A CERN for climate change

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In a Perspective article appearing in this week's *Proceedings of the National Academy of Sciences*, Tim Palmer (Oxford University), and Bjorn Stevens (Max Planck Society), critically reflect on the present state of Earth system modelling.

They argue that it is a mistake to frame understanding of global warming as the product of sophisticated models, because this framing understates the contributions of physical principles and simple models, as well as observations, in establishing this understanding.

Such a framing also inevitably leads to a downplaying of deficiencies in the state of Earth-system modelling—and this has implications for how the science develops. The contribution of Earth-system modelling to understanding of global warming has been important, but primarily to show that the theoretical frameworks for interpreting observations were, despite their many simplifications, on track. Now that the causes of global warming are settled, and the imperative that this places on reducing carbon emissions are clear, climate science is facing new challenges, for instance as Marotzke et al. (2017) point out, the need to understand the habitability of the planet and the ability of human populations to be resilient to the extremes of weather and climate that may accompany future warming."

To address these challenges and inform decision making about the rate of future warming and the risks of a warming world, a new modelling strategy is required. This strategy, Professors Palmer and Stevens argue, should exploit exascale computing and an emerging new generation of models; ones aim to reduce biases by representing—through known laws of physics rather than error prone semi-empirical approaches—important physical processes. Decades of experience in numerical weather prediction has, after all shown, that reducing biases leads to improved predictions. To develop this new generation of more physically based models, something that has been advocated before but now is becoming possible, Palmer and Stevens press for bold multi-national initiatives to bring together computational, computer and climate scientists to co-develop modelling systems that will fully exploit emerging technologies and exa-scale computing.

Asked whether he feared their critique of the present state of Earth system modelling might be exploited by those attempting to cast doubt on present understanding of global warming, Stevens replies: "It is important that scientists speak candidly. It shouldn't come as a surprise that we can understand some things (like the world is warming because of human activities) but not everything (like what this warming means for regional changes in weather, extremes, and the habitability of the planet). By not talking about the limits of our understanding we run the risk of failing to communicate the need for new scientific approaches, just when they are needed most."

When asked whether spending new money on such an international climate modelling initiative can be justified, Professor Palmer said: "By comparison with new particle colliders or space telescopes, the amount needed, maybe around $100 million per year, is very modest indeed. In addition, the benefit/cost ratio to society of having a much clearer picture of the dangers we are facing in the coming decades by our ongoing actions, seems extraordinarily large. To be honest, all is needed is the will to work together, across nations, on such a project. Then it will happen."

More information: Tim Palmer el al., "The scientific challenge of understanding and estimating climate change," *PNAS* (2019). www.pnas.org/cgi/doi/10.1073/pnas.1906691116

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