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A coupled modelling approach to quantify the microclimatic effects of green infrastructure on residential buildings

Introduction

Rising temperatures and the further intensification of the urban heat island (UHI) effect are major challenges for cities. They lead to an increase in energy demand for cooling which counteracts climate change mitigation efforts. Climate adaptation via urban green infrastructure (UGI) can significantly reduce the UHI effect. Our study aims at quantifying UGI measures at scale of an urban block with benefits for outdoor as well as indoor thermal comfort and buildings' energy demand by coupling microclimate modelling with thermal building simulation.

Research Approach and Preliminary Results

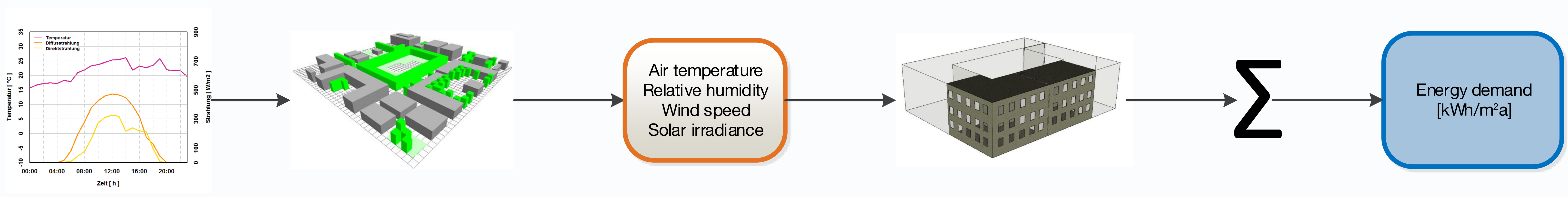
The microclimate modelling software ENVI-met simulates the surface-plant-air interaction in an urban quarter. We use ENVI-met to analyse outdoor thermal comfort conditions in different urban greening scenarios. In order to evaluate the effect of these scenarios on indoor thermal comfort and buildings' energy demand, we employ IDA Indoor Climate and Energy, a building performance simulation tool. As ENVI-met operates at a temporal resolution of single extreme weather days while analyses of energy demand and thus CO2 emissions are based on yearly records, an approach to coupling the simulation approaches needs to be developed. In our approach yearly weather files are clustered into typical-day categories. Test reference years defined by the German weather service are applied. A clustering of the data based on the variables ambient temperature and solar radiation with a hierarchical approach results in our case in five typical-day categories. For validation, simulations in IDA-ICE are undertaken first for the typical-day approach and secondly, on hourly basis over one year and are compared with each other. It shows a difference in heating demand between the detailed simulation and the typical-days of about 3% which can be evaluated as a reliable output.

Case area in Munich Maxvorstadt (© Microsoft Cooperation)

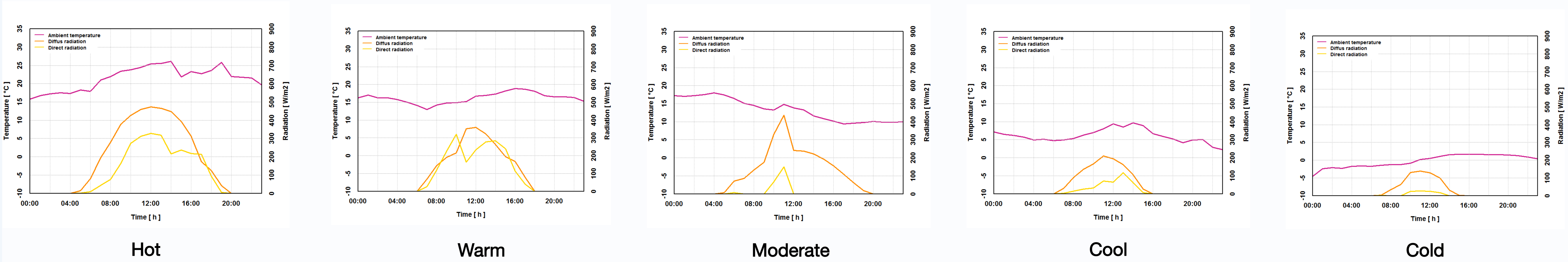
In a second step, an ENVI-met simulation is run for each of the typical-days for different UGI scenarios. The scenarios cover the UGI measures of green roofs, green facades and tree plantings. The meteorological output files of the calculations serve then as input for the building simulation. The methodological approach is tested for an urban block in Munich, Germany, representing a typical inner urban fabric with a high degree of compactness and surface sealing.

Conclusion and Outlook

The presented coupling of microclimate modelling with thermal building simulation allows a detailed analysis of how UGI measures at the building side as well as UGI measures in public space are reducing the potential for indoor overheating for the typical-days of a year. First results of our study clearly show that the approach of typical-days can be used to provide reliable results for a yearly based analysis. In the next work steps of our study ENVI-met simulations for all typical-day categories and greening scenarios as well as IDA ICE simulations with the produced output files will be conducted. Furthermore, we will assess the impact of combined UGI measures in greening scenarios and by linking them with technical cooling measures at building level. The results of this research are expected to serve as decision support for urban planners and city administrations when implementing UGI measures into practice.



Conceptual framework of research



Typical-days of the test reference year

Mitigation and Urban Green Infrastructure, a project at Centre for Urban Ecology and Climate Adaptation (ZSK)
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