Sesión Especial Número 1

A broad perspective on numerical and computational methods for offshore renewable energies

Organizadores
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Descripción

Offshore renewable energies, namely offshore wind, tidal and wave energies, represent sources of renewable energies that could provide in the near future a huge contribution towards a carbon-free society. For this reason, efforts in making these kinds of energies reliable and cheap are receiving a greater and greater interest from the scientific, technical and political community, through the deployment of several projects at various levels (local, national and European).

This session, whose contribution are inherent to mathematical applications for the sector of offshore renewable, will serve to provide a perspective of what has been done so far by the Spanish scientific universities and research centres with respect to the international community and identify eventually gaps which could be covered in the development of numerical and computational methods in order to accelerate the deployment of these kind of complex systems.

Programa

LUNES, 4 de febrero (tarde)

17:00 – 17:40	Sergio Fernández Ruano and Álvaro Rodríguez Luis (Instituto de Hidráulica Ambiental de Cantabria "IH-Cantabria") *Introduction to the study of the offshore structures used to harvest renewable energy.*
17:40 – 18:20	José Manuel Gutiérrez Llorente (IFCA. Instituto de Física de Cantabria (CSIC-UC)) *Climate data post-processing and downscaling.*
18:20 – 19:00	Markel Peñalba Retes (Mondragon Unibertsitatea / Maynooth University) *Mathematical modelling for effective control of wave energy converters: controller design and evaluation.*

Martes, 5 de febrero (tarde)

17:00 – 17:40	Claes Eskilsson (Aalborg University, Denmark / Research Institutes of Sweden, Sweden) *A high-order finite element Boussinesq model for modelling nonlinear wave-body interaction*
17:40 – 18:20	Margarida Moragues Ginard (BCAM - Basque Center for Applied Mathematics) *Two-phase flow simulations for marine energy applications*
18:20 – 19:00	Alejandro J. C. Crespo(Universidade de Vigo) *Smoothed Particle Hydrodynamics: A Lagrangian method for wave energy devices*

Introduction to the study of the offshore structures used to harvest renewable energy.

Sergio Fernández Ruano and Álvaro Rodríguez Luis

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Abstract. Wave energy converters will use the motion of the ocean to generate renewable energy and offshore wind turbine generators will be under the action of waves at the same time they extract the energy from the wind. The talk will be focus in the hydrodynamic fluid/structure interaction of both devices and the mooring problem as the way to maintain the position in the case of floating devices. The study of floating bodies is done using simplify models that ignore some of the physics presents in the ocean, as a first approach. These models are based in potential flow models, where viscosity is ignored. They can be studied in the time domain, or frequency domain. The second ones will be used together with transfer functions in Cummins equations to study the motion of the devices in its 6 DOFs. The results of such models will be complemented with those from viscous models. A floating device must be moored to maintain its position. Each of the catenary lines of the mooring system are analysed using a one dimensional wave equation in 3D. The most extended methodology is to use models based on finite method for the catenaries and couple them with the model that study the motion of the device.

Joint work with José Antonio Armesto Álvarez, Daniel de los Dolores Paradinas and Raúl Guanche García.

Climate data post-processing and downscaling

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Abstract. Weather prediction at different lead times (from a few days, to seasons and decades) build on global climate models which are numerically solved with typical resolutions ranging from 10 to 100 km. When compared to local historical observations, these models exhibit systematic biases (due to, e.g. the approximate representation of the orography) which should be calibrated to make the forecasts usable. This is a challenging problem and various statistical approaches have been proposed and recently inter-compared, each with different advantages and shortcomings. In this talk we present an overview of the different weather and climate prediction products available for the different lead times and discuss the advantages and limitations of the different postprocessing approaches.

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Mathematical modelling for effective control of wave energy converters: controller design and evaluation

Markel Peñalba Retes

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Abstract. Although the technical viability has been demonstrated for some devices, no prototype has yet demonstrated its commercial viability. In this respect, significant improvements are still necessary, so that wave energy can compete in the energy market with other (renewable) energy sources. Energy maximising control systems can significantly assist the cost reduction. However, the design of these control techniques relies heavily on mathematical models, which, for fast computation, are usually based on linear hydrodynamic models. Nevertheless, nonlinear effects [1], and dynamics and losses of the power take-off system can also play an important role when designing the control strategy [2]. Unfortunately, these last points are usually neglected or excessively simplified, which may lead to dramatic consequences. In order to verify the effectiveness of the control strategies in real conditions, more realistic numerical frameworks are necessary.

Referencias

[1] Peñalba, M., Ringwood, J.V. Linearisation-based nonlinearity measures for wave-to-wire models in wave energy. Ocean Engineering, 171, (2019): 496-504.

[2] Peñalba, M., Ringwood, J.V. A high-fidelity wave-to-wire model for wave energy converters. Renewable Energy, 134, (2019): 367-378.

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A high-order finite element Boussinesq model for modelling nonlinear wave-body interaction

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Abstract. Depth-integrated Boussinesq models are a standard tool in coastal engineering used to predict nonlinear dispersive wave propagation and transformation in the nearshore zone. We present a model based on the 'unified' Boussinesq approach for simulating nonlinear wave-body interaction. In the unified Boussinesq approach, initially proposed in Jiang [1] and recently analysed by Lannes [2], the domain is decomposed into a free surface domain and a body domain where importantly also the fluid under the body is treated with a depth-averaged approach. The equations are discretized in space using a high-order finite element method. The flux-based coupling between the domains follows the discontinous Galerkin approach. We illustrate the exponential convergence of the scheme and illustrate the method for 1D test cases of fixed and floating bodies.

Referencias

[1] Jiang, T. Ship waves in shallow water. Fortschritt-Berichte VDI Reihe 12, Verkehrstechnik, Fahrzeugtechnik; (2001).

[2] Lannes, D. On the dynamics of floating structures, Annals of PDE 3.1 (2017): 11.

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Two-phase flow simulations for marine energy applications

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Abstract. A conservative level-set methodology for the simulation of two-phase flows is presented, for which a variational multiscale stabilized finite element method is used. A compression technique is introduced within the level-set method. Floating devices are modeled by a simplified rigid body motion scheme and a deforming mesh approach, in which the mesh deforms elastically following the movement of the body. An implicit turbulence model is used, turbulence is then modeled through the numerical stabilization. The described methods are implemented in the open source parallel software FEniCS-HPC. The method is applied to the simulation of floating platforms related to marine energy in collaboration with Tecnalia R&I. Our simulation results are compared against some of their experimental data obtained in the experimental water tank. We also participate in the International Energy Agency-Ocean Energy Systems (IEA-OES) Task 10 project, in which a number of groups involving different methodologies compare their simulation results of several test cases on a heaving sphere.

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Smoothed Particle Hydrodynamics:
A Lagrangian method for wave energy devices

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Abstract. Smoothed Particle Hydrodynamics (SPH) is a Lagrangian meshless method. SPH discretises a continuum using a set of nodal points, called particles. In fluid dynamics, the discretised Navier-Stokes equations are locally integrated at the location of each of these particles, according to the physical properties of surrounding particles (determined by a distance based function). The conservation laws of continuum fluid dynamics are transformed from their partial differential form to a form suitable for particle based simulation using integral equations based on an interpolation function, which gives an estimate of values at a specific point. SPH is an ideal technique to simulate free-surface flows and violent wave-structure interaction since there is no special treatment to detect the free surface, and therefore large free-surface deformations can be efficiently treated since there is no mesh distortion. SPH captures accurately the highly nonlinear behaviour of wave-structure interactions and fluid-driven objects. The open-source DualSPHysics code is employed to simulate the interaction of sea waves with floating offshore Wave Energy Converters (WEC), in order to analyse their efficiency and survivability under high energetic sea states.

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