

# Here's what's driving the record autumn heat (it's not just carbon emissions)

October 12 2023, by Paulo Ceppi and Piers Forster

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Climate scientists have detected a striking jump in global temperatures during 2023. September was  $1.75^{\circ}\text{C}$  above Earth's pre-industrial average temperature and a whole half-degree Celsius warmer than the previous

hottest September.

These observations have been variously described as "[shocking](#)," "[mind-blowing](#)" and "[gobsmacking](#)" by leading scientists. So what's behind them?

Human activities, particularly [greenhouse](#) gas emissions from fossil fuel burning, are heating the climate. Some of this excess heat is emitted back to space as radiation. The rest is taken up by the climate system—the ocean, atmosphere and land—which causes warming.

But some human effects also cool the climate, partly countering the strong heating effect of [greenhouse gases](#) like carbon dioxide (CO<sub>2</sub>). Emissions of sulfur dioxide, from coal burning and the engines of container vessels, are one example. Nitrogen oxides emitted from car exhausts and fertilizers are another.

Both create particles called aerosols that reflect sunlight, offsetting some of the warming caused by greenhouse gases accumulating in the atmosphere. These pollution particles can also increase how reflective clouds are, further mitigating global heating.

Leading up to the high temperatures of 2023 is a steadily rising trend in the rate of heat taken up by the climate system. This acceleration is coming not only from increasing greenhouse gas emissions, but also from a [weakening of the cooling effect of aerosols](#), largely a result of more stringent air pollution regulations in many countries, from heavy industry and other sources.

One reason for the recent jump in [global temperatures](#) that's sometimes mentioned is stricter controls on sulfur emissions from the shipping industry, which were introduced in 2020. With less aerosol to reflect solar radiation, the argument goes, the warming trend caused by

greenhouse gases has accelerated.

## **Greenhouse gases up, aerosols down**

However, the climate effect of low sulfur rules in shipping is estimated to be very small—a few hundredths of a degree Celsius [since 2020](#). Instead, it is far more plausible that it is the longer-term accumulation of heat in recent decades, from the combined effects of gradually increasing [greenhouse gas emissions](#) and decreasing aerosols, that is driving record warmth this year.

Apart from greenhouse gases and aerosols, other factors have contributed to raising the rate of heating in recent months. The sun's intensity, which varies naturally in 11-year cycles, is currently approaching a peak—although this probably only contributes warming of [a few hundredths of a degree Celsius](#).

Two additional effects, both likely to be small, come from the Hunga Tonga–Hunga Ha'apai [volcanic eruption](#) in January 2022, which injected [large amounts of water vapor](#) (a potent greenhouse gas) into the stratosphere, plus a recent [decrease in the amount of Saharan dust](#) being blown onto the Atlantic ocean, allowing more sunlight to reach and warm the [ocean surface](#), possibly contributing to the exceptional [North Atlantic sea surface temperatures](#) recorded this year.

The global temperature jump in 2023 is unlikely to be explained by these changes alone. The global climate varies naturally from year to year, particularly as a result of fluctuations in the flow of heat between the atmosphere and the ocean. A big driver of these natural climate variations is the El Niño phenomenon, which occurs every few years and involves a burst of heat from the tropical Pacific Ocean into the atmosphere.

This year, an El Niño event is developing for the first time in half a decade after a series of La Niñas (the opposite phenomenon) that temporarily dampened global warming. After years of [excess heat](#) flowing into the ocean, the current El Niño is causing the release of some of this to the atmosphere.

## What's next?

The current El Niño event is still building, and so will likely continue to drive unusual warmth globally in the months to come. Longer term, global temperatures will vary from year to year, but the overall rising trend will continue for as long as humans continue emitting CO<sub>2</sub>.

Individual months or years in excess of 1.5°C above the pre-industrial average will become more frequent. Temperature thresholds above 1.5°C can be expected to be crossed with increasing frequency.

Only by rapidly reducing emissions of greenhouse gases towards zero can the level of global warming be limited. Our cities and farms must also become more resilient to future climate extremes. The devastation wreaked this summer from flooding, wildfires and heat waves must not become the new normal.

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