The limitations of climate models

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Even with the latest climate models, temperature projections are fraught with uncertainty (light areas around the temperature curves for different scenarios). Credit: Josef Kuster, ETH Zurich / Knutti and Sedlacek 2012 Nature Climate Change / Galyna Andrushko, Fotolia

(Phys.org)—How accurate is the latest generation of climate models? Climate physicist Reto Knutti from ETH Zurich has compared them with old models and draws a differentiated conclusion: while climate

modelling has made substantial progress in recent years, we also need to be aware of its limitations.

We know that scientists simulate the climate on the computer. A large proportion of their work, however, is devoted to improving and refining the simulations: they include recent research results into their computer models and test them with increasingly extensive sets of measurement data. Consequently, the climate models used today are not the same as those that were used five years ago when the Intergovernmental Panel on Climate Change (IPCC) published its last report. But is the evidence from the new, more complex and more detailed models still the same? Or have five years of climate research turned the old projections upside down?

It is questions like these that hundreds of climate researchers have been pursuing in recent years, joining forces to calculate the climate of the future with all thirty-five existing models. Together with his team, Reto Knutti, a professor of climate physics, analysed the data and compared it with that of the old models. In doing so, the ETH-Zurich researchers reached the conclusion: hardly anything has changed in the projections. From today's perspective, predictions five years ago were already remarkably good. "That's great news from scientist's point of view," says Knutti. Apparently, however, it is not all good: the uncertainties in the old projections still exist. "We're still convinced that the climate is changing because of the high levels of greenhouse gas emissions. However, the information on how much warmer or drier it's getting is still uncertain in many places," says Knutti. One is thus inclined to complain that the last five years of climate research have led nowhere – at least as far as the citizens or decision makers who rely on accurate projections are concerned.

Simplifying models in various ways

Knutti sees this in a somewhat more differentiated light. For him, there are plausible explanations as to why the uncertainties cannot be eliminated more effectively: they arise because each of the thirty-five models sets different priorities to break down the extremely complex climate system in such a way that it can even be simulated on a large-scale computer in the first place. The different models also yield slightly different results and thus a certain range of projections.

One would assume that the longer scientists concentrate on the climate, the more accurate the results of the model calculations should become and hence the projections of the individual models should converge. According to Knutti, however, this assumption might well be true in the long run, but not in the short term. After all, the more complex a model becomes, the more processes are factored into it and, unfortunately, the greater the uncertainty becomes in the short term. "The models might not have become more accurate in the last five years, but they are more reliable, especially since today's models consider more physical processes more realistically," says the climate physicist.

Weather more variable than one might think

As Knutti's results reveal, climate models might well enable tendencies to be calculated reliably, but they eventually reach their limits. One such limitation is also apparent in the present trend of making increasingly small-scale and short-term projections on the climate, says Knutti and refers to another study conducted by him and other climate researchers that was recently published. "Whether there will be an increase in heat waves or especially cold winters in the USA, in Europe or in Russia in the next twenty years certainly doesn't depend solely on climate change caused by humans," Knutti points out. The frequency of locally stable weather situations particularly has an impact on this. And these have greatly been influenced by such phenomena as North Atlantic Oscillation, which (unlike the long-term, manmade trend) cannot be

predicted several years in advance.

The problem with the new, short-term projections: the shorter the timescale, the smaller the influence of the manmade trend and the greater that of variable weather phenomena. Especially in the mid-latitudes we live in, the weather phenomena vary greatly and the climate change caused by humans is obscured by them. Therefore, as the researchers write in their study, it is difficult to make short and medium-term climate predictions, however good the models are.

Robust heat stress projections

The climate events that are difficult to predict also include extreme weather events such as flooding, periods of drought, or heat waves. Interestingly, however, the combined measures of temperature and atmospheric humidity can be predicted fairly well. All the climate models yield similar results for these measures, as Knutti and Erich Fischer, a senior researcher in his team, were able to demonstrate recently in a third study. "This is significant as the risk of heat stroke is greatest when it's hot and humid at the same time, for instance," says Fischer. The fact that the combined measures of temperature and atmospheric humidity can be predicted so well is linked to the fact that temperature and humidity also depend on each other through physical processes. One factor why temperatures were so high during the so-called heat wave of 2003, for example, is that it was so dry and hardly any soil moisture could evaporate anymore.

Even if climate projections sometimes reach their limits because of divergent predictions and the influence of unpredictable weather phenomena, accurate projections are thus perfectly feasible in certain areas, too – projections that will also influence the next IPCC report, which will be published in September 2013.

More information: Knutti R, Sedlacek J: Robustness and uncertainties in the new CIMP5 climate model projections. *Nature Climate Change*, 2012, Advance Online Publication, DOI: 10.1038/nclimate1716

Deser C, Knutti R, Solomon S, Phillips AS: Communication of the role of natural variability in future North American climate, *Nature Climate Change,* 2012, 2: 775-779, DOI: 10.1038/nclimate1562

Fischer EM, Knutti R: Robust projections of combined humidity and temperature extremes. *Nature Climate Change*, 2012, Advance Online Publication, DOI: 10.1038/nclimate1682

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