De la monitorización y los modelos numéricos a la evaluación del riesgo ambiental: integración de procesos hidrodinámicos y ecológicos

Workshop:

Innovación y cooperación frente a los contaminantes emergentes: de la detección a la acción hacia una gestión sostenible del agua
Vigo, 29/10/2025

Isabel Iglesias Fernández

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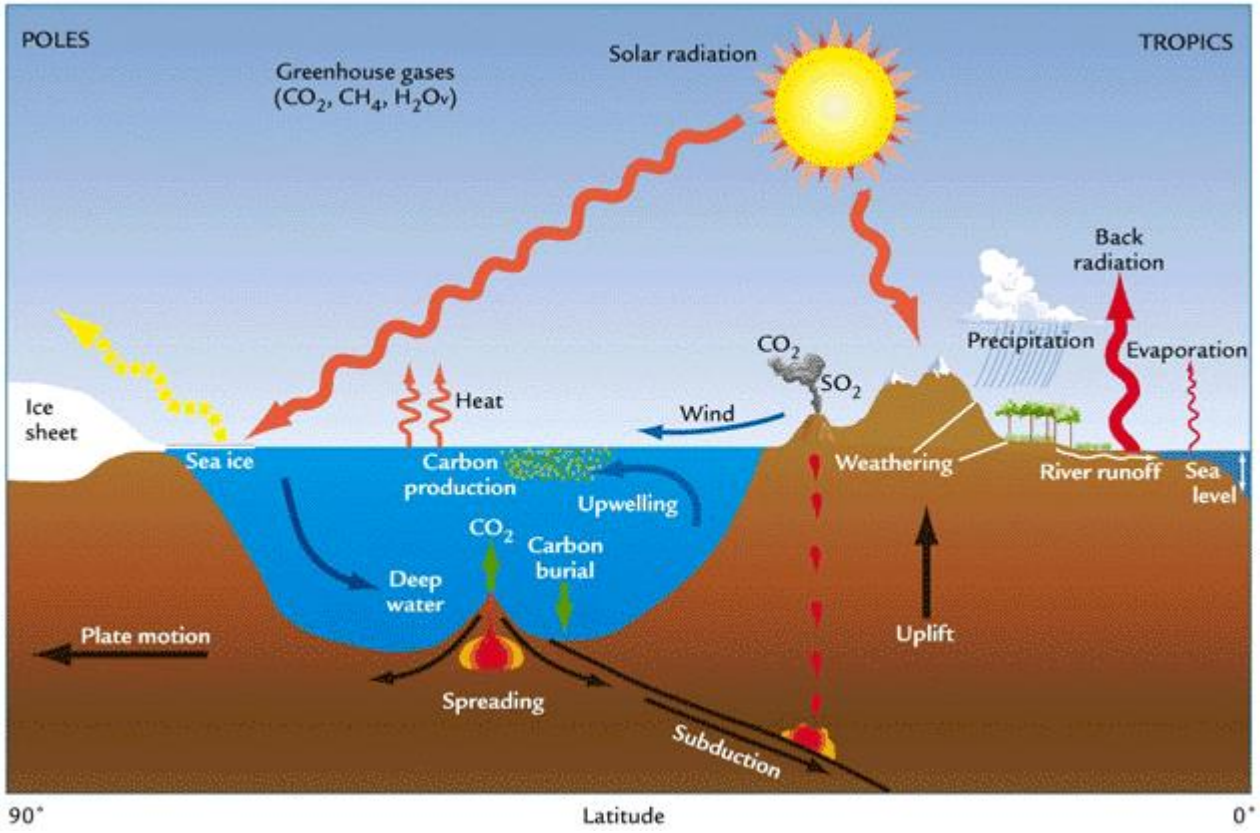
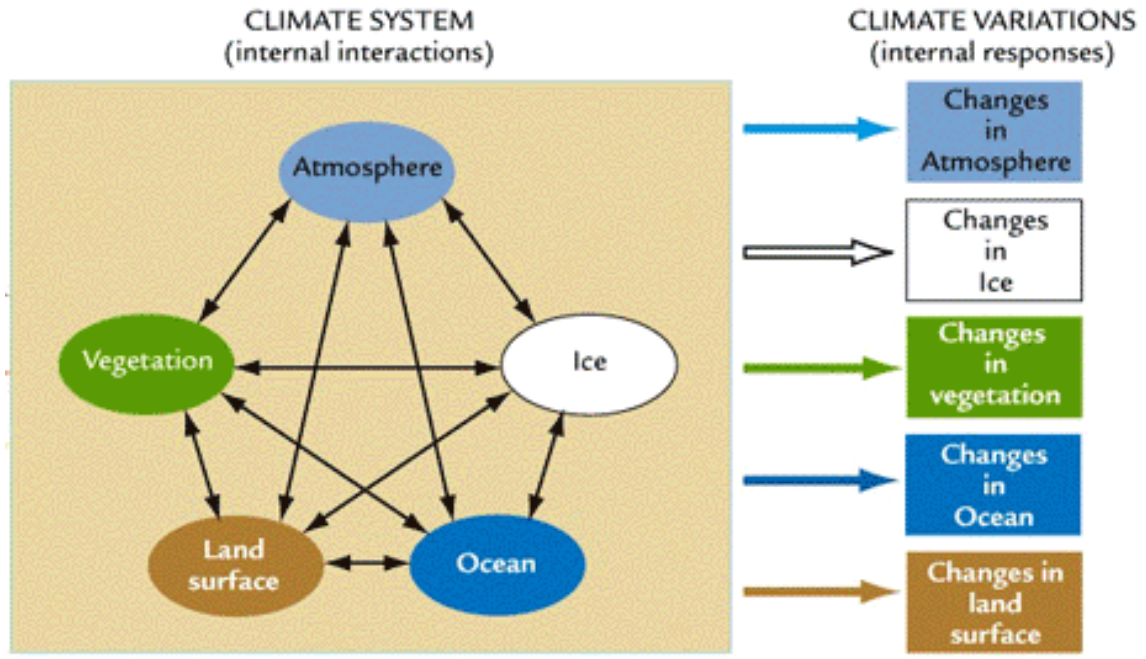
Numerical models

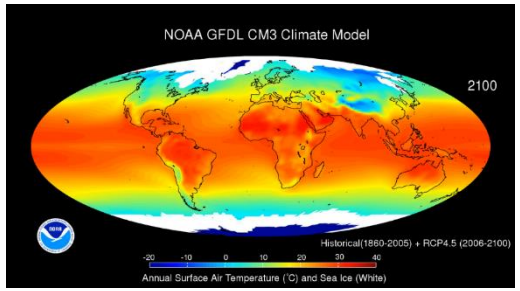
- Simulators of the terrestrial system
- Solve the equations that govern the laws and principles associated with the processes between different components of the climate system, as well as energy and mass exchanges.

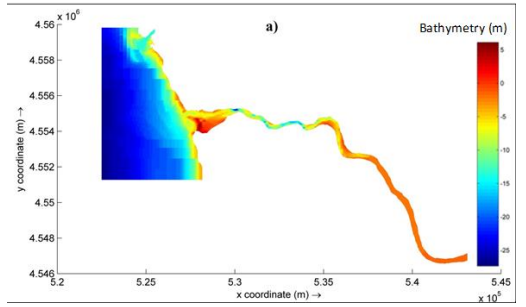


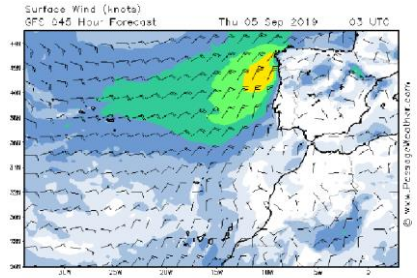


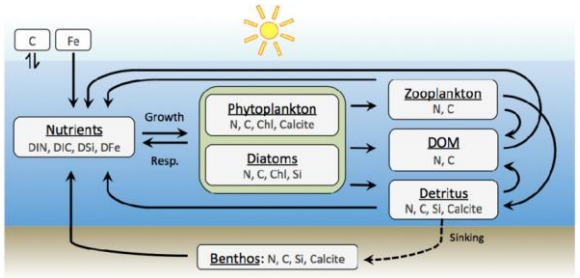
Numerical models

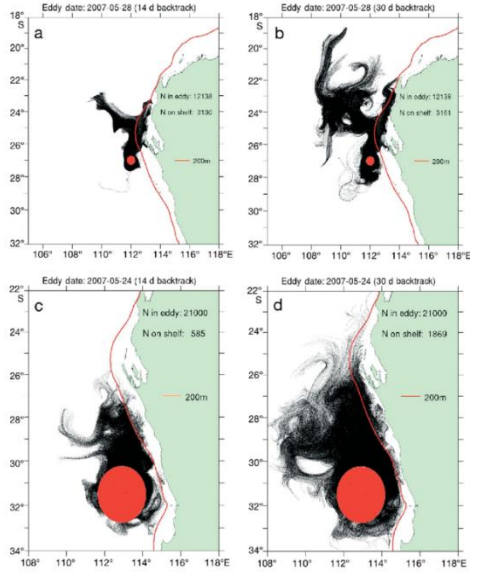
- Depending on the simulated processes and the climate system component that we want to investigate, we can have different numerical models:
- Meteorological
- Climatological
- Oceanic
- Estuarine
- Geological
- Biogeochemical
- …





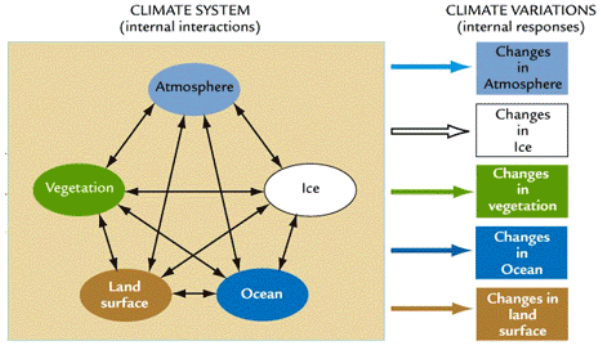






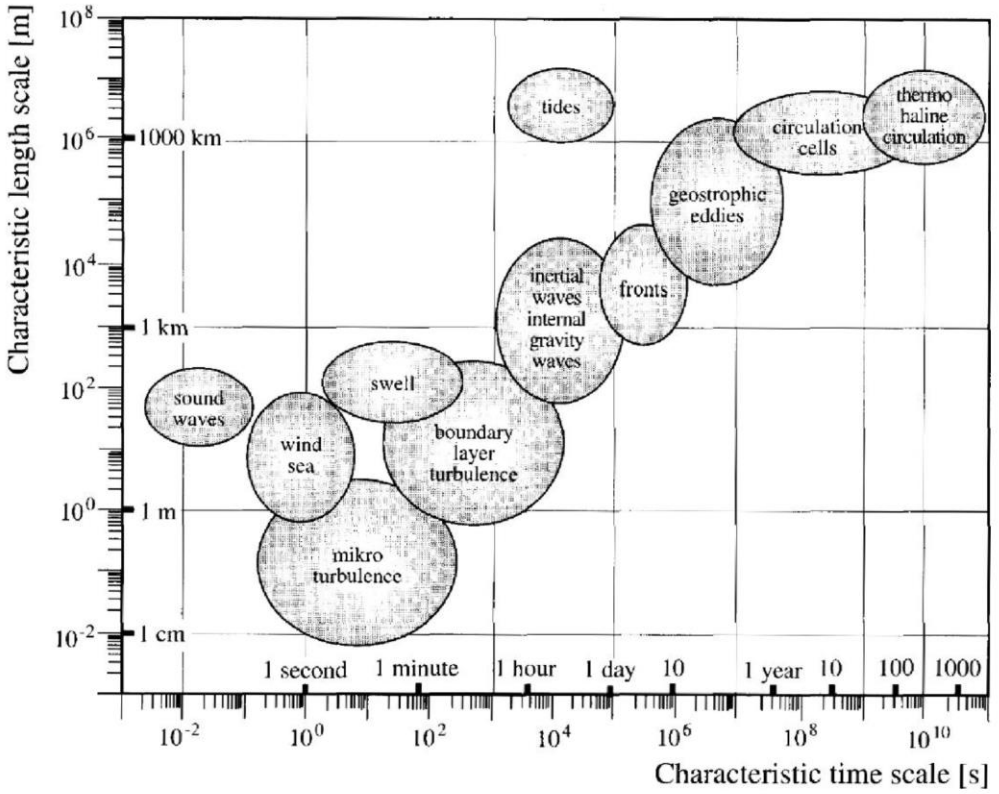
Increasing number of interactions

Increases the complexity of the model

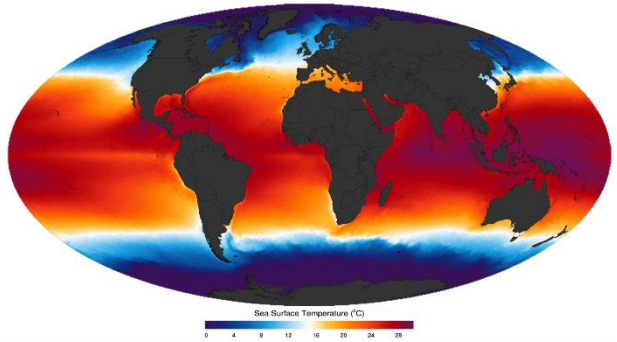


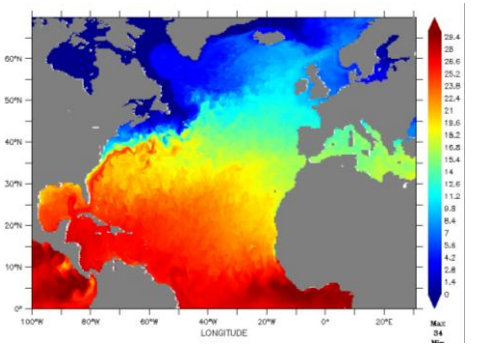
Numerical models

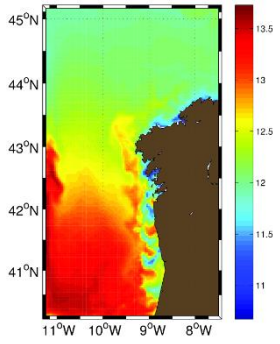
- Temporal and spatial resolution: Define the problem to be solved

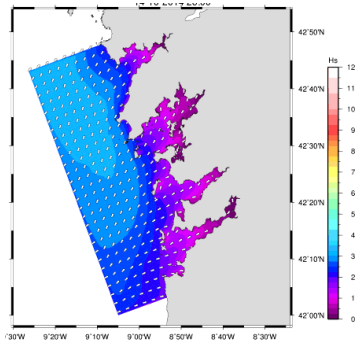


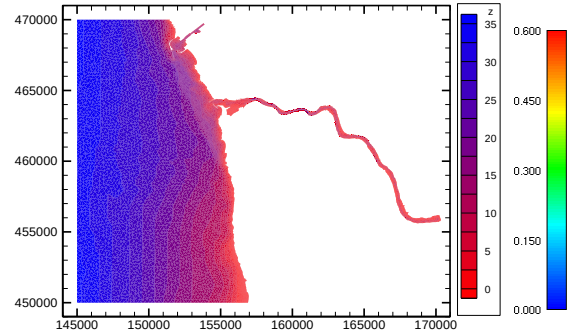
Burchard (2002)

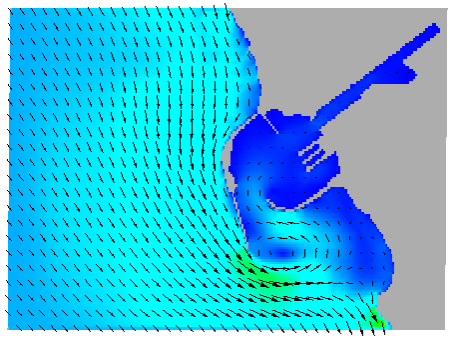


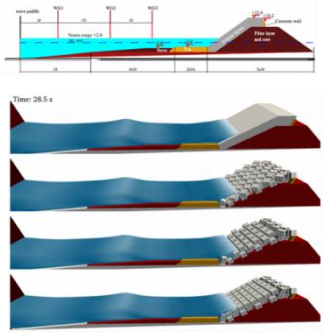


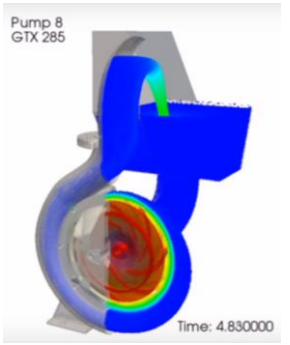






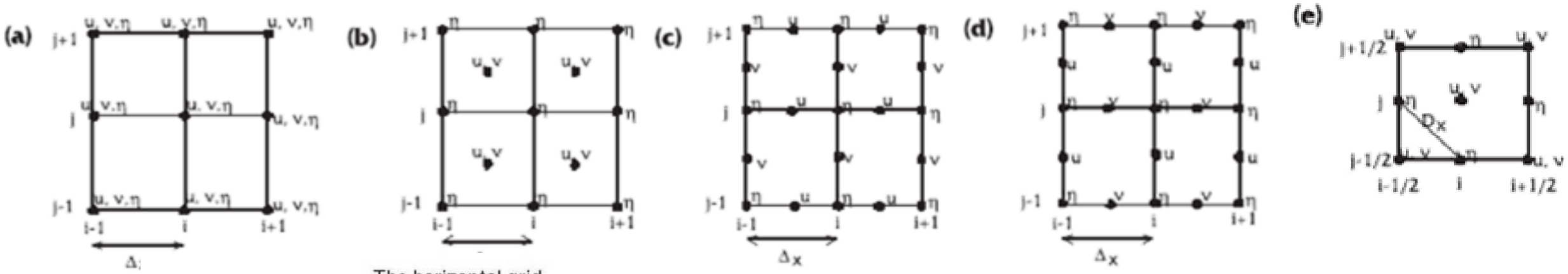


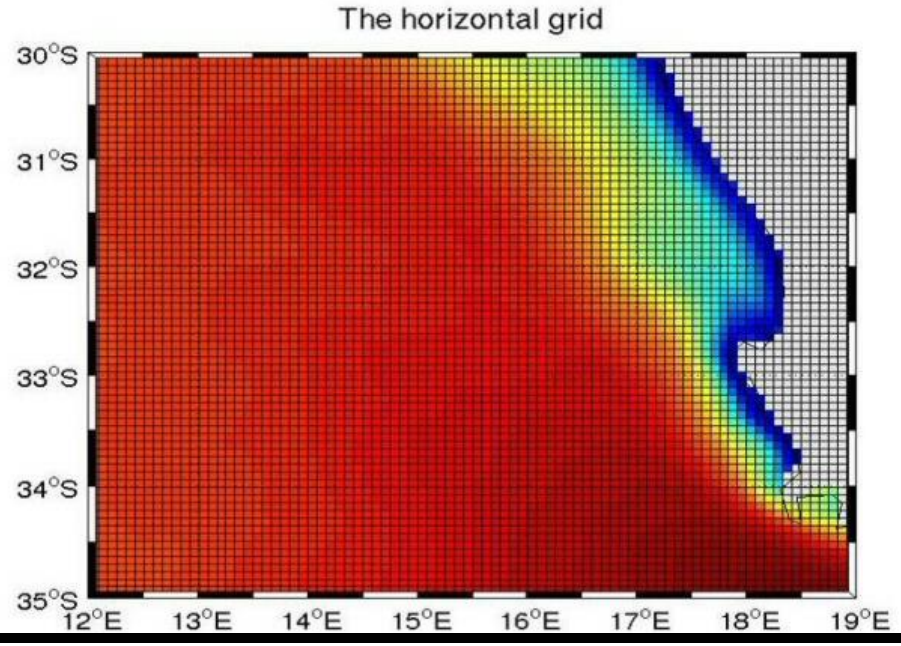


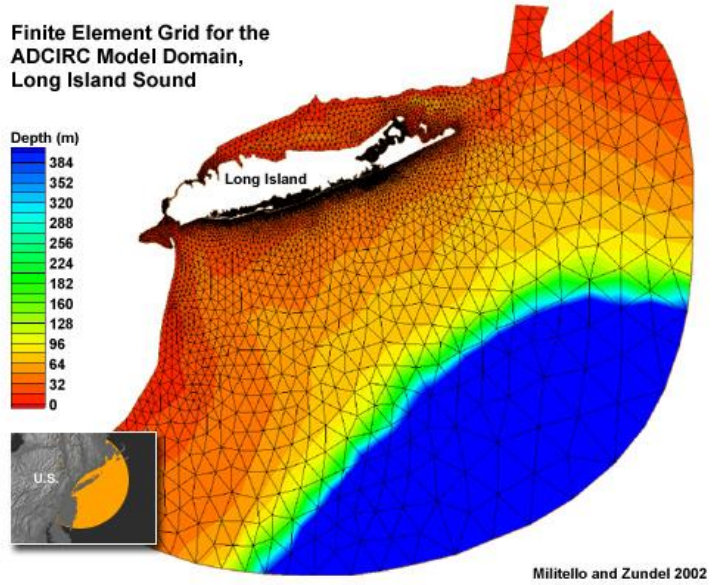


Numerical models

- Grids and parametrizations







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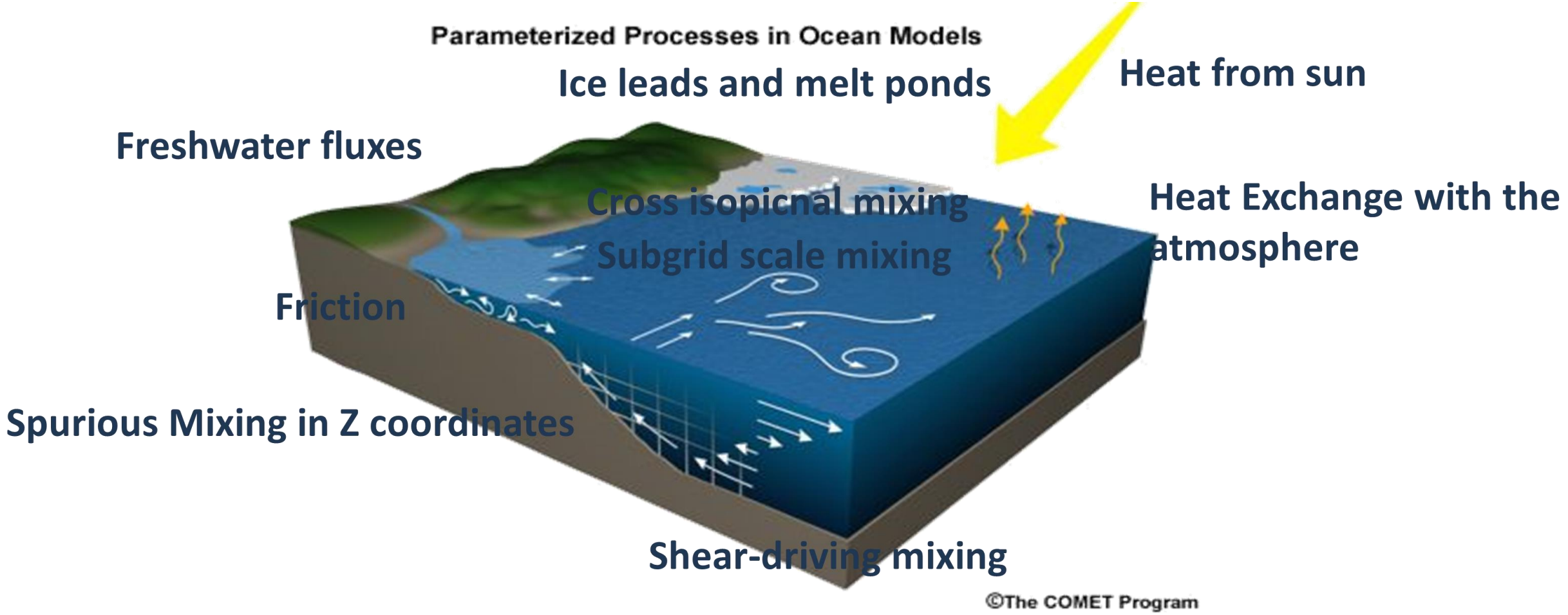

Numerical models

1
Software installation

2
Grid construction
Initial and boundary conditions
Forcing parameters

Grid construction

- Selection of the area
- Bathymetric/Topographic data
- Spatial resolution

Initial conditions

- Initial properties of the system (oceanic/atmospheric properties)

Boundary conditions

- Values of the variables that will be inserted in the grid boundaries continuously during the simulation (sea surface elevation, temperature, salinity, currents, …)

Forcing parameters

- Variables that will force the model externally during the simulation (wind, heat and freshwater fluxes, tides…)

Numerical models

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Software installation

2
Grid construction
Initial and boundary conditions
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3
Test simulation

4
Calibration

Numerical models

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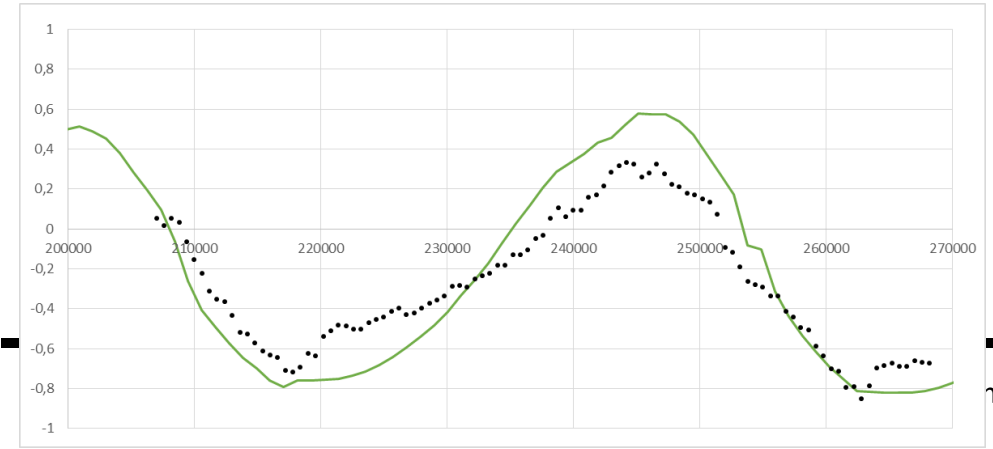
Test simulation

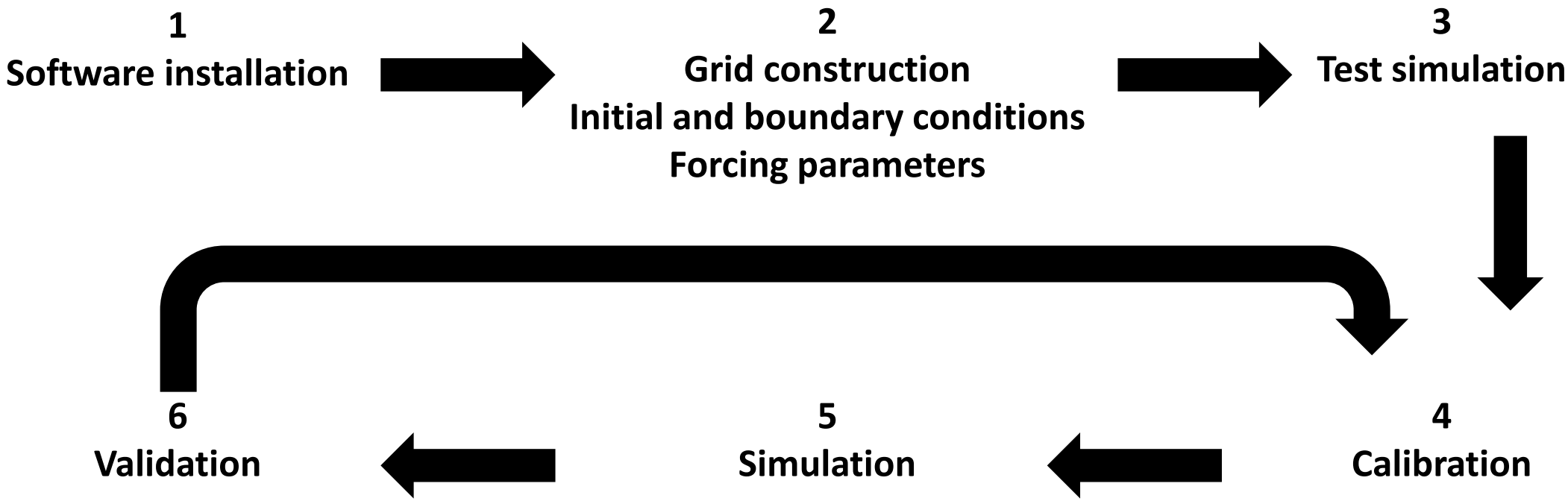
4
Calibration

5
Simulation

6
Validation



Numerical models



Numerical models

1
Software installation

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Grid construction
Initial and boundary conditions
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Test simulation

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Calibration

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Simulation

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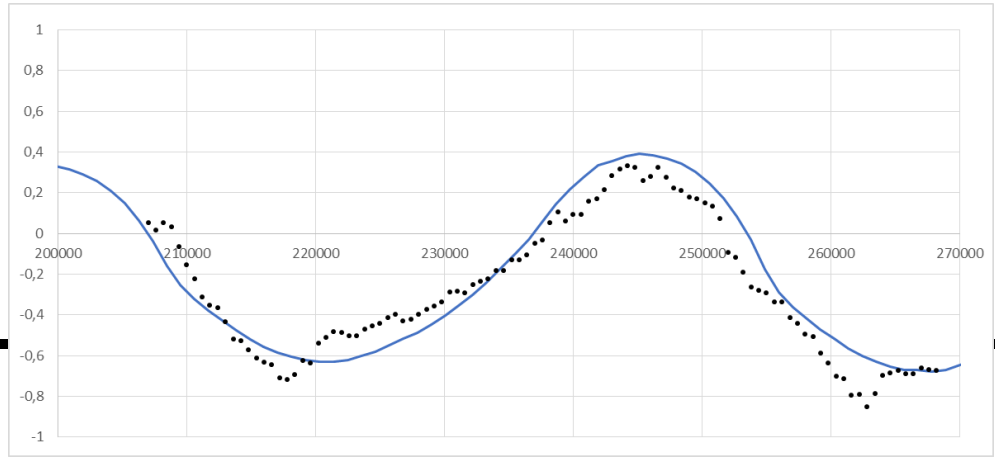
Validation

7
RESULTS!!!!



Numerical models: Importance of observations

- Importance of ocean observations for numerical models:
  - Define the initial conditions, the bathymetry of the grid, the forcing conditions.
  - Comparing model results with the reality of the system.

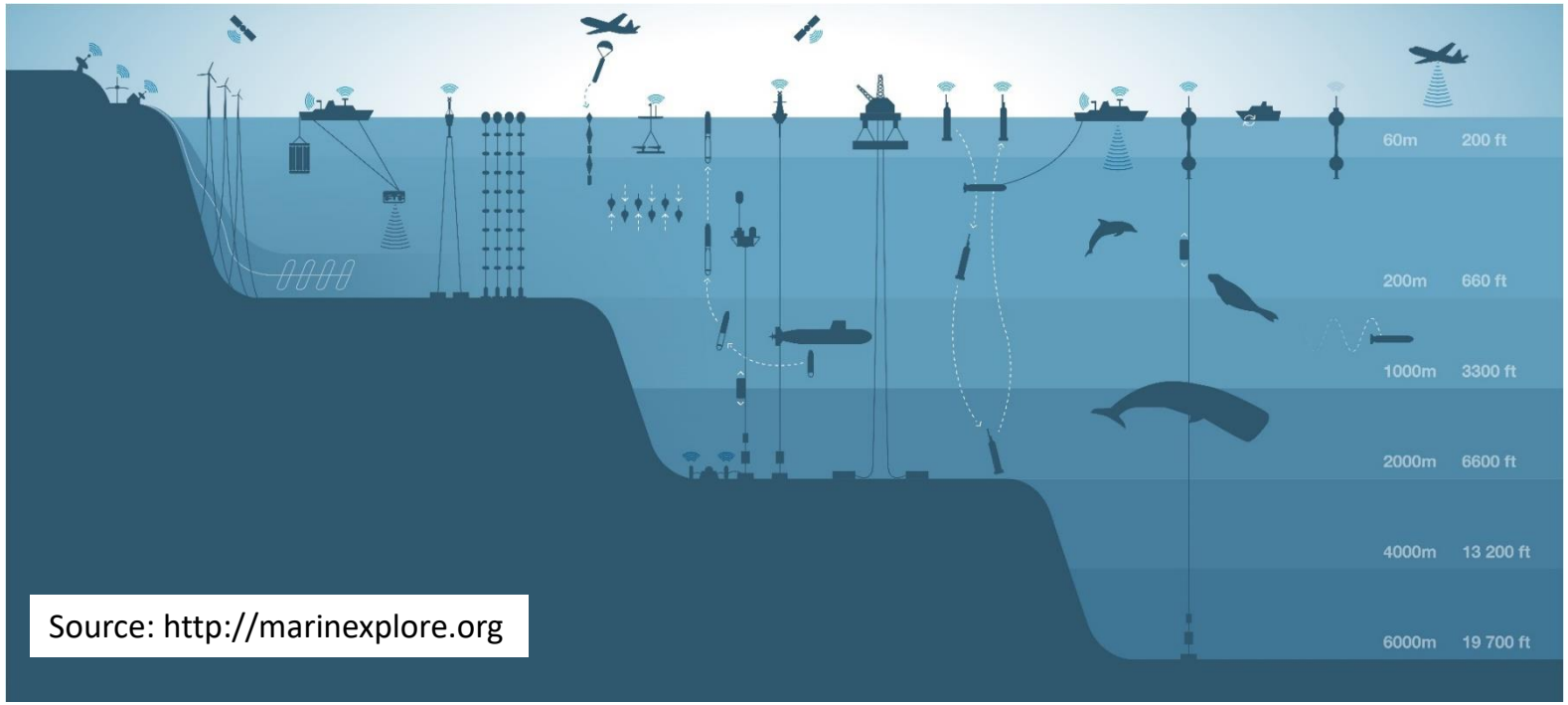




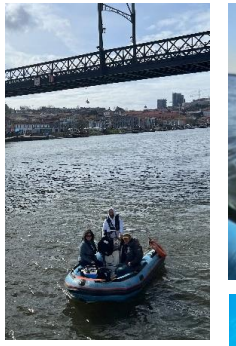


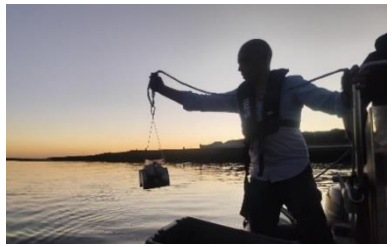
Numerical models: Importance of observations

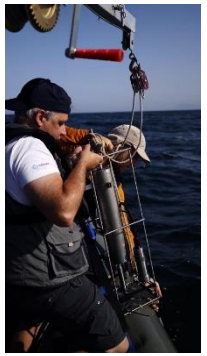
- Importance of ocean observations for numerical models:
  - Define the initial conditions, the bathymetry of the grid, the forcing conditions.
  - Comparing model results with the reality of the system.
- Data used:
  - Space: Sensors on satellites
  - Marine: Buoys, drifting buoys, gliders, ships, platforms, autonomous vehicles
  - Aerial: Drones, airplanes, hyperspectral cameras, Lidar, GNSS, etc...

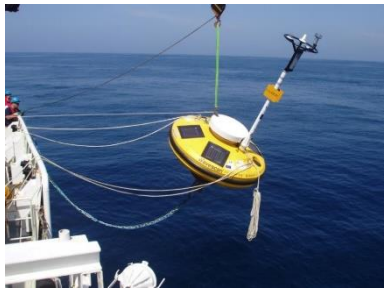


Source: http://marinexplore.org







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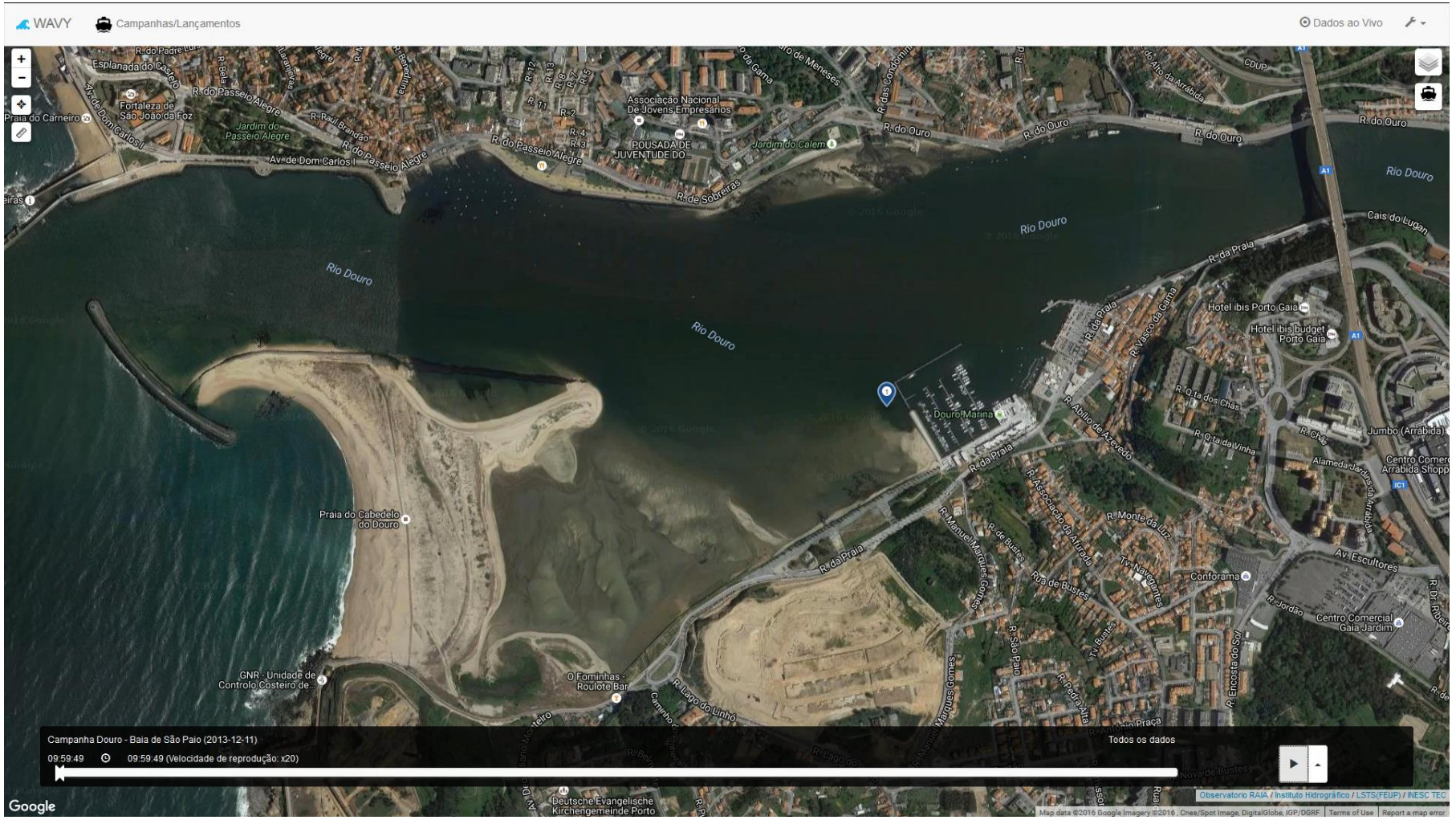
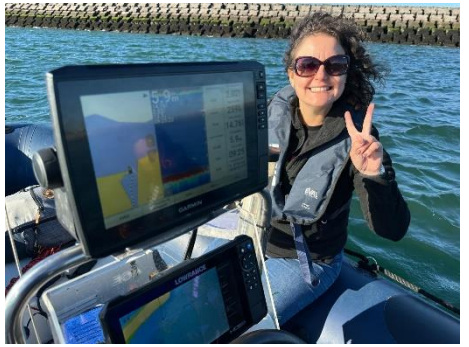
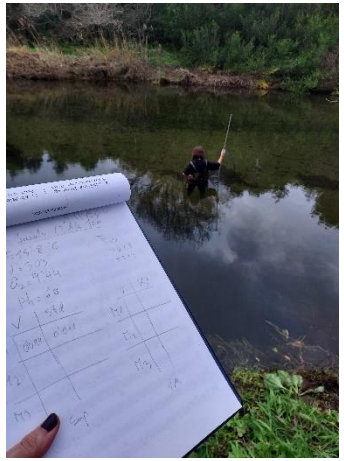


Numerical models : Importance of observations

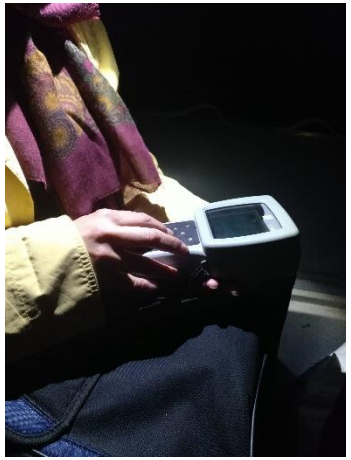
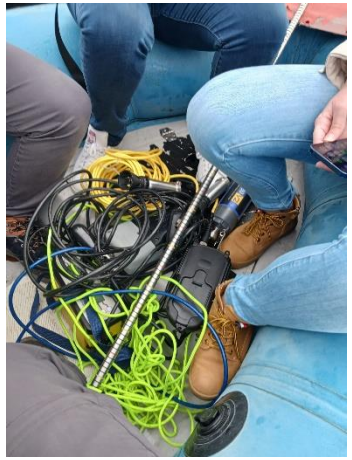
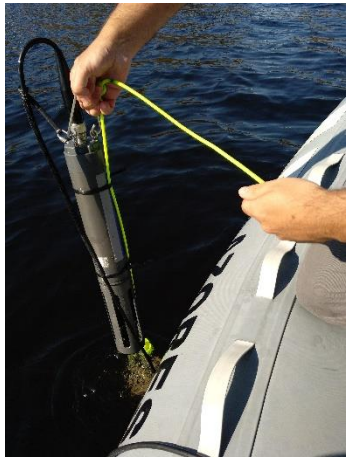



Campaigns

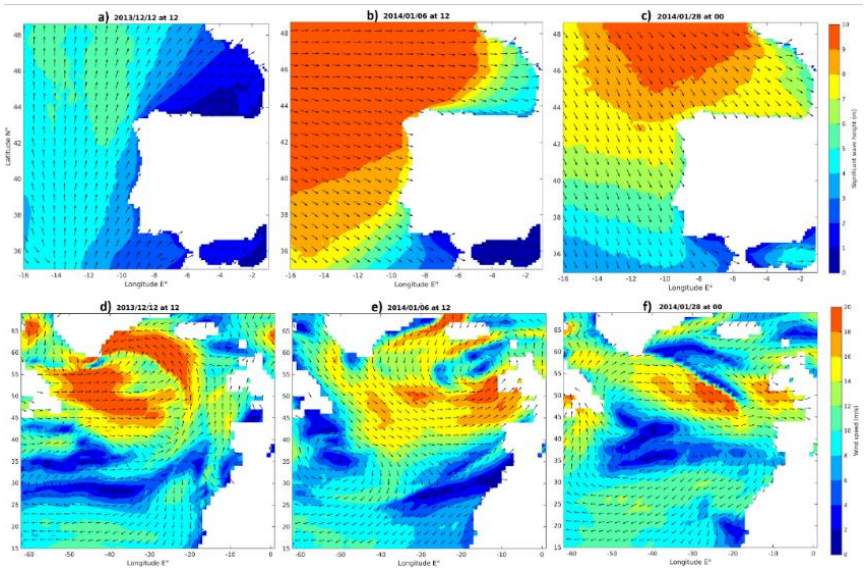
blue water

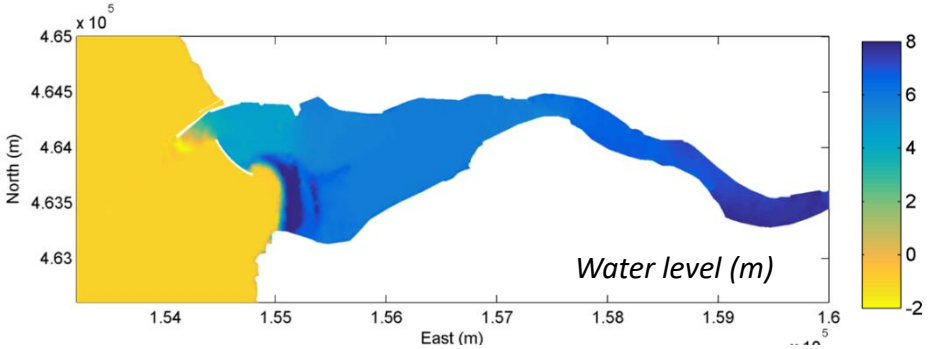


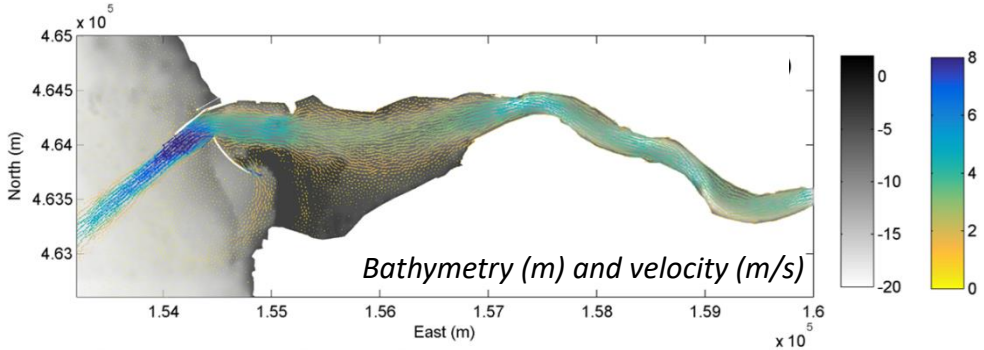





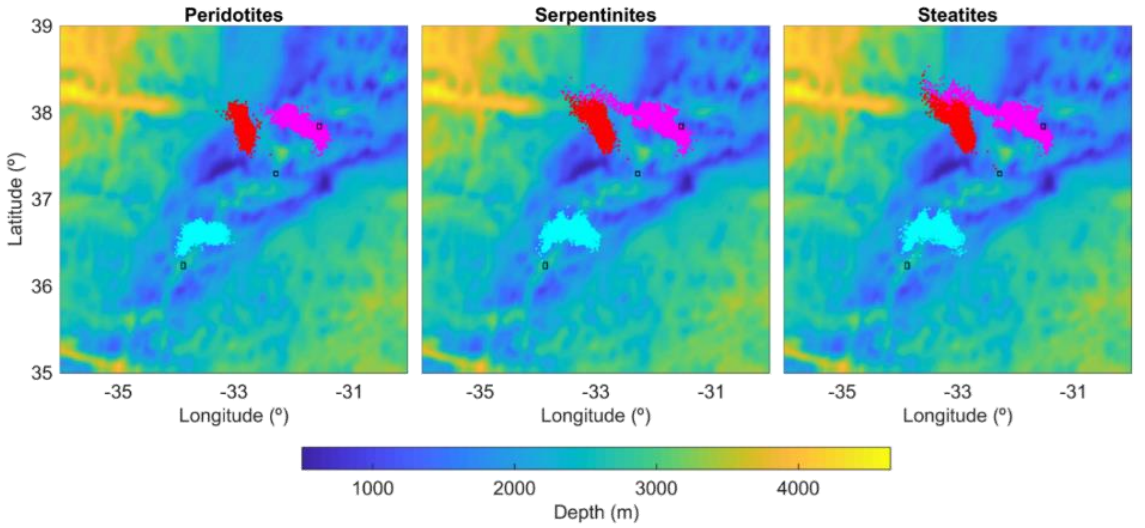
Importance of numerical models

- It is impossible to monitor every point => Lack of continuous, long-term observations.
- Numerical models help to overcome this lack of observation, characterise the behaviour of these areas and anticipate the effects of extreme events, anthropogenic activities or climate change.
- Valuable information for population's safety and ecosystems' sustainability
- Essential decision-making support tools for effective and integrated management.





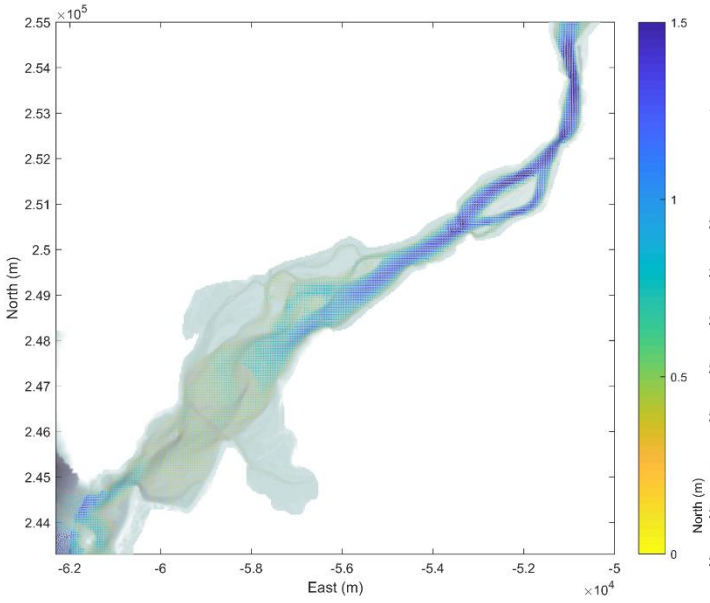




Numerical models for risk analysis

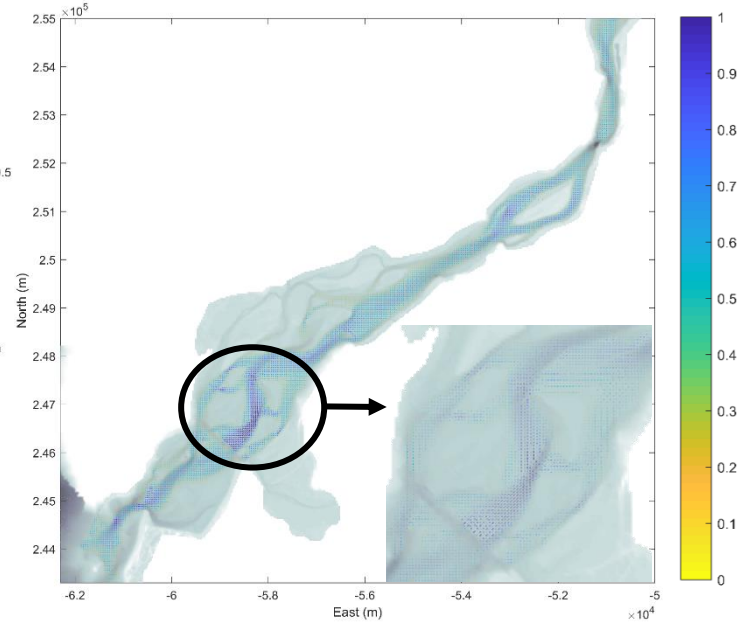
- Hydrodynamic and lagrangian models for contamination risk analysis at oceanic, coastal and estuarine locations:

	S1	S2	S3
Time	20 February–9 March 2006	1–13 December 2012	16–26 January 2013
Tide level	TPXO.2	TPXO.2	TPXO.2
River flow ($m^3\ s^{-1}$)	Daily mean	Hourly mean	Hourly mean
Run length (days)	18	13	11



Velocity (m/s) patterns for 110 m^3/s river flow during low tide conditions

Velocity (m/s) patterns for 3000 m^3/s river flow during high tide conditions



Numerical simulations	Return period (years)	River flow (m^3/s)		Scenario	Oceanic elevation (m)
		Minho	Douro		
S1	100	6038	17634	Historic	3.0
S2		6038	17634	RCP 4.5 2100	3.5
S3		6038	17634	RCP 8.5 2100	3.7
S4	1000	8262	24629	Historic	3.3
S5		8262	24629	RCP 4.5 2100	3.7
S6		8262	24629	RCP 8.5 2100	4

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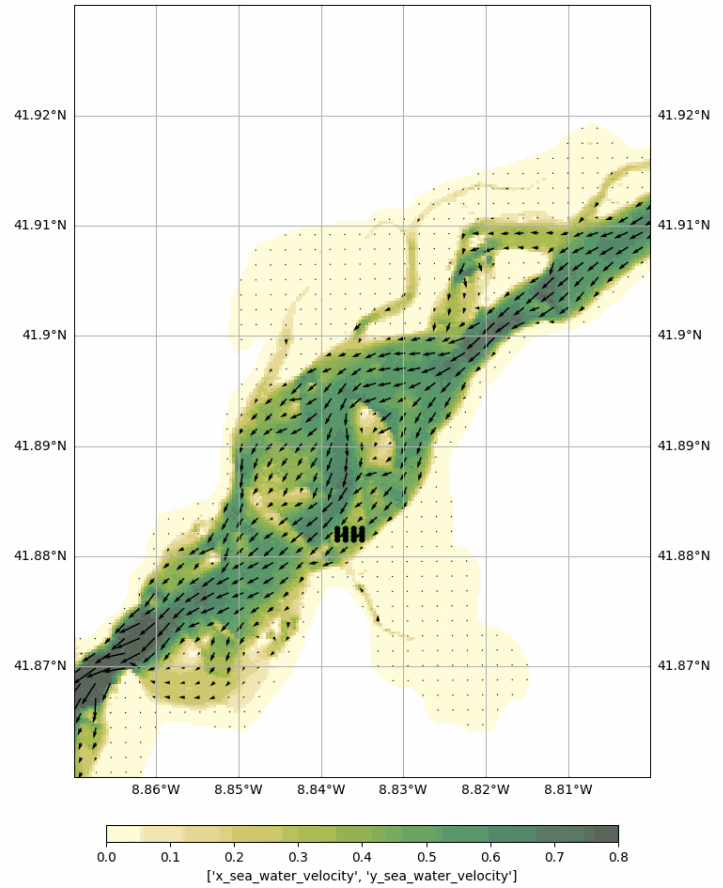
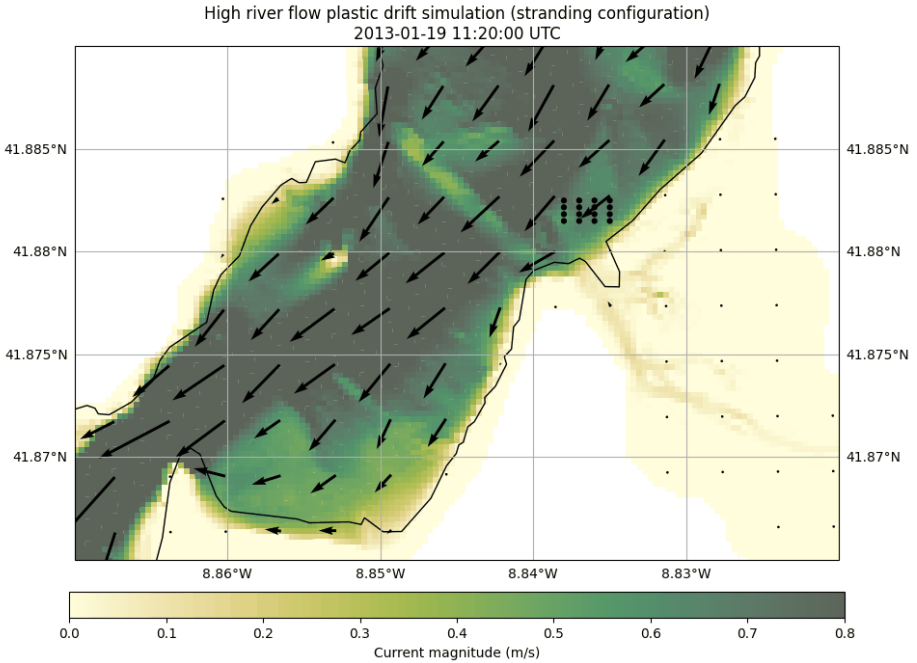
Numerical models





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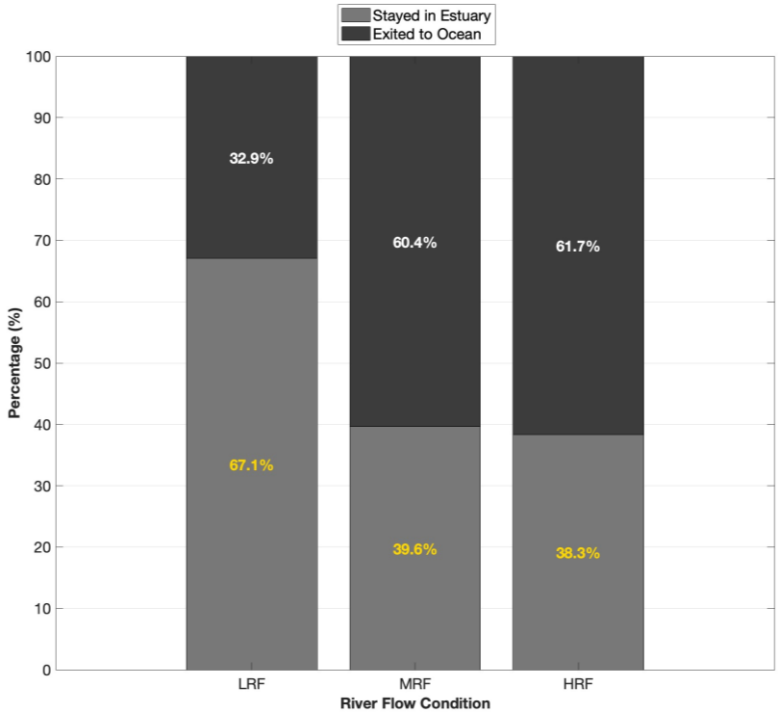

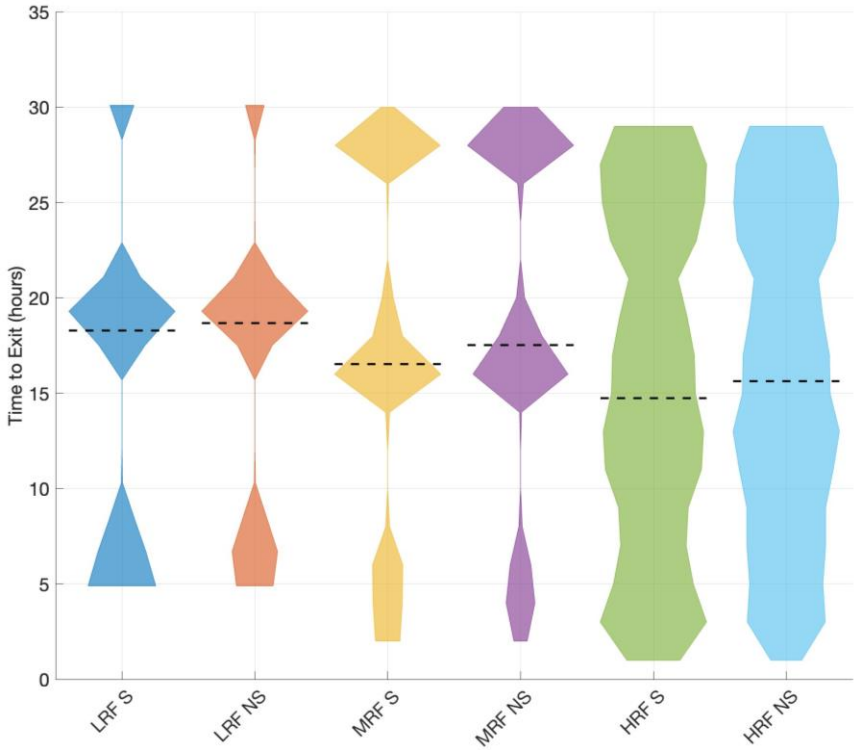

Numerical models for risk analysis

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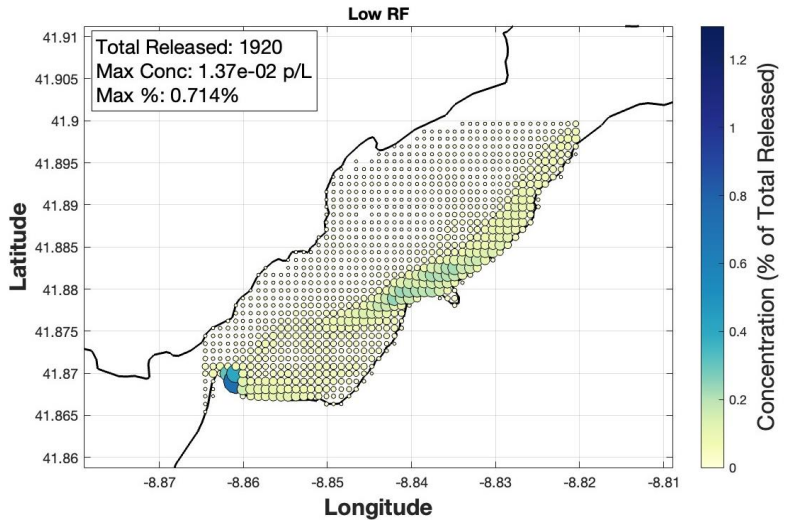
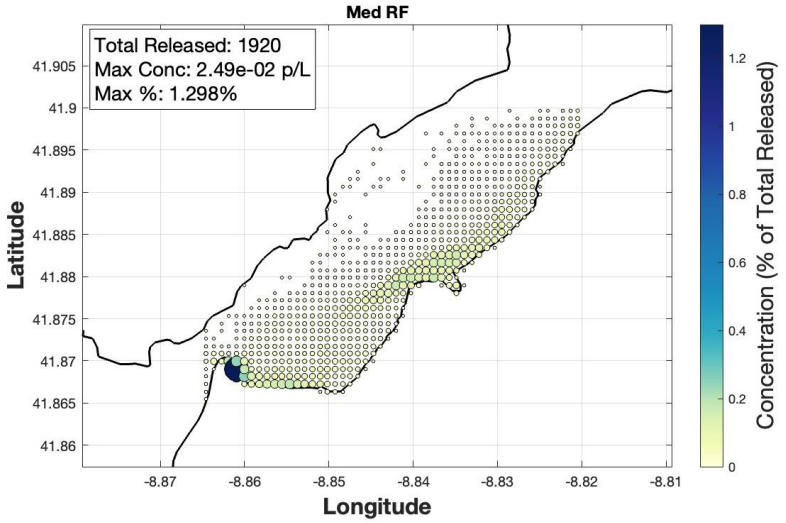
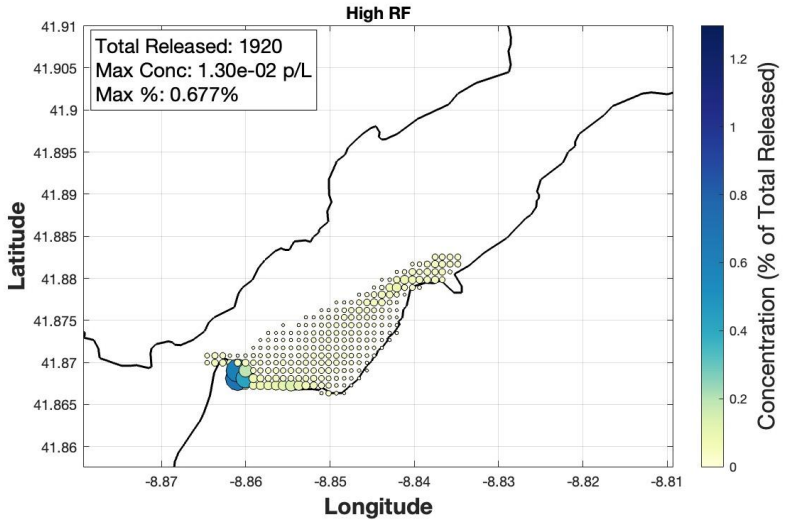


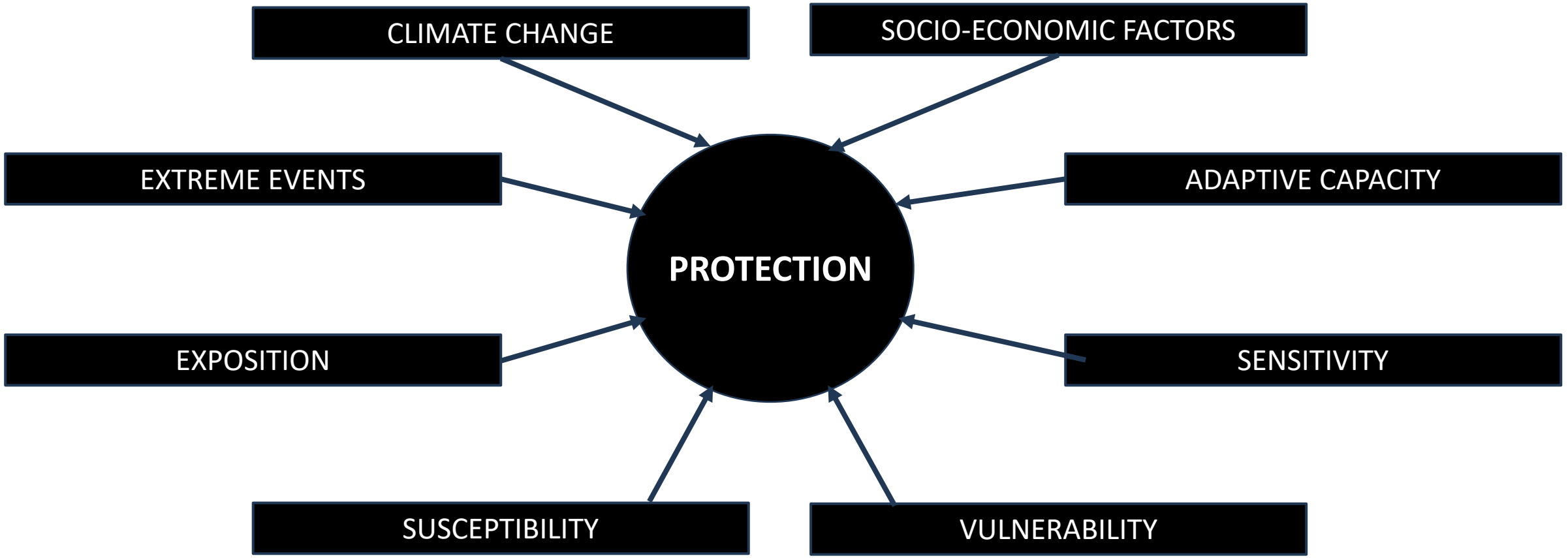




Numerical models

Numerical models for risk analysis

- But modelling is just another tool.
- A complete study needs to characterise the vulnerability, susceptibility, exposure, adaptive capacity, sensitivity and economic factors of a system in order to protect the community and the environment.



Muchas gracias!

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iiglesias@ciimar.up.pt

ciimar

U.PORTO
FACULDADE DE CIÊNCIAS
UNIVERSIDADE DO PORTO

blue water

Interreg
España – Portugal

red norwater

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