Carbon emissions

Our efforts to cope with extreme temperatures are making them worse

WHEN temperatures turn extreme, we rush to adjust our heating or cooling systems in an attempt to remain comfortable. With severe weather events becoming ever more frequent due to climate change, so too does our fiddling with the thermostat, which, in turn, is causing spikes in daily carbon dioxide emissions, leading to yet more climate change. Failing to break this vicious cycle will mean the problem only gets worse.

Zhu Liu at Tsinghua University, China, and his colleagues have been tracking global daily CO_2 emissions since January 2019 to examine how seasonal cycles, time of the week, the weather and other factors influence them. They used data collected between 2019 and 2022 to train a machine-learning algorithm to estimate daily CO_2 emissions back in time to 1970, at a global level and at a national level for key countries.

The results, unsurprisingly, revealed a large increase in global daily CO_2 emissions from 1970 to 2022, from 50.6 million tonnes a day on average in 1970 to 106.9 million tonnes a day in 2022. We already know emissions have risen dramatically over the past 50 years as countries around the world have industrialised.

More interestingly, Liu's team also identified a previously overlooked trend in increasing emissions due to extreme hot and cold days, defined as days where temperatures fell below the 5th percentile or above the 95th percentile from 1970 to 2022 for each country.

For example, daily emissions during extremely cold days jumped by 11 per cent in Germany over the study period, compared with the average for the corresponding month, and emissions increased by 4 per cent in Japan during extremely hot days.

The increase in emissions due to extreme heat events accelerated over the 2010s, when the average number of days of extreme heat experienced each year more than doubled compared with the 1970s. Between 2019 and 2022, daily emissions during extreme hot days in Japan were 12.3 per cent higher compared with the monthly average, for example (arXiv, doi.org/ndbp). "More frequent extreme temperature is resulting in more emissions," says Liu.

He warns that the emissions spikes are a consequence of poor adaptation to a rapidly changing climate. This will create a feedback loop where extreme weather drives higher emissions, which then intensifies climate change. "It's definitely not good news for the world... it's difficult to break," he says. Even an accelerated switch to renewable energy isn't a complete solution, as power plants, including renewable energy units, become less efficient in extreme temperatures, leading to an uptick in fossil fuel use to make up the difference.

The team also identified a "critical temperature" for each country, where emissions are generally at their lowest level. In China this temperature is 19.5°C (67.1°F), in the US it is 15°C (59°F) and in Japan it is 18.2°C (64.8°F). For most countries, when temperatures fall below or climb above this critical point, emissions start to increase.

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Team member Glen Peters at the Center for International Climate Research in Norway says governments will need to consider the impact of increasingly extreme weather and the way people respond to more and more uncomfortable conditions when designing future energy systems. "If you have an increased demand for cooling, and more people buy air conditioners, then it can amplify the effects," he says.

"Worsening climate impacts can affect societal emissions of greenhouse gases that are driving the warming of climate in the first place," says Richard Allan at the University of Reading, UK, leading to a "vicious cycle" of escalating emissions. "The new study is the first to really dig into day-to-day fluctuations and construct regional relationships between long-term changes in emissions and temperature."

Joeri Rogelj at Imperial College London says the study underscores the need for urgent climate policies to cut emissions and ensure low-carbon adaptation. "It just shows the importance of going to net zero, both to limit the amount of heat extremes, but also to limit the amount of additional CO_2 that gets produced because of those heat extremes," he says.

One limitation of the work is that the data the researchers used to train their algorithm includes two years of the coronavirus pandemic, which saw emissions dip globally. The algorithm also doesn't account for differences between 1970s society and the present day. Levels of access to air conditioning, for example, were a lot lower in the 1970s, meaning extreme heat days would have had a lower emissions impact back then. Even so, Alp Kucukelbir at Columbia University in New York says using machine learning is a good way to "fill in" data we would have liked to have collected in the past.

Both Peters and Allan say that even with uncertainties around the precise figures, the general trend towards more extreme temperatures causing higher emissions is clear. "Despite limitations, the findings do amplify existing knowledge that global warming will make emissions reductions even more challenging," says Allan. MC

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Higher temperatures mean people crank up the air conditioning more often