MOHID Modelling @ UAlg in Different Regions and Applications

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UAlg CIMA
UNIVERSIDADE DO ALGARVE
CENTRO DE INVESTIGAÇÃO MARINHA E AMBIENTAL

CiMA

AR NET
AQUATIC RESEARCH NETwork

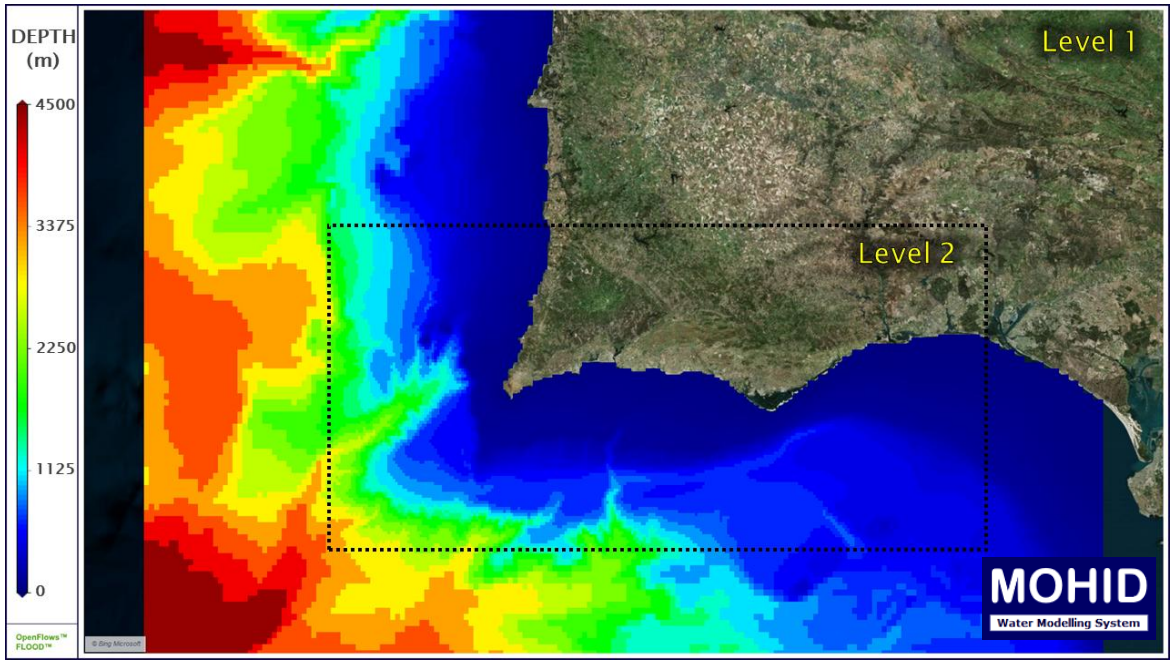
Summary

- SOMA Op. System (Coast of Algarve)
  - Op. System
  - Wave Modelling
  - Lagrangian Drifters & Oil Spill
  - AUV Campaigns
- BASIC – Cartagena (Colombia)
  - Op. System
  - Field Campaigns
- BASIC – MPA (Colombia)
- DR – SARGASSUM (Dominican Republic)
  - Modelling (calibration)
  - Field Experiments
- MOHID Scalability

SOMA (Sistema Operacional de Modelação do Algarve)

SOMA Op. System (Coast of Algarve)

- CMEMS Mercator
- NKUA Skiron
- FES2014 (Level 0)



(Janeiro et al., 2017)

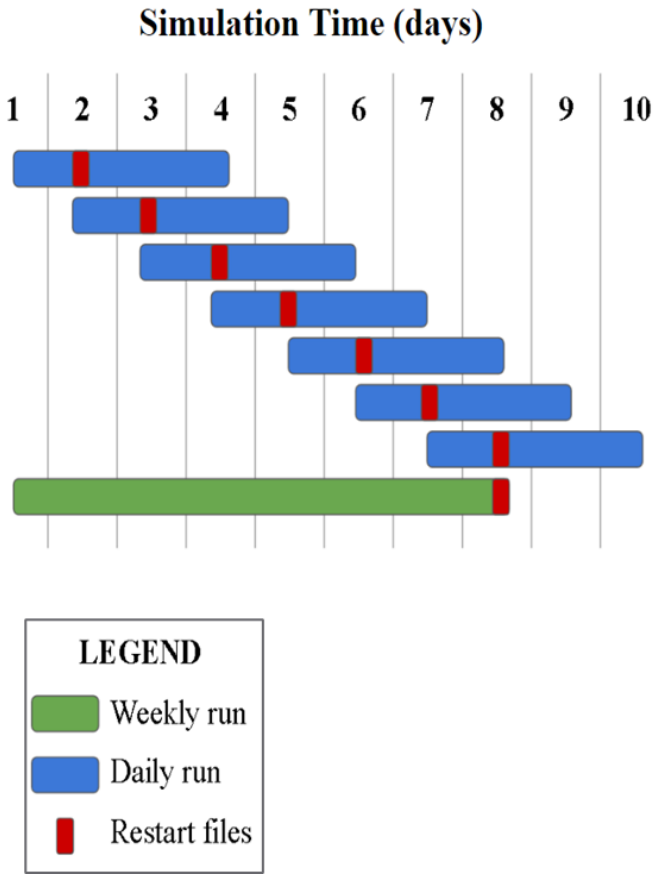
Two downscaling models

3D, 50 cartesian layers

- Level 1: 2 km grid
- Level 2: 1 km grid

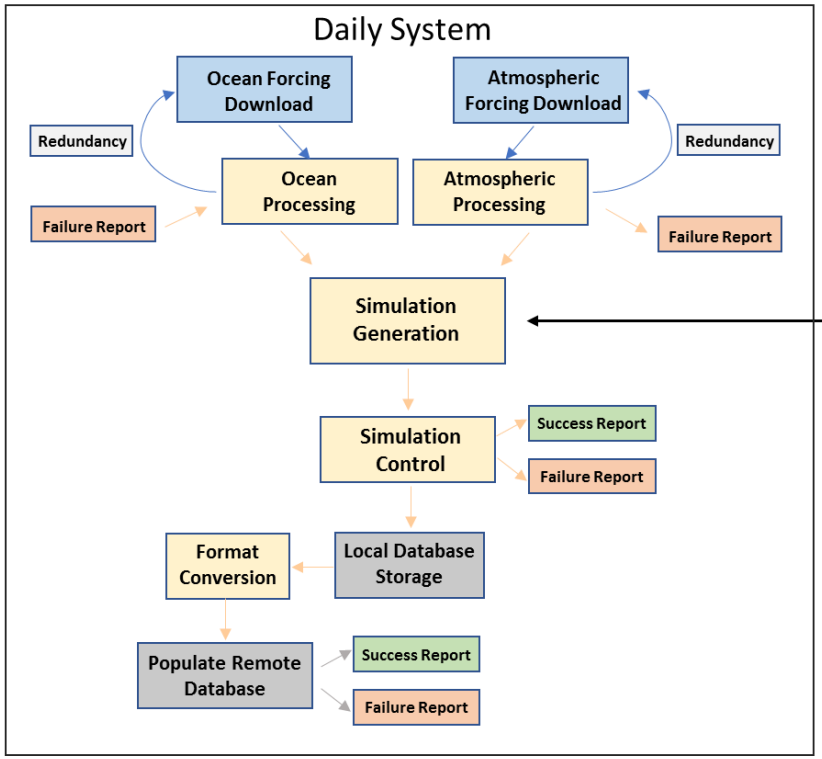
- Physics (u, v, S, T)
- Drifters / Oil Spills
- Waves
- Sediments

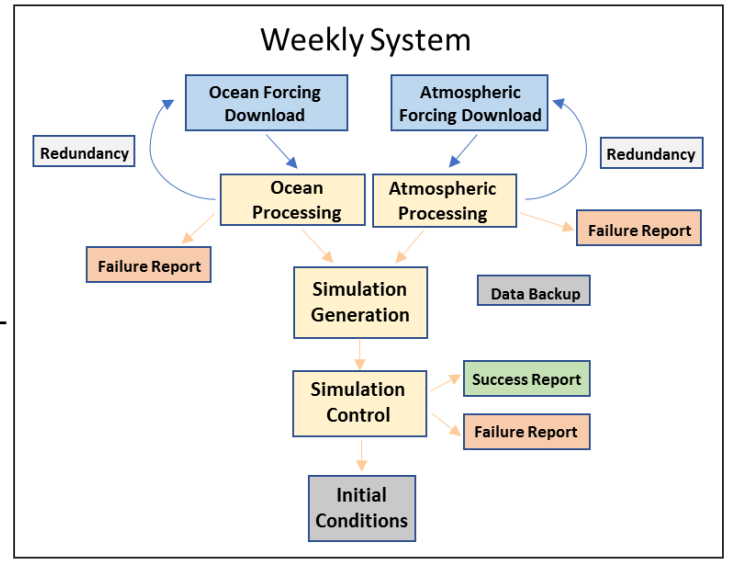
SOMA Op. System (Coast of Algarve)



SMS Coastal

(Mendonça et al., 2023)





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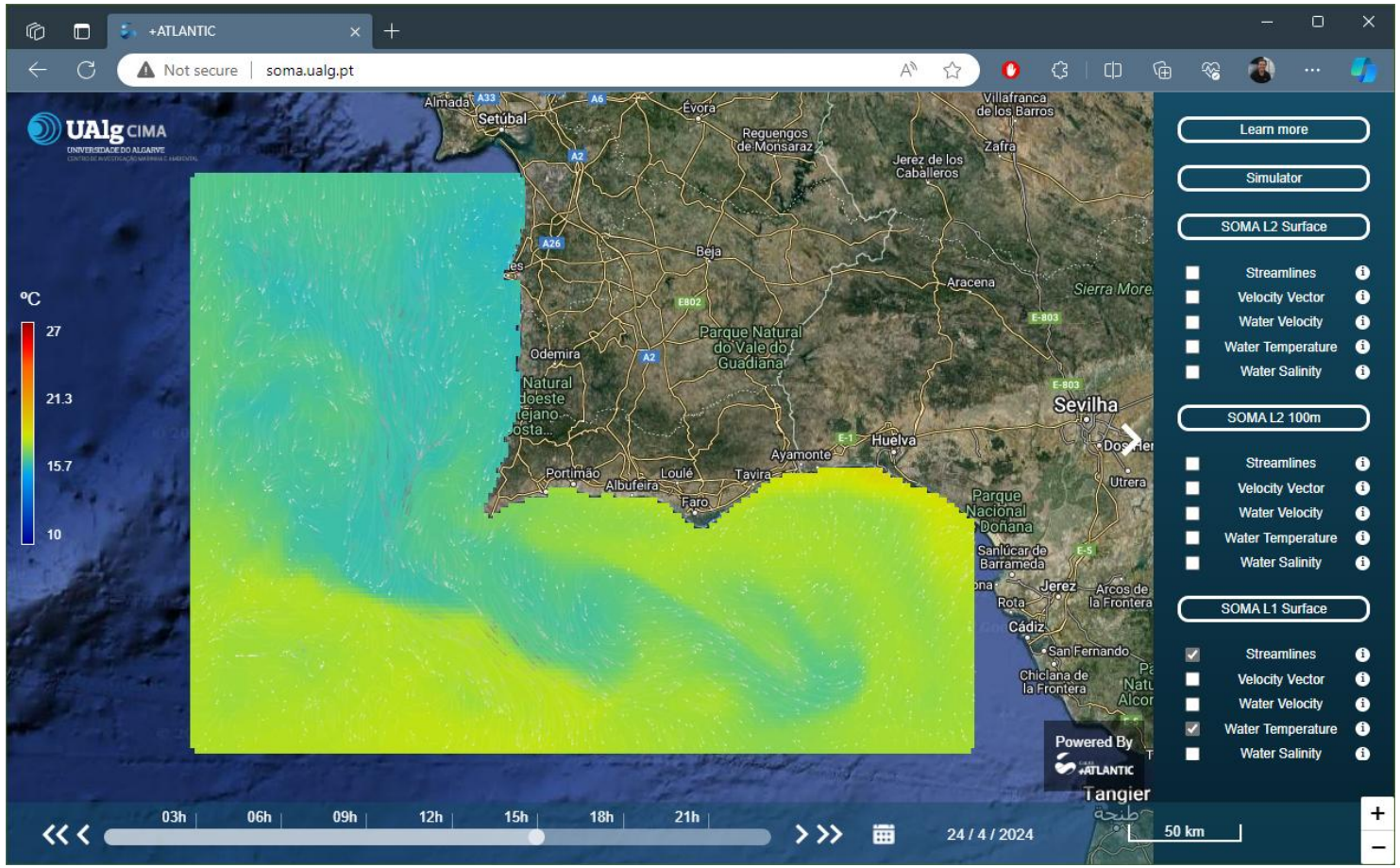
SOMA Op. System (Coast of Algarve)



Blue Ocean

Green Ocean

White Ocean

- Environmental monitoring
- Oil spill
- Search and Rescue

...

(https://soma.ualg.pt/) (https://cima-somathredds.ualg.pt/thredds/catalog.html)

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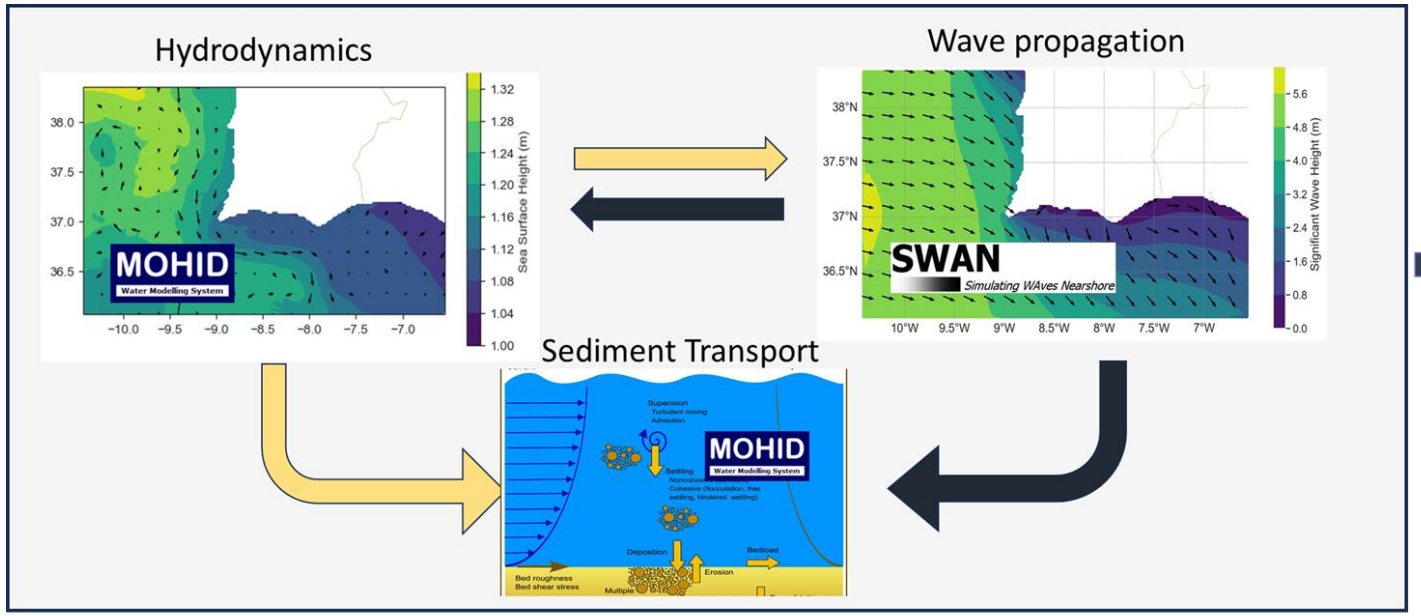
SOMA Op. System (Coast of Algarve)

Wave Modelling



Model Outputs

Tidal and residual currents

Wave-induced currents

Sediment flow

Threats computation

Material deterioration

Decontextualization

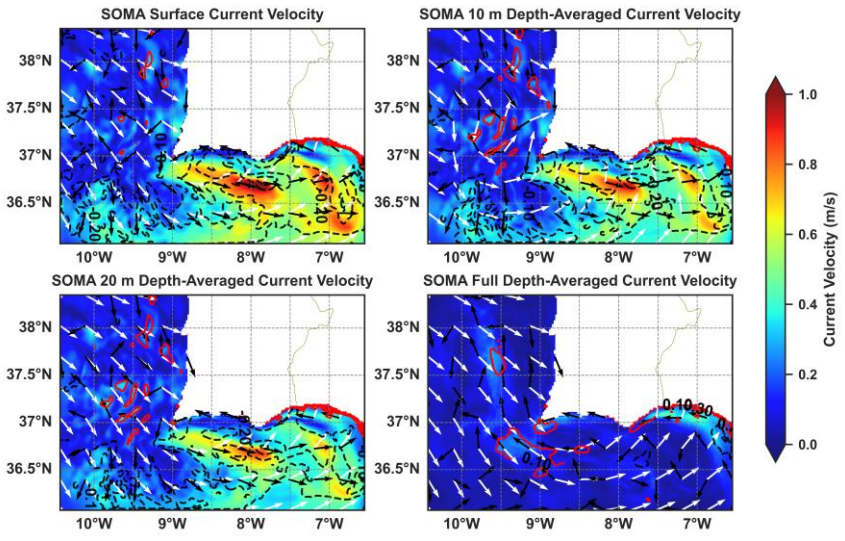
Sedimentation

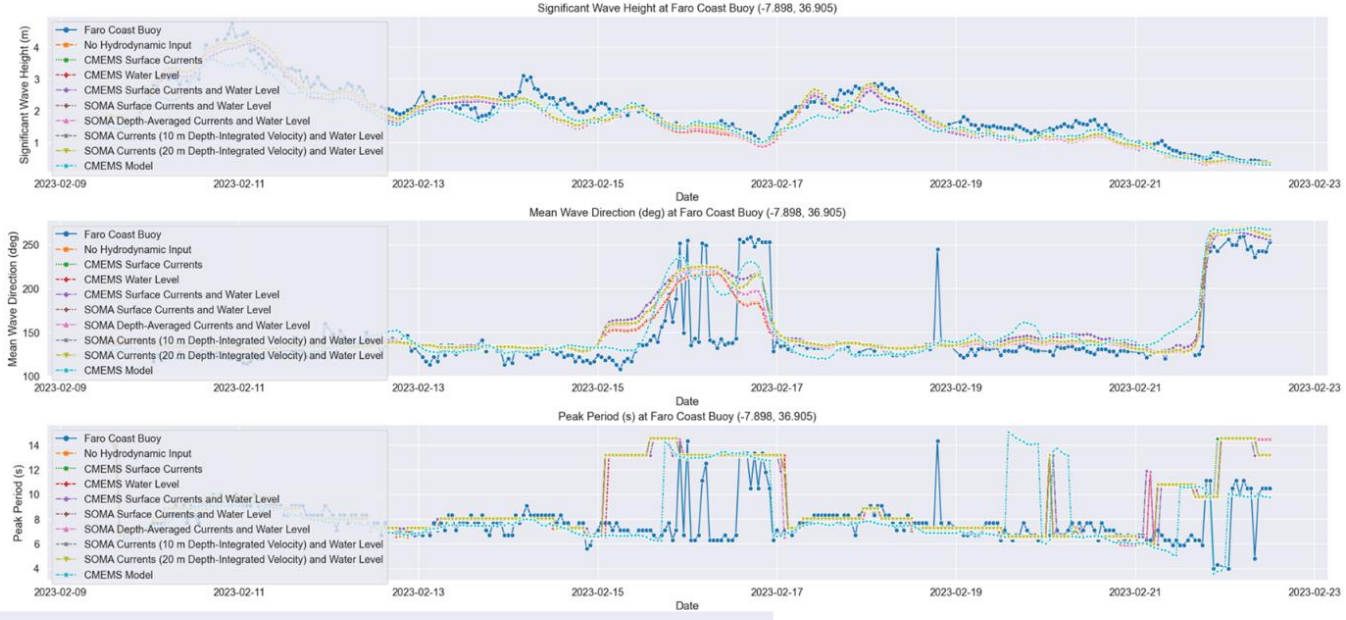
Risk assessment & Early Warning System

THETIDA DSS Web Based Interface

Mills et al., (Submitted)

SOMA Op. System (Coast of Algarve)





Level 1 SIMULATION 2023-10-21 12:00:00 - 2023-11-07 12:00:00 - WAVES COMING FROM WEST

	Faro Oceanic Buoy				Faro Coast Buoy				Cadiz Buoy				Sines Buoy			
RUN ID	RMSE (m)	BIAS (m)	MSS	R	RMSE (m)	BIAS (m)	MSS	R	RMSE (m)	BIAS (m)	MSS	R	RMSE (m)	BIAS (m)	MSS	R
No Hydrodynamic Input	0.526	0.407	0.905	0.926	0.246	-0.025	0.957	0.933	0.594	0.502	0.862	0.922	0.427	-0.112	0.979	0.966
SOMA Water Level Only	0.525	0.407	0.905	0.926	**0.242**	-0.034	**0.958**	0.933	0.593	0.501	0.862	0.921	0.421	-0.111	0.980	0.967
SOMA Surface Currents and Water Level	**0.472**	**0.356**	0.920	**0.931**	0.256	0.058	0.952	**0.923**	**0.430**	**0.323**	**0.919**	0.933	**0.398**	-0.048	**0.982**	0.967
SOMA Depth-Averaged Currents (up to 10 m) and Water Level	0.474	0.358	**0.919**	**0.931**	0.258	0.065	0.951	0.924	0.436	0.330	0.918	**0.934**	0.402	-0.047	**0.982**	0.967
SOMA Depth-Averaged Currents (up to 20 m) and Water Level	0.475	0.360	**0.919**	**0.931**	0.258	0.064	0.951	0.925	0.439	0.334	0.917	**0.934**	0.402	-0.048	**0.982**	0.967
SOMA Depth-Averaged Currents (Full Water Column) and Water Level	0.569	0.455	0.892	0.924	0.252	**0.005**	0.956	0.934	0.580	0.485	0.868	0.922	**0.398**	**-0.026**	**0.982**	**0.968**
CMEMS MODEL	**0.365**	**0.125**	**0.940**	0.902	**0.186**	**0.001**	0.966	0.943	0.265	**0.104**	0.959	0.939	**0.391**	-0.165	**0.983**	**0.975**

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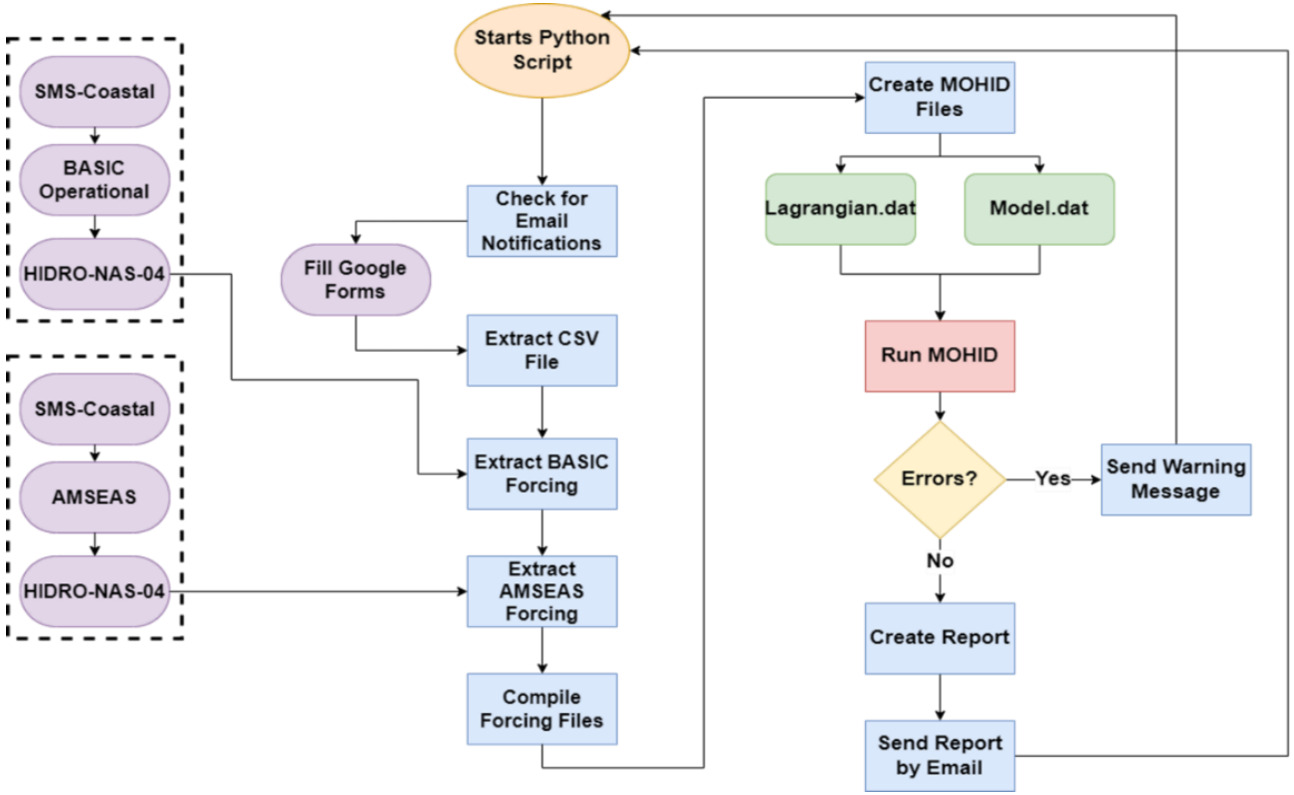
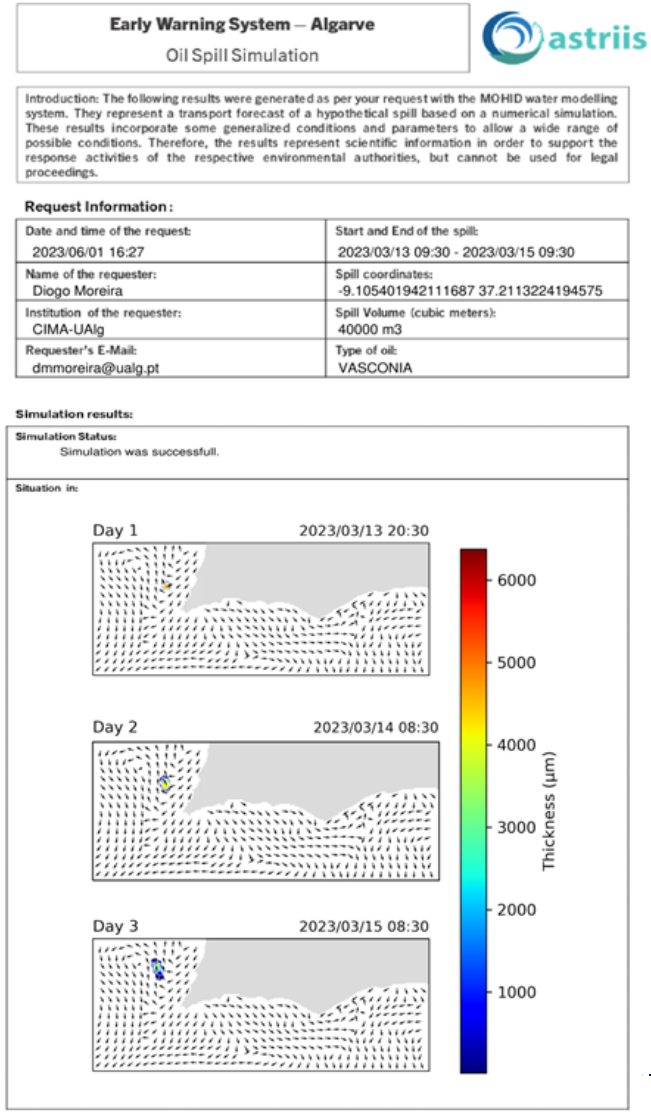
SOMA Op. System (Coast of Algarve)

Oil Spills





Early Warning System – Algarve

Oil Spill Simulation

astriis

Introduction: The following results were generated as per your request with the MOHID water modelling system. They represent a transport forecast of a hypothetical spill based on a numerical simulation. These results incorporate some generalized conditions and parameters to allow a wide range of possible conditions. Therefore, the results represent scientific information in order to support the response activities of the respective environmental authorities, but cannot be used for legal proceedings.

Request Information:

Date and time of the request: 2023/06/01 16:27	Start and End of the spill: 2023/03/13 09:30 - 2023/03/15 09:30
Name of the requester: Diogo Moreira	Spill coordinates: -9.105401942111687 37.2113224194575
Institution of the requester: CIMA-UAlg	Spill Volume (cubic meters): 40000 m3
Requester's E-Mail: dmmoreira@ualg.pt	Type of oil: VASCONIA

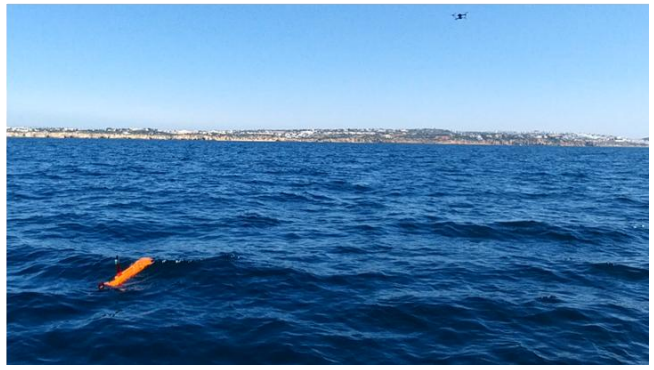
Simulation results:

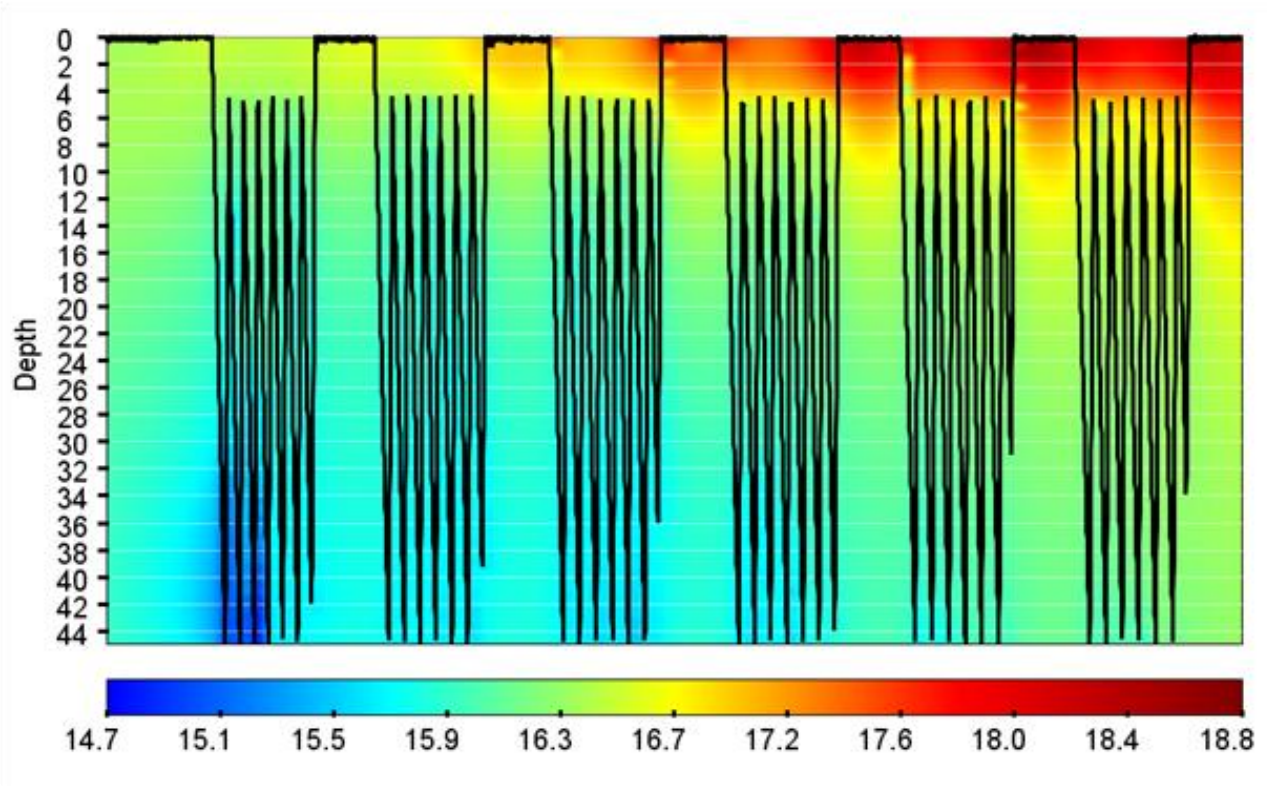
Simulation Status: Simulation was successfull.

Situation in:

SOMA Op. System (Coast of Algarve)

AUV Campaigns





BASIC – Cartagena, Colombia

BASIC
CARTAGENA
BASIN SEA INTERACTIONS WITH COMMUNITIES
INTERACCIONES ENTRE CUENCAS, MAR Y COMUNIDADES

CARDIQUE
Corporación Autónoma Regional del Canal del Dique

IDRC | CRDI
International Development Research Centre
Centre de recherches pour le développement international
Canada

BASIC – Cartagena, Colombia

7 Sigma Layers (5m)
+
15 Cartesian Layers

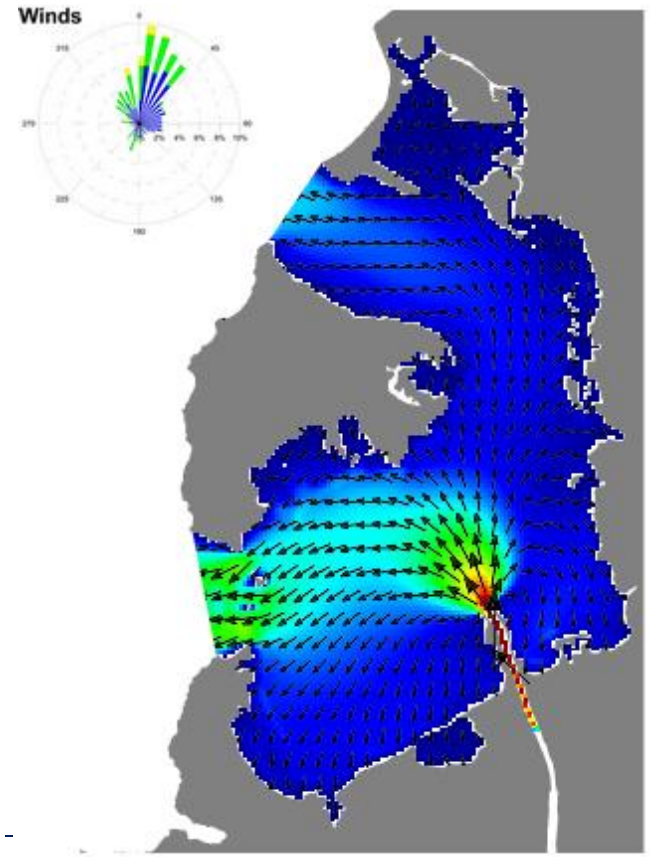
Bathymetry
Cartas Nauticas

Wind & Atm. Flux.
NAM 3h, 1 point

Boundaries
Tide: FES
T, S Campaigns

Field Data
(Density)

Field Data
(Susp Sed)



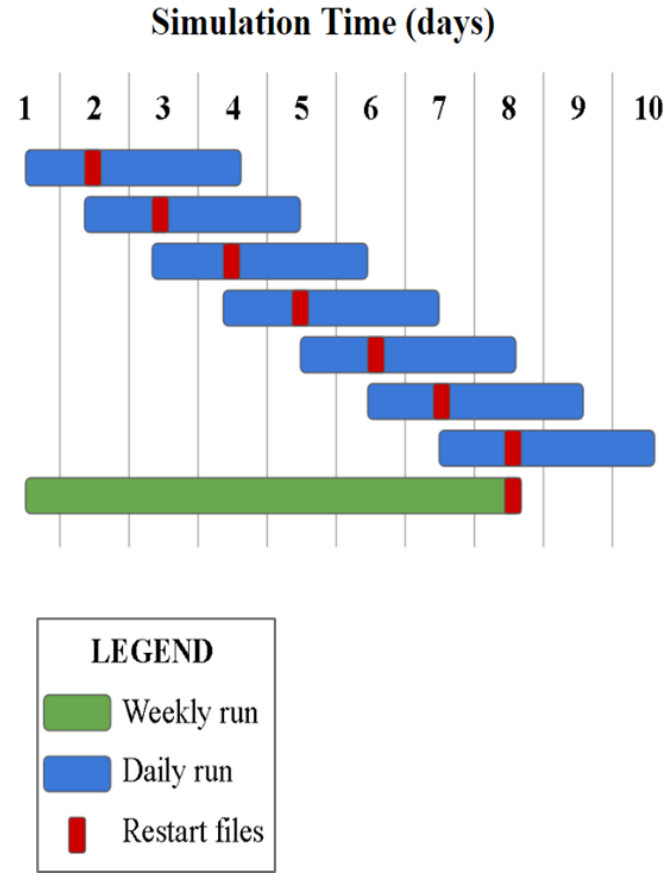
3 days Forecasts
U, V, W, T, S

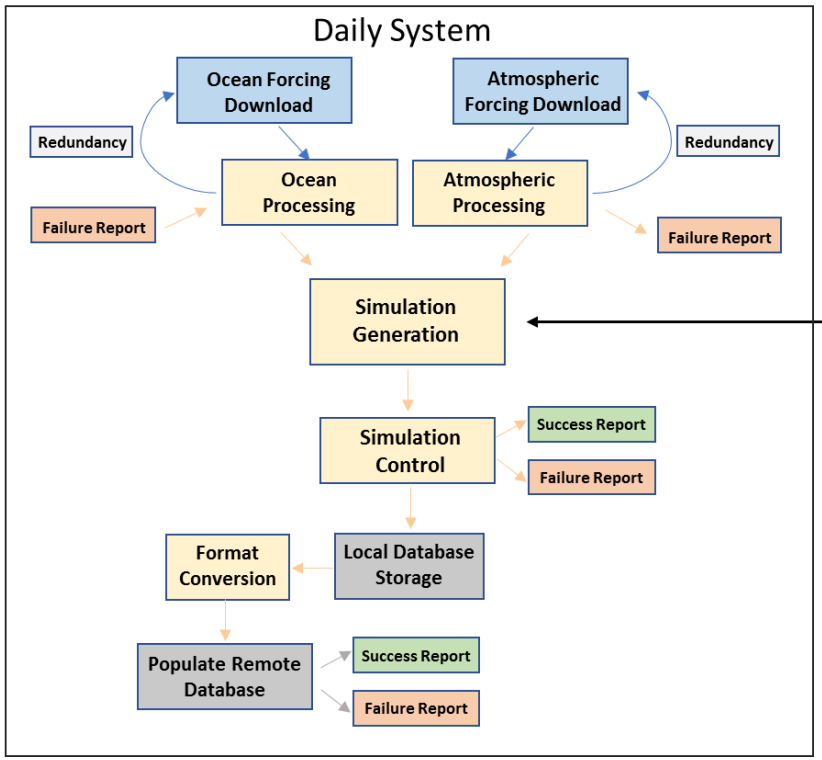
3 days Forecasts
Oil Spill Accidents

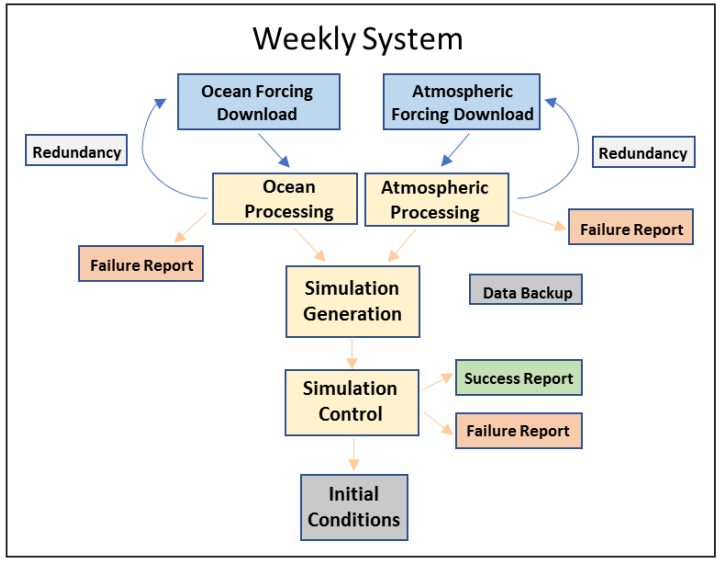
3 days Forecasts
Water Qual./HABs

BASIC – Cartagena, Colombia

SMS Coastal







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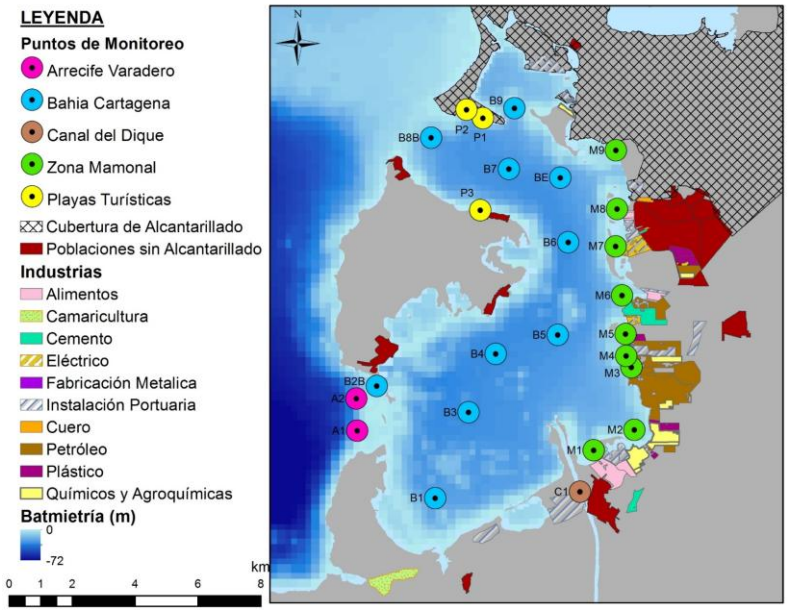
BASIC – Cartagena, Colombia

Field Campaigns



Tosic, M. et al, 2018
https://doi.org/10.1016/j.ecss.2017.08.035

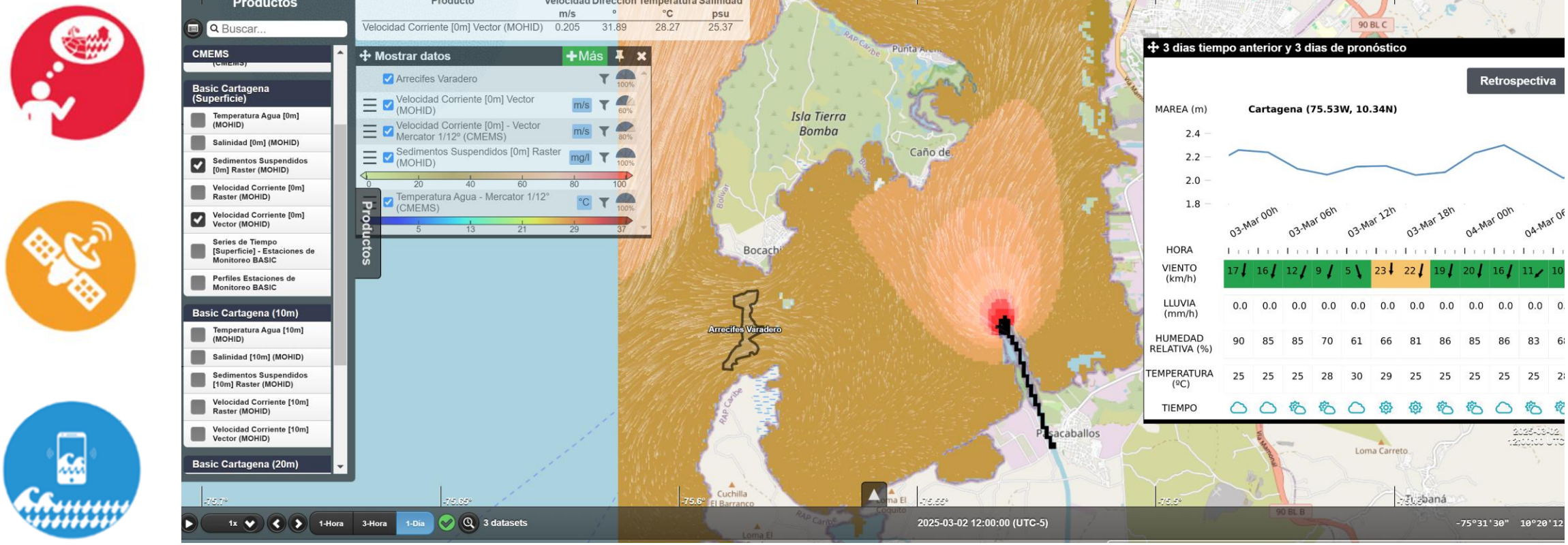
Tosic, M. et al, 2019a
https://doi.org/10.1016/j.jenvman.2019.01.104

Tosic, M. et al, 2019b
https://doi.org/10.1016/j.marpol.2019.103641

Tosic, M. et al, 2019c
https://doi.org/10.1016/j.ecss.2017.08.013

BASIC – Cartagena, Colombia

Web Portal



http://bahiacartagena.omega.eafit.edu.co/

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BASIC – MPA, Colombia

Fundação para a Ciência e a Tecnologia

PhD Diogo Moreira

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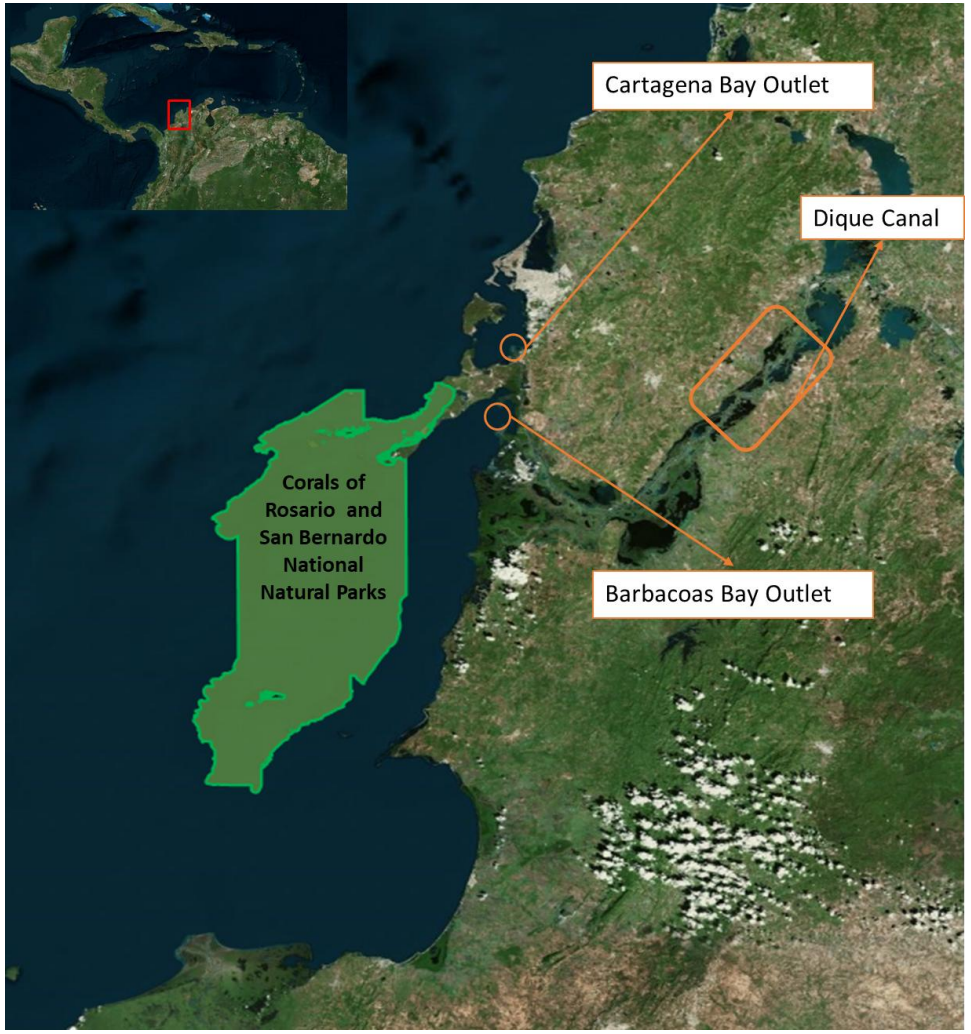

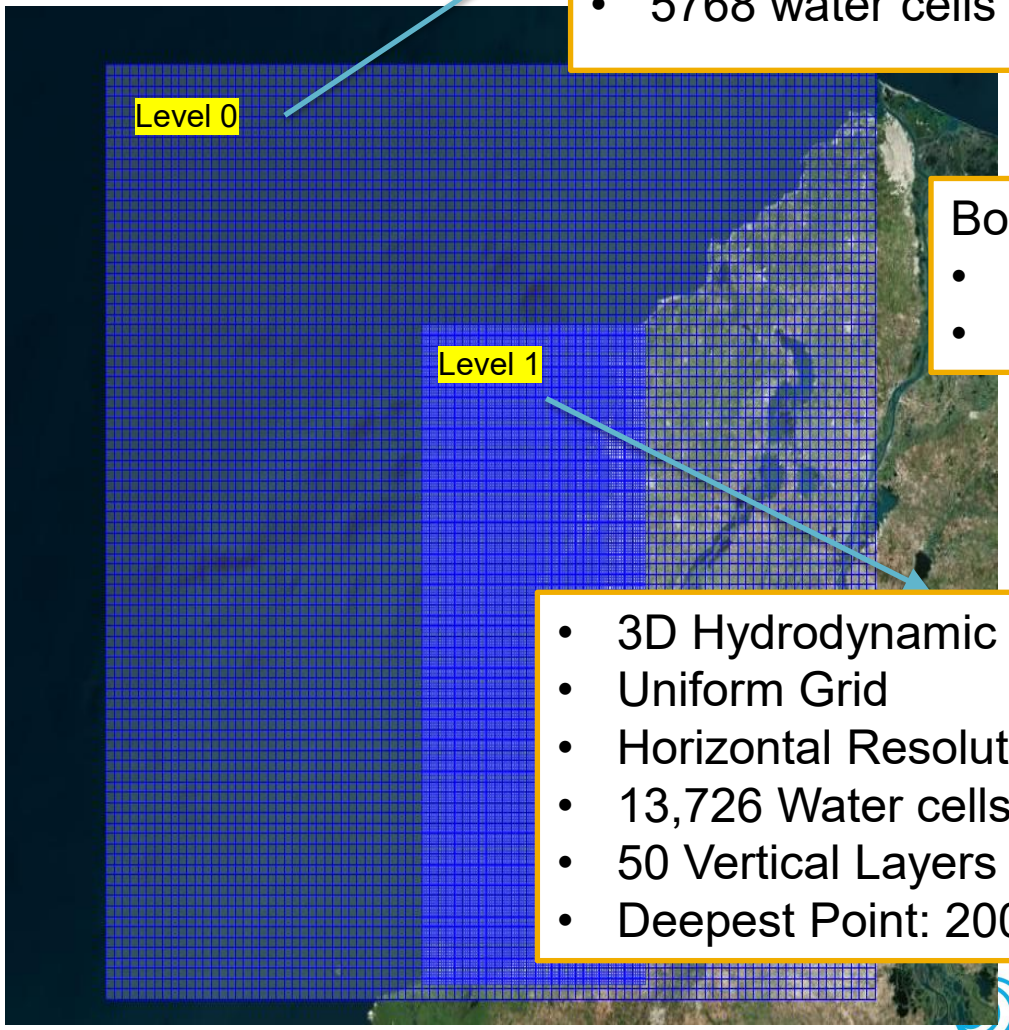

- 2D Tidal Model
- Uniform Grid
- Horizontal Resolution: 2 km
- 5768 water cells

Boundary conditions:
- CMEMS (Hydro)
- NAM (Meteo)

- 3D Hydrodynamic Model
- Uniform Grid
- Horizontal Resolution: 663 m
- 13,726 Water cells
- 50 Vertical Layers
- Deepest Point: 2000 m

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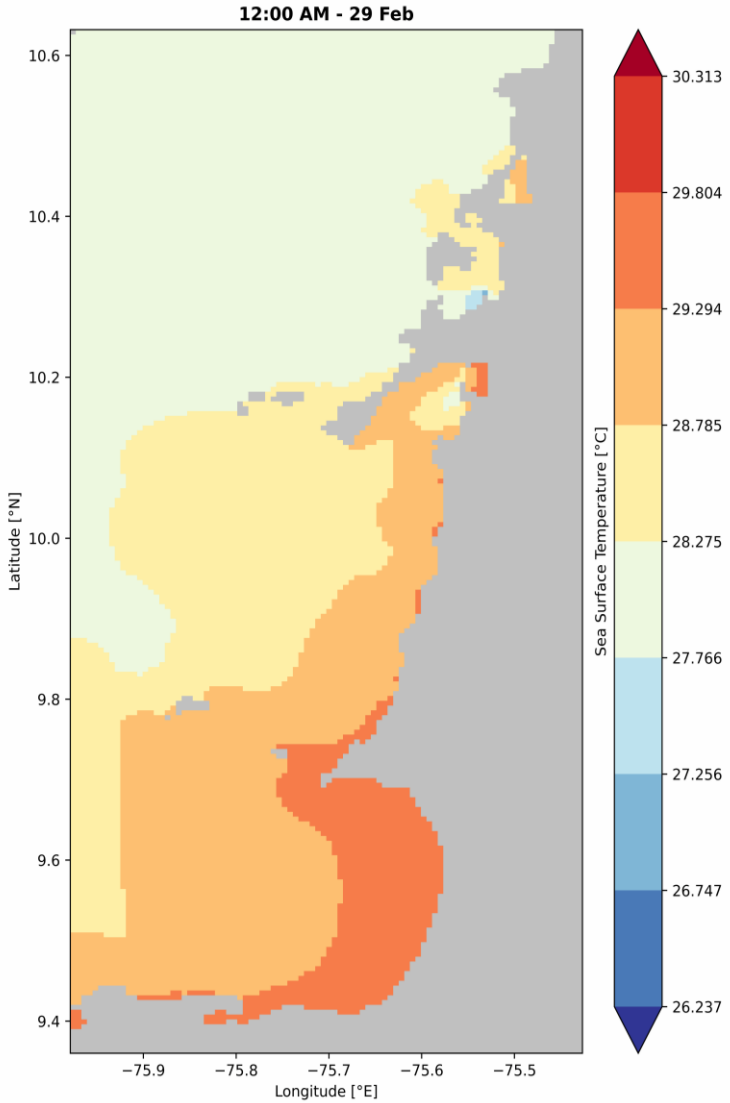
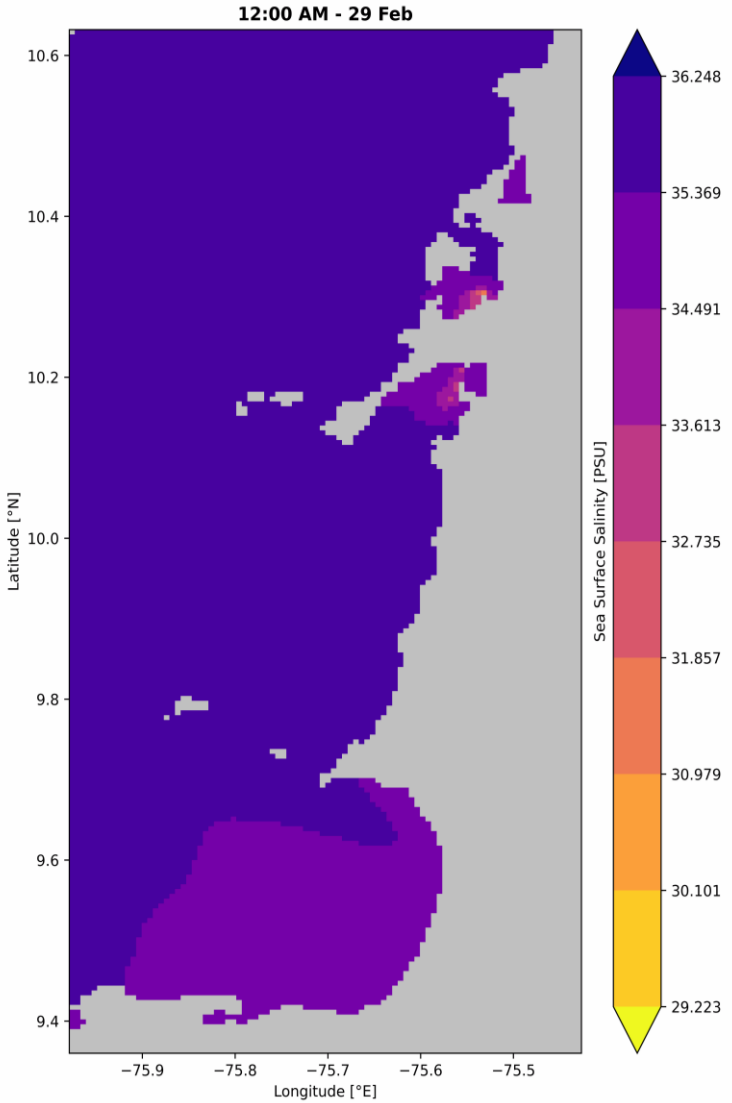
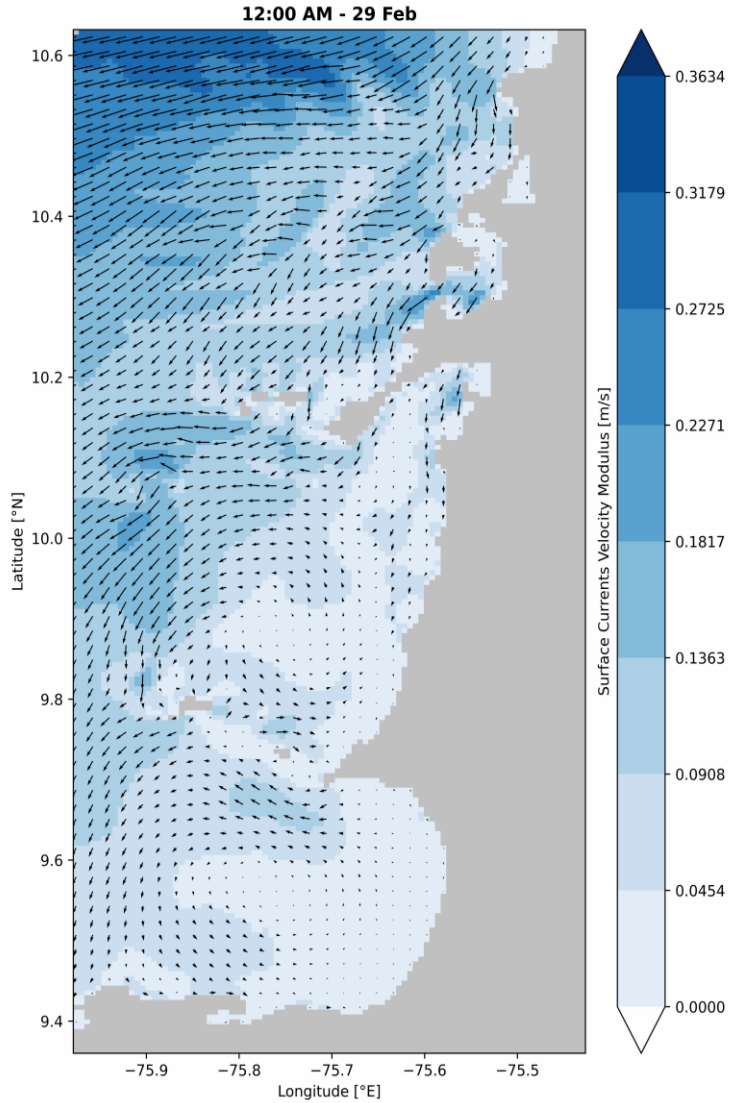
BASIC – MPA, Colombia

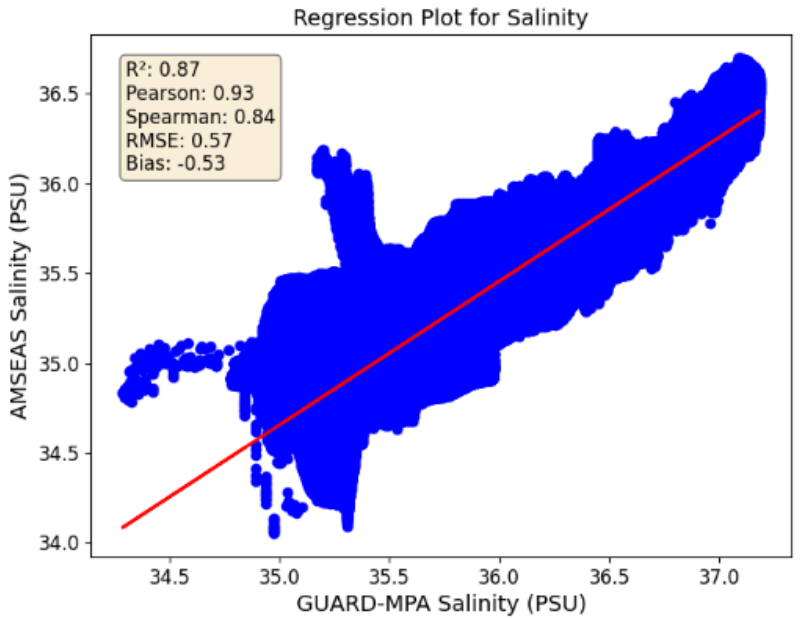


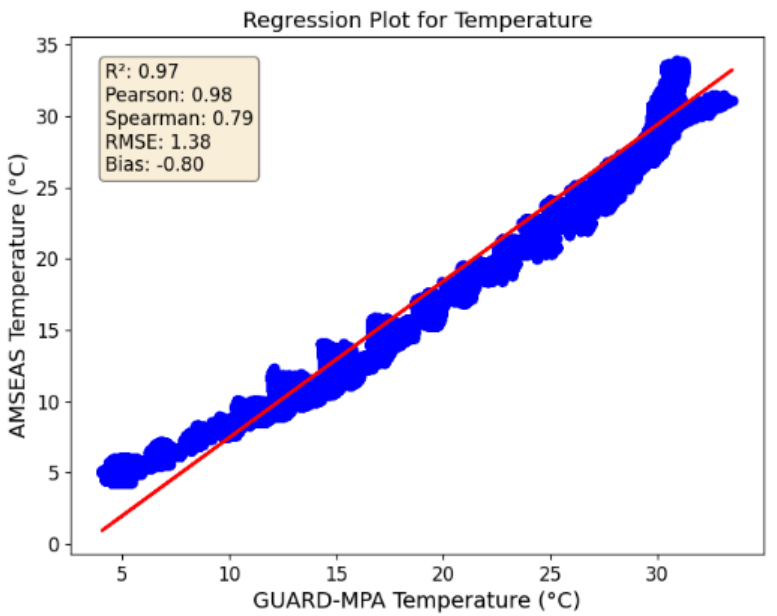




BASIC – MPA, Colombia

Comparison With AMSEAS





June 2024	Salinity (PSU)			Temperature (ºC)		
	Surface Layer	Full Domain	Point	Surfuc e Layer	Full Domain	Point
R-Squared	0.30	0.87	0.80	0.58	0.97	0.72
Pearson	0.55	0.93	0.89	0.76	0.98	0.85
Spearman	0.62	0.84	0.78	0.65	0.79	0.50
RMSE	0.59	0.57	0.56	0.46	1.38	1.16
BIAS	-0.56	-0.53	-0.53	0.22	-0.80	-0.76

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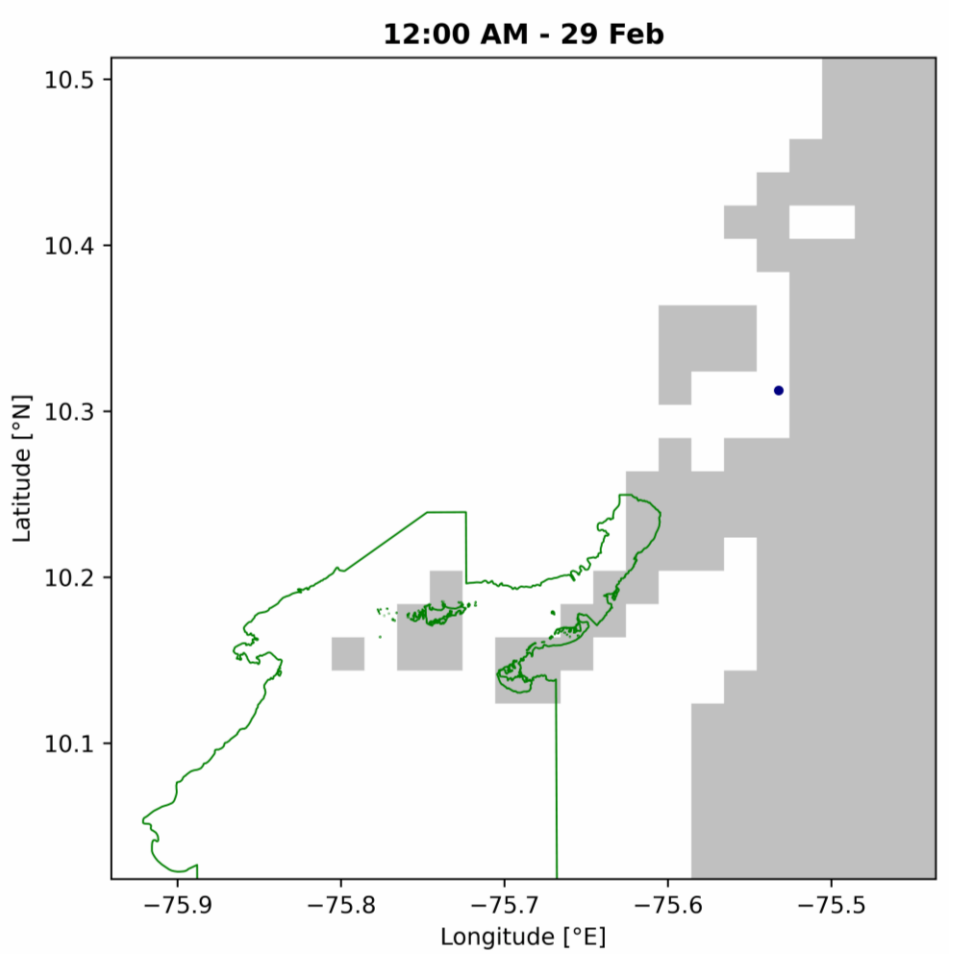

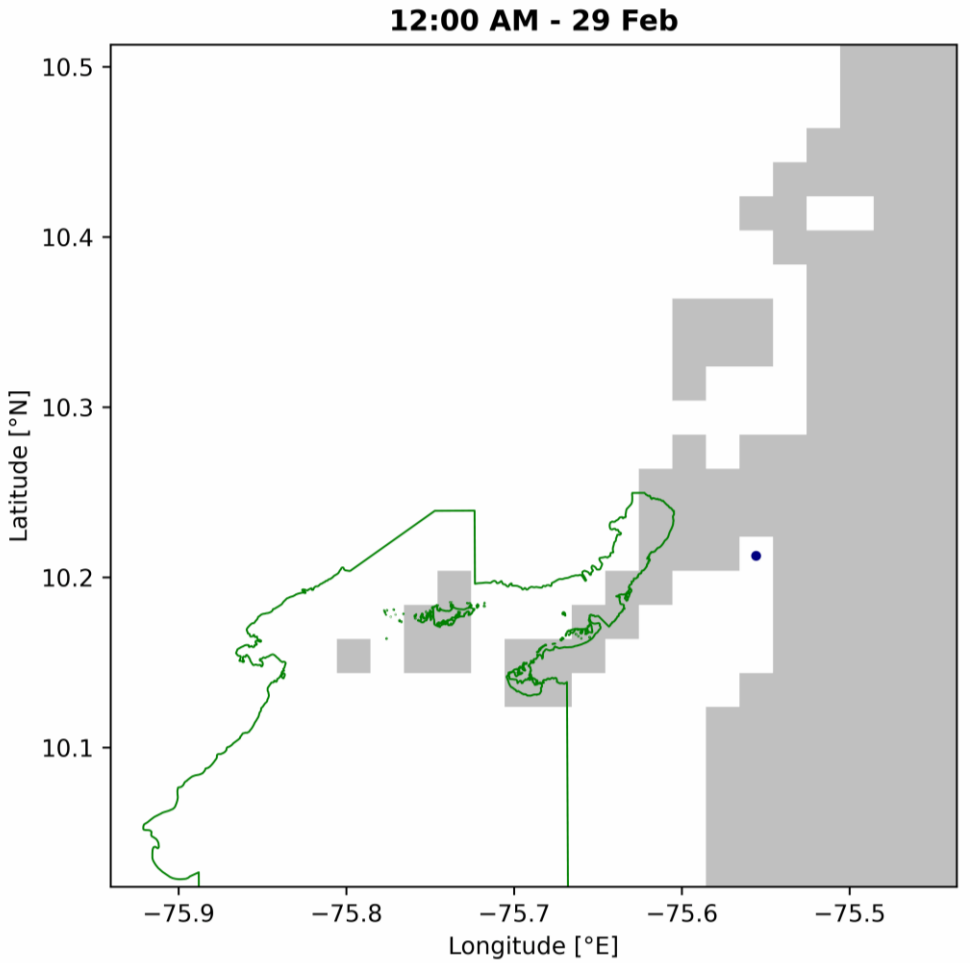

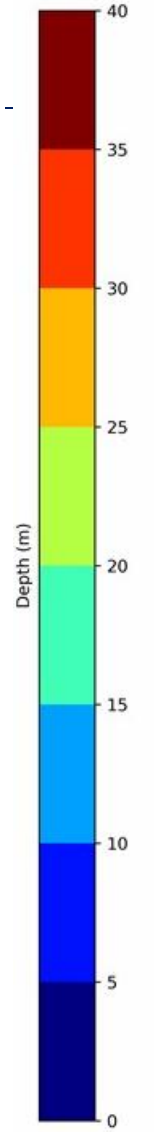

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Sargassum fate in Dominican Republic

Sargassum fate in Dominican Republic

Work Plan to:

Develop a hydrodynamic model coupled with a lagrangian model using global forecast

Calibrate and validate the model with observational data

Integrate Sargassum biological variables in the model

Implement the model operationally

Create hazard and risk maps

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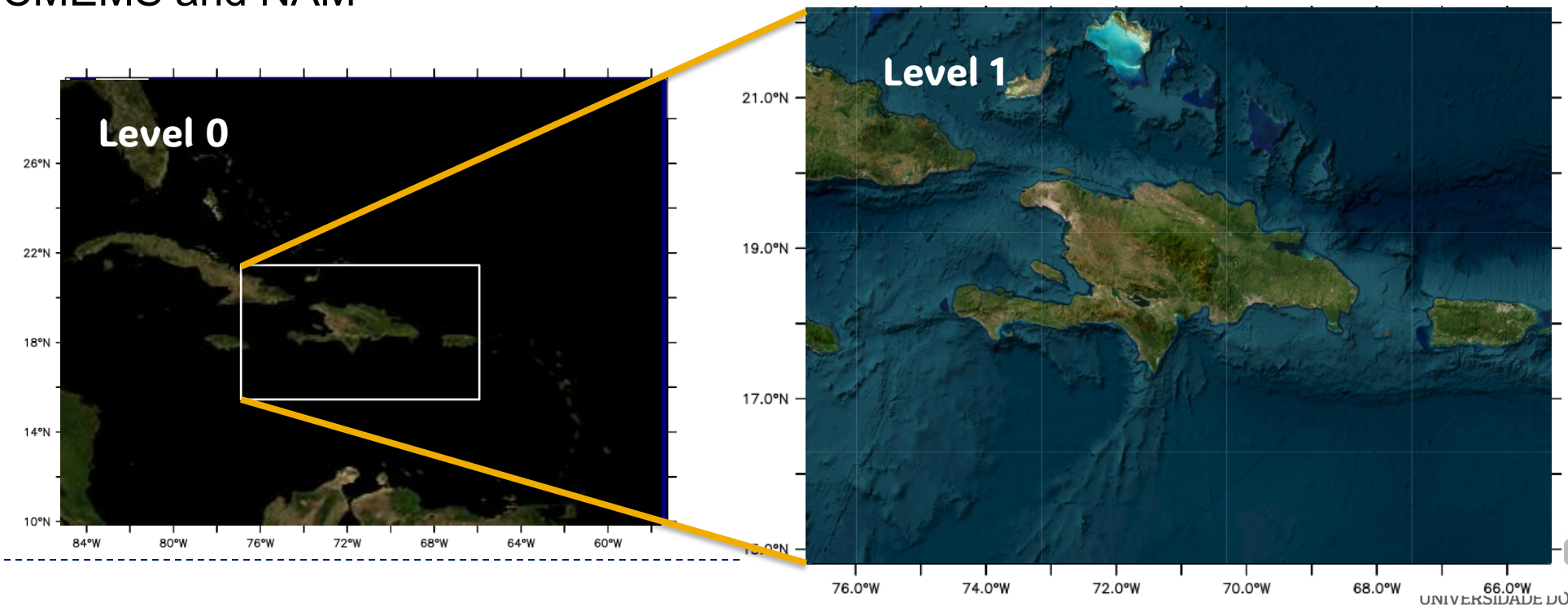
Sargassum fate in Dominican Republic

- MOHID Modelling System
- 3D Baroclinic
- Velocity, Salinity and Temperature
- Bathymetry: EMODNET
- Forcing CMEMS and NAM

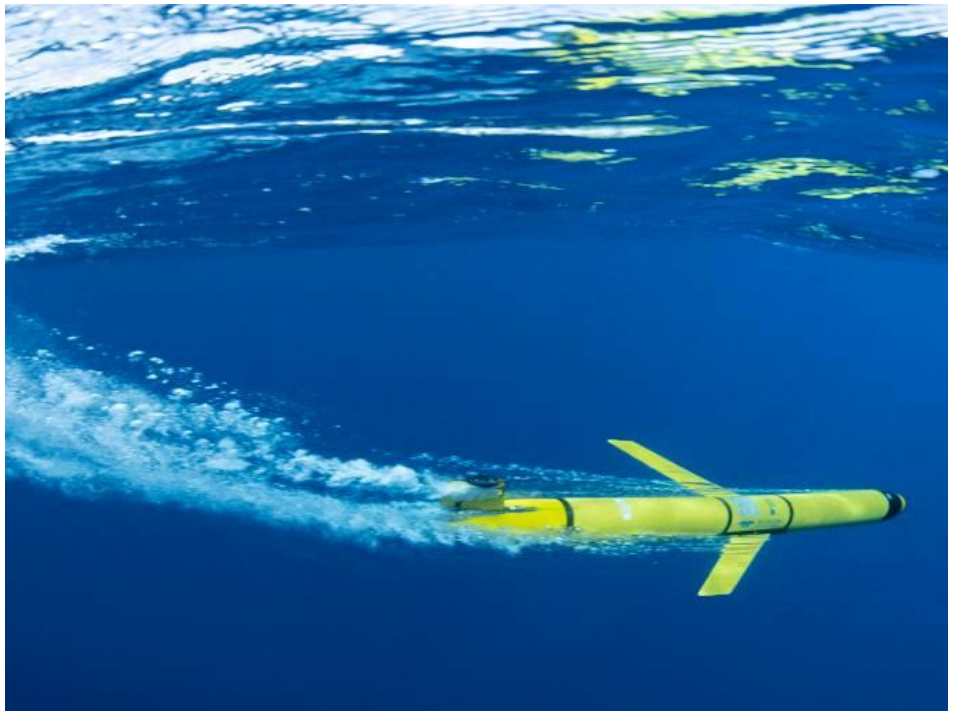
- 277 x 199 Horizontal Cells
- Cell size ≈ 5km
- 50 vertical cartesian layers



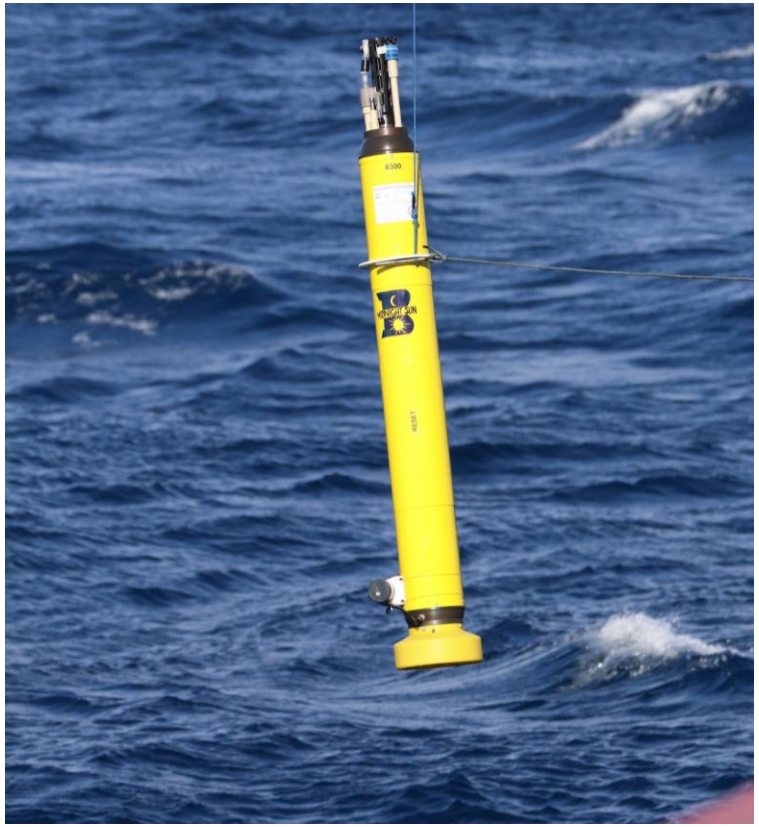
Sargassum fate in Dominican Republic

Hydrodynamic model calibration and validation:

- Hurricane Beryl
- Hurricane Ernesto
- Anticyclonic Conditions



Ocean Gliders



ARGO buoys

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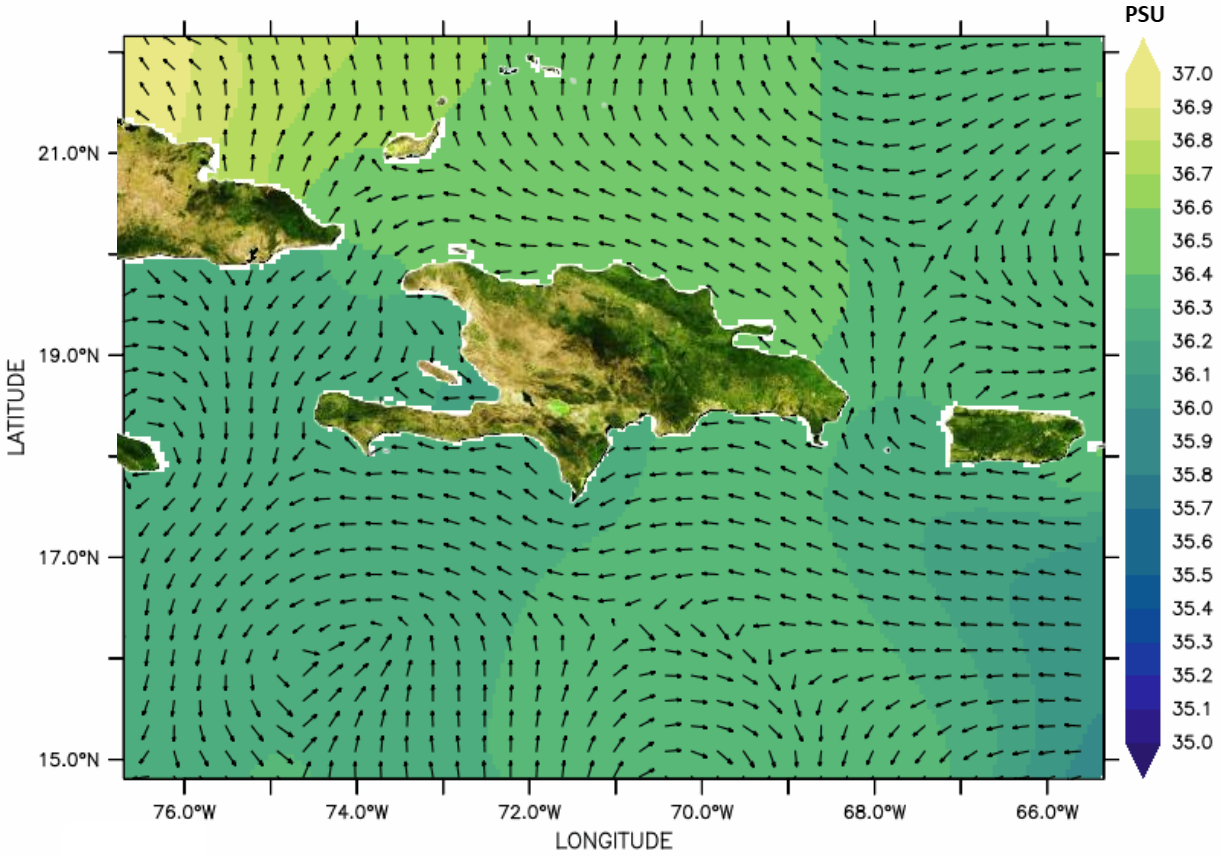
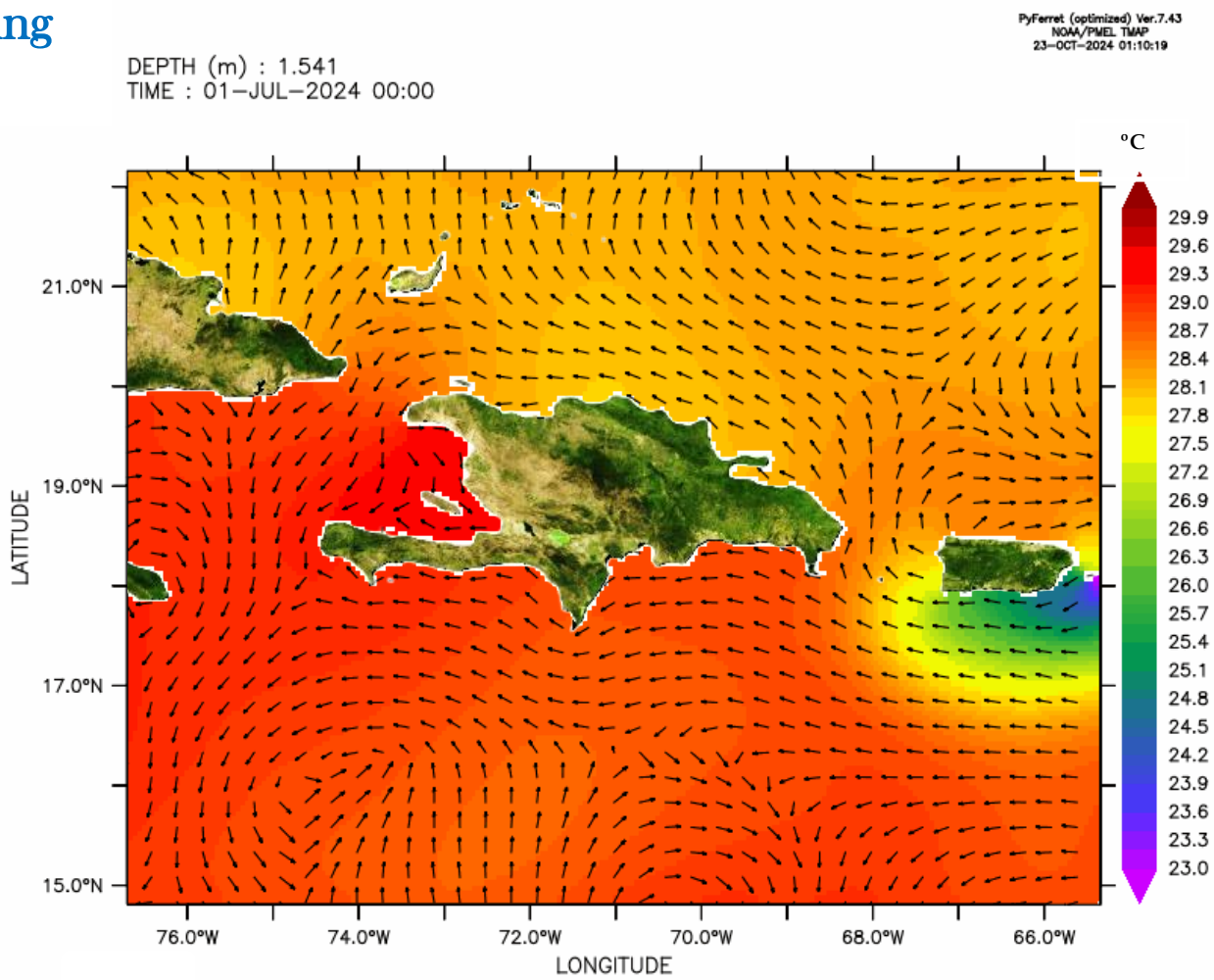
Hurricane Beryl
(01-04 July 2024)
Float 1902365 - Cycle 18
Float 4903051 - Cycle 198
Platform_code = 4802996
Platform_code = 4803957
Platform_code = 4802960
Argo Buoys and Gliders
Google INEGI

Sargassum fate in Dominican Republic

Model simulation during Hurricane Beryl



Velocity modulus and Salinity



Velocity modulus and Temperature

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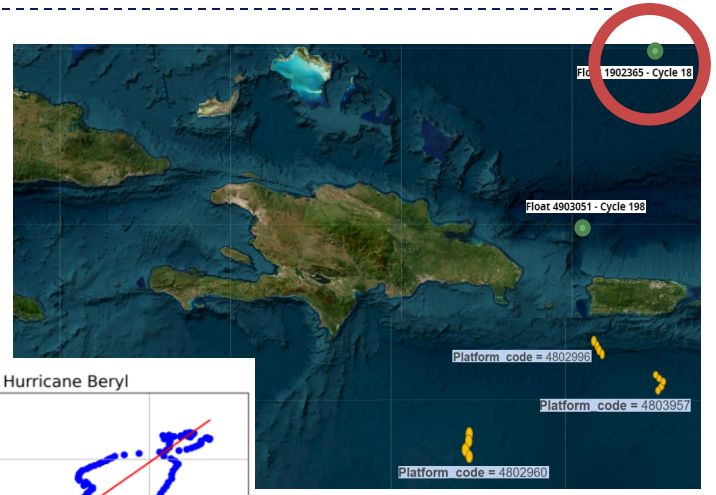
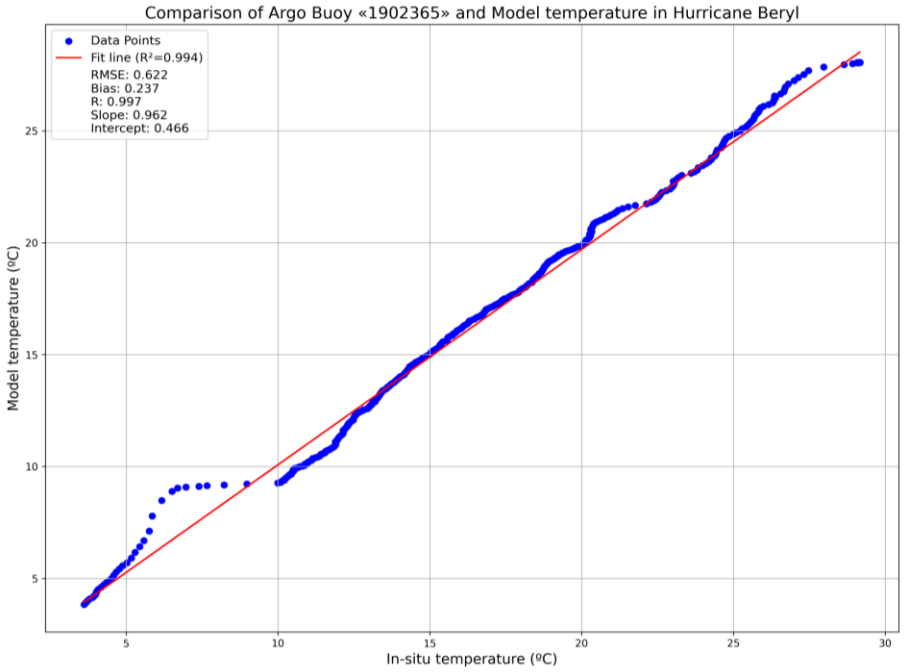
Sargassum fate in Dominican Republic

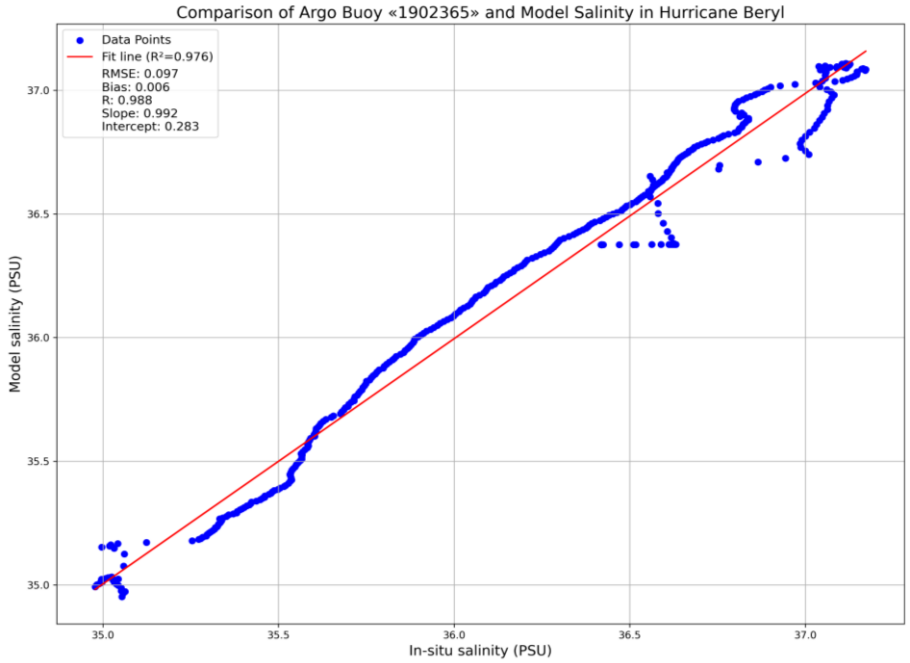
Comparison Argo Buoy #1902365:

Temp. RMSE: 0.622 ºC
Temp. R: 0.997

Salin. RMSE: 0.097 psu
Salin. R: 0.988







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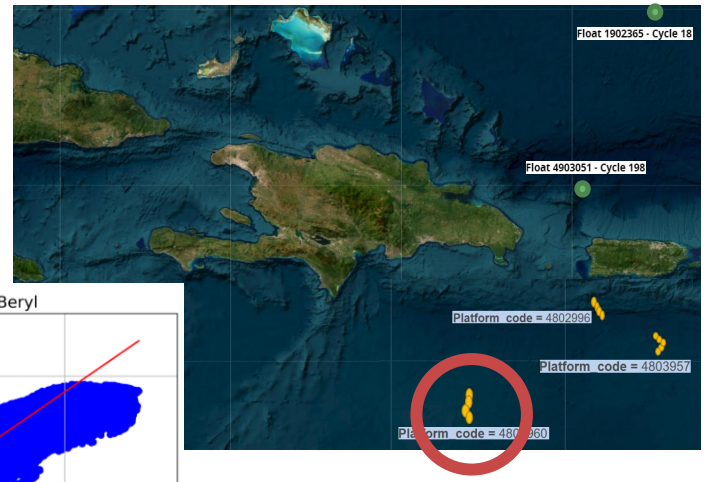
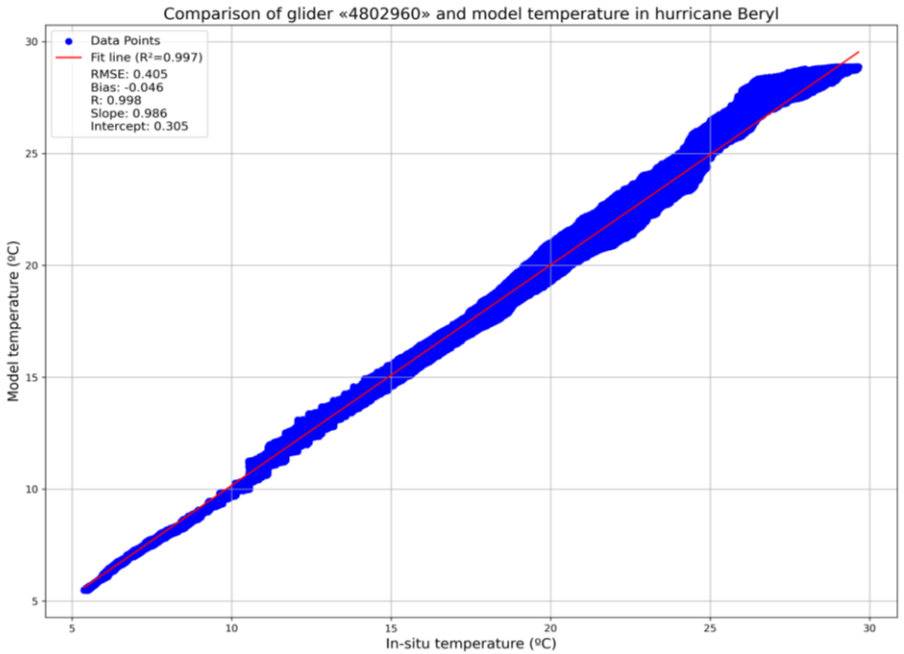
Sargassum fate in Dominican Republic

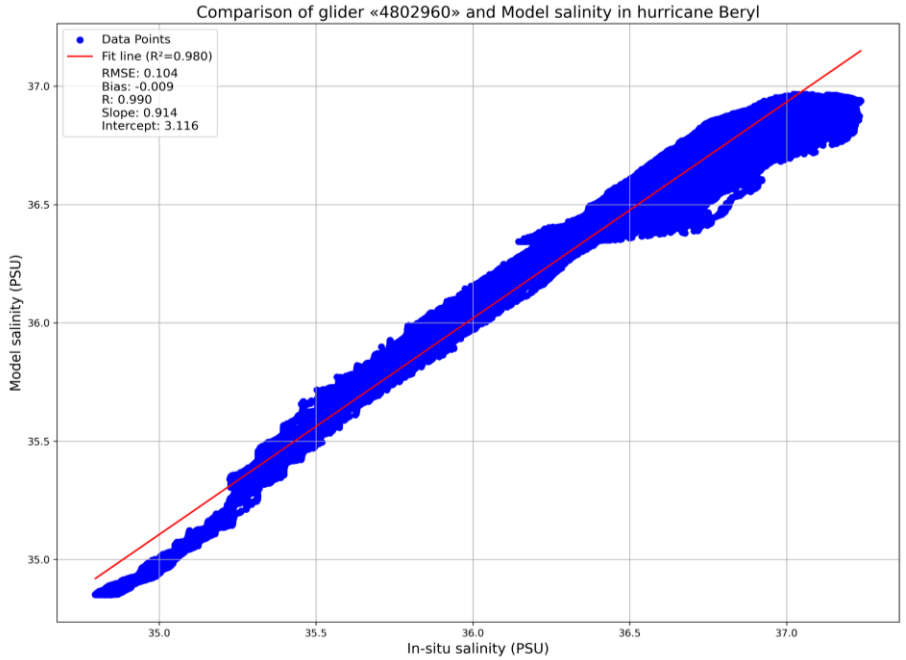
Comparison Glider #4802960:

Temp. RMSE: 0.405 ºC
Temp. R: 0.998

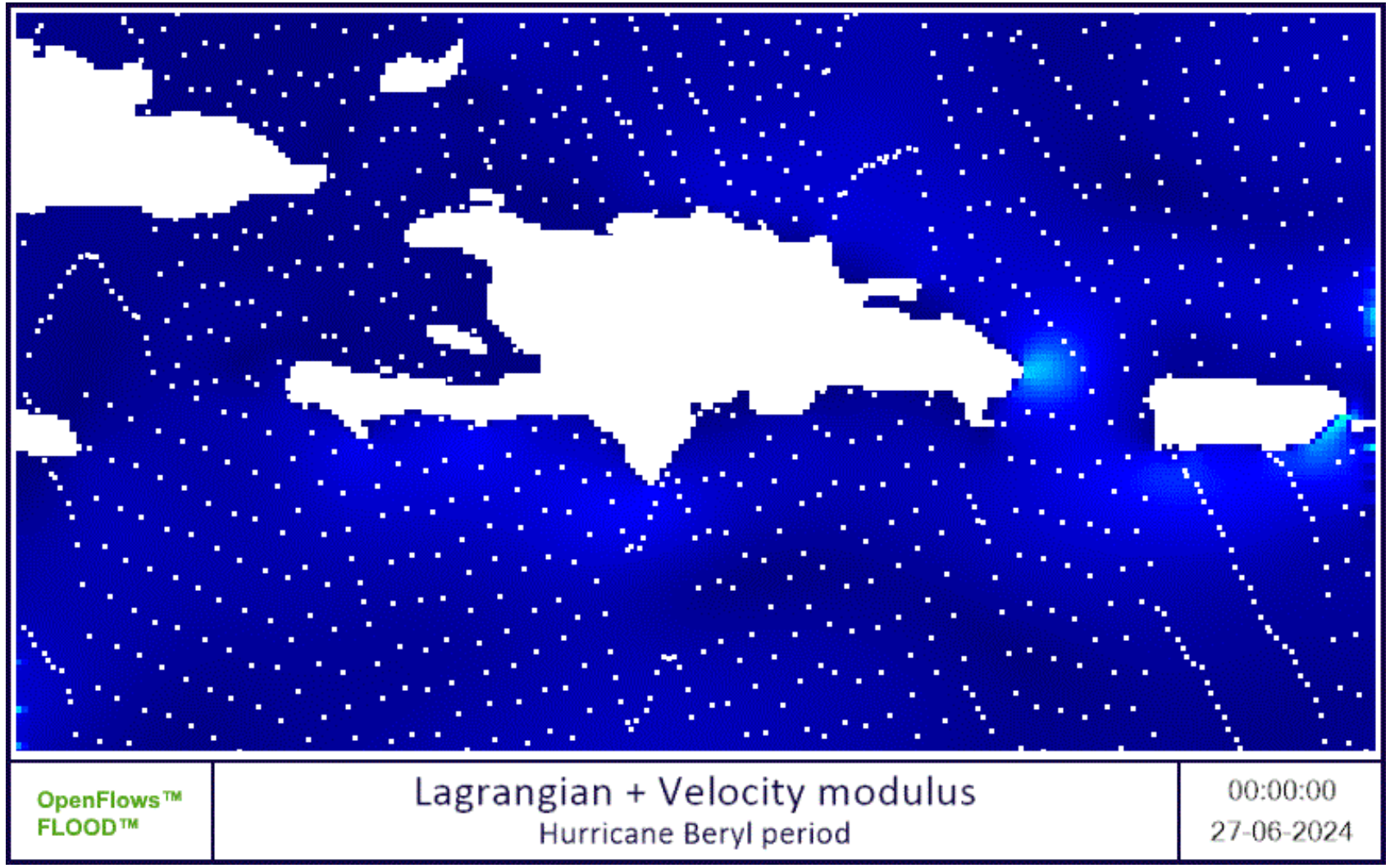
Salin. RMSE: 0.104 psu
Salin. R: 0.990







Sargassum fate in Dominican Republic



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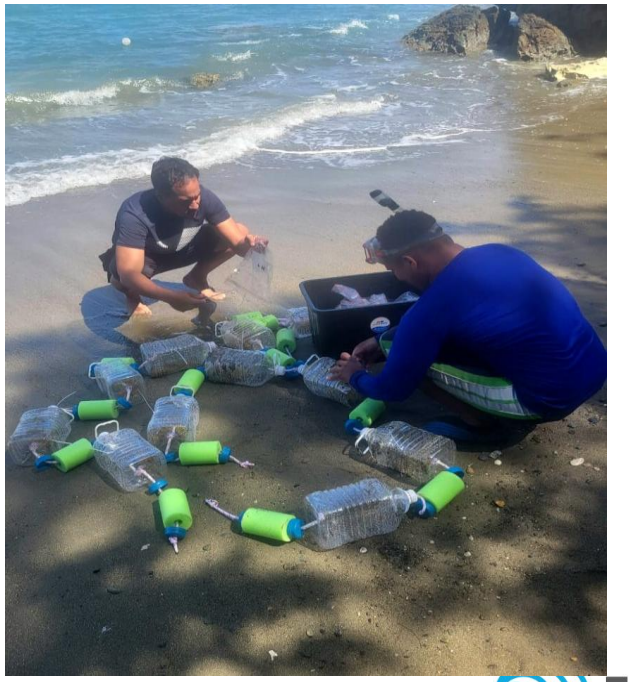
Sargassum fate in Dominican Republic

Field Campaigns



MOHID Scalability (OpenMP vs MPI)

MOHID Scalability (OpenMP vs MPI)

Metrics:

- **Speedup** is a measure of the time gain (reduction) of using several cores, when compared with using a single core:

$$S_n = \frac{T_1}{T_n}$$

Where T_1 is the time elapsed using 1 core and T_n is the time elapsed using n cores

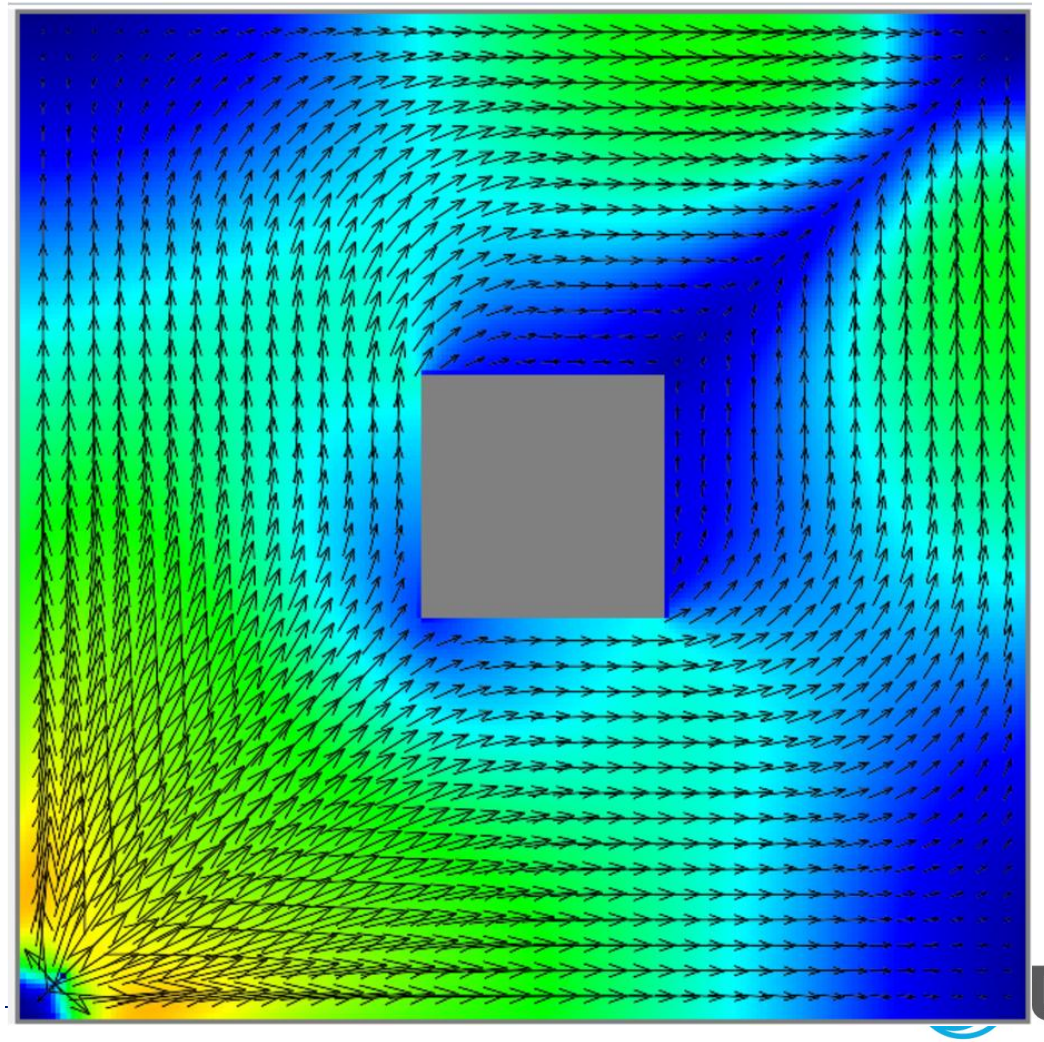
- **Efficiency** is measured as:

$$\varepsilon_n = \frac{S_n}{n}$$

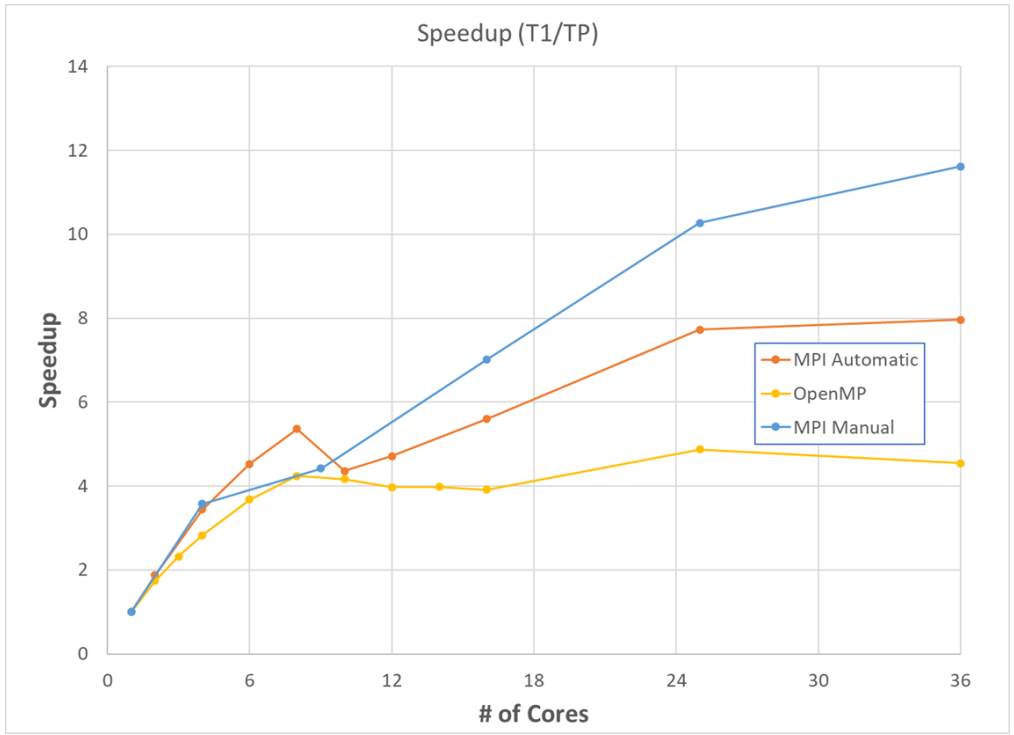
MOHID Scalability (OpenMP vs MPI)

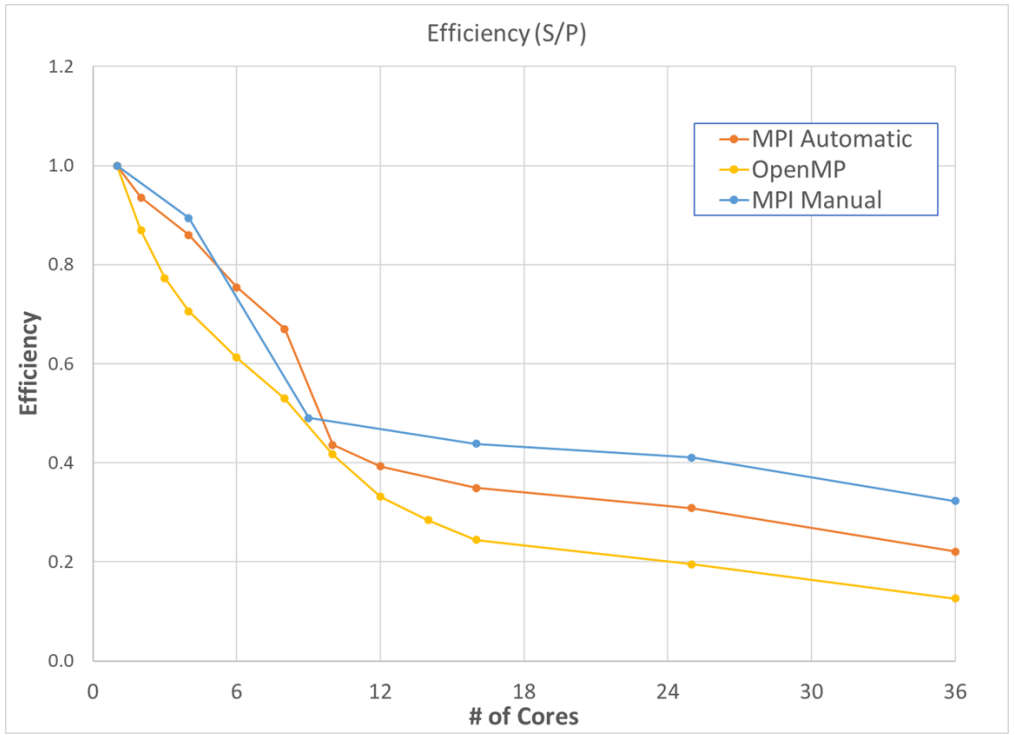
Square Lake Test

- $200\ \mathrm{X}\ 200\ \mathrm{cells} \approx 2.8\ km\ X\ 2.8\ km$
- $\Delta x = \Delta y = \frac{1}{8000^{\circ}} \approx 14\ m$
- $h = C^{te} = 10\ m$
- 10 Sigma layers
- A square island in the middle
- Water Discharges
- Salinity Transport
- GOTM

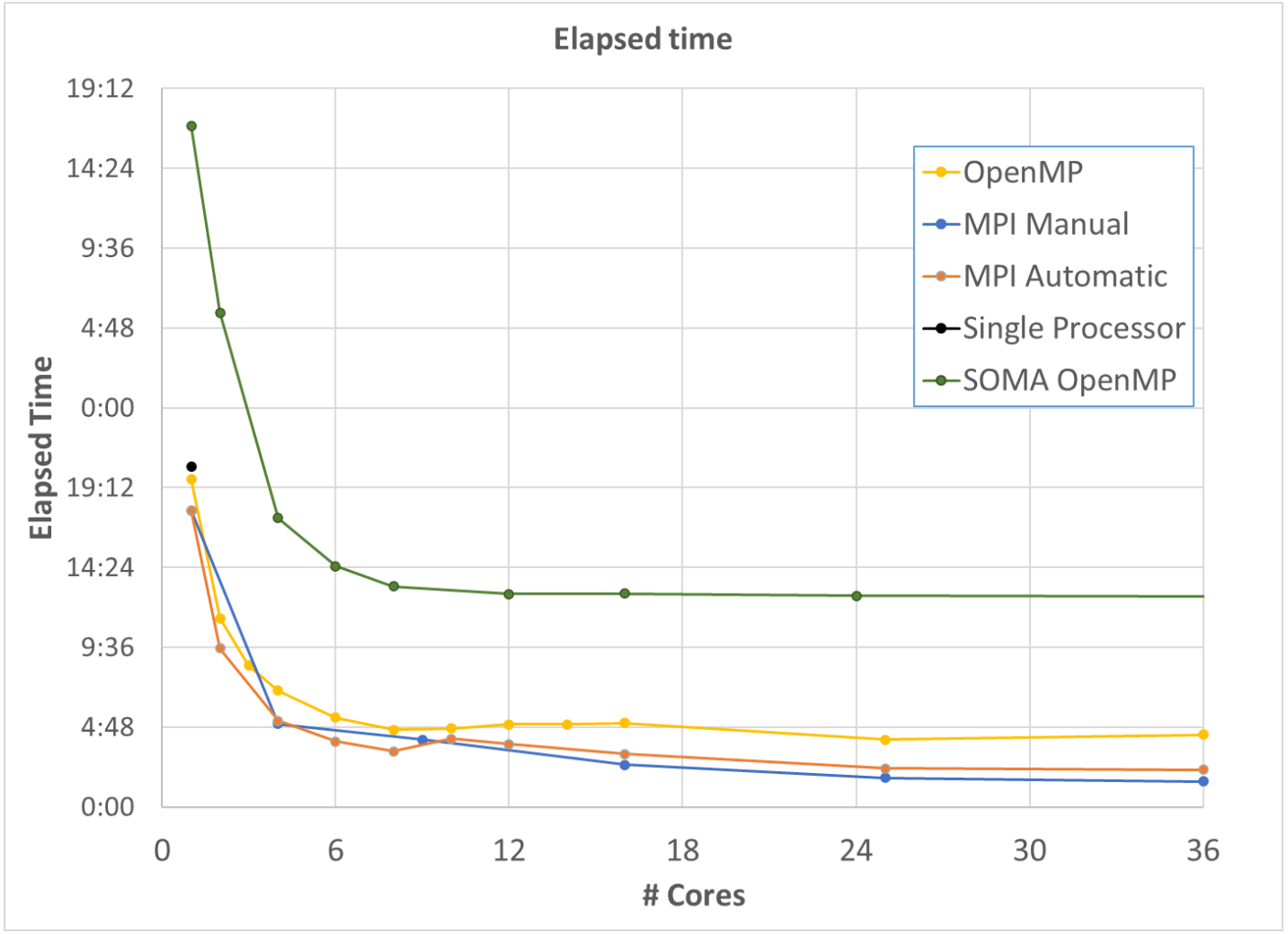


MOHID Scalability (OpenMP vs MPI)





MOHID Scalability (OpenMP vs MPI)



What to do with our 100 + core servers ?

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Thank You

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