New approach allows past data to be used to improve future climate projections

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Climate scientists are still grappling with one of the main questions of modern times: how high will global temperatures rise if the atmospheric concentration of carbon dioxide doubles. Many researchers are turning to the past because it holds clues to how nature reacted to climate change before the anthropogenic impact. The divergent results of this research, however, have made it difficult to make precise predictions about the impact of increased carbon dioxide on future warming. An international team of scientists have evaluated previously published estimates and assigned them consistent categories and terminology. This process should assist in limiting the range of estimates and make it easier to compare data from past climate changes and projections about future warming. The group has presented its new method in the current edition of the journal *Nature*.

The research group summarized, classified and compared data from more than 20 studies to make a potential prognosis about the expected future rise in the world's temperature. In these palaeoclimate studies climate sensitivity has been reconstructed on the basis of data derived from ice and sediment core. Climate sensitivity is a key parameter in the study of climate change. It describes the rise of the mean temperature of the earth's surface due to changes in the climate system. Specifically, its value represents the increase in global temperatures calculated by climate models, if the carbon dioxide content in the atmosphere doubles. Here, models were initialised with pre-industrial carbon dioxide concentrations.

The team was then faced with the challenge of comparing the assembled studies. Each study spoke of "climate sensitivity", but not all took the same factors into account. "We had to elaborate all the different assumptions and uncertainties, such as which studies look exclusively at carbon dioxide and which considered other greenhouse gases such as methane or the effect of reflection, the so called albedo, from ice surfaces. Only then could we compare the data. We also calculated the climate sensitivity data if we only considered greenhouse gases like carbon dioxide or added in albedo", explained Dr Peter Köhler, one of the article's main authors and climatologist at the Alfred Wegener Institute for Polar and Marine Research, part of the Helmholtz Association.

The research group was able to use its new method to differentiate ten different kinds of climate sensitivity. In a second phase of the project, they then worked on devising consistent terminology and concrete definitions. The new classification system should prevent future researchers from publishing widely divergent estimates of climate sensitivity based on differing assumptions. "Ideally, it should be clear from the start of a study what kind of climate sensitivity is being addressed. The factors considered by the researchers to be driving temperature change should be clear from the language used. Our terminology offers a conceptual framework to calculate climate sensitivity based on past climate data. We hope that this will improve evaluation of future climate projections", adds Köhler.

This work represents a significant advance for climatology. It is the first summary of what scientists have been able to reconstruct about climate sensitivity based on data from the past 65 million years and the assumptions that were behind the data. It also demonstrates that the climate forecasts in the IPCC reports agreed with the estimates of how nature has reacted to changes in the climate through the course of the earth's history.

The research team has not, however, achieved one of its goals. "We had hoped to limit the range of current assumptions about climate sensitivity. In its last report, the IPCC summarised that the global temperature would rise 2.1 to 4.4 degrees C if the atmospheric carbon dioxide level rises to double the pre-industrial values. As it turns out, our climate sensitivity values are currently within this same range" says Dr Köhler.

Further open questions will have to be addressed in order to obtain more precise figures. Scientists know, for example, that climate sensitivity depends on the predominant background climate at the time, i.e. whether climate is in an ice age or a warm age. But exactly how this background climate impacts climate sensitivity still has to be answered. The climatologists behind this study hope that the new conceptual framework will push further research in this direction.

The article is the outcome of a three-day colloquium held last year at the Royal Netherlands Academy of Arts and Sciences in Amsterdam, attended by more than 30 specialists in the field.

More information: "Making sense of palaeoclimate sensitivity" appeared in the 29 November issue of *Nature*. (doi: 10.1038/nature11574), Vol 491, pages 683-691.

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