Climate risks from exceeding 1.5°C reduced if warming swiftly reversed, says study

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Earth systems could be "tipped" into unstable states if warming overshoots the 1.5°C target, but impacts could be minimized if warming is swiftly reversed.

The Paris Agreement target to keep global warming below 1.5°C above pre-industrial levels was set to avoid the worst impacts of climate change. Studies have shown that if the target is "overshot," some of those impacts will still take place even if warming is reduced back below 1.5°C.

A study, led by the International Institute for Applied Systems Analysis (IIASA) and the Potsdam Institute for Climate Impact Research (PIK), and including Imperial College London researchers, shows that these impacts can be minimized if the 1.5°C overshoot is swiftly reversed. The results are published in *Nature Communications*.

Co-author Dr. Robin Lamboll, from the Center for Environmental Policy and the Grantham Institute at Imperial, said, "Our results show why reducing emissions this decade is crucial for the state of the planet. Failing to reach the Paris Agreement target risks reshaping the Earth's systems for centuries to come."

Core climate elements

Human-made climate change can destabilize large components of the Earth's system, such as ice sheets, ocean circulation patterns, or large biospheres. These are called "tipping elements," because once their state is changed, they do not easily change back. For instance, ice sheets may melt hundreds of times faster than they grow.

The researchers looked at current levels of climate action and scenarios for future greenhouse gas emissions, and analyzed the risk of destabilizing four of the core tipping elements: the Greenland Ice Sheet, the West Antarctic Ice Sheet, the Atlantic Meridional Overturning Circulation (the main ocean current system in the Atlantic Ocean), and the Amazon Rainforest.

The authors found that the risk of tipping over at least one of these elements by 2300 is substantial for several of the assessed future emission scenarios. Failing to return to below 1.5°C by 2100, despite reaching net-zero greenhouse gas emissions, results in tipping risks of up to 24% by 2300, meaning that in around a quarter of model runs at least one of the considered tipping elements has tipped.

Co-author Annika Ernest Högner from PIK said, "We see an increase in tipping risk with every tenth of a degree of overshoot above 1.5°C. If we were to also surpass 2°C of global warming, tipping risks would escalate even more rapidly. This is very concerning as scenarios that follow currently implemented climate policies are estimated to result in about 2.6°C global warming by the end of this century."

Vital for planetary stability

Co-lead author Tessa Möller, a researcher in the IIASA Energy, Climate, and Environment Program and at PIK, said, "Our results show that to effectively limit tipping risks over the coming centuries and beyond, we must achieve and maintain net-zero greenhouse gas emissions.

"Following current policies this century would commit us to a high tipping risk of 45% by 2300, even if temperatures are brought back to below 1.5°C after a period of overshoot."

According to the researchers, the advanced models currently used to study the Earth's systems are not yet able to fully capture the complicated behaviors, feedback loops, and interactions between some of the tipping elements.

To address this, the team used a simpler, stylized Earth system model that represents these tipping elements using four connected mathematical equations. By doing so, they also took future stabilizing interactions into

account, like the cooling effect of the weakening Atlantic Meridional Overturning Circulation onto the Northern Hemisphere.

More information: Tessa Möller et al, Achieving net zero greenhouse gas emissions critical to limit climate tipping risks, *Nature Communications* (2024). DOI: 10.1038/s41467-024-49863-0

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