New modeling method could drive better understanding of extreme heat waves

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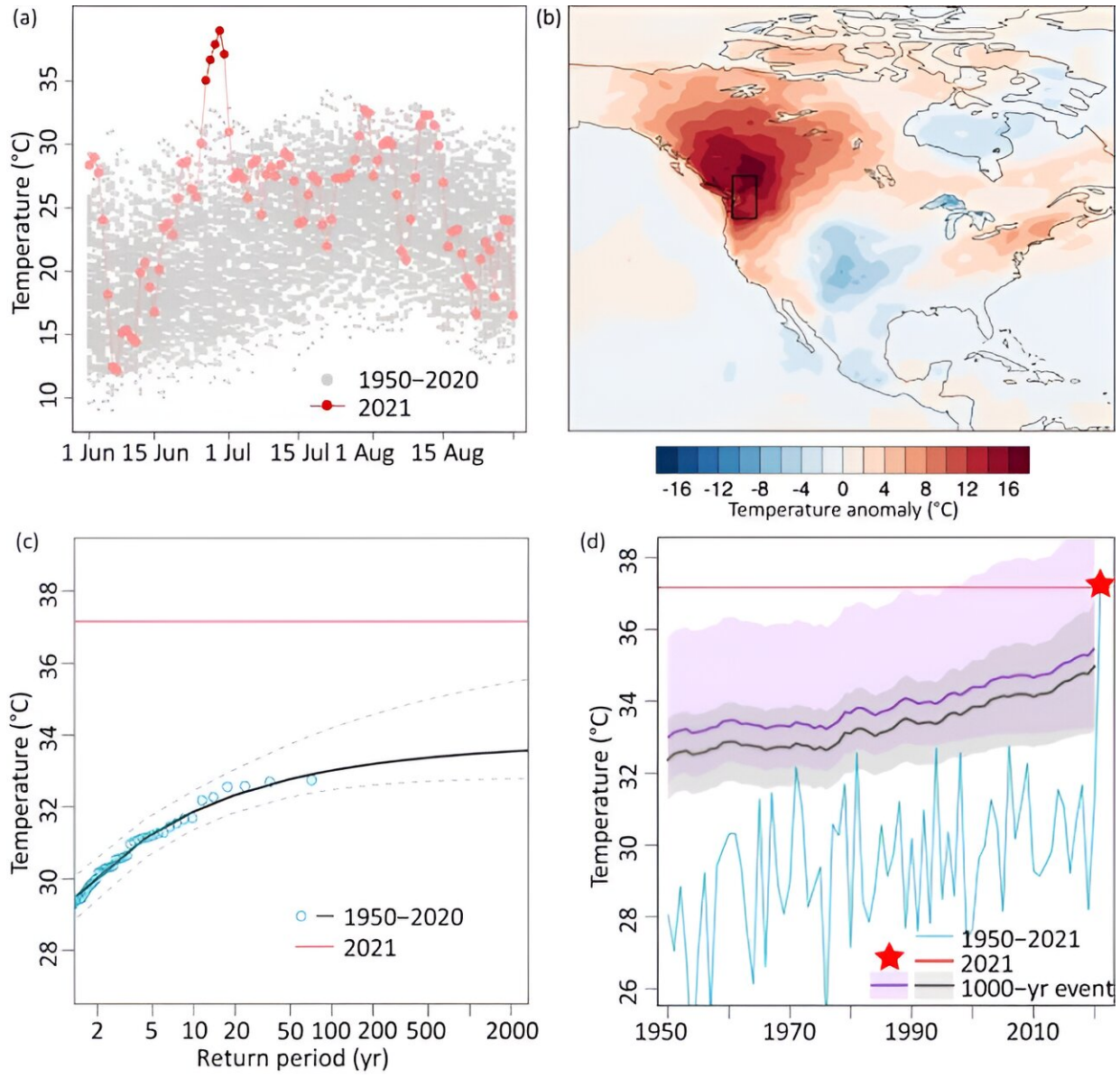

Characteristics of the 2021 Pacific Northwest (PNW) heat waves. Credit: *Nature Communications* (2023). DOI: 10.1038/s41467-023-40112-4

To prepare for extreme heat waves around the world—particularly in places known for cool summers—climate-simulation models that include a new computing concept may save tens of thousands of lives.

The concept, called "ensemble boosting," uses computationally efficient modeling to simulate a large set of extreme but plausible heat waves, all while avoiding hundreds of hours of expensive calculations on large computers.

The study on the new modeling method, led by scientists at ETH Zurich in Switzerland and Cornell University in the U.S., was published Aug. 22 in *Nature Communications*. Erich M. Fischer, professor at ETH Zurich, is corresponding author of "Storylines for Unprecedented Heatwaves Based on Ensemble Boosting."

"As a society, we don't always need to learn from our mistakes," said co-author Flavio Lehner, assistant professor of Earth and atmospheric sciences in the Cornell College of Agriculture and Life Sciences. "We can learn from our forecasts and predictions."

From late June to mid-July 2021, western North America, including the Pacific Northwest in the U.S. and British Columbia in Canada, broiled in an unprecedented heat wave. Lytton, British Columbia, for example, set a national Canadian record daily high temperature at 121.3 degrees Fahrenheit on June 29, 2021. During the excessive heat wave, more than 800 people died in Canada and more than 600 died in the U.S.

At the time, such an extreme event seemed unfathomable, and questions

arose whether climate models could even simulate such an event.

But by using ensemble boosting in current climate models, even more excessive heat events—in the face of worsening climate change—are seen as plausible.

Ensemble boosting takes the most extreme heat events found in current computer climate models and reruns them with tiny differences in the initial conditions—the butterfly effect, where miniscule changes bring large effects—to see if even more extreme heat events are possible.

"Computationally, it's much more affordable than running traditional climate model simulations, for hundreds or even thousands of years, in a computer and then find only two or three extreme heat wave events," said co-author Angeline Pendergrass, assistant professor of Earth and atmospheric sciences.

The goal of ensemble boosting is to find the envelope of just how extreme an event may be simulated by a climate model, she said.

"One of the challenges we have in climate science are the long timescales that need to be observed or simulated to quantitatively describe what is possible or probable in a given climate state," Pendergrass said. "Ensemble boosting is a way to sample the edges of the space of what is possible for an extreme event."

"With meteorological models, in terms of the weather timescale, we can forecast heat waves quite well," Lehner said. "If seven days from now we see that there is a heat wave on the horizon—and it looks like it's going to be extreme—meteorologists are excellent at making those predictions."

However, Lehner said, this is not enough warning to organize cooling

shelters for tens of thousands of people who don't usually have access to air conditioning. To prepare, long-term planning at municipal levels is needed. Ensemble boosting provides the worst-case scenario in a model format for the forthcoming decades that can be used for such planning.

"With climate change, what are the most extreme heat waves one could experience this century—irrespective of when exactly they would happen?" Lehner said. "This is providing a longer-term perspective."

In the Pacific Northwest, the climate is often cooler than in other parts of North America," Pendergrass said. "I heard the idea bandied about that it would be a good place to be during global warming, because it doesn't get too hot. I never heard arguments to the contrary. The Pacific Northwest heat wave event in 2021 was interesting because most people wouldn't have thought it was physically possible before it happened."

In addition to studying the Pacific Northwest, plus examining Chicago and Paris extreme temperatures in recent heat waves, the group now can determine an extreme heat wave is possible with state-of-the-art models. "We can say with more confidence that extreme temperatures as portrayed by climate models are a definite possibility in the future," Lehner said. "The climate models are up to the job."

More information: E. M. Fischer et al, Storylines for unprecedented heatwaves based on ensemble boosting, *Nature Communications* (2023). DOI: 10.1038/s41467-023-40112-4

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