Response to reviewer CC1

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.

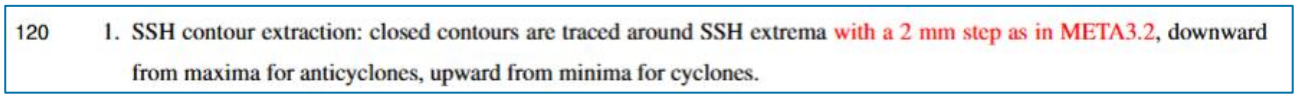
Building upon earlier product, the META team has released a new version, with the main advance of META4.0 being the explicit identification of eddy merging and splitting events. Eddy identification in META relies on SSH closed contours containing a single extremum, and the tracking method adopts an overlapping scheme. Based on single-trajectory eddy segments, the META team again applied this overlapping scheme to group multiple segments connected by merging and splitting events into one network. This dataset offers strong data and technical support for the study of eddy interactions. The data and methods are feasible, the writing is smooth, and the figures are detailed. I therefore recommend minor revision and acceptance after simple modifications.

We thank the reviewer for the positive assessment of the META4.0 dataset and for the constructive comments. We are pleased that the reviewer recognizes the potential of the network framework for the study of eddy interactions. The manuscript has been revised accordingly, and the specific comments are addressed below.

My specific comments and questions are as follows:

1) When extracting SSH contours, what interval is used? What considerations guided the choice of this value? After all, the contour interval adopted can slightly affect how boundaries are defined.

We thank the reviewer for this question. The SSH contour extraction uses a 2-mm contour interval, as already implemented in the PET framework. This value represents a compromise between accurately resolving contour geometry and maintaining a reasonable computational cost. A smaller interval would increase the number of candidate contours while providing only marginal changes in the detected eddy boundaries. This information has now been explicitly added to the manuscript.


120 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.

2) Some studies mark eddies missing for two consecutive days in the recognition field as dead. The META team has chosen a 7-day window here. Would a 7-day window be too broad, potentially grouping different eddies together? Have any relevant tests been conducted?

We thank the reviewer for this question. The purpose of the 7-day search window is to reduce trajectory fragmentation caused by temporary gaps in the altimetric mapping and detection process. The search is performed sequentially from day +1 to day +7 and stops as soon as a valid association is found. We agree that increasing the temporal window also increases the risk of incorrect associations. For this reason, the temporal extension is combined with a normalized overlap criterion, which strongly limits associations between unrelated eddies. Additional justification of this choice has been added to the manuscript.

as defined (Pegliasco et al., 2022):

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

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.

3) I would like to ask how the choice of a 10% overlap coefficient was made. I have conducted related experiments, and an overly small overlap coefficient can easily group together eddies that do not belong to the same segment. Changes in this overlap coefficient significantly affect the grouping of eddies and thus the final number of trajectories. At a coefficient of 10%, the overall number of trajectories tends to decrease relative to a more reasonable value.

We thank the reviewer for this important remark. We agree that the overlap threshold directly influences the resulting network topology and the number of reconstructed trajectories. The choice of a 10\% threshold results from a compromise between maintaining continuity across interaction events and avoiding unrealistic associations. For comparison, META3.1exp used a 5\% overlap threshold for trajectory tracking. In the context of network reconstruction, we increased this value to better account for the strong shape modifications that typically occur during merging and splitting events. Additional explanations regarding this choice have been added to the revised manuscript.

4) The team compared the 4.0 product with the 3.2 product (Figures 7–10). They mention that META4.0 “reduces artificial discontinuities and allows for a more consistent tracking of eddy lifecycles.” I have reservations about this view. The article also mentions that the radius and shape error evolve over the normalized life cycle and follow a birth–maturity–decay framework. Under this framework, even a single trajectory eddy is continuous throughout its own life cycle. So, can some eddies, after being merged by another eddy during their decay stage, still be regarded as belonging to that so-called lifecycle? Furthermore, the method adopted for identifying merging and splitting is itself a form of artificial processing. That is, if the 10% coefficient were to change, would Figures 7 to 10 need to be updated? I do believe that the greatest progress of META4.0 is that it provides powerful data and technical support for studying eddy interactions, and it offers a new perspective for researching eddy merging and splitting.

We thank the reviewer for this thoughtful comment. We agree that the network reconstruction depends on methodological choices such as the overlap threshold and therefore should not be interpreted as a

unique description of eddy evolution. Different parameter choices would indeed modify the resulting network topology and some of the statistics presented in Figures 7 to 10. Our objective, however, is not to redefine the intrinsic lifecycle of individual eddies, but to identify and represent interactions that are not accessible within a strictly single-trajectory framework. In this context, the main contribution of META4.0 is to explicitly document merging and splitting events and to provide a consistent network representation that allows these interactions to be analyzed at the global scale.

Following this comment, we revised the wording of the manuscript to avoid suggesting that the network framework necessarily provides a more physically correct description of eddy evolution. Instead, we emphasize that it provides an alternative and complementary representation designed specifically to investigate eddy interactions.

~~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.

5) In Figure 2b, the orange trajectory nearly intersects with the green trajectory during the decay stage. I am curious whether any merging events occurred at this stage.

We thank the reviewer for this observation. The apparent proximity between the orange and green segments in Figure 2b results from the fact that this panel displays latitude as a function of time. The two segments indeed reach similar latitudes at approximately the same time. However, they remain well separated in longitude, as shown in Figures 3a and 3b, and therefore no overlap or interaction event is identified between them.

6) Format and text issues in the figures: a) The legends in some figures are not sufficiently detailed. Various symbols should be clearly marked in the legends rather than only mentioned in the main text—for example, the hexagons and stars shown in Figures 2 and 3, the different lines representing eddy trajectories, and the various color maps for network spatial frequencies in Figure 20, etc. b) The title of Figure 17a should be “Evolution of eddy properties around death events”. c) The text on the horizontal and vertical axes of Figure 23b should be changed to English to be consistent with Figure 23a.

We thank the reviewer for these suggestions and mistakes. The legends, captions, titles have been revised throughout the manuscript.

Sincerely,

The authors