends to take us to higher and higher resolution models. These models represent atmospheric behaviour better and they look more realistic, but this lulls us into a false sense of security. Despite the "realistic" appearance of these models, we can't tell if they are accurate because we've never observed the planet in the warmed state that we're interested in.

High-resolution models also take a lot of computing time to run, and consequently they remove the possibility of exploring other uncertainties such as how we represent the carbon cycle or biogeochemical processes. There's a substantial risk therefore that we adapt society to be resilient to the changes in our models, when what might actually happen could be very different.

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If instead we were to address different ways of building our models and of accounting for the many uncertainties, this would give us a diversity of predictions. Having a better understanding of the wide range of different changes that could plausibly happen would enable us to be better prepared and is, in my view, crucial to building a robust response to climate change.

Q: How does the separation between disciplines, which approach the issue in very different ways, hamper our understanding of, and ability to act on, climate change?

Assessments of the economics of climate change and of the consequences for our societies, for our wealth, for our welfare etc., often don't take sufficient account of the uncertainties in the physical science. There is a real need for economists to understand the processes of the physical sciences better.

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However, if we want the physical climate sciences to help us prepare effectively for our future world, then we need to ask, what are the questions that are being addressed by agricultural scientists, by city planners, by economists and by policy makers. Only when we are clear what kind of information is being sought, can we direct the physical sciences in a useful way. At the moment, the physical scientists set the questions and pass on the resulting information to social scientists rather than focusing their experiments and models on what social scientists and society need to know most.

We are stuck in a traditional approach which is not serving society well.

Q: How could we enable greater interdisciplinary research around climate change?

We require big changes in how we do climate change research. We need to be a lot clearer about what we're trying to address and how the connections between disciplines work. I think that means high-level change to how we study the problem.

Historically climate change research has been very siloed, as academia generally is. There is a need for the research funders to grasp the nettle of wholesale change and for universities and research institutes to come together and create career paths that enable people to research across disciplinary boundaries.

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I don't think the importance of multidisciplinarity for understanding fundamental features of the threats posed by climate change has been fully recognised. There are still many funding calls that are essentially answer-driven. It's a "tell us what will happen to this bit of the system" approach, but that's not what climate change is. You can't tell what's going to happen to one aspect without connecting it with everything else. It's a big, complex problem and needs to be addressed as such.

As a starting point we need funding – 10, 20 million pounds – for a centre that can bring truly diverse researchers together from philosophy to physics to economics, and give them the stability of five to 10 years to work on these problems together. That's the starting place for better information about our climate future. It's also the starting place for training a cohort of experts who have both the breadth and depth of knowledge to be able to build climate resilient societies and communicate what climate change risks actually look like.

Note: This interview gives the views of the author, and not the position of the LSE Review of Books blog, or of the London School of Economics and Political Science. The interview was conducted by Anna D'Alton, Managing Editor of LSE Review of Books.

Main Image: Arctic sea ice by Kathryn Hansen / NASA on Flickr.
