Reviewers response on "Tracking Marine Debris in Northwest Spain: Assessing Wind Influence with a Lagrangian Transport Model."

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Reviewer 1

This paper investigates how the distribution of floating plastic debris in the Ria de Arausa that originates from Ulla River is affected by the windage term used in Lagrangian simulations. Using this model, they find that a lower wind drag results in higher nearshore accumulation and larger retention rates. Furthermore, they find that the beaching pattern is highly heterogenous, where over half of the beached particles stranded in only 10 of the 242 coastal segments of the Ria. The number of beached particles at these segments is correlated with the river flow rate, where they find highest correlation for the sections closest to the release point of the particles.

I think in general this set up of this study allows for interesting analysis, however I feel the analysis presented here is not complete. In addition, the way model settings are chosen and why there are valid is not sufficiently explained currently. There is no discussion on the limitations of the model used here and what this implies for the obtained results. Due to these points, I think mayor revisions are needed before this work is published. I provide the following comments and questions about the manuscript, which hopefully the authors will find useful.

Thank you for your feedback on our manuscript. Please find below our detailed responses to each of your comments.

Numerical model

Figure 1: *How were the inner/intermediate and outer region chosen? From the plot, it seems that they are not equally spaced relative to the river mouth.*

They were constructed by tracing perpendicular lines along the axis of the estuary. We modified the regions so they have approximately the same area all of them. Consequently all figures were recalculated.

Figure 2: *Why only show the wind roses of DJF and JJA? In the result section also the periods MAM and SON are considered and based on the results of Fig 6 it seems that the SON period has interesting wind characteristics. In addition, it would be good to not only show the wind but also the (average) Eulerian currents, as the particle distribution is strongly driven by this current. This would help with understanding the results.*

Thanks for your comment. We added the four wind roses into the text. As you may see, autumn and spring roses are an intermediate stage to winter and summer roses where the south western and north eastern winds are more pronounced. The 5-yrs mean currents roses were included into the Appendix section.

Is a homogenous beaching of 80% everywhere realistic? One would expect that the beaching is a function of the specific coastal features. I think the choices that went into setting this beaching parameter have to be part of the paper.

You are correct in this statement. The beaching probability helps us to consider different coastal areas where beach retention is different. In particular, in the MOHID-Lagrangian you can only set a percentage per simulation for the whole coastline, which is not fair either. But if you wanted to do a realistic retention study you would have to put together the results of different simulations. See Cloux et al. (2022) for other examples in the same region. However in this study we wanted to be sure that most of the particles reaching the coast are retained just to study their behavior, so we choose a high probability that they become beached. In other words, we work with the worst possible retention scenario to establish our relationships and statistics.

The effect of stokes drift is not separately included. Is the assumption here that this is captured by windage? How big is the effect of swell in this region? I feel this has to be discussed in the paper.

Within the estuarine, the effect of swell is really small, that's why we didn´t consider it in this paper. Please see the Wave Atlas elaborated by the regional meteorological office (MeteoGalicia) https://www.meteogalicia.gal/web/modelos-numericos/atlas-de-ondas for more details.

Why were windage factors of 1%, 3% and 5% chosen, and how realistic is this range compared to the windage of real buoyant plastics? I think the work would benefit from comparing these values by typical windage factors measured in experimental settings (for example for surface drifters) to show the relevance of this range.

Thanks for your comment. This is a good question and it always elucidate some discussion among oceanographers. In many papers people use a windage coefficient of 3%. For example, Irfan et al. (2024) used a coefficient proportional to the ratio between surfaces of the plastic above and beneath the sea surface. The coefficients were chosen to represent a variety of plastic debris of which transport was mostly governed either by wind (5%) or ocean surface currents (1%). The windage coefficient depends on the degree of particle exposure to air/water. As we wanted to observe the effect of wind on different plastic sizes we used different windage factors. A comment on that has been included into the text.

Why was the river input represented as a point quite far into the Ria, and not further back where the actual river mouth is located? Why were the particles not released over a line that spans the entire width of the estuary at the release point? With the current release point, there are coastal segments located behind the river input location, including segments 6 and 10. Which raises whether beaching of particles measured at these segments is realistic for plastic that originates from the river.

Thanks for the appreciation. As you know, the resolution of the hydrodynamic models is restricted and many times it is difficult to capture all the complexity of the orography. For the MOHID model, the mouth of the Ulla river is not well detailed, so we have to place our emission point a little further away. It is also necessary to make the emission points a bit farther away from the mesh points bordering the land, since the solution of the hydrodynamic field in these cells may not be entirely realistic and could push the particles towards regions outside the domain. Your suggestion of using an emission line that covers the entire mouth opening of the river is very interesting, but for our case, we believe that a point emission is the best approximation to a river, as we also did in Cloux et al. (2024).

I think the section on how particles were simulated should contain more information. Were particles simulated for a specific time (1 season/1 year) or were they simulated until they were beached or left the domain? And if particles were simulated for the entire 5 years, how does this *affect the analysis of the accumulation pattern done? As in the 5th year, the concentration of particles then will have increased.*

We have enhanced the description of how particles are released on the simulation.

Results

Figure 3: *the way the data is plotted makes it hard to compare, maybe a different color bar with more shades (like magma or viridis) and/or using a discrete colormap can help to see differences. In addition, it might be useful to plot the relative concentration change for the 5% relative to the 1% instead. It is not clear whether the concentration shown here is for particles that might be in a beach cell but are yet definitely beached? Or are particles that are permanently beached also considered?*

Thanks for your advice. We have modified this figure in the manuscript and clarified which particles we are considering for the representation.

You mention that the concentration of the northern part of the estuary is higher due to the Coriolis force. I think it would be better to say due to the currents/ or explain how the Coriolis force affects the currents in the estuary. For this it would be helpful to plot the Eulerian currents (and the seasonal variations therein if present) as well (see comment for fig 2). For plastics there can also be a direct Coriolis force working on the particle because of their inertia (see the Coriolis force in the Maxey-Riley equation for example on the work of Beron-Verra et al. 2019) thus the wording Coriolis force might be confusing.

The Coriolis effect plays an important role in how water enters and exits the Ría de Arousa (and other Galician rías). Surface outflow of river water is stronger on the northern margin which favors beaching there. We add some small comment on that in the paper.

How are the northern and southern regions defined? Are they right, resp. left compared as viewed from the river mouth in direction of the Ria? And is the Island then part of the northern or southern region? Or is it an actual north/south distribution, which seems a bit arbitrary as it does not align with the shape and orientation of the Ria? In general, the south has more area located further from the river mouth, thus that would automatically result in less beaching as particles already beached close to the river mouth cannot beach there.

We have described above how this division was made.

Figure 4 (and the discussion thereof in lines 120-128): *The discussion states that "during warmer months (MAM and JJA) beaching along the southern coast increases". However, the absolute value of particles beached decreases compared to the DFJ period as well for the south? Maybe of the total particles beached, the relative amount of particle beached in the south increases, but this is not a relevant quantity to highlight? Also, how does the number of beached particles relate to the total input for each period? I think this relative number would give more insight on if particles are more likely to beach in summer or winter or that there are just more particles released into the system in winter but beaching stays constant.*

Thanks for the comment. We have already enhanced this on the text.

Figure 5 and table 1 and discussion on the correlation: *Is the correlation the best quantity to measure? If you put a lot of particles in the system, you expect that a lot of particles beach a period T after you put them into the system. This period T will be a function of the total time a particle needs to reach the area. Thus, I do not think figure 5 is the most interesting figure to show. Also in table 1, it is expected that the time delay grows with distance and thus the direct correlation will become less. In addition, the regions selected are not suitable to reveal any non-trivial spatial pattern (especially as 6 and 10 are sort of located at/in the river mouth for the* *location of particle release here). I think a more useful quantity to study is the cross correlation and then measuring the time lag. Or since you do Lagrangian analysis you can calculate the age of the particle (i.e. how long ago they were released) at the point in time that they reach land/beach. This would be an analysis that can be done for all coastal segments, revealing if there are any patterns different from what you expect (further away from the river mouth the particles are older). You could consider normalizing the age with the distance from the coastal segment to the particle release location.*

Very interesting suggestion. We have calculated the time lags of all particles beaching at different locations. New figure 6 and Table 1 show these results. The distribution of time periods between emission and beaching are shown in the figure. They fit well to a Weibull distribution as expected since wind and surface currents drive particles. The most frequent time lags (mode of the distribution) are shown in Table 1 for different wind coefficients. As stated in the paper some interesting differences were observed in time lags even in between close locations.

Figure 6. *It seems that the inner, intermediate and outer regions are not equally spaced and/or of the same size. This would affect the results. I would expect that for the outer region there are particles that do not reenter the Ria and thus have a residence time of infinity. Or are particles removed from the simulation if they leave the simulation domain? Which is not similarly shaped to the inner and intermediate region set here. Are beached particles considered in the calculation of the residence time?*

For this calculation, we have taken into account particles that didn't strand. Then, for each region, we consider the time that each particle spends in each subregion. Indeed, as you mention, particles that leave the outer region are not considered anymore.

Conclusions

You state that wind also disperses particles more widely, but you do not show/highlight this in your result section.

This statement is related to figure 3 in which we show that larger windage means less accumulated particles in the inner zone of the river. This has already been pointed out in the results section, in the first paragraph.

Maybe highlight that the release location strongly affects the patterns of beaching in the Ria as your results are very different from Cloux et al. (2022) fig 4.

Thank you for this observation. We have commented out this in the new version of the paper. The release points, which in Cloux et al. (2022) were primarily along the entire Ria, are obviously a major factor for beaching. However, we also note the influence of release frequency as a major factor relating the link between the river flow rate and the beached particles.

There should be a discussion on the limitations of the model used here and how these might affect the results presented here.

You are right. We comment in the conclusions section some of the limitations of the model and future work to be done.

References

Cloux, S., Allen-Perkins, S., de Pablo, H., Garaboa-Paz, D., Montero, P. & Pérez-Muñuzuri, V. (2022), 'Validation of a lagrangian model for large-scale macroplastic tracer transport using mussel-peg in nw spain (ría de arousa)', Science of The Total Environment **822**, 153338.

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