

OPENCoastS⁺: a tool for on-demand forecasts of circulation and water quality in coastal regions

Demonstration course and hands-on training



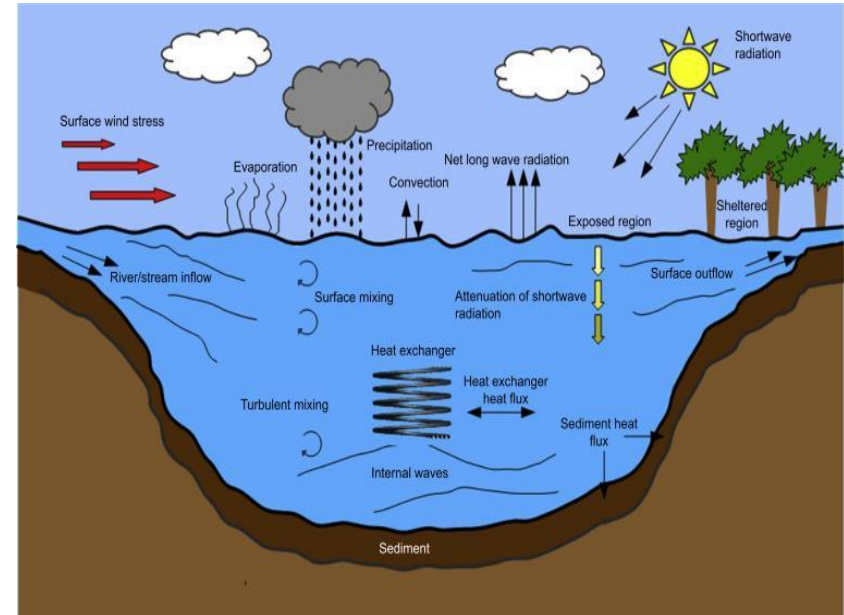
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Hydraulics and Environment Department, LNEC

3D baroclinic and water quality forecasts: relevance and OPENCoastS⁺ setup

3D baroclinic and water quality forecasts

Why are baroclinic effects important for circulation?

- Inside estuaries, baroclinic effects influence or even dominate the residual circulation, thereby driving the long-term fate of dissolved or suspended matter
- Baroclinic effects control to a large extent salinity intrusion in estuaries
- Stratification reduces turbulence, thus reducing vertical mixing and the impact of surface (wind) and bed (friction) stresses on the water column
- Internal tides play an important role in tidal energy dissipation in the ocean



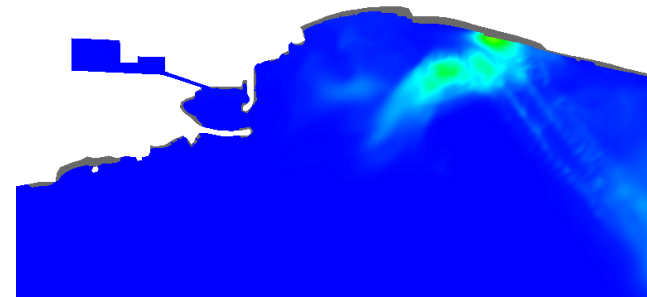
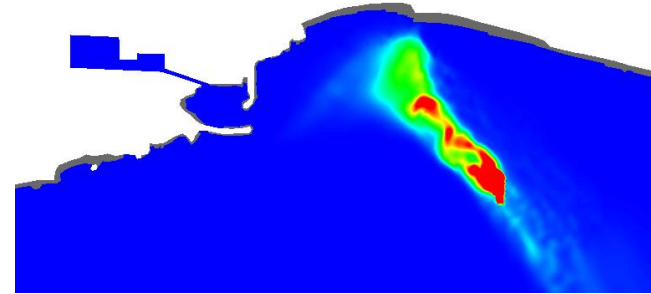
3D baroclinic and water quality forecasts

Water quality

- Circulation
- Atmospheric variables
- Contamination sources



Plumes from sewage outfalls



3D baroclinic and water quality forecasts

Establishment of the 3D model

Model domain

- Horizontal grid
- Vertical grid

Boundary conditions

- Forcing models
 - ✓ Ocean
 - ✓ River
 - ✓ Atmospheric

Parameters

- Time step
- Turbulence closure
- Friction coefficient
- ...

Initial conditions

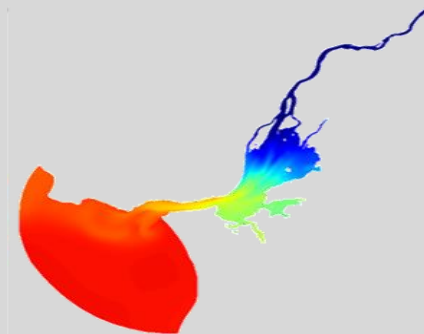
- Temperature and salinity fields

Calibration

Validation

Results

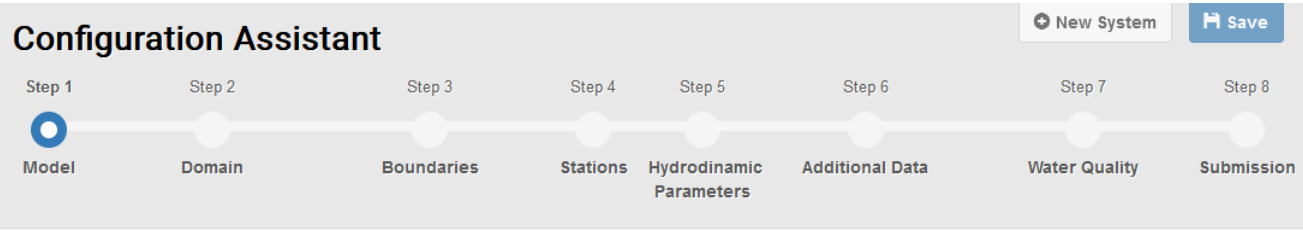
- Evaluation
- Analysis



3D baroclinic and water quality forecasts

Generate a 3D application in OPENCoastS⁺

Configuration Assistant



- **Step 1:** Select the configuration, model version and duration
- **Step 2:** Load and validate horizontal and vertical grids
- **Step 3:** Specify the boundary conditions
- **Step 4:** Define stations for time series
- **Step 5:** Define physical and numerical parameters
- **Step 6:** Define spatially-varying parameters
- **Step 7:** Define initial and boundary conditions for water quality*
- **Step 8:** Review and submit

*Step 7 is skipped by OPENCoastS⁺ because it does not exist in this case

Select run type

Baroclinic Simulation:

- ☐ No
- ☒ Yes (3D)

Waves:

- ☒ No
- ☐ Yes

Water Quality:

- ☒ No
- ☐ Generic Tracer
- ☐ Fecal Contamination

Select a model (*):

SCHISM-5.8

Select a period (*):

48h

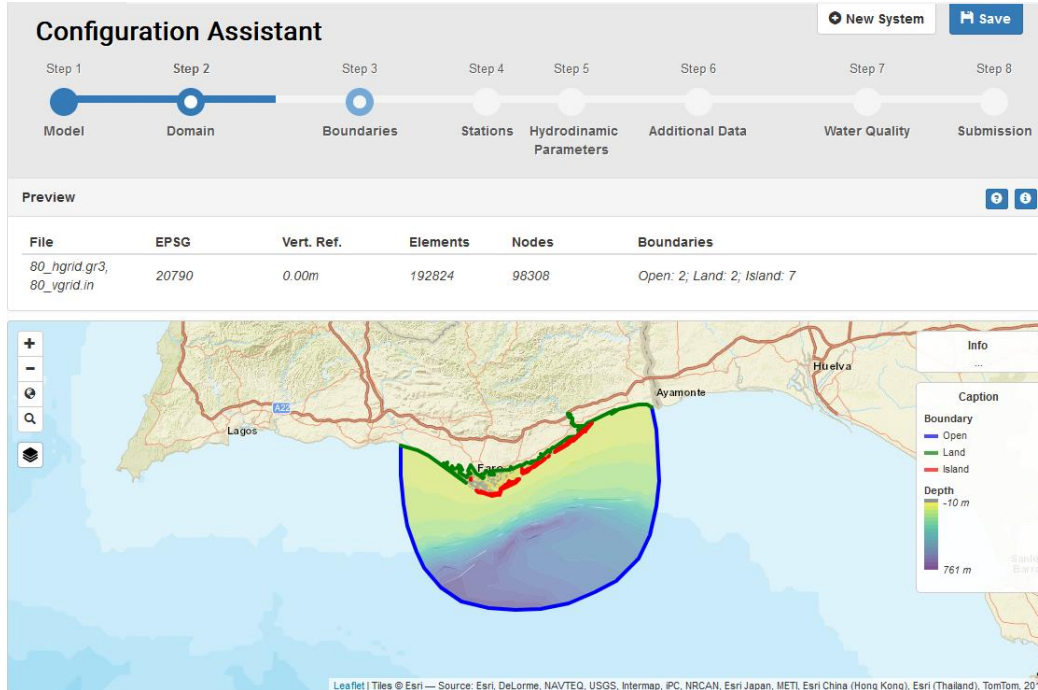
Configuration Assistant

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3D baroclinic and water quality forecasts

Generate a 3D application in OPENCoastS+



Step 2: Load and validate the horizontal and vertical grids

Is the grid at the right location?

Are the open and closed boundaries correct?

OPENCoastS+ simulates based on inputs: garbage in => garbage out!

3D baroclinic and water quality forecasts

Generate a 3D application in OPENCoastS⁺

Configuration Assistant New System Save

Step 1 Step 2 Step 3 Step 4 Step 5 Step 6 Step 7 Step 8

Model Domain **Boundaries** Stations Hydrodynamic Parameters Additional Data Water Quality Submission

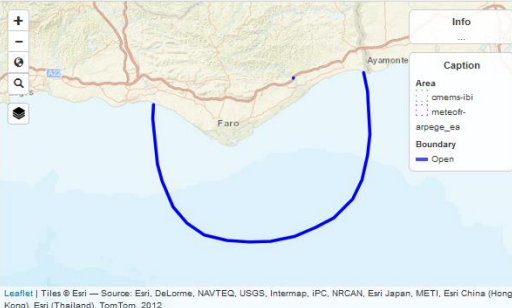
Define Boundary Conditions ? ?

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 Temperature: Copernicus - CMEMS Iberia-Biscay-Ireland Salinity: Copernicus - CMEMS Iberia-Biscay-Ireland
<input type="checkbox"/> open-2	River	Flow: annual=5 Temperature: annual=20 Salinity: annual=0

Define type and forcing condition



Leaflet | Tiles © Esri — Source: Esri, DeLorme, NAVTEQ, USGS, Intermap, IPC, NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, 2012

Forcings for Circulation to apply to all oceans boundaries:
FES2014 - Finite Element Solution

Forcings for Temperature and Salinity to apply to all oceans boundaries:
Copernicus - CMEMS | Iberia-Biscay-Ireland

Atmosphere Forcing:
Meteogalicia | WRF Iberia-Biscay

Various forcing options

Step 3: boundary conditions specification

- Specify: water levels and velocities at the ocean boundaries, river flow at the river boundaries
- Select the boundary by clicking on the box and choosing the boundary type
- By clicking on several boundaries simultaneously, boundary conditions will be the same in all of them
- Boundary conditions are the same in all ocean boundaries
- River boundaries: monthly or yearly climatology, or outside source of river flow forecasts

3D baroclinic and water quality forecasts

Generate a 3D application in OPENCoastS⁺

Configuration Assistant

Step 1 Model Step 2 Domain Step 3 Boundaries Step 4 Stations Step 5 Hydrodynamic Parameters Step 6 Additional Data Step 7 Water Quality Step 8 Submission

Define Stations

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).

Name	Latitude	Longitude	Comparison
<input type="checkbox"/> LaRocheleTG	46.15067	-1.23318	LaRocheleTG (46.15067, -1.23318)
<input type="checkbox"/> PortBlocTG	45.57033	-1.06878	PortBlocTG (45.57033, -1.06878)
<input type="checkbox"/> SocoaTG	43.40009	-1.68010	SocoaTG (43.40009, -1.68010)

Legend

- Area
- Boundary
- Open
- Land
- Inland
- Station
- Observation
- Comparison
- Virtual

Map

Table

Name	Latitude	Longitude	Comparison
<input type="checkbox"/> LaRocheleTG	46.15067	-1.23318	LaRocheleTG (46.15067, -1.23318)
<input type="checkbox"/> PortBlocTG	45.57033	-1.06878	PortBlocTG (45.57033, -1.06878)
<input checked="" type="checkbox"/> SocoaTG	43.40009	-1.68010	SocoaTG (43.40009, -1.68010)
<input checked="" type="checkbox"/> Santander	43.493746	-3.77037	SantanderTG (43.493746, -3.77037)
<input checked="" type="checkbox"/> north Santona	43.480793	-3.410568	

Map

Legend

- Area
- Boundary
- Open
- Land
- Inland
- Station
- Observation
- Comparison
- Virtual

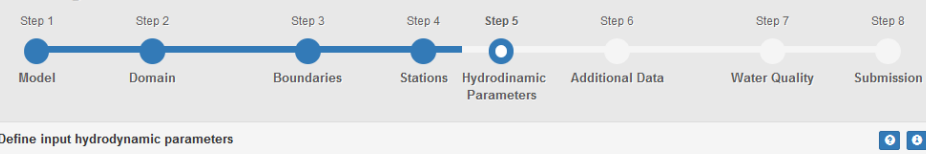
Step 4: Define stations to output time series

- Tidal stations available at EMODNet Physics within the model domain are proposed to the user
- Up to 5 stations in each deployment
- Stations can be real or virtual
- Results show up automatically in the VIEWER and can be downloaded with the time step of the model

3D baroclinic and water quality forecasts

Generate a 3D application in OPENCoastS+

Configuration Assistant



For the chosen model it is necessary to define all input hydrodynamic parameters for the simulation of this model. In this step the user will start from a predefined hydrodynamic parameters file and you can customize some of the hydrodynamic parameters.

Select one of the options:

- ☒ Predefined parameters
- ☐ Customize parameters

☒ Open Template param.nml

Method for computing velocity at nodes (indvel):

- ☒ 0 | conformal linear shape function
- ☐ 1 | averaging method

Stabilization methods

Horizontal viscosity option (ihorcon):

- ☒ 0 | no viscosity
- ☐ 1 | Laplacian
- ☐ 2 | bi-harmonic

Shapiro filter flag (ishapiro):

- ☒ on
- ☐ off

Shapiro filter strength (shapiro):

Wetting and drying

Min. water depth for wetting/drying (h0):

```
!parameter inputs via namelist convention.
!(1) Use ' ' (single quotes) for chars;
!(2) integer values are fine for real vars/arrays;
!(3) if multiple entries for a parameter are found, the last one wins - please avoid this
!(4) array inputs follow column major (like FORTRAN) and can spill to multiple lines
!(5) space allowed before/after '='

$SCORE
!=====
! Core (mandatory) parameters; no defaults
!=====
! Pre-processing option. Useful for checking grid violations.
ipre = 0 !Pre-processor flag (1: on; 0: off)

! Baroclinic/barotropic option. If ibc=0 (baroclinic model), ibtp is not used.
ibc = 0 !Baroclinic option
ibtp = 0

rnday = 2 !total run time in days
dt = 30. !time step in sec

! Grid for WAM (USE_WAM)
msc1 = 24 !same as msc in .nml ... for consistency check between SCHISM and WAM
msc2 = 24 !same as msc in .nml

! Define # of tracers in tracer modules (if enabled)
ntracer_gen = 0 !user defined module (USE_GEN)
ntracer_age = 0 !age calculation (USE_AGE). Must be 2*N where N is # of age tracers
sed_class = 0 !SED3D (USE_SED)
eco_class = 0 !ecoSim (USE_ECO): must be between [25,60]

! Global output controls
nspool = 60 !output step spool
ihfskip = 1440 !stack spool; every ihfskip steps will be put into 1_", 2_", etc...
/

$OPT
```

Step 5: Define hydrodynamic parameters

- Most parameters are fixed, based on LNEC's experience with model SCHISM
- A few parameters can be defined by the user. freedom is limited to ensure robustness

3D baroclinic and water quality forecasts

Generate a 3D application in OPENCoastS⁺

Configuration Assistant

New System

Save

Step 1

Step 2

Step 3

Step 4

Step 5

Step 6

Step 7

Step 8

Model

Domain

Boundaries

Stations

Hydrodynamic Parameters

Additional Data

Water Quality

Submission

Additional Information

In this step the user can select some additional parameters of the model, by specifying values or uploading a file for spatial variability of the values.

Drag coefficient [-]

Select one of the options:

Customize value

Upload file

Constant:

0.002

Albedo [-]

Select one of the options:

Customize value

Upload file

Constant:

0.06

Water type - integer between 1 and 7

Select one of the options:

Customize value

Upload file

Constant:

7

Temperature [°C] - Initial conditions

Select one of the options:

Customize value

Upload file

Step 6: Additional information

- Initial conditions: salinity, temperature
- Spatially-dependent parameters (albedo, friction coefficient, water type)

3D baroclinic and water quality forecasts

Generate a 3D application in OPENCoastS⁺

Configuration Assistant New System Save

Step 1 Step 2 Step 3 Step 4 Step 5 Step 6 Step 7 Step 8

Model Domain Boundaries Stations Hydrodynamic Parameters Additional Data Water Quality Submission

Submit Forecast System ? ?

Confirm the selected configurations and activate the forecast system.

Summary

- 1 Model
SCHISM-5.8 (48h)
Baroclinic Simulation: Yes (3D)
Waves: No
Water Quality: No
- 2 Domain
- 3 Boundaries
- 4 Stations
- 5 Hydrodynamic Parameters
- 6 Additional Data

Submit

Name (*):

Description:

☒ I accept Terms and Conditions of Use

Activate System

Step 8: Review and submit

- Input files can be downloaded to be used outside the platform
- It is possible to go back to any step (after step 2)

Forecast Systems Extension Requests New System

Systems Management

ID	Model	Name	Dates	State	
85	SCHISM-5.8 (48h) (Yes (3D))	Ria Formosa	Created to 11/15/2022 5:09 p.m. Start 11/15/2022 End 12/15/2022	Active	? ? ? ?
Created by afortunato@inec.pt					
84	SCHISM-5.8 (48h) (No)	Europa	Created to 11/14/2022 5:38 p.m. Start 11/14/2022 End 12/14/2022 Last run 11/15/2022	Active	? ? ? ?
Created by 786502508f74a0e9dcade0c32ea77c883279a168b2c3b25127d5954fa526c244@egi.eu Europa Basic					
83	SCHISM-5.8 (48h) (No)		Created to 11/09/2022 2:59 p.m.	Active	? ? ? ?
Created by afortunato@inec.pt					
80-39	SCHISM-5.8 (48h) (Yes (3D))			Active	? ? ? ?
Created by mfradigue@inec.pt					

Forecast System ID:85 activated successfully. The first results will be generated within the next 24 hours, you can consult them by accessing the Outputs Viewer from the menu.

Close

3D baroclinic and water quality forecasts

Generate a 3D application with water quality in OPENCoastS+

Configuration Assistant

New System

Save

Step 1

Step 2

Step 3

Step 4

Step 5

Step 6

Step 7

Step 8

Model

Domain

Boundaries

Stations

Hydrodynamic Parameters

Additional Data

Water Quality

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.

- Step 1: Select the configuration, model version and duration
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- Step 7: Define initial and boundary conditions for water quality
- Step 8: Review and submit

Select run type

Baroclinic Simulation:

- ☐ No
☒ Yes (3D)

Waves:

- ☒ No
☐ Yes

Water Quality:

- ☐ No
☐ Generic Tracer
☒ Fecal Contamination

Select a model (*): SCHISM-5.8

Select a period (*): 48h

3D baroclinic and water quality forecasts

Generate a 3D application with water quality in OPENCoastS+

Configuration Assistant

New System

Save

Step 1

Step 2

Step 3

Step 4

Step 5

Step 6

Step 7

Step 8

Model

Domain

Boundaries

Stations

Hydrodynamic Parameters

Additional Data

Water Quality

Submission

Additional Information

?

?

In this step the user can select some additional parameters of the model, by specifying values or uploading a file for spatial variability of the values. For the prediction of water quality conditions, the user has to select decay information and indicate the initial condition values or files.

Decay formula [-]

Select one of the options:

Canteras et al. 1995

E-coli constant:

Enterococcus constant:

Fraction of FIB aggregation to sediments [-]

Select one of the options:

Customize value

Upload file

Constant:

Sedimentation rate of FIB aggregation to sediments [m/s]

Select one of the options:

Customize value

Upload file

Constant:

Initial conditions for E-coli [UFC/100ml or MPN/100ml]

Select one of the options:

Customize value

Upload file

Constant:

Initial conditions for Enterococcus [UFC/100ml or MPN/100ml]

Select one of the options:


Customize value

Upload file

Constant:

Step 6: Additional information

- Initial conditions: *Salt*, *Temp*, water quality
- Spatially-varying parameters*
- Decay formulations: constant or dependent on environmental conditions
- Option to consider aggregation and settling with sediments



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15

3D baroclinic and water quality forecasts

Generate a 3D application with water quality in OPENCoastS+

Configuration Assistant ID: 86 New System Save

Step 1 Step 2 Step 3 Step 4 Step 5 Step 6 Step 7 Step 8

Model Domain Boundaries Stations Hydrodynamic Parameters Additional Data Water Quality Submission

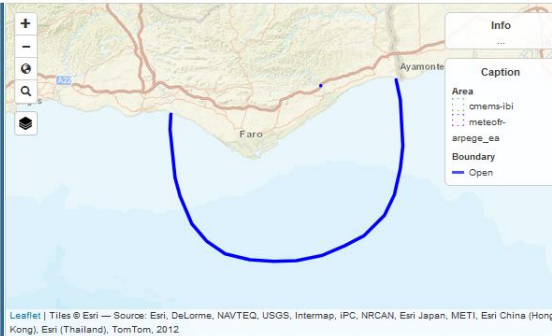
Define Water Quality conditions ? +

In case the user has chosen a simulation involving water quality, they should define the forcing conditions for each water quality variable in all oceanic and river boundaries. The user might also define other additional sources.

Select one or more boundaries for water quality conditions

ID	Type	Forcing
<input type="checkbox"/> open-1	Ocean	E-coli: annual=10 Enterococcus: annual=10
<input type="checkbox"/> open-2	River	E-coli: annual=100 Enterococcus: annual=100

Define water quality conditions



Additional point sources for water quality conditions: Define new source in the map or through coordinates

Step 7: Water quality

- Boundary conditions: water quality (concentration)
- Existence of other contamination sources (optional)

3D baroclinic and water quality forecasts

Generate a 3D application with water quality in OPENCoastS⁺

Configuration Assistant 10:46


Step 1 Model Step 2 Domain Step 3 Boundaries Step 4 Stations Step 5 Hydrodynamic Parameters Step 6 Additional Data Step 7 Water Quality Step 8 Submission

Define Water Quality sources

If the user chose to add additional sources for water quality, they should define the forcing conditions for all sources they add.

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

Name	Latitude	Longitude	Forcing
New Source			



Step 7: Water quality

- Other contamination sources: location, fluxes, salinity, temperature and concentration

New Source

Latitude (°): 37.023200 Longitude (°): -8.002338

Name (°):
CSO

Select water quality conditions for sources:

Flow Temperature Salinity E-coli **Enterococcus**

☒ Average annual contamination by Enterococcus: 1000

☐ Average monthly contamination by Enterococcus:

Jan [MPN/100]	Feb [MPN/100]	Mar [MPN/100]	Apr [MPN/100]	May [MPN/100]
Jun [MPN/100]	Jul [MPN/100]	Aug [MPN/100]	Sep [MPN/100]	Oct [MPN/100]
Nov [MPN/100]	Dec [MPN/100]			

Note: positive values mean incoming water fluxes; negative values mean outgoing water fluxes

☐ Source of water quality variables forecasts:

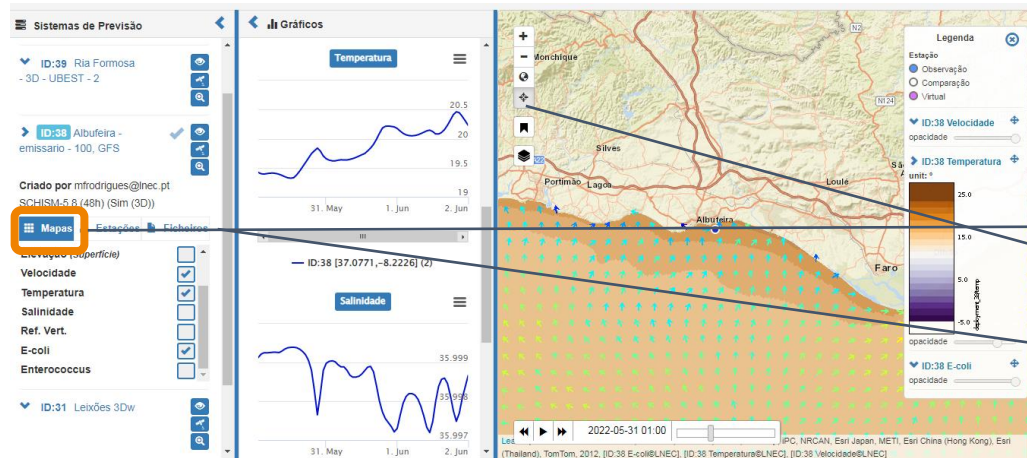
http://

Uri for flow forecast data collection (accepts dynamic uris)

Close Add

3D baroclinic and water quality forecasts

Manage and visualize results of the 3D water quality application



Viewer

- Maps and animations
- Time series (stations and on the fly)
- Download inputs and outputs

Team and contacts

Questions?

You can contact me at: afortunato@lnec.pt

Suggestions and corrections are most welcome. Thank you for your attention!

