

## Why a Two-Year Surge in Global Warmth is Worrying Scientists

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As 2023 came to a close, scientists had hoped that a stretch of record heat that emerged across the planet might finally begin to subside this year. It seemed likely that temporary conditions, including an El Niño climate pattern that has always been known to boost average global temperatures, would give way to let Earth cool down.

That didn't happen.

Instead, global temperatures remain at near-record levels. After [2023 ended up the warmest year in human history by far](#), 2024 is [almost certain to be even warmer](#). Now, some scientists say this could indicate that fundamental changes are happening to the global climate that are raising temperatures faster than anticipated.

“This shifts the odds towards probably more warming in the pipeline,” said Helge Goessling, a climate physicist at the Alfred Wegener Institute in Germany.

One or two years of such heat, however extraordinary, doesn't alone mean that the warming trajectory is hastening. Scientists are exploring a number of theories for why the heat has been so persistent.

The biggest factor, they agree, is that the world's oceans remain extraordinarily warm, far beyond what is usual — warmth that drives the temperature on land up, as well. This could prove to be a temporary phenomenon, just an unlucky two years, and could reverse.

“Temperatures could start plummeting in the next few months and we'd say it was just internal variability. I don't think we can rule that out yet,” said Zeke Hausfather, a climate scientist at Berkeley Earth. But he added, “I think signs are certainly pointing toward fairly persistent warmth.”

But some scientists are worried the oceans have become so warm that they won't cool down as much as they historically have, perhaps contributing to a feedback loop that will accelerate climate change.

“The global ocean is warming relentlessly year after year and is the best single indicator that the planet is warming,” said Kevin Trenberth, a distinguished scholar with the National Center for Atmospheric Research.

Other factors are temporary, even if they leave the world a bit hotter. One important one, scientists say, is that years of efforts to clean up air pollutants are having an unintended consequence — removing a layer in the atmosphere that was reflecting some of the sun's heat back into space.

Whatever the mix of factors or how long they last, scientists say the lack of clear explanation lowers their confidence that climate change will follow the established pattern that models have predicted.

“We can’t rule out eventually much bigger changes,” Hausfather said. “The more we research climate change, the more we learn that uncertainty isn’t our friend.”

Experts had been counting on the end of El Niño to help reverse the trend. The routine global climate pattern, driven by a pool of warmer-than-normal waters across the Pacific, peaked last winter. Usually about five months after El Niño peaks, global average temperatures start to cool down.

Often, that’s because El Niño is quickly replaced with La Niña. Under this pattern, the same strip of Pacific waters become colder than normal, creating a larger cooling effect on the planet. But La Niña hasn’t materialized as scientists predicted it would, either.

That leaves the world waiting for relief as it confronts what is forecast to be its first year above a long-feared threshold of planetary warming: average global temperatures 1.5 degrees Celsius warmer than they were two centuries ago, before humans started burning vast amounts of fossil fuels. (Formally crossing this threshold requires at least several years above it.)

The year 2023 is the current warmest year on record at 1.48 degrees Celsius above the preindustrial average. However, 2024 is expected to be at least [1.55 degrees](#), breaking the record set the year before. Last year’s record was further above the expected track of global warming than scientists had ever seen, by a margin of more than three tenths of a degree. This year, that margin is expected to be even larger.

While changes in temperatures of a degree or less may seem small, they can have large effects, Trenberth said.

Like “the straw that breaks the camel’s back,” he said.

That includes [increasing heat and humidity extremes](#) that are life-threatening, changing ocean heat patterns that could alter critical fisheries, and [melting glaciers](#) whose freshwater resources are key to energy generation. And scientists say if the temperature benchmarks are passed for multiple years at time, storms, floods and droughts will increase in intensity, too, with a host of domino effects.

## **Trouble with record warm waters**

Compared with past years when El Niño has faded, the current conditions are unlike any seen before.

A look at sea surface temperatures following three major El Niño years — 2024, 1998 and 1983 — reveal that a La Niña-like pattern was evident in all three years, with a patch of cooler-than-average conditions emerging in the equatorial Pacific Ocean.

But in 2024, the patch was narrow, unimpressive and dwarfed by warmer-than-average seas that cover most of the planet, including parts of every ocean basin.

Ocean temperatures following three major El Niño events reveal that 2024 is an outlier, with unprecedented warmth even after El Niño faded. (Ben Noll/The Washington Post; data source: ECMWF/ERA5)

Known as marine heat waves, these expansive blobs of unusual oceanic heat are typically defined as seas being much warmer than average, in the highest 10 percent of historical observations, across a wide area for a prolonged period. Strong to severe marine heat waves are occurring in the Atlantic, much of the Pacific, the western and eastern Indian Ocean, and in the Mediterranean Sea.

In October, ocean temperatures at that high threshold [covered more than a third of the planet](#). On the other end, less than 1 percent of the planet had ocean temperatures in the lowest 10 percent of historical values.

Warm and cold ocean temperature extremes should more closely offset each other. But what's happening is a clear demonstration that oceans, where heat accumulates fastest, are absorbing most of Earth's energy imbalance. Warm extremes are greatly exceeding cold ones.

That's a problem because what happens in the ocean doesn't stay in the ocean.

Marine heat wave conditions covered parts of all ocean basins as of early December, consistent with near-record global air and sea temperatures. (Ben Noll/The Washington Post. Data source: NOAA/Coral Reef Watch)

Because ocean water covers more than 70 percent of Earth, what happens there is critically important to temperatures and humidity on land, with coastal heat waves sometimes fueling terrestrial ones. Weather systems can sometimes linger, producing persistent sunny and wind-free days and bringing ideal conditions for marine heat wave development. These systems can sometimes straddle the land and the ocean, leading to a connected heat wave and transporting humidity.

Trenberth said increasing heat in the oceans, particularly the upper 1,000 feet, is a major factor in the relentless increases in average surface temperatures around the world.

And changes in ocean heat content can affect not just air temperatures, but sea ice, the energy available to storms and water cycles across the planet.

## **Factors that could trigger changes in global heat**

Research has begun to unpack what else may be triggering such changes in global heat.

[One recent study](#) found that a reduction in air pollution over the world's oceans may have contributed to 20 to 30 percent of the warming seen over the North Atlantic and North Pacific,

said Andrew Gettelman, a scientist at the Pacific Northwest National Laboratory and the study's lead author.

Restrictions on sulfur content in the fuels used by shipping liners, put in place in 2020, have dramatically reduced concentrations of sulfur dioxide particles that tend to encourage cloud formation. Though it means lower pollution levels, with fewer clouds, more solar radiation is hitting the oceans and warming them.

A study released Tuesday found that a decline in cloud cover likely contributed to perhaps 0.2 degrees Celsius in previously unexplained warming that hit the planet last year. Goessling and colleagues think that was the product of cleaner shipping emissions, as well as a positive feedback loop in which warming close to Earth's surface leads to reduced cloud cover, which leads to even more warming.

The study found that in 2023, planetary albedo — the amount of sunlight reflected back into space by light-colored surfaces including clouds, snow and ice cover — may have been at its lowest since at least 1940.

There have also been questions about the roles other factors may be playing, such as an [increase in stratospheric water vapor after a 2022 volcanic eruption](#).

But Earth's systems are so complex that it's been impossible to parse what exactly is happening to allow the surge in global temperatures to persist for so long.

“Is this just a blip, or is this actually an acceleration of the warming?” Gettelman said. “That's the thing everyone is trying to understand right now.”

## **What happens next?**

This year is widely expected to be the [warmest year on record](#), driven largely by the huge stores of ocean heat.

And for now, seasonal model guidance keeps the foot on the accelerator into early 2025, as far as widespread warmer-than-average seas go.

Because of record ocean heat and global temperatures, [atmospheric circulation patterns](#), jet streams and storm tracks across the planet will change. Temperature records will continue to be set.

How big these changes are partly depends on how much warming occurs in the year ahead. But that is unclear because the cooling that usually follows El Niño still hasn't arrived.

Warmer than average sea surface temperatures are forecast to continue to be widespread into early 2025. The above graphic shows projections through April. (Ben Noll/The Washington Post; data source: Copernicus Climate Change Service)

It's possible that normal planetary variations are playing a bigger role than scientists expect and that temperatures could soon begin to drop, said Hausfather, who also works for the payments company Stripe.

Even without the cooling influence of a La Niña, a stretch under neutral conditions, with neither a La Niña nor an El Niño, should mean some decline in global average temperatures, he said.

At the same time, if this year's unusual planetary warmth doesn't slow down into 2025, there would be nothing to prevent the next El Niño from sending global temperatures soaring — the starting point for the next El Niño would be that much higher. Whether that happens later in 2025 remains to be seen.

But the lack of clarity isn't a promising sign when some of the most plausible explanations allow for the most extreme global warming scenarios, Hausfather said.

"The fact that we don't know the answer here is not necessarily comforting to us," he said.