Inflow conditions, wall function and turbulence model for the simulation of ABL flows: application to flows over complex terrains and around obstacles

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There is an increasing interest in the application of Computational Fluid Dynamics (CFD) to the quantification of fluid flow in the lower atmosphere (troposphere and lower stratosphere) at the mesoscale, for weather prediction and wind resource assessment, and in the lower troposphere at the micro scale, where the highly turbulent atmospheric boundary layer (ABL) interacts directly with the human environment. Simulation of atmospheric flows at the meso and micro scales over both flat and complex domain is necessary for the estimation of wind loads on buildings and building heating requirements, to predict wind turbine loadings and for the optimal design of wind farms, and to predict and evaluate the production and transport of pollution in the atmosphere.

The simulation of ABL flows is generally performed using commercial CFD codes with RANS turbulence modelling, applying the standard k–ε model. However, this approach may result in an undesired decay of the velocity and turbulent fully–developed profiles specified at the inlet of the computational domain, due to an inconsistency between turbulence model, inflow conditions and wall function formulation. The present talk describes a new approach to overcome this problem, which consists in the modification of the turbulence model and wall function formulation to retrieve an overall consistent treatment of the ABL, under different stratification conditions. The methodology is demonstrated for the simulation of ABL flows over flat and complex terrains, and around buildings. The behaviour of linear and non-linear eddy-viscosity models in combination with zonal modelling is also discussed in details.