

# Greenhouse gases were the main driver of climate change in the deep past

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Greenhouse gases were the main driver of climate throughout the warmest period of the past 66 million years, providing insight into the drivers behind long-term climate change.

Antarctica and Australia separated around the end of the Eocene (56 to 22.9 million years ago), creating a deep water passage between them and changing [ocean circulation patterns](#). Some researchers believe these changes were the driver of cooling temperatures near the end of the Eocene 'hothouse' period, but some think declining levels of [carbon dioxide](#) were to blame.

If the cooling had been caused by changes in [ocean circulation](#), regions around the equator would have warmed as the polar regions cooled, shifting the distribution of heat on Earth. But changing the concentration of [greenhouse gases](#) would affect the total heat trapped in Earth's atmosphere, causing cooling everywhere (including in the tropics), which is what the researchers found. The findings were published in the journal *Nature*.

The synchronized evolution of tropical and polar [temperature](#) we reconstructed can only be explained by [greenhouse gas](#) forcing," said Margot Cramwinckel, a Ph.D. candidate at Utrecht University in the Netherlands and first author of the paper. "Our findings are uniquely compatible with the hypothesis that the long-term Eocene cooling was driven by greenhouse gasses. This greatly improves our understanding of the drivers behind long-term [climate](#) change, which is important in order to predict the development of future climate change."

Climate change often has more intense effects near the poles than elsewhere on the planet, a phenomenon known as polar amplification.

The study found that temperature change was more dramatic near the poles than in the tropics during the Eocene, even though most of the period was extremely warm, leaving little to no ice near the poles.

"Even in a largely ice-free world, the poles cooled more than the tropics as temperature dropped," Cramwinckel said. "This indicates that

greenhouse gas forcing by itself can cause polar amplification."

The researchers had one more question about polar amplification: does it reach some sort of limit?

"Our results support the idea that polar amplification saturates out at some point in warm climates and does not continue to increase with further warming," said Matthew Huber, a professor of earth, atmospheric and planetary sciences at Purdue University and co-author of the paper.

As a proxy for temperature, the research team looked at membrane lipids of simple, sea-surface dwelling organisms called Thaumarchaeota that change their membrane composition as temperatures change in deep sea sediment cores drilled near the Ivory Coast.

They combined these observations with climate models, produced by Huber's team at Purdue, to mesh together a timeline of temperature throughout the Eocene.

"The simulations took about four years of continuous computing to achieve equilibrated climate states at various carbon dioxide levels," Huber said. "For the first time, the climate model is capable of capturing the main trends in tropical sea surface temperatures and temperature gradients across a range of climate encompassing nearly 20 million years. The only problem is that the simulations required more carbon dioxide changes than observed, which demonstrates that this model is not sensitive enough to carbon dioxide."

Historically, researchers have had trouble reproducing temperature gradients between the tropics and the poles throughout the Eocene. These new climate models are capable of overcoming most of the issues faced by past models.

**More information:** Synchronous tropical and polar temperature evolution in the Eocene , *Nature* (2018). [DOI: 10.1038/s41586-018-0272-2](https://doi.org/10.1038/s41586-018-0272-2) , [www.nature.com/articles/s41586-018-0272-2](https://www.nature.com/articles/s41586-018-0272-2)

Provided by Purdue University

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