The impact of built form on urban microclimate at the scale of city blocks

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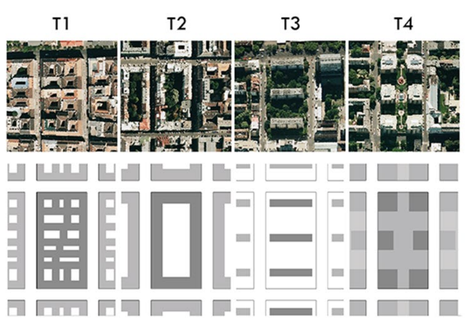
Introduction

One consequence of the twentieth-century developments in architecture is the lost understanding of environmental control by means of the built environment. While adequate thermal and lighting conditions within buildings are increasingly ensured by mechanical means, conditions around and between buildings are consistently neglected. Additionally, by emphasising the importance of surface materials and vegetations, urban heat island and climate change mitigation strategies commonly neglect the influence of built form. In light of these, the research intends to highlight the effect of building configurations on microclimates within urban blocks.

Methodology

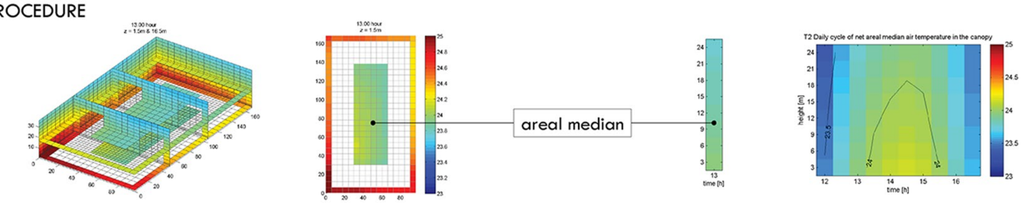
This comparative numerical simulation study employed ENVI-met for microclimate simulations and MATLAB for the analysis and visualization of the results.

- the models were developed on the basis of historic metropolitan urban block typologies of Budapest
- each model consisted of 9 identical urban blocks arranged in a 3x3 grid layout, of which the study focused on the central one
- the models resolution is 6 m horizontally and 3 m vertically
- the numerical simulation took Budapest as the location of the study with its characteristic weather conditions on a July day
- the baseline model with no buildings reproduces thes conditions as recorded by a local meteorological station
- the numerical simulations were run for 48 hours, the analysis was conducted on the second 24 hours
- the effects of orientation were examined by rotating the models 90 degrees counterclockwise at 30 degrees increments
- the study analyzed UCL microclimates within the volumes extracted from the central urban block
- the adopted analytical approach utilized areal medians calculated at different heights and times
- areal median values are represented with pseudocolor plots
- urban configurations were compared on the basis of potential air temperature, mean radiant temperature and human thermal comfort index (PMV)



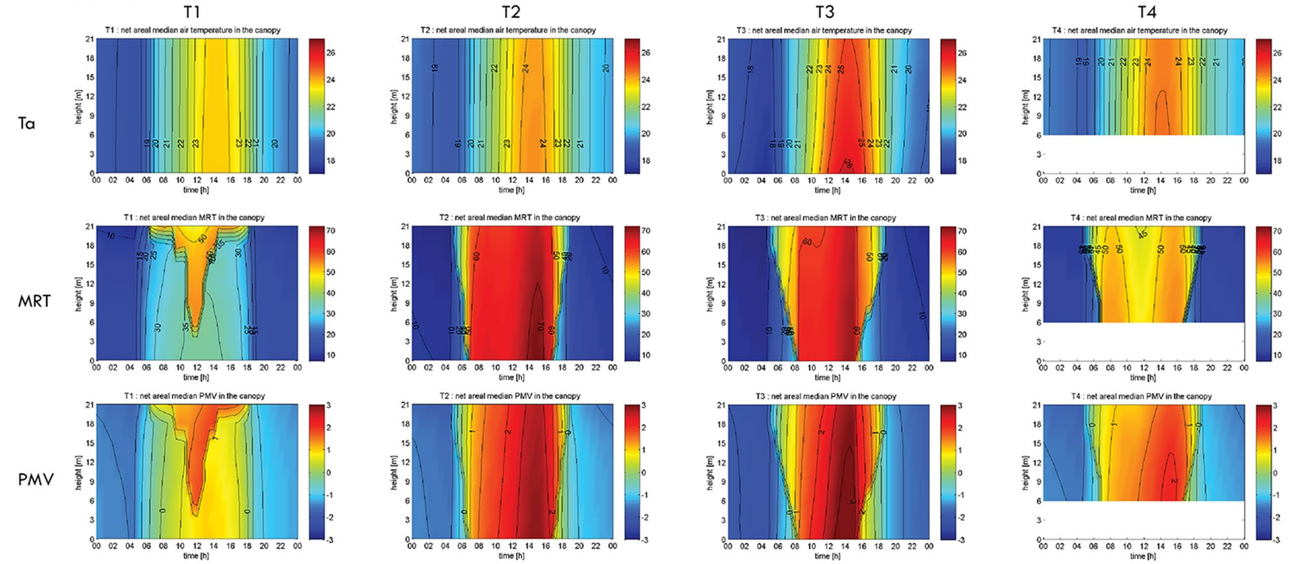
The four metropolitan urban blocks of Budapest and their model equivalents

ANALYTICAL PROCEDURE

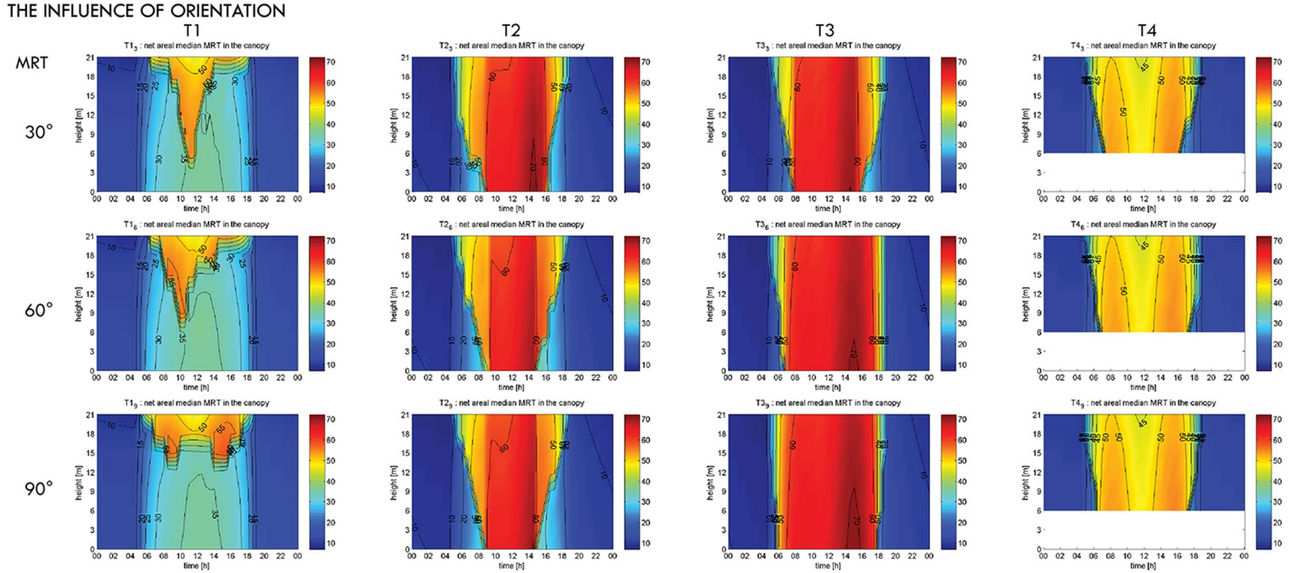


Results

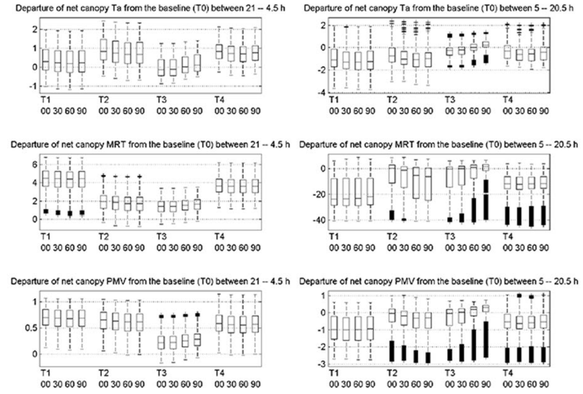
THE INFLUENCE OF FORM



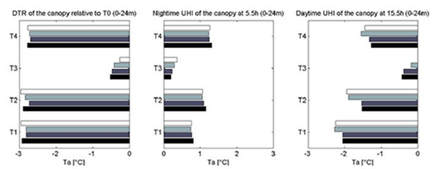
THE INFLUENCE OF ORIENTATION



Summary of Results



The influence of orientation on the diurnal canopy layer microclimate as expressed by the divergence of air temperature, MRT and PMV values from baseline conditions (T0) calculated for daytime (left) and nighttime (right).



Diurnal temperature range reductions along with day- and nighttime heat island magnitudes relative to the baseline condition (T0) calculated for the canopy layer of four typologies rotated 90 degrees in 30 degrees increments. Bar colors indicate the degree of rotation: black -- 0°; dark gray -- 30°; light gray -- 60°; white -- 90°.

Discussion and Conclusion

The analysis indicates that built form plays an important role in determining the urban microclimate. Buildings primarily interfere with short- and long-wave radiation. Consequently, the modified radiative environment of the UCL affects surface and air temperatures.

- within the boundaries of the study, predicted mean vote results reflect the superposition of air and mean radiant temperatures
- the analysis indicates that mean radiant temperature is sensitive to directionalities within the model
- mean radant temperature signals times and places with high surface and air temperatures

Since mean radiant temperature signals changes in the radiative environment and also governs human thermal comfort during warm weather, it could be adopted by planners and architects to analyze the effects of buildings and to develop successful climate mitigation strategies for urban environments.

Acknowledgements

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