Budget Analysis for Reactive Plume Transport over Urban Roughness

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ABSTRACT:

Air quality in urban areas is affected by many factors including the building geometry, street layout and wind flows, etc. Moreover, most pollutants emitted from vehicles at the pedestrian level are chemically reactive. Pollutants mix with each other in molecular scale that evolve to their secondary counterparts in the atmospheric boundary layer (ABL). Oxidation of nitrogen oxides is one of the reactions that attract considerable attention in the atmosphere. In this paper, the plume dispersion of a representative, irreversible chemical reaction, oxidation of nitric oxide (NO) to nitrogen dioxide (NO_2) by ozone (O_3) titration, is examined by large-eddy simulation (LES). To elucidate the mechanism of reactive pollutant transport, budget analysis for the transport equations is adopted. Results show that the advection term, turbulent diffusion term and chemistry term all affect the NO transport. The chemistry term is responsible for the NO dilution. The advection term and turbulent diffusion term, however, behave differently in the vertical direction, especially at the roof level, which reveals the importance of the roughness in pollutant transport. Cases of different building-height-to-street-width (aspect) ratios are compared to demonstrate the importance of surface roughness. Different background O_3 concentrations are employed to unveil the importance of chemistry term in the chemically reactive pollutant transport.

KEYWORDS: reactive plume, budget analysis, large-eddy simulation

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