Study investigates climate change's impact on intensity, frequency and duration of extreme-weather events

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In an article published in the *Proceedings of the National Academy of Sciences* Michael Mann, professor in the Department of Earth and

Environmental Science in the University of Pennsylvania's School of Arts & Sciences, and colleagues from Clemson University, the University of California Los Angeles, and Columbia University investigate the effects of climate change on exacerbating compounding heat and drought situations.

Their findings offer new insights into predicting their interplay, which will provide scientists and policymakers with a clearer and more holistic approach to preventing and preparing for extreme-weather events.

"We wanted to see how the state-of-the-art climate models used in the most recent assessment reports of the Intergovernmental Panel on Climate Change address the episodes of heat waves and droughts that have given rise to some of the worst wildfires we've witnessed in recent history," Mann says.

"We also wanted to get a better understanding of how often these events were occurring, their typical durations, and their intensity to improve not only our forecasting but approaches to mitigating further damage to human life."

Compound drought and heat wave events and their effects

The researchers document the deleterious effects of increasingly severe droughts and wildfires occurring in the past three years.

"Two standout events," Mann says, "were the 2020 California wildfires and the 2019–20 Australian bush fire season, which lasted nearly one whole year and came to be known as the Black Summer. These are known as compound drought and heat wave (CDHW) events and refer to situations wherein a region experiences both prolonged hot temperatures

and a shortage of water."

These conditions can occur together and worsen each other's impacts, the researchers say, and could potentially lead to heat-related illnesses and deaths, water scarcity for drinking and agriculture, reduced crop yields, increased wildfire risk, and ecological stress. They also note that anthropogenic climate change—climate change that is driven by human activity—can contribute to the frequency and severity of these events.

Projected impact of a worst-case versus moderate-case scenario

The researchers compared two contrasting socioeconomic pathways: the high-end or worst-case scenario, wherein society fails to mitigate the effects of anthropogenic climate change, and a moderate scenario, wherein some conservative measures are put in place and efforts are made to abide by them.

In the worst-case scenario, they found that by the late 21st century approximately 20% of global land areas are expected to witness approximately two CDHW events per year. These events could last for around 25 days and a fourfold increase in severity.

"Comparatively, the average CDHW frequency over the recent observed reference period was approximately 1.2 events per year, lasting less than 10 days, with far less severity," Mann says.

The most vulnerable geographical regions, such as eastern North America, southeastern South America, Central Europe, East Africa, Central Asia, and northern Australia, are projected to experience the largest increases in CDHW frequency by the end of the 21st century.

"Interestingly, places like Philadelphia and some of the regions in the eastern U.S. are where we expect to see an increase in these sorts of events; urban environments in the summertime will witness the highest relative frequency of these events," Mann says.

Critical need for proactive measures

The researchers emphasize the profound threat posed by more frequent and intense CDHW events in the coming decades and the dependence the emissions pathway chosen has on the severity of these events.

As climate change continues to unfold, addressing the escalating risks associated with CDHW events becomes crucial. This study contributes to the growing understanding of the projected changes in CDHWs and highlights the need for proactive measures, including emission reductions and adaptation strategies, to build resilience and safeguard vulnerable regions from the impacts of compound drought and heat wave events.

"Our findings provide important scientific context for the record heat and wildfire that we're witnessing right now here in the United States," Mann says.

"They underscore that we need to get off fossil fuels as quickly as possible to prevent a worsening of these dangerous combinations of heat and drought."

More information: Kumar P. Tripathy et al, Climate change will accelerate the high-end risk of compound drought and heatwave events, *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2219825120

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