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Turbulent transfer and concentration statistics in a street canyon with tree planting

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The exacerbation of the urban heat island due to global warming poses a serious risk to the health of citizens. Furthermore, the alteration of the urban microclimate affects air quality with an expected increase in the concentrations of harmful pollutants. Greening cities is an effective tool to mitigate these effects. However, the effect of tree planting in urban street canyons is still a debated topic. Despite their positive effect on temperature and their filtering action, trees can hinder air circulation thus limiting pollutant removal processes. In this context, it is essential to understand and model the effect of trees on the ventilation of street pollutants, heat and moisture . To this end, we present in this work the results of an experimental campaign conducted in a wind tunnel. An urban geometry with a street canyon perpendicular to the wind direction was reproduced. A linear source of passive scalar simulated the emission of pollutants from vehicular traffic. Reduced scale trees have been conceived to mimic a realistic aerodynamic behaviour. We investigated four different configurations of vegetation density: a street with no trees, two trees in the middle of the street, two rows of scattered trees and two dense rows of trees. Concentration and velocity measurements were performed in order to characterize the transfer processes of pollutants inside the street and to estimate a bulk vertical exchange rate. Results show that the presence of trees alters the concentration field in the street with a progressive shift from a nearly two-dimensional to a three-dimensional field. Despite the significant spatial variation in concentration, the presence of trees does not alter the overall efficiency of the ventilation as the vertical bulk exchange velocity remains almost constant in the different configurations. The statistical analysis of the turbulent concentration signal gives other insights in the transfer processes. The turbulent signal measured in different positions of the cavity and for different tree density follows a Gamma distribution with constant fluctuation intensity suggesting an almost universal behaviour within the canyon and providing a powerful modelling tool. Finally, combined measurements of concentration and velocity allows to measure the turbulent mass fluxes at the roof height and investigate their spectrum therefore enlightening the effect of trees on typical scales of motion.