XI International Conference on Computational Methods in Marine Engineering

Comparing actuator line and disc models for the hydrodynamic design of tidal stream turbine rotors

Huw A. Edwards[1,*], Xiaosheng Chen[1], Christopher R. Vogel[1] and Richard H. J. Willden[1]

[1] Department of Engineering Science, University of Oxford
Parks Road, Oxford, OX1 3PJ, UK
[*] huw.edwards@eng.ox.ac.uk

ABSTRACT

Actuator methods are a computationally efficient approach to wind and tidal turbine simulation, as the rotor can be modelled without the need to resolve the blade geometry and its boundary layers. This is beneficial when carrying out iterative rotor design processes as the blade geometry can be modified without mesh alteration. While the actuator line method requires more computational resource than the actuator disc approach, the discrete blade representation more closely matches the physics of a real rotor as tip vortices and helical wake structures are generated. Previous studies, such as those of Porté-Agel et al. (2011) and Martínez-Tossas et al. (2015), have compared actuator line and actuator disc models for specific rotor geometries with a focus on the power output and wake quantities. The current study is focused on the use of actuator methods as tools for iterative rotor design, so analysis prioritises the spanwise distribution of force and flow components, particularly in the tip vicinity. A novel rotor design algorithm is presented which implements the same design criteria as the McIntosh et al. (2011) design tool, but modelling the rotor using actuator lines as opposed to an actuator disc. RANS simulations using both actuator methods are compared against blade resolved results. The force predictions are improved by the use of tip corrections in both cases. However, the resulting distribution of streamwise velocity requires that no tip correction is used with the actuator disc-based design tool, and indicates that the disc-based design criteria of McIntosh et al. (2011) are incompatible with actuator line modelling.

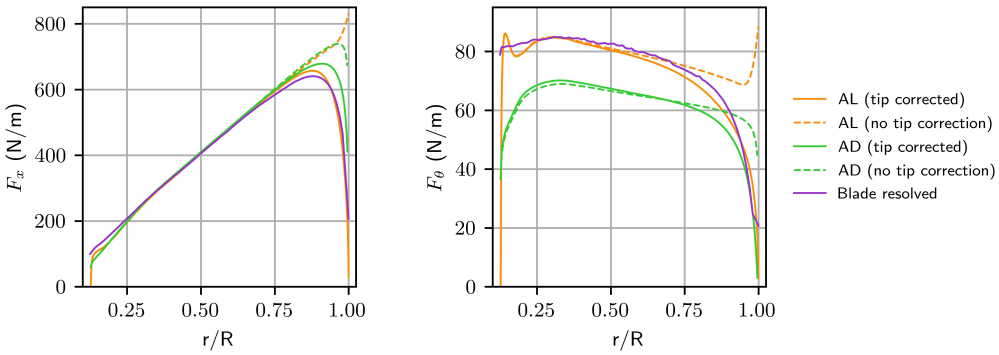

Figure 1: Comparison of the axial (left) and tangential (right) sectional force distributions predicted by actuator line (orange), actuator disc (green) and blade resolved (purple) RANS simulations with and without tip correction applied.

References

F. Porté-Agel, H. Lu and YT. Wu, A large-eddy simulation framework for wind energy applications, in Fifth International Symposium on Computational Wind Engineering, Chapel Hill, 2010.

L. A. Martínez-Tossas, M. J. Churchfield and S. Leonardi, Large eddy simulations of the flow past wind turbines: Actuator line and disk modeling, Wind Energy, 18:1047–1060, 2015.

S. C. Mcintosh, C. F. Fleming, and R. H. J. Willden, Embedded RANS-BEM Tidal Turbine Design, in Proceedings of the 9th European Wave and Tidal Energy Conference, Southampton, 2011.