Review of manuscript egusphere-2024-2773 entitled " Advances in Surface Water and Ocean Topography for Fine-scale Eddy Identification from Altimeter Sea Surface Height Merging Maps"

Main comment:

Within the manuscript the authors use the new SWOT high-resolution data to detect eddies in the South China Sea and compare the results with eddy identification from the conventional altimetry AVISO product and a merged product using a 2DVAR method. Their analysis show that the 2DVAR method exhibit better reconstruction of the fine-scale ocean dynamics compared to conventional altimetry-derived product.

The paper is well-written and well structured however the analysis is restricted only at showing that the 2DVAR is comparing better with SWOT than the conventional altimetry product. A result that is interesting and worth proving it but as far as I am concerned the publication lacks of analysis on the improvements brought by the new 2DVAR method concerning scientific questions. What do we learn, using this new data, in terms of fine-scale processes in this dynamical region ? Secondly, the publication will benefit from more robust statistical quantifications of the improvement of the new method. The authors only rely on statistics over the eddy radius and boundary detection. More quantification on the performance of the new 2DVAR method should be added (see comments below).

Lastly I feel like the title may be misleading. As is I was expecting some new findings on the fine-scale eddy identification in the South China Sea while the analysis stick with a comparison between higher resolution observations of the sea surface and a new methodology (2DVAR). Maybe the authors should consider to modify slightly the title if no further analysis are added to the manuscript.

To summarize, in its current form the paper is very interesting and brings some relevant evidence to validate the 2DVAR method but needs further analysis before it can be published. Therefore I would recommend to publish the manuscript after some major revision. Please find in the following my detailed comments.

Major comments:

1) The authors are using SWOT data from a pretty old version now (v0.3 on L 100). Two improved versions have been released for both CALVAL and Science phase: v1.0 or v1.0.2. I want to bring the authors attention on the fact that a new improved version of SWOT data (v2.0) is going to be released around December 2024. This new version (v2.0) is of particular interest because it is going to include a MDT correction that will improved SSH (and therefore ADT) estimates of about 5 cm. I believe this correction is of great interest for this study. I would thus recommend to re run the SWOT analysis using the latest version v2.0 (when available) or at the very least to use v1.0.2.

2) Section 2.3: I have several questions about the methodology to compare the performances of 2DVAR and AVISO with SWOT data:

- First the authors, only compare the eddies that are detected by conventional altimetry and SWOT. But I think a real and very interesting point would also be to quantify how much of the eddies observed by SWOT are NOT detected by conventional altimetry and 2DVAR ? And probably to compute a metric showing the better performance of 2DVAR in identifying fine scale features observed by SWOT and not by the conventional product.
- I understand how the method can identify eddy center and boundary (L 126-140) with a gridded product such as AVISO or 2DVAR but I do not get how the author can estimate eddy center/boundary using SWOT data considering that they only exhibit data on the swaths and that eddies can be partly outside of the observational bands of SWOT. Please provide more information.
- The authors normalize the position of eddy center and boundary by using SWOT data. This technique smooth the differences between gridded product and SWOT data based eddy identification. Why would

one want to do that if the point is to compare the performances of the different gridded product to adequately represent high resolution observation from SWOT ?

3) Section 3.1: The analysis of Fig.2 needs more explanations as it is not always straightforward to understand what is represented on Fig. 2. For example the colorbar ranges are different in all plots, I don't understand if the colors represent a number of eddies or the eddy radius ?

4) Section 3.2 "Eddy boundaries verification in space and time": The authors show one example of GDP drifter comparison with 2DVAR and AVISO. It is a good illustration however I think the authors should provide more statistics with a systematic comparison of drifters during the science phase to clearly demonstrate the better accuracy between in situ and 2DVAR compared to AVISO.

5) Section 3.3: These results seem inherently due to the different products resolution, so not really surprising. I think one of the main result of the study, listed also on L282, is mainly due to the fact that SWOT do not capture features > 120 km due to the swaths limitation, as stated by the authors on L 295. So I am not sure this result should appear like a main point of the paper since it is something that is limited by the data.

Minor comments:

L 33: "a kind of", I would state "is an estimate of sea surface height (SSH) above geoid."

L 37: Conventional altimetry does not really provide "high resolution" mapping since the resolved processes are mesoscale features (75-100 km). I would remove "high resolution" from the sentence and add "…tracking large and mesoscale ocean dynamic signals (Chelton…".

L 42: Worth mentioning the interpolation techniques (Pujol et al., 2016).

L 67-69: Please define the period for CALVAL and Science Phase for SWOT mission. I believe not all readers are aware of that (CALVAL: Mar-July 2023; SP: from August/September 2023). It seems to be done on Lines 106-107 but should appear when the terms are first used.

L 75: "fine scales" are not defined previously in the text. Please give details (maybe in the introduction?). Are the authors referring to submesoscales ? Or more classically to the transition scale between meso to submesoscales ?

L 87-88: There are different types of eddy identification methods: physical, geometric, Lagrangian or hybrid based methods. The authors need to provide some references here (among MCWilliams, 1990; Okubo, 1970; Weiss, 1991; Chelton et al., 2011; Sadarjoen and Post, 2000; Mkhinini et al., 2014; Laxenaire et al., 2018 …).

L 94: Is it based on Chelton et al., 2011 method ?

L 95-97: I guess the steps and amplitude in mm and cm are referring to distances on the maps. Can you please give the actual distance in kilometer to make a connection with data resolution ?

L 109-110: ".. and lack of interest in traditional technology". I would remove this comment since nadir data are still being used and methodologies developed to assess fine scale improvements near the coasts (Birol et al., 2021).

L 150: Did the authors performed any kind of treatment on the drifter trajectories (GDP)? For example, are the inertial oscillations removed from the trajectories before comparison ?

L 158: Depending on the authors definition of submesoscale, mesoscale and fine-scale (see previous comment) I would rather classify as “submsesoscale (Fig. 2a), fine-scale (Fig. 2b) and mesoscale (Fig. 2c)”.

L 166-169: I do not understand the reasoning here, please detail and rephrase.

L 175: I do not think that AVISO can catch eddies down to 15 km. Conventional altimetry typically see mesoscale features with diameter of about (75-100 km).

L 188-189: I think the maximum amplitude of SWOT eddies might change when the 5 cm bias will be corrected from MDT in the new SWOT data version 2.0… Worth checking out when the new data are available!

L 200: “The coloured slices are ..” ?

Fig. 3: SWOT data seems to be interpolated between swaths. Please provide information. Please specify in the caption that solid and dashed lines represent the contours of eddies as detected by 2DVAR and AVISO.

L 217: Do the authors have any clue why the contour of the 16.2N anticyclone is very different on the 04/07 while the contours are pretty consistent in the other days ?

L 218: I would change “high agreement” by “good agreement”.

L 224: It is not really surprising that AVISO does not identify 50 km eddies.

L 237: The section is not correctly numbered, it should be Section 3.3.

L 250: add space between “eddies” and “identified”.

Fig. 6-7: Please provide the period range for the analysis during the Science phase (also the number of SWOT passes used ?).

References:

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