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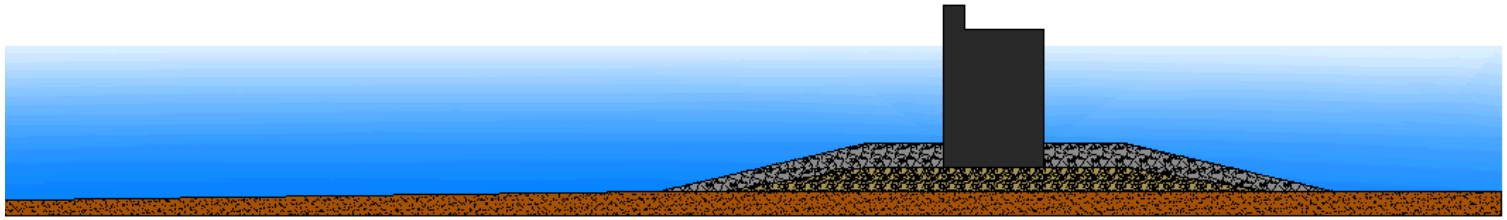
Example 3

Irregular waves interaction with a vertical breakwater



Maria Maza (mazame@unican.es)

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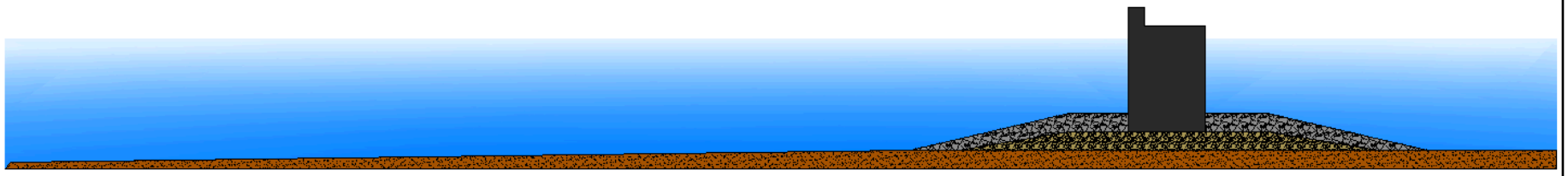
Study of a Vertical Breakwater

A vertical breakwater is studied in this example. The breakwater is composed by a vertical caisson disposed over a rubble mound.

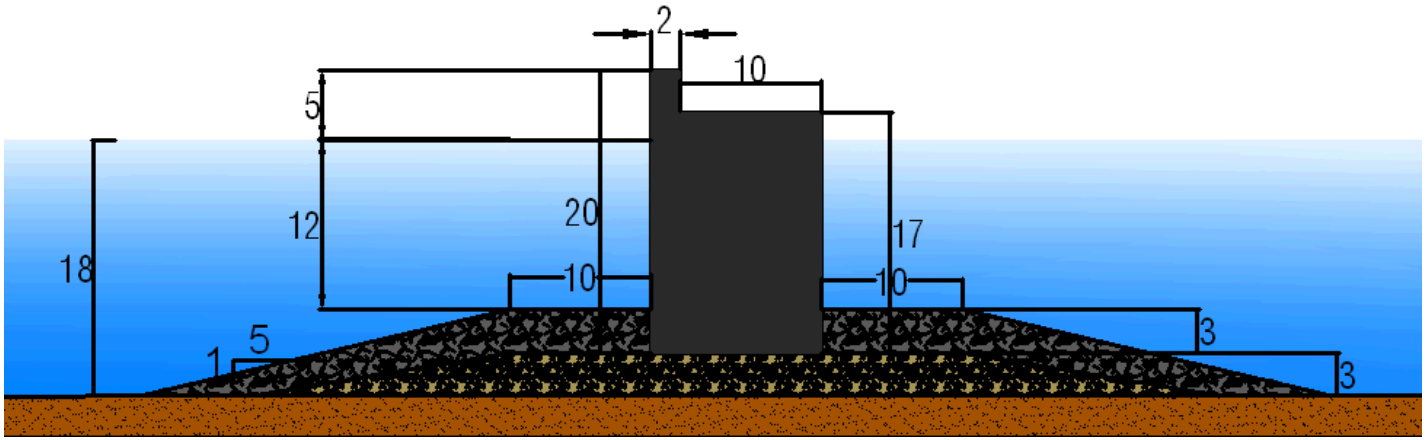
The bathymetry has a uniform 1:100 slope from the wave generation region to the toe of the structure. The seabed is considered horizontal at the breakwater location

The water depth in front of the breakwater is 18m. The submerged berm crest is 12 m deep. The vertical breakwater freeboard is 5 m. The rubble-mound slopes are 5H:1V.



Study of a Vertical Breakwater

The foundation is built by an outer layer made of 5 t quarry stones. The inner layer is formed by quarry material of 0.3 m of nominal diameter.



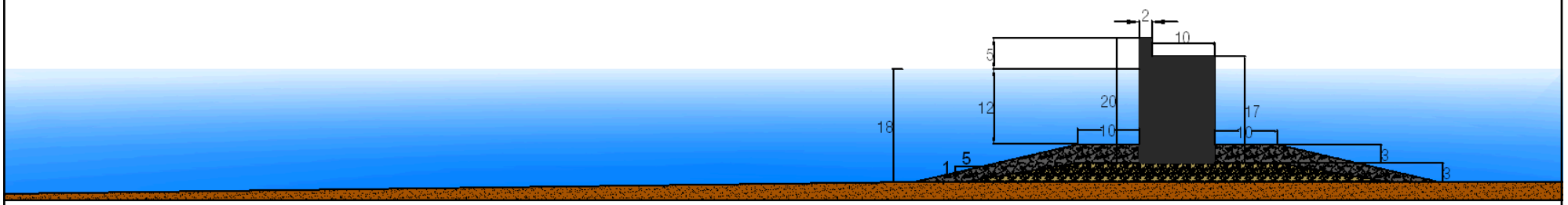
The purpose of this example is to study the interaction between irregular waves and a vertical breakwater.

The breakwater is tested considering **irregular waves** with a significant wave height equal to **9m** and a peak wave period of **12s**. Wave energy is distributed following a **Jonswap**-type spectrum with a peak enhancemnt factor of **3.3**.

Study of a Vertical Breakwater

IH2-VOF model is used to obtain the free surface, horizontal and vertical velocities, pressure and turbulence in the entire domain. Maximum pressure and forces in the structure are calculated. Furthermore, energy spectra and free surface time series in some desired locations are obtained.

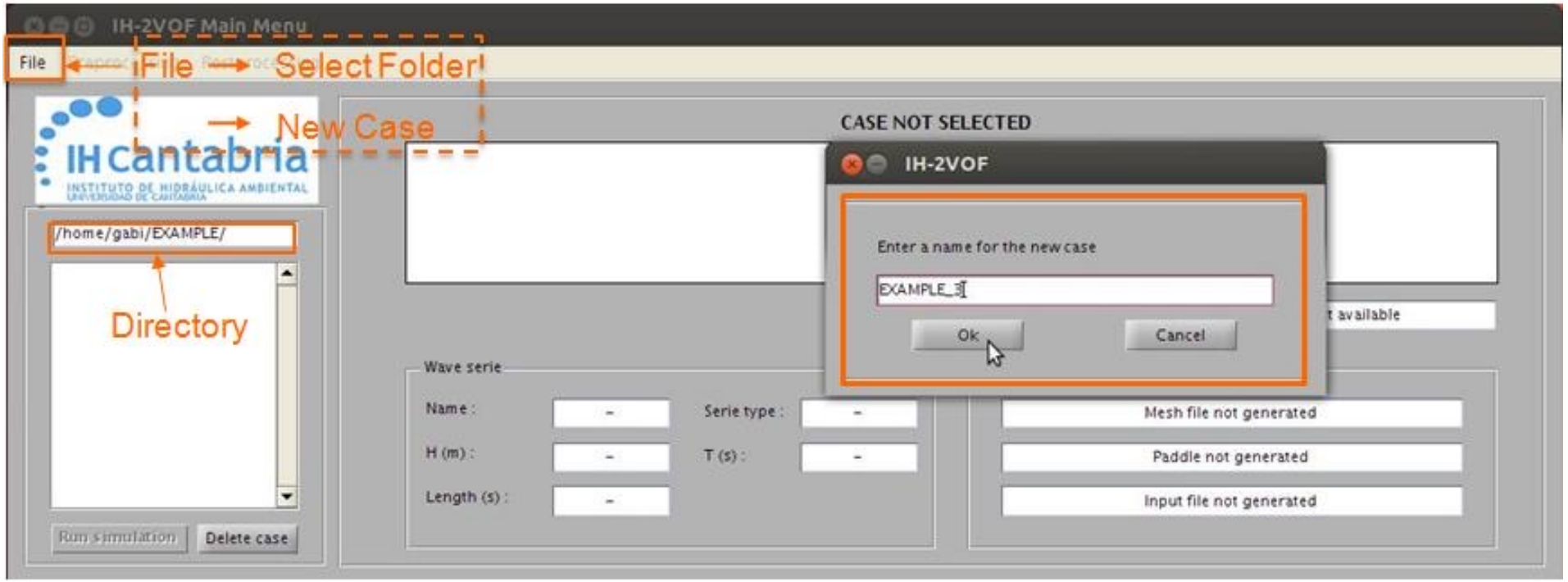
- **Objectives:**
  - Wave conditions analysis: time series, wave spectra
  - Overtopping
  - Pressure: stability analysis, forces in the caisson



CREATE NEW CASE

- Select directory, Select Folder

- Create New Case



STEPS

---------- **PREPROCESSING**----------

-MESH GENERATION

-SECTION 1: “IMPORT GEOMETRY/GENERATE MESH FILE”

-SECTION 2: “GENERATE/IMPORT WAVE CONDITIONS”

-SECTION 3: “GENERATE PADDLE”

-SECTION 4: “GENERATE INPUT FILE”

---------- **POSTPROCESSING**----------

-WAVE GAUGES

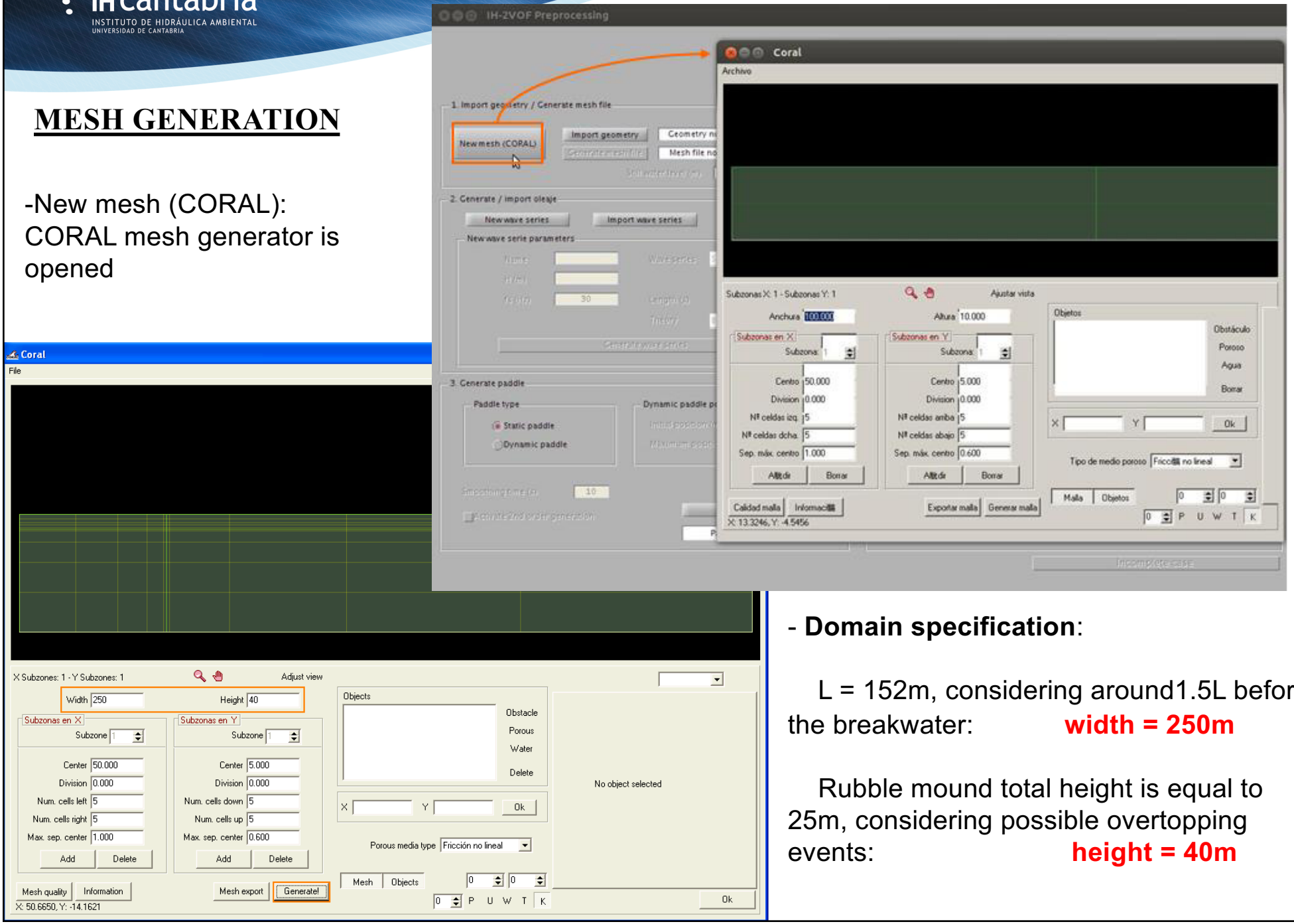
-OVERTOPPING

-PRESSURE

-DRAWFAST

MESH GENERATION

-New mesh (CORAL): CORAL mesh generator is opened



- **Domain specification**:

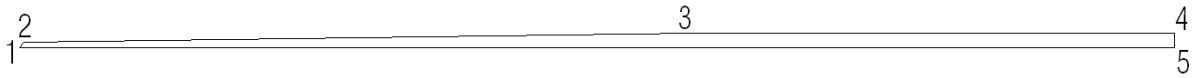
L = 152m, considering around1.5L before the breakwater: **width = 250m**

Rubble mound total height is equal to 25m, considering possible overtopping events: **height = 40m**

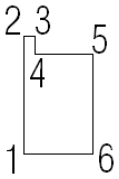
MESH GENERATION: Defining the elements

Introduce **obstacles**:

-Bathymetry →



-Crown wall →

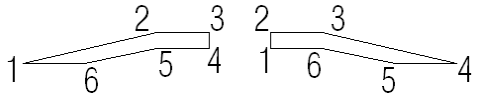


Element	Vertices	X Coordinate	Y Coordinate
Bathymetry	1	-1	-1
	2	-0.8	0
	3	146	2
	4	251	2
	5	251	-1
Caisson	1	181.5	6
	2	181.5	26
	3	184	26
	4	184	23
	5	194	23
	6	194	6

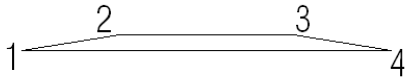
MESH GENERATION: Defining the elements

Introduce **porous media**:

- Rubble mound →



-Core →



Element	Vertices	X Coordinate	Y Coordinate
Core	1	154	2
	2	172	6
	3	204	6
	4	222	2
Rubble mound 1	1	146	2
	2	172	9
	3	181.5	9
	4	181.5	6
	5	172	6
	6	154	2
Rubble mound 2	1	194	6
	2	194	9
	3	204	9
	4	230	2
	5	222	2
	6	204	6

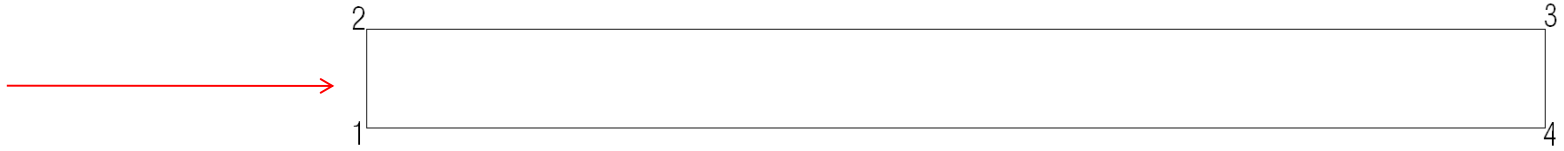
MESH GENERATION: Defining the elements

Introduce porous media properties:

Characteristic	Rubble Mound 1	Rubble Mound 2 & 3
Porosity	0.35	0.45
Linear friction coef.	200	200
Non-Linear friction coef.	0.70	1.00
Added mass coef.	0.34	0.34
D50	0.30	1.25

MESH GENERATION: Defining the elements

Introduce water:

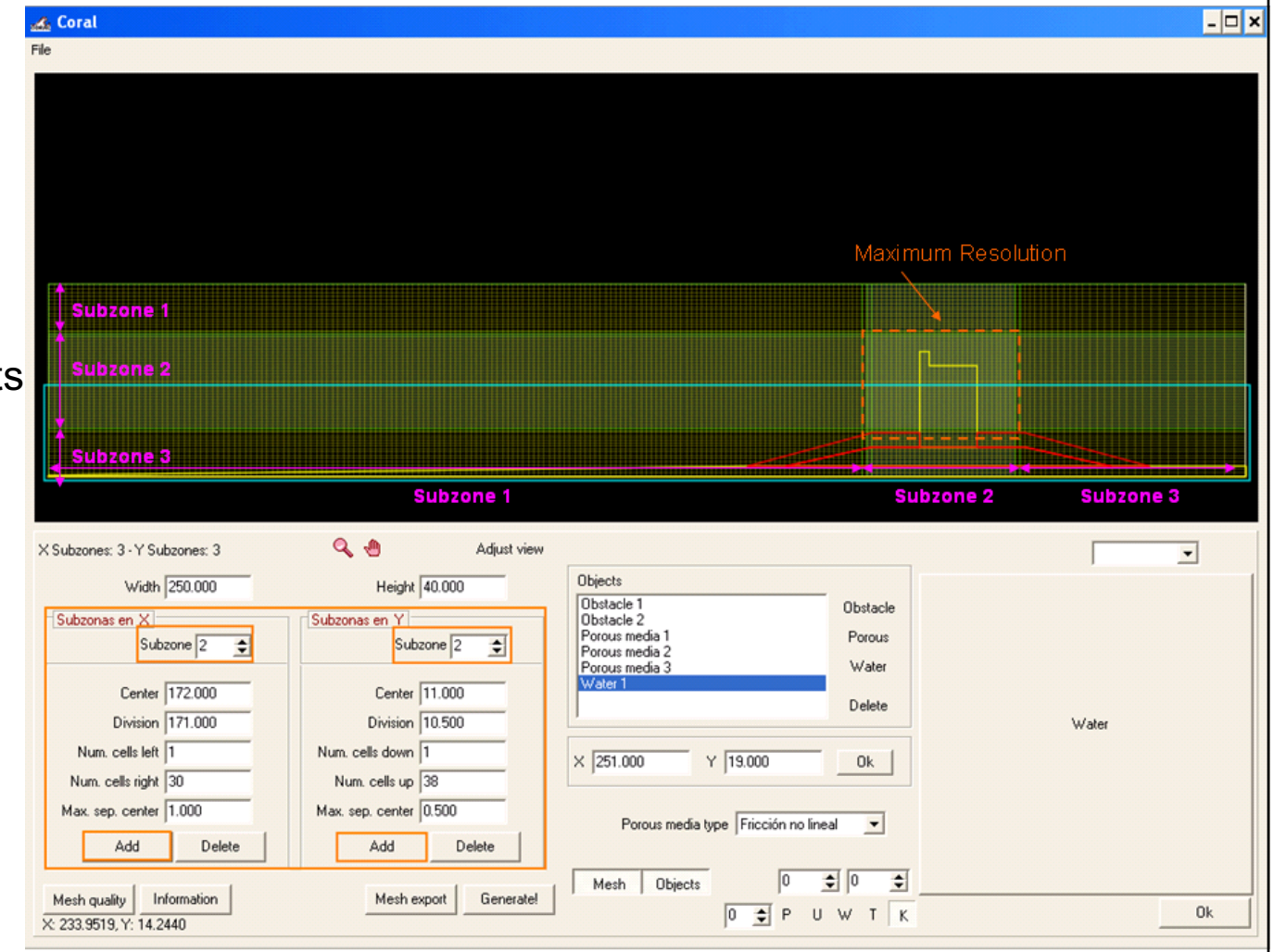


Element	Vertices	X Coordinate	Y Coordinate
Water	1	-1	-1
	2	-1	20
	3	251	20
	4	251	-1

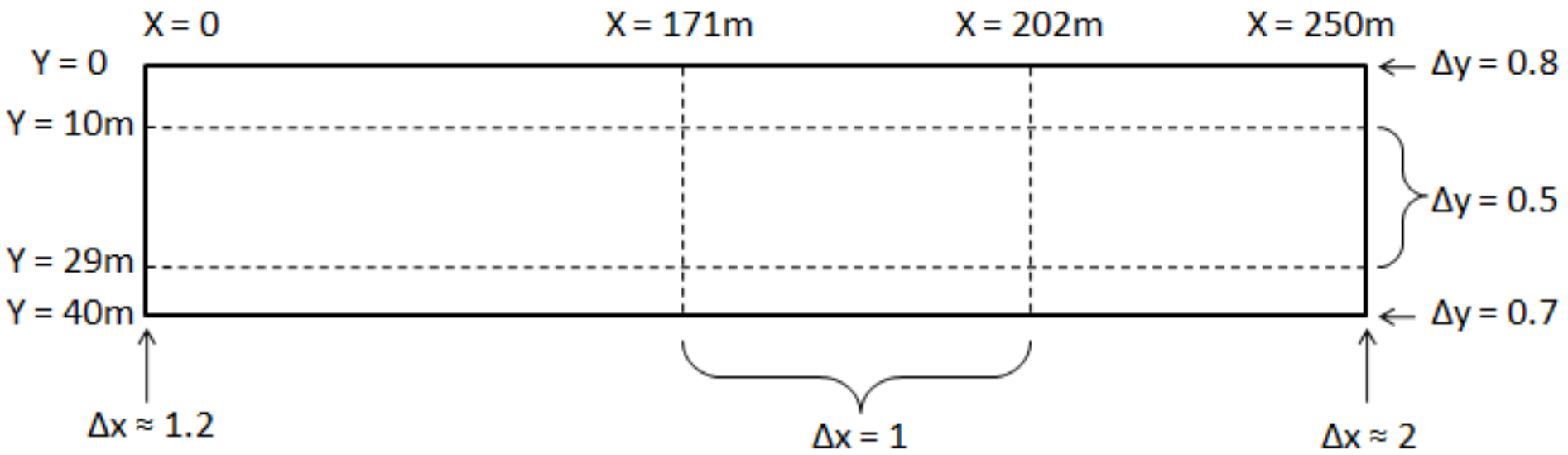
MESH GENERATION: Spatial discretization

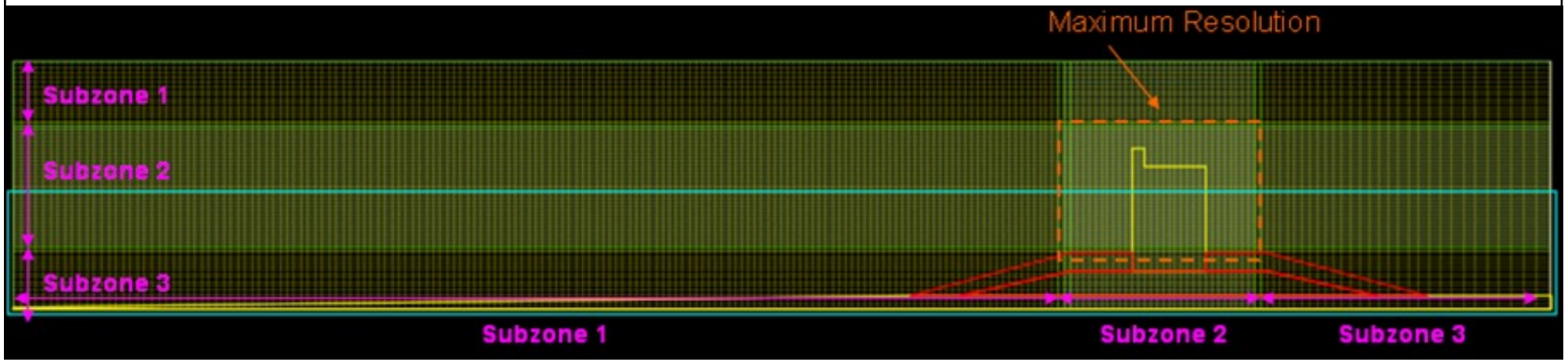
At least 10 cells per wave height! (H = 9m)
→ Δy = 0.9m
Because overtopping events areexpected
→ Δy = 0.5m

Aspect ratio: Δx/Δy=2
→ Δx = 1 m



Variable grid system in both the horizontal and the vertical directions : three subzones



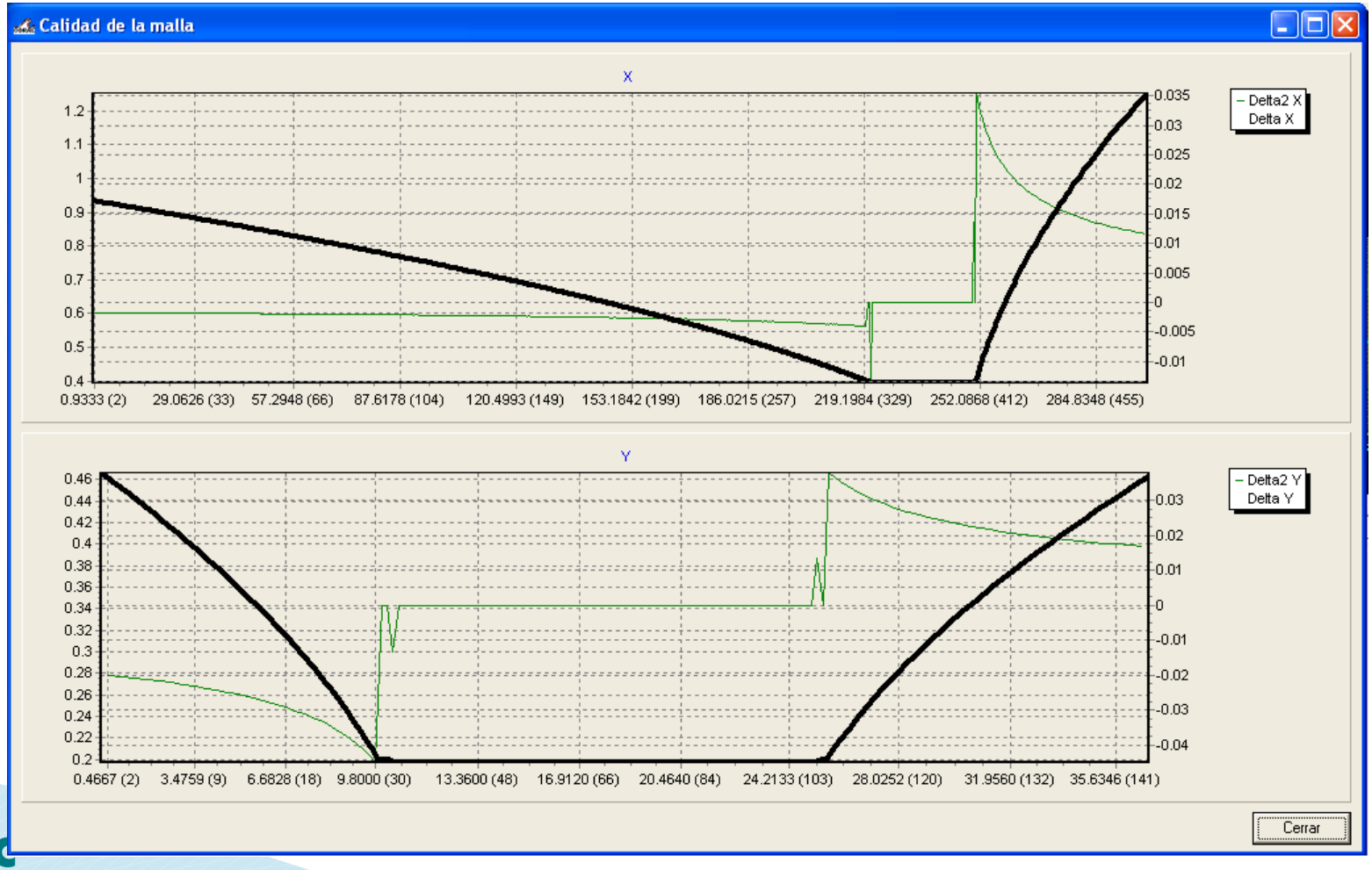


MESH GENERATION: Spatial discretization

	X Direction			Y Direction		
	Subzone 1	Subzone 2	Subzone 3	Subzone 1	Subzone 2	Subzone 3
Center	170.00	172.00	203.00	10.00	11.00	29.50
Division	0.00	171.00	202.00	0.00	10.50	29.00
Num. cells left	155	1	1	15	1	1
Num. cells right	1	31	30	1	36	16
Max. sep. center	1.00	1.00	1.00	0.50	0.50	0.50

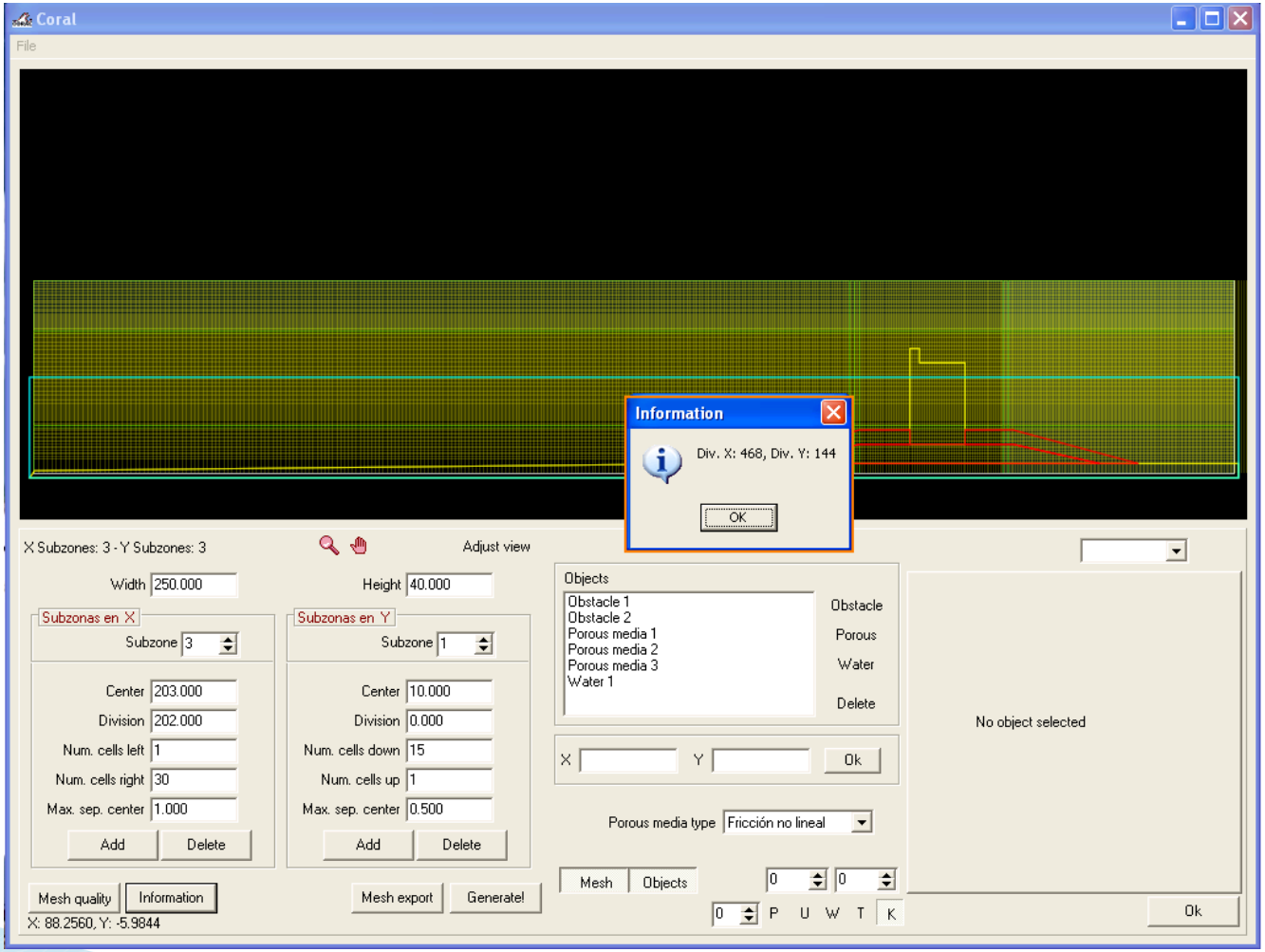
MESH GENERATION: Mesh quality

By pressing button “Mesh quality”:



MESH GENERATION: Mesh info

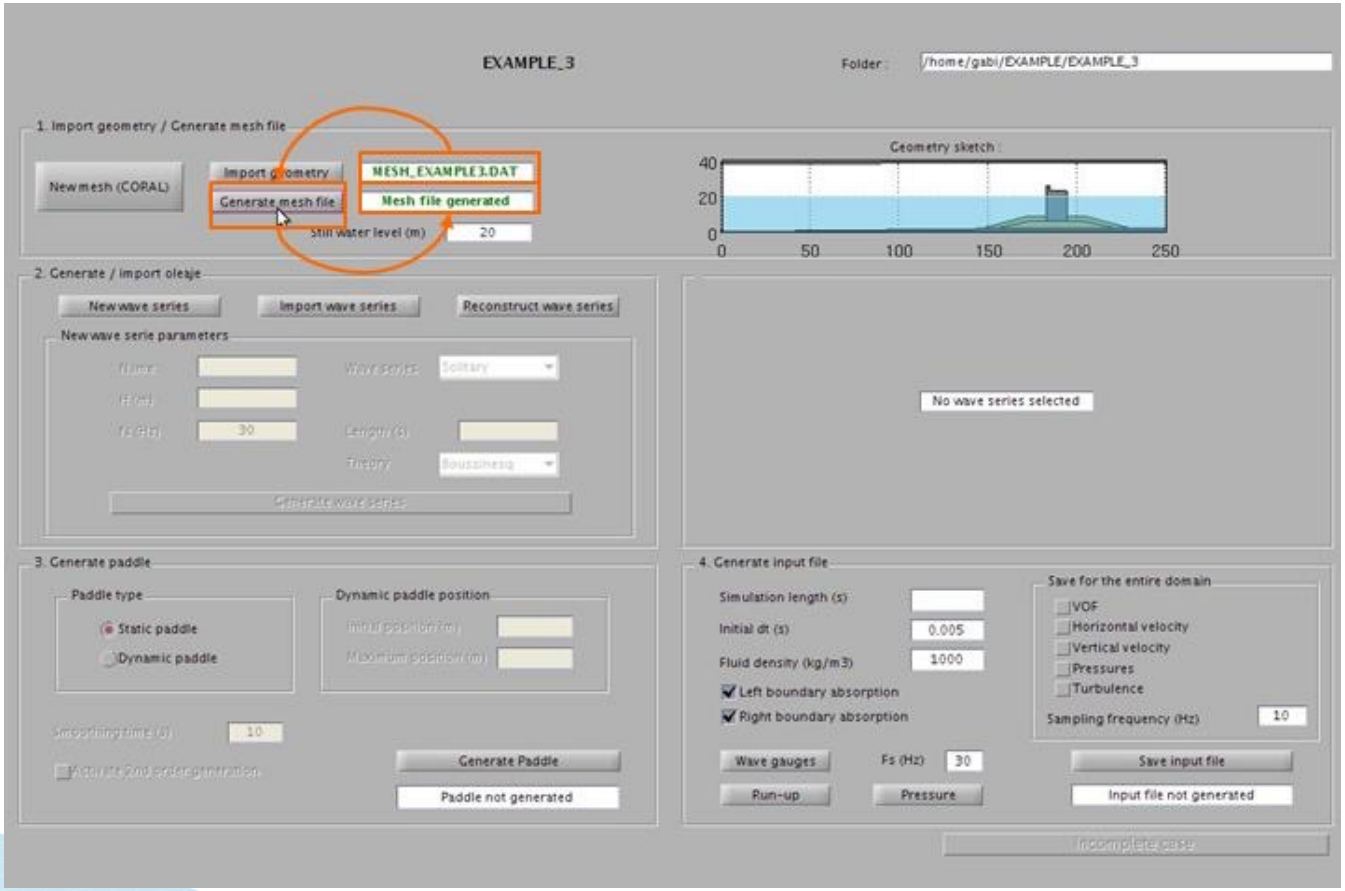
By pressing button “Information”:



SECTION 1 : "IMPORT GEOMETRY/GENERATE MESH FILE"

-Saving the generated mesh its ***".dat"*** file appears in green in the GUI

-Mesh characteristics are exported to a ***"Mesh.mes"***



SECTION 2 : "GENERATE/IMPORT WAVE CONDITIONS"

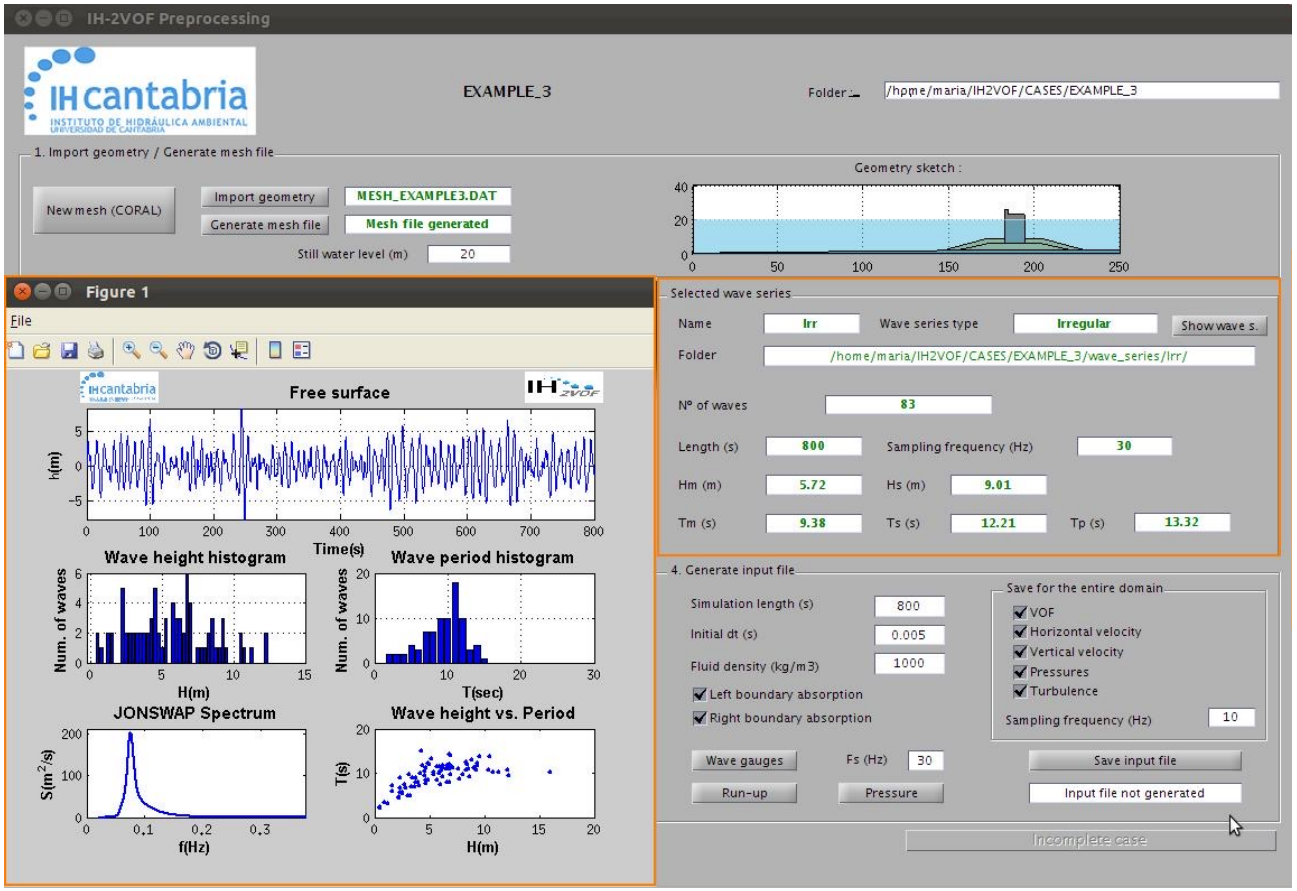
-Wave series: Irregular

-Hs = 9m

-Tp = 12s

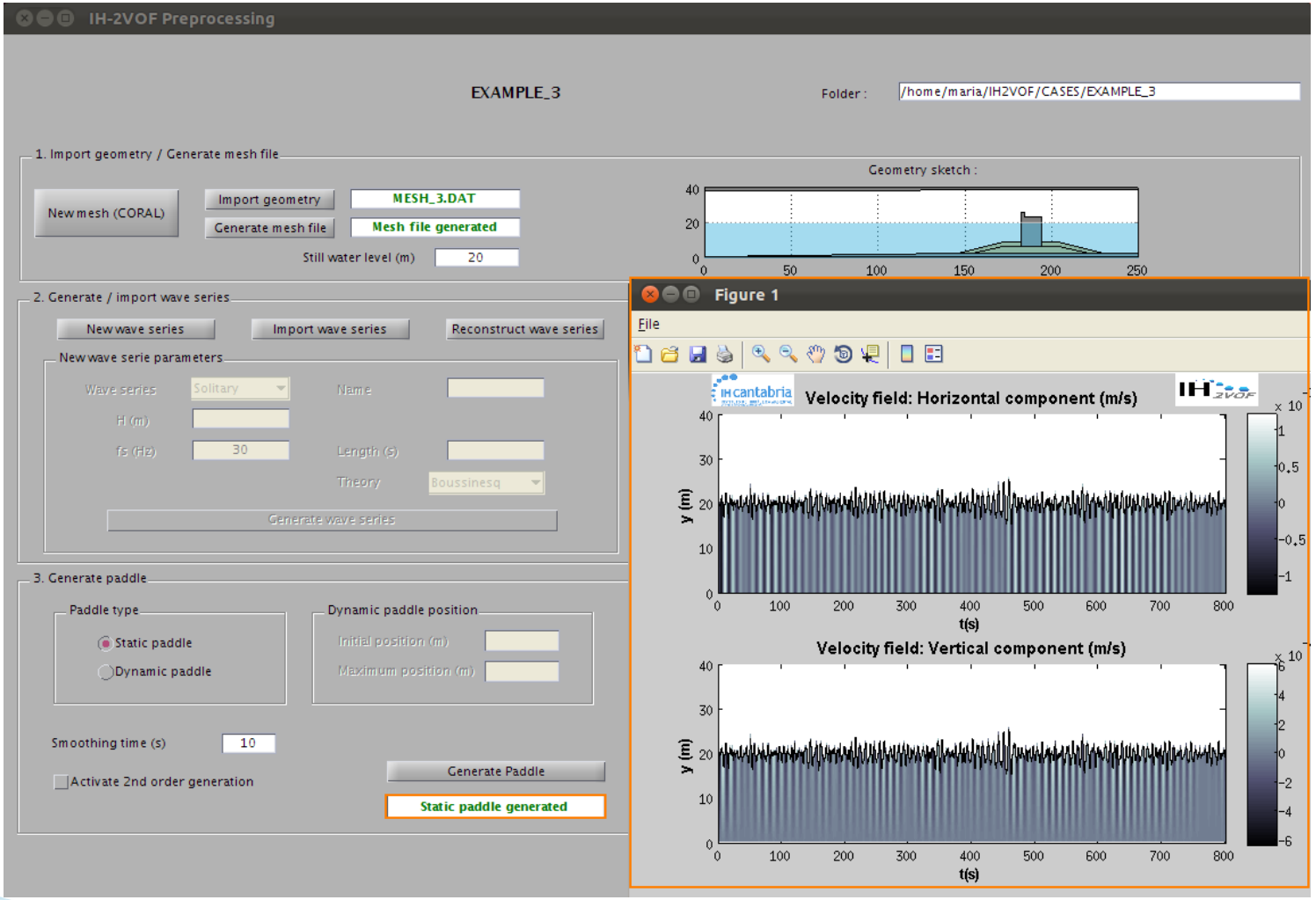
- Time series 800 s long

Generate wave series

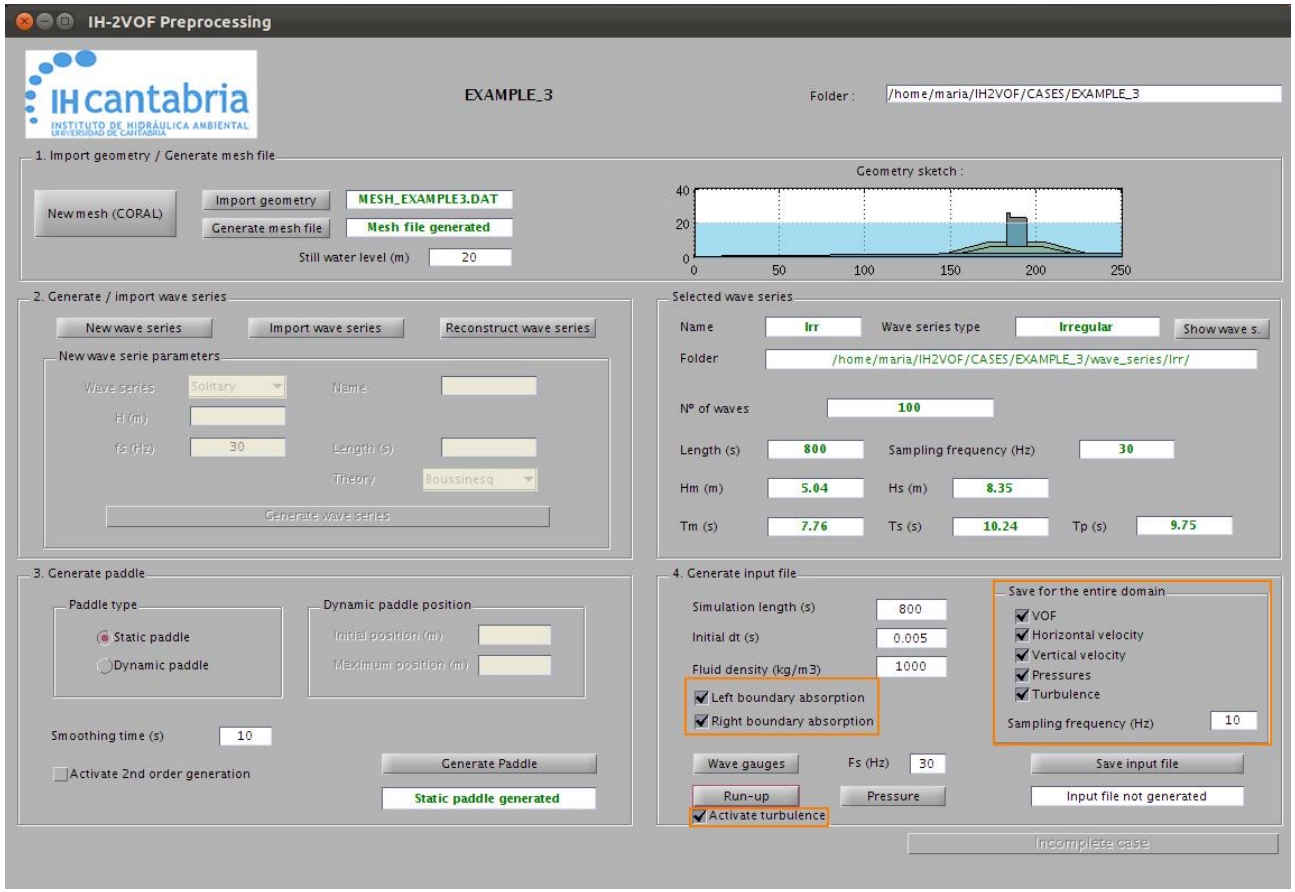


SECTION 3 : "GENERATE PADDLE

-Static wave paddle



SECTION 4 : "GENERATE INPUT FILE"



- Simulation length = 200 s

- Initial dt = 0.005 s

- Left and right boundary absorption are activated

- VOF, horizontal and vertical velocity, pressure fields and turbulent intensity are saved

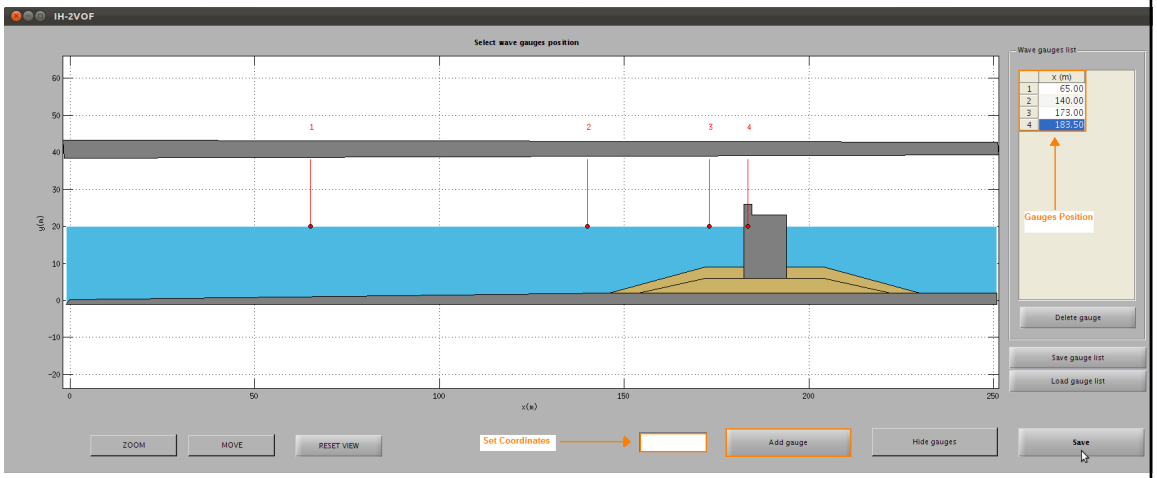
SECTION 4 : "GENERATE INPUT FILE" – *Wave gauges*

Different wave gauges are disposed in the domain to measured the wave conditions and overtopping.

Gauge	X(m)
1	65
2	140
3	173
4	183.5

Press the button *Wave gauges - Add gauge*

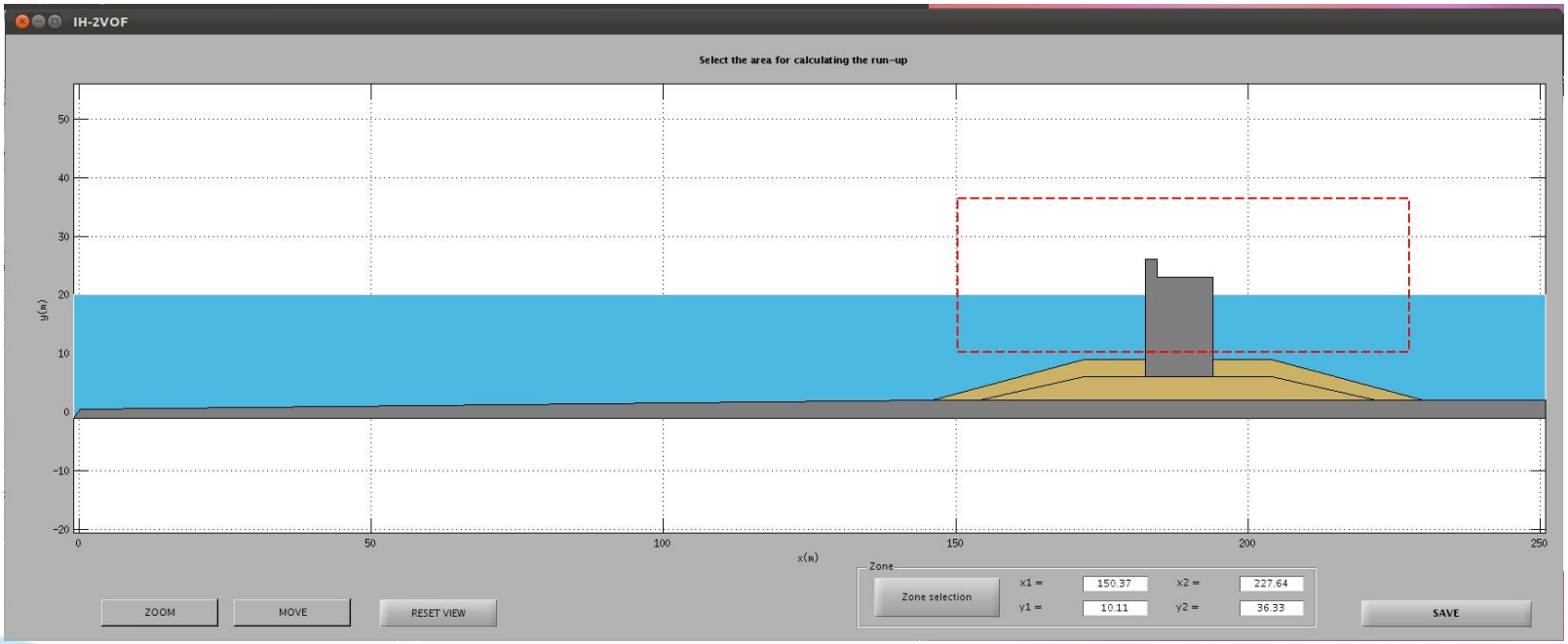
Gauges positions are specified



SECTION 4 : "GENERATE INPUT FILE" – *Run-up*

Press the button *Run-up*

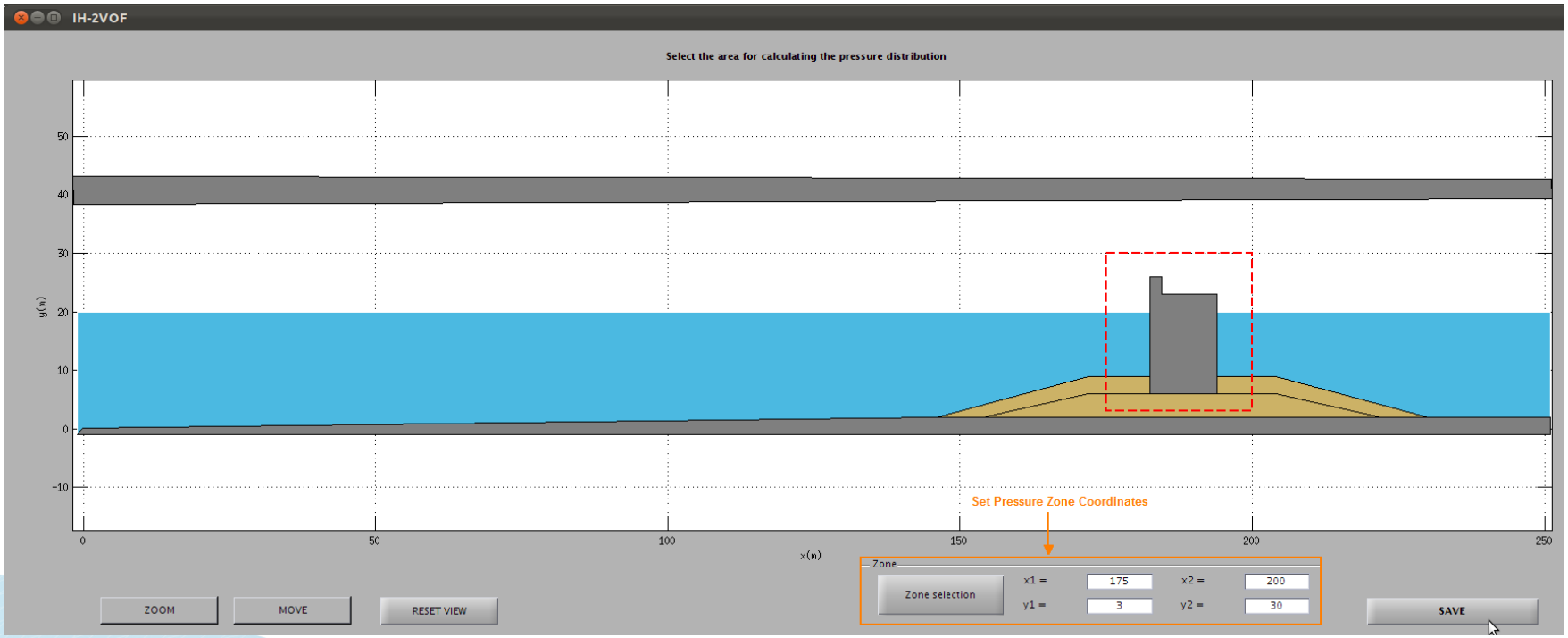
The area where run-up is calculated is selected specifying two vertices



SECTION 4 : "GENERATE INPUT FILE" – *Pressure*

Press the button *Pressure*

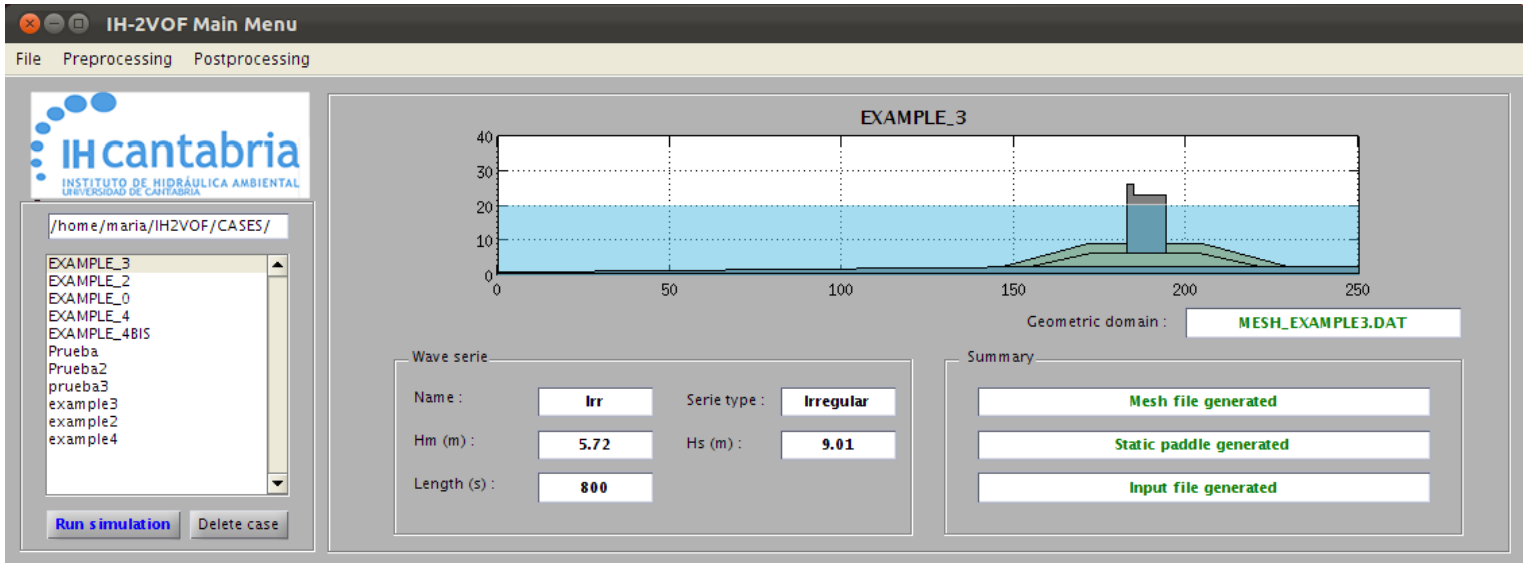
The area where pressure is calculated is selected specifying two vertices



SUMMARY

All the variables are defined
The input file is saved

➔the case is ready to be simulated

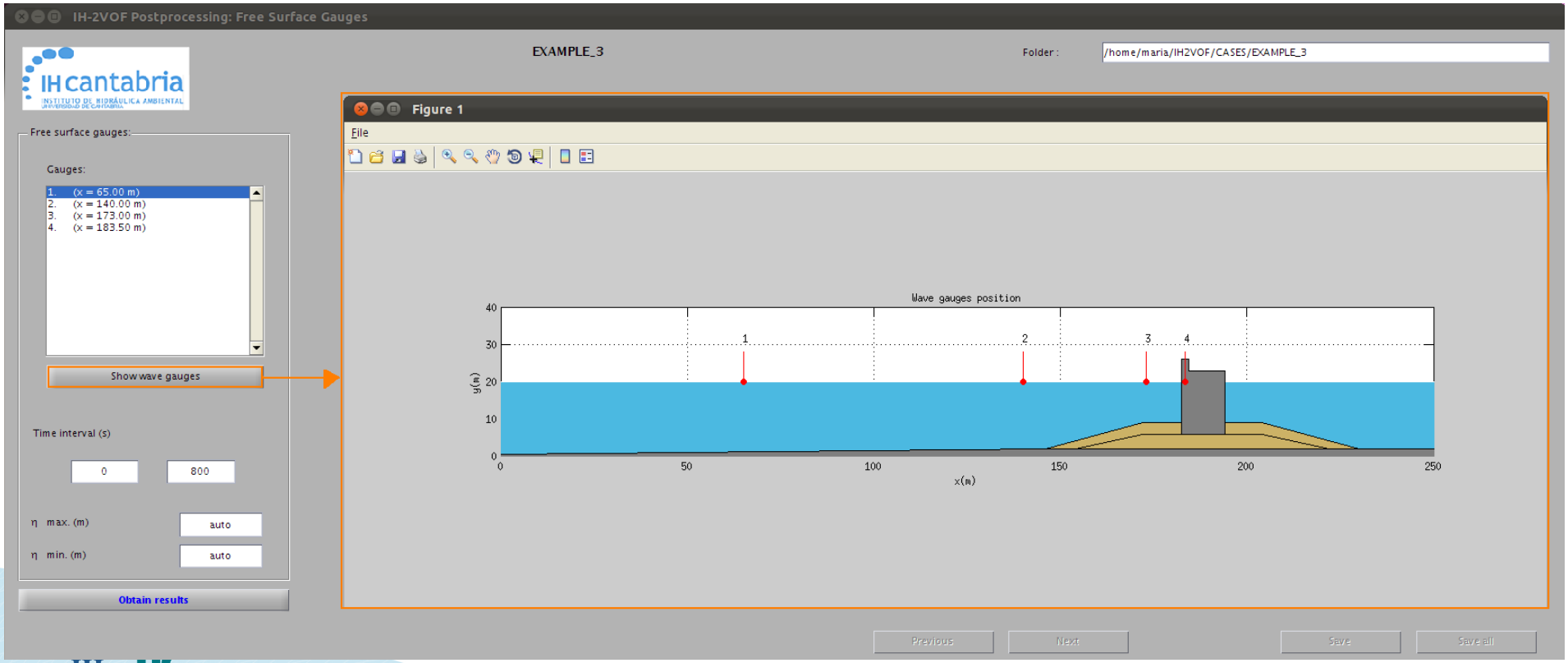


The simulation will starts by pressing the button *Run simulation*

WAVE GAUGES – Show wave gauges

- 4 wave gauges were disposed along the domain.

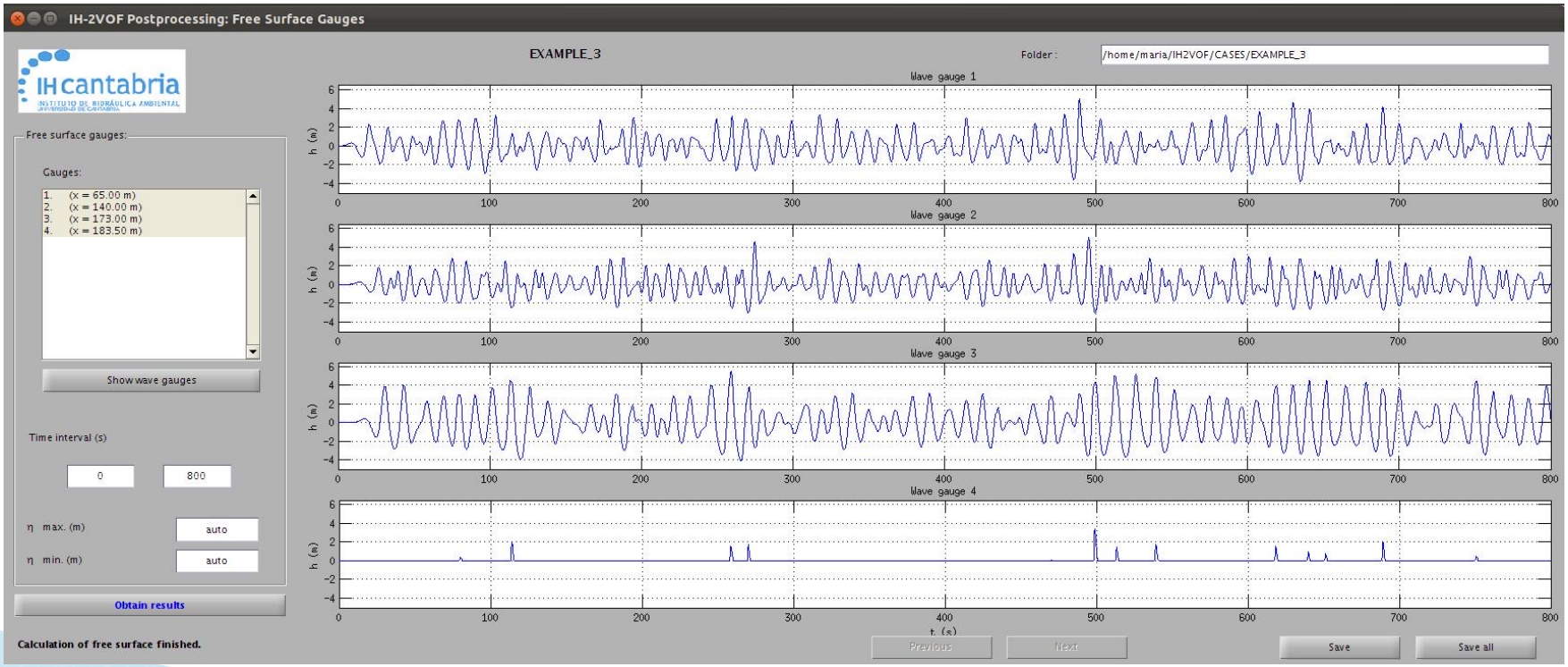
Postprocessing → *Free surface gauges* → *Show wave gauges*



WAVE GAUGES – Time series

-Results of the free surface elevation are obtained by pressing the button

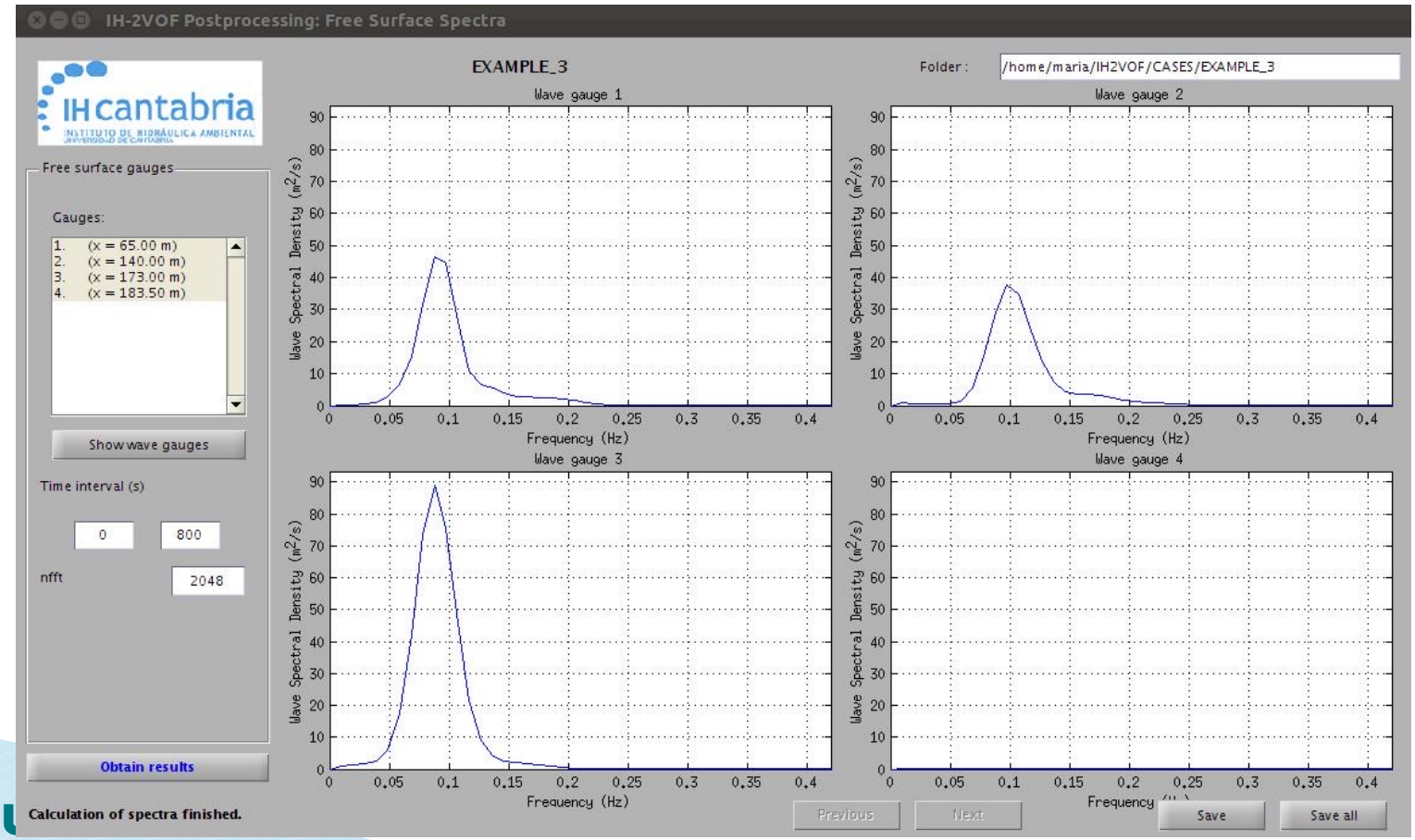
Postprocessing → *Free surface gauges* → *Time Series* → *Obtain results*



WAVE GAUGES – Spectra

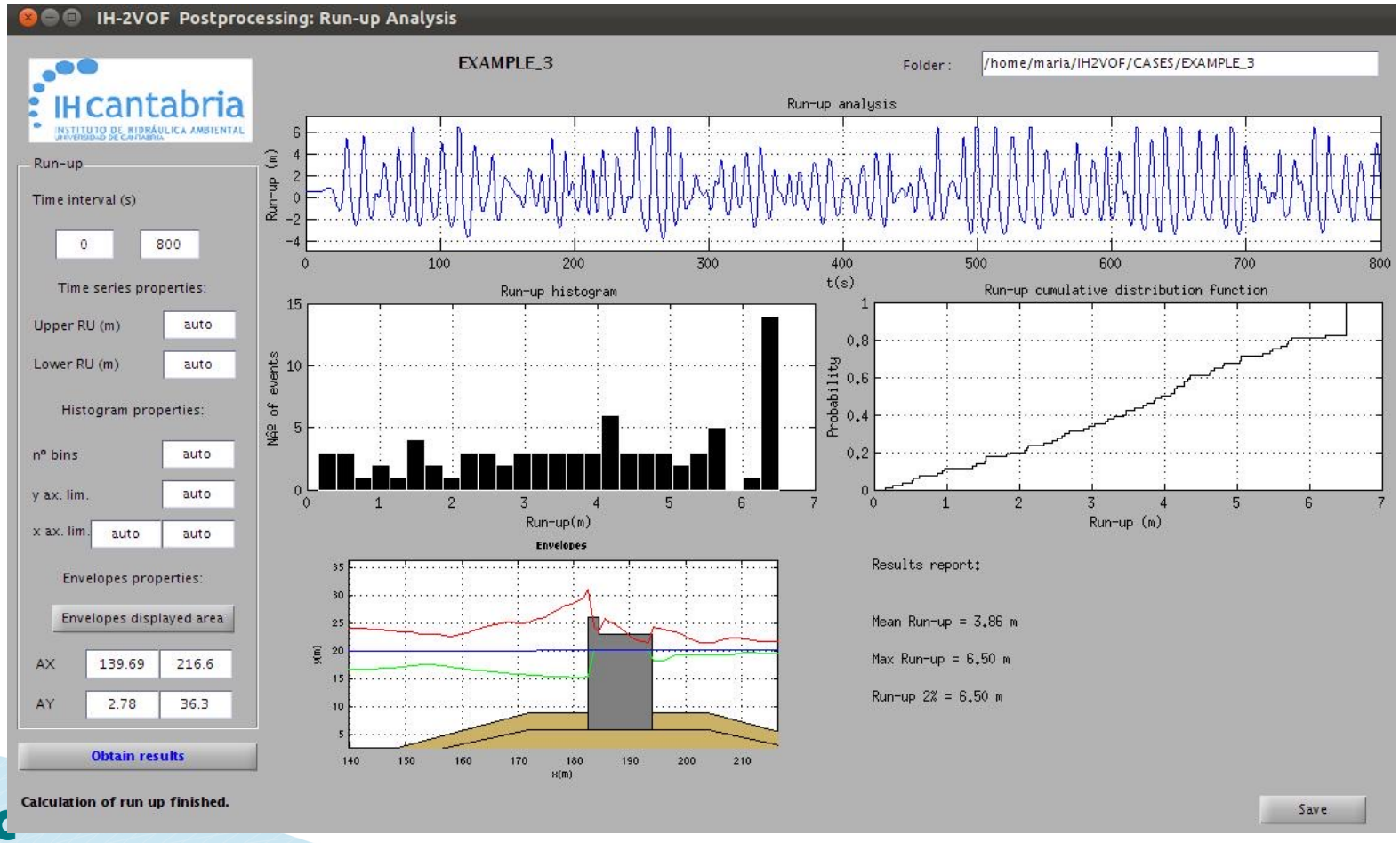
- Energy spectra associated to each one of the selected gauges before the simulation can be obtained

Postprocessing → *Free surface gauges* → *Spectra* → *Obtain results*



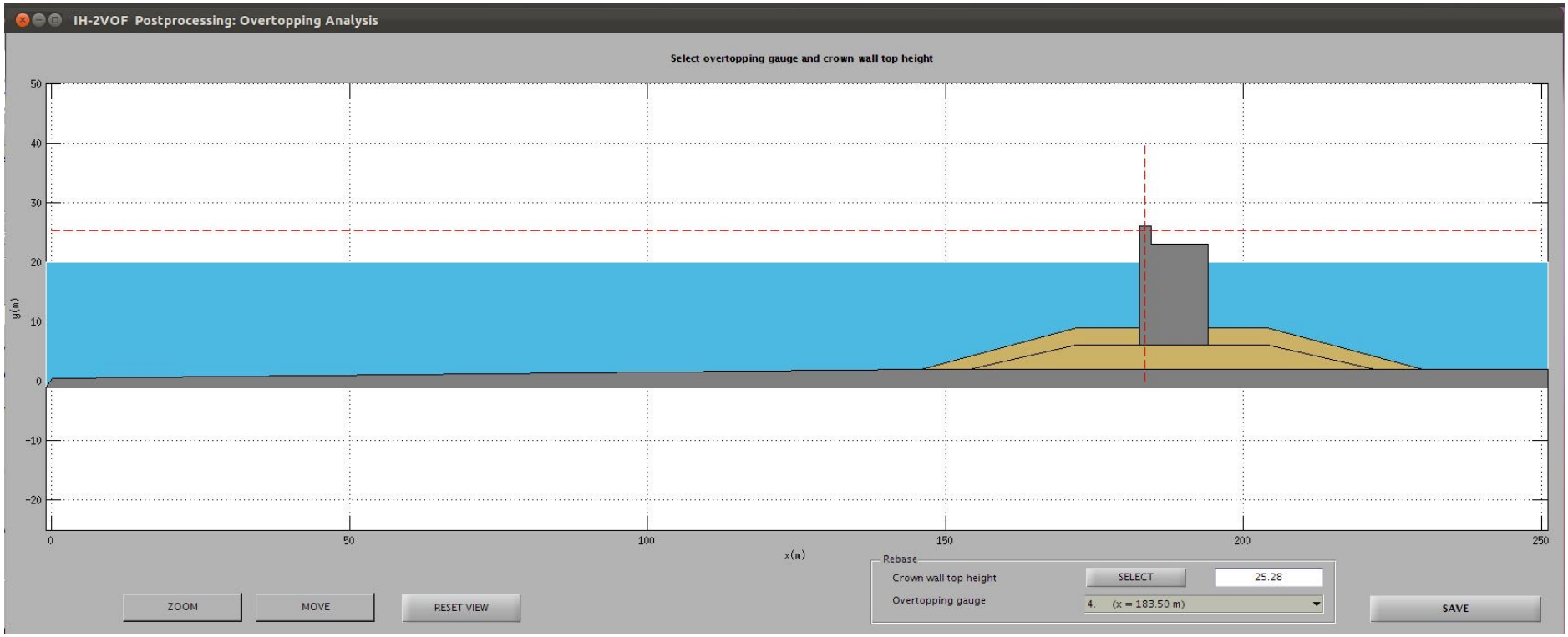
RUN-UP

Postprocessing → *Run-up Analysis*



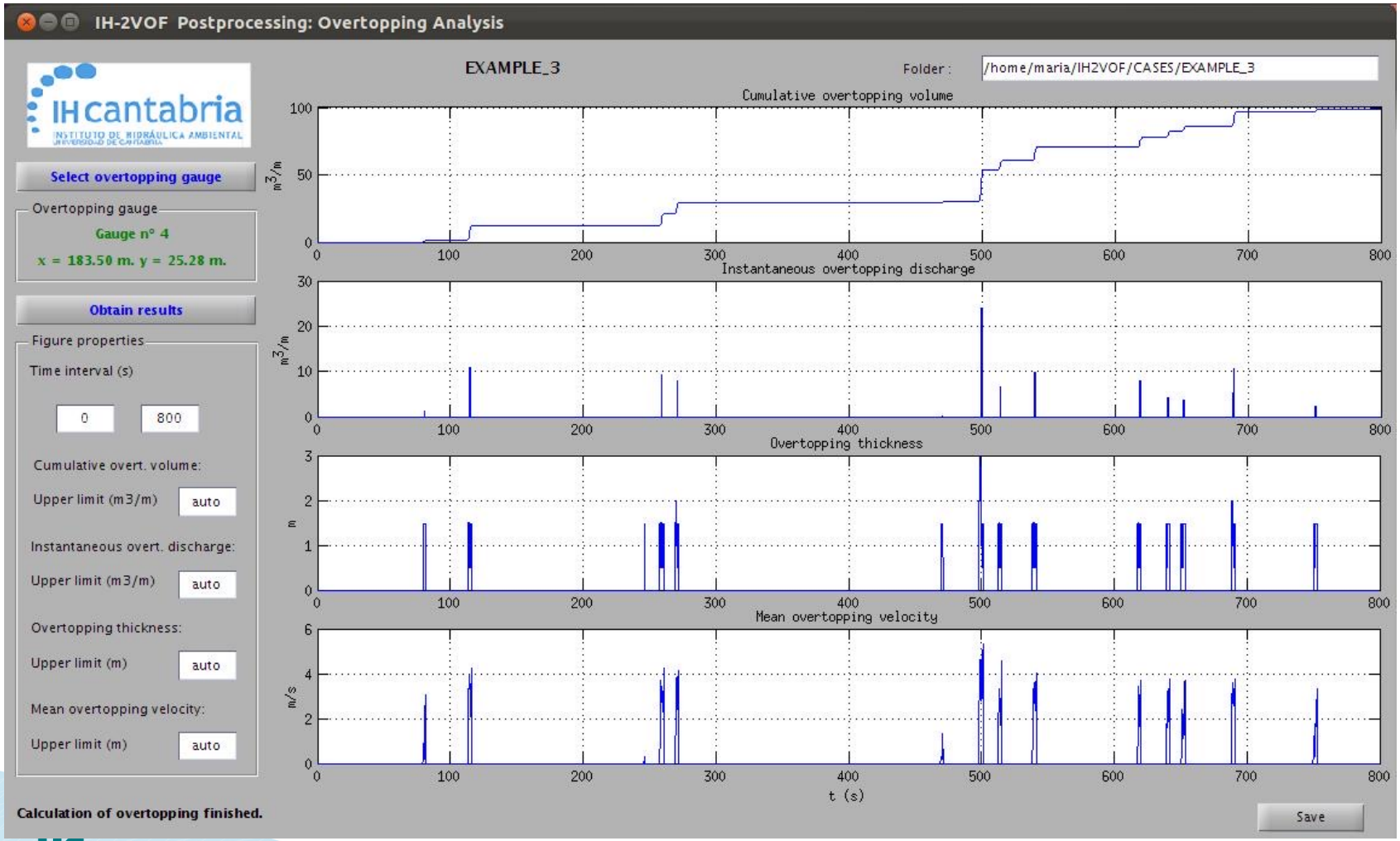
OVERTOPPING

- Select overtopping gauge: *Postprocessing* → *Overtopping Analysis*



OVERTOPPING

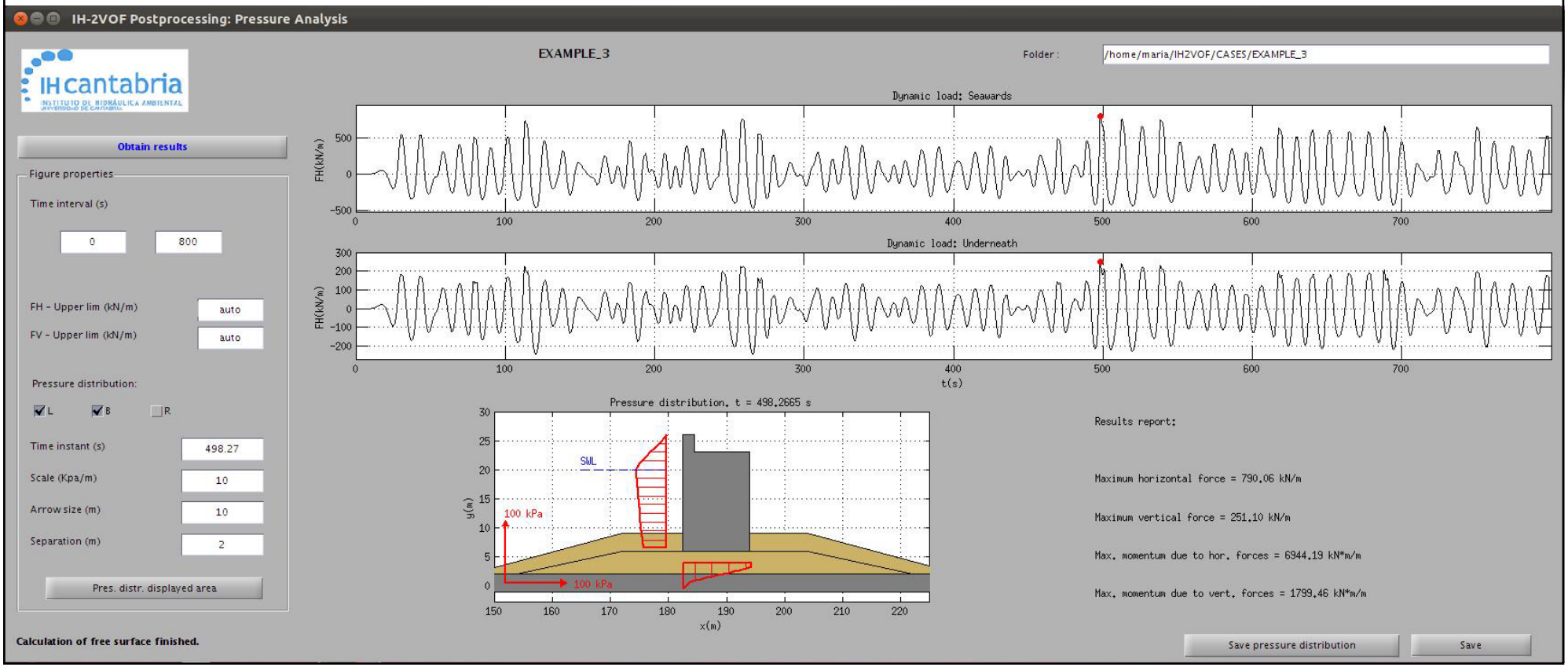
- Obtain results:



PRESSURE

- The produced pressure over the structure is calculated as well as the maximum forces.

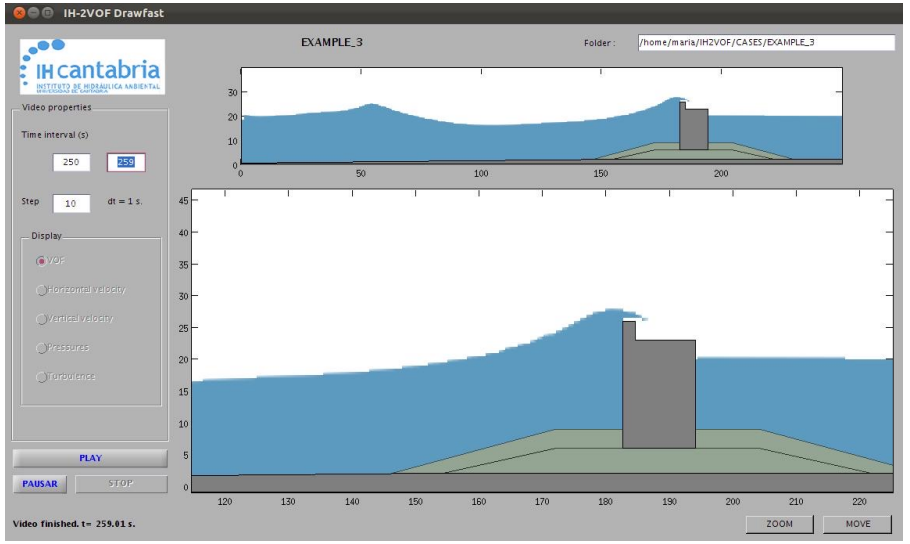
Postprocessing → *Pressure Analysis*



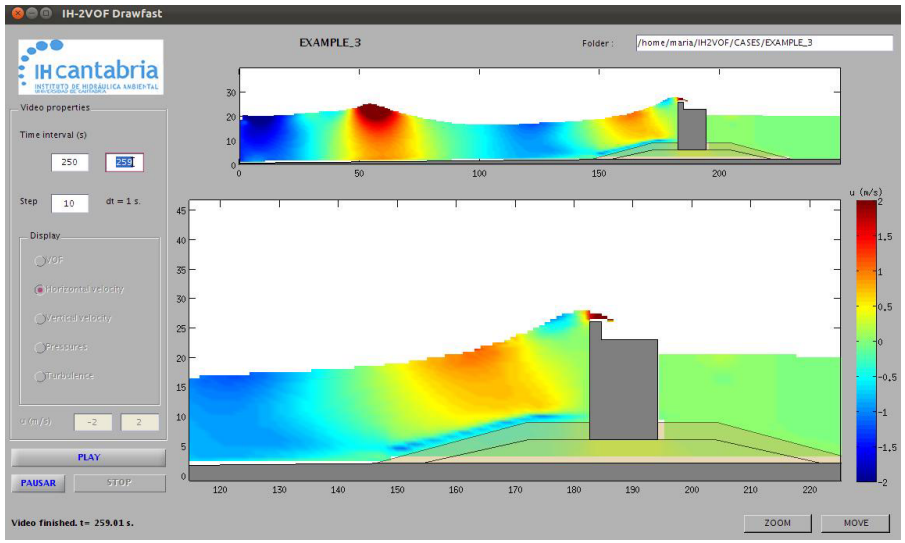
DRAWFAST

The visualization properties: initial time, final time and time step can be chosen, as well as the variable to display.

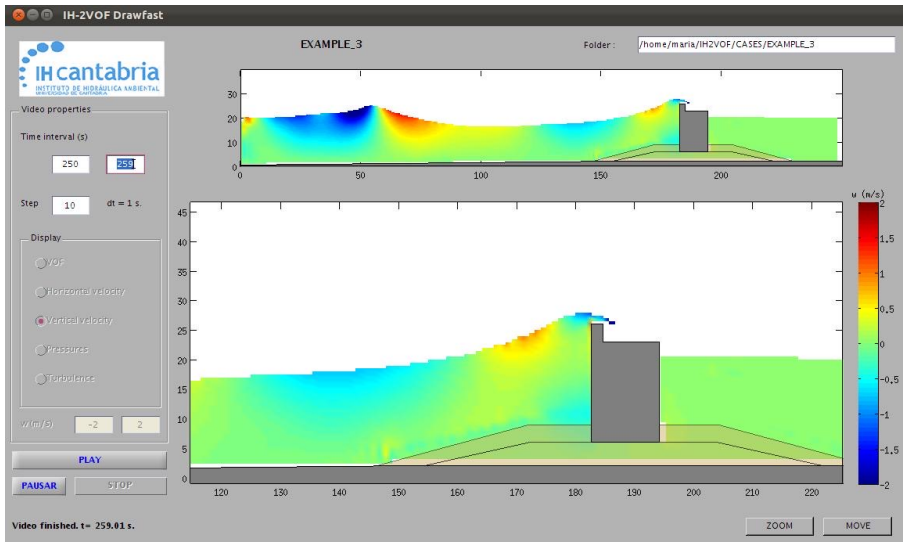
A zoom of the area of interest can be done using zoom controls in the figure below.



VOF drawfast

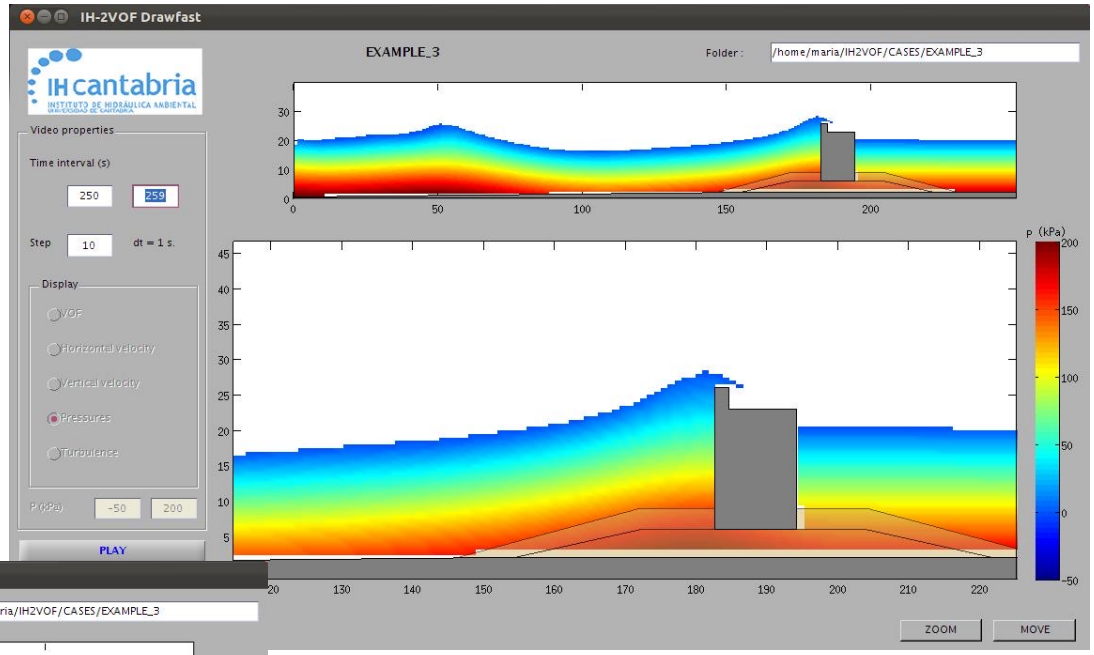


Horizontal Velocity drawfast

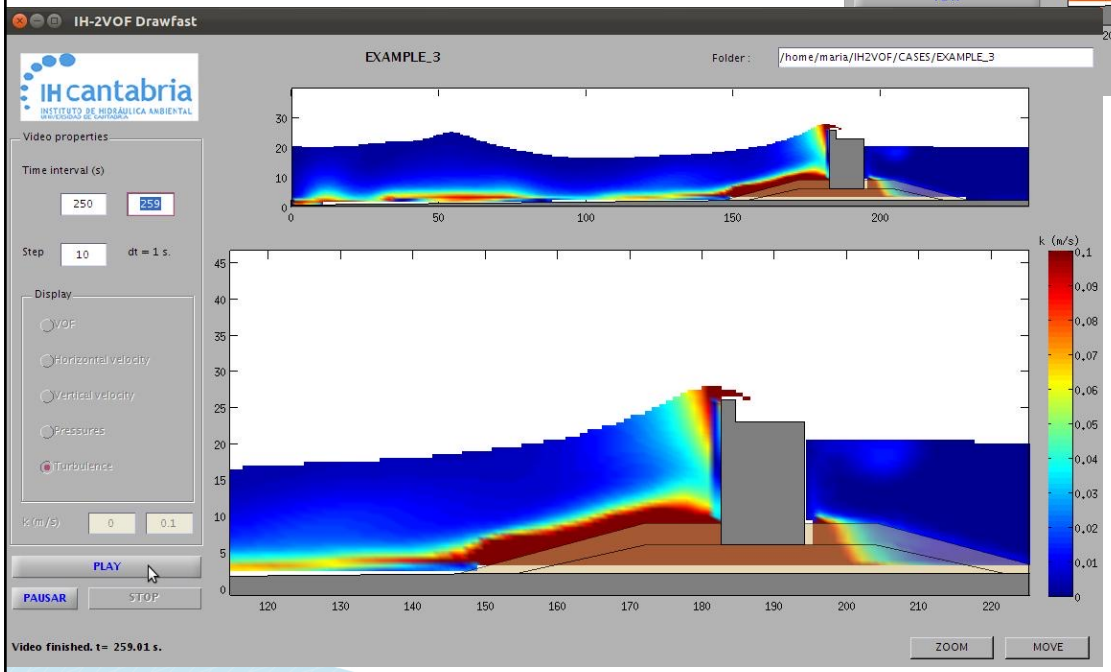


Vertical Velocity drawfast

DRAWFAST



Pressure drawfast



Turbulencedrawfast

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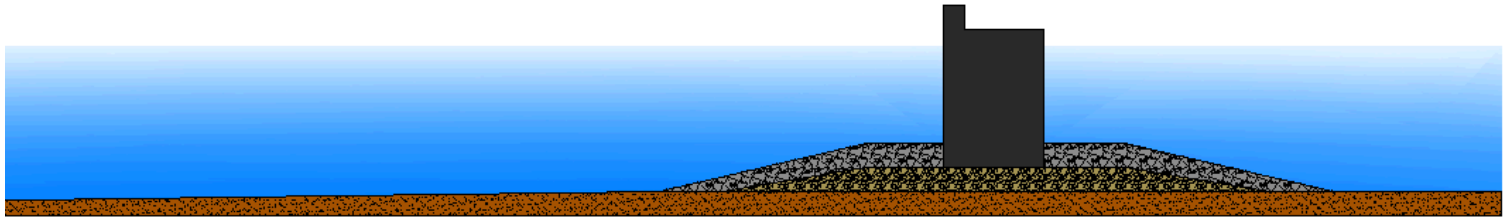
Example 3

Irregular waves interaction with a vertical breakwater



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