RANS SIMULATION OF THE NEUTRAL ATMOSPHERIC BOUNDARY LAYER USING OpenFOAM

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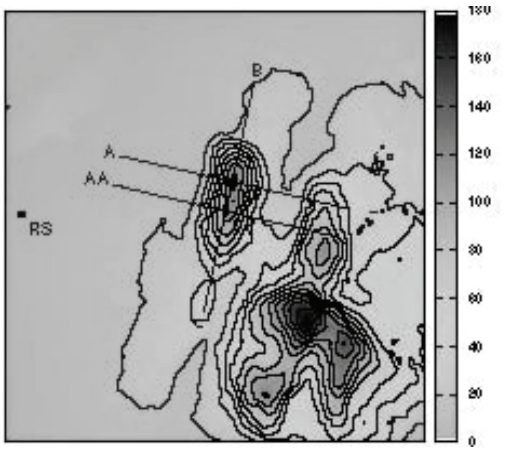
The present project is part of the effort of the EA department to apply and validate the Open-FOAM open source CFD toolbox on the simulation of atmospheric flows. In particular, the aim of this specific project is to investigate the capabilities of OpenFOAM in the RANS simulation of the atmospheric boundary layer. It is motivated by the fact that RANS still remains the most used option for the simulation on this scale, due to the high computational costs associated with LES. However, it is well known that RANS models in general purpose CFD solvers are not able to provide homogeneous ABL profiles for velocity and turbulence quantities. Horizontal non-uniformity can be observed in the results, since the wall treatment implemented in CFD packages is not coherent with the fully developed inlet profiles found in the literature.

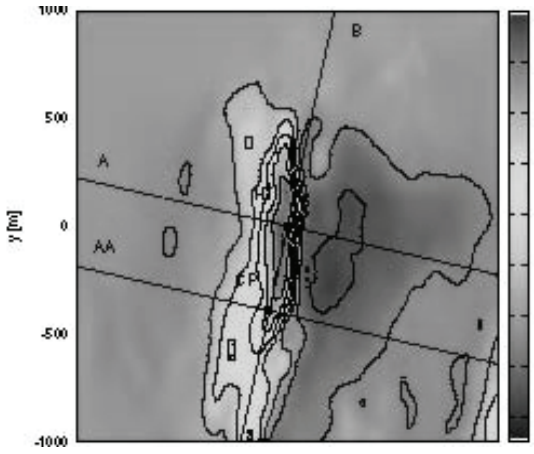
The main goal of the present project is to find suitable wall and inlet conditions and to propose a comprehensive numerical approach to ensure the homogeneity.

A novel approach is implemented and tested in OpenFOAM, based on the modification of the standard wall treatment for rough surfaces and the improved formulation of the k-epsilon turbulence model. In particular, a new wall function and additional source terms for the trans¬port equations of turbulence kinetic energy and its dissipation are proposed, to ensure the con¬sistency between the fully developed inlet profiles and the turbulence model itself.

To date, the numerical implementation has been verified on simple 2D simulations, and validated on more complex 2D and 3D cases, such as the numerical simulation of a 2D and 3D simplified hills. The final validation was a 3D full scale simulation, using the real geometry of the Askervein hill. The OpenFOAM CFD toolbox is proved to be sufficient in the simulation of the neutral atmospheric boundary layer with the applied improvements on the numerics.



(a) Terrain elevation of Askervein Hill



(b) Wall shear stress on the ground surface