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Can climate adaptation solutions fix the urban heat island? An assessment of the thermal conditions during heat waves in Vienna impacted by climate change and urban development scenarios for the mid-21st-century

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Climate change threatens to exacerbate existing problems in urban areas arising from the urban heat island. Furthermore, expansion of urban areas and rising urban populations will increase the numbers of people exposed to hazards in these vulnerable areas. We therefore urgently need study of these environments and in-depth assessment of potential climate adaptation measures.

We present a study of heat wave impacts across the urban landscape of Vienna for different future development pathways and for both present and future climatic conditions. We have created two different urban development scenarios that estimate potential urban sprawl and optimized development concerning future building construction in Vienna and have built a digital representation of each within the Town Energy Balance (TEB) urban surface model. In addition, we select two heat waves of similar frequency of return representative for present and future conditions (following the RCP8.5 scenario) of the mid 21st century and use the Weather Research and Forecasting Model (WRF) to simulate both heat wave events. We then couple the two representations urban Vienna in TEB with the WRF heat wave simulations to estimate air temperature, surface temperatures and human thermal comfort during the heat waves. We then identify and apply a set of adaptation measures within TEB to try to identify potential solutions to the problems associated with the urban heat island.

Global and regional climate change under the RCP8.5 scenario causes the future heat wave to be more severe showing an increase of daily maximum air temperature in Vienna by 7 K; the daily minimum air temperature will increase by 2-4 K. We find that changes caused by urban growth or densification mainly affect air temperature and human thermal comfort local to where new urbanisation takes place and does not occur significantly in the existing central districts.

Exploring adaptation solutions, we find that a combination of near zero-energy standards and increasing albedo of building materials on the city scale accomplishes a maximum reduction of urban canyon temperature of 0.9 K for the minima and 0.2 K for the maxima. Local scale changes of different adaption measures show that insulation of buildings alone increases the maximum wall surface temperatures by more than 10 K or the maximum mean radiant temperature (MRT) in the canyon by 5 K. Therefore, additional adaptation to reduce MRT within the urban canyons like tree shade are needed to complement the proposed measures.

This study concludes that the rising air temperatures expected by climate change puts an unprecedented heat burden on Viennese inhabitants, which cannot easily be reduced by measures concerning buildings within the city itself. Additionally, measures such as planting trees to provide shade, regional water sensitive planning and global reduction of greenhouse gas emissions in order to reduce temperature extremes are required.

We are now actively seeking to apply this set of tools to a wider set of cases in order to try to find effective solutions to projected warming resulting from climate change in urban areas.