IMPERIAL
Grantham Institute

Background briefing

Limiting temperature increase to 1.5°C above pre-industrial levels

2024

Contents

Key points

- **The Paris Agreement 1.5°C target has not yet been missed**: in 2023 and 2024 we have experienced some temporary temperature spikes where the global average temperature was more than 1.5°C above pre-industrial levels. This is of great concern, but the long-term average global temperature increase is currently at around 1.2°C.
- We are, however, **at high risk of exceeding the 1.5°C level**; at current emission levels, the remaining global carbon budget will be exhausted within about 5 years.
- We therefore need to set out ambitious plans to rapidly move away from fossil fuels and scale up clean alternatives to reduce emissions across all parts of the economy. This will slow down and halt warming, with a possibility that this is below or around 1.5°C.
- **It makes sense to pursue rigorous mitigation efforts** – with every fraction of a degree of warming beyond 1.5°C, impacts will become more severe, and the costs of adaptation will be greater.

How close are we to a global average temperature increase of 1.5°C?

In 2015, the world adopted the Paris Agreement, "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."

To date, human-caused climate change has resulted in a decadal average of 1.19°C of warming compared with pre-industrial levels. This is already increasing the intensity of harmful extreme weather events, including Hurricanes Milton and Helene in the USA and record-breaking rainfall across Central Europe in 2024. Attribution analysis has concluded that more than 80% of the Earth's population were exposed to climate-change-related heat in July 2023.

Temporary exceedance of 1.5°C

In 2023 and 2024, we saw periods where the daily and monthly global average temperature was more than 1.5°C warmer than pre-industrial times. However, the Paris Agreement refers to a long-term average temperature increase typically measured over several decades. So a short-term increase of this nature does not yet imply that we have crossed the 1.5°C limit of the Paris Agreement, but it is nevertheless of concern.

It is also likely that the *annual* average global temperature will temporarily reach 1.5°C in the near future. Again, this does not mean a failure to achieve the Paris Agreement goal. However, temporary increases of this nature do indicate that the situation is getting worse and should be considered as a warning sign.

When might temperature increase reach 1.5°C?

Although we have not yet reached a 1.5°C level of global warming, our current temperature trajectory implies we will.

The window of opportunity to achieve the Paris 1.5°C goal is rapidly closing. Several recent assessments have demonstrated that keeping below 1.5°C will be an immense challenge:

- The IPCC's 6th Assessment Report concluded that, based on mitigation plans put forward in 2021, it is likely (that is, more than 66% probability) that warming will exceed 1.5°C during the 21st century.
- The UN's 2023 Global Stocktake concluded that "global emissions are not in line with modelled global mitigation pathways consistent with the temperature goal of the Paris Agreement".
- The recent assessment of global carbon budgets found that if carbon dioxide emissions remain at 2022 levels, the carbon budget to keep temperature increases below 1.5°C will be exhausted by around 2029. (This calculation only includes carbon dioxide. The estimated date for reaching 1.5°C occurs several years after this budget is exhausted because it also considers the effects of other emissions.)

What happens if global warming goes beyond 1.5°C?

The 1.5°C threshold is not a cliff edge, but the severity of climate impacts is projected to increase strongly between 1.5°C and 2°C. This was acknowledged by the international community when it set the Paris Agreement goal of 1.5°C "recognizing that this would significantly reduce the risks and impacts of climate change".

We are already experiencing impacts associated with temporary temperature spikes of more than 1.5°C, but these are not representative of the impacts we would experience with a long-term temperature increase of 1.5°C, which would be more severe. Increases of 2°C or more would lead to even more serious impacts, some of which may be irreversible, such as the Greenland and West Antarctic ice sheets melting.

Every fraction of a degree matters

The goal of 1.5°C has been selected because it represents our best understanding of an 'acceptable' level of global warming. However, it is not a cliff edge; our situation will certainly be worse if we exceed this level, but it will be worse still if temperatures increase by 2°C or more.

With every fraction of a degree of warming beyond 1.5°C, impacts will become more severe and the costs of adaptation will be greater. Therefore it is evident that keeping temperatures as close as possible to 1.5°C should be a priority.

If temperatures do go above 1.5°C, this only makes the case for rapid mitigation action stronger.

Is it possible to reverse temperature increases?

Once carbon dioxide has been emitted, the amount of carbon dioxide in the atmosphere declines slowly over thousands of years. This means that higher temperatures associated with those emissions will likely persist for many human lifetimes; even if we stopped all carbon dioxide emissions tomorrow, we — and future generations — would continue to live with around the 1.2°C of global warming that has already occurred, along with the associated impacts.

Gradual temperature decreases might be achieved by using carbon dioxide removal techniques. In some scenarios, scientists envision that we use these techniques to bring temperatures from over 1.5°C to back below by the end of the century. Scenarios in which this happens are referred to as 'overshoot' scenarios. This would not reverse all the effects of climate change—such as animal extinction, and deaths resulting from extreme heat in the meantime—but might limit some effects, such as sea level rise, and reduce the duration of others.

Importantly, though, economic assessments suggest that in the long run, it is more expensive to 'overshoot' than to take early mitigation activity. This is because although the costs associated with reducing emissions might be lower in the short-term (due to slower efforts to decarbonise) this is more than outweighed by the higher longer-term costs of having to rely on carbon dioxide removal and from the economic losses that will result from the more severe climate impacts associated with higher levels of warming.

Authors and contacts

This background briefing was written by:

- Professor Joeri Rogelj, Professor of Climate Science and Policy, Centre for Environmental Policy
- Dr Robin Lamboll, Research Fellow, Centre for Environmental Policy
- Dr Caterina Brandmayr, Director of Policy and Translation, Grantham Institute
- Jenny Bird, Campaign Manager, Grantham Institute

Media enquiries: grantham.media@imperial.ac.uk
Policy enquiries: j.bird@imperial.ac.uk

Further reading

- Climate Change Tracker (a web platform that tracks action against climate change).
- Lamboll, R.D., Nicholls, Z.R.J., Smith, C.J. et al. 2023. Assessing the size and uncertainty of remaining carbon budgets. Nature Climate Change.
- Forster, P. M., Smith, C., Walsh, T., Lamb, W. F., Lamboll, R., Hall, B., Hauser, M., Ribes, A., Rosen, D., Gillett, N. P., Palmer, M. D., Rogelj, J., von Schuckmann, K., Trewin, B., Allen, M., Andrew, R., Betts, R. A., Borger, A., Boyer, T., Broersma, J. A., Buontempo, C., Burgess, S., Cagnazzo, C., Cheng, L., Friedlingstein, P., Gettelman, A., Gütschow, J., Ishii, M., Jenkins, S., Lan, X., Morice, C., Mühle, J., Kadow, C., Kennedy, J., Killick, R. E., Krummel, P. B., Minx, J. C., Myhre, G., Naik, V., Peters, G. P., Pirani, A., Pongratz, J., Schleussner, C.-F., Seneviratne, S. I., Szopa, S., Thorne, P., Kovilakam, M. V. M., Majamäki, E., Jalkanen, J.-P., van Marle, M., Hoesly, R. M., Rohde, R., Schumacher, D., van der Werf, G., Vose, R., Zickfeld, K., Zhang, X., Masson-Delmotte, V., and Zhai, P.: Indicators of Global Climate Change 2023: annual update of key indicators of the state of the climate system and human influence, Earth Syst. Sci. Data, 16, 2625–2658.
- World Weather Attribution (analyses of how climate change influences the intensity and likelihood of specific extreme weather events).
- UNFCCC Technical dialogue of the first global stocktake. Synthesis report by the co-facilitators on the technical dialogue, September 2023.
- IPCC AR6 Synthesis Report: Climate Change 2023, 2023.
- CO2RE Greenhouse Gas Removal Hub, What is Greenhouse Gas Removal (GGR)?
- Drouet, L., Bosetti, V., Padoan, S.A., Aleluia Reis, L., Bertram, C., Dalla Longa, F., Després, J., Emmerling, J., Fosse, F., Fragkiadakis, K. and Frank, S., 2021. Net zero-emission pathways reduce the physical and economic risks of climate change. Nature Climate Change, 11(12), pp.1070-1076.
- IPCC Special Report: Global Warming of 1.5°C, 2018.
- World Meteorological Organisation, 2024. WMO Global Annual to Decadal Climate Update (2024-2028), Geneva, 5 June 2024.

Please cite as:

Rogelj, J., Lamboll, R., Brandmayr, C., and Bird, J. (2024). Limiting temperature increase to 1.5°C above pre-industrial levels. Grantham Institute background briefing.