Goal Oriented Error Estimation and Mesh Adaptivity for Tidal Turbine Modelling

J. G. Wallwork, M. D. Piggott, N. X. Barral, S. C. Kramer

Earth Science and Engineering Department, Imperial College London

In the face of climate change, it is becoming increasingly important for governments to consider lower carbon forms of energy generation. Alongside nuclear and conventional renewable energy extraction techniques, a significant amount of low-carbon, renewable energy may be captured from the tides. Tides are - unlike solar and wind sources - temporally *reliable*.

The location of new tidal power plants impacts highly upon their effectiveness. The positioning of a tidal array may be framed mathematically as an optimisation problem [1], whose solution can lead to an increase in yield.

The objective functional (relating to the power output) used in the optimisation problem also provides a basis for goal-oriented error estimation. By application of dual weighted residual error estimation to the nonlinear shallow water equations, we have developed a mesh adaptive algorithm which seeks to minimise the error in the assessment of tidal power plant output.

A discontinuous Galerkin approach is applied, using the *Thetis* coastal ocean finite element model [2]. Mesh optimisation is performed for both steady and unsteady simulations. Comparisons are made with fixed meshes and adaptive meshes resulting from other error estimators.

References

[1] Funke, S. W., Farrell, P. E. and Piggott, M. D.: Tidal turbine array optimisation using the adjoint approach, Renewable Energy, 63:658-673, Elsevier (2014).

[2] Kärnä, T., Kramer, S. C., Mitchell, L., Ham, D. A., Piggott, M. D., and Baptista, A. M.: Thetis coastal ocean model: discontinuous Galerkin discretization for the three-dimensional hydrostatic equations, Geosci. Model Dev., 11:4359-4382 (2018).