An urban surface scheme and derivation of its parameters

Sebastian Schubert

Potsdam Institute for Climate Impact Research

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

The **multi-layer building energy parameterization** scheme (BEP) by Martilli et al. (2002) is currently implemented into the mesoscale weather and climate model CCLM to enhance its application to cities. CCLM operates on a latitude longitude grid with a rotated pole of grid sizes of at least 1 km^2. Consequently, BEP needs **effective urban morphology data** for that grid size to parametrize subgrid-scale effects.

1. Description of BEP

1.1 Street Canyon Model

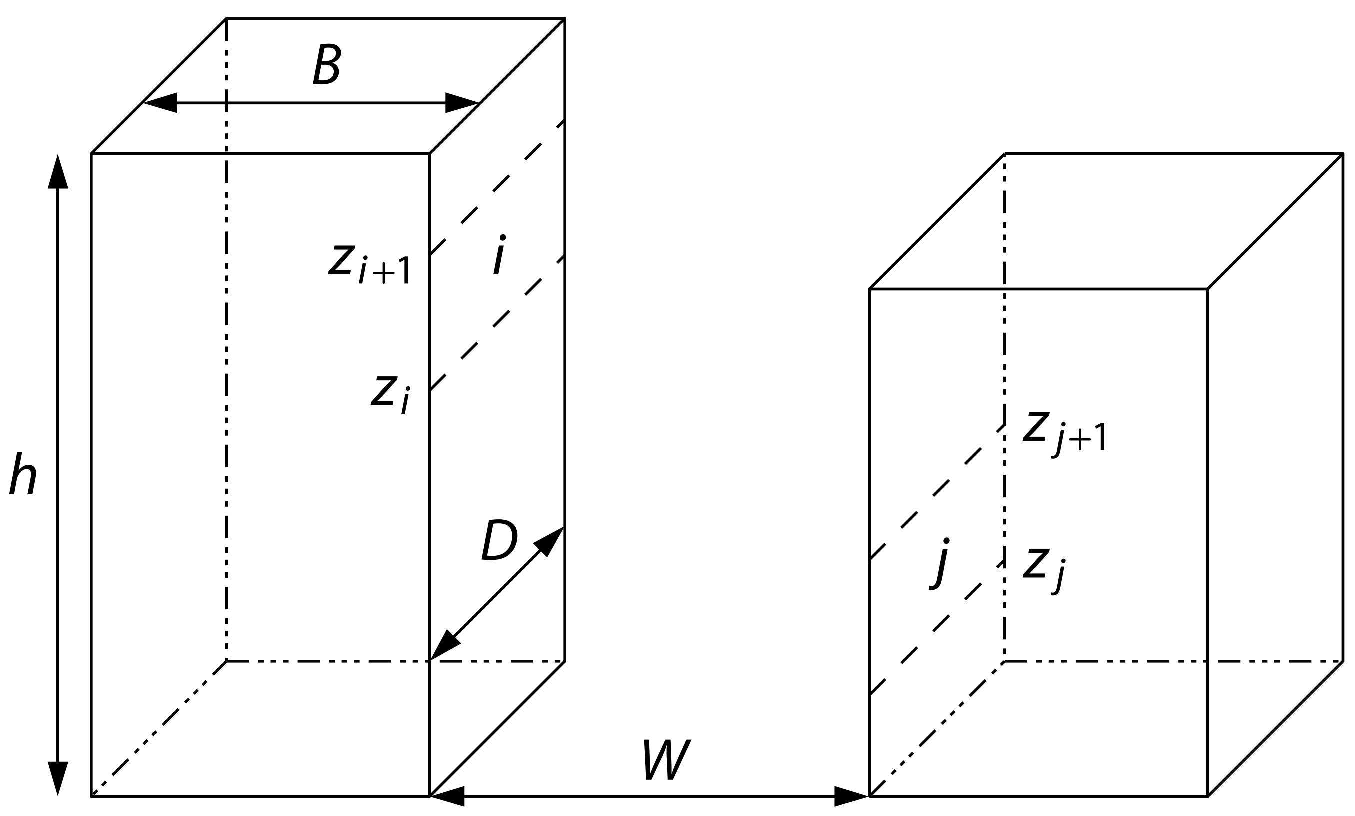

Figure 1: *Basic urban street canyon model (Martilli et al. 2002):* ***building width*** *B,* ***street width*** *W and* ***canyon length*** *D. For every grid cell, the* ***distribution of the height*** *h of the building is given by $\gamma(h)$. The urban layer is divided in several height levels i. Further parameters:* ***canyon angle*** *χ relative to north-south direction,* ***urban fraction*** *F in a grid cell.*

1.2 Physical Processes

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

2. Derivation of urban parameters

Former studies using BEP or similar schemes used the urban class approach (e.g. Grossman-Clarke et al. 2005), i.e. each grid cell consists of several kinds of urban classes and each class is defined by several typical parameters; alternatively, only a small region of the city was analysed (e.g. Ratti et al. 2002). Highly detailed urban building data in the CityGML format (Gröger et al. 2008) is available for Berlin (e.g. fig. 2) and can be used to **derive different urban input parameters for every grid cell**. The programme for this purpose is written in Java and uses the citygml4j library.

The grid size and the street directions considered for the model run are set by the user. These parameters define the **canyon length** *D*. By definition of BEP, the urban fraction of a cell corresponds to 100 % impervious surface coverage. Therefore, the **urban fraction** *F* in a cell is set to the impervious surface coverage of the cell (fig. 3). This is the only parameter which cannot be concluded from a building only CityGML data set. The **fraction cover of buildings** A_B is given by the area of the building's ground surfaces (fig. 4); the **fraction of street surfaces** A_S is given by $A_S = F - A_B$. The **building height probability** $\gamma(h)$ (e.g. fig. 5) is determined by the **distribution of building heights weighted by the respective ground area**. Here, the heights of the several roof levels of a building are averaged (weighted by the roof surface size of the level) to define *the* height of a building.

The **normal of a wall surface** is projected onto the horizontal plane to define the **canyon angle** χ of that surface and the **street width** *W* is calculated from the **average distance to other wall surfaces** which are visible to each other (fig. 6). For simplicity, visibility in this case is defined only with respect to the centroids of the walls' polygons. The **building width** *B* (fig. 7) follows directly from the requirement that the total building and street surfaces of the simplified model equal that of the input data (Martilli 2009), which results in

$$\frac{A_B}{A_S} = \frac{B}{W}, \qquad (1)$$

$$\Rightarrow B = \frac{A_B}{F - A_B} W. \qquad (2)$$

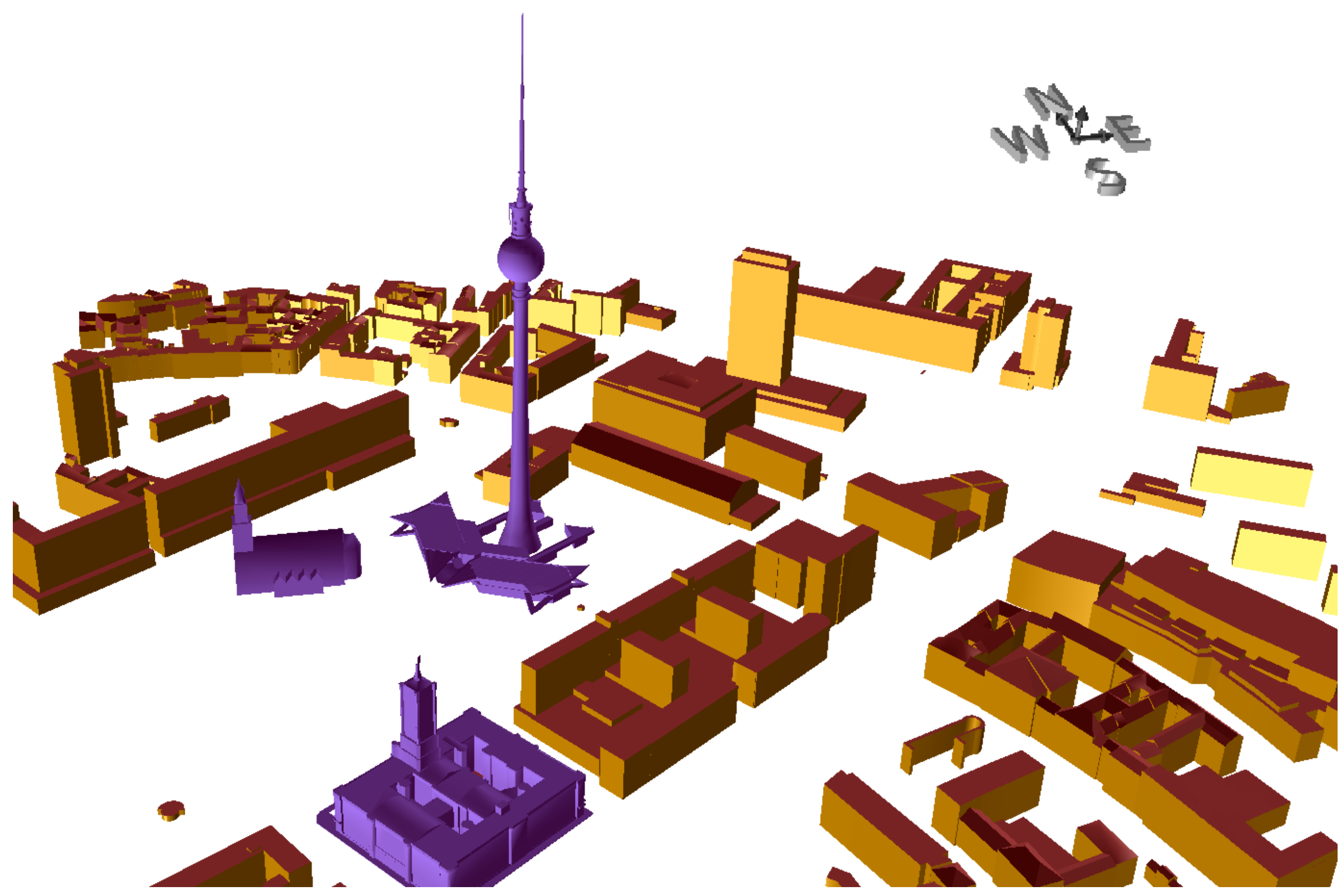

Figure 2: *Rendered example of the 3d data in CityGML LOD2 format used to derive the urban parameters: Berlin Alexanderplatz and the TV tower*

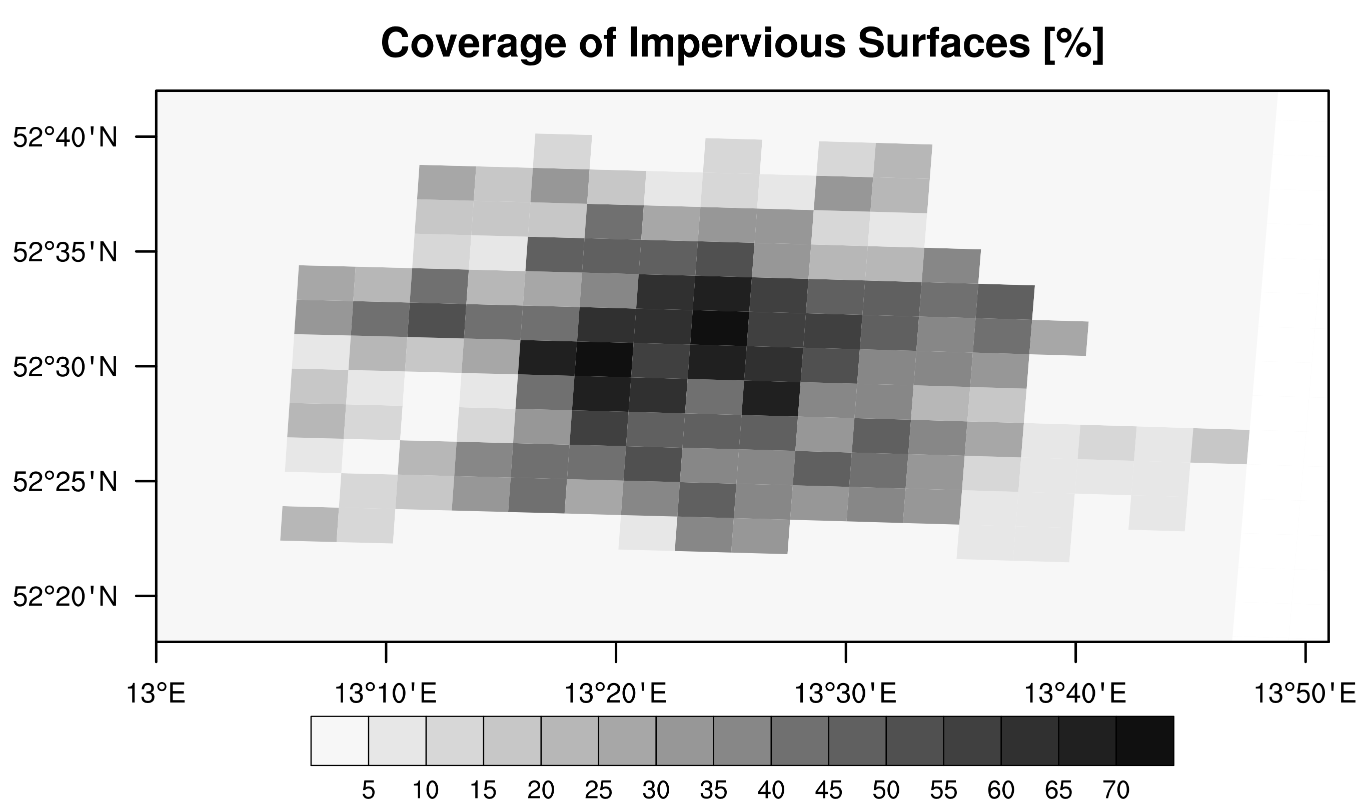

Figure 3: *Impervious surfaces coverage in Berlin. This value is used to define the urban fraction F.*

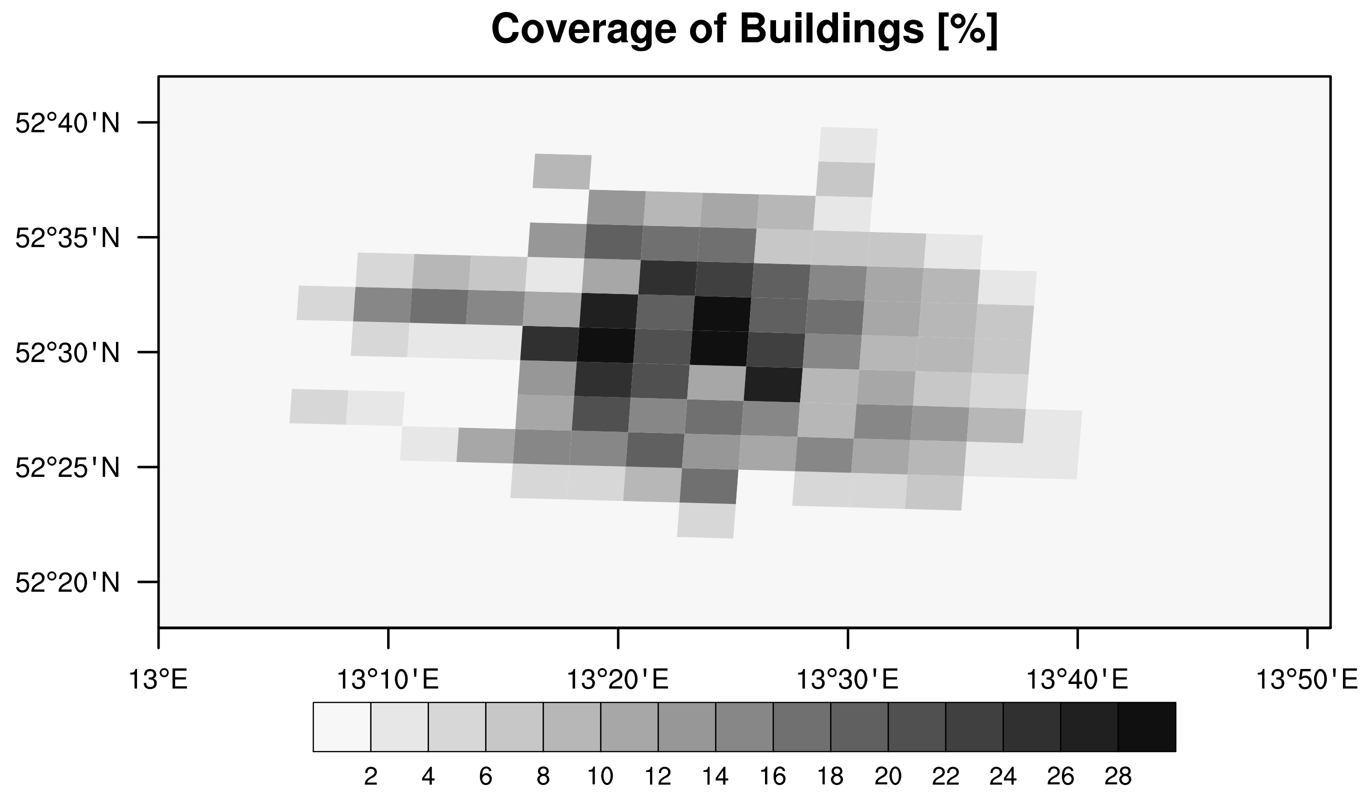

Figure 4: *Fraction of buildings A_B in Berlin defined by the ground surfaces of the buildings.*

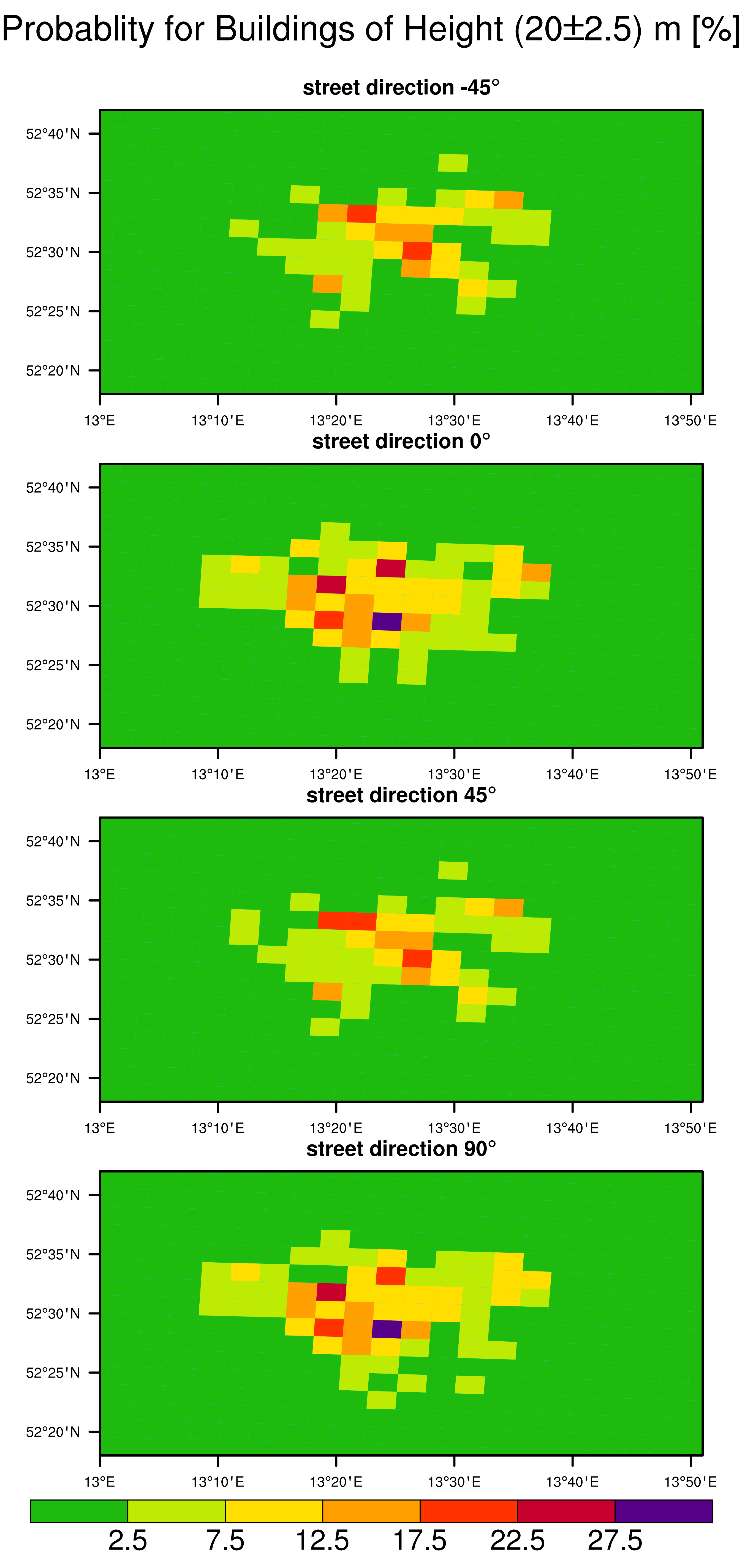

Figure 5: *Probability of buildings $\gamma(20\,\mathrm{m})$ to have a height $(20 \pm 2.5)\mathrm{m}$ for different canyon angles relative to the north-south direction in Berlin. Note that distributions for angles which are 90° apart are similar.*

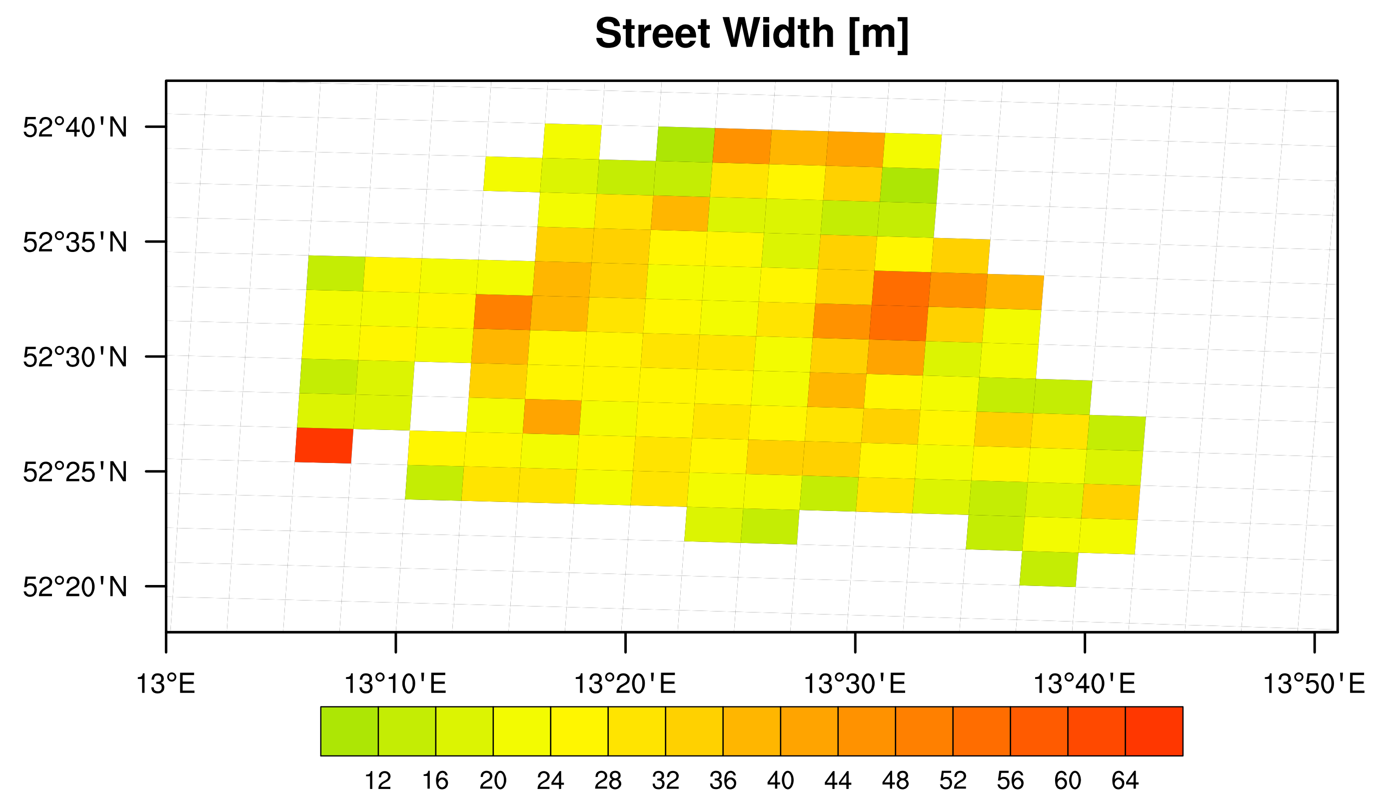

Figure 6: *Street width W for canyons with a north-south direction in Berlin calculated from the average distance of wall surfaces.*

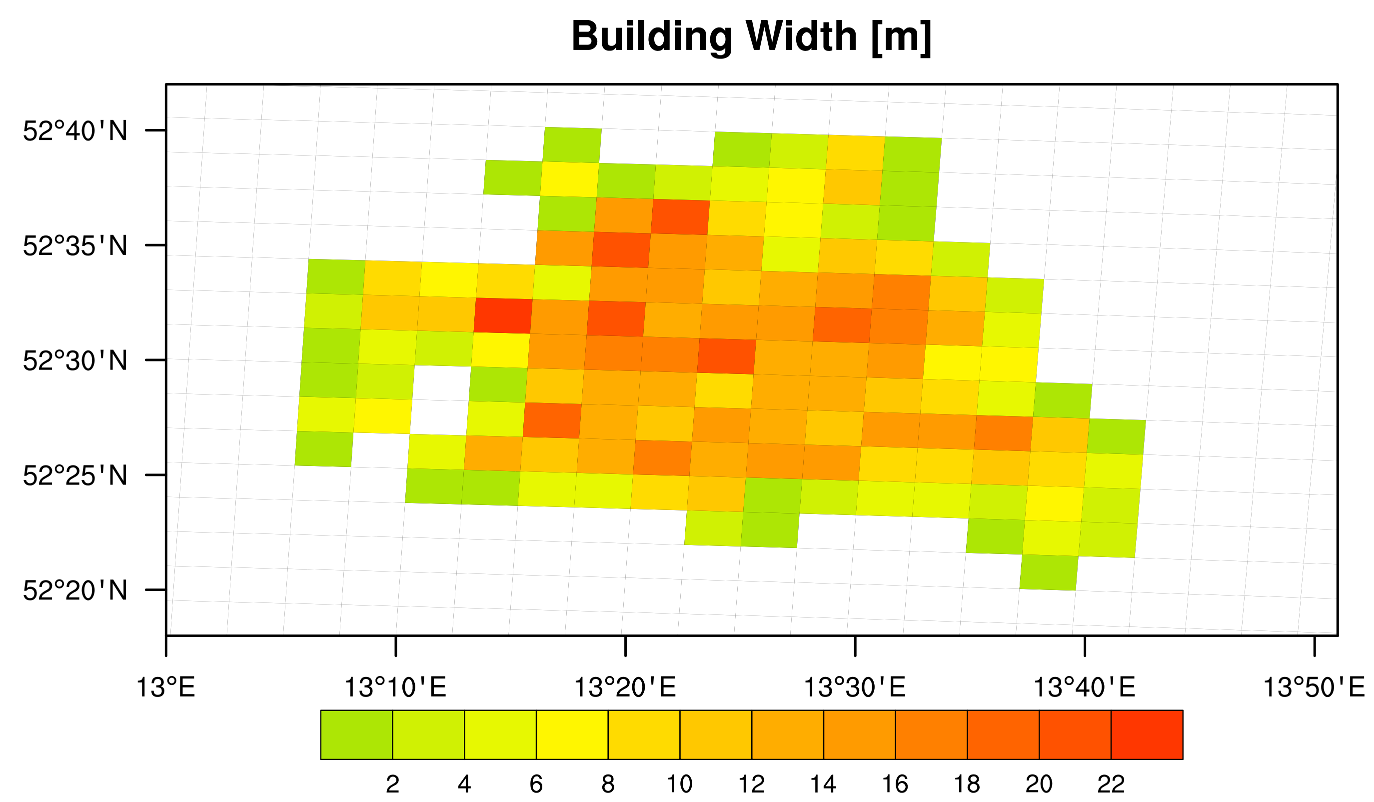

Figure 7: *Building width B for canyons with a north-south direction in Berlin calculated from eq. (2).*

3. Acknowledgements

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