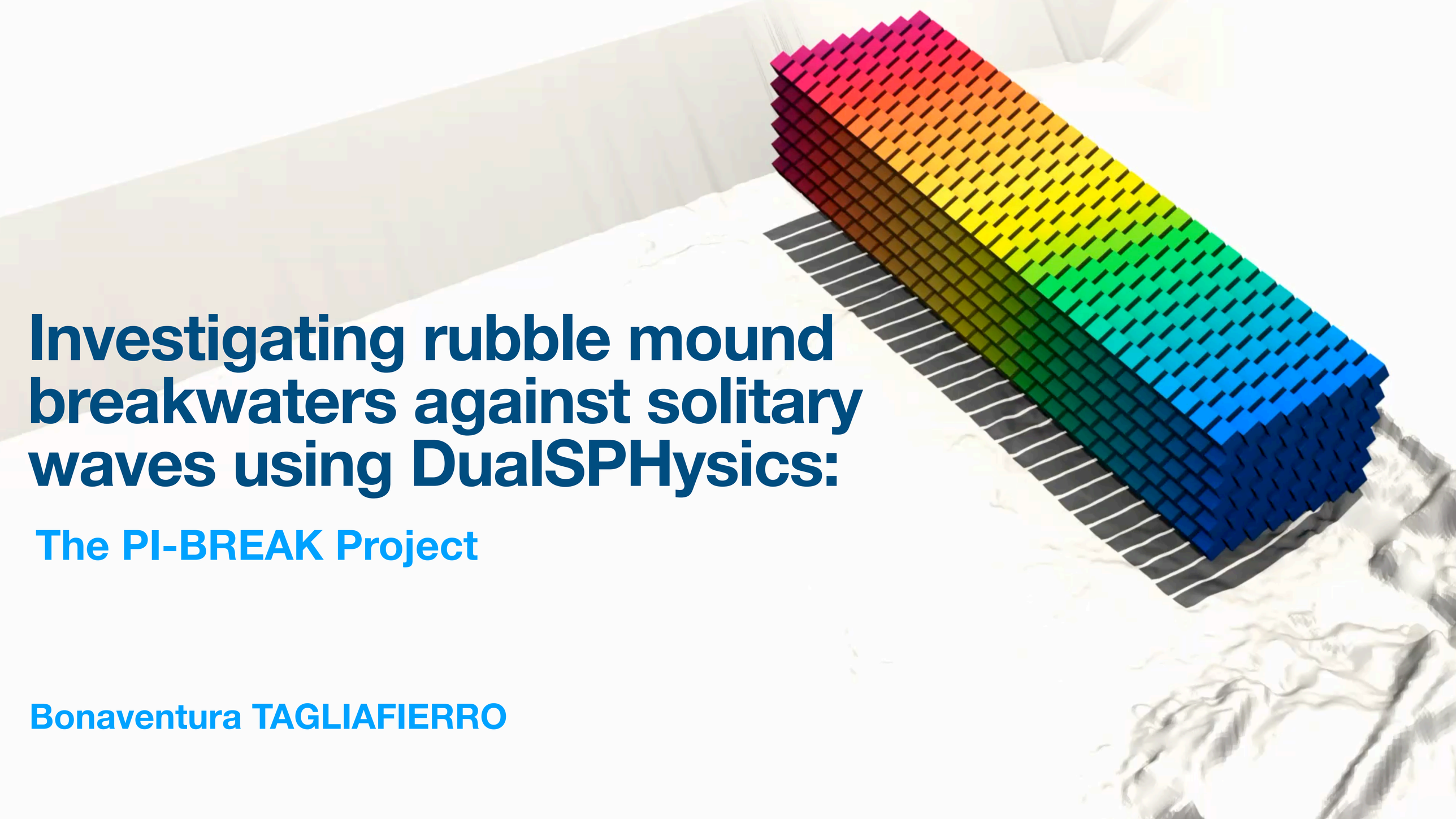

Investigating rubble mound breakwaters against solitary waves using DualSPHysics:

The PI-BREAK Project

Bonaventura TAGLIAFIERRO

PI-BREAK Project

Predictive Intelligent system to optimize BREAKwater maintenance

- PI: Corrado ALTOMARE
- Iván MARTÍNEZ-ESTEVÉZ
- José M. DOMÍNGUEZ
- Alejandro J.C. CRESPO
- Moncho GÓMEZ-GESTEIRA

MINISTERIO DE CIENCIA E INNOVACIÓN

Financiado por la Unión Europea NextGenerationEU

Plan de Recuperación, Transformación y Resiliencia

AGENCIA ESTATAL DE INVESTIGACIÓN

Laboratori d'Enginyeria Marítima

UNIVERSITAT POLITÈCNICA DE CATALUNYA

PI-BREAK Project

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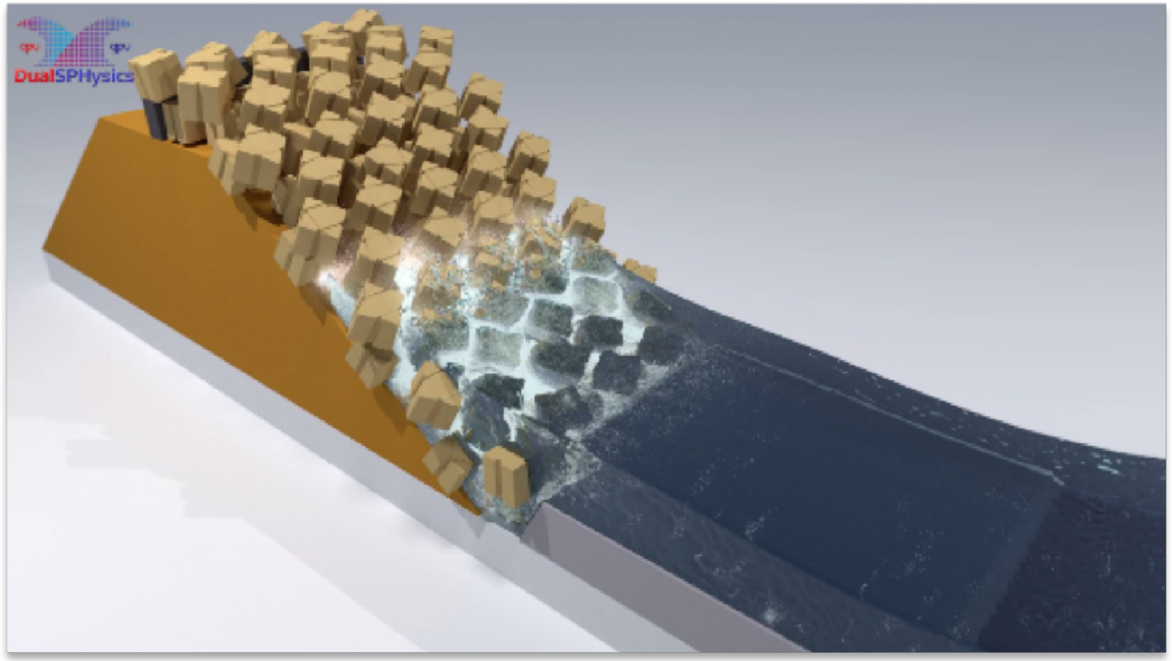
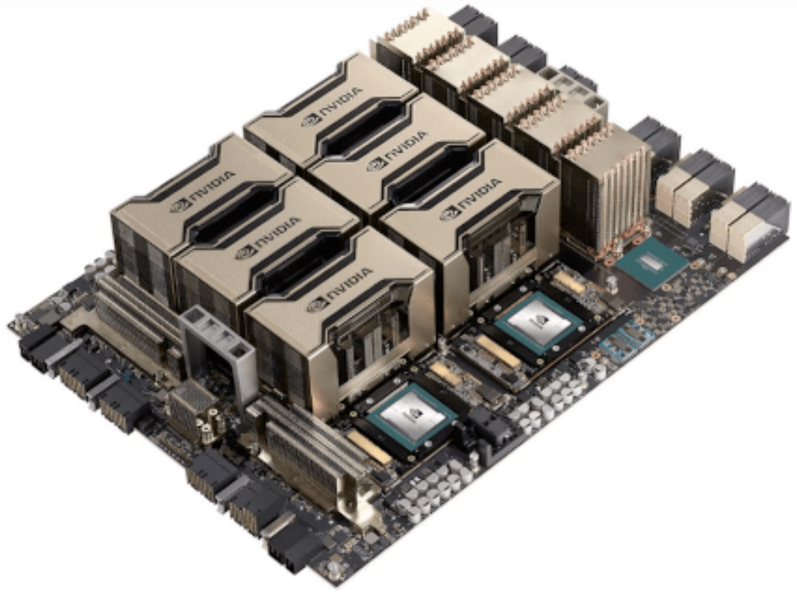


WP3: synthetic data generation

- Multi-scale wave modeling
- Multi-GPU computation



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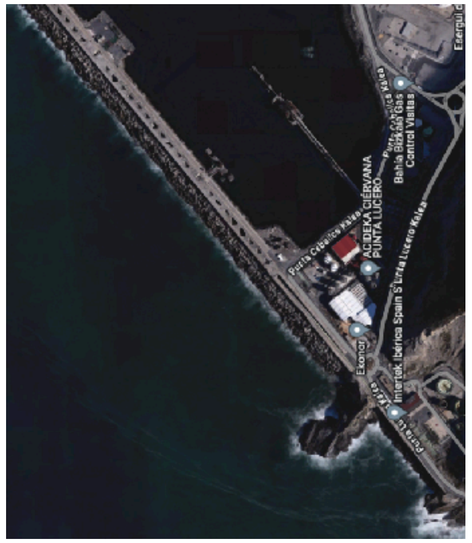
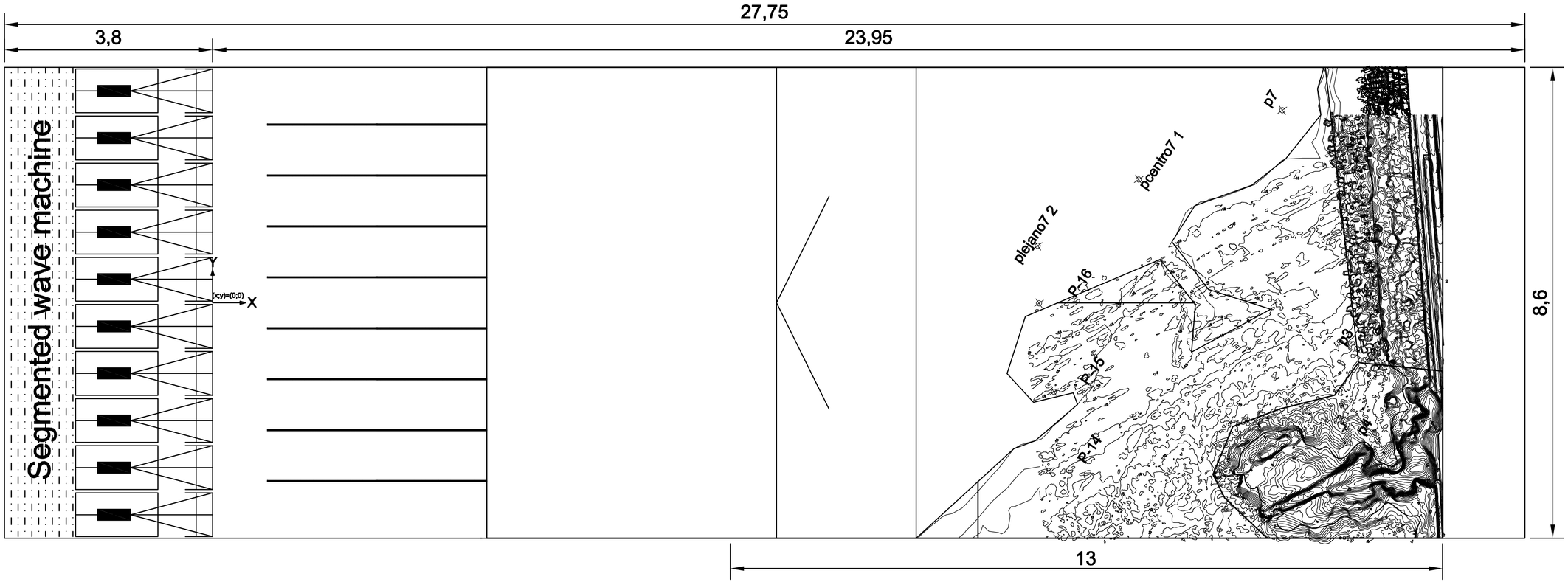
Setup TOD-IHC

1/45 scaled bathymetry

3D reconstructution of the bathymetry from field data.
This is the setup that we would consider for our validations.

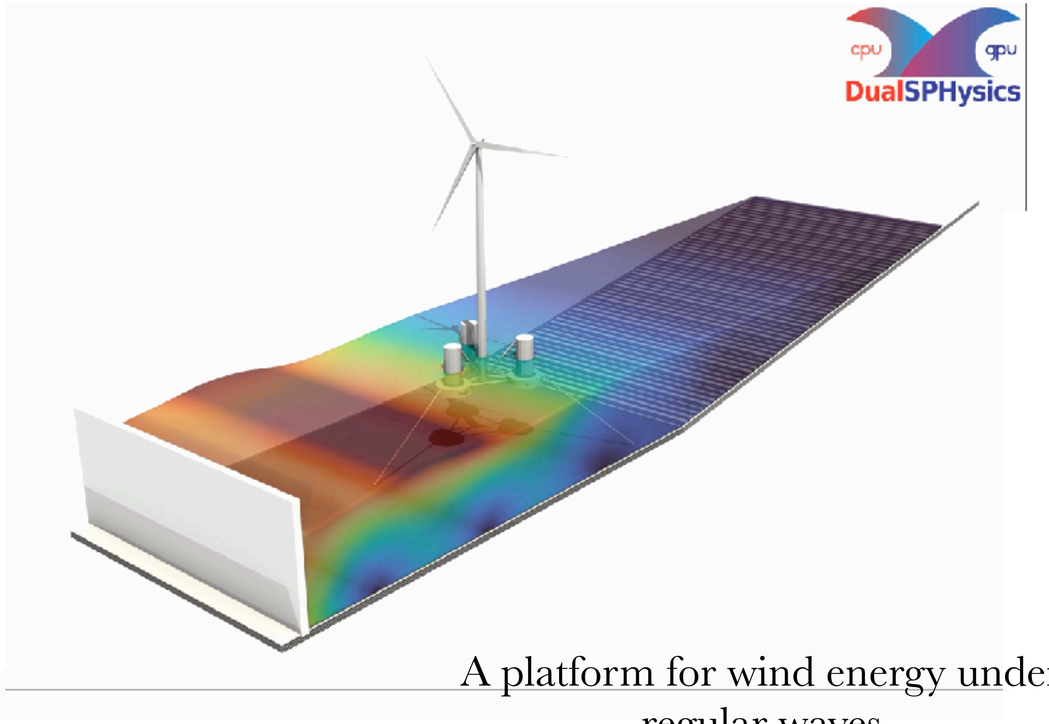




DualSPHysics

Open source SPH solver

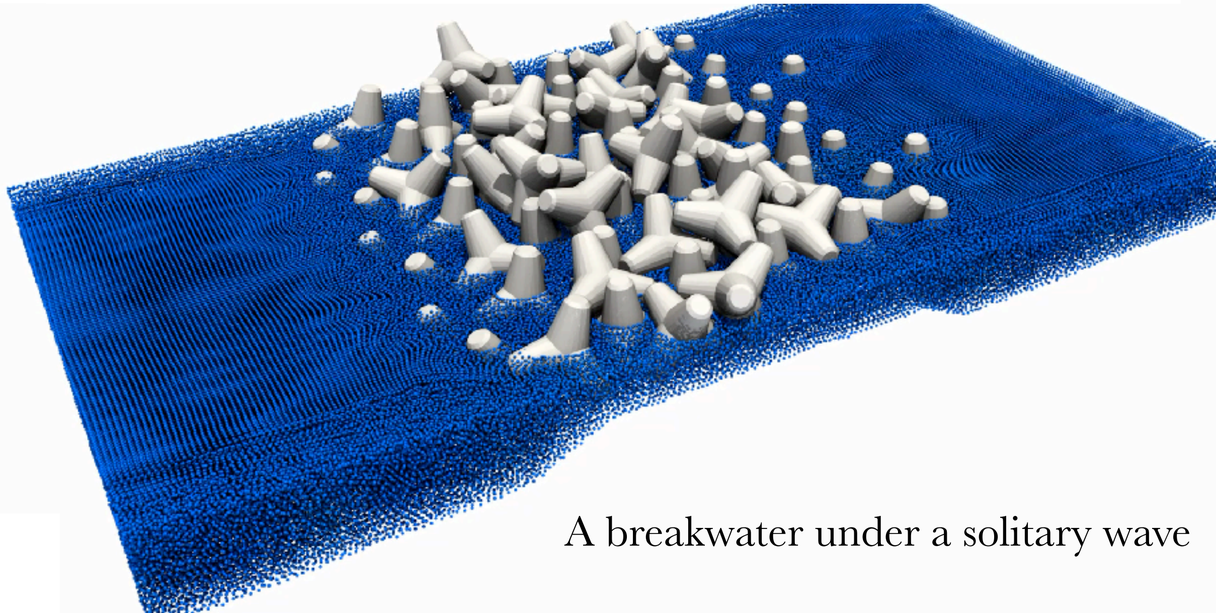
Mono-dispersed SPH implementation
Coupling to improve the physics
Single phase



A platform for wind energy under regular waves

Features

- CPU/GPU Implementation (C++/Cuda)
- Highly parallelized for GPU units (only one so far)
- Pre- and Post-processing tools
- Open source



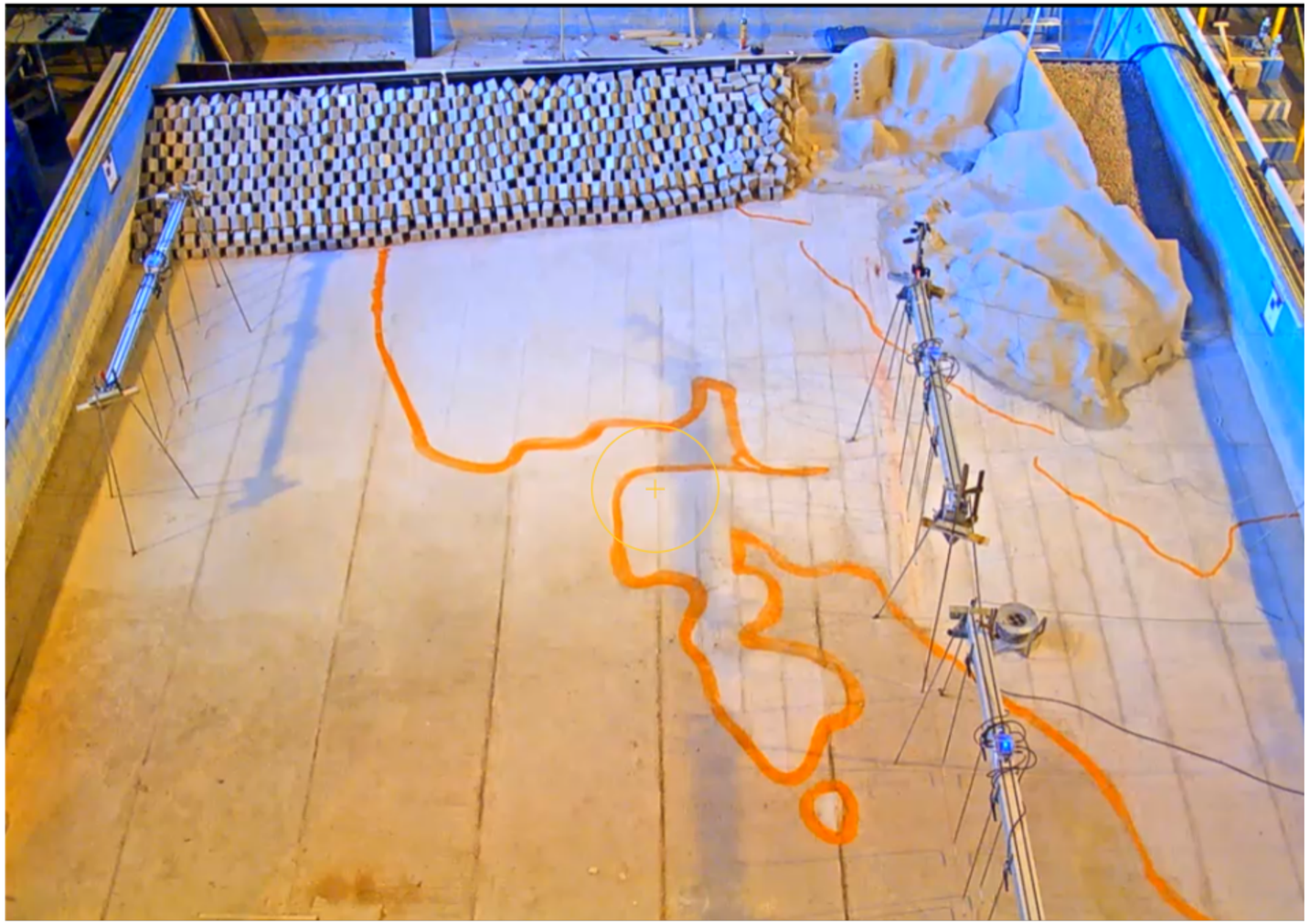
A breakwater under a solitary wave

Domínguez, J.M., Fourtakas, G., Altomare, C. *et al.* DualSPHysics: from fluid dynamics to multiphysics problems. *Comp. Part. Mech.* **9**, 867–895 (2022). https://doi.org/10.1007/s40571-021-00404-2

Setup TOD-IHC

1/45 scaled bathymetry

- More than 1000 blocks
- Complex bathymetry
- The blocks move only after long sea-states
- Fully-3D simulation

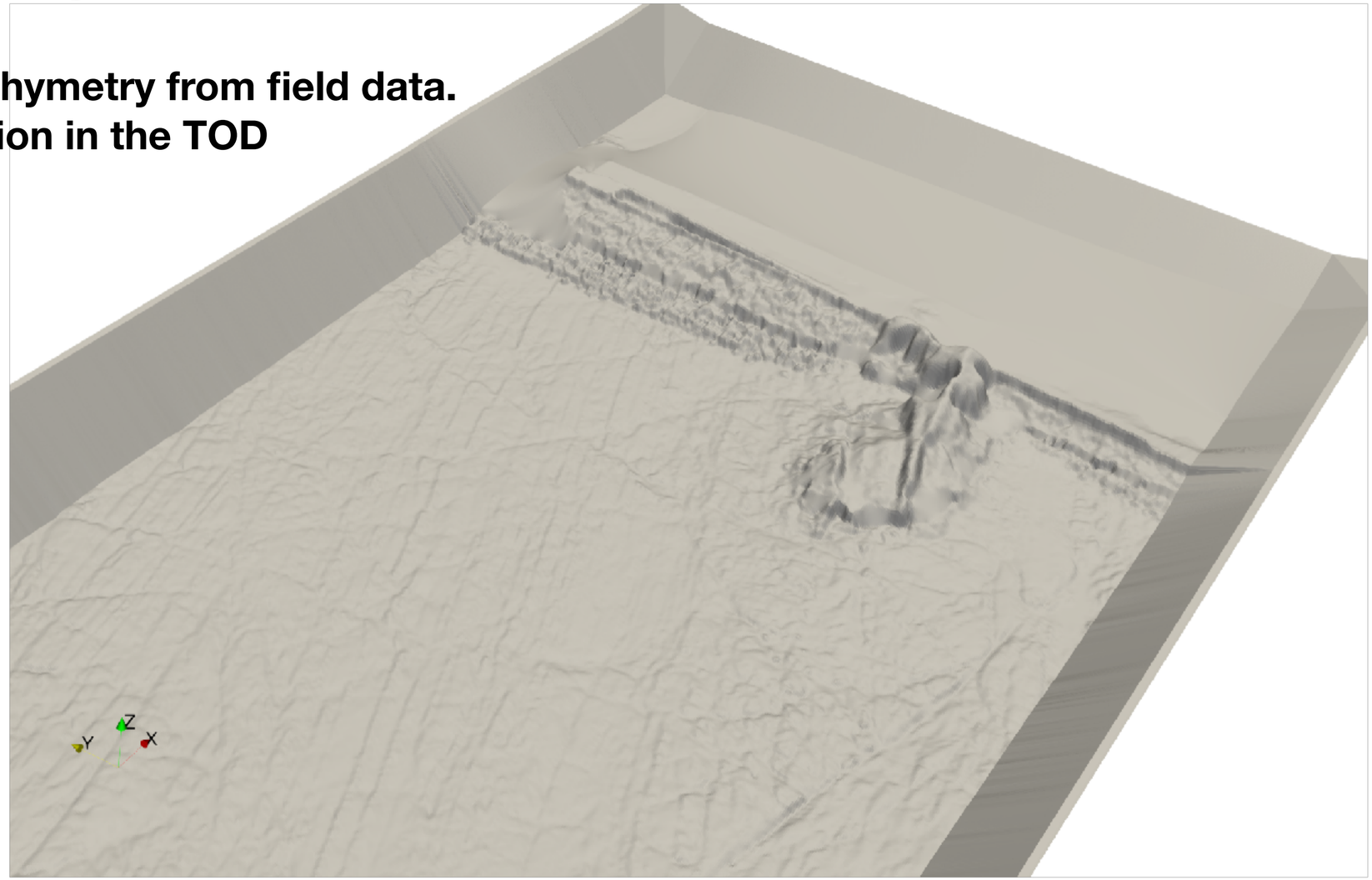


Wave basin arranged in Santander for this project

Setup TOD-IHC

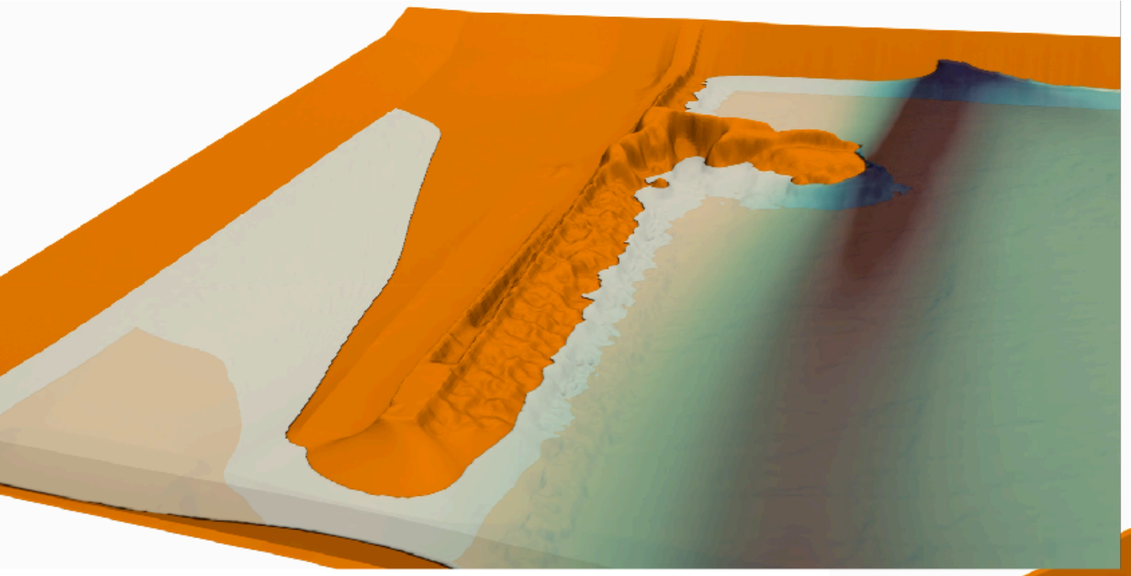
1/45 scaled bathymetry

3D reconstructution of the bathymetry from field data.
We would need the configutation in the TOD

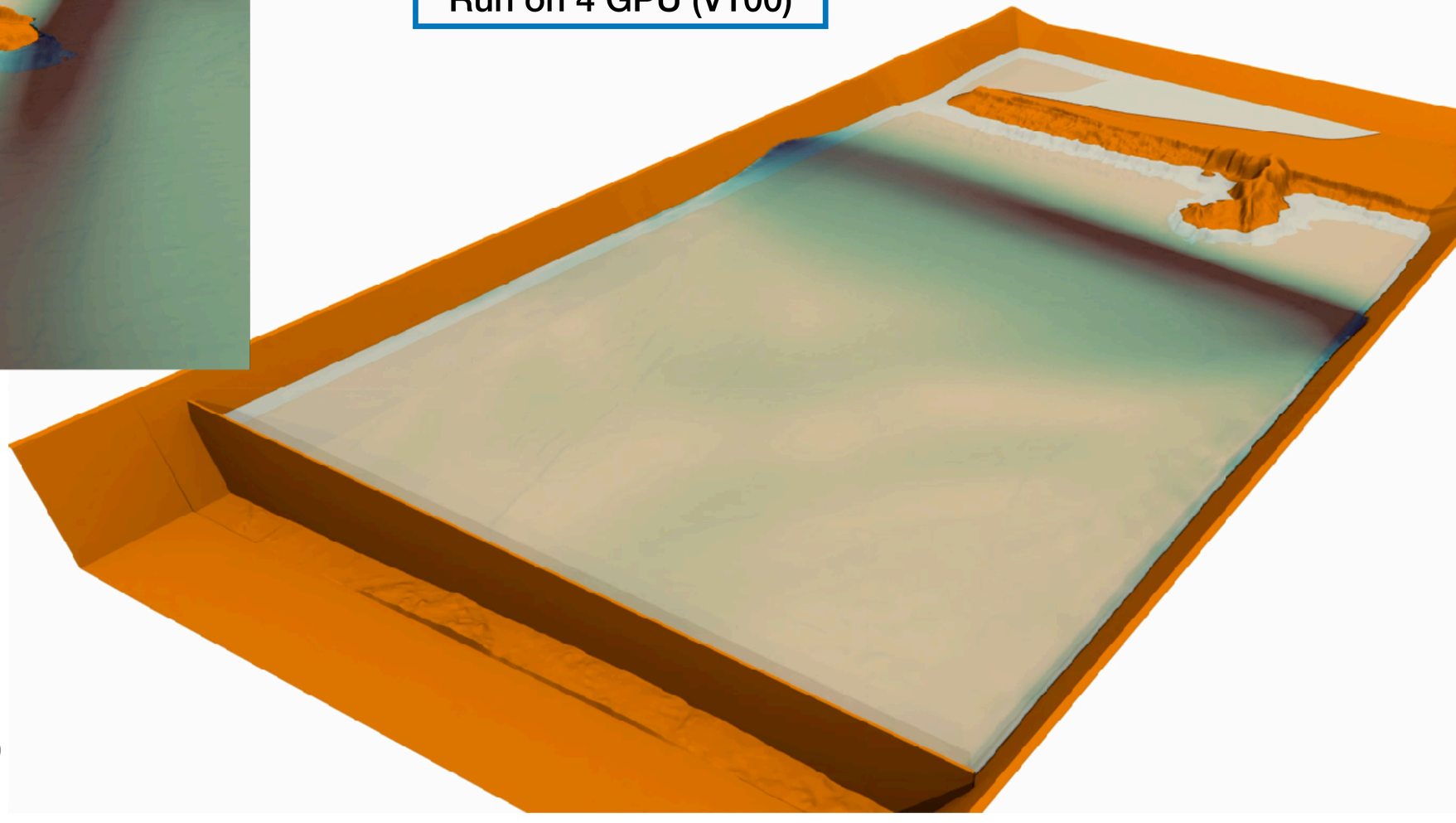


Numerical TOD-UPC

Multi-GPU simulation



Resolution *dp*=L/10
100 M particles
Run on 4 GPU (V100)



Fully 3D
Example of a solitary wave

Note: *L* is the meaningful size of a block (5.00 m)

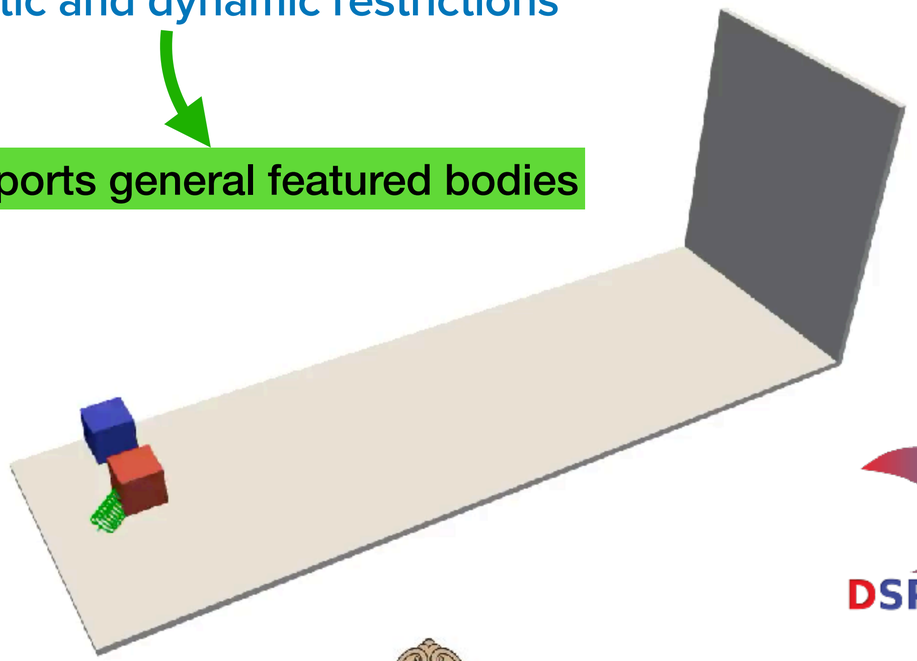
Getting blocks in

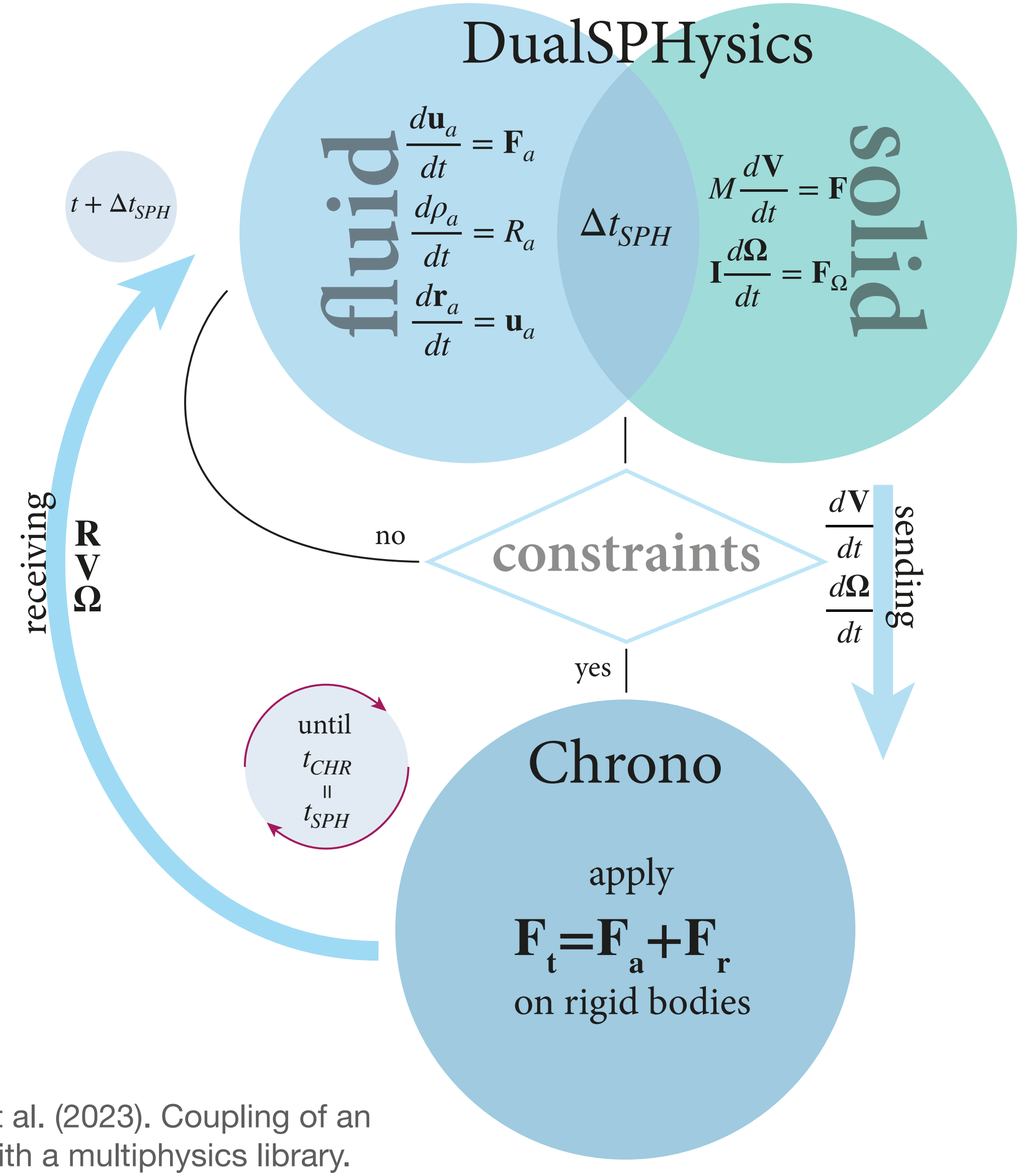
From Project Chrono

Open source multiphysics library

Multi-body support
Smooth and non-smooth contacts
Kinematic and dynamic restrictions

Supports general featured bodies





Martínez-Estévez, I. et al. (2023). Coupling of an SPH-based solver with a multiphysics library. *Computer Physics Communications, 283*, 108581. https://doi.org/10.1016/j.cpc.2022.108581

Courtesy of Salvatore Capasso

From Project Chrono

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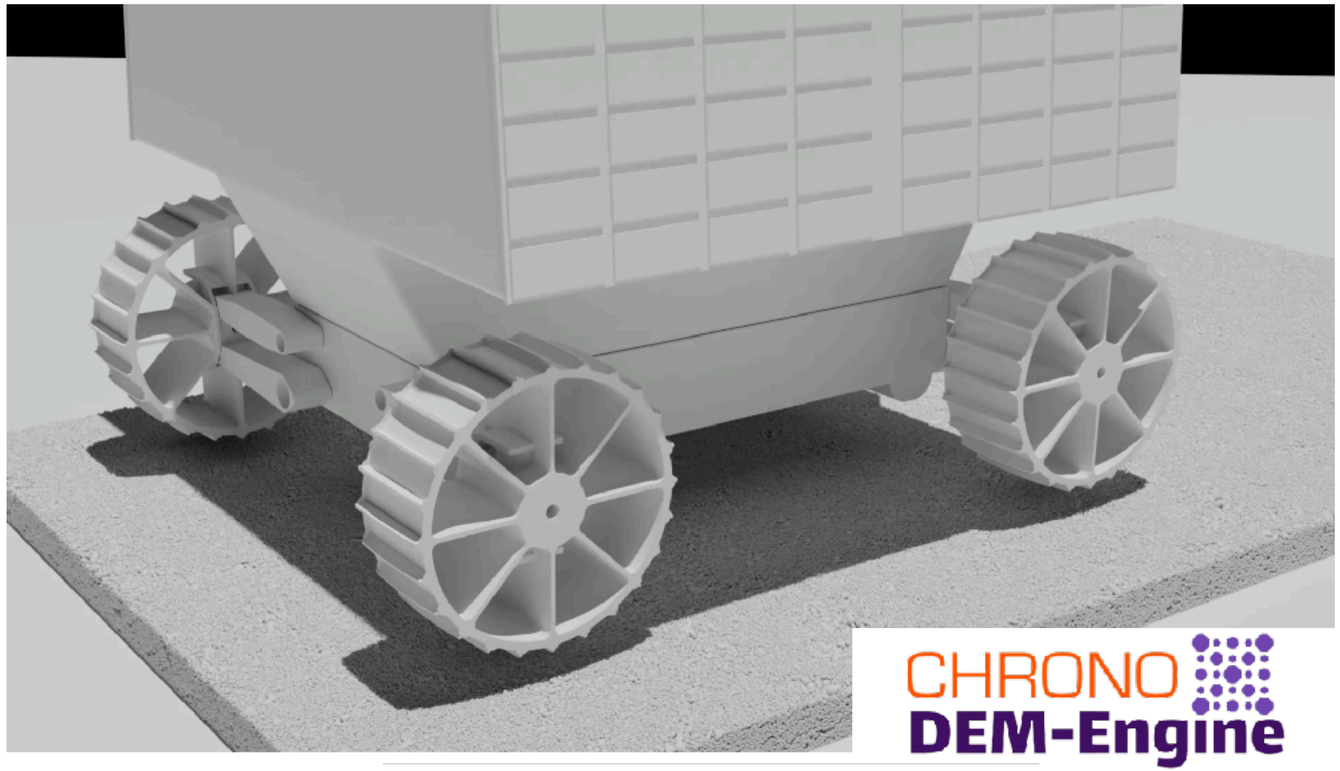
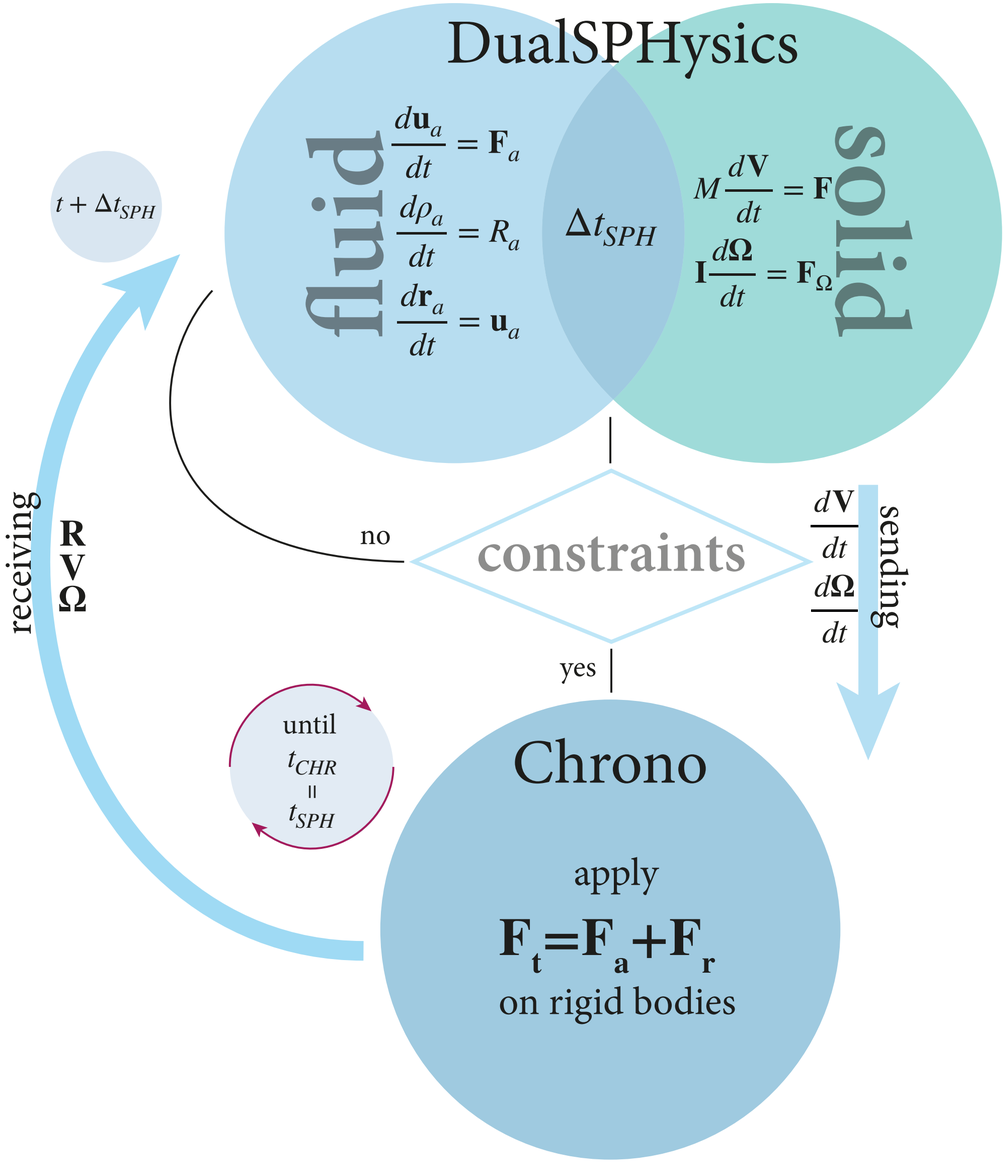
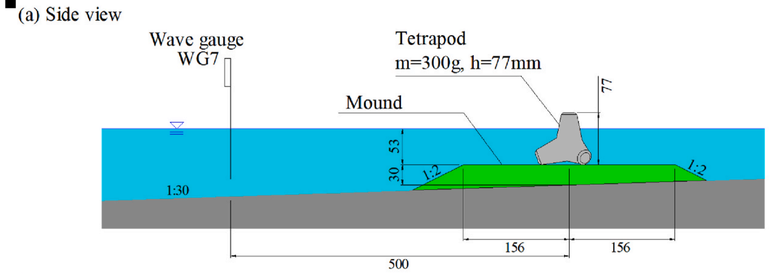


CHRONO DEM-Engine

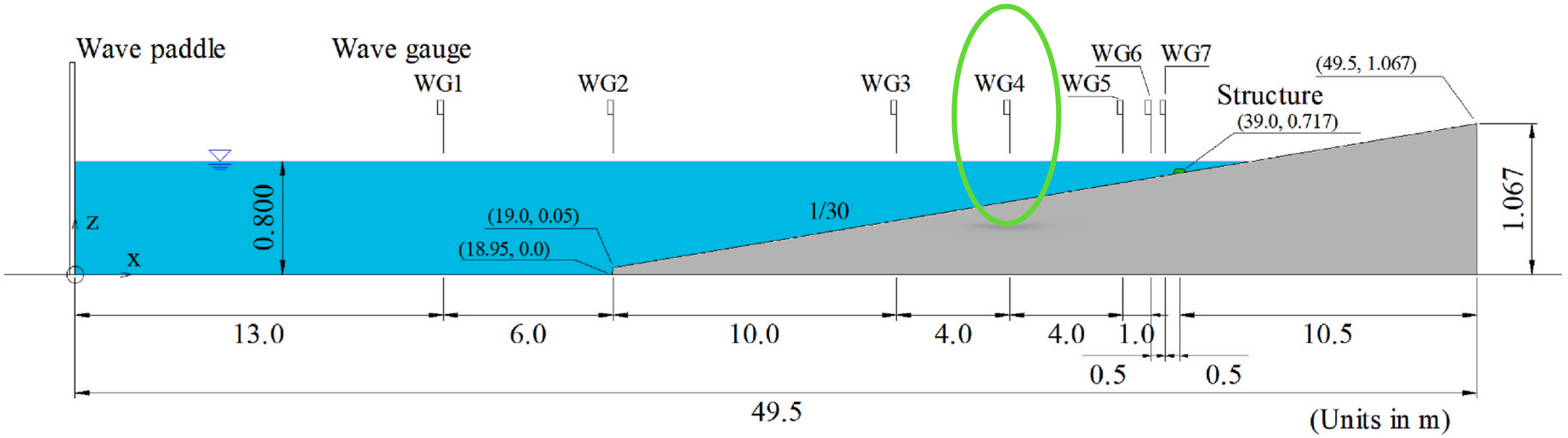


Interaction between Tetrapods and Wave

Tsunami wave generation and propagation

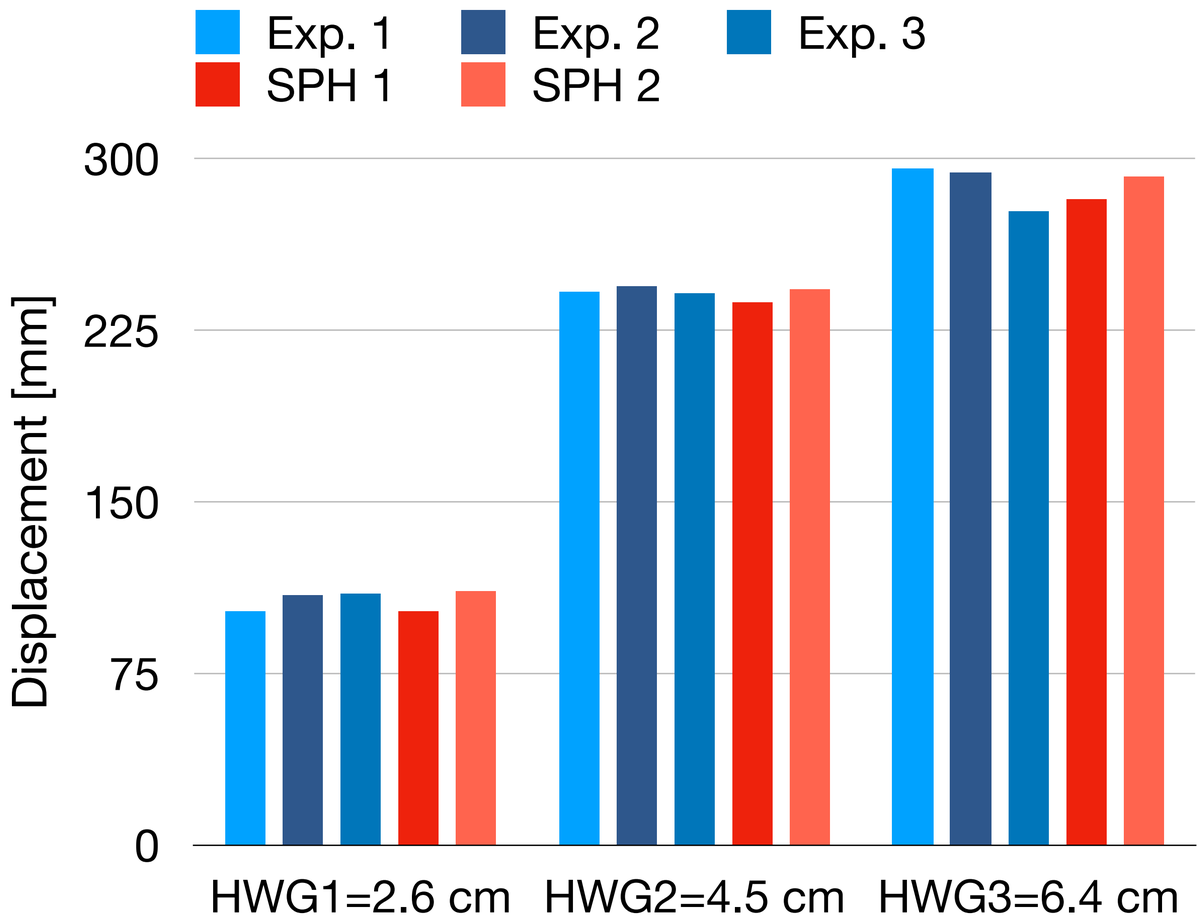


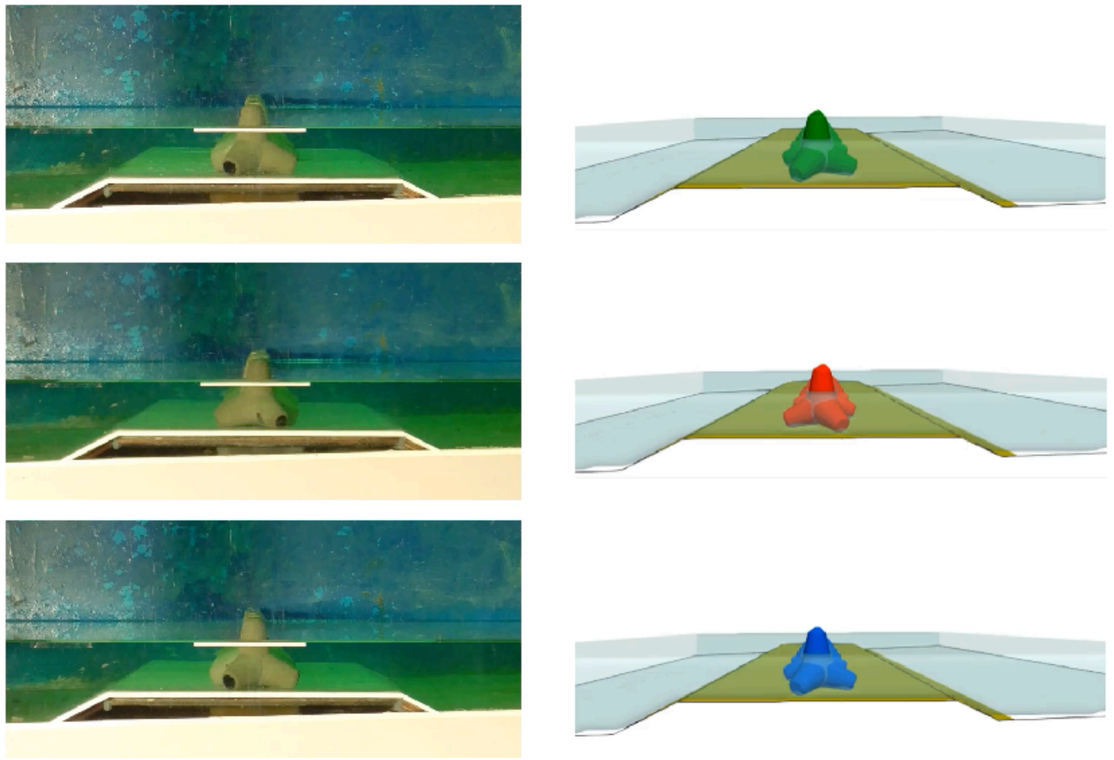
Mitsui, J., et al. (2023). DualSPHysics modelling to analyse the response of Tetrapods against solitary wave. *Coastal Engineering, 183*, 104315. https://doi.org/10.1016/j.coastaleng.2023.104315

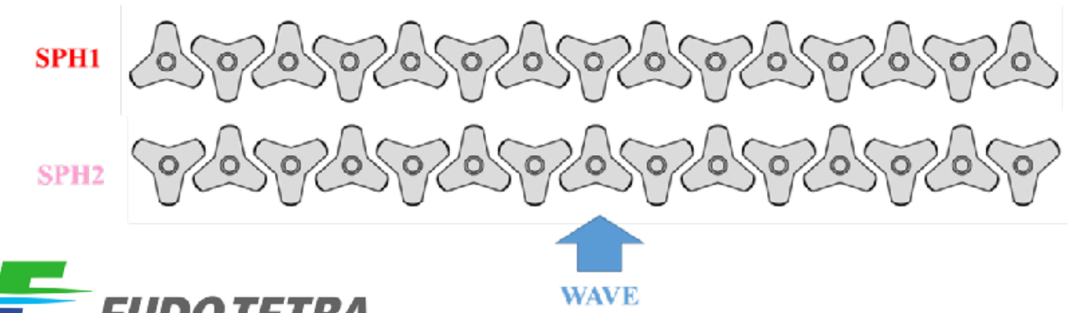


Interaction between Tetrapods and Wave

PVC mound





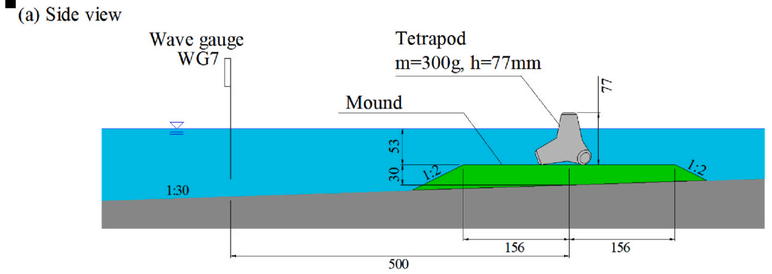


FUDOTETRA

Courtesy of Alex Crespo

Interaction between Tetrapods and Wave

Tsunami wave generation and propagation



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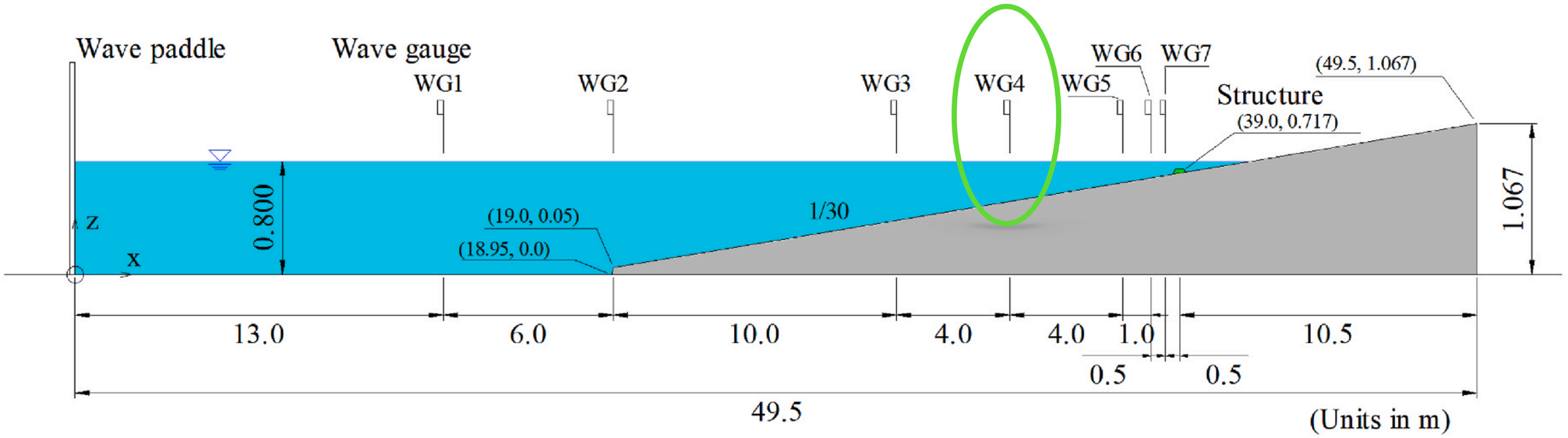
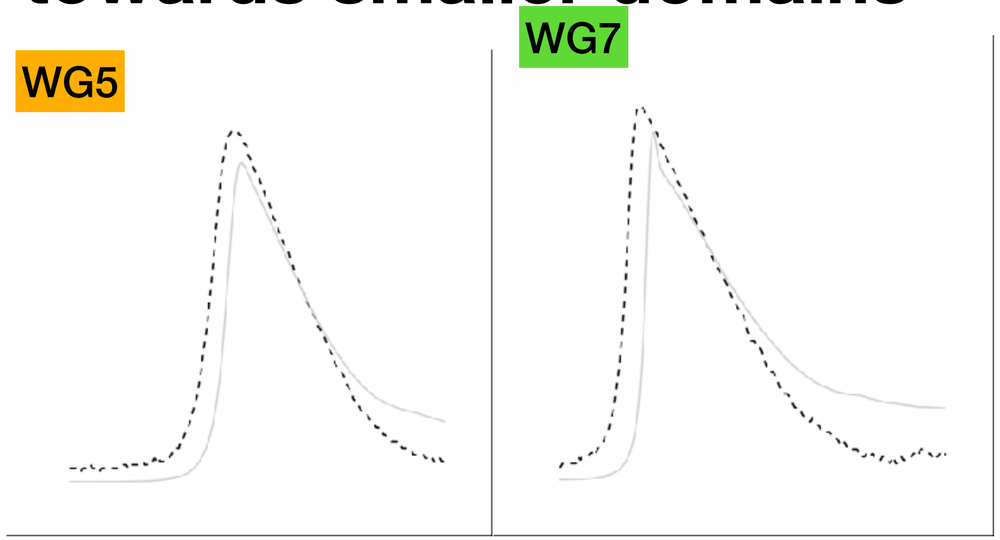
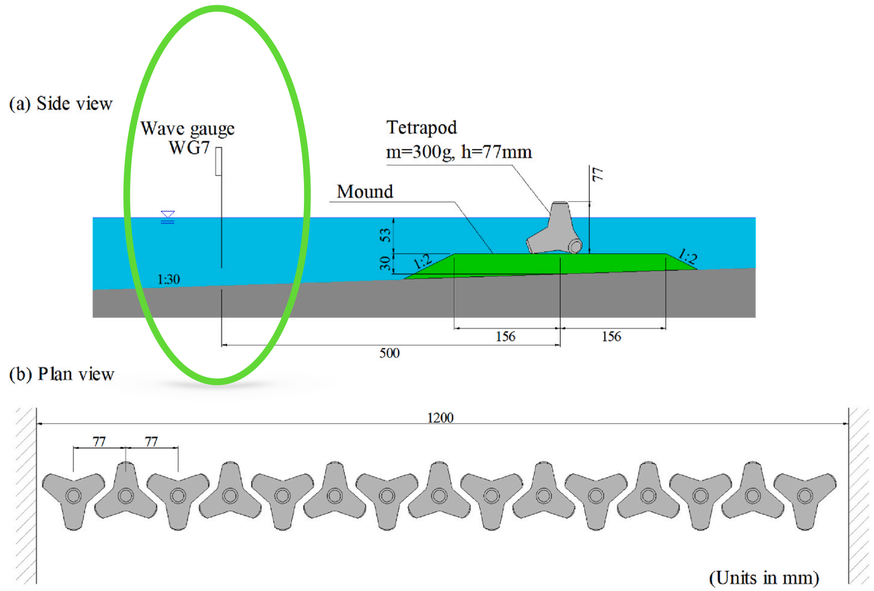


Multi-scaling the simulation

Moving towards smaller domains





Based on the approach developed in Clamond and Germain (1999), the law of motion is derived from the first-order shallow water solution (KdV)

Tagliafierro, B. Et al. (2023). An Insightful Tool for the Response of Armor Block Breakwaters on Impermeable Bed Combining Numerical Modeling Techniques. In *Proceedings of the 33rd (2023) ISOPE*, Ottawa, Canada. ISBN: 978-1-880653-80-7

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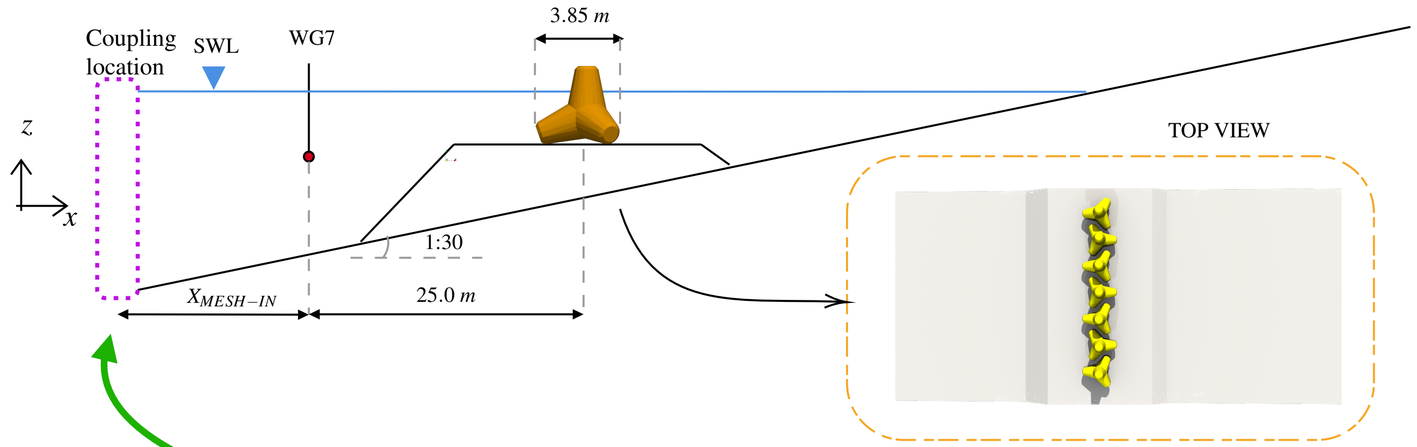

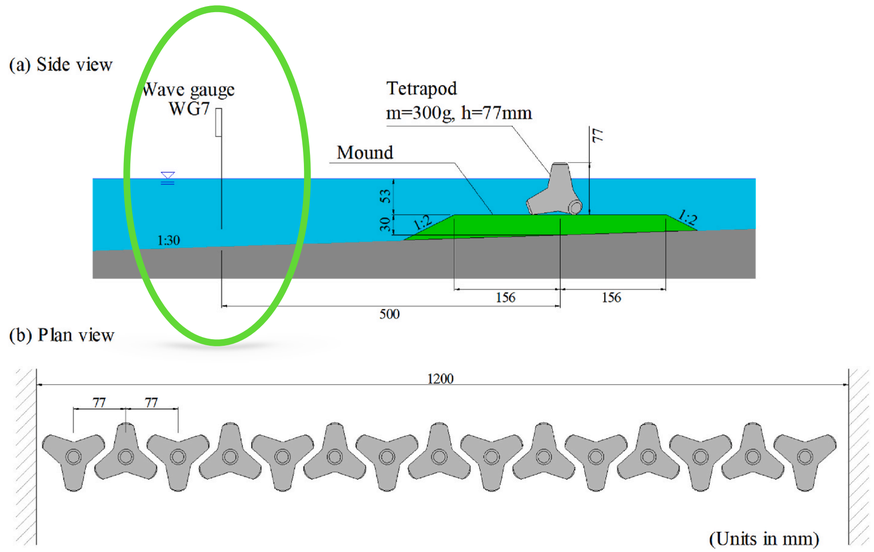

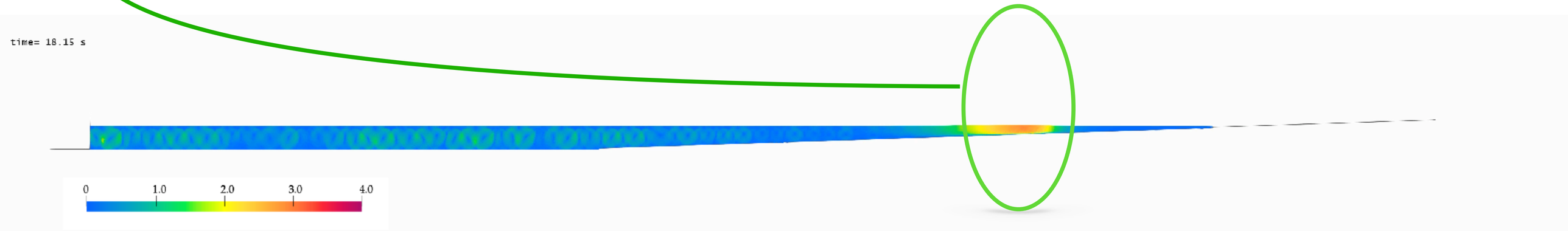

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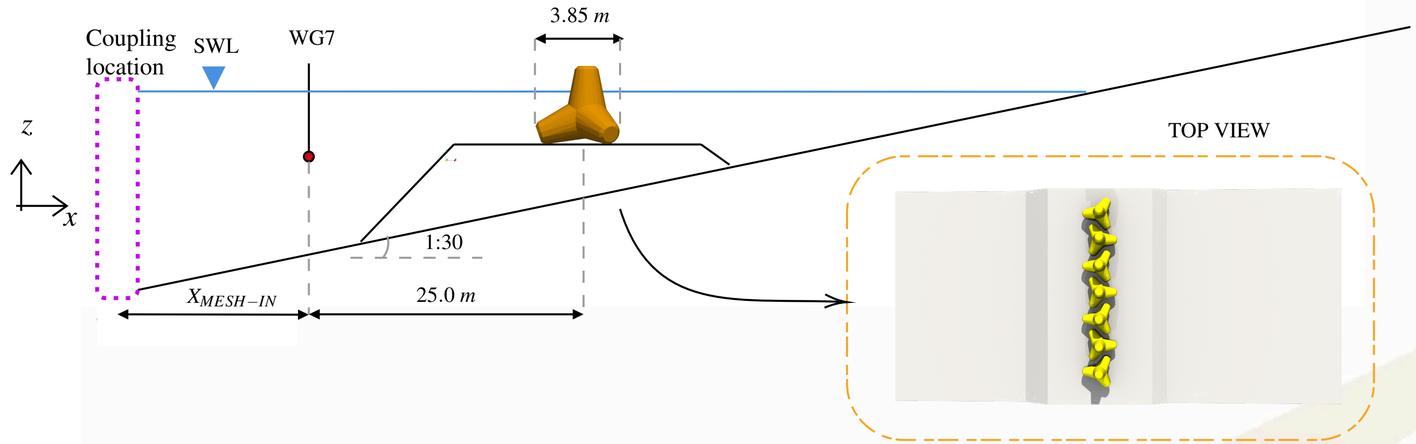
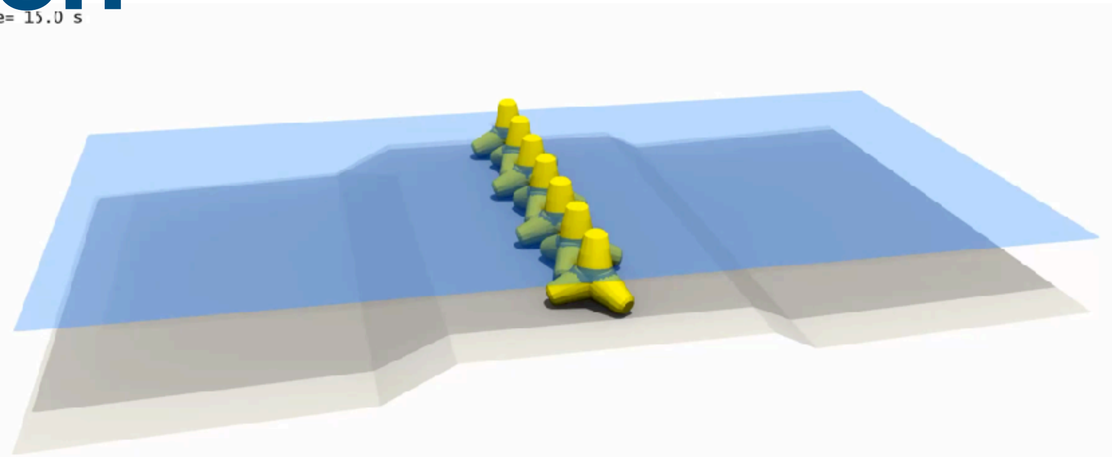
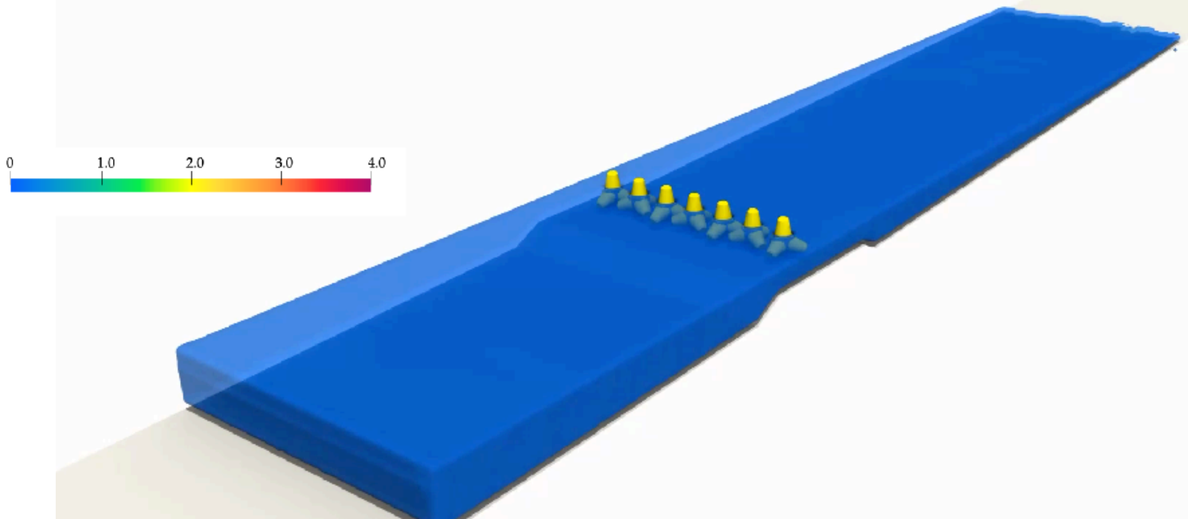
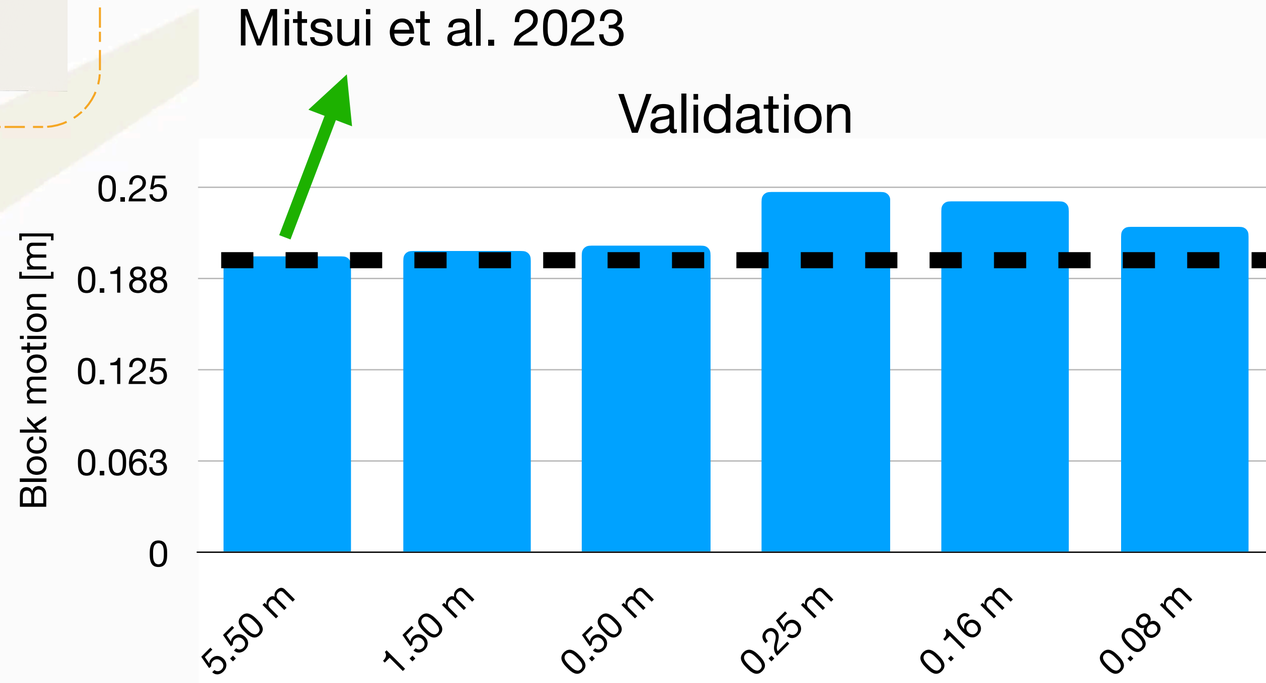




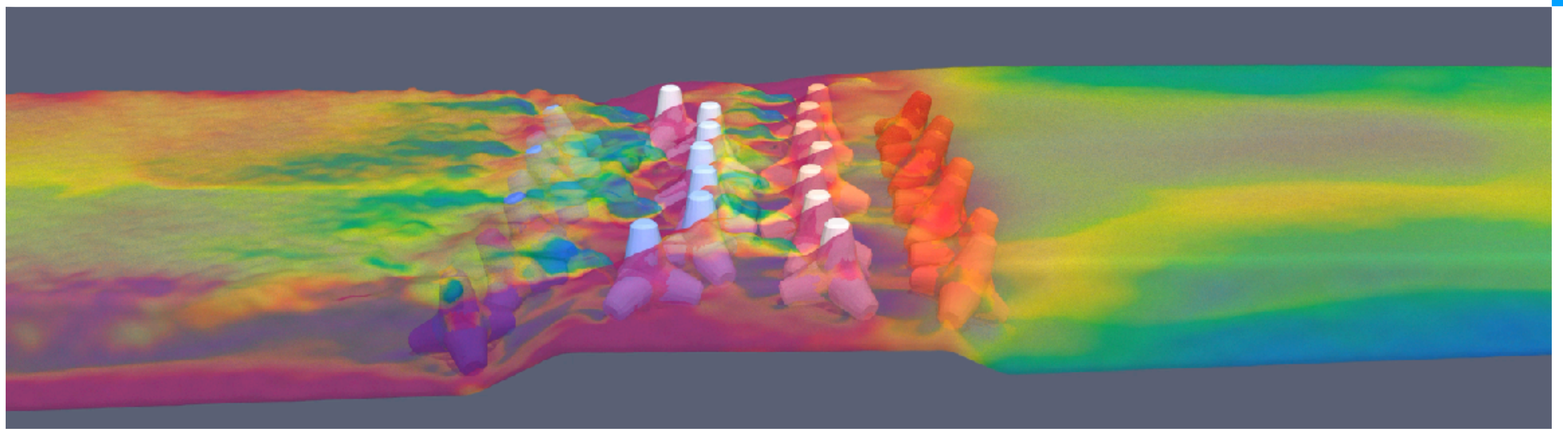




Multi-scaling the simulation

Moving towards smaller domains

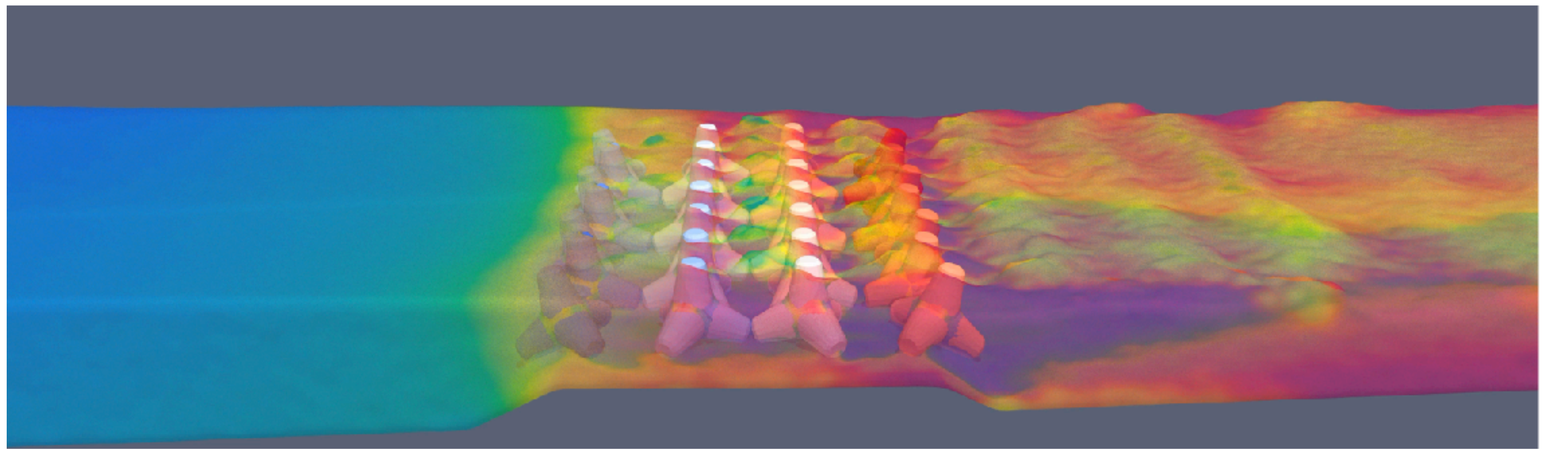
Chrono



Total runtime = 37 h

Martínez-Estévez, I. et al. (2023). Coupling of an SPH-based solver with a multiphysics library. *Computer Physics Communications, 283*, 108581. https://doi.org/10.1016/j.cpc.2022.108581

DEM



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Canelas, R. B. et al. (2016). SPH–DCDEM model for arbitrary geometries in free surface solid–fluid flows. *Computer Physics Communications, 202*, 131-140. https://doi.org/10.1016/j.cpc.2016.01.006

Multi-scaling the simulation

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Chrono

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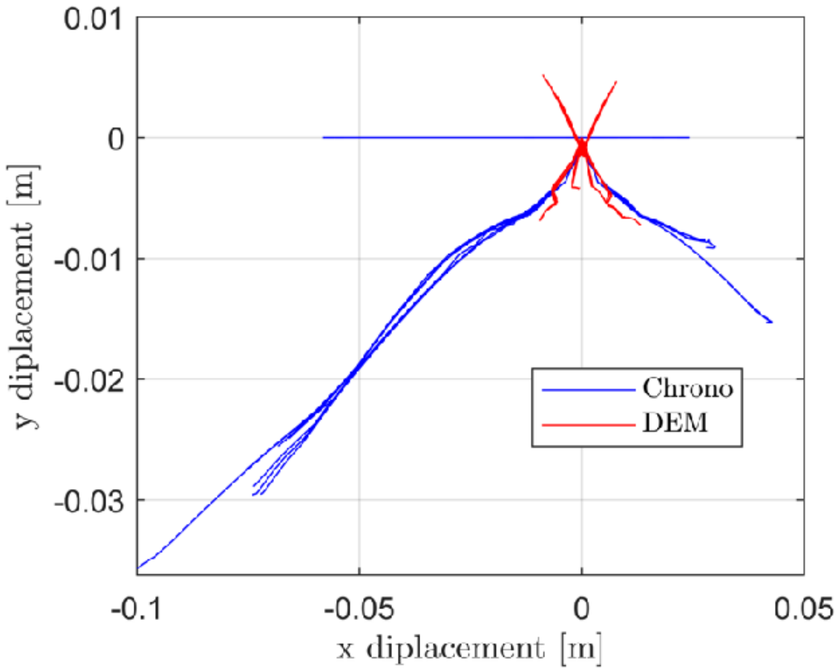

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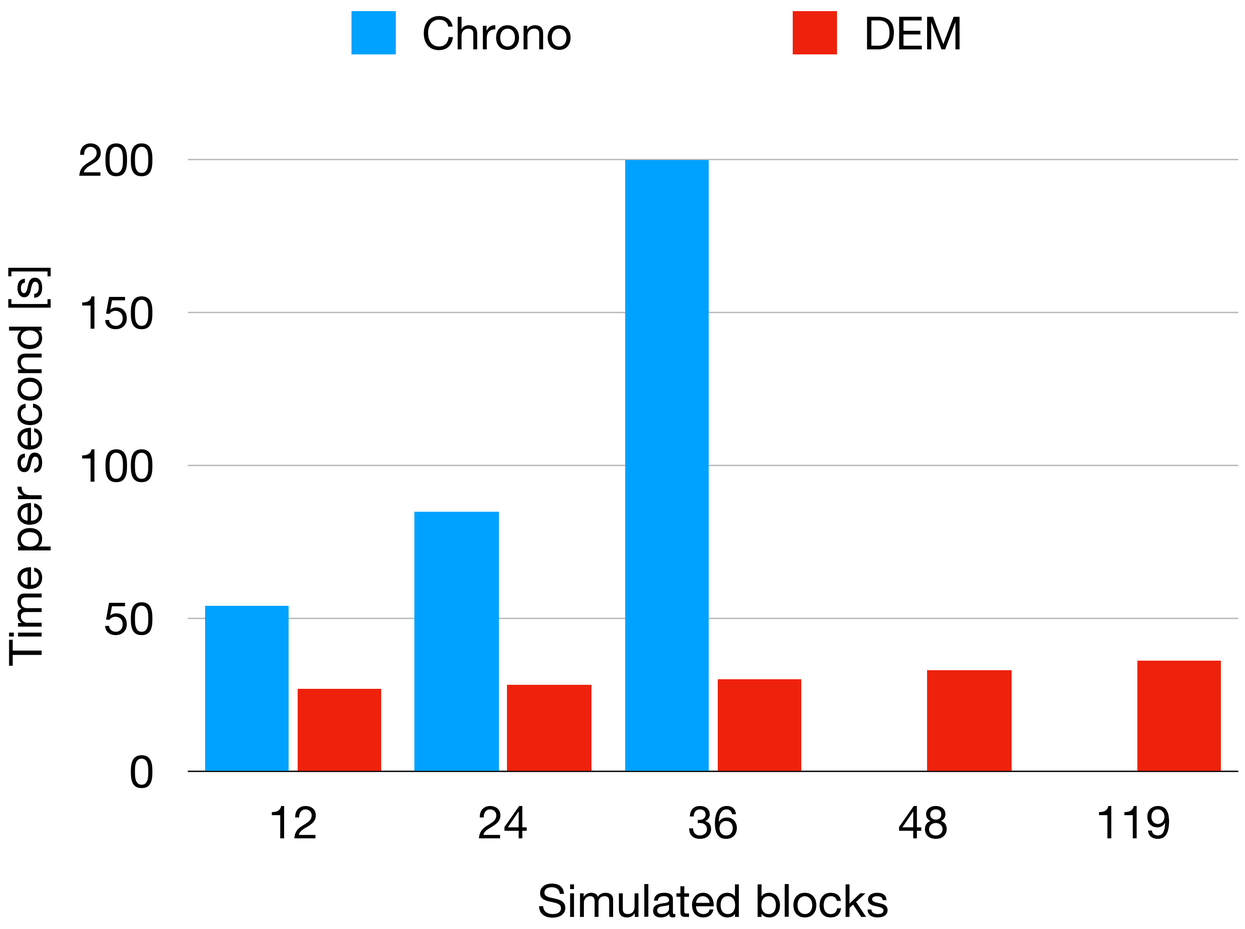
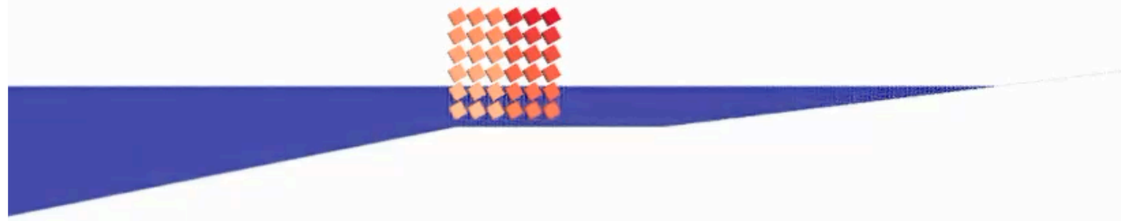
The figure charts the path followed by each single block in the two simulations.

Multi-scaling the simulation

Moving towards smaller domains





200k fluid particles

Further considerations

Further considerations

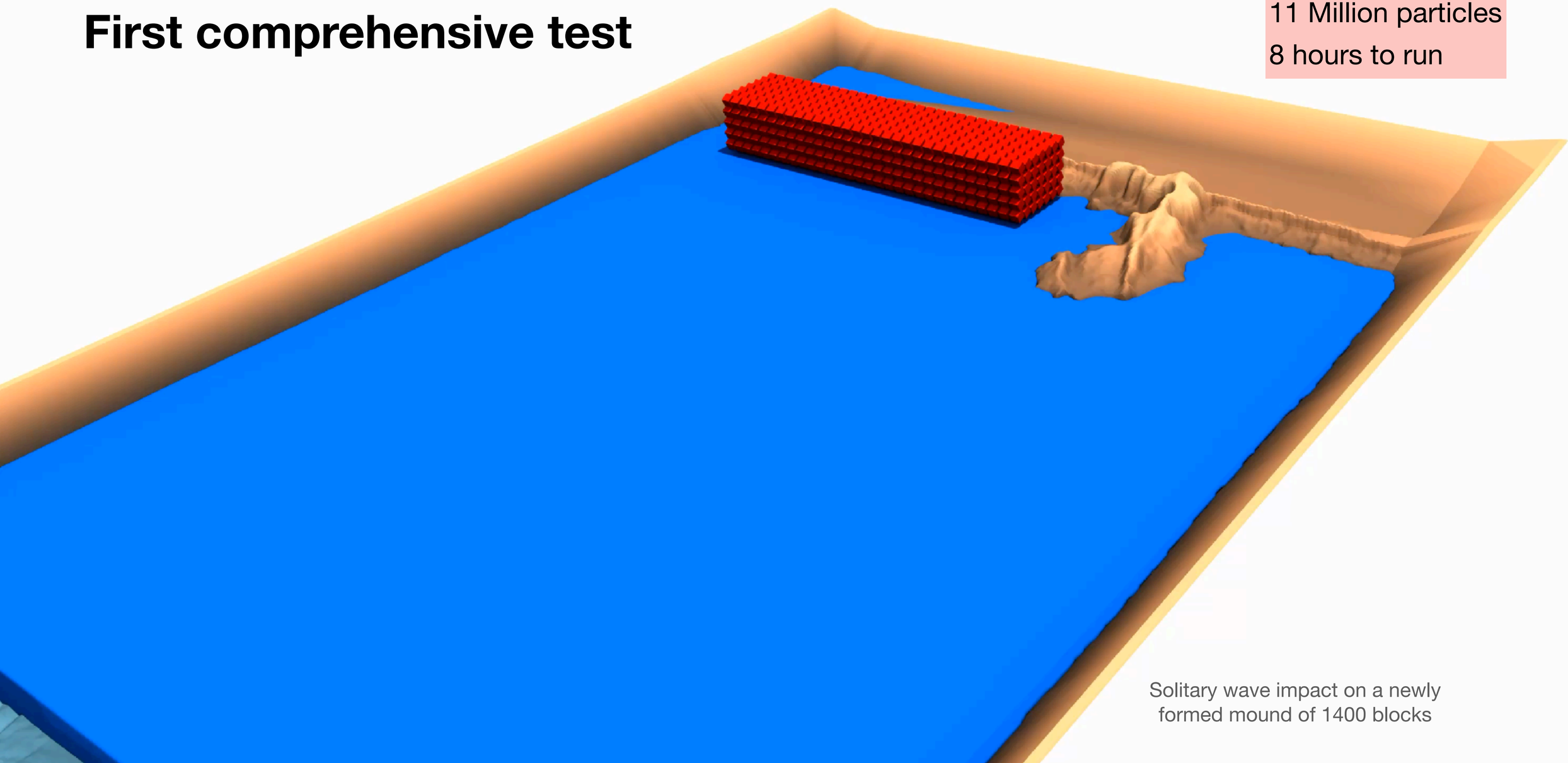
First comprehensive test

1400 blocks

dp=L/6

11 Million particles

8 hours to run

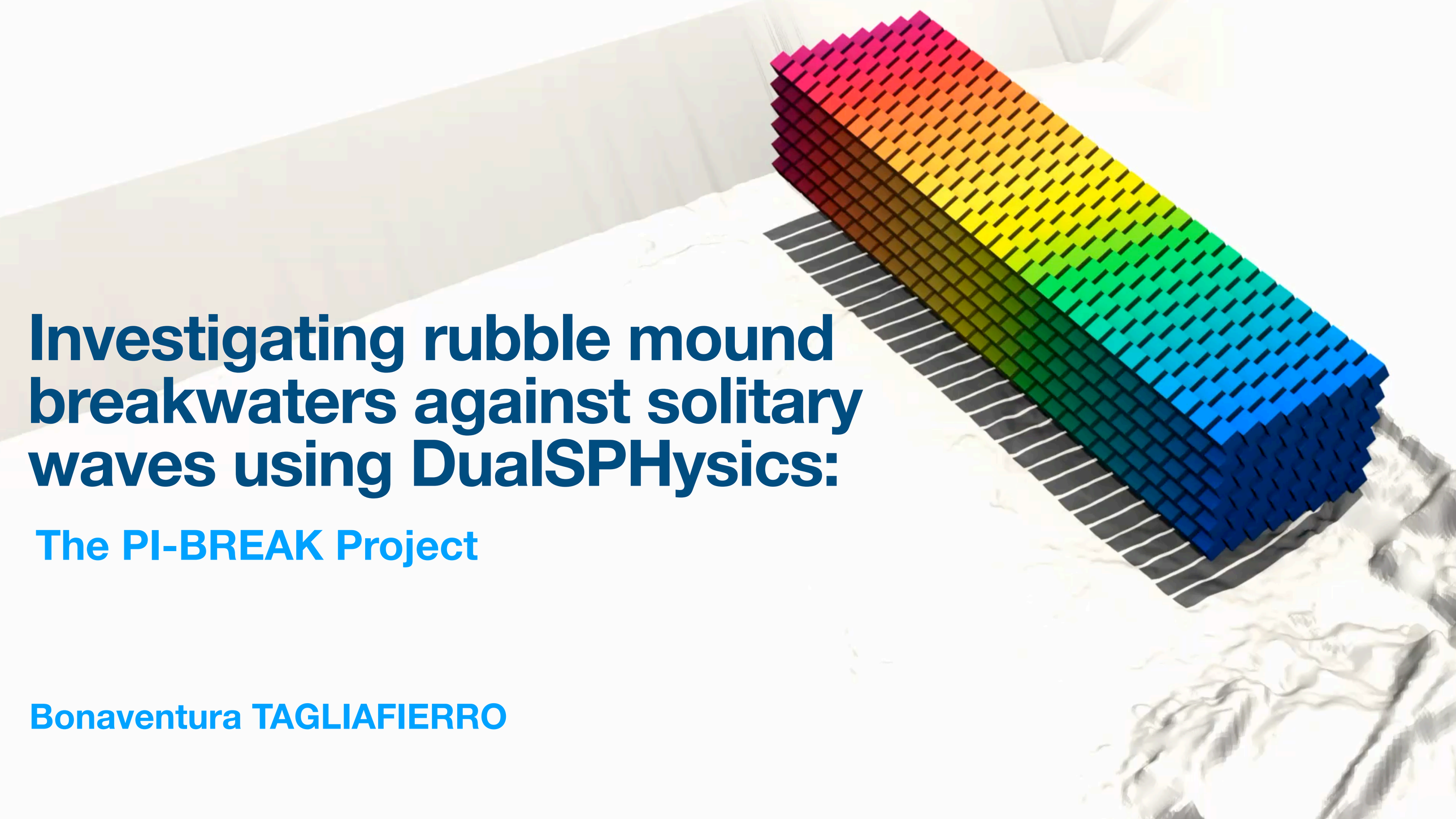


Solitary wave impact on a newly formed mound of 1400 blocks

Further considerations

Concluding remarks

- Fluid simulation for big coastal area (Multi-GPU)
- Targeting domain reduction doable for short events (Multi-scale)
- Enriching simulations with complex coastal structure comes with many options
- To be seen what works best for blocks (balance of resources)



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