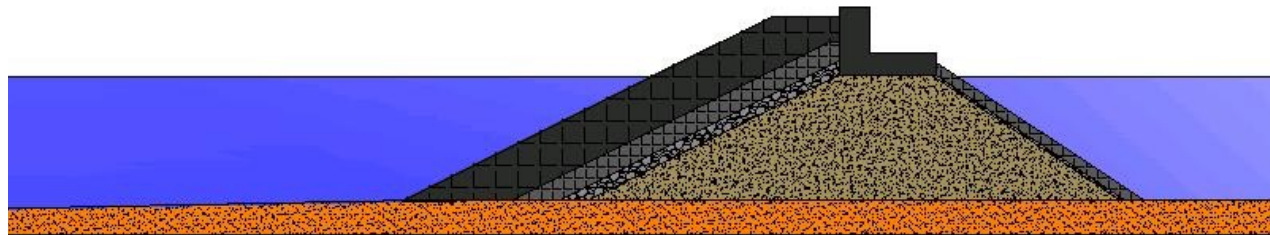


Example 2

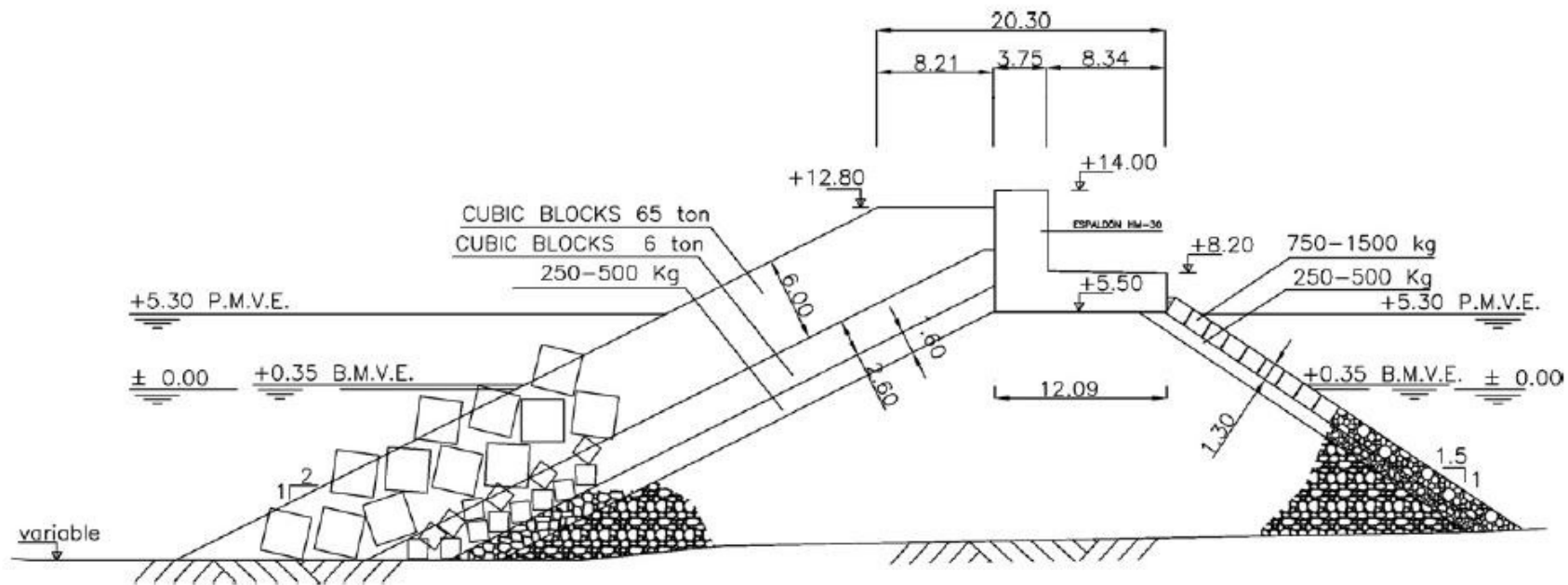
Regular wave interaction with a rubble-mound breakwater



Maria Maza (mazame@unican.es)

Study of a Rubble mound Breakwater

In this example the interaction of a **regular wave train** with a rubble-mound breakwater is considered.



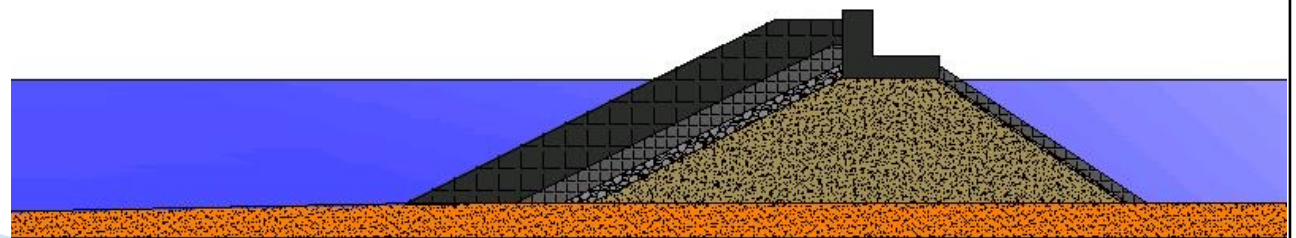
The bottom has a uniform slope 1:50 in front of the breakwater. The breakwater is assumed to be founded on a horizontal bottom.

Study of a Rubble mound Breakwater

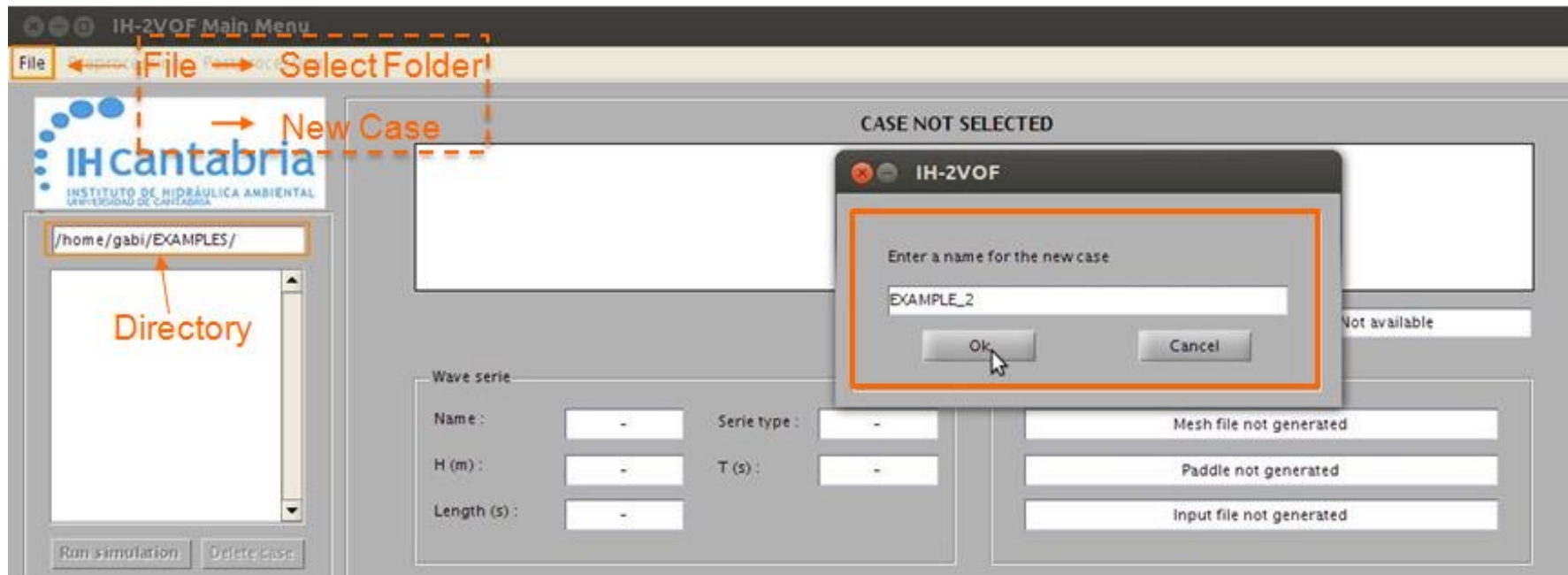
The breakwater is tested considering **regular wave conditions** with a wave height equal to **10m** and a wave period of **14s**.

The purpose of this example is to study the interaction between regular waves and a rubble-mound breakwater. Different functional variables will be analyzed:

- Wave run-up
- Overtopping discharge
- Wave induced forces on the crown-wall



- Select directory, Select Folder
- Create New Case



PREPROCESSING

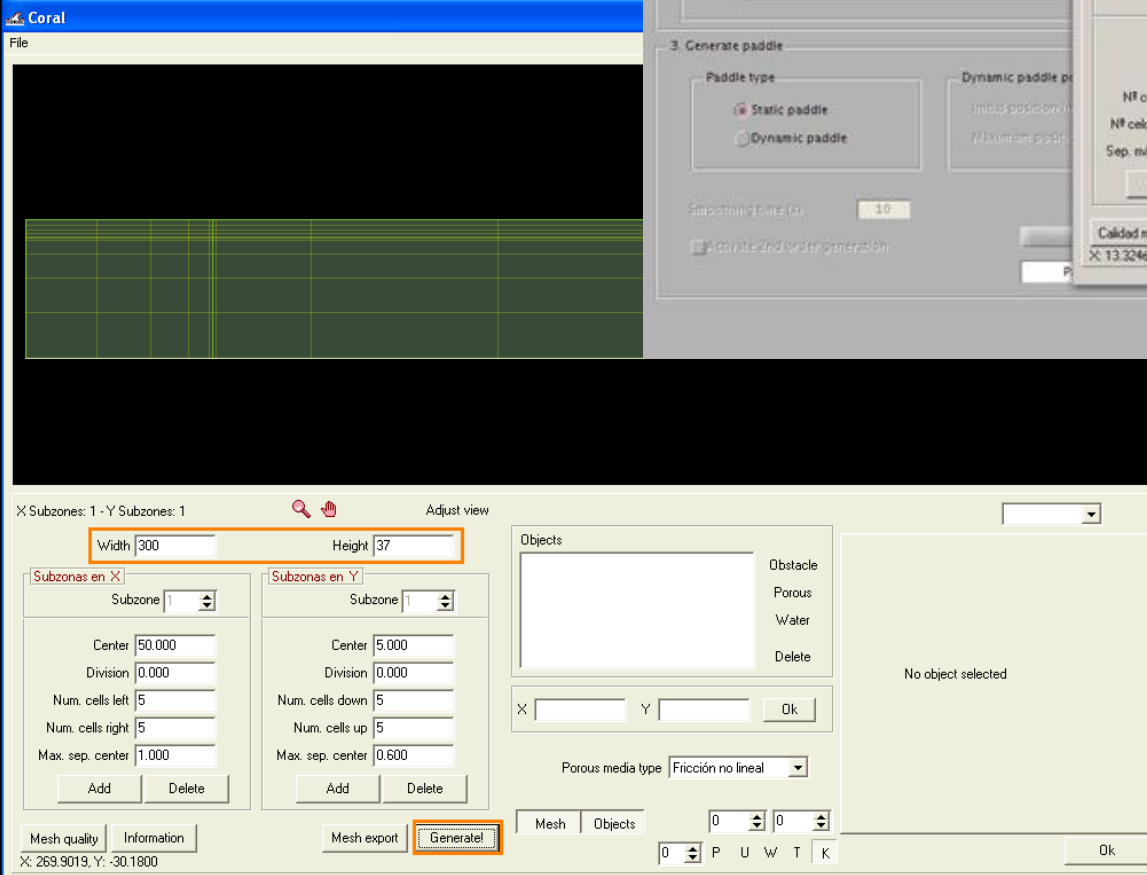
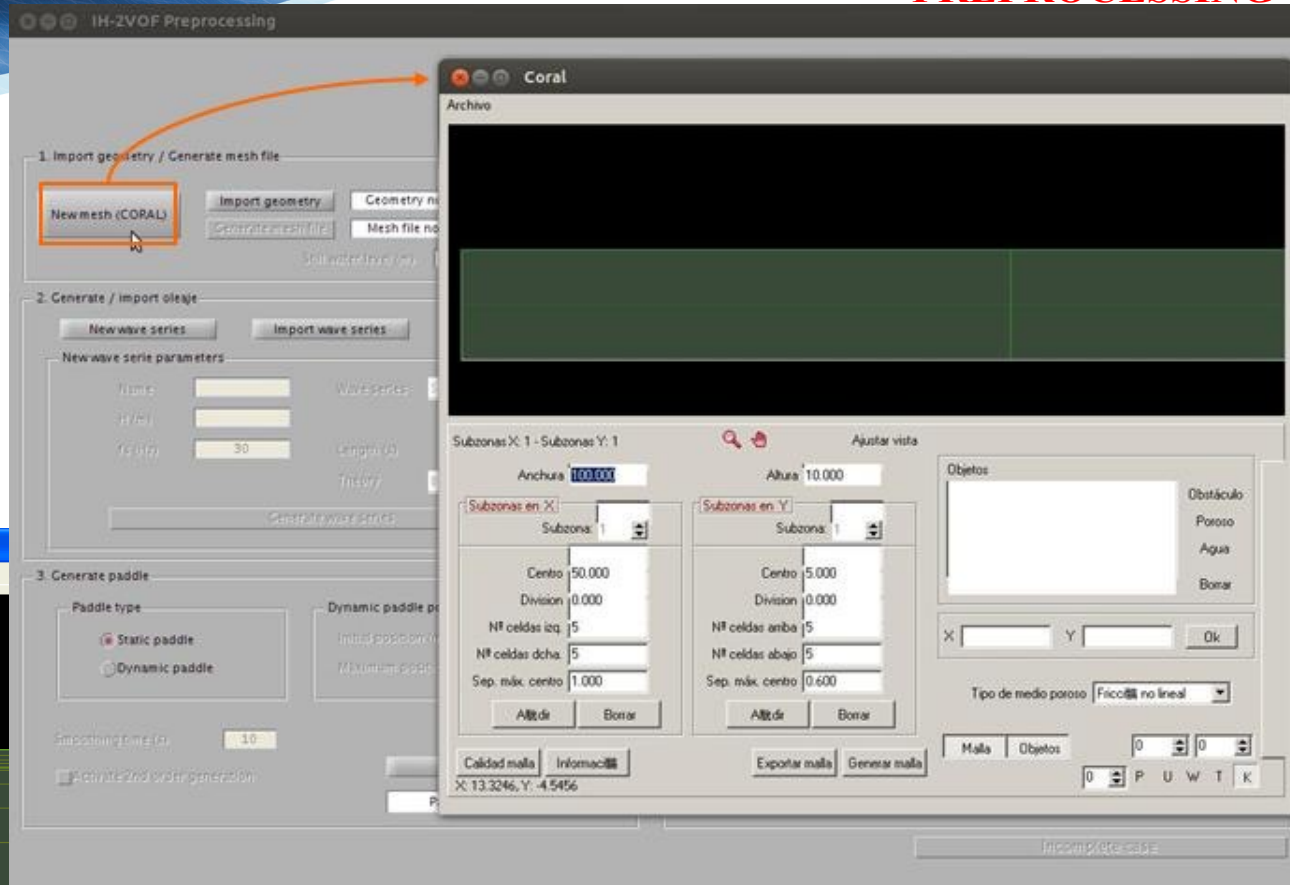
- MESH GENERATION
- SECTION 1: "IMPORT GEOMETRY/GENERATE MESH FILE"
- SECTION 2: "GENERATE/IMPORT WAVE CONDITIONS"
- SECTION 3: "GENERATE PADDLE"
- SECTION 4: "GENERATE INPUT FILE"

POSTPROCESSING

- WAVE GAUGES
- RUN UP
- OVERTOPPING
- PRESSURE
- DRAWFAST

MESH GENERATION

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



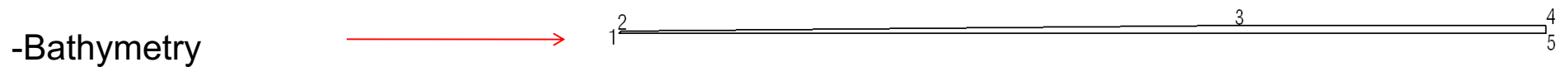
- Domain specification:

$L = 162\text{m}$, considering $1.5L$ before the breakwater: **width = 320 m**

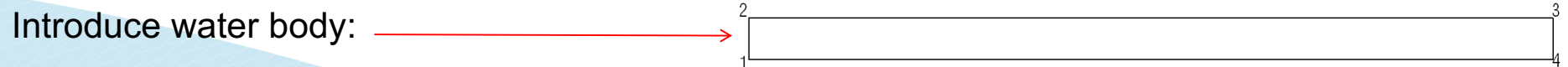
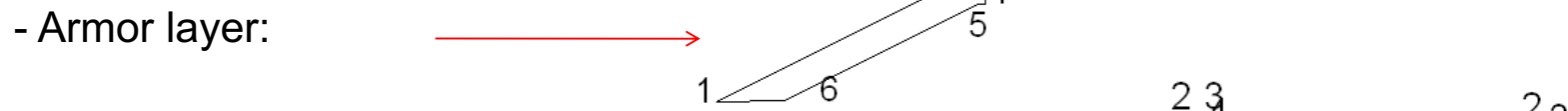
Rubble mound total height is equal to 28m, considering possible overtopping events: **height = 44 m**

MESH GENERATION: Defining the elements

Introduce obstacles:



Introduce porous media:



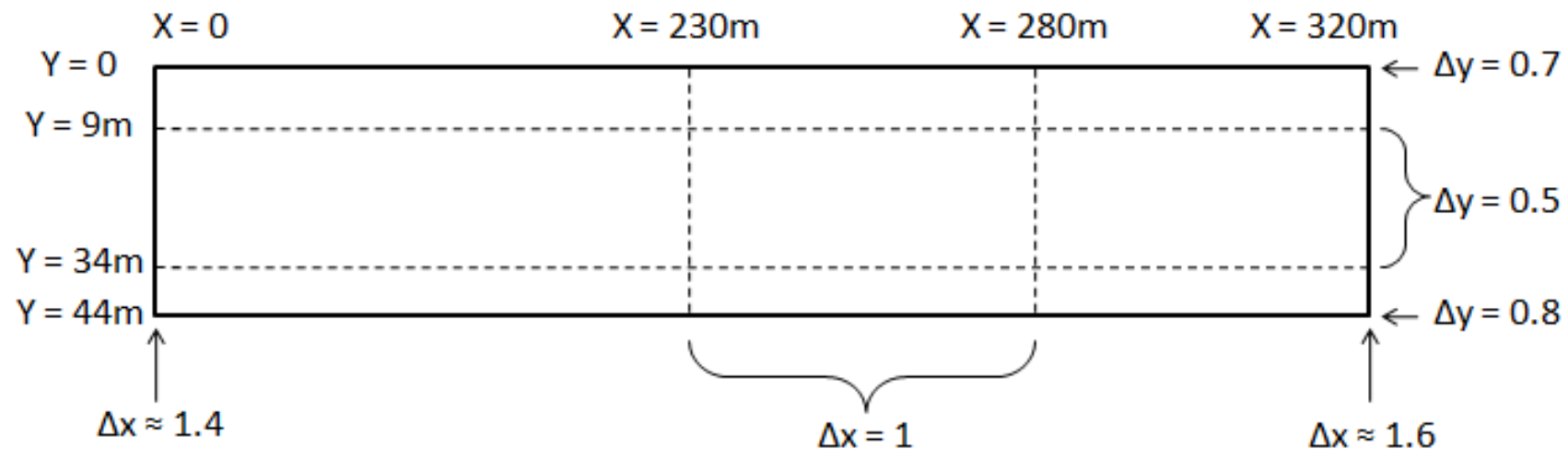
MESH GENERATION: Defining the elements

Introduce porous media properties:

Characteristic	Core	Under layer 2	Under layer 1	Armor layer	Leeward layer 2	Leeward layer 1
Porosity	0.20	0.30	0.35	0.40	0.25	0.30
Linear friction coef.	200	200	200	200	200	200
Non-Linear friction coef.	0.80	1.00	1.10	1.1	1	1.00
Added mass coef.	0.34	0.34	0.34	0.34	0.34	0.34
D50	0.30	0.61	1.37	3.00	0.40	0.60

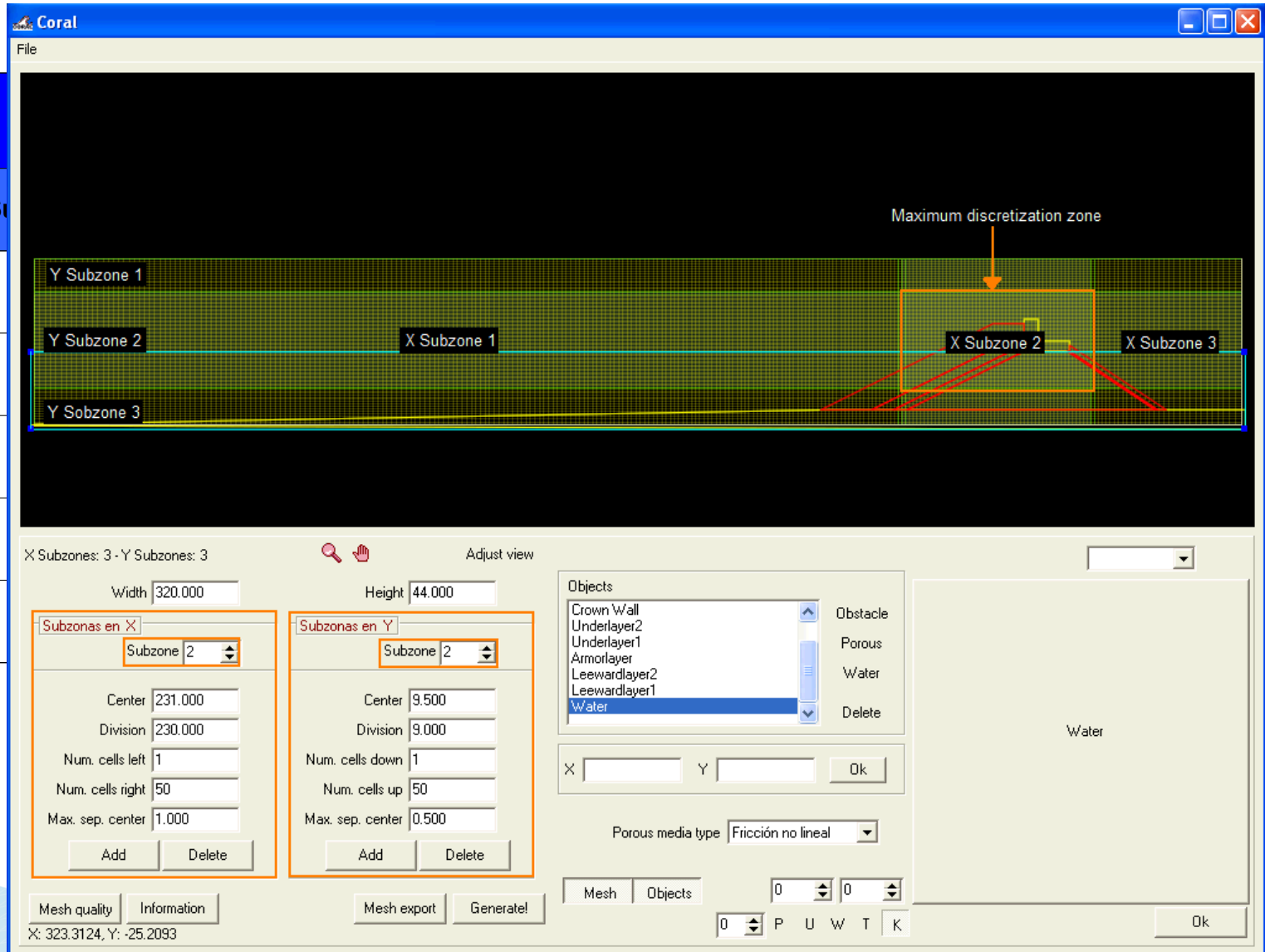
MESH GENERATION: Spatial discretization

- A variable grid is chosen to mesh the domain.
- The maximum resolution zone is placed around the breakwater.
- The tested wave height will be 10 m $\rightarrow \Delta y = 1\text{m}$. As overtopping events are expected in this case, a small vertical discretization is considered $\rightarrow \Delta y = 0.5\text{m}$.
- An aspect ratio equal to $\Delta x / \Delta y = 2$ is selected which means $\Delta x = 1\text{m}$.



MESH GENERATION: Spatial discretization

Center	S
Division	
Num. cells left	
Num. cells right	
Max. sep. center	



Coral

File

Maximum discretization zone

Y Subzone 1
Y Subzone 2
Y Subzone 3

X Subzone 1
X Subzone 2
X Subzone 3

X Subzones: 3 - Y Subzones: 3

Width: 320.000 Height: 44.000

Subzonas en X: Subzone 2

Subzonas en Y: Subzone 2

Center: 231.000 Center: 9.500
 Division: 230.000 Division: 9.000
 Num. cells left: 1 Num. cells down: 1
 Num. cells right: 50 Num. cells up: 50
 Max. sep. center: 1.000 Max. sep. center: 0.500

Objects: Crown Wall, Underlayer2, Underlayer1, Armorlayer, Leewardlayer2, Leewardlayer1, Water

Obstacle, Porous, Water, Delete

Porous media type: Fricción no lineal

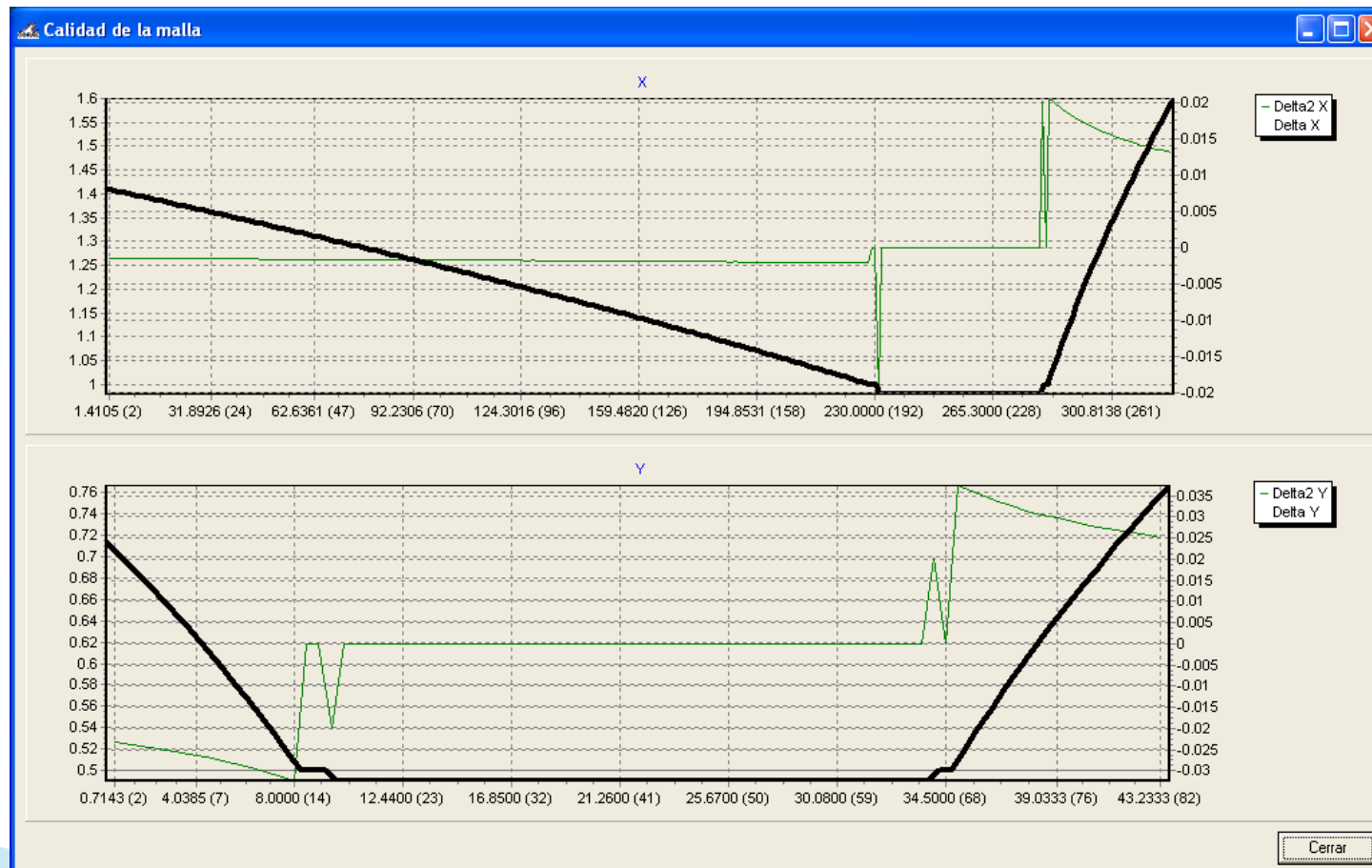
Mesh Objects 0 0

0 P U W T K

X: 323.3124, Y: -25.2093

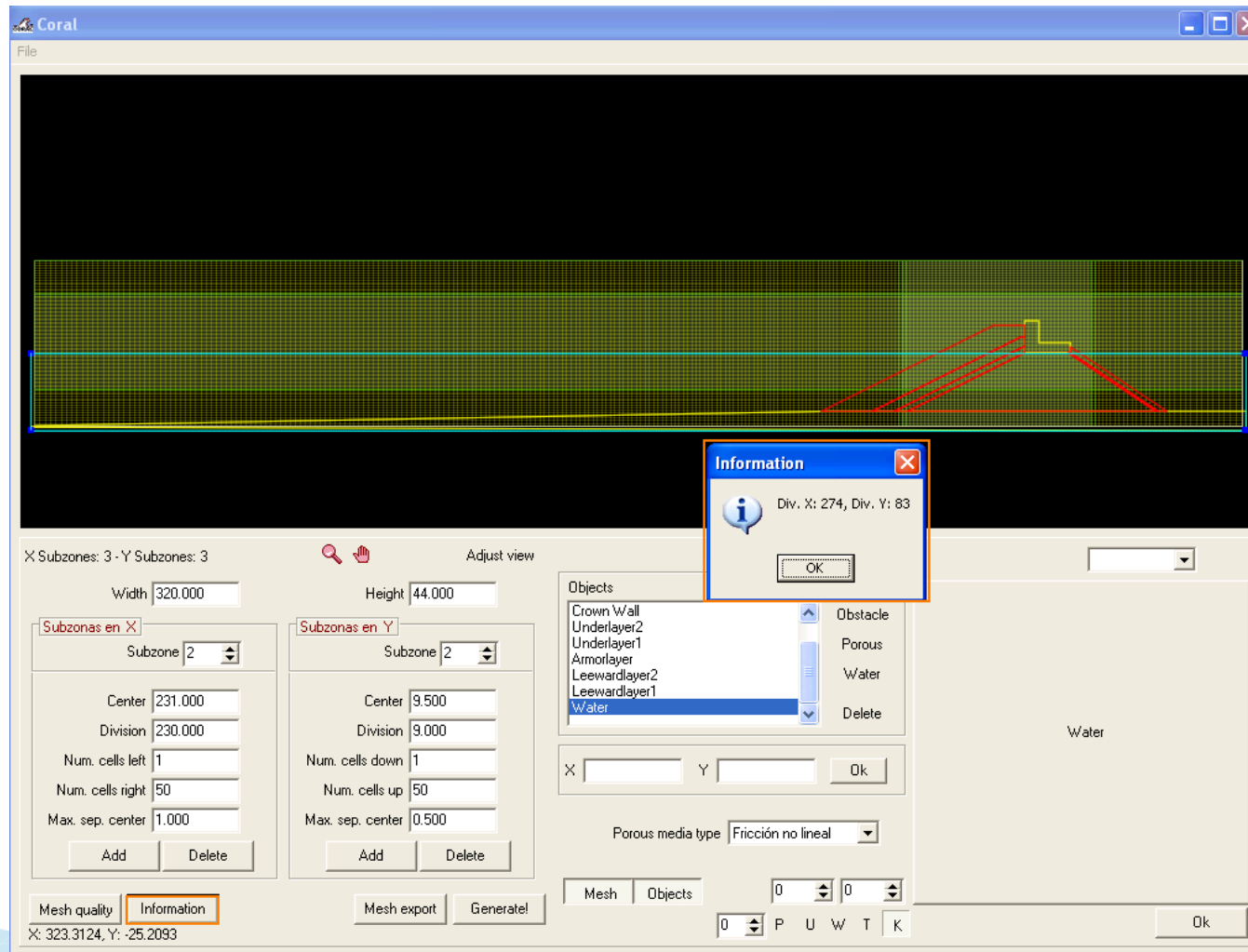
MESH GENERATION: Mesh quality

By pressing button “Mesh quality”:



MESH GENERATION: Mesh info

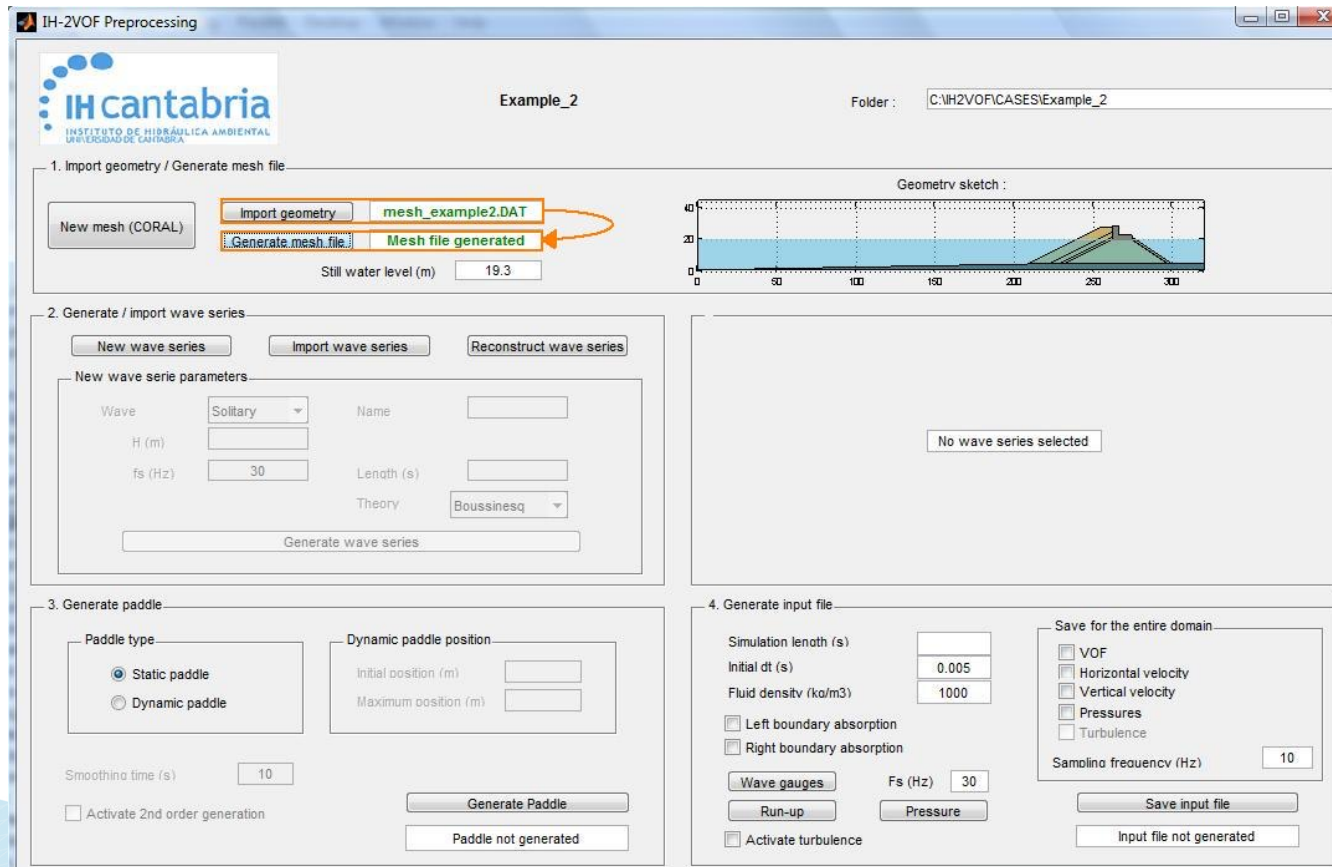
By pressing button “Information”:



SECTION 1 : “IMPORT GEOMETRY/GENERATE MESH FILE”

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

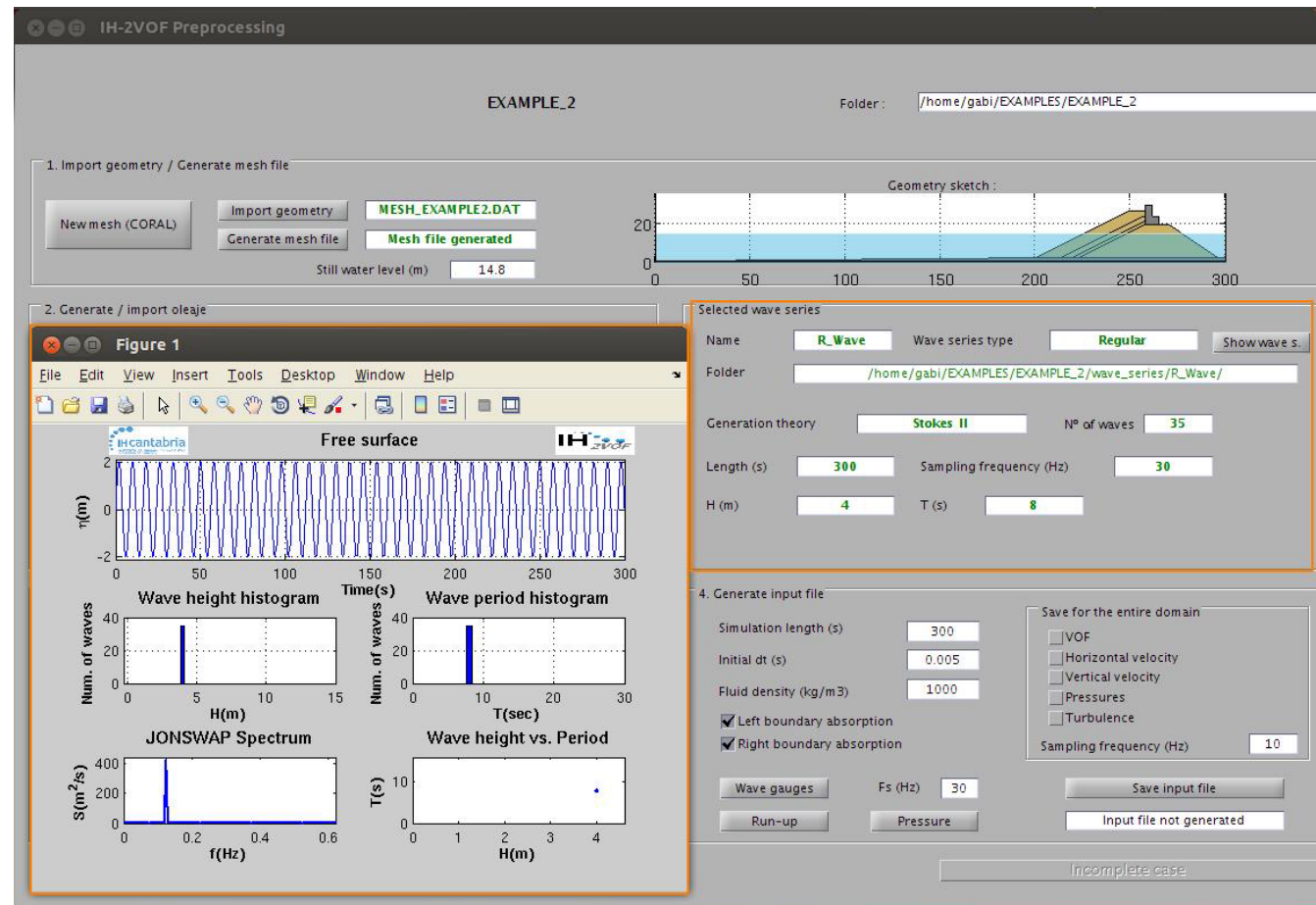
-Mesh characteristics are exported to a **“Mesh.mesh”**



SECTION 2 : “GENERATE/IMPORT WAVE CONDITIONS”

- Wave series: Regular
- H = 10 m high
- T = 14 s
- Time series 200 s long
- Stokes V

Generate wave series



The screenshot displays the IH-2VOF Preprocessing software interface for 'EXAMPLE_2'. The main window shows a 'Geometry sketch' of a coastal structure. A 'Figure 1' window is open, displaying several plots: 'Free surface' (a time-series plot of water surface elevation η (m) vs Time(s)), 'Wave height histogram' (a bar chart of wave heights), 'Wave period histogram' (a bar chart of wave periods), 'JONSWAP Spectrum' (a plot of spectral density S (m²/s) vs frequency f (Hz)), and 'Wave height vs. Period' (a scatter plot of wave height H(m) vs period T(s)).

The 'Selected wave series' panel on the right is highlighted with an orange border and contains the following settings:

- Name: **R_Wave**
- Wave series type: **Regular**
- Folder: **/home/gabi/EXAMPLES/EXAMPLE_2/wave_series/R_Wave/**
- Generation theory: **Stokes II**
- N° of waves: **35**
- Length (s): **300**
- Sampling frequency (Hz): **30**
- H (m): **4**
- T (s): **8**

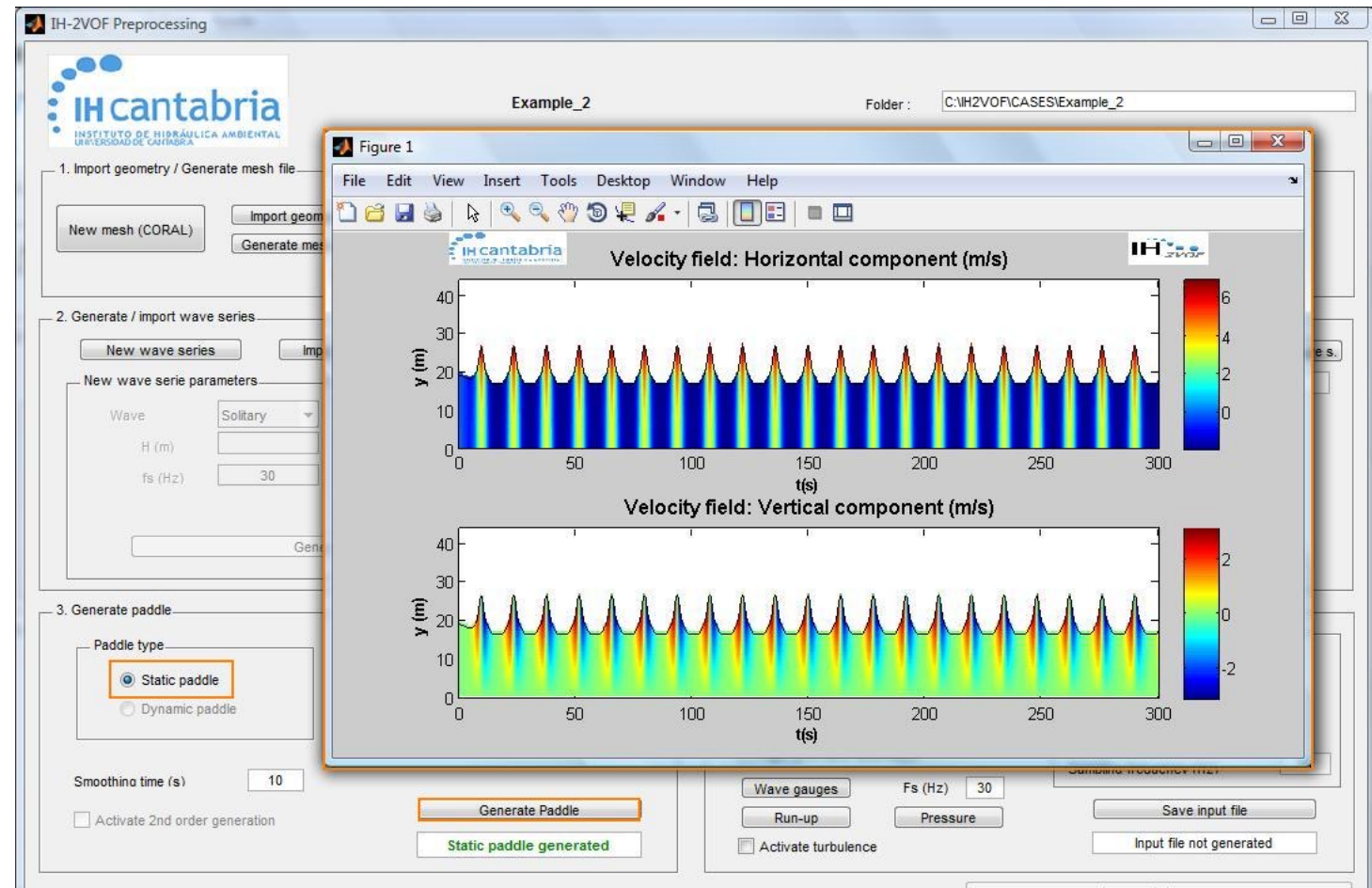
The '4. Generate input file' panel at the bottom right shows simulation parameters:

- Simulation length (s): **300**
- Initial dt (s): **0.005**
- Fluid density (kg/m³): **1000**
- Left boundary absorption
- Right boundary absorption
- Save for the entire domain:
 - IVOF
 - Horizontal velocity
 - Vertical velocity
 - Pressures
 - Turbulence
- Sampling frequency (Hz): **10**

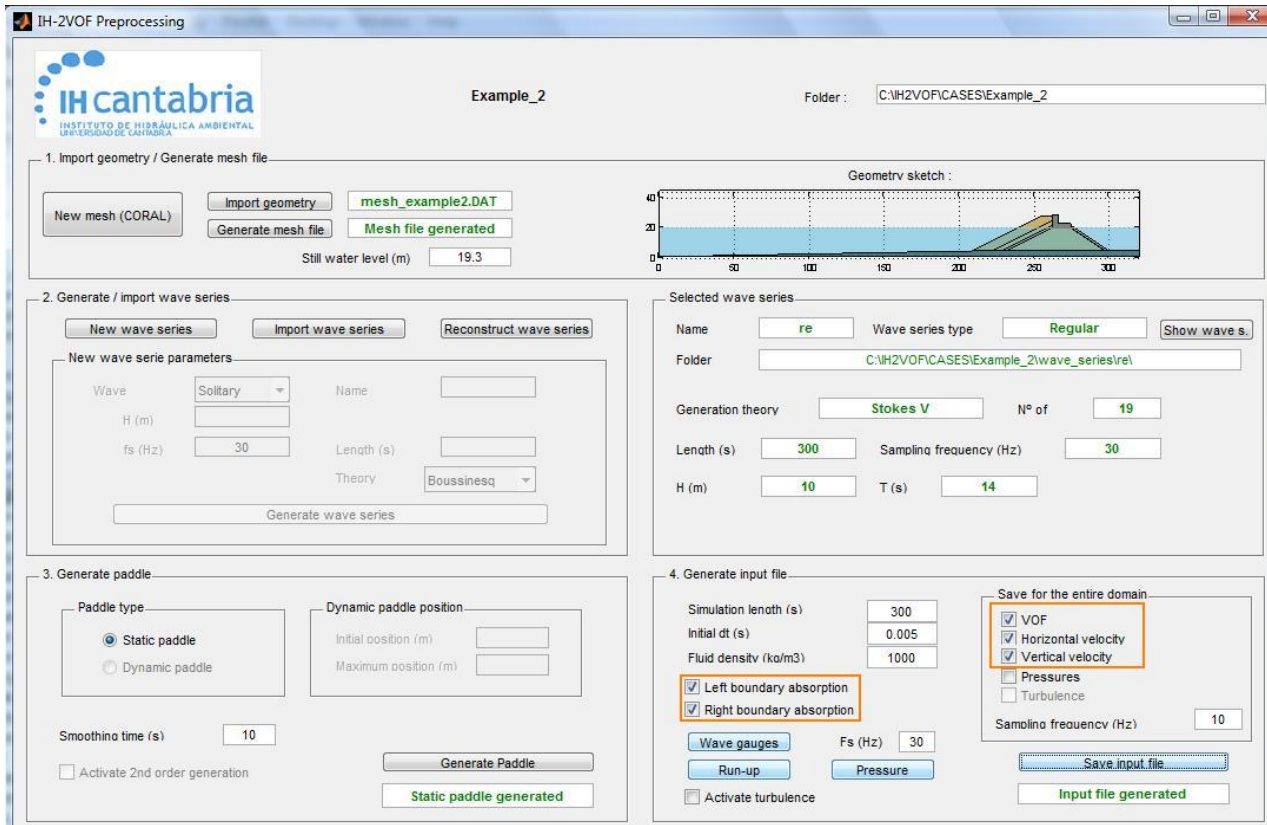
Buttons for 'Wave gauges', 'Fs (Hz) 30', 'Run-up', 'Pressure', and 'Save input file' are visible. The status at the bottom indicates 'Input file not generated' and 'Incomplete case'.

SECTION 3 : “GENERATE PADDLE”

-Static wave paddle



SECTION 4 : “GENERATE INPUT FILE”



The screenshot shows the 'IH-2VOF Preprocessing' software interface. The window title is 'IH-2VOF Preprocessing'. The main area is divided into four sections:

- 1. Import geometry / Generate mesh file:** Includes buttons for 'New mesh (CORAL)', 'Import geometry', 'Generate mesh file', and 'Reconstruct wave series'. A 'Still water level (m)' field is set to 19.3. A 'Geometry sketch' plot shows a cross-section of a structure with a water level.
- 2. Generate / import wave series:** Includes buttons for 'New wave series', 'Import wave series', and 'Reconstruct wave series'. A 'New wave series parameters' section has 'Wave' set to 'Solitary', 'Name' empty, 'H (m)' empty, 'fs (Hz)' set to 30, 'Length (s)' empty, and 'Theory' set to 'Boussinesq'. A 'Selected wave series' section has 'Name' set to 're', 'Wave series type' set to 'Regular', 'Folder' set to 'C:\IH2VOF\CASES\Example_2\wave_series\re', 'Generation theory' set to 'Stokes V', 'N° of' set to 19, 'Length (s)' set to 300, 'Sampling frequency (Hz)' set to 30, 'H (m)' set to 10, and 'T (s)' set to 14.
- 3. Generate paddle:** Includes 'Paddle type' (Static paddle selected) and 'Dynamic paddle position' (Initial position (m) and Maximum position (m) empty). A 'Smoother time (s)' field is set to 10. A 'Generate Paddle' button and 'Static paddle generated' status are present.
- 4. Generate input file:** Includes 'Simulation length (s)' set to 300, 'Initial dt (s)' set to 0.005, 'Fluid density (kg/m3)' set to 1000, 'Left boundary absorption' checked, 'Right boundary absorption' checked, 'Wave gauges' button, 'Run-up' button, 'Pressure' button, 'Activate turbulence' checkbox, 'Save for the entire domain' section (VOF, Horizontal velocity, and Vertical velocity checked), 'Sampling frequency (Hz)' set to 10, 'Save input file' button, and 'Input file generated' status.

- Simulation length = 200 s

- Initial dt = 0.005 s (por defecto)

- Left and right boundary absorption are activated

- VOF, horizontal and vertical velocity fields are saved

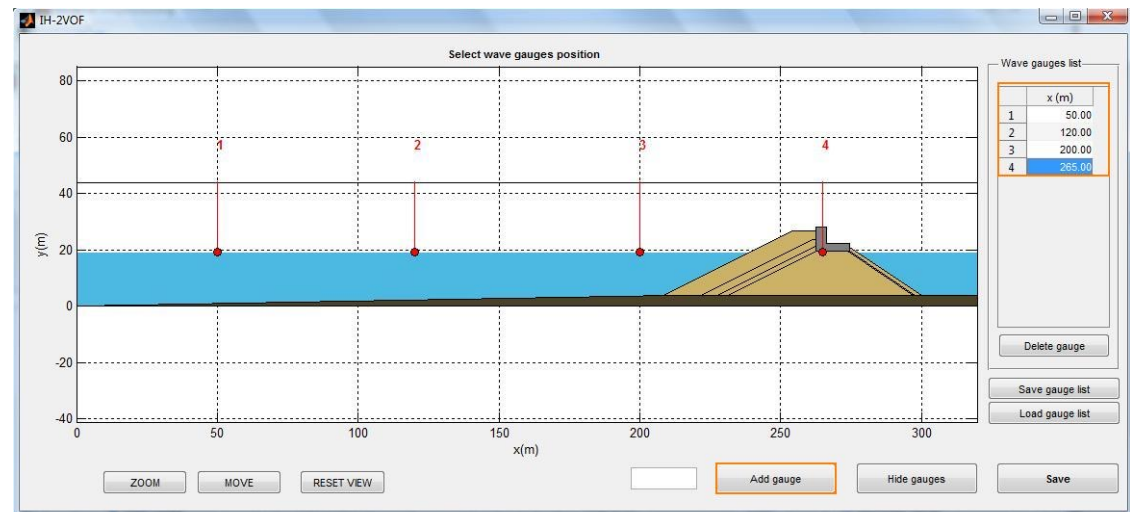
SECTION 4 : “GENERATE INPUT FILE” – *Wave gauges*

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

Gauge	X(m)
1	50
2	120
3	200
4	265

Press the button *Wave gauges - Add gauge*

Gauges positions are specified

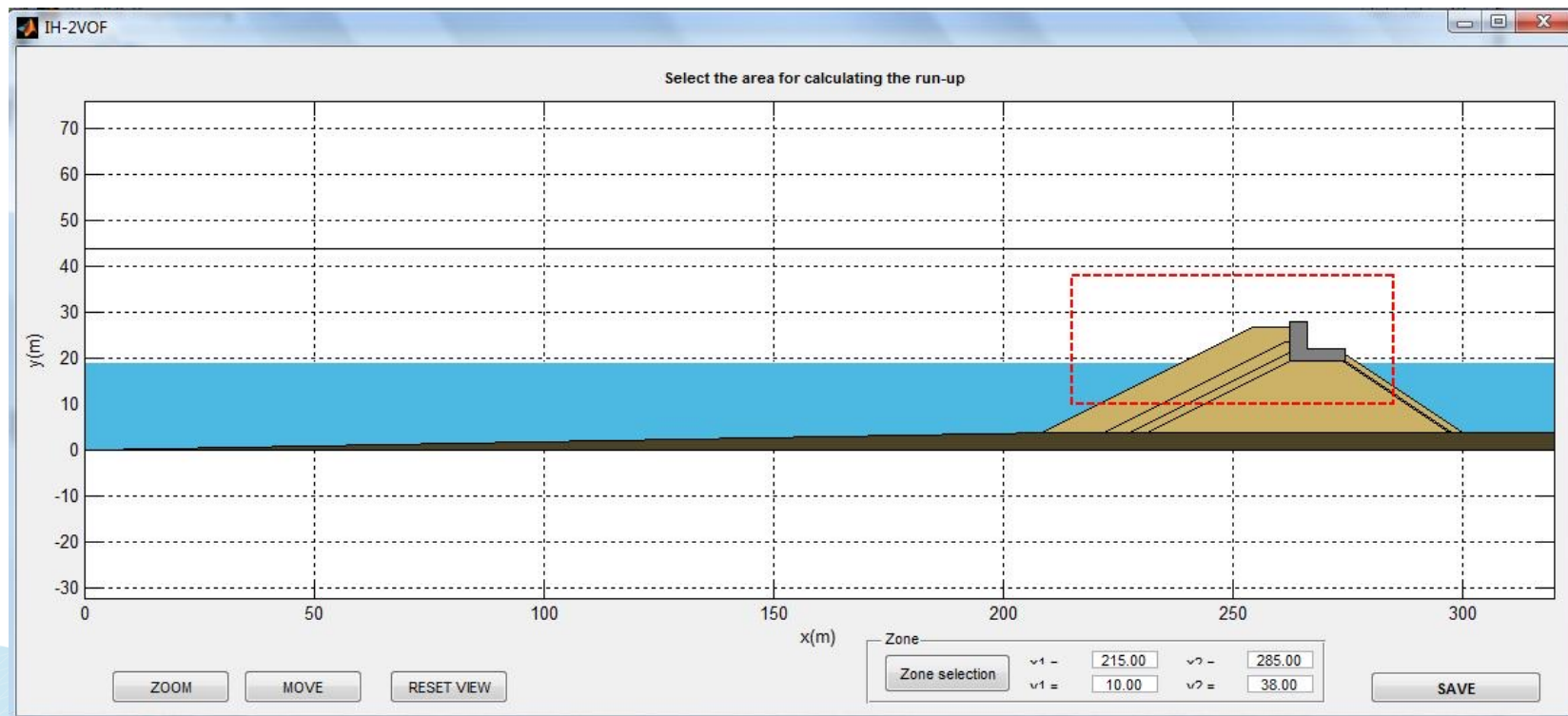


SECTION 4 : “GENERATE INPUT FILE” – *Run-up*

Press the button

Run-up

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

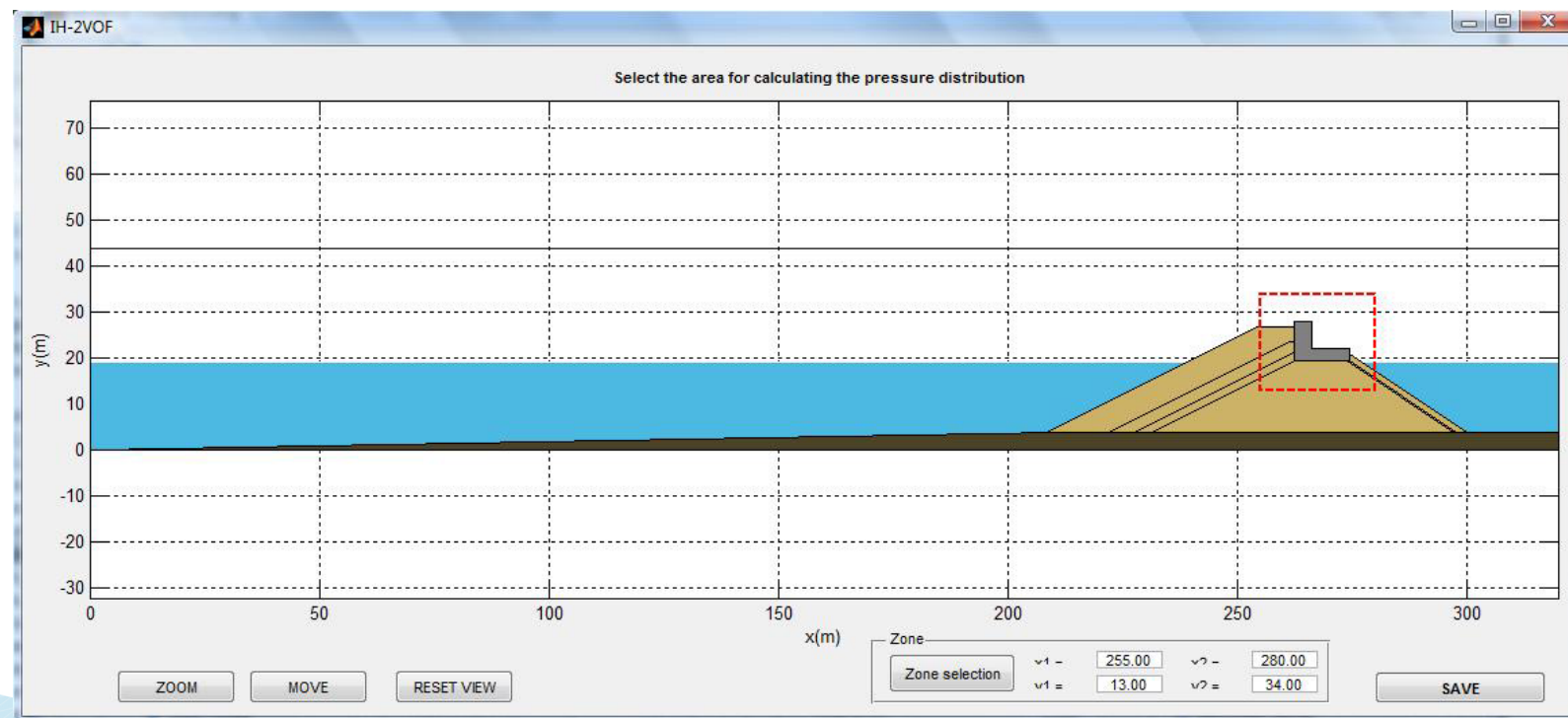


SECTION 4 : “GENERATE INPUT FILE” – *Pressure*

Press the button

Pressure

The area where pressure is calculated is selected specifying two vertices

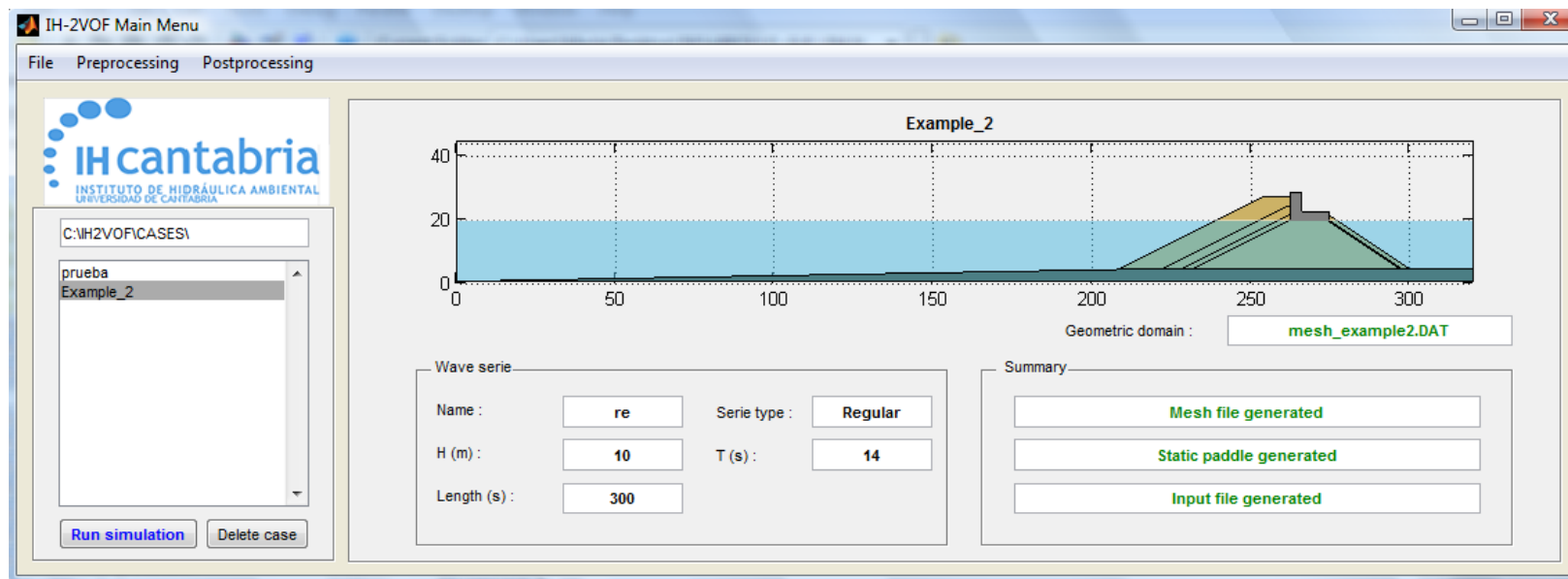


SUMMARY

All the variables are defined

The input file is saved

→ the case is ready to be simulated



The simulation which will starts by pressing the button

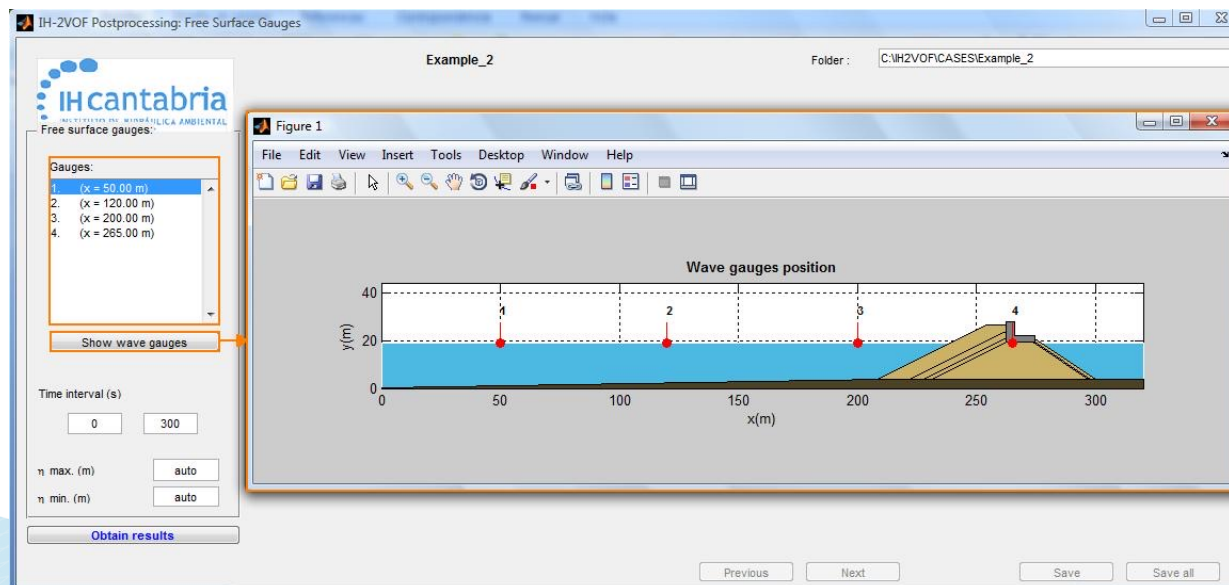
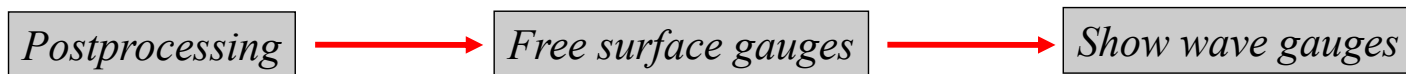
Run simulation

POSTPROCESSING

In the present example different aspects are analyzed:

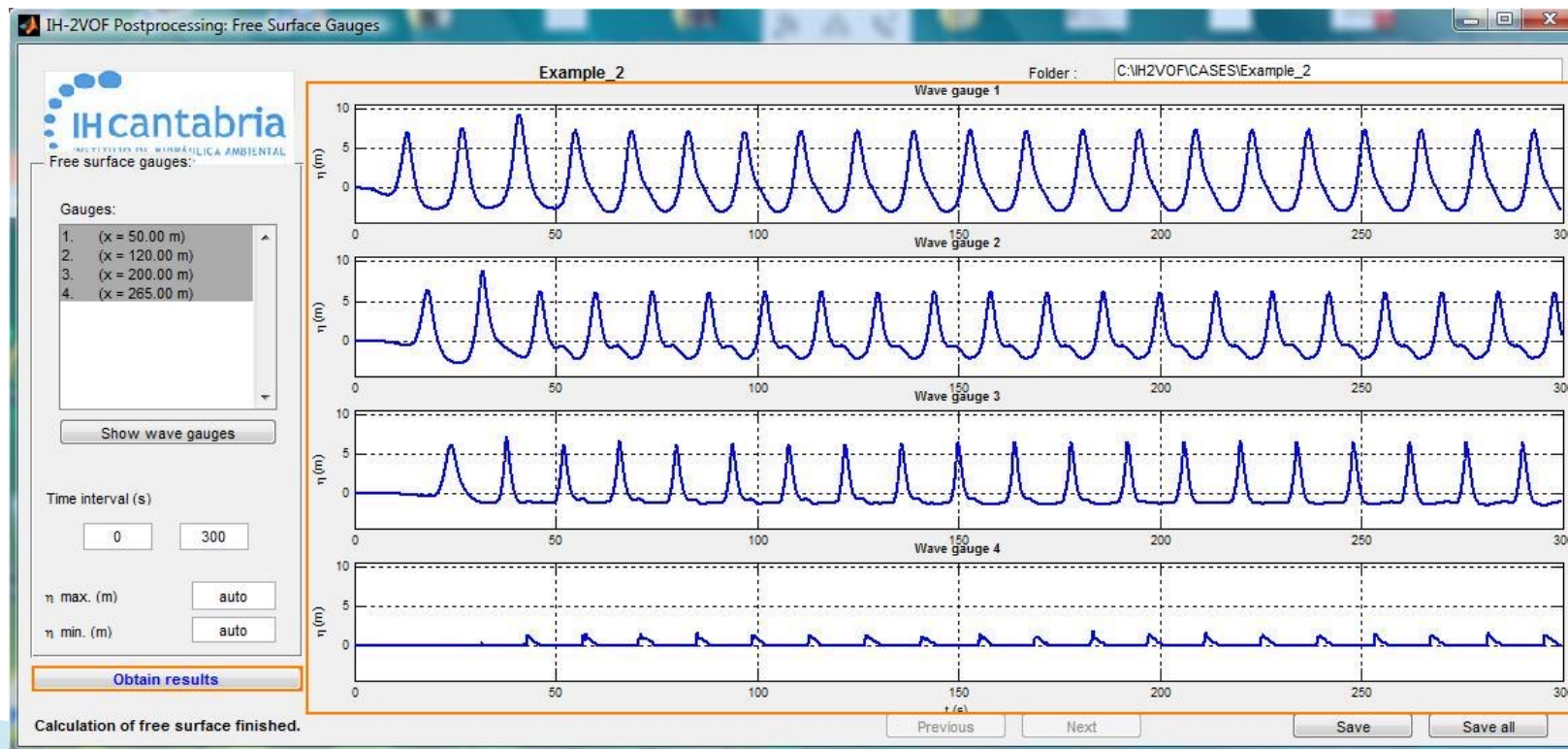
- Free surface evolution
- The energy spectra evolution
- The run-up
- The overtopping
- Pressure around the crown-wall
- Visual analysis

WAVE GAUGES – Time series



WAVE GAUGES – Time series

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



WAVE GAUGES – Spectra

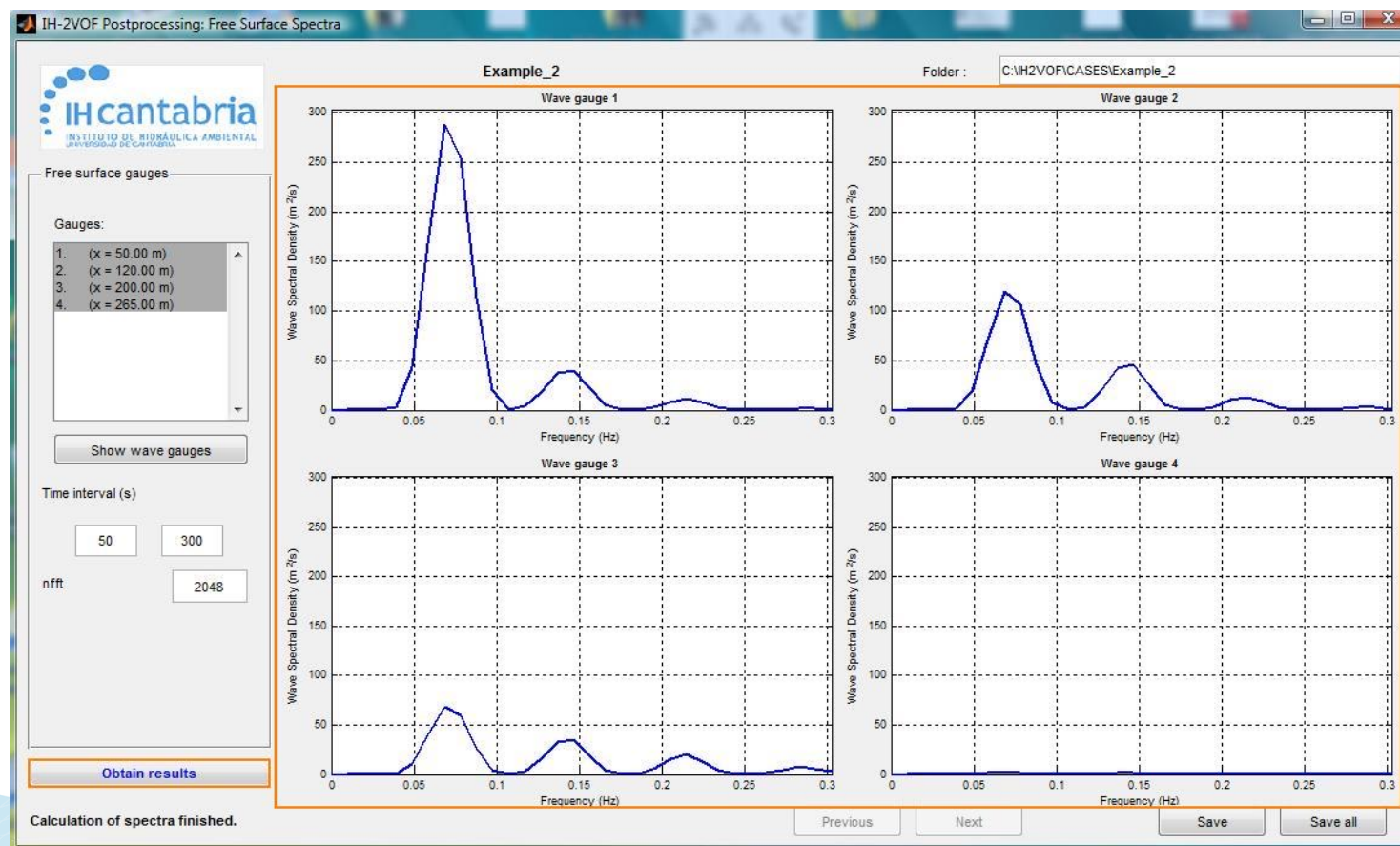
- Energy spectra associated to each one of the selected gauges before the simulation can be obtained

Postprocessing

Free surface gauges

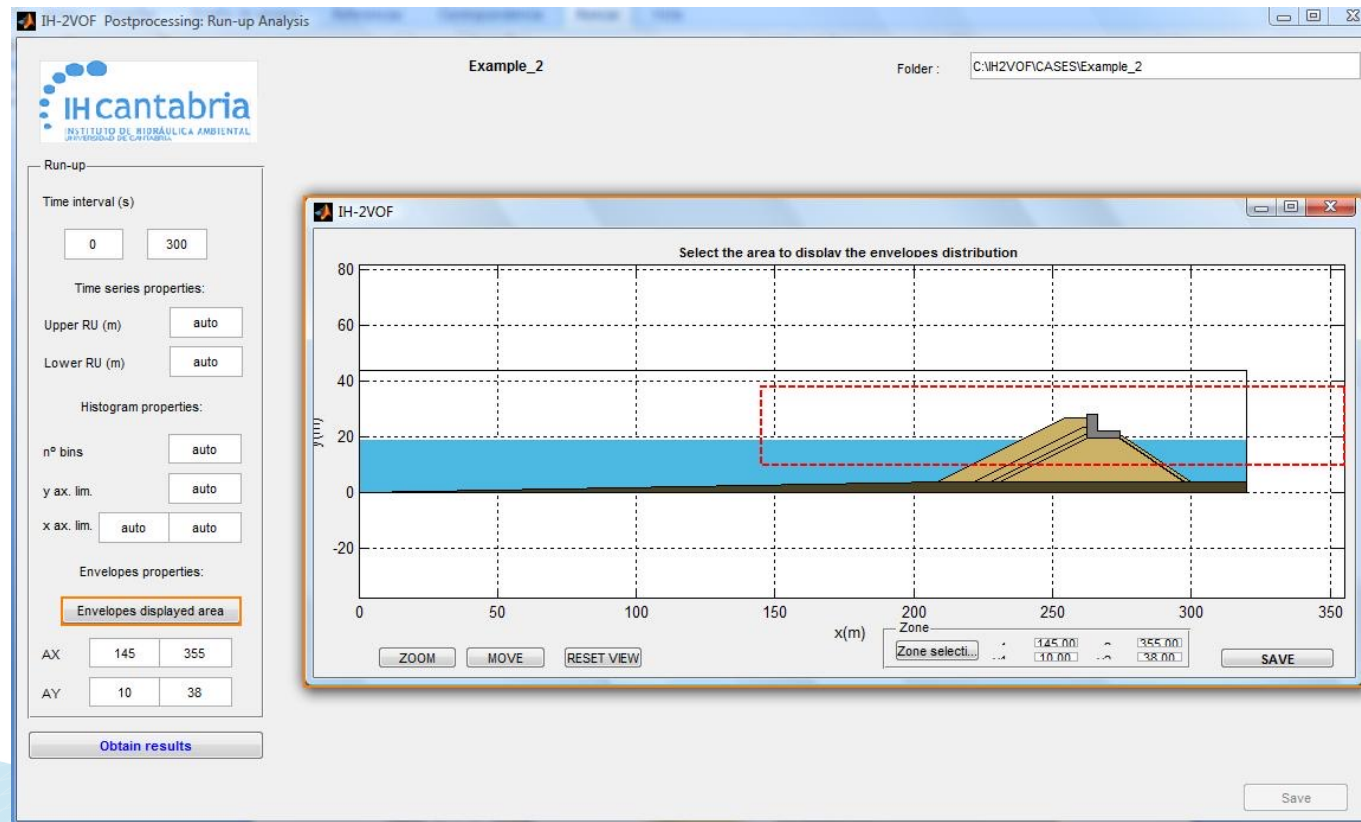
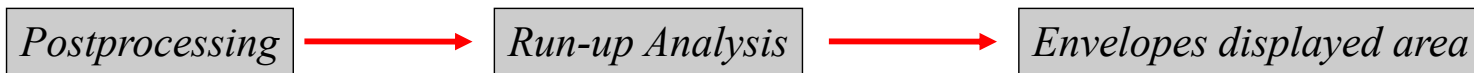
Spectra

Obtain results



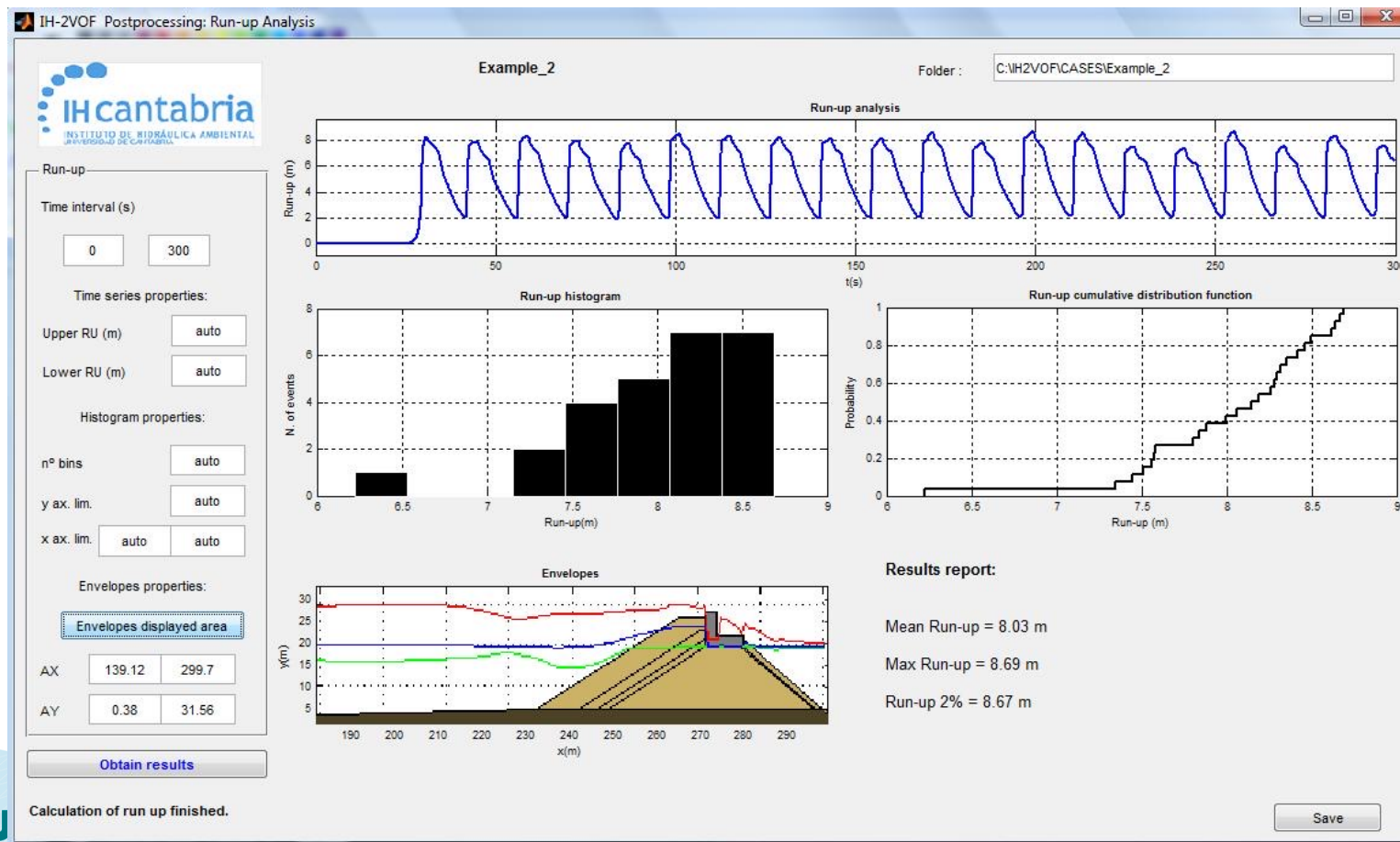
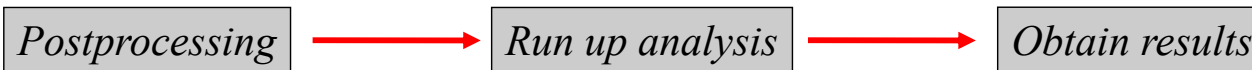
RUN UP – Envelopes displayed area

- The run up produced over the structure can be calculated.



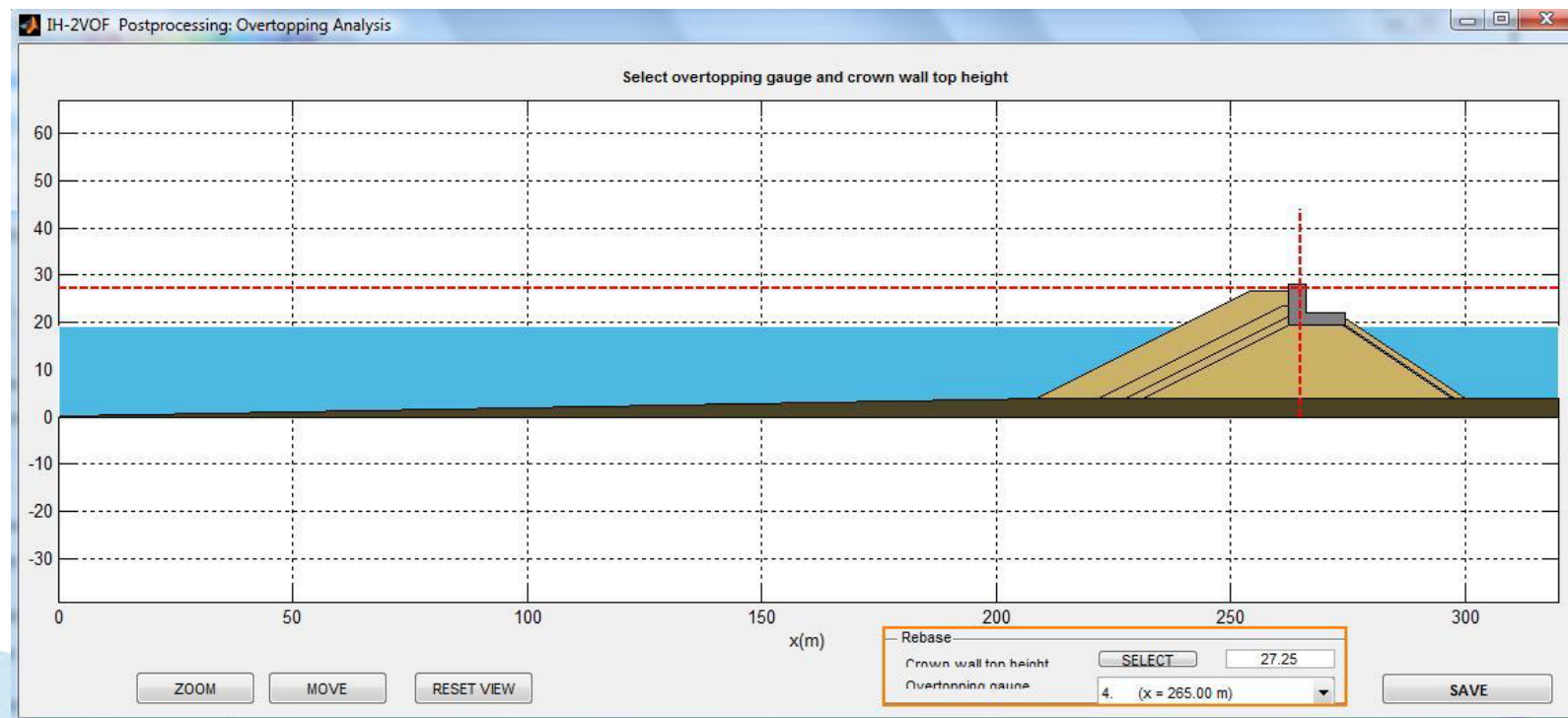
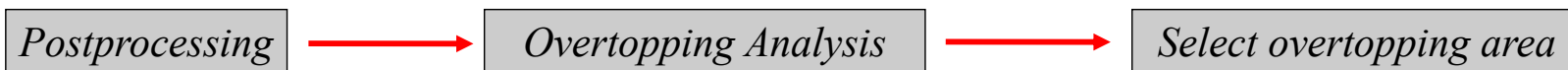
RUN UP – Obtain results

- Run up results shows the run up time series in which the scale can be chosen.



OVERTOPPING– Select overtopping area

- The overtopping produce over the structure is analyzed.
- The gauge where the overtopping is calculated is selected as well as the crown wall top height, as is shown in Figure .

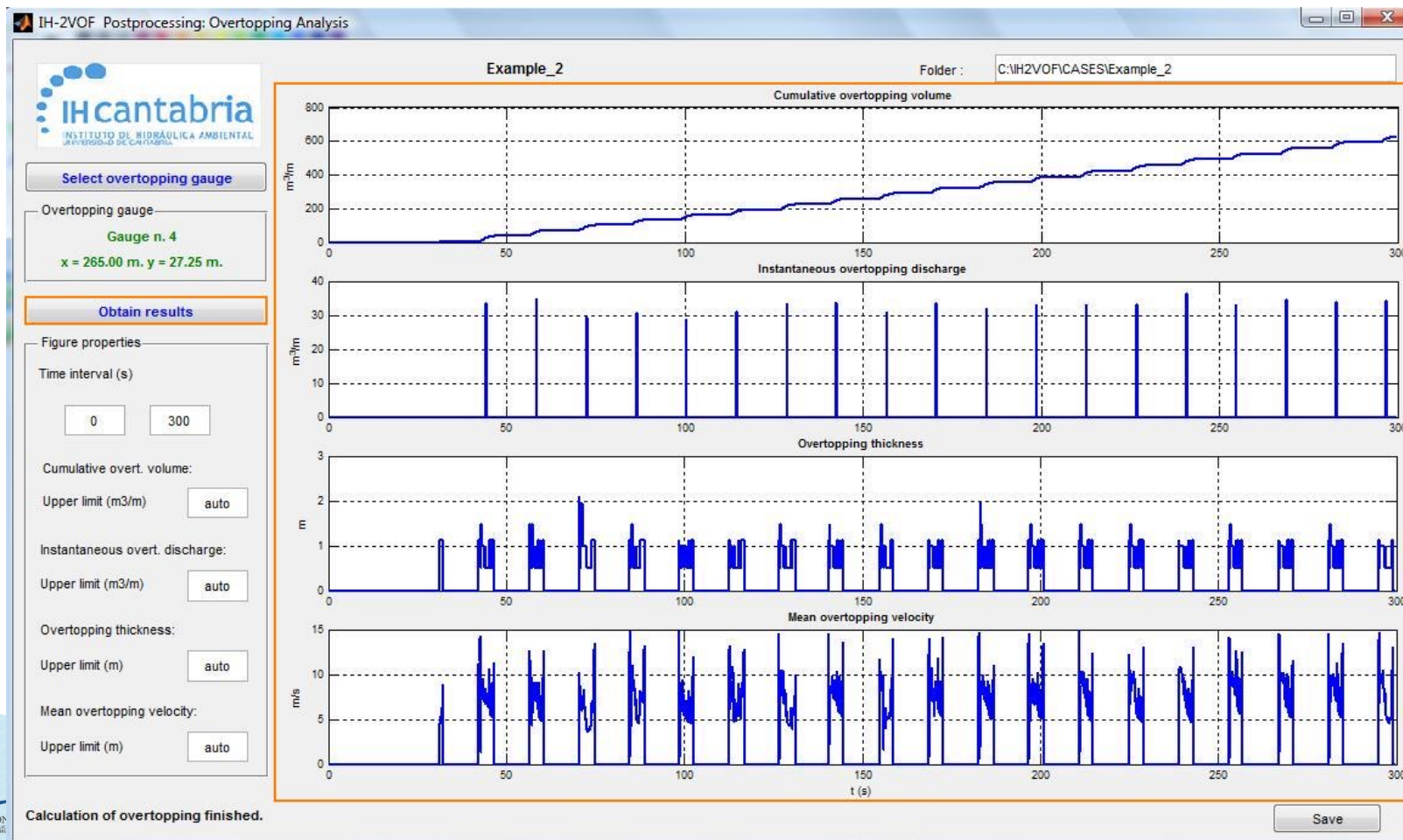


OVERTOPPING– Obtain results

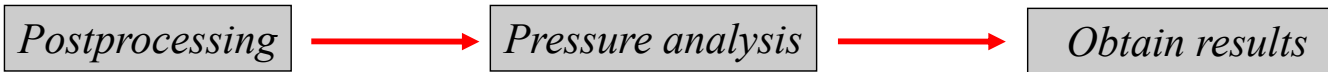


Pressing the button *Obtain results*:

- The cumulative overtopping volume.
- The instantaneous overtopping discharge.
- Overtopping thickness and the mean overtopping velocity



PRESSURE– Obtain results



Example_2 Folder: C:\IH2VOFCASES\Example_2

Dynamic load: Seawards
 FH(kN/m) vs t(s)

Dynamic load: Underneath
 FH(kN/m) vs t(s)

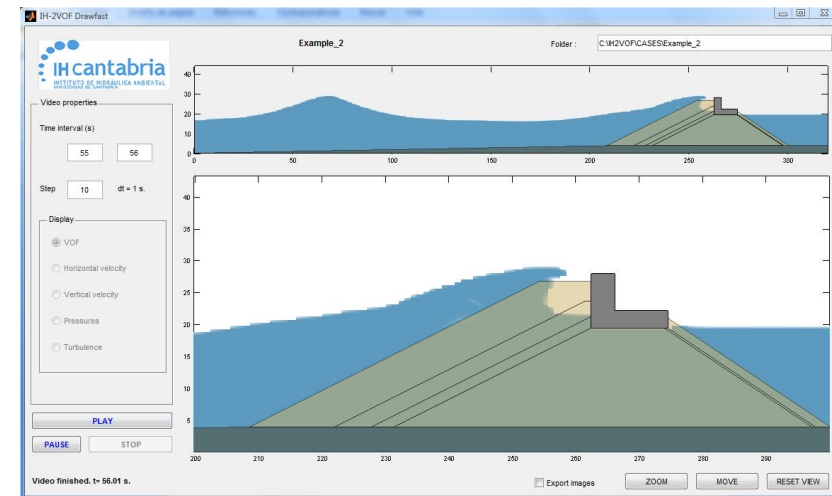
Pressure distribution. t = 253.3995 s
 y(m) vs x(m)

Results report:
 Maximum horizontal force = 844.63 kN/m
 Maximum vertical force = 569.97 kN/m
 Max. momentum due to hor. forces = 2788.41 kN*m/m
 Max. momentum due to vert. forces = 4271.16 kN*m/m

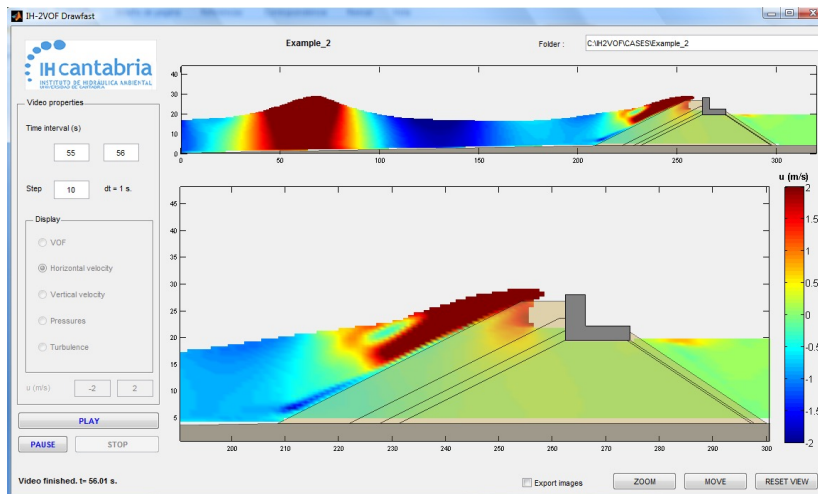
Save pressure distribution Save

DRAWFAST

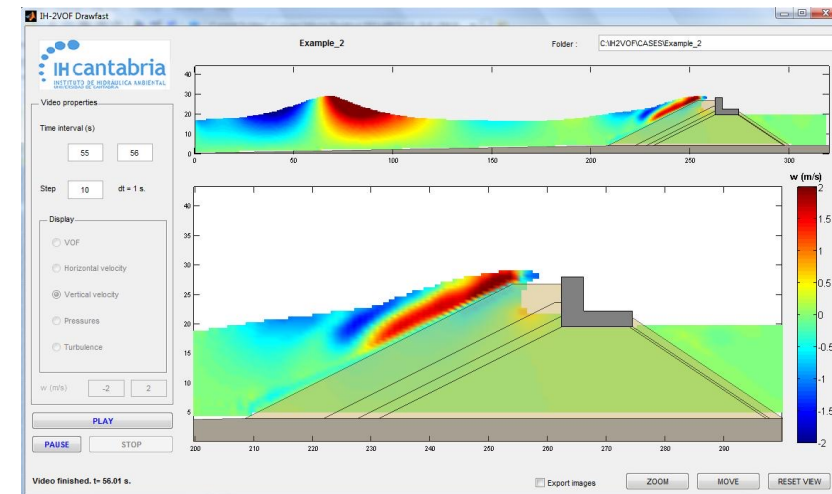
- A video of the different variables chosen before the simulation can be seen.
- Choose the initial time, final time and time step
- The lower panel allows a zoom of the area of interest



VOF drawfast



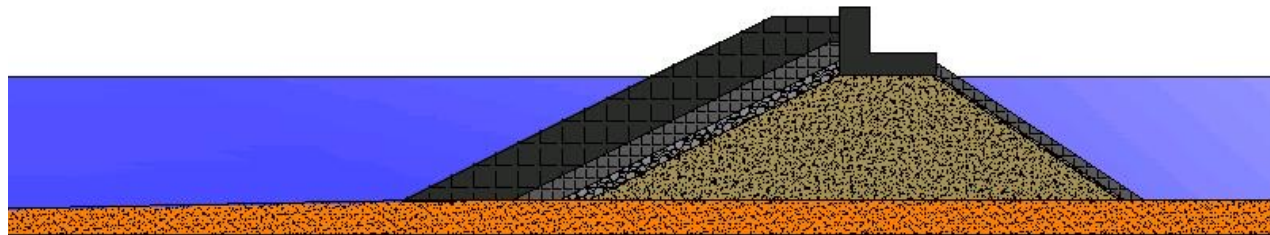
Horizontal Velocity drawfast



Vertical Velocity drawfast

Example 2

Regular wave interaction with a rubble-mound breakwater



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