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Parameterizing Urban Canopy Layer transport in an Lagrangian Particle Dispersion Model

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The percentage of people living in urban areas is rising worldwide, crossed 50% in 2007 and is even higher in developed countries. High population density and numerous sources of air pollution in close proximity can lead to health issues. Therefore it is important to understand the nature of urban pollutant dispersion. In the last decades this field has experienced considerable progress, however the influence of large roughness elements is complex and has as of yet not been completely described.

Hence, this work studied urban particle dispersion close to source and ground. It used an existing, steady state, three-dimensional Lagrangian particle dispersion model, which includes Roughness Sublayer parameterizations of turbulence and flow. The model is valid for convective and neutral to stable conditions and uses the kernel method for concentration calculation. As most Lagrangian models, its lower boundary is the zero-plane displacement, which means that roughly the lower two-thirds of the mean building height are not included in the model. This missing layer roughly coincides with the Urban Canopy Layer.

An earlier work “traps” particles hitting the lower model boundary for a recirculation period, which is calculated under the assumption of a vortex in skimming flow, before “releasing” them again. The authors hypothesize that improving the lower boundary condition by including Urban Canopy Layer transport could improve model predictions. This was tested herein by not only trapping the particles, but also advecting them with a mean, parameterized flow in the Urban Canopy Layer. Now the model calculates the trapping period based on either recirculation due to vortex motion in skimming flow regimes or vertical velocity if no vortex forms, depending on incidence angle of the wind on a randomly chosen street canyon. The influence of this modification, as well as the model’s sensitivity to parameterization constants, was investigated. To reach this goal, the model was initialized and compared with meteorological and SF_6 tracer measurements from the Basel UrBan Boundary Layer Experiment (BUBBLE).

The proposed modification does not improve the model’s agreement with concentration observations, even though the trapping time shows promising agreement with measurements. Additionally, the modification’s influence is smaller than those of different turbulence profiles, zero-plane displacement height and Roughness Sublayer height.