The time window for the 1.5-degree target is closing
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Climate change even without emissions: Even if all fossil fuel burning was stopped immediately, and mankind did not release any further CO2 and other climate-relevant substances, global warming would continue. It would reach around 1.1 degrees by the end of this century alone. Credit: picture alliance/ZB/eurolfuembild

Earth’s climate is out of balance: the planet has been warming since industrialization began, because CO2 increasingly collects in the atmosphere. Even an immediate stop of all emissions would not bring global warming to a sudden halt, reveals a study by Thorsten Mauritsen, Research Group Leader at the Hamburg-based Max Planck Institute for Meteorology, and his colleague Robert Pincus, a scientist at the University of Colorado in the US: in this case, in addition to previous warming of 0.8 degrees Celsius, another 0.3 degrees Celsius would be added by the end of this century alone.

The climate is an extremely inertial system – it reacts only slowly to changes and takes a long time to regain equilibrium. Researchers also observe this with regard to climate change, which began with the industrial age: "The excess energy currently being fed into the Earth system is primarily absorbed by the oceans," explains Thorsten Mauritsen of the Max Planck Institute for Meteorology in Hamburg. Thus, if there were no oceans, the temperature of the atmosphere would increase even faster. But the enormous volume of water in the world's oceans takes a long time to warm up. 'It has a long reaction time, because it has a large heat capacity', says Mauritsen. The oceans therefore always lag behind global warming and will thus also continue to heat up even if humankind were to immediately stop emitting greenhouse gases. However, with time, the oceans will absorb less and less heat from the atmosphere and the cooling effect on the atmosphere will wane. Finally, after thousands of years, the climate system would reach equilibrium again, at higher ocean and atmospheric temperatures.

The magnitude of this committed warming – that is, the warming already caused by previous emissions, but which will only occur in the future – was determined by Mauritsen and his colleague Robert Pincus of the University of Colorado using a simple method. They have presented the results in the journal *Nature Climate Change*. In contrast to previous studies, they dispensed with the use of complex climate models and instead based their study on observational data. They then analysed the sensitivity of the climate's reaction to the greenhouse gas CO2.

**CO2 persists for millennia in the atmosphere**

Because CO2 is not the only gas that is released when burning coal, oil and gas, Mauritsen and Pincus incorporated further emissions in their investigation, including aerosols and other greenhouse gases, such as methane, nitrogen oxides and carbon monoxide. While CO2 persists in the atmosphere for millennia and exercises its warming effect throughout the entire period, aerosols are washed out of the air again after only a few days. Methane, nitrogen oxides and carbon...
monoxide are also quite short-lived; their lifetime in the atmosphere is less than ten years.

However, the impacts of atmospheric pollutants are different: aerosols reflect sunlight back into space and thus have a cooling effect on the climate. "These particles mask some of the warming caused by the greenhouse gas CO2," says Mauritsen. If all fossil emissions were stopped, a short burst of warming should initially be anticipated due to the absence of the cooling aerosols. A reduction in the short-lived greenhouse gases methane, nitrogen oxides and carbon monoxide would produce the reverse effect: their disappearance would alleviate warming slightly.

Possible warming between 0.7 and 1.8 degrees Celsius

For the purpose of their study, Mauritsen and Pincus assumed that all emissions abruptly cease in 2017. In this case, the results show, Earth's climate would, in the long term – that is, after several thousand years – reach equilibrium at a temperature 1.5-degrees Celsius above the 1850 level. To date, Earth has already heated up by 0.8 degrees compared to the average pre-industrialisation temperature. "So, several more tenths would be added to this value," explains Mauritsen. According to the study, global warming would be increased by 1.3 degrees Celsius compared to the pre-industrial age by the end of the 21st century. Consequently, the climate would move a long way down the path to equilibrium during this century.

In another analysis variant, Mauritsen and Pincus additionally incorporated the fact that the oceans also react sluggishly as a CO2 sink. They gradually absorb some of the carbon dioxide accumulating in the atmosphere. This effect limits the committed warming by the end of the century to 1.1 degrees Celsius. According to the study, the possible range in this case was between 0.7 and 1.8 degrees Celsius.

The 1.5-degree target is not yet completely unrealistic

According to the authors, the value of the study is that it provides the foundation for reality-checking specific temperature targets – for example the target of limiting global warming to 1.5-degrees Celsius agreed in the Paris climate accord. Mauritsen and Pincus find a 13 percent probability that the emissions discharged to date are already sufficient to warm the Earth permanently by more than 1.5-degrees – and that the Paris target already cannot be met. The uncertainty in the analyses is caused by currently not knowing exactly how sensitively the climate system will react to increasing CO2 concentrations.

It may therefore still be possible to reach the target. However, the time window for achieving this is closing rapidly: "At the current rate of emissions, it will take around another 15 to 30 years until the risk of exceeding the 1.5-degree target reaches fifty percent," reports Mauritsen. Prior to the study, the researcher was convinced that the 1.5-degree target was already surpassed due to past emissions. "I was somewhat irritated that this target was even discussed at the Paris agreement negotiations," he says. "But as I continued to study the literature and then performed my own analyses, I eventually had to realize that it is not completely impossible. That's a positive result."

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