Geophysical Research Abstracts
Vol. 19, EGU2017-13832-2, 2017
EGU General Assembly 2017

Three-dimensional modelling for assessment of far-field impact of tidal stream turbine: A case study at the Anglesey Coast, Wales, UK

Xiaorong Li (1), Ming Li (2), and Judith Wolf (3)

(1) School of Environmental Sciences, University of Liverpool, United Kingdom (xiaorong.li@liverpool.ac.uk), (2) School of Engineering, University of Liverpool, United Kingdom (m.li@liverpool.ac.uk), (3) National Oceanography Centre, Liverpool, United Kingdom (jaw@noc.ac.uk)

As a response to worldwide climate change, clean non-carbon renewable energy resources have been gaining significant attention. Among a range of renewable alternatives, tidal stream energy is considered very promising; due to its consistent predictability and availability. To investigate impacts of tidal stream devices on their surroundings, prototype experiments involving small scale laboratory studies have been implemented. Computational Flow Dynamics (CFD) modelling is also commonly applied to study turbine behaviours. However, these studies focus on impacts of the turbine in the near-field scale. As a result, in order to study and predict the far-field impacts caused by the operation of turbines, large scale 2D and 3D numerical oceanography models have been used, with routines added to reflect the impacts of turbines. In comparison to 2D models, 3D models are advantageous in providing complete prediction of vertical flow structures and hence mixing in the wake of a turbine.

This research aims to deliver a thorough 3D tidal stream turbine simulation system, by considering major coastal processes, i.e. current, waves and sediment transport, based on a 3D wave-current-sediment fully coupled numerical oceanography model — the Unstructured Grid Finite Volume Community Ocean Model (FVCOM). The energy extraction of turbines is simulated by adding a body force to the momentum equations. Across the water depth, the coefficient related to the additional body force is given different values according to the turbine configuration and operation to reflect the vertical variation of the turbine's impacts on the passing flow. Three turbulence perturbation terms are added to the turbulence closure to simulate the turbine-induced turbulence generation, dissipation and interference for the turbulence length-scale. Impacts of turbine operation on surface waves are also considered by modification of wave energy flux across the device. A thorough validation study is carried out in which the developed model is tested; based on a combination of laboratory measured data and CFD simulated results. The developed turbine simulation system is then applied to the Anglesey coast, North Wales, UK for a case study.

The validation study suggests that the developed turbine simulation system is able to accurately simulate both hydrodynamics and wave dynamics in the turbine wake. The case study with 18 turbines (diameter is 15 m) modelled individually in the waterway between the north-west Anglesey and the Skerries reveals impacts of the turbine farm on free surface elevation, flow field, turbulence kinetic energy (TKE), surface waves, bottom shear stress and suspended sediment transport. The wake is observable up to 4.5 km downstream of the device farm. Flow near the bed in the wake is accelerated, leading to enhanced bottom shear stress. The device farm has a strong influence on TKE and hence the vertical mixing of suspended sediment in the wake. Further, the eastwards directed residual sediment transport along the north coast of Anglesey is found to be weakened by the turbine farm.