An Urban Surface Scheme and Input Parameters

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The **multi-layer building energy parameterization** scheme (BEP) by Martilli et al. (2002) is currently implemented into the CCLM to enhance the application of the model to cities.

1. Description of BEP

1.1 Street Canyon Model

BEP uses a simplified model of buildings. The **urban fraction** part of every CCLM grid cell consists of **street canyons** with the length of the cell D, which are characterized by

- the **building width** B and
- the **canyon width** W (cf. fig. 1),
- the **street angle** ζ (cf. fig. 2) and
- a **height level and direction dependent building probability** $\gamma(h)$.

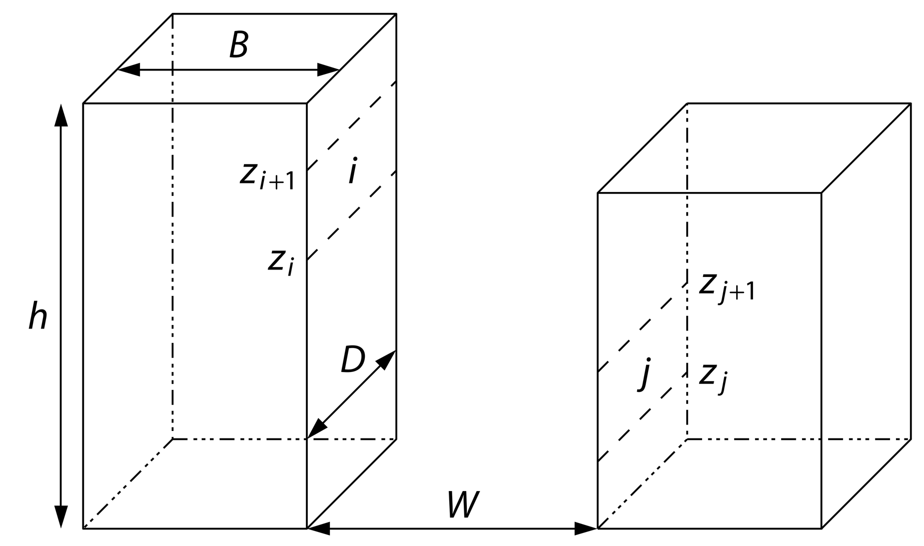


Figure 1: *Basic urban street canyon model (Martilli et al. 2002)*

1.2 Physical Processes

With these street canyon parameters, the following effects are considered:

- **reduced sky visibility** (cf. fig. 3(b)) and **reflections and emissions** from other urban surfaces (roofs, walls, roads) to calculate radiation budget at every building height level,
- **one dimensional heat diffusion** to determine the surface temperature of every urban surface,
- effects of horizontal and vertical urban surfaces on wind fields, temperature and TKE, which result in **additional tendency terms** in the governing equations,
- **modified turbulent length scales** to incorporate the size of the buildings.

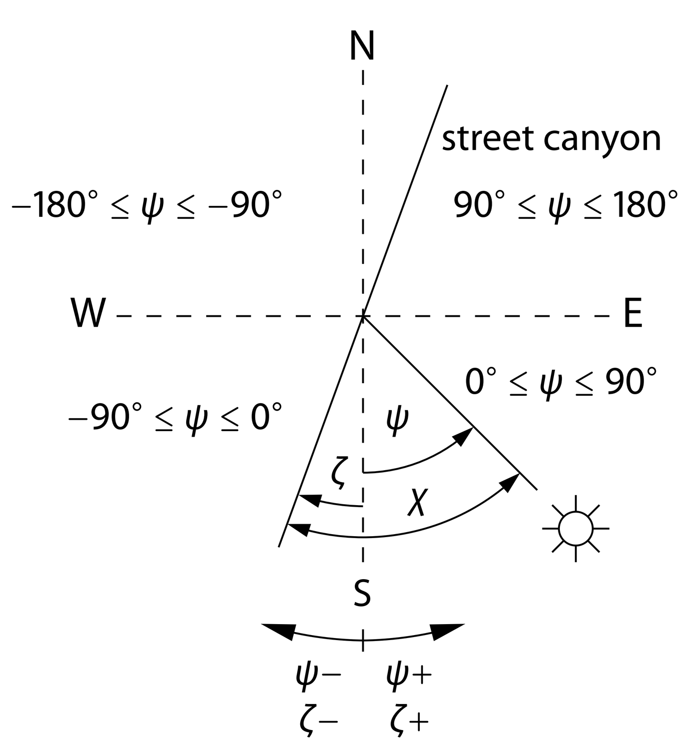
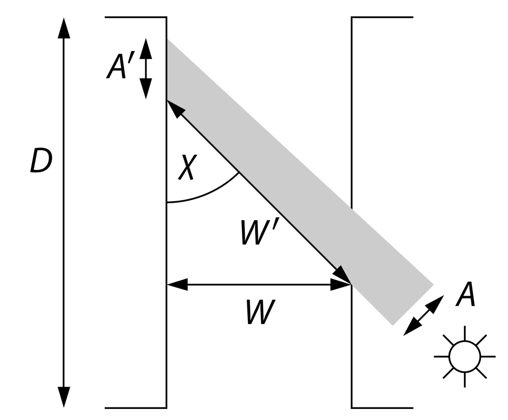
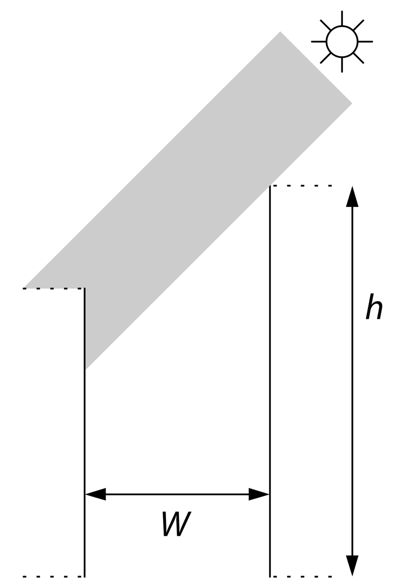


Figure 2: *The angle χ between the urban street canyon and the sun is calculated from the street direction ζ and the solar azimuth ψ.*



(a) View on the street canyon from above



(b) View on the street canyon from the side

Figure 3: *Visualization of the effective sunlit wall surface A' and canyon width W' in (a) and the shade effect in (b)*

1.3 Implementation and Enhancements

In the CCLM implementation, we will test potential enhancements of BEP (partly depicted in fig. 4):

- **treat roof surfaces consistently** with other urban surfaces for radiation processes,
- consider the **vertical distribution of buildings in the radiation transfer scheme of CCLM**, which offers the possibility to make urban radiation processes dependent on the wavelength,
- look for numerical techniques to **increase the calculation speed**,
- research **alternative street canyon representations** which include vegetation.

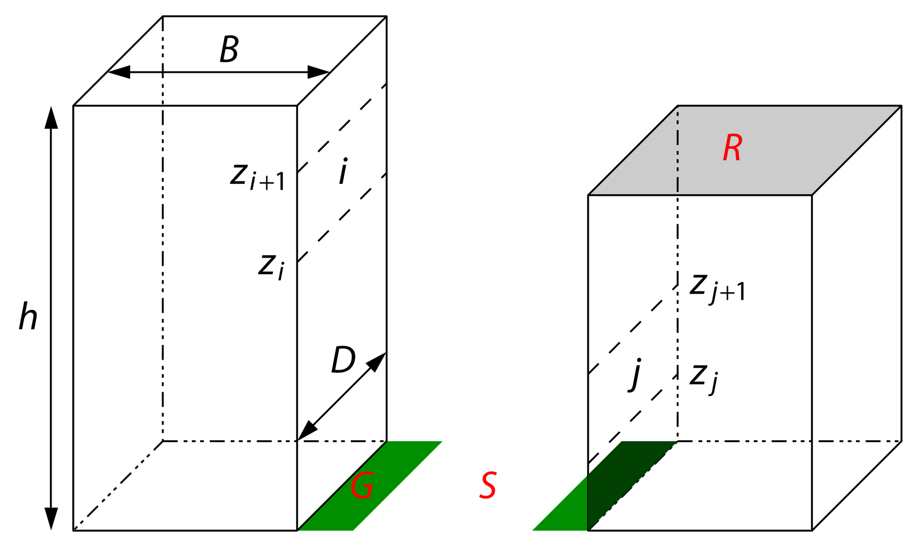


Figure 4: *Planned model enhancements (compare with fig. 1)*

2. Derivation of urban parameters

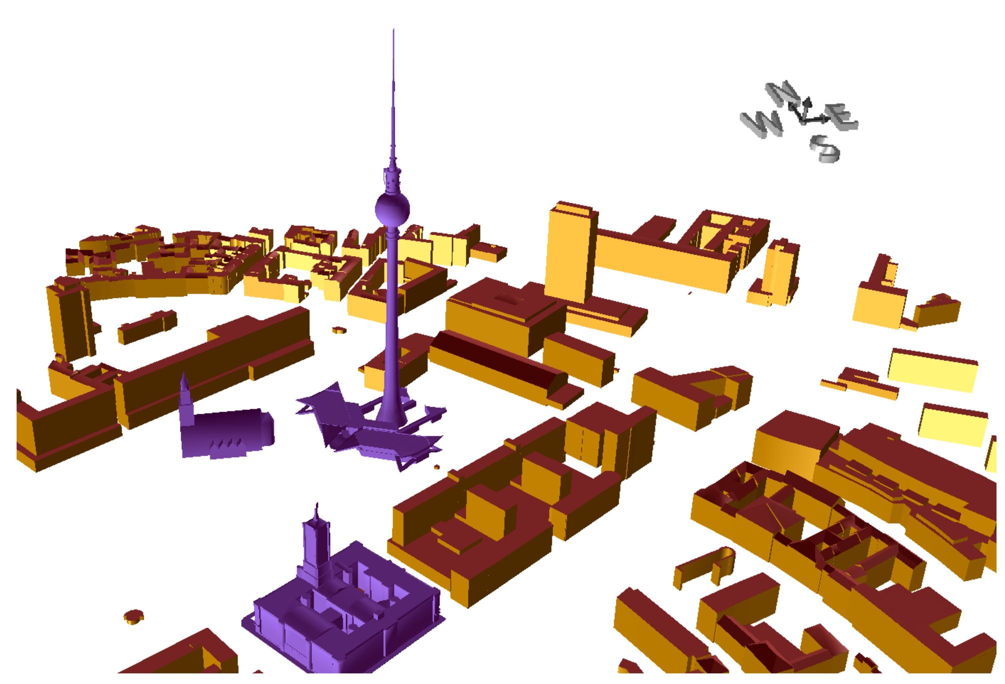


Figure 5: *Example of the 3d data used to derive the urban parameters: Berlin Alexanderplatz and the TV tower*

Highly detailed urban building data (e.g. fig. 5) can be used to **derive different urban input parameters for every grid cell**. The following keynotes describe our ansatz to determine the urban parameters:

- fraction cover of buildings: area of the building's ground surfaces (fig. 6),
- building height probability $\gamma(h)$: area weighted heights of the buildings (cf. fig. 7),
- street direction ζ: direction of wall surface,
- canyon width W: weighted average distance to other wall surfaces,
- other parameters: use the assumption that the total roof and ground surface of the buildings in every grid cell is equal to that in reality (Martilli 2009).

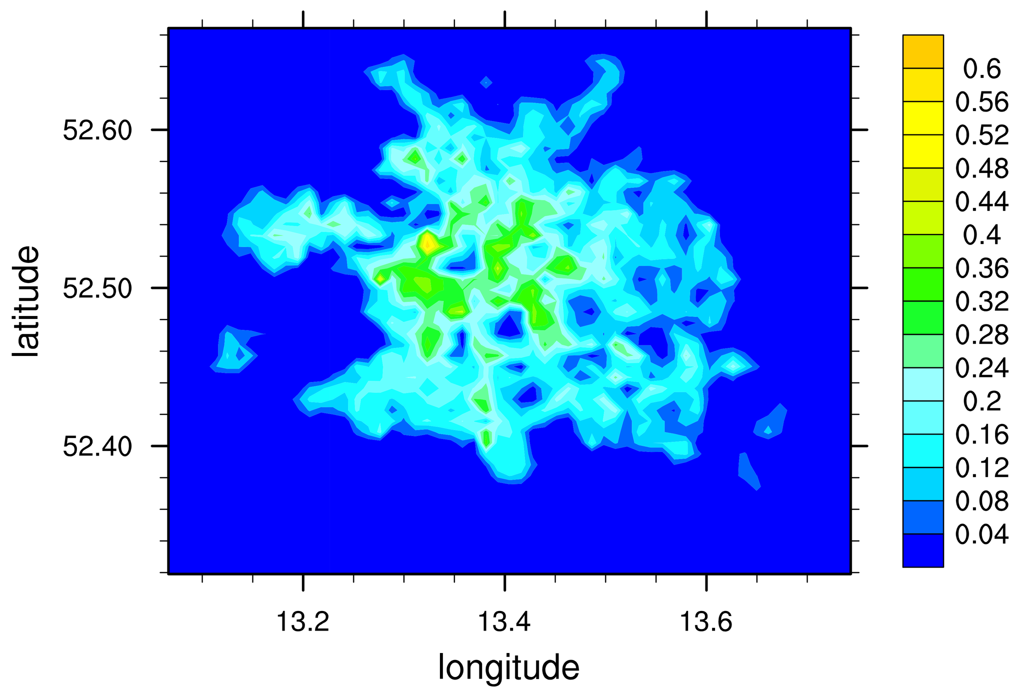


Figure 6: *Fraction of buildings in the city of Berlin (meridional grid spacing: 0.0069°, zonal grid spacing: 0.0117°)*

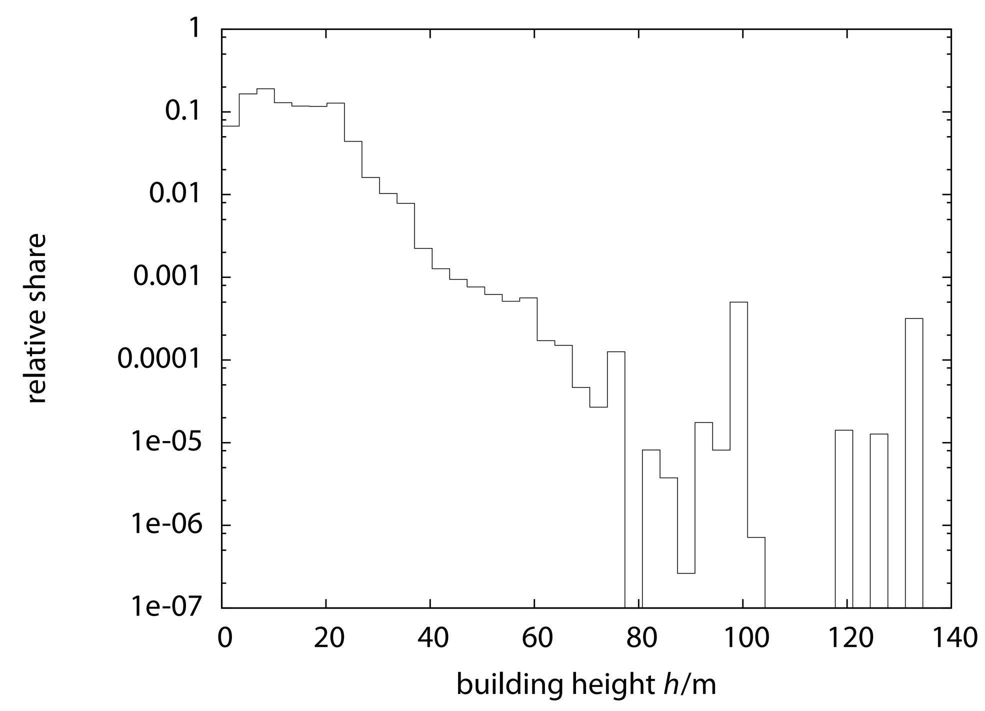


Figure 7: *Distribution of building heights in the city of Berlin (note the semi-logarithmic scale)*

3. Acknowledgements

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References

Martilli, A. (2009). 'On the Derivation of Input Parameters for Urban Canopy Models from Urban Morphological Datasets'. In: *Boundary-Layer Meteorology* 130.2, pp. 301–306.

Martilli, A., A. Clappier and M.W. Rotach (2002). 'An urban surface exchange parameterisation for mesoscale models'. In: *Boundary-Layer Meteorology* 104.2, pp. 261–304.