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High-resolution urban air quality modelling using PALM 6.0

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Cities continue expanding and population densities increasing in the urbanizing world. This induces various environmental challenges such as decreased air quality and, in the warming climate, increased thermal stress. However, both these challenges can be mitigated with successful urban planning solutions that allow the ventilation of heat and pollutants out of street canyons and other city structures. Following the recent developments, the large-eddy simulation (LES) model PALM enables assessing urban air quality and ventilation in different planning solutions already in the planning phase.

Recently, an online chemistry module for gaseous species and a sectional aerosol module SALSA2.0 have been implemented into PALM. The gas-phase-chemistry is based on the Kinetic PreProcessor making it flexible in the choice of complexity. SALSA2.0 resolves the impact of coagulation, condensation, nucleation and dry deposition on the aerosol size distribution and chemical composition. Additionally, the description of radiative transfer and energy balance of urban surfaces, which can strongly affect the air flow, is being continuously improved. Hence, the complex interactions between the urban morphology, meteorological conditions and air pollution can be resolved.

In our recent studies, we showed how introducing variation to building height and limiting the street-canyon length could improve pollutant ventilation and air quality in a real urban neighbourhood. Furthermore, by implementing SALSA2.0, we illustrated that aerosol concentrations at the pedestrian level are dominated by the local wind conditions and emissions. Still, dry deposition on tree leaves and solid surfaces could decrease concentrations over 20%. At the same time, traditionally-positioned street trees decrease pollutant ventilation in street canyons. Our results suggest that the improvement of pedestrian-level air quality by aerosol dry deposition on vegetation is clearly weaker than its deterioration due to decreased ventilation. Aerosol concentrations demonstrate a negative correlation with the volume fraction of tree crowns in a street canyon.