

ADVANCES IN NUMERICAL MODELING AND DATA ANALYSIS ON WATER RESOURCES RELATED ISSUES

Rodrigo Amado Garcia Silva





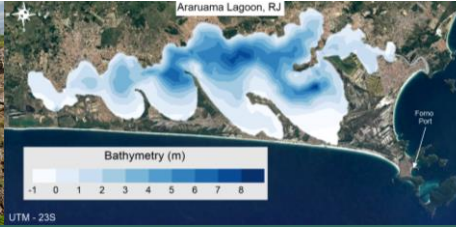
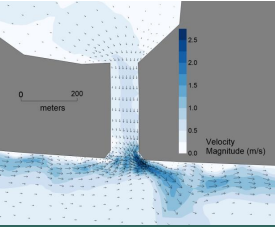
Coastal and Oceanographic Engineering Area (Ocean Engineering Program)

- Research Engineer (postdoc)
- Issues: Environmental hydrodynamics, wave generation and propagation, sediment transport, coastal vulnerability, water quality



HidroAmb – Water Resources and Environmental Engineering

- Director and Environmental Engineer
- Issues: the same

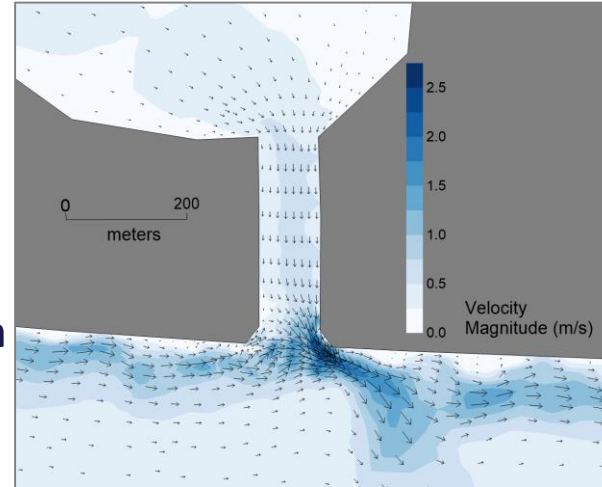


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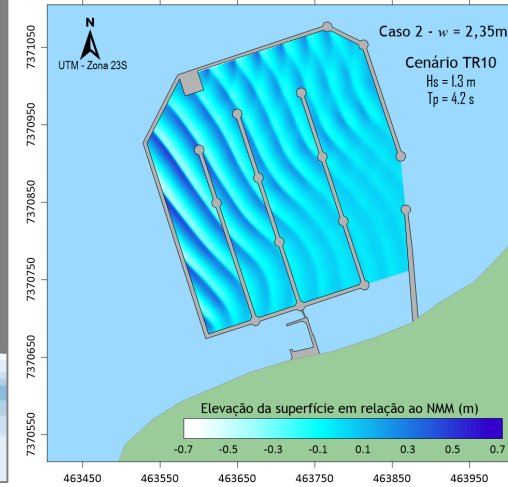
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Water resources related issues

- Environmental Hydrodynamics
- Wave generation and propagation
- Sediment transport
- Pollutant transport and dispersion

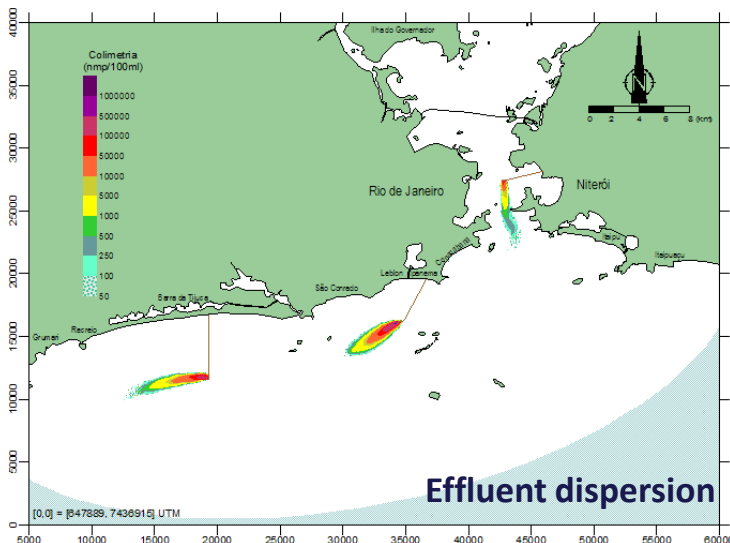


Hydrodynamics

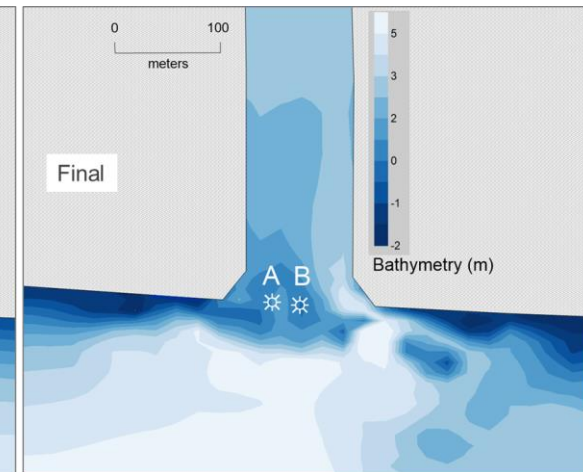
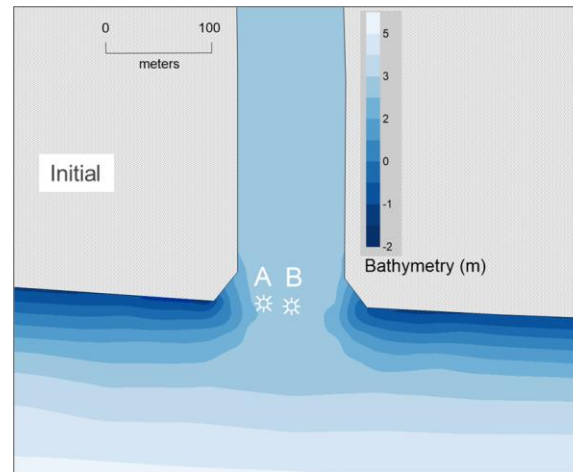


Wave propagation

Morphodynamics



Effluent dispersion



Initial Bathymetry (m)

Final Bathymetry (m)



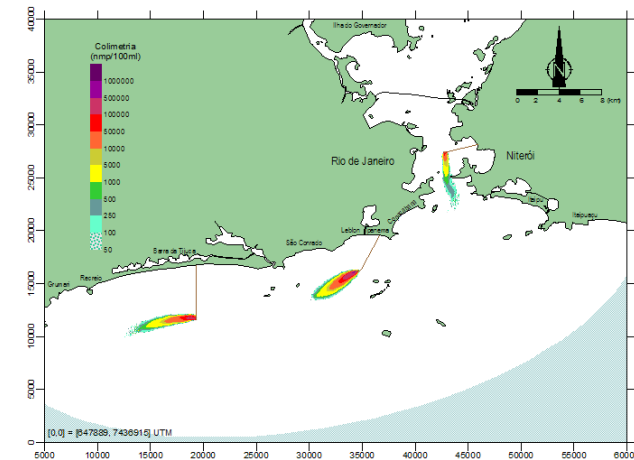
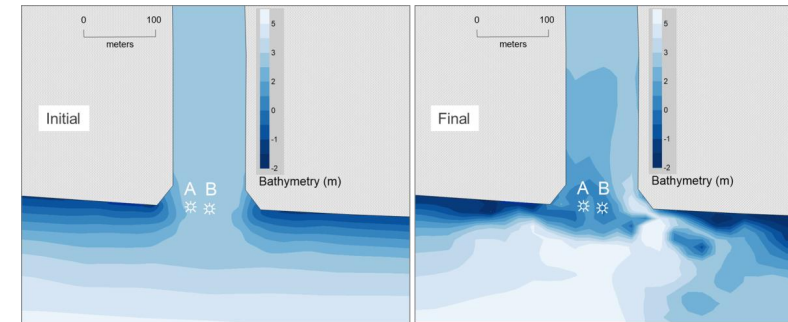
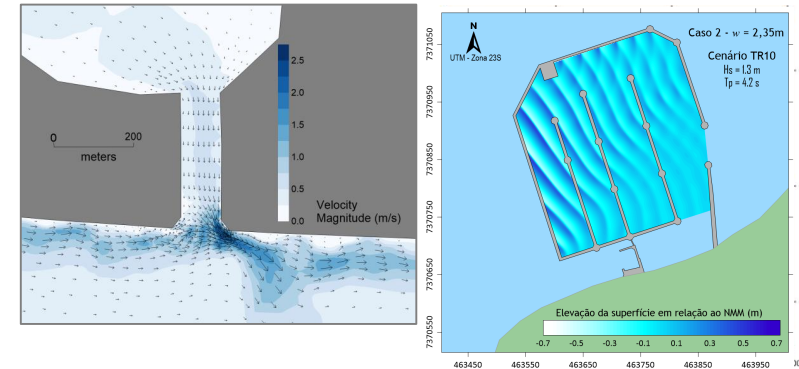
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Water resources related issues

- Environmental Hydrodynamics
- Wave propagation
- Sediment transport
- Pollutant transport and dispersion

ALL NONLINEAR PHENOMENA!!





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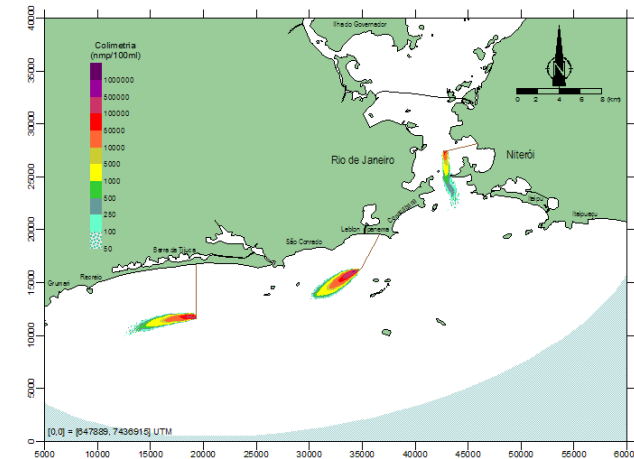
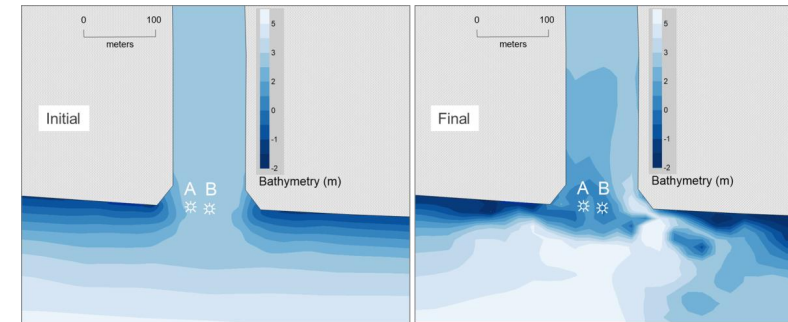
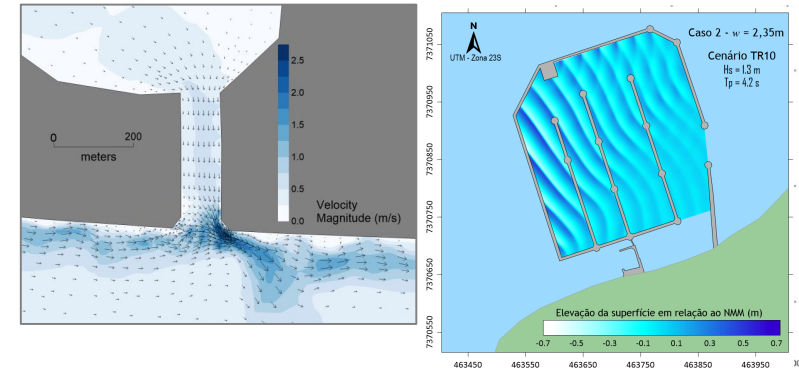
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ALL NONLINEAR PHENOMENA!!

**Simulation requires numerical solution
of nonlinear differential equations**



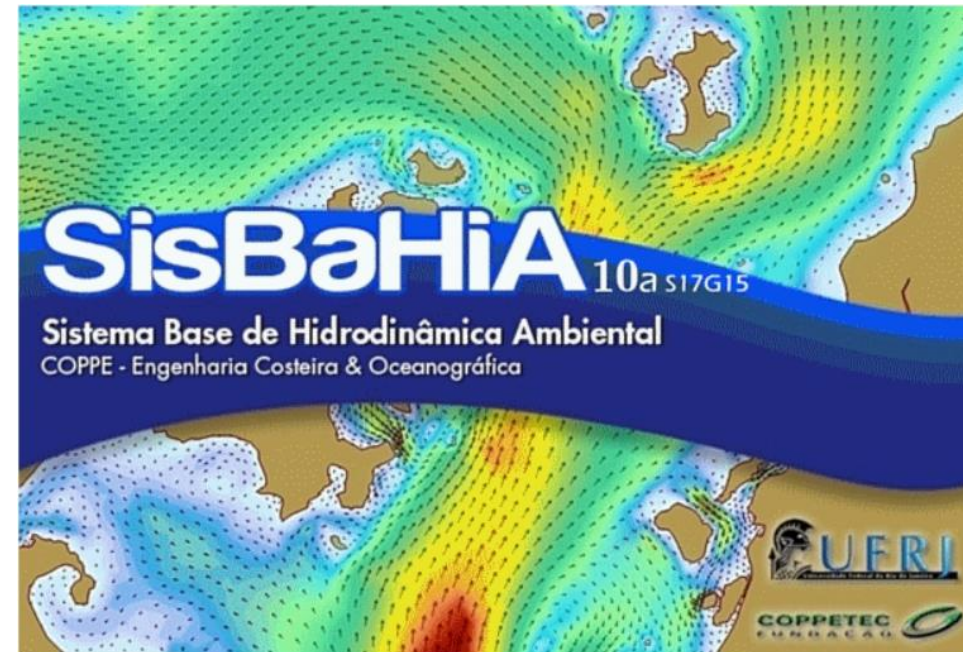


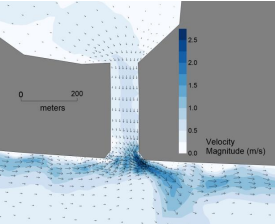
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SisBaHiA – Environmental Hydrodynamics Base System

- Computational modeling system provided by COPPE/UFRJ
- Environmental modeling of water bodies with complex geometry, as rivers, estuaries, lagoons, bays, coasts, reservoirs, etc.
- Open code (Fortran) free software
- Finite elements and finite difference numerical models



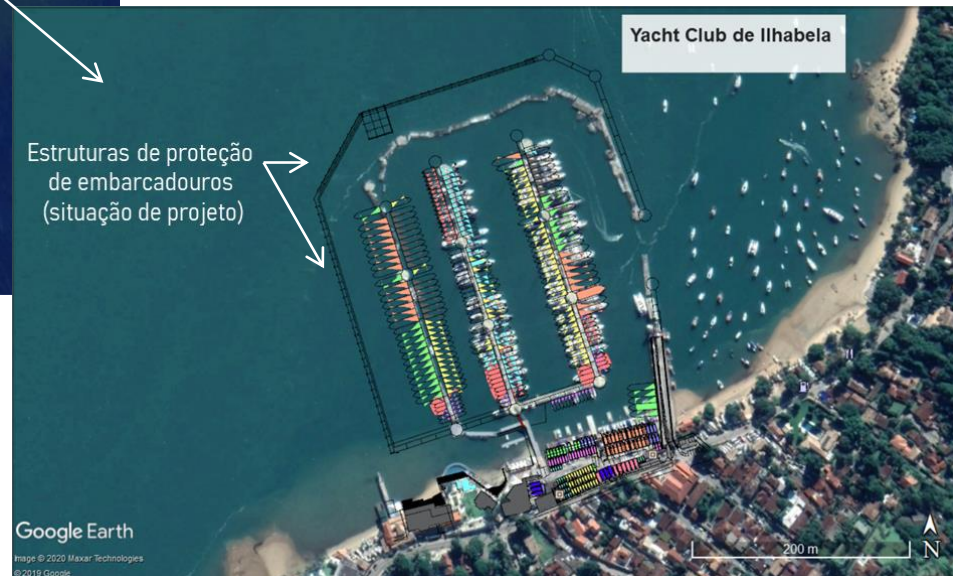
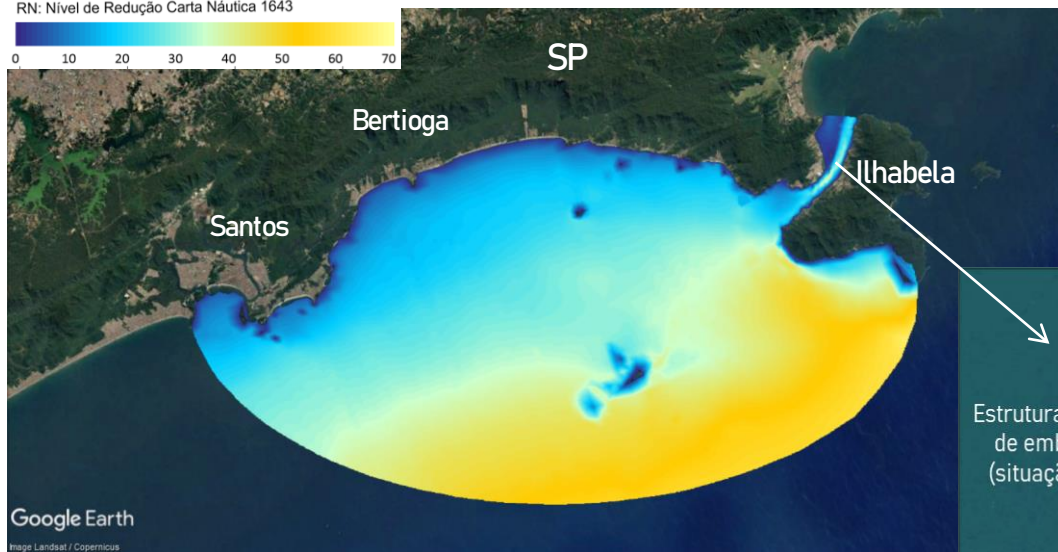
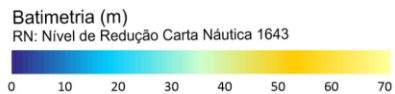
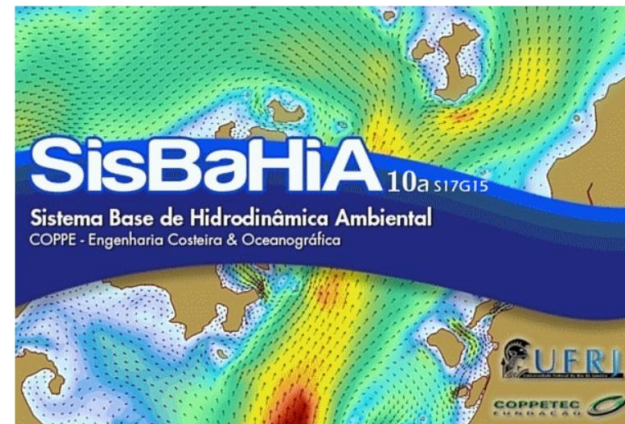
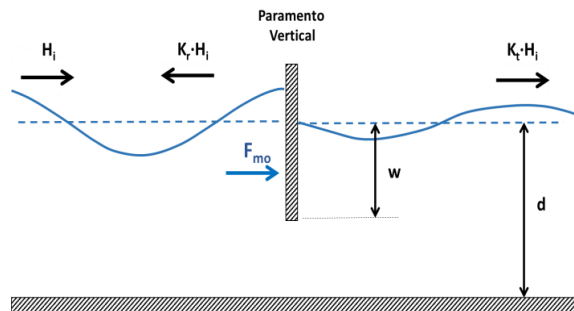


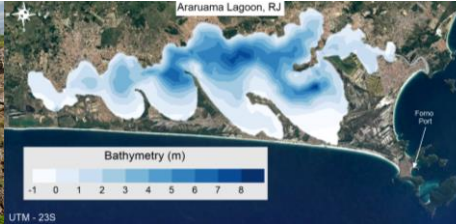
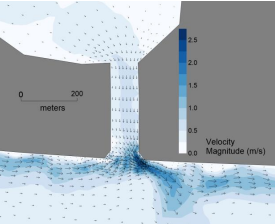
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How does it work?

Example: Ilhabela – SP





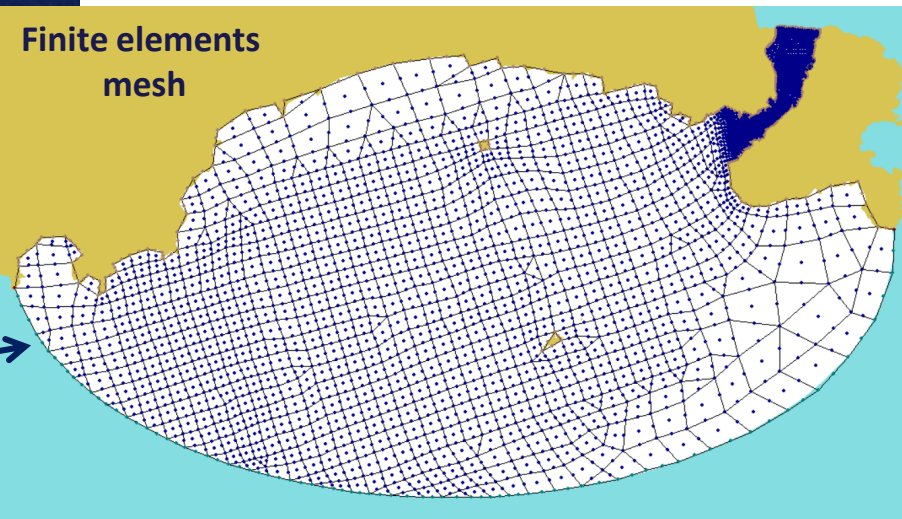
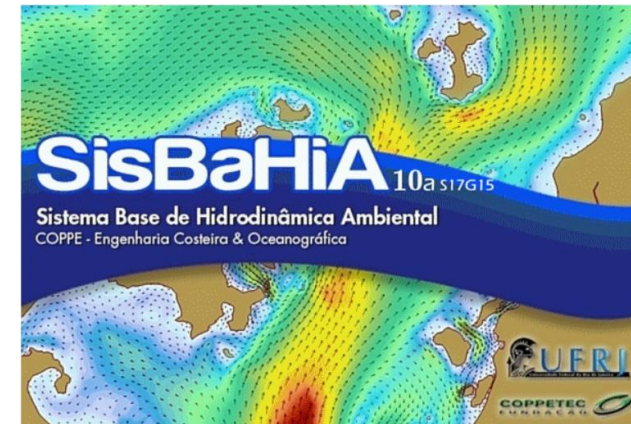
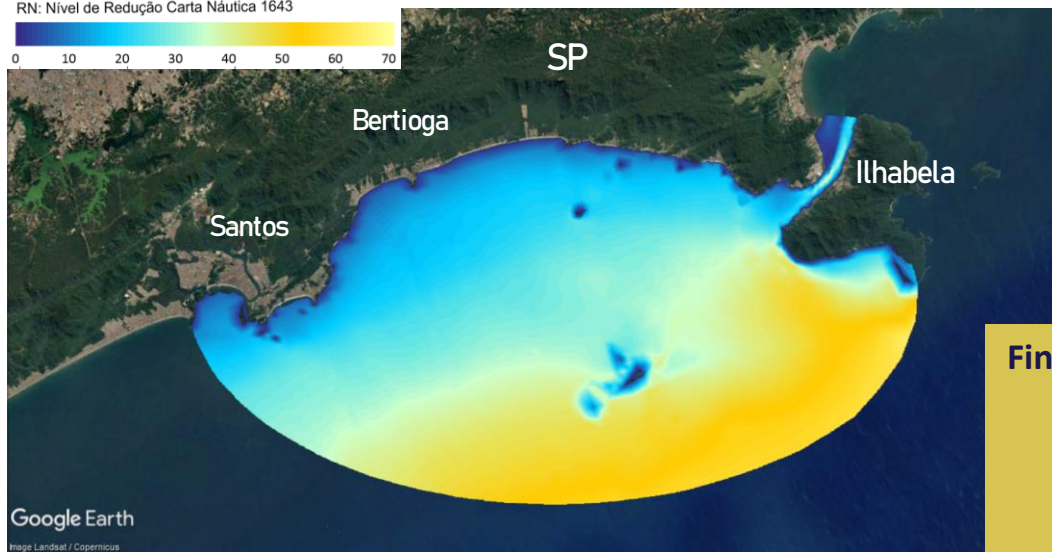
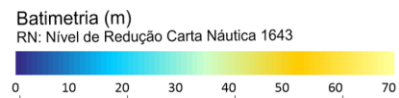
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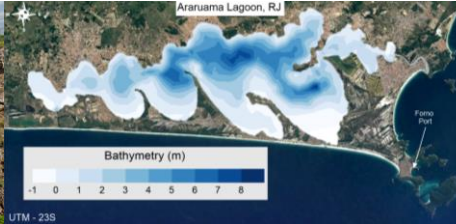
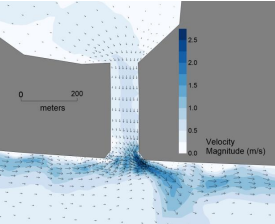
How does it work?

Example: Ilhabela – SP

➤ Digital terrain model



Bathymetry data



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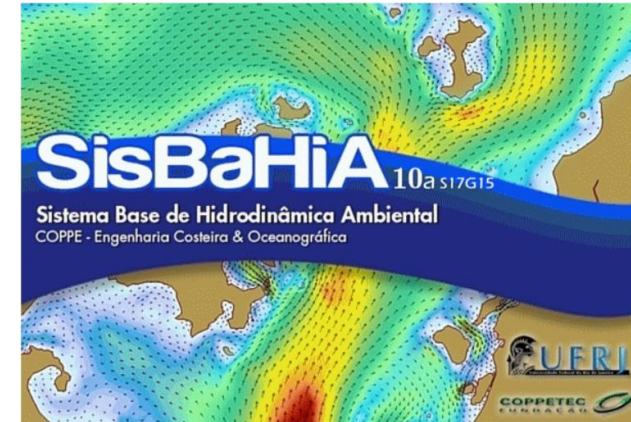
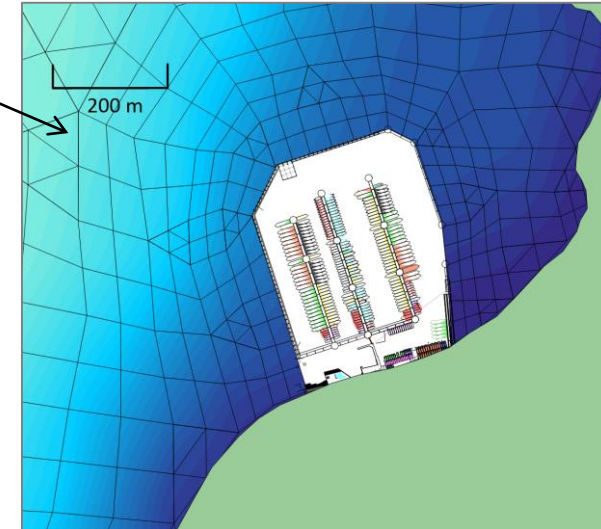
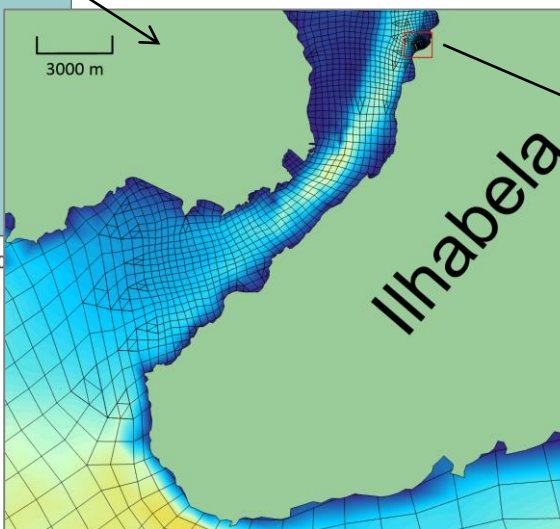
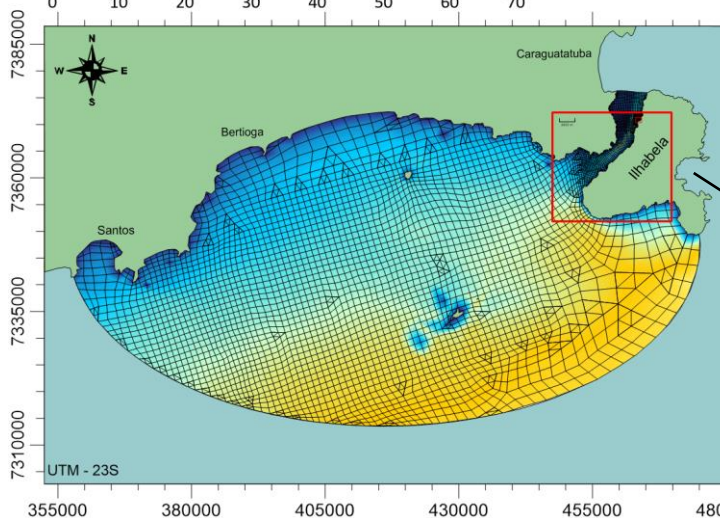
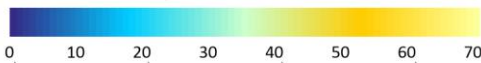
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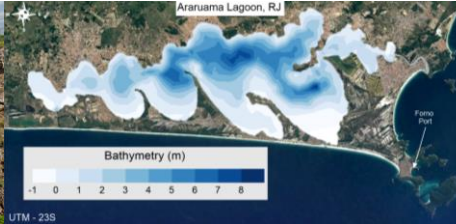
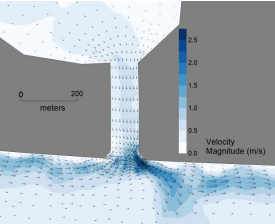
How does it work?

Example: Ilhabela – SP

➤ Digital terrain model

Batimetria (m)
RN: Nível de Redução Carta Náutica 1643





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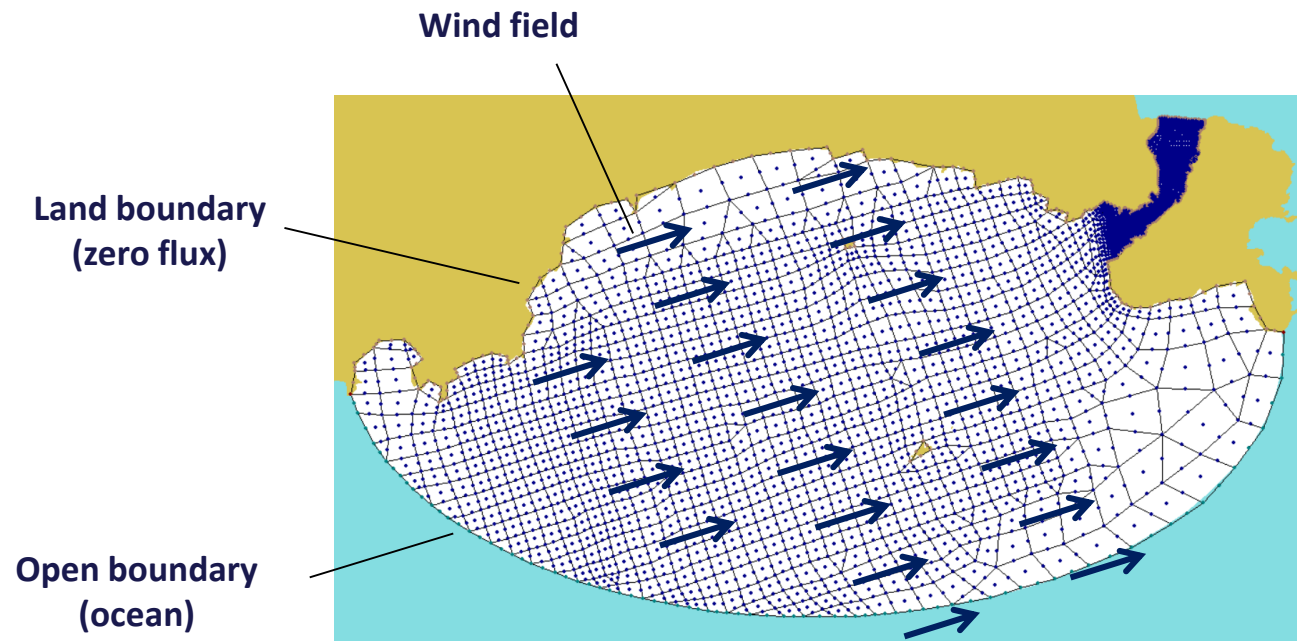
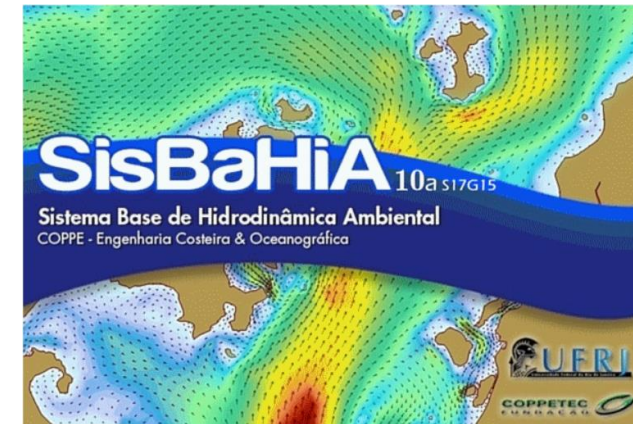
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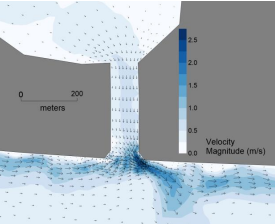
Example: Ilhabela – SP

Simulated phenomena: wind waves generation

Input data:

- Bathymetry (DTM)
- Winds
- Boundary conditions





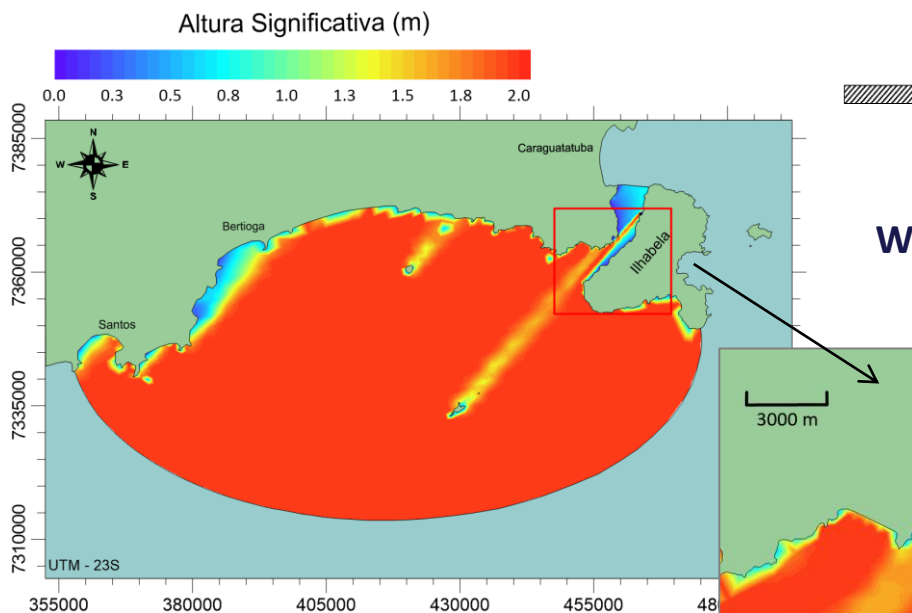
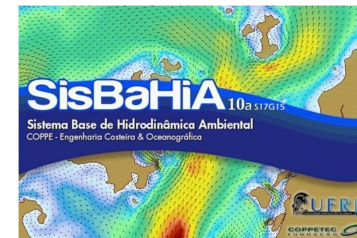
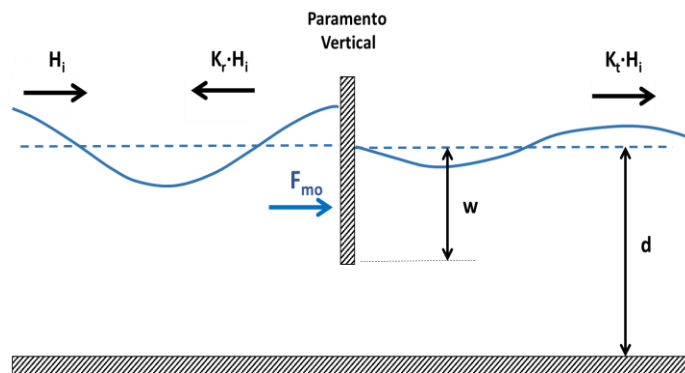
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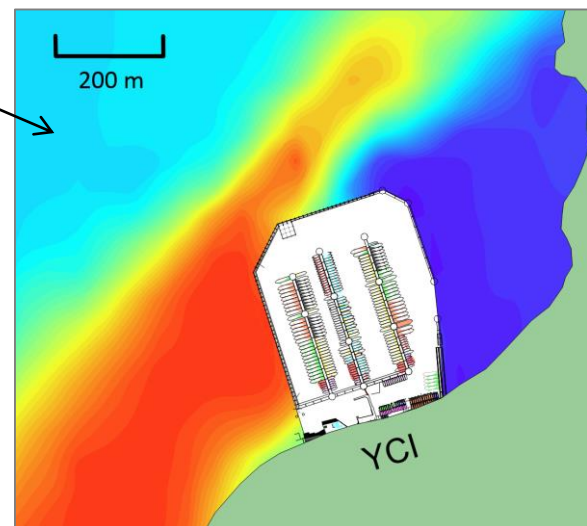
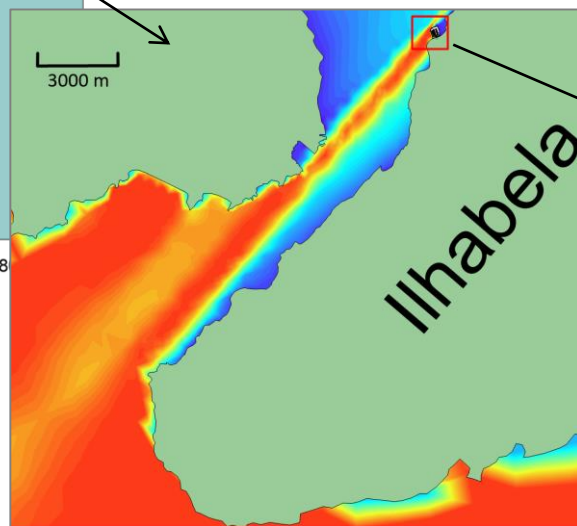
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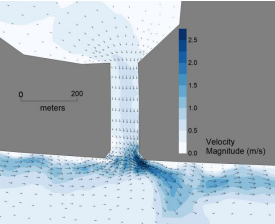
Example: Ilhabela – SP

➤ Results



Wave height (m)





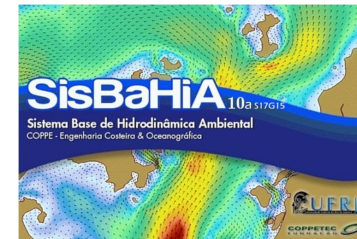
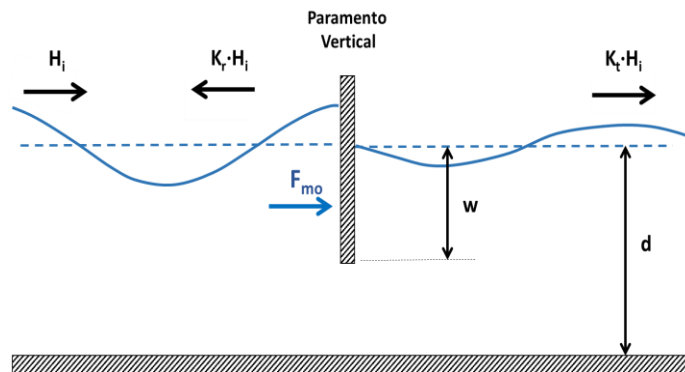
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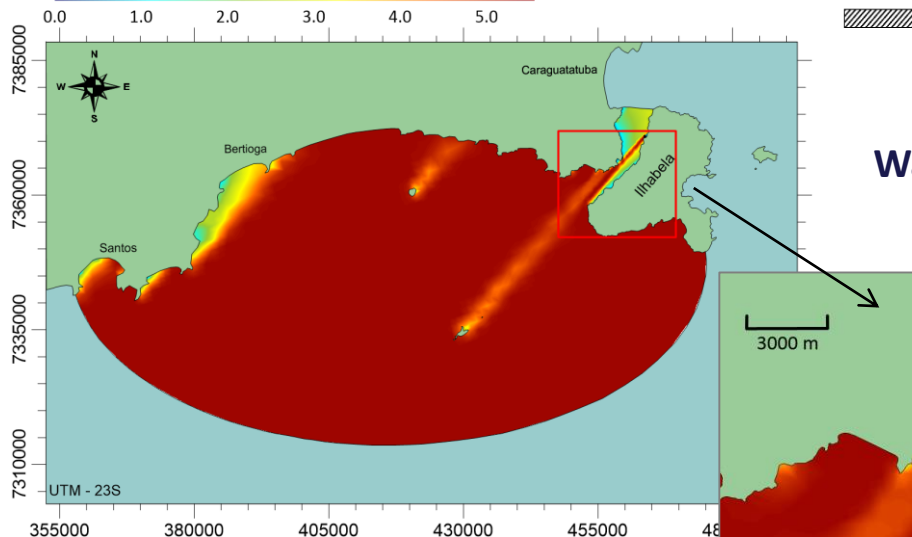
How does it work?

Example: Ilhabela – SP

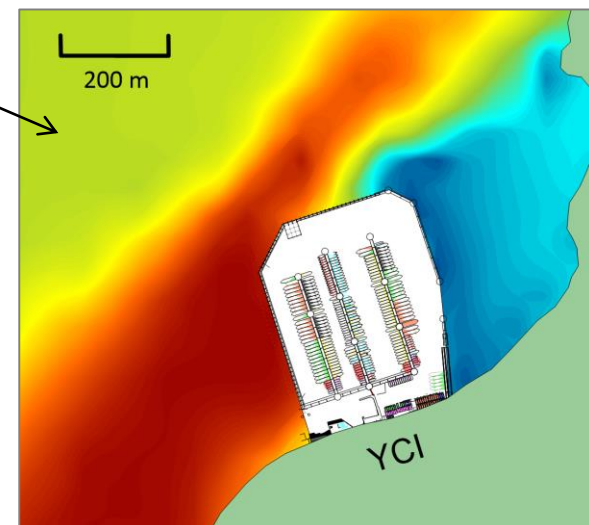
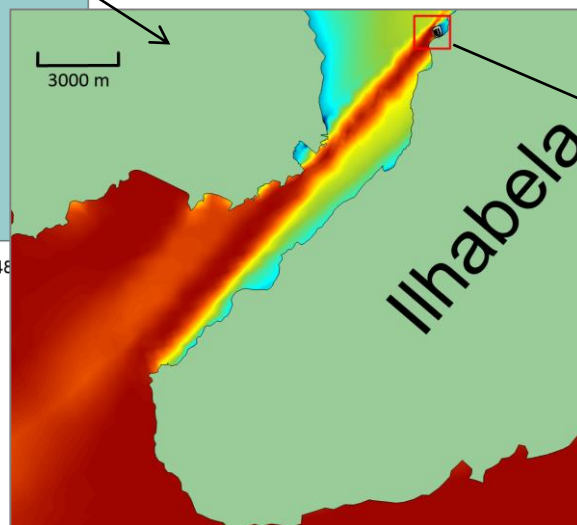
➤ Results

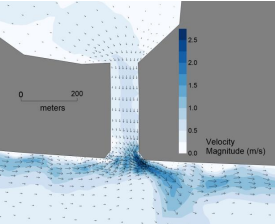


Período de Pico (s)



Wave period (m)





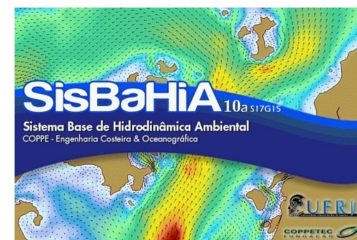
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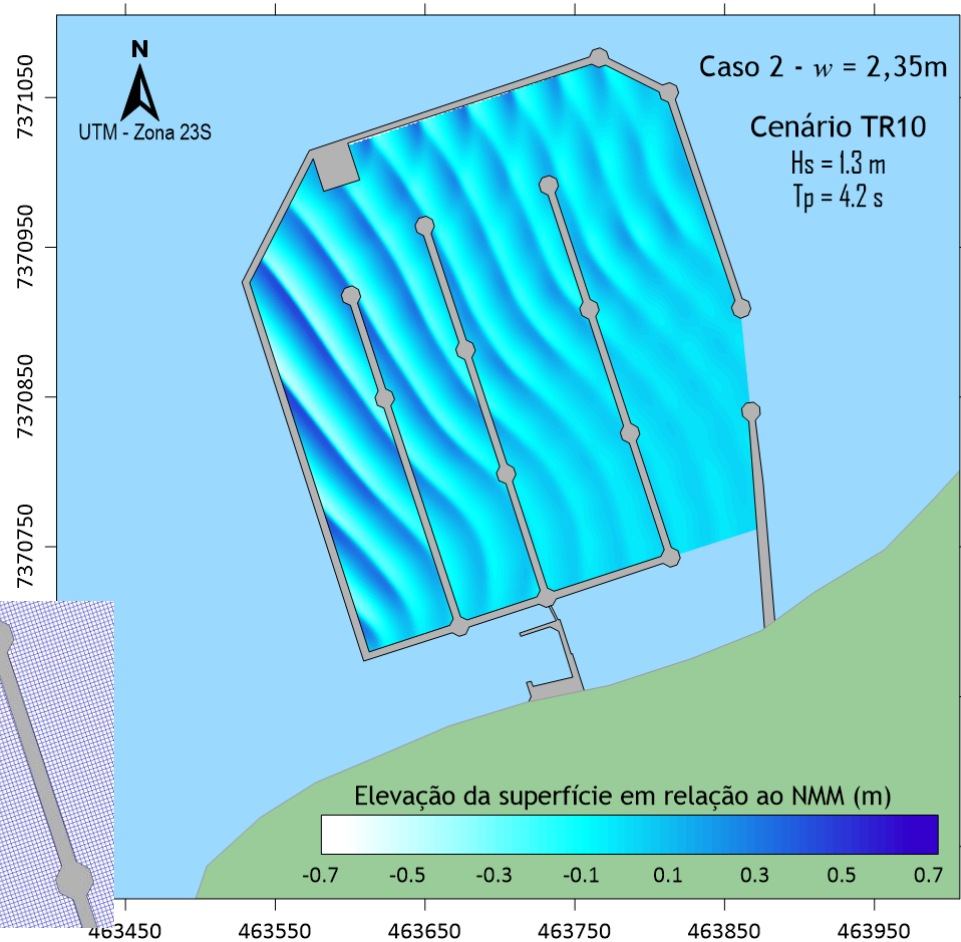
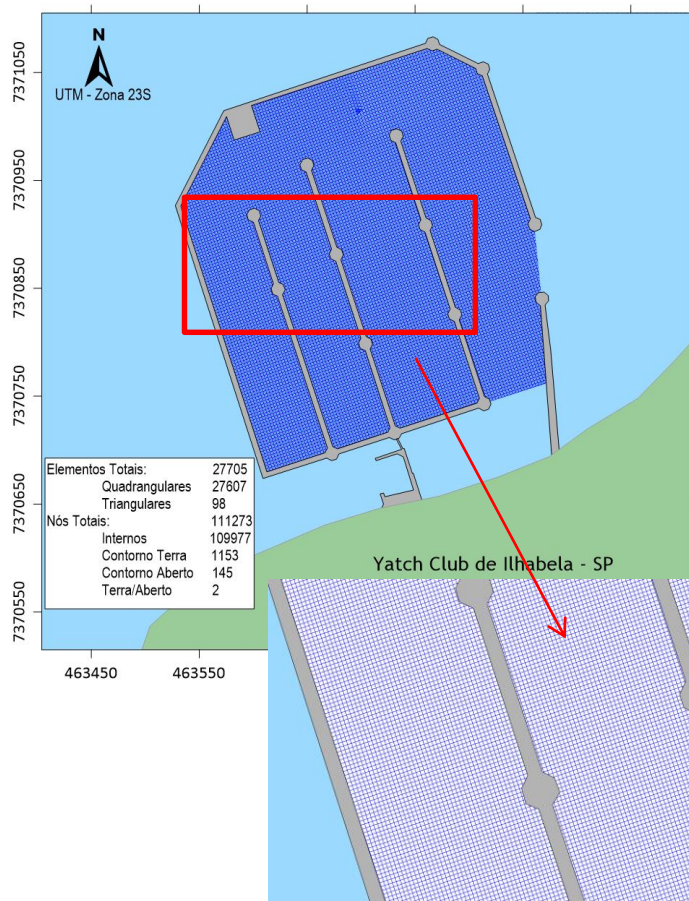
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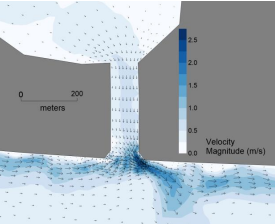
Example: Ilhabela – SP

➤ Results



Wave inside the harbour





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Data analysis

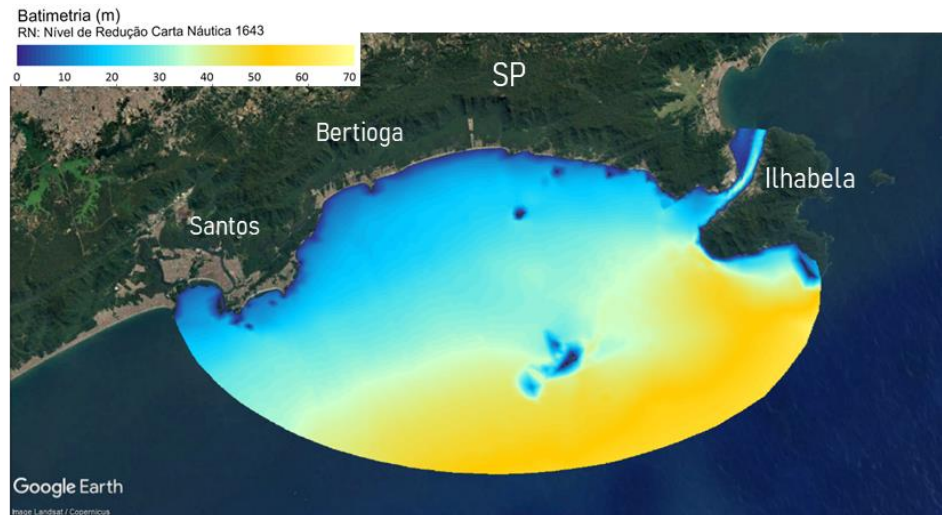


Google Earth
(model domain)

**Georeferenced
map layers**

Bathymetry data

Sea bottom surface

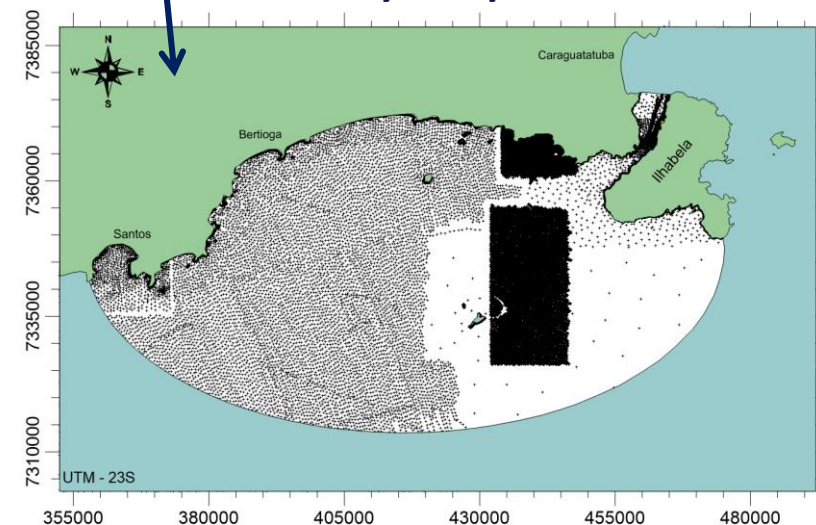


Interpolation methods

- Kriging
- Delaunay triangulation
- Minimum curvature
- Natural neighbor
- etc



Surfer
(2D and 3D mapping)

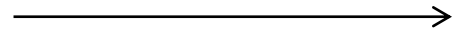




Data analysis

- Wind data acquisition

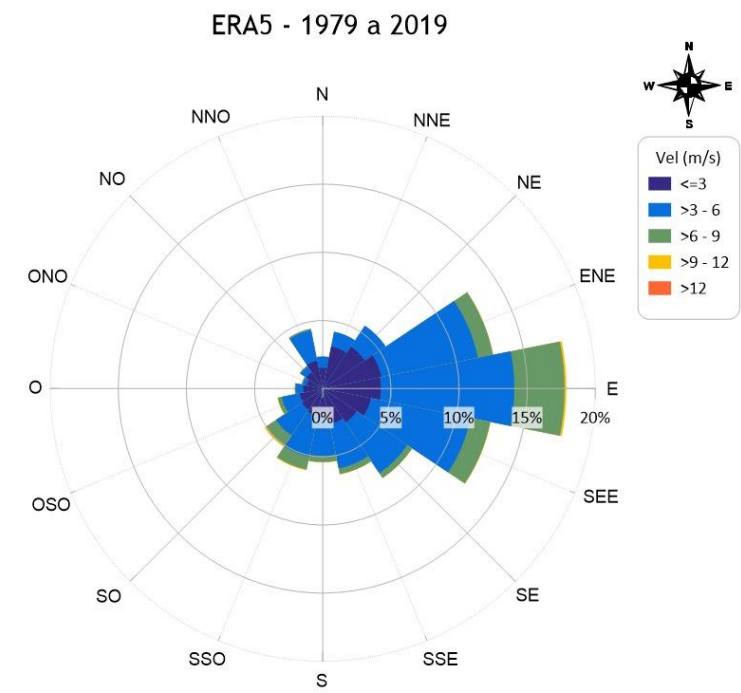
Grapher
(2D and 3D graphing and analysis)

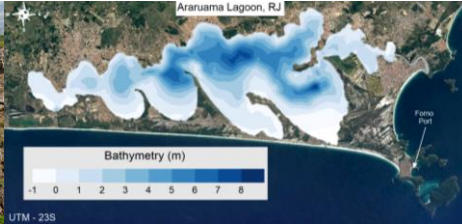
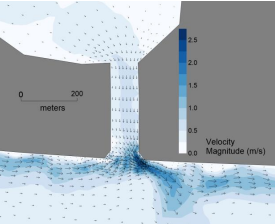


Wind data analysis

Global atmospheric models

- Wind data
- NETCDF format
- Python interface





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Model setup and execution



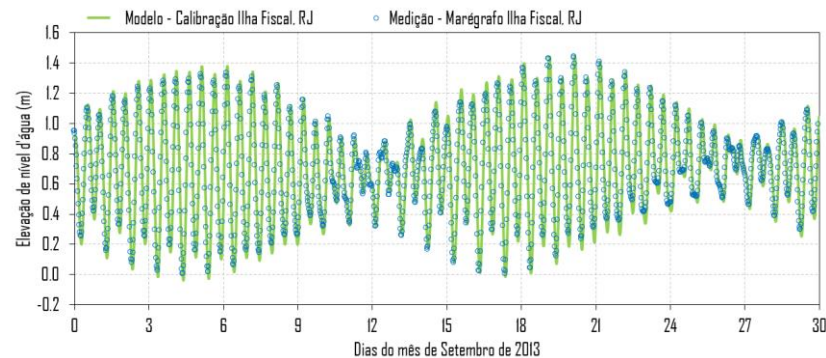
Microsoft Access
(or any similar database tool)



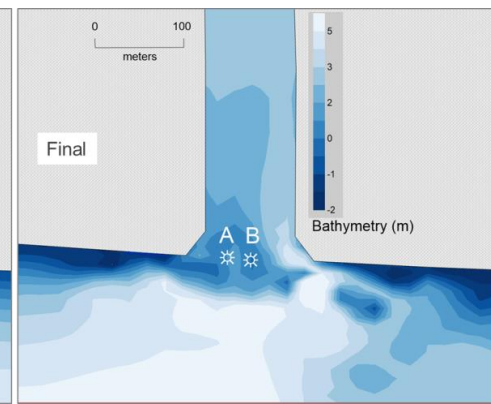
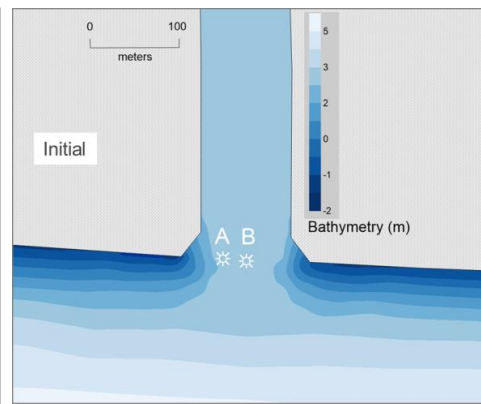
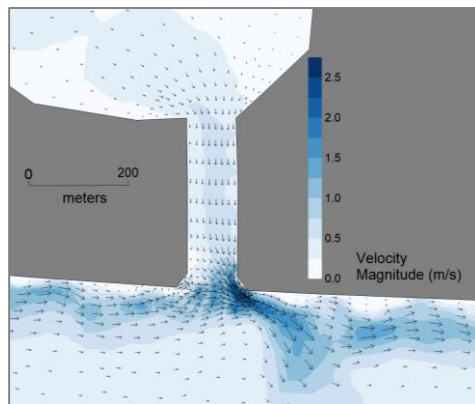
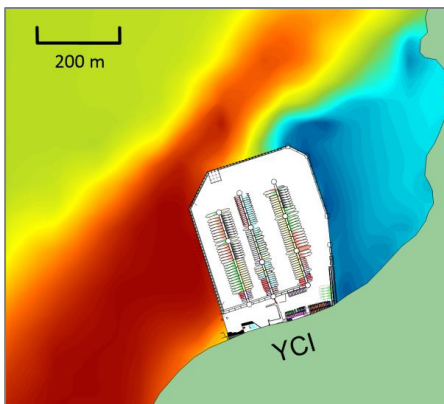
Results analysis

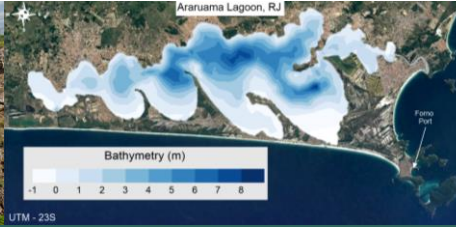
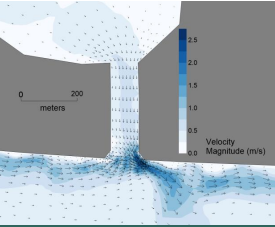


Grapher
(temporal results)



Surfer
(spatial results)





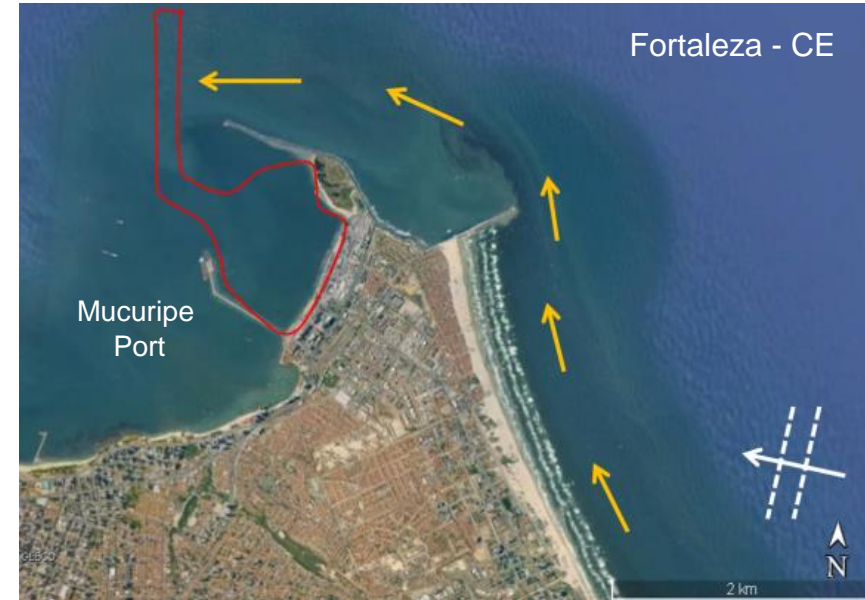
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Research and Development

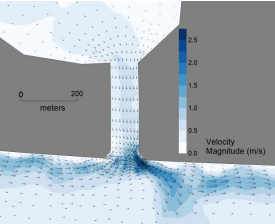
- Nearshore morphological processes
- Wave induced sediment transport

Port sedimentation



Coastal erosion

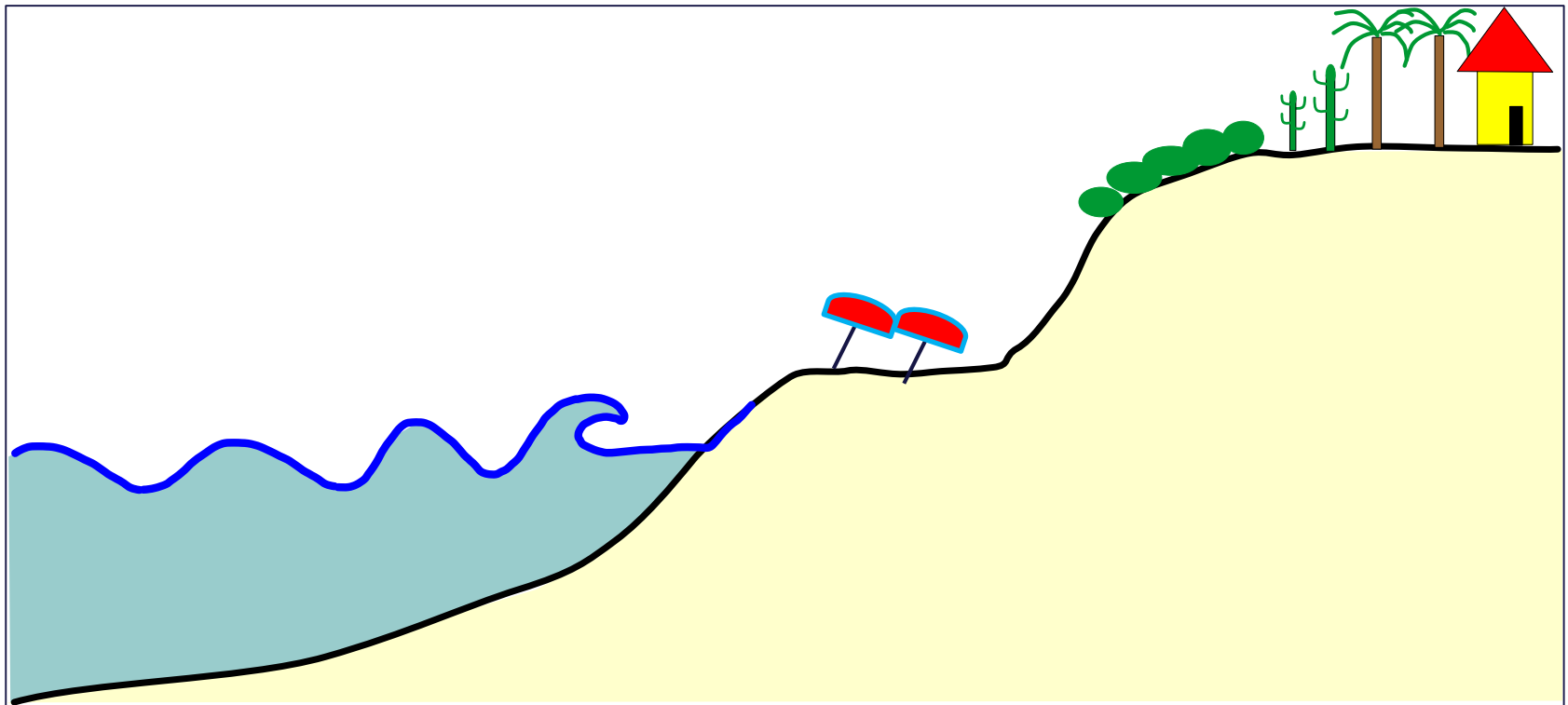


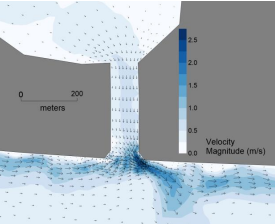


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Beach erosion

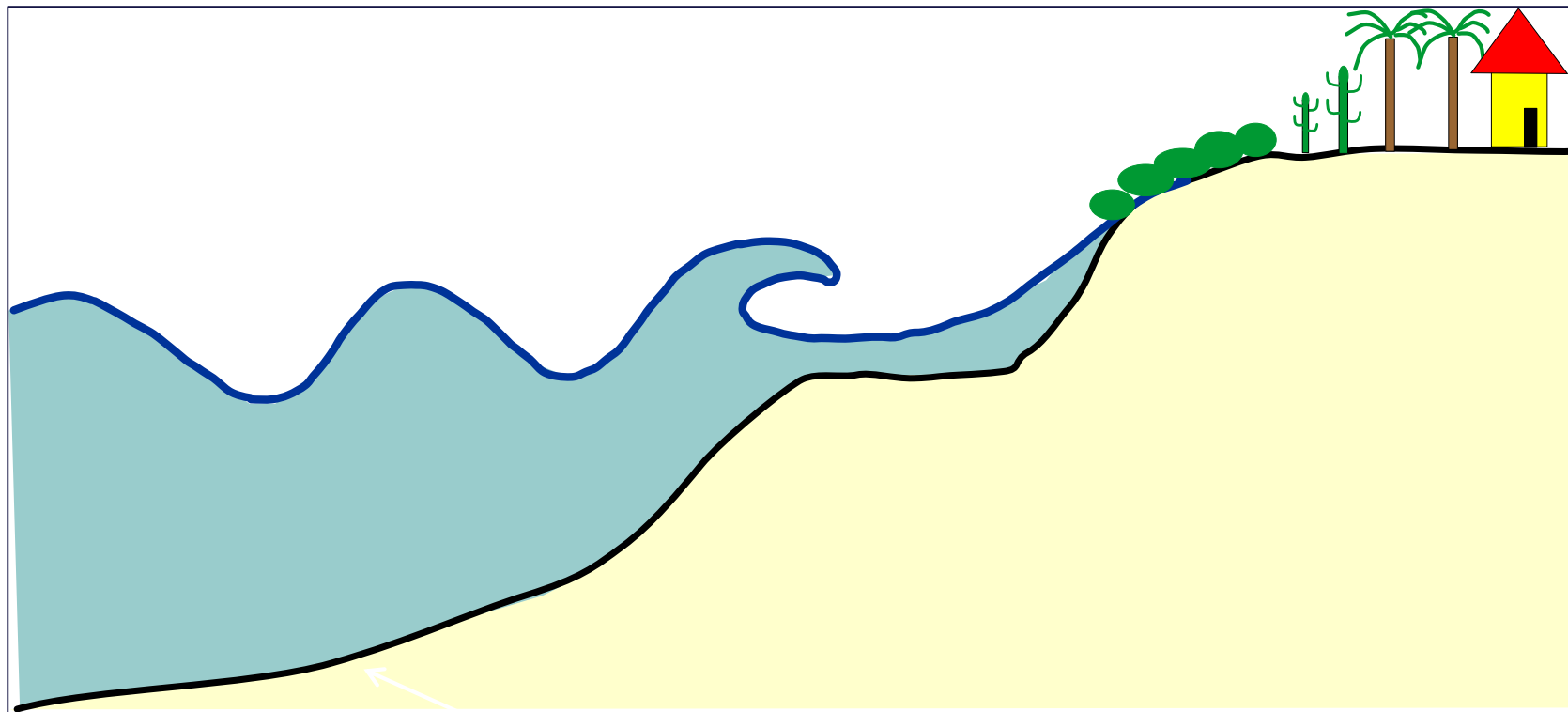


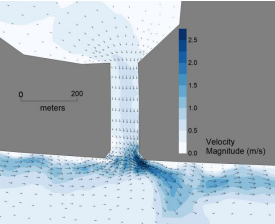


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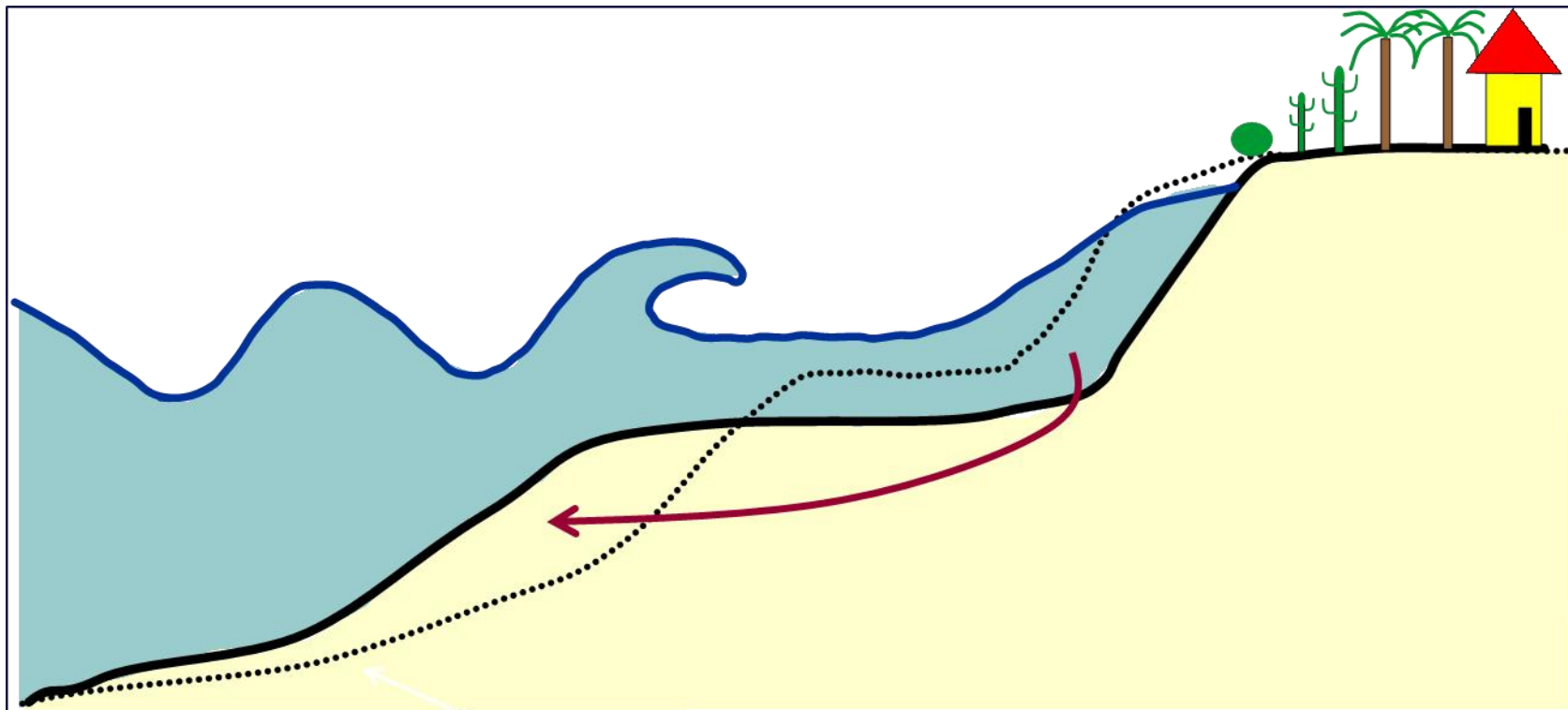


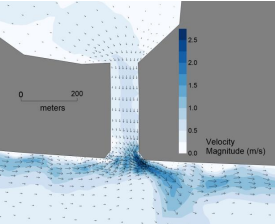


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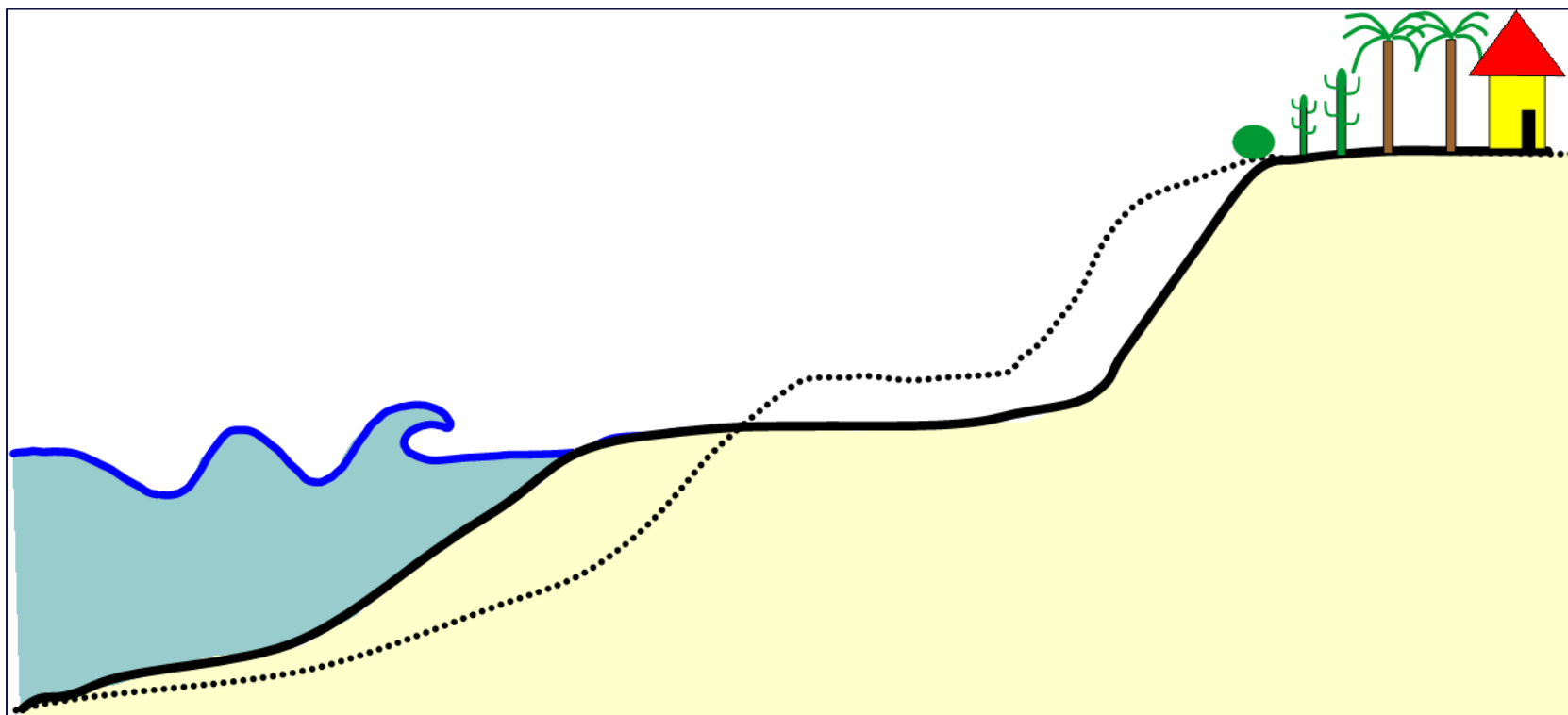


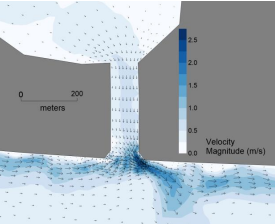


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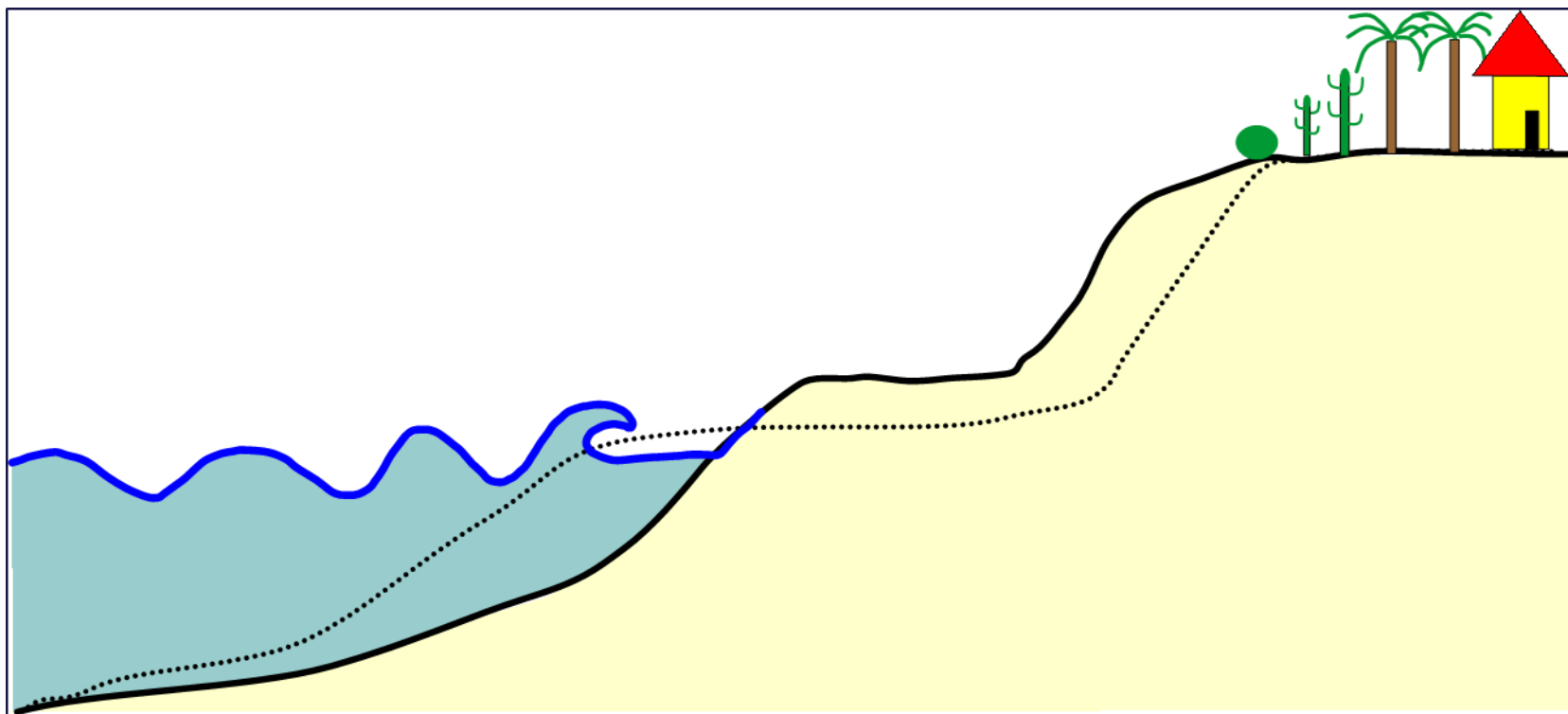


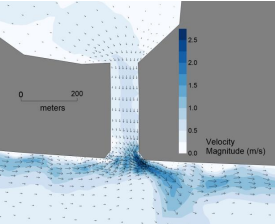


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Beach erosion



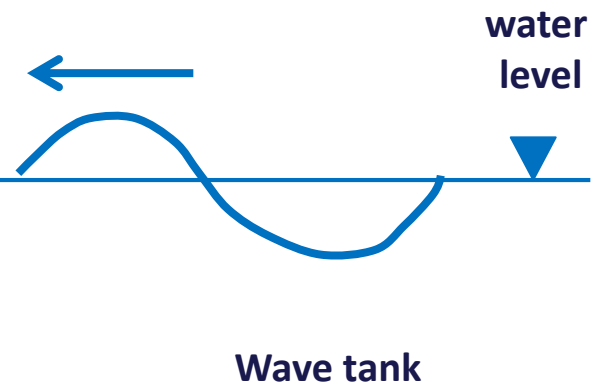
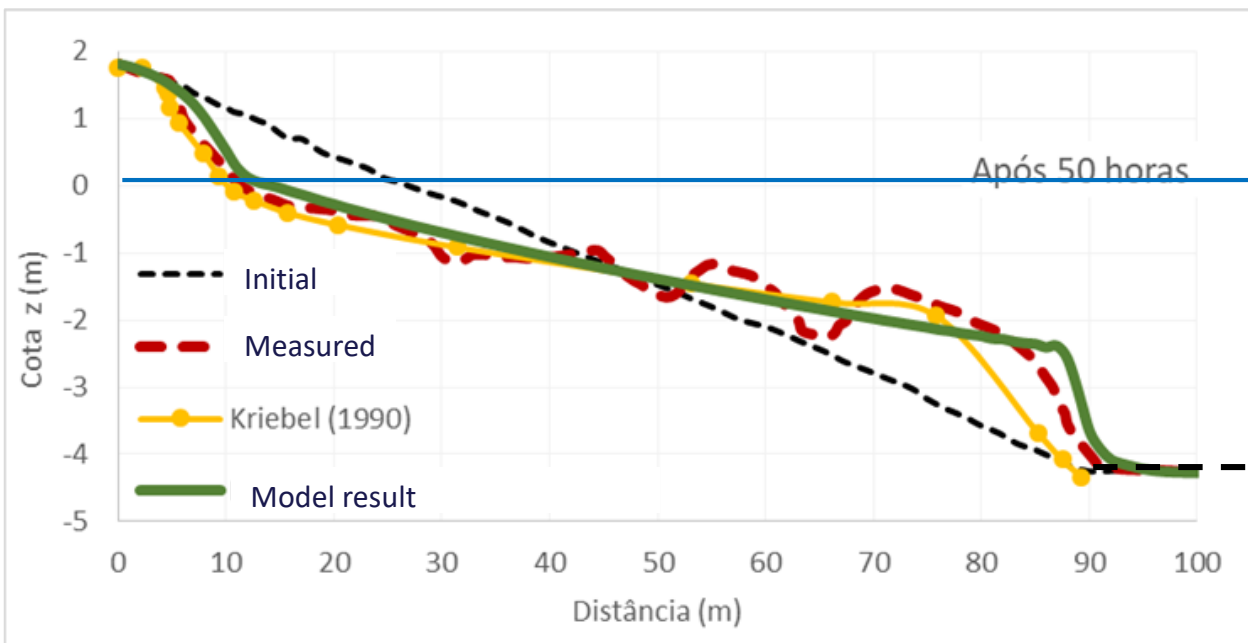
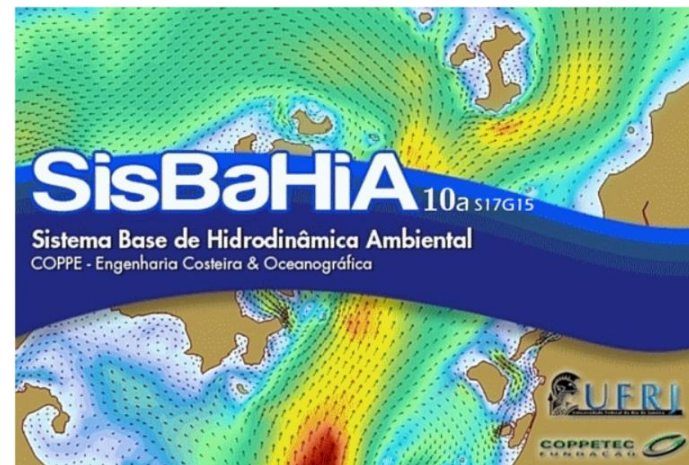


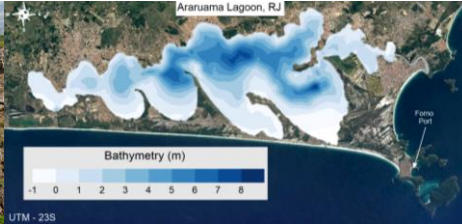
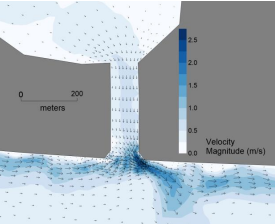
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Beach erosion model

Beach Profile



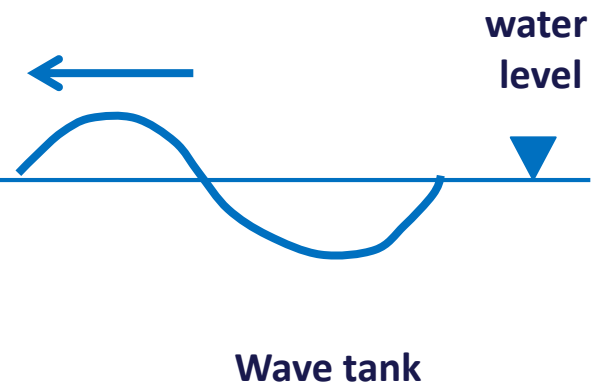
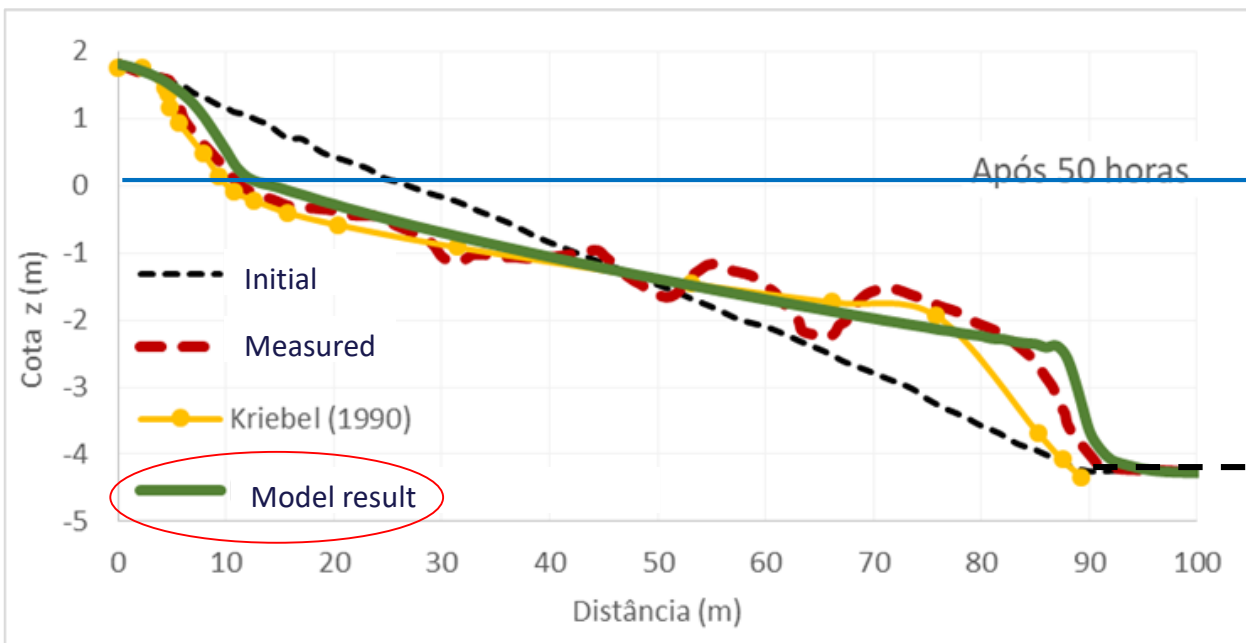


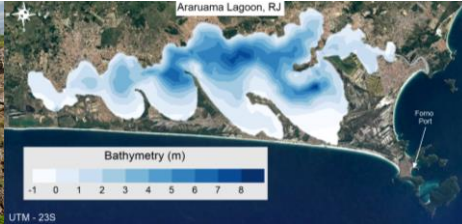
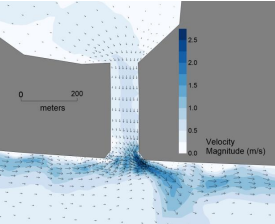
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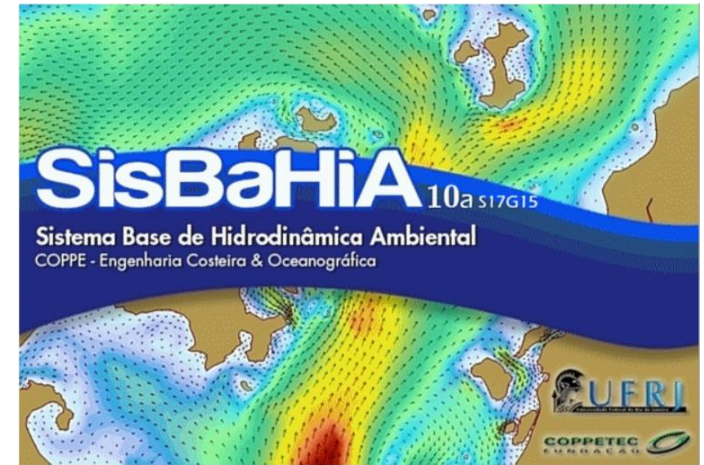


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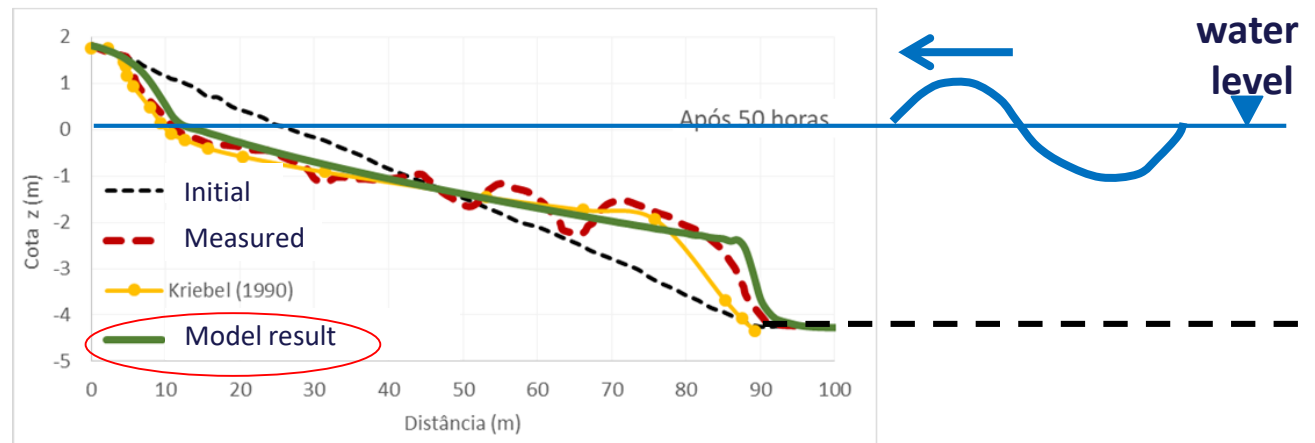
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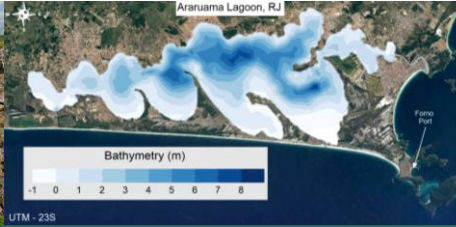
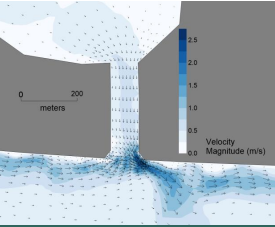
Beach erosion model

➤ Good results



Beach Profile



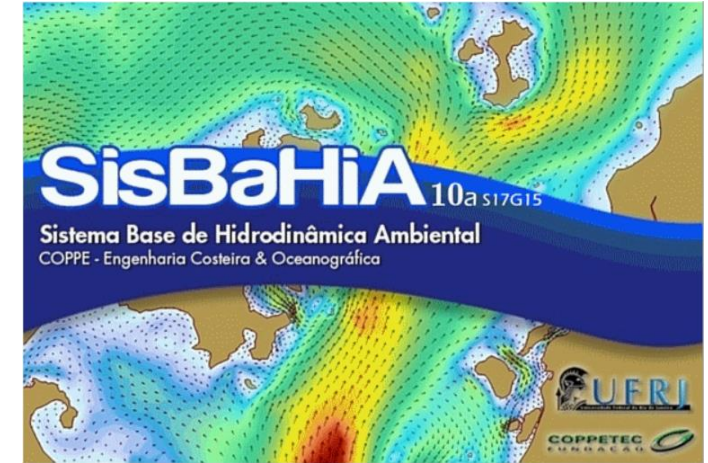


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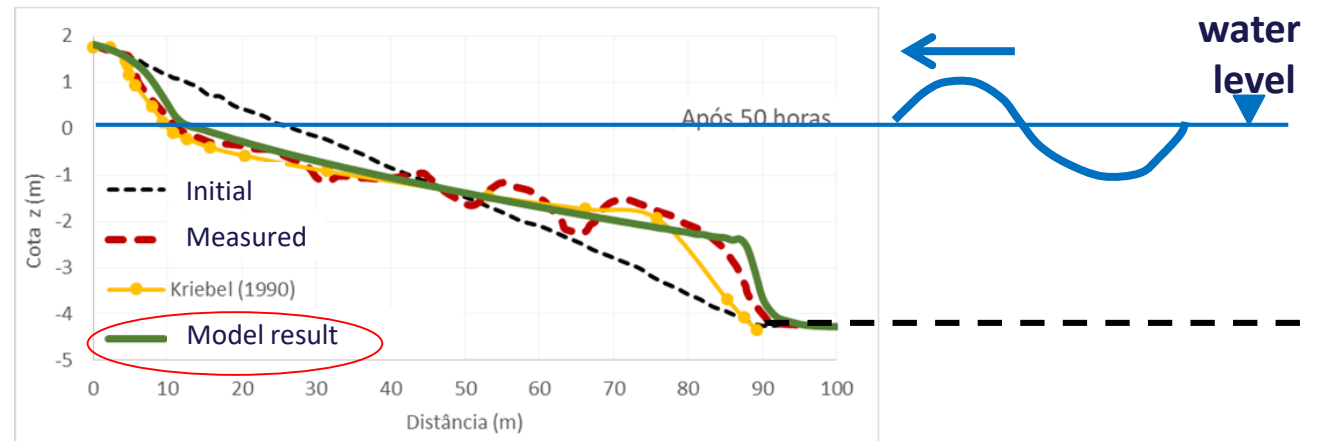
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Beach erosion model

- Good results
- Highly dependent on case to case calibration



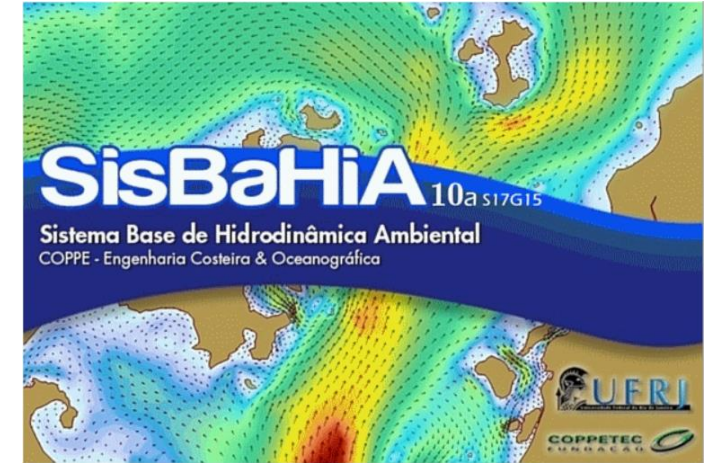
Beach Profile



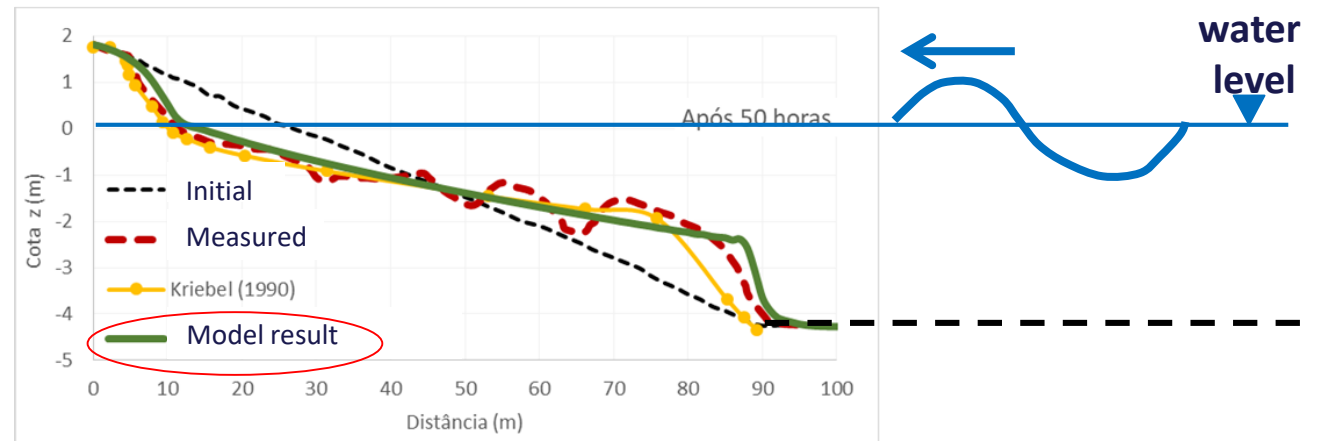


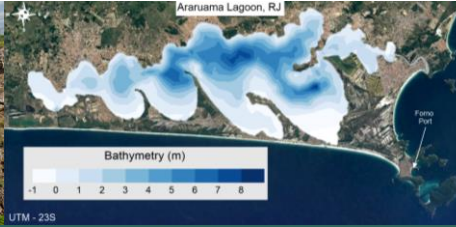
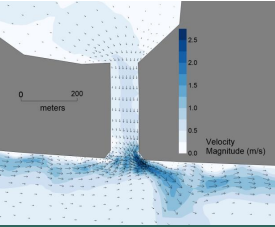
Beach erosion model

- Good results
- Highly dependent on case to case calibration
- Several parameters involved



Beach Profile



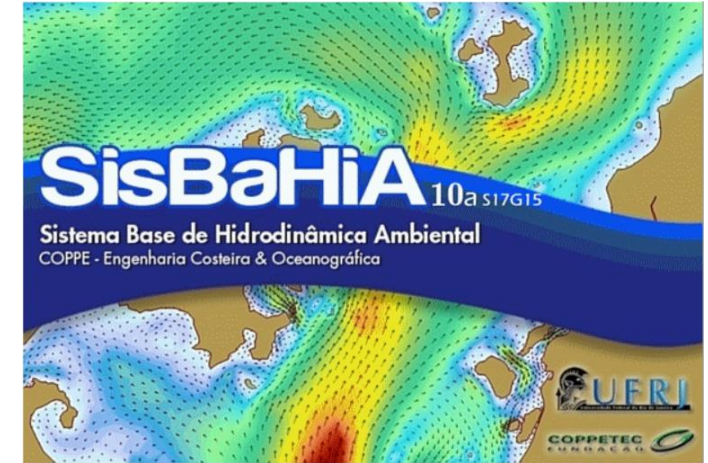


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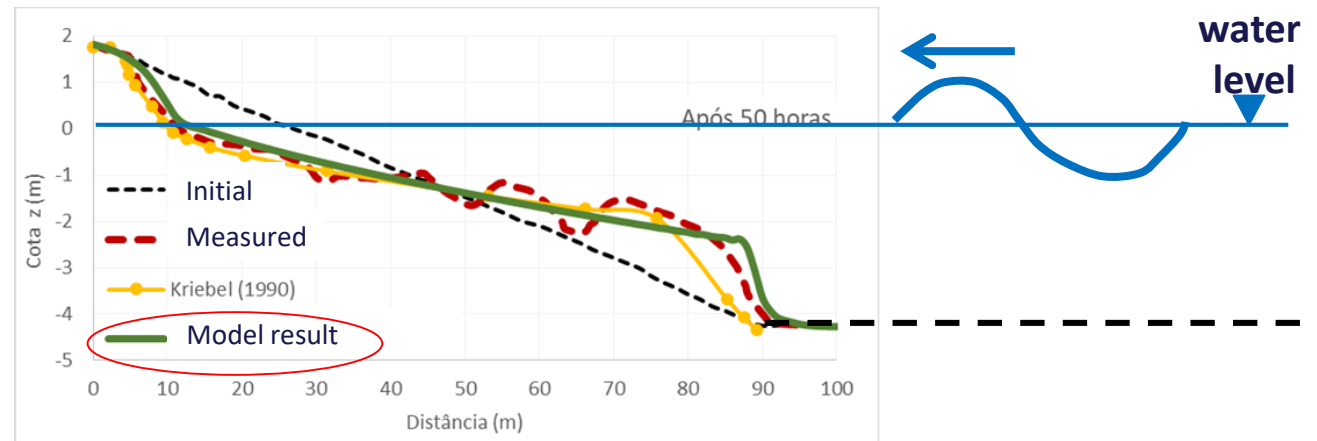
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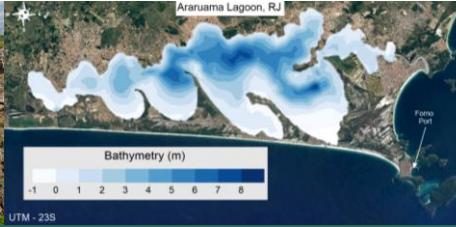
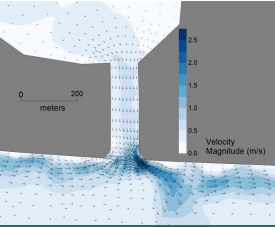
Beach erosion model

- Good results
- Highly dependent on case to case calibration
- Several parameters involved
- Nonlinearity expressed in the data



Beach Profile



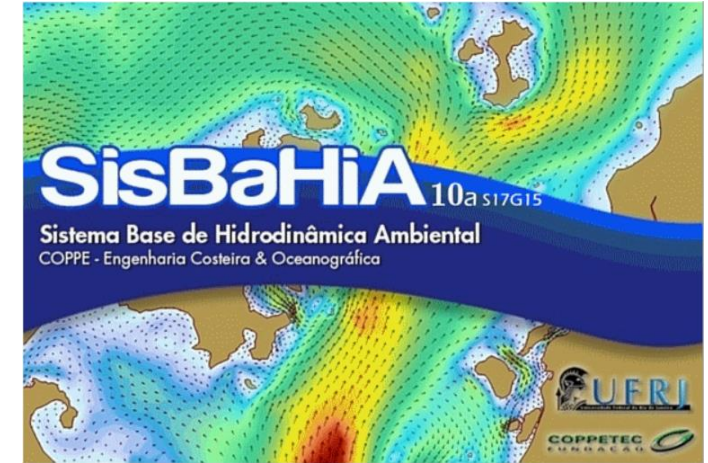


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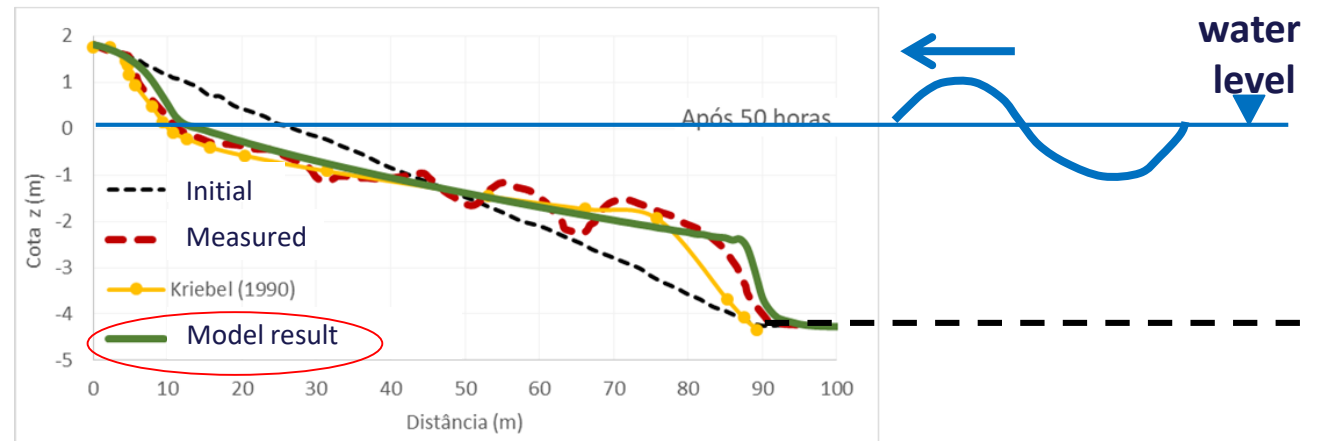
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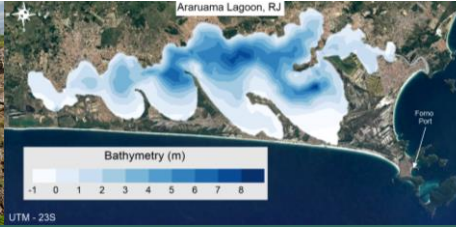
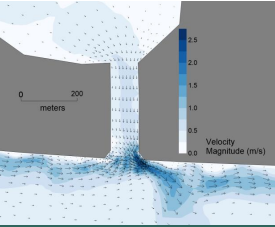
Beach erosion model

- Good results
- Highly dependent on case to case calibration
- Several parameters involved
- Nonlinearity expressed in the data
- Upcoming research: how to find a pattern?



Beach Profile



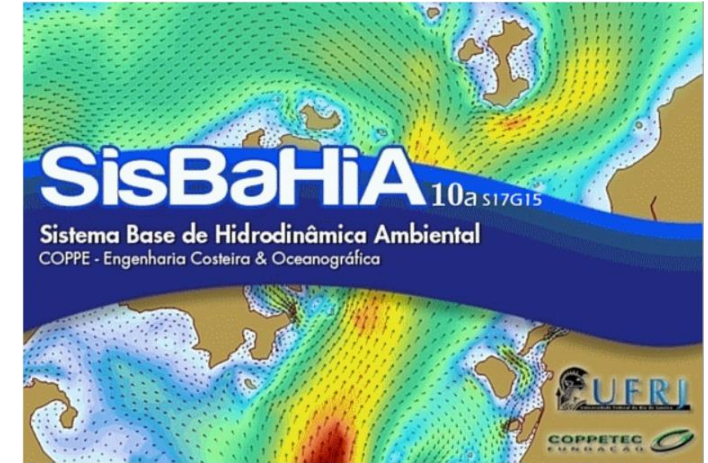


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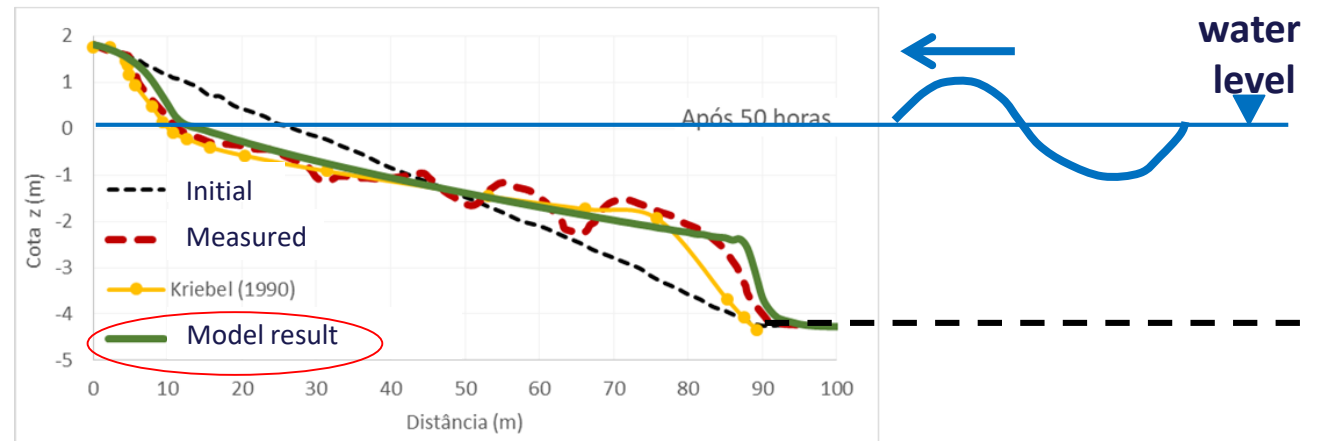
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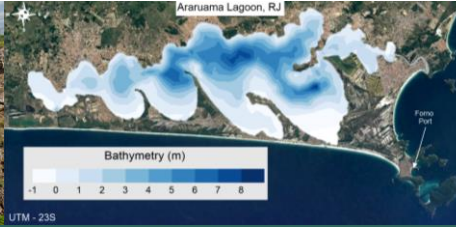
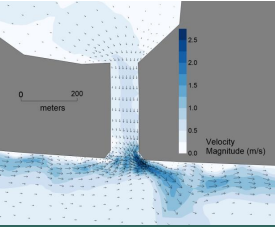
Beach erosion model

- Good results
- Highly dependent on case to case calibration
- Several parameters involved
- Nonlinearity expressed in the data
- Upcoming research: how to find a pattern?
 - Machine learning



Beach Profile





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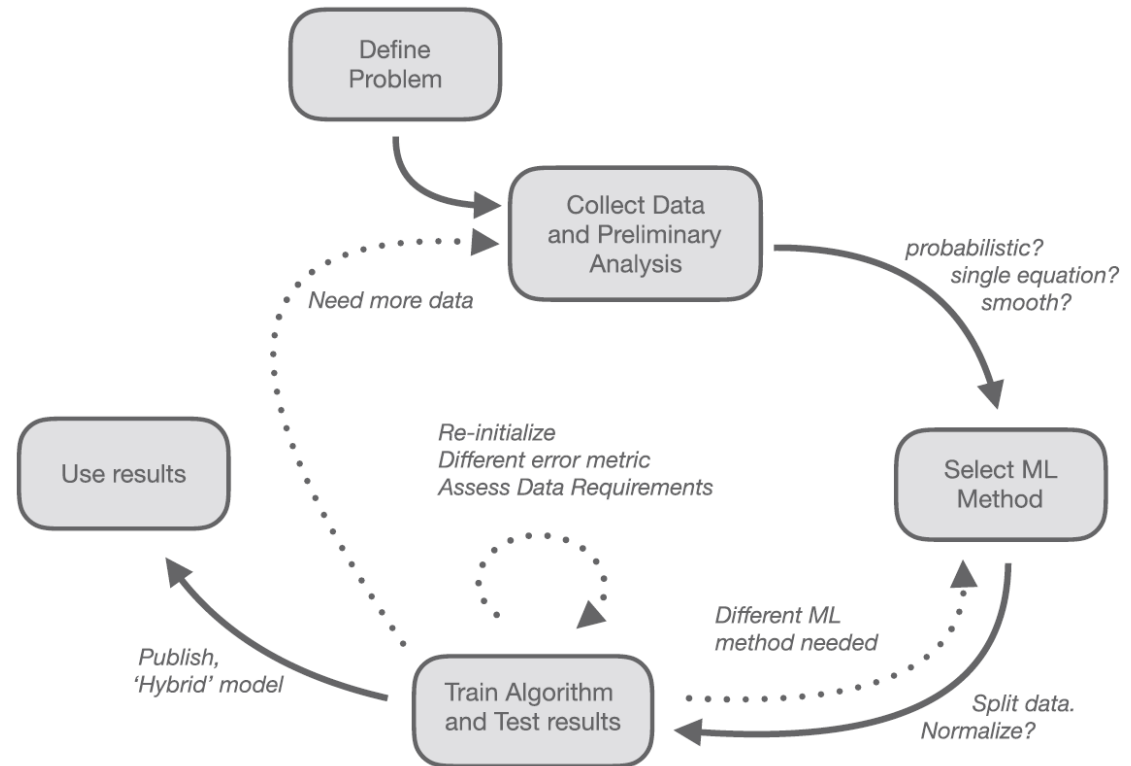
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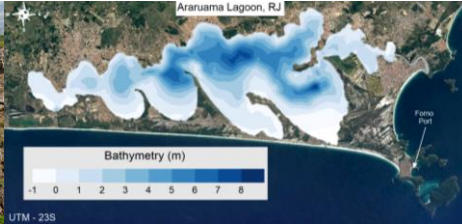
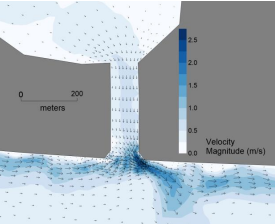
Machine learning

Several methods:

- Artificial neural networks;
- Genetic algorithms;
- Bayesian networks;
- Regression trees;
- etc

Goldstein et. al (2019)





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Thanks a lot!

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