The Influence of Green Areas and Building Characteristics on the Air Temperatures during Extreme Heat Events in Berlin, Germany

S. Schubert[1]*, S. Grossman-Clarke[1]

[1] Potsdam Institute for Climate Impact Research

*sebastian.schubert@pik-potsdam.de, Tel.: +49-(0)331-288-2592

We estimate the **influence of possible adaption measures** of the city of Berlin to **Extreme Heat Events** (EHE). Here, we focus on the influence of **vegetation** and the **albedo of roofs** on near surface air temperatures during an EHE, which are simulated using the mesoscale climate model COSMO-CLM (CCLM) and the online coupled urban Double Canyon Effect Parametrization Scheme (DCEP). First, we introduce the models CCLM and DCEP. Second, we describe the derivation of urban input parameter for the city of Berlin and last, we present results of simulations with modified urban parameters.

1. Mesoscale Climate and Weather Model CCLM

The CCLM model is a non-hydrostatic limited-area regional climate model developed from the operational weather forecast Local Model (LM) of the German Weather Service (Steppeler et al. 2003) by the CLM-Community. Since 2005 it has been the Community-Model of the German climate research. Meanwhile it is used and further developed by several other weather services organized in the COnsortium for Small-scale MOdelling (COSMO). In this sense the COSMO-CLM or CCLM model system is a unified model system for Numerical Weather Prediction and Regional Climate Modelling.

2. Multilayer Street Canyon Model DCEP

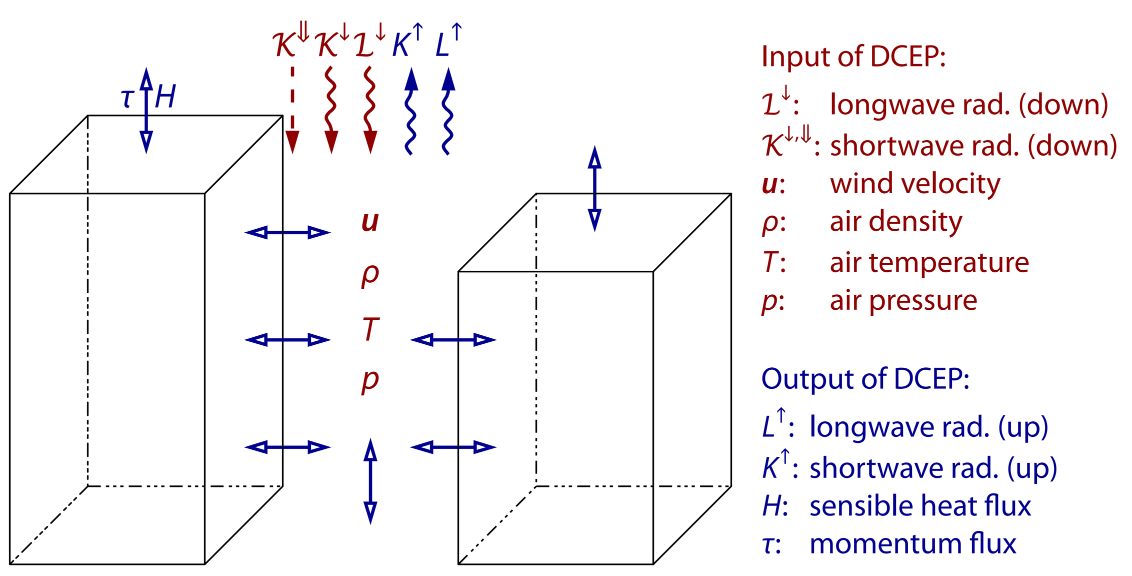

Figure 1: *Summary of the input and output variables of DCEP. A street canyon is characterized by its street and building width, a building height distribution and a street orientation.*

DCEP (Schubert et al. 2012, accepted) is based on the Building Effect Parametrization model by Martilli et al. (2002).

Features:

- **reduced sky visibility** and **reflections and emissions** from other urban surfaces (roofs, walls, roads)
- **effects of urban surfaces on wind fields, temperature and TKE**
- **modified turbulent length scales**

Compared to BEP, DCEP

- differentiates between **direct and diffuse solar radiation**,
- **conserves the radiative energy** and
- **includes the roofs into the radiative exchange** between the urban surfaces.

3. Building Parameters for Berlin

Highly detailed 3d building data in CityGML format (>460 000 buildings) is available for Berlin (fig. 2). We developed an algorithm to **derive urban input parameters** from this data **for every grid cell** of the regional climate model (e.g. fig. 5).

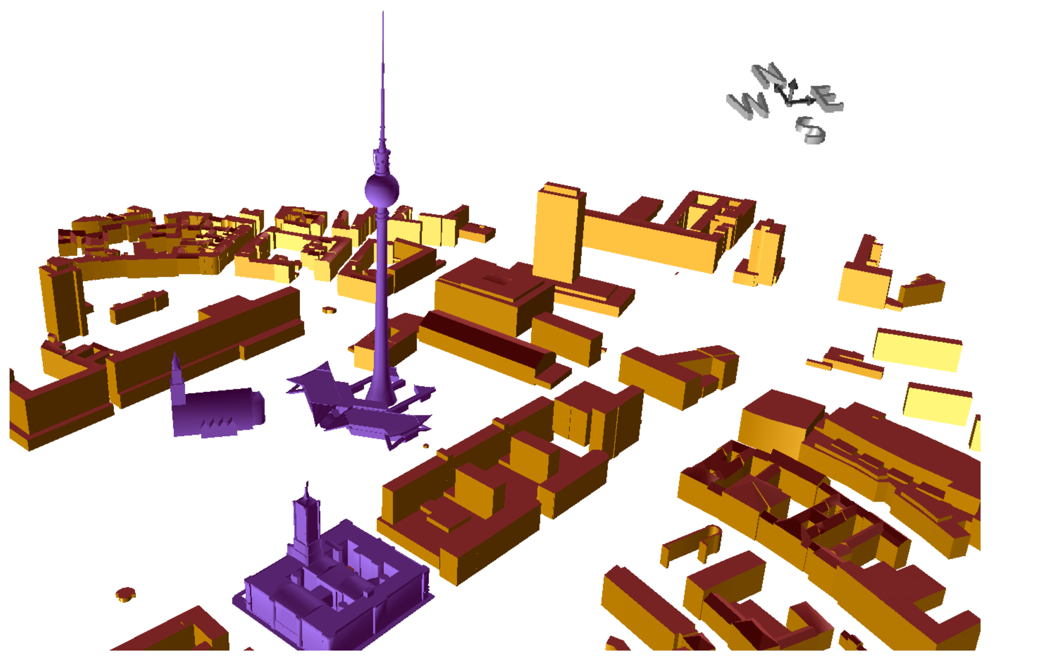

Figure 2: *Rendered example of the 3d data of Berlin in CityGML format*

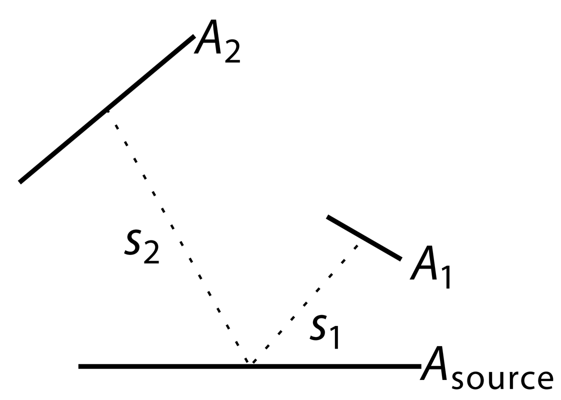

Figure 3: *Averaging of street widths. In this example, the distances s_1 and s_2 between the "source area" and the "receiving areas" are weighted by A_1 and A_2, respectively.*

The effective urban parameters for DCEP are calculated using the following approach:

canyon length is defined by the model's grid size

urban fraction (fig. 4) is set to the impervious surface coverage of the cell

building height probability is determined by the distribution of building heights weighted by the respective ground area

canyon angle of a wall surface is defined by the normal of that surface projected onto the horizontal

street width (fig. 5) is calculated from the average distance to other wall surfaces which are visible to each other (see fig. 3)

building width (fig. 6) follows directly from the requirement that the total building and street surfaces of the simplified model equal that of the input data

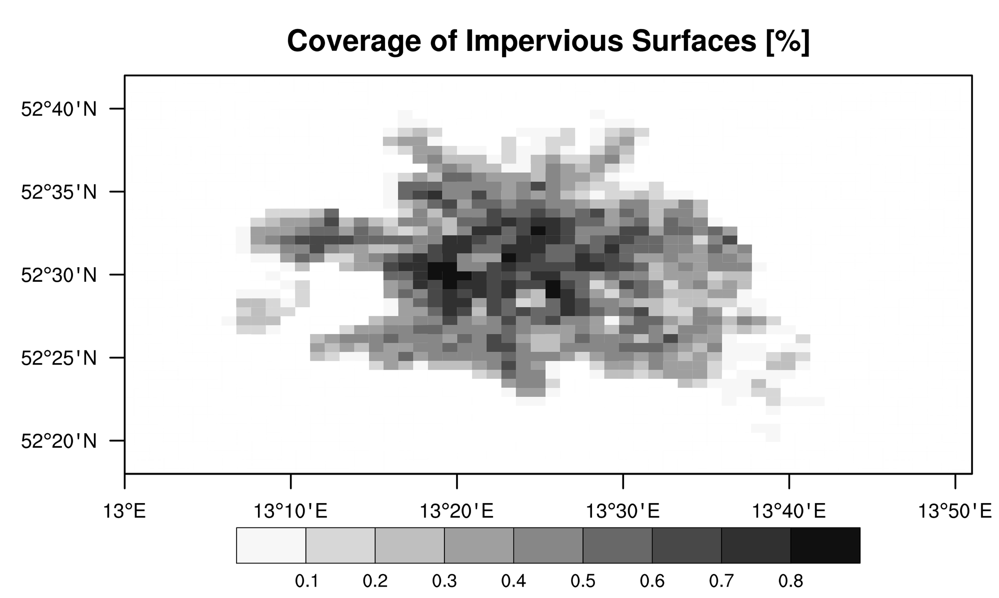

Figure 4: *Street width in Berlin derived from 3d CityGML data*

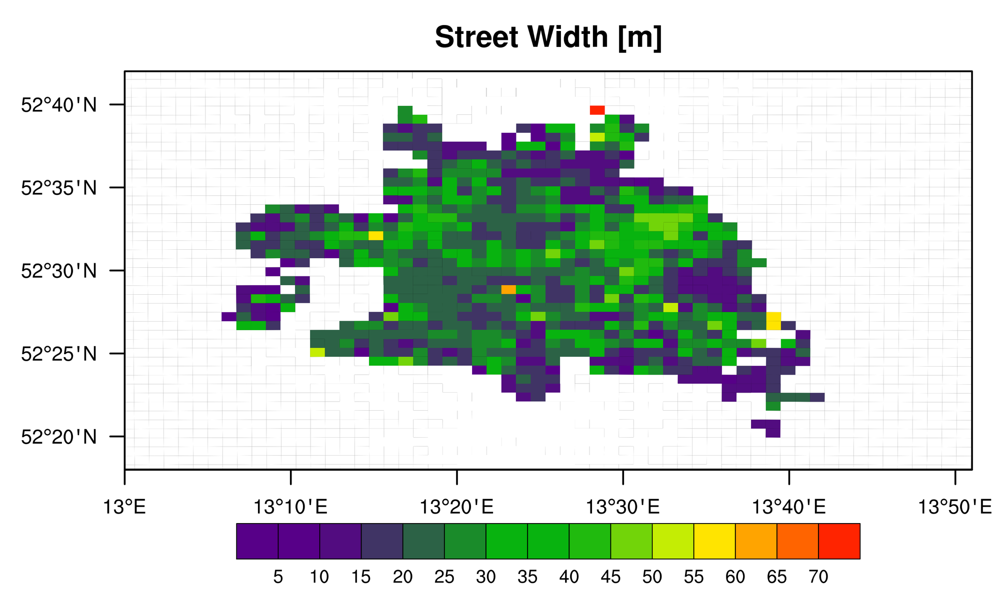

Figure 5: *Street width in Berlin derived from 3d CityGML data*

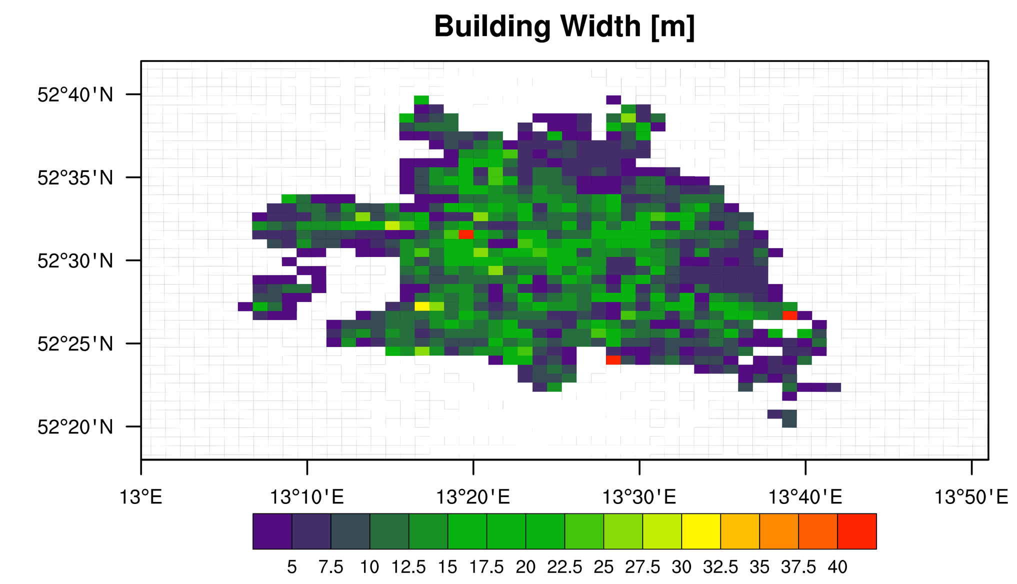

Figure 6: *Building width in Berlin derived from 3d CityGML data*

4. Adaptation Measures

We conducted CCLM simulations with one way nested grids of resolutions of approx. 25 km (without DCEP), 7 km (without DCEP), 2.8 km (with DCEP) and 1 km (with DCEP) for the EHE in 2003. The initial and 6 hourly boundary conditions are provided by ERA-Interim reanalysis data (Dee et al. 2011). All nesting steps used spectral nudging (Rockel et al. 2008). The initial soil water content for the 25 km resolution run was taken from a simulation with the same setup as the 25 km run starting in January 1995.

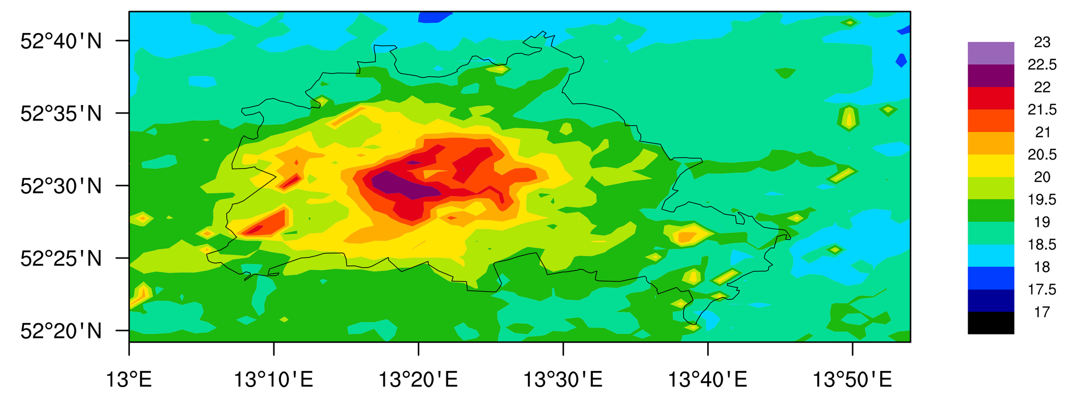

Figure 7: *Urban heat island of Berlin, 2003-08-10 5am CET as simulated with CCLM and DCEP with a resolution of 1 km.*

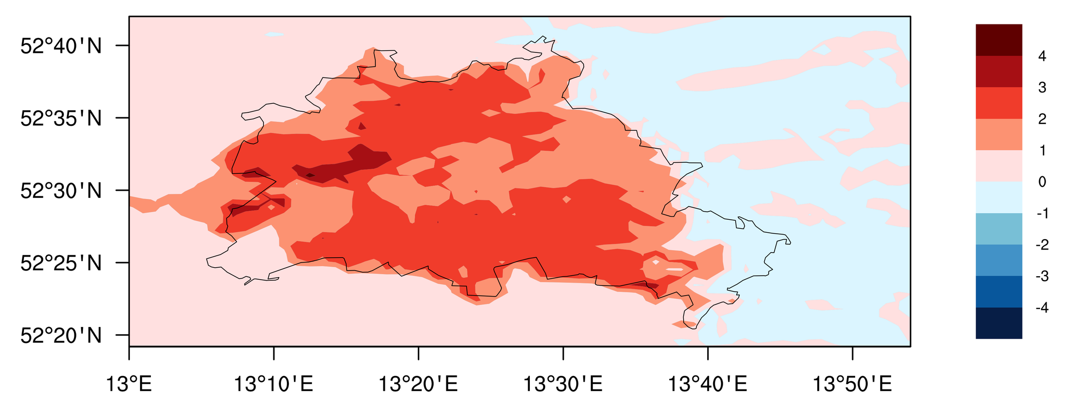

Figure 8: *Temperature increase in Berlin, 2003-08-10 5am CET, when simulated with no vegetation in the urban grid cells compared to the reference simulation in fig. 7*

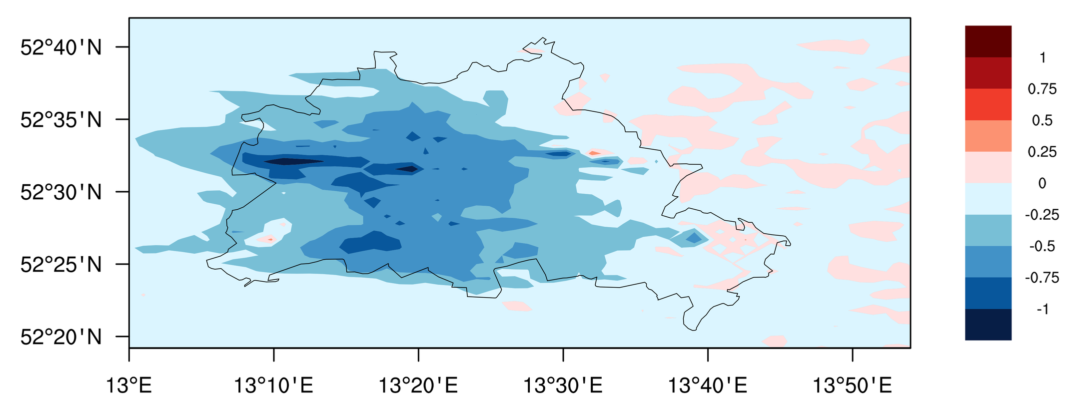

Figure 9: *Temperature differences in Berlin, 2003-08-10 12pm CET (noon), when simulated with a roof albedo of 0.65 compared to the albedo of the reference simulation of 0.18 in fig. 7*

5. Acknowledgements

We like to thank the city of Berlin for the supply of the 3d Berlin data as well as the European Union for supporting the creation of this data through the European Regional Development Fund. Furthermore, the map of the impervious surface coverage is based on data from the Urban and Environmental Information System of the Senate Department for Urban Development of Berlin.