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Microplastic trajectories and fates in the Canary Current System using TrackMPD

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Introduction and objectives

The pollution caused by marine microplastic debris is a significant environmental problem that affects the world's oceans. Nowadays, it is estimated that the anual input of plastics into the oceans is approximately a hundred times greater than the amount that can actually be located (Poulain et al., 2019). Therefore, the knowledge of the fluxes, pathways, and fate of these plastics is quite incomplete (van Sebille et al., 2020). In this study, the main objective is to increase the understanding of this topic through sensitivity analysis of microplastic trajectories and fates to physical processes in the Canary Current System by employing the TrackMPD modelling framework.

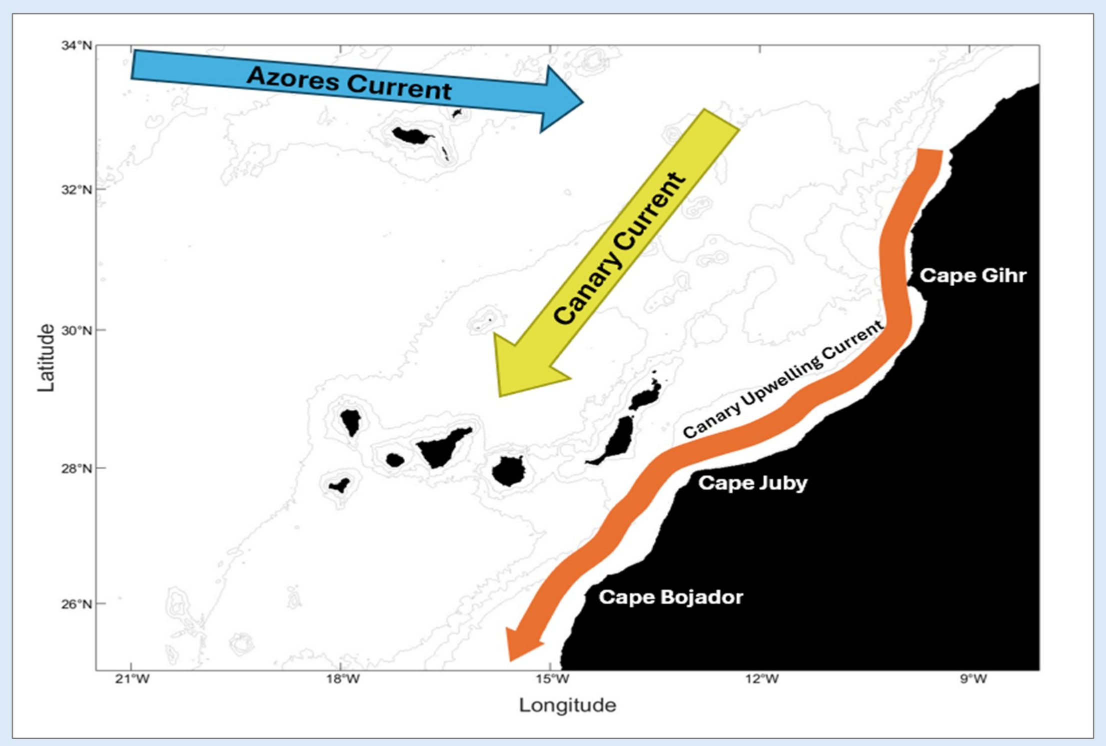

Figure 1. General surface circulation in the Canary Current System.

Data and methods

Particle releasing
320 virtual particles released upstream the Canary Islands for 90 days

Horizontal velocity field input
Copernicus Marine Service
Hourly 0.028º x 0.028º IBI Ocean Analysis and Forecasting

Modeling Framework
TrackMPD_v2.3
Open-access toolbox developed in MATLAB by Jalón-Rojas et al. (2019)
TrackMPD

12 Sensitivity tests

- **Advection Schemes**
  RK2, RK4 and Euler Method
- **Horizontal dispersion coefficient (m^2/s)**
  0 (Control scenario), 0.5, 2, 5 and 10

Comparisons between scenarios

- **Descriptive visualization**
- **Dimensionless Skill Score**
  Based on normalized cumulative Lagrangian separation between control scenarios and remaining cases (Liu & Weisberg,2011)
  Values range between 0 (trajectories completely different) and 1 (trajectories completely identical)

Results & Discussion

In all cases, the Skill Scores have average values above 0.8, which at first suggests that there are no significant differences between the studied scenarios and their control scenarios.

The Skill Scores in *Figure 2* shows how increasing the horizontal dispersion coefficient value leads to increased variability and a lower average Skill Score. There is a reduction in the mean Skill Score around 8% with an increase in the dispersion coefficent from 0 $m2/s$ to 10 $m2/s$. This is an expected outcome since horizontal dispersion is modeled with random numbers, meaning that a higher K_h would imply greater variation among the trajectories. However, the variations are not very pronounced either, suggesting that the trajectories are somewhat insensitive to the horizontal dispersion coefficient. This effect shows no significant differences between advection schemes.

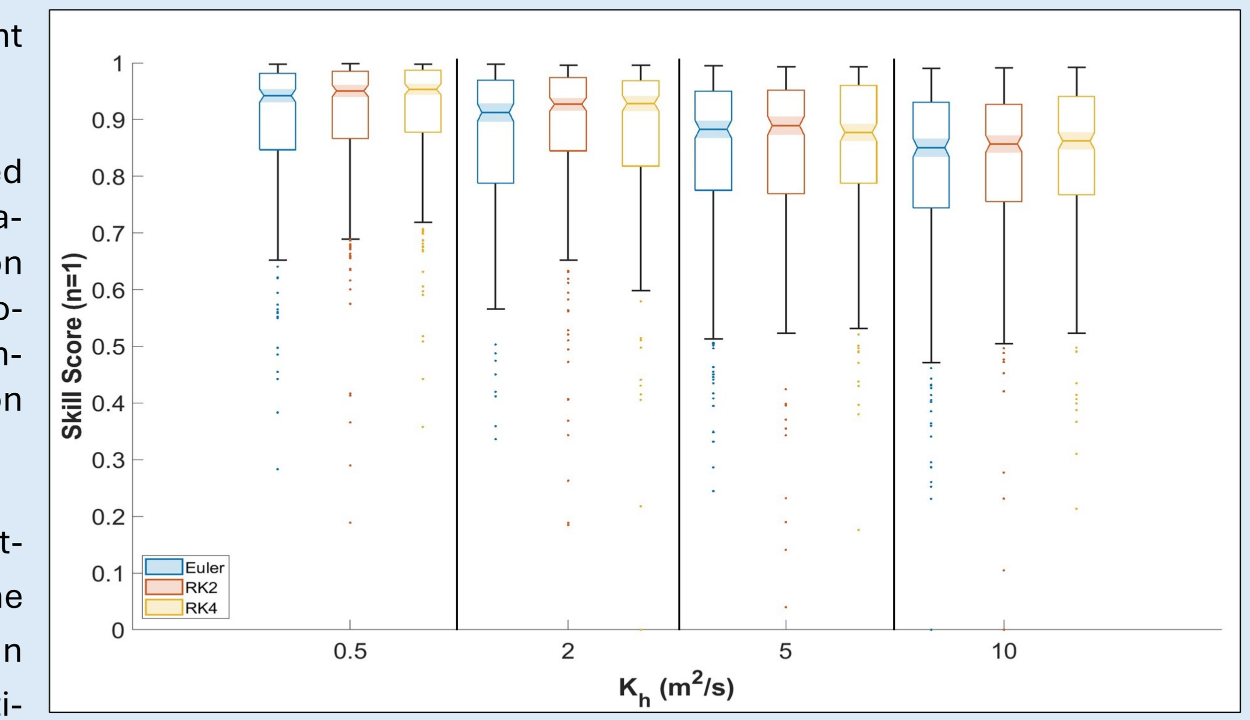

Figure 2. Skill Score (n=1) obtained in each scenario comparing the advection scheme and horizontal dispersion coefficients (along the x-axis).

The Skill Scores in Figure 2 also show differences in variability between advection schemes. Generally, except with $Kh=2\ m2/s$, the Euler method exhibiting greater variability than RK2, and RK2 in turn greater than RK4. This could be related to the mesoscale activity in the area, as the trajectories using lower-order methods (Euler Method and RK2) show less defined eddies north of the islands than RK4.

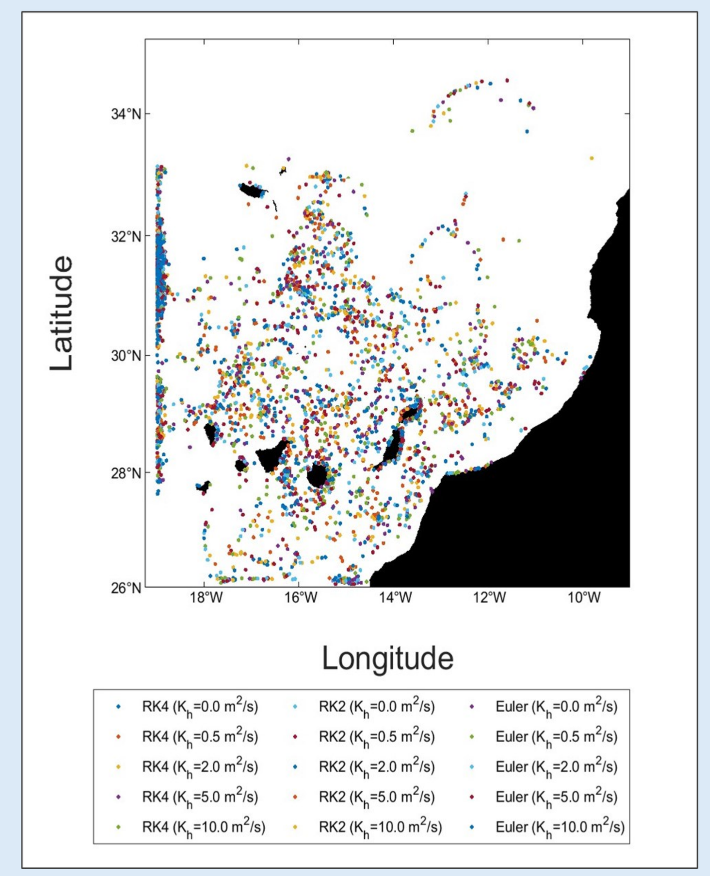

Figure 3. Final position of the virtual particles in all scenarios considered.

The trajectories (see Supplementary Material) illustrate how the mesoscale activity in the area plays a significant role in particle transport, both north and south of the islands. Furthermore, the effect of the coastal jet located east of the islands, the Canary Upwelling Current, on the African coast, is noteworthy as it significantly influences the trajectories, primarily causing transport towards the southeast.

After 90 days of simulation, Figure 3 shows that the majority of particles remain in open ocean, and those that reach the coast mainly do so on the northern and eastern coasts of the islands. This is consistent with the idea that the arrival of microplastics on the shoreline aligns with the Canary Current, as suggested by previous works (Baztan at al., 2014; Herrera et al., 2018; Vega-Moreno et al., 2024). Additionally, the results are in line with former studies that demonstrate a high variability in the arrival of microplastics at coastlines of the islands, which may be linked to mesoscale activity (Baztan et al., 2014 ; Álvarez-Hernández et al., 2019) .

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Conclusions

There is an **effect of horizontal dispersion** on the trajectories, as revealed by the Skill Score variability

The trajectories **are strongly affected by mesoscale phenomena** such as eddies and the coastal jet. This leads to a high variability in particle beaching between the islands

The predominant reason for the northern and eastern areas of the islands being most affected is **the orientation of the Canary Current** in agreement with previous works

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