

## Responses to reviewers' comments on "The OCEAN ICE hydrography profiles compilation and climatology"

We thank both reviewers for their comments. We have substantially revised the manuscript and believe that it is much improved as a result.

### Reviewer #1

*This manuscript presents a new compilation of seal-based, CTD and Argo profiles in the Southern and an associated monthly climatology. A limited exercise of validation is proposed through comparison with the global World Ocean Atlas 2023, a product known for its mediocre quality in the region (e.g. Yamazaki et al 2023).*

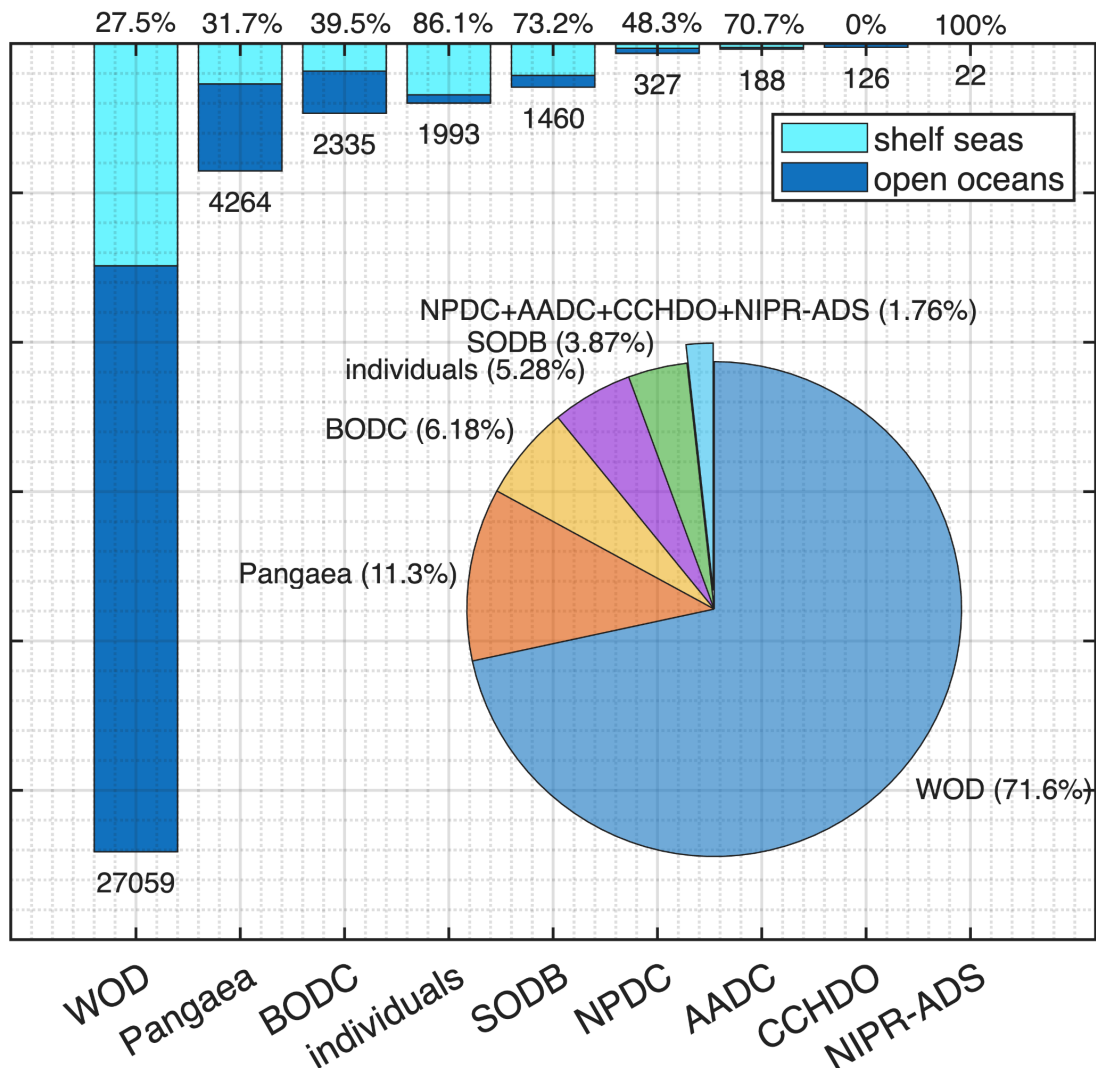
*Much better products than WOA23 exist in the literature (SOSE, Pauthenet et al. 2021, Yamazaki et al 2023), but no meaningful comparisons are provided with this new product. It would be useful to know in what sense this new climatology would improve upon previously published products. This is particularly true of Yamazaki et al 2023 which shares many similarities with this product in terms of datasets or interpolation method.*

*I recommend rejection of the manuscript. Judging on the current description, I can not find any added value in the data compilation, and I do not find any salient feature that would make the proposed climatology product superior to other existing products, such as Yamazaki et al 2023.*

We appreciate the reviewer's concerns about our work. However, to our knowledge, no one has done a similar data compilation as thoroughly as we have here where we assembled CTD data from various data repositories in addition to individual datasets unavailable in repositories (**Figure R1**). The chart shown in **Figure R1** suggested that 28.4% of the CTD data does not come from WOD, and nearly 20% among which (5.28% among the total and nearly 2000 profiles) are not publicly available from these data centres. On the continental shelf, 12813 CTD profiles were assembled, 5317 (>40%) among which are non-WOD data. We highlighted this at **Line 166-169** in the revised manuscript with additional panel h in **Figure 2**.

Concerning the climatology, whilst it is certainly fair to request a comparison with other products (mentioned in the first submitted version, but not assessed in the manuscript), we respectfully disagree with the recommendation for rejecting the manuscript without additional consideration about the novelty of the method used and the increased horizontal resolution that the method provides in Antarctic shelf seas which basically risks throwing away perfectly acceptable and innovative work. We hope that the substantial revisions described below will strengthen the novelty and convince the reviewer that this work has genuine added value to the community from both the data compilation and the climatology. Assuming that the climatology we created did not differ significantly from other products (which is not the case, as we will show in the revision), it could at the very least provide evidence of reproducibility and lack of sensitivity to methodological

approach, which is an essential though poorly considered element of the scientific endeavour, and so on this ground alone could have been considered with more leniency.



**Figure R1.** The proportion of CTD profiles from various data repositories and individuals. Although WOD is the main source for CTD profiles (71.6%), there is a significant fraction of data (28.4%) from other data centres, over 5% among which are unavailable in public data centres.

In the reviewed version we :

(1) address the reviewer’s concerns about data quality, adding a comprehensive quality control procedure following modified CODC-QC (Tan et al. 2023; Tan et al., 2025) on the O:I profile compilation.

2) The O:I climatology was then recomputed based on the comprehensively quality-controlled O:I profile compilation and used for comparison with 3 climatologies, including 2 SO-focused climatologies, namely Pauthenet et al. 2021 (an updated version of Schmidtko et al. 2013 in the Southern Ocean) and Yamazaki et al 2025 (a refined version of Southern Ocean focused climatology with a WOA23 initial field). Detailed comparisons

provide clear evidence of biases in existing products that our new climatology corrects for, within its own limitations.

The comparisons are updated in [Figure 11-14](#) in the revised manuscript.

We hope the reviewer will agree that our compilation and the climatology products we produce are novel and provide a significant improvement on the representation of Antarctic shelf seas.

*Comments:*

*The data compilation presented here is basically a pooling of existing databases. Practically no effort is made to validate or adjust further existing data. While it is useful that the authors would share the dataset they used to produce the climatology for verification purpose, there is no added value in this data compilation, and therefore no reason to advertise it as a product.*

We understand the reviewer's concerns on the level of the quality control procedure conducted on the O:I compilation. Three key points to take away from the quality control detailed below: **(1)** CODC-QC system (Tan et al. 2023) was adopted for its efficiency of flagging bad data without sacrificing losing (false flagging) good data, **(2)** modifications were made to accommodate Southern Ocean and Antarctic continental shelf, **(3)** low rejection rate overall after the QC procedure applied while improving the data quality as detailed below and in manuscript section 2.2 ([Line 122-158, Figure 3, Table 1](#)).

We had performed visual assessments of data quality and removed obvious outliers but applied a minimalist approach. In the revised manuscript, we therefore conducted a more comprehensive quality control procedure based on the CAS Ocean Data Center Quality Control system (CODC-QC) for temperature and salinity profiles (Tan et al. 2023; Tan et al. 2025). We used the CODC-QC for our study because the CODC-QC had been meticulously analyzed and evaluated by many previous benchmark studies with other international QC systems such as WOD-QC and ICDC-QC that the CODC-QC is good at detecting bad data as much as possible while paying an acceptable low price of sacrificing good data (Tan et al., 2023, 2025). Additional texts and figures are presented in the revised manuscript in section 2.2 ([Line 122-158, Figure 3, Table 1](#)). A few modifications are applied before using the original CODC-QC method, which was originally designed for the global open oceans. Modifications are explained in Table 1 in the revised manuscript but also here in **Table R1**. CODC-QC procedure consists of 14 checks for temperature profiles and 12 checks for the salinity profiles. 12 checks are common for both temperature and salinity data, despite different parameter settings (**Table R1**). All quality checks are performed on the originally measured depth levels.

CODC-QC names	OCEAN ICE adaptation	Reasons for modification
1. Basic information check	used	
2. Sample level order check	used	

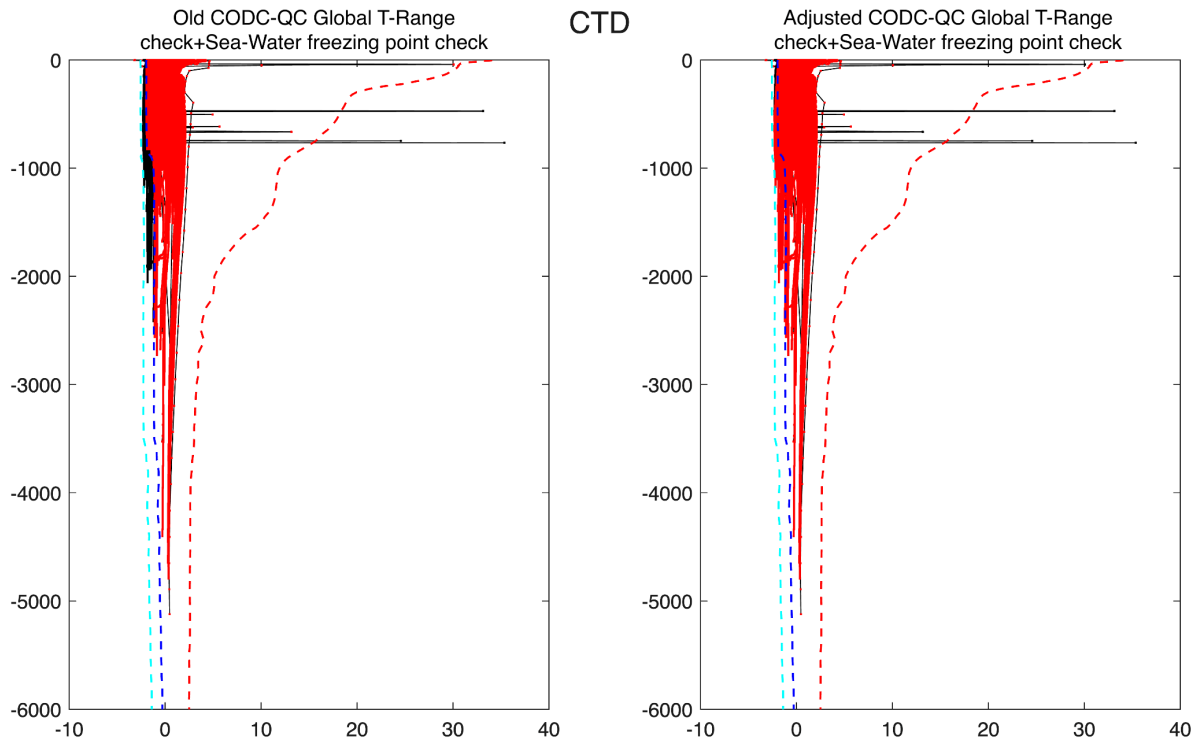
3. Instrument maximum depth check	deactivated	Crude assumption on the nominal operation depth does not necessarily apply for various CTD instruments and Argo/Seal profilers.
4. Local bottom depth check	deactivated	Inaccurate positions of under-ice profiles violate the premise of the bottom depth check+incomplete topography information in Southern Ocean and Antarctic shelf seas.
5. Global range check	used	CODC-QC lower bound is too warm for cold Antarctic shelf water.
6. Local climatology range check	used	OCEAN ICE profile compilation used to determine the local climatology range
7. Constant value check	used	
8. Spike check	used	
9. Density inversion check	deactivated	Unstable water columns can be sampled in the Antarctic shelf seas+a density stabilisation scheme is applied to the gridded product in the end.
10. Multiple extrema check	used	
11. Global vertical gradient check	used	
12. Local climatology gradient check	deactivated	This check is regarded as highly sensitive to false negatives and thus may sacrifice many good measurements, especially in the Antarctic shelf seas which are generally poorly sampled. This study prefers keeping as many good measurements as possible because precious sampling in the Antarctic shelf seas is very rare.
13. Sea-water freezing point check (Temperature only)	used	
14. Instrument specific XBT check (Temperature only)	deactivated	Not applicable

**Table R1** Summary of CODC-QC procedures and the adaptations made in this study.

We performed some modifications to the aforementioned CODC-QC procedures to better fit our compilation purposes.

We offset the lower bound of the temperature global range by 0.6°C to release cold temperature observation from being flagged as bad by the original CODC-QC global range check. We then allow the sea-water freezing check to pick out those that are unrealistically colder than the local freezing point. This modification avoids applying a hard cutoff that flags supercold Antarctic shelf water as bad. The benefit of doing so is illustrated in the **Figure R2** below where we compare the CTD shelf sea temperature casts between the original CODC-QC global range check+sea-water freezing point check and the adjusted global range check+sea-water freezing check. As we can see in Figure R1, cold temperature observation in the left panel is flagged bad because of the hard cutoff applied by the global temperature range lower bound that is too warm. On the right panel, when the lower bound is adjusted, these data are actually physically sound as they

are still above the local freezing point. Since the global temperature/salinity range used in CODC-QC system is based on the evaluation of the probability distribution function (PDF) of all the temperature and salinity in their database which is based on the World Ocean Database (WOD), we understand that this issue here is mainly because the WOD profiles are pre-dominantly obtained in the open ocean, and the data on the Antarctic continental shelf seas, especially CTD profiles that are typically cold, are not always fully included in the World Ocean Database which can lead to a warm bias when constructing global temperature PDF and consequently the lower bound based on the 0.5% quantile definition.



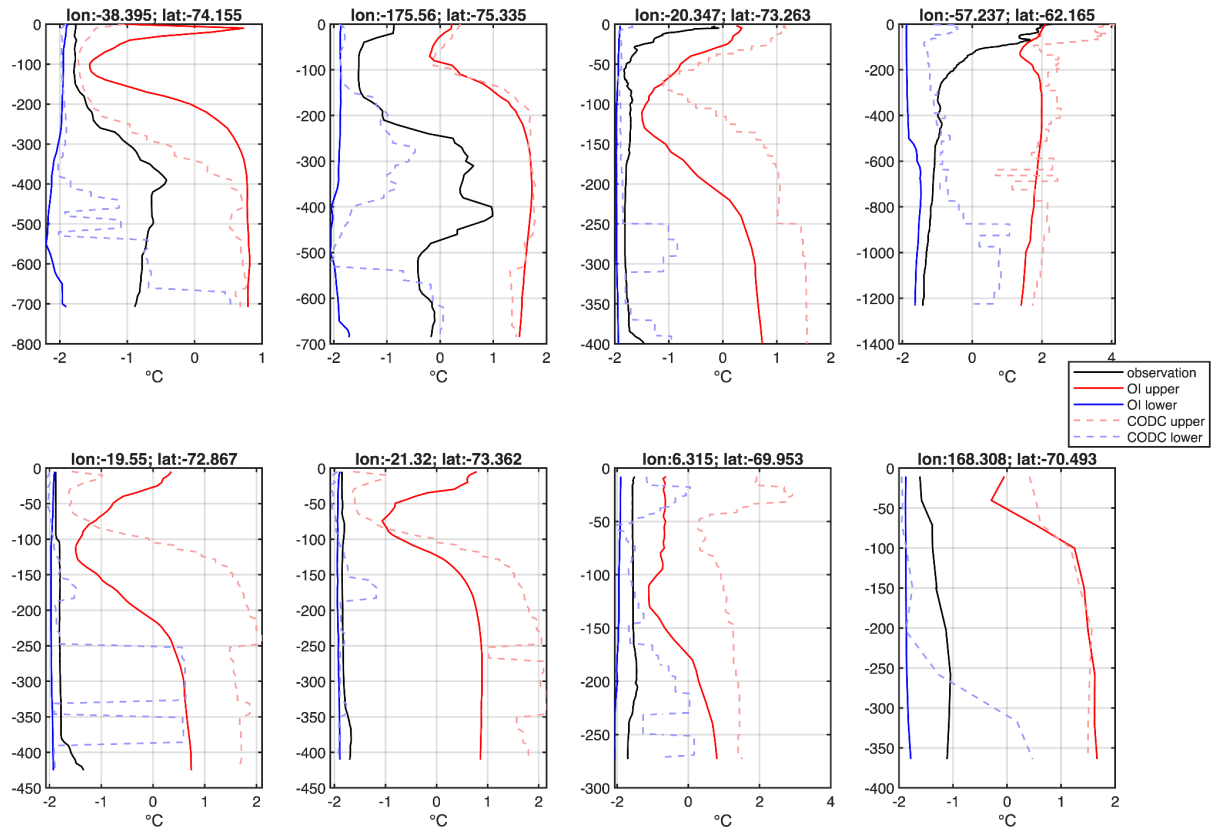
**Figure R2.** CTD shelf temperature profiles flagged using original CODC-QC Global T-Range bound+Sea-water freezing point check (left) and adjusted lower bound+Sea-Water freezing point check (right, and in this study). Red dots are those flagged good and black lines are flagged bad data. Original CODC-QC temperature range bounds are shown by blue (lower) and red (upper) dashed lines, modified lower bound in light blue.

The CODC-QC local climatology gradient checks are removed as the assumption of the temperature and salinity following a bounded preset gradient pattern is a strong quality control constraint. The function of this check is to filter out consecutive ‘outliers’ that lead to ‘anomalous’ vertical bending determined by the gradient bounds. However, this check is regarded as too strict (i.e., highly sensitive to false negatives): although it can ensure different types of errors according to the shape of the profile, it may mistakenly flag too many good measurements that seems to be physically reasonable (Tan et al., 2023) and thus it is not always safe to flag out these determined outliers without sufficient knowledge of their cause. The physically unrealistic outliers and statistically significant outliers function can be selected in a less subjective fashion by the spike check and a carefully defined local climatology range.

We also removed the density inversion check as a density stabilisation scheme is applied on the gridded product at the end since the isobaric climatology does not inherently

account for the vertical stability of each profile (Yamazaki et al. 2025). The instrument specific check for XBT is not applicable to our compilation as the dataset does not contain any XBT data.

Below is a summary of the CODC-QC checks that are applied and modified in the revised work.

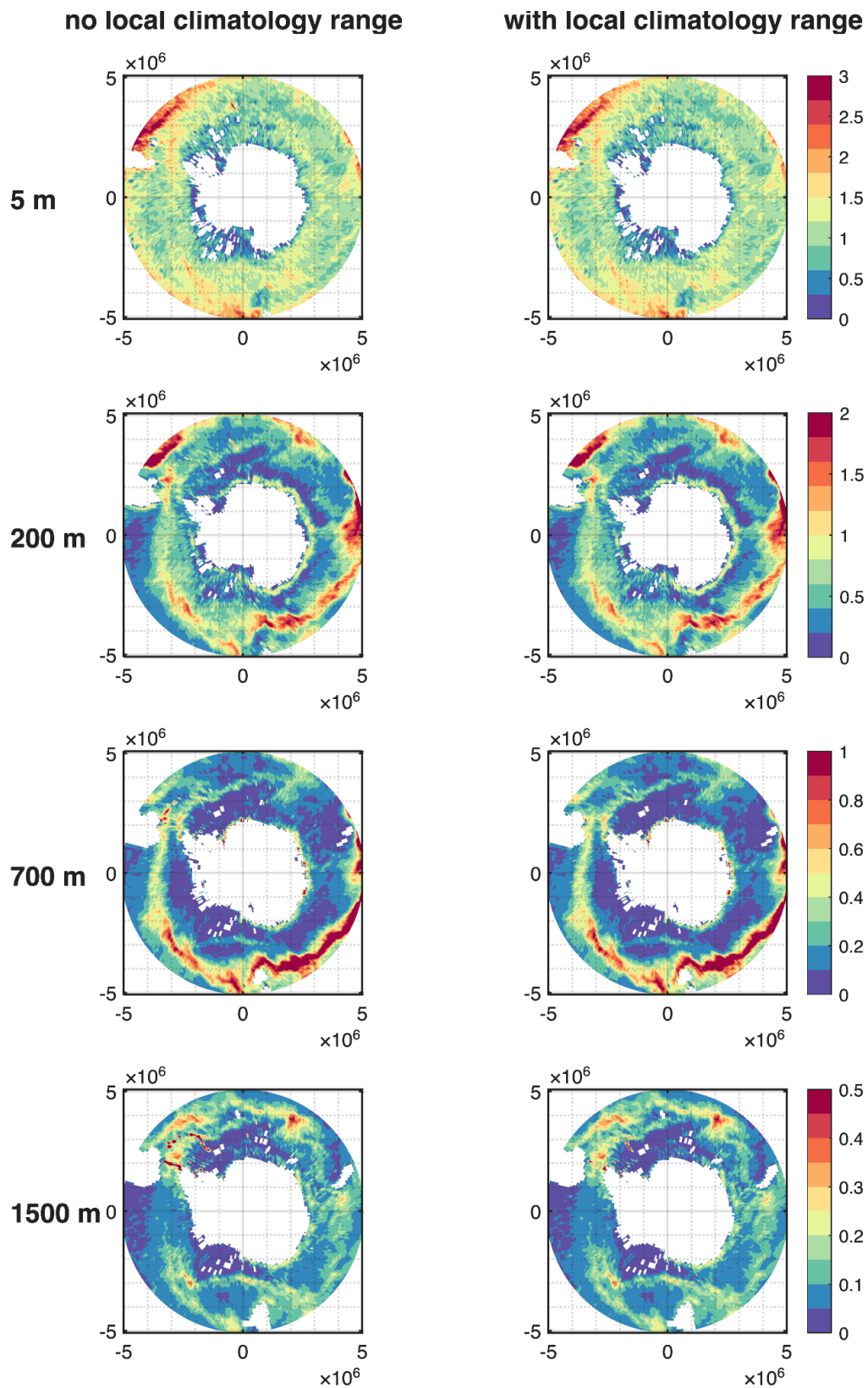


**Figure R3** Examples of the mismatch between the CODC local climatology bounds and OCEAN ICE local climatology bounds for temperature profiles.

We followed the CODC method to preprocess the profiles by adopting all the general crude checks (Tan et al. 2023; Tan et al., 2025) before passing the profiles for constructing local climatology bound to exclude bad observations before making the local climatology. These crude checks include all the checks that are used or adapted listed in **Table R1** except for the local climatology range and local climatology gradient range. We then reconstruct the local climatology range using the data returned by the fast-marching algorithm at each climatological central grid. A weighted PDF is constructed for temperature and salinity at different depth levels using the along-isobath distancing weighting alone to identify the upper (99.5%) and lower bound (0.5%). The reason for avoiding using the standard deviation based definition is to acknowledge that the distribution of temperature and salinity does not often yield a normal distribution and is typically skewed. The skewness is pronounced in the Southern Ocean due to the presence of ACC (Tan et al. 2023). The weighted PDF function reconstruction is similar to Tan et al. (2023) where the topographic barriers are considered when sampling surrounding data for their conventional PDF function construction. The benefit of using OCEAN ICE profile compilation rather than CODC data compilation to construct local

climatology range is obvious - it avoids a systematic shift of the centers and the tails of the distribution that can sometimes lead to false flagging (i.e., false positive) (**Figure R3**) caused by the mismatch of the source data.

The improvement of the data quality can be reflected by the standard deviation map of temperature at 5 m, 200 m, 700 m and 1500 m as an example before and after the local climatology range check quality control applied (**Figure R4**). In cases when local climatology range check is applied, the high standard deviation patches in the open ocean are reduced especially in the deeper depth while the bands of high standard deviation region that stand for dynamic feature of ocean circulation (i.e. ACC, ASF) are retained. We discard the data that are flagged bad by at least one of the individual QC checks that were used or modified as stated in **Table R1**. The overall rejection rate of data at the observed level is **0.51%** for temperature and **0.63%** for salinity.



**Figure R4.** Standard deviation of temperature at  $1^\circ \times 1^\circ$  grid for data with and without local climatology range check applied at 4 standard depth levels. The local climatology range check improves some patches of high standard deviation in the open ocean especially at deeper depth levels.

*The description of data is lacking many critical details. This is particularly true for the MEOP-CTD dataset which represents more than half the data in number of profiles. No*

*reference is provided nor any information regarding the data quality or processing. For people who themselves produce data such as the authors, it is very surprising to see such lack of recognition for the work other people are doing to make data available to the community.*

The reviewer may have skipped over important sections in the original manuscript and the bibliography. We did provide the reference of MEOP-CTD dataset (itself a curated version of instrumented-seal based observations) in section 2.1 in the original manuscript. Also in the original manuscript, the first paragraph of section 2.2 further detailed the method we applied to determine which profiles were going to be used in our database based on the QC flags provided by the data sources. So, we are surprised by the reviewer's statement. We fully agree that citation of data sources and methods is an integral part of scientific endeavour. In the revised manuscript, it may further alleviate the reviewer's concerns about the data quality that we added a layer of quality control on the overall database based on the CODC-QC method (Tan et al. 2023), as detailed earlier.

*The authors compare their product with WOA23, finding their product to be better. This is hardly a surprise as WOA23 is not a very good product in the region. A thorough comparison with better products such as Yamazaki et al 2023 or SOSE, and maybe some others such as MIMOC or Pauthenet et al. 2021, appears essential to assess the real added value of this new product.*

We thank the reviewer for their suggestion of comparing the presented climatology product with more SO-focused climatologies. We had refrained from doing so earlier because most other climatologies do rely on the World Ocean Database as a source (at least for CTD profiles), so suffer from the missing samples on the Antarctic continental shelf, were focused on shallower depth ranges, and applied coarse interpolation schemes likely to misrepresent shelf sea properties. In the revised manuscript, we repeated the comparison done between OI climatology and WOA23 on two other climatology products suggested by the reviewer that are dedicated to the Southern Ocean: 1) Pauthenet et al. 2021, a Southern Ocean (south of 60°S) monthly climatology over the top 380 m, hereafter Pauthenet21, constructed purely based on the Fast-Marching algorithm and 2) Yamazaki et al. 2025, hereafter Yamazaki25, a Southern Ocean (south of 40°S) monthly climatology over the upper 1000 m constructed using the DIVAnd method and WOA23 as the initial field. We understand that the reviewer recommends Yamazaki et al. 2023 climatology, which is the preprint version of the Yamazaki et al. 2025. The new comparisons are presented in revised **Figure 11-14**.

We re-wrote the whole section 4.4 to describe the new comparison - In general, Yamazaki25 compares better with the OI climatology in terms of the representation of key water masses such as ISW and HSSW because of its carefully tuned parameters including its spatially-varying decorrelation length scale. However, there is a slight incompleteness in Yamazaki's climatology in representing the continental shelf water mass structure because it only covers the upper 1000 m. This means that Yamazaki25 only partially represents the deep basin in front of Filchner-Ronne Ice Shelf and Ross

Ice Shelf and deep troughs on Weddell and Ross continental shelf. Pauthenet21 only covers the top 380m so it doesn't have the capacity for a complete representation of shelf sea water masses including variants of dense shelf water. In addition, although Yamazaki25 outperforms the Pauthenet21 and WOA23 climatologies in terms of representing key water masses in T-S space and in volume, the bathymetry issue and overall larger decorrelation length-scale, exemplified by Amundsen Sea vertical section, and embedded in WOA23 reported in the original manuscript, persists, leading to bias in temperature and salinity field at the shelf break region.

## **Reviewer #2**

*Overall, the manuscript is of high quality and worthy of prompt publication in ESSD for benefiting the scientific community. However, there are some issues that need to be addressed before publication.*

### *Major comments*

*I think the most striking benefit of the presented O:I climatology over existing products is its extension to the inner shelf and ice cavities. However, the manuscript at present does not provide performance metrics against the observation data sufficiently to allow readers to evaluate its reproducibility over the shelf. In general, the Antarctic shelves severely suffer from the data paucity, likely requiring the estimated field to be extrapolated over a long distance, especially under the ice shelves. A more thorough, quantitative assessment of interpolation performance over the shelf (e.g., statistics of observation data residuals, mapping with the original scattered data) needs to be included. Caveats for the use of such inner shelf data also need to be explicitly acknowledged, unless low confidence estimations are masked. Furthermore, it is also highly recommended to add evaluation of the interpolation performance in deep waters (below 2,000 m offshore) in comparison to WOA23, which has been widely recognized and utilized. I believe addressing these points will improve the presentation of how this dataset is better than the other product and why it is meanwhile for the scientific community.*

We thank the reviewer for their thoughtful comments. In the original manuscript, section 4.1 described (perhaps too briefly) the calculation of the uncertainty in the interpolation scheme which we proposed to use as a guide for confidence in the climatology. However, we understand that we did not demonstrate that this was also applied in the ice cavities. To make that clearer, and in this way further highlight the existence of a metric to describe the confidence users should place on the O:I climatology at individual locations, we have modified **Figure 7g** that now shows the error map field in as well as outside of the cavities. Further, we briefly describe the method used to extend the field underneath the cavity in **Line 357-362**. Since there are no data sampled under the ice shelf being used to create the cavity field, the suggested approach such as the data residual and mapping with original scattered data would not be applicable. Over the continental shelf regions, as pointed out by the reviewer, data paucity is the major issue for objective mapping uncertainty, the modified standard error (MSE) -

defined as scaling the weighted standard deviation with data count within local ellipses - sufficiently captures the data paucity in these regions.

Our data compilation is only coherent within the top 2000 meters, where CTD, ARGO and instrumented seal observations overlap. Below 2000 meters, there are mainly CTD profiles, creating a large sample gap and sampling inhomogeneity in the vertical. This inhomogeneity would create artificial vertical gradients. Furthermore, Antarctic shelf seas seldom host depth deeper than 2000m, so our profile compilation below 2000m depth would look sensibly similar to that available in the World Ocean Database. We are therefore not sure if our climatology extended in the deeper range would provide an advance in comparison to WOA23 in that respect. Therefore, we have refrained from extending it to depth in the comparison with other climatologies.

Minor comments

*L154 “one realization where each quintile is sampled”: Does this mean simply keeping searching until 5 data points are obtained within the search range, or 5 samples are collected continuously assessing if the data values constitute sinusoidal variation? If the former case, how does the method guarantee its sufficiency of capturing their sinusoidal variation? If the latter case, what is the sampling threshold for the variation applied at each grid?*

We thank the reviewer for pointing out potential lack of clarity in our explanation. The “one realization where each quintile is sampled” means that under the current searching radius, among all data that fall within this radius, if we put them in ascending order of time and find 5 consecutive quintile sampled at least once, then we complete this realization and record the searching radius. The decomposition of a temporal period in 5 quintiles is to ensure the minimum temporal frequency required to fit a sinusoidal-type of variation which is regarded as the canonical representation of any variability. As the reviewer points out, this 5 quintile sampling strategy is applied at each grid for different assessing periods to obtain the minimum search radius at each grid that fits the definition of ‘at least one sample in each quintile’. We further emphasized the need to sample across 5 consecutive quintiles in the revised text (Line 190), for clarity.

*L198 “ellipse of influence”: how is this conceptually different from a correlation scale in the conventional optimal interpolation? In this relation, after reading the whole manuscript, I could not understand how the adopted interpolation method is compared with the conventional optimal interpolation and why the adopted method is thought to be better. Please explain somewhere.*

We thank the reviewer for raising this point. In our manuscript, the terms ellipse of influence and decorrelation length scales refer to the same underlying concept. We adopt the term ellipse of influence primarily for clarity in describing anisotropy and orientation in the weighting used for the interpolation.

In many studies, decorrelation length scales are expressed separately as zonal and meridional components. While this representation is convenient in a fixed coordinate system, it becomes less intuitive when the principal directions of variability are not aligned with the zonal–meridional axes—for example, when they follow SSH contours.

By using the ellipse of influence, we can describe both the magnitude and the orientation of the decorrelation scales in a unified framework. The ellipse naturally captures anisotropy (through its major and minor axes) and allows it to be rotated to align with physically relevant directions (e.g., along SSH contours), which simplifies the interpretation.

For this reason, although the two terms are conceptually equivalent, we prefer the term ellipse of influence in this manuscript as it provides a clearer and more flexible description.

Recognising that our description may have lacked clarity, we decomposed the original section 4.1 into subsections.

In the revised manuscript, we further added a sentence [Line 242-250](#) to guide the reader: “Conceptually, the ellipse of influence method below is akin to applying distance weighted objective interpolation with elements of anisotropy along the major and minor axes of the ellipse (see below).” and “Recognising that the anisotropy of ocean properties is driven by its dynamics, we first describe the main direction of anisotropy using ellipses and perform an elliptically weighted Gaussian interpolation function in densely sampled regions. For those regions that are poorly or not sampled, we instead need to use a different method based on a Fast-Marching algorithm and use the local sampling density to regulate the relative contribution of each interpolation method. We provide a step-by-step description below.”.

The adopted method possesses following features - (1) SSH-aligned anisotropy captures flow-following coherence; (2) bathymetry-dependent length scales distinguish shelf from open ocean; (3) FM extension fills data-sparse regions conventional OI cannot reach (i.e., ice cavity). Some of these features might be partially achieved either explicitly or implicitly in other objective mapping methods, such as the one presented in Yamazaki et al. 2025. But we believe that it is the details in the parameter tuning (e.g. the horizontal scaling) and the profile database that makes the most difference in our practice.

*L214: What is the time period of SSH modelled by SOSE? Does the temporal variation of SSH in SOSE will affect the results? How much?*

The time period of SSH from SOSE is from the 139th iteration which spans from 2013 to 2021. Temporal variability in SSH should indeed represent variations in circulation and its anisotropy. Whilst we are confident SOSE has a reasonable ability to represent the mean circulation and associated SSH around Antarctica, we surmise its ability to represent temporal variability is much more debatable. For this reason, we have

refrained from using a temporally varying SSH field. We however agree that this is an area where progress could be made in the future with the advent of satellite-derived SSH product in sea-ice covered regions. We fully acknowledge the underlying influence of the choice of SSH product and its temporal context on the gridded climatology; we added texts in [Line 269-275](#) to highlight this point.

*L224 “The orientation of the ellipse on the continental shelf follows the local topography gradient”: The authors may want to define the ellipse orientation as its major axis direction then correct this sentence to ‘follows the local topography contour’*

We thank the reviewer for pointing out this ambiguity. We re-wrote the sentence into: The alignment of the ellipse major axis follows the local topography gradient. Same applies to where the term ‘orientation’ is mentioned for the first time in [Line 263](#), the original sentence now reads “For the O:I climatology, instead of applying zonally oriented ellipse clusters, the alignment of ellipse major axis, i.e. the orientation of each ellipse, is determined using the sea surface height (SSH) contour”.

*L228 “The choice of the horizontal resolution is to accommodate the shelf ellipse size”: The shelf ellipse size seems determined by the fixed value that connects offshore (L221), which is based on the SOSE SSH contours. Assuming the SOSE field had 1/6<sup>th</sup> degree grids, the chosen grid size of 0.2x0.1 is fairly small and maybe even smaller than the SOSE grid. Overall, I could not understand 1) how the listed values of correlation length scales are determined offshore and 2) how the choice of such small grid size is justified. I suspect there is missing information that required to reproduce these values, maybe something hidden under L219 “In our algorithm”. This point is also relevant to calibration of tuning parameters essential for the best estimation.*

The choice of 0.2x0.1 degree roughly corresponds to 8x11 km in the Antarctic continental shelf at 70°S. The grid size defines the spacing of the centre of ellipses, and we chose this grid size so that the adjacent ellipses on the continental shelf partially overlap to achieve a smoothed finish of the gridding given the size of the ellipse is 44.5 x 22.2 km on the continental shelf. The choice is also intended to represent some of the along-ice shelf gradient that can be resolved with the abundance of observation data, such as in front of the Pine Island Ice Front, which spans roughly about 40km in length, and where we know persistent gradient exists from synoptic surveys. With a roughly 10km sliding stride defined by the grid size, it allows for the mapping to resolve spatial variations if there are any. Indeed, we understand that this grid resolution can be a bit ‘unnecessarily’ high for some other shelf seas where data are sparser, and perhaps a slight ‘overkill’ for the open ocean. However, we still decided to use 0.2x0.1° as our grid size because it is computationally acceptable to perform the mapping and it prioritises the accurate representation of the sharp horizontal gradient in regions where enough data allows its capture on the continental shelf.

*L246 “a fast-marching (FM) algorithm is performed to search for and select data beyond the spatial bound defined by ellipses”: Was the FM scheme applied for the entire dataset including offshore? What does “where a simple average metric within ellipses loses meaning” specifically mean?*

Yes, the FM scheme was applied for the entire dataset at all grids including the offshore region. The sentence “where a simple average metric within ellipses loses meaning” points out the fact that in regions where the data is sparse, there will be cases where no data is found within the ellipse. We have revised the text to more simply state: “where little to no data is present within ellipses” at [Line 305-306](#).

*L286: What is “the weighted standard deviation”? What makes this interpolation error metrics larger; e.g., less data density or wider spread of measured values?*

The weighted standard deviation is estimated following

$$\sigma_w = \sqrt{\frac{\sum_{i=1}^M w_i (x_i - \bar{x}_w)^2}{\sum_{i=1}^M w_i}},$$

where  $x_i$  is the observation,  $w_i$  is the weighting assigned to the observation and  $\bar{x}_w$  is the weighted climatological mean. The weighted standard deviation is used to be consistent with the weighted mean field that represents the climatology. The modified standard error is an analogy to standard error which is formulated as the standard deviation scaled by the square root of sample size. In our practice, to acknowledge the data sparsity and reflect that on the uncertainty metric, we use the count of valid data within the ellipse instead of the overall number of data (determined by the FM algorithm) used to produce the weighted mean to scale the standard deviation. Therefore, low data density will lead to much larger modified standard error and a wider spread of measured values would lead to a larger weighted standard deviation.

*L388 “as noted in Barker and McDougall (2017)” and L389 “a thorough comparison of the two methods tested in this study”: It appears that Barker and McDougall (2017) did not describe the VA method (but Chu and Fan’s CMA) nor cite Wang et al. (2012). Please explain.*

The reviewer is correct: Barker and McDougall (2017) did not perform the comparison with VA but only CMA, which is an older version of VA. Wang et al. (2012) also did not perform any comparison between VA and the MA that was re-developed in Barker and McDougall 2017, so in this work it is perhaps the first time that the two methods are compared directly side by side. However, both methods have performed arguably well in terms of density stabilisation, only with marginal difference on the magnitude of correction. Therefore, in the revised manuscript, we decided not to comment on which method is better but simply stated that we use MA as it is slightly more effective and easy to implement in [Line 446-450](#). We also removed the sentence mentioning the comparison between methods in the literature.

*Figure 9: “temperature maximum below 100 m” is likely too shallow for upper CDW north of the SACCF.*

*Temperature: [https://woceatlas.tamu.edu/images/printed/jpg/I9\\_ptm.jpg](https://woceatlas.tamu.edu/images/printed/jpg/I9_ptm.jpg)*

*Oxygen: [https://woceatlas.tamu.edu/images/printed/jpg/I9\\_oxy.jpg](https://woceatlas.tamu.edu/images/printed/jpg/I9_oxy.jpg)*

We thank the reviewer’s comment on the definition of CDW in the northern bound of our domain. It is indeed too shallow for CDW to be defined as temperature maximum below 100m. In other literature, the representation of CDW is often bounded by the dynamic boundary of ACC front, to the north of which the Sub-Antarctic Mode Water and Antarctic Intermediate Water reside on top of the CDW and are warmer. To avoid the ambiguity, we instead only show the CDW metrics south of the SACCF in the revised **Figure 10**.

*Figure 10: Although this figure provides how the O:I climatology is different from WOA23, it might be difficult for readers to know which is better in general outside the featured sections.*

*Summary: I suggest adding a brief explanation about how the presented climatology can be compared with the existing datasets such as WOA23 and Yamazaki et al. and why the present dataset matters for the scientific community.*

Thank you for the suggestion. The strength of O:I climatology lies mainly in its representation of sharp continental shelf gradient and dense shelf water signature compared to WOA23. In light of this and the comments made by reviewer#1, we updated the evaluation of our climatology by comparing it with Pauthenet et al. 2021 and Yamazaki et al. 2025. The former is constructed using Fast-Marching algorithm only, which can potentially highlight the difference made by the ellipse of influence. The latter is a climatology constructed using the DIVAnd method with the initial field extracted from WOA23. Therefore, we retain our main comparison between O:I and the other two climatology products on the continental shelf and update **Figure 11** to **Figure 14**. We re-wrote the whole section 4.4 to describe the new comparison, highlight the differences with other products, and the O:I climatology better representation of spatial gradients in Antarctic shelf seas.