The effect of anthropogenic climate change on heat waves in the United States.

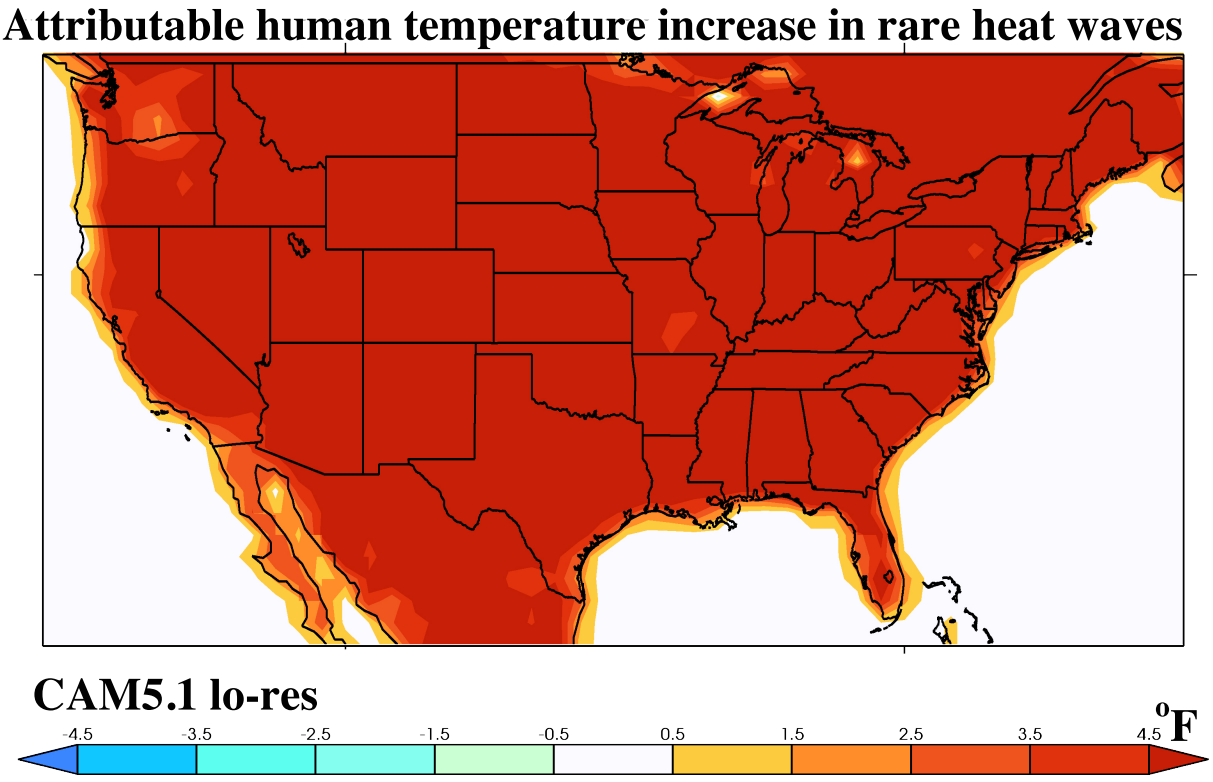
Michael Wehner

The human influence on extreme heat waves is clear (Min et al. 2013; Zwiers et al. 2011).

The unusually hot temperatures in the western United States in the summer of 2021 are a case in point. Below is an attribution statement about how climate change has currently affected the US heat waves as well as some projections of how much climate change will further increase their severity. These statements are based on previously published papers.

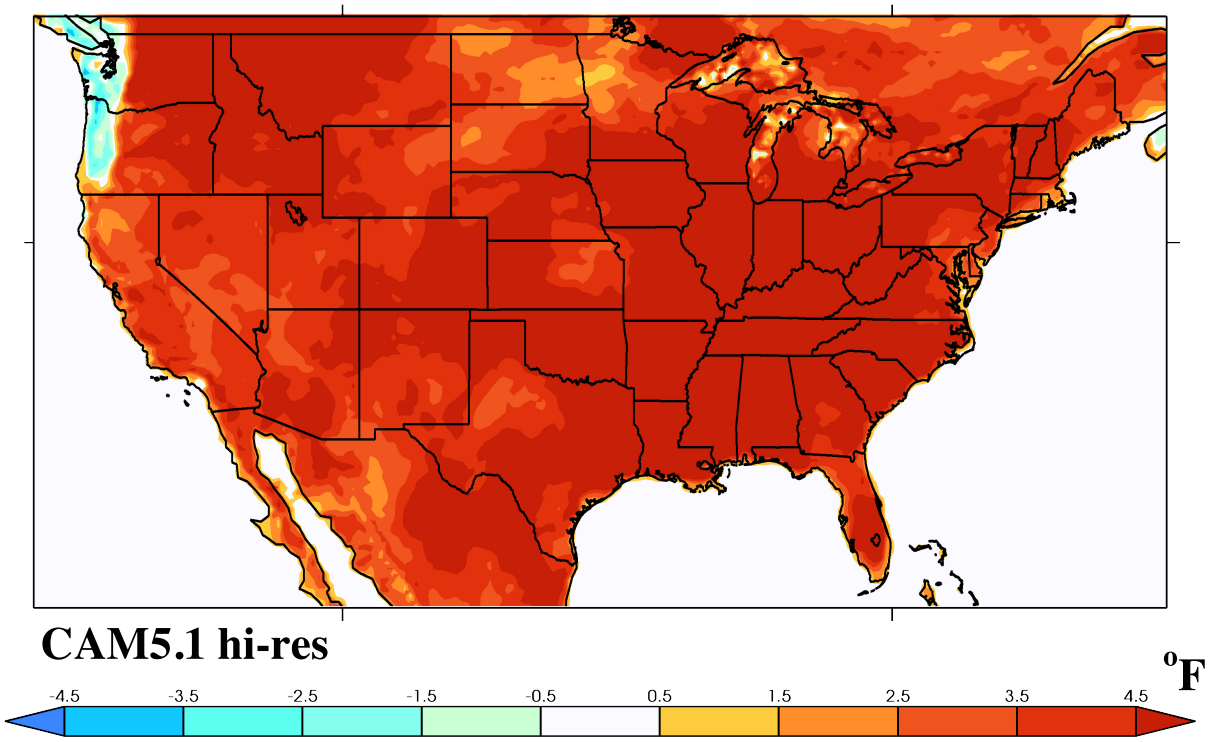
Currently, climate change has caused rare heat waves to be 3 to 5 degrees warmer over most of the conterminous United States (adapted from Wehner et al 2018).

Below are some example model results leading to this statement. It is important to remember that natural variability cannot be entirely removed as the number of simulations is finite. Hence, some of the apparent spatial structure is simply climate noise. But the statement above is supported by these figures and many others.



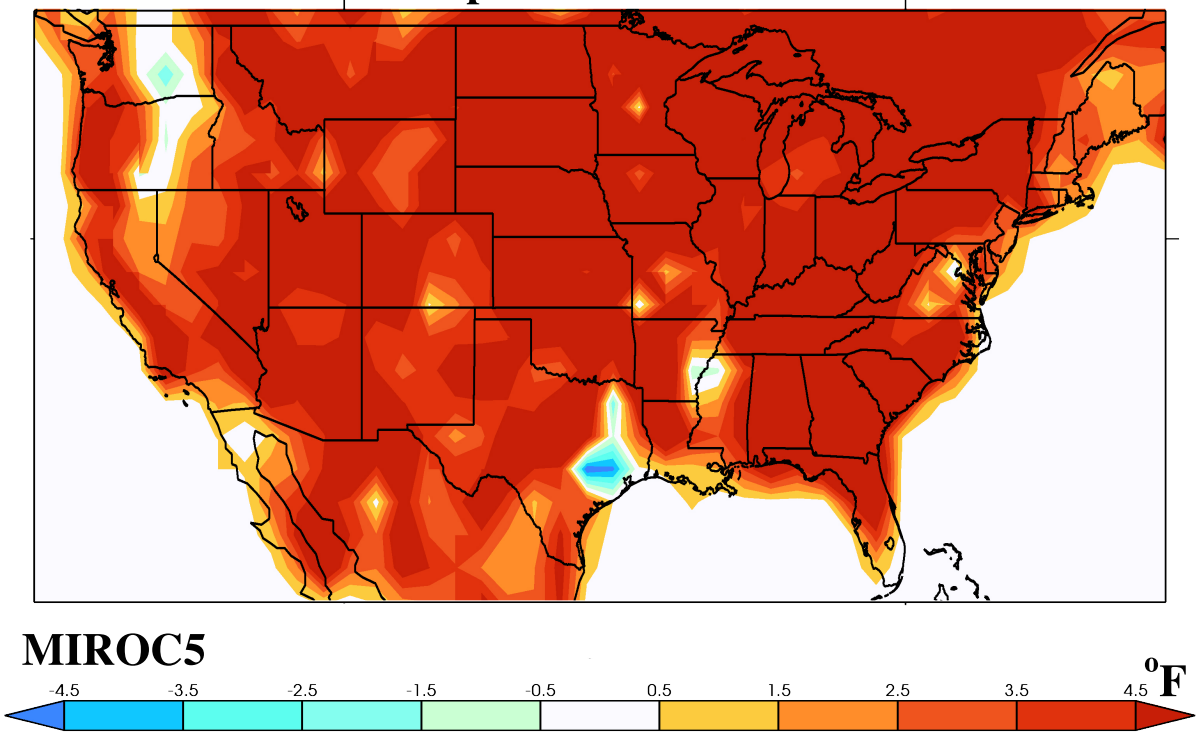
The CAM5.1 lo-res model has a resolution of 100km. This is a very robust result as the number of simulation pairs is about 100. This is the model contributed to the 2021 WWA Pacific Northwest heat wave attribution statement because it well matches the observations in the region. This model is very similar to the multi-model average.

Attributable human temperature increase in rare heat waves



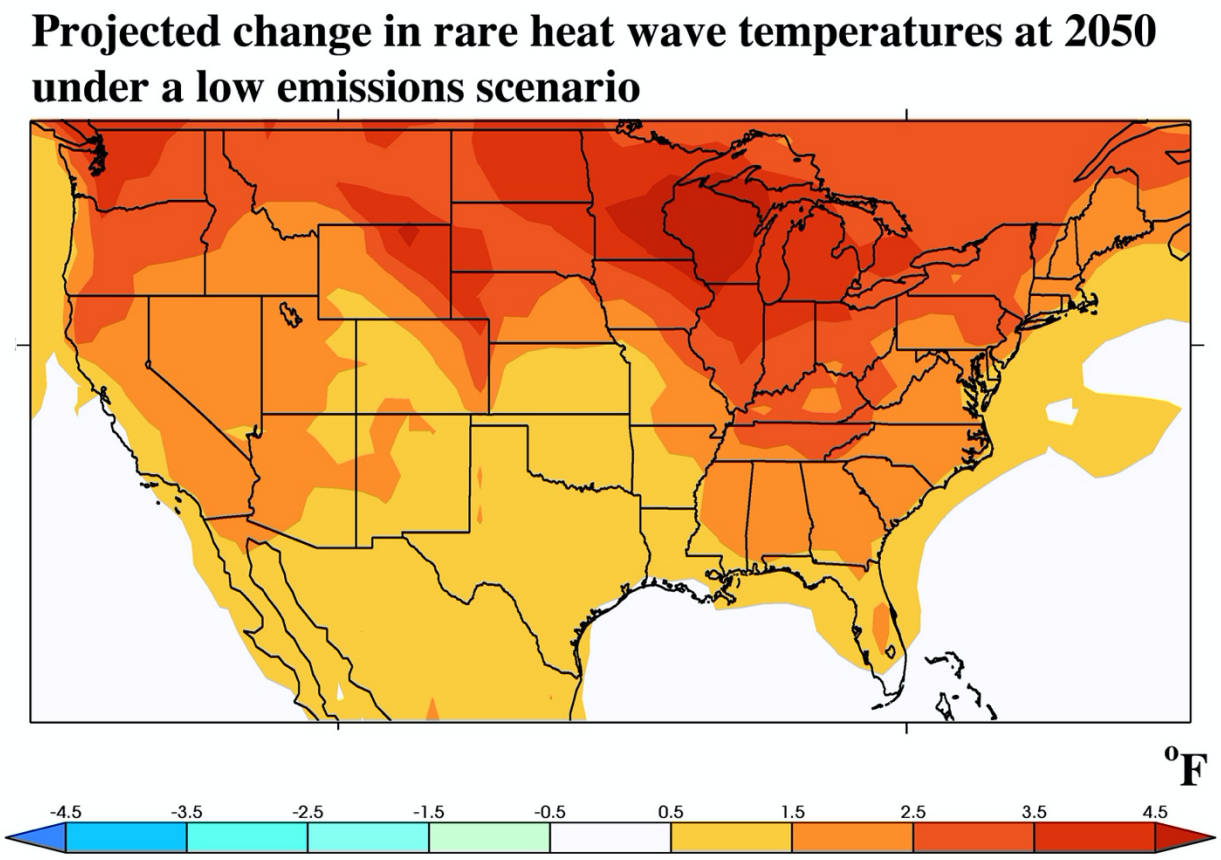
The CAM5.1 hi-res model has a resolution of 25km. While it better matches the topography, due to computer limitations, there are only 5 pairs of simulations. While the larger values in the east than in the west are likely robust, other fine scale details may not be.

Attributable human temperature increase in rare heat waves



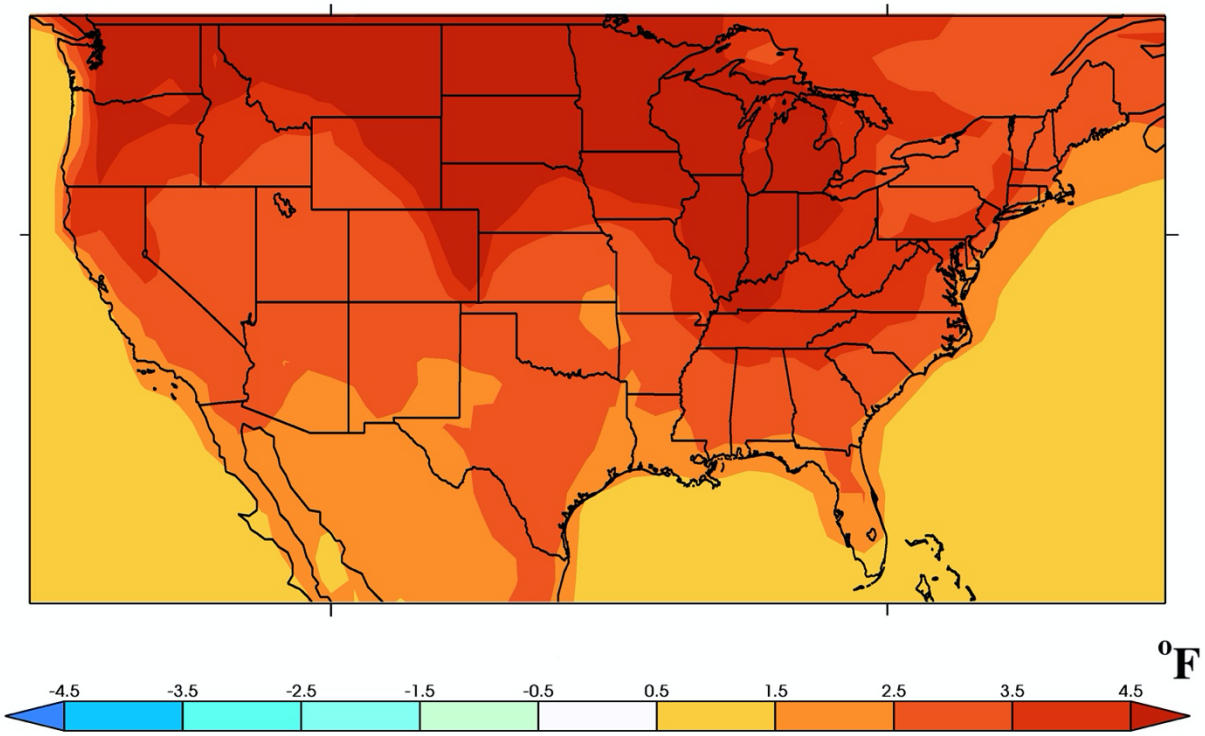
The MIROC5 model has a resolution of about 50km. It is known to be hyperactive to aerosols (particulate air pollution), which may be responsible for some of the fine scale structures.

Heat waves will continue to get hotter in the future depending on emissions scenarios and time frame. Without reductions in greenhouse gas emissions, extreme heatwaves will be more than 5°F warmer than now throughout the conterminous United States. Taken directly from the CESM large ensemble simulations presented in Tebaldi and Wehner 2018:



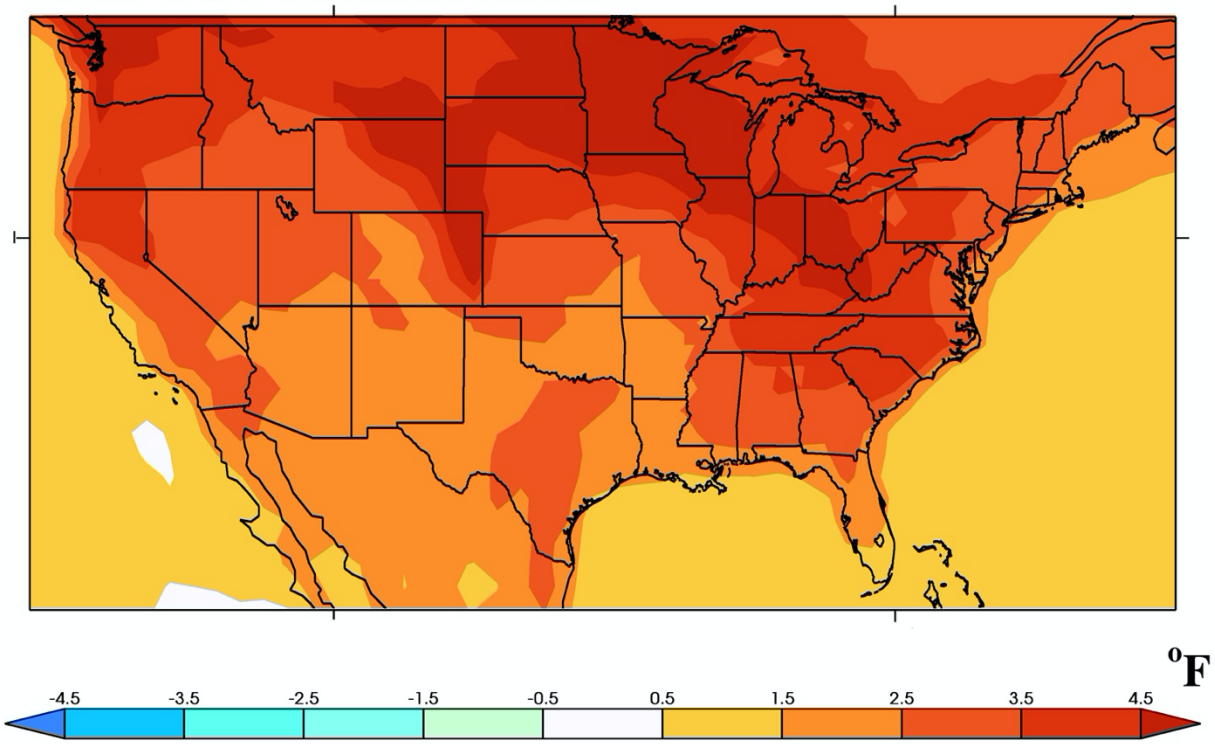
Under the lower emissions scenario, US heat waves would be about 1-3 degrees Fahrenheit warmer than now at mid-century (2050).

Projected change in rare heat wave temperatures at 2050 under a high emissions scenario



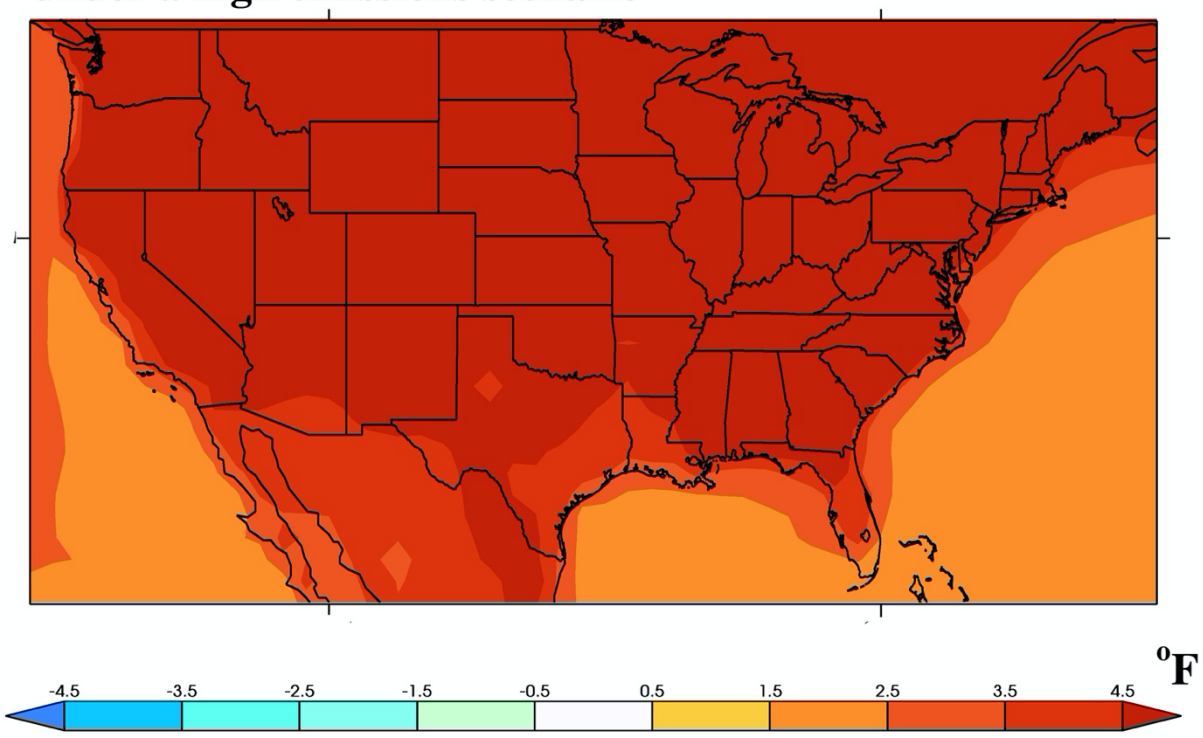
Under the higher emissions scenario, US heat waves would be about 3-5 degrees Fahrenheit warmer at mid-century (2050).

Projected change in rare heat wave temperatures at 2080 under a low emissions scenario



Under the lower emissions scenario, US heat waves would be also be about 3-5 degrees Fahrenheit warmer than now at late-century (2080).

Projected change in rare heat wave temperatures at 2080 under a high emissions scenario



Under the higher emissions scenario, US heat waves would be also be more than 5 degrees Fahrenheit warmer than now at late-century (2080).

References:

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These statements are my own scientific opinion and do not necessarily reflect the positions of the Lawrence Berkeley National Laboratory, the University of California nor the US Department of Energy.

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