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Q&A

Q&A with Dr. Joeri Rogelj: A research agenda for overshoot

Prof. Joeri Rogelj, Director of Research at the Grantham Institute and Professor of Climate Science and Policy at the Centre for Environmental Policy at Imperial College London, a Senior Research Scholar at the International Institute for Applied Systems Analysis (IIASA), conducts world-leading research connecting climate and earth system science with policy and societal change. We recently spoke with him about the impacts of temperature overshoot and the research needed to address the unknowns of going beyond the historic "safe operating space" of human civilization—and the process of returning. The views of Prof. Rogelj are his only and do not necessarily reflect those of ICL or IIASA.

First, can you briefly introduce the concept of the "carbon budget" for our readers, and explain how it is relevant for net-zero targets?

Global warming is roughly proportional to the total amount of carbon dioxide (CO_2) that is ever added to the atmosphere by human activities (IPCC 2021). That relationship means that we can calculate the total amount of CO_2 that is consistent with keeping global warming to a specific warming limit, such as 1.5°C. That total amount is called the total carbon budget. Logically, the only way of staying within a carbon budget is to stop adding CO_2 to the atmosphere and that requires bringing global CO_2 emissions down to zero. As a consequence, net-zero emissions targets represent key milestones in the global response to the climate challenge.

How can the carbon budget be useful for assessing progress in climate action and what does it mean for the risks of overshoot?

Over the past century, human activity and economies have already emitted a very large amount of CO_2. The current tally stands at over 2,500 billion tons of CO_2 ($GtCO_2$). What remains is known as the remaining carbon budget (Rogelj et al. 2019a). Recently, we updated our best estimates of these remaining budgets and we found that unless global CO_2 emissions start to decline, the budget compatible with limiting warming to 1.5°C would be exhausted in about 6 years.

The carbon budget concept therefore also provides a straightforward way of understanding whether we are on track. If estimated future emissions implied by current pledges and policies exceed the

Joeri Rogelj. Photo: Ivan Boll
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total carbon budget for 1.5°C or 2°C, we know that they are failing to meet their goal. This shortfall in action means that the possibility of exceeding 1.5°C of global warming is a real possibility.

Most recent analysis confirms this assessment. As the chances for limiting warming below 1.5°C are shrinking, policymakers are trying to understand the implications of a so-called overshoot. In such a world, 1.5°C of global warming is first exceeded due to a lack of sufficient near-term emissions reductions but with the hope that this is only temporary. Global warming is expected to peak at a level higher than 1.5°C, once global CO_2 emissions have been reduced to net zero. Subsequently, the active removal of CO_2 from the atmosphere over the course of multiple decades and centuries would again reduce warming below 1.5°C.

Key characteristics of such pathways are the magnitude and duration of the overshoot. The smaller the magnitude and the shorter the duration, the lower the impacts.

The research and policy community have long used climate and socioeconomic scenarios to identify key pathways to meet climate goals. However, many of these pathways focus on end-of-century outcomes. How do you see pathways being used to most impactfully interrogate a future with temperature overshoot?

For a long time, the scientific community created scenarios that aimed to meet a climate goal in 2100 without asking specific questions about what happens to global warming over the course of the century. Such an approach, however, makes no sense for ambitious climate targets in the context of the Paris Agreement. The Paris Agreement long-term temperature goal sets a target of holding "the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (UNFCCC 2015). This goal does not refer to the year 2100. For 1.5°C, the goal is more aspirational, but the Paris Agreement does not suggest that global warming can be much higher over the course of the century. Pathways that by design consider overshoot of temperature targets are therefore not providing policymakers with the right information.

Instead, we have recently suggested a more transparent and honest way of describing pathways that temporarily exceed a specific temperature limit. We suggest that pathways should be defined in terms of their peak warming and their subsequent gradual temperature decline. Their peak warming is proportional to the maximum cumulative emissions that are emitted until a pathway reaches net zero. The subsequent temperature decline by the level of net negative CO_2 emissions that can be achieved and sustained. This approach, we argue, avoids risky overshoot pathways.

Net-negative carbon dioxide emissions is not the only climate "lever" we have for mitigation. What other climate forcers are important for reducing the magnitude and duration of climate overshoot?

Getting to grips with the CO_2 problem is essential to halt global warming. However, non-CO_2 greenhouse gas emissions and particularly methane emissions play an important role in limiting or exacerbating overshoot. Current methane emissions contribute about half a degree of global warming. In deep and ambitious mitigation scenarios, they are projected to roughly halve by mid-century, which would strongly reduce their contribution to warming. Methane is released both during extraction and use of fossil fuels as well as agricultural activities such rice paddies or the meat and dairy industry are a key source. Eliminating methane emissions from fossil fuel activities is a no-brainer, as in many cases it is cost-effective to avoid them. For agriculture, it is more a question of implementing all known measures to keep absolute methane emissions as low as possible. Any failure to reduce these non-CO_2 greenhouse gas emissions to their absolute minimum will result in global temperatures that are higher than they could be with more damages, losses, and suffering as a consequence.

In current research and policy, what "red flags" or concerning aspects do you see in discussions of overshoot scenarios?

The overshoot discourse is riddled with red flags. A first red flag is our general overconfidence when discussing overshoot pathways. I see overconfidence in how we think the planet will respond to our emissions and how easy it would geophysically be to achieve an overshoot trajectory, overconfidence in how plausible, feasible, and sustainable the required levels of CO_2 removal are, and overconfidence in how our society would deal with the consequences and climate impacts during such an overshoot. Much of this discourse focusses on central estimates of how the Earth system might behave or optimistic estimates about immature technologies. It by and large fails to account for the risks.

The same is true for suggestions to use solar radiation modification to keep warming from exceeding 1.5°C. These are, in my view, ill-informed and extremely risky. Counteracting the greenhouse effect by trying to reflect sunlight results in a world that is most likely cooler, but therefore not safer. Solar radiation modification imperfectly offsets greenhouse gas warming and can disrupt the hydrological cycle. Starting solar radiation modification is also shown to result in a multi-century commitment to deploy CO_2 removal, with all its ensuing costs and risks. Finally, the deployment of solar radiation modification would also require global coordination, collaboration, and agreement at a scale never witnessed before in history. Spraying reflecting substances in the atmosphere is cheap, and that means that anyone with a decent amount of finance could unilaterally do it. This can be a country, but equally a billionaire, be it in California or in Mumbai. Deciding when to stop, what the ideal degree of cooling is, or how much risk is tolerable is much harder.

Given that the world may top 1.5°C above pre-industrial average temperatures this year, what do you think is the most important thing to communicate to policymakers and the public?

Insufficient climate action to date have brought us to a place where exceeding 1.5°C becomes increasingly plausible. This has implications for policy, particularly for adaptation. However, even if the world exceeds 1.5°C of global warming, this changes very little to the focus of mitigation policy. We can always continue to pursue limiting warming to 1.5°C as per the Paris Agreement. We do this, first and foremost, by reducing global greenhouse gas emissions from today onwards and putting them on a steady and steep downward trajectory. At the same time, sustainable CO_2 removal needs to be pursued, not as an alternative, but as a means to further increase mitigation ambition and ultimately, potentially, contribute to a temperature reversal.

DECLARATION OF INTERESTS

The author declares no competing interests.

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