MICROCLIMATIC EFFECTS OF A SMALL URBAN PARK IN A DENSELY BUILD UP AREA: MEASSUREMENTS AND MODEL SIMULATIONS

Esther Lahme*, Michael Bruse
*University of Bochum, Bochum, Germany

Abstract

The investigation of the effects of urban green spaces on microclimate and air quality is one of the work packages in the framework of the European Union project BUGS (Benefits of urban green space, 2001–2004). The methods used to approach this issue are double tracked: One method is the measurement of local climate and air quality data, the other is the simulation of the climatic conditions at the selected locations using the numerical microclimate model ENVI-met (Bruse and Fleer 1998). This presentation focuses on the activities carried out in the year 2002 in which the main target of the project was to investigate the effects of a small urban park surrounded by a densely build up area on microclimate and air quality.

Key words: Urban climate, Numerical Simulation, Urban green

1. INTRODUCTION

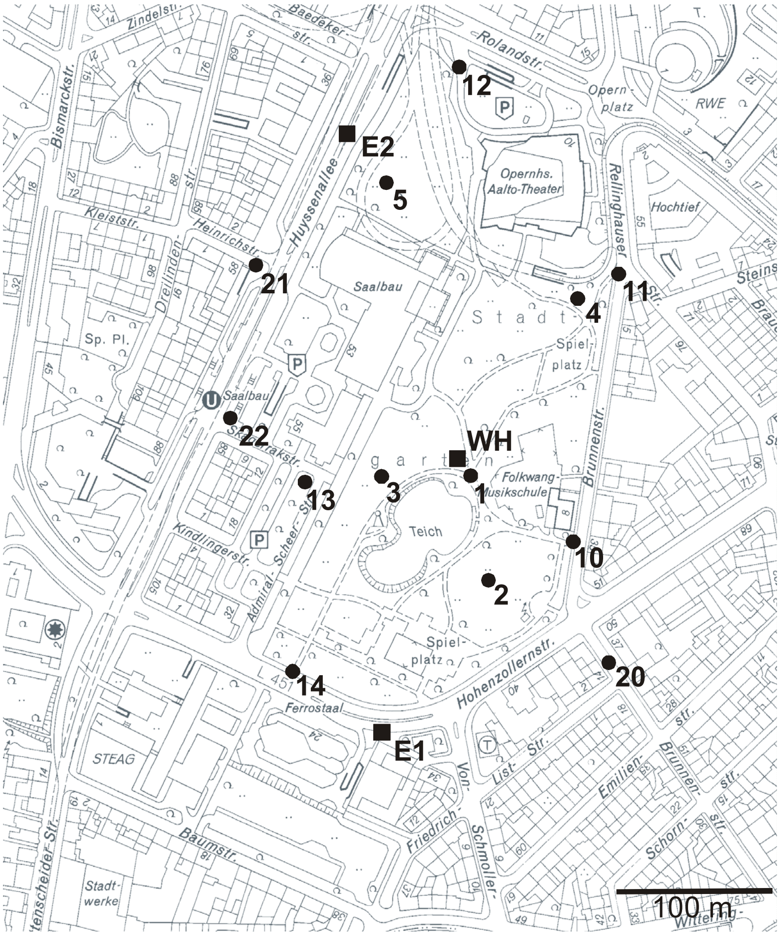
The main objective of the EU funded project BUGS (Benefits of urban green space) is to analyse, to what extend urban green spaces can be used to enhance the quality of urban life and to decrease the urban sprawl. Besides many other aspects such as noise, traffic or social implications, the influence of urban green on the local microclimate is one of the research targets of BUGS.
In the first phase of BUGS, the tools used to analyse different planning scenarios have been improved to fit the needs of the project. One of this improvement steps has been the improvement of the microscale climate model ENVI-met (Bruse and Fleer 1998) and the comparison of simulated with observed data. The poster presented on this conference will give an overview over selected results from the field campaigns and will compare them with the data obtained from the numerical simulation.

2. THE MEASUREMENT CAMPAIGN

The measurement campaigns were carried out in and around the "Stadtgarten", which is a relatively small park area close to the CBD of Essen, Germany. The city of Essen is situated in the center of the Ruhrgebiet-Area, a large agglomeration of cities in Western Germany. The town is positioned in the transition between the flatlands of the “Münsterland” in the north and the more mountainous “Bergischen Land” in the south.

The field campaigns consisted of three permanent climate stations operating in and around the park and of some in-depth manual measurements by foot and climate bus during selected autochthonous weather situations. Figure 1 shows the distribution of the permanent stations and the measurement reference points in the area of the Stadtgarten. The permanent stations WH, E1, E2 recorded air temperature, humidity, wind speed and –direction in approximately 3 m height all through the vegetation period from March to November 2002. The in-depth campaigns were executed using manual measuring devices recording air temperature in 0.05 m and 2 m height using NiCr-Ni sensors with an accuracy of +/- 0.4 K. In addition, the surface brightness temperature have been recorded using infrared measurement technique with a relatively coarse resolution of only 1 K and an accuracy of 2.0 K. Other data such as wind direction and speed have also been taken at all manual measurement points, but produced too huge uncertainties due to technical and handling limitations to be interpreted.
Several in-depth campaigns have been executed in 2002. The one that was selected here as it seems to offer the most representative weather conditions from all campaigns was executed on the 13th of September 2002. On that day, three in-depth tours have been carried out starting at 15:30, 19:30 and 22:00 CET. The obtained data have been linearly related to the time of starting the routes. That unavoidable method adds some uncertainties to the data in case of the routes walked by food because they have been more than an hour long and the assumption of a linear cooling rate might be wrong for some of the points.

* Corresponding author address: Esther Lahme, Department of Geography, University of Bochum, Building NA 4/170, D-44780 Bochum, Germany; e-mail: Esther.S.Lahme@rub.de



Measurement stations and points:

WH, E1, E2: Permanent Stations

1 – 5: M. points inside the park
10 – 14: M. points park- built up interface
20 – 22: M. points inside built up area

Detailed description:

E1:
Situated at Hohenzollernstrasse, a four-lane major urban street limiting the Stadtgarten to the south.

WH:
Placed near the center of Stadtgarten next to a junction of paved pathways and to the central lake ("Teich")

E2:
Placed on the western side of Stadtgarten at Huyssenallee on a small central strip covered with a short hedge. Huyssenallee is an ally like four-lane major urban street.

Points 1 – 5:
Placed inside the park. P1 above a sealed path (gravel/asphalt), the others above grass

Points 10 – 14:
Placed at the border of the park above gravel path (P10), asphalt (P11,12) pavement (P13) and cobblestones (P14)

Points 20 – 22:
Placed in builtup area above pavement (P20,22) and grass (P21)

Figure 1: Distribution of measurement stations and measurement points in the Stadtgarten area

2. Model Simulations

The model simulations have been carried out with the three-dimensional non-hydrostatic climate model ENVI-met Version 3.0 (Bruse and Fleer 1998) which has been updated in the context of the BUGS project. For the model simulations, the area around the Stadtgarten has been transformed in a model grid with the dimension 90 x 112 x 20 grids with a resolution of 6 m x 6 m x 2m resulting in an total area of 540 x 672 m in the horizontal extension. Figure 2 shows the arrangement of the model area as well as the position of the buildings, the vegetation and the reference points E1, E2, WH and TR (not analysed here). Note that the model area is rotated 26° out of grid north. The different shades of green indicate different densities of vegetation. In this simulation, the wind was blowing constantly with 0.5 m/s in 10 above ground from NE.

The model has not been nested into another model providing meteorological data at the model borders. The only data provided have been the initial values of air temperature, humidity etc. for the beginning of the 48 hours simulation cycle. Running a microscale model in such a non-nested way makes it impossible to reproduce trends in the meteorological data that came from larger scale phenomena (change of wind direction, air mass advection,…). On the other hand, the dynamics of the model domain become more visible if no external data are forced into the model.
Several simulations have been carried out to investigate the dynamics of the park and to compare it with measured data.

3. Presented Results

The poster presents several results from the measurement campaigns as well as from the model simulations. Both results are compared with each other in order to identify weaknesses in the model and to define the range of uncertainty both in numerical simulation as well as in the field experiments.

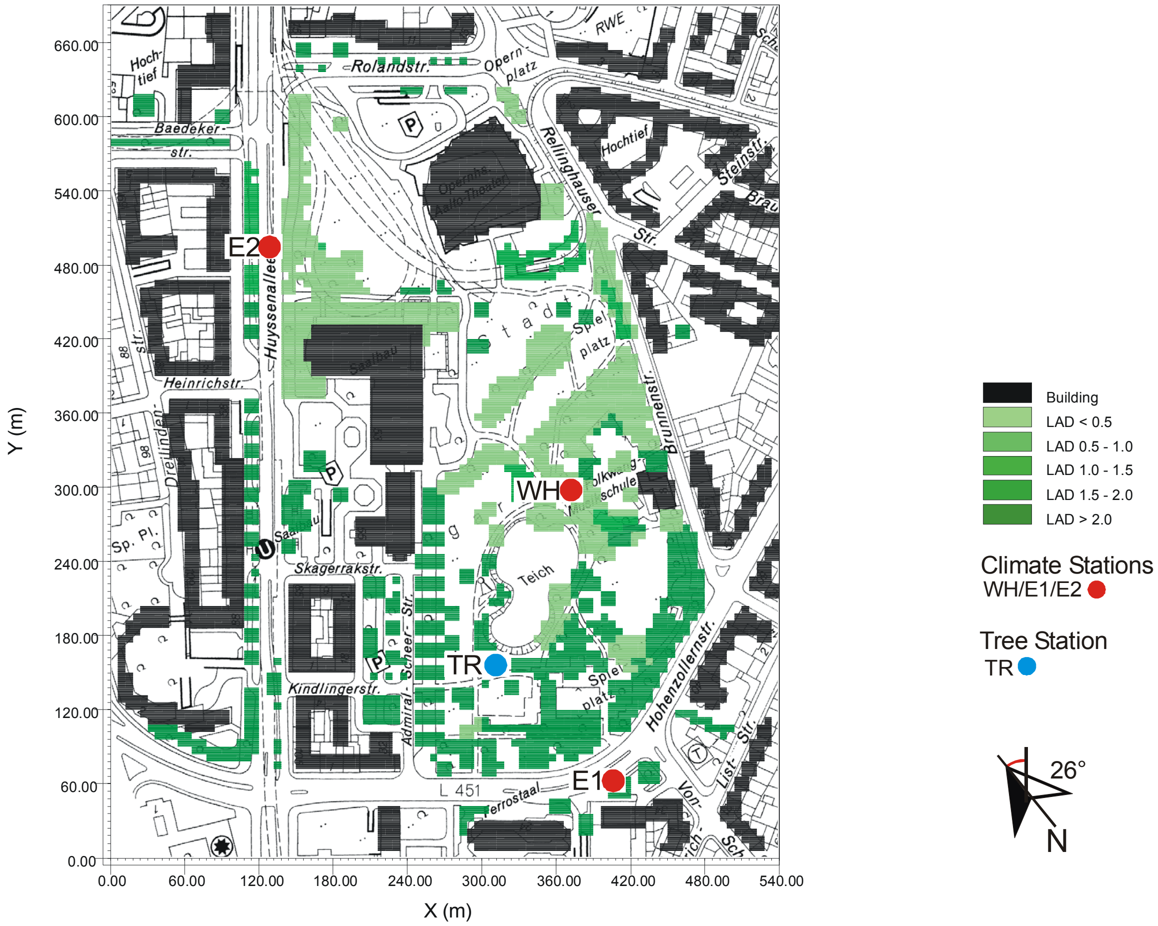


Figure 2: Model setup used for the ENVI-met simulations of the Stadtgarten area.

Figure 3 shows the comparison between the observed air temperature at the 13 measurement points in 2 m height and the corresponding model results at 1.8 m height (due to the vertical model resolution). The data show the results from the in-depth campaigns started at 15:30 and 22:00 CET. Two model simulations are plotted against the data: one called “wet” with an well watered inner Park area (50-60% relative soil humidity) and the other called “dry” with less available Water (30-40% relative soil humidity).

During the day, the observed maximum temperatures are clustering around the 21 °C level. Inside the build-up area significant differences can be observed depending on radiative situations at the single points. There is no clear tendency in the differences between the simulated data and the observed ones. During the night, it can be noticed that the temperatures inside the build-up area are well reproduced whereas the simulated data are too high inside the park area. One of the reasons for his effect is certainly the fact, that the model is not able to calculate katabatic flows out of the park. Instead, it assumes a constant wind coming from NE direction. This results for example in lower simulated temperatures at P14 which is leeward of the park and receives the cold air from the inner park areas. In contrast P10 is too warm in the model simulation. During the measurement campaigns it could be observed that actually there is a katabatic flow at this point coming out of the park and decreasing the air temperature at P10 significantly.

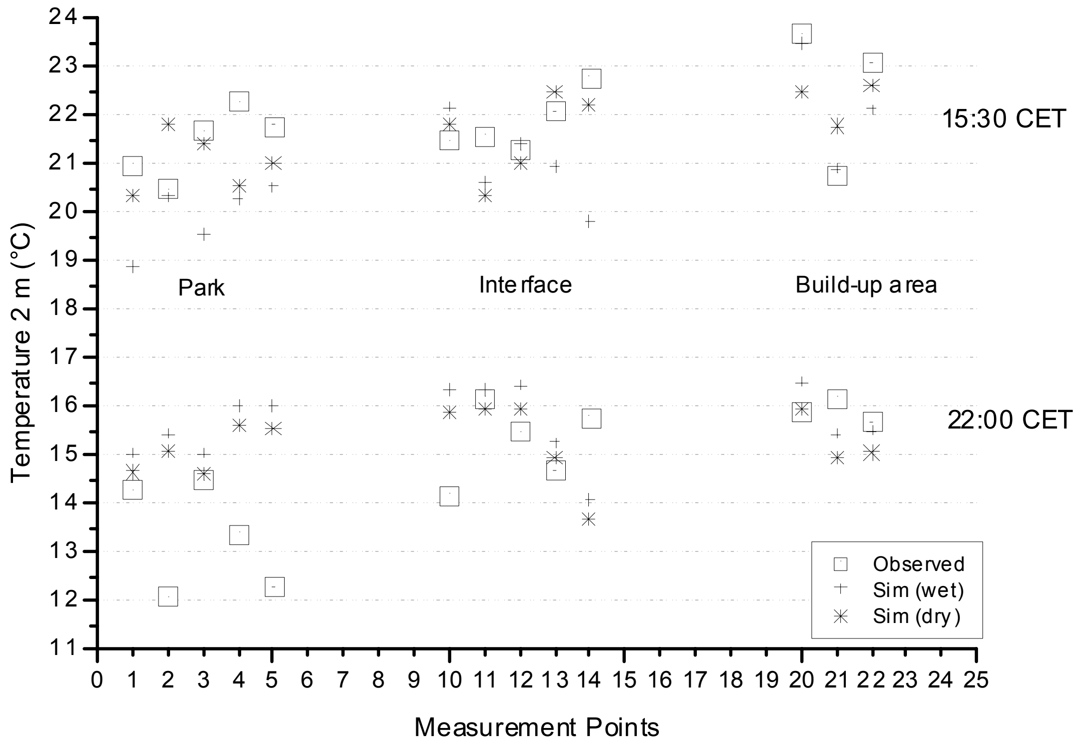


Figure 3: Comparison between observed and simulated air temperature at the in-depth measurement points

Conclusions

During the year 2002 several measurement campaigns have been made in the area of the Stadtgarten. These results found here have been compared to model results obtained with the model ENVI-met. It was found, that even for a non-nested model run, ENVI-met reproduces the observed data with a sufficient accuracy. However, some phenomena such as katabatic flows that have been observed in the measurement campaigns could not be reproduced by the model due to the model physics used. This problem is not of a physical nature, but a problem of limited computer resources not allowing to resolve these sensible wind flows. Overall, it has been proved that ENVI-met is a reliable tool to simulate the different urban scenarios to be designed in the framework of the BUGS project .

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