Mapping the Pathways of Marine Litter: Insights from 3D Ocean Trajectories and Vertical Dynamics

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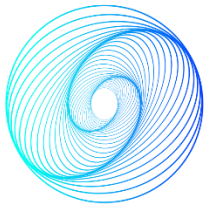

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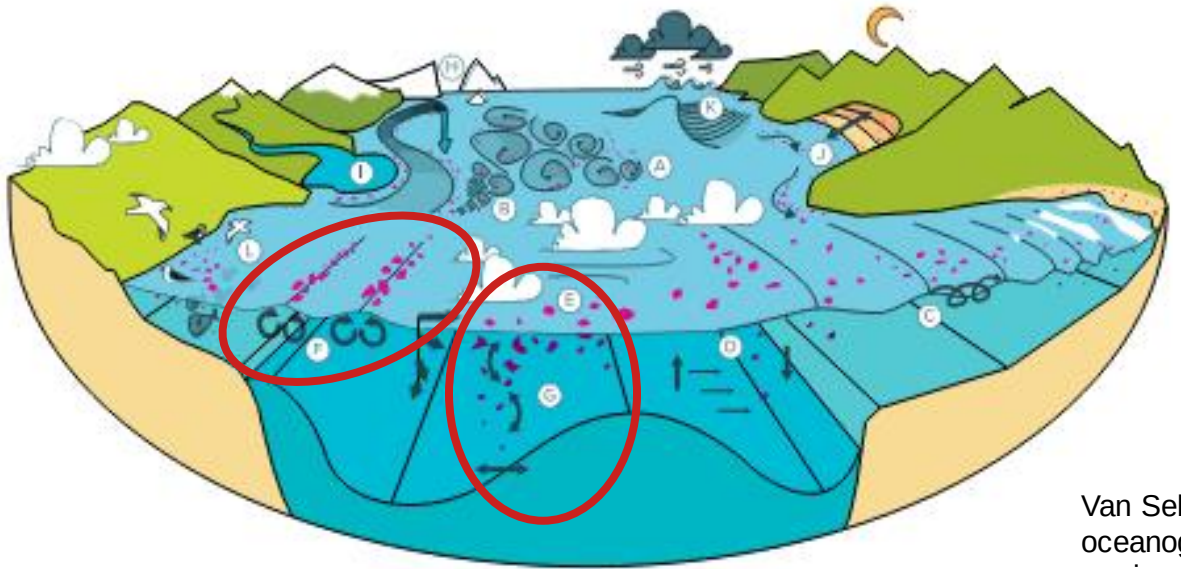
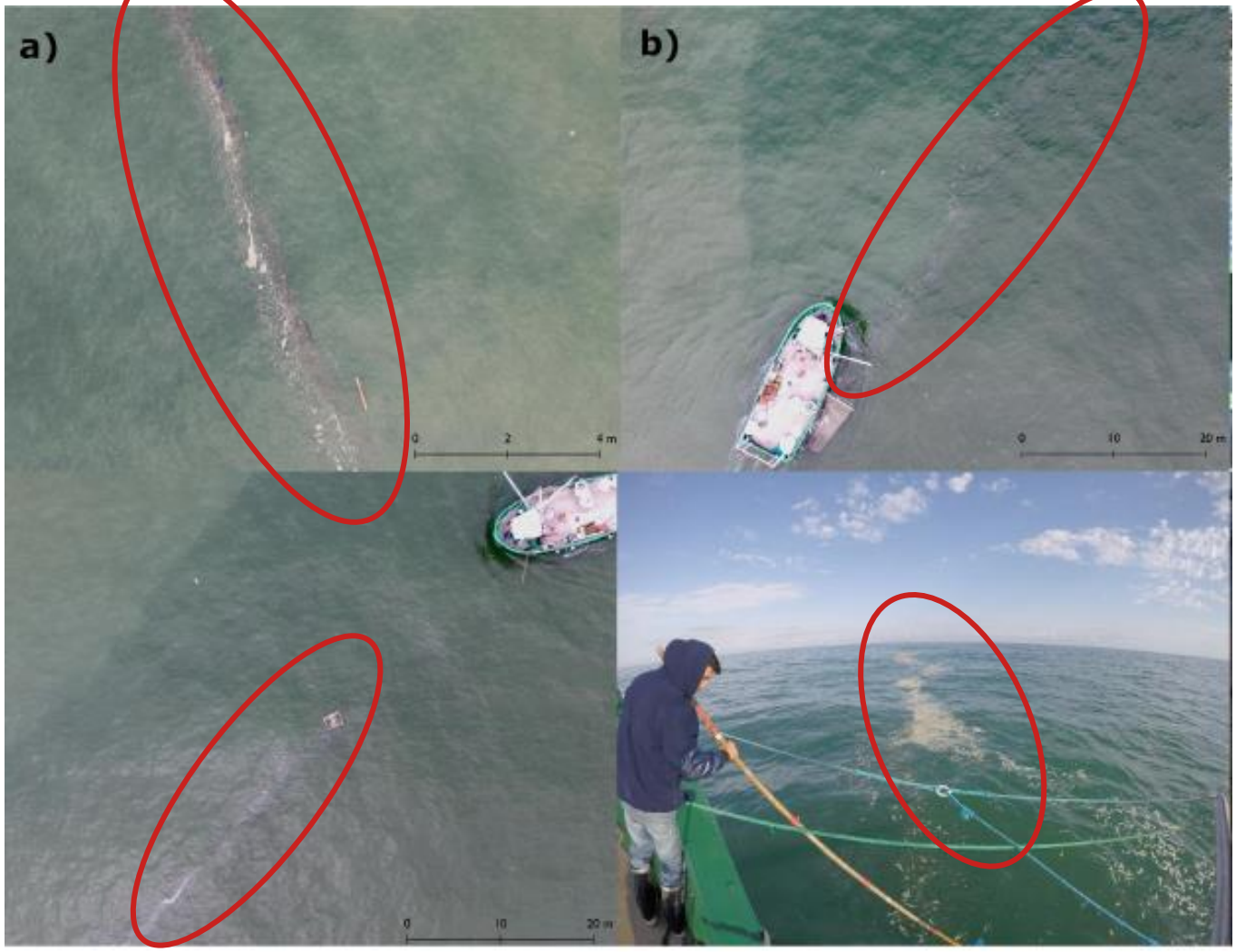
Motivation and context*

Our work focuses on the motion of **fluid particles** within a **vertical column**. This helps us to understand the complexity of such motion, but also unravels the mysteries surrounding the displacement of **particles that neither float strictly nor sink completely**.



Van Sebille, E, et al. "The physical oceanography of the transport of floating marine debris." Environmental Research Letters 15.2 (2020): 023003.

Motivation and context



Ruiz, Irene, et al. "Litter windrows in the south-east coast of the Bay of Biscay: an ocean process enabling effective active fishing for litter." Frontiers in marine science 7 (2020): 308.

How?*

Our methodology is based on the **identification of a relationship** between the **horizontal coherent structures and the vertical motion** associated with them. For this purpose, we will use **Lagrangian trajectories and quantities** that allow us to study the **coherence of fluids**.

Lagrangian Divergence

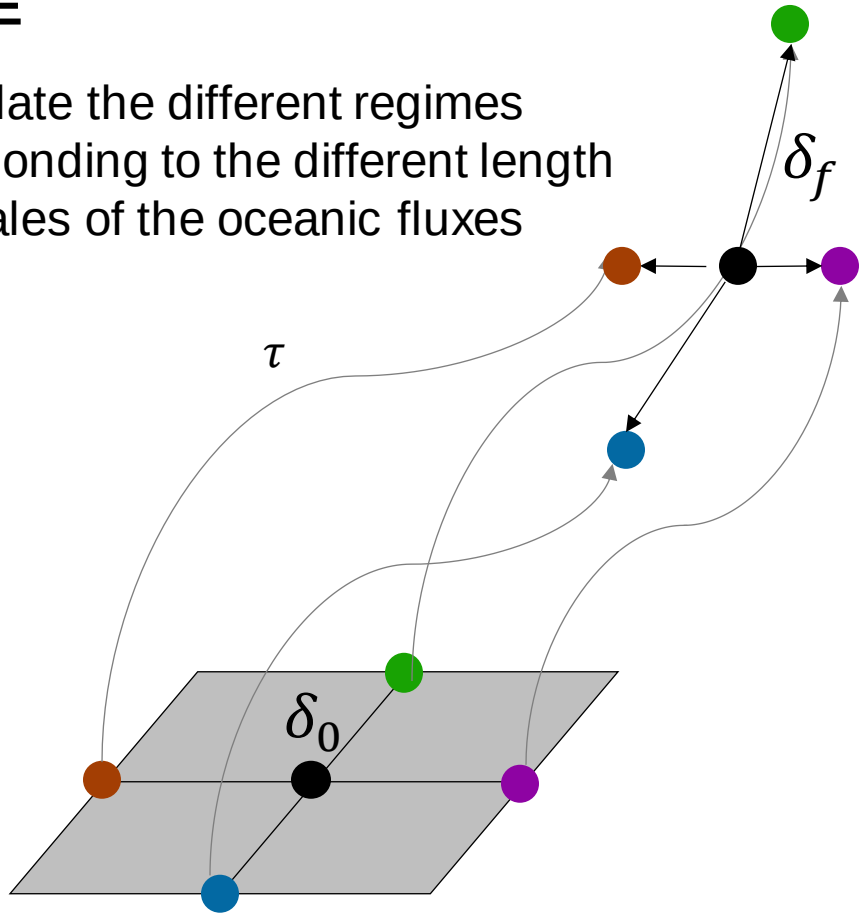
Finite Lyapunov Exponents

- FTLE
- **FSLE**

Lagrangian Quantities*

FSLE

Isolate the different regimes corresponding to the different length scales of the oceanic fluxes



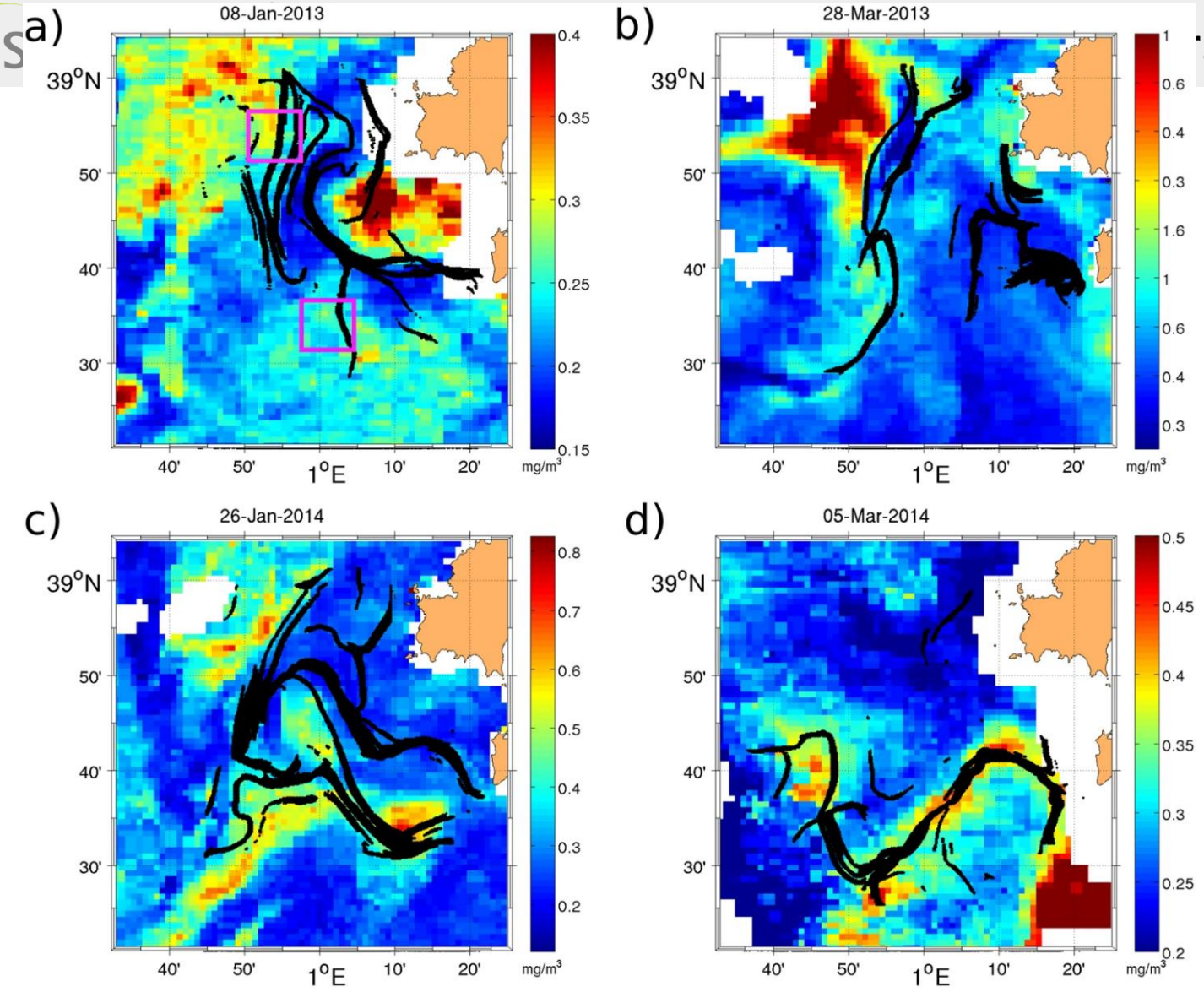
$$\lambda = \frac{1}{|\tau|} \ln\left(\frac{\delta_f}{\delta_o}\right)$$

δ_0 = inital distance between particles

δ_f = thresold distance

τ = time to get δ_f

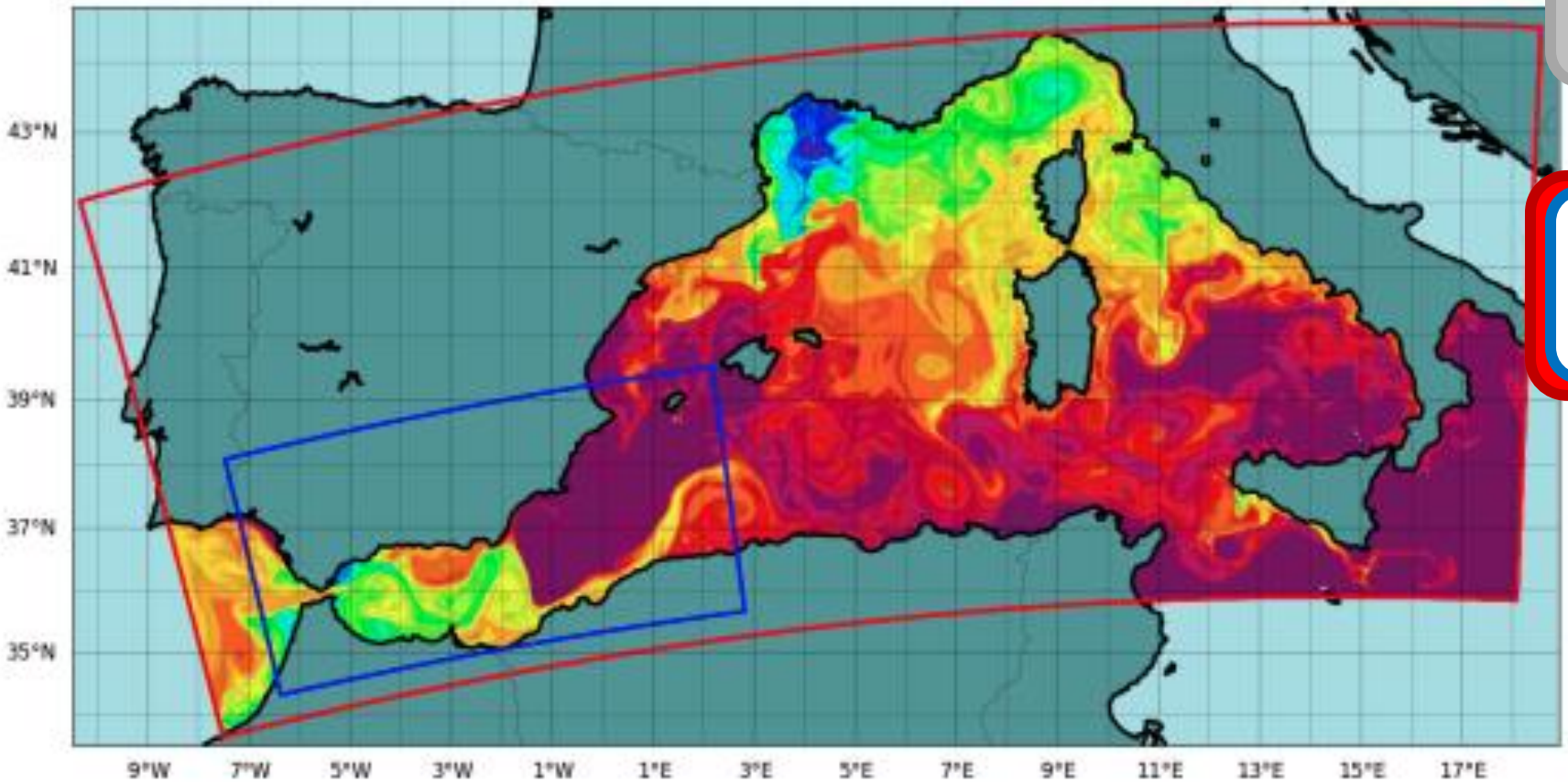
rangian Quantities*



Hernández-Carrasco, I. et. al.. Effect of small scale transport processes on phytoplankton distribution in coastal seas. Scientific reports, 2018, 8(1), 8613.

Input data*

2010 - 2013

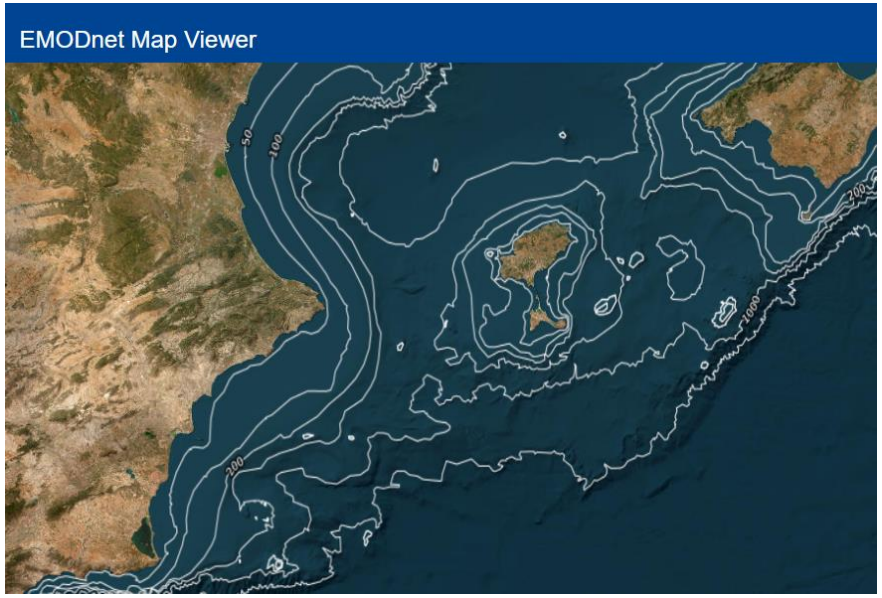


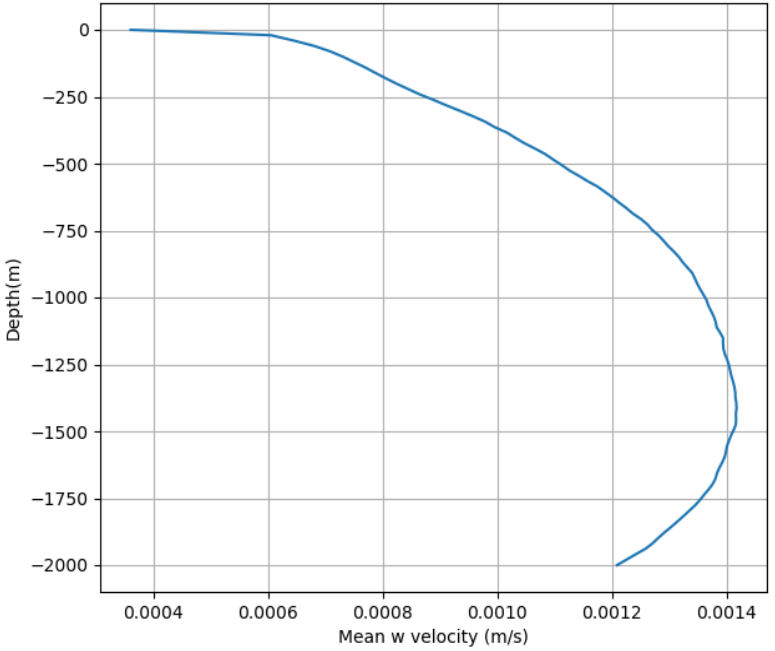
dx = 1500m
dt = 24 h

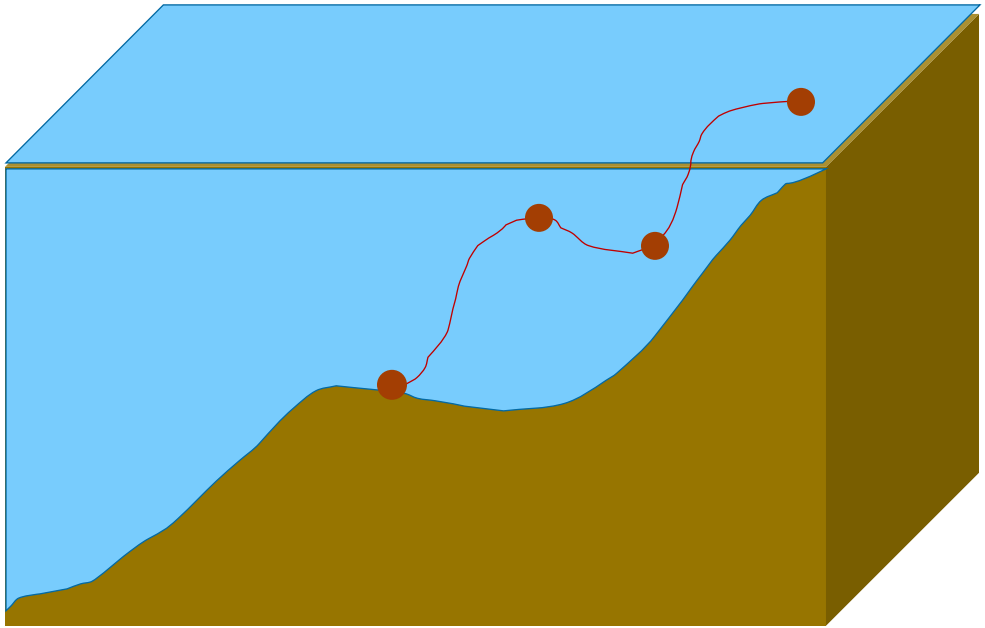
dx = 500m
dt = 3 h

Input data*

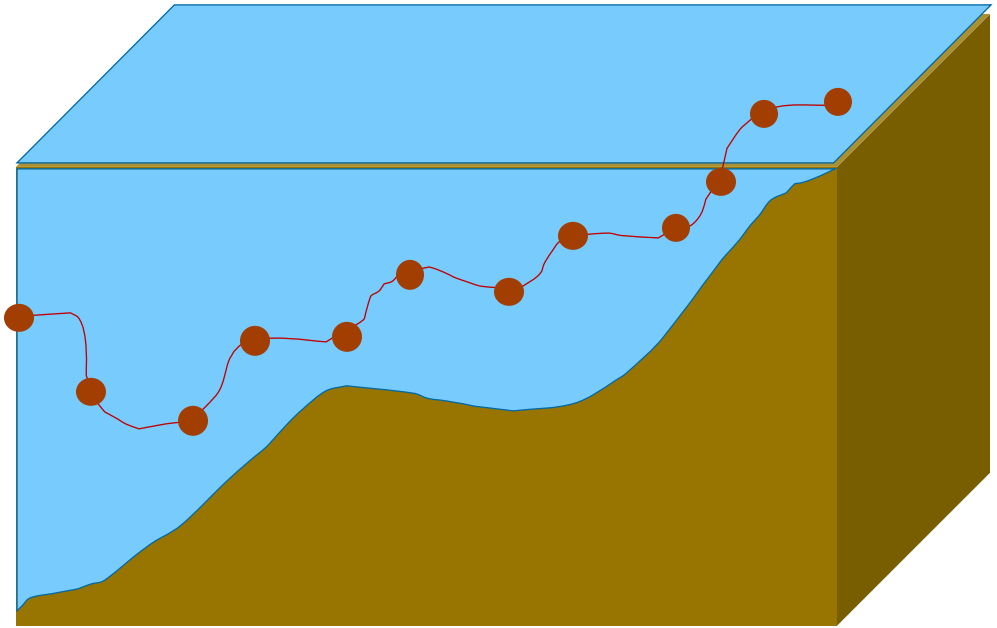
But integrating **3D trajectories** in a domain at **high resolution** can be challenging because we need **large spatiotemporal domains**. But not only is this computationally expensive, but in areas with **strong dynamics**, particles can leave the domain. Also the **integration step** plays a decisive role, depending on the **area** we consider.





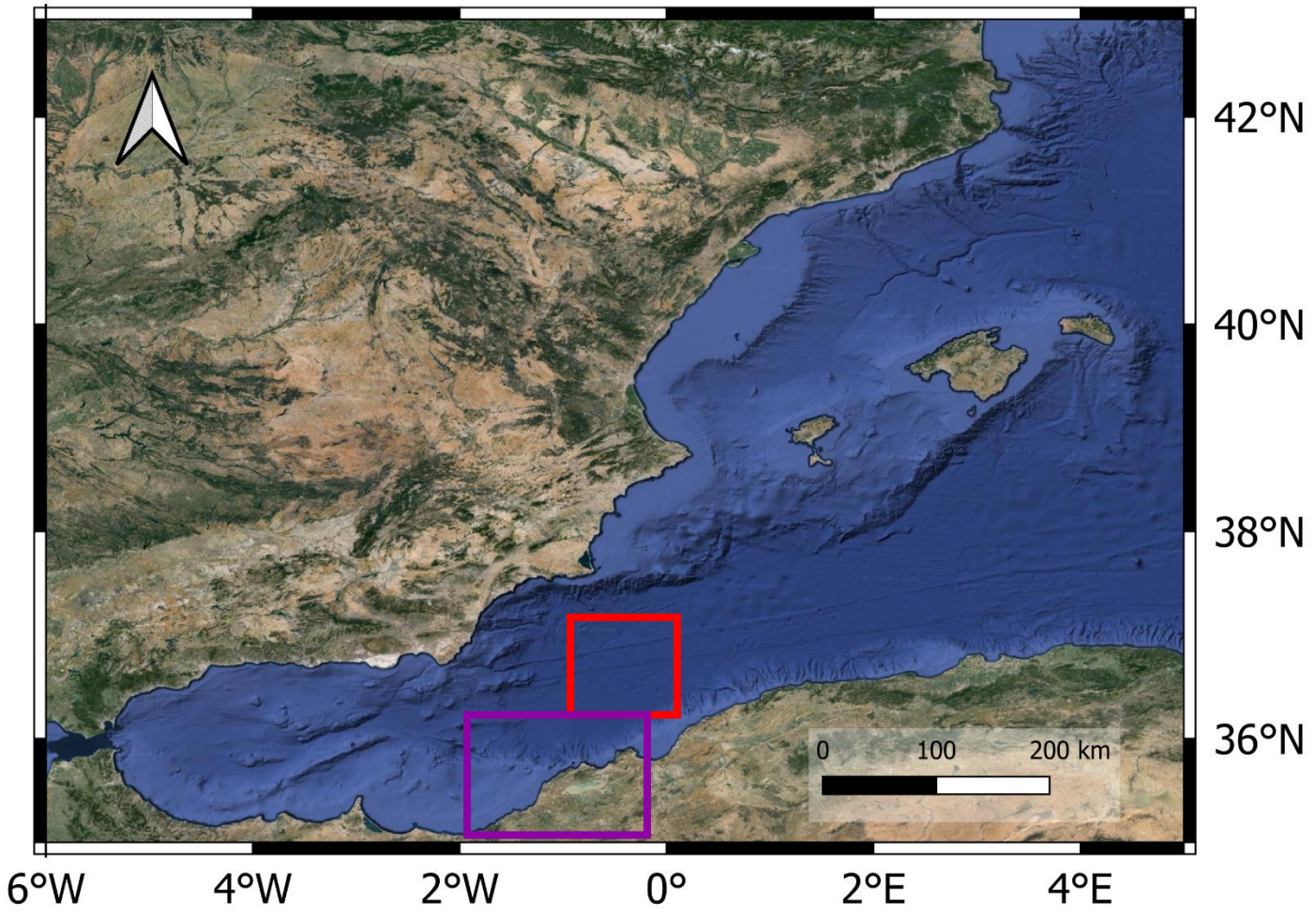


dt_1

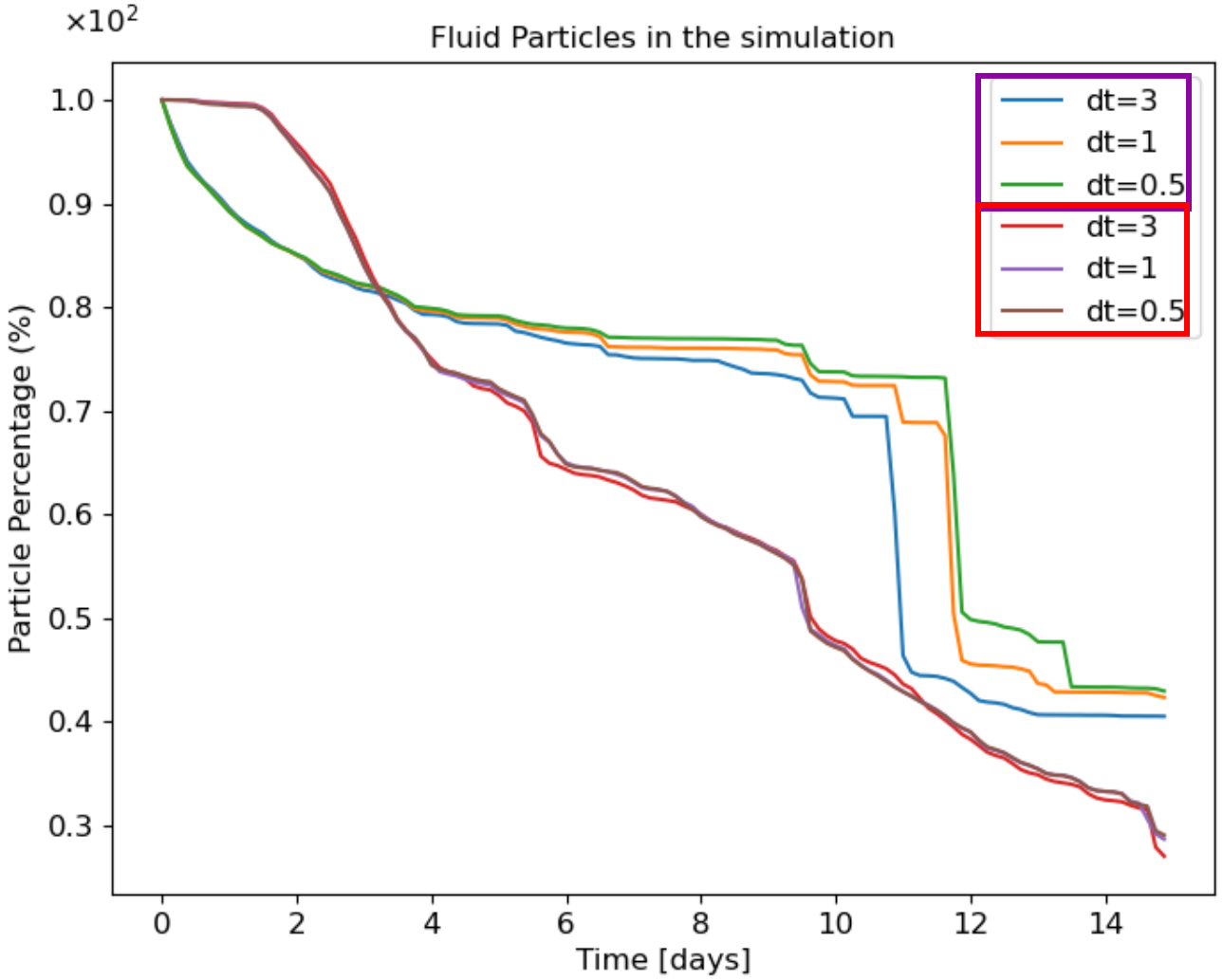


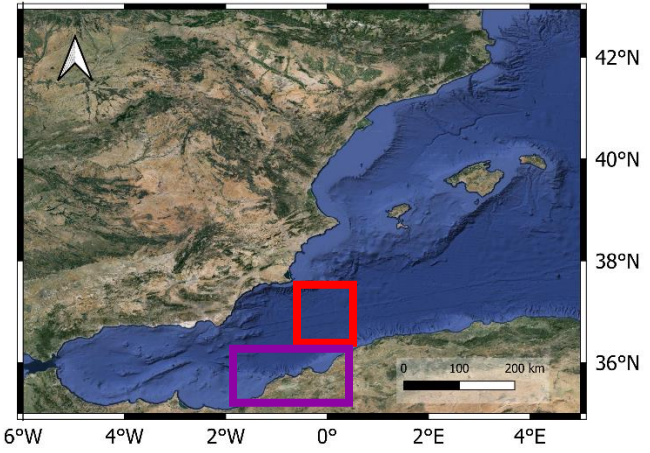
$dt_2 = dt_1/3$

Input data*



Results

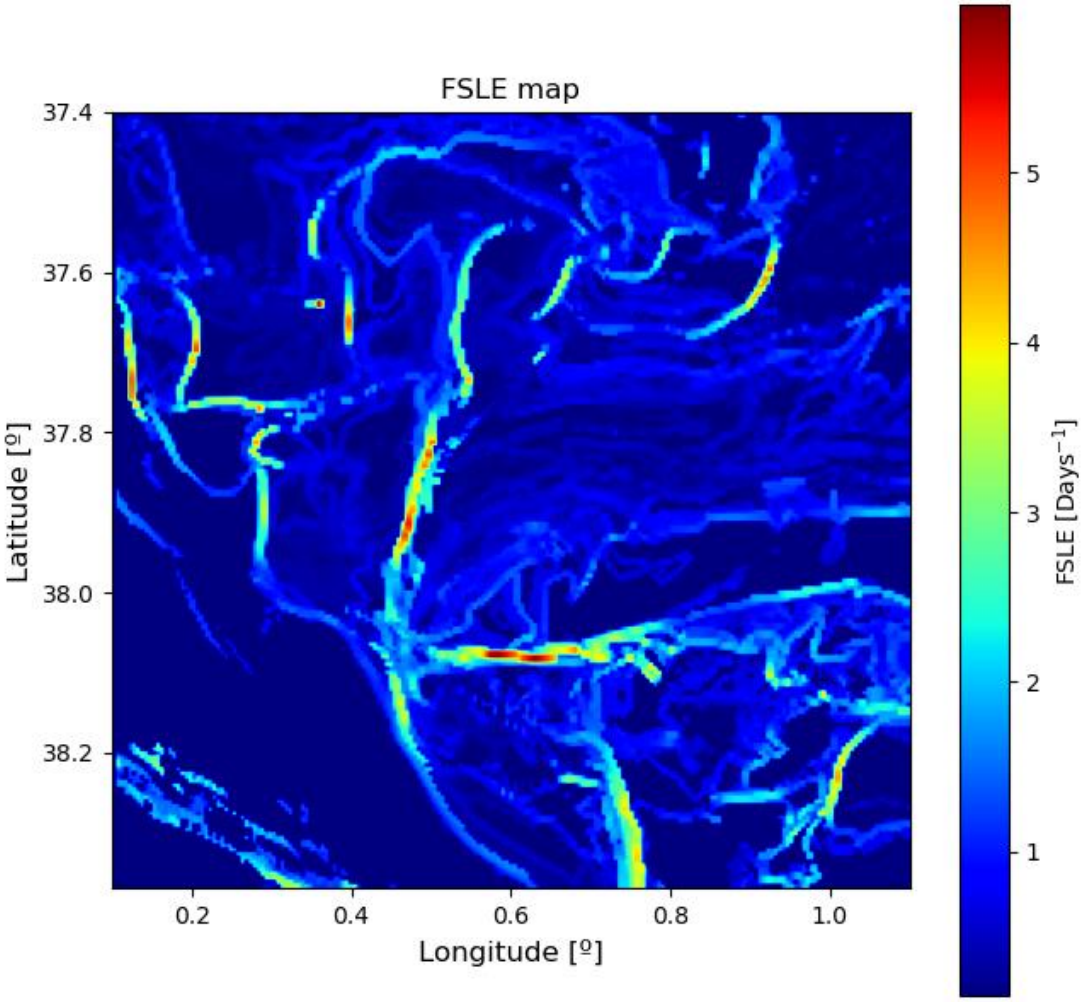

×10^2
Fluid Particles in the simulation
dt=3
dt=1
dt=0.5
dt=3
dt=1
dt=0.5
Particle Percentage (%)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0
2
4
6
8
10
12
14
Time [days]


42°N
40°N
38°N
36°N
6°W
4°W
2°W
0°
2°E
4°E
0
100
200 km

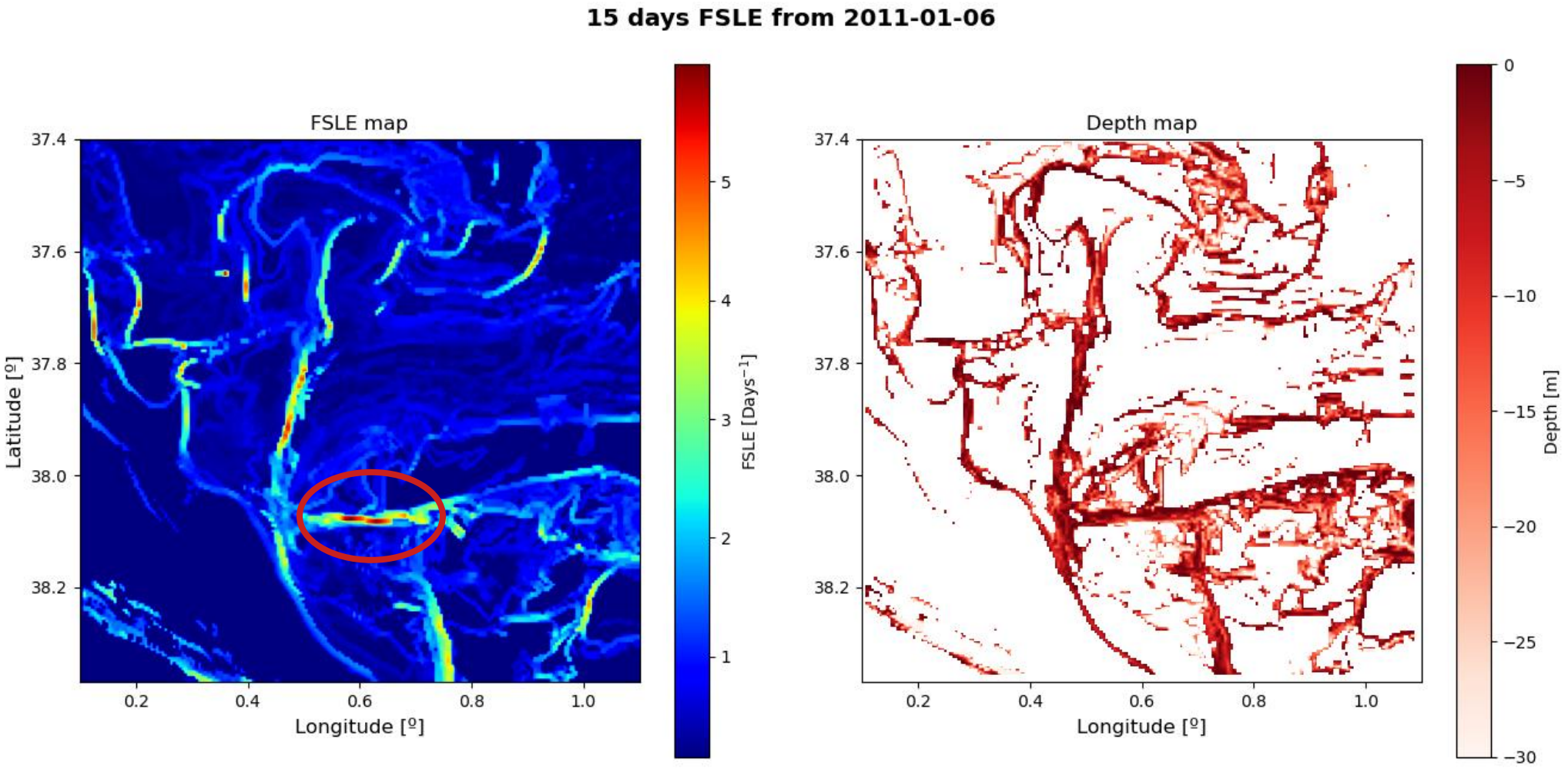
Results

Configuration

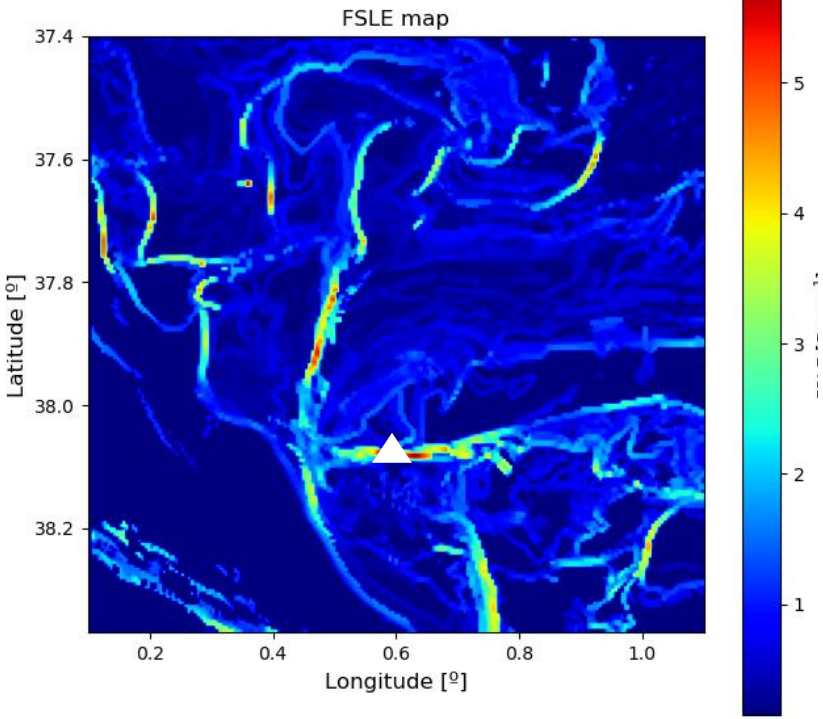
$\Delta x = 0.005^{o} \sim 500$ m
$\Delta t = 1$ h
$Z = 0$
$T = 20$ days
$\delta_f = 10\ \delta_0$

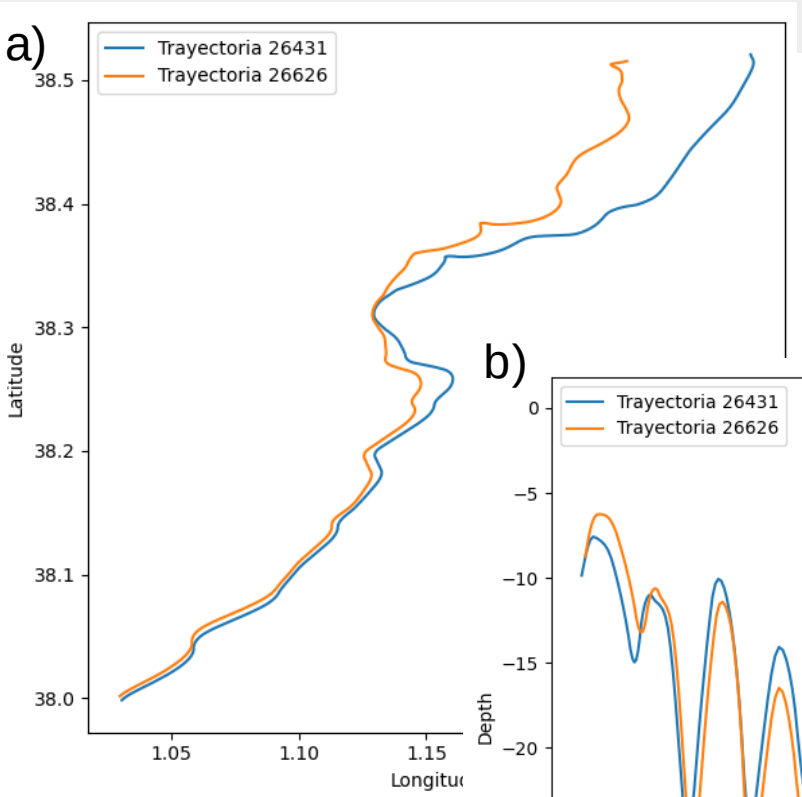


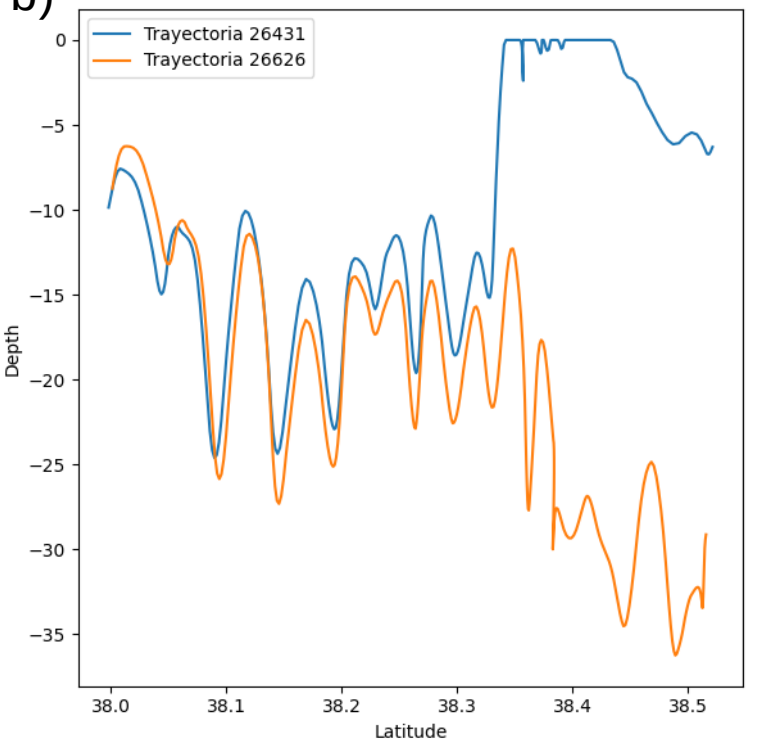
Results


15 days FSLE from 2011-01-06
FSLE map
Latitude [º]
Longitude [º]
FSLE [Days^{-1}]
Depth map
Depth [m]

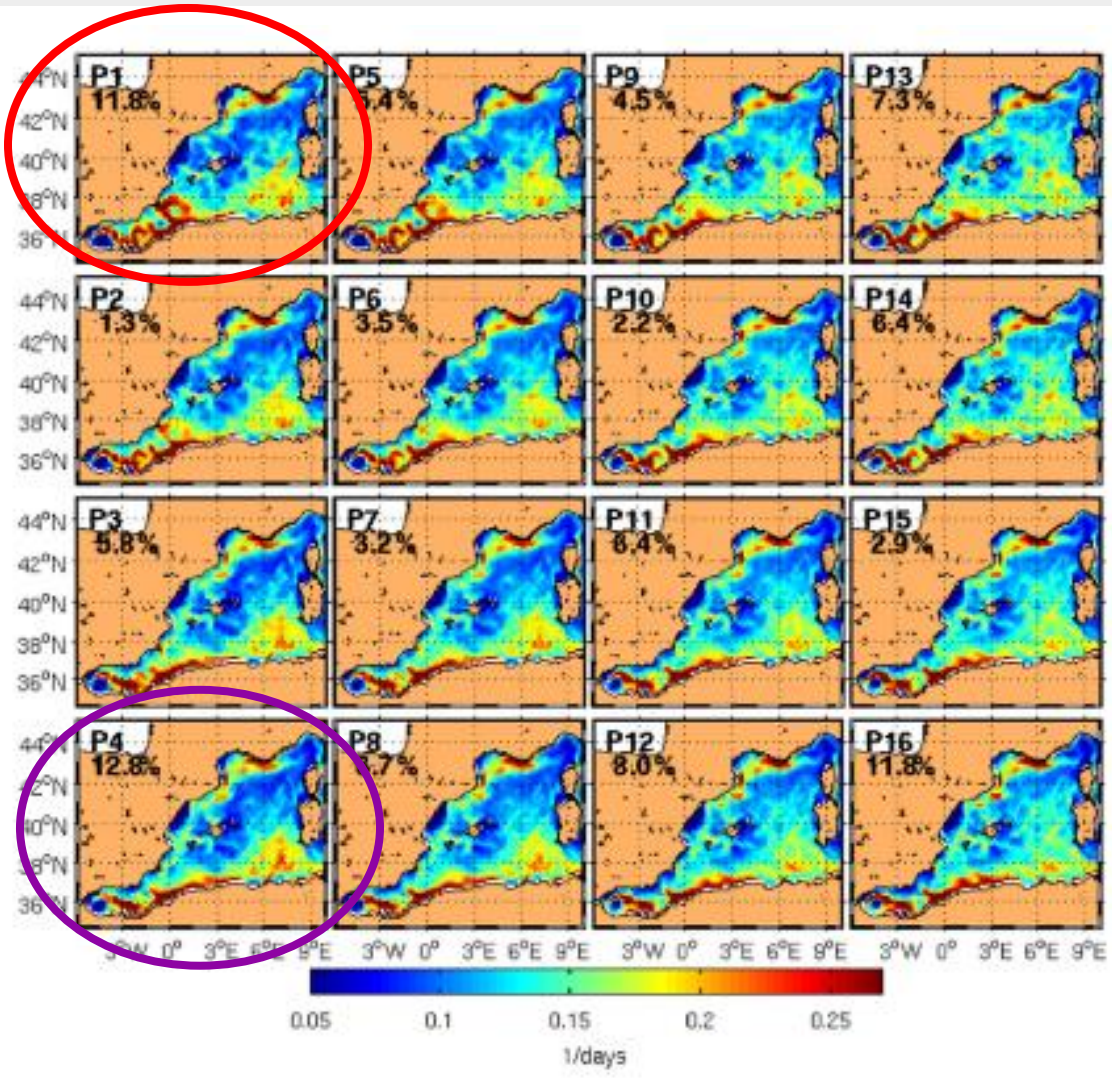
Results*

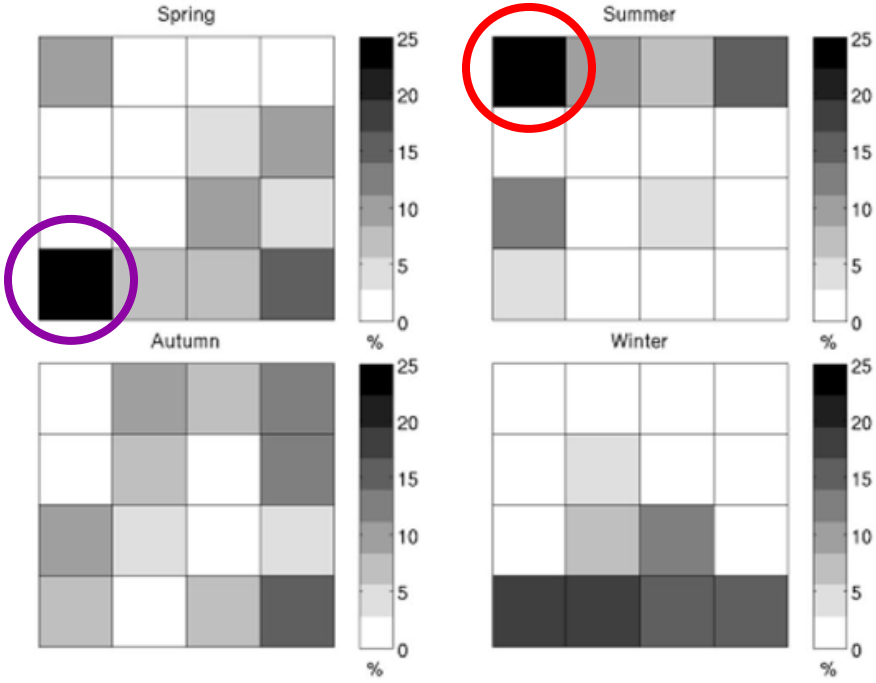

FSLE map
Latitude [º]
Longitude [º]
37.4
37.6
37.8
38.0
38.2
0.2
0.4
0.6
0.8
1.0
1
2
3
4
5


a)
Trayectoria 26431
Trayectoria 26626
Latitude
38.0
38.1
38.2
38.3
38.4
38.5
1.05
1.10
1.15


b)
Trayectoria 26431
Trayectoria 26626
Depth
0
−5
−10
−15
−20
−25
−30
−35
38.0
38.1
38.2
38.3
38.4
38.5
Latitude

Future Scope*





Hernández-Carrasco, I., & Orfila, A. (2018). The role of an intense front on the connectivity of the western Mediterranean Sea: The cartagena-Tenes front. Journal of Geophysical Research: Oceans, 123(6), 4398-4422.

Take Home Message*

Main Conclusions

- It is important to consider a **small integration step** if we want to integrate at **high resolution near the coast**.
- The **time consistency** of these patterns is essential before associating them with movements in the vertical.

Future Work

- We are looking for a way to make a **meaningful statistic** for the surface depth relationship.

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THANK YOU

for your attention

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