A general overview of OpenFOAM as an open source numerical wave tank

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During the last years, the complexity of coastal and offshore structures has grown significantly. One example is the evolution of foundation types for offshore wind turbines from basic monopiles towards complex jacket structures and very recently up to innovative floating wind turbines. This increasing complexity results in a great interest for numerical tools in addition to analytical verification methods and traditional small-scale experimental modelling. Numerical modelling is nowadays very popular for R&D activities due to the availability of extremely powerful computational resources. Since a few years, the coastal and offshore community shows interest in numerical wave tanks (NWTs) to answer specific design questions for a structure installed offshore or nearshore.

A NWT is the equivalent of a physical wave basin and they share the same objective: reproducing the physics as observed in the ocean or the sea in a controllable environment to study physical processes in detail or to check design criteria. In this overview, the NWT is implemented in the open source Computational Fluid Dynamics (CFD) software OpenFOAM. Over the past years, three main branches are developed and made available by the OpenFOAM Foundation, OpenCFD and the foam-extend community. OpenFOAM is used (i) to solve the Navier-Stokes equations to calculate the hydrodynamics (i.e. pressure and velocity) and (ii) to apply the Volume of Fluid method to determine the position of the free water surface in the numerical wave flume. Furthermore, boundary conditions for wave generation and absorption are mostly adopted from toolboxes such as waves2foam, IHFOAM and olaFlow. In addition, those three toolboxes are able to simulate the flow through porous media such as breakwaters for example. Also currents, with or without waves, are generated in NWTs in order to enhance the reproduction of the physics observed in reality. Recommendations for turbulence modelling (i.e. RANS or LES) are provided by many authors. We emphasise our recent work where we enhanced the predictive skills of NWTs by applying buoyancy-modified RANS turbulence models [1,2]. Furthermore, a NWT is very suitable to study fluid-structure interactions such as wave run-up on structures, wave attack on storm walls and floating structures subjected to specified wave conditions. As an example, we developed an accelerated coupling algorithm for simulations of floating structures in a NWT [3]. Lastly, NWTs are coupled with a sediment transport module to study the evolution of the bottom in the swash zone under wave and/or current action [4].

Nowadays, NWTs are under continuous development to reduce the disadvantages. Firstly, enhanced predictions of complex processes such as the hydraulic stability of rubble mound breakwaters are still lacking. Secondly, NWTs suffer from long calculation times especially for long duration tests. Thirdly, the obtained results are only as good as the physics involved in the equations being solved. Therefore, physical wave basis are always needed complementary to NWTs such as the coastal and offshore basin which is now under construction at the GreenBridge science park in Ostend (Belgium).

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PREFACE

This is the 'Book of Abstracts' of the 18th edition of the VLIZ Marine Science Day, a one-day event that was organised on 21 March 2018 in the MEC Staf Versluys in Bredene.

This annual event has become more and more successful over the years. With almost 400 participants and more than 100 scientific contributions, it is fair to say that it is the place to be for Flemish marine researchers and for the end-users of their research. It is an important networking opportunity, where scientists can meet and interact with their peers, learn from each other, build their personal professional network and establish links for collaborative and interdisciplinary research.

Marine scientists from all Flemish universities and scientific institutes – and representing all marine science disciplines – have contributed to this volume. The book thus illustrates the diversity, quality and relevance of the marine sciences in Flanders (and Belgium): it provides a beautiful and comprehensive snapshot of the state-of-the-art of marine scientific research in Flanders.

Pre-doc and post-doc scientists present their research in an exciting way and communicate their fascinating science – and its importance to society – to the wider public. We thus hope to demonstrate the excellence of Flemish marine science and to increase its national and international visibility.

The volume of research that is presented here holds a great promise for the future. It shows that marine science is a very lively discipline in Flanders, and that a new generation stands ready to address the grand challenges and opportunities that our seas and oceans represent.

For the second year, the Brilliant Marine Research Ideas are awarded, an initiative sponsored through the philanthropy scheme of VLIZ. We are proud to announce that last year's winners present their results here at the VLIZ Marine Science Day.

I want to congratulate all participants with their contributions, and I invite them all to become members of VLIZ and to actively participate in our events and activities in the future.

Bredene, 21 March 2018

Prof. Dr Jan Mees

General Director VLIZ

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