EGU24-18319, updated on 18 Jan 2025
https://doi.org/10.5194/egusphere-egu24-18319
EGU General Assembly 2024

Wind tunnel study on the influence of vegetation density and wind direction on urban canyon ventilation

Annika Vittoria Del Ponte[1,2], Sofia Fellini[1], Massimo Marro[2], Pietro Salizzoni[2], and Luca Ridolfi[1]
[1]Politecnico di Torino, Dipartimento di ingegneria per l'ambiente, il territorio e le infrastrutture (DIATI), Turin, Italy
[2]Univ Lyon, Ecole Centrale de Lyon, CNRS, Univ Claude Bernard Lyon 1, INSA Lyon, LMFA UMR5509, 69130, Ecully, France

Inserting vegetation within the urban environment mitigates the urban heat island effect, the flooding risk, and improves air quality. However, its aerodynamic effect has remarkable impact on the pollutant transport and, consequently, on human health comfort. Indeed, the presence of vegetation within an urban canyon leads to non-trivial patterns of pollutant concentration and mass fluxes, as a consequence of complex mean and turbulent velocity fields. In addition to the vegetation density, the flow structure within canyons is influenced by their geometry and by the wind direction.

The aim of the present study is to experimentally investigate the velocity field within a canyon, varying the vegetation density and the wind direction. We measured flow velocity statistics within an indefinitely long street canyon, with unit height-to-width ratio, subject to a neutrally stratified boundary layer modeled in the wind tunnel of École Centrale de Lyon. The aerodynamic impact of vegetation was reproduced by inserting plastic miniatures of trees along the two long sides of the canyon. We considered an empty canyon and a vegetated canyon, whose longitudinal axes are oriented with angles of 0°, 30°, and 60° with respect to the external wind flow.

Results reveal that when the canyon is inclined with respect to the external wind direction the mean flow follows a complex helicoidal structure. The presence of trees decreases significantly the mean longitudinal velocity and weakens the transversal circulation in the inclined canyon. The dampening effect of the mean longitudinal flow is more marked increasing the inclination angle of the canyon. Turbulent fluctuations are enhanced above the tree crowns, mostly when the wind blows parallel to the canyon axis. On the contrary, turbulent fluctuations decreases at tree trunk and crown levels, in particular when the canyon is inclined of 60° with respect to the external wind direction. Spectra of the velocity signal show that the presence of trees induces an evident shift of the energy peak towards high frequencies.

The collected data constitute a step forward to understand and modeling the urban microclimate.