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Simposio Internacional sobre Sistemas de Emisarios 2023

International Symposium on Outfall Systems 2023

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# Comparison between Eulerian and Lagrangian approaches to pollutant transport modelling in shallow coastal waters

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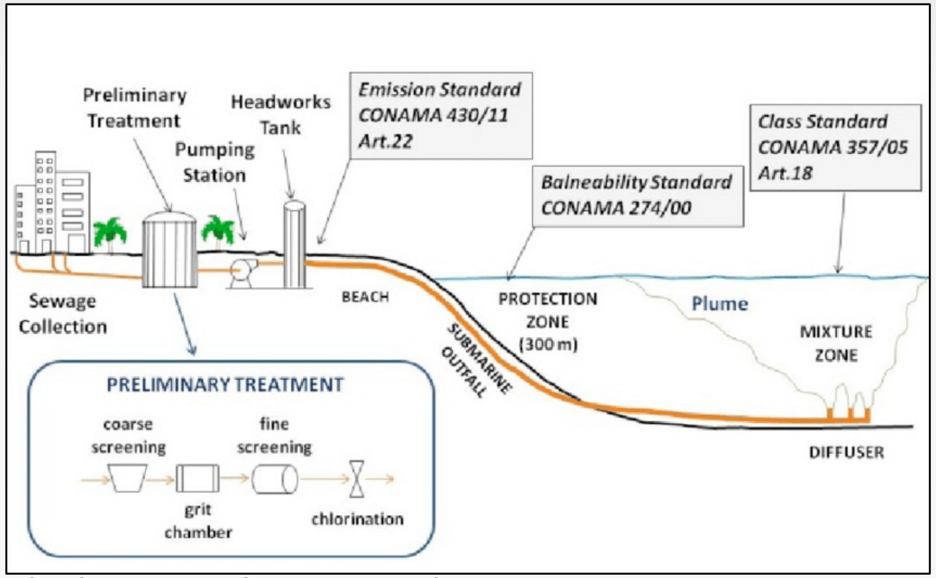
# INTRODUCTION

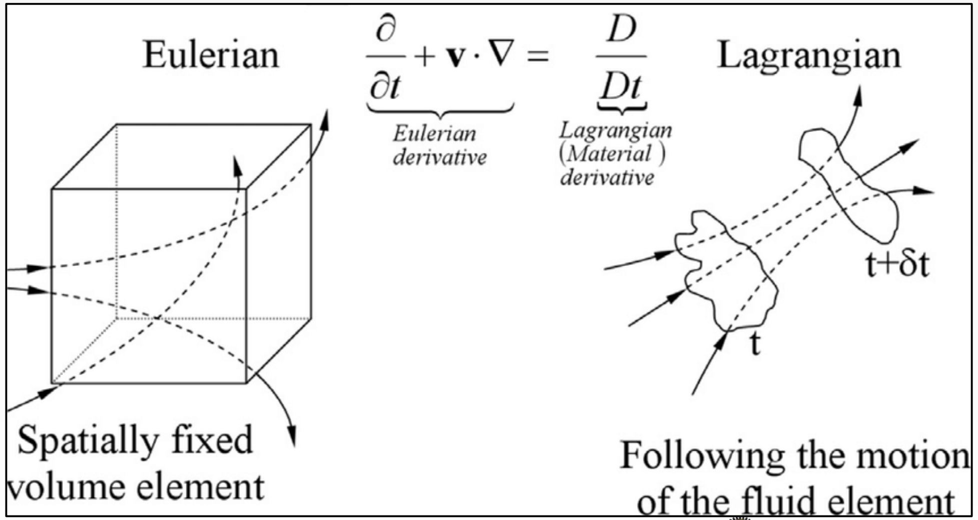



(Ortiz, Neto and Yanes, 2016)

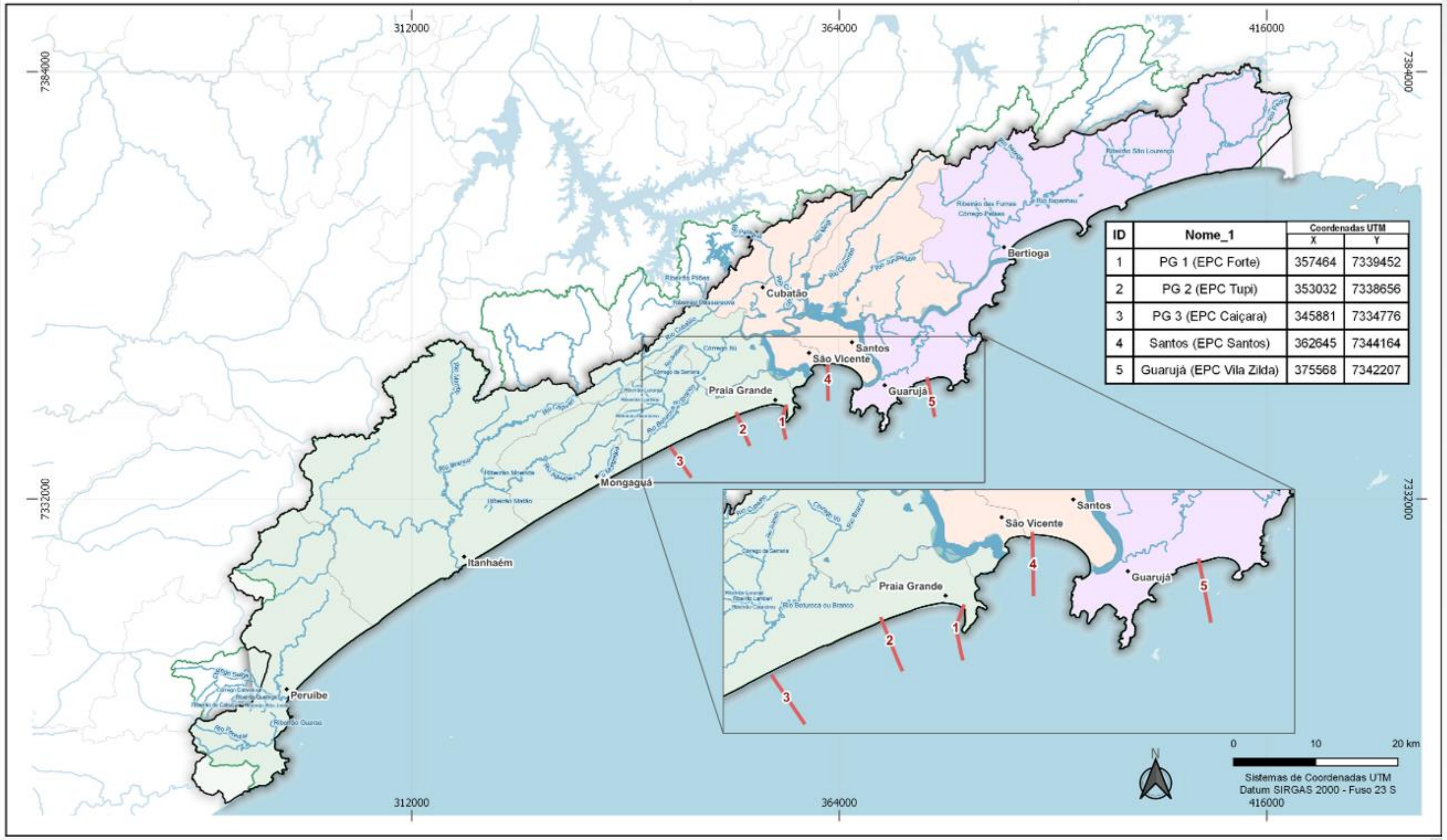
Pollutant release → Environmental impact

Lagrangian
X
Eulerian
→ Accuracy and consistency of the model

(Shadloo, Oger and Touzé, 2016)



# INTRODUCTION




| ID | Nome_1 | Coordenadas UTM X | Coordenadas UTM Y |
|---|---|---|---|
| 1 | PG 1 (EPC Forte) | 357464 | 7339452 |
| 2 | PG 2 (EPC Tupi) | 353032 | 7338656 |
| 3 | PG 3 (EPC Caiçara) | 345881 | 7334776 |
| 4 | Santos (EPC Santos) | 362645 | 7344164 |
| 5 | Guarujá (EPC Vila Zilda) | 375568 | 7342207 |

Santos (4) and Guarujá (5)

↓

Preliminary treatment
Disinfection

Praia Grande (1,2,3)

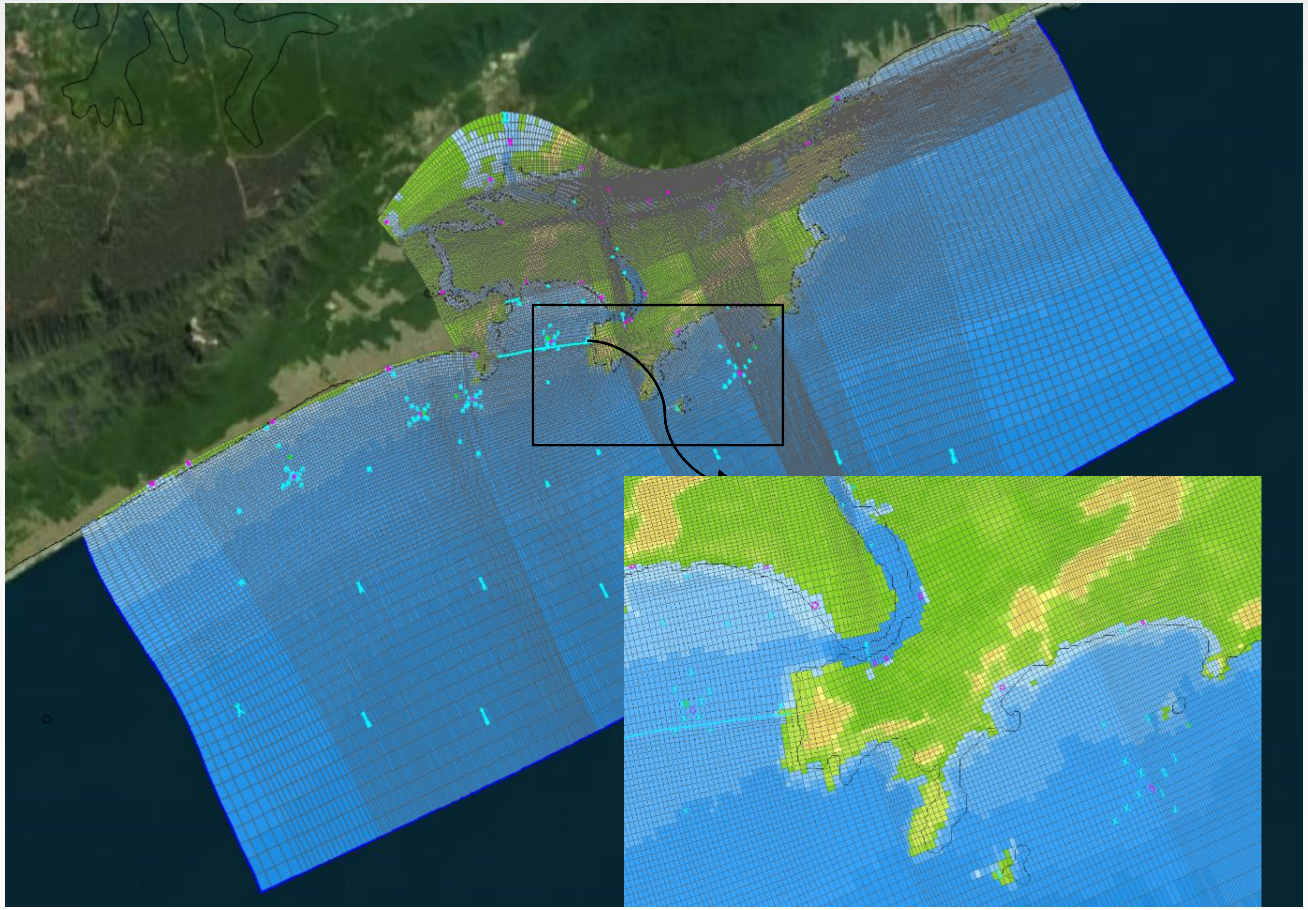
↓

Preliminary treatment

# METHODOLOGY - HYDRODYNAMICS

Model characteristics:

- 2DH model
- Low stratification of water column
- Shallow waters transient equations
- Hydrostatic distribution of pressure
- Incompressible flow
- Boussinesq hypotesis
- κ-ε closure scheme
- Astronomical ocean data used for open boundary condition



Model forcings:

- Wind
- Temperature
- Salinity

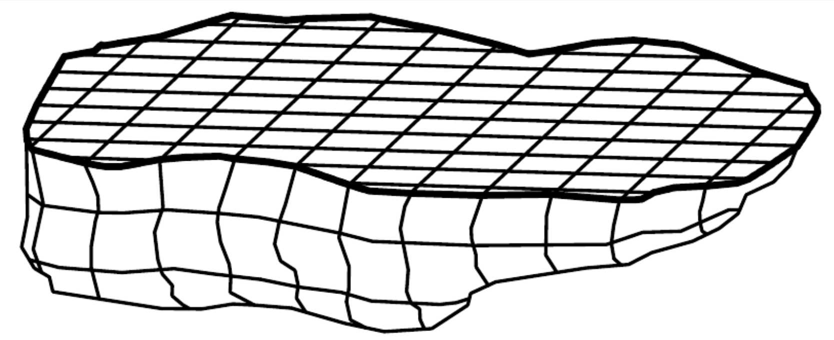
Initial conditions:

- Water level = 0 m
- Temperature = 25.68 ºC
- Salinity = 35.28 ppt

# METHODOLOGY - EULERIAN VS. LAGRANGEAN (DELFT3D – WAQ/PART)

Advection + Diffusion + Reaction governing equation:

$$\frac{\partial C}{\partial t} + v_x \frac{\partial C}{\partial x} - D_x \frac{\partial^2 C}{\partial x^2} + v_y \frac{\partial C}{\partial y} - D_y \frac{\partial^2 C}{\partial y^2} + v_z \frac{\partial C}{\partial z} - D_z \frac{\partial^2 C}{\partial z^2} = S + f_R(C,t)$$



## Initial condition:

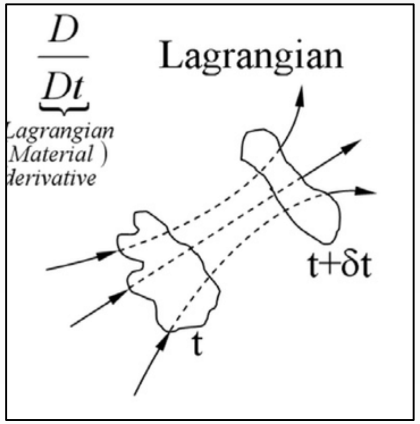
- Background concentration of analyzed parameters = 0
- Dissolved oxygen = 8 mg $L^{-1}$

## Main sources:

- Ocean outfalls
- Streams and tributary channels

## Model characteristics:

- Dynamic 3-D particle tracking model
- Horizontal and vertical dispersion coefficients treated separately
- Transport is split between
  - advection (currents and wind)
  - horizontal/vertical dispersion (random walk)

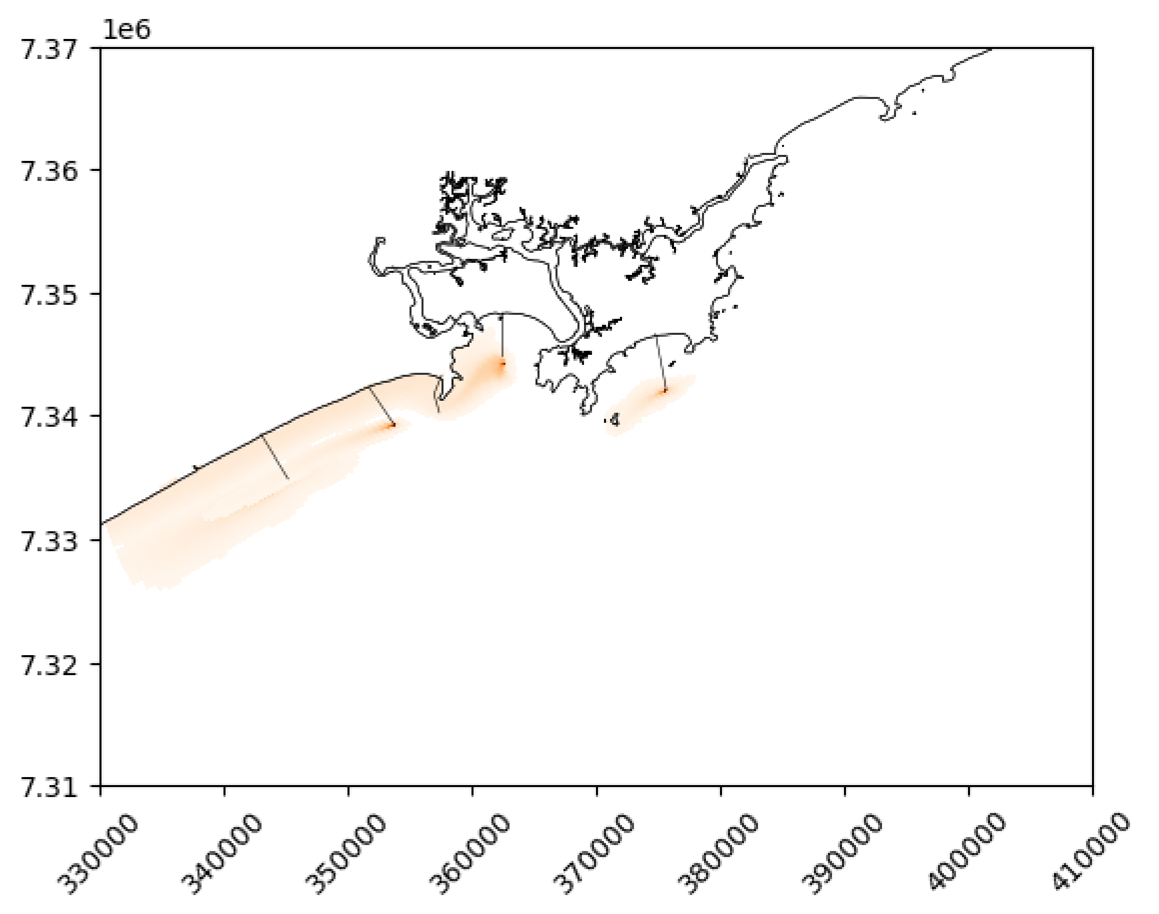



$$x(t+\Delta t) = x(t) + \int_0^{\Delta t} \left(\frac{dx}{dt}\right) dt$$

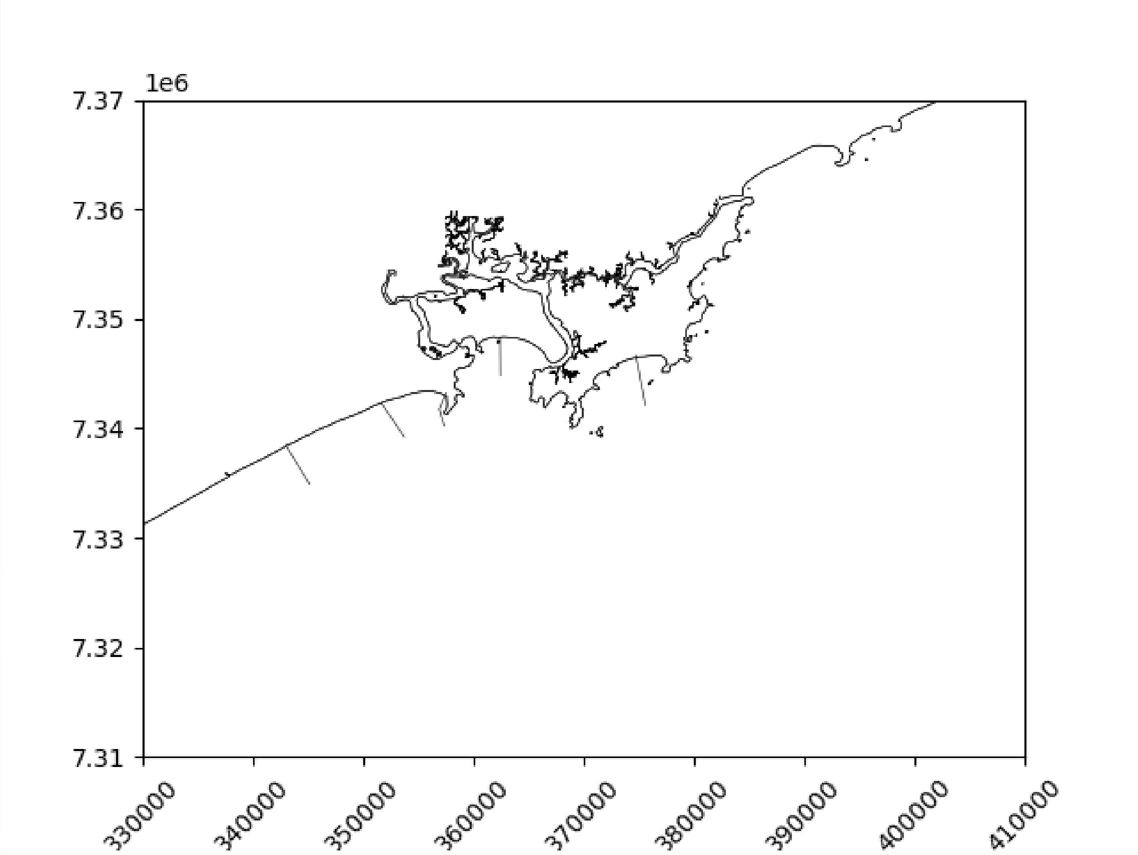
$$D_{x,y} = a t^b$$

# RESULTS – TRANSPORT PREVIW - FLOW (EULERIAN)

Mean spread of plume - FLOW




Plume spread - FLOW

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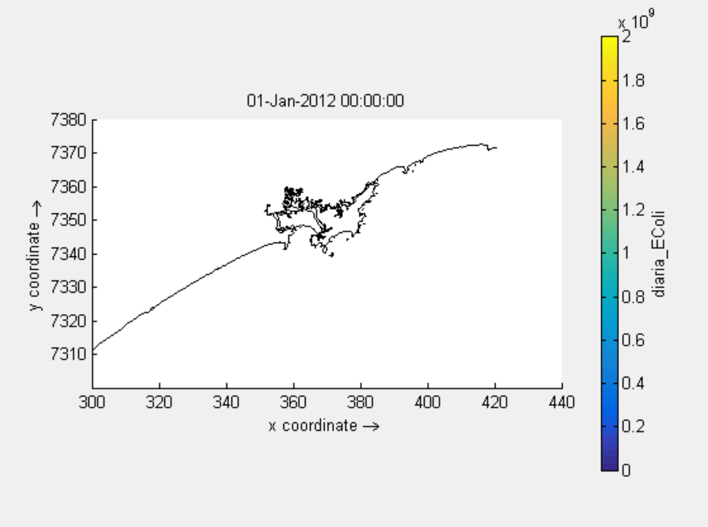
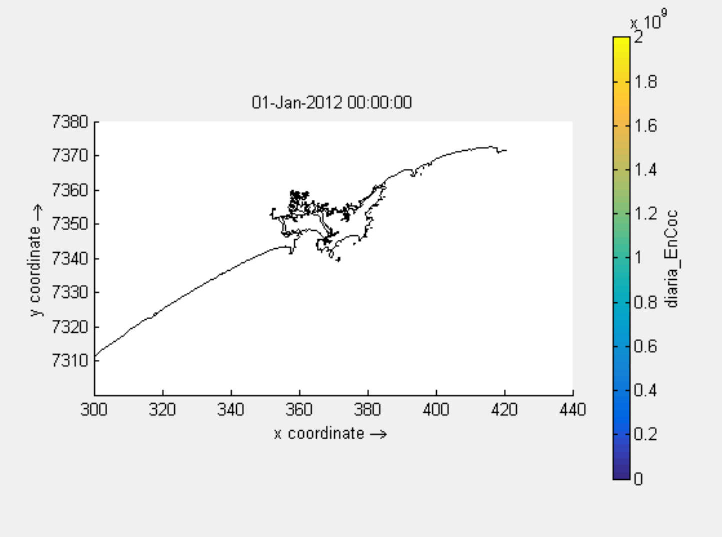
# RESULTS – EULERIAN (DELFT3D – WAQ) – E. COLI

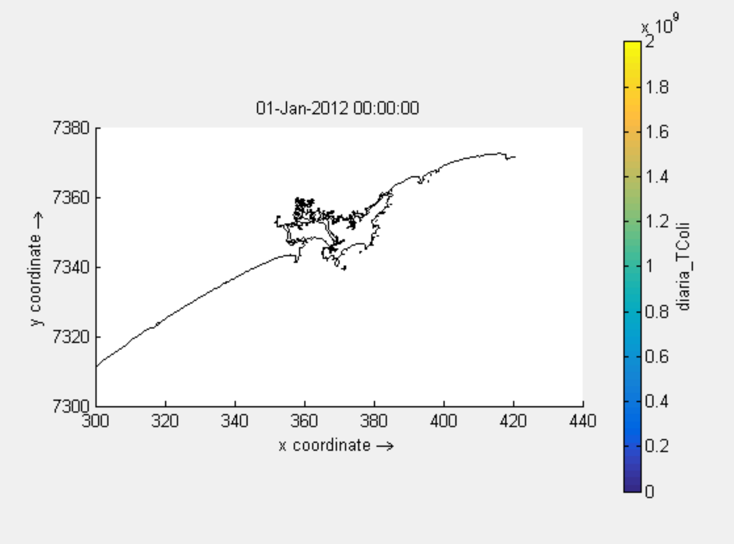
Mean (30 days) – E. coli – filter of 800NMP/100ml



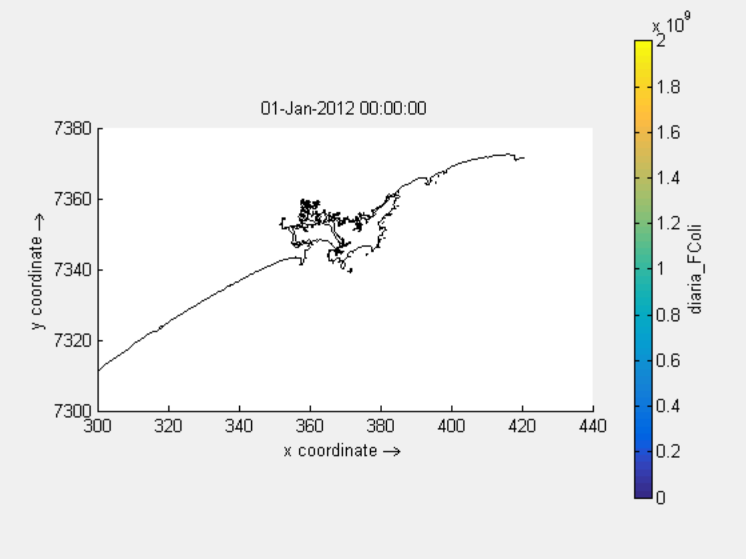

Mean (30 days) – Enterococcus – filter of 100NMP/100ml




Mean (30 days) – Total coliforms – filter of 1000 NMP/100ml




Mean (30 days) – Fecal coliforms – filter of 1000NMP/100ml

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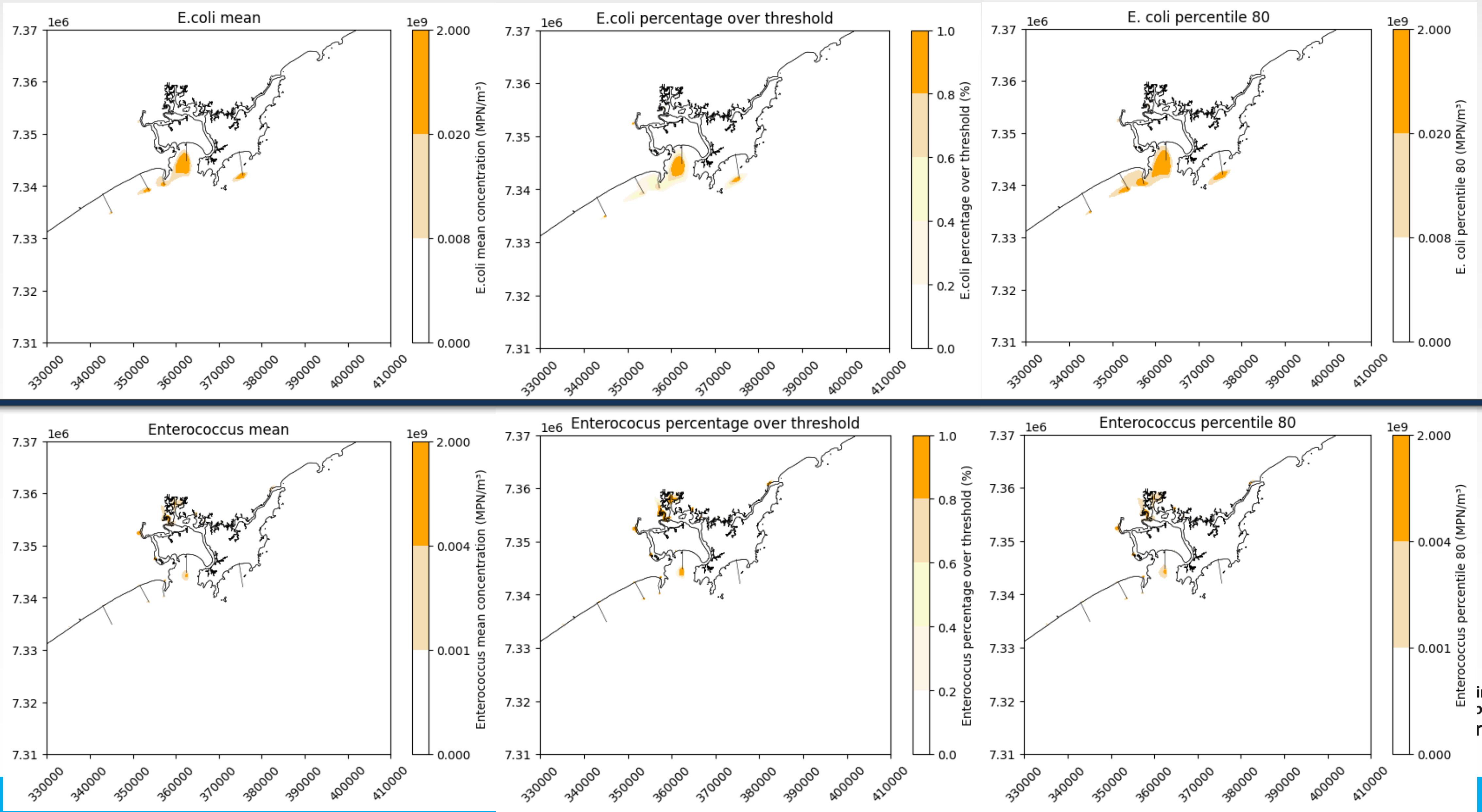
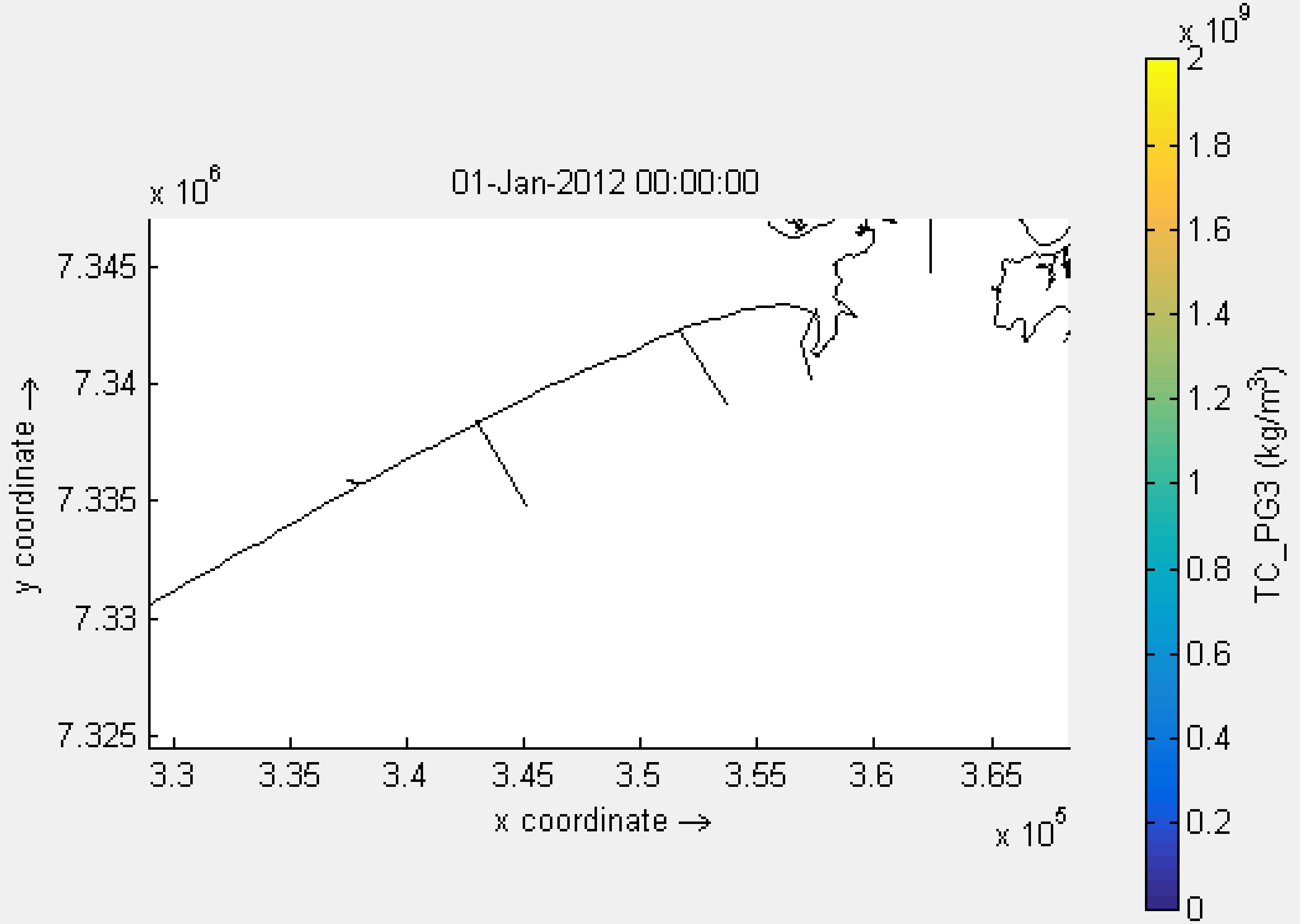
# RESULTS – EULERIAN (DELFT3D – WAQ) – STATISTICS

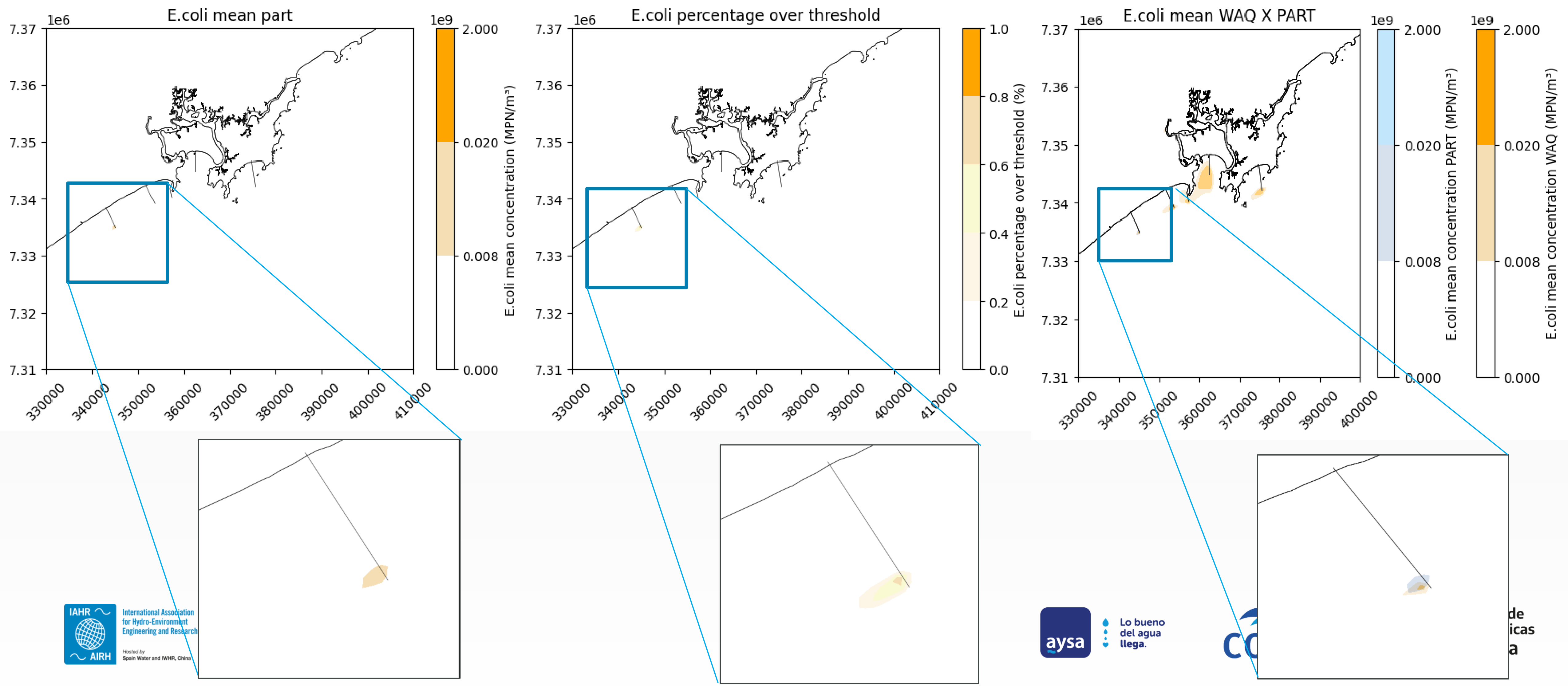


# RESULTS – LAGRANGIAN (DELFT3D – PART) – PG3

Plume spread



# RESULTS – LAGRANGIAN (DELFT3D – PART) – PG3 – E. COLI

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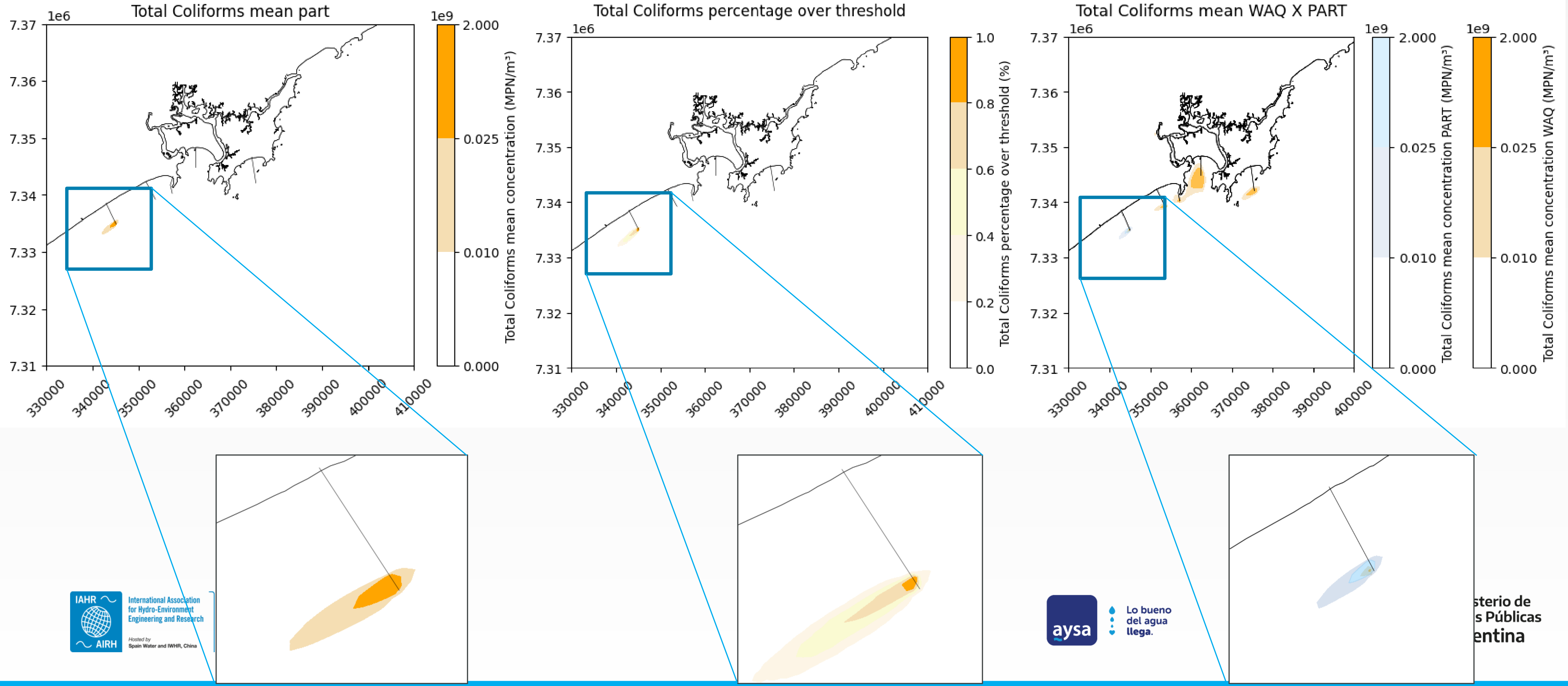
# RESULTS – LAGRANGIAN (DELFT3D – PART) – PG3 – TOTAL COLIFORMS

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# CONCLUDING REMARKS

- Eulerian approach
  - Calibrated model
  - Varying decay rate of analyzed parameters
  - Closure model solved via k-e scheme

- Solves concentration via finite volume method, thus may cause numerical diffusion when dealing with elevated concentration gradients
- In the Eulerian scheme, the pollutant is diluted to a whole grid cell soon after being emitted from a point source so that the concentration is reduced instantaneously
- Provide information for the whole domain

- Lagrangian approach
  - Not calibrated model, thus results are thoroughly associated with the velocity field obtained from hydrodynamics
  - Constant minimum decay rate

- Solves concentration of the particle via decay rate, T90
- Virtually free of numerical diffusion
- The concentration of the pollutant is associated with a particle not the whole grid cell, thus if there are not enough particles the outcome may not be realistic
- Depends on the velocity field originated from an Eulerian hydrodynamic simulation

# CONCLUDING REMARKS

- Preliminary results indicate:
  - Plume size and concentration for E. Coli parameter diverged sligthly between each one of the applied concepts
    - Lagrangian approach resulted in a less concentrated and smaller mean plume – Adequate calibration of the model may result in a smaller sized and concentration plume
  - Enterococcus parameter maintained its pattern for both approaches
  - Similar overall dispersion pattern between both approaches

# TASKS FOR THE FUTURE

- Simulate the remaining outfall systems as point-sources
- Apply varying decay rate for the analysed parameters
- Adequately calibrate the particle model
- Evaluate and compare the resulting plume from both approaches

- Simulate the ramaining outfall systems as nonpoint-sources
- Evaluate the effects of nonpoint-sources as a continuous discharge for the particle track model

Thank you
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