Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., author comment AC1
https://doi.org/10.5194/acp-2022-287-AC1, 2022

Reply on RC1

Alice Maison et al.

Author comment on "Parameterizing the aerodynamic effect of trees in street canyons for the street network model MUNICH using the CFD model Code_Saturne" by Alice Maison et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-287-AC1, 2022

The paper proposed a parameterization to include the aerodynamic effect of tree crowns in the MUNICH street-network model. For that, simulations using Code_Saturne CFD code are performed varying the Leaf Area Index, the crown volume fraction, and the ratio between tree and street height for three types of street canyons. The effects of these parameters over the horizontal velocity (Ustreet) and vertical transfer coefficient (qvert) in treeless and tree conditions are studied. Then, these effects are included in MUNICH horizontal and vertical transfer parameterization from Maison et al. (2022) which is based on Wang (2012, 2014). The qvert and Ustreet calculated with the new MUNICH parameterization including trees agree with Code_Saturne simulations. The parameterized wind profile is closer to Code_Saturne for winds near the middle of the tree crown. The paper is well structured and written. The assumptions are well explained, with a clear methodology, interesting results which are well supported by the plots, and conclusions in concordance with the journal scope. This work represents an improvement on MUNICH formulations with the potential of improving air quality simulation inside urban canyons. I think this paper is also a good example of the process of building new parameterization in street-network models.

Minor revisions are detailed below:

Specific comments:

- Line 106. A definition of phi, the angle formed by the wind direction above the roof and the direction of the street, is missing.

Authors' response: The definition of phi is added line 106.

- Further details on Code_Saturne configuration are required. Specifically, What are the criteria to determine the location of the trees (7m from the wall)?

Authors' response: The following sentence is added (line 142): "The tree crown centers are located in a position on the X axis so that the largest crowns (CVF ≈ 25%) do not reach the street walls for the three street canyons studied."

- What are the criteria to determine the maximum height of the Domain?

Authors' response: The maximum height of the domain is equal to 3 times the building height ("Maximum height of the domain **(3H)**" is added in table 1). This factor of three on the mean building height is usually considered the height of the urban canopy (or the "Roughness Sub Layer") where the flow is highly spatially variable (Roth 2000).

- It is not clear if the reason for using a two-dimensional set-up is only to save computational time or is it a required adaptation to compare Code_Saturne simulation with MUNICH (in line 89).

Authors' response: MUNICH corresponds to a simplified representation of the geometry of street canyons and considers a network of segments of homogeneous street in the street direction (Y axis). It is thus necessary to perform CFD studies using simplified geometries to stay within this generic approach. So the main reason for using a 2D setup is to compare Code_Saturne simulations with MUNICH on those street segments. Some 3D CFD computations have also been performed for comparison purposes (not shown).

In Appendix 3 (line 371) "To save computing time" is removed.

- Fig 1. The location of the background and location of the inlet can be added in Fig. 1. Like in Fig 1. in Maison et al. (2022)

Authors' response: Background and location of the inlet and outlet borders are added on Fig. 1.

- Line 232-236. More details should be given on the reasons for the reduction of the effect on qvert (RD_qvert) in Intermediate and Narrow Canyons with high LAI values and small h/H ratio (Fig 3(b) and Fig 3(c)).

Authors' response: These reductions of RD_qvert in IC and NC with high LAI values and small h/H ratios are due to differences in detailed micro-scale flow and turbulence changes.

In the intermediate canyon, when the LAI increases, the wind speed decreases at the tree crown level but increases between the tree crowns. When the h/H ratio is low (h/H = 0.36 and 0.5), this reacceleration is located at the bottom leewards side of the street where the tracer concentrations are the highest. This leads to an increase of the tracer dispersion and a decrease in the street average concentration. Therefore, an increase of LAI induces a lower RD_qvert.

In the narrow canyon, this variation of qvert due to tree effects can also be related to the turbulent viscosity. The turbulent viscosity is decreased at the crown level and under the tree crown but is increased above the tree crown. When the h/H ratio is low, this area above the tree crown where the turbulent viscosity is increased is larger than for higher h/H ratios leading to more vertical transfer between the street and the background. This induces slightly lower street average concentration and a reduced effect of the tree crown on qvert (RD_qvert).

Overall, these variations due to micro-scale effects are relatively low (0 to 3%) and have a negligible impact on the global effect of trees in street canyons.

To discuss this issue, the following paragraph is added in the article: "This reduction of the tree effect on qvert when LAI or CVF increases for small h/H ratios in IC and NC can be explained by micro-scale effects (modified air flow path and turbulent viscosity) and is left out of the scope of the present study due to the corresponding low amplitude. Besides, investigation of such micro-scale effects would probably require more advanced turbulence models (switching from a first-order model (k-□□) to a second-order one (Rij-SSG (Speziale et al., 1991)), or a 3D Large Eddy Simulation (LES))."

- Fig 4. What is the meaning of ER in Fig 4 subtitles? It can be added to the figure label.

Authors' response: It is RD (relative deviation) and not ER, the figure subtitles are corrected.

Technical corrections:

- For consistency, Eq (15) and Eq (16) are missing the " x 100" as it is expressed in % in the plots and analysis and also in NMAE and NMB equations.

Authors' response: Equations (15) and (16) are corrected.

- Line 280: Eq. (2) should be Eq. (4)

Authors' response: The reference is corrected.

- Line 286: The two introduced parameters to be determined based on Code_Saturne are f_bxt and Cu.

Authors' response: The parameters f_bxt and Cu are added Line 286.

- Line 333: It should be "street-network model MUNICH".

Authors' response: Line 333 is corrected.

References:

Roth, M. (2000). Review of atmospheric turbulence over cities. Quarterly Journal of the

Royal Meteorological Society, 126(564), 941-990.
https://doi.org/10.1002/qj.49712656409