A spectral/hp element depth-integrated model for nonlinear wave–body interaction

We present a depth-integrated Boussinesq model for the efficient simulation of nonlinear wave–body interaction. The model exploits a 'unified' Boussinesq framework, i.e. the fluid under the body is also treated with the depth-integrated approach. The unified Boussinesq approach was initially proposed by Jiang (2001) and recently analyzed by Lannes (2017). The choice of Boussinesq-type equations removes the vertical dimension of the problem, resulting in a wave–body model with adequate precision for weakly nonlinear and dispersive waves expressed in horizontal dimensions only. The framework involves the coupling of two different domains with different flow characteristics. Inside each domain, the continuous spectral/hp element method is used to solve the appropriate flow model since it allows to achieve high-order, possibly exponential, convergence for non-breaking waves. Flux-based conditions for the domain coupling are used, following the recipes provided by the discontinuous Galerkin framework. The main contribution of this work is the inclusion of floating surface-piercing bodies in the conventional depth-integrated Boussinesq framework and the use of a spectral/hp element method for high-order accurate numerical discretization in space. The model is verified using manufactured solutions and validated against published results for wave–body interaction. The model is shown to have excellent accuracy and is relevant for applications of waves interacting with wave energy devices.