Five Years, that's all we've got until 1.5°C

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BRIEFING NOTE 494

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THE WORLD JUST HAD ITS HOTTEST YEAR ON RECORD

Every month since June 2023 has been the warmest on record, making 2023 the warmest year on record by a substantial margin (Figure 1). According to [Copernicus Climate Change Service (C3S)](#) November as a whole had an average global surface temperature of 14.22°C, which is about 1.75°C above the pre-industrial average (1850-1900), and for the first time, two days were over 2°C above the pre-industrial average. This should serve as a sobering reminder of what is already well established: Earths global mean temperature (GMT) is increasing and will soon exceed the 1.5°C threshold beyond which dangerous and potentially irreversible impacts will occur, and adaptation will become increasingly difficult.

The 1.5°C threshold was established at the 2015 the United Nations Climate Change Conference of the Parties (COP21) in response to the growing urgency of climate impacts. In a landmark international treaty, nearly every country in the world, 196 nations, signed onto the Paris Agreement, a legally binding international treaty on climate change, which pledged to hold "the increase in 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 above pre-industrial levels."
According to the [United Nations](#), to limit global warming to 1.5°C, greenhouse gas emissions must peak before 2025 at the latest and decline 43% by 2030.

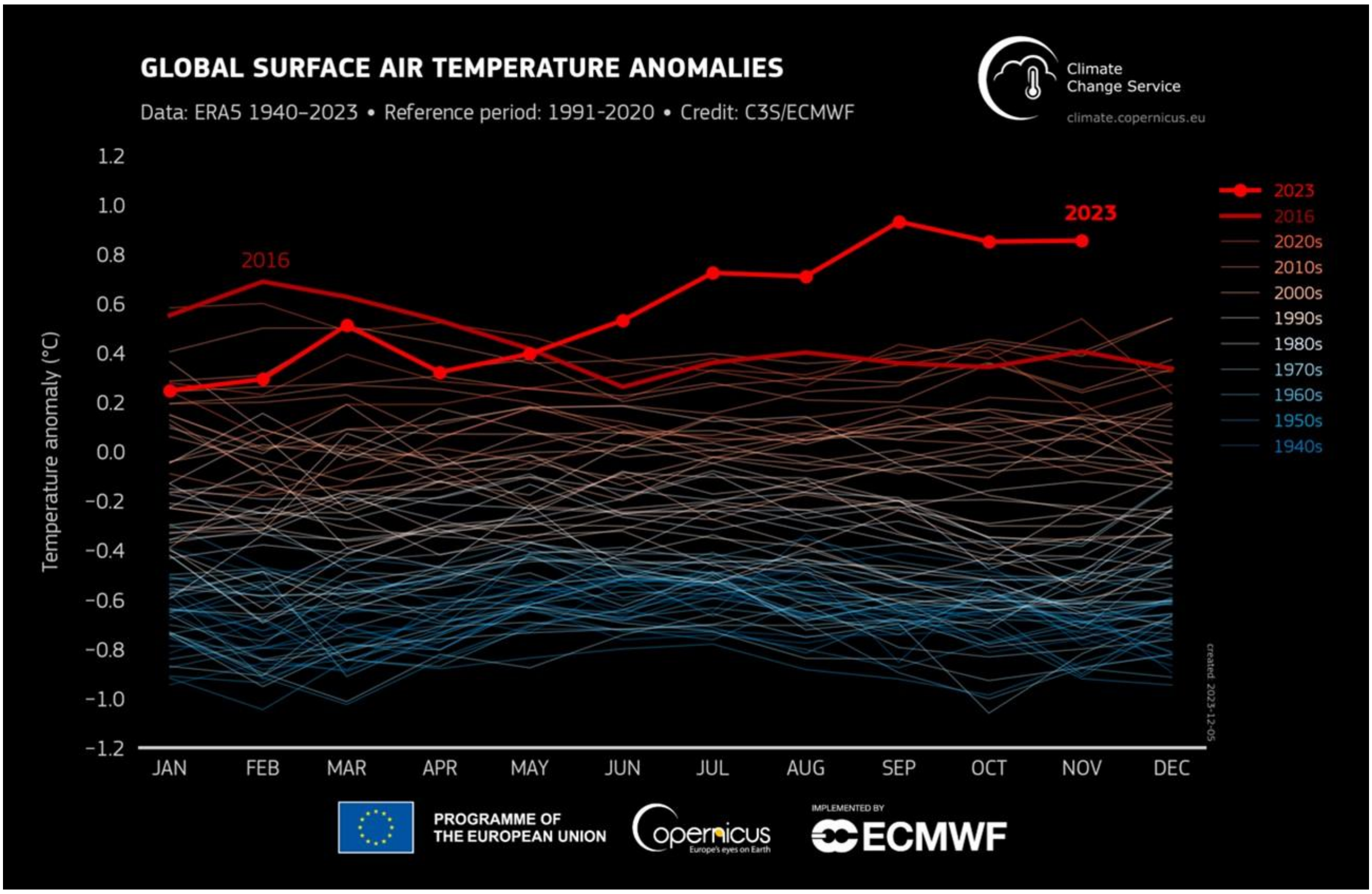

Figure 1. *Global surface air temperature anomalies from the European Centre for Medium Range Weather Forecasting ERA5 reanalysis showing just how warm the latter half of 2023 has been compared to the past 80 years.*

FIVE YEARS, THAT'S ALL WE'VE GOT

Recent research by Lamboll et al., (2023) shows the remaining 1.5°C carbon budget is down to about five years. Increasing temperatures are directly correlated to the amount of additional CO_2 that enters Earth's atmosphere. The term "Carbon Budget" describes the amount of CO_2 that can be emitted into Earth's atmosphere, and the corresponding temperature increases. Lamboll et al., (2023) estimate that as of the beginning of 2023, to achieve a 50-50 chance of limiting global warming to 1.5°C, only another 250 gigatonnes (billion metric tonnes) of CO_2 can be emitted. The global level of emissions is presently 40 gigatonnes of CO_2 per year giving just 6 years from the beginning of 2023, or about 5 years from now.

The remaining carbon budget and 5-year timeframe calculated by Lamboll et al., (2023) are slightly less than was estimated in the latest Intergovernmental Panel on Climate Change (IPCC) report published in August 2021. The revised calculation is consistent with an assessment published by 50 leading climate scientists in June (Forster et al., 2023), and takes into consideration current emission of CO_2, other greenhouse gasses, and contributory factors such as the continuing reduction in aerosol pollution.

Understanding when this happens is important because the target is written into the Paris climate agreement; its aim of "pursuing efforts to limit the temperature increase to 1.5 °C" would then mean taking action to reverse global warming, not just stopping it — a much greater demand (Betts et al 2023).

HOW WILL WE KNOW WHEN WE HAVE BREACHED 1.5?

Measuring change in Earth's temperature turns out to be more complex than it sounds. When the 1.5°C threshold ambition was set at the Paris COP in 2015 there was no agreed upon method as to how this should be defined or measured—even the "pre-industrial" baseline period was not specified, although it is generally agreed upon as being 1850-1900. This itself is problematic, because without an agreed metric there can be no consensus as to when the threshold is breached, inevitably leading to more distraction and delay in implementing effective mitigation.
GMT is increasing but not smoothly, it varies from year-to-year due to natural climate variability (Figure 2). For example, it is usually hotter during El Niño years and cooler during La Niña years. The current El Niño is one reason why temperatures are much higher in 2023 compared to 2022. GMT rise has already exceeded 1.5°C briefly for a month or more in 2016, 2017, 2019, 2020 and 2023. To account for year-to-year variations when measuring global warming, the best-practice approach is to average over a 20-year period attached to a midpoint, where for example GMT in 2010 is calculated as the mean of 2001 to 2020.

The problem with this approach is that to determine GMT in 2023, we would need to have observations for 2014 to 2033. Observations of future climate are clearly not available, so if Lamboll et al., (2023) are correct and the 1.5°C threshold is breached in 2028, this can't be confirmed by observations until 2038.

Betts et al (2023) have recently proposed a novel solution, whereby present-day GMT can be determined by combining the past 10 years of observations with the next 10 years of simulated temperatures from global climate models. While there are some limitations to this approach, it offers the best available method to track real-time GMT. They are advocating for the international community to adopt a single, agreed metric for policy purposes to provide clarity in determining GMT increase.

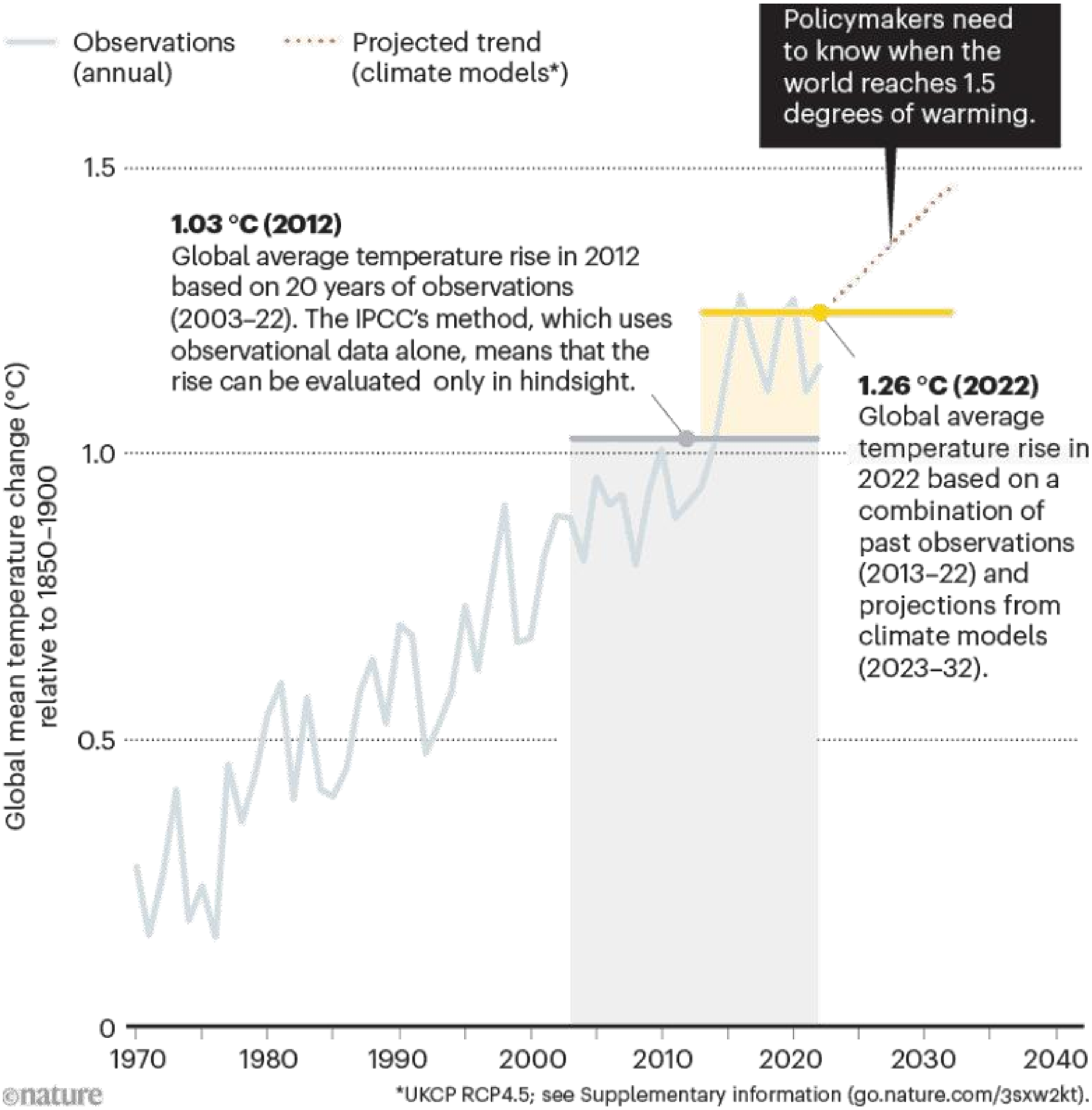

Figure 2. *Global mean temperature are not increasing smoothly leading to challenges in identifying when thresholds are breached. Betts et al (2023) have proposed an approach that combines observations and global climate model simulations to provide real-time estimates. Source Betts et al (2023).*

WHY DOES 1.5°C MATTER?

As COP28 concludes in Dubai, representatives from 197 countries have been presented with a global stocktake of progress towards achieving the ambition of the Paris climate agreement. In essence: the world is falling far short of the 1.5°C goal, and the longer we wait, the harder it becomes. Figure 3 shows a current best estimate of projected global warming by 2100 based on pledges that countries have made as part of the Paris agreement—noting that most countries are not achieving these.

While the 1.5°C limit has always been considered somewhat aspirational, research since 2015 has confirmed that with every increment of change, climate related risks will increase. Even if the 1.5°C threshold is achieved, current warming ensures there will still be many negative impacts compared to the climate of last century, including heat stress still increasing, sea level still rising, and food security and access to water still decreasing. At 1.5°C, about 14 percent of Earth's population will be exposed to severe heatwaves at least once every five years, while at 2°C that number jumps to 37 percent. For more examples, Buis (2019) provides a neat summary of the IPCC Special Report on Global Warming.

Global climate models paint a bleak picture of life in a warmer world. But they are probably underestimating the real risk, as they do not simulate many complex thresholds and tipping points. Crossing those thresholds could lead to non-linear and irreversible effects on natural systems that are crucial to human livelihoods (Smith and Lamboll 2023; Toffelson 2023). A multi-author report lead by Professor Tim Lenton from the University of Exeter's Global Systems Institute outlines 26 climate tipping points: thresholds that, if crossed, would result in potentially irreversible change to Earth's systems. These include coral reefs, ice sheets in Greenland and West Antarctic, boreal forests, the Amazon rainforest, and global ocean circulation systems.

Regardless of the outcomes from COP28, Earth's GMT will continue to rise, and so too will challenges associated with adapting to increasing climate risk in a warmer world.

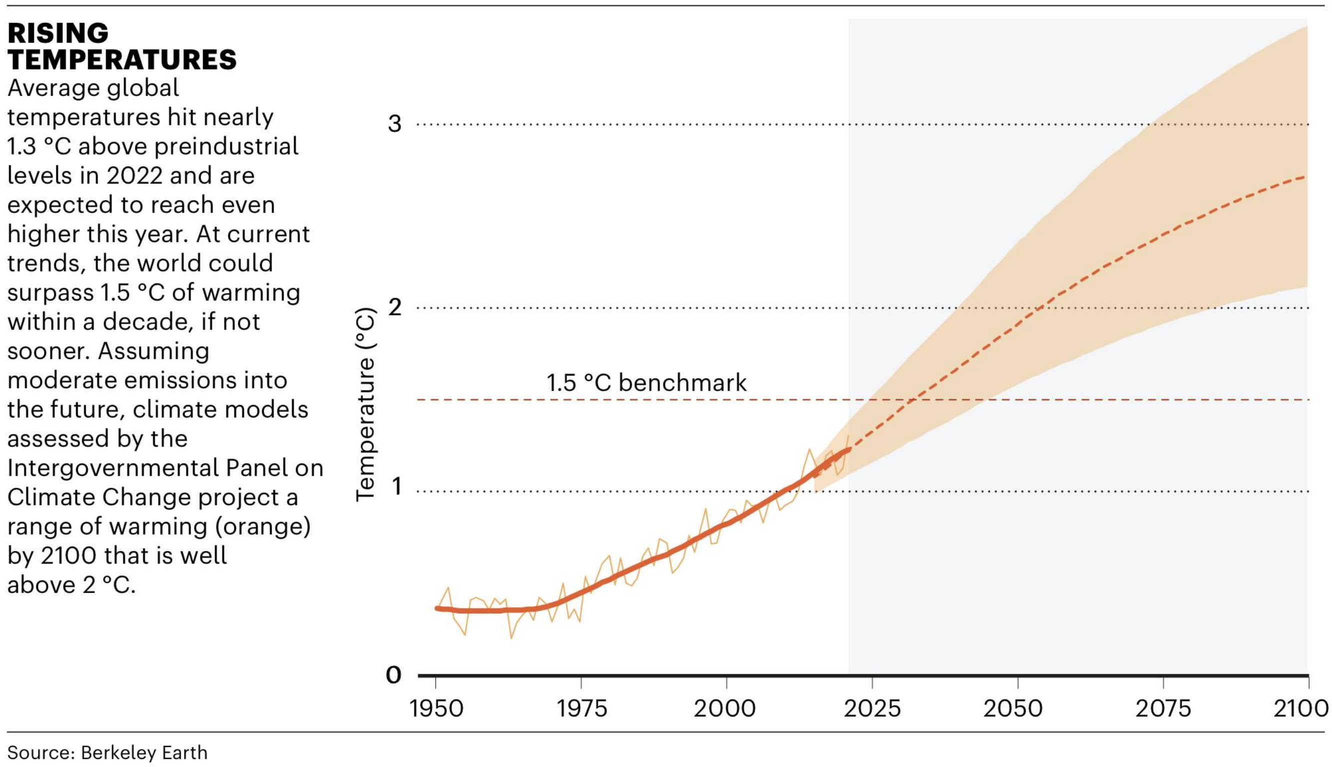

Figure 3. *Current best estimate of projected global warming by 2100 based on pledges that countries have made as part of the Paris agreement (source Tollefson, 2023)*

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