

International analysis narrows range of climate's sensitivity to carbon dioxide

July 22 2020



A blazing sunset lights up the evening sky. Credit: NOAA (Unsplash)

The most advanced and comprehensive analysis of climate sensitivity yet undertaken has revealed with more confidence than ever before how sensitive the Earth's climate is to carbon dioxide.

For more than 40 years, the estimated likely range of the eventual global temperature response to a doubling of atmospheric carbon dioxide compared to preindustrial levels has stubbornly remained at 1.5°C-4.5°C.

This new research, revealed in a 165-page, peer-reviewed journal article commissioned by the World Climate Research Programme (WCRP) written over four years, finds that the true climate sensitivity is unlikely to be in the lowest part of the 1.5-4.5°C range. The analysis indicates that if atmospheric carbon dioxide levels double from their pre-industrial levels and are maintained, the world would probably experience eventual warming from 2.3-4.5°C. The researchers found there would be less than 5% chance of staying below 2°C and a 6-18% chance of exceeding 4.5°C.

With the Earth's temperature already at around 1.2°C above preindustrial levels, if greenhouse gas emissions trajectories continue unabated the world can expect to see a doubling of carbon dioxide in the next 60-80 years.

"Narrowing the range of climate sensitivity has been a major challenge since the seminal US National Research Council paper came up with a 1.5-4.5°C range in 1979 (Charney et al). That same range was still quoted in the most recent IPCC report," said lead author Prof Steven Sherwood, a University of New South Wales chief investigator with the ARC Centre of Excellence for Climate Extremes.

The research was only made possible by bringing together an international team of researchers from a wide range of climate disciplines. Using temperature records since the [industrial revolution](#), paleoclimate records to estimate prehistoric temperatures, satellite observations and detailed models that examine the physics of interactions within the climate system the team were able to combine

more independent lines of evidence than any previous study to get their results.

These lines of evidence were then combined in a statistically rigorous way allowing the team to find where the results overlapped. This allowed them to converge on the best estimate of climate sensitivity. The team found that, with new developments, the various lines of evidence corroborated one another leading to more confidence in the result. The 2.3-4.5°C range accounts cautiously for alternative views or assumptions and "unknown unknowns," with a more straightforward calculation yielding an even narrower 2.6-3.9°C likely range.

"This paper brings together what we know about climate sensitivity from measurements of atmospheric processes, the historical warming, and warm and cold climates of the past. Statistically combined, these estimates make it improbable that climate sensitivity is at the low end of the IPCC range and confirm the upper range. This adds to the credibility of climate model simulations of future climate," said co-author Gabi Hegerl from the University of Edinburgh.

"An important part of the process was to ensure that the lines of evidence were more or less independent," said Prof Sherwood. "You can think of it as the mathematical version of trying to determine if a rumor you hear separately from two people could have sprung from the same source; or if one of two eyewitnesses to a crime has been influenced by hearing the story of the other one."

The researchers then went another step further and identified the conditions that would be required for the climate sensitivity to lie outside this most likely range.

The researchers show that low [climate](#) sensitivities previously thought to be plausible, around 1.5-2°C, could only occur if there were multiple

unexpected and unconnected errors in the [data analysis](#) (for example unexpected cloud behavior and patterns of long-term ocean warming), underlying their judgment that these low values are now extremely unlikely.

A different set of circumstances make it unlikely that global temperatures would rise more than 4.5°C for a doubling of [carbon dioxide](#) from pre-industrial times, although these higher temperature responses are still more likely than very low sensitivities.

Even with this qualification, the three-year long research process initiated by the WCRP with double-checking at every step, a detailed examination of the physical processes and an understanding of the conditions required for the estimate has finally consolidated an advance on the 40-year-problem.

"These results are a testament to the importance of cross-disciplinary research along with slow, careful science and perfectly highlight how international co-operation can unpick our most vexing problems," said co-author Prof Eelco Rohling from the Australian National University.

"If international policymakers can find the same focus and spirit of co-operation as these researchers then it will give us hope that we can forestall the worst of global warming."

Provided by University of New South Wales

Citation: International analysis narrows range of climate's sensitivity to carbon dioxide (2020, July 22) retrieved 20 September 2024 from <https://phys.org/news/2020-07-international-analysis-narrows-range-climate.html>

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