Conference Paper, Published Version

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Next generation of waves2Foam

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The modelling of free surface flows for riverine, coastal or offshore applications is often faced with the challenge of absorbing any internal disturbance due to initial conditions or outgoing waves at the boundaries. This led to developments of numerical beaches, sponge layers, and absorbing boundary conditions (like perfectly matching layers and Sommerfeld-type conditions). In the framework of OpenFoam, the relaxation zone technique in waves2Foam (Jacobsen et al, 2012) and the shallow-water based boundary absorption in IHFoam/OlaFlow (Higuera et al., 2013) are widely used techniques. Neither method is perfect.

The waves2Foam framework allows for low reflection coefficients for a wide range of non-dimensional wave numbers (kh), but it comes at the cost of a considerable extension of the computational domain. Furthermore, it has proved difficult to apply the relaxation zone technique to absorb waves (disturbances) on an upstream boundary of a hydraulic structure, while achieving a fixed discharge without restraints to the water level. IHFoam/OlaFlow is based on the assumption of shallow-water waves, so the condition quickly results is unsatisfactory reflection coefficients.

In this work, the first steps of eliminating the deficiencies in the two existing methods are presented. The new development is a boundary-based absorption and generation method for 2DV applications, which can be tuned for reflection less than 5% over a wide range of kh, e.g. 0.0-2.5 (Borsboom and Jacobsen, In preparation). The starting point is the Sommerfeld transmissive boundary condition. In this context, 2DV means that the boundary condition is strictly derived for normal incident waves, though it is still possible to apply the absorption technique in 3D.

Applications of the method are presented, where the performance as an absorbing boundary condition is shown for regular and irregular waves. Furthermore, it is shown that the method allows for combined generation and absorption at the same boundary. Finally, results for the validation of flow over a hydraulically rough weir is shown, where the capability of absorbing translatory waves at the upstream boundary, while ensuring a target discharge without restraints on the upstream water level is shown.

Literature

Borsboom, M.J.A.; Jacobsen, N.G. (In preparation): A non-reflective boundary for normal incident, dispersive waves.

Higuera, P.; Lara, J.L.; Losada, I.J. (2013): Realistic wave generation and active wave absorption for Navier-Stokes models. Application of OpenFoam®. Coastal Engineering, 71, 102-118.

Jacobsen, N.G.; Fuhrman, D.R.; Fredsøe, J. (2012): A Wave Generation Toolbox for the Open-Source CFD Library: OpenFoam®. International Journal for Numerical Methods in Fluids, 70(9), 1073-1088.