Study finds heat waves are becoming more frequent and more deadly

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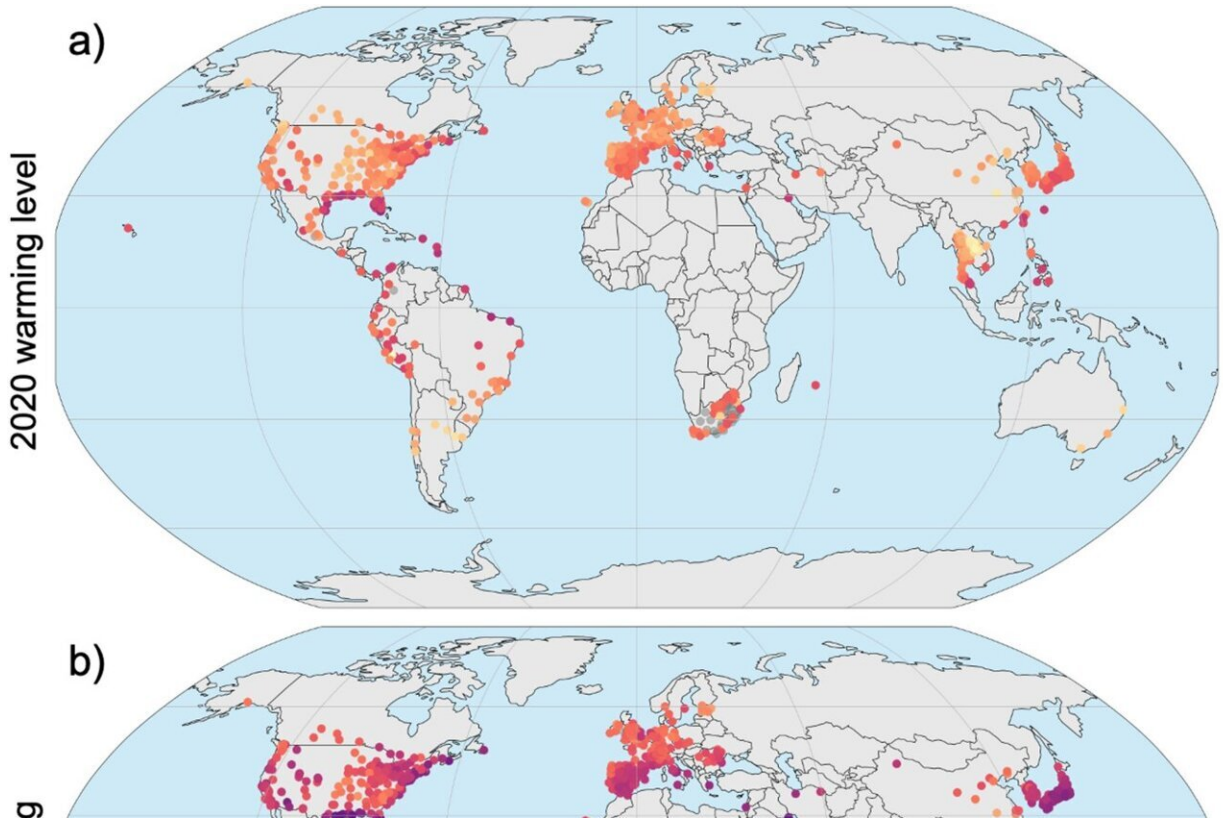

Changes in return periods of a 1-in-100-year season in the 748 locations. Changes in return periods for the climate of 2020 (warming level of 1.2°C, a), at 1.5°C warming (b) and at 2.0°C warming (c) compared to the risk in the climate of 2000 (0.7°C warming). The figure displays the new return period of the location-specific 1-in-100-year heat-mortality level of 2000. The color-scale is logarithmic. The gray dots denote locations with inconclusive results due to their spread in uncertainty. Credit: *Nature Communications* (2023). DOI: 10.1038/s41467-023-40599-x

The risk of fatal heat waves has risen sharply over the past 20 years. In the future, such extreme weather will become more frequent and heat-related excess mortality will increase. Europe will be particularly affected, as ETH Zurich researchers show.

Heat waves of the kind we are currently experiencing are particularly deadly for the elderly, the sick and the poor. The 2003 heat wave, which saw temperatures in Europe reach 47.5°C, was one of the worst natural disasters of recent decades, claiming an estimated 45,000 to 70,000 victims in the space of a few weeks. Forests burned, crops withered in the fields and emergency wards in the cities were full to capacity.

Globally, costs totaled around 13 billion US dollars. Nevertheless, the public remains less aware of the risks of heat waves than of other climate-related extremes. This is a problem, as a study published in the journal *Nature Communications* points out. Heat waves like the one we saw in 2003 could become the new norm in the coming years.

Epidemiology and climate modeling combined

Researchers from the Institute for Environmental Decisions at ETH Zurich collaborated with an international group of epidemiologists on the study. Since 2013, they have been systematically collecting data on daily heat-related excess mortality for 748 cities and communities in 47 countries in Europe, Southeast Asia, Latin America, the U.S. and Canada.

The researchers used this dataset to calculate the relationship between the average daily temperature and mortality for all 748 locations. From this, they were able to establish each location's ideal temperature, where excess mortality is at its lowest. In Bangkok, for example, this value is

30°C, in São Paulo 23°C, in Paris 21°C and in Zurich 18°C.

Physically plausible weather extremes modeled

Every tenth of a degree above this ideal value increases excess mortality. "Not all heat is the same," explains Samuel Lüthi, lead author of the study and doctoral student under David Bresch, Professor for Weather and Climate Risks. "The same temperature has a completely different impact on heat-related excess mortality in the populations of Athens and Zurich."

This depends not only on the temperature, but also on physiology (acclimatization), behavior (long siestas in the middle of the day), urban planning (green spaces versus concrete), the demographic structure of the population, and the local health care system.

Using this ideal value, the researchers calculated how excess mortality would develop with an average global temperature increase of 0.7° (the value in 2000), 1.2° (the value in 2020), 1.5° and 2°. They used five particularly powerful climate models, known as SMILEs (single-model initial-condition large ensembles).

"We ran the same model up to 84 times, with slightly different weather conditions each round. That gave us a multitude of possible weather systems that are likely to occur if there is a certain amount of CO_2 in the atmosphere," explains Lüthi. The researchers then coupled this data with an epidemiological model to calculate the corresponding heat mortality.

Previous projections of heat-related mortality were mostly based on calculations that used one climate model over a specific period of time. "Our method allows us to quantify extremes in the climate system much more effectively and reduce uncertainties that arise from the idiosyncrasies of certain models." Using supercomputers, Lüthi has

calculated the impact of more than 7,000 years of physically possible weather phenomena on heat-related mortality. The corresponding dataset is more than 1 terabyte in size.

Up to 15% of deaths heat related

The results show that the risk of heat waves with high excess mortality has already increased dramatically over the past 20 years. "The excess mortality of a hot summer like 2003 used to be considered an extreme, once-in-a-century event. We now expect it to occur once every 10 to 20 years," says Lüthi, "or, in a world that is 2° warmer, every two to five years in many places."

Heat mortality figures that were considered highly improbable in 2000 (once every 500 years), will occur 14 times every 100 years in a 2° scenario. Assuming no adaptation to the heat, the probability of mortality during such extreme heat waves will increase by a factor of 69.

Regions that are particularly at risk of escalating heat waves include the Gulf and Atlantic coasts of the U.S., the Pacific coast of Latin America, the Middle East, Southeast Asia and the Mediterranean region. Even in moderate climate scenarios, a hot summer in these regions can result in 10% of all deaths in a country being heat-related.

Paris was particularly affected by the heat wave in 2003. The figure at that time was 5% to 7%; that means in the French metropolis alone, the heat wave led to the premature deaths—from dehydration, heatstroke and heart attack—of around 2,700 people.

"According to our calculations, up to 15% of deaths in Paris could be heat-related in future," says Lüthi. Europe is among the hotspots—particularly southern Europe. There are two factors that come into play here: temperatures here are rising twice as fast as the global

mean, and the population is disproportionately older.

A worrying outlook

"The results frightened me," says the 30-year-old climate scientist. "While I was working on the study, I always tried to look behind the figures and see the real lives of people who are affected by the changes. It's worrying." Particularly, as he points out, because the assumptions underlying the modeling are actually on the conservative side.

The study assumes that the global average temperature is on track to increase by a maximum of 1.5°C to 2°C, but with greenhouse gas emissions at their current levels, the more likely figure is 2.6°. And future scenarios do not take account of the projected population growth, migration to cities and the increase in the number of older people—all factors that are likely to increase heat-related excess mortality even further. The study also lacked epidemiological data for Africa and India, both regions heavily affected by the climate crisis and poverty.

As the researchers state, the results underline the urgency for action. In order to at least curb increasing heat waves, the most important step is to phase out fossil fuels as quickly as possible, Lüthi asserts. The study shows that although the risk is already high at 1.5°, it is still significantly lower than at 2°. However, society can also partly adapt to higher temperatures to reduce the impact of future heat waves. "We should now prepare and manage the unavoidable, while avoiding the unmanageable at all costs," Lüthi recommends.

More information: Samuel Lüthi et al, Rapid increase in the risk of heat-related mortality, *Nature Communications* (2023). DOI: 10.1038/s41467-023-40599-x

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