Geophysical Research Abstracts
Vol. 21, EGU2019-9782, 2019
EGU General Assembly 2019

Optimization of Building Patterns for Better Air Quality Using GPU-Based Large Eddy Simulation

Kristóf Gergely and Papp Bálint
Budapest University of Technology and Economics, Department of Fluid Mechanics, Hungary (kristof@ara.bme.hu)

Several earlier studies (e.g. [1–2]) pointed out the advantages of Large Eddy Simulation (LES) in modelling microscale dispersion, however, due to its high computational cost, most LES based studies focus on a single geometrical configuration without investigating the effects of different geometrical parameters.
In this study, a virtual wind tunnel is presented, constructed in ANSYS Discovery Live, which is a GPU-based software originally developed for mechanical engineering applications. The applied software allows for altering the geometry or post-processing "on the fly", while the results are being constantly updated by the solver. These features enable the rapid comparison of numerous design concepts with decent accuracy.
The dispersion of traffic induced air pollutants is analyzed by utilizing the analogy between heat and mass transport processes. Using the presented methodology, converged LES results can be obtained for an urban dispersion scenario involving a few (< 20) buildings within an hour of computational time on a high-end gaming video card. Using passive turbulence generators at the inlet combined with a relatively short preparatory section, the proposed numerical wind tunnel configuration is capable of producing the mean velocity and turbulence intensity profiles characterizing the urban boundary layer. In our previous study [3] the numerical model has been validated by comparing the resultant flow and the pollutant fields with known wind tunnel data.
In the present study, the application of the numerical wind tunnel is demonstrated. The flow and concentration fields are compared in the cases of various building arrangements of equal useful volumes. The building pattern of highest pollutant removal efficiency can be identified using the mass Stanton number resulting from the numerical model. The dependence of the Stanton number on various geometrical parameters is analyzed.
In conclusion, building patterns containing higher objects in a staggered arrangement displayed superior pollutant removal performance and improved air quality at pedestrian level.

References:
[1] Tominaga, Y.; Stathopoulos, T. (2013): CFD Simulation of Near-Field Pollutant Dispersion in the Urban Environment: A Review of Current Modeling Techniques. Atmospheric Environment 79, 716-730. https://doi.org/10.1016/j.atmosenv.2013.07.028
[2] So, E.S.P.; Chan, A.T.Y.; Wong, A.Y.T. (2005): Large Eddy Simulation of Wind Flow and Pollutant Dispersion in a Street Canyon. Atmospheric Environment 39 (20), 3573-3582. https://doi.org/10.1016/j.atmosenv.2005.02.044
[3] Kristóf, G.; Papp, B. (2018). Application of GPU-Based Large Eddy Simulation in Urban Dispersion Studies. Atmosphere 9 (11), 442. https://doi.org/10.3390/atmos9110442

Acknowledgments: This study was funded by grant no. K 124439, NKFIH from the National Research, Development, and Innovation Office, Hungary. The research reported in this publication was supported by the Higher Education Excellence Program of the Ministry of Human Capacities, within the framework of the Water Science and Disaster Prevention Research Area of the Budapest University of Technology and Economics (BME FIKP-VÍZ).