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A Multi-Scale Numerical Method for Simulating an Onshore Wind Farm over Complex Terrain

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Extended Abstract

Nowadays, wind developers pay more attention to exploit the wind resource in complex terrain [1]. However, accurately assessing the operation characteristics of wind farms, in particular for those in the real atmosphere, is still challenging. Therefore, developing a feasible numerical method is vital to sustainable development and utilization of the wind industry. As an alternative approach, the numerical method can flexibly handle various terrains and different atmospheric inflow boundary conditions, and it can obtain comprehensive and continuous information of the target wind farm. Besides, it is not restricted by the spatial and temporal scales of the wind farm. According to the scale of the simulated wind farm, the modeling can be divided into two categories respectively, *i.e.*, the mesoscale simulation using the weather prediction models and the microscale simulation based on the computational fluid dynamics (CFD) approaches. The majority of mesoscale modeling studies focused on wind resource assessment and operational analyze for wind turbines in onshore or offshore wind farms [2]. It can obtain the flow characteristics of the whole wind farm under real ABL, but it is difficult to illustrate the flow details and the operation property for each wind turbine. Moreover, the microscale simulation based on the CFD approach plays a crucial role in modeling the wake flow, operation characteristics, and layout optimization of each wind turbine in the wind farm [3, 4], however, these simulations almost rely on the general experienced atmospheric conditions. Therefore, detecting the real-like ABL condition is an indispensable factor to improve modeling accuracy. Balancing the pros and cons of the mesoscale and microscale model, coupling mesoscale and microscale model has become a promising approach for evaluating the performance of the wind farms [5, 6]. It is worth noting that these mesoscale-microscale coupled models enhance the accuracy of the wind farm simulation compared with the results simulated by the microscale or mesoscale model.

Despite the merits of the coupled model for simulating the realistic wind farm in complex terrain, it still has some omission and limitation: a) the mesoscale flow condition around the target wind farm will be unavoidably changed by the wake flow induced by the presented substantial wind farms; b) the wind turbines have to timely adjust according to the variable inflow wind during the operating process to maintain the optimal energy conversion efficiency. To this end, the contribution of this study is to develop a multiscale model that incorporated the mesoscale model coupled with a wind farm parameterization and the microscale model embedded with the wind turbine control strategies. This multiscale method can improve the fidelity of the wind property simulation by resolving the interaction between wind farms.

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