XI International Conference on Computational Methods in Marine Engineering

Advances in Actuator based methods for modelling energy extraction

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ABSTRACT

Energy extraction from flows, wind and tide, are increasingly a multi-scale problem with different modelling approaches used depending on required analysis outcomes. Whilst detailed rotor flow problems including unsteady and three-dimensional effects may be better approached using resolved boundary simulations, we are often interested in larger scale flow interactions across multiple flow scales for which some of the details of the local flow problem can be neglected or appropriately modelled. Virtual rotor representation through actuator-based models have been developed as in important class of modelling tool that can be used in a computationally tractable manner allowing focus on the salient feature of study – be it wake, interaction or loading. However, validation and assessment of error is key to ensuring that modelling approaches and computational results are used appropriately.

The talk will provide an overview of available actuator-based approaches and will discuss implicit assumptions and provide some assessment of capabilities and fidelity of several approaches through reporting on the outcome of a large-scale community benchmarking project focused on modelling of a highly instrumented tidal turbine tested as part of the Supergen programme.

Actuator models make implicit assumptions around separation of flow scales with force imposition on flows reduced to planes, lines or defined regions of influence. Whilst this separation is useful it provides opportunity for flow mis-assessment if implicit scale separation is not understood, and opportunities for instabilities to develop due to flow sampling and force imposition on co-located spaces. A range of flow sampling and force imposition techniques have been developed to counter the instability issue which can themselves give rise to further complications through spatial resolution and time stepping requirements. The talk will review common methods and developed solutions.

Actuator based models may make further assumptions about local flow two-dimensionality. Whilst this assumption may be entirely appropriate over much of the blade span, detailed analysis of blade tip flows reveals departure from two-dimensional behaviour that cannot be accounted for using inflow modification or standard tip-correction techniques. The talk will discuss the need for and use us of anisotropic load-based modification techniques that correctly account for lift reduction and drag increase as blade tips are approached.