

# Planet now at risk of heading toward 'hothouse Earth' state

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Keeping global warming to within 1.5-2 degrees C may be more difficult than previously assessed, according to researchers. An international team of scientists has published a study in the *Proceedings of the National Academy of Sciences (PNAS)* showing that even if the carbon emission reductions called for in the Paris Agreement are met, there is a risk of Earth entering what the scientists call "Hothouse Earth" conditions.

A "Hothouse Earth" climate will, in the long term, stabilize at a global average of 4-5 degrees C higher than pre-industrial temperatures with sea level 10 to 60 meters higher than today, the paper says. The authors conclude it is now urgent to greatly accelerate the transition toward an emission-free world economy.

"Human emissions of greenhouse gas are not the sole determinant of temperature on Earth. Our study suggests that human-induced [global warming](#) of 2 degrees C may trigger other Earth system processes, often called feedbacks, that can drive further warming—even if we stop emitting [greenhouse gases](#)," says lead author Will Steffen from the Australian National University and Stockholm Resilience Centre. "Avoiding this scenario requires a redirection of human actions from exploitation to stewardship of the Earth system."

Currently, global average temperatures are just over 1 degrees C above pre-industrial and rising at 0.17 degrees C per decade.

The authors of the study consider 10 natural feedback processes, some of which are "tipping elements" that lead to abrupt change if a critical threshold is crossed. These feedbacks could turn from being beneficial, by storing carbon, to a source of uncontrollable emission in a warmer world. These feedbacks are permafrost thaw, loss of methane hydrates from the ocean floor, weakening land and ocean carbon sinks, increasing bacterial respiration in the oceans, Amazon rainforest dieback, boreal forest dieback, reduction of northern hemisphere snow cover, loss of Arctic summer sea ice, and reduction of Antarctic sea ice and polar ice sheets.

"These tipping elements can potentially act like a row of dominoes. Once one is pushed over, it pushes Earth toward another. It may be very difficult or impossible to stop the whole row of dominoes from tumbling over. Places on Earth will become uninhabitable if 'Hothouse Earth'

becomes the reality," adds co-author Johan Rockström, executive director of the Stockholm Resilience Centre and incoming co-director of the Potsdam Institute for Climate Impact Research.

Hans Joachim Schellnhuber, director of the Potsdam Institute for Climate Impact Research, says, "We show how industrial-age greenhouse gas emissions force our climate, and ultimately the Earth system, out of balance. In particular, we address tipping elements in the planetary machinery that might, once a certain stress level has been passed, one by one change fundamentally, rapidly, and perhaps irreversibly. This cascade of events may tip the entire Earth system into a new mode of operation."

"What we do not know yet is whether the climate system can be safely 'parked' near 2 degrees C above preindustrial levels, as the Paris Agreement envisages. Or if it will, once pushed so far, slip down the slope towards a hothouse planet. Research must assess this risk as soon as possible."

## **Cutting greenhouse gases is not enough**

Maximizing the chances of avoiding a "Hothouse Earth" requires not only reduction of carbon dioxide and other [greenhouse gas emissions](#), but also enhancement and/or creation of new biological carbon stores, for example, through improved forest, agricultural and soil management; biodiversity conservation; and technologies that remove carbon dioxide from the atmosphere and store it underground, the paper says. Critically, the study emphasizes that these measures must be underpinned by fundamental societal changes that are required to maintain a "Stabilized Earth" where temperatures are ~2 degrees C warmer than the pre-industrial era.

"Climate and other global changes show us that we humans are

impacting the Earth system at the global level. This means that we as a global community can also manage our relationship with the system to influence future planetary conditions. This study identifies some of the levers that can be used to do so," concludes co-author, Katherine Richardson from the University of Copenhagen.

**More information:** Will Steffen et al., "Trajectories of the Earth System in the Anthropocene," *PNAS* (2018).

[www.pnas.org/cgi/doi/10.1073/pnas.1810141115](https://www.pnas.org/cgi/doi/10.1073/pnas.1810141115)

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