# Assessment of the urban aerosol distribution and emissions from domestic heating

**Urban air quality modelling within the MOSAIK II project - An enhanced aerosol description for PALM-4U**

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## In Short

- Urban air pollution is a major environment issue and is associated with significant global impact on human health and disease burden
- Numerical modelling can provide insights into physical and chemical processes of gas-phase pollutants and help formulate effective mitigation strategies
- LES models such as PALM-4U enable urban-scale air quality simulations to be conducted with high accuracy and realism, provided that they are conducted at a very high spatial resolutions over a large region of interest
- Various aerosol models are available to calculate equilibrium composition, phase state, and size distribution of various aerosols with gas-phase precursors, which could be integrated into PALM-4U
- As part of the MOSAIK-II project, the capability of the newly implemented PALM-4U chemistry and emission modules will be extended to include enhanced aaerosol description

Urbanization has led to rapid displacement of the natural environment, as well as an elevated, concentrated consumption of resources and energy, resulting in severe air pollution. The World Health Organization (WHO) estimates that air pollution alone is responsible for seven million premature deaths worldwide each year. As a result, plans for future-oriented and sustainable development are urgently needed in urban areas to ascertain existing standards of living for inhabitants in a clean and safe environment. To this end, numerical modelling can provide valuable insights into the emission, dispersion, chemical transformation and removal processes of air pollutants in urban canopies, allowing sound, effective mitigation measures to be conceived, developed, and implemented.

Further, accurate representations of these physical processes requires fine-scale turbulence-resolving simulations that can resolve urban structures, surface heat fluxes on building façades and ground surfaces, and terrain variations, which can be achieved using large-eddy simultion (LES) models, such as PALM-4U [1]. During the initial phase of the MOSAIK project, the PALM-4U model has been extended to include modules for gas-phase chemistry and traffic emissions [2], based on the kinetic preprocessor (KPP) [3], which allows numerical studies pertaining to urban air quality to be conducted. Several simulations have been performed for the city of Berlin with various available chemical mechanisms [4], as illustrated in Figure 1. However, due to resource constraints, most simulations are restricted to relatively coarse resolutions ($\Delta x \geq$ 10 m) and small region of interest ($\leq$ 2 km $\times$ 2 km), which produces only satisfactory results for diagnostic purposes. Thus simulations with larger domain size and finer grid resolutions are much more desirable to further develop, evaluate and explore of chemistry and emission modules of PALM-4U.

In particular, ambient aerosol concentrations are elevated in urban areas [5]. Aerosols are complex mixtures of primary and secondary particulate matters (PM), ranging from coarse (< 10$\mu$m), fine (< 2.5$\mu$m), and ultrafine (< 0.1$\mu$m) levels. Special attention is paid to ultrafine particles (UFPs), which upon inhalation can penetrate deep into the respiratory system and subsequently diffuse into other systems, such as the central nervous system. A limited number of modelling studies focus on UFPs [6], but none concerns the application the LES techniques to model pertinent physical and chemical processes of UFPs on an urban or city region scale. Models such as ISORROPIA [7], MARS [8], as well as others [9] are available for calculating equilibrium composition of phase state of various aerosols with gas-phase precursors, using bi-modal log-normal distribution to represent sub-micron particles, i.e., UFPs. These models could be integrated into the PALM-4U chemistry and emission modules.

Therefore, as part of the BMBF-funded project MOSAIK-II, the proposed project aims to extend the capabilities of the PALM-4U chemistry and emissions modules to include an enhanced description for aerosols, enabling modelling of PMs mass and concentrations as well as their sizing distributions down to UFPs and other components. Extensive

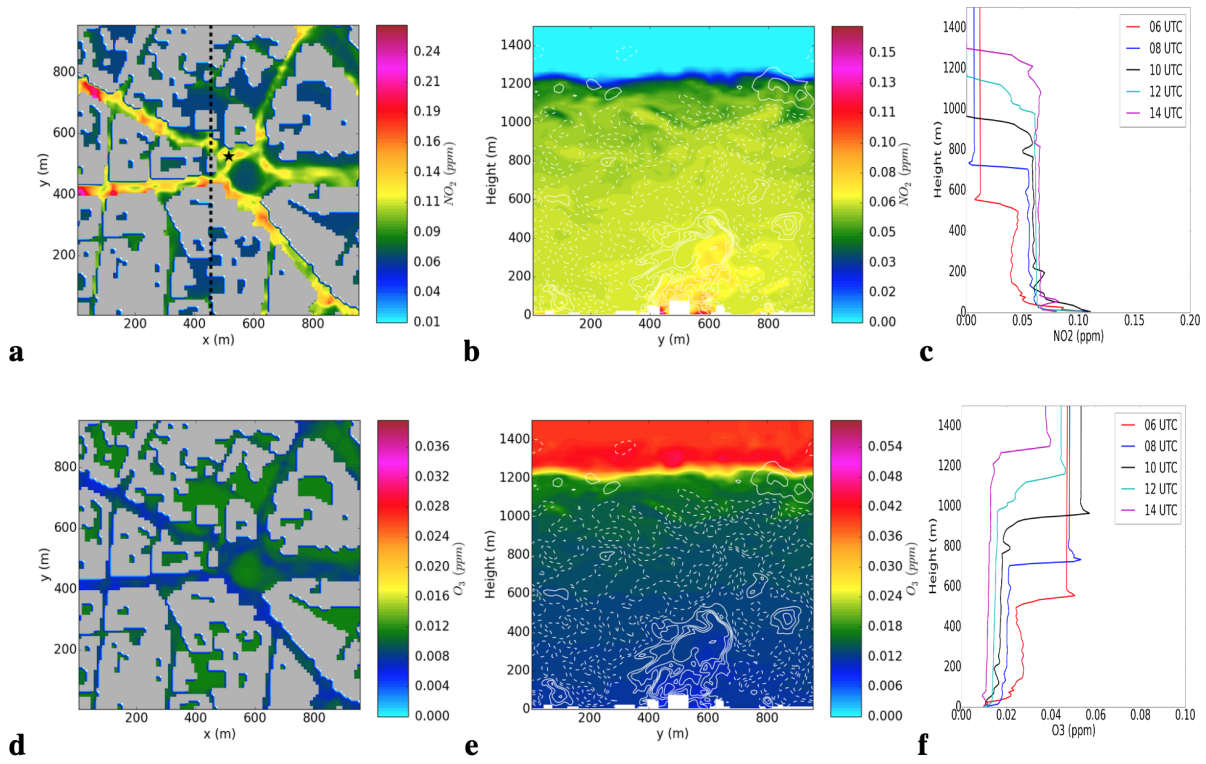


***Figure 1:*** *Simulated pollutant concentrations of (a-c) $NO_2$ and (d-f) $O_3$ over Ernst-Reuter-Platz (Berlin, Germany) at 13:30 UTC. (a,d) horizontal (X-Y) cross-section, with dashed line indicates location of vertical cross-section, and star marker indicates location of vertical profile; (b,e) vertical (Y-Z) cross-section; (c,f) vertical profiles at different simulation times. Adapted from [4].*

simulations will be subsequently conducted using PALM-4U at high resolution over a large region of interest to carry out sensitivity studies, with the intent of identifying the impact of urban development and urban emission sources on pollutant formation, transport, transformation, and removal.

## WWW

https://palm.muk.uni-hannover.de/mosaik/

## More Information


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## Project Partners

- Leibniz Universität Hannover
- Karlsruher Institut für Technologie
- Technische Universität Berlin
- Humboldt Universität zu Berlin
- Ludwig-Maximilians-Universität München
- Deutsches Zentrum für Luft- und Raumfahrt
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