Faster Arctic warming hastens 2-degree-Celsius rise by eight years, finds modeling study

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German research ship Polarstern amid Arctic sea ice. Credit: Alfred-Wegener-Institut. multimedia.awi.de/mosaic/#1699635434973_1

Faster warming in the Arctic will be responsible for a global 2 C temperature rise being reached eight years earlier than if the region were warming at the average global rate, according to a new modeling study

led by UCL researchers.

The Arctic is currently warming nearly four times faster than the global average rate. The new study, published in the journal *Earth System Dynamics*, aimed to estimate the impact of this faster warming on how quickly the global temperature thresholds of 1.5 C and 2 C, set down in the Paris Agreement, are likely to be breached.

To do this, the research team created alternative climate change projections in which rapid Arctic warming was not occurring. They then compared temperatures in this hypothetical world with those of the "real-world" models and examined the timing with which the critical Paris Agreement thresholds of 1.5 C and 2 C were breached. They found that in the models without fast Arctic warming, the thresholds were breached five and eight years later, respectively, than their "real-world" projected dates of 2031 and 2051.

In addition, they found that disproportionately fast Arctic warming, known as Arctic amplification, added disproportionate uncertainty to forecasts, as the variation in model projections for the region is larger than for the rest of the planet.

Alistair Duffey (UCL Earth Sciences), a Ph.D. candidate and lead author of the study, said, "Our study highlights the global importance of rapid Arctic warming by quantifying its large impact on when we are likely to breach critical climate thresholds. Arctic warming also adds substantial uncertainty to climate forecasts. These findings underscore the need for more extensive monitoring of temperatures in the region, both in-situ and via satellites, and for a better understanding of the processes occurring there, which can be used to improve forecasts of global temperature rise."

The study does not attempt to quantify the ways in which Arctic

warming affects the rest of the world, for instance through the retreat of sea ice that helps to keep the planet cool, but instead estimates the direct contribution of Arctic warming to global temperature increases.

Co-author Professor Julienne Stroeve (UCL Earth Sciences, the University of Manitoba, Canada, and the U.S. National Snow and Ice Data Center), said, "While our study focuses on how Arctic warming affects global temperature change, the local impacts should not be overlooked. A 2 C temperature rise globally would result in a 4 C annual mean rise in the Arctic, and a 7 C rise in winter, with profound consequences for local people and ecosystems.

"In addition, rapid warming in the Arctic has global consequences that we do not account for in this study, including sea level rise and the thawing of permafrost, which leads to more carbon being released into the air."

3D picture of the floe based on highly resolved aerial imagery from the helicopter nadir camera. Credit: Alfred-Wegener-Institut / Niels Fuchs. multimedia.awi.de/mosaic/#1699635434973_1

Co-author Dr. Robbie Mallett (University of Manitoba and Honorary Research Fellow at UCL Earth Sciences), said, "Arctic climate change is often overlooked by politicians because most of the region is outside national boundaries. Our study shows how much the Arctic impacts global targets like the Paris Agreement, and hopefully draws attention to the crisis that's already unfolding in the region."

Arctic amplification, which is strongest in the winter months, is caused by several factors. One is the retreat of sea ice, meaning more sunlight (and heat) is absorbed by water instead of being reflected back into space. Another factor is less vertical mixing of air in the poles than in the tropics, which keeps warmer air close to the Earth's surface.

For the study, researchers looked at an ensemble of 40 climate models that informed the UN's 2021 climate change report. These models divide Earth's surface into a three-dimensional grid of cells, modeling physical processes occurring within each cell.

The research team modified the output of the models to create an alternative world in which rapid Arctic warming was not occurring, by setting the rate of change of temperature in the region north of 66° North equal to that of the rest of the planet. They looked at how the removal of rapid Arctic warming would affect temperature projections in a plausible intermediate emissions scenario and calculated the average temperature projection across all models.

In addition, they looked at how removing rapid Arctic warming from the

models would affect more pessimistic or optimistic scenarios. For example, in a more optimistic scenario, where emissions are cut sharply and net zero is reached shortly after 2050, Arctic amplification causes a seven-year difference in the time of passing 1.5°C.

Temperature projections for the Arctic varied more substantially between the models than for other parts of the globe, accounting for 15% of the uncertainty in projections, despite the region only making up 4% of the global surface area.

The 1.5 C and 2 C limits are regarded as having been breached when average global temperatures over a 20-year period are 1.5 C or 2 C higher than in pre-industrial times.

The goal of the Paris Agreement, an international treaty, is to keep the global average temperature to "well below 2° C above pre-industrial levels" and pursue efforts "to limit the temperature increase to 1.5° C."

The Arctic is thought to have warmed by 2.7 C since the pre-industrial era, and this warming is believed to have accelerated since the start of the 21st century.

More information: Arctic Amplification's Contribution to Breaches of the Paris Agreement, *Earth System Dynamics* (2023). doi.org/10.5194/esd-14-1165-2023

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