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APPLICATION OF LATTICE BOLTZMANN METHODS FOR LARGE-EDDY SIMULATION OF WIND TURBINE ROTOR WAKE AERODYNAMICS

Ralf Deiterding[1], Christos Gkoudesnes[1] and Aden Cox[1]

[1] Aerodynamics and Flight Mechanics Research Group
University of Southampton, Highfield Campus, Southampton SO17 1BJ, UK
e-mail: r.deiterding@soton.ac.uk, web page: http://rdeiterding.website

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The rotor of an operating horizontal axis wind turbine creates a large-scale turbulent rotating wake structure. High fidelity large eddy simulation (LES) is a promising avenue to improve on the understanding of the propagation of rotor wakes and how they interact with downwind turbines. While the majority of available computational fluid dynamics methods for wind engineering approximate the incompressible or weakly compressible Navier-Stokes equations, we utilize the lattice Boltzmann method (LBM) that is computationally inexpensive, explicit in time and easily parallelize. Further, the LBM adds little numerical dissipation making it especially suitable for wake propagation simulation.

While in previous work [1, 2], we had focused on modeling wind turbines as resolved moving embedded surface mesh structures, we concentrate here on approaches representing wind turbine rotors with actuator disk and actuator line models. The required momentum forces are considered as part of the particle collision process intrinsic to LBM.

Utilizing our parallel block-structured adaptive mesh refinement framework AMROC, dynamic mesh adaptation based on vorticity magnitude is used to capture wakes with high fidelity. We utilize a Smagorinsky-type LES turbulence model embedded into the LBM to enable aerodynamic computations with realistic Reynolds number. For verification, isotropic turbulence with continuous momentum forcing on a uniform periodic lattice has been simulated directly as well as on coarser scales using the LES model. Computations modeling primarily Vestas V27 turbines will be used to compare wake prediction results from the adaptive LBM when resolving the moving structures and when using actuator models at coarser resolutions.

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