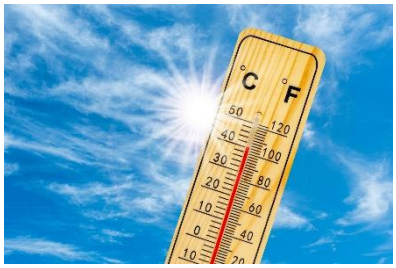
UK CLIMATE RESILIENCE PROGRAMME

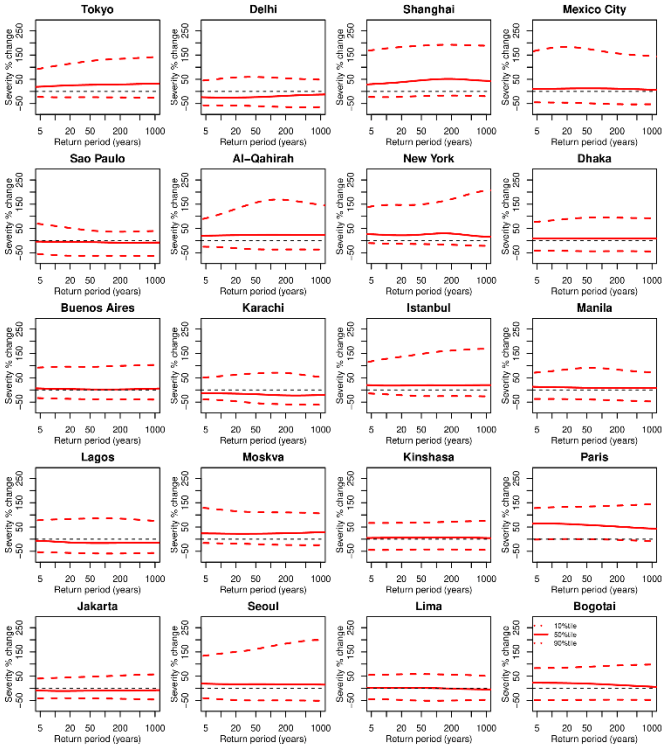
Understanding rare heatwaves and their current and future probability



Why this is important: Heatwaves can cause significant impacts to people and infrastructure. An understanding of the absolute probabilities of rare heatwaves of different durations and temperatures for both present and future climates is limited. Calculating such probabilities directly from current climate model simulations is difficult as they do not provide sufficient numbers of these rare events. An additional complication is the wide range of durations and critical levels being used to define a heatwave.

What the UKCR programme is doing: To address this limitation a new heatwave simulation model has been developed applicable to a range of heatwave definitions that accounts for day of year and level of global warming enabling the estimation of probabilities for heatwaves more extreme than observed in either the observational data or in future simulations. The methodology combines the model simulations with a statistical approach to create large sets of simulated, plausible heatwave events from which precise probabilities can be calculated. Present and future heatwave severity, duration and frequency statistics derived from the Coupled Model Intercomparison Project phase 5 (CMIP5) archive for the 20 most populous global cities (as of 2018) have been completed. For each city 10^6 plausible heatwave events have been simulated for each CMIP5 member for the years 2006 and 2099.

Results so far: The heatwave simulator can closely reproduce the heatwave climatology (intensity, severity and duration) of a 3500-year model (HadCM3) control run with atmospheric carbon dioxide concentrations held at pre-industrial levels even though it was trained on a 100-year high emission climate change scenario. By studying the return level curves for individual heatwave events in each of the 20 most populous global cities results show that for any given city, daily temperature changes are constant across heatwaves of different duration, as well as heatwaves of different rarity. For all cities, absolute temperatures of heatwaves of 4 to 10-day durations are found to significantly increase by between 3.4 to 6.6°C between 2006 and 2099. Six cities are found to have increases in longer duration heatwaves relative to shorter



Future changes (%) in heatwave severity for 20 cities between 2006-2099 with respect to return period (derived from CMIP5 models forced by RCP8.5). Median changes shown by the solid red (10th/90th percentile by dashed red lower/upper) set of curves in each panel.

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durations (Seoul, Paris, Moskva, New York, Shanghai & Tokyo) and one (Karachi) to shorter durations relative to longer. Paris shows the largest increase in long durations, with the rate of 10-day duration events projected to increase by 130% by 2099. For ten cities the changes in heatwave severity are found to be significantly different from zero, with eight increasing over time. Positive severity changes correspond to heatwaves becoming more impactful through either becoming hotter and/or longer. Of the 20 cities, Paris is found to have the largest increase in severity corresponding to mean temperatures for 5-day heatwaves increasing by 3.4°C or 1.7°C for 10-day heatwaves.

What is next? A paper describing the new methodology and future projections has been submitted for publication to the journal “Weather and Climate Extremes”. Additionally, within the UKCR programme the results will be made available to the pilot Urban Climate Service as a means to reach users. Future research within the programme will focus on extremes of other climate variables including rainfall and wind across the UK. Wider research will explore applications for the thermal response of buildings and critical infrastructure. Night-time maximum temperatures and humidity are also important metrics that drive heatwave impacts - incorporating these is the subject of ongoing research.

Reference: Brown, S. J., Future changes in heatwave severity, duration and frequency due to climate change for the most populous cities (Submitted; *Weather and Climate Extremes*)