Geophysical Research Abstracts
Vol. 14, EGU2012-7857, 2012
EGU General Assembly 2012

Atmospheric turbulence in urban environments: large-eddy simulation and experiment

D. Hertwig (1), R. Nguyen van yen (2), G. Patnaik (3), and B. Leitl (1)

(1) Meteorological Institute, KlimaCampus, University of Hamburg, Germany (denise.hertwig@zmaw.de), (2) Mathematical Institute, Geophysical Fluid Dynamics, Free University of Berlin, Germany, (3) Laboratory for Computational Physics & Fluid Dynamics, U.S. Naval Research Laboratory, Washington D.C., USA

The description of atmospheric turbulence in densely built urban environments is a major theoretical challenge, which has wide-ranging practical implications – regarding for example pollutant dispersion, wind comfort, and many other micro-climatic issues. The traditional approach to adopt obstacle-resolving micro-scale meteorological models based on Reynolds-averaged equations is strongly limited by its inherent inability to provide spatio-temporal data. Although more advanced models, such as large-eddy simulation (LES), are now technically applicable to this problem, the precise validation of their output is still a matter of ongoing investigation, which is particularly challenging due to the time-dependent nature of the problem.

In this work, we undertake a systematic comparison between results of urban LES computations and boundary-layer wind-tunnel measurements of turbulent flow in the inner city of Hamburg, Germany. The experimental data were acquired for neutral atmospheric stratification within an urban model on a scale of 1:350, under well-defined and documented boundary constraints. Background information about the atmospheric inflow conditions for both the physical and numerical model was deduced from suburban field site measurements. LES computations were conducted by the U.S. Naval Research Laboratory using the code FAST3D-CT that is based on the monotone integrated LES methodology (MILES).

The validation focuses on the comparison of time-series information and the characterization of turbulent flow structures within and above the urban canopy. Densely spaced measurements in vertical profiles and horizontal flow layers allow for the investigation of the urban boundary-layer development across the city. Typical obstacle-induced urban flow scenarios provide further test cases for detailed analyses. Besides mean flow and turbulence statistics, velocity histograms, fluctuation time scales, spectral information and statistics of the Reynolds stress decomposition are compared. Using wavelet transforms, scale-dependent analyses of the experimental and numerical flow fields are performed, which allow for the comparison of high order statistics to which the preceding diagnostics are blind. Finally, particular challenges connected to the validation of time-resolved simulations in contrast to standard approaches for steady-state solutions are discussed with an emphasis on specific demands in the case of urban applications.