

Airflow Study for a Cluster of Campus Buildings using Different Turbulence Modeling Approaches

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Abstract

Obtaining accurate numerical simulations of airflows for actual building clusters is time consuming due to a vast variety of characteristic flow patterns, combined with a wide spectrum of spatial and temporal scales. In order to provide a faster, yet reliable and simple modeling approach for simulation of outdoor airflow around multiple buildings, the present study evaluated a performance of the modified zero-equation turbulence model (ZEQ). A comprehensive set of velocity field measurements in the wind tunnel experiment was conducted, and the results were used to calibrate the ZEQ model. Additional measured data are used for the validation of different turbulence modeling approaches. The performance of the modified and improved zero-equation turbulence model was compared to the revised “Kato-Launder” version of the “k- ϵ ” model (MMK), and Large Eddy Simulations (LES) using the standard Smagorinsky Subgrid-scale model (SMG). The validation revealed a satisfactory performance of the calibrated ZEQ turbulence model in predicting streamwise mean velocity profiles, and demonstrated its comparative competitiveness with the two other turbulence modeling approaches. A less than satisfactory agreement between numerical results and measured data was identified in the prediction of vertical and lateral velocity components regardless of the turbulence modeling approach. Overall, the calibrated ZEQ turbulence model provided results that were comparable to MMK and SMG and required substantially smaller computational resources. An additional outcome of the present study is a recommendation for future research to improve performance of the calibrated ZEQ turbulence model using more advanced experimental techniques and implementation of macroscopic morphological parameters to account for realistic representation of the buildings settings in urban areas.

Keywords: Turbulent eddy viscosity, Zero-equation (ZEQ) turbulence model, Revised “Kato-Launder” turbulence model (MMK), Smagorinsky Subgrid-scale model (SMG), Airflow around multiple buildings, Wind tunnel experiment

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