

Recent Advances in Lattice-Boltzmann-based Large-eddy Simulations of Wind Turbines

Henrik Asmuth^a and Stefan Ivanell^a

^aUppsala University, Department of Earth Sciences, Wind Energy Group

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E-mail: henrik.asmuth@geo.uu.se

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1 Extended Abstract

Over the past decade, the lattice Boltzmann method (LBM) has emerged to a mature alternative to classical computational fluid dynamics approaches [1]. The main advantage of the method when compared to Navier-Stokes-based formulations, is a significantly increased computational performance, see, e.g. [2, 3]. Nevertheless, applications of the LBM in wind energy and atmospheric flows are still rare, in contrast to other fields of fluid dynamics.

In two recent studies we have shown the general feasibility of wind turbine simulations using the LBM and the actuator line model (ALM) [4, 5]. The two studies served the validation of the presented model as well as the investigation of various fundamental aspects of the simulated wakes in comparison to standard finite volume Navier-Stokes (NS) approaches. The blade loads and near-wake velocity of the LBM-ALM generally showed very good agreement with the NS-reference. The main differences were found in the onset of turbulence in the wake. In line with other similar code-to-code comparisons, e.g., [6], these are likely to be related to the different orders of accuracy in diffusion of the two numerical schemes. Exemplary contour plots are given in Fig. 1.

Generally, the studies underline that wind turbine simulations with the LBM are feasible. At the same time they highlight the superior computational performance of the method, especially when using

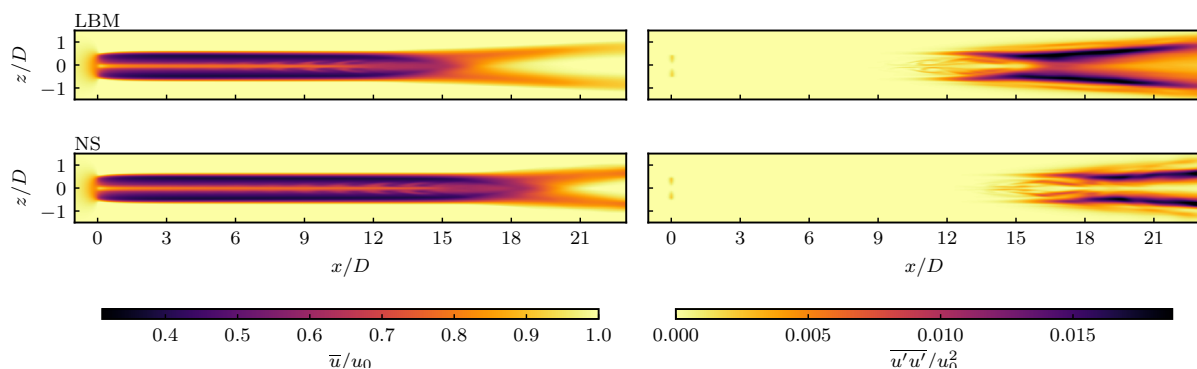


Figure 1: Contour plots of the mean stream-wise velocity \bar{u} (left) and Reynolds-stress $\overline{u'u'}$ (right) in the central stream-wise plane with the cumulant LBM [7, 8] (top) and NS finite-volume (bottom) approach.

GPU (Graphics Processing Units) implementations. As for the cases discussed here, the wall-clock time of the NS reference simulations running on about 1000 CPU-cores was about 20 times as much as the referring LBM case on a single GPU.

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