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A simple one-dimensional model for urban canopy flows

Wai Chi Cheng and Fernando Porté-Agel

Wind Engineering and Renewable Energy Laboratory (WIRE), École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland (wai.cheng@epfl.ch)

In urban canopy parameterizations, an urban canopy is usually modelled as a drag force on the flow, and the turbulent shear stress is parametrized by various methods. One of the most common methods to parametrize the turbulent shear stress in urban canopies is to use a mixing length (l_m) model. Different mixing length models have been proposed in the literature, and recent direct numerical simulation and large-eddy simulation (LES) studies have shown that these models underpredict the value of l_m in urban canopies. The high value of l_m in the canopies is in fact related to the turbulence generated at the high-shear region near the top of the canopy, which is similar to that in a plane mixing layer. By considering this effect, a new simple mixing length model is proposed based on physical arguments. The results of the new l_m model and the previous models are compared with the LES results of flows within and above uniform cube arrays of different densities. The comparison clearly demonstrates the better performance of the new model in predicting the wind profiles especially near the top of the urban canopies. For the drag coefficient (C_d) representing an urban canopy, previous studies found that its value depends on the building density. Here, a simple model for C_d is suggested by considering the spatial distribution of mean wind within canopies of different building densities. The model prediction is found to agree reasonably well with the LES results.