PERFORMANCE EVALUATION OF CFD CODES FOR ATMOSPHERIC FLOWS IN COMPLEX TERRAINS

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CONFIDENTIAL REPORT

The objective of this project is to evaluate the performance of three CFD codes, OpenFOAM, StarCCM+ and Fluent, in the estimation of wind resources on complex terrains. Several difficulties appear in this kind of topology such as flow separation, recirculation and unsteadiness in the area of interest. The study has been done in three steps, with an increasing complexity in the flow pattern.

The first test case consisted in verifying that a fully developed neutrally stratified atmospheric boundary layer (ABL) can be maintained along an empty fetch. Three different set of boundary conditions are compared. The Richards & Hoxey approach, which assume a constant profile of turbulent kinetic energy, results in horizontally homogeneous profile. The simplified Parente & Benocci approach presents higher horizontal gradients but assumes a turbulent kinetic energy profile varying with height, which is closer from wind tunnel and field measurements. The last approach, which uses wind tunnel measurements as inlet profile, presents horizontal gradients of the same order of magnitude as the simplified Parente & Benocci approach. This test case has been done with the three CFD codes and similar performances were obtained for all of them.

The second test case concerns the ABL flow over the Askervein hill, which can be considered as a mildly complex terrain. The flow is computed in a 3D domain at real scale. The results obtained with StarCCM+ were compared to field measurements and to a previous numerical simulation made with Fluent [Rodrigues, 2005]. The two codes present equivalent performances. It is observed that it is more difficult to predict the flow in the lee side than in the windward side of the hill.

The third step of this project concerned the flow over the Alaiz test wind farm in Spain. A two-dimensional domain at wind tunnel scale has been used for the simulations. The numerical results are compared with experimental data obtained on a small scale model in the L1-B wind tunnel by S. Buckingham. A sensitivity study to various parameters was performed first. It could be seen that the topography of the upstream region has a strong influence on the flow in the region of interest. The three different inlet profiles presented in the first test case have been used as inlet condition. The results are closer from wind tunnel measurements when experimental data are used as inlet condition. The three different codes have been compared. It appears that OpenFOAM performs better to reproduce the velocity field with a difference of 7% compared to wind tunnel measurements, while 8 and 10% are obtained with Fluent and StarCCM+ respectively. The three codes are present equivalent performances to reproduce the turbulent kinetic energy field with a difference of 17% compared to wind tunnel measurements.

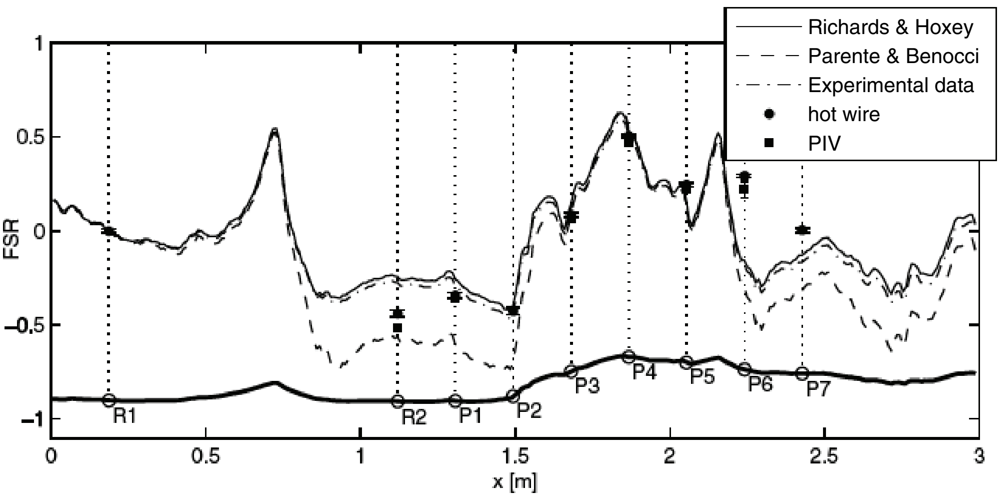

Figure 1: Fractional speed-up ratio at 90 meters above ground level over the Alaiz Mountain. Comparison of numerical results obtained in OpenFOAM with three different inlet profiles and experimental measurements obtained by hot wire and PIV techniques in the L1-B wind tunnel.