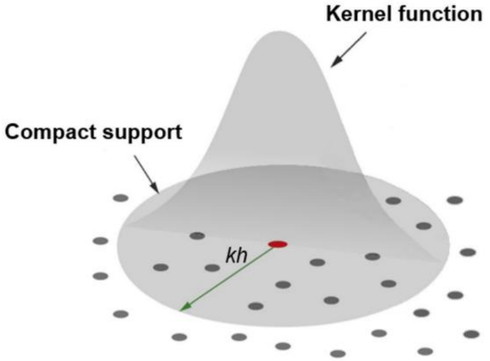
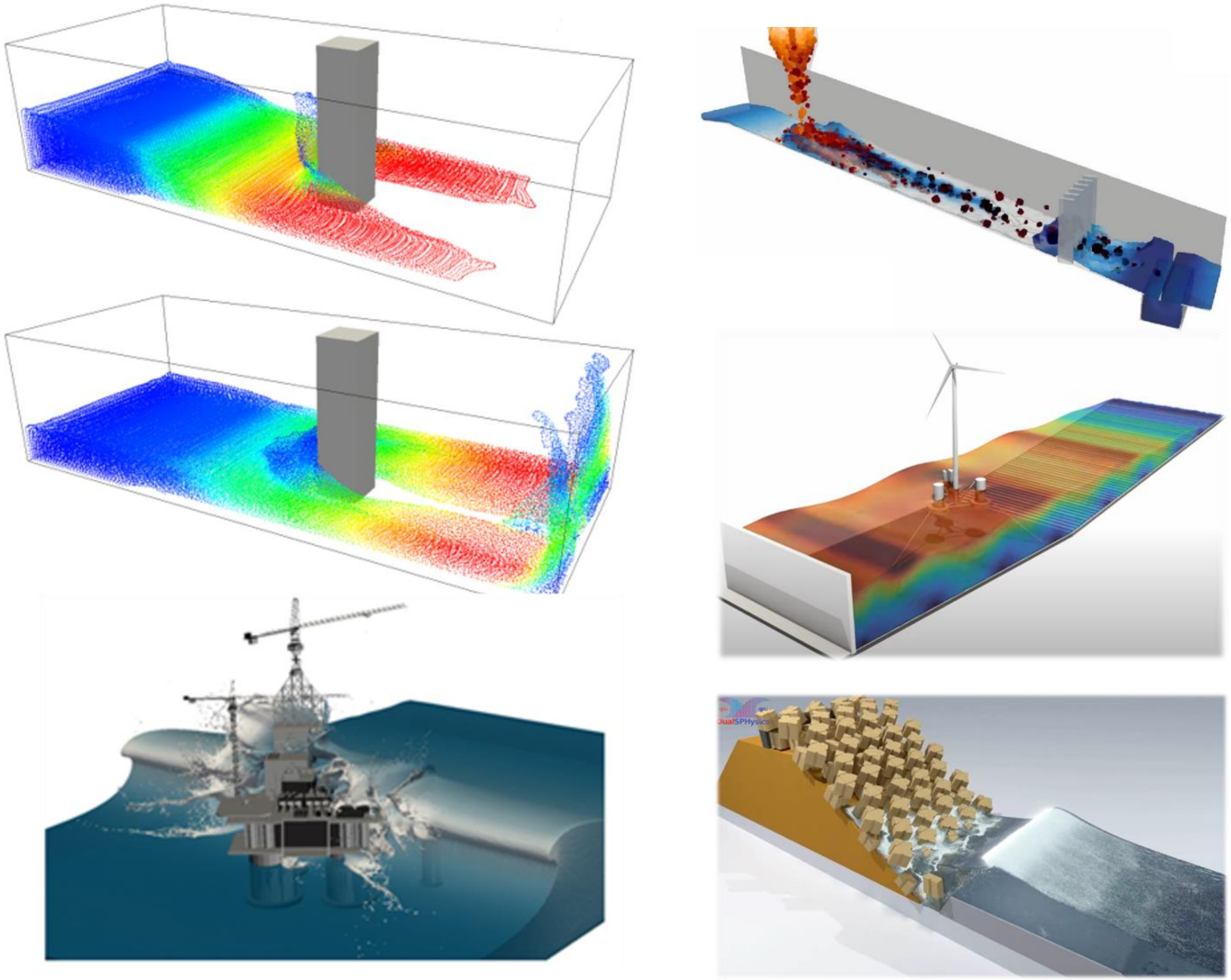
Novelties on DualSPHysics v5.2

JOSÉ M. DOMÍNGUEZ & ANGELO TAFUNI

Overview of DualSPHysics

Implementation of **Smoothed Particle Hydronynamics** method for **complex fluid dynamics** using HPC techniques





Overview of DualSPHysics

It includes **two implementations**:

- **CPU**: C++ and OpenMP.
- **GPU**: CUDA.

Both options optimized for the best performance of each architecture.

SPH HIGHLY PARALLELISED

GPU	CPU
	
NVIDIA CUDA	C++

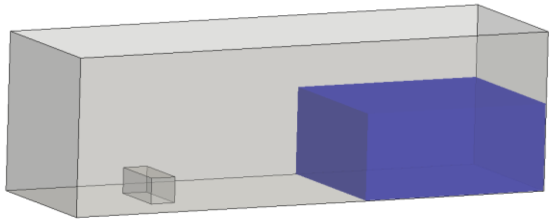
GPU x100 CPU

Overview of DualSPHysics

cpu gpu DualSPHysics

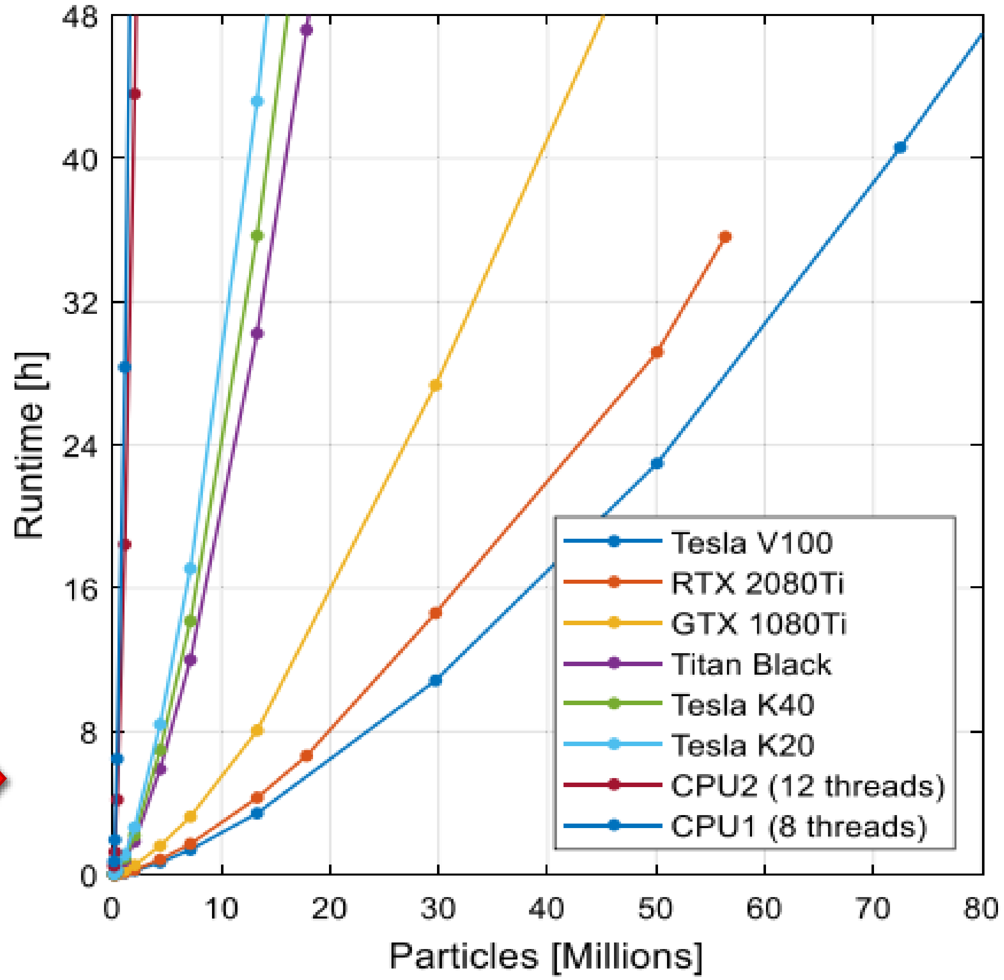
Testcase for performance test

Dam break flow impacting an obstacle (experiment by kleefsman et al., 2005). 2 physical seconds of simulation.



2M particles on multi-core **CPU** (12 threads) in **44h**
&
80M particles on **GPU** Tesla V100 in **47h**

SPH HIGHLY PARALLELISED



Overview of DualSPHysics

cpu gpu
DualSPHysics

SPH HIGHLY PARALLELISED

Testcase for performance test

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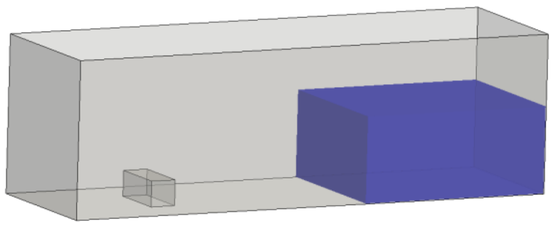
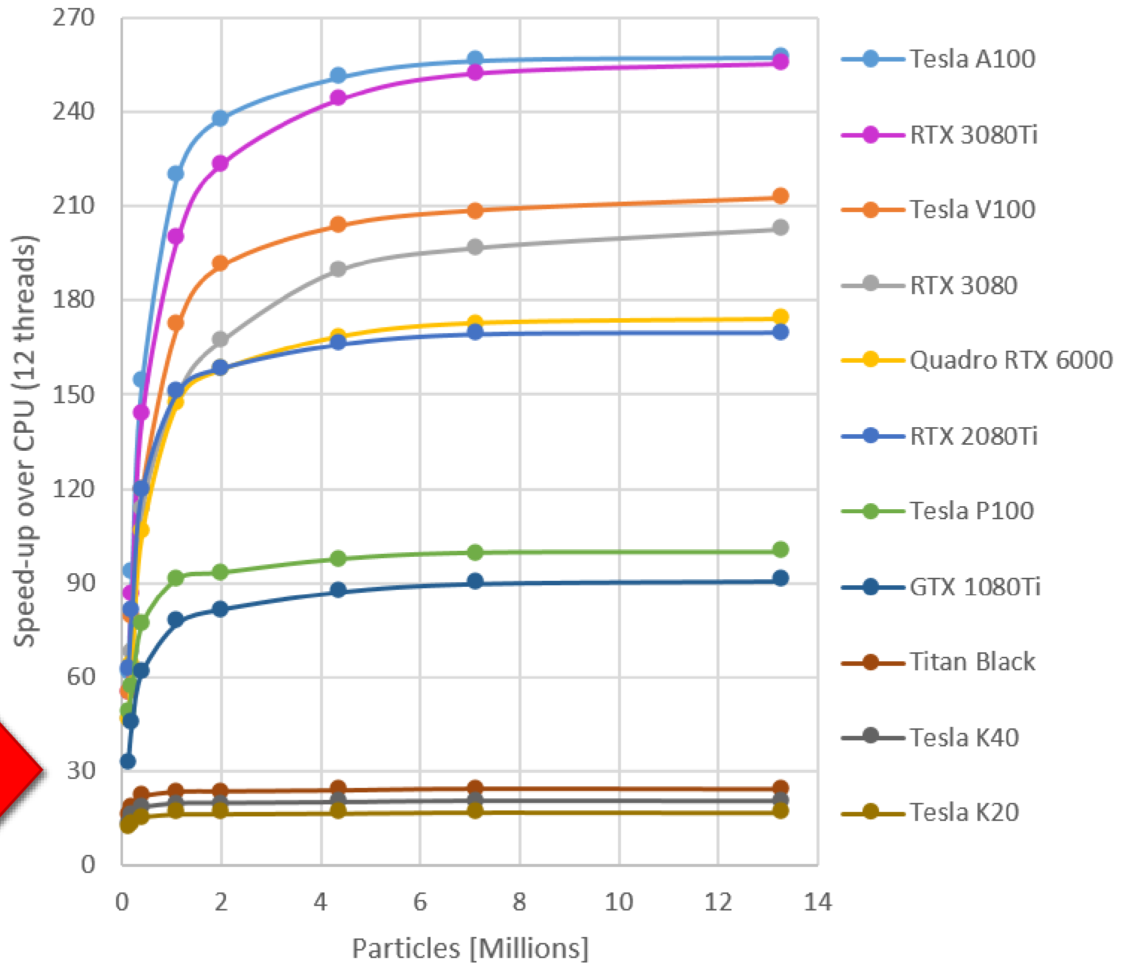


Speed-up: 257x on **Tesla A100**
255x on **RTX 3080Ti**
over
CPU Intel Core i7-8700K
(12 threads)



Overview of DualSPHysics

COLLABORATIVE PROJECT

OPEN-SOURCE CODE

LGPL (Lesser General Public License) can be **used in commercial applications**. Software can be incorporated into both free software and proprietary software.

DEVELOPERS:

Universidade de Vigo, Spain
The University of Manchester, UK
Instituto Superior Tecnico, Lisbon, Portugal
Università degli studi di Parma, Italy
Universitat Politècnica de Catalunya, Spain
New Jersey Institute of Technology, USA

COLLABORATORS:

Flanders Hydraulics Research , Belgium
Universidad Politécnica de Madrid, Spain
TECNALIA. Inspiring Business, Spain
Imperial College London, UK
Universiteit Gent, Belgium
University of Salerno, Italy
Universidad de Guanajuato, Mexico
…

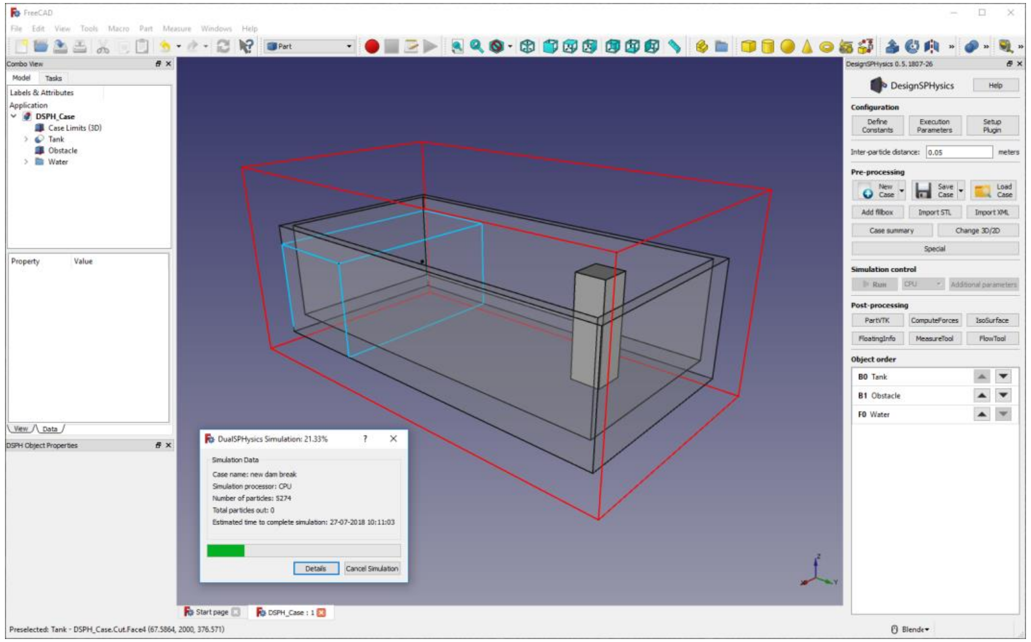
Overview of DualSPHysics

DesignSPHysics

(Graphical User Interface)

FreeCAD

Open Source parametric 3D CAD modeler



COMPLETE TOOLKIT

- SPH solver
- Pre-processing tools
- Post-processing tools

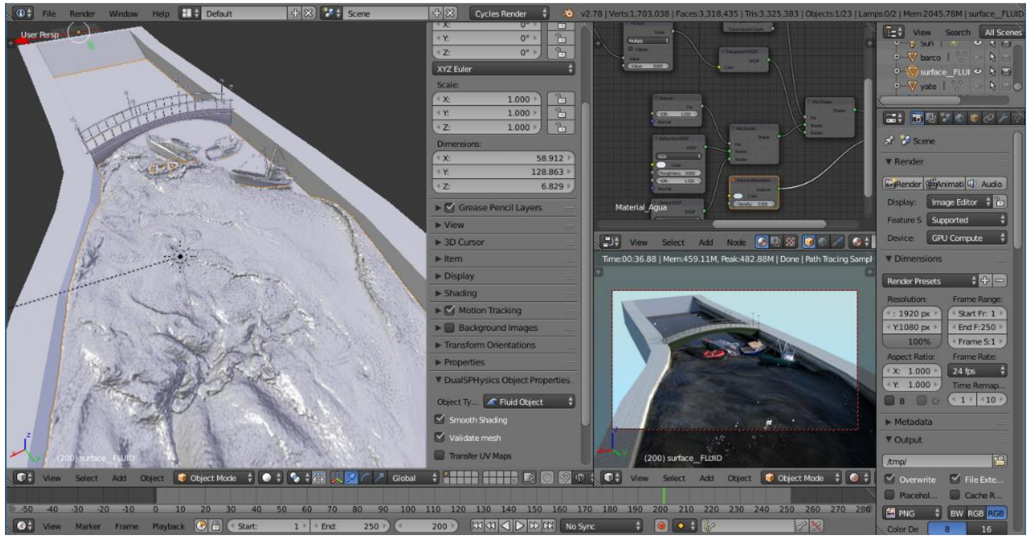
but also…

- Graphical User Interface
- Advanced visualisation

VisualSPHysics

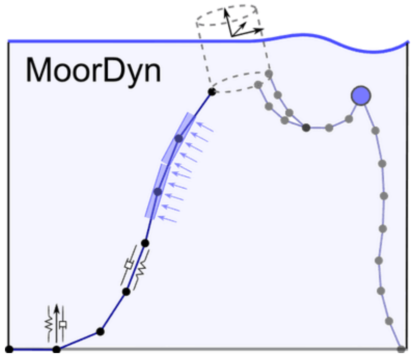
(Advanced visualisation tool)

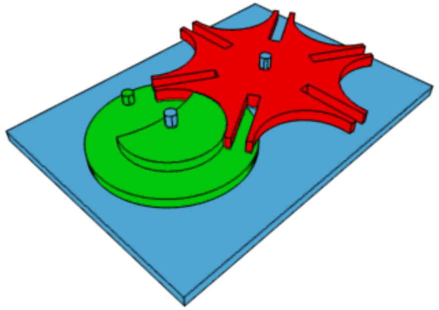
blender™

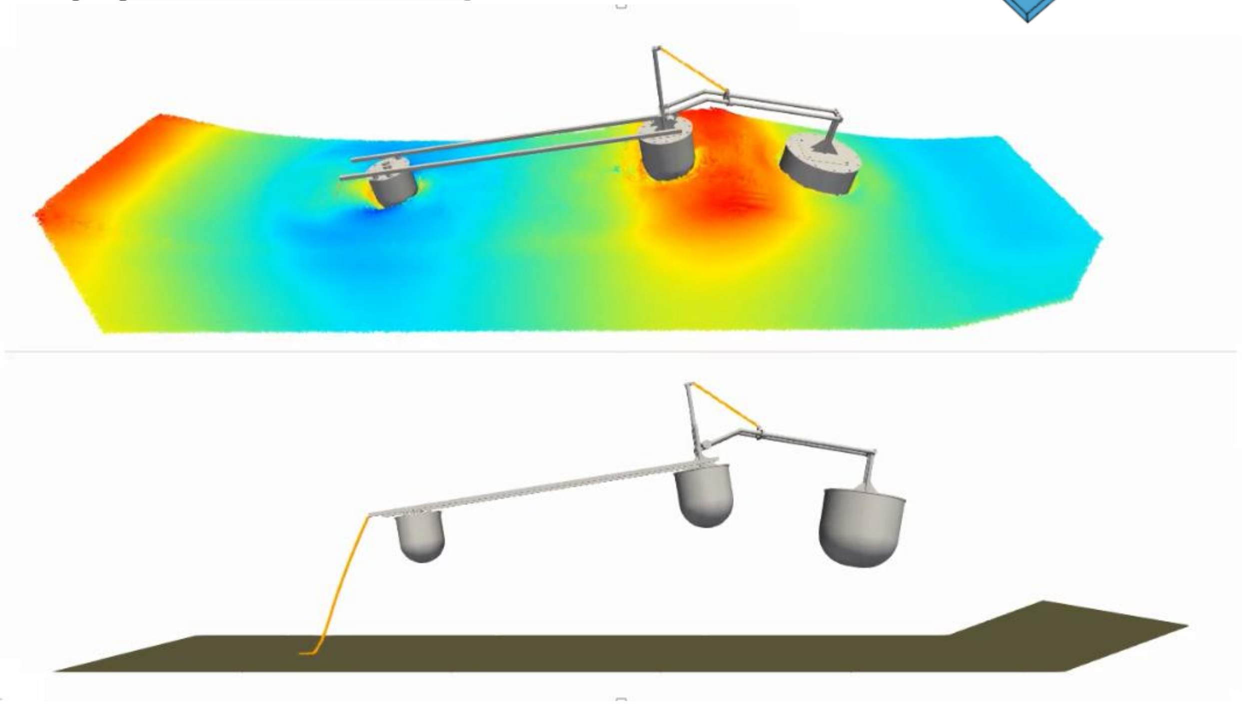


Overview of DualSPHysics

MoorDyn





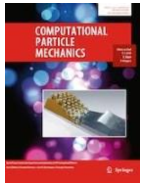


COUPLING WITH OTHER MODELS

To enable multi-physics simulations:

- Discrete Element Method
- Project Chrono for complex mechanisms
- MoorDyn for moored floating bodies
- Wave propagation models SWASH

Overview of DualSPHysics



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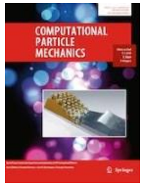
Formulation and capabilities

- SPH approaches:
  - **Single phase free-surface flow solver**
  - Multi-phase: liquid and gas
  - Multi-phase: non-Newtonian flows
- Kernel functions:
  - Cubic Spline (Monaghan and Lattanzio, 1985)
  - Quintic Wendland (Wendland, 1995)
- Density diffusion Term:
  - Molteni (Molteni and Colagrossi, 2009)
  - Fourtakas (Fourtakas et al., 2019)
- Viscosity:
  - Artificial (Monaghan, 1992)
  - Laminar + SPS turbulence model (Dalrymple & Rogers, 2006)
- Weakly compressible approach using Tait's equation of state (Batchelor, 1974)
- Time integration scheme:
  - Verlet (Verlet, 1967)
  - Symplectic (Leimkhuler, 1996)
- Variable time step (Monaghan and Kos, 1999)
- Shifting algorithm (Lind et al., 2012)
- Boundary conditions:
  - Dynamic boundary conditions (Crespo et al., 2007)
  - Modified Dynamic boundary conditions (English et al., 2022)
- Periodic open boundaries (Gómez-Gesteira et al., 2012)
- Inflow-outflow boundary conditions (Tafuni et al., 2018)
- External forces (Longshaw and Rogers, 2015)

Overview of DualSPHysics



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Formulation and capabilities

- Floating objects (Monaghan et al., 2003)
- **Floating objects with mDBC support**

- **Lagrangian formulation for flexible fluid-structure interaction (O'Connor et al., 2021)**

- Coupling with Discrete Element Method (Canelas et al., 2016)
- Coupling with Project Chrono (Canelas et al., 2018; Martínez-Estévez et al., 2022)
- Coupling with MoorDyn (Domínguez et al., 2019)

- Piston- and flap-type long-crested second-order wave generation (Altomare et al., 2017)
- Solitary waves (Domínguez et al., 2019)
- **Focused waves (Whittaker et al., 2017)**

- Passive and Active Wave Absorption System (Altomare et al., 2017)

- Relaxation Zone method and coupling with wave propagation models (Altomare et al., 2018)

- Non-linear wave generation and absorption using open boundaries (Verbrugghe et al., 2019)

Overview of DualSPHysics

Post-processing tools:

A number of post-processing and visualisation tools are available in DualSPHysics

- ***Metrics*** such as "time for end of simulation", computational times per feature, etc., restart checkpoints.

- ***PartVTK*** (VTK, ASCII)
  - Fluid, boundary, or any other type of particle
  - Any field variable (pressure, velocity, vorticity, etc)
  - Choice between fixed, moving, floating, type, mk, etc.
  - Excluded particles

- ***MeasureTool*** - Analysis of numerical measurements
  - Measure any field variable at any position
  - Fixed in space
  - Changes with time
  - Detection of free surface flow

- ***ComputeForces***
  - Calculate the forces exerted on an object
  - Calculate moments about an axis
  - Fixed in space
  - Changes with time

- ***FloatingInfo*** - Obtain data of the floating objects
  - Linear velocity, angular velocity,
  - Displacement of the centre,
  - Motions and angles of rotation

- ***FlowTool***
  - Several flow rate computations

- ***BoundaryVTK***
  - Compute body motions
  - Applies body motions to external geometry

- ***IsoSurface*** - Creation of iso-surfaces for visualising large number of particles

- ***TracerParts* - Extract particle trajectory for visualisation**

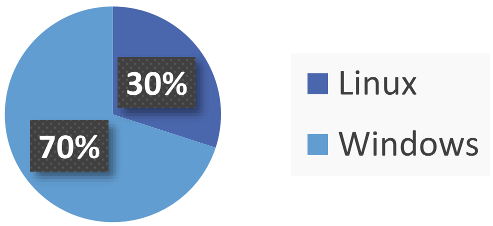
- ***VisualSPHysics***
  - Visualisation plug-in specifically created for using Blender with DualSPHysics

Downloads growth

DUALSPHYSICS - ALL VERSIONS

Downloads: 117,844 (70% Windows)

https://dual.sphysics.org/downloads/



DUALSPHYSICS V1.2 (2011)
Downloads: 701 (65% Windows)

DUALSPHYSICS V2.0 (2012)
Downloads: 6,472 (71% Windows)

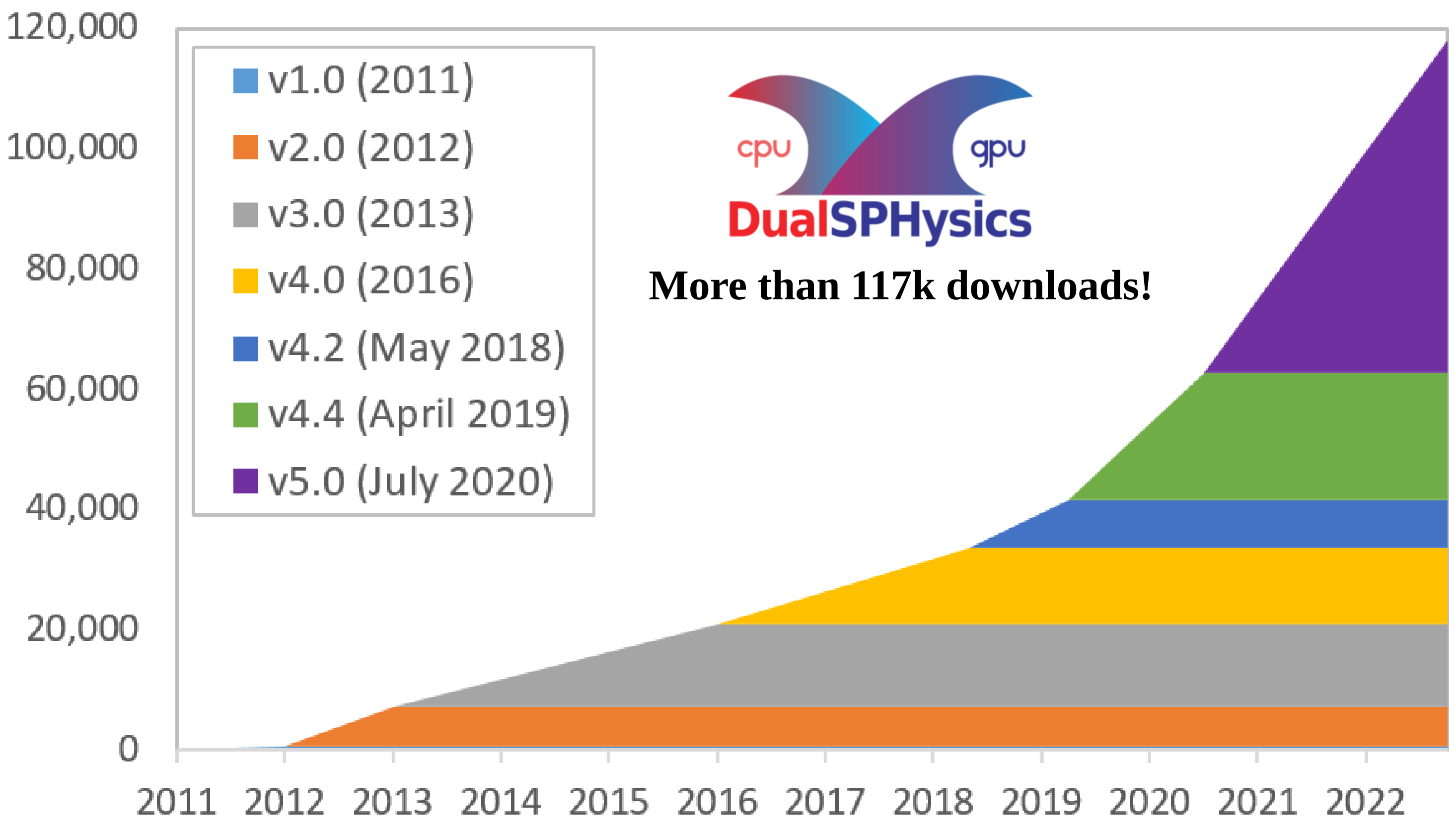
DUALSPHYSICS V3.0 (2013-2015)
Downloads: 13,863 (73% Windows)

DUALSPHYSICS V4.0 (2016)
Downloads: 12,676 (72% Windows)

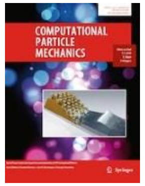
DUALSPHYSICS V4.2 (May 2018)
Downloads: 7,777

DUALSPHYSICS V4.4 (April 2019)
Downloads: 21,152

DUALSPHYSICS V5.0 (July 2020)
Downloads: 55,203



Main novelties in v5.2



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Pre-processing novelties:

- Advanced method to fill external geometries.
- Improved file with normals data.
- Automatic bathymetry from elevation points.

SPH Solver novelties:

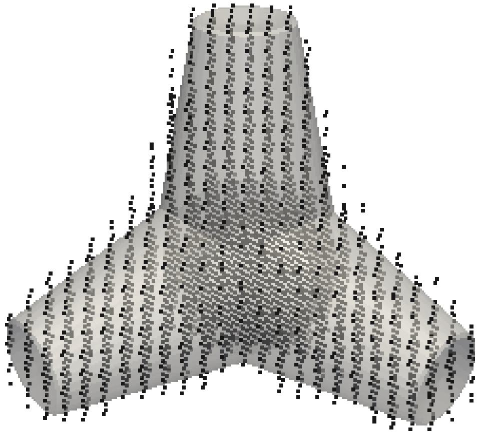
- DualSPHysics updated for latest compilers.
- DualSPHysics compiled for AMD GPUs.
- Enables mDBC for floating bodies.
- New options to define normal vectors in DualSPHysics.
- Focused waves generation.
- Lagrangian formulation for flexible structures

Post-processing novelties:

- New post-processing tool for particle trajectories.
- New options to calculate fluid elevation and depth.
- Calculation of fluid energy with PartVTK.
- Simple definition of measurement positions by execution parameters.

Main novelties in v5.2

Advanced method to fill external geometries (STL, VTK, PLY)



Normal mode:

- Works with any geometry.

but..

- Fill option only works when the centre is inside the model.
- Create particles outside the model and this is a **major problem to calculate the normals automatically**.

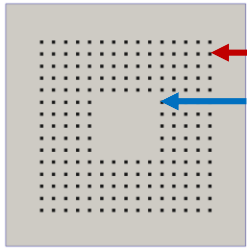
Advanced mode:

- Only particles are created inside the model.
- Fills any closed model.
- Filling depth is configurable.
- Distance to the surface to fill is configurable (useful for mDBC use).

but..

- The external geometry must be correct:
  1) Closed model and no holes
  2) Same orientation on all faces
  3) No faces inside

Advanced mode - Filling depth configurable by *depthmin* and *depthmax*:

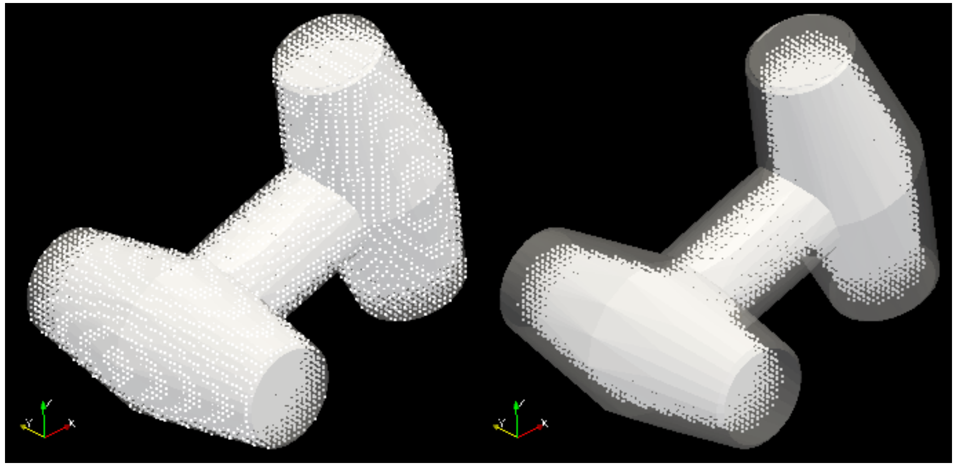


Depthmin = 3x Dp (initial interparticle distance)

Depthmax = 7x Dp

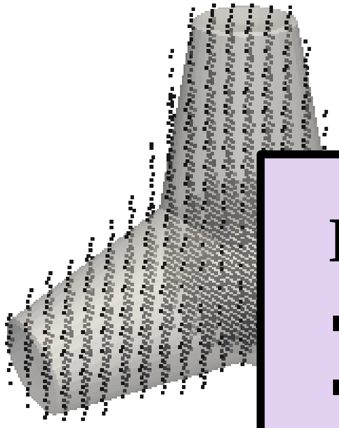
```
<drawfilevtk file="Box.vtk" autofill="true"
advanced="true">
    <depth depthmin="#Dp*3" depthmax="#Dp*7"/>
</drawfilevtk>
```

Model filled with *depthmin=0* | Model filled with *depthmin=0.2*



Main novelties in v5.2

Advanced method to fill external geometries (STL, VTK, PLY)



Normal mode:

- Works with any geometry.

but

Advanced mode - Filling depth configurable by *depthmin* and *depthmax*:

rticle distance)

" autofill="true"

" depthmax="#Dp*7"/>

Examples available in the full package v5.2 BETA:

- `DualSPHysics_v5.2_BETA\examples\others\AdvancedDrawFile`
- `DualSPHysics_v5.2_BETA\examples\mdbc\09_FloatingDuck`

Advanced mode:

- Only particles are created inside the model.
- Fills any closed model.
- Filling depth is configurable.
- Distance to the surface to fill is configurable (useful for mDBC use).

but..

- The external geometry must be correct:
  1) Closed model and no holes
  2) Same orientation on all faces
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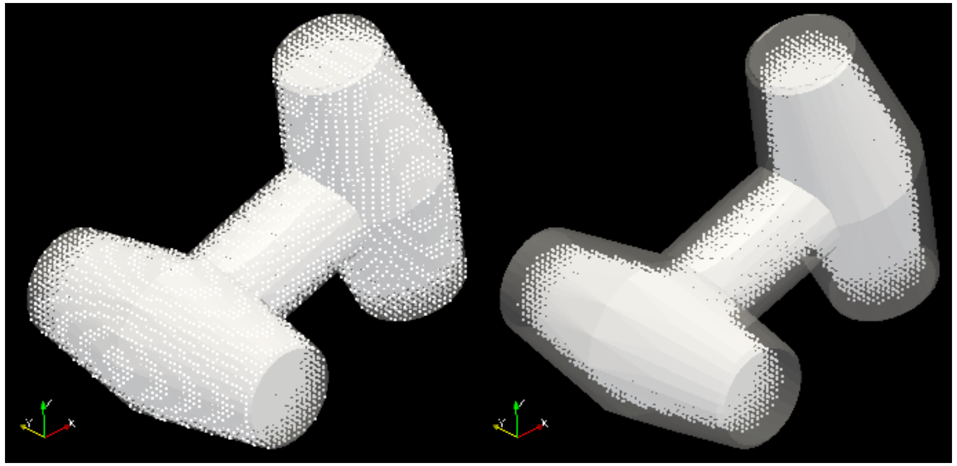
Model filled with *depthmin=0*

Model filled with *depthmin=0.2*



Main novelties in v5.2

Improved file with normals data

Normals calculation in v5.0:

- GenCase generates a huge intermediate file (File_NormalData.nbi4) with information on geometry and nearby boundary particles.
- DualSPHysics loads this huge file and compute normals for mDBC.
- Does not work with complex case and the intermediate file size is larger than 4 GB.

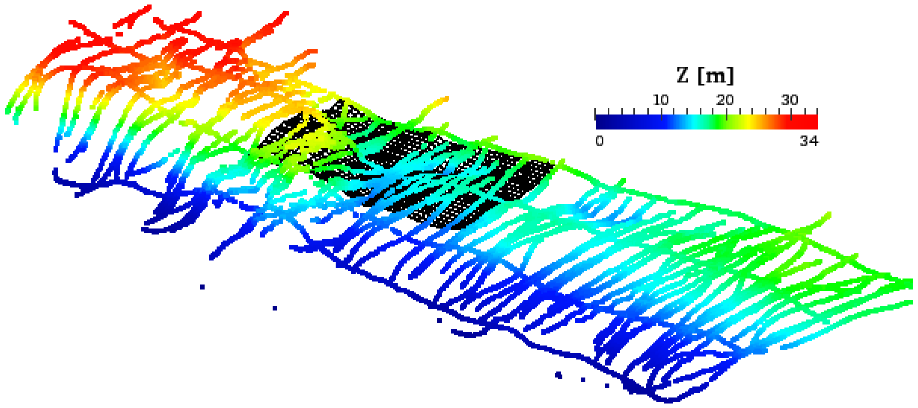
Normals calculation in v5.2:

- GenCase generates a small file (File_Normals.nbi4) with computed normal vectors from geometry.
- GenCase also generates VTK files for quick checking.
- DualSPHysics only loads this small file with normals for mDBC.
- The DualSPHysics code is simpler and easier.

Main novelties in v5.2

Automatic bathymetry from elevation points

File XYZ with points

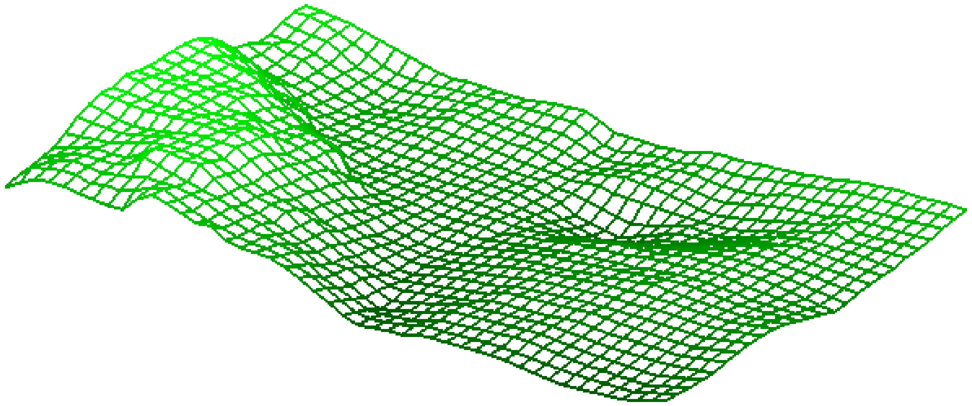



```
<drawbathymetry>
    <zpoints file="Points.xyz">
        <move x="-439998.30" y="-1148505.00" z="0" />
        <rotate angx="0" angy="0" angz="0" />
        <scale x="1" y="1" z="2" />
    </zpoints>
    <grid dp="2">
        <initdomain>
            <point x="180" y="30" />
            <size x="90" y="50" />
        </initdomain>
    </grid>
</drawbathymetry>
```

<drawbathymetry>: load a XYZ or VTK file with points (x,y,z) and draw a bathymetry surface of the selected area.

- Includes options to select, move, rotate, scale the input points (x,y,z)
- Several options to define the grid generated from XYZ points.
- Allows to extend borders or modify border height to create smooth beach or walls automatically.
- Enables the use of periodic boundary conditions adapting the limits.

Grid generated from XYZ points in selected area



Main novelties in v5.2

Automatic bathymetry from elevation points

```
<!-- Bathymetry from file XYZ -->
<setmkbound mk="0"/>
<drawbathymetry>
  <zpoints file="Points.xyz">
      <move x="-439998.30" y="-1148505.00" z="0"/>
      <rotate angx="0" angy="0" angz="0" />
      <scale x="1" y="1" z="2" />
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  </zpoints>
  <grid dp="2">
      <initdomain>
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          <size x="90" y="50" />
      </initdomain>
      <expands>
          <xmin size="10" z="15" size2="8" />
          <xmax size="1"  z="27" />
          <ymin size="1"  z="27" />
          <ymax size="1"  z="27" />
      </expands>
      <finalmove x="-162" y="-30" z="-19" />
  </grid>
  <savepoints value="true" comment="Saves VTK with
     final for debug (default=0)" />
  <savegrid value="true" comment="Saves VTK with
     final grid cells for debug (default=0)" />
</drawbathymetry>
```

Configuration for points XYZ

Configuration for grid

Options for debug

<drawbathymetry>: load a XYZ or VTK file with points (x,y,z) and draw a bathymetry surface of the selected area.

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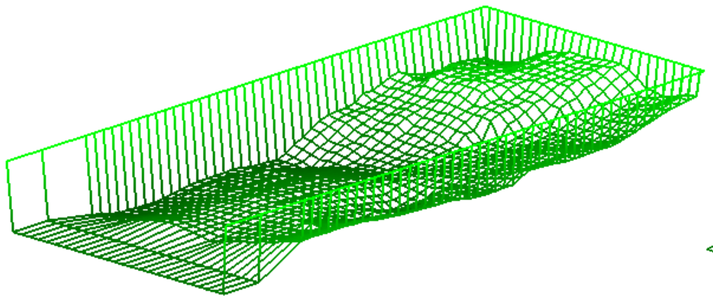
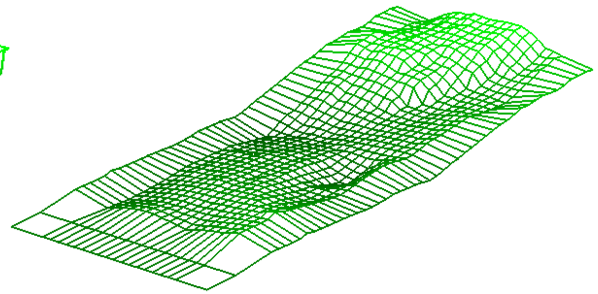


Example of grid **with walls** using **<expands>**



Example **for periodic conditions**

Main novelties in v5.2

Automatic bathymetry from elevation points

```
<!-- Bathymetry from file XYZ -->
<setmkbound mk="0"/>
<drawbathymetry>
    <zpoints file="Points.xyz">
        <move x="-439998.30" y="-1148505.00" z="0"/>
        <rotate angx=
        <scale x="1"
        <selection>
            <point x=
            <size x="
        </selection>
    </zpoints>
    <grid dp="2">
        <initdomain>
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        <expands>
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        </expands>
        <finalmove x="-162" y="-30" z="-19" />
    </grid>
    <savepoints value="true" comment="Saves VTK with
       final for debug (default=0)" />
    <savegrid value="true" comment="Saves VTK with
       final grid cells for debug (default=0)" />
</drawbathymetry>
```

Configuration for points XYZ

Configuration for grid

Options for debug

<drawbathymetry>: load a XYZ or VTK file with points (x,y,z) and draw a bathymetry surface of the selected area.

input points (x,y,z)

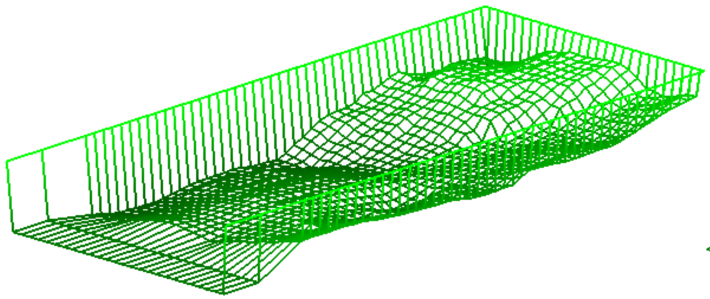
XYZ points.

to create smooth

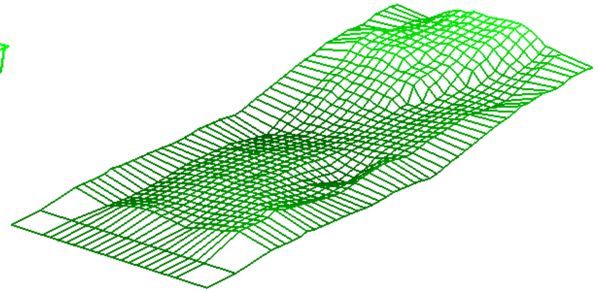
adapting the limits.

Examples available in the full package v5.2 BETA:

- DualSPHysics_v5.2_BETA\examples\main\18_Bathymetry



Example of grid **with walls** using **<expands>**



Example **for periodic conditions**

Main novelties in v5.2

DualSPHysics updated for latest compilers

- Microsoft Visual Studio 2022
- GNU G++ compiler 11.0 version
- CUDA Toolkit 11.7

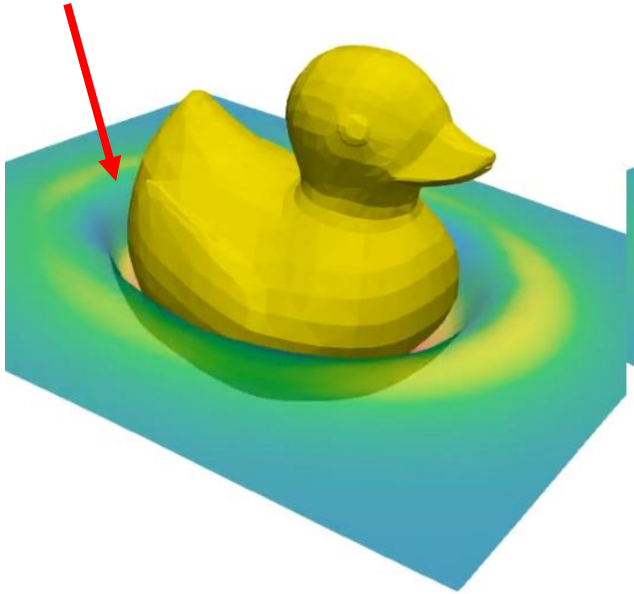
DualSPHysics compiled for AMD GPUs

- HIP-Clang and ROCm toolset (only Linux)

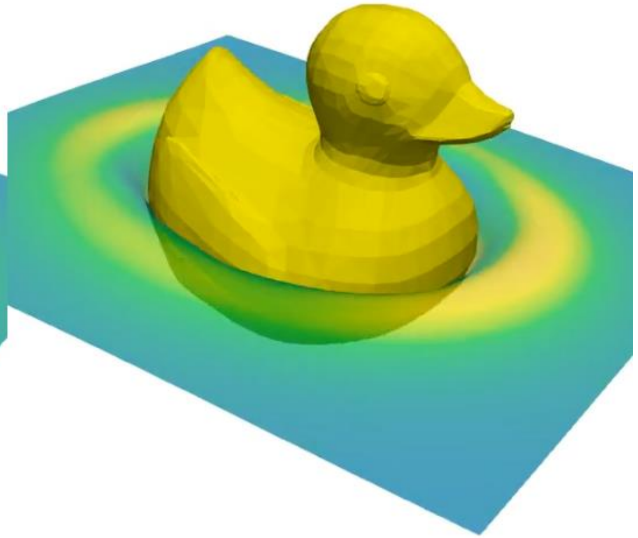
Enables mDBC for floating bodies

- Avoids gap between fluid and boundaries
- Increases accuracy with low resolution

Floating duck using **DBC** and **gap** between fluid and boundary



Floating duck using **mDBC**, more accurate and avoids gaps



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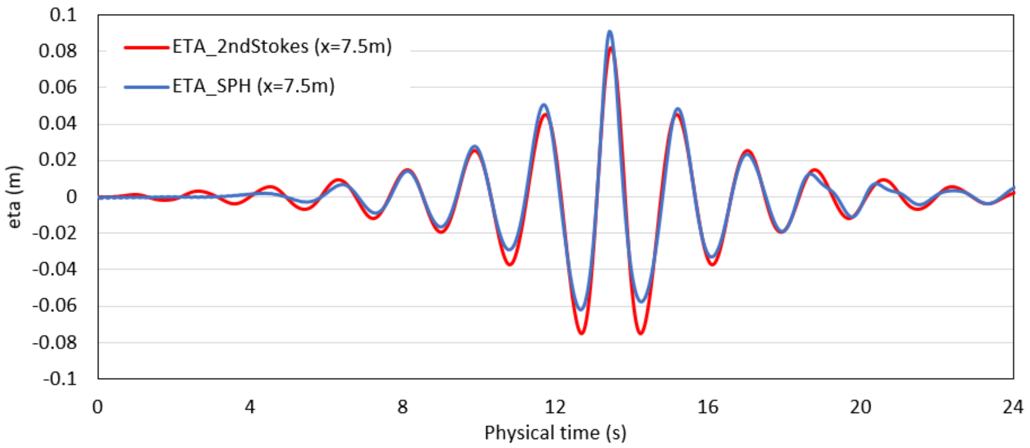
Examples available in the full package v5.2 BETA:

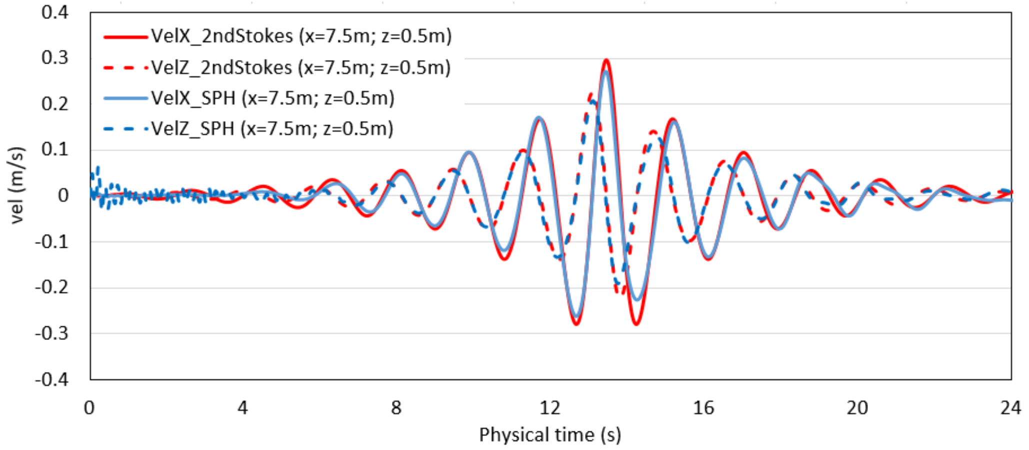
- DualSPHysics_v5.2_BETA\examples\mdbc\08_FloatingWaves
- DualSPHysics_v5.2_BETA\examples\mdbc\09_FloatingDuck

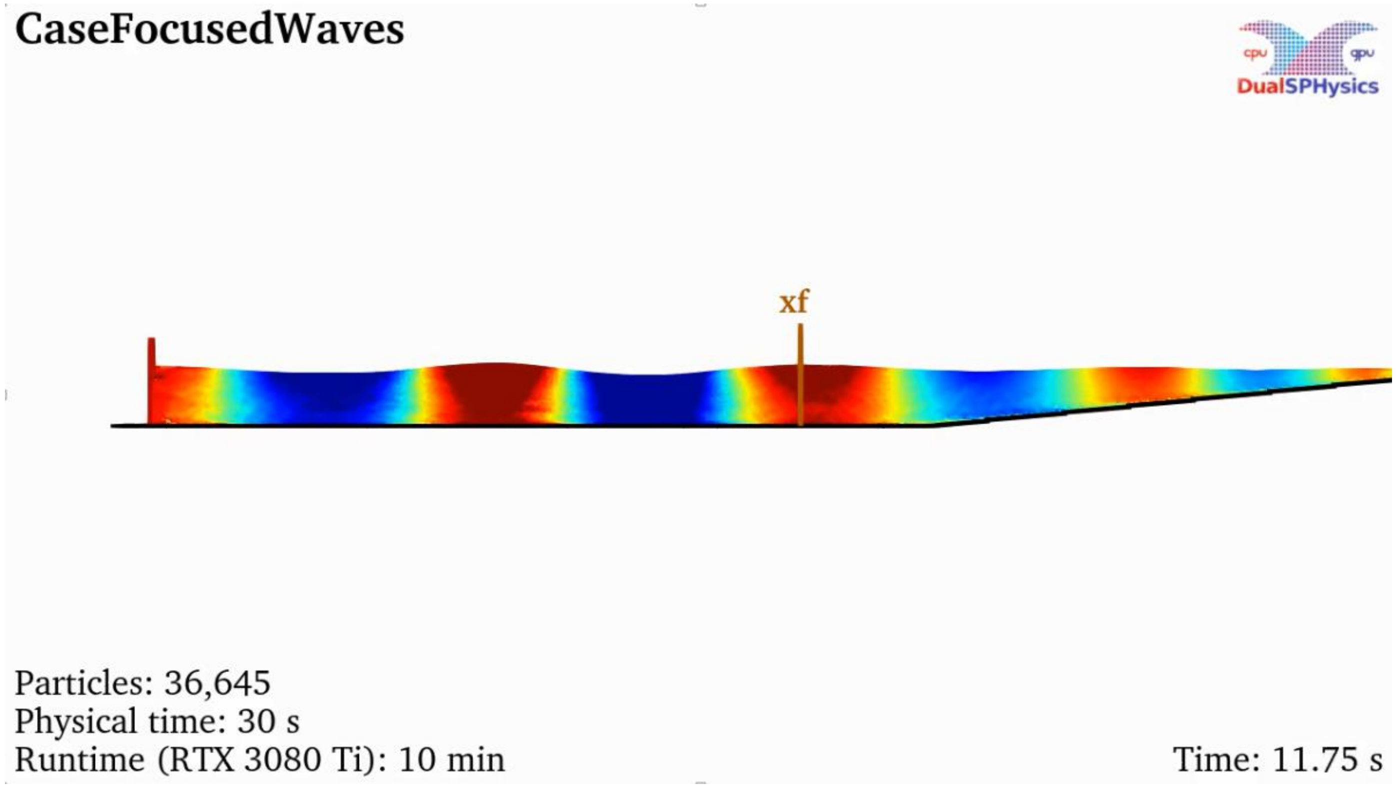
Main novelties in v5.2

Focused waves generation

- Serie of regular waves to generate the máximum wave at the focus position.
- Efficient way to replicate extreme wave conditions (short time serie is required).







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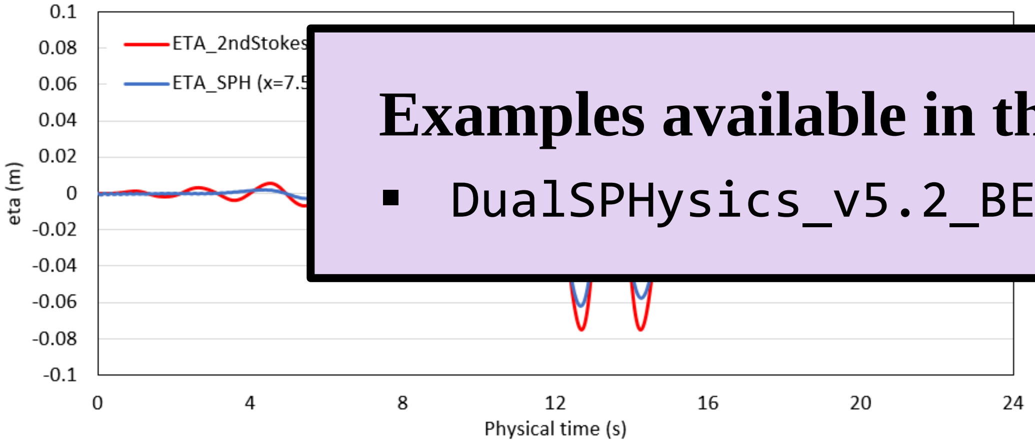
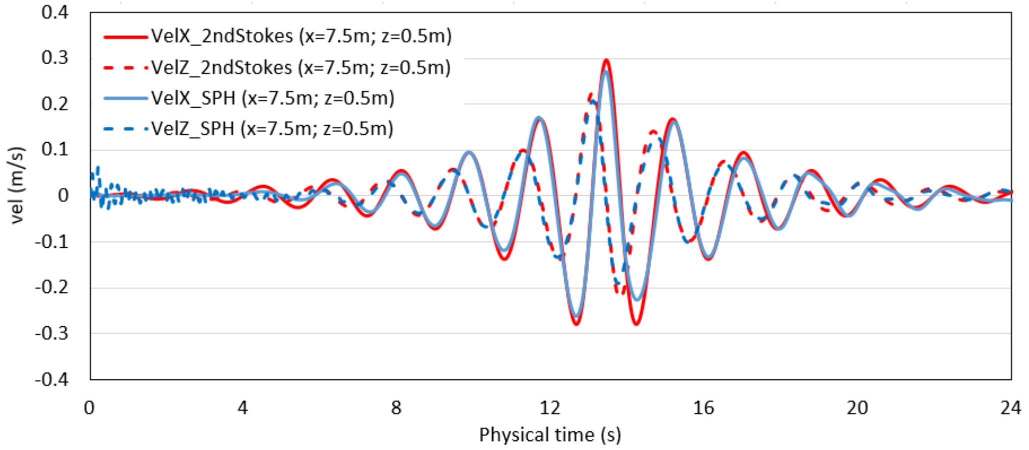
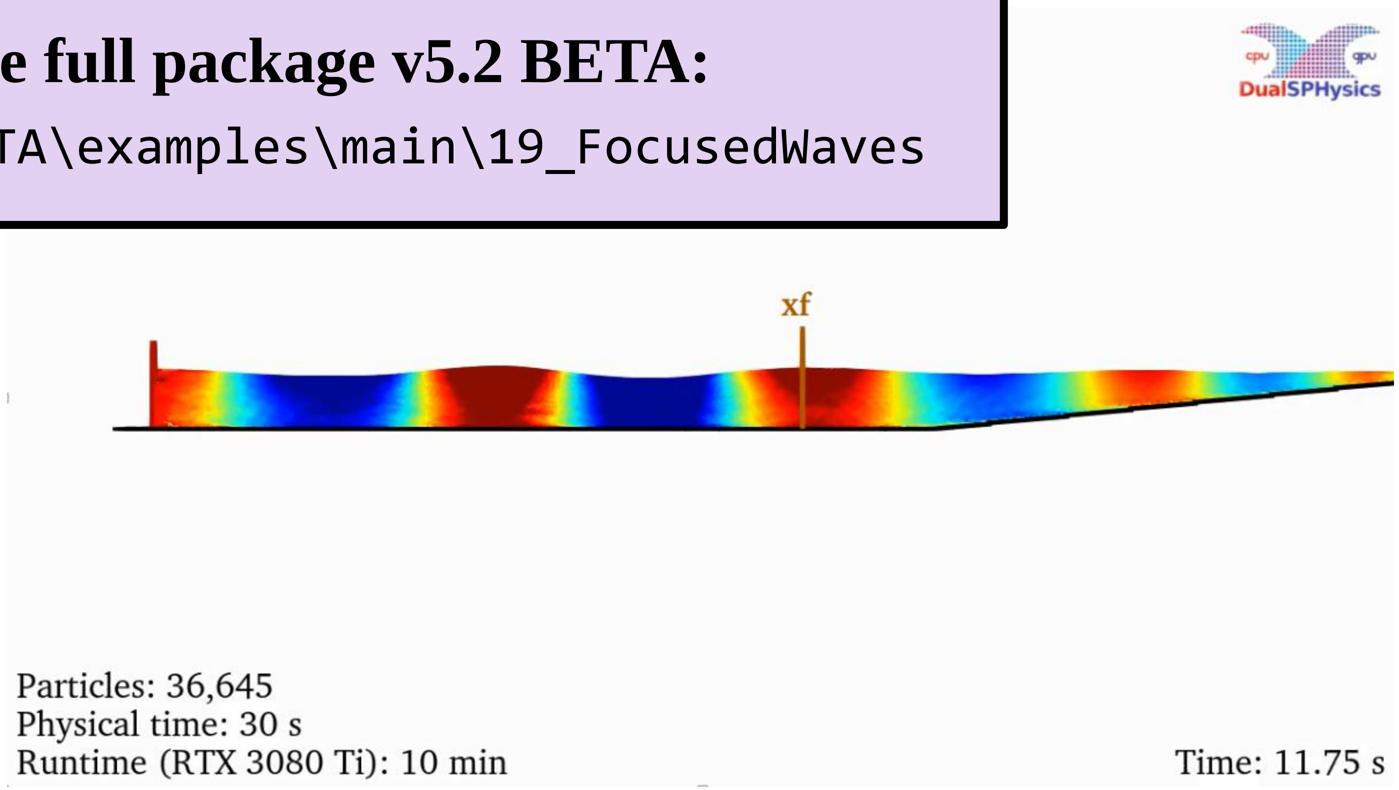




Examples available in the full package v5.2 BETA:

- `DualSPHysics_v5.2_BETA\examples\main\19_FocusedWaves`



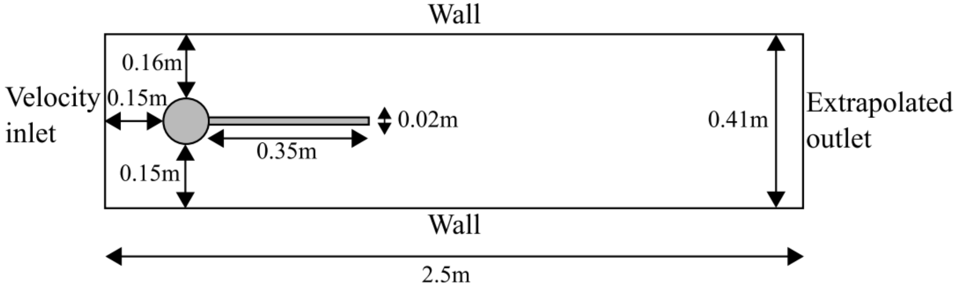
Main novelties in v5.2

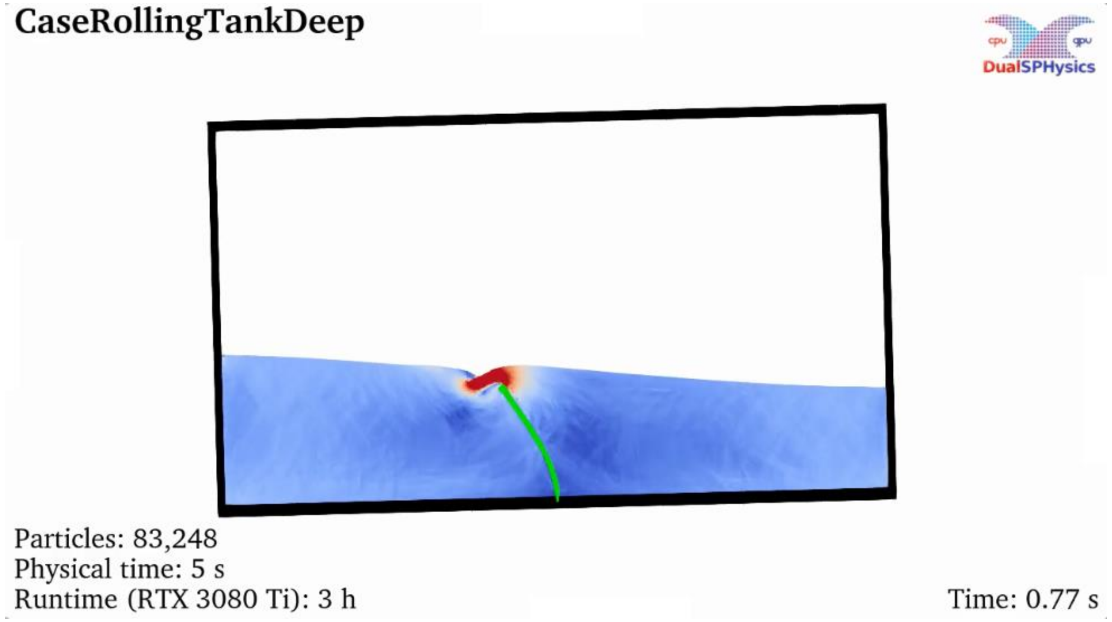
J. O'Connor, B.D. Rogers. 2021. **A fluid–structure interaction model for free-surface flows and flexible structures using smoothed particle hydrodynamics on a GPU.** Journal of Fluids and Structures. 104: 103312. doi:10.1016/j.jfluidstructs.2021.103312

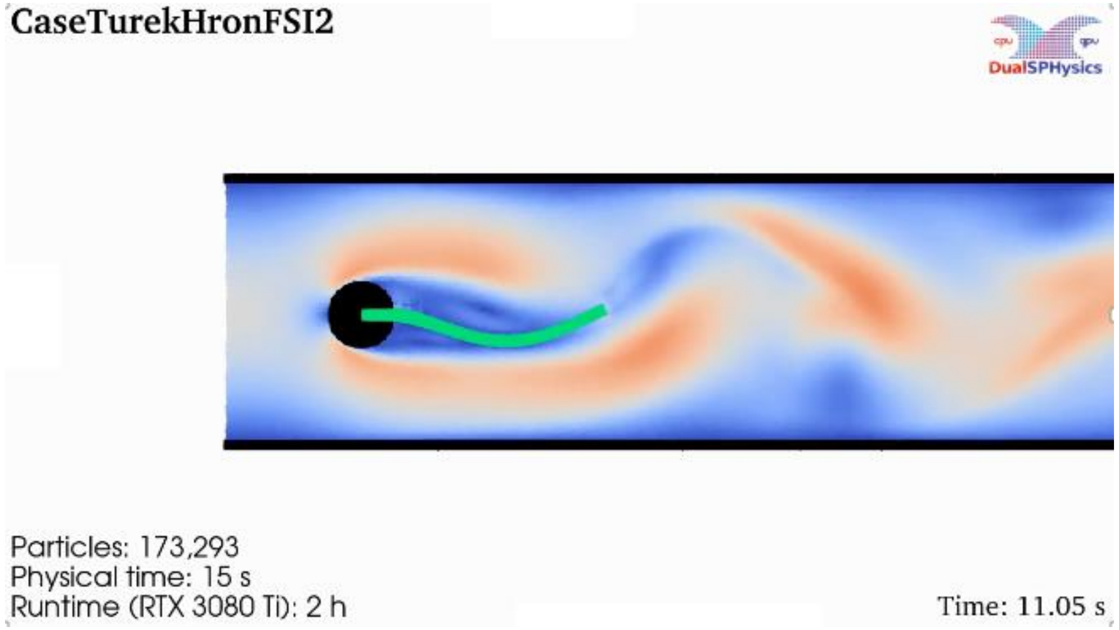
Lagrangian formulation for flexible structures

- Numerical model for violent hydrodynamics of free-surface flows interacting with flexible structures using SPH.
- Total Lagrangian formulation with kernel correction and zero-energy mode suppression.

Schematic of FSI benchmark case from Turek & Hron (2006).
Source: O'Connor and Rogers (2021).







Main novelties in v5.2

J. O'Connor, B.D. Rogers. 2021. **A fluid–structure interaction model for free-surface flows and flexible structures using smoothed particle hydrodynamics on a GPU.** Journal of Fluids and Structures. 104: 103312. doi:10.1016/j.jfluidstructs.2021.103312

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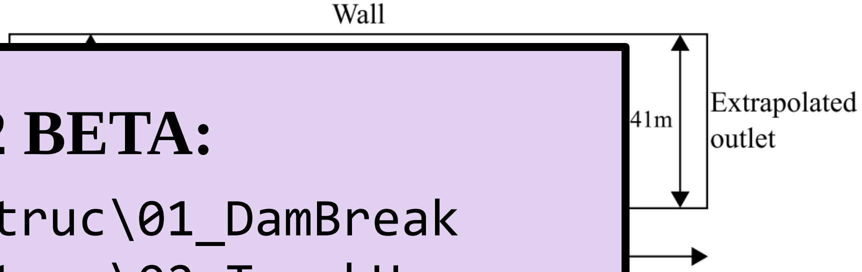
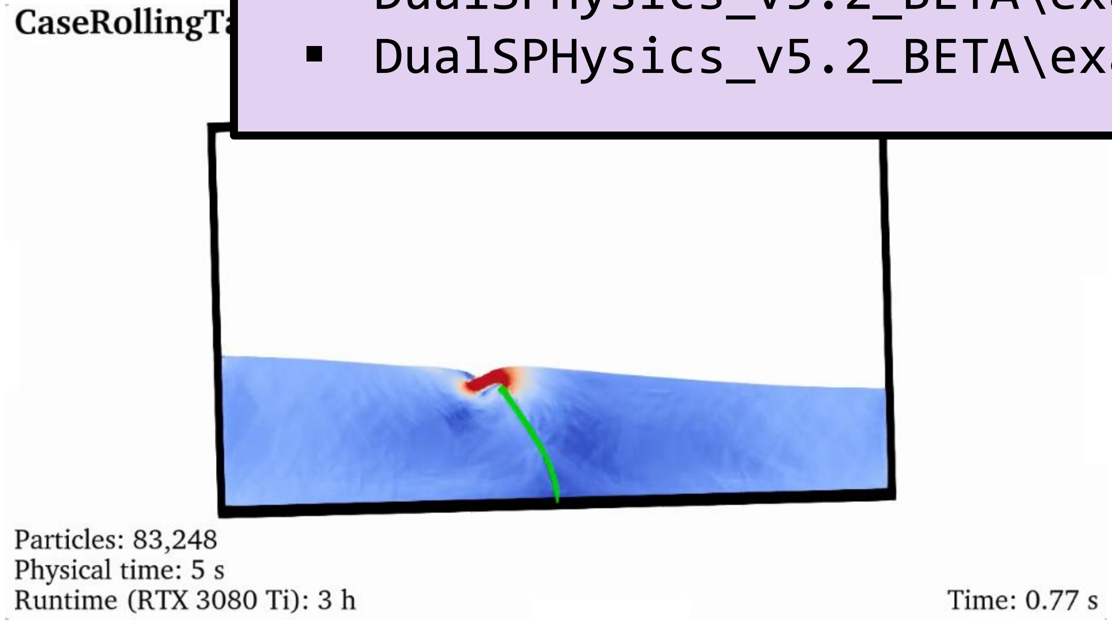
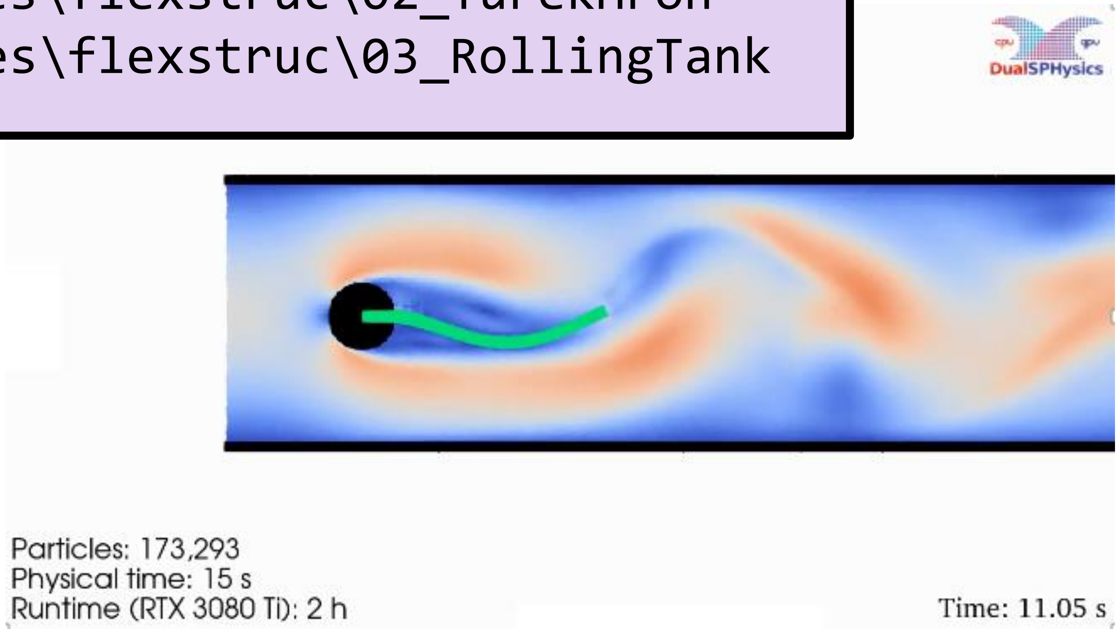


Examples available in the full package v5.2 BETA:

- DualSPHysics_v5.2_BETA\examples\flexstruc\01_DamBreak
- DualSPHysics_v5.2_BETA\examples\flexstruc\02_TurekHron
- DualSPHysics_v5.2_BETA\examples\flexstruc\03_RollingTank



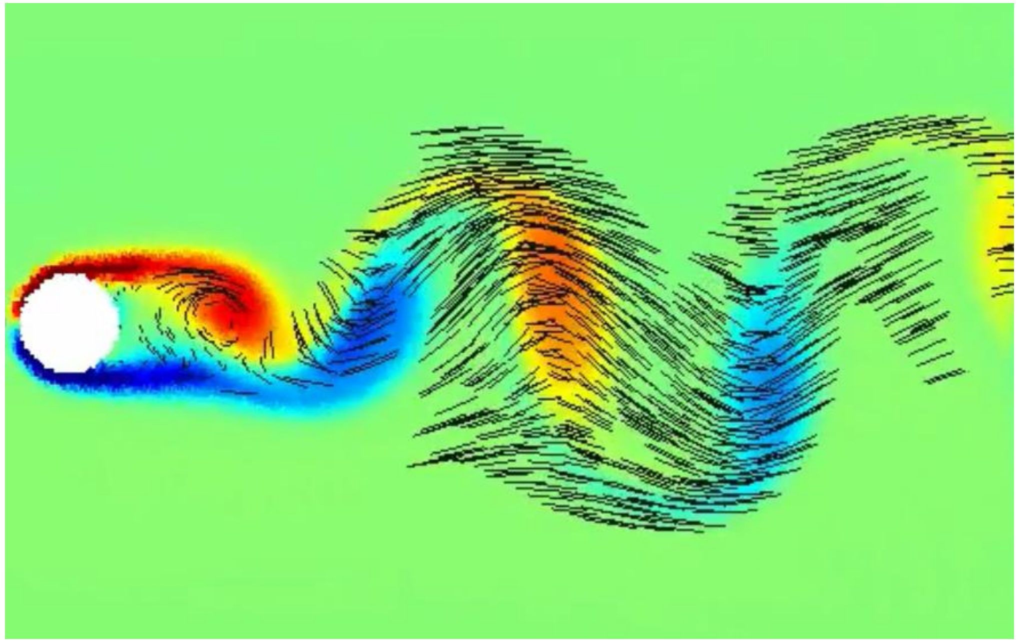


Main novelties in v5.2

New post-processing tool for particle trajectories

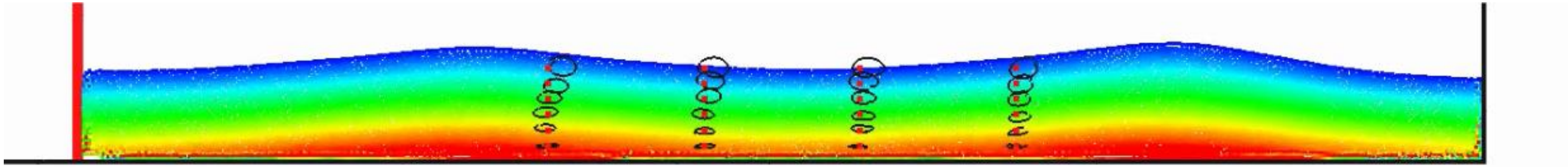
- **<u>TracerParts</u>** tool draws the trajectories of particles.
- Simple selection of particles by id, position or grid of positions.

Flow pass cylinder

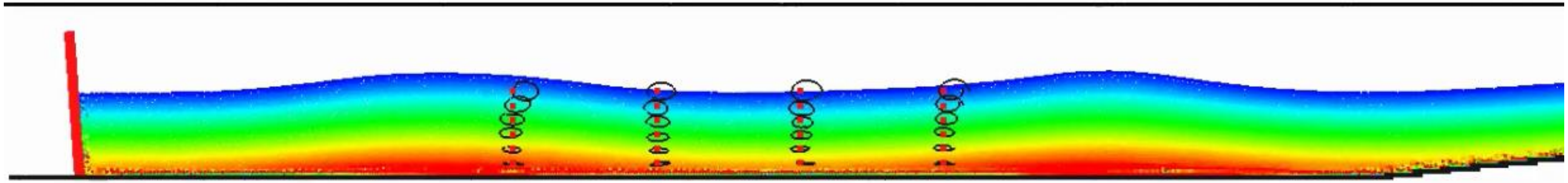


Fluid particle trajectories under regular waves

Regular waves with AWAS



Regular waves with dissipative beach



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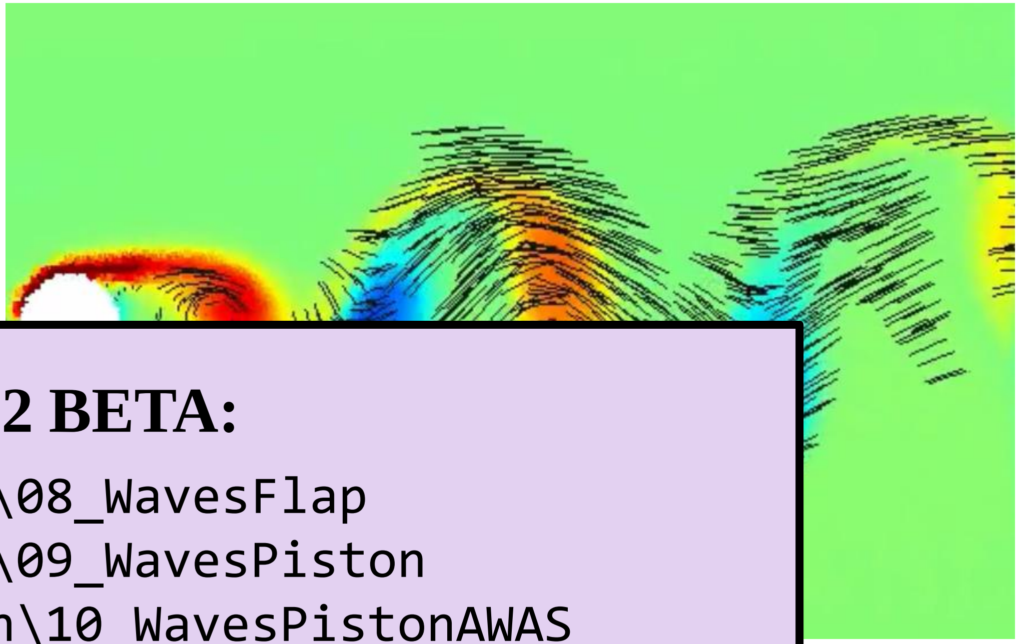
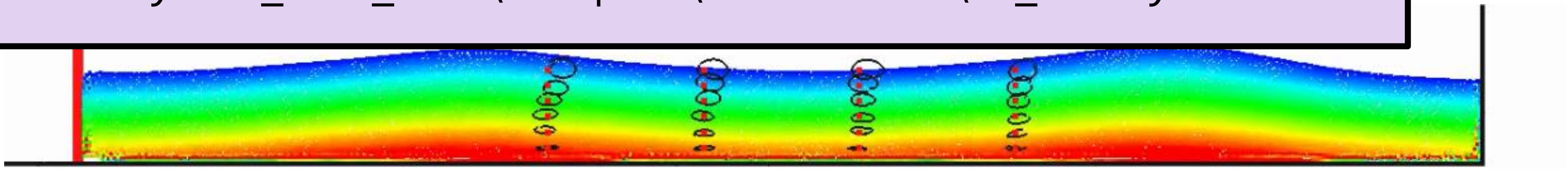


Examples available in the full package v5.2 BETA:

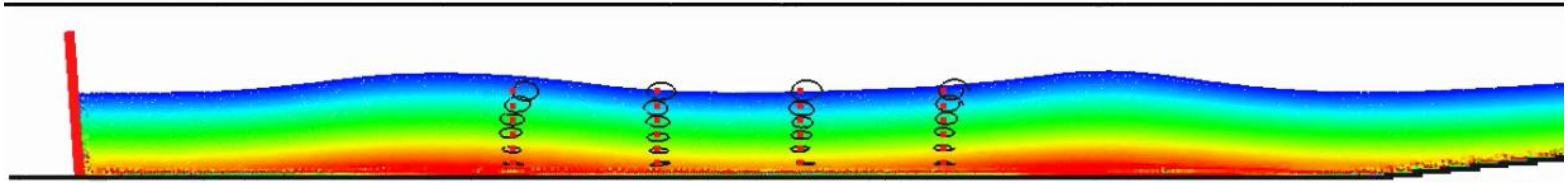
- DualSPHysics_v5.2_BETA\examples\main\08_WavesFlap
- DualSPHysics_v5.2_BETA\examples\main\09_WavesPiston
- DDualSPHysics_v5.2_BETA\examples\main\10_WavesPistonAWAS
- DualSPHysics_v5.2_BETA\examples\inletoutlet\01_FlowCylinder

Fluid pa

Regular waves with AWAS



Regular waves with dissipative beach



Main novelties in v5.2

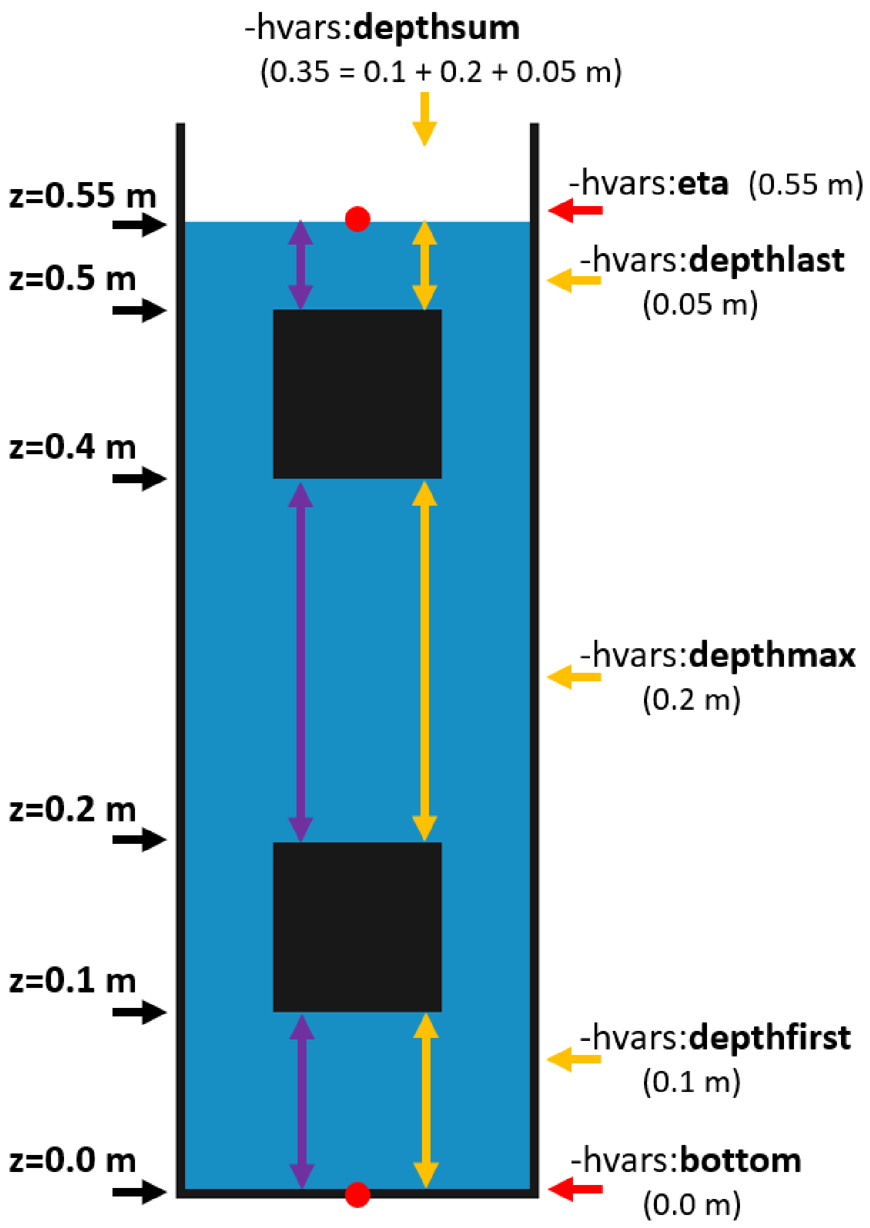
New options to calculate fluid elevation and depth

- MeasureTool calculates free-surface elevation, but also bottom free-surface and different depth values: *depthsum*, *depthmax*, *depthlast*, *depthfirst* and *depthrop*.
- Generates CSV files for analysis and VTK files for visualization.

```
-hvars[:<values>] Defines height values to be computed
                  (+ means include, - means do not include)
   +/-all:        To choose or reject all options
   +/-eta:        Elevation for each column x,y (equal to -elevation)
   +/-bottom:     Fluid bottom for each column x,y
   +/-depthsum:   Sum of depths for each column x,y
   +/-depthmax:   Maximum depth for each column x,y
   +/-depthlast:  Last depth (near surface) for each column x,y
   +/-depthfirst: First depth (near bottom) for each column x,y
   +/-depthrhop:  Total depth calculated by integral of density at x,y
```

$$DepthRhop = \sum_{i}^{n} \frac{\rho_i dz}{\rho_0} \approx DepthSum$$

n measuring points separated by *dz*



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Examples available in the full package v5.2 BETA:

- `DualSPHysics_v5.2_BETA\examples\main\18_Bathymetry`

```
-hvars[:<values>

    +/-all:
    +/-eta:
    +/-bottom:     Fluid bottom for each column x,y
    +/-depthsum:   Sum of depths for each column x,y
    +/-depthmax:   Maximum depth for each column x,y
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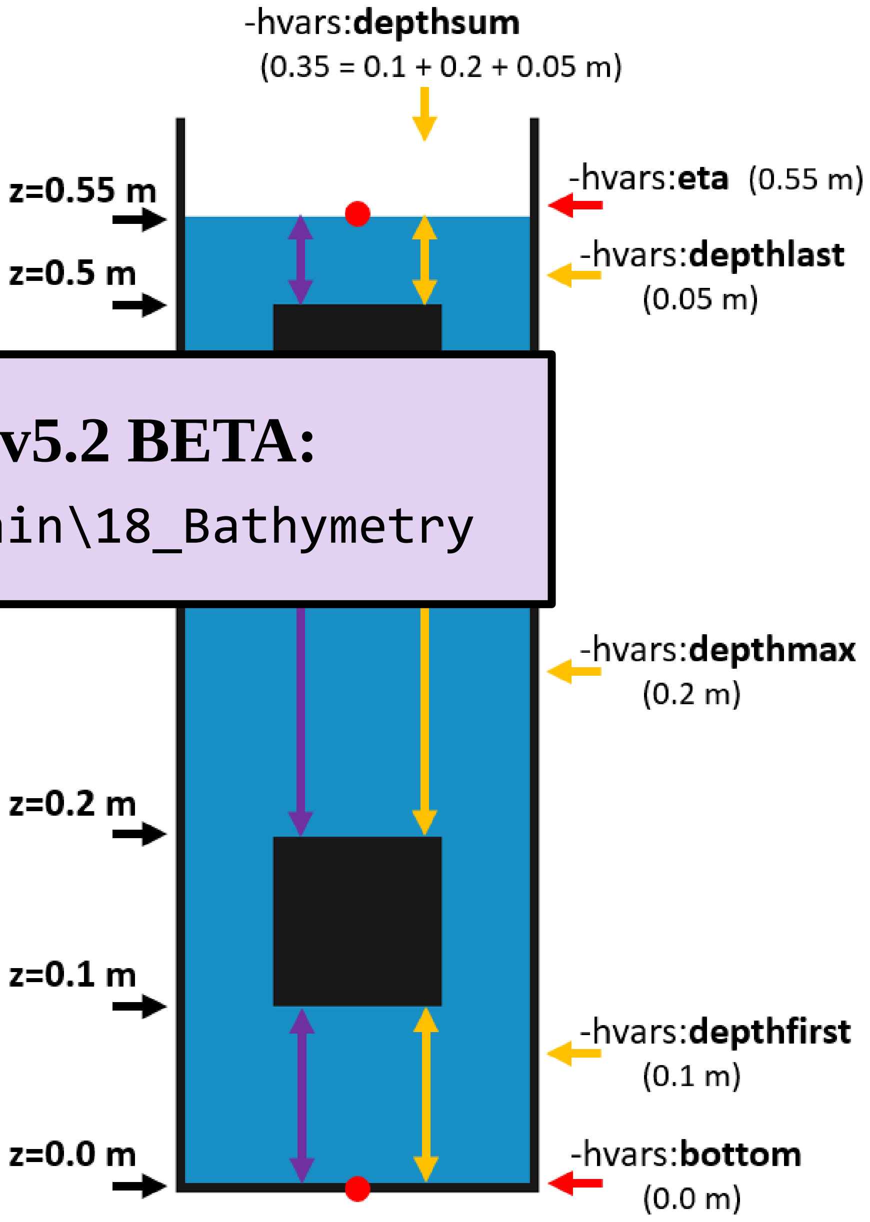
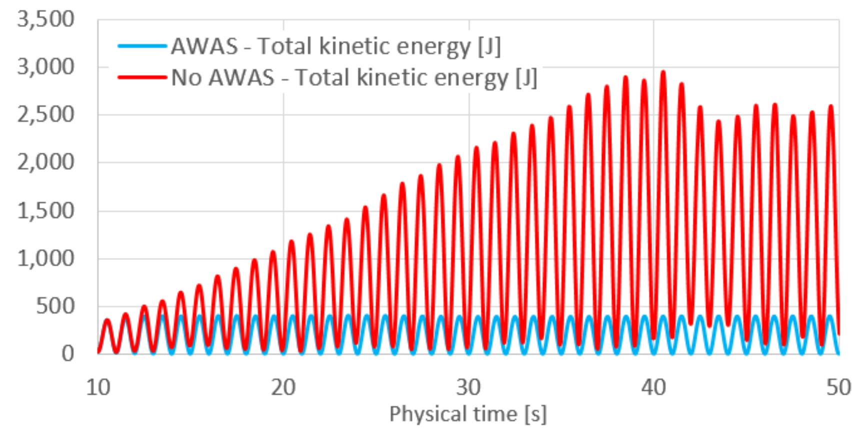
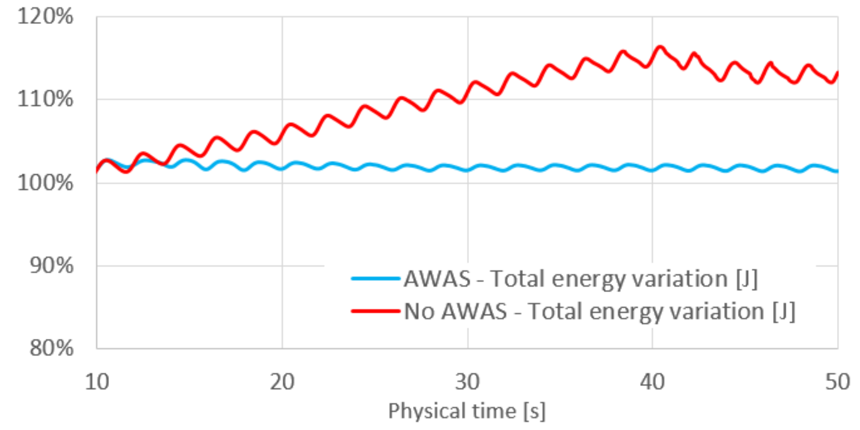


Main novelties in v5.2

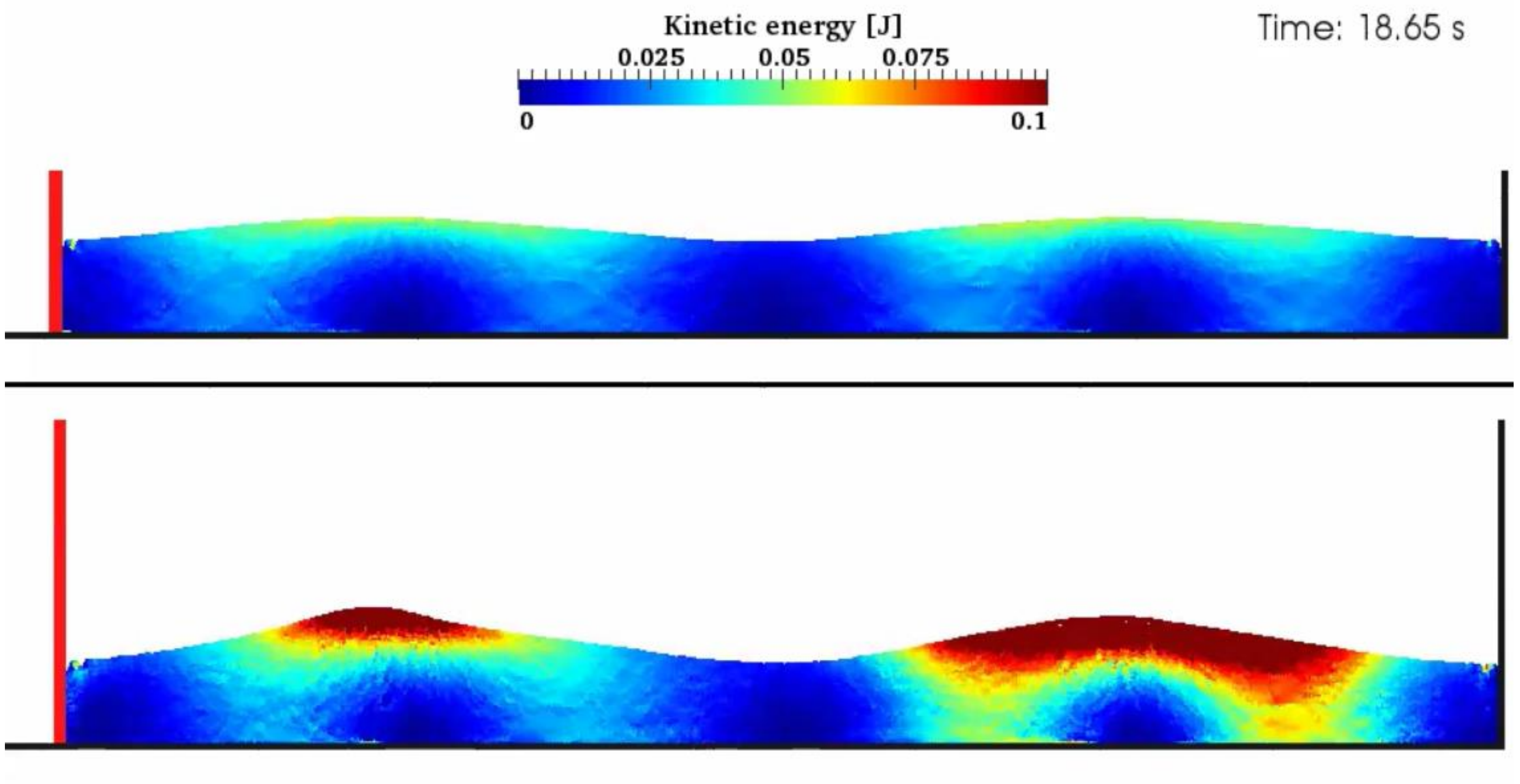
Calculation of fluid energy with PartVTK

- PartVTK computes fluid energy values: kinetic, potential, internal and total energy.
- Computes total fluid energy and energy per particle.





Shows **fluid energy** under regular waves **using AWAS** and **without AWAS**



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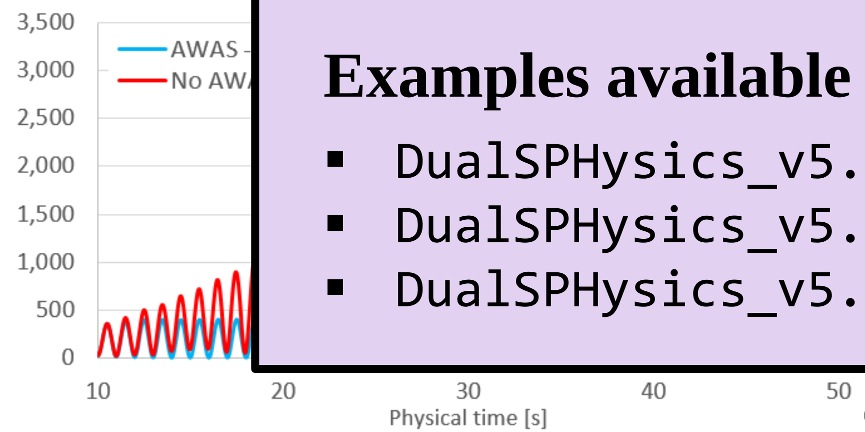
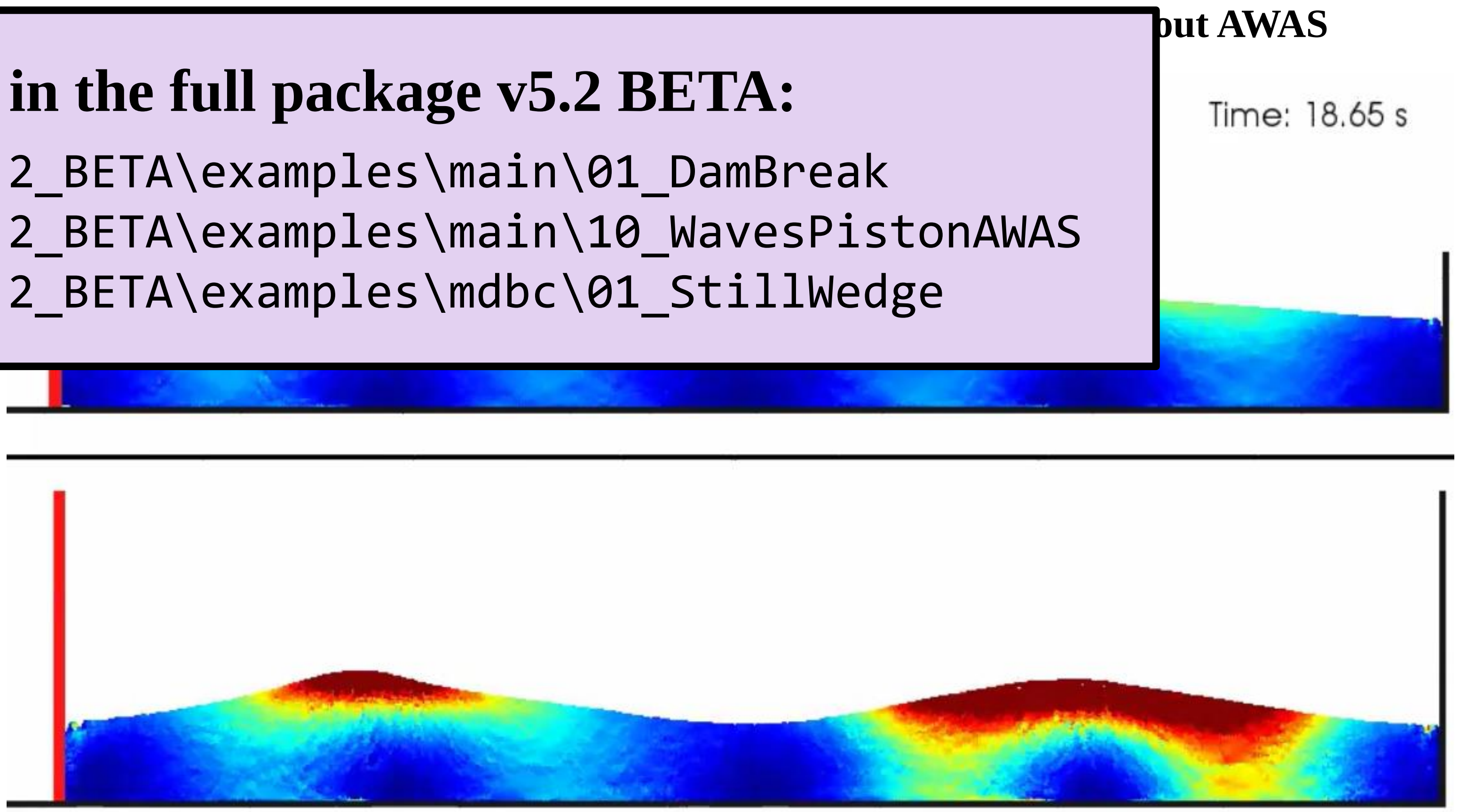
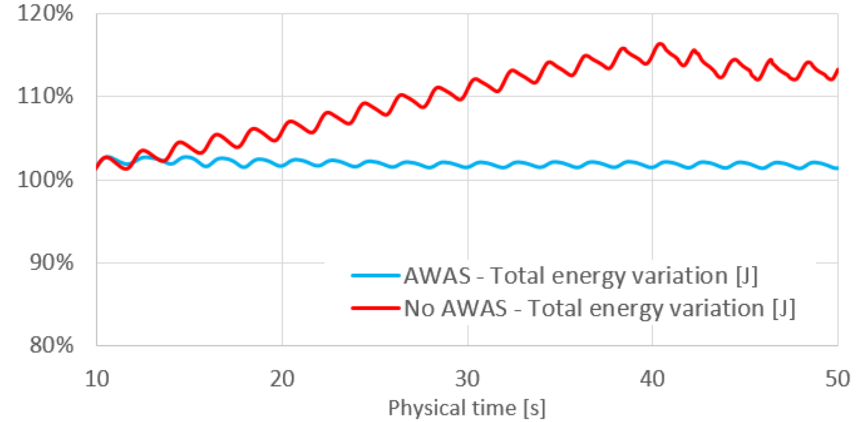


Examples available in the full package v5.2 BETA:

- `DualSPHysics_v5.2_BETA\examples\main\01_DamBreak`
- `DualSPHysics_v5.2_BETA\examples\main\10_WavesPistonAWAS`
- `DualSPHysics_v5.2_BETA\examples\mdbc\01_StillWedge`





How to download DuaSPHysics v5.2 beta

DualSPHysics
Version 5.2 beta

New version only available to workshop attendees!!

The full package v5.2 includes:

- Several SPH approaches
- New pre- and post-processing tools
- Improved documentation guides
- More than 100 examples (including new features)

Download the full package from:
https://dual.sphysics.org/sphcourse/DualSPHysics_v5.2_BETA/

User: [redacted]
Password: [redacted]

J.M. Domínguez, G. Fourtakas, C. Altomare, R.B. Canelas, A. Tafuni, O. García-Feal, I. Martínez-Estévez, A. Mokos, R. Vacondio, A.J.C. Crespo, B.D. Rogers, P.K. Stansby, M. Gómez-Gesteira. 2022. **DualSPHysics: from fluid dynamics to multiphysics problems.** Computational Particle Mechanics. 9(5): 867-895. doi:10.1007/s40571-021-00404-2

Latest Literature Achievements

(a) Quality of Publications

Civil & Structural Engineering

Coastal & Environmental Engineering

Computational Mechanics

Ocean Engineering & Oceanography

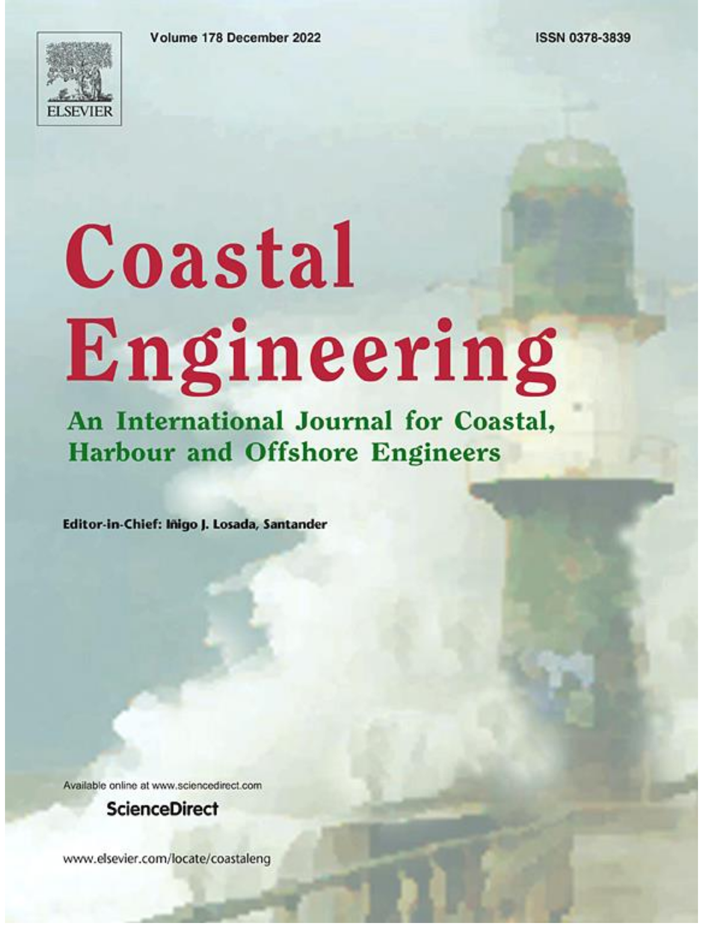
Mechanical Engineering

Computer Science

Geotechnical Engineering & Engineering Geology

Latest Literature Achievements

(b) Citations



<u>Most citations in the last three years</u>:

Coastal Engineering 153 (2019) 103560

ELSEVIER

Contents lists available at ScienceDirect

Coastal Engineering

journal homepage: http://www.elsevier.com/locate/coastaleng

SPH simulation of floating structures with moorings

José M. Domínguez [a], Alejandro J.C. Crespo [a,*], Matthew Hall [b], Corrado Altomare [c,d], Minghao Wu [d], Vasiliki Stratigaki [d], Peter Troch [d], Lorenzo Cappietti [e], Moncho Gómez-Gesteira [a]

[a] Environmental Physics Laboratory, Universidade de Vigo, Campus As Lagoas s/n, 32004, Ourense, Spain
[b] Faculty of Sustainable Design Engineering, University of Prince Edward Island, Charlottetown, Canada
[c] Flanders Hydraulic Research, Berchemlei 115, 2140, Antwerp, Belgium
[d] Department of Civil Engineering, Ghent University, Technologiepark 904, 9052, Ghent, Belgium
[e] Department of Civil and Environmental Engineering, University of Florence, Florence, Italy

ARTICLE INFO

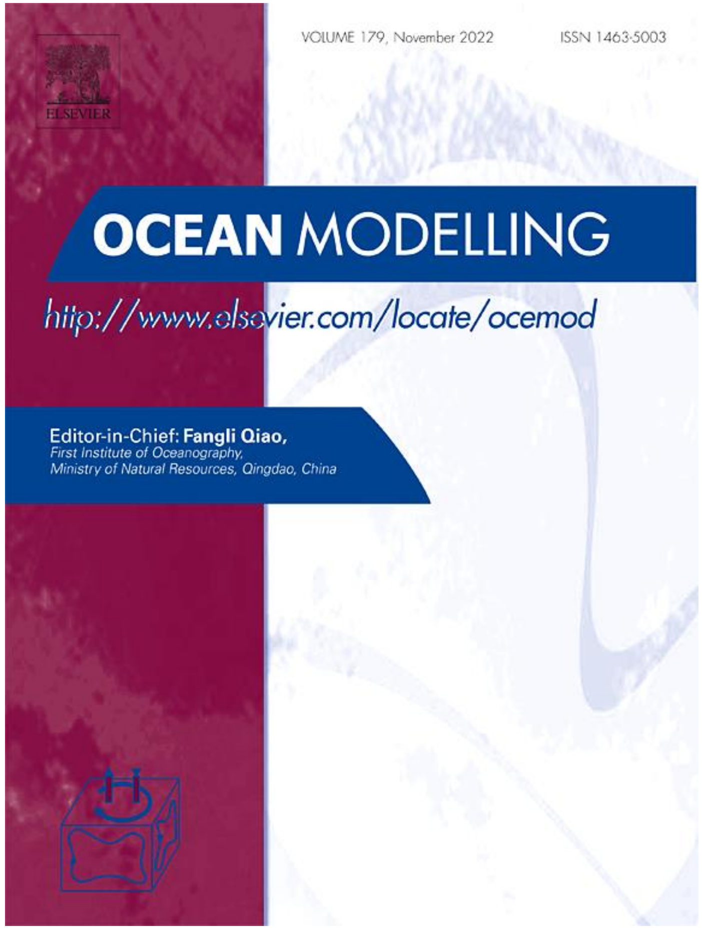
Keywords:
Numerical modelling
Meshless methods
Smoothed particle hydrodynamics
Floating bodies

ABSTRACT

The open-source code DualSPHysics is applied to simulate the interaction of sea waves with floating offshore structures, which are typically moored to the seabed, such as vessels, boats, floating breakwaters and wave energy converters (WECs). The goal is to develop a numerical tool that allows the study of the survivability of floating moored devices under highly energetic sea states, obtaining the optimum mooring layout to increase

Latest Literature Achievements

(b) Citations



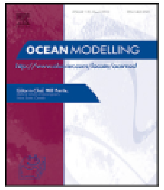
<u>Third most cited paper in the last three years</u>:

Ocean Modelling 144 (2019) 101481

Contents lists available at ScienceDirect

Ocean Modelling

journal homepage: www.elsevier.com/locate/ocemod



Numerical simulations of surf zone wave dynamics using Smoothed Particle Hydrodynamics

R.J. Lowe [a,b,c,d,*], M.L. Buckley [a,d], C. Altomare [e,f], D.P. Rijnsdorp [a,d], Y. Yao [g], T. Suzuki [h,i], J.D. Bricker [i]

[a] *Oceans Graduate School and UWA Oceans Institute, The University of Western Australia, Crawley, Australia*
[b] *School of Earth Sciences, The University of Western Australia, Crawley, Australia*
[c] *ARC Centre of Excellence for Coral Reef Studies, The University of Western Australia, Crawley, Australia*
[d] *Wave Energy Research Centre, The University of Western Australia, Crawley, Australia*
[e] *Universitat Politècnica de Catalunya – Barcelona Tech, Barcelona, Spain*
[f] *Ghent University, Ghent, Belgium*
[g] *Changsha University of Science and Technology, Changsha, China*
[h] *Flanders Hydraulics Research, Antwerp, Belgium*
[i] *Department of Hydraulic Engineering, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, Netherlands*

ARTICLE INFO

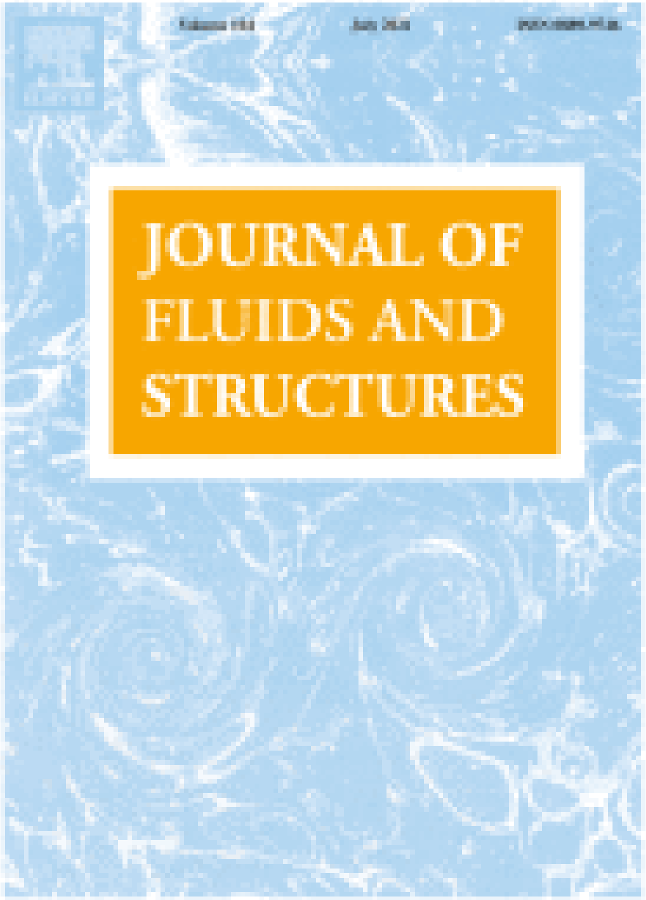
Keywords:
Surf zone
Wave transformation
Wave-induced currents
Wave modelling
Smoothed Particle Hydrodynamics

ABSTRACT

In this study we investigated the capabilities of the mesh-free, Lagrangian particle method (Smoothed Particle Hydrodynamics, SPH) to simulate the detailed hydrodynamic processes generated by both spilling and plunging breaking waves within the surf zone. The weakly-compressible SPH code DualSPHysics was applied to simulate wave breaking over two distinct bathymetric profiles (a plane beach and fringing reef) and compared to experimental flume measurements of waves, flows, and mean water levels. Despite the simulations spanning

Latest Literature Achievements

(c) Downloads



<u>Third most downloaded paper in the last 90 days</u>:

Journal of Fluids and Structures 104 (2021) 103312

Contents lists available at ScienceDirect

Journal of Fluids and Structures

journal homepage: www.elsevier.com/locate/jfs

ELSEVIER

A fluid–structure interaction model for free-surface flows and flexible structures using smoothed particle hydrodynamics on a GPU

Joseph O'Connor *, Benedict D. Rogers

Department of Mechanical, Aerospace and Civil Engineering, University of Manchester, Manchester, UK

A R T I C L E   I N F O

Article history:
Received 9 March 2020
Received in revised form 18 February 2021
Accepted 6 May 2021
Available online 15 May 2021

Keywords:
Smoothed particle hydrodynamics
Fluid–structure interaction

A B S T R A C T

This paper presents the development of a numerical model for violent hydrodynamics of free-surface flows interacting with flexible structures using the meshless smoothed particle hydrodynamics (SPH) method accelerated with a graphics processing unit (GPU). The present work implements a unified SPH framework to solve both the fluid and structural dynamics within the open-source SPH code DualSPHysics. Well-known deficiencies with SPH-based structural modelling (linear inconsistency, tensile instability and rank deficiency) are addressed by adopting a Total Lagrangian formulation with kernel correction and zero-energy mode suppression. The fluid–structure coupling is

Latest Literature Achievements

(d) Special Issue on CPM

Volume 9, issue 5, September 2022 (15 contributions):
"*Latest developments and application of SPH using DualSPHysics*"
Issue editors:
Corrado Altomare, José M. Domínguez, Georgios Fourtakas

The papers below were the most downloaded ones in CPM in 2021:

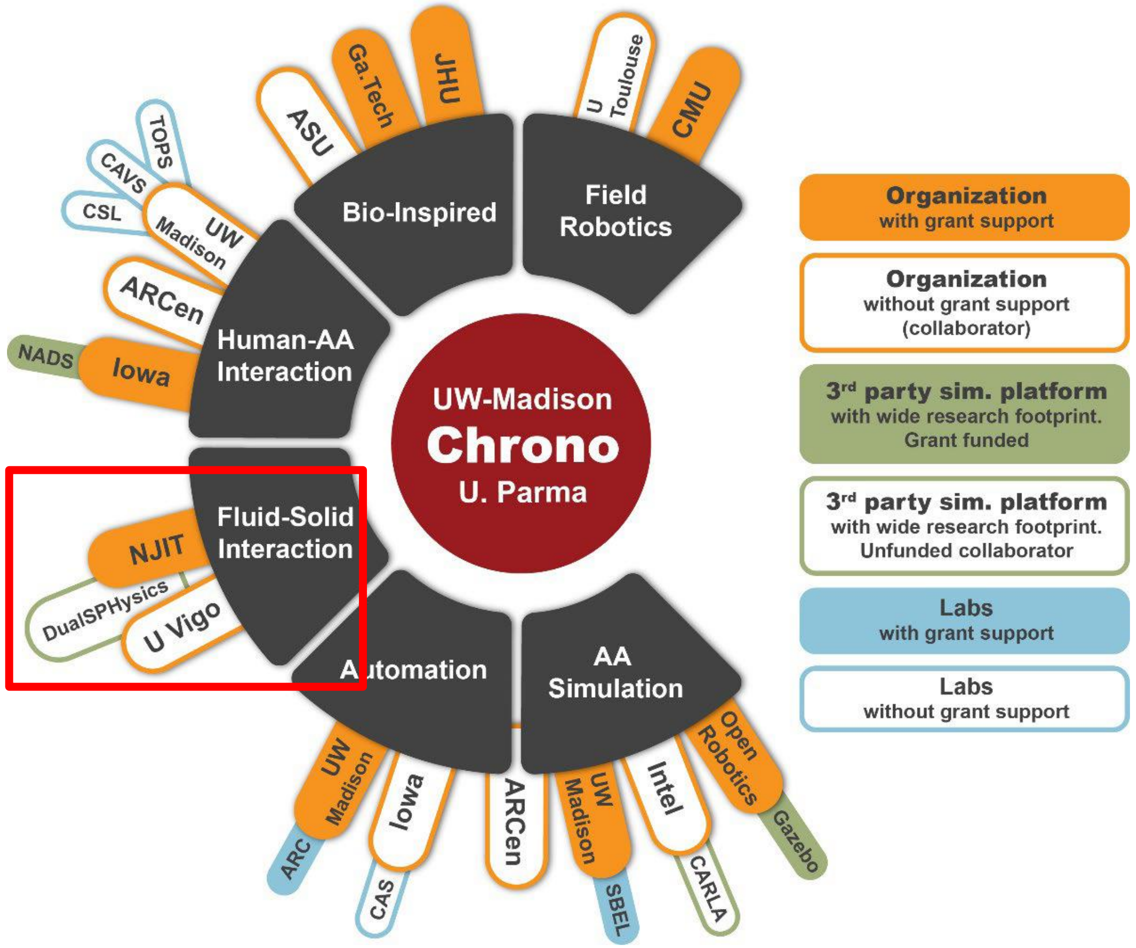
1. DualSPHysics: from fluid dynamics to multiphysics problems
JM Domínguez, G Fourtakas, C Altomare, RB Canelas, A Tafuni, ...

2. Grand challenges for SPH numerical schemes
R Vacondio, C Altomare, M De Leffe, X Hu, D Le Touzé, S Lind, ...

3. Modified dynamic boundary conditions for general-purpose SPH: Application to tank sloshing, dam break and fish pass problems
A English, JM Domínguez, R Vacondio, AJC Crespo, PK Stansby,...

Latest International Projects

Simulating Autonomous Agents and the Human-Autonomous Agent Interaction



National Science Foundation
WHERE DISCOVERIES BEGIN

THE UNIVERSITY of WISCONSIN MADISON

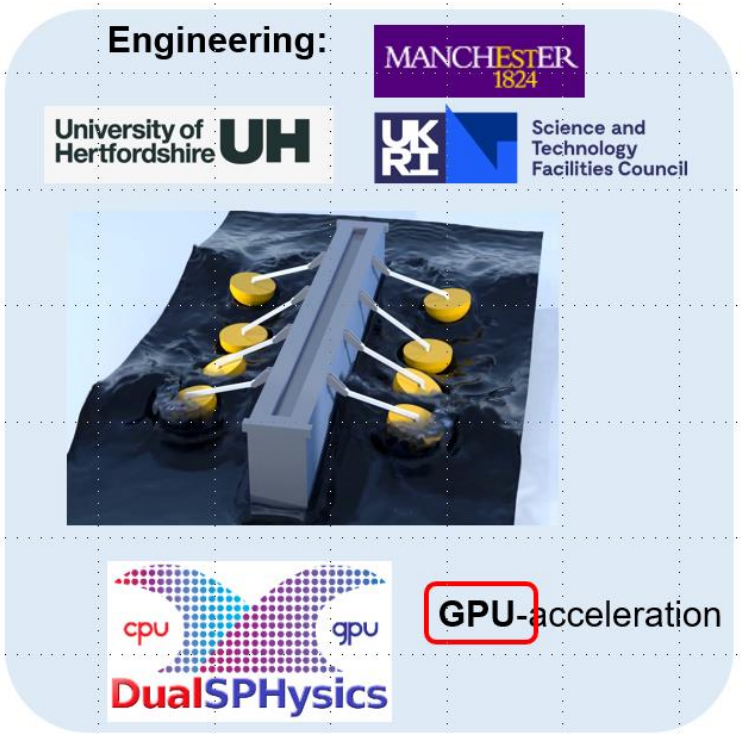
Chrono-DualSPHysics further integration in support of fluid-solid interaction simulation

NEW JERSEY INSTITUTE OF TECHNOLOGY Founded 1881

UNIVERSIDADE DE VIGO

Latest International Projects

Exascale Computing ALgorithms & Infrastructures Benefiting UK Research (ExCALIBUR)



Aim: redesign of high-priority computer codes & algorithms for Exascale (**10^{18} FLOPS**)

£46 million ($58 million) over 5 years 2019-2024 across multiple sectors

High-Priority Use Cases: (i) Weather & Climate, (ii) Fusion, etc.

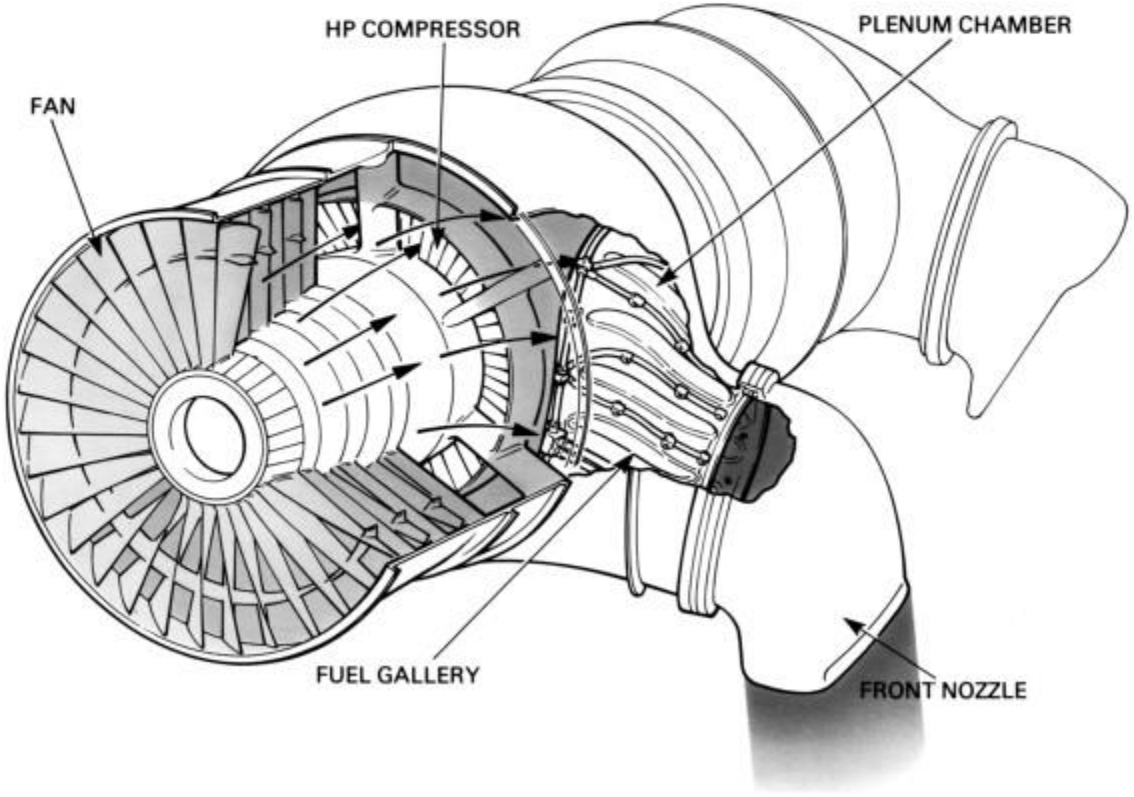
https://excalibur.ac.uk

£3m project: **PAX-HPC: Particles at Exascale for High-Performance Computing**

Latest International Projects

DualSPHysics for General Motors

General Motors



2-year project that will see the development of:

1. A variable resolution strategy in DualSPHysics that works for 3-D geometries on GPU
2. Advanced boundary conditions for modeling engine components across different levels of resolution
3. Improved pre- and post-processing tools

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UNIVERSITÀ DI PARMA

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References Involving DualSPHysics

DualSPHysics

Home | Features | Developers | Downloads | Documentation | Events | Forum | References

Journal papers

Reference paper (link)

Domínguez JM, Fourtakas G, Altomare C, Canelas RB, Tafuni A, García-Feal O, Martínez-Estévez I, Mokos A, Vacondio R, Crespo AJC, Rogers BD, Stansby PK, Gómez-Gesteira M. 2022. DualSPHysics: from fluid dynamics to multiphysics problems. Computational Particle Mechanics, 9(5), 867-895. doi:10.1007/s40571-021-00404-2.

Zotero database of journal papers using DualSPHysics:
https://www.zotero.org/groups/2862487/dualsphysics/library

2022

Brito M, Bernardo F, Neves MG, Neves DRCB, Crespo AJC, Domínguez JM. 2022. Numerical Model of Constrained Wave Energy Hyperbaric Converter under Full-Scale Sea Wave Conditions. Journal of Marine Science and Engineering, 10(10), 1489. doi:10.3390/jmse10101489.

Tagliafierro B, Karimirad M, Martínez-Estévez I, Domínguez JM, Viccione G, Crespo AJC. 2022. Numerical Assessment of a Tension-Leg

References Involving DualSPHysics

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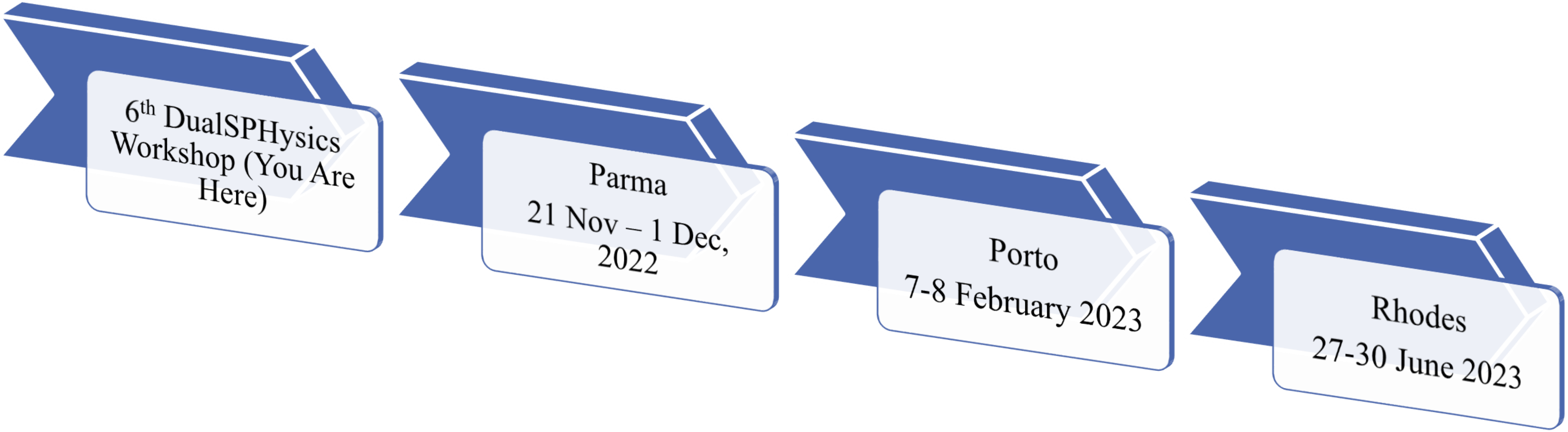
  - Core Library

Title	Creator	Date
3D numerical simulation of debris-flow motion using SPH ...	Wang et al.	2016
A decoupled SPH-FEM analysis of hydrodynamic wave pre...	Wu et al.	2022-10-01
A DEM approach for simulating flexible beam elements wit...	Capasso et al.	2022-01-29
A fluid–structure interaction model for free-surface flows a...	O'Connor and Rogers	2021-07-01
A numerical study of a taut-moored point-absorber wave ...	Tagliafierro et al.	2022-04-01
A phase-field lattice Boltzmann method for the solution of ...	De Rosis and Tafuni	2020
A three-dimensional fluid-structure interaction model base...	Ng et al.	2022
A two-phase simulation of wave impact on a horizontal de...	Sun et al.	2015
Comparative study of standard WC-SPH and MPS solvers f...	Bakti et al.	2016
Composite modelling of subaerial landslide-tsunamis in dif...	Heller et al.	2016
Coupling methodology for smoothed particle hydrodynam...	Verbrugghe et al.	2018
DualSPHysics: A numerical tool to simulate real breakwaters	Zhang et al.	2018
DualSPHysics: from fluid dynamics to multiphysics problems	Domínguez et al.	2021-03-29
DualSPHysics: Open-source parallel CFD solver based on S...	Crespo et al.	2015-02
Ensuring numerical stability of wave propagation by tuning...	Rota Roselli et al.	2018

https://www.zotero.org/groups/2862487/dualsphysics/library

Upcoming DualSPHysics-Related Events



Stay tuned for the **7th DualSPHysics International Workshop** announcement later on

How to download DuaSPHysics v5.2 beta

cpu gpu

DualSPHysics

Version 5.2 beta

New version only available to workshop attendees!!

The full package v5.2 includes:

- Several SPH approaches
- New pre- and post-processing tools
- Improved documentation guides
- More than 100 examples (including new features)

Download the full package from:
https://dual.sphysics.org/sphcourse/DualSPHysics_v5.2_BETA/

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J.M. Domínguez, G. Fourtakas, C. Altomare, R.B. Canelas, A. Tafuni, O. García-Feal, I. Martínez-Estévez, A. Mokos, R. Vacondio, A.J.C. Crespo, B.D. Rogers, P.K. Stansby, M. Gómez-Gesteira. 2022. **DualSPHysics: from fluid dynamics to multiphysics problems.** Computational Particle Mechanics. 9(5): 867-895. doi:10.1007/s40571-021-00404-2