Dear Editor,

Enclosed herewith please find the revision of the manuscript entitled: "Surface evolution and wind effects during a cyclonic eddy splitting event in the Balearic Sea". We thank the reviewers for their thorough reading of the text and helpful comments. Below is our detailed response (in **bold** and *italics*) and description of the modifications in the manuscript (underlined), while the attached new version of the paper explicitly shows all revisions in red and as ~~strikeouts~~. Following these modifications to both the text and the figures, we hope that the manuscript is now satisfactory for publication in Ocean Science (OS).

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Reviewer #1
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I find the manuscript well written and logically clear. The dynamics of the impact of the wind on the eddy split are also clear. I suggest publishing the manuscript with some minor revisions. My detailed comments are below.

R: We thank the reviewer for the positive and thoughtful review and have implemented the changes described below to address the detailed comments.

1. In the introduction, as stated by the authors, the wind forcing is not needed for eddies to split. However, the eddy splitting event in this study was strongly associated with the strong wind. I think the physical mechanisms about the eddy split in previous studies should be added and reviewed here.

   R: The reviewer rightly points out that we glossed over these other physical mechanisms. We have fixed this oversight by expanding on the first paragraph. See lines 26 – 30.

2. Figure 3 is interesting. As Stern (1965) stated, the classic wind-eddy interaction can induce vertical tilt in an eddy. Recent studies have found that mesoscale eddies in the world's oceans predominantly exhibit vertical tilt (e.g., Li et al., 2022). The vertical tilted eddy can induce a dipolar vertical velocity distribution (e.g., Figs. 6 & 8), which aligns with the statement in the manuscript. Does the eddy in the study exhibit vertical tilt?

   R: This is an interesting question. Unfortunately, the drifter data is not sufficiently resolved to answer it conclusively. We have now added a mention of the wind-induced vertical tilt on lines 176 – 178 and on lines 517 – 518.

3. The top part of Figure 4 is clear, but the regions are too large to clearly show the information in the two subfigures on the bottom left. Similar issues arise in Figures 5A–B and 5D–E. Please revise the figures accordingly.

   R: We have zoomed in on the region of interest in the two bottom left panels of Figure 4, as well as in Figures 5 – 11.

References

- Stern, M. E.: Interaction of a uniform wind stress with a geostrophic vortex, Deep Sea Res., 12, 355–367, https://doi.org/10.1016/0011-610 7471(65)90007-0, 1965.
- Li, H., Xu, F., & Wang, G. (2022). Global mapping of mesoscale eddy vertical tilt. Journal of Geophysical Research: Oceans, 127, e2022JC019131. https://doi.org/10.1029/2022JC019131

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Reviewer #2
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General comments

The manuscript presents a detailed observational analysis of a rare and scientifically relevant phenomenon: the splitting of a cyclonic eddy in the Balearic Sea, documented during the CALYPSO 2022 experiment. The combination of drifter clusters, hydrography, wind measurements, and satellite observations provides a dataset that allows the authors to link eddy internal dynamics with surface wind forcing and nonlinear Ekman pumping. This manuscript contributes to the understanding of mesoscale–submesoscale interactions and the role of winds in modulating eddy-driven vertical exchanges.

Overall, the analysis is rigorous, the methods are clearly described, and the paper is well written. However, some aspects of the interpretation could be better balanced between observational evidence and theoretical expectations. In particular, the discussion of wind effects sometimes appears speculative given the sparse spatial coverage, and could benefit from a more cautious phrasing. Additionally, the manuscript would gain from a clearer separation of what is firmly supported by the observations versus what is inferred or hypothesized.

With these refinements, the paper has the potential to be an excellent contribution. I therefore recommend publication after moderate revisions.

R: We thank the reviewer for the positive feedback on the manuscript and for pointing out specific aspects that would improve our contribution. We have gone through the manuscript and rephrased several paragraphs to separate observational results from interpretation and discussion more clearly. <u>In particular we updated section 5.1.5 and substantially rewrote section 6.</u>

Specific comments

1. Novelty and positioning:

   While the introduction situates the work within the literature, the manuscript relies heavily on Middleton et al. (2025, Science Advances), which has already analyzed the causal mechanisms of the same eddy breakup. To strengthen the impact, the authors should articulate more clearly what is genuinely new in this study compared to Middleton et al. (2025). For example, the use of surface drifters to resolve fine-scale divergence and vertical velocity, and the explicit quantification of wind-driven nonlinear Ekman pumping, could be emphasized as distinct contributions. Without this clarification, the present work risks being perceived as a secondary companion to the Science Advances article rather than an independent advance.

   R: We thank the reviewer for this comment and have edited the introduction and parts of section 2.1 to focus more clearly on our contribution and to place the results of Middleton et al. (2025) into better context. <u>See lines 55 – 69, and section 5.1.5 and 6.</u>

2. Main objective:

   In lines 50–58, the manuscript outlines the approach taken in this study. However, it would improve clarity if the authors explicitly formulated the study objectives (e.g., as a concise list). This would help readers clearly distinguish the novel aims of the paper and align them with the results and conclusions.

   R: We clarified the objectives of our work adding a new paragraph with the three main results of our analysis at <u>new lines 58–69.</u>

3. Previous history:

   The authors inform that "The eddy could be identified in satellite chlorophyll concentration maps as early as 17 February 2022 and was targeted for intense sampling starting 23 February". Could they provide an animation with the history of the eddy from the beginning with remote sensing pictures as Supplementary material?

   R: The drifter animation in the Supplementary Materials does show the chlorophyll concentration as a background field. But we have now added another animation, with just the chlorophyll data over the longer timeframe, as requested.

4. Eddy shape and Rossby number. Line 84

   Could the authors justify how the eddy shape induces instability? Could they provide the Rossby number for this eddy?

   R: A paragraph was added in Section 1, lines 26–30 discussing eddy shape and splitting from previous papers as requested also by Reviewer 1. We have also added a line in Section 2.1, lines 96–97 to clarify the explanation by Middleton et al., 2025.

   As for the Rossby number R for this eddy, it is of order 1, as indicated by vorticity ζ of order f. This is now reported on line 90, and further confirmed by the present paper that shows values exceeding f in the surface layer.

5. Ekman pumping:

   The manuscript introduces the relative wind stress formulation (lines 130), which is appropriate when surface currents are of comparable magnitude to the wind. However, it would be helpful if the authors quantified whether this was indeed the case during the studied event (e.g., comparing typical current speeds from drifters with wind speeds). Otherwise, the reader cannot assess whether the nonlinear Ekman pumping calculation captures a first-order effect or only a minor correction.

   R: We agree with the reviewer, and indeed this assessment is already included in the paper in Section 5.2, lines 387–388, 394–397. There we provide typical current and wind speed values as well as ζ and its gradient, that are essential for the nonlinear Ekman pumping calculation (eq 7). We find that the w_ζ component of Ekman pumping is negligible with respect to w while $w_{\nabla\zeta}$ is of the same order.

6. Vertical velocity estimation:

   The derivation of vertical velocities from colocated divergence estimates (Eq. 11, Sect. 4.2) is central to the analysis. While the method is standard, the final estimates may be highly sensitive to errors in the horizontal divergence (e.g., due to drifter separation or noise). It would strengthen the manuscript if the authors quantified or at least discussed the associated uncertainties, so that readers can better assess the robustness of the reported magnitudes.

   R: We agree, and thank the reviewer for this very useful suggestion. A discussion on the uncertainties associated with the method for divergence estimation was added in section 4.1 (lines 243 - 261). We also have computed the Statistical Errors for the binned divergence and propagated them to the vertical velocity w for 23 February, when enough data were available to compute w (lines 287 - 290). A figure has also been added in Supplementary material (SM4).

7. Figures:

   Figures 5–9 are informative but quite dense. In some cases (e.g., panels b–d), it is difficult to visually link divergence, strain, and vorticity fields. A suggestion would be to add schematic overlays or arrows indicating the main features discussed in the text. Enlarging key panels could also improve readability. And zoom in the maps to present the information with larger detail might also help.

   R: As also suggested by Reviewer 1, we enlarged the maps of Figures 4 to 11 and we further zoomed into the domain to enhance the readability of the sea surface patterns. We did not add schematic overlays because the figures are already dense, but we enlarged the size of the arrows of the velocity field to improve the pattern visualization.

8. Traceability of results:

   The derivation of vertical velocities from divergence estimates (Eq. 11) is central to the analysis. While the method is standard, it would help readers if the uncertainties associated with this estimate (due to drifter separation, divergence noise, etc.) were quantified or at least discussed more explicitly.

   R: We agree, and thank the reviewer for this very useful suggestion. As already mentioned for point nr.6, a discussion on the uncertainties associated with the method for divergence estimation was added in section 4.1 (lines 243 - 261). We also have computed the Statistical Errors for the binned divergence and propagated them to the vertical velocity w for 23 February, when enough data were available to compute w (lines 287 - 290). A figure has also been added in Supplementary material (SM4).

9. Biogeochemical implications:

   The introduction briefly mentions the role of cyclones in nutrient pumping and carbon export. The conclusions could be strengthened by revisiting these implications in light of the observed upwelling/downwelling magnitudes and their potential impact on tracer transport.

   R: We commented on the possible bio-physical mechanisms and effects on biochemical tracers distribution in the summary and discussion at new lines 511-515.

10. Link to M24:

    There is a direct link to a manuscript that wasn't unpublished at the time of the submission. I have found it published now. In any case, the continuous link to that manuscript is maybe excessive. For instance, the "summary and discussion" section is totally focused on a comparison with that manuscript and almost no other is mentioned (only Dauhajre and McWilliams, 2018). The manuscript would benefit from a major rewriting of this final section to provide a wider comparison with other manuscripts; moreover, that section might also compile the main limitations of the methodology applied and also state some final conclusions linked to the objectives of the manuscript.

    R: We thank the reviewer for the suggestion. We have rephrased the Section 6, focusing on the specific findings of the present paper as stated in the Introduction and providing a more extended discussion on limitations and comparison with other manuscripts.

Minor comments

- Page 3, l. 55: "drifters with drogues centered at 0.4 m and 0.75 m for the surface and at 15 m depth for the near-surface" → rephrase to avoid possible ambiguity ("surface drifters at 0.4–0.75 m, near-surface at 15 m").

  R: We rephrased for greater clarity. See line 69. The focus here is on the evolution of the eddy within the surface layer and its interaction with the wind, as illuminated by the surface (drogued at 0.4 and 0.75 m) and near-surface (drogued at 15 m) drifter observations.

- Page 6, ll. 173 to 178 and elsewhere: CaC instead CARTHE and CODE

  R: We have replaced "CARTHE and CODE" with the acronym "CaC" in these two places. However, we retained the full names in the Conclusions to retain clarity for readers who may have only skimmed the body and to serve as a reminder of what drifters were used.

- How many drifters were deployed?

  R: Thanks for pointing out this oversight! The drifter numbers are now specified on lines 199–201. Of the 140 CARTHE drifters released during the cruise, 53 were in the area of interest (black box in Fig. 1) during this time. Similarly, 32 of 70 released CODE drifters and 22 of 68 deployed SVP drifters entered the area and time period of the analysis.

- Sections 5.1.2, 5.1.3, 5.1.4. Letters in the text referring to the panels in figures 7 and 8 are mostly wrong.

  R: Oops! We reorganized the figures and forgot to update the references in the text. We have now gone through all figure panel references and fixed them.

- Sections 5.1.2 to 5.1.5 provide a comparison with the M24 manuscript. As that would be expected for a discussion section, I suggest the authors to move those comments to the final Discussion section.

  R: We have followed the reviewer suggestion removing the detailed comparison with M25 from the specific subsections of 5.1, and we have compacted them in the Synopsis subsection 5.1.5.

- Minor typos:

  - l. 163: "aignificant" → "significant".
  - l. 259: "exteme" → "extreme".
  - l. 421: "velocitity" → "velocity".

  R: Thank you. These have been corrected.