

Evaluation of the microscale model MIMO with wind-tunnel measurements

Contribution to subproject SATURN

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Microscale computational fluid dynamics (CFD) models represent a state of the art tool that takes into account the urban structure explicitly and provide a useful method for the investigation of the airflow in complex configurations as well as for the assessment and prediction of air pollution dispersion in cities. For this reason, the proper validation of such models is a fundamental requirement for its practical application.

Individual activities aimed at the evaluation of the microscale model MIMO against existing high-quality wind-tunnel experimental data. MIMO is a prognostic microscale model solving the Reynolds averaged conservation equations for mass, momentum and energy together with additional transport equations for scalar quantities such as potential temperature, turbulent kinetic energy and specific humidity. In this study the standard $k-\epsilon$ turbulence model was applied. Its validation has been based on several test cases, ranging from simple two dimensional cases to more complex three-dimensional configurations, some of these cases being included in model intercomparison exercises (cf. Sahn et al., 2001; Ketznel et al., 2001). Here, results from a wall-mounted cube and a finite array of squared shaped rings of buildings are considered. The experimental database used was obtained at the BLASIUS wind tunnel at the Meteorological Institute of the University of Hamburg at a scale of 1:200.

The wall-mounted cube case was defined as the geometrically simplest three-dimensional case to investigate the performance of the code in reproducing the flow field around an idealised building, while the three-dimensional multiple arrays of buildings is encompassed a more complex case for reproducing the flow and dispersion characteristics. MIMO was found capable of reproducing the flow patterns in both cases. In particular for the cube case, MIMO predicts an impingement region at the windward side of the obstacle, a main horseshoe vortex wrapping around the cube and an extended lee vortex formed in the cavity zone immediately behind the cube which interacts with the horseshoe vortex. For the array case, significant departures from the typical vortex structure developed in an infinitely long square street canyon were observed with the main vortex in one of the formed street canyons to have its centre shifted upwards and towards the leeward wall. The use of the standard $k-\epsilon$ turbulence model was identified as the principal factor being responsible for the deviation between model results and measurements regarding the turbulent kinetic energy predictions, while the small differences in the flow close to the solid boundaries are attributed mainly to the discrete implementation of the wall-function by the code.

References

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