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Urban Street Canyons: Coupling Dynamics, Chemistry and Atmospheric Pre-processing

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Atmospheric composition within the urban environment, particularly within street canyons (formed by a road running between two rows of buildings), has a direct effect on the air quality of an environment in which a large majority of people live and work. The composition of air within a street canyon is determined by the composition of background air mixed in from above, advection of air into and out of the canyon, vehicle exhaust and other emissions from within the street, together with the mixing and chemical processing of pollutants within the canyon. This occurs on a timescale of a few seconds to minutes and as a result, within-canyon atmospheric processes can have a significant effect on atmospheric composition on such timescales.

This paper outlines the results of a modelling study of composition on the street canyon scale, integrating the combined effects of emissions, dynamics and chemistry. The work builds upon an existing dynamical model of canyon atmospheric motion (Large Eddy Simulation (LES) model) by adding a detailed chemical reaction scheme. Previous studies have considered basic NO_X-O_3 cycles with only a small number of chemical reactions included.

Initially, a zero-dimensional box model was used to develop and assess the accuracy of a suitable reduced chemical scheme to be included within the LES. The reduced chemical scheme, based upon a subset of the Master Chemical Mechanism (MCM), includes 51 chemical species and 136 reactions. Vehicle emissions taken from the UK National Atmospheric Emissions Inventory (NAEI) were subsequently added to the box model. These elements were then combined with the canyon dynamics simulated by the Large Eddy Simulation (LES) model. Previous work demonstrates that the enhanced model is a suitable tool to be used to further investigate the combined effects of mixing and chemical processing upon air quality within the street canyon.

We present a comparison of oxidant levels within the canyon calculated using the LES model, i.e. integrating both dynamics and chemistry, with those determined using the box model. The results are used to investigate the extent of within-canyon processing of exhaust emissions before their escape to the wider atmosphere. A representative flux of pollutants out of the urban canopy into the overlying boundary layer is also determined. This may then be applied, as a modification to the raw emission rates, in larger scale regional and neighbourhood models.