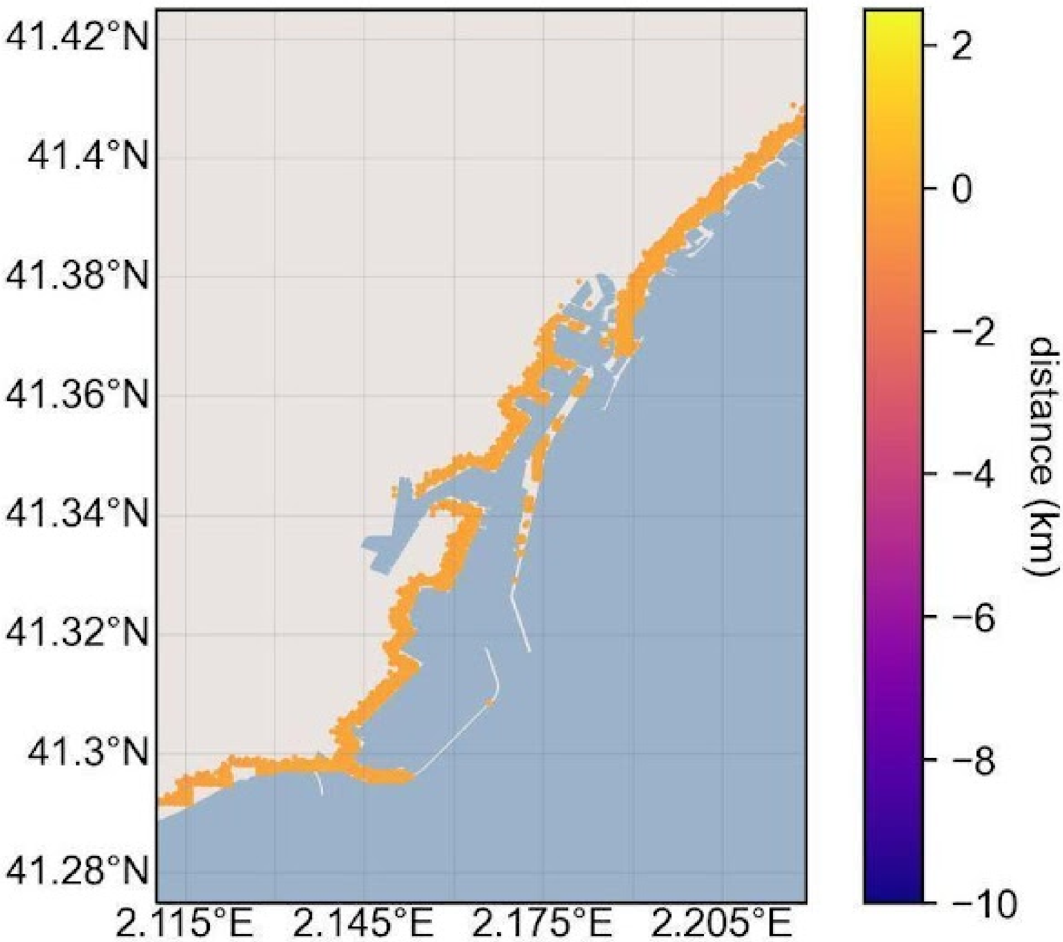
I thank the authors for their detailed response to my review. The purpose of the manuscript is now clearer to me, and I agree with the authors that a well-documented and transferable modelling system including beaching would be a useful contribution to the modelling community. This resolves one of my major concerns about the manuscript. I agree with most of the authors' responses to most other points raised in my review, and look forward to reading the revised manuscript.

However, I am writing this pre-emptive comment as a few points in my review may not have been made clearly enough, and I would like to clarify a couple of (significant) remaining concerns before the manuscript is revised.

Most importantly, I am still not convinced by the manuscript's claim that beaching scenario 2 is an improvement over beaching scenario 1. This is implied at several points in the manuscript, and is stated explicitly in lines 551-559. The only justification for this claim appears to be Figure 7, based on the beaching locations in scenario 2 conforming best with the real coastline (which is obvious, because scenario 2, by definition, only allows beaching at the real coastline – this outcome is predetermined). However, the purpose of this model is presumably not to produce something that *looks* realistic, but rather something that has skillful and useful predictive capacity (e.g. predicting accumulation hotspots). Predicting that beaching occurs at the real coastline is not useful, since we already know that.

- The main is purpose is not to predict that beaching occurs at the coastline, but to predict where beaching occurs along the coastline with greater certainty and precision. For example, using the real coastline we can determine which beaches around the Barcelona coastline experience greater amounts of particle beaching after discharges from a heavy rainfall event. If we used the coastline as per the hydrodynamic grids, even with a maximum resolution of 70 m, it would be difficult to determine where exactly beaching is more likely to occur, let alone with coarser resolutions. Using the distance-to-shore data, small-scale geometric structures are considered especially if they are in an area where high-resolution hydrodynamic data is being used. Using these data can produce results which are of more practical use at small and localised scales, such as the present study.

- Below is a closeup plot of how the hydrodynamic grids sees the Barcelona city area with Scenario 1 (detection using hydrodynamics). The port grid data (resolution of 70 m) applies to most of this image except the bottom left corner below 41.3N where the coastal grid data applies (resolution of 350 m). Even though the coastal grid is still high resolution, the beaching pattern is quite jagged. Where the port grid applies a lot of the structures such as piers and groynes and even areas within the port itself are missed out. Please see the image below in a closeup of the beaches to the north see this point in more detail



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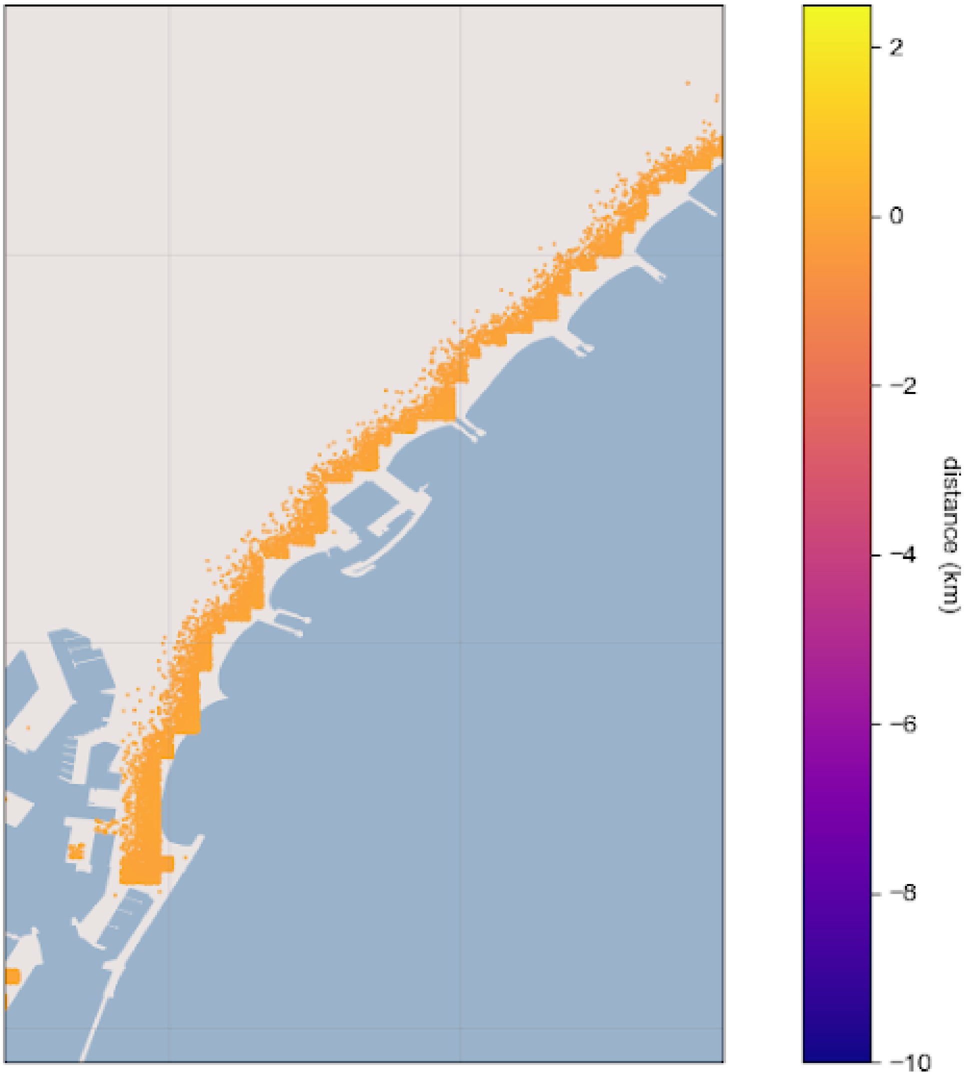
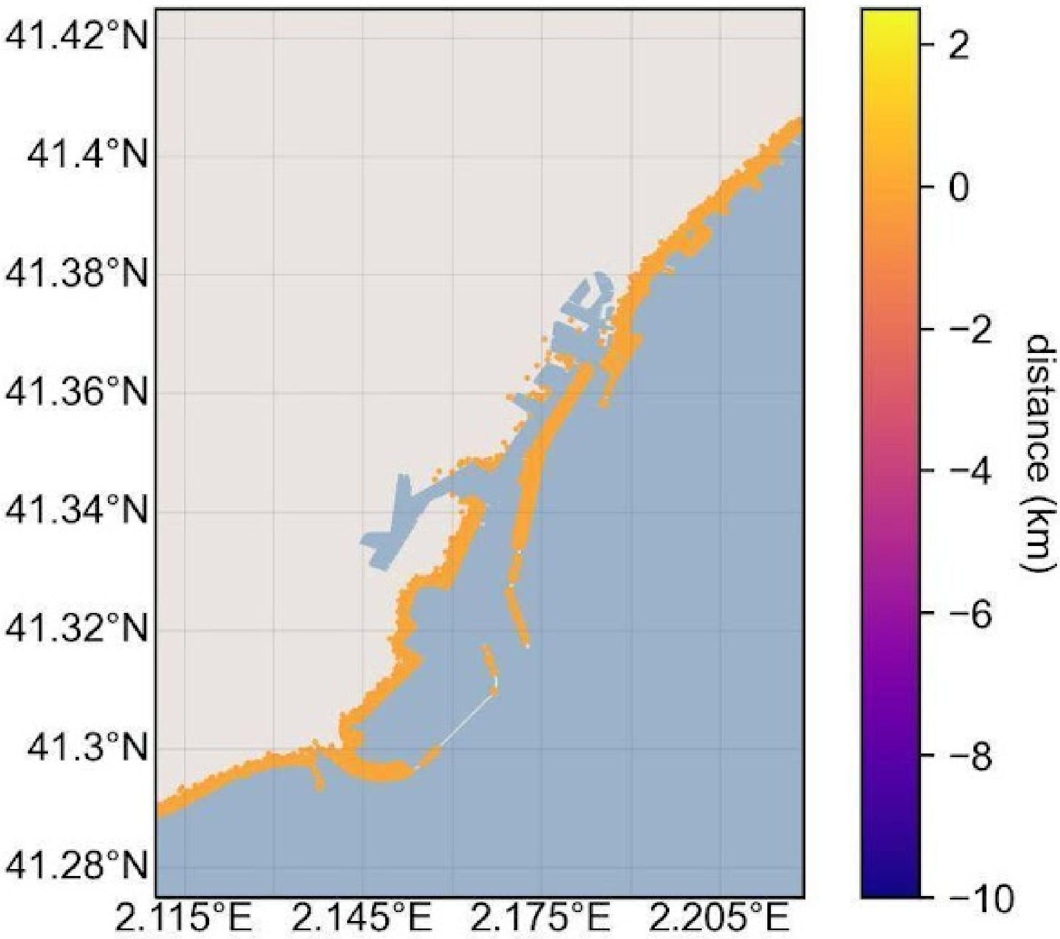
- This is a closeup from the image above of the area above 41.36N, with a closeup view of the Barcelona beaches using the hydrodynamic grids as detection where the highest resolution hydrodynamic data applies. Structures, individual zones or beaches are difficult to distinguish or not at all.



- Below is the same area using the distance-to-shore parameter. The coastline, including port structures, beaching patterns are much more closely matched in terms of the real coastline.



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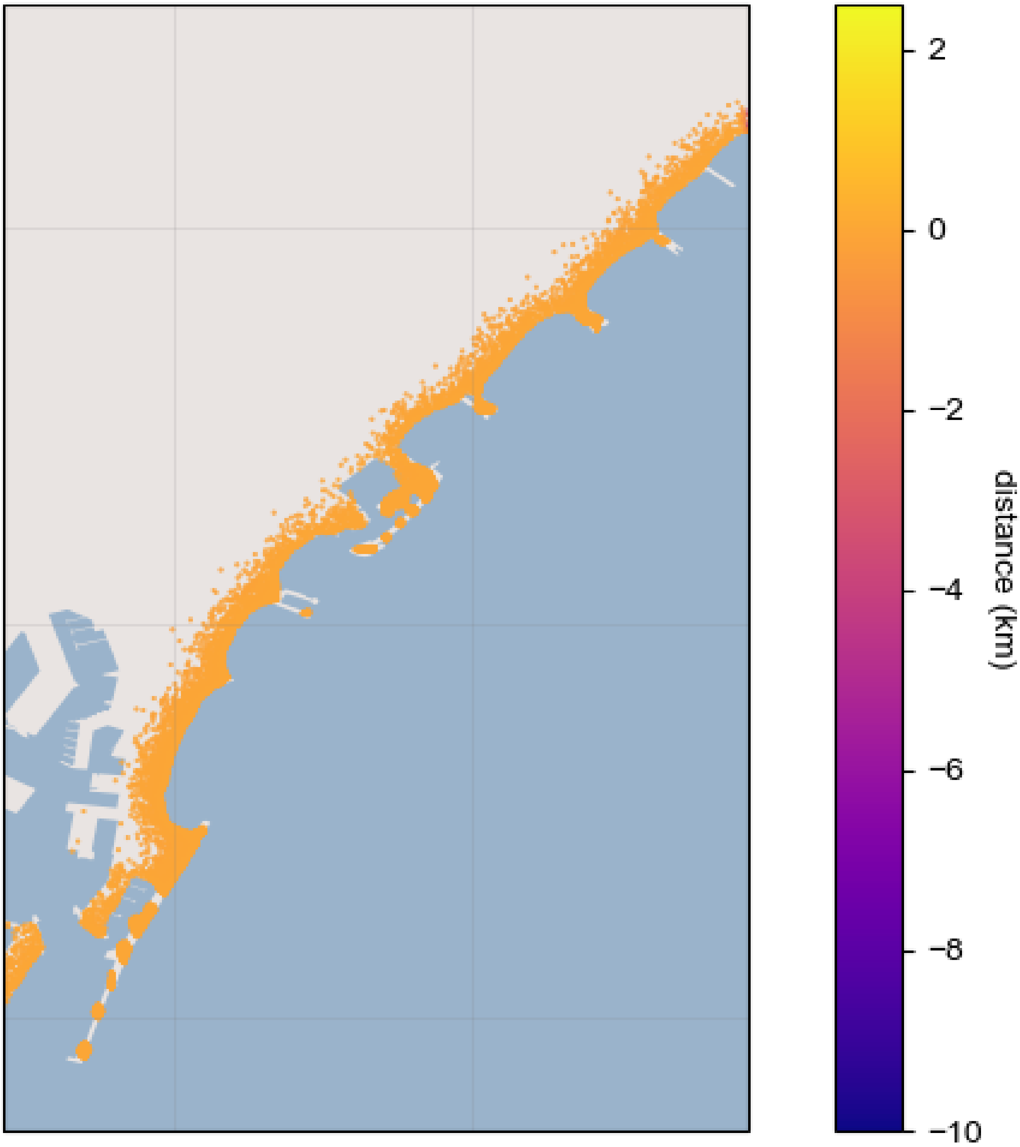
- Closeup of the Barcelona beaches using the distance-to-grid parameter. Beaches, and small-scale structures are “seen” and more precise measurements in these areas can be conducted. Additionally, further parameterisations more specific to beach-scale dynamics could be developed with this system as areas of future research.

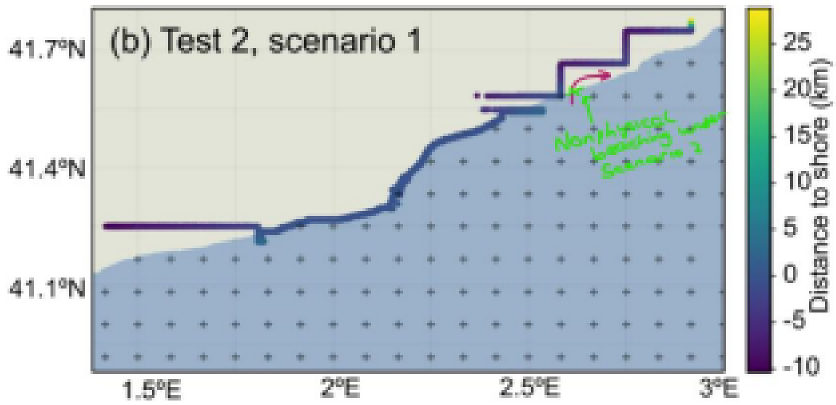


- With the above comparison, it is hoped that in discerning potential accumulation zones at a local scale, having a distance-to-shore parameter to determine beaching shows more reasonable patterns at the very least and may be of more practical use in beach debris management.
- We focus on small or localised scales instead of larger scales where such detail is not required and having such precision is no longer meaningful.
- We are doing further work using a further nested grid within the 70 m port grid to explore coastal processes in more detail. This grid would have a resolution of 14 m.
- Using the beaching module with the hydrodynamic grids it would be very difficult, if not impossible, to quantify how much debris reaches specific beaches, for example.
- The caveats are discussed in the revised manuscript.

I do not think it is obvious that scenario 2 would have improved performance for predicting things stakeholders would be interested in (e.g. accumulation hotspots), because the ‘real’ coastline is not consistent with the hydrodynamic model grids.

- The sensitivity analysis highlights that the real coastline differs substantially from how the hydrodynamic grids “see” the coastline and this can have substantial effects on where particles are considered beached at small scales. The assumption that stakeholders may not be interested in how the real coastline is resolved in terms of particle beaching accumulation may be true for large-scale studies, where the real coastline may not even be relevant. However, we would argue that at small scales, the concerns and requirements can be quite different and knowing which areas are affected gains relevance, as shown in the closeup plots above.

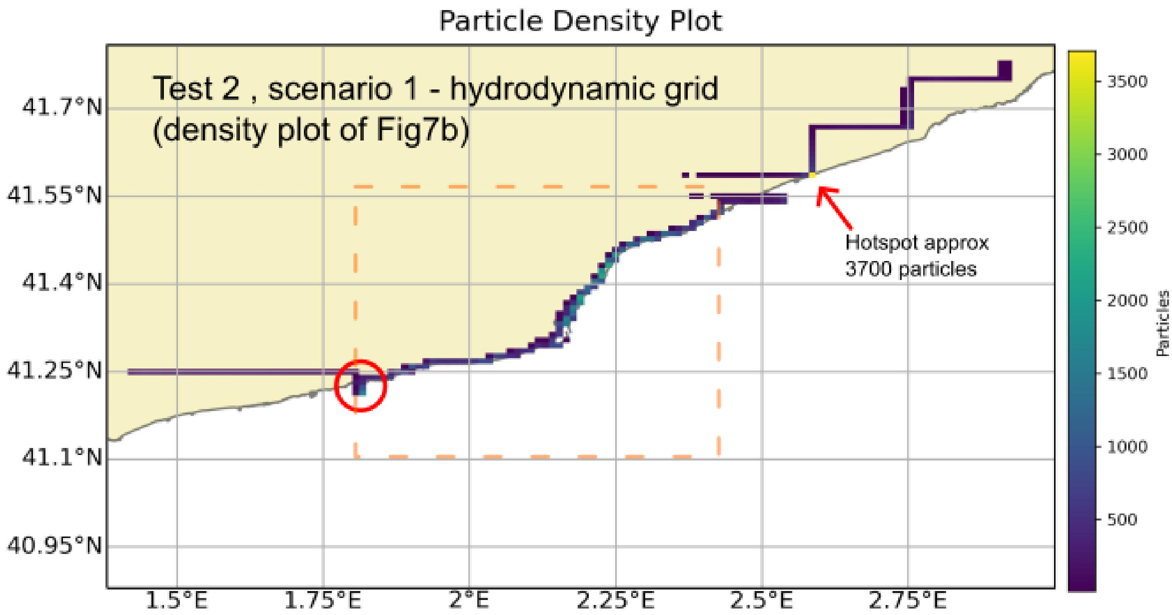
For example, it is clear by comparing the top-right of Figs 7(b) and (d) that the CMEMS-IBI grid has ocean cells that intersect with the ‘real’ coastline. The hydrodynamics of CMEMS-IBI are blind to the ‘real’ coastline, however, so particles can travel into the ‘real’ coastline despite following nondivergent flow. Under scenario 2, where particles beach as soon as they reach the ‘real’ coastline (and setting aside the effects of Stokes drift), if there were, say, a NE-ward along-shore current, this would result in a convergence of particles beaching (as particles are being carried into the coast by the currents). This behaviour is <u>not physically meaningful</u>, as from the perspective of the hydrodynamic model (and therefore the underlying physics), the particles are not converging against the coast.

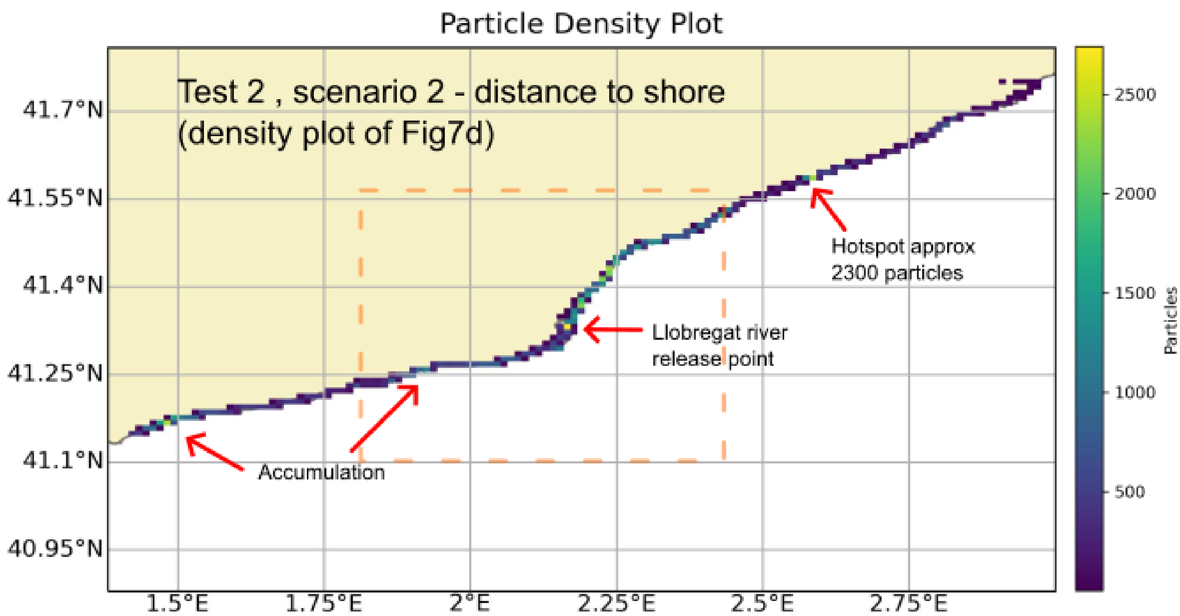


- The example above shows alongshore current close to the coastline in an area where the low-resolution CMEMS grid applies. The resolution of 2.5 km in these areas mean that such coastal processes are not resolved hydrodynamically anyway. Therefore it would be very unlikely for particles to reach the real coastline that would otherwise be caught in a current resulting from a coastal process where low-resolution hydrodynamic data applies.

If I were going about evaluating these beaching scenarios, I would plot the density of beached particles per unit length of coastline, along the coast. It is obvious that scenario 2 will generate beaching locations that conform well with the coastline. It is not obvious that scenario 2 can predict which areas are high and low risk for beaching debris.

- Beaching along the coastline density plot for the homogeneous release in the beaching sensitivity analysis hydrodynamic grid as detection (above) and distance-to-shore as detection (below). Artefacts are shown in red, the area where high-resolution hydrodynamic data is shown in the dashed orange rectangle. One pixel represents approx 1km^2.





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- Aside from the qualitative differences between using the hydrodynamic grids (above) and distance-to-shore grid (below), there are artefacts (red circle) when using the hydrodynamic grids also visible in Fig7a and b in the manuscript. At 41.6N and 2.6E there is a hotspot at the intersection of the edges of the hydrodynamic boundary, which is much more prominent when using the hydrodynamic grids. At this point, it is the low-resolution data that is being used in the simulation. The hotspot appears to be substantially attenuated

when using the distance-to-shore parameter probably due to particles crossing the boundary in a less focussed point over a stretch of the coastline. The reason for the hotspot is out of the scope of the analysis but it is nevertheless surprising given the distance from the release points.

- As expected, the distance-to-shore scenario does correctly show a hotspot (>2500 particles) around the Llobregat River release point given the geometry and hydrodynamic conditions. This does not seem to register when using the hydrodynamic grids as boundary detection showing that the complex geometry of that area that is adjacent to the Barcelona port is better resolved when using the distance-to-shore parameter, thus having a visible effect on where particles become beached.
- Likewise, there are several other hotspots within the high-resolution areas and outside of these which are picked up by the distance-to-shore beaching scenario and not by the hydrodynamic grid boundary detection scenario.
- From the two density maps, it would appear that when the distance-to-shore parameter is used the resulting densities along the shoreline align more closely to what would be expected from the area at such a scale, including an important hotspot at the main release point, which would justify recommending using the distance-to-shore parameter along with high-resolution hydrodynamic data at localised scales.
- Beaching density maps were not included because numerically it was seen that the majority of beaching occurred around the Llobregat river mouth for both nested grids and the CMEMS only grid, and this could obscure any beaching patterns diagrammatically speaking. The beaching patterns of deposition along the coastline based on the distance were deemed more useful.

It is of course entirely up to the authors how they wish to compare these beaching scenarios, but I do not see how the manuscript, in its current form, can make a justified recommendation about which scenario is ‘best’.

- Given the above example, the reduction in beaching artefacts, the independence from the resolution of the hydrodynamic grids across the domain where varying resolutions are used, the low risk of missing coastal processes where the low-resolution grid applies that does not resolve these processes anyway, we believe that the recommendation for the use of a distance-to-shore approach to beaching for small scale studies is justified.
- In the revised manuscript in the discussion, we replaced lines 551-559 with:
  A distinct approach to particle beaching was provided in scenario 2 which introduced a deterministic beaching model that relied on a physical shoreline and pre-calculated distance data of nodes to the shoreline in a grid(s) used in a fieldset. This way, the distance between particles and the shoreline could be calculated during the simulation to determine when and where they cross the land-water boundary as illustrated in the beaching sensitivity analysis Fig.Xc and Fig.Xd. Furthermore, the distance-to-shore beaching module is independent of the hydrodynamic data resolution. This parameterisation effectively tells a particle the minimum distance to the predetermined shoreline in real-time, and if the distance to the shore is <0 the particle becomes beached. This method can offer a more precise detection of particle beaching along the shoreline at smaller coastal scales. Using the distance to the shoreline and a physical boundary detection ensures consistency throughout the study domain, even when nesting grids of varying resolutions. Additionally, the interpolation and grid nesting capabilities of Parcels allowed distance calculations to not

be limited by a decrease in spatial resolution throughout the domain. Shoreline detection based on a physical boundary does have some limitations, such as relying on the availability of high-resolution spatial data and requiring preprocessing steps. While obtaining detailed coastline data may not be feasible for larger-scale studies, the advantages it offers for smaller-scale studies are substantial, particularly when assessing the impact of beaching at a localised level.

- In the conclusion we state:
  The LOCATE model effectively integrated high-resolution hydrodynamic data around areas of high interest and used high-resolution shoreline data, providing greater confidence and precision in the detection of the land-water boundary and particle accumulation zones, which becomes more salient the smaller the scale of the study.

The other clarification I wanted to make was on the diffusive parameterisation. I did not intend to question the use of kh =10 m^2s^{-1} for the IBI-CMEMS grid. My question is why the same value of Kh was used for the finer (coastal and harbour) grids, which should have a much lower value of Kh, or none at all?

- We understand that the dispersion process depends on the size of the mesh and resolution used, and in theory should be variable depending on the resolution of the data used and also on the velocities therein. In practice, however, we do not have experimental or empirical data to know for sure what value of Kh to use at these scales. We therefore thought it best to be prudent to this respect and use the same Kh value throughout the study domain for consistency while recognising that this is an area of future research. In November 2023 we finished a drifter campaign where we released a series of drifters in pairs and groups from selected areas close to the Barcelona coastline (such as Bogatell beach or the Llobregat river mouth) where we will try to validate the parameters of dispersion in this area and with the scales used in this study. Nevertheless, the validation of the drifter data for this work showed good skill score values, given that these trajectories were within where the high-resolution data applied and that a Kh value of 10 m^2s^{-1} was used.