Research Reveals Sensitivity of Earth's Climate to Carbon Dioxide

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Researchers who performed the most detailed and advanced study of climate sensitivity have now reported more confidently about the sensitivity level of Earth's climate to carbon dioxide. This is the first study of its kind to be performed, to date.

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 °C–4.5 °C range in 1979. Image Credit: NOAA (Unsplash).

For over four decades, the projected likely range of the ultimate worldwide temperature response to a doubling of carbon dioxide in the air when compared to pre-industrial levels has continued to remain at 1.5 °C–4.5 °C. The latest study revealed that the actual climate sensitivity is too far-fetched to be in the lowest part of the 1.5 °C–4.5 °C range.

The research was written over four years and has been described in a 165-page, peer-reviewed journal article commissioned by the World Climate Research Programme (WCRP). It indicates that if carbon dioxide levels in the air increase by two-fold from their pre-industrial levels and continue to persist, the world is likely to experience ultimate warming from 2.3 °C to 4.5 °C.

The scientists observed that there would be a 6%–18% chance of surpassing 4.5 °C and less than 5% chance of remaining below 2 °C.

The temperature of the Earth has already touched about 1.2 °C higher than preindustrial levels. Furthermore, if greenhouse gas emissions trajectories continue to persist, the world is likely to witness a doubling of atmospheric carbon dioxide in the next six to eight decades.

> *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 °C–4.5 °C range in 1979 (Charney et al). That same range was still quoted in the most recent IPCC report.*
>
> *Steven Sherwood, Study Lead Author and Professor, UNSW Sydney*

Sherwood is also the chief investigator with the ARC Centre of Excellence for Climate Extremes.

The collaboration of an international team of researchers from a broad range of climate disciplines has led to this latest research. During the study, the team used paleoclimate records to predict prehistoric temperatures, temperature records since the industrial revolution, satellite observations, and comprehensive models that analyze the physics of communications within the climate system.

Following this, the researchers integrated more individual lines of proof than provided by any previous studies to obtain their results. These independent lines of proof were subsequently integrated in a statistically stringent manner that allowed the researchers to spot where exactly the results overlapped. This approach enabled the team to converge on the best estimate of climate sensitivity.

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The researchers also observed that, with the latest developments, the numerous lines of proof validated each other, resulting in more confidence in the outcome. The 2.3 °C–4.5 °C temperature range carefully accounts for alternative assumptions or views and "unknown unknowns," with a more upfront calculation producing a likely range that is even narrower from 2.6 °C to 3.9 °C.

> *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.*
>
> *Gabi Hegerl, Study Co-Author, University of Edinburgh*

"*An important part of the process was to ensure that the lines of evidence were more or less independent*," added Professor Sherwood. "*You can think of it as the mathematical version of trying to determine if a rumour 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.*"

Subsequently, the scientists went one step further and detected the conditions that would be needed for the climate sensitivity to lie beyond this most probable range.

The scientists demonstrated that low climate sensitivities, which were earlier believed to be credible, around 1.5 °C–2 °C, could only happen if the data analysis contains numerous unconnected and unforeseen errors (for instance, unforeseen cloud patterns and behavior of long-term ocean warming), reinforcing their judgment that such low values are quite unlikely today.

Another set of situations makes it implausible that global temperatures would increase over 4.5 °C for a doubling of atmospheric carbon dioxide from preindustrial times, even though these responses of higher temperatures are still more likely than extremely low sensitivities.

In spite of this qualification, the three-year-long research procedure launched by the WCRP with cross-checking at each step, a comprehensive analysis of the physical procedures, and an inference of the conditions needed for the estimate has eventually consolidated an advance on the four-decade issue.

> *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.*
>
> *Eelco Rohling, Study Co-Author and Professor, 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*," Rohling concluded.

Journal Reference:

Sherwood, S., *et al.* (2020) An assessment of Earth's climate sensitivity using multiple lines of evidence. *Reviews of Geophysics*. doi.org/10.1029/2019RG000678.

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