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Effects of spatial heterogeneity of leaf density and crown spacing of canopy patches on dry deposition rates

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Trees have a large role in improving urban air quality, among other mechanisms, through dry deposition of scalars and aerosols on leaf surfaces. We tested the role of leaf density and canopy structure in modulating the rate of dry deposition. We simulated the interactions between a virtual forest patch and deposition rate of an arbitrary scalar using the Parallelized Large Eddy Simulation Model (PALM). Two canopy structures were considered: a homogenous canopy; and canopy stripes perpendicular to the wind direction. For each canopy stripe scenario, we considered thin, intermediate, and wide stripes, while the space between stripes equals the stripes' width. Four leaf area densities were considered for each case. The results showed that stripes perpendicular to the wind direction had a larger deposition per leaf area than homogeneous canopies, and denser canopies had more total deposition, but lower per-leaf area rate. Our results can be explained by canopy-induced turbulence structures that couple the air within and above the canopy and lead to more effective leaf area where this coupling is stronger. We aggregate our results to the whole-patch scale and suggest a canopy-structure and leaf-area dependent correction to the canopy resistance parameter so to be used in coarse models that resolve dry deposition.