

The Extreme Heat Waves that Shouldn't Exist

Regions accustomed to more mild climates have been recording dangerously high temperatures.

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You might expect that as global temperatures inch upward each year, heat waves would intensify at a similarly steady pace. Yet research reveals a more alarming trend: the temperatures reached in many heat waves are so extreme that they far outpace the results of climate models, defying all predictions and explanations.

A recent study by Columbia scientists, which appears in the *Proceedings of the National Academy of Sciences*, looks at heat waves over the past sixty-five years, identifying regions where their severity has increased more dramatically than would have been expected, given the rise in average local temperatures. In these areas, which are situated on every continent except Antarctica, heat waves have killed tens of thousands of people, withered crops and forests, and sparked devastating wildfires.

“This is about extreme trends that are the outcome of physical interactions we might not completely understand,” says lead author [Kai Kornhuber](#), a climate physicist at the Columbia Climate School’s Lamont-Doherty Earth Observatory. His coauthors on the report are Columbia climate scientists [Richard Seager](#) ’90GSAS and [Mingfang Ting](#), graduate student Samuel Bartusek, and climatologist Hans Joachim Schellnhuber of the International Institute for Applied Systems Analysis in Austria.

Their study provides the first worldwide map of regions in which maximum temperatures have been broken by outsize, sometimes astonishing amounts. For example, a nine-day wave that hammered the US Pacific Northwest and southwestern Canada in June 2021 exceeded daily records in some places by more than 50°F. This included the highest temperature ever recorded in Canada: 121°F, in Lytton, British Columbia. The town burned to the ground the next day in a wildfire driven by the drying of vegetation.

Kornhuber and his colleagues found that the most hard-hit regions include populous central China, Japan, Korea, the Arabian Peninsula, eastern Australia, and parts of Africa. Others include Canada’s Northwest Territories and the southern end of South America. Parts of Texas and New Mexico appear on the map, though they are not among the worst afflicted.

According to the study, the strongest and most persistent hotspot is in northwestern Europe, where sequences of heat waves contributed to an estimated 60,000 deaths in 2022 and 47,000 in 2023. These disasters affected Germany, France, the United Kingdom, and the Netherlands, where the hottest days of the year have been warming at twice the rate of average summer temperatures. As in the Pacific Northwest and Canada, air conditioning in the region remains uncommon, since such extreme heat waves were once unheard of. Experts say this likely compounded the death toll.

The newly identified hotspots are not the only places where extreme heat is proving deadly, of course. Across the world, heat waves are becoming more frequent and severe. In the US, which has largely been spared the most shocking temperature spikes, excessive heat nevertheless kills more people than all other weather-related causes combined, including hurricanes, tornadoes, and floods. One recent study found that the US annual death toll from heat-related events has sharply increased in recent years, with 2,325 deaths in 2023. This has recently led to calls for heat waves to be named, as hurricanes are, to heighten public awareness and motivate governments to prepare.

“These heat waves are usually linked to very severe health impacts and can be disastrous for agriculture, vegetation, and infrastructure,” said Kornhuber, who, along with several Columbia colleagues, is also investigating the atmospheric and climatic forces driving these extremes. “We’re not built for them, and we might not be able to adapt fast enough.”

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