Dear Editor,

Thank you for giving me the opportunity to review the manuscript by Gamot et al., titled *"META4.0: a new mesoscale eddy network atlas derived from altimetry"* This study attempts to extend mesoscale eddy tracking from a single-trajectory representation within the existing META framework to an explicit network representation that includes merging and splitting events, and provides corresponding global statistical analyses and validation results. In terms of topic selection, the work has certain potential value, especially its focus on eddy interaction processes, which is meaningful for improving existing mesoscale eddy data products.

However, I believe the manuscript is not yet suitable for direct publication and requires major revision before further consideration. The main reasons are: the tracking method is highly subjective, particularly lacking sufficient explanation of parameter definitions, threshold bases, time window settings, and event determination logic; the interpretation of results somewhat exceeds the support of existing evidence, especially regarding the physical interpretation of merge/split events remains inadequate; the validation section is not yet adequate in terms of independence, statistical representativeness, or generality; furthermore, although the paper claims that the network method can reduce artificial breaks and extend eddy lifetimes, it has not sufficiently demonstrated that these extended connections are physically more realistic and reliable. For ESSD, the parameter robustness of data products and the validation framework should be more thoroughly supported, which is a weak point in the current version of this manuscript.

Overall, I suggest the authors systematically supplement and substantially revise the manuscript, focusing on parameter sensitivity, the objectivity of event identification, and the completeness of the validation framework. Until these core issues are adequately addressed, I do not recommend acceptance of the manuscript in its current form.

Major Comments:

1. Inconsistency between Abstract and Validation Section

The abstract states that independent datasets, including sea surface temperature (SST) and chlorophyll concentration (CHL), were used for qualitative validation of selected events, implying that both SST and CHL are part of the external validation framework. However, in Section 3.3.5, the manuscript only presents validation based solely on chlorophyll concentration (CHL), including one representative merging event and one

representative splitting event. I could not find corresponding SST validation content in the current manuscript. Additionally, the geographic context of the selected validation cases is not clearly described. This inconsistency should be corrected. The authors should:

(1) Add SST validation consistent with the abstract; or (2) revise the abstract and related statements to align with the actual content of the main text.

It is recommended that the manuscript clearly specify where these validation cases are located and explain why these regions were chosen, which would further enhance the paper's persuasiveness.

2. Unclear Parameter Definitions and Subjective Selection; Suggest Adding Parameter Basis and Sensitivity Tests

The authors propose that two eddies are considered connected if their normalized overlap area exceeds 10%, and they allow the search window to be extended forward by 7 days under the premise that the eddy remains "geographically consistent." This part is not clearly described. The manuscript does not explicitly define the mathematical expression of normalized overlap area, nor clearly explain the specific criteria for "geographically consistent." Moreover, the basis for choosing the 10% overlap threshold and the 7-day time window is insufficient. It is recommended to evaluate the impact of these parameter settings on event identification results through sensitivity tests. Therefore, the authors should supplement clearer methodological descriptions, including:

- The mathematical expression of normalized overlap area;
- The specific meaning and criteria of "geographically consistent";
- The rationale for selecting a 10% overlap threshold and a 7-day window.

It is suggested to add parameter sensitivity analyses, for example, comparing overlap thresholds of 5%, 10%, and 15%, and time windows of 3, 5, and 7 days, to assess their effects on event counts, lifetime distributions, proportions of long-lived networks, and spatial distributions of merge/split events. Currently, the robustness of conclusions against parameter variations is not sufficiently demonstrated.

3. The Parameters Defining Tracking and Merge/Split Events Are Highly Subjective

The network grouping adopts a relatively loose design: analysis is limited to same-polarity eddies; a connection is established when the normalized overlap area exceeds 10%, an overlap-based association approach previously reflected in Liang Sun et al. (2016, GEM: a dynamic tracking model for Mesoscale Eddies in the ocean);

the search can be extended forward up to 7 days; and no constraints imposed on radius or amplitude changes. In the segmentation stage, successors and predecessors are mainly selected based on maximum polygon overlap, while merge/split events are topologically defined from these connections. From a data product perspective, this design is understandable, but event identification mainly relies on geometric continuity rather than stronger dynamical or material coherence constraints, and the criteria remain largely empirical.

This is important because a pair of overlapping contours alone does not necessarily prove a physically meaningful merge or split event. The particle advection analysis provided later is helpful but is conducted after the network has been constructed to assess coherence. As the authors themselves admit, the particle advection uses the same altimetry product as the eddy detection, so this validation is not fully independent of the detection method; furthermore, topological continuity based on contours and material coherence are related but not equivalent. Therefore, I suggest that the authors:

- More explicitly discuss these limitations more explicitly and appropriately moderate the term “physical validation” where necessary.
- More directly compare this framework with tracking methods based on particle advection or other Lagrangian criteria that have stronger objectivity.
- At a minimum, clarify precisely what exactly the current coherence experiments validate and what they do not.

In addition, recent studies have explored more objective particle advection-based tracking strategies, such as Alexandra E. Jones-Kellett et al. (2024, *A Lagrangian Coherent Eddy Atlas for Biogeochemical Applications in the North Pacific Subtropical Gyre*), Tian et al. (2025, *A Black Hole Eddy Dataset of North Pacific Ocean based on satellite altimetry*), and Tian et al. (2022, *SLA-Based Orthogonal Parallel Detection of Global Rotationally Coherent Lagrangian Vortices*). The authors are encouraged to refer to these papers and the more objective tracking methods they mention.

4. The Choice of Resolution for Analyzing Merge and Split Events Deserves Further Discussion

The manuscript uses the DT2021 global daily ADT field with a spatial resolution of 1/4°, explicitly choosing to retain the full, unfiltered ADT signal. This choice is reasonable and clearly documented. However, merge and split events are highly sensitive to small-scale deformations and transient structural changes. Since the paper

emphasizes interaction processes rather than just long-lived trajectories, I believe the manuscript should more fully discuss whether the current spatial resolution is sufficient to robustly identify these events, especially in energetic western boundary currents and coastal regions. The authors are advised to:

- Evaluate whether utilizing higher-resolution full-satellite products (e.g., SEALEVEL_GLO_PHY_L4_MY_008_047) affects the inferred statistics of merge and split events.

Even if such experiments are beyond the scope of this paper, the manuscript should more clearly explain how the effective resolution of the dataset affects the detection of interaction events and whether certain event types might be under-resolved or over-fragmented.

5. The paper demonstrates that the Network Method “Extends Lifetimes” but Has Not Fully Proven That the “Extended Lifetimes Are More Realistic”

The manuscript clearly shows in comparison with META3.2, that the network-based approach reduces the number of birth/death events, indicating that the new method technically reduces “artificial breaks” within the single-trajectory framework, which is an important contribution.

However, the current issue is that while the paper sufficiently demonstrates that the network method reduces trajectory fragmentation and extends lifetimes, it has not adequately proven that these additional connections correspond to more realistic physical evolution rather than simply resulting from looser connection rules. The authors should strengthen the argument in this part, possibly by checking the credibility of new connections using in situ observational data or other means.

6. Adding More Regionally Diverse Event-Level Cases Would Help Strengthen the Paper’s Persuasiveness

The manuscript includes a demo network in Section 3.1 and one representative merge case and one representative split case in Section 3.3.5. While these examples are helpful, but for a paper focused on eddy networks and event identification, the event-level presentation still lacks regional diversity. Global distribution maps are useful but cannot fully replace detailed regional cases. The authors are encouraged to:

- Add at least 2 to 3 representative cases from dynamically distinct regions, such as western boundary current areas.

This would help readers assess the method’s applicability under different eddy

dynamic environments and make the paper more convincing at the “network event” level.

7. CHL Validation Is a Valuable Supplement but Currently Mainly at the Case Study Level; Suggest Further Adding More General Statistical Validation

The authors use CHL data to show one merge case and one split case, which is valuable as it provides independent visual evidence beyond altimetry-based geometric identification. However, the validation remains mainly at the case study level, with evidence strength closer to illustrative examples rather than quantitative global-scale validation. Two cases are insufficient to support judgments on 30 years of global merge/split identification or to demonstrate that these events have similar reliability across different ocean regions, dynamic environments, and seasons. Therefore, the authors should further generalize the existing cases into more universal statistical results. Therefore, the authors are encouraged to:

- Randomly sample a certain number of merge/split events in several typical regions and statistically assess the proportion that show corresponding structures in CHL or SST;
- Providing recognition rates by region, eddy type, and event type.

Minor Comments:

- Section 3.4 uses clustering to propose eddy network type classification. I think the internal presentation logic of this section can be improved. Since Figures 21 and 22 summarize the average properties and distributions defining these clusters, it might be clearer to present and discuss Figures 21 and 22 first, then show Figure 20 (which gives the spatial distribution of the final categories).

- Figure 4: It is recommended to use a continuous colorbar to better show the variation pattern of shape error.

There are still several issues related to grammar, clarity of expression, redundant wording, and terminology consistency throughout the manuscript. The authors are advised to carefully proofread the entire text and further improve language clarity. Some specific suggestions:

- Page 3: The product name is not consistent throughout the manuscript. The text alternates between “META4.0,” “META4.0-Networks,” “META4.0 network

dataset," and "META4.0 networks." It is recommended to unify the product name throughout the manuscript, and if necessary, introduce an abbreviation only at first occurrence.

- Line 143:

"...https://py-eddy-tracker.readthedocs.io/en/latest/python_module/..." contains formatting errors.

- Line 148:

In the sentence describing the network schematic, the phrase "splits and give birth" contains a grammatical error. It should be corrected to "splits and gives birth."

- Line 148:

The term "observations" is ambiguous and should be further clarified in the methods and figure captions.

Near Line 148, the authors write "The first segment is composed of four observations represented by the dots." The meaning of "observations" is unclear. For readers unfamiliar with the data structure, do these dots represent:

(1) Eddy centroid positions;
(2) Feature points extracted from contours;
(3) Or some kind of seed points/representative points?

Since the figure uses dots to represent observations within a segment, the correspondence between the contour structure and the dots is not explained, which may cause confusion. If the dots are only for visualizing temporal order within the segment, it is recommended to state this explicitly in the Figure 1 caption to avoid readers mistaking them for seed points or other internal algorithm nodes.

- Lines 203-204:

The shape error definition has already been given earlier and does not need to be repeated here.

- Line 205:

Shape error and ellipticity seem to be conflated here. The authors should clarify whether these are equivalent and unify terminology throughout the manuscript.

- Line 383:

The phrase “Performing particle advection both forward and backward in time allows to characterize the directionality of coherence...” is grammatically incorrect. It should be revised to “allows characterization of.”

In summary, I believe this manuscript presents a promising and potentially valuable dataset, but it would be improved by a more rigorous validation framework, a more objective tracking method, and more regionally representative event-level evidence. I hope these comments will help the authors revise and improve the manuscript.

Sincerely,
Reviewer