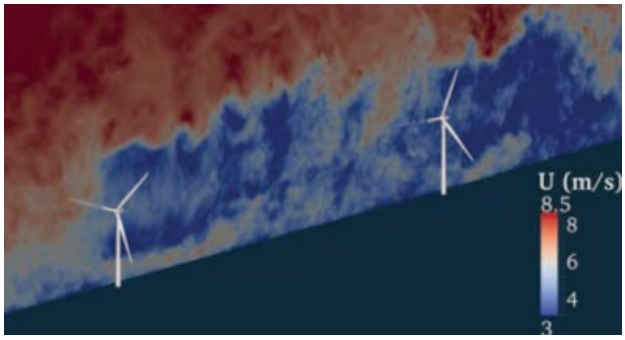
High performance computing on simulating wind turbines / wind farms using lattice Boltzmann methods

Background and motivation



European Commission (EC) intends to achieve climate neutrality in the EU by 2050, and the first attempt is to reduce 55% of the greenhouse gases by 2030. The upcoming trend will be pushing clean power generation, such as wind farms. There have been numerous studies on wind farms using traditional CFD method shown in the presented figure. [1] However, numerical investigations on lattice Boltzmann methods are still in the early stage.

The design of a wind farm needs a good estimation of the electrical power generated by wind energy. Thus, it is essential to have a proper model of power generation from a wind turbine as well as have good predictions from the wind farm.

Objectives

The goal of the present proposal is to provide a high-fidelity numerical solution for simulating single wind turbine or a wind farm. Both single and multiple wind turbines with flow field interaction will be performed. We will estimate the power generation for single and multiple wind farms.

Methods and tools

Numerical simulations: the flow field solver is using LBM coupled with Smagorinsky subgrid scale model. The flow field will interact with wind turbine via the actuator line modelling. The code we are using is called HaeroLB which is written in C/C++ framework and developed by our research group. Simulations will be conducted on the cluster of National Supercomputer Center.

Number of students: 1 student

Prerequisites: CFD, linux, matlab/python, knowledge in LBM and C/C++ programming is a plus.

Tasks

- Literature review on actuator line model and wind farms.
- Validation of existing actuator line model for a single wind turbine.
- A wind farm simulation: multiple wind turbines interactions and compare with existing wind farm data.
- Estimation on power generation for single / multiple wind turbines.
- Post processing on fluid flow analysis and scientific visualization using Paraview/Tecplot.
- Write a thesis report.

Contacts

Supervisor: Dr. Xiao Xue (xiaox@chalmers.se)

Examiner: Assoc. Prof. Huadong Yao

[1] Churchfield MJ, et. al, Journal of Turbulence, 2014