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Physico-Chemical Aerosol Dispersion in Urban Environments

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The spatial heterogeneity of urban street canyons and the complex interplay of chemically, spatially and temporally varying ultrafine particle emission sources as a function of micrometeorological and meteorological factors represents a challenge to both computational fluid dynamical modelling approaches and field observations. Intensive measurement campaigns or networks generally have insufficient spatial resolution or temporal resolution respectively to adequately represent the entire vertical or horizontal spatial structure of aerosol and these must be informed by numerical dispersion modeling combined with realistic aerosol physico-chemical descriptions to be of benefit to epidemiological studies. Predictions of vertical and horizontal structure of aerosols in street canyons are therefore required to inform future directives regarding recommended sampling and monitoring protocols.

Here we compare first-order eddy viscosity turbulence closure CFD predictions with recent measurement results demonstrating the impact of different relative contributions of convective and turbulent diffusivities on aerosol distribution profiles at different locations within street canyons.

We describe preliminary results with a CFD model where we have incorporated more realistic aerosol processes such as condensation and coagulation by oxidation and condensation of hydrocarbon species. We examine how these processes influence the vertical and horizontal distributions of aerosol parameters.

From the dynamical perspective we investigate the different factors that influence the aerosol exchange velocity between street canyons and the urban boundary layer above. Both vertical turbulent fluxes as well as the fluxes due to mean flow are shown to contribute to the overall ventilation characteristics of a street canyon.

We then compare emission velocity structure within and above the canyon and compare these with observations, e.g. Longley et al. (2004). We then discuss these in context with tower based micrometeorological flux measurements that were obtained from the CITYFLUX and REPARTEE studies, Martin et al. (2009).

Whilst undoubtedly crude these comparisons may be used as a starting point for linking street level concentrations to those measured above the urban roughness layer e.g. on large scale micrometeorological flux measurement towers as used in REPARTEE and CITYFLUX with potential for validating high resolution regional scale air quality models.

How such approaches can be used to facilitate parameterizations suitable for other modelling platforms such as those that are more appropriate to the epidemiological study domain still remains a challenge. Again as a starting point we discuss potential linkages with ultrafine aerosol affinity zones, Harris et al. (2009), which can be derived using Geographical Information Science tools (GISc) model techniques. These zones require city specific validation. While this can be achieved partly by traditional sampling networks coupled with intensive micrometeorological canyon flux observations, these are expensive. There is potential cost benefit therefore to using area averaged flux footprint databases, determined by long term large tower based micrometeorological measurement systems, to inform many of these modeling approaches.

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