

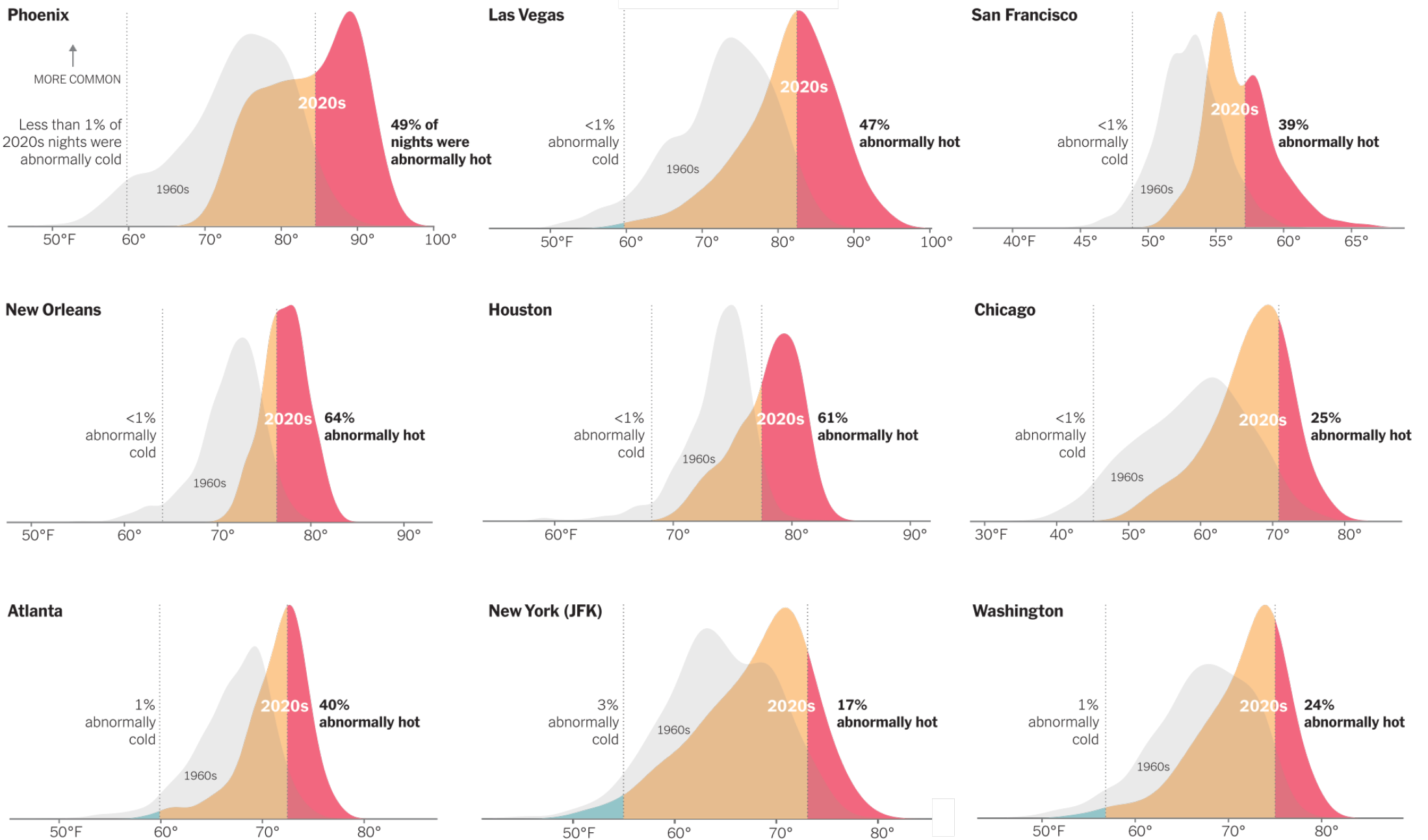
National

The New York Times

'You're not going to see the impact in a linear basis. It happens exponentially.'

ANGEL HSU, an expert on public policy and the environment, on how climate change will affect cities

Summer minimum temperatures in:



Source: NOAA's Global Historical Climatology Network. Note: Distributions show daily minimum temperatures for the summer months (June-August) in each decade at airport weather stations. Nights are considered abnormally cold or hot based on the 5th and 95th percentile of 1960s temperatures. Temperature ranges for each chart are scaled to the summer nighttime temperature ranges for each city.

THE NEW YORK TIMES

Hot Summer Nights Get Hotter, and More Dangerous

By AATISH BHATIA and JOSH KATZ

This summer was unusually hot, especially at night. Minimum temperatures were the hottest on record for every state on the West Coast and parts of the Northeast. Most other states neared their record highs for overnight temperatures this meteorological summer (June through August).

This is part of a trend that aligns with the predictions of climate models: Across the U.S., nights are warming faster than days. This effect is amplified in cities, which are typically warmer than their surroundings. "At nighttime, the deserts cool off really, really fast, but our city does not," said Jennifer Vanos, a professor in the School of Sustainability at Arizona State University, referring to Phoenix.

"Not having that break from the heat is really hard on the human body — it builds up," she said. "And knowing the temperatures in Phoenix, we're going to be in the 90s overnight and we're going to be up to 110 sometimes in the day. None of those are safe for a person that doesn't have access to air-conditioning."

To see how summer nights have gotten hotter in recent decades, we charted 60 years of daily weather data from nearly 250 U.S. airports that have kept consistent weather records.

These charts show a clear trend: Nighttime temperatures that would have been unusually hot in the 1960s are increasingly common.

The warming trend seen in these charts reflects two factors that add together: Global warming from human activity is raising the planet's background temperature, and many cities are becoming more urbanized.

Rising extremes

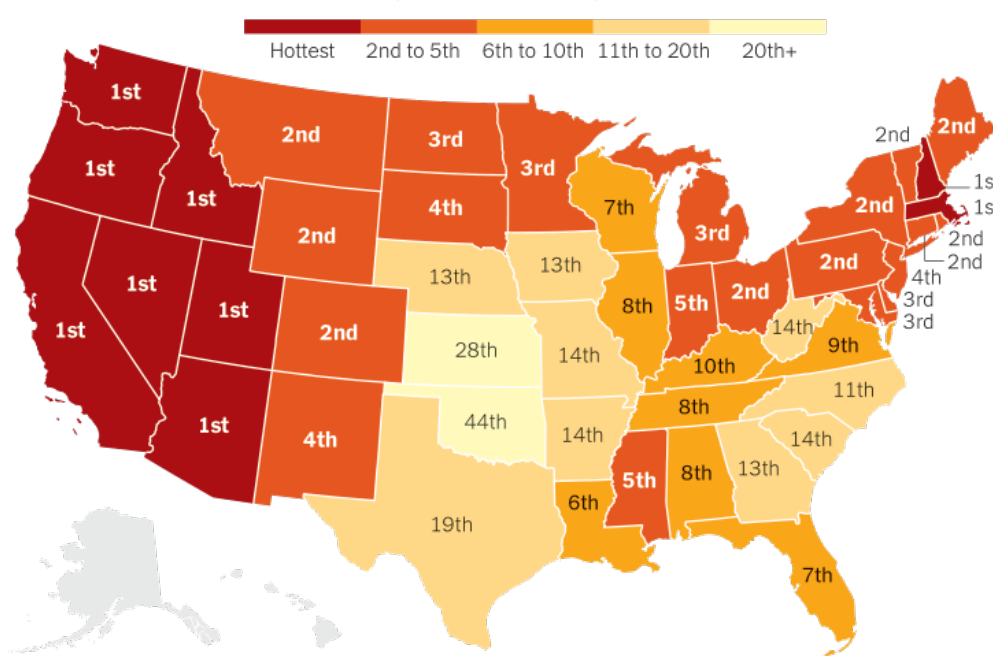
While average nighttime temperatures are on the rise, it's the extremes — that is, the number of abnormally hot nights — that are rising the fastest.

A small shift in the average can mean a large change in the frequency of extreme events, with big consequences for climate change.

When the average temperature increases, the distribution of daily temperatures shifts toward its tail end. "We are making that tail fatter," said Claudia Tebaldi, a climate scientist at the Pacific Northwest National Laboratory. "And so the possibility of experi-

In 2021, Many States Experienced Their Hottest Summer Nights

2021 summer minimum temperature ranks, compared with records since 1895



Source: NOAA's National Centers for Environmental Information; data for Alaska and Hawaii not available

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encing a day that belongs to the tail is higher than it used to be."

There's a saying among climate scientists: "The sting is in the tail." Extreme weather, although rare, does the most damage. And as climate change pushes weather distributions toward their tail end, extreme weather becomes more common.

This past summer was a clear demonstration of this sting. June's record-breaking heat wave in the Pacific Northwest would have been "virtually impossible without climate change," according to an analysis by an international team of climate researchers. The study found that such an extreme heat wave is at least 150 times more likely because of human-caused global warming (which has raised global average temperatures by about 2 degrees Fahrenheit).

And if the world warms by another 1.4 degrees Fahrenheit — which could happen this century without a drastic drop in greenhouse gas emissions — the study concluded that such extreme heat waves "would occur roughly every 5 to 10 years."

Hotter in the city

Over several decades, most large U.S. cities have warmed "at more than twice the rate of the planet as a whole," according to research co-authored by Brian Stone, a professor of environmental planning at Georgia Tech.

This is primarily because cities contain a lot of concrete, asphalt and brick. These materials act like sponges for heat. They soak up sunlight during the day, hold on to this heat and release it overnight. Cities also have fewer trees than their surrounding areas, which reduces shade and moisture, causing urban temperatures to rise further.

"I think people notice this when they're walking around cities," Professor Vanos said. "You can feel that heat at nighttime radiating off that surface. That's the heat that was being absorbed all day."

To a lesser extent, cities are also warming because of human activity. A study in Portland, Ore., found the air above roadways and commercial districts was up to 4 degrees Fahrenheit cooler on weekends, when there were fewer cars on the roads and less activity in commercial buildings.

Cars can contribute to city heat as well. "Internal combustion engines are uniquely inefficient," said Professor Stone, as they typically use about 20 percent of the energy released in

burning gasoline, while the remaining 80 percent ends up as waste heat.

Air-conditioners can also warm cities, by using electricity and by extracting heat from indoor spaces and pumping it outdoors. A study in Phoenix showed that air-conditioners can increase outdoor air temperatures by 2 degrees Fahrenheit.

Disproportionate impacts

As cities get hotter, the burden of extreme heat is unequally distributed. Within cities, the hottest neighborhoods tend to be those where people of color and poorer people live. These areas have fewer trees and more paved surfaces.

Poorer communities are also less likely to use air-conditioners during heat waves, which increases the risk of heat-related death. "Either they don't have it in their home or they are not using it because of the monthly electric bills that are too high," said Jaime Madrigano, an environmental epidemiologist and policy researcher at RAND Corporation (which is a nonprofit research institute).

Her research on New York City has shown that Black New Yorkers are more likely than other groups to die during heat waves, and that deaths during heat waves were higher in neighborhoods with fewer green spaces. These environmental inequalities are linked to sys-

temically racist practices (such as redlining neighborhoods), which have created large racial disparities in income, housing and health.

Earlier this year, a study that used satellite imagery to infer urban heat showed that people of color lived in hotter parts of a city in all but six of the largest 175 U.S. cities. In particular, Black residents lived in neighborhoods where summer daytime ground temperatures were 3 degrees Fahrenheit hotter on average compared with neighborhoods where white residents lived.

The research found a similar pattern with income: People living below the poverty line resided in hotter parts of a city compared with wealthier residents.

"This is not an isolated problem, this is not a single one-off anecdote," said Angel Hsu, an author of the research and a professor of public policy and environment at the University of North Carolina. "This is actually a widespread, pervasive problem."

As the climate warms, extreme heat will become more intense and more frequent. The recent report by the Intergovernmental Panel on Climate Change warns that for every added increment of global warming, the changes in extremes will continue to get larger, leading to more unprecedented heat waves, droughts and heavy rains.

"You're not going to see the impact in a linear basis," said Professor Hsu, referring to how climate change will affect cities. "It happens exponentially."

Methodology: Starting from NOAA's Global Historical Climatology Network, we selected weather stations in U.S. airports that have daily records since 1960. We filtered this list to include only weather stations with a near-complete weather record (those with at least 95 percent of days accounted for in the summer months of each decade). We excluded data points that failed NOAA's quality assurance checks.

Note: Airports are often on the outskirts of cities, which tend to be cooler than city centers. But airports are also roughly similar to dense city centers in their urbanization patterns: They are paved with concrete and have few trees, which makes them warmer than their rural surroundings. Daily temperature readings from airport weather stations may vary slightly over time because of instrument relocations and changes associated with automation, which occurred primarily in the 1990s. But these variations are generally small compared with the warming trends observed at these stations.