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# Global record-breaking 2018 heatwave due to human-induced climate change

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In recent decades heatwaves caused devastating impacts on natural and human systems. Most of these heatwaves were much more likely because of anthropogenic climate change. We conducted a case study for the 2018 early boreal summer, where temperature records were observed in many countries of the Northern Hemisphere. The extreme temperatures led to the death of hundreds of people, triggered wildfires and crop failure and caused damages to infrastructure in North America, Europe, and Asia. The heatwave area in 2018 covered more than a fifth of the densely populated and key agricultural regions in northern mid-latitudes on average every day between May and July 2018, rendering it an unprecedented event. Though record-breaking in the observations, the event occurs in climate model simulations of today's climate. In an even warmer climate, similar global-scale heatwave areas can be expected to become much less exceptional. For instance, simulations from the CMIP5 multi-model ensemble show that under a +2 °C global warming a 2018-like event would occur nearly every year. The areal extent experiencing extreme heat over densely populated and key agricultural regions in the northern mid-latitudes every day between May and July is projected to linearly increase with global mean temperature at a rate of 16% per degree warming.

By estimating probabilities of exceeding 2018 heatwave areas with and without anthropogenic forcing, we assess the human influence on this type of event. Using simulations from the CMIP5 ensemble, we demonstrate that it is virtually certain (i.e. >99% according to IPCC calibrated language) that a 2018-like heatwave area could not have occurred without human-induced climate change. Thus, the 2018 global-scale heatwave event possibly constitutes the first climate phenomenon that can be uniquely attributed to human-induced global warming.