Hernandez *et al.* Review

General comments

Hernandez *et al.* introduce a modelling framework (LOCATE) for simulating marine dispersal in coastal regions using nested hydrodynamic grids. The authors apply LOCATE to a nested model of the Barcelona coastline (forced by a regional CMEMS model), and compare trajectory forecasting skill and beaching behaviour between the (higher resolution) nested model and (lower resolution) regional model, as well as the sensitivity of beaching to three beaching parameterisations.

Although LOCATE has been used in previous studies, this manuscript represents a considerable effort to document, describe, and illustrate a potential application for the framework. This is a great example of 'open science', and the quality of figures is also very high. Unfortunately, in its current form, the manuscript suffers from a lack of purpose and clarity, and feels more like a detailed supplement to Castro-Rosero *et al.* (2023). If the main purpose of the manuscript is to facilitate the wider adoption of LOCATE, the manuscript should clearly explain the advantages of LOCATE over just using Parcels directly, since the nested grid capability of Parcels is already quite accessible (i.e. if I were to investigate dispersal across nested grids, it is not clear to me why I would use LOCATE rather than 'pure' Parcels). If the main purpose is to instead explore the utility of nested grids for particle tracking in coastal waters, more thorough validation is needed than comparison with a single drifter profile. I realise that there is limited observational data available given the small domain size (using drogued drifters may help), but many of the manuscript's claims about "model accuracy" are weakly supported by evidence, and the manuscript therefore provides limited insights into the (dis)advantages of using nested grids beyond "there are differences". I also have concerns about some aspects of the methods, and other aspects were very difficult for me to understand.

If the authors can address the general comments above, then I would recommend major revisions to the manuscript (please see the attached document for specific and technical comments).

First of all, we wish to thank the referee for their extensive review and comments which have raised some very valid points.

The purpose of LOCATE is to provide a system to facilitate the study of the dispersion of marine debris in small-scale coastal settings. To achieve this, the use of nested hydrodynamic grids with high-resolution data is applied, and although this could be done using Parcels alone as suggested by the referee, the main purpose of LOCATE's methodology is to do so in conjunction with an appropriate method for detecting when and where particles arrive on land with as much precision as possible from the hydrodynamic data available and often given the complex coastal geometry. Given that coastal areas can experience very high amounts of beaching, special emphasis has been placed on the detection of the beaching of particles. This is especially relevant for areas such as the Barcelona coastline described in this study characterized by a complex geometry with a major harbour and several marinas (Port Olimpic, Forum), groynes, breakwaters and so on. Barcelona experiences discharge of debris on the coastline from various sources, such as rivers or other discharge outlets commonly found in urbanised coastal areas where debris is transported and interacts with the described complex geometry.

A beaching module based on a distance-to-shore parameter that detects the pre-calculated real shoreline by using distance data within grids during the simulation is included in LOCATE, which could be adapted to other areas where high-resolution coastline data may be available. The beaching module developed within LOCATE allows for a precise determination of which areas can be more affected by particle beaching. The beaching module adapts to each computational grid. In small-scale studies, such as this one, such precision and highly granular information which can be determined in the post-simulation analysis when using the distance-based beaching module, is pertinent to being able to determine which areas, such as specific beaches or port structures, could be more at risk of receiving debris.

In the present work, it is shown that LOCATE's use of high-resolution hydrodynamic data that resolves coastal processes in conjunction with the distance-to-shore beaching module, allowed for substantially greater precision in terms of the measurements of where particles became beached. The reason for this is that by using these data together, complex geometric structures can be solved to a much greater extent than using the IBI-CMEMS grid alone where such structures are not taken into account or 'seen' due to the grid's coarse resolution. Furthermore, using the current velocity as a land detection parameter to determine when and where a particle becomes beached has been shown in this study to be insufficient and imprecise at localised scales, even if this has been widely used by other studies, albeit at much larger, even global scales.

The LOCATE model offers areas of functionality tailored towards use for coastal areas that would require substantial time investment and programming using Parcels from scratch. As mentioned above, the distance-to-shore beaching module can be used as a tool to determine where exactly particles become beached independently of hydrodynamic data resolution, while recreating real-life scenarios such as the continuous release of particles by a river or other discharge outlet can be easily achieved with relatively minor configurations. LOCATE can also be easily configured to track particle dispersion of one-off releases, such as runoff events, or even track drifters or tracers. Since there are high-resolution circulation data available throughout the Spanish coastline via the Spanish Port Authority (Puertos del Estado), LOCATE could be easily applied for similar studies in any of those areas with relative ease. Although Parcels is the engine behind the LOCATE model, it lacks the necessary considerations and requirements, which are included within LOCATE, to provide precise simulations of marine debris at localised coastal scales.

The concern about the model's accuracy is duly noted and in return, what we propose is that the model can be used for more precise measurements of particle beaching at localised settings. The abstract and conclusion have been edited to reflect this change. The model's validation has been extended with data on two more drifters that serve to increase the model's confidence to be used in coastal settings, where more consistent good skill scores were achieved when using the nested grids than using only the IBI-CMNEMS grid. However, the use of nested grids alone is not the sole focus of LOCATE as outlined above.

It is hoped that the concerns shown in the comments by the referee are addressed in the above statement and in the response to each of their points. Far from being a "detailed supplement" to other published works which have also used LOCATE to simulate the dispersion of particles, this work sets out to present a complete outline of the purpose and functionality available in LOCATE for use in coastal areas which may be affected by high amounts of beaching of debris.

With this in mind, the abstract (below), section 1.4 (objectives) and conclusion have been modified to reflect the points made above to offer greater clarity regarding the purpose of the study and the objectives. To avoid further confusion and add clarity the title has been shortened to:

LOCATE v1.0: Numerical Modelling of Floating Marine Debris Dispersion and Beaching in Coastal Regions Using Parcels v2.4.2

Specific comments

1. The abstract is long compared to the number of key messages from the paper. I would recommend condensing the abstract to make it easier for readers to identify the main points.
   - Reword abstract to:
     The transport mechanisms of floating marine debris in coastal zones remain poorly understood due to complex geometries and the influence of coastal processes, posing difficulties in incorporating them into Lagrangian numerical models. The numerical model LOCATE overcomes these challenges by coupling Eulerian hydrodynamic data at varying resolutions within nested grids using Parcels, a Lagrangian particle solver, to accurately simulate the motion of plastic particles where a high spatial coverage and resolution are required to resolve coastal processes. A particle beaching module was developed within LOCATE to address the detection of particles that cross the land-water boundary at coastal scales, using the pre-calculated distance of particles to the shoreline using high-resolution shoreline data during the simulation. This module displayed the highest precision of spatiotemporal beaching patterns relative to the real shoreline when compared to land detection mechanisms using solely hydrodynamic data in a beaching sensitivity analysis. Nested grids performed better than a coarse-resolution grid when analysing the model's dispersion skill by comparing drifter data and simulated trajectories. Another hydrodynamic grid configuration comparison applied the same observational debris discharge data as simulation input from two rivers around the Barcelona coastline, and the distance-based beaching module. High variability of beaching amounts between corresponding demarcated coastal areas was observed between simulations suggesting variations were influenced by coastal processes being resolved when using nested grids, with overall beaching levels >92% in each simulation. The model's ability to resolve complex coastal geometrical structures using nested grids was also demonstrated based on the particle residence times in areas of intricate shoreline configuration that were otherwise undetectable using the coarse-resolution grid. LOCATE can effectively integrate high-resolution hydrodynamic data within nested grids to model the dispersion of particles at coastal scales and represent deposition patterns with greater precision of particle beaching locations using high-resolution shoreline data.

2. Section 1.2 covers the dynamics of beaching debris in great detail, but most is of little relevance to the paper (since most of these dynamics are not investigated). I would recommend condensing.
   - Lines 55 -60 has been removed altogether and the remaining paragraph on beaching can then be integrated into the previous section
3. Section 1.4 begins by stating that the "goal of the present work is to simulate particles taking into account coastal processes using nested hydrodynamic grids at varying resolutions". I

would argue that this is the *method*, not the *goal*. As stated in the general comments, I would recommend clarifying what the actual goal of the paper is.

- Change lines 88-89 to:

  The current study aims to present the functionality of a nested grid approach using high-resolution hydrodynamic data in conjunction with a particle beaching module that uses a distance-to-shore-based detection of the real shoreline, can resolve coastal processes and complex geometric structures at localised scales to better represent particle deposition patterns, accumulation and hot spots.

4. Section 2.2: What is the frequency of the Eulerian model output used in LOCATE? Line 159 states that "data are calculated daily" – daily strikes me as very low compared to the timescales over which currents resolved by a 2.5 km model (and certainly 350/70 m) change.

- Modified the sentence on line 159 to:

  Coastal and harbour grids use the numerical model based on the Regional Ocean Modelling System (ROMS) (ROMS 2022, Shchepetkin, 2005). Coastal simulations with an hourly data frequency that use data from metocean operational products are nested into the IBI-CMEMS forecast solution using the SAMOA system (Alvarez-Fanjul, et al., 2018, Garcia-Leon et al., 2022, Sotillo, et al., 2015).

5. I cannot see any reference to tides in the manuscript outside of the introduction. Were tides not included in these simulations and, if not, why?

- The Barcelona coastline is microtidal so tides are not considered, this has been added to the manuscript.

6. Section 2.3: Why was model output interpolated to a 'regular' grid (presumably A-grid)? As described in the OceanParcels documentation[1], A-grids introduce interpolation problems whereby particles get artificially stuck at the model coastline, because both velocity components approach zero at the coastline (i.e. particles will always stagnate at the coastline of an A-grid, regardless of the strength of any along-shore currents). Particularly given the focus of this manuscript on beaching, I am concerned about the potential for beaching to occur due to interpolation artefacts, rather than any physical reason. The authors could consider using the original C-grids instead, or the free-slip boundary condition that was recently implemented in Parcels[2].

- This was a mistake on my part, and I apologise for the confusion. Line 181 can be changed to:

  "Circulation data as numerical simulations available from PdE through the OPeNDAP server were provided in A-grids. Although the IBI-CMEMS grid also had an A-grid configuration, further configuration was necessary due to the coastal and harbour grids being oriented towards the coastline, having areas which contained no data. To overcome this, an interpolation between the three grids that filled out empty values in the grids with higher resolution with the equivalent spatiotemporal data from the lower resolution grids in these points was carried out using the

[1] https://docs.oceanparcels.org/en/latest/examples/documentation_stuck_particles.html

[2] https://docs.oceanparcels.org/en/latest/examples/documentation_unstuck_Agrid.html#3.-Slip-boundaryconditions

UPC_resample_datasets script. The result of this interpolation can be seen in Fig.2a.”

The interpolation from a C-grid to an A-grid configuration happens before the data is served by the OPeNDAP server. Therefore, the data available from the Spanish port authority (PdE) through the OPeNDAP server is not available in C-grid configuration. However, using nested regular grids does make applying them in Parcels a lot easier. At UPC we also perform Hydrodynamic numerical simulations and we indeed collaborate with Puetos del Estado to optimize the OPeNDAP data information therefore we are able to perform simulations with C-grid. However, such simulations are performed in large computing machines and are not accessible to everyone. Therefore, we have decided to keep the model accessible through the use of OPeNDAP.

Regarding difficulties with A-grids such as particles becoming stuck, the particles are deleted from the simulation when it is determined that they reach land, which is one of the solutions outlined in the Parcels document provided to prevent this. In fact, the beaching parameters take full advantage of this functionality, as well as when particles are exported so they do not become ‘stuck’ on the grid boundary. The deleting of particles is described in line 260. The following line has been added to the end of section 2.3:
“Artificial stagnation of particles on the coastline, which can be a concern when using A-grids was circumvented by deleting the particles on crossing a predetermined land-water boundary as described in section 2.6.”

7. Section 2.5: Given that LOCATE uses a constant value for K, most of the detail in lines 233-243 is unnecessary and should be removed. I am also confused by the choice of a constant value for K (10 m^2 s^{-1}). Should this not be scale-dependent? Okubo (1971) would suggest that a value of 10 m^2 s^{-1} would be appropriate to reproduce the effects of unresolved scales of motion at a resolution of around 10 km, much coarser than the resolution used in this study.
    - Similar studies using similar resolution scales use a Kh value of $10m^2s^{-1}$ mentioned in Okubo 1971:
      Onink, V., Jongedijk, C. E., Hoffman, M. J., van Sebille, E., & Laufkötter, C. (2021). Global simulations of marine plastic transport show plastic trapping in coastal zones. *Environmental Research Letters*, *16*(6). https://doi.org/10.1088/1748-9326/abecbd

      Onink, V., Kaandorp, M. L. A., Van Sebille, E., & Laufkötter, C. (2022). Influence of Particle Size and Fragmentation on Large-Scale Microplastic Transport in the Mediterranean Sea. *Environmental Science and Technology*, *56*(22), 15528–15540. https://doi.org/10.1021/acs.est.2c03363

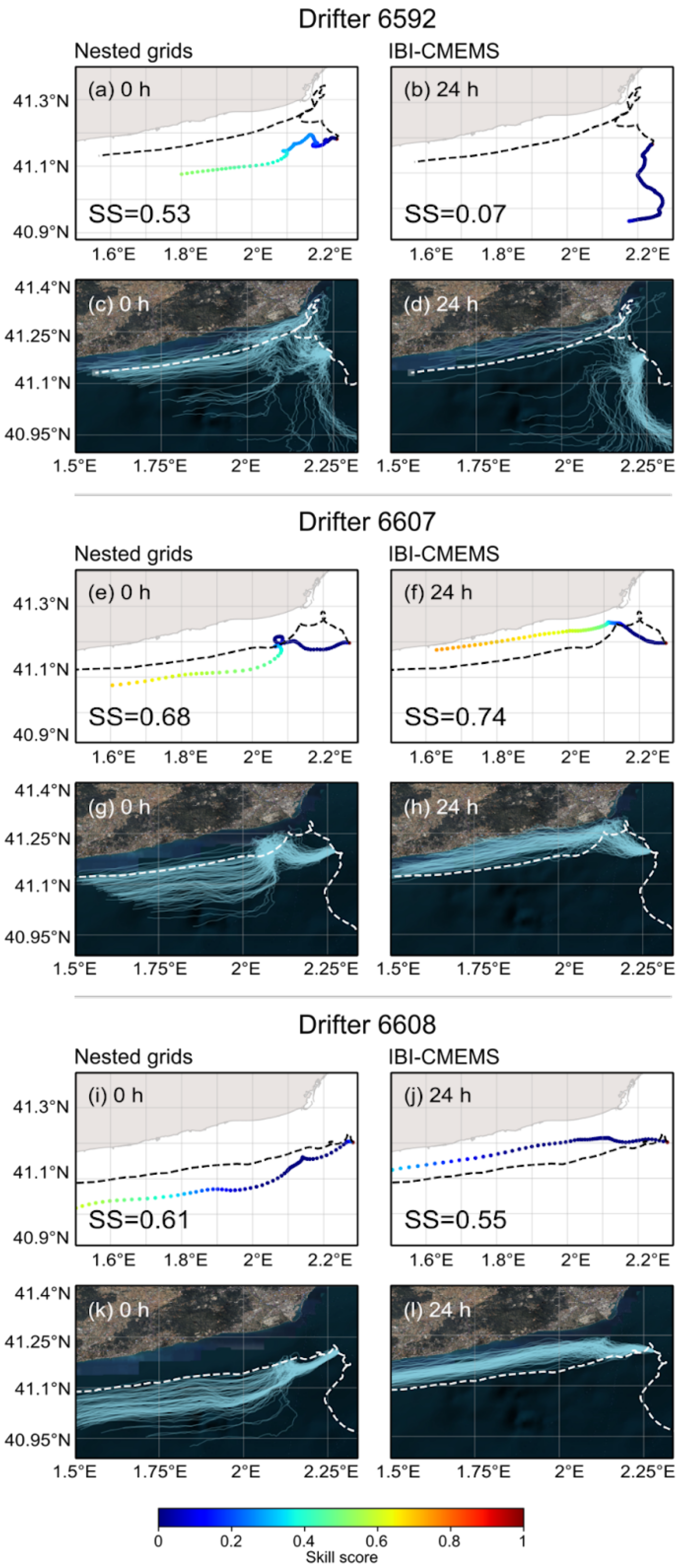
      Citing the Okubo 1971 paper and using $10m^2s^{-1}$
      Liubartseva, S., Coppini, G., Lecci, R., & Clementi, E. (2018). Tracking plastics in the Mediterranean: 2D Lagrangian model. Marine Pollution Bulletin, 129(1), 151–162. https://doi.org/10.1016/j.marpolbul.2018.02.019

Under the section of "Dispersal model"
Lacerda, A. L., Rodrigues, L. D., Van Sebille, E., Rodrigues, F. L., Ribeiro, L., Secchi, E. R., Kessler, F., & Proietti, M. C. (2019). Plastics in sea surface waters around the Antarctic Peninsula. *Scientific Reports*, *9*(1), 1-12. https://doi.org/10.1038/s41598-019-40311-4

Since this is used in studies that use either the same or similar resolution to the IBI-CMEMS grid we see no reason to use a different value, especially since there are no data on diffusivity values in this region. Values $5m^2s^{-1}$ to $10m^2s^{-1}$ were not found to materially affect where particles end up in preliminary simulations. The paper for Okubo 1971 will be cited accordingly.

8. Section 2.7: I am surprised by the decision to use undrogued drifters. Drifters lacking a drogue experience a significant direct push from the wind due to the exposed part of the drifter (Poulain et al., 2009), which is not included in LOCATE. Although the authors' concern about velocity shear within the upper water column is valid, there is some evidence that surface currents reasonably represent the forces driving drogued drifter movement (Imzilen et al., 2023). Using drogued drifters may also increase the number of drifters available to the authors for use in validation.
   - In Parcels virtual particles by default do not have size, shape or buoyancy defined, which for these simulations is not an issue since the particles are assumed to be floating just beneath the surface. This is mentioned in line 518 as to why wind drag data is not included. Stokes drift data is considered with the IBI-WAV data, which has been shown to have a considerable effect on drifter trajectories, especially over large distances. Moreover, laboratory experiments have shown that floating particles move with Stokes drift velocity unaffected by particle size and density (Alsina, et al 2020).
   - Even though in the article it is mentioned that only drogueless drifters are used, this term was imprecise and will be changed to "drifters with drogues < 1 m" which includes CODE drifters used in this study. The decision to use this limitation on the drifter drogue depth was made to take Stokes drift into consideration.
     Thus, line 266 has been changed to:
     "Drifter data were selected on the condition of having drogues < 1 m to assess only the influence of surface currents, including Stokes drift, as it is assumed more realistic for a floating particle."
   - In the provided article by Imzilen et al 2023 they hypothesided that the impact of Stokes drift on dFAD trajectories would be minor given their considerable subsurface structure and transport patterns that closely resemble those of drogued drifters. In our case we are considering virtual particles just beneath the surface as a proxy for floating macrolitter, thus using data from drifters with drogues of typically 15 m would not have provided with an appropriate comparison given that Stokes drift is reduced at that depth, and we do include Stokes drift data on the simulations.
9. Section 2.7: I am uncomfortable with the use of the word "validation" for the comparison with a single drifter. Is this really enough data to count as validation?
   - There were data for 2 other drifters that were not included in the article because even though their trajectories did cross the area where the high-resolution grids apply, they crossed the area where the coastal grid applied (resolution of 350 m) but

not where the harbour grid applied (resolution 70 m). The drifter that was featured, however, did benefit from crossing all grids. We hope that having the trajectories of 3 drifters is sufficient for a preliminary work while addressing the need for more data (as mentioned in the discussion). The data for the other 2 drifters and their skill scores have been included in the following figure:



- Line 269 has been changed to:

  "Validation simulations were conducted for the available drifters. CODE drifter 6592, deployed in February 2022 was chosen as the most suitable because its trajectory crossed the coastal and harbour grids for a period long enough to analyse the skill of the model to forecast the trajectory 6, 24, or 72 h ahead, compared as a function of when the forecast started. CODE drifters 6607 and 6608 only crossed the coastal domain and were released within a minute of each other in March 2022."

- Line paragraph from 274 in the method has been changed to:

  "For drifter 6592, simulations were conducted from the point where the trajectory transected the coastal grid boundary, at coordinates 41.18162°N and 2.24084°E. The provided data did not include timestamps, only a deployed and end date, so the drifter trajectory was temporally interpolated to provide hourly data points where 100 particles were released at every step. Particles were released between the period 9 March 2022 18:11:00 to 14 March 2022 18:11:00. The number of particles was determined through a sensitivity analysis of the standard deviation using varying amounts of particles (Castro-Rosero et al.,2023). Simulations for drifter 6607 were conducted at coordinates 41.19657°N and 2.27386°E from the period 11 March 2022 09:14:00 to 14 March 2022 22:14:00, and for drifter 6608 from coordinates 41.20218°N and 2.28279°E from the period 12 March 2022 07:13:00 to 15 March 2022 09:13:00. The same simulations were conducted using nested grids and using the IBI-CMEMS grid only."
- Added this paragraph after line 383 in Results:

  "As seen in Fig.(plot above), the SS of drifter 6652 was much better when using the nested grids than only the IBI-CMEMS grid (SS=0.53 compared to SS=0.07). For drifter 6608 the IBI-CMEMS grid performed slightly better (SS=0.74 compared with SS=0.68). Qualitatively, it can be observed that the particle trajectories using the IBI-CMEMS grid were being displaced towards the coastline with substantial beaching of particles, while the particle trajectories with the nested grids moved further out to sea, with the real drifter trajectories somewhat in the middle. In both cases, the difference in SS is only 0.06 which can be taken as being minimal."
- Lines 441 to 449 in the discussion has been changed to:

  "This is indicative of the challenges associated with predicting trajectories close to the shoreline influenced by coastal processes, amplified by the strong influence of the alongshore northern current as seen south of the Barcelona city area in Fig.6g to Fig.6j and in the trajectories in Fig 7 (above plot). There is a notable difference in how the different grids performed during the dates of the simulation, with the IBI-CMEMS grid showing the northern current much closer to the coastline than the higher-resolution grids, with a greater probability for beaching as seen for drifter 6607 (Fig.7(h)). The consistently good and generally better SS values of the simulated drifter trajectories when using the nested grids compared to more variable results when using the IBI-CMEMS grid, demonstrate that the model can be effectively validated with the nested grids producing generally more favourable results. Drawing direct comparisons between nested grids and the IBI-CMEMS grid using the SS test, however, is challenging. Within a single trajectory, the influence and contribution of each grid as a particle moves across different domains cannot be isolated due to the cumulative nature of the test, even if it is possible to numerically determine which grid has provided the hydrodynamic data for that time-step. Additionally, an area of future work would be to address the paucity of available and suitable drifter information at coastal scales where high-resolution hydrodynamic data may apply, to increase the statistical robustness of additional validation analyses."

10. Section 2.7: How were drifter trajectories temporally interpolated if there are no timestamps associated with locations?

    - A linear interpolation was the most prudent way to do this. Changed line 275 to:
      "The provided data did not include timestamps, only a deployed and end date. It was assumed, however, that the drifter was fully operational and recording data at regular intervals, thus a reconstructed trajectory using the coordinates and the number of data points available were linearly interpolated to provide hourly data points, from which 100 particles were released at every step."

11. Section 2.8: I cannot find a precise definition for the residence time in this manuscript – please clarify how this was calculated.

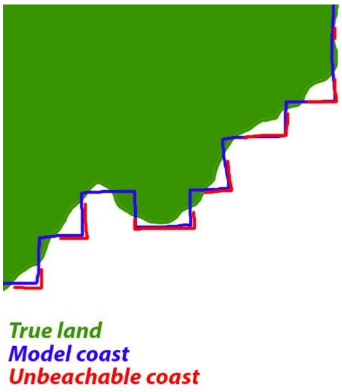
    - Added the definition to line 27:
      "(the time it spends in a region of interest)"

12. Section 2.8: Since the manuscript does not investigate or validate the temporal variability of debris accumulation, I do not see the point of varying the input rate of debris.

    - Since observational data were available from the Schirinzi et al 2020 article, the decision was made to use a real-life scenario to test LOCATE's capabilities for simulating the beaching of particles on a real shoreline based on the distance to shore beaching parameter, and test high-resolution data to solve complex geometric structures in the study domain. The analysis of the main simulation in this article using nested grids comparing to hydrodynamic conditions and beach cleanup data is being prepared for another publication. Including that side of the analysis would have been too much and taken away from the focus of this work.

13. Section 2.9: If I understand correctly that scenario 2 defines the distance-to-shore relative to the true (rather than model) coastline, would this not make it impossible for debris to beach in many places? There are presumably parts of the model grid where ocean cells do not quite reach the true coastline (see below), so it is never possible for the distance-to-shore parameter to reach zero here, and therefore also impossible for particles to beach? In any case, I do not understand the point of using the real coastline in a beaching parameterisation – particles within the simulation do not 'know' anything about the real

coastline, they only ‘know’ about the model coastline.



- While it is true that there are some cells with no data as seen in Fig.2, the interpolation performed by Parcels with land data (zero values) means that these cells will have interpolated velocity data. This can be seen in the beaching patterns in Fig 7b when all the beaching occurs on land cells not at sea cells.
- The point of using the real shoreline with a distance-to-shore beaching parameter was to avoid such beaching patterns that could make identifying exactly when a particle crosses the land-water boundary impossible at small scales such as this study. Given that all cells around the shore have velocity data given by the grids or by interpolation with zero-value adjacent land cells, having the beaching parameter set to “when the distance to the shoreline is less than zero” gives a much better indication of where exactly a particle crosses the boundary than simply using the current velocity as a land detector, especially where the resolution of the IBI-CMEMS grid applies, which is 2.5 km per cell. Therefore, particles do ‘know’ where the real coastline is because this distance-to-shore data is used in the simulation as nested distance grids in a Fieldset. together with the hydrodynamic grids in another Fieldset while conducting the simulation. This is explained in the paragraph in line 336.
- Clarified in line 336 to:
  “Given that kernels in Parcels are limited to basic arithmetic operations and conditions, Parcel’s interpolation capabilities were utilised to calculate the real-time minimum distance between particle and shoreline for scenarios 2 and 3 with distance data available in a fieldset, so that particles can effectively detect the real shoreline given a beaching parameter.”
- Changed line 536 to:
  “The beaching pattern in Figure 7b shows that there are no areas around the coastline that are left uncovered by data, and that beaching always occurs on land. Even if some cells around the coastline do not have velocity data as seen in Fig. 2, Parcels’ interpolation capabilities use the zero velocity values from adjacent land cells to interpolate velocities of shoreline cells without velocity data.”

14. Section 2.9: I do not understand scenario 3. Lines 533-535 makes it sound like particles beached if they travelled less than 1.694 km in 6 hours, but I am not sure if this is correct.
- That is correct. While the scenario may not seem realistic, it is a scenario created to reflect the time dependency of some beaching parameters used in other studies,

whether deterministic or probabilistic. This scenario assumes that all particles become beached eventually if they get close enough to land for a minimum amount of time.

15. Section 3.1: I did not understand this section (particularly what was meant by 'horizons') until I read Révelard et al., (2021). Please clarify (probably in the methods) the methods, i.e. comparing the skill of the model to *forecast* the trajectory of a drifter 6/24/72 h ahead, as a function of when the forecast started.
    - Mentioned in point 9 as an amendment to line 269

16. Figure 6: How is the 'mean trajectory' defined? Is this just the arithmetic mean of all latitudes and longitudes at a point in time?
    - That is correct.

17. Figure 7: Please use a divergent colourmap for these figures, centred at 0. The use of a sequential colourmap makes it very difficult to tell which particles are close to the coastline, versus which have over/undershot.
    - Understood and agree, the figure has been modified to this effect.

18. Section 3.2: Please specify which beaching scenario was used for Figure 9 and lines 403-418.
    - Scenario 2 was used for all simulations after the beaching sensitivity analysis and was used for the results in Fig.8 and Fig.9. The use of beaching scenario 2 will be mentioned in lines 395 and 403.

19. Figure 8: The left and right panels do not seem to correspond in this figure. For example, lots of blue particles appear in the far SW corner on May 31 (left), but not in the panel on the right.
    - The images do correspond even if the patterns may differ slightly. This is because the plots on the right are heatmaps of particle concentrations (num of particles/km^2) and while there may be particles showing blue dots on the left side plots, the concentrations may be low and not be enough to show on the heatmaps. That is why both plots were shown for comparison.

20. Section 4.1: Is it not surprising that the regional grid did not perform considerably worse than the nested grid? This is one of the most interesting observations in the manuscript for me (that the regional grid often had similar performance to the nested grid), and seems to somewhat contradict the manuscript's conclusion that using nested grid improves the accuracy of predictions (although there is insufficient validation in the manuscript to be sure).

- Agreed, it is not surprising that the regional grid does not perform considerably worse than using the nested grids, as outlined in line 158, "Coastal and harbour grids use the numerical model based on the Regional Ocean Modelling System (ROMS) and data are calculated daily using coastal simulations using data from metocean operational products nested into the IBI-CMEMS forecast solution using the SAMOA system… "
- However, it seems that the focus is slightly misunderstood and for that, the abstract has been edited. This study looks at the performance of IBI-CMEMS/nested grids with regard to beaching as well as forecasting trajectories. The validation using 3 drifter buoys showed somewhat better results using the nested grids. What we argue is that using IBI-CMEMS alone at small scales does not solve complex geometric

structures, and thus cannot provide accurate beaching accumulation hot spots. Complex structures are missed completely, as seen in Fig.9 where the port area registers particle residence times 18 times less than when using high-resolution data. The accuracy of the predictions is in the context of where beaching occurs at small scales aided by the high-resolution data that considers the complex geometry of the coastline. This is mentioned in line 480:

"Solely relying on large-scale, low-resolution grids such as IBI-CMEMS is insufficient for coastal-scale simulations, although some limitations exist in the high-resolution hydrodynamic data utilised in this study"

21. Section 4.2: Line 540 states that, under scenario 1, particles can travel "several kilometres inland before being considered beached". Along similar lines to my comment on Section 2.9, does this really matter? Is it really a problem that beaching locations are 'wrong' by a few kilometres in a model with a resolution of a few kilometres?
    - It does matter very much at local and coastal scales, which is precisely the problem that this study aims to highlight. This study is localised around the Barcelona coastline and therefore having a model that predicts that debris becomes beached several kilometres inland renders it useless in knowing which beaches in or around the city, would be more affected by debris being released by the surrounding rivers after a rainfall event. This could have management implications for how/when cleanups are conducted. This is a small-scale study which differs from the global scale or Mediterranean scale studies of a similar nature done so far. Hence, why the distance-to-shore beaching module was developed.

22. Section 5: The manuscript does not validate any beaching predictions, so there is no data to support the claim that "using real-time particle distance to the shoreline… can accurately model particle arriving time and beaching locations". Similarly, no data has been presented to support the claim that "LOCATE… provides accurate depictions of accumulation zones and debris hot-spots…", at least not in this manuscript.
    - The results show how complex structures are completely missed when only using the IBI-CMEMS grid, as described in point 21. Therefore, using the distance-to-shore beaching module and high-resolution hydrodynamic data can give greater confidence in the accuracy of the particle beaching locations when these data are applied. This point is made in the edited conclusion.

23. Table A1: This table may not set out to be exhaustive but, in case of interest (as this is quite a nice compilation of beaching parameterisations that could be useful for others), some other studies using 'deterministic' parameterisations include Bosi et al., 2021; Cardoso & Caldeira, 2021; Critchell & Lambrechts, 2016; Dobler et al., 2019; Seo & Park, 2020; Zhang et al., 2020. Some other studies using 'probabilistic' parameterisations include Kaandorp et al., 2023; van der Mheen et al., 2020; Vogt-Vincent et al., 2023.
    - Thank you - these have been added to table A1.

24. Did the authors observe any artefacts in particle concentrations along the nested domain boundaries? There are quite striking discontinuities in surface velocity along domain boundaries in Figure 2, and it would be interesting to know whether this causes any artificial particle convergence/divergence at these boundaries.

- Yes, there were instances where particles would converge at some places around the coastal and IBI-CMEMS boundary because of cells where the current velocity was especially slow at that moment in time. The particles would be kept drifting until velocity data in the cell at another moment in time would allow it to move along since they did not cross the land/water boundary. Any artificial convergence was temporary and sporadic. This was a limitation of the hydrodynamic data provided, thus out of our control. However, any effect this could have had on the residence times could be taken as minimal and would not have affected the areas of interest which was where the high-resolution data applied.

Technical comments/corrections

1. Lines 29-31: The number of references for the physics of marine dispersal is excessive in my view. I would recommend condensing, e.g. just using van Sebille et al., (2020).
   - Understood, changed as advised above.
2. Lines 31-33: It is not clear to me why this sentence is relevant. Lines 31-36 could be removed for brevity.
   - Understood. Both sentences were removed.
3. Line 40: This is a very specific range (50-600 m). Where is this range from?
   - This range is observed in the Catalan coastline, with the outer value of the range applying during stormy conditions. However, the range itself can be removed.
4. Line 42: Are density gradients really a *driver* of coastal currents (is the driver not the process that generated the density gradients in the first place, e.g. upwelling/downwelling)?
   - True, modified.
5. Line 45: The referenced paper by Stokes was published in 1880, not 2009!
   - Agreed, this has been changed. I quoted the print publication by Cambridge University Press which is the available version with the DOI, not the original date.
6. Line 70: Would recommend changing “high spatial discretisation” to “fine spatial discretisation”.
   - Thank you. Modified.
7. Line 82: I do not follow how this relationship is exponential. Computational costs should scale broadly linearly with the area modelled, and a polynomial (not exponential) relationship with the model resolution.
   - Removed the word exponentially altogether.
8. Lines 160-161: Please separate the references for ROMS, IBI-CMEMS, and SAMOA.
   - Done.
9. Line 172: Typo (‘downlaod’)
   - Thank you, done.
10. Line 174-178: I would recommend giving the resolution of the wave model here (I assume 1/20 degree, based on line 494).
    - Thank you, done. It is 1/20º
11. Line 198: It is not clear what is meant by “typical stochasticity”. I assume the authors meant subgrid scale diffusion.
    - Done.

12. Line 242-243: Citing OPeNDAP is unnecessary here (the text is describing the data itself, not OPeNDAP).

- Done

13. Line 246: Please state or cite where the value (1/3) for the variance of the random process comes from.

- The figure of ⅓ for the variance of random uniform probability distribution can be found in a number of studies:
  Table 1 on:
  Scutt Phillips, J., Sen Gupta, A., Senina, I., van Sebille, E., Lange, M., Lehodey, P., Hampton, J., & Nicol, S. (2018). An individual-based model of skipjack tuna (Katsuwonus pelamis) movement in the tropical Pacific ocean. *Progress in Oceanography*, *164*(February), 63–74. https://doi.org/10.1016/j.pocean.2018.04.007

  Equation 1 on:
  Ross, O. N., & Sharples, J. (2004). Recipe for 1-D Lagrangian particle tracking models in space-varying diffusivity. *Limnology and Oceanography: Methods*, *2*(9), 289–302. https://doi.org/10.4319/lom.2004.2.289

  Also in a more recent paper in Section 2.2, equation 1:
  Onink, V., Kaandorp, M. L. A., Van Sebille, E., & Laufkötter, C. (2022). Influence of Particle Size and Fragmentation on Large-Scale Microplastic Transport in the Mediterranean Sea. *Environmental Science and Technology*, *56*(22), 15528–15540. https://doi.org/10.1021/acs.est.2c03363

  Equation 1 in:
  Onink, V., Jongedijk, C. E., Hoffman, M. J., van Sebille, E., & Laufkötter, C. (2021). Global simulations of marine plastic transport show plastic trapping in coastal zones. *Environmental Research Letters*, *16*(6). https://doi.org/10.1088/1748-9326/abecbd

  Also, equation 2 in:
  Castro-Rosero, L. M., Hernandez, I., Alsina, J. M., & Espino, M. (2023). Transport and accumulation of floating marine litter in the Black Sea: insights from numerical modeling. *Frontiers in Marine Science*, *10*(August), 1–19. https://doi.org/10.3389/fmars.2023.1213333

14. Table 3: It is a bit confusing using the same numbering for sensitivity test and beaching scenario. It may be clearer to remove the sensitivity test numbering, and change sensitivity test 1 to test 1R (beaching scenario 1, river release), test 2 to 2R, test 4 to 1H, etc.

- Understood, done.

15. Figure 6 caption, last line: I assume "(f) to (j) should be "(h) to (l)".

- Yes, apologies for the oversight.

16. Lines 365-402: This paragraph is unrelated to beaching, so should not be in section 3.2.

- Agreed. This was an oversight with the positioning of the figures etc. A subsection heading was created for lines 395 onwards
  3.3 Simulations of river release particles

17. Line 404-405: This line implies that no particles were retained (at sea, unbeached). Is this correct?

   - That is correct. By the end of the simulation, all particles had either become beached or were exported from the domain.

18. Line 406-408: Although it is possible to work this out from context, please specify that "The Prat de Llobregat area *had* 12.7% more particles…" means that 12.7% more particles *beached*. This sentence also makes it sound like these are relative percentages, whereas based on Figure 9 it looks like these are absolute percentages.

   - Rephrased line 408 to:
     "The Prat de Llobregat area received 12.7% more beached particles with the IBI-CMEMS simulation (24.0% with the IBI-CMEMS grid compared to 11.3% with nested grids), whereas the Llobregat River mouth showed 8.7% more beached particles with the nested grid simulation (43.5% with nested grids compared to 34.8% with the IBI-CMEMS grid)."

19. Line 431: Typo ("harbourss")

   - Thank you. Done

20. Lines 439-441: Please state for which configuration the SS value was higher (presumably the nested grid).

   - Correct, it was the nested grids. Clarified.

21. Line 483: I would recommend replacing "wave-induced currents" with "wave-induced Eulerian (mean) currents". The Stokes drift is not a current, but some readers might be confused.

   - Thanks, done.

22. Line 520: Please specify that "both simulations" refers to the regional vs nested grids.

   - That is correct, done.

23. Lines 570-571: The manuscript does not discuss the difference in computational cost between the regional and nested configurations, so I would recommend removing this sentence (or quantifying the difference in computational cost, and moving this to the discussion).

   - Agree, removed. What was meant was that using the distance-based grid for the distance-to-shore calculation did not noticeably affect the simulation time.

24. The labels "IBI-CMEMS" and "regional grid" are used interchangeably in this manuscript, which can get confusing. I would stick to one of them.

   - Agree, the nomenclature has been standardised.

References

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