

# Answer to reviewers

## Reviewer 1

<https://sp.copernicus.org/preprints/sp-2025-17#RC1>

In this study, the authors compare eddy detections from the classical DUACS altimetric product with detections obtained from a newly released product (MIOST-K) that incorporates SWOT KaRIn data. They demonstrate that assimilating SWOT data improves eddy detection and show that this enhancement has important implications for estimating eddy kinetic energy (EKE) and for assessing the particle export/retention that eddies may induce. In my opinion, the manuscript is of great interest and is generally well presented. The value of the study is twofold:

- It validates the new product with respect to mesoscale eddy detection.
- It places these results in the context of an ecologically important process along the North African coast—an aspect that is too often overlooked in recent studies. The point you make at the end of the introduction (L90–91) is particularly relevant.

I have a remark that I would like the authors to address before the manuscript can be accepted for publication. This comment is intended to improve the quality of the paper and do not call into question the validity of the findings. I therefore recommend a **major revision** to allow the authors to address the following points thoroughly. Please note that, as English is not my native language, I have not corrected spelling or grammar.

### Main remarks:

1. The goal of this study is to assess the improvement in eddy characterization obtained by including SWOT measurements in a gridded product. The authors make a convincing case overall, but in my opinion they overlook a crucial aspect of the comparison: Did SWOT actually sample the eddies they are analyzing?

As the authors know, SWOT provides 2D measurements of eddy structure, which is valuable for understanding their dynamics and estimating EKE. However, the manuscript never indicates whether the eddies under study were indeed sampled by SWOT.

We thank the reviewer for these important remarks. We agree that the relationship between direct SWOT sampling and the reconstructed mesoscale structures should be interpreted carefully. The MIOST-K product does not rely solely on SWOT observations acquired on the exact day being reconstructed, but combines SWOT KaRIn wide-swath observations, SWOT nadir observations, and other nadir altimeter measurements within

a temporal window around the target date ( $\pm 10$  days), with decreasing weights assigned to observations further away in time. As a result, improvements in mesoscale representation may arise not only from direct SWOT sampling on a given day, but also from the temporal propagation and reconstruction of mesoscale structures sampled during nearby overpasses.

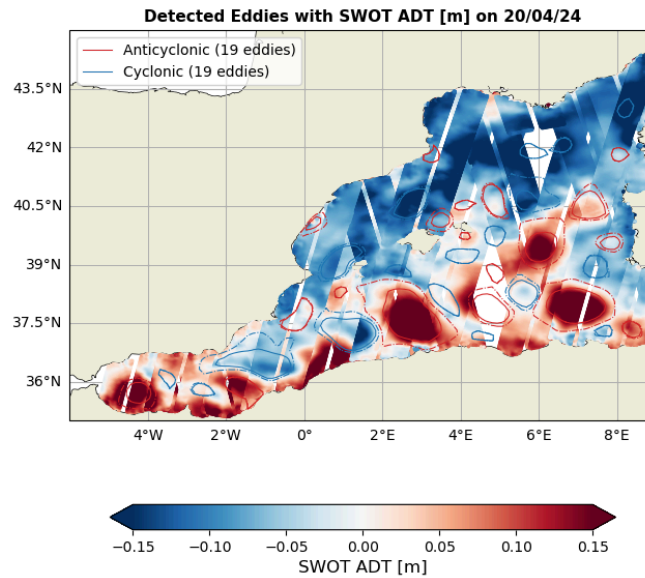
We agree that explicitly mentioning this point improves the interpretation of the results, particularly for localized mesoscale features. We therefore clarified this aspect in the revised manuscript in the subsection 2.2 MIOST with SWOT KaRIn (MIOST-K):

“The reconstruction combines SWOT KaRIn wide-swath observations, SWOT nadir data, and conventional nadir altimeter measurements within broad spatio-temporal windows around the target date. In Delayed-Time (DT) mode, both past and future observations are incorporated to constrain the interpolation process, with decreasing weights assigned to observations farther away in time. This allows mesoscale structures sampled during nearby overpasses to contribute to the reconstructed daily fields beyond the instantaneous SWOT and nadir ground-track coverage (see Fig. A1 for an example of the SWOT coverage contributing to the reconstruction of day 20/04/24). (Ballarotta (2025c))”

For example, in Fig. 3C, the authors present the EKE field for a specific date. Where did SWOT pass on that day? According to “whereisswot.onrender.com” SWOT sampled the western part of the basin between approximately Valencia and Oran. Thus, for this particular case, SWOT did help resolve structures around  $\sim 38^\circ\text{N}$ ,  $1^\circ\text{E}$ . However, the increased detection of small structures on the eastern part of the basin can only result from SWOT passes on other days and is therefore, to some extent, an interpolation artifact.

I strongly encourage the authors to explicitly account for the actual sampling of eddies by SWOT. This could be done, for example, by overlaying SWOT ground tracks or including raw SWOT measurements (e.g., from the L3\_LR\_SSH product). The authors could also flag eddies that were directly sampled by SWOT and evaluate whether the improvements in detection/EKE/advection arise from genuine observations or from the interpolation procedure used in the gridding process.

To further clarify the relationship between SWOT sampling and the reconstructed eddy fields, we also added a supplementary figure (figure A1 shown below) showing the detected eddies on 20/04/2024 together with the SWOT KaRIn swath coverage contributing to the MIOST-K reconstruction within the  $\pm 10$  day temporal window used by the product.



To further address this point, we also examined the SWOT KaRIn sampling associated with the three Algerian eddies used in the retention analysis. All three eddies were observed during multiple SWOT overpasses throughout their respective 20-day advection periods (approximately five overpasses for each case). We added this information to the revised manuscript (see below) and supplementary material. This further supports that the retention examples are informed by repeated SWOT observations within the reconstruction windows, rather than arising solely from unconstrained interpolation of the gridded product.

“All three eddies were observed during multiple SWOT KaRIn overpasses throughout their respective 20-day advection periods (approximately five overpasses for each case), supporting the use of these examples to assess the influence of SWOT-enhanced reconstruction on particle retention estimates.”

## Minor remarks:

2. The abstract should include the findings, and the name of the product used.

We thank the reviewer for the suggestion.. We have taken into account these remarks and have updated the abstract to:

“Mesoscale ocean variability plays a crucial role in regional circulation, heat transport, and the distribution of tracers such as nutrients, biological material, and pollutants. Mesoscale eddies are key drivers of these ocean dynamics, and their observation (particularly of small-scale and coastal structures) has been limited by the resolution of conventional altimetry products. The Surface Water and Ocean Topography (SWOT) mission provides unprecedented high-resolution sea surface height data, offering new opportunities to refine mesoscale observations and improve our understanding of their impact on surface ocean dynamics. In this study, we assess the potential of a new gridded altimetry product that incorporates SWOT wide-swath data (MIOST-K) and its differences with respect to the reference and widely used Copernicus Marine

Environment Monitoring Service (CMEMS) product DUACS-OI, based solely in nadir altimetry. We analyze the eddy field in the western Mediterranean region, important for many different socio-economic activities like tourism, maritime transport, and fisheries and aquaculture. Compared to DUACS-OI, MIOST-K identifies a larger number of mesoscale eddies, particularly in coastal regions, and generally exhibits higher eddy kinetic energy (EKE) associated with the detected structures. We identify differences not only in the number of eddies, but also in their characteristics: e.g. size and associated EKE. This is relevant for defining optimum marine traffic routes, but also for operational activities such as marine pollution management. To evaluate the implications of these differences for transport and retention processes, we analyse the retention capacity of Algerian Eddies, which in the past have been found relevant in the transport of marine debris between the North African coast and the Balearic Islands. MIOST-K leads to substantially different particle retention estimates for some eddies, highlighting the sensitivity of transport processes to mesoscale circulation representation. Our findings evaluate how well SWOT-enhanced data affects the representation of mesoscale eddies and their velocity structures, showing important implications for ocean monitoring, climate studies, and marine ecosystem management.”

3. L125 : define outer and inner contour (e.g., contour of maximal azimuthal velocity)

We thank the reviewer for the suggestion. We clarified the physical meaning of both contours in the revised manuscript to:

“Two types of contours are identified by the algorithm: the effective contour (outermost closed contour defining the eddy extent) and the speed contour (inner contour corresponding to the region of maximum mean azimuthal geostrophic velocity). Further details can be found in Mason et al. (2014).”

4. L144: “We consider...by advection” : this information is not needed

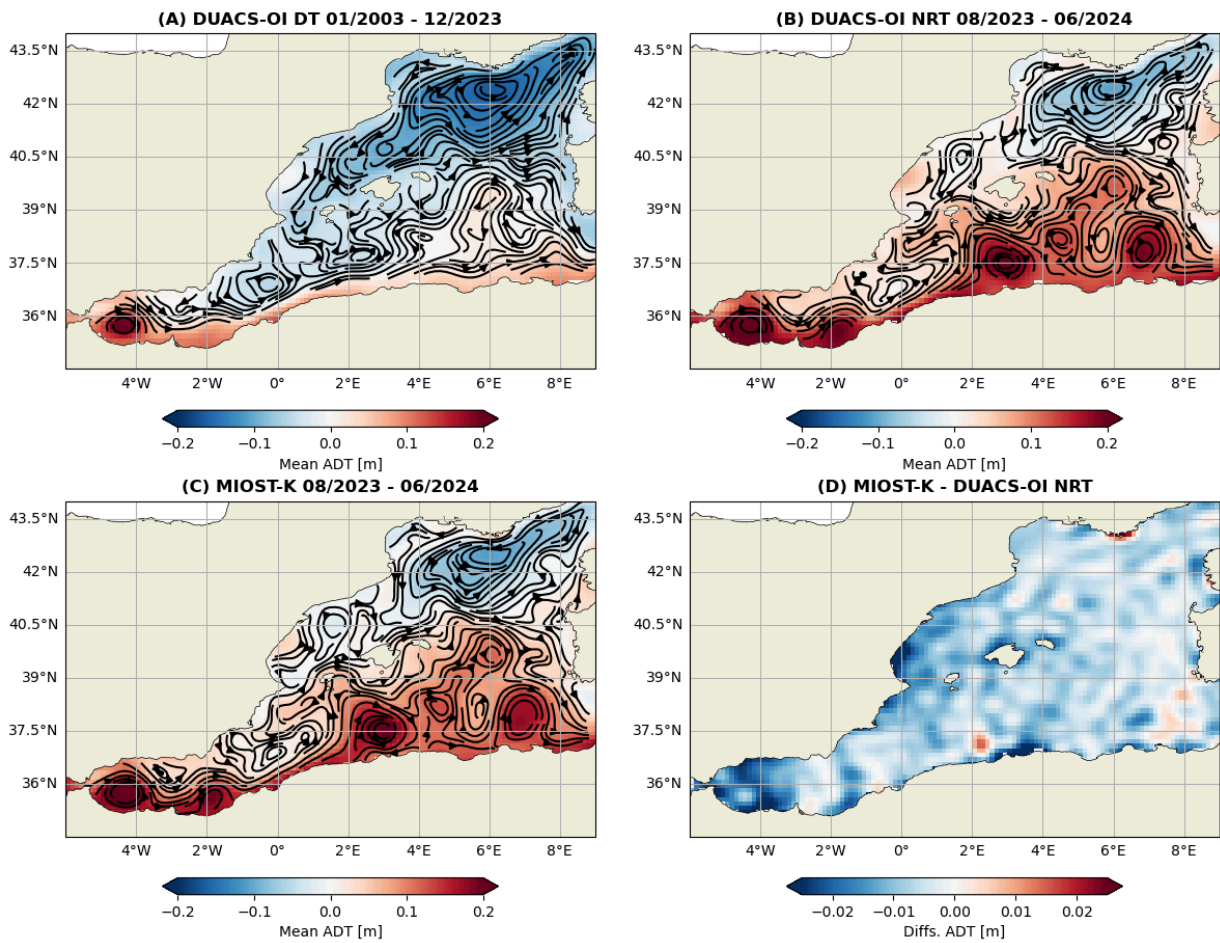
We thank the reviewer for the comment. We agree that the original phrasing was somewhat generic; however, we consider this information important because it explicitly defines the physical assumptions of the Lagrangian simulations and clarifies that no additional processes (e.g. diffusion, wind forcing, sinking, or particle inertia) were included. To improve clarity, we rephrased the sentence as follows:

“Particles are treated as passive, infinitesimal, and buoyant tracers transported exclusively by horizontal advection, with no additional physical processes included.”

5. 1 the figure is not of good quality, you could consider decreasing the size of the colorbar, change the colormap to emphasize small scale details and do a difference 1C-1B to emphasize the changes induced by SWOT assimilation

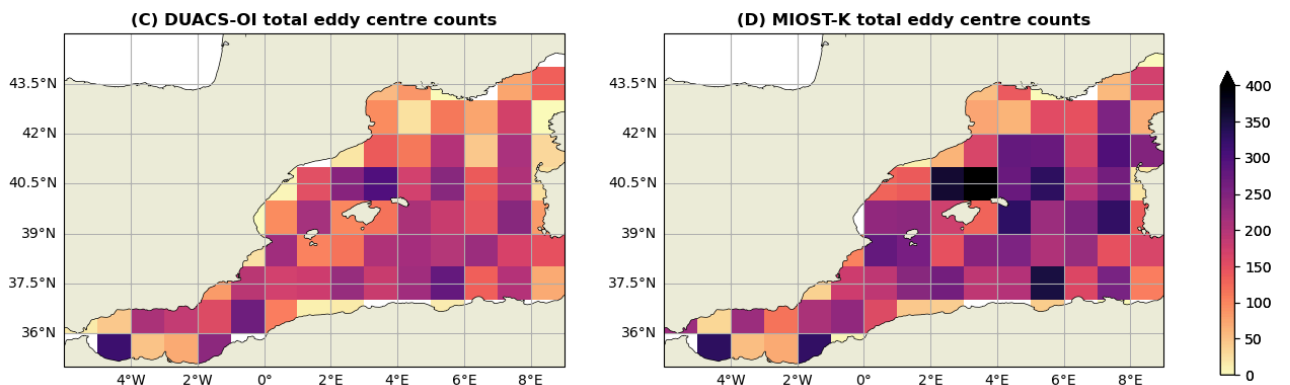
We thank the reviewer for the suggestion. We revised Fig. 1 to improve readability by reducing the size of the colorbars and adding a new difference panel (Fig. 1D), showing

the mean ADT differences between MIOST-K and DUACS-OI. This additional panel helps emphasize the changes associated with the inclusion of SWOT observations, particularly at smaller spatial scales and in coastal regions.



6. 2 add a map of eddy density, i.e., the number of eddy center per e.g.,  $1 \times 1^\circ$  bins

We thank the reviewer for the comment. We added new subfigures of the total eddy centre count in  $1 \times 1^\circ$  bins for the total eddies daily detected in DUACS-OI and MIOST-K, as well as the corresponding text in the results section:



“The spatial distribution of eddy centre counts, computed in 1 by  $1^\circ$  bins over the full study period, is shown in panels (C) and (D). Both products identify high eddy activity in the central and northwestern Mediterranean and the Alboran Sea, although MIOST-K

generally detects a larger number of eddies, particularly in coastal regions such as west of Corsica (also observed in Fig. 2A and B).”

7. It is not clear what is shown in Fig. 3E

We thank the reviewer for pointing this out. We agree that the original terminology (‘mean EKE’) was ambiguous because the analysis involves two levels of averaging:

- (i) the spatially averaged EKE within each detected eddy contour, and
- (ii) the daily average computed across all detected eddies.

To clarify this, we revised the figure labels and caption terminology. Panels B and D now refer to ‘eddy-averaged EKE’, while panel E refers to the ‘Daily mean of eddy-averaged EKE’. We also updated the caption to explicitly describe the averaging procedure.