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Assessment of human thermal comfort and mitigation measures in different urban climatotopes

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This study analyses thermal comfort in the model city of Oberhausen as an example for the densely populated metropolitan region Ruhr, Germany. As thermal loads increase due to climate change negative impacts especially for city dwellers will arise. Therefore mitigation strategies should be developed and considered in urban planning today to prevent future thermal stress.
The method consists of the combination of in-situ measurements and numerical model simulations. So in a first step the actual thermal situation is determined and then possible mitigation strategies are derived.
A measuring network was installed in eight climatotopes for a one year period recording air temperature, relative humidity, wind speed and wind direction. Based on these parameters the human thermal comfort in terms of physiological equivalent temperature (PET) was calculated by RayMan Pro software. Thus the human comfort of different climatotopes was determined. Heat stress in different land uses varies, so excess thermal loads in urban areas could be detected.
Based on the measuring results mitigation strategies were developed, such as increasing areas with high evaporation capacity (green areas and water bodies). These strategies were implemented as different plan scenarios in the microscale urban climate model ENVI-met. The best measure should be identified by comparing the range and effect of these scenarios. Simulations were run in three of the eight climatotopes (city center, suburban and open land site) to analyse the effectiveness of the mitigation strategies in several land use structures. These cover the range of values of all eight climatotopes and therefore provide representative results. In the model area of 21 ha total, the modified section in the different plan scenarios was 1 ha. Thus the effect of small-scale changes could be analysed. Such areas can arise due to population decline and structural changes and hold conversion potential. Emphasis was also laid on analysing the effectiveness of water bodies, which need further research in contrast to well analysed vegetation areas.
Results show different thermal loads in the miscellaneous climatotopes due to land use structures. Both measurements and model simulations demonstrate the positive effect on thermal comfort due to augmentation of areas with high evaporation capacity. These effects can be especially well detected in summer, when heat stress is most pronounced. The measurement based PET calculations show a maximum difference of 4 K PET between inner city and open land site in summer nights. Simulation results overall present a PET reduction of 1-3 K. The average PET reduction in the city center site is about 2 K, while the maximum reduction in the suburban site can exceed 5 K. In urban areas parks are particularly advisable as mitigation measure, because they reduce thermal stress both by tree shading and evapotranspiration.