Paths out of uncertainty: Increasing extreme confidence

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Long-term and average changes are in the focus of the discussion on climate change: globally, as the different scientific climate models all predict, it will be warmer on Earth at the end of the century. For decision-makers and people affected by climate change, however, information on the frequency and intensity of extreme events such as heat and cold extremes, heavy rainfall or dry spells are at least as important as indications of average values. Moreover, for them projections about the next ten, twenty, thirty or forty years are usually more relevant than the long-term view to the end of the century. The problem: for the short and medium term, the models yield extremely different results.

Does that mean that the models are not working? No, says Erich Fischer, a senior scientist at the Institute for Atmospheric and Climate Science at ETH Zurich, who has been investigating the causes of the major discrepancies in the short and medium-term projections. In a study just published in the journal "*Nature Climate Change*", he concludes that they are mostly caused by natural, chaotic and thus unpredictable fluctuations in the climate system. There is certainly potential for improving climate models, Fischer says. "However, even if we had a perfect model for the medium-term, there would still be uncertainties."

Butterfly effect simulated

The researchers obtained their results from a simulation of the well-

known butterfly effect, which states that slightly different starting conditions can vastly influence a development in the longer term ("Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?"): the scientists calculated the future climate twenty-one times using one of the leading climate models, deliberately changing the temperatures on Day 1 of the calculation ever so slightly for every point on Earth – by a maximum of one hundred billionths of a degree Celsius.

This revealed that the differences in the maximum and minimum annual temperatures and the intensive precipitation between 2016 and 2035 were almost as great in the realisations of this one model as the known differences between the various models. From these results the researchers concluded that the majority of the differences are due to the starting conditions and thus chaos, not the uncertainties of the models.

What can be predicted and what can't

"Our study reveals that we have to live with uncertainties in local, medium-term projec-tions," says Fischer. A Swiss farmer, for instance, cannot expect any accurate predic-tions on the changes in climate extremes on the Swiss Central Plateau in the next thirty to forty years, even if it is clear that the heat extremes and periods of heavy rainfall in the long-term trend will be more intense by the end of the century.

However, this does not mean to say that no scientific projections about the coming decades are possible. The ETH-Zurich scientists have found ways to make such projections – by considering large regions or the entire world. This enabled them to demonstrate that the intensity of heat extremes and periods of heavy rainfall will not increase equally everywhere on Earth: while heat extremes will become significantly more intense on two thirds of the land surface within three decades, there will be no significant changes in a third of the area. And as far as heavy rainfall is concerned, it will increase by ten per cent in a quarter of

the area and less than ten per cent in the remaining three quarters.

Risks predictable

The ETH-Zurich researchers make similar projections for large individual regions such as Europe, the USA, China or Australia. In all these regions, the climate models predict an increase in the intensity of heat waves in the next thirty years and heavy rainfall in the next fifty years. For institutions with a global focus, such as reinsurance companies or food multinationals, such predictions are extremely useful, even if it is unclear where exactly the extreme events will occur. "The different models agree that changes in extreme weather events will occur and how strong they will be, but not where they will be the strongest. This is largely determined by chaos," says Fischer. In physics, it is common for a single condition not to be predictable but probably the average. Fischer compares it with road traffic: if speed limits are increased, we can predict that there will more traffic accidents. Where exactly the next accident will take place, however, we cannot tell.

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