CCP-WSI Training Events

Rutherford Appleton Laboratory, Didcot, UK

24-25th May 2018

CCP-WSI Training Event

25th May 2018, Rutherford Appleton Laboratory, Didcot, UK

The CCP-WSI Project and WSI Applications

including "lightning talks"

Dr Ed Ransley

Aims & Objectives

- Over-arching Aims:
  - Develop and maintain a robust and efficient computational WSI modelling tool
  - Build the community of researchers and developers around WSI
  - Provide a focus for software development and code rationalisation

- Four major project objectives:
  1. Build and grow a community of researchers, data, code and expertise
     - With the shared objective of building a NWT facility and the capacity for high quality research
  2. Bring together experimentalists, computer scientists and CFD engineers
     - Allow development of and sharing of ideas and processes for validation
  3. Provide advanced training in computer science and software development
     - Verification and validation of computational models
     - Characterisation of data arising from experiments
     - Outreach activities for schools and the general public
  4. Provide a framework for innovation and development of strategic software
     - Driven by focus group, workshops and road mapping exercises

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a Collaborative Computational Project in Wave Structure Interaction

Focus on developing an open-source NWT

- Bring the whole community and development activities together
  - Networking activities, focus groups and workshops
  - Road mapping exercises to inform CCP-WSI strategy
- Held in a central code repository
  - Professional software engineered and maintainable
  - Shared and future-proofed whilst protecting individual's intellectual property
- Tested and validated against measurement data
  - Using new fundamental experiments for bench marking and validation

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WSI Applications

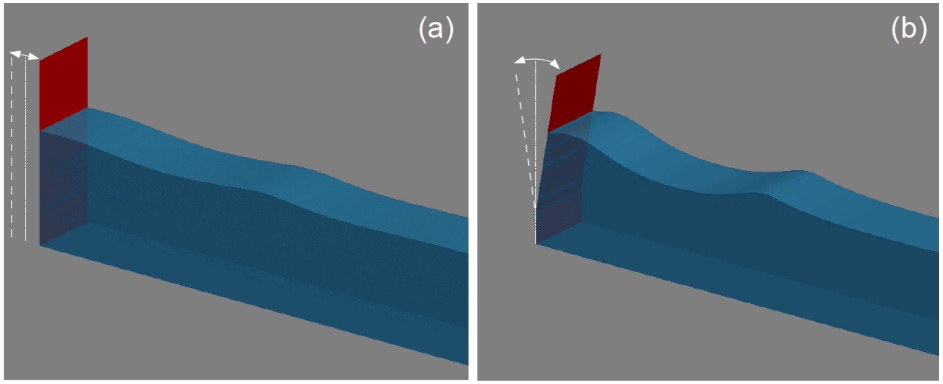
Numerical wave makers

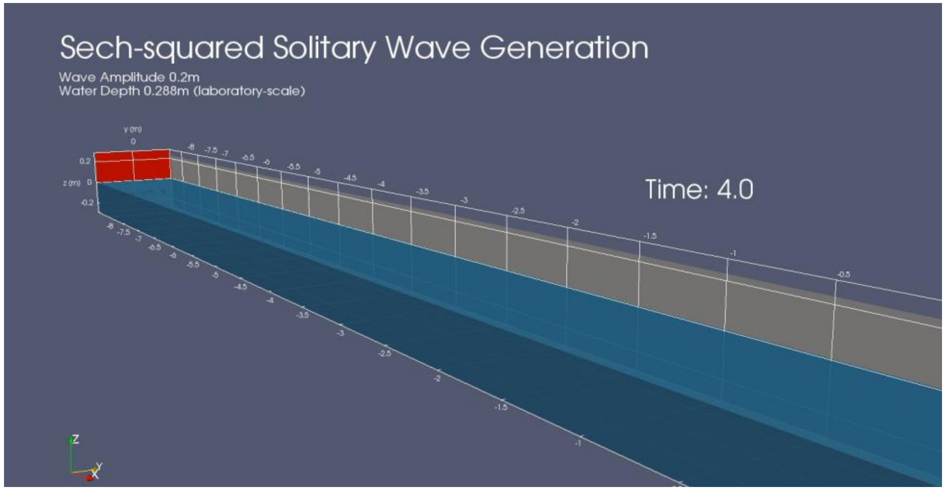
NEW CODE

- Flap and piston-type wave makers in OpenFOAM
  - Regular waves
  - Sech^2 solitary waves
  - Cnoidal waves (wip)
  - Second-order corrected wave maker (wip)

CASES

- Reproduction of physical experiments
- Shallow water wave generation





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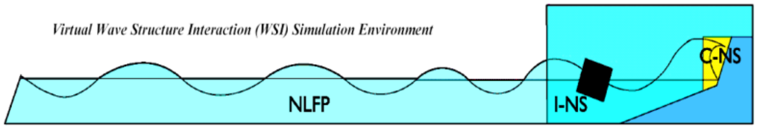
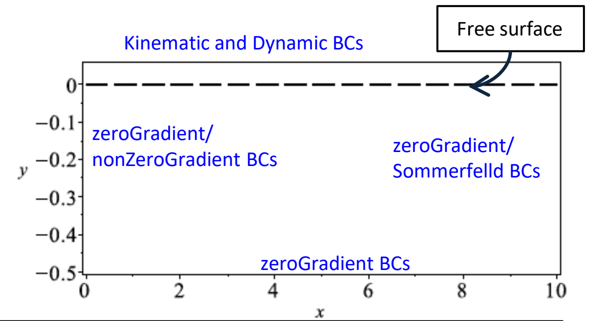
Fully Nonlinear Potential Flow Solver



NEW CODE

- Solution to the Laplace equation in fluid domain
  - Neumann and Dirichlet boundary conditions
- Kinematic boundary condition at the free surface
  - Moving mesh to accommodate free surface deformation
- Active generation and absorption of single phase free surface flows

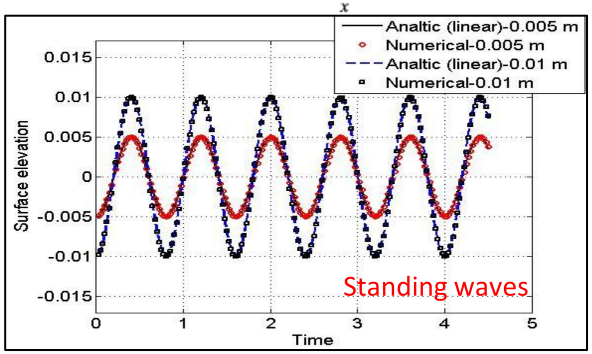


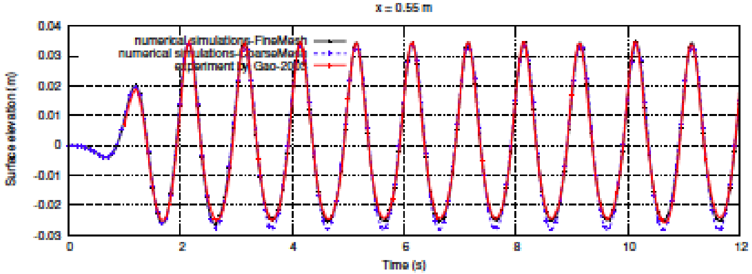
NEW COUPLING

- Coupling with Incompressible Navier-Stokes solver

CASES

- Standing waves
  - Compared with available analytical results
- Progressive waves
  - Compared to experimental data (Gao, 2013)





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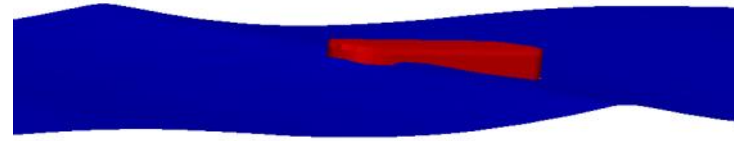
FROTH (EP/J012866/1)



Hu et al. 2016, 'A Numerical and experimental Study of a Simplified FPSO in Extreme Free Surface Waves', in Proceedings of the 26th international Offshore and Polar Engineering Conference, June 26 – July 2, 2016, Rhodes, Greece

NEW CODE

- Extreme wave generation boundary conditions added to waves2Foam (OpenFOAM)
  - Focused wave group (NewWave)
  - Second-order Stokes theory

CASES

- Focused wave interaction with an FPSO
- Cylinder in heave and heave & pitch motion
- Fixed and floating moored FPSO (6DOF)
- Extreme wave impact on a hull
  - Slight breaking, flip-through, large air pocket, broken wave

Mai, T., Hu, ZZ, Greaves, D and Raby, A. (2015) Investigation of Hydroelasticity: Wave Impact on a Truncated Vertical Wall, ISOPE, 2015, Hawaii.

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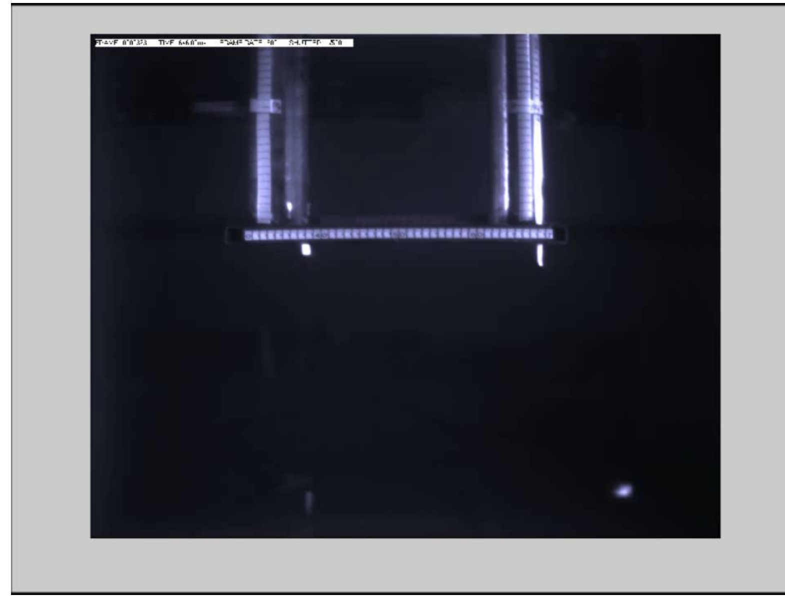
NEW CODE

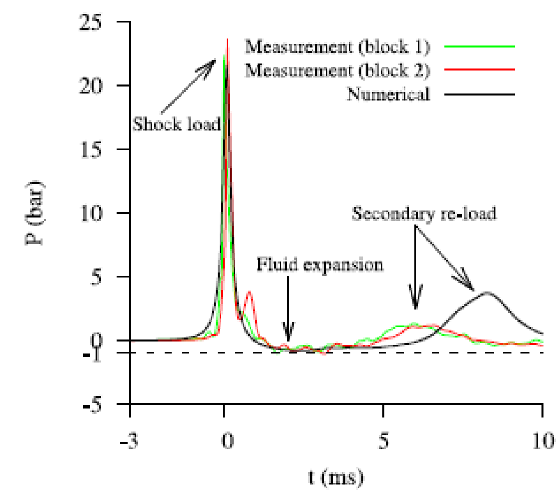
- Compressible air and water/air bubble mixture model

CASES

- Drop test into pure and aerated water



Ma, Z. H., Causon, D. M., Qian, L., Mingham, C.G., Mai, T., Greaves, D. and Raby, A. 2016
Pure and aerated water entry of a flat plate, Phys. Fluids 28, 016104 (2016);
http://dx.doi.org/10.1063/1.4940043



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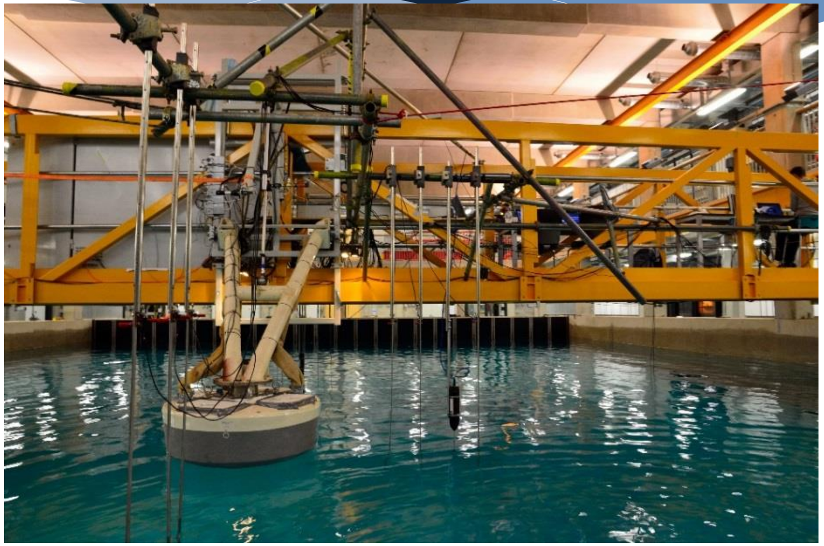
Survivability of WECs

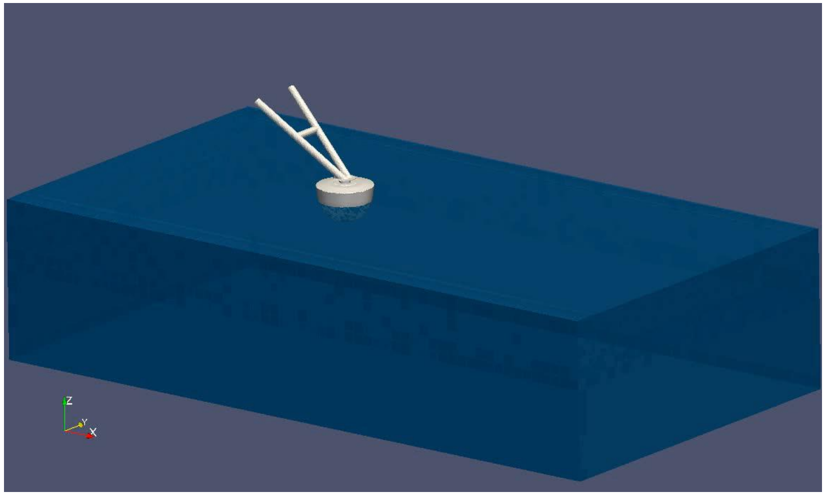
NEW CODE

- Numerical wave makers
- Focused wave generation using waves2Foam
- New ‘restraints’ for moored WECs
    - Coupled PTO model

CASES

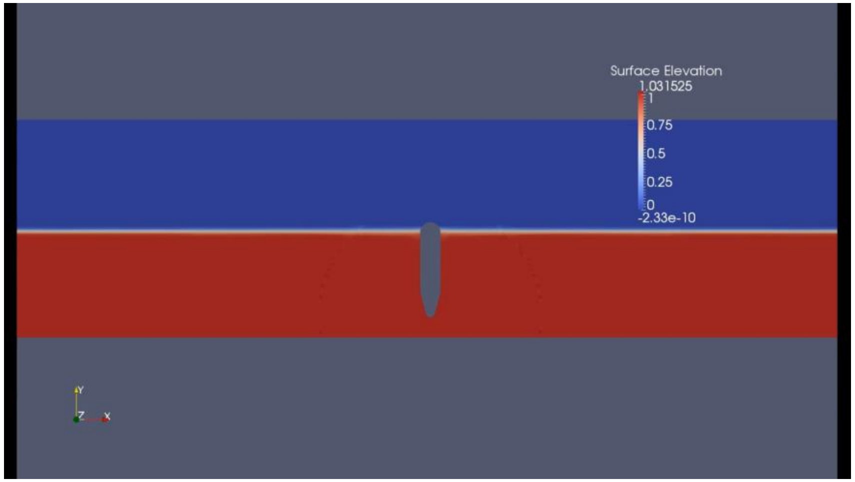
- Fixed truncated circular cylinder
- Moored hemispherical bottomed buoy
- The Wavestar machine
- The Seabased Wave Energy Converter





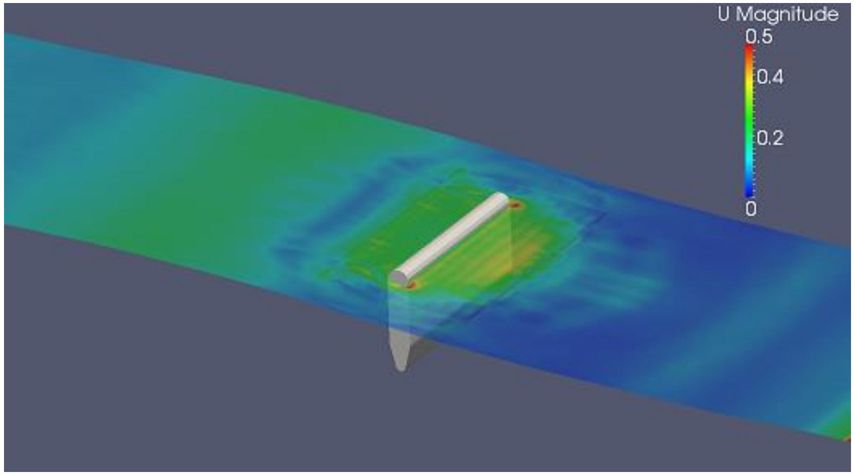
Ransley, E. J., Greaves, D. M., Raby, A., Simmonds, D., Jakobsen, M. M., Kramer, M. 2017, RANS-VOF modelling of the Wavestar point absorber, Renewable Energy, 109, pp 49-65

Interaction of waves with a bottom-hinged flap-type WEC



CASES

- Dynamic behaviour of oscillating wave surge converter (OWSC)
  - Power take-off (PTO) drive unit
    - linear damping
    - torque limit (cut off)
  - Different wave conditions in a 2D and 3D NWT.
    - regular operational waves
    - oblique waves
    - extreme waves in intermediate water depth.



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Tan Loh, T., Greaves, D., Mäki, T., Vuorinen, M., Simmonds, D., Kyte, A., Numerical Modelling of the WaveRoller Device Using OpenFOAM, in Proceedings of the 3rd Asian Wave and Tidal Energy Conference (AWTEC), 24-28 October 2016: Marina Bay Sands, Singapore.

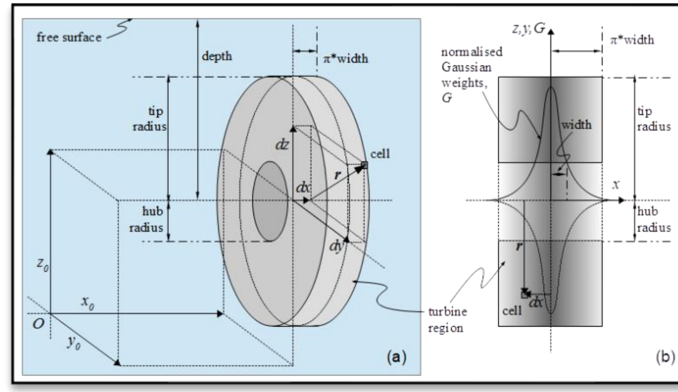
Floating Tidal Stream Concepts (iUK102217 & iUK103499)

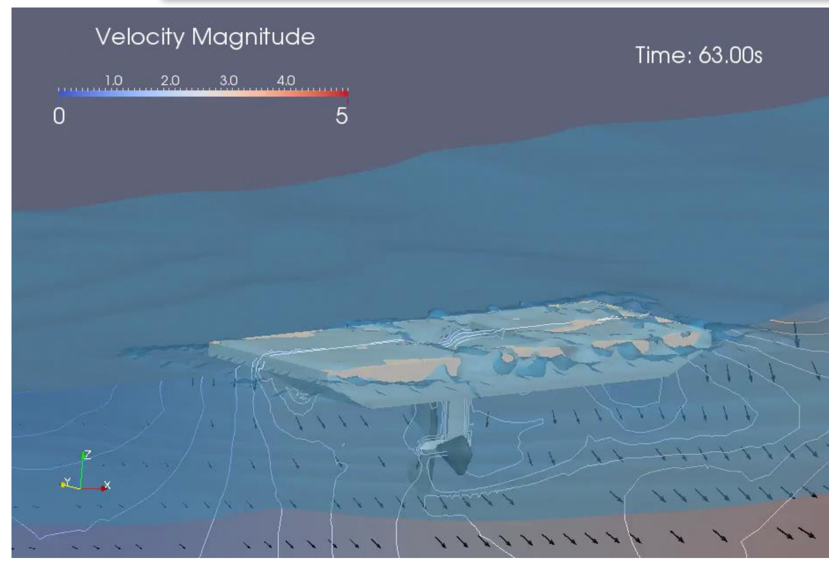
NEW CODE

- New libraries allowing for applied body forces
  - Turbine classes - analytical & real turbine data
  - Multiple turbines
    - Any number, size, orientation…
- Coupled turbine models with rigid body solver
  - Body motion ↔ turbine thrust
    - Turbine position up-dated at run-time
  - Turbine thrust ↔ fluid velocity
    - Additional source term in U equation
- Mooring models
  - Based on Orcaflex outputs

CASES

- MTG Tidal Raft Platform Concept





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Ransley et al. 2016, 'Coupled RANS-VOF Modelling of Floating Tidal Stream Concepts', in Proceedings of the 4th Marine Energy Technology Symposium, April 25-27, 2016, Washington ,DC

Initial mesh deformation library:

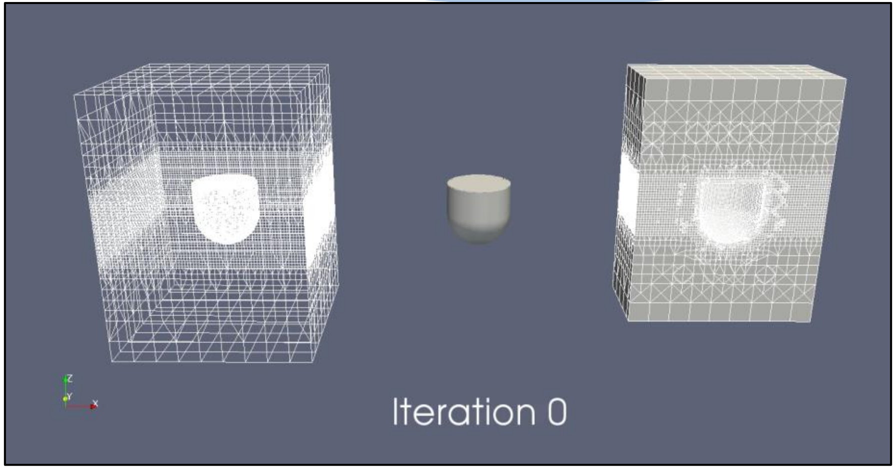
`deformDyMMesh`

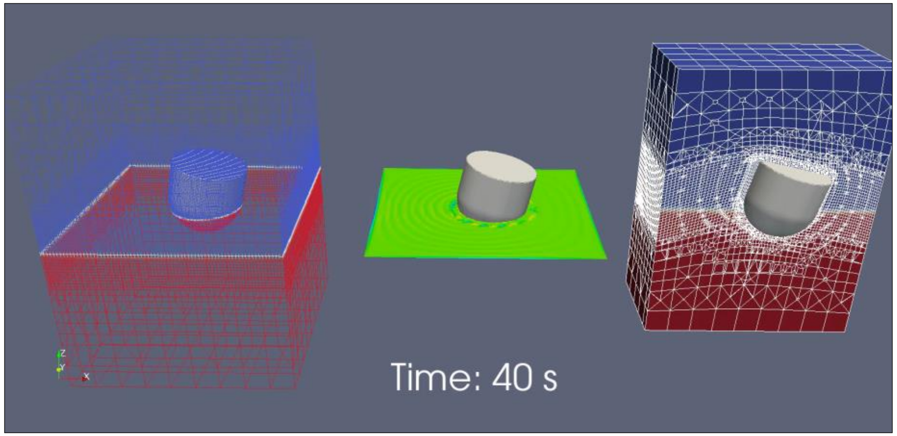
NEW CODE

- Pre-positioning of structures using the `rigidBodyMotionSolver` library

CASES

- 'Hot-start' CFD
- Coupling with BEM code (WaveDyn)





Musiedlak, P.-H., Greaves, D., Ransley, E., Child, B., Hann, M., Iglesias, G., 2018. A temporal coupling approach between a Navier-Stokes solver and a linear, time-domain model with application to wave energy converters, in Proceedings of the 6th European Conference on Computational Mechanics (ECCM 6)/7th European Conference on Computational Fluid Dynamics (ECFD 7), 11 – 15 June 2018: Glasgow, UK.

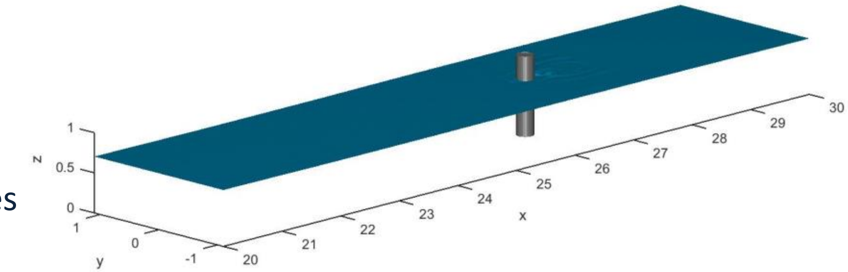
Floating structure with forward speed in extreme waves

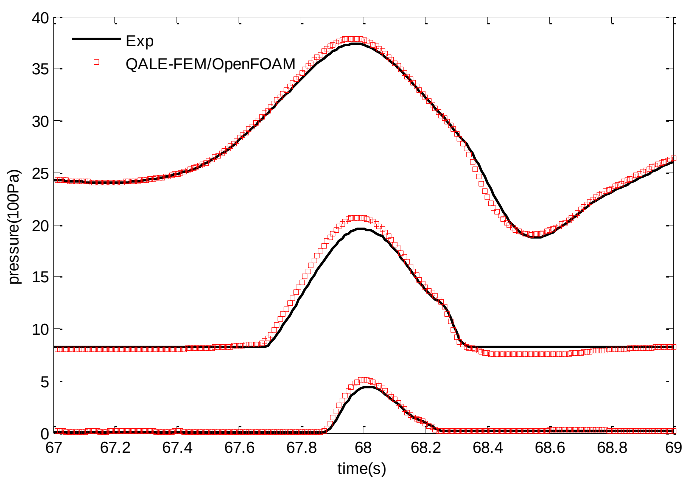
NEW COUPLING

- QALE-FEM ↔ OpenFOAM (waves2FOAM)
- New QALE-FEM library with overset technology
  - Effective wave generation and absorption techniques
  - Generating highly nonlinear waves
  - Interface to couple with NS solver
    - Translational zone or overset grid technology
- Coupled with waves2FOAM
- Improve the robustness

CASES

- Moving cylinder in extreme focusing waves





cylinder facing incident wave (f_l = 0.34 Hz to f_u = 1.02 Hz. G_a = 0.002, cylinder moves towards the wave paddle with speed of 0.25m/s (small domain: OpenFOAM)

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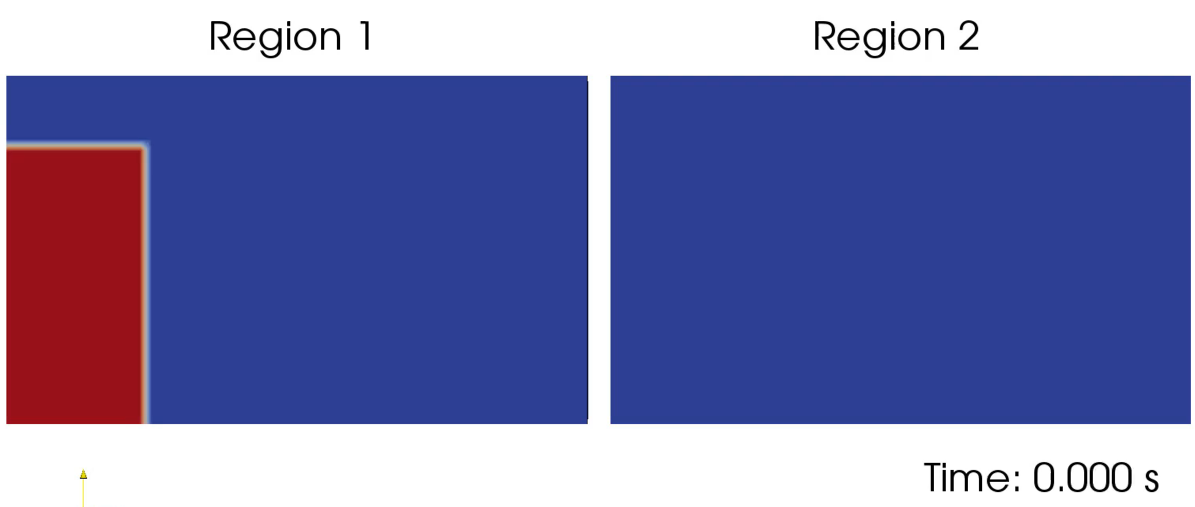
Multi-region solver for ‘zonal CFD’: `wsiFoam`

NEW CODE

- A multi-region coupling scheme for compressible and incompressible flow solvers for two-phase flow in a numerical wave tank (Martínez Ferrer et a. (2016)
- Code up-dated for OpenFOAM 5.0 as part of eCSE12-08

CASES

- Dam break with incompressible and compressible, two-phase solvers
- Floating buoy in focused waves
- Zonal CFD



P. J. Martínez Ferrer, D. M. Causon, L. Qian, C. G. Mingham and Z. H. Ma. A multi-region coupling scheme for compressible and incompressible flow solvers for two-phase flow in a numerical wave tank. Computer & Fluids 125, 116–129 (2016). DOI:10.1016/j.compfluid.2015.11.005

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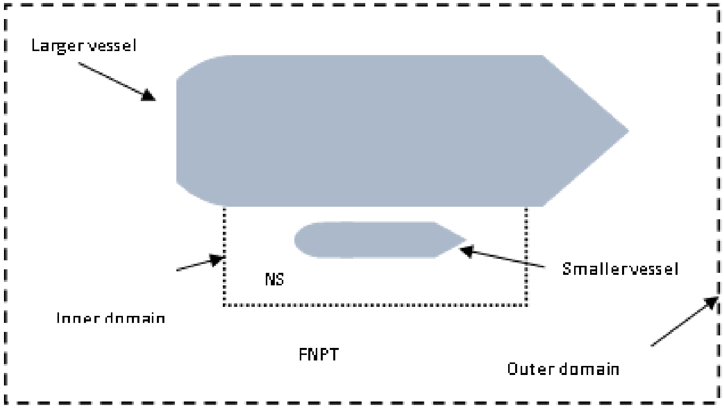
A Zonal CFD Approach for Fully Nonlinear Simulations of Two Vessels in Launch and Recovery Operations (EP/N008847/1)

CODE

- Foam-extend-3.1/extend-bazaar
- Elastic body deformation in two-phase solver

CASES

- Interaction between multiple fluid flows with free surface



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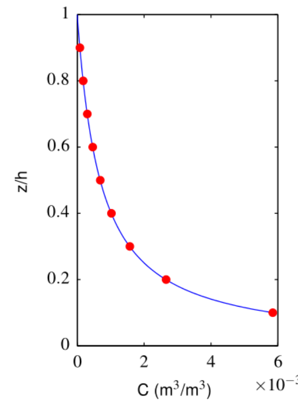
Suspended Sediment Model

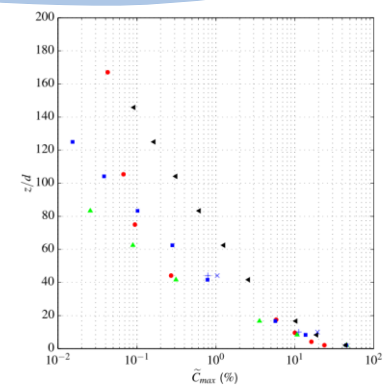
NEW CODE

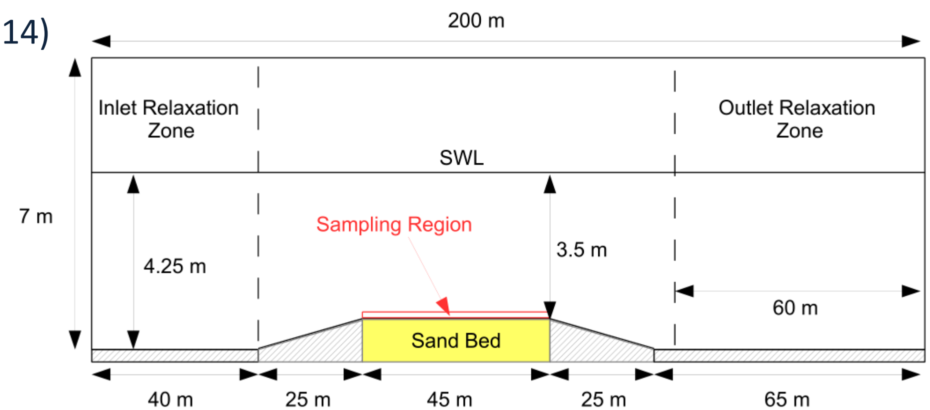
- Transport of suspended sediment concentration
  - Coupled with existing solvers and libraries
    - Steady-state solver (simpleFoam)
    - Multiphase solver (interFoam)
    - Wave generation (waves2Foam)
- Created new libraries
  - Modified turbulence models (Brown et al., 2014)
  - Boundary condition
    - Flux based on sediment pickup and deposition

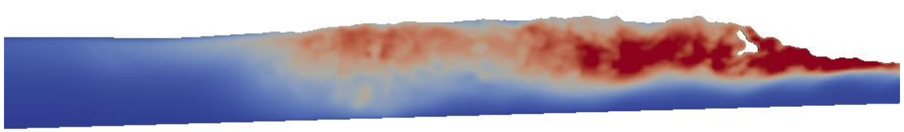
CASES

- Steady-state flows
- Regular waves
- Breaking waves on a sloping beach









Brown, S. A., Magar, V., Greaves, D. M. and Conley, D. C. (2014), An evaluation of RANS turbulence closure models for spilling breakers ., in 'Proceedings of the 34th International Conference on Coastal Engineering', Vol. 1, p. 5.

Up-coming Events

CCP-WSI Blind Test Series 1: Showcase

Location: ISOPE2018, Sapporo, Japan

Date: Thursday 14th June 2018

EVENT DETAILS

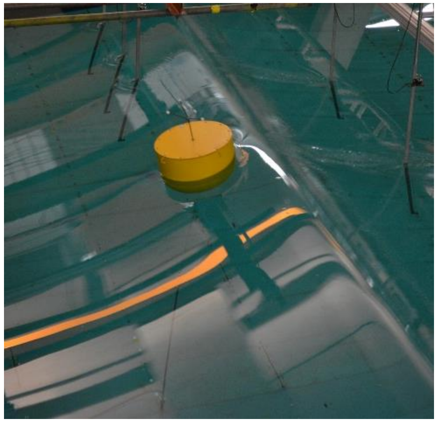
- Presentations from participants over 3 special sessions
- Release and comparison with blind test measurements
- Discussion group
- Submission for publication is IJOPE
- Data set upload to the CCP-WSI test case database

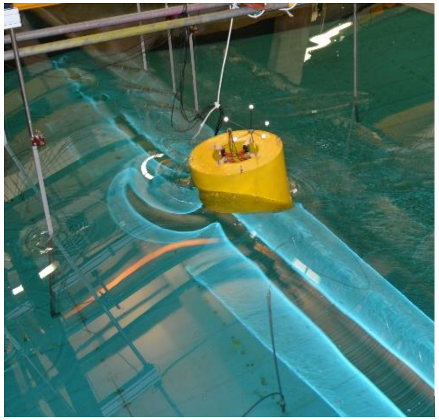
CCP-WSI Blind Test Series 2: Release

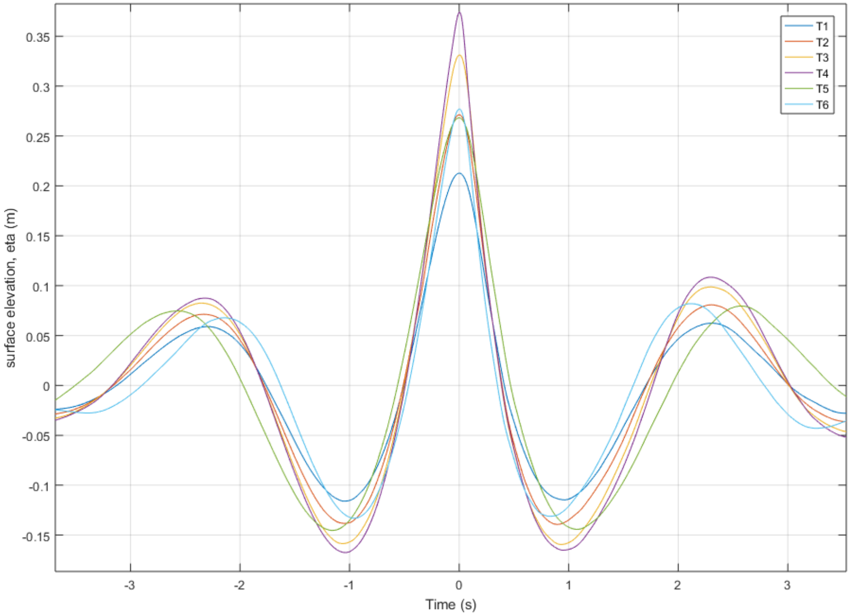
Date: ASAP

EVENT DETAILS

- Invitation to participate
- Release of the empty tank data and case description







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CCP-WSI Focus Group Workshop 2

Location: University of Exeter, UK

Date: w/c 17th September 2018 (tbc)

Time: 10:30 -16:45

EVENT DETAILS

- A forum for Wave Structure Interaction (WSI) discussions
- Bring together CCP-WSI project partners, industry representatives & the wider WSI community
- Develop a priority list of WSI challenges in the context of industry needs
- Inform future targeted focus group meetings
- Develop a roadmap for CCP-WSI activities
- Inform future UK research funding calls

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and now for some ….

“Lightning Talks”