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Heat stress projections for major European cities from high-resolution regional climate model simulations

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Cities are hotspots of human heat stress due to their large number of inhabitants and the urban heat island effect leading to amplified temperatures. Exposure to heat stress in urban areas is projected to further increase in the future, mainly due to climate change and expected increases in the number of people living in cities. The impacts of climate change in cities have been investigated in numerous studies, but rarely using climate models due to their coarse spatial resolution compared to the typical areal extent of cities. Recent advances in regional climate modelling now give access to an ensemble of high-resolution simulations for Europe, allowing for much more detailed analyses of small-scale features, such as city climate.

Focusing on Europe, we compare the evolution of several heat stress indicators for 36 major European cities, based on regional climate model simulations from EURO-CORDEX. The applied EURO-CORDEX ensemble (Vautard et al., 2020) has a spatial resolution of 0.11° (~11 km; comparable to the extent of large cities) and contains over 60 ensemble members, allowing thus for robust multi-model analyses of climate change on city levels. We analyze changes in heat stress both relative to the climatological heat stress variability in each city during 1981-2010 using the Heat Wave Magnitude Index daily (HWMId, Russo et al., 2015) and in absolute terms by counting the yearly number of exceedances of impact-relevant thresholds. Relative and absolute heat stress increase throughout Europe but with distinct patterns. Absolute heat stress increases predominantly in Southern Europe, primarily due to the hotter climate in the South. Relative changes are also highest in Southern Europe but exhibit a secondary maximum in Northern Europe, while being lowest in Central Europe. The main reason for this pattern is that day-to-day variability in heat stress indicators during present climate conditions is highest in Central Europe but lower in Southern and Northern Europe. Large Northern European cities, which are all located at the shore, are further influenced by different heat stress evolutions over land and sea surfaces.

As human vulnerability does not only depend on the absolute heat stress but also on what people are adapted to (i.e., the climatological range), the results of this study highlight that cities in all parts of Europe – including in Northern Europe – must prepare for higher heat stress in the future.

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