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Parameterization of Pollutant Plume Dispersion in Neutral Stratification over Hypothetical Urban Areas

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Nowadays, people are more aware of the air quality than ever. Ground-level pollutants from human activities and vehicles are the primary pollutant sources, which adversely affect the health and living quality of urban inhabitants. Therefore, a simple and reliable air pollutant dispersion model is necessary to estimate concentration distribution and evaluate pollutant problems.

The Gaussian model of plume dispersion, which is one of the earliest atmospheric dispersion models developed, is still commonly used to estimate the downwind pollutant concentration distribution. Dispersion coefficients (σ_z), or the standard deviation of vertical pollutant concentration distribution, is one of the major parameters in the Gaussian plume dispersion model. However, the effects of surface roughness and terrain topography, which can substantially modify the pollutant transport processes, are barely taken into account. In this study, surface roughness and terrain topography are combined into a single variable - the friction factor (f). Its effect on σ_z is examined using computational fluid dynamics (CFD) and the Renormalization Group (RNG) $k-?$ turbulence model.

Computational domains consist of idealized two-dimensional street canyons of eight different shapes together with eighteen different building-height-to-street-width (aspect) ratios (*ARs*) are used in the CFD simulations. These configurations cover the characteristic skimming flow, wake interference and isolated roughness regimes that are used to represent various hypothetical urban areas with a single parameter f. A ground-level pollutant source is placed in the centre of the computational domain and the pollutant transport by the prevailing wind flow and diffusion are calculated. It is found that σ_z is a function of both f and distance from the pollutant source. Furthermore, σ_z strongly depends on and is proportional to f. Hence, it is suggested that the friction factor f is a suitable parameter for pollutant distribution and concentration estimate within urban boundary layer (UBL).