OpenFOAM simulations of atmospheric flow over complex terrain

Performance in a blind comparison of CFD codes

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Abstract

Risø DTU, the National Laboratory for Sustainable Energy of Denmark, recently organized a blind comparison of flow models for the evaluation of wind over complex terrain [1] based on a new dataset of measurements collected on the isolated presqu'ile of Bolund [2]. One of the primary objectives of this exercise was to evaluate the accuracy of current wind resource assessment methods in complex terrain. This flow case meets the requirement of "complex" as, for primary wind directions, the orography resembles a forward-facing step and, with respect to the shallow boundary layer developed over open water, the step height is relatively large. Participation was open to all and, although the boundary conditions were fairly rigidly specified for consistency, modelers were free to employ their method of choice to estimate the flow field. The overwhelming majority of participants submitted RANS/2-eqn solutions including ÉTS and Vattenfall who applied the *RNG k-ε* and standard *k-ε* closure models, respectively.

The results of the blind comparison were announced at a workshop on December 3rd, 2009. Of the over 50 submissions, 12 solutions were selected by the organizing committee as best approximating the measurements. Seven different flow solvers appear in the top ten. The two OpenFOAM simulations submitted by the authors ranked first and fifth with overall mean errors in predicted velocity of 13% and 14%. Typical results for mean horizontal wind speed at two heights along a primary wind direction are shown in Figure 1 for each model along with available experimental data. Two important conclusions that may be drawn from this exercise are a) more research is needed to properly simulate ABL flow over complex terrain especially in regards to turbulence modeling, and, of special importance to the OpenFOAM community, b) the quality of the simulation appears to be much more dependent on the user than the software.

A brief review of current best practices for simulating surface layer flow and a discussion of how these practices have been implemented in the two OpenFOAM submissions will be presented.

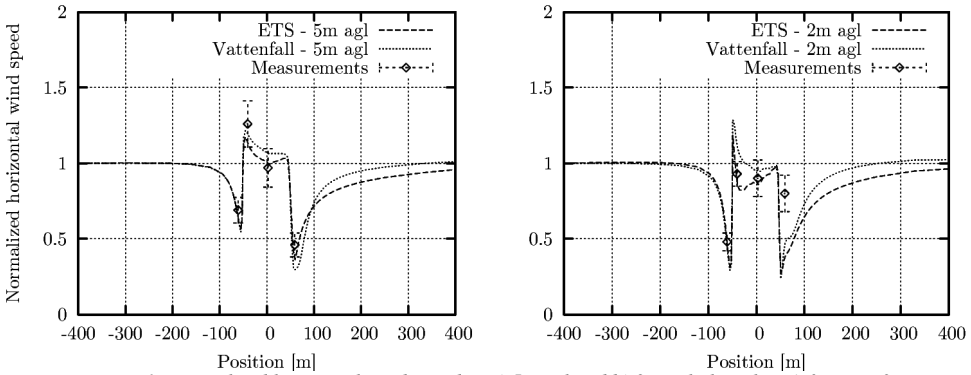

Figure 1: Normalized horizontal wind speed at a) 5m agl and b) 2m agl along line A for case 3

Key words: atmospheric boundary layer, turbulence modeling, complex terrain, wind energy.

References

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