

Zooming In: The Importance of Detail in PALM Urban Climate Modelling

Sensitivity of the PALM model to different input data sources and urban parametrisations

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In Short

- Microscale modelling provides detailed insight into urban thermal conditions
- Requirement of detailed input data for reliable model results in conflict with data availability
- Exploring alternative, open datasets to generate urban surface description within the PALM model
- Testing the applicability of urban parametrisation schemes at different spatial resolutions

Urban areas represent a profound transformation of the natural environment, leading to significant changes in air temperature, wind patterns, and pollutant concentrations. One of the most well-known effects is the urban heat island phenomenon, where cities tend to be warmer than their rural surroundings, particularly at night. This effect is not uniform; it varies both spatially and over the course of the day within the city. When combined with hot summer days, the urban heat island can intensify heat stress and increase health risks for urban populations. To better understand these complex thermal conditions, microscale urban climate models are used that can simulate how temperatures and other climate factors change across a city and over time. One widely used tool is the PALM model system, which is capable of modelling urban climates at very fine scales while also accounting for broader regional weather effects. The accuracy of PALM has been demonstrated in wind tunnel experiments and real-world measurement campaigns, showing that it can reliably reproduce observed temperature patterns. The model has further been evaluated with crowdsourced air temperature. This approach proved valuable as the crowdsourced data has a high spatial and temporal resolutions and reduces the dependency of model evaluation on measurement campaigns and traditional measurement networks. Figure 1 shows the model evaluation with crowdsourced data for a summer period in the city of Dortmund.

The model's performance is highly sensitive to how the urban surface is described - factors such as surface materials and soil moisture can significantly

influence the results. Therefore, providing detailed and accurate information about the urban environment is essential for generating reliable model outputs.

In Germany, high-resolution and high-quality geographic datasets are freely available, enabling detailed simulations. However, such datasets are not always accessible or may be costly to obtain in other parts of Europe and the world. In these situations, researchers must turn to alternative datasets or use urban parameterisation schemes, which simplify the representation of the city to make simulations possible with less detailed data. On the European scale, many alternative datasets can be acquired from the Copernicus Land Monitoring service. Many datasets are created from satellite remote sensing sources. Their finest available spatial resolution is 10 m. At a global scale, the datasets are also often generated from satellite remote sensing. However, the datasets are usually produced at coarser resolutions of 30 to 100 metres. Additionally, citizen science projects like the OpenStreetMap project generate data which can be used to derive a description of the urban surface. Urban parameterisation schemes in PALM include the DCEP (Double-Canyon Effects Parametrization) and SLUrb (Single Layer Urban canopy model) schemes. Both schemes describe the three-dimensional structure of the city without explicitly resolving it. A third option is the Local Climate Zone (LCZ) wizard. LCZs describes the urban form and fabric on a spatial scale of a few hundred metres and characterise it in terms of e.g., building height and density as well as fraction of impervious and pervious surfaces. The LCZ wizard enables the generation of a generic three-dimensional urban description for PALM based on LCZ maps. Despite their practical importance, the impact of using lower-quality or less detailed input data on the reliability of model results has not yet been fully quantified.

The proposed project aims to assess the usefulness of alternative datasets and urban parameterisations for producing reliable urban climate simulations. The first part of the project will explore alternative, open datasets which are available on the European to global scale to determine how well they can be used to describe the urban surface in the PALM model. The second part will investigate different urban parameterisation schemes that allow for simulations without explicitly resolving the full three-dimensional structure of the city, thus reducing the need for highly detailed data. These alternative approaches will be

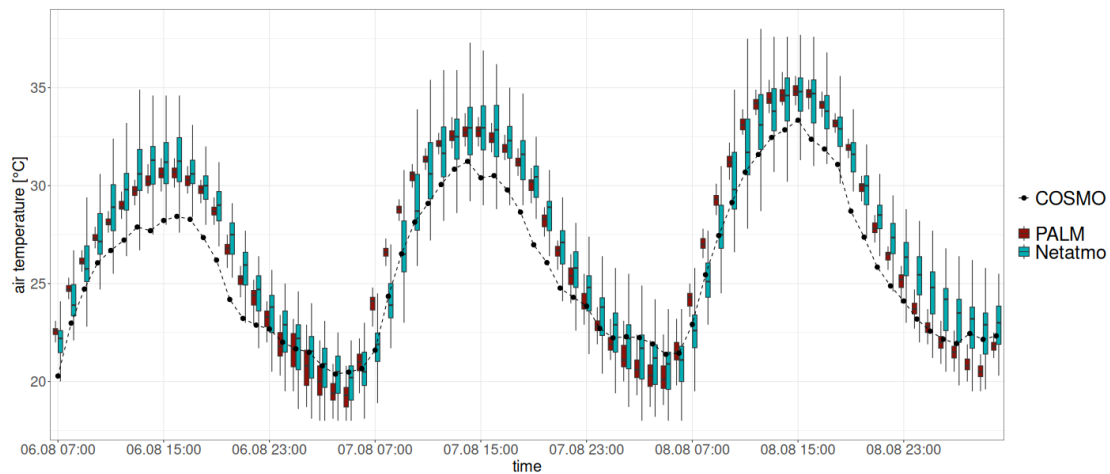


Figure 1: Boxplot timeseries of PALM modelled air temperature (red boxes) and crowdsourced air temperature data (blue boxes) for a three-day summer period in Dortmund in August 2020. Black line denotes the air temperature boundary conditions derived from the COSMO-D2 model.

systematically compared against a baseline scenario created using high resolution and high-quality data. The modelling domains will cover a range of spatial resolutions, from 64 metres down to 2 metres, allowing for an evaluation of which approaches are best suited for different levels of detail.

The study area for this project is the city of Dortmund, chosen due to previous modelling work and the recent establishment of a new measurement network. Model results from each scenario will be evaluated using crowdsourced air temperature data, which have proven valuable in previous studies in Bochum and Vienna due to their high spatial and temporal coverage. Additionally, the new measurement network in Dortmund will provide further data on humidity and thermal comfort, recognising that air temperature is only one aspect of heat exposure. The overarching goal of the project is to develop a best-practice guide that outlines which datasets and urban parameterisations should be used depending on the spatial resolution and modelling objectives. This guide will support both researchers and urban planners in selecting the most appropriate methods for their needs, ultimately advancing the application of urban climate model PALM in both scientific research and practical planning contexts.

WWW

<https://www.geographie.ruhr-uni-bochum.de/klima/index.html.de>

More Information

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DFG Subject Area

313-01 and 317-01