Response to reviewer RC4

We would like to thank the Editor and the reviewer for their careful reading of the manuscript and for their constructive comments. We believe that their suggestions have significantly improved the quality and clarity of the paper.

In the following document, reviewer comments are reproduced in black and our responses are given in blue. For transparency, each substantive modification is accompanied by a screenshot of the revised manuscript with track changes enabled. Additions and modifications are highlighted in red, whereas removed text appears as strikethrough text.

In this paper, the authors present META4.0, the latest version of the META database suite for eddy detection from altimetry. The novelty is that it accounts for merging and splitting of eddies to build networks of interconnected eddies, and the authors also provide a set of tools to analyze these networks. This database suite is clearly of great interest to the community, as shown for example by the around 200 citations of the reference META3.1exp paper (Pegliasco et al., 2022), and I expect META4.0 to be equally valuable.

That said, this paper needs substantial work to reach the standard expected for ESSD. The review was complicated by the feeling of reading an internal technical report rather than a scientific paper. Data description is unclear (e.g., the covered periods only appear near the end, and the use of all sat data is only apparent indirectly through Figure 12), methods are not clearly explained (e.g., the Lagrangian scheme, or the exact differences with META3.X), and I would not be able to reproduce the results without digging into the shared code. There are also many errors in the figures, few references to dynamical features or related scientific literature outside the introduction, and claims about the database's robustness and effectiveness are not well supported by the figures or text. There is also no discussion of the possible weaknesses of the method, whether related to the use of altimetry itself or to the algorithm.

I also feel the paper spends as much space presenting the diagnostic tool as the database itself, which weakens it: the tool's capabilities are listed without a clear discussion of results, giving the impression of unfinished work. I would suggest focusing on the database, with a few statistics demonstrating its importance and a clear description of what changed between META3.1exp (Pegliasco et al., 2022) and META4.0 and why. If the authors want to keep the diagnostics section, they could either trim it to a short list or expand it with a real discussion of results, but this last option would require a lot of work.

We thank the reviewer for these general comments. We agree that the primary objective of the paper is to describe the META4.0 dataset itself. However, we consider the diagnostic and visualization tools to be an important component of the contribution. As eddy atlases become increasingly complex, moving from isolated trajectories to interconnected networks, dedicated tools are essential for exploring, understanding, and ultimately making effective use of the dataset. In our view, a dataset is most valuable when it can be readily accessed, analyzed, and interpreted by the community. For this reason, we chose to retain a substantial, although revised and clarified, presentation of the analysis framework accompanying META4.0.

More generally, we carefully considered all of the reviewer's remarks. The revised manuscript now provides a clearer description of the dataset and its temporal coverage, a more explicit comparison with previous META releases, additional methodological details regarding parameter choices and algorithmic design, a more cautious interpretation of some results, and an expanded discussion of limitations. We believe that these revisions substantially improve both the readability and the scientific positioning of the manuscript while preserving its dual objective of describing the dataset and the tools developed to analyze it. We hope that the revised manuscript now better meets the standards expected for an ESSD data paper and satisfactorily addresses the concerns raised by the reviewer.

I advise major revision, but I strongly encourage the authors to continue, as I think this database deserves to be released and supported by a solid scientific article.

I took notes while reading the paper to help you improve it; I list them here:

1. Title: you had "Global" in the Pegliasco et al. 2022 manuscript, and I think it's a good idea to keep this term.

We thank the reviewer for this suggestion which has been taken into account.

META4.0: a new global mesoscale eddy network atlas derived from altimetry

2. L7: "completes the classical single-trajectory view": as you clearly state later, there has been effort since at least 2018 to account for these events and consider networks, so it's not clear that "classical" still holds.

We thank the reviewer for this remark and removed the term "classical" in the revised manuscript.

jectories are organized into networks of interconnected eddies. This network-based representation complements the ~~classical~~ single-trajectory view of eddy life cycles by explicitly accounting for eddy interactions.

3. L11: It's not clear why this is presented as a "new insight," since, as clearly stated in the introduction, META4.0 builds upon progress made by other methods. The first method to explicitly define eddy trajectories as networks was introduced regionally by Laxenaire et al. (2018), in parallel with Le Vu et al. (2018) (regional) and Cui et al. (2019) (global) who referred to multi-core eddies to assess merging and splitting. It's therefore not clear why, seven years later, you present this as a "new insight." Perhaps instead highlight that you provide a longer time series (three decades) or, if you have the evidence, more robust outputs, but "new insight" feels misleading as worded.

We thank the reviewer for this comment. The "new insight" was relative to the use of the diagnostics tools as well as some validation allowing network representation and analysis that, to the best of our knowledge, is not proposed in any paper addressing eddies networks. However, the sentence have been modified to better describe the novelty:

decades. These tools and analyses ~~provide new insights into~~ offer new diagnostics for investigating network properties, eddy lifetimes, and the spatial and temporal distribution of merging and splitting events of the META4.0 atlas. Clustering analyses

4. General comment on Introduction: I was a bit surprised that you split the introduction into subsections, but since it's quite long, it does make it easier to read. It's also a bit odd that, after L70, you no longer refer to the bibliography of "1.4 Eddy network and interaction" but instead just describe META4.0 directly, so it might need a new subsection title.

We thank the reviewer for this suggestion and added a subsection title in the revised manuscript.

1.5 The META4.0 atlas

Building upon this progress, we present the META4.0~~-Networks~~ atlas, the new global version of the Mesoscale Eddy Trajectory

5. L44: Since, up to my knowledge, only META3.1exp was associated to a published article, we have to trust that the different versions "progressively improved." While I'm quite confident that's true, don't you have technical notes or documentation explaining the differences? This ties in with a related comment in the Data/Methods section: I think you need to say more about how META4.0 differs from META3.X and why those changes were made.

We thank the reviewer for this comment and added a few sentences to better explain the difference between the previous version of the META atlas and the presented version.

continuity with previous versions while adding a new dimension for studying eddy connectivity and interactions. As mentioned in Section 1.3, previous versions of the META atlas relied on a single-trajectory tracking approach, whereas META4.0 provides a network-based representation of eddy trajectories. It should be noted that the META4.0 eddy detection framework is identical to that used in the previous META3.2 version.

6. General comment on Data and methods: Parameter choices are not well explained (e.g., why 10% for the overlap threshold, why no high-pass filtering of SSH when META3.1 with PET did apply one?). The way the steps are presented doesn't always make them easy to follow. For example, the overlap concept is introduced at L155 (without being fully explained), stating that it creates "chains of linked observations" (I assume this means using "best predecessor"?), and only afterward are the events described, before the reindexing is introduced. Is the reindexing a postprocessing step, by the way? For an ESSD paper, I would expect a clear definition of the algorithm and a discussion of the method's limitations, as there is currently no discussion of the imperfections of altimetry, except when noting that short segments are removed. Yet we might expect that a long time extension combined with a low overlap threshold could, at least occasionally (e.g., for small eddies in regions with strong currents), link eddies that are not actually related in reality.

We thank the reviewer for these comments. This comment overlaps substantially with comments or reviewers RC2 and RC3. The manuscript has been revised accordingly and the same modifications are summarized below for completeness.

In the data and method section the overlap function has been explicitly added.

The grouping step links daily detections into spatio-temporal networks based on their geometric overlap across consecutive days. Two eddies are connected if their ~~normalized overlap area~~ intersection-over-union (IoU) overlap score O exceeds 10% , as defined (Pegliasco et al., 2022):

$$O(eddy_{ref}, eddy_{study}) = \frac{\mathrm{Area}(eddy_{ref} \cap eddy_{study})}{\mathrm{Area}(eddy_{ref} \cup eddy_{study})}. \quad (1)$$

A paragraph has been added to discuss the resolution of the products.

(MDT), and would therefore be partially masked in SLA fields. The ADT fields used here are the global daily products from the DT2021 reprocessing (Faugère et al. (2022)), with a 1/4° grid resolution and corresponding to the all-satellite (all-sat) configuration.. The effective resolution of the altimetric product influences the detection of eddies and their interactions, with smaller and shorter-lived features being more difficult to resolve and therefore potentially underrepresented in the resulting networks. Consequently, some merging and splitting events involving small-scale structures may not be fully captured. The present atlas is based on the DT2021 1/4° reprocessing in order to ensure consistency with the META3.2 atlas and to perform comparisons of the tracking methodologies (see Section 3.2.2). A new version based on the DT2024 reprocessing at 1/8° resolution is currently under development and is expected to improve the representation of smaller-scale eddies and their interactions.

Finally, the paragraph discussing the choice of parameters has also been completed.

In addition, a hybrid criterion is used to retain configurations for which the area of the smaller contour is almost entirely included within the larger contour, even when the IoU overlap ratio defined above falls below the threshold.

To account for occasional missing detections, resulting from mapping limitations or temporary detection failures, the search is extended up to seven days forward~~, provided that eddies remain geographically consistent~~. This allows eddies belonging to the same trajectory to be reconnected when intermediate detections are missing. No constraint is imposed on radius or amplitude variations, allowing the detection of rapid size changes associated with merging or splitting. These tracking parameters were selected empirically based on extensive expert evaluation of trajectory continuity and network consistency. They build upon the methodology developed for previous versions of the META atlas Pegliasco et al. (2022), while being adjusted to improve the identification of merging and splitting events in the network framework. In particular, the temporal search window was extended from 5 days in META3.2 to 7 days in META4.0. Indeed, merging and splitting events are often associated with deformations of the eddy contours and rapid changes in their properties (see Section 3.3.3), which can increase the occurrence of temporary detection gaps. A longer temporal window therefore improves the reconnection of eddies belonging to the same network while remaining short enough to limit spurious associations. In should be added that the complete workflow is implemented in the open-source `pyeddytracker` library, which allows users to modify the tracking parameters and generate customized eddy trajectories, networks, and associated statistics according to their specific applications.

7. L95: You could use the Ierapetra eddy as an example, as shown in Figure 1b of Ioannou et al. (2017), https://doi.org/10.1002/2017JC013158.

We thank the reviewer for this suggestion. The ierapetra example is available in the online documentation, see:

https://py-eddy-tracker.readthedocs.io/en/latest/python_module/16_network/pet_ioannou_2017_case.html#sphx-glr-python-module-16-network-pet-ioannou-2017-case-py

In this section a simpler network has been chosen for pedagogical concerns.

8. L90: Altimetric "all-sat" or "two-sat"?

We thank the reviewer for this question. DUACS DT2021 ADT products are “all-sat” products. We mentioned it in the data section.

(MDT), and would therefore be partially masked in SLA fields. The ADT fields used here are the global daily products from the DT2021 reprocessing (Faugère et al. (2022)), with a 1/4° grid resolution and corresponding to the all-satellite (all-sat) configuration.. The effective resolution of the altimetric product influences the detection of eddies and their interactions, with smaller

9. L97: While it's true that spatial filtering is applied in Chelton et al. (2011), Chelton et al. (2011) did not use Okubo-Weiss; instead, they associated SSH pixels. They discuss the weaknesses of the Okubo-Weiss parameter in their Appendix B1 and present their own method in B2. In addition, META3.1exp (Pegliasco et al., 2022), which also used the PET algorithm to detect eddies, also applied a high-pass filter. This matters because you state that no filter is applied here, since you detect closed SSH contours rather than using Okubo-Weiss (or connected pixels as in Chelton et al.), but META3.1exp already used PET, so this justification is not fully consistent. Could you add some information or an example explaining this choice?

We thank the reviewer for this comment. A sentence has been added to complete the justification.

Unlike early approaches such as Chelton et al. (2011), which relied on the Okubo–Weiss parameter to isolate rotational structures from a non-rotative background, spatial filtering to the ADT fields is no longer applied. Filtering was originally introduced to reduce large-scale gradients and noise that affected vorticity-based methods. However, the contour-based approach adopted here is inherently less sensitive to background flow variations, as it directly identifies closed SSH contours enclosing extrema. Furthermore, sensitivity experiments indicated that spatial filtering can locally alter the geometry of SSH contours

and occasionally lead to the detection of large structures that are not supported by the independently observed circulation patterns. In line with the methodology of Ioannou et al. (2024) (ToEddies), we therefore retain the full, unfiltered ADT signal, preserving the complete range of observed altimetric variability and ensuring a more faithful representation of mesoscale and submesoscale dynamics.

10. L107 and following: There are many similarities with META3.1exp (Pegliasco et al., 2022). You could state clearly if there weren't many changes. What about the 2 mm step for contour extraction? Is Visvalingam new to PET? It's not clear what you mean by "facilitating further analyses and data colocation."

We thank the reviewer for this remark and added the 2mm step information.

1. SSH contour extraction: closed contours are traced around SSH extrema with a 2 mm step as in META3.2, downward from maxima for anticyclones, upward from minima for cyclones.

We also modified the sentence on the Visvalingam algorithm in order to make it clearer.

3. Interpolation and diagnostics: validated contours and mean radial speed profiles are interpolated over 30 points using the visvalingam algorithm as in META3.2 (Visvalingam (2016)) ~~, facilitating further analyses and data colocation (SST, color, salinity, Argo, etc.).~~

11. L120-121: Very interesting: do you plan to one day use your algorithm to quantify these types of interactions?

We thank the reviewer for this suggestion. This is not currently planned, but we agree that such analyses could represent an interesting future application of the network framework.

12. L125: What is a "normalized overlap area"? Is it close to the "similarity coefficient" from Pegliasco et al. (2022)? Why 10%?

We thank the reviewer for this remark and we already answer, see response to comment 6.

13. L126: A time extension is fairly common in eddy detection methods; you could reference other approaches to show this isn't a novel choice. Also, why 7 days specifically? Is it linked to the altimetric satellite orbit? Given that eddies with radii of several tens of km travel at around 10 km/day, don't you think a 10% threshold risks associating unrelated eddies? Maybe add a note on that.

We thank the reviewer for these questions. As mentioned in response to comment 6, a sentence has been added in order to explain the overlap ratio. Moreover, 10% is adapted to the formula as can be seen in the META 3.1exp paper. Indeed, META3.1exp used a threshold of 5%. This threshold has been increased to better capture the merging and splitting events associated with strong and quick shape modifications. The 7-days window has been justified.

14. L133: If you find a matching eddy at day +1, do you still keep checking eddies up to day +7, or do you stop? If you continue, do you, in the algorithm, end up counting the same eddy multiple times (i.e., for a single trajectory without merging, if you associate eddies at t+1, t+2, t+3, ..., t+7 starting from t, then repeat the process starting from t+1, associating t+2, t+3, etc.)? I expect that, if yes, you then filter and count only eddies once, but isn't it time consuming?

The algorithm searches for a matching eddy sequentially from day +1 up to day +7. As soon as a valid association is found, the search stops and the corresponding observation is selected as the continuation of the trajectory. Therefore, if a match is found at day +1, days +2 to +7 are not explored. So no, the routine is not time consuming. To give an idea, once the detection done the networking can be performed in less than an hour, on a standard workstation using a single CPU thread. Also, may you have any question about encoding aspect, all codes are available: https://github.com/AntSimi/py-eddy-tracker/tree/master.

15. L143: Broken/incomplete link (URL longer than the page width).

We thank the reviewer for this remark, the link has been repaired.

> The segmentation procedure is illustrated in the PET documentation notebooks (https://py-eddy-tracker.readthedocs.io/en/latest/python_module/16_network/pet_segmentation_anim.html#sphx-glr-python-module-16-network-pet-segmentation-anim-py), which provide visual examples and interactive tools for reproducing this step.

16. L145 and Figure 1: Are "trajectory segments" different from "eddy segments"? I found the description of segments and trajectories hard to follow. Are they the same thing? Segments start and stop at events, but if they "win" the event, do they continue rather than stop? For example, in

this figure, segment 2 undergoes a splitting event (giving rise to segment 3) but continues. You give this example without explaining how you determine which segment "wins" during these events. Expert readers might infer it, but I think it could be confusing for others.

We thank the reviewer for this comment. All "trajectory" terms have been replaced by "segments" when necessary to avoid any misunderstanding or confusion.

– Each group is segmented into individual ~~trajectories~~ segments, capturing the full life cycle of eddies, including births, deaths, splits, and merges.

17. L156: How is the overlap computed? Is it normalized? Does the larger eddy always "win"?

Please see response to comments 6 and 13, the overlap equation has been given. Yes, the association corresponding to the largest normalized overlap is retained.

18. L157: You write "segment (trajectory)." Again, does this mean the two terms refer to the same thing? In ToEddies, we also use the term "segment," but with a different meaning: a trajectory is composed of multiple segments, and segments always begin with a birth, death, merging, or splitting event. If "segment" means the same as "trajectory" here, I'd suggest not using the term "segment" this way, since it seems to add confusion without adding information beyond "trajectory." If trajectories and segements are different, that's of course not a problem if it doesn't mean the same thing as in ToEddies, but please clarify.

Please see response to comment 16.

19. L165: Maybe this reindexing step answers my earlier question. Using the same splitting example: two new segments are created, but afterward, using the "maximal polygon overlap" (L156), do you reindex one of the new segments to match the one before the split? What exactly do you mean by "continuity" here?

We thank the reviewer for these questions. One segment (the principal) is maintained while another one is created (splitting case) or dies (merging case). The explanation of this step has been fully revised to better explain the process.

– Segment reindexing: ~~when an interaction occurs, segments involved in merging or splitting events are reindexed to ensure a consistent identification of the main trajectory. The main segment is selected based on continuity and overlap criteria, rather than on the order in which observations are processed.~~ when a merging or splitting event occurs, segment identifiers are reassigned to preserve continuity along the main trajectory. The branch exhibiting the largest overlap with the parent segment is considered the continuation of the trajectory and retains the original segment identifier. In a splitting event, secondary branches are assigned new identifiers, whereas in a merging event, the non-primary branch terminates. This procedure ensures that segment identities are determined by geometric continuity rather than by the order in which observations are processed.

20. L169-170: Why would connections involving several segments is never considered as detection mistakes, while connections to a single segment would be?

We thank the reviewer for this remark. The paragraph has been completed in order to answer.

4. Postprocessing

– Short segments (i.e., less than 3 observations) that don't connect several segments are removed from their networks ~~in order to prevent event detection mistakes.~~ and treated as isolated features. These segments generally correspond to brief separations that are unlikely to represent robust interaction events. By contrast, short segments that connect multiple branches are retained because they contribute to the network topology and may represent genuine merging or splitting events.

21. L172: Why "trajectories" now (rather than "segments")?

Please see responses to comments 16 and 18.

22. L174-176: Very interesting: do you have numbers for how often these cases occur? Perhaps add references showing this can happen in reality, or, if there's no direct observational evidence, insight from geophysical fluid mechanics theory. Alternatively, if you think this is actually an artifact of altimetric field reconstruction rather than a real phenomenon, it might be worth stating that explicitly.

We thank the reviewer for this questions. The corresponding paragraph has been expanded to better explain this design choice and clarify the interpretation of these rare events. It is indeed very interesting to look at these particular events. A detailed analysis of the occurrence and nature of multi-eddy interaction events is left for future studies using the atlas.

It should be noted that the segmentation algorithm does not impose any restriction on the number of eddies involved in merging or splitting events. ~~In principle, more than two eddies may merge, and a single eddy may split into more than two offspring eddies.~~ Consequently, the resulting network topology is not limited to pairwise interactions: more than two eddies may merge into a single segment, and a single segment may split into multiple offspring segments. This design choice avoids introducing *a priori* constraints on the network structure and allows the atlas to represent all interaction patterns identified by the tracking algorithm.

23. L187: "pyeddytracker" is spelled differently than at L106.

We thank the reviewer for this remark. The typo has been fixed and harmonized in the whole revised manuscript.

24. L190: How was this network selected? Why not use a network already studied in a previous publication (from altimetry using merging/splitting events, and/or supported by observations)? A small inset map showing the location of the selected network on a world map could help orient the reader. We only see time/latitude (Figure 2) or longitude/latitude (Figure 3) later on, and it takes some effort to figure out where we are.

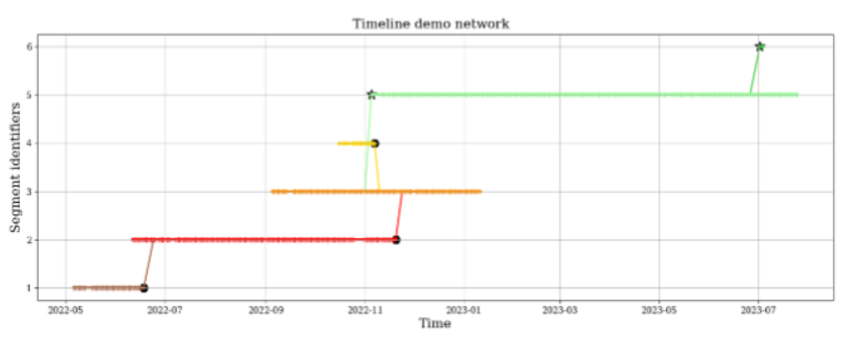
We thank the reviewer for this suggestion. The objective of Section 3.1 is primarily to introduce the visualization and analysis tools available within the py-eddy-tracker framework rather than to discuss the physical characteristics of a particular network. The selected example was therefore chosen because it provides a simple and representative illustration of the different diagnostics. For this reason, we preferred not to add an additional global localization figure and instead focus on the methodological aspects presented in this section.

25. L192 (and elsewhere in the manuscript): The extensive use of numbered lists and dashed bullet points gives the impression of reading a technical report rather than a scientific journal article. This doesn't necessarily need to change, since it doesn't prevent understanding, but making an effort to write this more smoothly could improve readability in places.

We thank the reviewer for this suggestion. We agree that excessive use of lists may sometimes affect the narrative flow of a manuscript. However, in the present study, many of the enumerated and bullet-pointed sections are intended to describe dataset characteristics, methodological steps, software functionalities, or analysis outputs. We deliberately adopted this structure to improve readability and facilitate access to specific information, which is a common objective in data description papers and software-oriented sections. Nevertheless, we carefully reviewed the manuscript and revised several passages to improve readability, while retaining lists in places where they provide a clearer presentation of methodological or technical information.

26. Figure 2 / L196: You write in the text that segments are ordered by segment identifier, while Figure 2a labels this "Order of Segments." This seems misleading, especially since the notion of "order" in eddy networks was introduced by Laxenaire et al. (2018), and doesn't match what you show here: they defined it as a way to indicate the number of merging/splitting events separating a trajectory from the origin trajectory of the network. For example, trajectories 4 and 5 in Figure 2a would have the same "order" under their definition. If I understand correctly, what you call "Order of Segments" here actually corresponds to the segment index as defined in your Data section. There's no problem using the word "order" with a different meaning than Laxenaire et al. (2018), but you should be clear about what it means here, as it could otherwise mislead readers familiar with their work.

We thank the reviewer for pointing out this potential ambiguity. Our intention was not to refer to the network "order" as defined by Laxenaire et al. (2018), but simply to display the identifier assigned to each segment during the segmentation procedure. To avoid any confusion with the terminology introduced in previous studies, we have replaced "Order of Segments" by "Segment Identifier" in the figure and corresponding text.



(a) Demo network timeline function of the ~~segments' orders~~ segment identifiers.

27. L203: The shape error needs more explanation of its role: okay, it quantifies "the deviation from an idealized circular eddy," but how? I saw a bit more information in L113 but that still very short. This parameter, presented as-is, is a clear example of how the presentation differs from META3.1exp. Indeed, for reference, Pegliasco et al. (2022) state: "For the outermost closed contour encompassing only one extremum, a shape error test is performed. This test, similar to Kurian et al. (2011) verifies that the ratio between the areal sum deviations of the contour from its best fit circle and the area of this best fit circle is below a certain value. This specification aims to avoid the selection of eddies with shapes too different from circles, where rotation is not possible, as for banana shapes for example. In Mason et al. (2014) and Kurian et al. (2011), the shape error was limited to 55%. We increase this value to 70% to ensure that elongated eddies are detected, a case often visible in highly dynamic regions and when eddies are interacting."

We thank the reviewer for this comment. The shape-error metric and associated threshold are inherited from the META3.1exp/META3.2 framework and are not specific to META4.0. Because the focus of the manuscript is the introduction of eddy networks rather than the eddy-detection methodology itself, this criterion was only briefly described. We nevertheless agree that additional clarification is useful and have expanded the text to explain both its definition and purpose.

> – have a shape error ~~(deviation from a best-fit circle)~~ below 70%~~, ensuring realistic geometries while allowing elongated shapes.~~ Following Pegliasco et al. (2022), the shape error is defined as the normalized areal difference between the contour and its best-fit circle. This criterion excludes highly irregular non-rotating structures while allowing elongated eddies associated with energetic flows and eddy interactions.

28. Figure 4: This is not "latitude" on the y-axis.

We thank the reviewer for pointing this out. The label has been corrected.

29. Table 2: You give numbers but I couldn't find the exact covered periods... and again, "all-sat" or "two-sat"?

We thank the reviewer for these remarks. The covered period as well as the configuration correspond to those of the data product used to perform the detection, it has been specified in the data section.

> (MDT), and would therefore be partially masked in SLA fields. The ADT fields used here are the global daily products from the DT2021 reprocessing (Faugère et al. (2022)), with a 1/4° grid resolution and corresponding to the all-satellite (all-sat) configuration and covering the 1993-2021 period. The effective resolution of the altimetric product influences the detection of

30. L230: Do you have information on the size and intensity of these "lonely" eddies? Are they small/weak eddies? Are eddies discarded because they belong to short segments (postprocessing step, L169) later becoming "lonely" eddies? If they are small and weak, this could be linked to eddy detection errors as discussed in, for example, Stegner et al. (2021), https://doi.org/10.1029/2021JC017475.

We thank the reviewer for this suggestion. We confirm that a fraction of the lonely eddies originates from the post-processing step that removes short segments not contributing to the connectivity of the network. We did not perform a specific analysis of the size and amplitude distributions of lonely eddies in the present study. Such an investigation could indeed provide useful insight into their nature and potential relationship with detection uncertainty. However, the objective of this manuscript is primarily to describe the construction and characteristics of the META4.0-Networks dataset rather than to investigate the physical properties of individual eddy categories. We therefore leave this analysis for future work.

31. Figure 5: Why not separate anticyclonic and cyclonic eddies? Figure 6: Not very clear in the pdf. Could the resolution be improved? And again, why not separate cyclonic and anticyclonic eddies? Some studies suggest anticyclones are more persistent, do you find the same?

We thank the reviewer for these suggestions. Following this recommendation, statistics for cyclonic and anticyclonic eddies have been added separately in Table 2.

Properties	Number of observations	Number of networks	Number of segments	Number of merging events	Number of splitting events	Number of lonely eddies
AC	29,353,140	934,475	1,098,337	91,034	89,127	491,378
C	31,338,295	1,004,983	1,183,206	97,226	97,483	506,599
AC+C	60,691,435	1,939,458	2,281,543	188,260	186,610	997,977

Table 2. Global characteristics of the META4.0~~-Networks~~ dataset. AC: Anticyclonic eddies global atlas. C: cyclonic eddies global atlas. AC+C: META4.0~~-Networks~~ global atlas.

However, we chose to keep the combined representation in the figures for the sake of conciseness. The manuscript already contains 24 figures, most of them composed of several panels, and systematically separating cyclonic and anticyclonic eddies for all diagnostics would substantially increase the number of figures while providing limited additional insight for the main objectives of this data paper. A detailed comparison of cyclonic and anticyclonic network properties and dynamics would constitute a dedicated scientific study beyond the scope of this dataset description paper. Nevertheless, the polarity-separated statistics now provided in Table 2 offer a first overview of these differences.

32. Section 3.3.2: Could you provide a table similar to Table 2 for META3.2 (and/or for META3.1exp, which is published)? Of course, there's no network information for META3.2, but if I understand correctly, segments/trajectories in META4.0 correspond to segments in META3.2? Perhaps normalize by year, or give a daily eddy count as in Table 2 of Pegliasco et al. (2022)?

We thank the reviewer for this suggestion. We considered adding a summary table for META3.2. However, many of the metrics reported in Table 2 are specific to the network representation and are therefore not defined in the META3.2 single-trajectory framework. Instead, we chose to dedicate Section 3.2.2 (“Comparison with the META3.2 single-trajectory dataset”) to a detailed comparison between the two datasets. This section provides a more informative assessment of the differences between META3.2 and META4.0 than a summary table, including comparisons of event statistics, lifetime distributions, and tracking continuity. We therefore believe that this dedicated analysis better highlights the impact of the network framework than a direct table-to-table comparison.

33. Figures 7 and 8: Why not separate anticyclonic and cyclonic eddies? You give observations/year, which is good, but do you use exactly the same period for both datasets? I'm not saying this would change the results, but it should be stated somewhere. Also, would the number of birth+splitting in META4.0 correspond to the number of birth in META3.2, and would death+merging in META4.0 correspond to death in META3.2? If so, this could support the sentence "this difference arises because..."

We thank the reviewer for this remark. The two datasets do not cover exactly the same period, as META4.0 extends approximately two years beyond META3.2. While this difference is not expected to qualitatively affect the conclusions of the comparison, we agree that it should be explicitly stated and a sentence has been added. We have therefore clarified the respective temporal coverage of the two datasets in the manuscript.

> **3.2.2 Comparison with the META3.2 single-trajectory dataset**
>
> In this section, the META4.0 network-based atlas is compared with the META3.2 single-trajectory dataset. It should be noted that META4.0 covers a slightly longer time period than META3.2 (approximately two additional years). However, the diagnostics presented below are expressed in relative terms or normalized frequencies, so this difference is not expected to significantly affect the interpretation of the results.

Regarding the separation of cyclonic and anticyclonic eddies, the objective of Figures 7 and 8 is to illustrate the overall impact of the network framework on birth and death statistics. As mentioned in response to comment 31, introducing separate diagnostics for the two polarities would substantially increase the number of figures and discussion without being directly related to the main objective of the manuscript, which is the description of the network dataset. We nevertheless agree that such a comparison would be interesting.

34. L249: "as both datasets are derived from the same...": I understand from this that the PET eddy detection used in META4.0 is exactly the same as in META3.2. So, for example, was the high-pass filtering used in META3.1exp no longer used in META3.2? This is the kind of question I would expect to already know the answer to from the Data/Methods section, rather than encountering it for the first time in the Results.

The absence of high-pass filtering is indeed discussed in the Data and Methods section (Lines 97-103 in the original manuscript) and is therefore introduced before the Results section.

Moreover, the manuscript has been revised to clarify these methodological aspects and to better highlight the differences with previous META versions (see our response to Comment 9).

35. L250: "it reduces artificial discontinuities and allows for more consistent tracking": most likely true, but this could also link unrelated eddies.

36. Figure 9: Why not separate anticyclonic and cyclonic eddies?

Please see our response to comments 31 and 33.

37. Figure 9a: I would have expected closer agreement between the two datasets: if the same PET detection is used and trajectories equal segments, I would expect the (nearly) same curves. I'm also not sure I understand the counting method: does 5x10-7 at 3500 days in Figure 9a mean 30 eddies out of 60,000,000 have lifetimes longer than 2000 days? Figure 9b: I'm not sure I understand this one either: it looks like 5x10-7 at 7000 days, implying a 20-year-long network? And is the fraction based on number of networks or number of observations? Sorry if I'm missing something, but the numbers aren't clear to me.

We thank the reviewer for these questions. The curves are indeed nearly the same. They really separate each other for the last 10% longest trajectories. The fraction is the number of segments or networks as stated in the legend. Yes, this interpretation is correct. A very small number of networks exhibit durations exceeding 20 years. These correspond mainly to networks associated with long-lived and recurrent eddy activity in regions hosting quasi-permanent structures.

38. L261-263: You state that, as META4.0 detects and connects a larger number of eddies, the visual comparison "confirms" that the network approach gives better results, but this may not be strictly true. For example, you state that 10% is the minimum overlap used, but with a 1% overlap threshold you would likely detect and connect more eddies. Would you say that results using a 1% minimum overlap "confirm" the network approach too? I expect not, since you selected (while I do not know why) 10%. I know this is hard to confirm visually and hard to find independent data, but at minimum, you could support the claim using established results from the literature.

We thank the reviewer for this remark. We agree that the visual comparison alone cannot demonstrate that all additional connections correspond to more realistic eddy evolution. The purpose of this figure is to illustrate the differences between the two tracking frameworks rather than to provide a definitive validation of the network methodology. We therefore replaced the term "confirms" by a more cautious formulation. The plausibility of the reconstructed connections is discussed separately using chlorophyll observations, Lagrangian coherence analyses, and the methodological choices described in the manuscript. Accordingly, the statement has been revised to avoid overinterpreting the visual comparison.

META4.0 detects and connects a larger number of eddies above this threshold compared with META3.2, especially in regions of intense mesoscale activity such as the western boundary currents and the Southern Ocean. ~~This visual comparison confirms that the network approach enhances the detection of persistent eddy structures and reduces artificial fragmentation.~~ This visual comparison is consistent with the idea that the network approach reduces trajectory fragmentation and improves the representation of persistent eddy structures.

39. L265: Same remark: you state that these diagnostics provide a "more robust representation of mesoscale eddy dynamics," but nothing demonstrated here actually confirms that. What you've shown is that the representation is more complex, not necessarily more robust.

We thank the reviewer for its comment. We replaced "more robust representation" with a more neutral formulation that better reflects what is directly supported by the results.

This visual comparison is consistent with the idea that the network approach reduces trajectory fragmentation and improves the representation of persistent eddy structures.

~~Overall, these diagnostics demonstrate that the network-based tracking extends eddy lifetimes beyond what is observed with isolated trajectories, providing a more robust representation of mesoscale eddy dynamics.~~ Overall, these diagnostics highlight the ability of network-based tracking to represent eddy interactions and extended lifecycles beyond what can be captured using isolated trajectories.

40. Figure 10: What about the short networks? You should show where they are located, as this could be informative. Also, I think a figure showing the total number of eddies is missing (similar to Figure 5, but for all eddies that are part of a network), to show that the spatial coverage differs from that shown in Figure 10a. Legend not easy to read, and even incomplete, in Figure 10b.

We thank the reviewer for this suggestion. We thank the reviewer for this suggestion. Figure 10 focuses on long-lived networks (>365 days) because these are the structures for which the network framework has the strongest impact, as shown in Figure 9. Including shorter-lived networks would make the figure considerably more crowded while adding limited information regarding the differences between META3.2 and META4.0.

41. L269: You clearly indicate here that you count pixels within eddy contours. Did you do the same for Figures 5, 7, etc.? If not, why the change in counting method? I don't understand why this would "emphasize the spatial regions": the difference between counting by eddy center versus by contour is that the latter accounts for both position and size (large eddies get more pixels, so more weight, than small ones), whereas counting by center weights large and small eddies equally. Also, in the case of merging, do you count the merged eddy, or the two (or more) eddies that merged? What about splitting?

We thank the reviewer for pointing this out. Different counting approaches were intentionally used because the corresponding figures address different questions. For the comparison between META3.2 and META4.0 (Figures 5, 7, and related diagnostics), events are counted using eddy centers. This avoids introducing differences associated with eddy size and contour geometry, which may vary between datasets and could bias the comparison of birth and death statistics. In contrast, Figure 11 aims to identify the geographical regions where merging and splitting interactions occur most frequently. In this case, counting the pixels covered by eddies involved in an interaction provides a spatial representation of the affected regions rather than a simple count of event locations. For splitting events, the contours of the parent eddies are used, whereas for merging events the contours of the resulting eddies are considered. The manuscript has been revised to clarify this distinction and the rationale behind these two complementary approaches.

~~Figure shows frequency maps of merging and splitting events. These maps are computed as the fraction of pixels covered by eddy contours involved in merging or splitting. This approach emphasizes the spatial regions where such interactions most frequently occur.~~ Figure 11 shows frequency maps of merging and splitting events. Unlike the previous diagnostics, which are based on eddy centers, these maps are computed from the fraction of pixels covered by eddy contours involved in merging or

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splitting events. This representation is intended to highlight the geographical regions affected by eddy interactions and therefore accounts for the spatial extent of the eddies involved.

42. Figure 11: Why not separate anticyclonic and cyclonic eddies? Panels a and b are, as you note in the text, very similar. Wouldn't you find the same pattern in a version of Figure 5 that included all eddies in networks, rather than just lonely eddies? I agree this is because the region is dynamically active, but that just reflects there being many eddies there. It would be more interesting to highlight where the two panels differ. For example, I see more merging in the

Mozambique Channel, and more splitting upstream of it and in the Madagascar retroflection region. If you can identify a dynamical explanation for this, it would support the idea that the merging/splitting hotspots identified by your network approach are dynamically meaningful, which would strengthen confidence in the method.

We thank the reviewer for this interesting observation. As for several other diagnostics, we chose not to separate cyclonic and anticyclonic eddies in order to keep the number of figures manageable and to focus on the global characteristics of the network dataset, as already mentioned in response to comments 31, 33 and 36. The objective of Figure 11 is primarily to document the large-scale spatial distribution of interaction events rather than to investigate polarity-dependent dynamics. We agree that regional differences between merging and splitting patterns, such as those highlighted by the reviewer in the Mozambique Channel and Madagascar regions, are potentially indicative of underlying dynamical processes. However, a detailed physical interpretation of these regional features would require dedicated analyses beyond the scope of the present data description paper. Our objective here is mainly to show that interaction events are not randomly distributed but concentrate in dynamically active regions where eddy interactions are expected to occur.

43. Figure 12: I think this is the first place where the exact period covered is clearly stated! Why not reproduce Figure 4 of Pegliasco et al. (2022) to show the period covered by satellite missions, rather than just their launch dates?

We thank the reviewer for this suggestion. The temporal coverage of the atlas is indeed inherited from the DT2021 altimetric product and has now been specified in Table 2. In Figure 12, we chose to indicate only the launch dates of the main satellite missions for conciseness, as reproducing the complete mission-coverage figure from Pegliasco et al. (2022) would require substantial figure space while providing information that is already documented in detail in the description of the underlying altimetric product and previous META publications. To facilitate access to this information, we have added a reference to Pegliasco et al. (2022), where the full temporal coverage of the satellite missions is presented.

Figure 12. Temporal evolution of merging and splitting events. Temporal evolution of merging and splitting events. Vertical lines indicate the launch dates of the main satellite altimetry missions. The corresponding temporal coverage of the satellite missions and altimetric products is described in detail in Pegliasco et al. (2022).

44. L276: What are the "four points per year"? Seasons?

We thank the reviewer for pointing this out. The wording was indeed ambiguous. The time series is not based on seasons but on successive 90-day bins used to reduce short-term variability and improve the readability of the figure over the 30-year period. This has now been clarified in the manuscript.

Figure 12 shows the temporal evolution of the number of merging and splitting events over the 30-year record ~~, with four points per year.~~ Event counts are aggregated into successive 90-day bins to improve the readability of the long-term time series.
340 The number of events remains relatively stable, between 1300 and 1700 per trimester, without evidence of long-term trends. Abrupt variations mainly coincide with changes in the altimeter constellation and the associated observing system, as described in Pegliasco et al. (2022).

45. L280: "Pegliasco et al. (2022)" instead of "(Pegliasco et al. 2022)" (citation format).

We thank the reviewer for this remark which has been taken into account in the revised manuscript.

46. L285: This normalization isn't clear to me. For example, in the case of a splitting event, one segment/trajectory continues while a new one begins. Are the eddies before and after the split, within the continuing segment, normalized by the same value, while the newly created segment is normalized by the maximum value it reaches after the split? I was actually a bit disappointed reading the text, because looking at the figure, I noticed that shape-error values before and after 20 days around an event look comparable; yet merged eddies are on average larger than eddies that merge, and the opposite is true for splitting. Showing this kind of behavior more explicitly would strengthen the case that these are genuine merging/splitting events, since artificial separations caused by altimetric error would not be expected to show notable size differences 20 days before and 20 days after the event. Also, how do you handle eddies that are not active 20 days before or after the event? What about successive merging/splitting events occurring within less than 40 days of each other?

    L297-298: Very good that the absolute values confirm this! Is that also the case 20 days before and 20 days after? I think this is a strong point in favor of your merging/splitting detection; I would suggest presenting this as a figure (or numbers), even if only in the appendix.

We thank the reviewer for these remarks. Eddy properties are normalized by the maximum value reached during the lifetime of each individual segment, before and after an event. Therefore, parent and offspring segments involved in a splitting event (and similarly segments involved in a merging event) are normalized independently. When a segment is not available at a given time lag, it does not contribute to the corresponding statistics. Following the reviewer's suggestion, the corresponding diagnostics expressed in absolute units have also been added in Appendix A.

Appendix B: Absolute evolution of eddy properties during interaction events

For completeness, Figures B1 and B2 present the same diagnostics as Figures 13 and 14, but using absolute values rather than normalized quantities.

While the normalization adopted in the main text facilitates comparison between eddies of different sizes and amplitudes, the absolute diagnostics provide the physical magnitude of the variations associated with interaction events. The results are consistent with the conclusions drawn from the normalized analysis: merging events generally produce larger eddies, whereas splitting events result in smaller offspring structures. The increase in shape error before interactions and the subsequent relaxation toward more stable configurations are also visible in absolute units.

As noted by the reviewer, merged eddies are on average larger than the eddies involved in the merging process, whereas the opposite behaviour is observed for splitting events. This is visible in both the normalized and absolute diagnostics. In contrast, the shape error measures the departure from an ideal circular shape rather than the eddy size itself. The figures show that shape error tends to increase near interaction events, indicating stronger deformation, and then returns to more stable values away from the event. The similar values observed before and after the interactions are therefore consistent with the interpretation that eddies undergo a transient deformation during the merging or splitting process before recovering more regular shapes.

47. L303-307: The merged altimetric product is constructed via optimal interpolation. Wouldn't this tend to make structures appear to grow or decay slowly before and after the periods where the eddy is actually captured by altimetric tracks? Are similar tendencies also found in, for example, numerical models? Or, if you repeat this analysis using only long-lived trajectories (which should be less affected by optimal interpolation at the start/end of their lifetime), do you get the same result? I think Figures 16 and 17 suggest that the answer is no since after 15 days the evolution appears to reach a plateau.

We thank the reviewer for this remark. The purpose of this analysis is not to establish the physical origin of the observed evolution in eddy properties throughout their lifetime, but rather to provide a reference framework against which the merging and splitting diagnostics can be compared. We agree that part of the evolution observed near birth and death may reflect characteristics of the detection process and/or the gridded altimetric product. However, the objective of Figures 15-17 is simply to contrast the classical birth-maturity-decay framework with the behavior observed around interaction events. A detailed assessment of the respective contributions of physical processes, detection effects, and altimetric mapping would require a dedicated study and is beyond the scope of the present dataset description paper.

48. L322: You don't give any information on the CLS CatSat chlorophyll product: no DOI, no reference. At minimum, please explain it, or use a freely available product instead.

We thank the reviewer for this remark. The chlorophyll product is not used in either the eddy detection, tracking, or statistical analyses presented in this study. Its sole purpose is to provide an independent tracer field for the qualitative visualization of a few selected examples of merging and splitting events. Because no quantitative metric is derived from this product and none of the conclusions of the manuscript depend on it, we believe that the use of the CLS CatSat dataset for illustration purposes is appropriate. The objective of these figures is simply to show that the detected structures can also be identified in an independent tracer field, rather than to perform a formal validation. To avoid any misunderstanding, the role of the chlorophyll product has been clarified in the revised manuscript.
We also note that the same CLS CatSat product has been used in previous META releases for similar qualitative comparisons: ESSD - META3.1exp: a new global mesoscale eddy trajectory atlas derived from altimetry. We now use the same formulation used in the previous article.

~~Finally, a qualitative validation of merging and splitting detections is provided using independent chlorophyll concentration (CHL) fields. The CLS CatSat chlorophyll product is used to cross-check the occurrence of interaction events. One representative example of each interaction type is shown.~~ Finally, the plausibility of some selected merging and splitting events is assessed using an independent chlorophyll concentration (CHL) product. The CLS CatSat chlorophyll fields (data courtesy of CLS) are not used to detect eddies or interaction events but provide an independent tracer field against which the altimetry eddy detections can be qualitatively compared.

49. Figures 18 and 19: No colormaps shown... I can't see the latitude. Are these known merging/splitting eddies?

We thank the reviewer for these remarks. We agree that the readability of the figures can be improved and have therefore added the corresponding color scales. The examples shown in Figures 18 and 19 were not selected because they correspond to previously documented merging or splitting events. Rather, they were chosen as representative and clearly identifiable examples for which both the altimetric and chlorophyll fields provide a sufficiently complete and interpretable visualization throughout the evolution of the interaction. Their purpose is therefore illustrative, namely to demonstrate how the network detections relate to independent tracer structures, rather than to revisit a specific event previously described in the literature.

50. L328: "are also visible": not sure this is accurate. You only show that, at least in two examples, they can be seen.

We thank the reviewer for pointing this out, the whole section has been revised and an Appendix A has been added in order to show two more cases of merging and splitting events in the Gulf Stream and Aghulas areas. Finally, the perspective paragraph has been reformulated in order to discuss the possibility of a global quantitative validation based on independent tracers.

~~Finally, a qualitative validation of merging and splitting detections is provided using independent chlorophyll concentration (CHL) fields. The CLS CatSat chlorophyll product is used to cross-check the occurrence of interaction events. One representative example of each interaction type is shown.~~ Finally, the plausibility of some selected merging and splitting events is assessed using an independent chlorophyll concentration (CHL) product. The CLS CatSat chlorophyll fields (data courtesy of CLS) are not used to detect eddies or interaction events but provide an independent tracer field against which the altimetry eddy detections can be qualitatively compared.

~~Figure illustrates a merging event observed both in the ADT field (Figure) and in the CHL field (Figure), across four dates capturing the situation before, during, and after the event. Similarly, Figure presents a splitting event documented in both ADT (Figure) and CHL (Figure). For each case, the corresponding network timelines are also displayed, providing additional confirmation of the detected interactions.~~ Figure 18 illustrates a merging event identified from altimetry. The ADT-derived eddy contours are superimposed on both the ADT and CHL fields across four dates spanning the evolution of the event. Similarly, Figure 19 presents a splitting event identified from altimetry and examined using the corresponding chlorophyll fields. For each case, the associated network timeline is also shown. Both examples are located off southeastern Australia (approximately 95 – 120°E and -40 – -30°S), a region of active mesoscale variability.

The chlorophyll structures exhibit spatial patterns and temporal evolution that are consistent with the interaction events inferred from the altimetric eddy network. While CHL does not provide an independent detection of the eddy boundaries, it offers an independent tracer perspective supporting the interpretation of the detected merging and splitting events.

~~These examples confirm that merging and splitting events detected from altimetry are also visible in independent fields, reinforcing the robustness of the methodology. However, conducting systematic detections at the global scale from CHL fields remains challenging due to their high sensitivity to factors such as cloud cover and atmospheric corrections.~~ These examples show that the interaction events identified from altimetry are associated with coherent signatures in an independent tracer field.

Appendix A: Additional surface chlorophyll concentration qualitative validation examples

To complement the examples presented in Section 3.3.5, additional merging and splitting events are shown in two other dynamically active regions: the Agulhas and the Gulf Stream zones. As in the main text, ADT-derived eddy contours are superimposed on surface chlorophyll concentration fields.

Figure A1 and Figure A2 present one merging event and one splitting event observed in the Agulhas region. Figure A3 and Figure A4 show equivalent examples in the Gulf Stream system. In all cases, the chlorophyll fields exhibit coherent structures whose evolution is qualitatively consistent with the interaction events inferred from the altimetric network.

These figures are not intended to provide an exhaustive validation of merging and splitting detections. However, they offer additional qualitative evidence that the interaction events reconstructed from altimetric observations are associated with identifiable tracer structures across multiple regions of the global ocean.

Particular attention will be devoted to the development of quantitative validation approaches for merging and splitting events based on independent observations, including biogeochemical tracers and in situ measurements. Such analyses will help confirm the physical realism of reconstructed eddy interactions and further improve the characterization of mesoscale connectivity.

51. Figure 20: Why no distinction between anticyclones and cyclones?

Please see responses to comments 31, 33, 36 and 42.

52. L340: Did you try computing the maximum latitude and longitude differences separately? It could be interesting to identify zonally versus meridionally oriented networks. I have to say I like this clustering method. I think that, with careful choice of the parameters, it could indeed be a nice way to find patterns in such a complex database of eddy networks.

We thank the reviewer for this positive feedback and for the suggestion. We agree that separating the zonal and meridional extents of networks could provide additional information on their geometry and potentially distinguish between preferentially zonal and meridional modes of organization. In the present study, we intentionally limited the number of clustering variables in order to keep the typology simple and easily interpretable. The spatial extent was therefore represented by a single metric corresponding to the maximum distance between two eddies within a network. We agree that introducing directional metrics could provide an interesting refinement of the proposed classification and represents a promising avenue for future work.

53. Group 2: There's no constraint on latitude. Why do you think these are found near the equator? Perhaps because of the very large Rossby radius of deformation there? Are you confident that the geostrophic assumption holds in this region?

We thank the reviewer for this interesting remark. Latitude is indeed not used as an input variable in the clustering procedure. The equatorial concentration of Group 2 therefore emerges naturally from the combination of network properties used by the algorithm. We speculate that this behavior may be related to the larger characteristic spatial scales observed in the tropics, consistent with the increase of the Rossby radius of deformation toward low latitudes. A dedicated investigation of the mechanisms responsible for the emergence of the different network classes would require a more focused study.

54. Figure 21: You define groups 0 to 4 in the figure, but the text and Figure 22 use groups 1 to 5.

We thank the reviewer for pointing this out. The legend has been modified.

55. 3.5 Lagrangian detection of eddies: Lagrangian eddy detection is itself an active research field; maybe give at least a few references. Researchers from that community often argue that Eulerian detection methods don't guarantee that the detected eddies actually trap particles. It's a good idea that you made the effort to check this, but you don't provide enough detail on your methodology to make it reproducible. For example, at L378: how do you advect the particles? Do you use a specific tool such as Parcels? If not, please provide some information about the numerical scheme used. Also, do "coherence" and "auto-coherence" mean the same thing?

We thank the reviewer for this valuable comment. We agree that Lagrangian eddy detection and coherence assessment constitute an active field of research and deserve clearer positioning with respect to the present work. Following the reviewer's suggestion, we have added references to studies based on Lagrangian approaches.

The coherence of eddy segments and their associated networks is assessed using Lagrangian particle advection experiments. Lagrangian approaches based on particle trajectories and Lagrangian coherent structures have been widely used to characterize

eddy transport and coherence properties (e.g. Abernathey and Haller (2018); Jones-Kellett and Follows (2024); Tian et al. (2025).

Approaches based directly on Lagrangian coherent structures or particle trajectories characterize eddy coherence using explicitly Lagrangian criteria. In contrast, META4.0 relies on an Eulerian detection and tracking framework based on contour geometry and overlap criteria. The purpose of the particle-advection experiments presented here is therefore not to reproduce such Lagrangian tracking methodologies, but rather to assess whether the reconstructed network topology is consistent with the transport properties implied by the velocity field.

The objective of the present analysis is not to perform a Lagrangian eddy detection, but rather to assess whether the network topology reconstructed from Eulerian eddy tracking is consistent with the transport properties implied by the velocity field. We also expanded the methodological description of the particle-advection experiments by providing additional details on the numerical implementation and trajectory integration procedure, ensuring reproducibility. Finally, we clarified the terminology used throughout the section. In particular, autocoherence refers to the coherence score computed for a segment with respect to itself after forward or backward advection, whereas coherence is used more generally when discussing transport retention associated with segments, merging events, and splitting events.

To perform this assessment, particles are uniformly initialized at a spatial resolution of $1/50°$ within the eddy speed contour at a reference date d. Particle trajectories are then integrated both forward and backward in time over a 7-day window. Particle trajectories are computed using the Lagrangian advection module of the open-source `pyeddytracker` package, which relies on a fourth-order Runge-Kutta (RK4) integration scheme. At $d \pm 7$ days, particle positions are analyzed and assigned to the

Figure 23 presents the raw and cumulative distributions of segment autocoherence scores for anticyclonic and cyclonic eddy networks. For a given segment, the resulting score is referred to as autocoherence because particle positions are compared with the future or past evolution of the same segment. In both atlases, the raw distributions exhibit a pronounced maximum at high

56. Figure 24a: Nice figure, and I understand why it's placed here to introduce M, M1, M2, etc., but you could show it earlier in the text, even if the naming convention would only make full sense at this point. I think Figure 24 does a reasonable job showing that merging/splitting events are fairly well detected (though it could also simply reflect that merged eddies M are larger than M1/M2). Since the Lagrangian method itself isn't well explained, however, this isn't entirely clear.

We thank the reviewer for this suggestion. We agree that Figure 24a provides a clear schematic representation of merging and splitting events. However, its primary purpose is to introduce the notation (M, M1, M2, S, S1, S2) used in the Lagrangian coherence analysis presented in this section. For this reason, we believe it is best placed alongside the corresponding diagnostics. Earlier in the manuscript, the segmentation procedure and the definition of interaction events are already illustrated using dedicated figures in the Data and Methods section. We therefore prefer to keep Figure 24 in its current location. As mentioned in the previous response, additional details on the Lagrangian methodology have been added in the revised manuscript to improve reproducibility and facilitate the interpretation of the coherence diagnostics.

57. General comment on the Conclusion: The conclusion isn't bad in itself, but it's long while not always conveying clear information. The final paragraph on future developments is of great interest, but it isn't linked to existing related work, whether using numerical models or Argo profiles. Additionally, you mention "next-generation sea surface height products" without mentioning the SWOT mission.

We thank the reviewer for these remarks. We agree that the future developments section could better connect the perspectives offered by META4.0 to ongoing observational efforts. Following the reviewer's suggestion, we revised this paragraph to explicitly mention the SWOT mission and to better position the future use of Argo observations within the broader context of eddy characterization studies. The conclusion has been revised accordingly while preserving its overall structure, which aims to summarize both the main characteristics of the dataset and the different validation analyses presented throughout the manuscript.

> Future developments will include the application of the detection and tracking methods to next-generation sea surface height products, including datasets benefiting from the SWOT mission and forthcoming high-resolution altimetric products. In paral-

I am, of course, available for a next round of review and really hope the authors will make the effort to improve the manuscript, as I strongly support the publication of this database in ESSD.

Rémi Laxenaire

Sincerely,

The authors