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An Experimental (Wind Tunnel) and Numerical (CFD) Study on the Flow over Hills

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Abstract : The shape of the wind velocity profile changes according to local features of terrain shape and roughness, which are parameters responsible for defining the Atmospheric Boundary Layer (ABL) profile. Air flow characteristics over and around landforms, such as hills, are of considerable importance for applications related to Wind Farm and Turbine Engineering. The air flow is accelerated on top of hills, which can represent a decisive factor for Wind Turbine placement choices. The present work focuses on the study of ABL behavior as a function of slope and surface roughness of hill-shaped landforms, using the Computational Fluid Dynamics (CFD) to build wind velocity and turbulent intensity profiles. Reynolds-Averaged Navier-Stokes (RANS) equations are closed using the SST k-ω turbulence model; numerical results are compared to experimental data measured in wind tunnel over scale models of the hills under consideration. Eight hill models with slopes varying from 25° to 68° were tested for two types of terrain categories in 2D and 3D, and two analytical codes are used to represent the inlet velocity profiles. Numerical results for the velocity profiles show differences under 4% when compared to their respective experimental data. Turbulent intensity profiles show maximum differences around 7% when compared to experimental data; this can be explained by not being possible to insert inlet turbulent intensity profiles in the simulations. Alternatively, constant values based on the averages of the turbulent intensity at the wind tunnel inlet were used.

Keywords : Atmospheric Boundary Layer, Computational Fluid Dynamic (CFD), Numerical Modeling, Wind Tunnel
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