

MS No.: essd-2025-683

Title: A Global Eddy Splitting and Merging Trajectory Dataset Based on Satellite Altimetry Utilizing Eddygroup, Eddytree and Eddygraph

Author(s): Fenglin Tian et al.

**Dear Reviewer,**

We highly appreciate the detailed and valuable comments of the referee on our manuscript entitled “A Global Eddy Splitting and Merging Trajectory Dataset Based on Satellite Altimetry Utilizing Eddygroup, Eddytree and Eddygraph (ID: essd-2025-683)”. These comments are all valuable and helpful for revising and improving our paper, as well as providing important guidance for our research. In the past few days, we have referred to the comments and improved the paper.

As follows, we would like to clarify some of the points raised by the Reviewer. The original comments begin with “**Comment**” and are quoted in italicized font, the responses begin with “**Response**” in normal font, **the original sentences and phrases are in blue letters, the revised sentences and phrases are in red letters, and the line number in the revised manuscript is highlighted in yellow.** We appreciate the Reviewer’s warm work and taking the time to review the manuscript, and we hope that the corrections will meet with approval.

Yours Sincerely,

Fenglin Tian, Xiangwen Kong, Yingying Zhao, Ge Chen

2026-3-1

## List of Major Changes:

Contents	Description of major changes	Corresponding to the reviewers' comments
Improved Conceptual Definitions and Method Transparency	<ol style="list-style-type: none"> <li>1. We clarified the definitions of seed point, eddygroup, multi-core eddy, and eddygroup polarity.</li> <li>2. We revised the related descriptions and schematic figure to improve clarity and reproducibility.</li> </ol>	RC1
Enhanced Tracking and Normalization Methodology	<ol style="list-style-type: none"> <li>1. We clarified the tracking workflow from segments to branches and eddygraphs.</li> <li>2. We expanded the description of the normalization procedure for two-eddy structures, parent eddygroups, and post-merging/pre-splitting structures.</li> </ol>	RC1 and RC2
Addition of Quantitative Dataset Information	<ol style="list-style-type: none"> <li>1. We added key quantitative statistics of the dataset in the abstract, including the numbers of eddies, eddygroups, eddytrees, and eddygraphs.</li> <li>2. We supplemented statistics on the size of large root-node eddygroups and the proportions of two-object versus multi-object events.</li> </ol>	RC1
Clarification of Identification Parameters and Dataset Coverage	<ol style="list-style-type: none"> <li>1. We clarified the main identification parameters, including pixel-number threshold, shape error, amplitude threshold, and seed-point window size.</li> <li>2. We explained their relation to spatial resolution and clarified the current limitation in the Arctic Ocean.</li> </ol>	RC1 and RC2
Refinement of Figures and Result Presentation	Several figures were revised to improve readability and consistency with the text, including clearer legends, added event-date annotations, improved color schemes, and a zoomed-in panel for the Hawaiian Islands region.	RC1
Strengthened Discussion and Manuscript-Wide Revision	We refined the discussion of splitting and merging processes, clarified the current scope of the study, and thoroughly revised the manuscript for language, grammar, wording, figure citations, and formula accuracy.	RC1 and RC2

## To RC 1:

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### **Comment:**

*This manuscript presents a novel and valuable dataset detailing the complex behaviors of mesoscale eddies, specifically their splitting and merging. The work is generally well-organized and the figures are illustrative. However, there are still some aspects of the methodology, result and presentation require clarification and minor revision to enhance the manuscript's rigor, clarity, and overall quality before it can be considered for publication in ESSD.*

### **Response:**

Thank you for the constructive comments on our study. We are pleased that the reviewer recognizes the value of this dataset in describing the complex behaviors of mesoscale eddies, particularly their splitting and merging processes, and considers the manuscript to be well organized with informative figures. Following the reviewer's suggestions, we have thoroughly revised the manuscript, with particular attention to further clarifying and improving the descriptions of the methodology, the interpretation of the results, and the overall presentation to enhance the rigor of the study. All specific revisions are addressed point by point in the responses below and have been marked accordingly in the revised manuscript.

### **Major Comments:**

#### **Comment:**

*1. Lines 91-93, 142-143, 153-154, 160, Fig. 1: The definition and representation of 'Eddygroup' raise several interconnected questions:*

*(1) Polarity of dipole structures: The manuscript does not discuss the handling of dipole eddies (a cyclone and anticyclone in close proximity) within the 'Eddygroup' framework. What proportion of identified 'Eddygroup' are such dipoles? Is it physically meaningful to define a single polarity for an 'Eddygroup' that contains both cyclonic and anticyclonic features, as implied by the color-coding in Figure 1? This simplification could potentially bias the analysis of regional polarity distributions, such as the very low proportion of cyclonic eddies south of the Kuroshio Extension shown in*

Figure 2.

(2) *Group size and scale: The concept of a ‘root eddygroup’ could theoretically grow to encompass basin-scale features (e.g., a gyre). What is the physical rationale for grouping such large-scale features? The manuscript should report the statistical distribution of ‘Eddygroup’ sizes (e.g., maximum diameter or area) over the 31-year dataset to provide context.*

(3) *There are inconsistencies in Figure 1 that need clarification. Specifically, ‘Eddygroup 4’ is shown without a ‘seed point’, which appears to contradict the definition provided in Lines 133-135. Furthermore, the caption for Figure 1 must explicitly state what the red and blue points signify.*

**(1)Response:** Thank you for your thorough reading and insightful comments. Dipoles represent an important form of interaction occurring between eddies of opposite polarity. However, this study primarily focuses on the processes of eddy splitting and merging. Our statistical results show that nearly all splitting and merging events occur between eddies of the same polarity. Nevertheless, eddygroup structures usually contain multiple eddies, and dipole eddies can also be present within them. Considering the limitation of the manuscript length, the statistical characteristics and further analysis of dipoles contained within eddygroups will be investigated in future work. In addition, the multi-year distribution map of eddytree polarity and ocean circulation shown in Fig. 14, distinct cyclonic and anticyclonic eddytree structures are observed on the two sides of strong warm–cold current confluence regions. This structure exhibits a dipole-like spatial pattern, characterized by a pair of cyclonic and anticyclonic eddytrees separated by a relatively strong jet. The relevant description has been added to the manuscript.

- Original sentence:

“(2) in frontal zones where strong cold and warm currents meet, such as the Oyashio–Kuroshio (1–3) and Labrador–Gulf Stream Current (2–4) confluence zones, a distinct boundary between cyclonic and anticyclonic eddytrees is observed, which extends from the circulation into the interior ocean and gradually weakens;”

- Revised sentence:

“(2) in frontal zones where strong cold and warm currents meet, such as the Oyashio–

Kuroshio (1–3) and Labrador–Gulf Stream Current (2–4) confluence zones, a distinct boundary between cyclonic and anticyclonic eddytrees is observed, forming a dipole-like eddytree structure. This boundary extends into the interior ocean and gradually weakens;” (Please see Line 379-382)

Regarding the definition of eddygroup polarity, this study adopts a criterion similar to that used for eddy polarity. Specifically, the polarity of an eddygroup is determined by comparing the mean height of its internal child nodes with the boundary height of the eddygroup: if the mean height exceeds the boundary height, the eddygroup is classified as anticyclonic; otherwise, it is classified as cyclonic. We believe that eddygroup polarity reflects physical characteristics similar to those of eddy polarity to some extent. However, its detailed physical oceanographic significance still requires further investigation, which will be explored in future work.

In addition, an anticyclonic eddygroup may contain cyclonic eddies and cyclonic eddygroups, and a cyclonic eddygroup may also contain anticyclonic eddies and anticyclonic eddygroups. Considering the length of the manuscript, the statistical characteristics and mechanisms of these relationships will be further investigated in future work based on the dataset presented in this paper.

Based on the above discussion, we have revised the corresponding statements in the Future Work section of the manuscript accordingly:

- Original sentence:

“First, the present study only provides a preliminary exploration of the relationship between eddytree structures and large-scale ocean circulation.”

- Revised sentence:

“First, this study provides a preliminary definition of the polarity of eddygroups and eddytrees; however, their physical oceanographic significance still requires further investigation. The inclusion relationships between eddygroups and eddies of different polarities, along with the interaction mechanisms of dipoles within eddygroups, also remain to be explored. In addition, this study only presents a preliminary exploration of the relationship between eddytree structures and large-scale ocean circulation.”

(Please see Line 605-609)

**(2)Response:** Thank you for the valuable comments. In theory, the area of the largest root-node eddygroup in an eddytree could extend to the basin scale (e.g., in regions near the Kuroshio Extension or the Gulf Stream). However, the corresponding physical significance still requires further investigation, and this issue will be explored in future work.

We conducted a further analysis of the spatial distribution of large root-node eddygroups. The major large-scale eddygroups consistently occupy several distinct regions, including the anticyclonic eddygroup south of the Kuroshio Extension, the cyclonic eddygroup north of the Kuroshio Extension, the anticyclonic eddygroup south of the Gulf Stream, the cyclonic eddygroup north of the Gulf Stream, and the anticyclonic eddygroup near the Brazil Current. Our statistics show that the average areas of these root-node eddygroups over 31 years are approximately 8.67 million km<sup>2</sup> (the anticyclonic eddygroup south of the Kuroshio Extension), 4.45 million km<sup>2</sup> (the cyclonic eddygroup north of the Kuroshio Extension), 7.30 million km<sup>2</sup> (the anticyclonic eddygroup south of the Gulf Stream), 3.35 million km<sup>2</sup> (the cyclonic eddygroup north of the Gulf Stream), and 5.05 million km<sup>2</sup> (the anticyclonic eddygroup near the Brazil Current), respectively. The largest eddygroup occurred on 8 October 1994 south of the Kuroshio Extension, with an area exceeding 19.64 million km<sup>2</sup>. The corresponding information has been added to the manuscript.

- Added sentence:

“According to our statistics, the mean areas of the anticyclonic eddygroup south of the Kuroshio Extension, the cyclonic eddygroup north of the Kuroshio Extension, the anticyclonic eddygroup south of the Gulf Stream, the cyclonic eddygroup north of the Gulf Stream, and the anticyclonic eddygroup near the Brazil Current are approximately 8.67 million km<sup>2</sup> (the anticyclonic eddygroup south of the Kuroshio Extension), 4.45 million km<sup>2</sup> (the cyclonic eddygroup north of the Kuroshio Extension), 7.30 million km<sup>2</sup> (the anticyclonic eddygroup south of the Gulf Stream), 3.35 million km<sup>2</sup> (the cyclonic eddygroup north of the Gulf Stream), and 5.05 million km<sup>2</sup> (the anticyclonic eddygroup near the Brazil Current), respectively. Among them, the largest eddygroup occurred on 8 October 1994 south of the Kuroshio Extension, with an area exceeding

19.64 million km<sup>2</sup>.” (Please see Line 364-371)

**(3)Response:**

Thank you for your thorough review. We have made the following revisions to address the issue:

- Regarding the absence of a seed point in Eddygroup 4, the original manuscript’s description was unclear and may have led to confusion. Therefore, we have re-examined and revised the definition of an eddygroup as follows:

- Original sentence:

“A multi-core eddy is defined as a closed contour enclosing multiple seed points and is considered as a special type of eddy. An eddygroup is defined as a closed contour that encloses multiple seed points or eddies.”

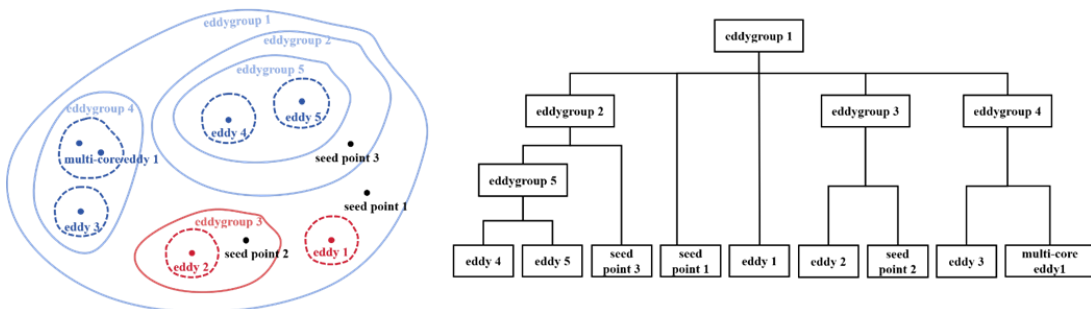
- Revised sentence:

“An eddygroup is defined as a closed contour region containing two or more objects (seed points, eddies, or nested eddygroups). If the region contains only multiple seed points, it is defined as a multi-core eddy.” (Please see Line 147-149)

With this updated definition, Eddygroup 4 in Figure 1, which includes one eddy and one multi-core eddy, meets the criteria of containing two objects and thus aligns with the definition used in this study.

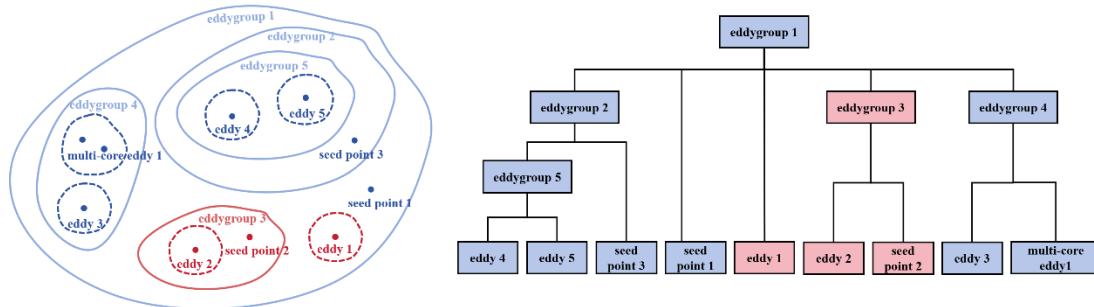
- The caption of Figure 1 did not clearly explain the meaning of the differently colored points. In response, we have revised Figure 1 and its corresponding caption accordingly. In addition, the polarity of the seed points is now distinguished in the figure based on whether they correspond to local maxima or local minima. The specific revisions are as follows:

- Original figure:



**Figure 1: Schematic illustration of seed points, eddies, multi-core eddies, eddygroups, and the eddytree. In the left panel, red and blue dashed lines represent anticyclonic and cyclonic eddies or multi-core eddies, respectively, whereas red and blue solid lines denote anticyclonic and cyclonic eddygroups, respectively. The right panel shows the nested relationships as illustrated in the left panel.**

- Revised figure:



**Figure 1: Schematic illustration of seed points, eddies, multi-core eddies, eddygroups, and the eddytree. In the left panel, red and blue dashed lines represent anticyclonic and cyclonic eddies or multi-core eddies, respectively, whereas red and blue solid lines denote anticyclonic and cyclonic eddygroups, respectively. Red and blue points represent anticyclonic and cyclonic seed points, respectively. The right panel shows the nested relationships as illustrated in the left panel, blue and red background rectangles denote cyclonic and anticyclonic polarities, respectively. (Please see Line 155-159)**

**Comment:**

2. (1) The exact role of a ‘seed point’ needs to be clarified (lines 133-135). What is its specific function, and how does it differ from the eddy’s center of mass (centroid)? This distinction is crucial for understanding the tracking logic. (2) Lines 217-218: The threshold for grouping eddies, defined as up to 4000 grid points (equivalent to an area of  $500^{\circ} \times 500^{\circ}$ ), appears exceptionally large—potentially covering half an ocean basin. Please verify and clarify this critical parameter. What is the observed maximum size of an ‘Eddygroup’ in the 31-year dataset? Additionally, please define the ‘shape error’ mentioned in Line 218. (3) In line 260, please specify if the “predicted position of an eddy” refers to its centroid.

**(1)Response:** We appreciate your thoughtful comment regarding the seed points. Seed points are defined as local extrema. Since cyclonic and anticyclonic eddies exhibit concave and convex geometric characteristics, respectively, the occurrence of an extremum generally indicates that the region is likely located within an eddy or has the potential to develop into an eddy. To clarify this, we have added the description of seed points in the manuscript:

- Added sentence:

“The occurrence of a seed point generally indicates that the region is likely located within an eddy or has the potential to develop into an eddy; therefore, the identification of seed points forms the basis for eddy detection.” (Please see Line 142-144)

A seed point within an eddy represents the highest or lowest point in the eddy’s geometric structure, whereas the eddy centroid represents the geometric center of the eddy in two-dimensional space. Previous research has used the central particle of a rotating body to represent an eddy and to perform particle drifting during eddy tracking (Jones-Kellett and Follows, 2024), or have tracked eddies using the eddy centroid (Mason et al., 2014). Compared with seed points, the eddy centroid more accurately reflects the overall spatial position of an eddy. Therefore, the centroid is used for particle drifting during tracking for identified eddies, whereas seed points are used for particle drifting for regions where eddies have not yet formed.

Reference:

Jones-Kellett, A. E. and Follows, M. J.: A Lagrangian coherent eddy atlas for biogeochemical applications in the North Pacific Subtropical Gyre, *Earth System Science Data*, 16, 1475-1501, <https://doi.org/10.5194/essd-16-1475-2024>, 2024.

Mason, E., Pascual, A., and McWilliams, J. C.: A New Sea Surface Height–Based Code for Oceanic Mesoscale Eddy Tracking, *Journal of Atmospheric and Oceanic Technology*, 31, 1181-1188, <https://doi.org/10.1175/jtech-d-14-00019.1>, 2014.

**(2)Response:** Thank you for your careful reviewing the eddy detection method section. Following previous studies (Mason et al., 2014; Faghmous et al., 2015), the pixel number  $I$ , which is used to constrain the eddy area, is set to  $20 \leq I \leq 4000$ . The upper limit  $I = 4000$  corresponds to an area of  $0.125^\circ \times 0.125^\circ \times 4000$ , which equals  $62.5 \text{ deg}^2$ , roughly the size of a circle with a radius of  $4.46^\circ$ . Therefore, this parameter represents the area of the enclosed region rather than the length of its boundary.

The issue regarding the maximum scale of eddygroups has been addressed in our response to Major Comment 1(2). The manuscript has been revised accordingly.

In addition, the shape error parameter ( $\leq 55\%$ ) used in the eddy identification follows previous studies (Mason et al., 2014). This parameter is defined as the ratio of the total area difference between the closed contour and its fitted circle to the area of that circle.

Therefore, a smaller shape error indicates that the eddy shape is closer to a circle. We have also made the corresponding revisions in the manuscript:

- Added sentence:

“The shape error is introduced to constrain the morphological characteristics of eddies and is defined as the ratio of the total area difference between the closed contour and its fitted circle to the area of that circle. Thus, a smaller shape error indicates that the eddy’s shape is closer to an ideal circle.” (Please see Line 228-231)

Reference:

Mason, E., Pascual, A., and McWilliams, J. C.: A New Sea Surface Height–Based Code for Oceanic Mesoscale Eddy Tracking, *Journal of Atmospheric and Oceanic Technology*, 31, 1181-1188, <https://doi.org/10.1175/jtech-d-14-00019.1>, 2014.

Faghmous, J. H., Frenger, I., Yao, Y., Warmka, R., Lindell, A., and Kumar, V.: A daily global mesoscale ocean eddy dataset from satellite altimetry, *Scientific Data*, 2, <https://doi.org/10.1038/sdata.2015.28>, 2015.

**(3)Response:** Thank you for your careful review. We have revised the manuscript accordingly to provide a clearer explanation of this point:

- Original sentence:

“If the predicted position of an eddy or seed point on day  $i$  falls within an eddy on day  $i+1$ , the state is classified as a live segment; If predicted positions from two different eddies or seed points on day  $i$  fall into the same eddy on day  $i+1$ , the state is classified as a merged segment;”

- Revised sentence:

“If the predicted position of an eddy centroid or a seed point on day  $i$  falls within an eddy on day  $i+1$ , the state is classified as a live segment; If the predicted positions of two objects (either eddy centroids or seed points) on day  $i$  fall within the same eddy on day  $i+1$ , the state is classified as a merged segment;” (Please see Line 280-282)

### **Specific Comments and Minor Revisions:**

#### **Comment:**

1. *The abstract would be significantly strengthened by including key quantitative results, such as the total number of eddies, seed points, Eddygroups, Eddytrees, and*

*Eddygraphs identified in the dataset.*

**Response:** Thank you for the valuable suggestion. The original abstract did not include quantitative details about the dataset statistics. Following the reviewer's suggestion, we have added the main statistical results of the dataset to the abstract to present the scale and characteristics of the dataset more clearly.

- Added sentence:

“The identification dataset contains 56,948,049 eddies and 29,842,033 eddygroups, from which 12,198,840 eddytrees were constructed. The tracking dataset contains 925,381 eddygraphs associated with splitting and merging events.” (Please see Line 19-21)

**Comment:**

*2. Line 40: When introducing eddy detection methods, the Lagrangian perspective should be given a brief (1-2 sentence) description. It would also be helpful to succinctly state the fundamental difference between the Eulerian and Lagrangian eddy detection methods.*

**Response:** Thank you for the valuable suggestion. Following the reviewer's recommendation, we have added a brief description of Lagrangian eddy detection methods and clarified the differences between Eulerian and Lagrangian approaches to provide a clearer comparison between the two methods.

- Original sentence:

“Eulerian methods are relatively simple and efficient, and can be broadly classified into three categories.”

- Revised sentence:

“Lagrangian methods identify eddy structures by analyzing the motion of fluid particles over a finite time interval, typically requiring significant computational resources. Among them, the black-hole eddy method identifies eddies by locating materially closed eddy boundaries based on the theory of Lagrangian coherent structures (LCS) (Tian et al., 2025). The LAVD method detects eddies by computing the Lagrangian-averaged vorticity deviation and identifying fluid structures that rotate coherently around a core over a finite time interval (Tian et al., 2022). In contrast,

Eulerian eddy detection methods identify eddies based on instantaneous flow-field properties and are computationally simpler and more efficient. These Eulerian methods are generally classified into three categories.” (Please see Line 43-50)

Reference:

Tian, F., Zhao, Y., Qin, L., Long, S., and Chen, G.: A Black Hole Eddy dataset of North Pacific Ocean based on satellite altimetry, *Earth System Science Data*, 17, 7119-7145, <https://doi.org/10.5194/essd-17-7119-2025>, 2025.

Tian, F., Wang, M., Liu, X., He, Q., and Chen, G.: SLA-Based Orthogonal Parallel Detection of Global Rotationally Coherent Lagrangian Vortices, *Journal of Atmospheric and Oceanic Technology*, 39, 823-836, <https://doi.org/10.1175/jtech-d-21-0103.1>, 2022.

**Comment:**

*3. Line 63: The authors' 2021 work is mentioned here. It would be highly informative to compare the characteristics of eddy splitting and merging in the North Pacific with those observed in other global oceans in the Results section (e.g., section 3.1).*

**Response:** Thank you for the valuable suggestion. In our previous study, we primarily examined mesoscale eddy splitting and merging events in the North Pacific. In contrast, the present study extends this analysis to the global ocean and constructs a global-scale dataset. Since eddytrees and eddygroups exhibit highly uneven spatial distributions across the ocean, the frequencies of splitting and merging events of leaf-node eddies in eddytrees also vary significantly among different oceanic regions.

This study mainly concentrates on identification method and overall statistical characteristics of eddy splitting and merging events on a global scale. A systematic comparison of these events among different ocean regions has not yet been conducted. In future work, we plan to further investigate regional differences in eddy splitting and merging events and to compare the splitting and merging behaviors of eddies within eddytree structures and independent eddies, in order to provide a more comprehensive understanding of the regional characteristics of mesoscale eddy splitting and merging processes throughout the global ocean.

- Added sentence:

“this study develops a global dataset of eddy splitting and merging events, but the variations in their spatial distribution across different ocean regions need more detailed examination.” (Please see Line 616-618)

**Comment:**

4. Line 180: Does the analysis consider splitting or merging events involving more than two eddies simultaneously (e.g., three eddies merging into one eddy)? If so, what is the approximate proportion of such multi-eddy events?

**Response:** Thank you for the constructive comments. While tracking the processes of eddy splitting and merging, we do observe instances where multiple eddies merge or a single eddy splits into multiple parts. According to our statistics, in merging events, the proportion of events involving three or more eddies/seed points is 8.52%; and in splitting events, 4.13% result in three or more objects. Overall, eddy merging is dominated by events involving two objects, and eddy splitting mainly characterized by events producing two objects. Therefore, this study primarily focuses on the merging between two eddies and the splitting of an eddy into two. More complex cases involving multiple eddies merging or splitting into multiple eddies will be further investigated in future work. The corresponding information has been added in the manuscript:

- Added sentence:

“Taking the merging of two eddies and the splitting of an eddy into two eddies as examples,” (Please see Line 182)

- Added sentence:

“Among these, merging events involving two eddies or seed points account for 91.48% of all merging events, whereas events splitting into two objects account for 95.87% of all splitting events.” (Please see Line 351-353)

- Added sentence:

“Additionally, the research primarily concentrates on the morphological characteristics of the eddy splitting and merging processes involving two eddies, while those involving three or more eddies remain to be further explored.” (Please see Line 618-619)

**Comment:**

5. *Figure 9 (Line 265): Please add a legend or caption text to explain the meaning of the black, blue, and red points in Figure 9.*

**Response:** Thank you for the helpful suggestion. Following the reviewer's recommendation, we have added an explanation to the caption of Figure 9 to clarify the meanings of the black, blue, and red points, enhancing the figure's clarity.

- Original sentence:

“Figure 9. Schematic illustration of the segment construction. In this figure, black denotes eddies on day  $i$ , blue denotes eddies on day  $i+1$ , and red dots represent predicted particle positions on day  $i+1$ , advected from day  $i$  by particle drifting.”

- Revised sentence:

“Figure 9. Schematic illustration of the segment construction. The black closed contours represent eddies on day  $i$ , and the black dots denote the eddy centroids or seed points of multi-core eddies on day  $i$ . The blue closed contours represent eddies on day  $i+1$ , and the blue dots denote the eddy centroids on day  $i+1$ . The red dots represent predicted particle positions on day  $i+1$ , advected from day  $i$  by particle drifting.”

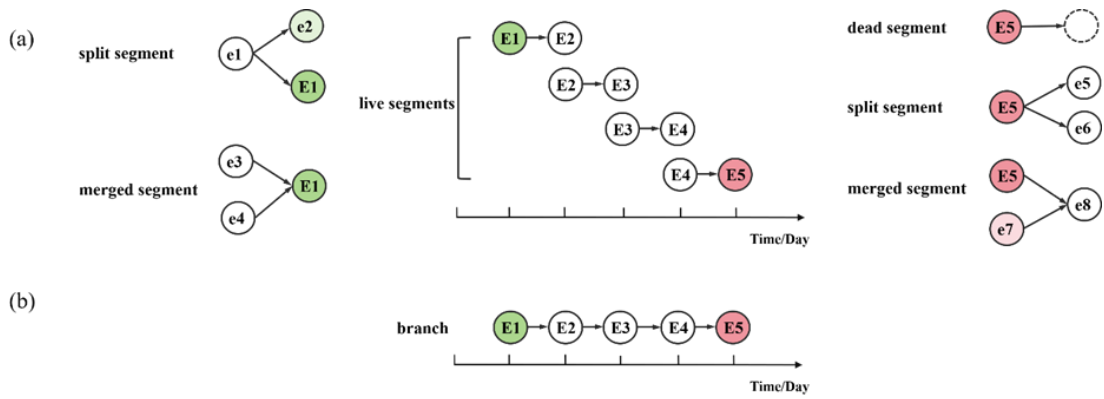
(Please see Line 286-289)

**Comment:**

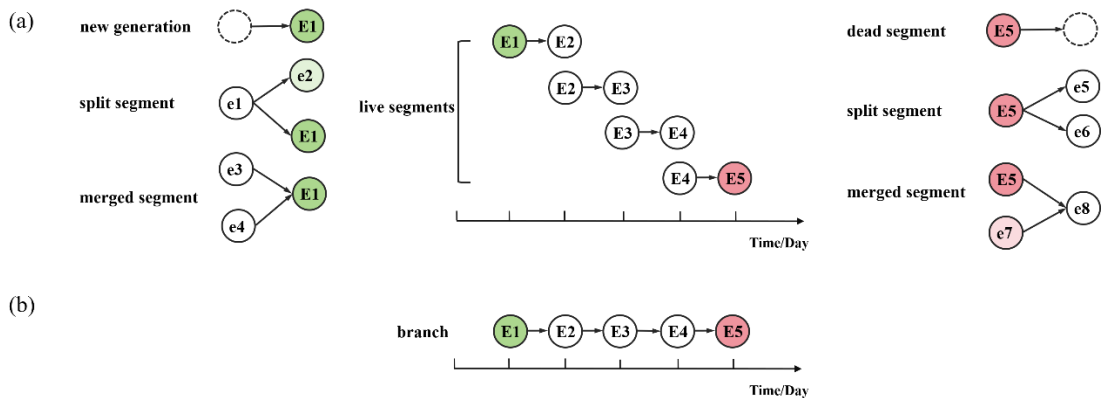
6. *Figure 10 (Line 280): To improve clarity and align with the text, it is recommended to add a third schematic to the left side of Figure 10 illustrating a "new generation" of an eddy.*

**Response:** We appreciate the useful suggestion. Following the reviewer's recommendation, we have added an extra schematic on the left side of Figure 10 to illustrate the case of a newly generated eddy (“new generation”). This modification improves the consistency between the figure and the text, and enhances the clarity and completeness of the figure.

- Original figure:



- Revised figure:

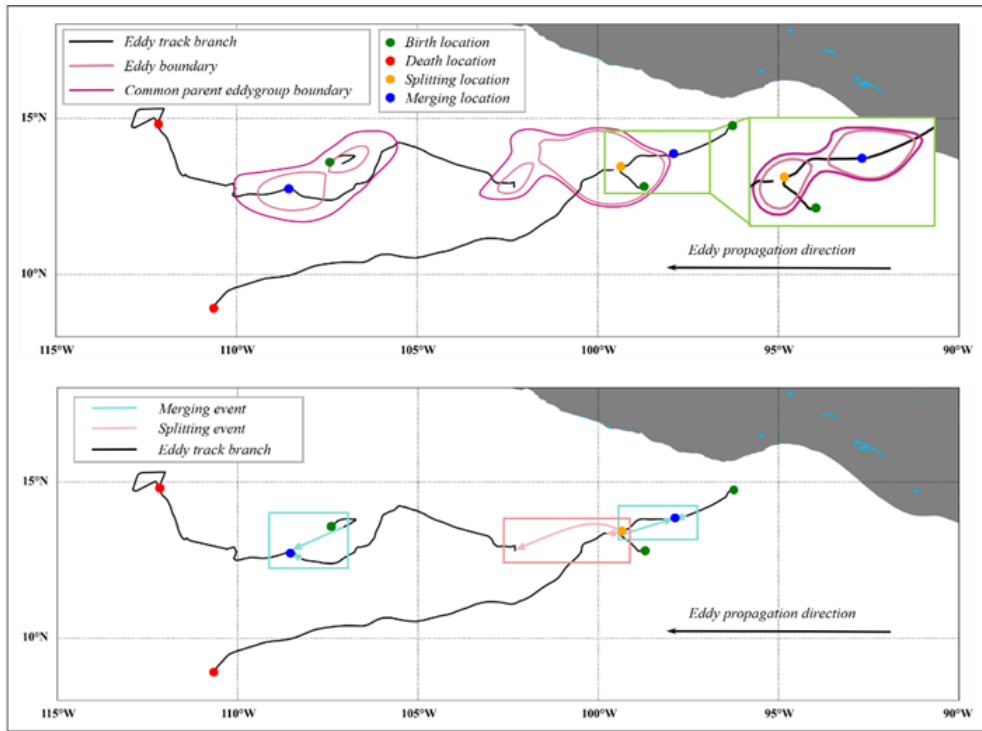


**Comment:**

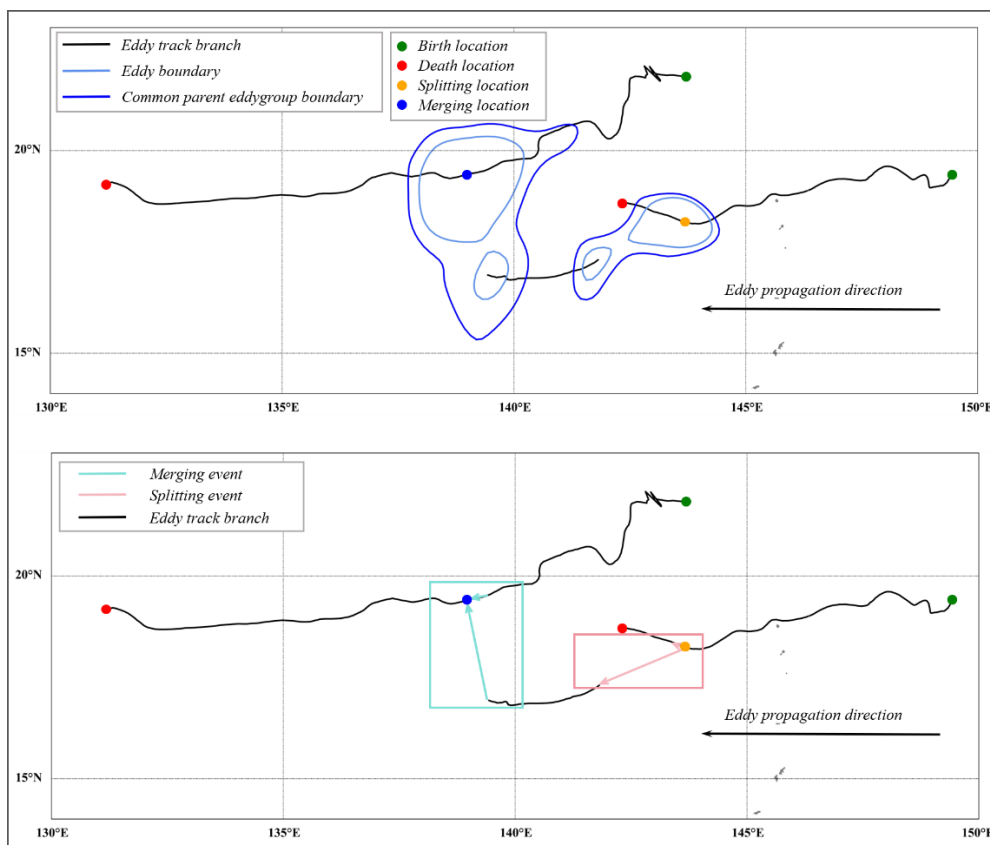
7. Figure 12 (Lines 295): This is a key figure for demonstrating the tracking. It would greatly benefit the readers if the specific dates (or timesteps) for the initiation and completion of each splitting and merging event were annotated directly on the figure panels. Also, please correct the figure citation in the text; it should be Figure 12, not Figure 18 (lines 303, 306).

**Response:** Thank you for the careful examination of the tracking results. As suggested by the reviewer, annotating the timing of splitting and merging events on the figure can more clearly illustrate the evolution of these events and improve the informativeness and readability of the figure. Accordingly, we have added annotations indicating the dates of eddy birth, death, splitting, and merging at the corresponding positions in the figure, using corresponding colors. The figure caption has also been updated accordingly.

- Original figure:

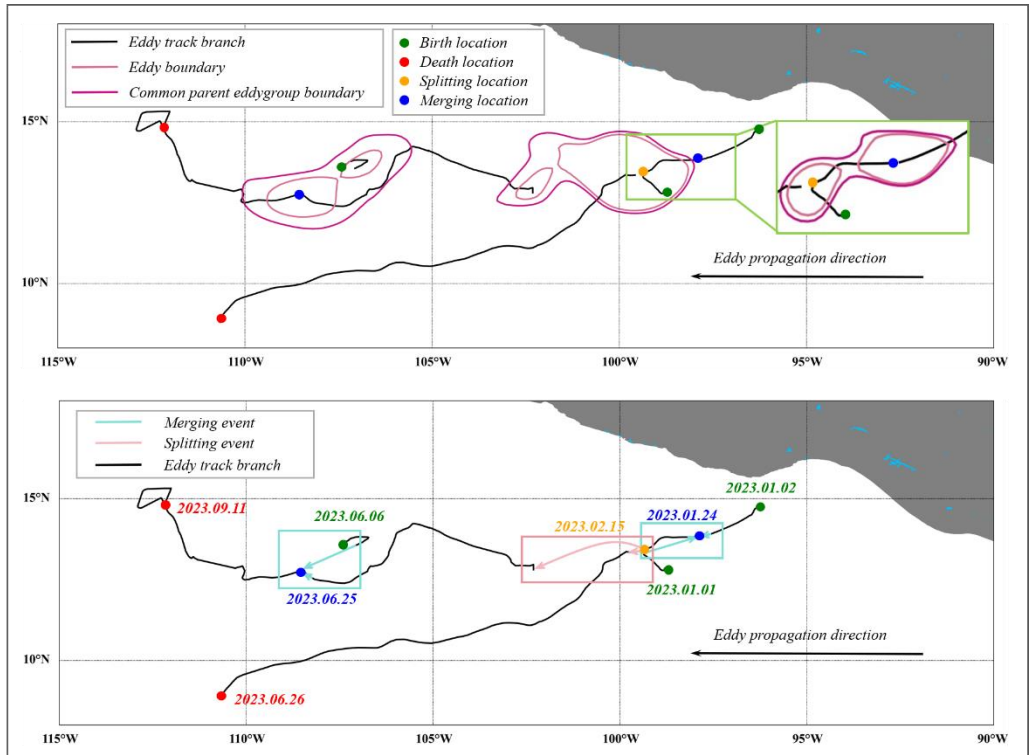


(a)

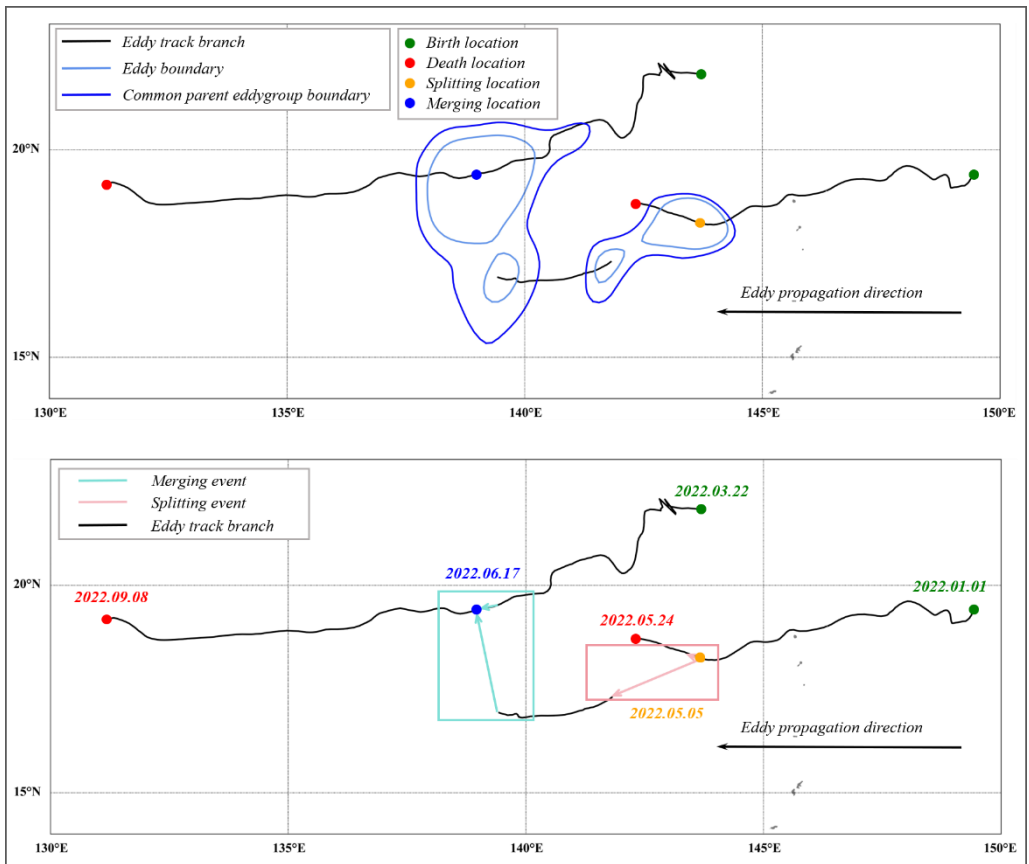


(b)

- Revised figure:



(a)



(b)

- Added sentence:

“The dates marked in green, red, yellow, and blue indicate the timing of eddy birth, death, splitting, and merging, respectively.” (Please see Line 327-328)

In addition, the incorrect figure citations in the manuscript have been corrected. The previously cited Figure 18 has been revised to Figure 12. (Please see Line 332 and Line 335)

**Comment:**

8. Figure 14 (Line 350): For enhanced clarity, consider drawing a box on Figure 14 to highlight the Karman vortex street region near the Hawaiian Islands mentioned in the text (Line 345). Furthermore, the current colorbar makes it difficult to distinguish lifetime anomalies between -100 and 100 days. A suggested improvement is to use a diverging colormap with a clear break at zero, for example, a yellow-orange-red scheme for positive values (0-300 days) and a light-to-dark blue/purple scheme for negative values (-300-0 days).

**Response:** Thank you for your constructive suggestions regarding the figure. Following the reviewer’s comments, we have revised Figure 14 to improve its clarity and readability.

Firstly, we added a zoomed-in section of the area near the Hawaiian Islands on the bottom of the figure to better depict the spatial pattern of the Kármán vortex street, making it more consistent with the description in the text.

Secondly, to improve differentiation within the -100 to 100 range on the original colorbar, we modified it by using white to represent zero and applying a diverging color scheme—cool colors indicate negative values and warm colors indicate positive values. This change makes it easier to distinguish positive and negative variations around zero in the annual mean distribution of eddytrees. Additionally, to further enhance the overall readability of the figure, we adjusted the colors of the arrows and land areas to match the new colorbar.

Correspondingly, the figure caption and two related descriptions in the manuscript have been revised. The detailed revisions are as follows:

- Original figure:

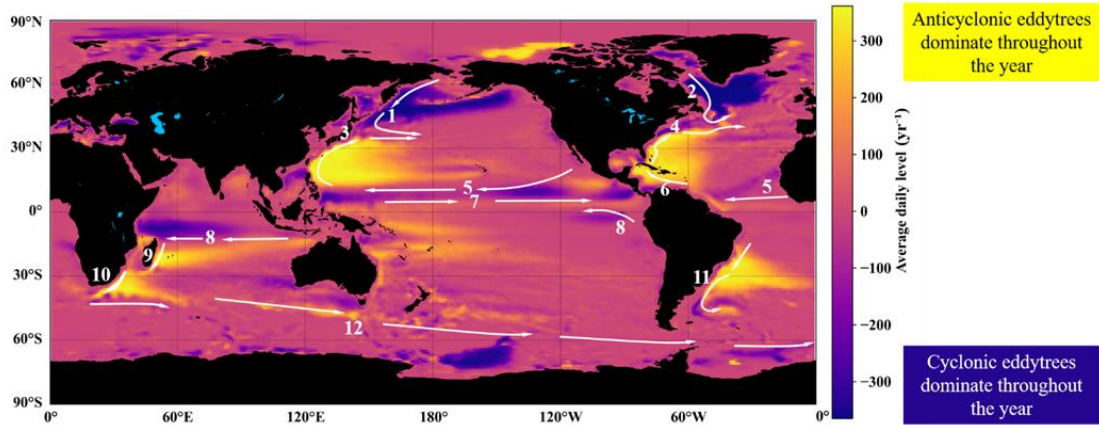


Figure 14. Annual average distribution of eddytree root polarities and associated ocean circulation. Numbers in the figure indicate: 1 – Oyashio Current, 2 – Labrador Current, 3 – Kuroshio, 4 – Gulf Stream, 5 – North Equatorial Current, 6 – Caribbean Current, 7 – Equatorial Counter Current, 8 – South Equatorial Current, 9 – East Madagascar Current, 10 – Agulhas Current, 11 – Brazil Current, 12 – Antarctic Circumpolar Current.

- Revised figure:

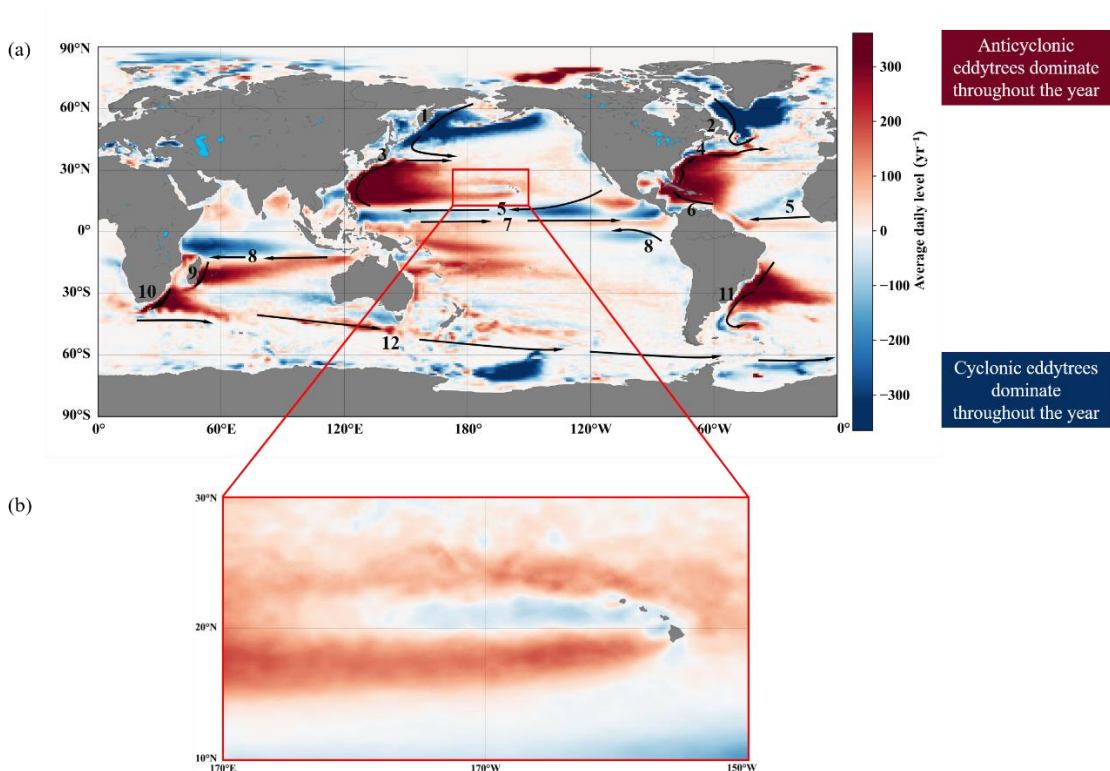


Figure 14. Annual average distribution of eddytree root polarities and associated ocean circulation. In panel (a), Numbers indicate: 1 – Oyashio Current, 2 – Labrador Current, 3 – Kuroshio, 4 – Gulf Stream, 5 – North Equatorial Current, 6 – Caribbean Current, 7 – Equatorial Counter Current, 8 – South Equatorial Current, 9 – East Madagascar Current, 10 – Agulhas Current, 11 – Brazil Current, 12 – Antarctic Circumpolar Current. Panel (b) shows a zoomed-in view of the annual mean distribution of eddytrees near the Hawaiian Islands. (Please see Line 388-392)

- Original sentence:

“(1) In western boundary regions, strong currents constrained by continental margins—such as the 3–Kuroshio, 4–Gulf Stream, 6–Caribbean Current, 9–East Madagascar Current, 10–Agulhas Current, and 11–Brazil Current—are associated with values exceeding  $+300 \text{ yr}^{-1}$  (shown in bright yellow), indicating a persistent dominance of anticyclonic eddytrees;”

- Revised sentence:

“(1) In western boundary regions, strong currents constrained by continental margins—such as the 3–Kuroshio, 4–Gulf Stream, 6–Caribbean Current, 9–East Madagascar Current, 10–Agulhas Current, and 11–Brazil Current—are associated with values exceeding  $+300 \text{ yr}^{-1}$  (shown in dark red), indicating a persistent dominance of anticyclonic eddytrees;” (Please see Line 377-379)

- Original sentence:

“(3) in open-ocean regions, island topography such as the Hawaiian Islands obstructs the flow, resulting in von Kármán–type vortex-street structures in the wake region of the islands;”

- Revised sentence:

“(3) in open-ocean regions, island topography such as the Hawaiian Islands obstructs the flow, resulting in von Kármán–type vortex-street structures in the wake region of the islands (as shown in Figure. 14b);” (Please see Line 382-384)

**Comment:**

*9. Lines 395-398: The observation that the number of splitting events increases after filtering is counterintuitive, especially since earlier (Line 372) it was stated that before filtering, merging events were three times more frequent than splitting events. Please provide a clear explanation for why the filtering criteria preferentially retain or identify more splitting events.*

**Response:** Thank you for raising this important question. In the initial statistical analysis, the number of merging events is approximately three times that of splitting events. This difference might be partly due to survivor bias. After splitting events, many newly generated eddies are relatively small in scale and may be difficult to detect using

the currently available altimetry observations, potentially causing an undercount of splitting events in the data. In addition, this study primarily focuses on merging events involving two eddies and splitting events producing two eddies. After applying the filtering criteria, some merging events that do not meet the research conditions are excluded, while part of the splitting events are retained, which increases the proportion of splitting events in the filtered data.

The underlying reasons for this phenomenon require further investigation and will be explored in future work.

**Comment:**

*10. Technical Corrections:*

*(1) Lines 142-143: This text appears to be a repetition of lines 135-137 and should be removed.*

*(2) Line 415: Please explicitly define  $d(n)$  as the distance between the centroids of two eddies.*

**(1)Response:** Thank you for your careful review. Regarding the comment that lines 142–143 repeat the content of lines 135–137, we would like to clarify that lines 135–137 explain the polarity determination method for eddies, while lines 142–143 address the method for eddygroups. Since the two criteria are based on similar principles, their descriptions are also similar. In the original manuscript, the description of the eddygroup polarity criterion was somewhat redundant and may have caused confusion. To improve clarity and avoid ambiguity, we have revised the relevant description in the manuscript.

- Original sentence:

“Applying the same polarity criterion, the polarity of an eddygroup is distinguished by calculating the mean height of its children—the seed points, the centroids of eddies and multi-core eddies—together with the boundary height of the child node eddygroup, and comparing this mean value to the boundary height of the eddygroup. If the mean height exceeds the boundary height, the eddygroup is classified as anticyclonic; otherwise, it is classified as cyclonic.”

- Revised sentence:

“Applying the same polarity criterion, this study also determines the polarity of an eddygroup. Specifically, the average height of the objects directly contained within the eddygroup is calculated, where the height of seed points, the centroid height of eddies and multi-core eddies, and the boundary height of nested eddygroups are used, respectively. If this average value exceeds the boundary height of the eddygroup, it is classified as an anticyclonic eddygroup; otherwise, it is classified as a cyclonic eddygroup.” (Please see Line 149-153)

**(2)Response:** Thank you for the helpful suggestion of the normalization method. The explanation of  $d(n)$  in the original manuscript was not sufficiently clear. Following the reviewer’s suggestion, we have added a clarification in the revised manuscript, defining  $d(n)$  as the distance between the centroids of the two eddies:

- Original sentence:

“To remove scale differences, the mean distance  $d(n)$  between the two eddies on day  $n$  (prior to merging or after splitting) is used to define a scaling factor  $S(n)$ .”

- Revised sentence:

“To remove scale differences, the mean distance  $d(n)$  between the centroids of the two eddies on day  $n$  (prior to merging or after splitting) is used to define a scaling factor  $S(n)$ .” (Please see Line 454-456)

To RC 2:

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**Comment:**

*This data paper presents a nice framework for global eddy identification and tracking by enhancing the efficiency of the detection algorithm and incorporating a particle-drift approach for trajectory tracking. The authors provide a 31-year dataset (1993-2023) containing daily global eddy identification results and related parameters, together with annually compiled trajectories of eddy splitting and merging events. This dataset responds to the current demand for long-term, systematically organized records of eddy evolution and has high value for research on ocean transport processes and climate variability. Furthermore, the manuscript innovatively extracts representative splitting and merging cases from the tracking dataset and applies a normalization*

*approach to investigate morphological changes of eddies and eddy groups during these interaction processes.*

*While the study demonstrates technical effort in dataset construction and attempts to summarize the statistical characteristics of eddy evolution, several aspects of the manuscript could be improved. Although the morphological analysis of eddies is meaningful, important methodological details remain insufficiently transparent; despite being described as a global dataset, the results seem to lack representation of high-latitude Arctic regions, raising questions about the effective spatial coverage of the dataset; the current analysis focuses primarily on morphological aspects of splitting and merging events, while further exploration of these processes could enhance the scientific depth of the study. In addition, the manuscript would benefit from improvements in language clarity and organization.*

*With clearer methodological description, more comprehensive spatial coverage, and strengthened analysis of eddy interaction processes, the dataset has the potential to make a valuable contribution to ESSD and the broader community studying oceanic eddies.*

**Response:**

Thank you for the thorough review of our work and the helpful feedback provided. We are glad that the reviewer recognizes the value of the dataset created in this study for identifying and tracking global mesoscale eddies, along with its potential significance for research on ocean transport processes and climate variability. We also sincerely appreciate the reviewer's valuable suggestions regarding the dataset construction methodology, the spatial coverage, and the analysis of eddy splitting and merging processes. Following the reviewer's comments, all corresponding revisions have been addressed point by point below and incorporated into the revised manuscript.

**Major Comments:**

**Comment:**

*1. Inadequate Algorithm Description and Lack of Code to Reproduce the Dataset*

*The manuscript describes the algorithms used for eddy identification, as well as for tracking eddy splitting and merging. However, the implementation details provided are*

*still insufficient, which limits the reproducibility of the dataset. The authors are therefore encouraged to:*

*(1) Publicly release or share the relevant source code;*

*(2) Provide a more thorough explanation of the eddy tracking process, specifically how segments are linked into branches and then structured into eddygraphs, as currently this is only depicted through schematic diagrams.*

*Without clearer methodological documentation, the reproducibility and long-term usability of the dataset could be limited.*

**(1)Response:** Thank you for your valuable suggestion. We fully understand the reviewer's concerns about the availability of the source code and the reproducibility of the dataset. However, due to institutional intellectual property restrictions, we are currently unable to make the source code for the eddy splitting and merging identification and tracking algorithm publicly available. Additionally, the algorithm is still being refined through ongoing internal optimization. We intend to continue this work in the future and plan to release updated versions of the dataset to support further research on the evolution of mesoscale eddies.

**(2)Response:** Thank you for your valuable suggestion. We recognize that the original manuscript did not provide enough detail about the eddy tracking process, especially concerning how segments are linked into branches and then organized into eddygraphs. Following the reviewer's suggestion, we have added a more detailed explanation in the corresponding section of the revised manuscript. The updated text is as follows:

- Original sentence:

“These segments are then linked sequentially under the constraint that the surviving target on day  $I$  corresponds to the identical target on day  $i+1$ .”

- Revised sentence:

“Since each segment records the survival relationship of an eddy between two consecutive days, the surviving target identified in the segment on day  $i$  can be used to link the live segments from day  $i$  to day  $i+1$ . Following the same rule, the live segments between day  $i+1$  and day  $i+2$  are then connected, and this procedure continues sequentially, linking live segments from consecutive days into a continuous trajectory

until no corresponding live segment can be found on the following day.” (Please see Line 293-297)

- Added sentence:

“For example, if a branch terminates with a merging event, there must exist other branches that merge into the same target eddy at the same time. Conversely, if a branch terminates with a splitting event, multiple new eddies are generated on the next day, which are then used to establish connections with the corresponding branches on that day.” (Please see Line 308-311)

**Comment:**

*2. Insufficient Detail in the Methodological Normalization Process*

*The manuscript presents a complete workflow for eddy identification, tracking, and morphological normalization. However, the explanation of the normalization procedure lacks sufficient technical detail to enable replication of the results. In particular, the normalization strategy for eddygroups is not clearly explained. In multi-eddy systems, it remains unclear how the relative spatial configuration among individual eddies and the eddygroup is preserved during the normalization process, and whether the transformation might introduce geometric distortions.*

*The authors are therefore encouraged to:*

- (1) Provide a more detailed description of the normalization algorithm and clearly explain how eddygroup structures are handled;*
- (2) Consider providing code or pseudocode.*

**(1)Response:** We appreciate your thorough review of the normalization method and your insightful suggestions. In the original manuscript, the normalization approach for eddygroups was not described in sufficient detail, and the procedure for maintaining the relative spatial relationships between eddies and eddygroups during normalization process was not clearly explained. Following the reviewer’s suggestion, we have supplemented the relevant methodological description in the revised manuscript, offering a more comprehensive explanation of the normalization process. The revised text is as follows:

- Original sentence:

“The angle  $\theta$  required to rotate this line to the horizontal is recorded, and a corresponding rotation is applied to both the eddy boundaries and the ADT background field, yielding Fig. 18b.”

- Revised sentence:

“To eliminate the influence of orientation differences of two-eddy structures across different events, the rotation angle  $\theta$  required to align the line connecting the centroids with the horizontal direction was calculated and recorded for each event at every time point. The corresponding eddy boundaries and ADT background fields were then rotated by this angle, producing the configuration shown in Fig. 18b.” (Please see Line 451-454)

- Added sentence:

“Based on the previously described two-eddy normalization procedure, the corresponding parent eddygroups were also normalized. First, the midpoint of the line connecting the centroids of the two eddies was chosen as the origin to establish the normalized coordinate system. Using the same origin as the two-eddy normalization avoids introducing relative displacement errors and preserves the spatial relationship between the parent eddygroup and the two-eddy structure throughout the normalization procedure. Next, the boundary of the parent eddygroup was then rotated by the same angle  $\theta$  derived from the corresponding two-eddy event to ensure consistent orientation. Subsequently, the scaling parameter  $S(n)$  associated with the same event was applied to scale-normalize the boundary of the parent eddygroup, yielding normalized eddygroups for each event and each time point.” (Please see Line 460-467)

- Added sentence:

“After orientation alignment, scale normalization was applied to the single-eddy structures that appear after merging and before splitting. Specifically, the scaling parameter  $S(n)$ , derived from the two-eddy structure at the nearest time step within the same event, was used to adjust the single-eddy boundary and its corresponding background field. Since the size of the eddies involved in the same merging or splitting event typically remains relatively stable over a short period, adopting the scaling parameter determined during the two-eddy stage helps maintain scale consistency in

the normalized results before and after the event, thereby facilitating meaningful comparisons of morphological characteristics across different stages.” (Please see Line 472-478)

**(2)Response:** Thank you for pointing out this issue. In response, we have expanded and clarified the relevant methodological descriptions related to the normalization process in the revised manuscript to make them more complete and transparent. Specifically, we have provided detailed explanations of the normalization procedures for the two-eddy structure, parent eddygroup, single-eddy structure, and the associated background field normalization. The code implementation follows the same procedures as those described in the manuscript.

In addition, the typical eddy splitting and merging events presented in the manuscript have been included in the dataset, enabling readers to reproduce the corresponding normalization results. With these revisions and clarifications, we believe that the current methodological description sufficiently reflects the algorithmic workflow; therefore, pseudocode has not been provided separately.

**Comment:**

*3. Lack of Sensitivity Analysis for Key Identification Parameters*

*The identification framework relies on several threshold-based criteria (e.g.,  $20 \leq I \leq 4000$ , shape error  $\leq 55\%$ , amplitude  $\geq 1$  cm, and a  $5 \times 5$  window for seed point detection). These parameters may produce region-dependent effects under different dynamical regimes (e.g., high vs. low latitudes, strong vs. weak current systems). However, the manuscript does not include a sensitivity analysis of these parameter choices.*

*Specifically:*

*(1) The potential differences in detection results across different ocean regions under the same parameter settings, as well as the influence of alternative parameter values on eddy counts, spatial distribution, and splitting–merging statistics, are not investigated;*

*(2) The relationship between the amplitude threshold and the spatial resolution of the dataset is not discussed.*

*Without such analysis, the robustness and general applicability of the dataset remain*

*insufficiently demonstrated.*

**(1)Response:** We appreciate your suggestion regarding the identification parameters. Compared with other identification approaches, SLA-based eddy detection methods are better suited for large-scale and global applications. Previous researches have applied identification parameters including eddy amplitude, area, and shape error to identify eddies on a global scale and obtained stable results. Subsequently, (Tian et al., 2019) further confirmed the applicability and reliability of this SLA-based approach for global eddy identification using all-satellite SLA data.

In this study, we follow the identification framework and parameter settings adopted in the aforementioned studies, focusing primarily on creating a global eddy dataset. Therefore, we did not perform a detailed sensitivity analysis of how parameter settings might affect identification outcomes in different ocean regions.

Reference:

Tian, F., Wu, D., Yuan, L., and Chen, G.: Impacts of the efficiencies of identification and tracking algorithms on the statistical properties of global mesoscale eddies using merged altimeter data, *International Journal of Remote Sensing*, 41, 2835-2860, <https://doi.org/10.1080/01431161.2019.1694724>, 2019.

**(2)Response :** Thank you for raising this issue. In the original manuscript, the identification parameters were not described in sufficient detail, and the relationship between the pixel-number constraint and the spatial resolution was not clearly explained. Following your suggestion, we have supplemented the description of these parameters and added the following text in the revised manuscript.

“The number of pixels  $I$  is used to constrain the area of mesoscale eddies. Referring to the parameter values adopted in previous studies,  $I$  between 20 and 4000 in this study; this number increases as the grid resolution becomes finer. The shape error is introduced to constrain the morphological characteristics of eddies and is defined as the ratio of the total area difference between the closed contour and its fitted circle to the area of that circle. Thus, a smaller shape error indicates that the eddy’s shape is closer to an ideal circle. In addition, the constraint on eddy amplitude is related to the contour generation interval chosen for this study, which is set as 0.5 cm; therefore, the eddy

amplitude is required to exceed at least two contour intervals. The size of the seed point detection window is also related to the spatial resolution of the data: higher spatial resolution leads to a denser data grid and a larger number of pixels within the seed point detection window.” (Please see Line 226-234)

**Comment:**

*4. Global Scope of the Dataset and Limited Representation of the Arctic Region*

*The dataset is described as a global ocean product; however, the figures presented in the manuscript show very limited or absent eddy detection in the high-latitude Arctic Ocean. Given the increasing importance of Arctic dynamics in the context of rapid sea-ice retreat and its role in the global climate system, mesoscale eddy activity in this region is of growing scientific interest. It remains unclear:*

*(1) Whether the current methodology is capable of reliably identifying and tracking eddies in the Arctic Ocean;*

*(2) Whether future versions of the dataset are planned to include the Arctic region.*

*At present, there appears to be a discrepancy between the dataset’s stated global scope and its effective spatial coverage. This limitation should be clarified more transparently in the manuscript.*

**(1)Response:** Thank you for raising this important question about the spatial coverage of the “global” dataset and for highlighting the scientific importance of mesoscale eddies in the Arctic Ocean.

Currently, most ocean products derived from satellite altimetry, such as the CMEMS ADT dataset used in this study, are provided on a regular latitude–longitude grid. In high-latitude regions, the convergence of meridians and the presence of sea ice can affect the spatial distribution and quality of satellite altimetry data. As a result, the continuity and reliability of sea surface height data in the Arctic Ocean are relatively limited. Under these conditions, when using the method outlined in this study to identify eddies in the Arctic region, the identification results might be less reliable.

In principle, the identification and tracking framework used in this study can also be applied to Arctic eddy detection, provided that reliable and continuous sea surface height data are available.

**(2)Response:** Regarding the future development of the dataset, we appreciate the reviewer's forward-looking suggestion. As the quality of satellite observations in polar areas continues to improve, if high-quality sea surface height and flow field data for the Arctic Ocean become available in the future, upcoming versions of the dataset will aim to expand coverage to the Arctic region, thereby providing more comprehensive support for global mesoscale eddy studies.

**Comment:**

*5. Limited Exploration of Dynamical and Kinematic Aspects*

*The analysis primarily focuses mainly on the morphological characteristics of eddies and eddygroups. While these results are useful for understanding structural evolution during eddy interactions, the dataset appears to contain additional daily dynamical parameters (e.g., amplitude, mean velocity, radius, and position) that could support further analysis. The manuscript would benefit from exploring the dynamical and kinematic aspects of splitting and merging processes. For example:*

*(1) Examining changes in kinetic energy or intensity before and after splitting or merging events;*

*(2) Investigating whether trajectory deflections, angular momentum variation, or pre-splitting rotations occur during these processes;*

*(3) Exploring the relationships among morphological, dynamical, and kinematic characteristics.*

*Such analyses could further enhance the scientific value of the dataset and its application to studies of eddy evolution.*

**Response:**

Thank you for this insightful suggestion. We fully agree with the reviewer that further dynamical and kinematic analyses of eddy splitting and merging processes would provide valuable insights. As the reviewer noted, several parameters, including eddy amplitude, mean velocity, radius, and position, have already been calculated and recorded during the eddy identification stage. These parameters serve as a crucial foundation for further study of the dynamical and kinematic aspects of eddy interactions. However, considering the scope and length of the manuscript, as well as the nature of

this data-focused paper, a systematic dynamical and kinematic analysis of eddy splitting and merging processes is not included here. We plan to address these analyses in future research using this dataset. Accordingly, the relevant statements in the future work section of the manuscript have been revised.

- Added sentence:

“Additionally, the research primarily concentrates on the morphological characteristics of the eddy splitting and merging processes involving two eddies, while those involving three or more eddies remain to be further explored. And their dynamical and kinematic mechanisms still need further investigation.” (Please see Line 618-620)

**(1)Response:** Thank you for this suggestion. Analyzing changes in eddy kinetic energy or intensity before and after splitting or merging events would certainly enhance our understanding of energy changes during eddy interactions. The dataset already contains relevant dynamical parameters, offering a solid foundation for these analyses. We plan to conduct these investigations in future research using this dataset.

**(2)Response:** Thank you for this valuable suggestion. Investigating whether eddies exhibit trajectory deflection, angular momentum variation, or possible rotation features before splitting events is crucial for comprehending the kinematic mechanisms behind eddy interactions. These aspects will be further explored in future studies based on this dataset.

**(3)Response :** We appreciate this important suggestion. The connection among morphological features, dynamical and kinematic properties is truly a crucial factor in comprehending the mechanisms of eddy evolution. Future studies will further investigate these relationships based on the dataset introduced in this work.

#### **Minor Comments:**

*The manuscript still contains several issues related to grammar, wording clarity, redundancy, and terminology consistency. Some sentences are overly long or contain ambiguous expressions. The authors are encouraged to carefully proofread the manuscript and improve language clarity.*

**Response:**

Thank you for the reviewer's suggestion. Following the reviewer's comments, we have revised the manuscript accordingly, focusing especially on correcting language issues identified in the manuscript, including grammatical corrections, reduction of redundant expressions, and clarification of ambiguous terminology.

**Comment 1:**

*Line 11:*

*"... that encloses a seed point (a local extremum) ..."*

*"(a local extremum)" should be "(local extremum)". The definition is somewhat wordy.*

**Response:** Thank you for pointing out the grammatical redundancy. We have removed the preposition "a" in the revised manuscript. (Please see Line 11)

**Comment2:**

*Line 46:*

*"... the SLA-based method is not constrained by threshold parameters ..."*

*This is potentially misleading: SLA-based methods typically still use thresholds (amplitude, radius, contour step).*

*Suggested revision: "...is less dependent on certain threshold parameters..."*

**Response:** Thank you for pointing out that the statement was overly absolute. SLA-based method does indeed involve certain identification parameters. We have revised the sentence in the manuscript to: "... the SLA-based method is less dependent on certain threshold parameters." (Please see Line 53-54)

**Comment 3:**

*Line 47:*

*"... the most widely eddy identification method at present."*

*Suggested revision: "...the most widely used eddy identification method at present."*

**Response:** Thank you for pointing out this wording issue. We have revised the sentence to "... the most widely used eddy identification method at present." in the revised manuscript. (Please see Line 55)

**Comment 4:**

*Line 51:*

*“... essential for understanding of interactions between eddies.”*

*Suggested revision: “...essential for understanding interactions between eddies.” (or “...for understanding eddy–eddy interactions.”)*

**Response:** Thank you for pointing out this wording issue. We have revised the sentence to “... essential for understanding interactions between eddies” in the revised manuscript. (Please see Line 59)

**Comment 5:**

*Line 53:*

*“... do not introduce new kind of vertical structures...”*

*Should be: “...do not introduce new kinds of vertical structures...”*

**Response:** Thank you for your suggestion. We have removed the unnecessary preposition, and the sentence now reads: “... do not introduce new kinds of vertical structures...” in the revised manuscript. (Please see Line 61)

**Comment 6:**

*Line 95:*

*“... makes the following contributions:(1) We ...”*

*Missing space after colon.*

**Response:** Thank you for pointing this out. The formatting issue has been corrected in the revised manuscript. (Please see Line 103)

**Comment 7:**

*Line 98:*

*“... leading to the creation of splitting and merging tracking algorithm ...”*

*Missing article. Should be: “... leading to the creation of a splitting and merging tracking algorithm ...”*

**Response:** Thank you for pointing out this grammatical issue. We have added the missing article and revised the sentence to “... leading to the creation of a splitting and merging tracking algorithm ...” in the revised manuscript. (Please see Line 106)

**Comment 8:**

*Line 103:*

*“... and anticyclonic eddytrees structures ...”*

*Redundancy. Should be: “... and anticyclonic eddytree structures ...”*

**Response:** Thank you for pointing out this redundancy. We have revised the phrase to “... anticyclonic eddytree structures ...” in the revised manuscript. (Please see Line 111)

**Comment 9:**

*Line 176:*

*“... and underscore that ...” should be “... and underscores that ...”*

**Response:** Thank you for pointing out this grammatical error. We have corrected the verb form to “underscores” in the revised manuscript. (Please see Line 188)

**Comment 10:**

*Line 214:*

*“... with the primary distinction arising from the spatial resolution of the dataset.”*

*Later you specify  $0.125^\circ \times 0.125^\circ$ , but it may help to explicitly state how resolution affects thresholds (I, amplitude, contour interval).*

**Response:** This comment is similar to Major Comment 3(2). Please see our response to Major Comment 2 for detailed explanations. The manuscript has been revised accordingly.

**Comment 11:**

*Line 225:*

*“... area-sorted eddygroups are inputted ...”*

*“inputted” should be “input”.*

**Response:** Thank you for pointing out this wording issue. We have corrected “inputted” to “input” in the revised manuscript. (Please see Line 245)

**Comment 12:**

*“... points of brunches likewise ...”*

*“brunches” should be “branches”.*

**Response:** Thank you for pointing out the typo. We have corrected “brunches” to “branches” in the revised manuscript. (Please see Line 298)

**Comment 13:**

*Line 303 and 306:*

*You are discussing Figure 12 but refer to Fig. 18a/18b.*

**Response:** Thank you for pointing out this inconsistency. The figure references have been corrected to **Fig. 12a** and **Fig. 12b** in the revised manuscript. (Please see Lines 332 and Line 335)

**Comment 14:**

*Line 422:*

*“... and rotated to aligned with ...”*

*“to aligned” should be “to align”.*

**Response:** Thank you for pointing out this grammatical error. We have corrected “to aligned” to “to align” in the revised manuscript. (Please see Line 470)

**Comment 15:**

*Line 446:*

*“... the dull pole contains the ...”*

*Should be: “... the dull pole containing the ...”*

**Response:** Thank you for pointing out this grammatical inconsistency. We have revised “contains” to “containing” in the revised manuscript to maintain parallel structure. (Please see Line 500)

**Comment 16:**

*Line 474:*

*“ $a_1$  and  $a_2$  represent the longer and shorter major semi-axes”*

*Please verify whether the formula is correct. Otherwise, the value of  $A$  would always be negative.*

**Response:** Thank you for carefully checking the formula and for pointing out this issue. We confirm that this was a typographical error in the formula. The expression has now been corrected in the revised manuscript. This correction does not affect the calculations or the results presented in the study. (Please see Line 528)

**Comment 17:**

*Line 551:*

*“... However, many works remain to be done in the future.”*

*Suggested revision: “However, several topics remain for future work.”*

**Response:** Thank you for the helpful suggestion. We have revised the sentence to “However, several topics remain for future work.” in the revised manuscript. (Please see Line 605)