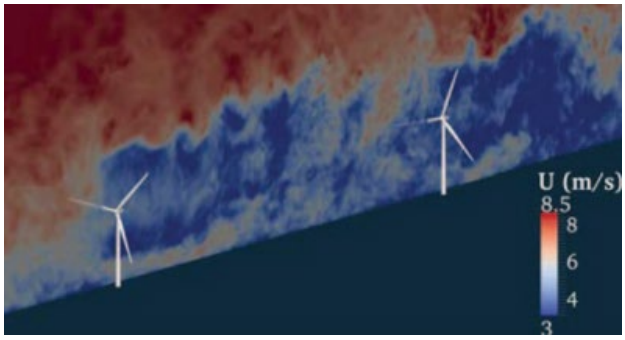
GPU acceleration on large eddy simulations for a wind farm using lattice Boltzmann methods

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. However, time-consuming and high-costly simulations are commonly not acceptable for early-stage design in the industry. The graphics processing unit (GPU) provides a promising tool for the lattice Boltzmann methods (LBM), due to its intrinsically designed as massively parallelization architecture which fits well with the LBM algorithm.

Objectives

The goal of the present proposal is to improve the performance of multi-CPU lattice Boltzmann methods to single GPU/multi-GPU using CUDA framework. Validation cases will be performed by simulating single wind turbine and multiple wind turbines. The GPU version of the code will cross check with CPU version of the code. You will provide performance analysis of the GPU acceleration compare with CPU code and existing GPU code.

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. You are expected to contribute to the in-house LBM code developed at division of Fluid dynamics.

Number of students: 1 student

Prerequisites: C/C++, linux, matlab/python, knowledge in CUDA or CFD is a plus.

Tasks

- Literature review on state-of-the-art LBM GPU acceleration methods.
- Validation of single GPU code by comparing reference results for wind turbine simulation.
- Comparing different memory layout for LBM algorithm.
- Performance modelling for GPU implementation and compare with CPU version of the code.
- If opportunity arise, we can simulate multiple GPUs by simulating a wind farm.
- Post processing on fluid flow analysis and scientific visualization using Paraview/Tecplot.
- Write a thesis report.

Contacts

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