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A coupled Immersed Boundary Method and Actuator Surface Method for Wind Turbine Simulation

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ABSTRACT

Annual wind energy generation was valued at an estimated £3.6bn in 2023 in the UK alone, and at a fixed levelized cost of energy this value would increase to £9.5bn should the UK offshore wind targets be met. Effective transition to renewable energy generation is a key pillar in the global net-zero thrust and industry is growing quickly to meet this critical challenge. In addition to the rapid expansion of the number of wind farms in operation, there is a pressing need to extract the maximum value from existing and planned infrastructure. These needs are driving the continuous development of efficient Hybrid Navier-Stokes methods to predict wind farm aerodynamic performance. These methods combine a steady or unsteady representation of the atmospheric boundary layer with a simplified blade model utilising Actuator Disc, Actuator Line or Actuator Surface Methods. Here we focus on the application and validation of a recently developed coupled Immersed Boundary Method and Actuator Surface Model (IBM-ASM) using the Delayed Detached Eddy Simulation as utilised in rotorcraft studies by Park et al (2024) and Linton and Thornber (2024). The two validation cases presented include (i) the New MEXICO wind turbine of Boorsma et al. 2018 and (ii) the Lillgrund Offshore Wind Farm, Churchfield et al., 2012. The solver results are in good agreement with existing wind tunnel measurements and prior numerical data in both normal and yawed conditions. The full presentation includes the results of computations of the Siemens SWT-2.3-93 in the Lillgrund configuration. Finally, we conclude by summarising the key advantages and disadvantages of the IBM-ASM approach.

References

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