



COUPLING BETWEEN DUALSPHYSICS AND SWASH MODELS AND LATEST APPLICATIONS TO COASTAL ENGINEERING PROBLEMS

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Numerical modelling: WHAT FOR?



Physical modelling



Flooding



Damage



3 basic concepts...

Which reality do we want to simulate?

Which are the coupling techniques we explored?

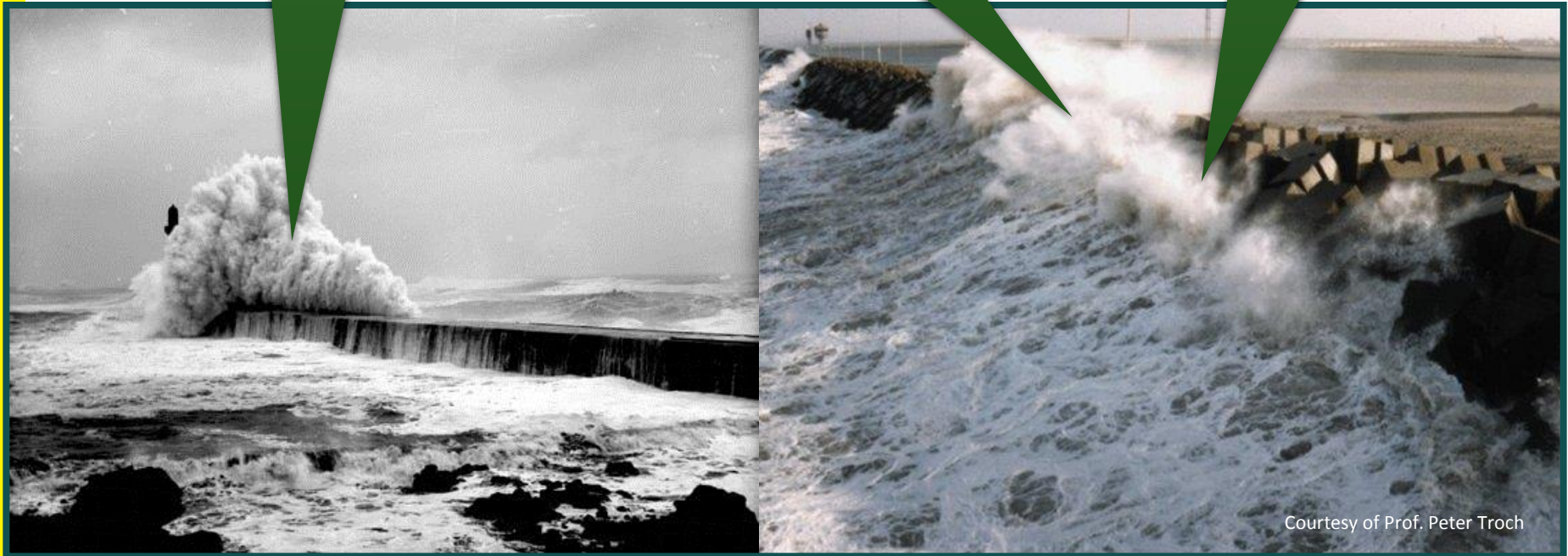
How efficient and accurate is the coupling?

We (I) bet on SPH: why?

Violent hydrodynamics

Non-linearity

**Wave-object and
Object-object
interactions**



Courtesy of Prof. Peter Troch



Flanders
State of the Art

Disadvantages of (WC)SPH



Accuracy

Noise in density and pressure field
(affecting wave propagation)

Boundary conditions (GRAND
CHALLENGE)

Convergence (GRAND
CHALLENGE)

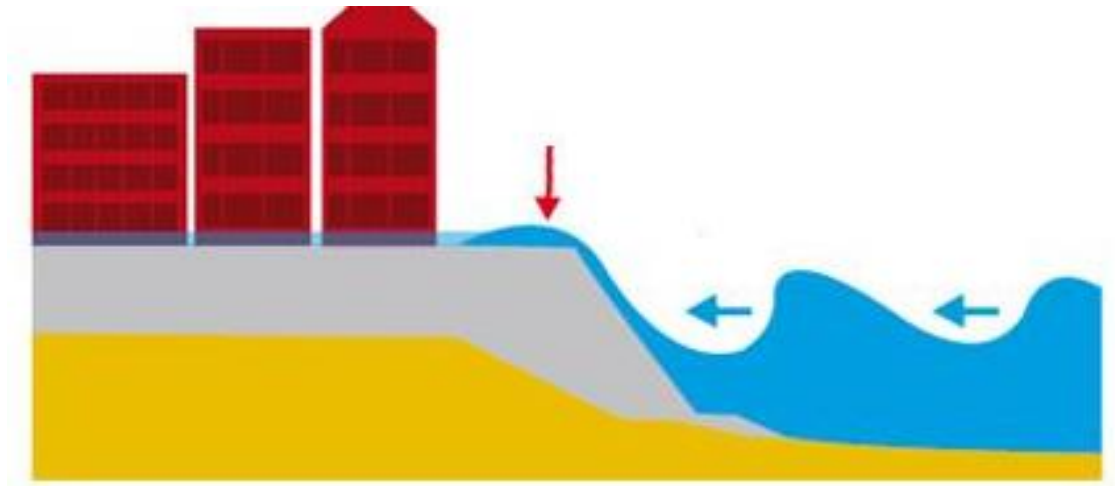
Computational cost

NS equations

Weakly Compressible Nature

Number of Neighbors

What do we aim at?



Accurate wave generation
Good wave transformation



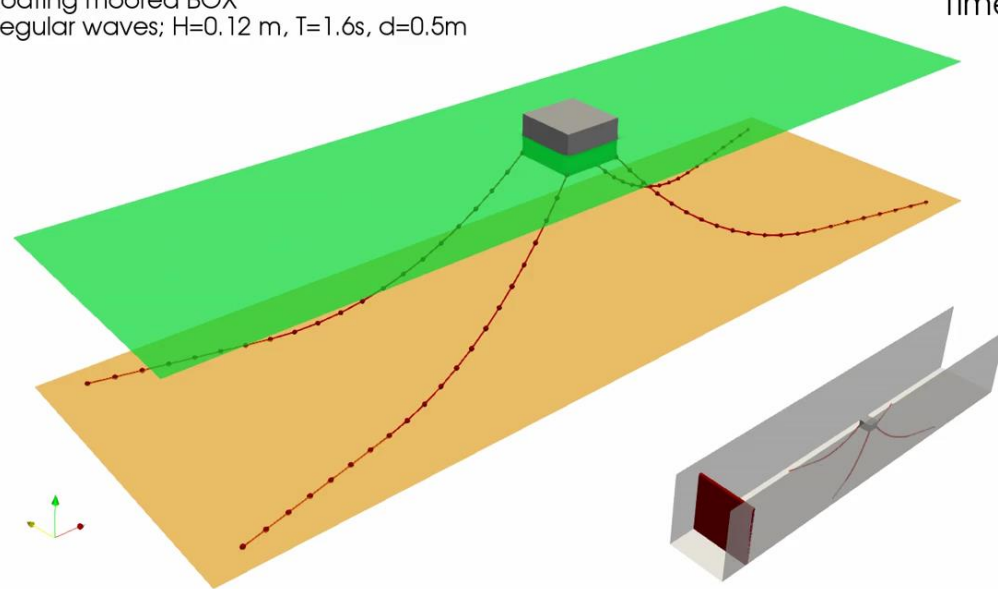
Reasonable computational cost
Accurate and detailed modelling
of wave-structure interaction



What do we aim at?

UGHENT:
 Floating moored BOX
 Regular waves; $H=0.12$ m, $T=1.6s$, $d=0.5m$

Time: 0.00 s



recently.... DualSPHysics
 (+ MoorDyn)

Esflowc

Efficiency and survivability of floating Oscillating Water Column Wave Energy Converters moored to the seabed

GHENT UNIVERSITY (COORDINATOR), BELGIUM

UNIVERSIDADE DE VIGO, SPAIN IST - UNIVERSIDADE DE LISBOA, PORTUGAL	THE UNIVERSITY OF MANCHESTER, UNITED KINGDOM UNIVERSITÀ DEGLI STUDI FIRENZE, ITALY
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Universidade de Vigo

TÉCNICO LISBOA

GHENT UNIVERSITY

MANCHESTER
The University of Manchester

UNIVERSITÀ DEGLI STUDI FIRENZE

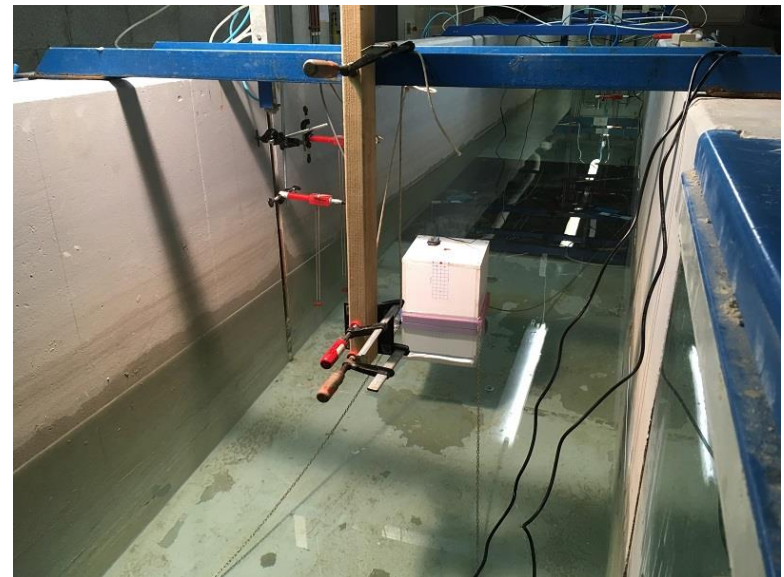
A MARINET2 TRANSNATIONAL ACCESS PROJECT (EU H2020 PROGRAMME UNDER GRANT AGREEMENT NO 731084)
 SUPPORTED ALSO BY THE RESEARCH FOUNDATION FLANDERS (FWO), BELGIUM - FWO OPR.2.0 - FWO RESEARCH PROJECT NO. 3G029T14

INFRASTRUCTURES: LABIMA-UNIFI, WAVE-CURRENT FLUME (WCF) AND COASTAL ENGINEERING RESEARCH GROUP OF GHENT UNIVERSITY, LARGE WAVE FLUME

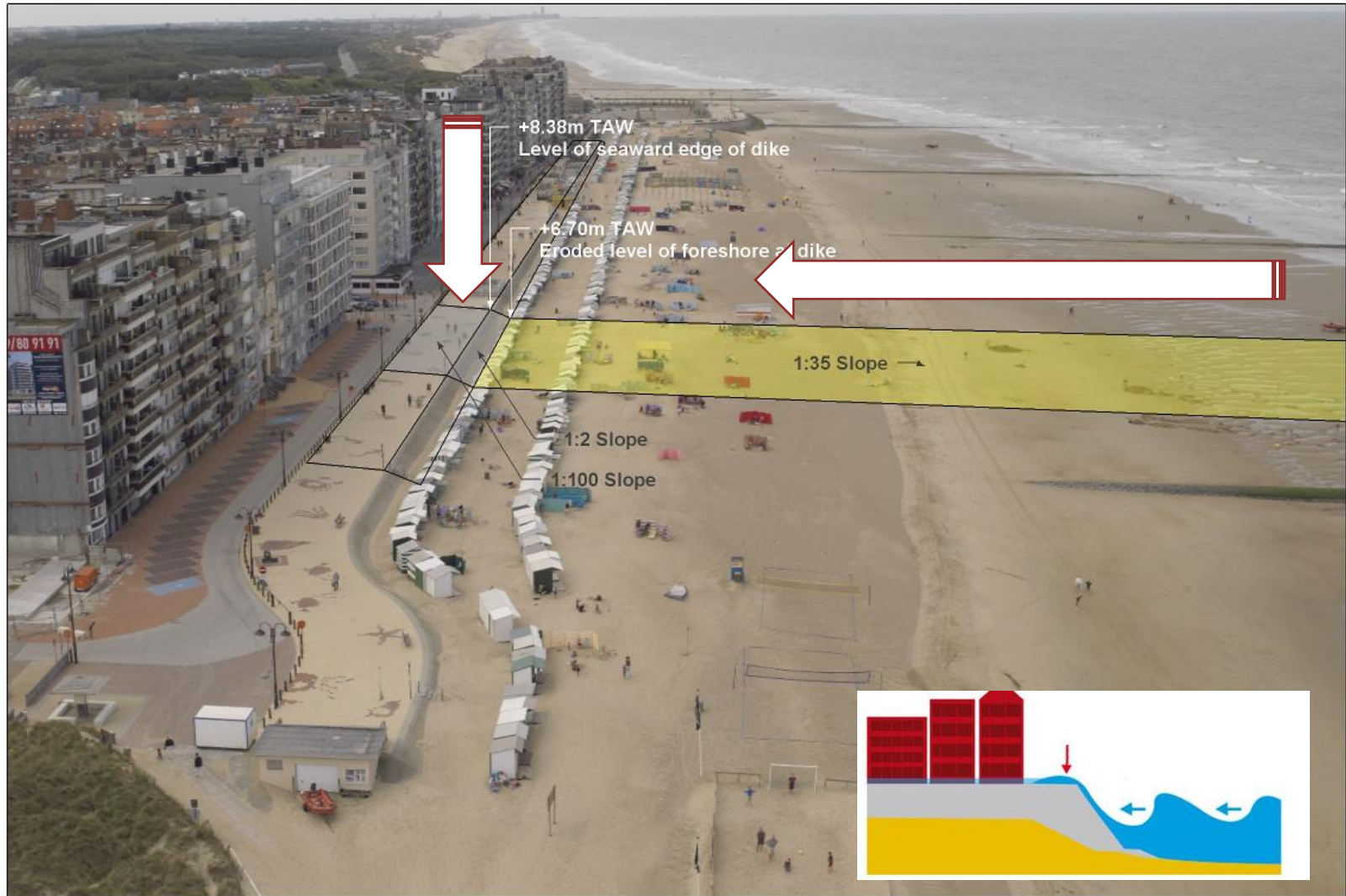
Fonds Wetenschappelijk Onderzoek Vlaanderen
Opening new horizons

H2020

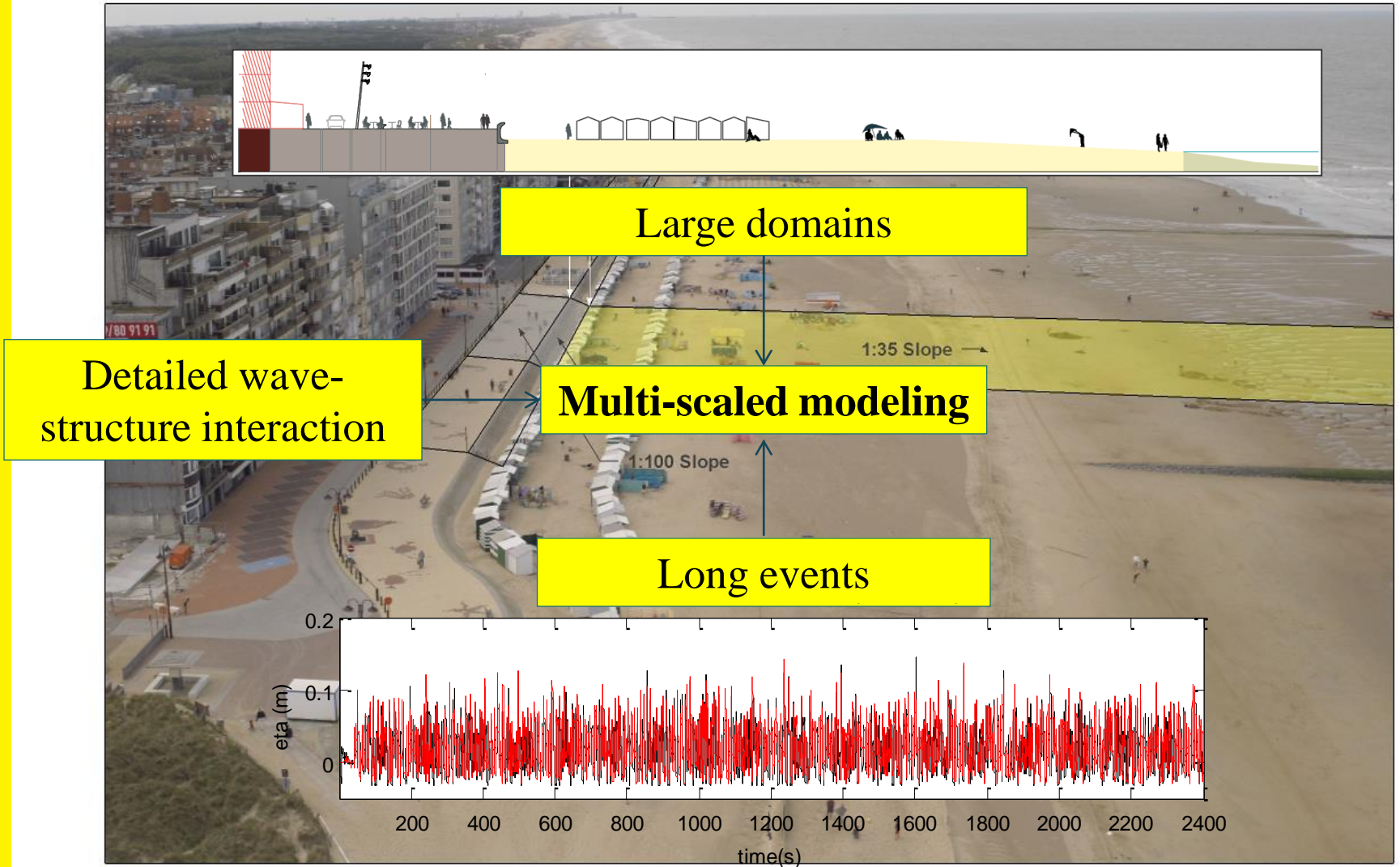
MarINET2
Public Transnational Infrastructure Network for Emerging Energy Technologies



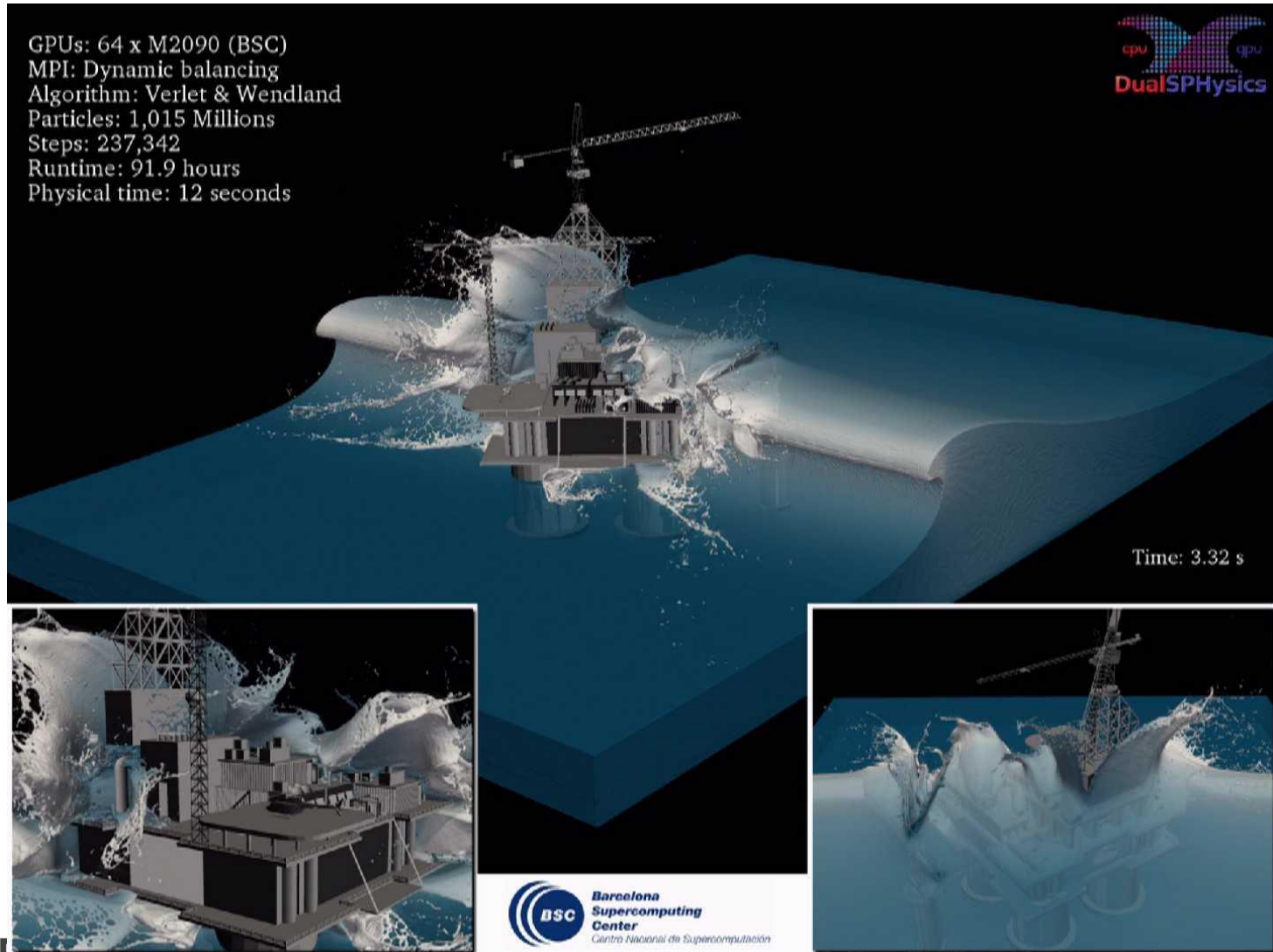
What do we aim at?



What do we aim at?

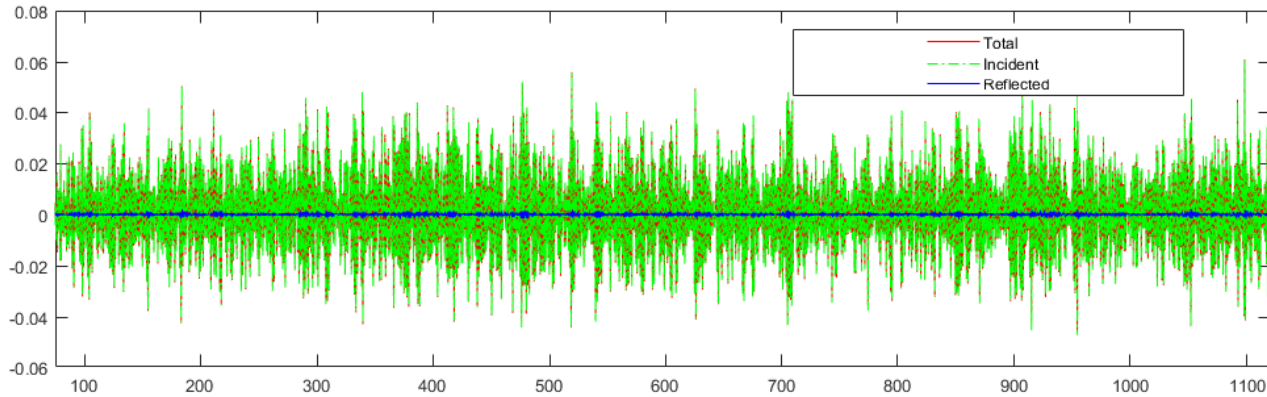


Large domains: DONE!!

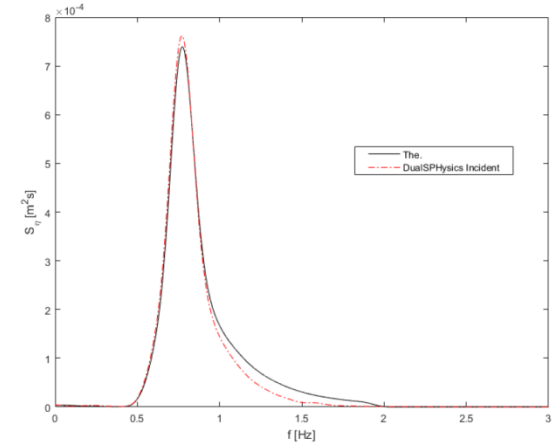
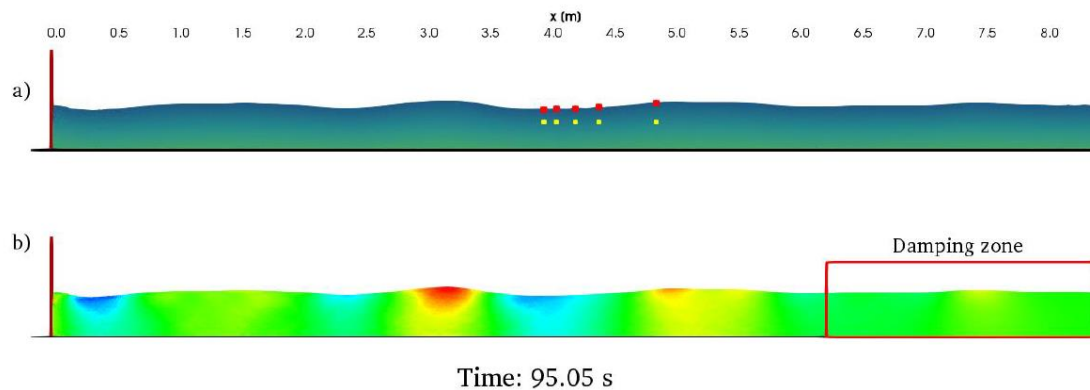


Flinders
State of the Art

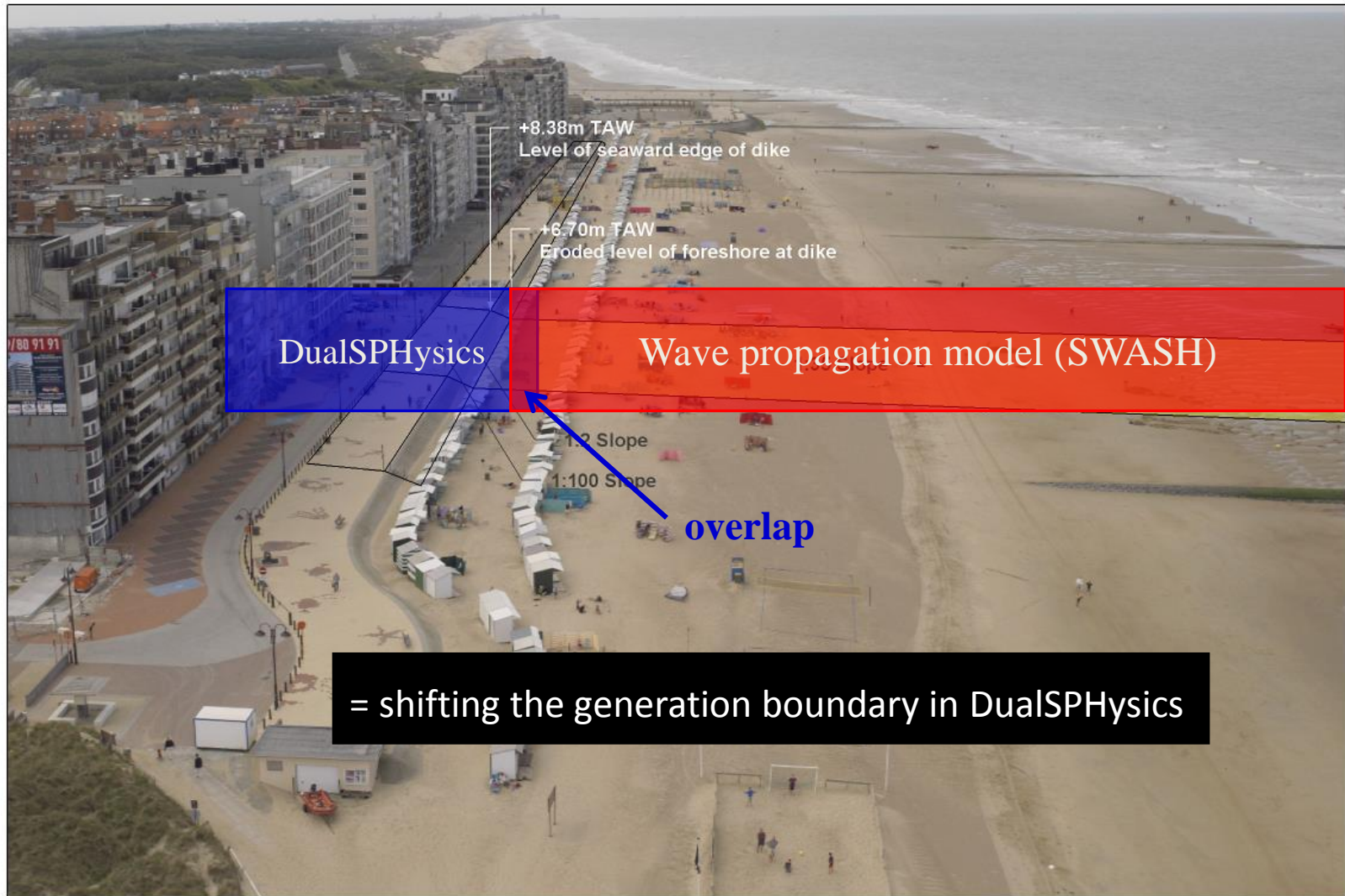
Long events: 1000 waves DONE!!



23.6h runtime
(on Tesla K20c)
for 82,541 fluid
particles

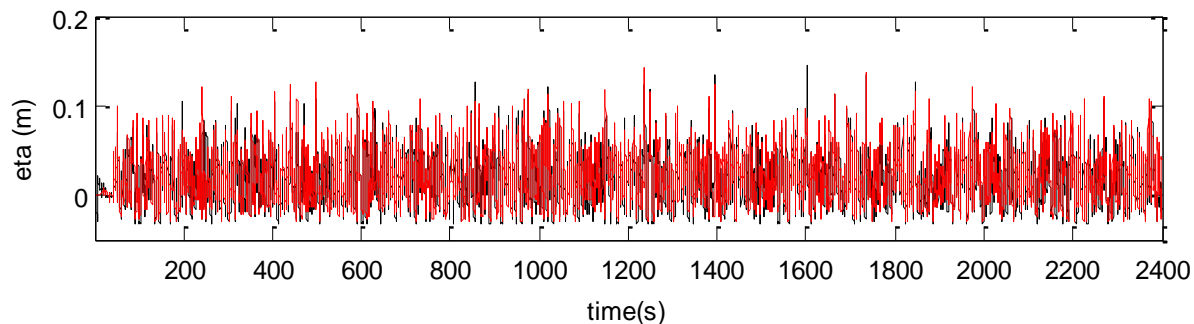


COUPLING basic principle



COUPLING with SWASH

- ❑ **SWASH**=Simulating WAve till Shore
- ❑ **NLSW** equation model
- ❑ **Time domain model** for simulating non-hydrostatic, free-surface and rotational flow.
- ❑ It simulates accurately **surface wave and velocity field** from deep water.
- ❑ **Not suitable to deal with abrupt changes of shape** of the coastal structures.



COUPLING with SWASH

Wave generation and propagation with SPH to study wave-structure interaction

- Accurate in terms of free surface elevation and orbital velocities
- Efficient (domain can be smaller)
- More applicability (calculation time window can be longer)

(1) Altomare et al. (2015)

Coupling with SWASH using moving boundaries



(2) Usui et al. (2017)

Relaxation Zone technique



(3) Tafuni et al. (2017)

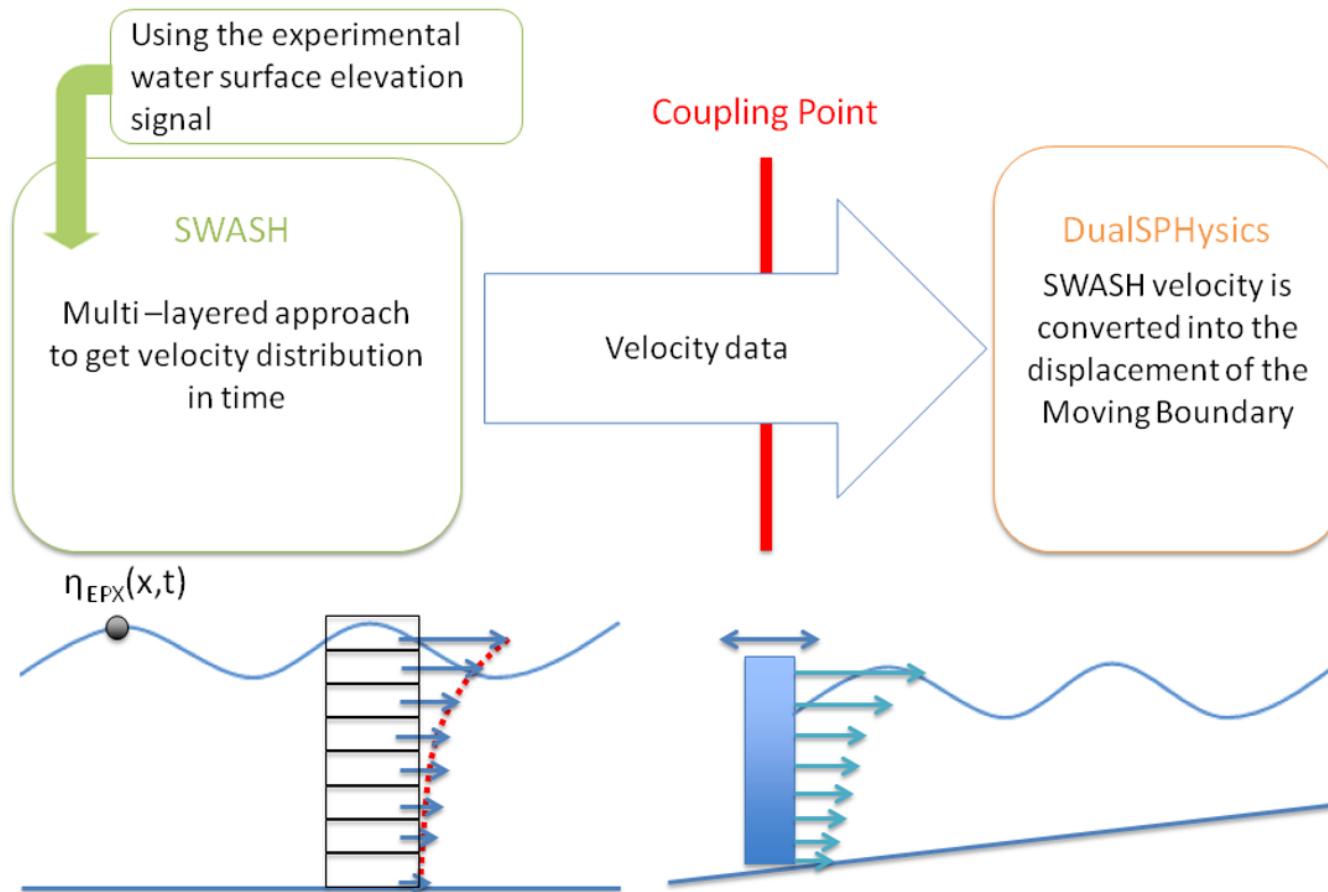
Open boundaries: inlet & outlet conditions

offshore + breaking/surf zone?



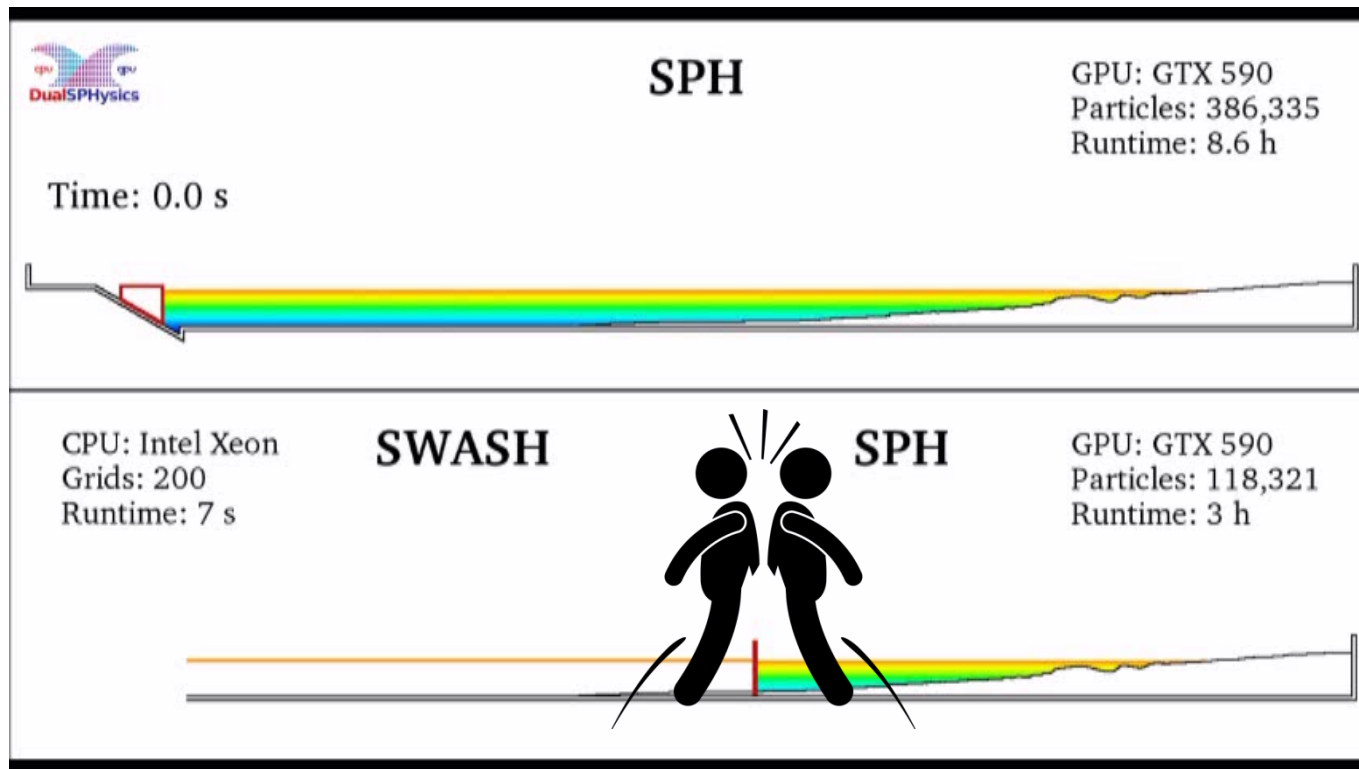
COUPLING with SWASH (1)

MB (Moving boundary): Altomare et al (2015)



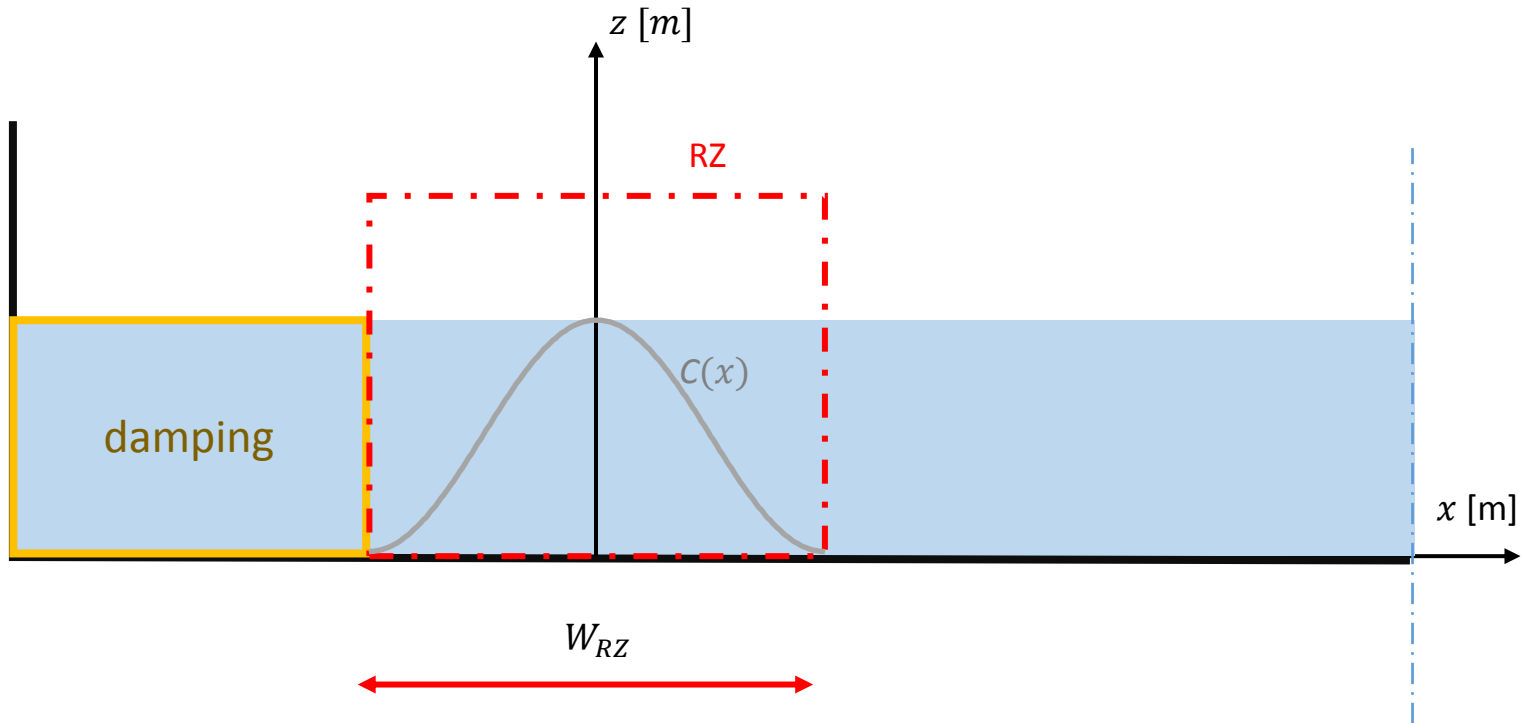
COUPLING with SWASH (1)

MB (Moving boundary): Altomare et al (2015)



COUPLING with SWASH (2)

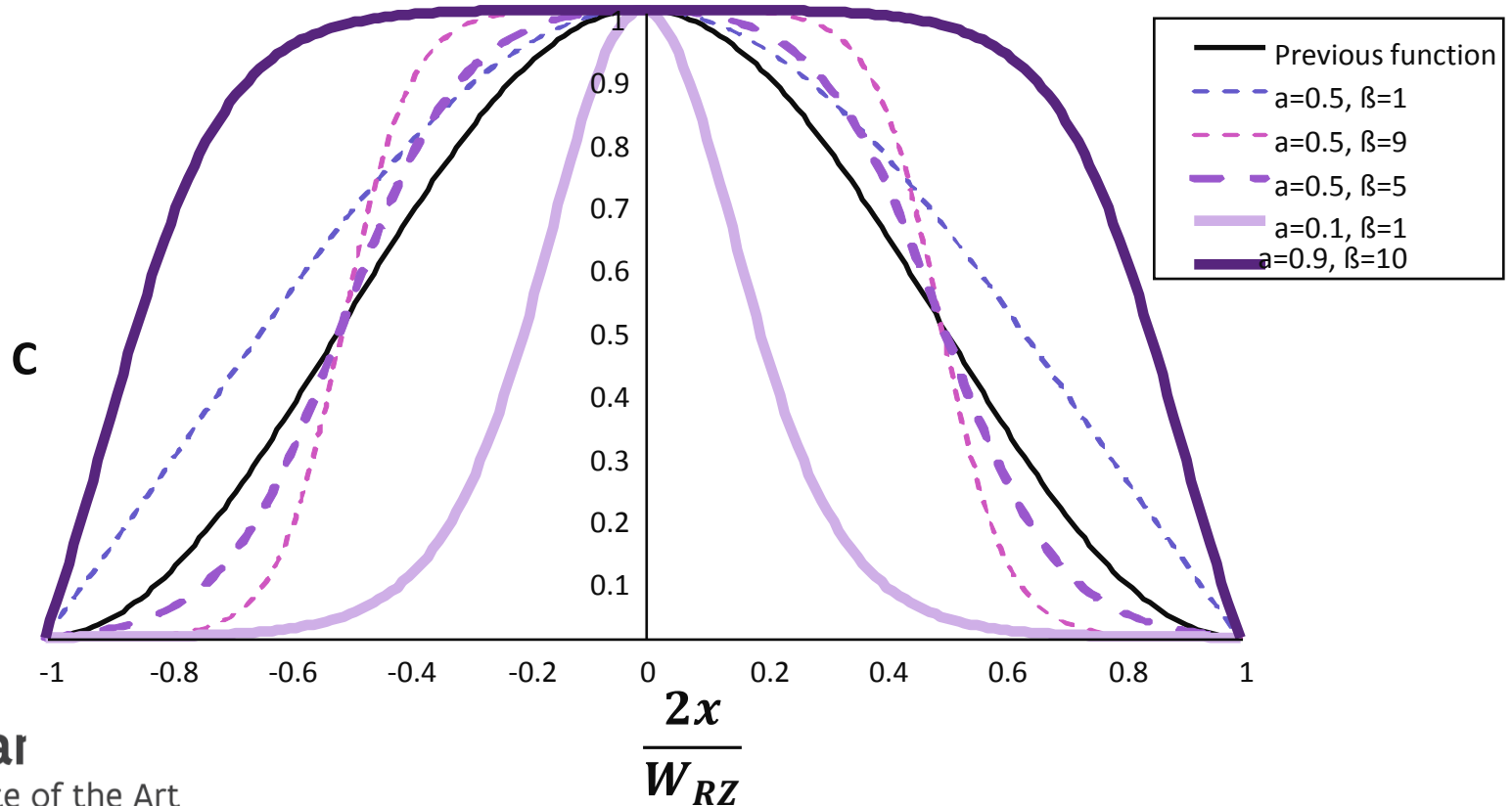
Relaxation zone (RZ) + damping



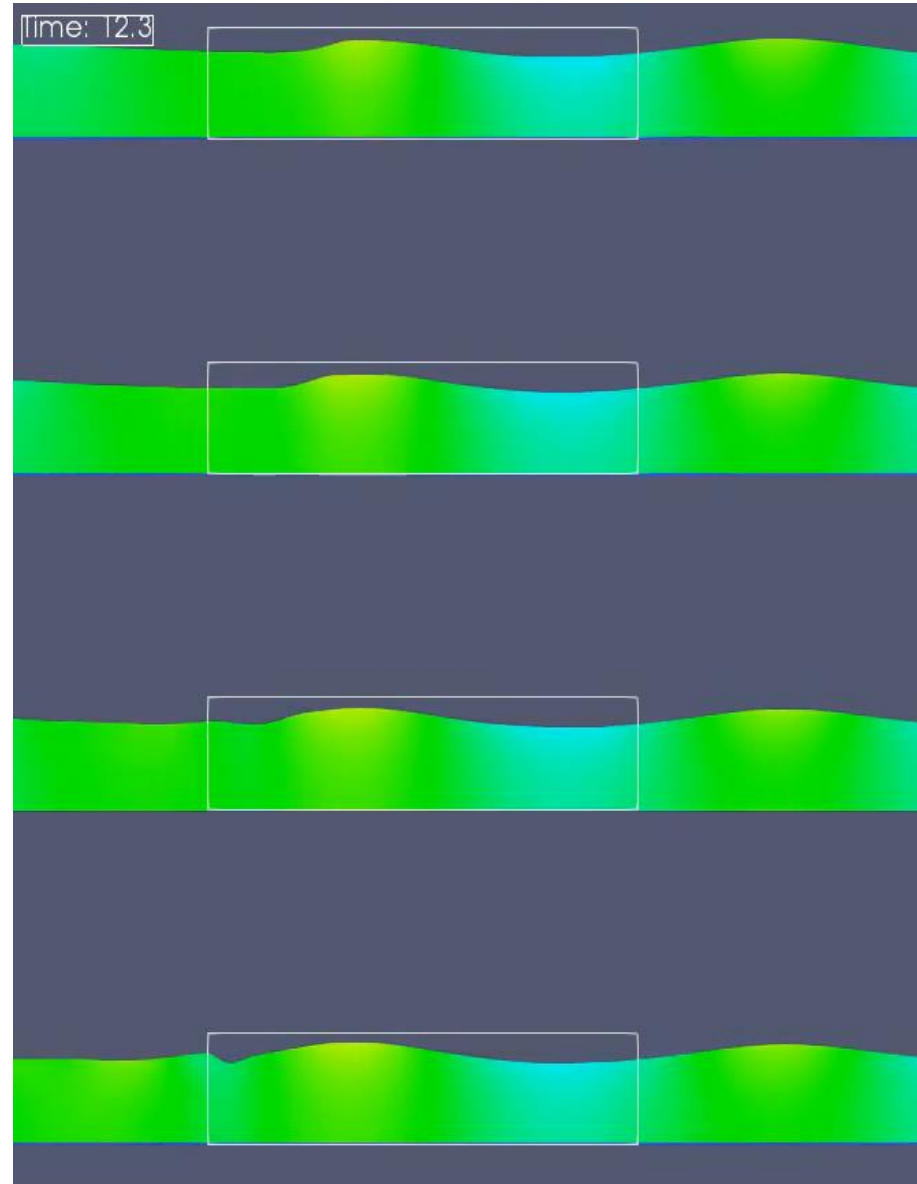
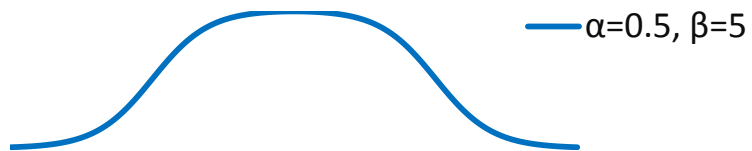
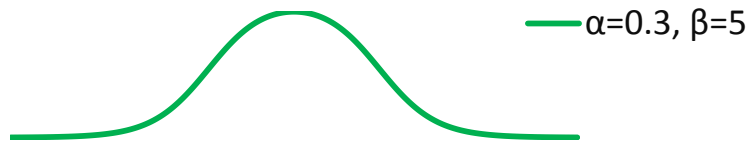
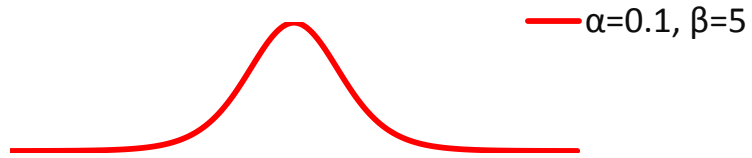
$$\bar{v}(x, z, t)_{RZ} = C(x)\bar{v}_{theory} + (1 - C(x))\bar{v}_{SPH}$$

COUPLING with SWASH (2)

$$C(x, \alpha, \beta) = \frac{\left\{ \tanh\left(\left(\frac{2x}{W_{RZ}} + \alpha\right)\beta\right) - \tanh\left(\left(\frac{2x}{W_{RZ}} - \alpha\right)\beta\right) \right\} - \left\{ \tanh((1 + \alpha)\beta) - \tanh((1 - \alpha)\beta) \right\}}{\left\{ \tanh(\alpha\beta) - \tanh(-\alpha\beta) \right\} - \left\{ \tanh((1 + \alpha)\beta) - \tanh((1 - \alpha)\beta) \right\}}$$



Different C functions

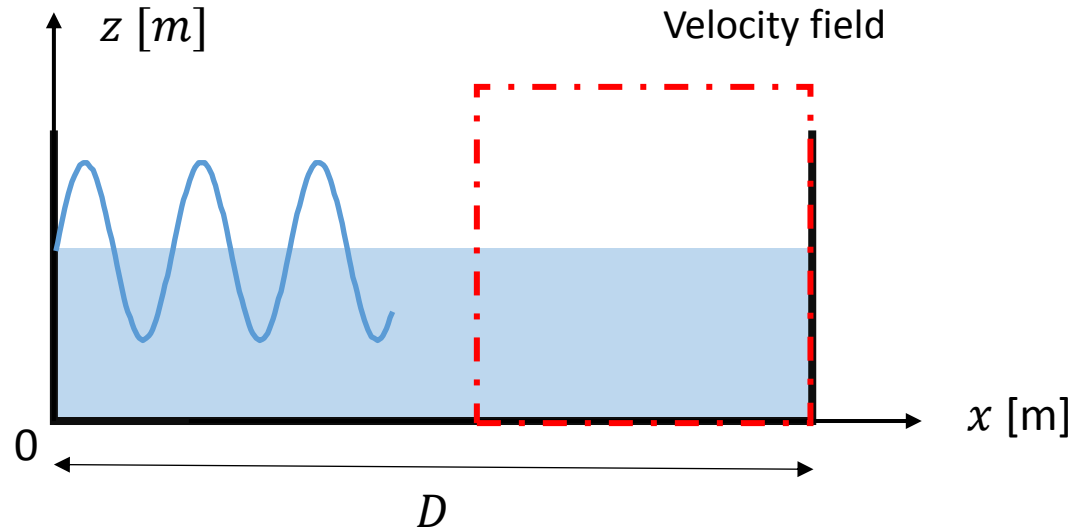


RZ-SWASH

SWASH model

Input=H,T,d

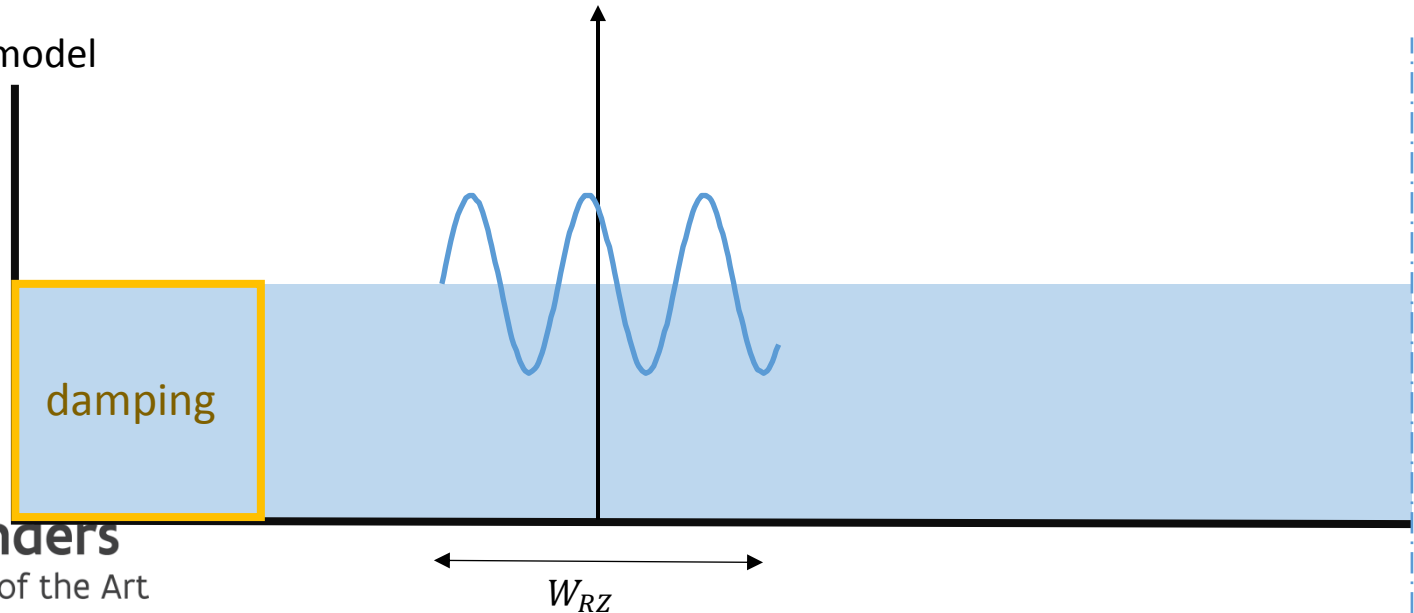
Run



SPH model

Input=SWASH model

Run



A CASE OF STUDY

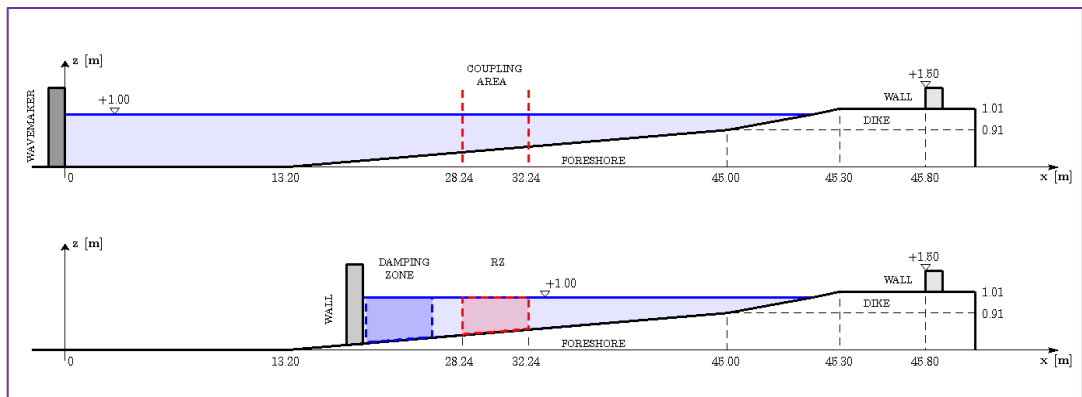
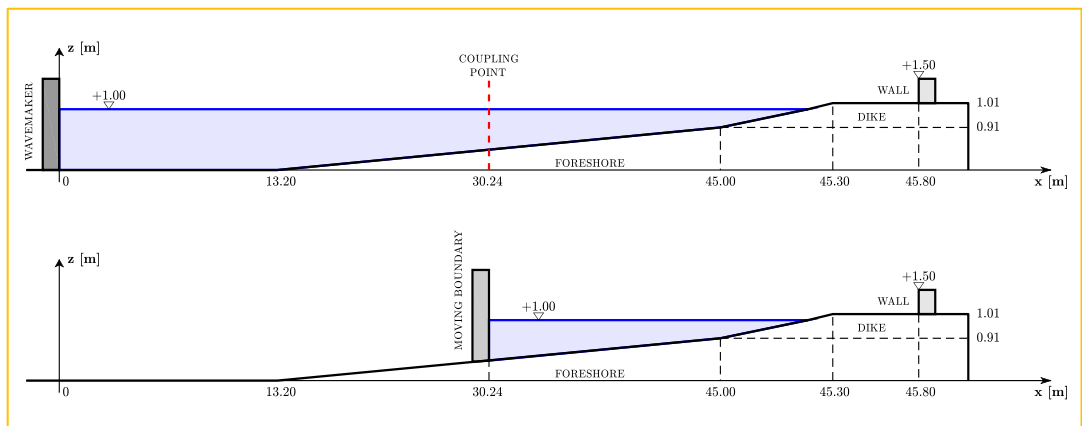
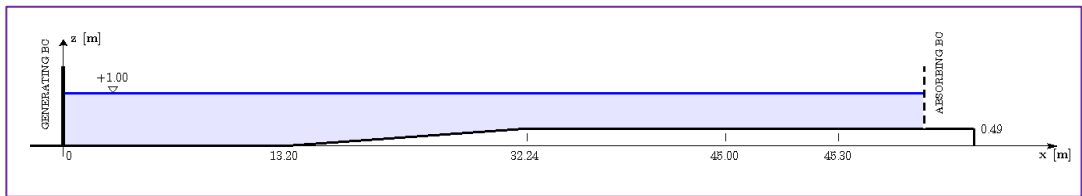
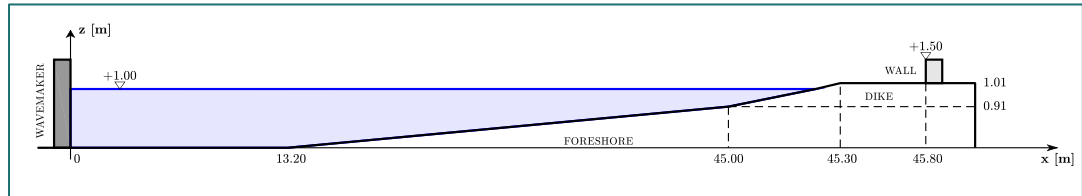
DualSPHysics stand-alone

SWASH

MB (Altomare et al., 2015)

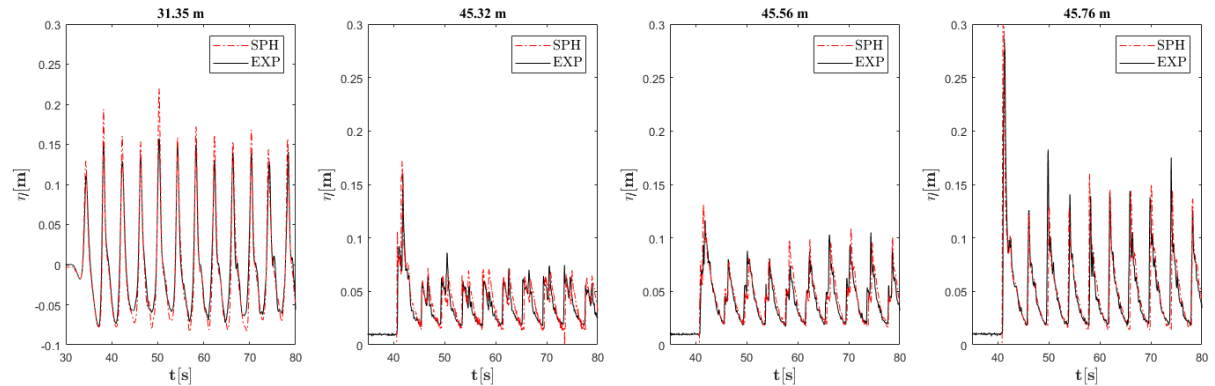
Relaxation Zone

Wave overtopping of sea dikes with very shallow foreshores

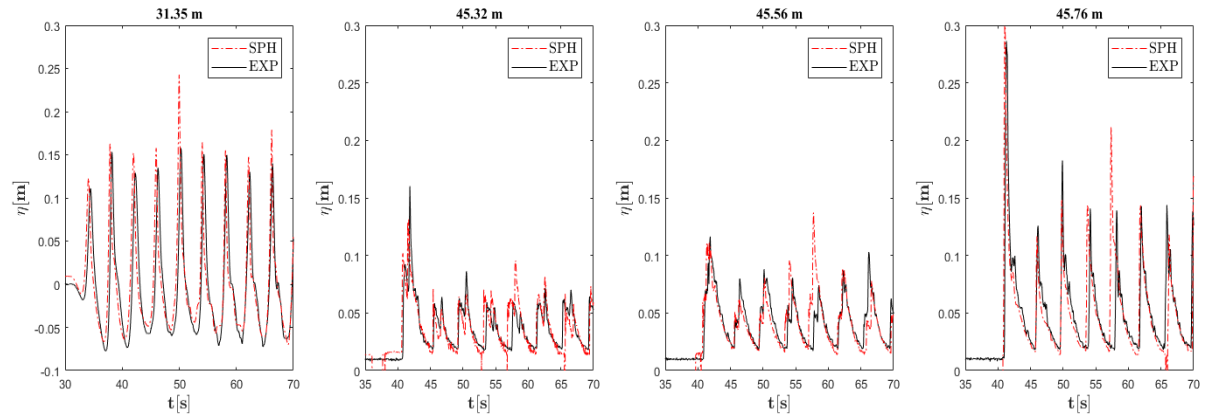


A CASE OF STUDY

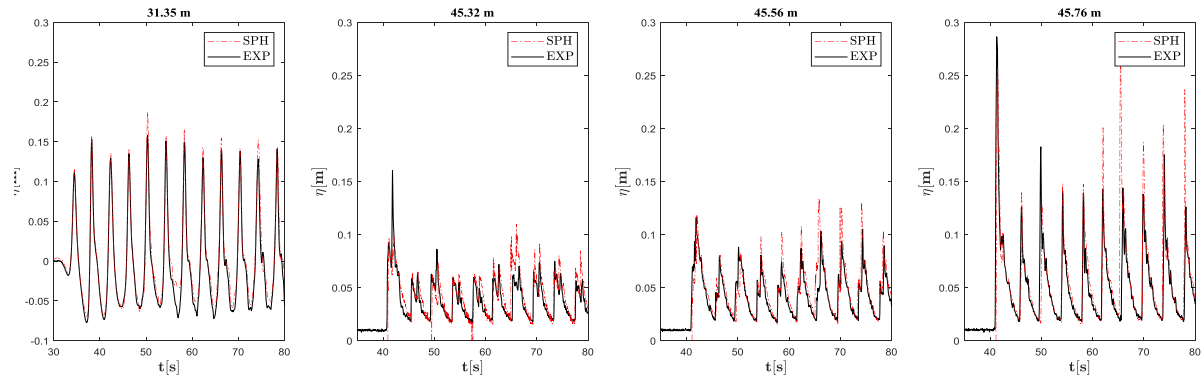
DualSPHysics stand-alone



MB (Altomare et al., 2015)

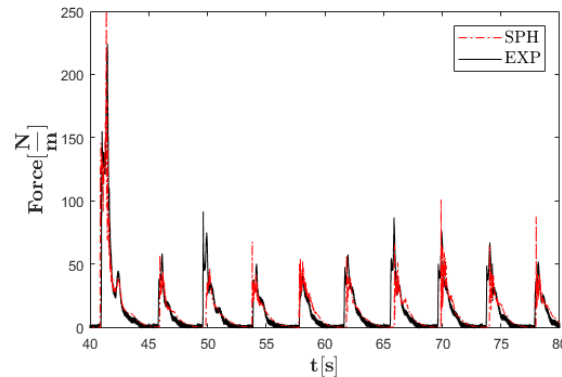


Relaxation Zone

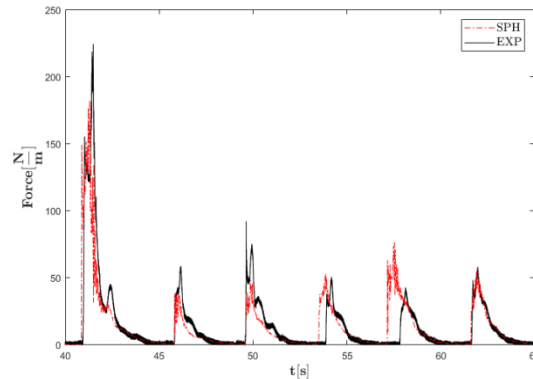


A CASE OF STUDY

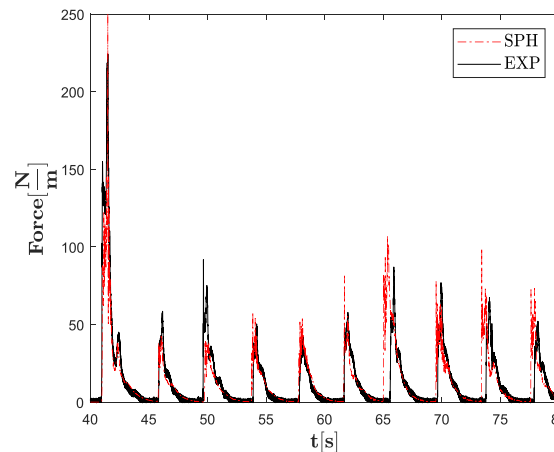
DualSPHysics stand-alone



MB (Altomare et al., 2015)



Relaxation Zone



GeForceGTX Titan X

$n_{particle} = 3,389,266$
 $Runtime = 95.62h$

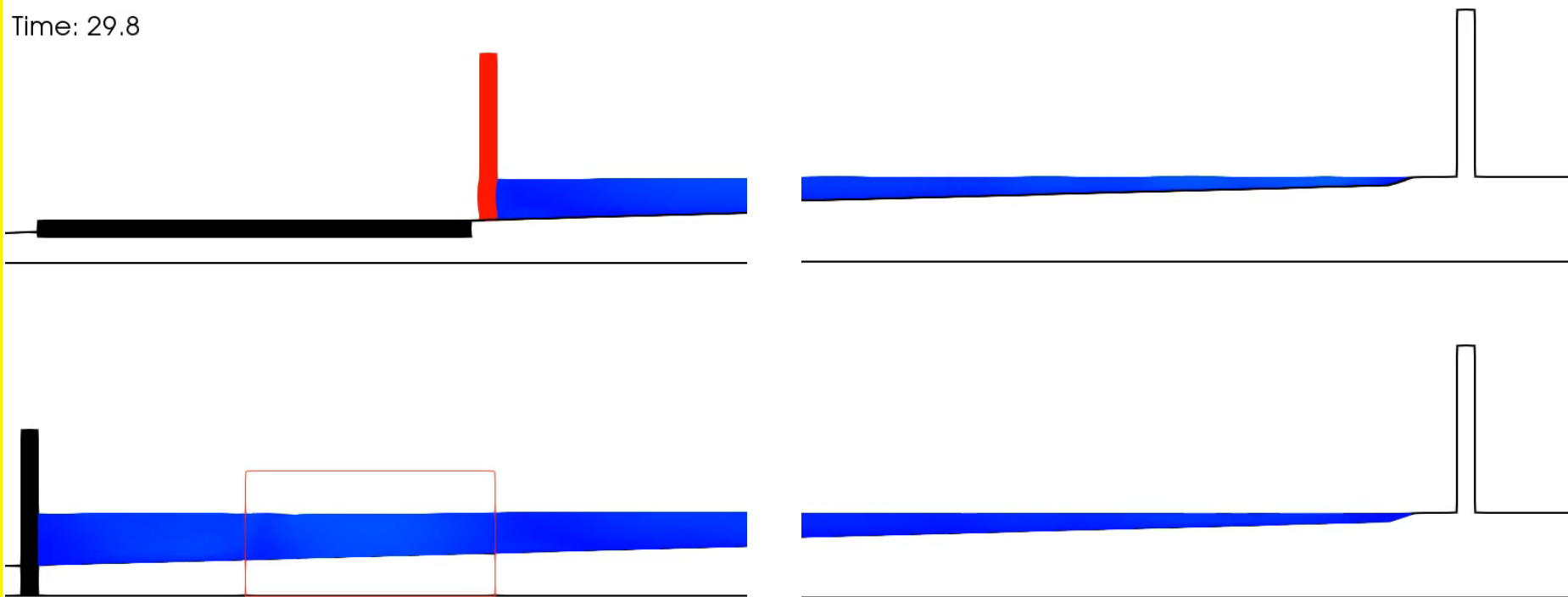
$n_{particle} = 494,388$
 $x_{coupling} = 31.25m$
 $Runtime = 9.95 h$

$n_{particle} = 1,269,820$
 $x_{coupling} = 24.00 m$
 $Runtime = 22.65 h$

A CASE OF STUDY

MB vs RZ-SWASH

Time: 29.8

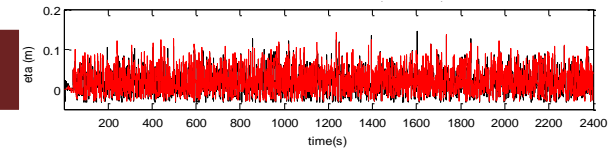


Conclusions

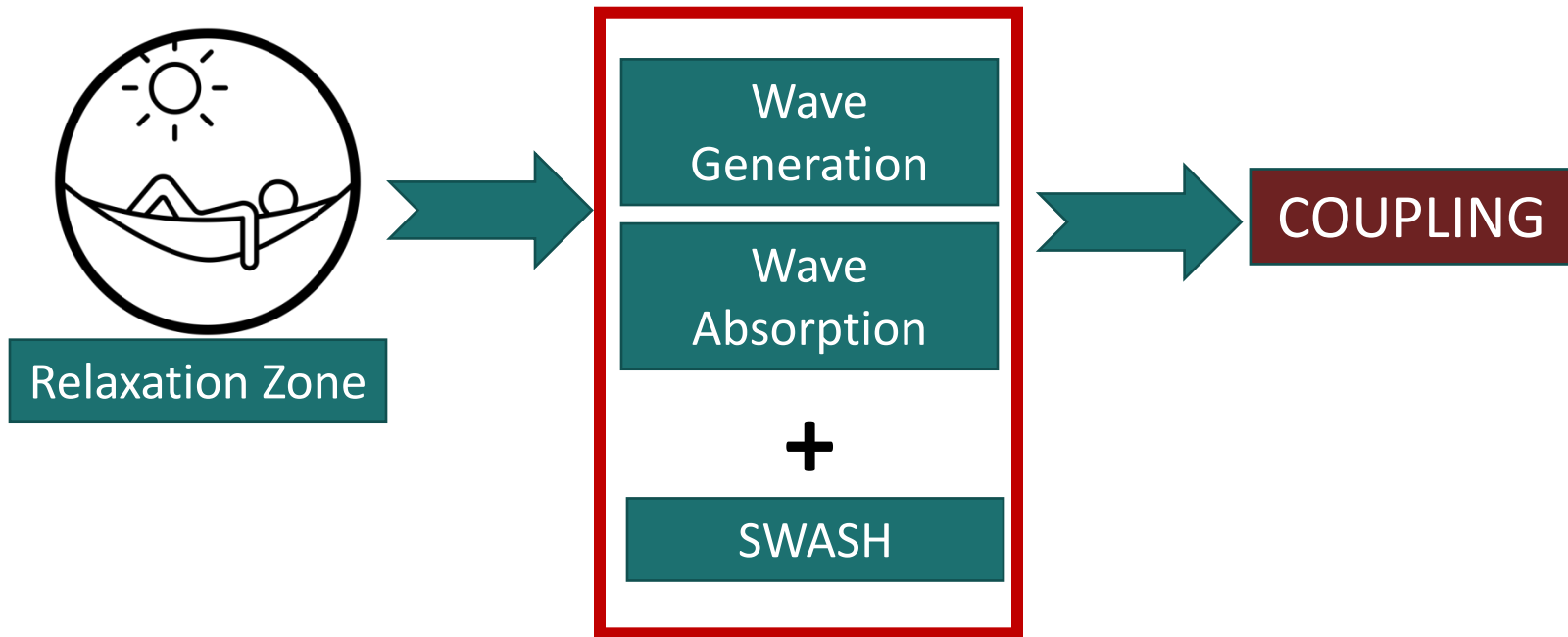


Remind our target

- Multi scale
- Multi phase
- Long duration
- Large domain



Conclusions



Speed up



Accuracy

To be continued...