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Vertical turbulent transport in an urban street canyon

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Air pollution in urban areas is a major concern for citizens' health. Rapid urbanization and climate change will further exacerbate the deterioration of air quality in the near future. As the dispersion of pollutants in the urban canopy is governed by air flows and transport phenomena, fluid mechanics plays a crucial role to predict pollutant concentration and evaluate the efficiency of mitigation strategies. The focus is on the dynamics in the street canyons, where pollution emitters and subjects exposed are extremely close and ventilation is inhibited by the presence of tall buildings on both sides.

In this framework, we propose wind tunnel experiments aimed at investigating the dynamics of mass exchange between a street canyon and the overlying atmosphere. We consider the case of a street oriented perpendicular to the wind direction. In this configuration, vertical transport is the only way out for pollutants released from a line source at street level.

Keeping the external flow unaltered, we analyse the effect of different boundary conditions at the building walls and the presence of obstacles within the canyon. The boundary conditions are modified by alternatively heating the windward and leeward walls of the canyon, by changing its aspect ratio and by introducing roughness elements at walls. Two rows of model trees are arranged at the sides of a street canyon to simulate urban vegetation.

Velocity and concentration measurements are performed within the canyon and a characteristic exchange velocity between the street canyon and the overlying atmosphere is estimated to quantify the overall canyon ventilation in the different configurations.

Results evidence that mass transfer is mainly driven by the fluctuating component of the turbulent flow. Moreover, the experimental dataset is valuable in validating numerical simulations of air pollution in cities and provides city planners with first recommendations for the sustainable design of urban environments.