Effect of Coriolis force on wind farm performance

Chair: Physics of Fluids Group
Supervision: Assistant Prof. Richard J.A.M. Stevens (r.j.a.m.stevens@utwente.nl)
Daily supervisor: MSc. Srinidhi Nagarada Gadde (s.nagaradagadde@utwente.nl)

With growing global interest in renewable energy, increasingly, large wind farms arrays are being designed and constructed. Optimization of wind farm design will be necessary to address the growing interest and demand for wind energy in the future. Improving wind farm design, however, requires an intimate knowledge of the turbulent flow in the atmospheric boundary layer (ABL). Turbulent flow in the atmosphere is affected by a number of factors such as the rotation of the Earth, thermal stratification, moisture content, etc. Rotation of the Earth gives rise to Coriolis force which deflects the wind as it moves away from the surface of the earth, giving rise to what is famously known as the Ekman boundary layer. Consequently, the wakes of the wind turbines are also redirected, which directly affects the power produced by the wind turbines [1]. Furthermore, entrainment of the fluid from outer layers of the boundary layer also affects the power production. Figure 1 shows various flow physics involved in a wind farm boundary layer interaction. Preliminary studies have yielded valuable insights into this flow. This link provides a video of the previous studies. The purpose of the present project is to analyze the performance of a wind farm in an Ekman boundary layer in neutral stratification. The effect of Coriolis force on the wind farm power production will be studied. Towards this end, high-fidelity wall-modeled large eddy simulations (LES) will be performed using a Fortran-based pseudo-spectral code utilizing the Dutch national supercomputer facilities in Amsterdam. The study will be instrumental in increasing our understanding of the interaction between ABL and wind farms.

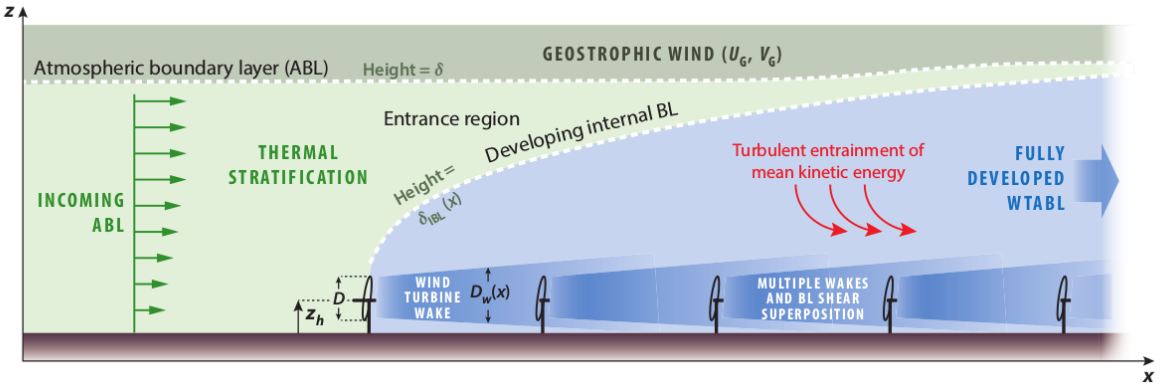

Figure 1: Turbulent flow phenomena in a wind farm. Figure adapted from Stevens and Meneveau[2].

References

[1] M. P. van der Laan and N. N. Sørensen. Why the coriolis force turns a wind farm wake clockwise in the northern hemisphere. *Wind Energy Science*, 2(1):285–294, 2017.

[2] Richard J.A.M. Stevens and Charles Meneveau. Flow structure and turbulence in wind farms. *Annual Review of Fluid Mechanics*, 49(1):311–339, 2017.