

Wake Field Interaction in 3D Tidal Turbine Arrays: Numerical Analysis for the Pentland Firth

Abstract

This study presents a methodology for applying the three-dimensional actuator disk-RANS technique in modeling tidal energy converters within a regional-scale simulation. Of particular interest are the robustness of the applied momentum source term and its effectiveness in modeling an array of full-sized tidal turbines under realistic hydrodynamic and operational conditions. The Inner Sound region, which is the site of commercial-scale deployment projects of the Pentland Firth in Scotland, is chosen as the study area. While the actuator disk approach had been used in past studies to parameterize the far-wake region of horizontal-axis tidal turbines, details of its three-dimensional implementation have not been thoroughly discussed. Criteria adopted in deciding the array location are presented in this study, along with the actuator disks' detailed setup and constraints. The models are subjected to one operational characteristic that is similar to commercial devices in service to examine the accuracy of the imposed source term under complex flow conditions. The results demonstrate that the thickness of the disk imposed in the source term has a pronounced influence on the model outputs. In addition to accurately modeling flow propagation and wake interactions, the models are also able to replicate the observed asymmetrical tidal currents in the region. Because there is currently limited published material on the detailed application of the actuator disk approach in ocean-scale models, this study is hoped to fill the research gap and provide evidence, guidance, and examples of best practices for future studies.

Keywords

Actuator disk; Flow interactions; Hydrodynamic characteristic; Inner sound; Pentland Firth; Telemac3D