

IMPLEMENTATION AND VALIDATION OF AN OPERATIONAL FORECASTING SYSTEM FOR NEARSHORE HYDRODYNAMICS WITH OPENCoastS

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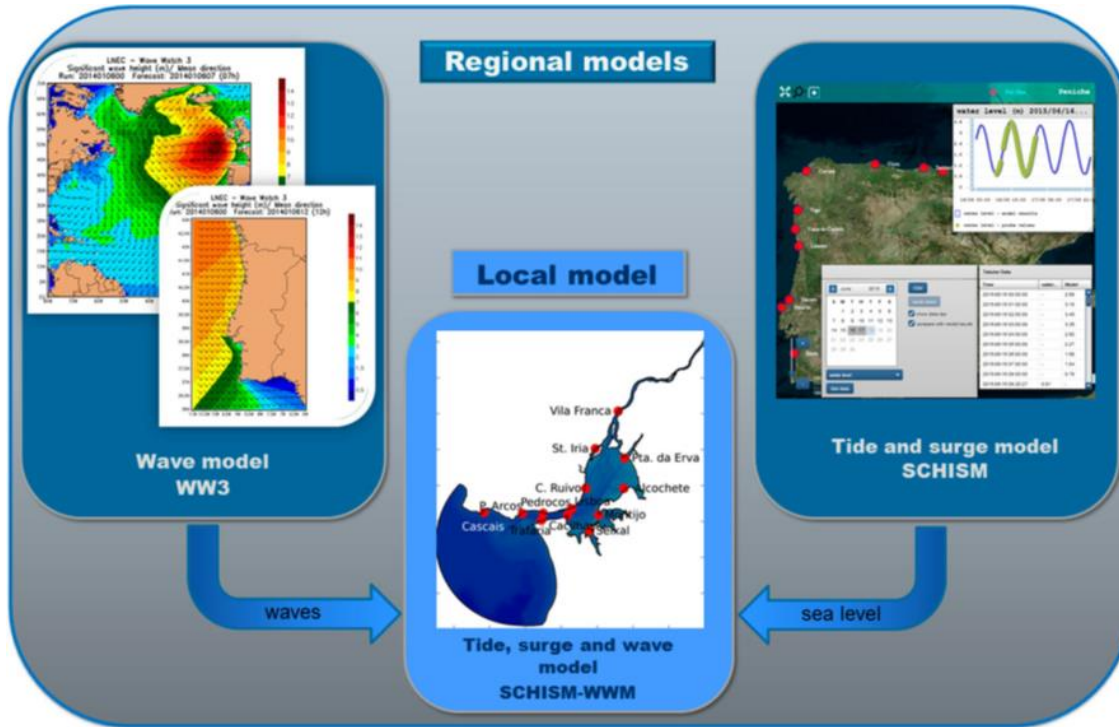
² Universidade de Aveiro, Aveiro, Portugal.

Presentation outline

- Introducing Nearshore Forecasting
 - Aims, solutions and existing services
- The OPENCoastS service
 - On-demand, user-defined forecasting system
- Implementation and validation of OPENCoastS at Cova-Gala beach
 - Grid generation, system configuration and model validation
- Hurricane Epsilon showcase
 - Anticipating the arrival of a massive swell
- Conclusion
 - Incorporating the XBeach model and providing morphodynamic services

Nearshore Forecasting Systems

LNEC's Water Information Forecast Framework



Fortunato *et al.*, 2017 - <http://ariel.lnec.pt/>

- Model architecture to bridge basin scale oceanic and atmospheric prediction with local scale predictions relevant for coastal activities
- Predictions of water levels, flow velocities and wave parameters at the scale of an estuary, a harbour or a beach

Nearshore Forecasting Systems

- *Why:* Safety of coastal communities, Safety and optimisation of navigation routes, Recreational bathing (rip current hazard, surf)... (Aquaculture!)
- *How:* Local-scale surface flow models forced by larger oceanic and atmospheric models
- *Who:* Authorities, Research institutes, Universities (<https://hidrografico.pt/prev.surf> - PT; <https://marc.ifremer.fr/> - FR; <http://ariel.lnec.pt/> - PT; <https://www.channelcoast.org/ccoresources/sweep/> - UK)
- *Advantage:* Maintained by the provider (no maintenance for the user)
- *Drawback:* May not be satisfying in terms of spatial coverage and resolution

The OPENCoastS service



Oliveira *et al.*, 2020 - <https://opencoasts.ncg.ingrid.pt/>

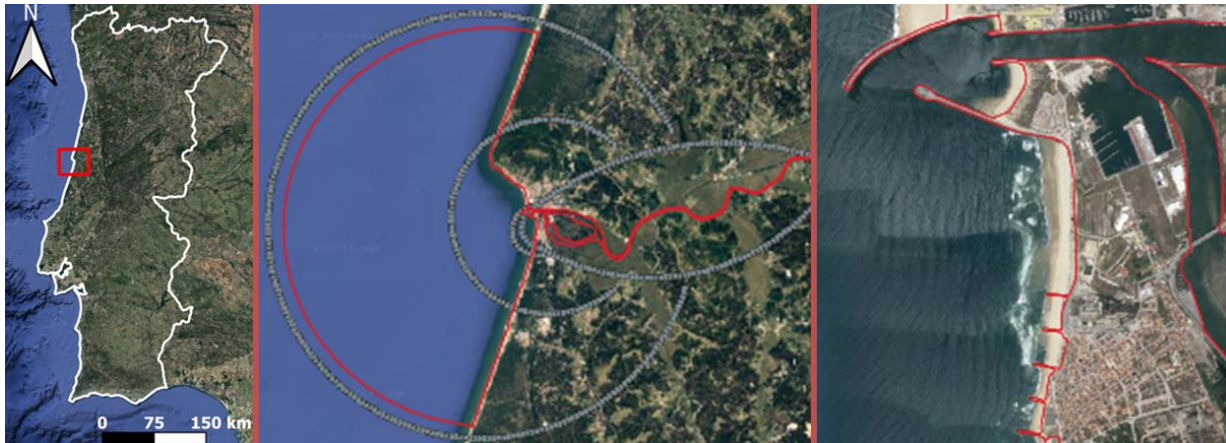
- Free and dematerialized on-demand, service
- User-defined areas and resolution
- Daily forecasts of **water levels**, **currents** and **wave parameters** for 48h
- Based on the **SCHISM** modelling suite
- Limited-to-no user-maintenance

Configuration Assistant

The platform provides a Configuration Assistant for the assembly of the forecast systems. The following steps are part of the Configuration Assistant for forecasts based on the SCHISM Model:

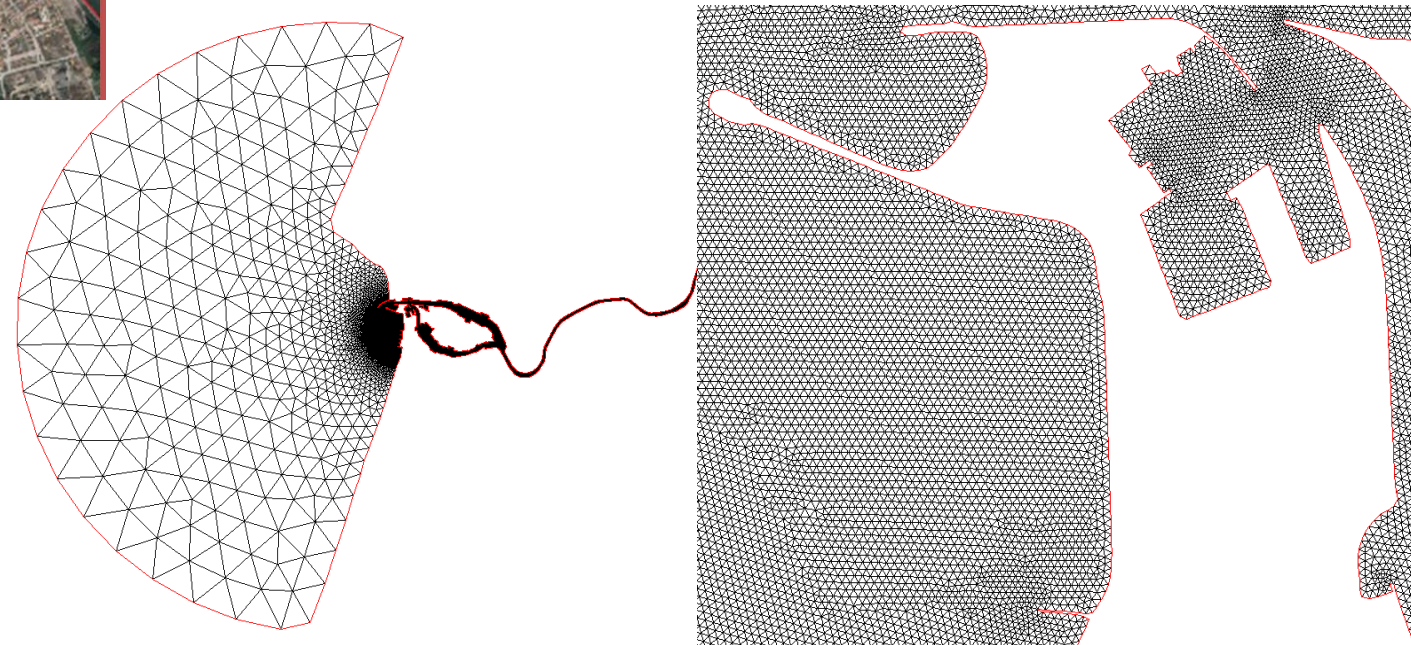


Cova-Gala test case: grid



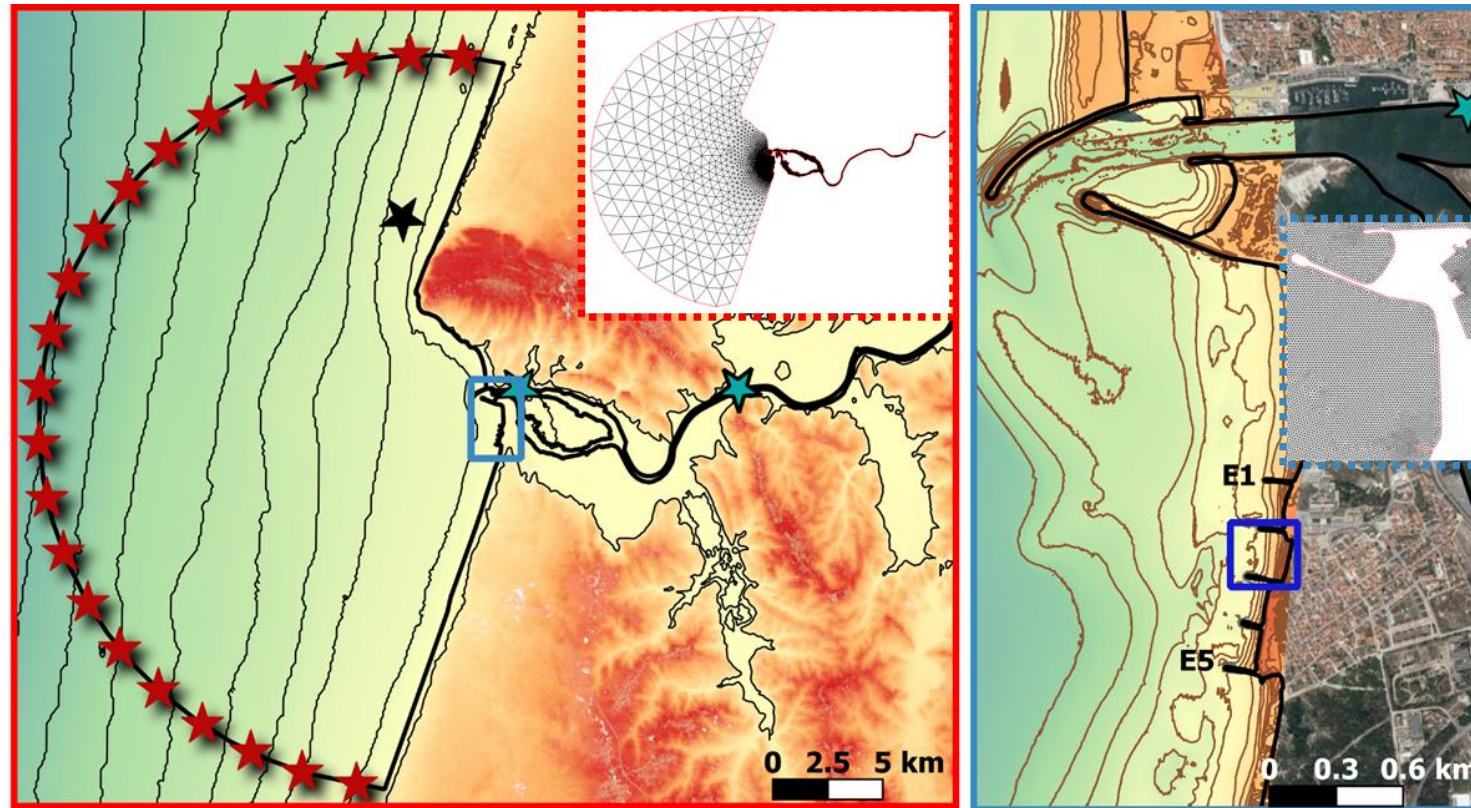
- Boundaries drawn with **QGIS**
- Unstructured-grid created with the plugin **GMSH** and edited with **nicegrid4** (49684 nodes - 94892 elements)

"hgrid.gr3" ←
Sole and unique required input!



Cova-Gala test case: bathy

- *hgrid.gr3* bathymetry interpolated from EMODNET and COSMO 2019



Cova-Gala test case: configuration assistant

Configuration Assistant

New System

Save

Step 1

Step 2

Step 3

Step 4

Step 5

Step 6

Step 7

Model

Domain

Boundaries

Stations

Parameters

Additional Data

Submission

Select Model

?

!

This Configuration Assistant aims to set up a forecast system on demand in an area chosen by the user. In this step the user will choose the run type, the model to use and the daily forecast range. 3D run types are only available to users with advanced permissions.

Select run type:

☐ 2D Barotropic

☐ 3D Baroclinic

☒ 2D Waves & currents

Select a model (*):

SCHISM-v5.4.1

▼

Select a period (*):

48h

▼

Cova-Gala test case: configuration assistant

Configuration Assistant

[New System](#)[Save](#)

Step 1

Step 2

Step 3

Step 4

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Step 6

Step 7

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Upload Grid

[?](#)[i](#)

In this step the user has to provide the computational grid for the forecast in the format adequate to the model chosen in the previous step. This grid will represent the geographical domain of study. The user must also indicate the horizontal and vertical coordinate system of the grid.

→ Select a horizontal grid (*):

Browse...

hgrid.gr3

Coordinate Reference System for the grid:

or enter an EPSG code (*):

EPSG:3763 | ETRS89 / PT-TM06

3763

Vertical reference of the grid:

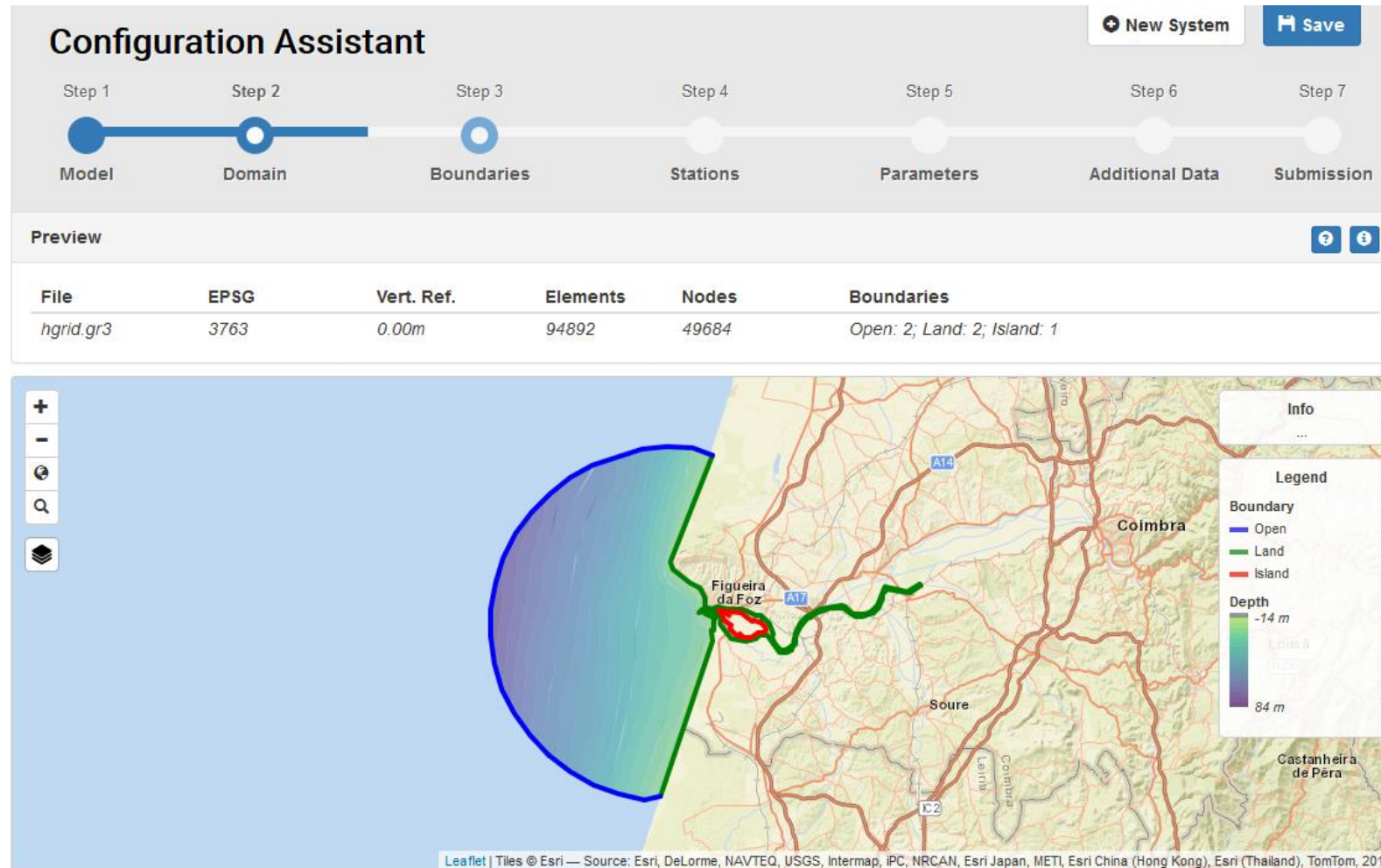
or enter a vertical displacement in meters (*):

0

Calculate a suggestion for the time step (dt):

☐ It may increase significantly the processing time.

Cova-Gala test case: configuration assistant



Cova-Gala test case: configuration assistant

Configuration Assistant

New System

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In this step the user has to define the forcing sources for the ocean, river and atmospheric boundaries, from the available options.

Select one or more boundaries and define their type and forcing condition

ID	Type	Forcing
<input type="checkbox"/> open-1	Ocean	Circulation: FES2014 - Finite Element Solution Waves: North Atlantic WW3
<input type="checkbox"/> open-2	River	annual=5

Define type and forcing condition

+

-

🌐

🔍

📶

Info

...

Legend

Area

na-ww3

cmems-ibi

meteo-fr-arpege_ea

prism2017

Boundary

Open

Forcings for Circulation to apply to all oceans boundaries:

FES2014 - Finite Element Solution

Forcings for Waves to apply to all oceans boundaries:

North Atlantic WW3

Ocean boundaries outside the forcing area will not be considered.

Atmospheric forcing:

GFS - Global Forecast System NOAA/NCEP

Cova-Gala test case: configuration assistant

Configuration Assistant

New System

Save

Step 1

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Define Stations

?

i

In this step the user defines the stations (virtual sensors) in which time series are extracted with full model resolution. These can be locations where real time data is available, (predefined comparison stations) or other places of interest (virtual stations).

Select/Deselect desired stations. You can add new stations by selecting a location on the map or using the button New Station.
Note: If the list is empty at startup this means that there are no observation stations located within the grid domain.

Name	Latitude	Longitude	Comparison
<input checked="" type="checkbox"/> Port Entrance	40.142818	-8.875837	

New Station

+

-

🌐

🔍

📍

📶

Map of Cova-Gala area showing boundaries and stations.

Info

Legend

Boundary

Open

Land

Island

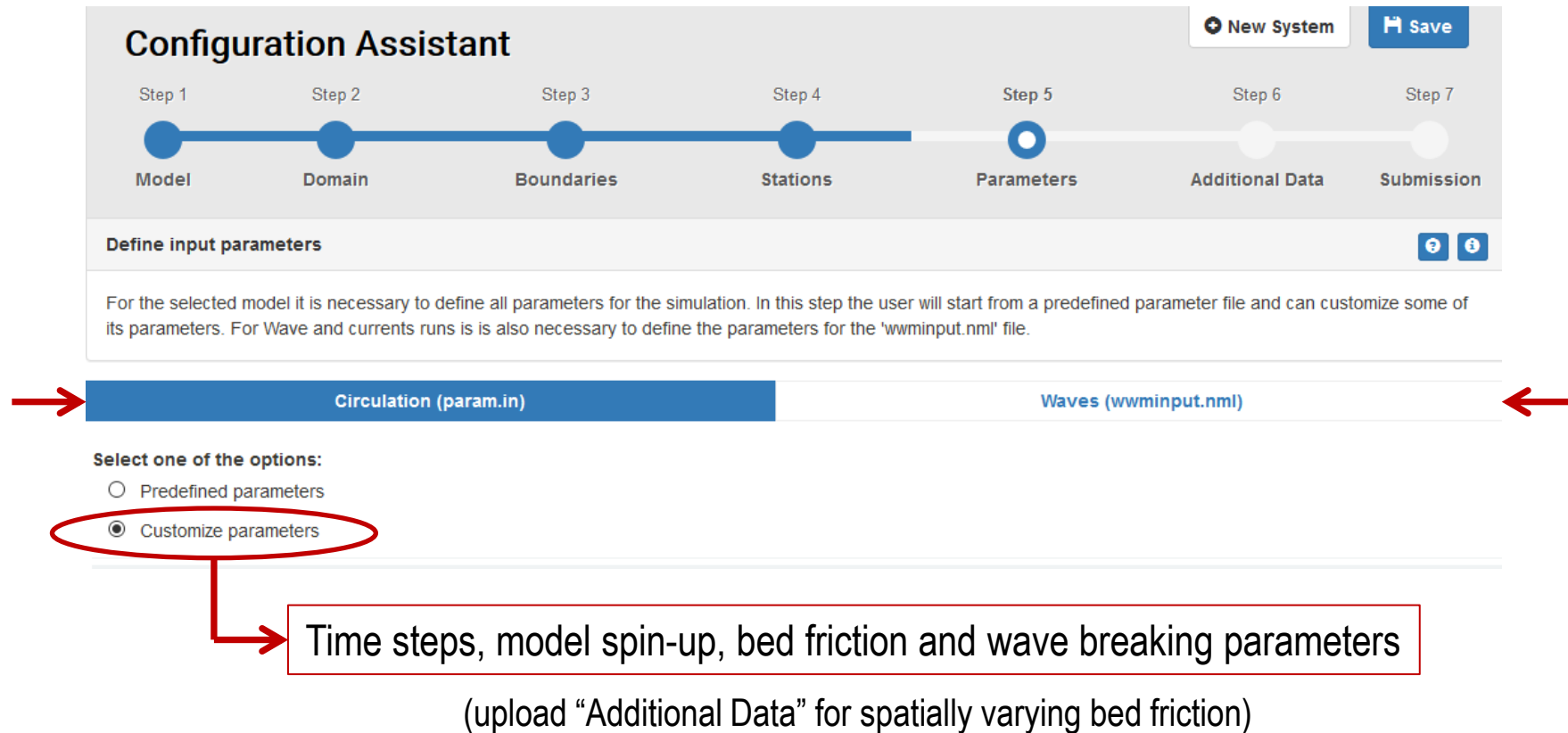
Station

Observation

Comparison

Virtual

Cova-Gala test case: configuration assistant



Configuration Assistant New System Save

Step 1 Step 2 Step 3 Step 4 Step 5 Step 6 Step 7

Model Domain Boundaries Stations Parameters Additional Data Submission

Define input parameters ? !

For the selected model it is necessary to define all parameters for the simulation. In this step the user will start from a predefined parameter file and can customize some of its parameters. For Wave and currents runs is is also necessary to define the parameters for the 'wwminput.nml' file.

Circulation (param.in) **Waves (wwminput.nml)**

Select one of the options:

☐ Predefined parameters

☒ Customize parameters

Time steps, model spin-up, bed friction and wave breaking parameters
(upload "Additional Data" for spatially varying bed friction)

Cova-Gala test case: configuration assistant

Configuration Assistant

[New System](#)[Save](#)

Step 1

Step 2

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Step 5

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Model

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Submission

Submit Forecast System

[?](#)[i](#)

Confirm the selected configurations and activate the forecast system.

Summary

1 Model

2 Domain

3 Boundaries

4 Stations

5 Parameters

6 Additional Data

Submit

Name (*):
Cova-Gala

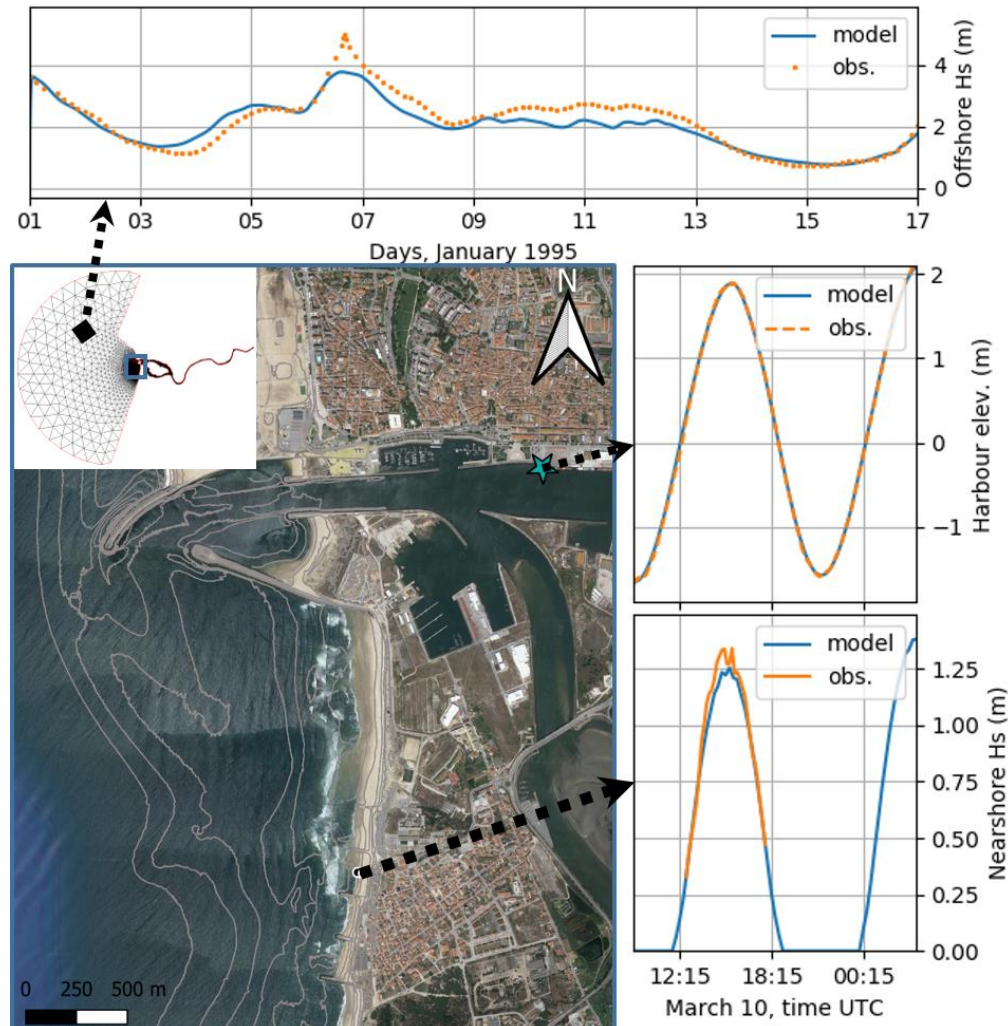
Description:
Nearshore forecast of Figueira da Foz harbor entrance

☒ I Accept [Terms and conditions of use](#)

[Activate System](#)

Forecast created!

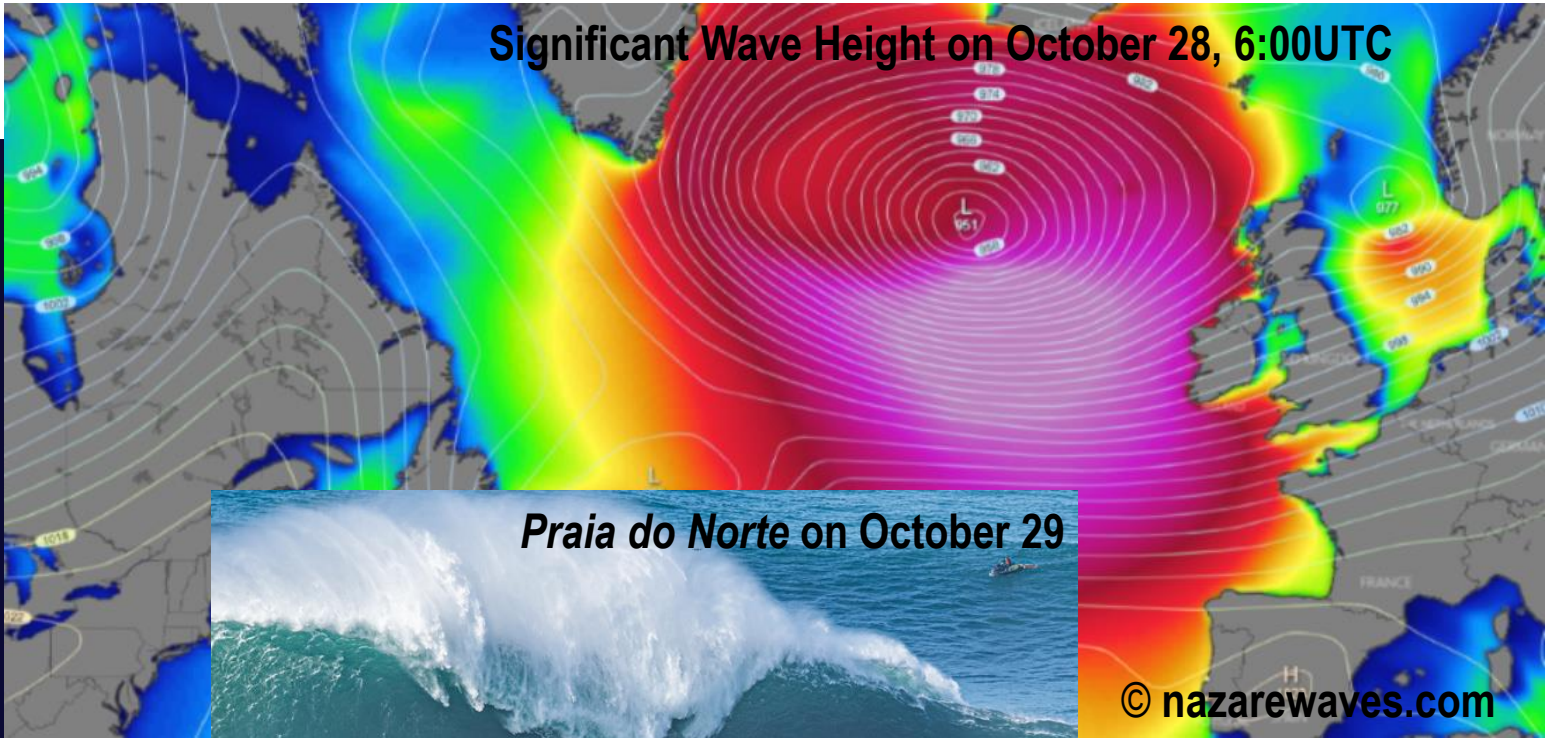
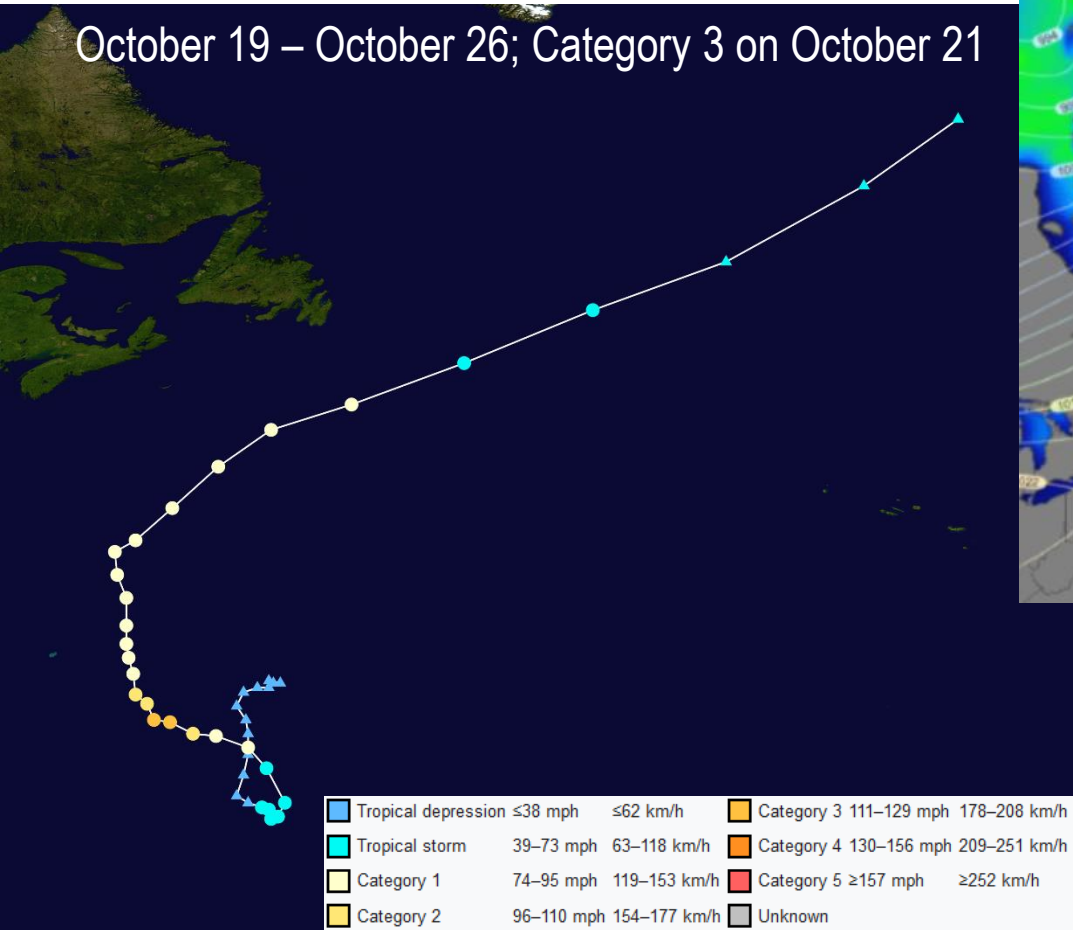
Cova-Gala test case: model validation



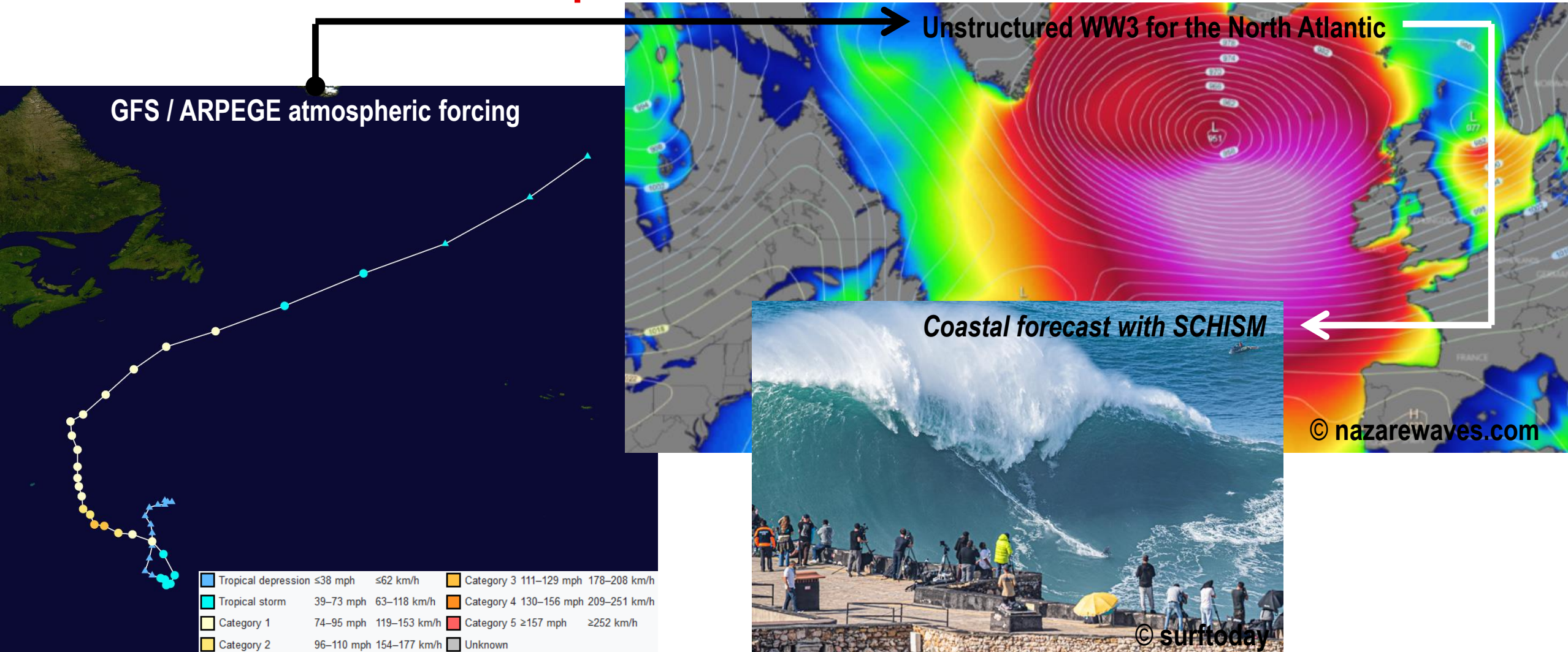
	Hs (m)		Elevation (m)	
	Bias	Drms	Bias	Drms
Offshore buoy	-0.53	0.77	-	-
IH Tide Gauge	-	-	-0.01	0.04
Nearshore PT	-0.04	0.06	0.26	0.26

(Manning's $n = 0.023 \text{ m}^{-1/3} \cdot \text{s}$; Gamma = 0.68)

Hurricane Epsilon across the North Atlantic (October 2020)

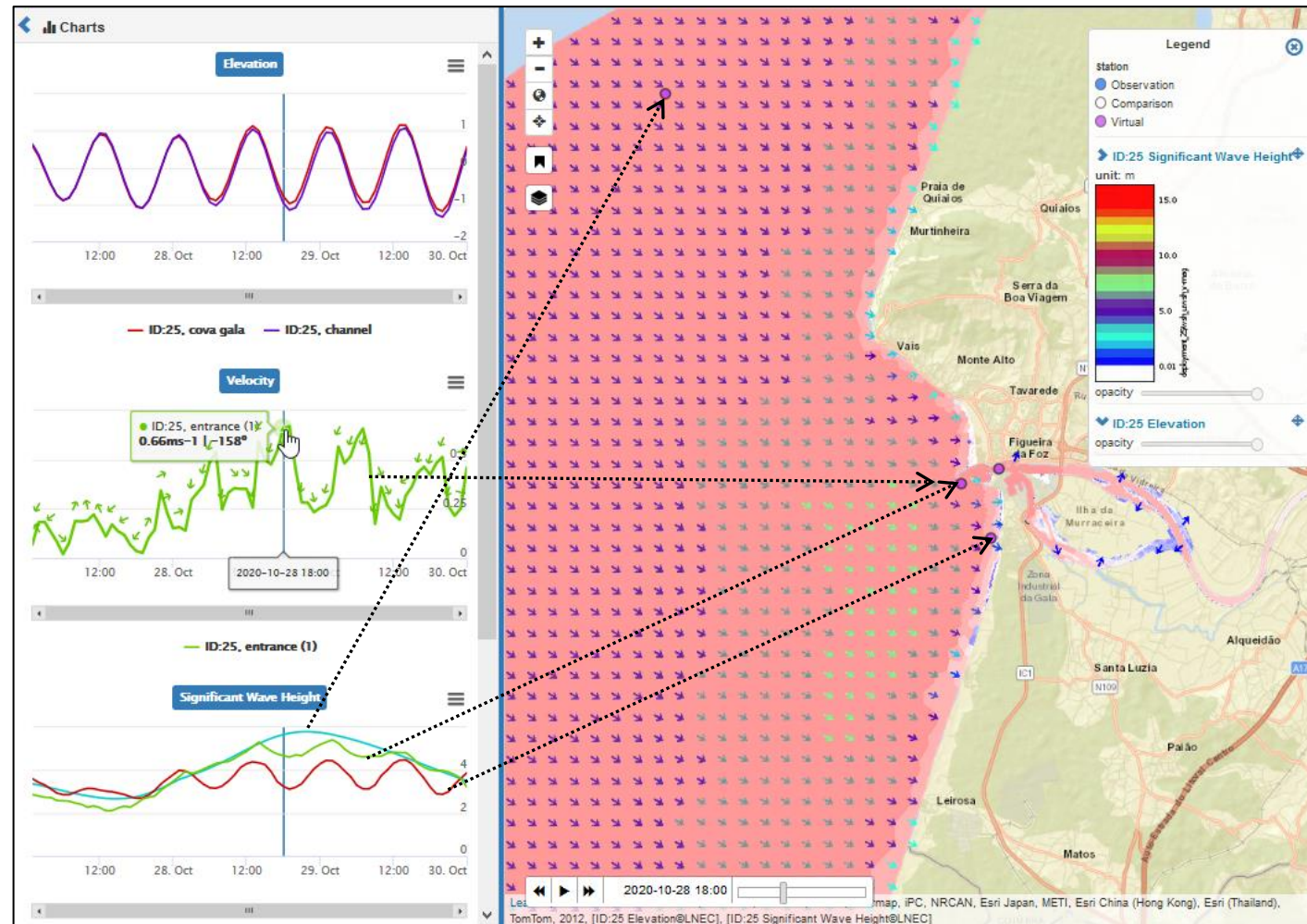


Hurricane Epsilon within OPENCoastS



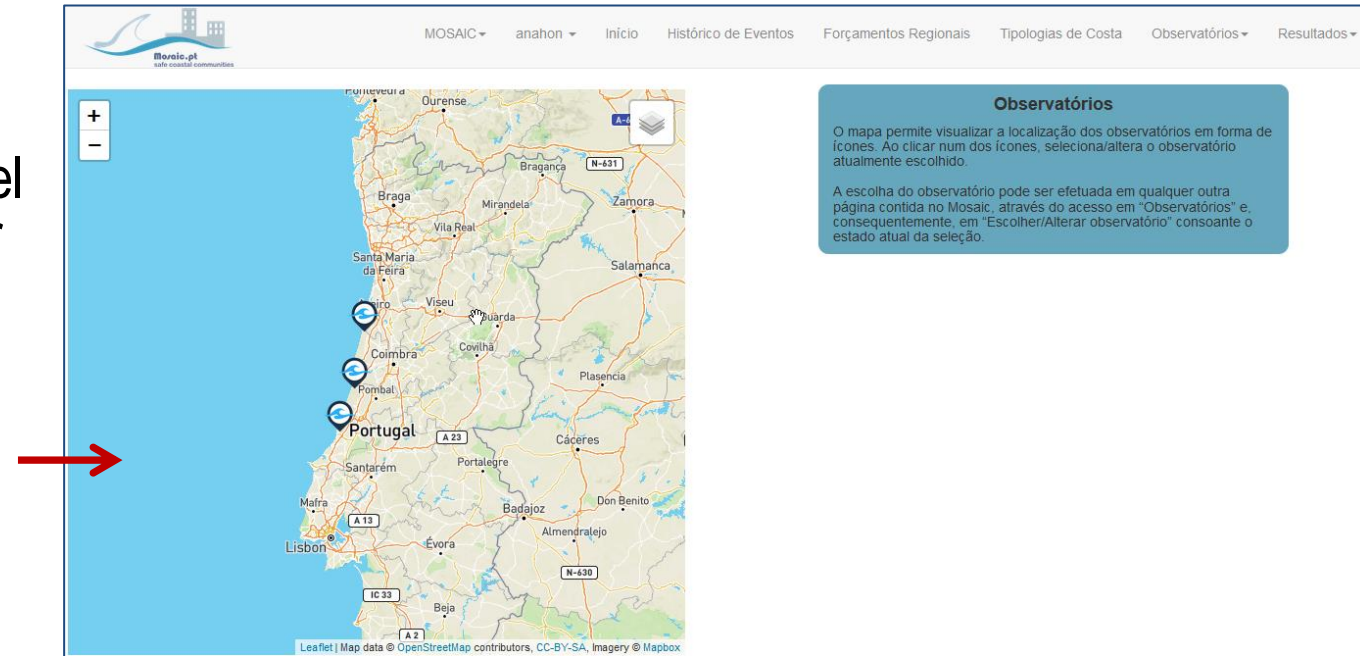
Hurricane Epsilon at Cova-Gala

- October 28, morning forecast
 - Peak of the storm around 6:00 pm
 - Increased velocities near the harbour entrance
 - Increased wave height around the entrance's ebb-delta
 - Strong tidal modulation of the nearshore wave-height along the downdrift coast
 - Greater surge along the beaches compared to the harbour



Concluding remarks

- Possibility to retrieve all inputs (forcings and model parameter files) through the interface
- Possibility to download all actual and previous model outputs (spatial and punctual) from the interface, for visualization in third-party software for instance
- No API yet, but the backend architecture feeds the MOSAIC.PT portal for the project's observatories forecast
- Ongoing work includes the coupling between SCHISM and smaller scale XBeach morphodynamic models



Acknowledgements

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Thank you for your attention!