

**Review of the manuscript: "Impact of Grid resolution on the abyssal ocean representation in numerical models: a focus on the Vema Channel"**

The study investigates the representation of abyssal waters in three reanalysis models (ECCO, SODA, and GLORYS) and one OGCM (OFES) across the region extending from the Weddell Sea—where deep and bottom waters are formed—to the Brazil Basin, where they flow northward. Model performance is evaluated against the WOA18 climatology as well as in situ observations (moorings and CTD data). This comprehensive assessment of existing reanalyses and models provides valuable insights for future studies in this region.

Given that the four models differ in their grid resolution, the authors further explore the impact of increased horizontal and bottom vertical resolution using additional simulations with FESOM. These experiments offer important insights into how model resolution affects the representation of deep and bottom waters, and more broadly, improve our understanding of the role of resolution in simulating ocean circulation and water mass properties.

The manuscript is well written, and the results clearly stated however the manuscript would benefit from a more extensive and defined discussion section.

Main/general comments

1. The model descriptions in the Methods section are quite brief, and some key information is currently missing. To help readers better understand the differences between the models, it would be beneficial to provide additional details beyond the grid configuration. In particular, the authors should consider including information on bathymetry, mixing parameterisations, boundary conditions, and any other relevant model components. This would make it easier to interpret the results and identify the sources of inter-model differences.
2. The results presented are very interesting; however, their overall impact would be strengthened by a more in-depth discussion of the mechanisms driving the differences between the four models. While the FESOM simulations are used to explore the impact of horizontal and vertical resolution, the connection with the other models is not fully developed. Expanding this discussion would help readers understand how the FESOM-based findings relate to and explain the variability seen across the models.

It would also be useful to include a more explicit comparison of the five models in terms of their configurations, such as core model structure, bathymetry, data assimilation (including whether assimilation is performed in this region and which datasets are used), diffusivity and mixing schemes, dissipation, and sea-

ice representation. These factors are likely to influence the simulation of deep waters and could provide valuable insight into the differences observed.

Additionally, a short paragraph discussing the limitations of the climatology and observational datasets used for validation—particularly in this region—would improve the robustness of the study.

Finally, incorporating references on the impact of model resolution on ocean circulation could further support and contextualise the interpretation of the results.

3. In general, the figure captions are missing information. Please make sure that all the features on the figure are described in the caption to help the reader navigate the figure.

## Comments

Line 42: it is not clear if the 3 latitudes are the latitudes of the moorings. Please rephrase.

Line 81: can the authors provide more information regarding the frequency of the measurements, if they are all done on the same month, etc

Lines 83-84: the mention of the PIES instruments at the same location is a bit confusing as those observations are not used in this study. Please rephrase or edit the sentence.

Figure 1: It would be helpful to have latitude and longitude on the maps

Figure 1 caption: 'Green diamonds mark **CTD** sites' – add CTD

Table 1: for SAMBAR, is it a typo the year '2020' in the last column?

Line 104: are the outputs snapshots or averages? The authors could mention that only (I suppose) monthly outputs have been used in this study.

Lines 106-107: It is unclear if this sentence 'The product ...' refers to the atmospheric forcing or to the model.

Line 126: The format of the reference is wrong. First names are displayed instead of the last name of the authors.

Line 131: 'We assess...' it feels like the sentence is incomplete.

Section 2.6: can the authors add more details about the initial conditions and forcing of the ocean?

Line 135: is '1958-2019' the period of the atmospheric data or of the model? Please clarify and rephrase.

Line 135: what do the authors mean by 'the model focuses on the upper ocean'? The reader might wonder why this model would be used in this study if it is not made for deep ocean. The last 3 sentences would benefit some rewriting to improve the message.

Line 155: please replace 'first' by 'reference' and delete '(from reference)'

Line 158: I might be better to have the depth in meter to be coherent with the other models.

Line 159: Can the authors explain what they mean by 'the base horizontal resolution was set to 30 km'?

Line 161/167: replace 'from' by 'for'

Line 163: is this simulation less deep than the other one? How many more levels are added?

Table 2: add 'atmospheric' with 'forcing'. Also, only for the table, the authors might choose to have all resolutions in km or in degrees for coherence between the models.

Lines 189-191: 'This feature...' It would be interesting to expand this in the discussion on the limitations of the climatology for validating the models

Figure 2- caption: Can you clarify what the authors mean by 'total'?

Lines 246-261: This paragraph could be used later on to discuss the differences between models as it doesn't really compare with observations as the rest of the section.

Line 251/261: what do the authors mean by 'the outputs are not continuous in time'? Is it not monthly outputs? If it is not, how is it taken in consideration in the different analyses?

Lines 254-261: it would be interesting to understand these trends and their possible impact on the results.

Section 3.2: are the T-S diagrams an average of the points in the white boxes per level (from surface to bottom) or all grid points are represented? Also Fig. 3a and 3b are not directly described in the text, especially how it transitions from one to another.

Line 272: if possible, please add the location of the Scotia Ridge on a map.

Figure 3: the authors might consider to change the colorbar to depth instead of number of points to highlight the location of the difference water masses on the vertical.

Figure 3 – caption: the colorbars are not explained in the caption.

Line 289: the use of the word 'discontinuity' here is not clear to me. Can the authors clarify what they mean by this.

Line 295: again, I am confused with the use of 'discontinuities'. Are they expected to be the same?

Section 3.3: at which latitude is the cross-section? Have the authors considered the nearest grid point for each model or did they interpolate the results to the exact same latitude?

Line 305: Is the absence of the Vema Channel only at this latitude or is it not at all present? Having looked at a map, the Vema Channel extends from 28S to 32S.

Line 317: could it also be due to a bathymetry blockage?

Lines 318-319: Any ideas why OFES presents a cooling in the Vema Channel and the Brazil Basin?

Figure 4 – caption: please move (a), (b), etc before the model name. On a different note, is there a particular reason for why the authors have highlighted the isotherm 0.04?

Lines 325/347: please replace 'four products' by 'four models' for clarity.

Line 327: It is very interesting that GLORYS shows such a high monthly variability especially in the deep ocean. Do the authors have any ideas why it is happening? It seems very strange. Could they be snapshots and the other models are monthly average?

Figure 5: On the Taylor diagrams the authors could consider plotting the normalised standard deviation instead of the standard deviation (normalised by the reference). On another note, what are the thick grey lines represent? If they are the standard deviation, why do they not align with the thin lines? Regarding the time series for SAMBA, how can you have SODA (finishing in 2019 in Table 1) and GLORYS (finishing in 2018)?

Figure 5 – caption: 'temperature **monthly** time series' – add 'monthly'

Line 377: remove 'a pattern common to all four FESOM simulations'.

Lines 385-389: This paragraph is somewhat difficult to follow and would benefit from clarification. If its purpose is to compare the first four models with FESOM R to link the results from the FESOM simulations to the different performance between the models due to the different resolution – if it is what the authors are trying to demonstrate, I would suggest moving it to the discussion. If so, a similar figure could be made but this time of the difference of the four models with the different FESOM simulations (only for temperature).

Line 393: please remove 'comparable pattern obtained with GLORYS (Fig. 2d)'

Line 397: please remove 'resembling the pattern observed in SODA (Fig. 2c), but with higher temperatures'

Lines 405-410: move the paragraph after the salinity sigma4 descriptions and if possible add some references to support your reasoning.

Figure 8 – caption: please include the description of the colorbars in the caption. As mentioned previously the authors might consider replacing the first colorbar to depth instead number of points.

Line 486: please include the value of the correlation. 0.8 is very high, any idea why FESOM R is reproducing the pattern so well for CLIVAR?

Line 492: add correlation value

Line 493: where are the RMSE values?

Line 499: the highest correlation value is about 0.2 I think which does not show any correlation. The author might want to change the sentence to highlight the fact that the four simulations do not show any correlation with observations.

Supplements: the name of the figures do not match the ones in the main text.

Data availability: Copernicus and OFES2 links do not get to the right pages. Also none of the zenodo links worked

Video supplement: I wasn't able to access the video.

## **Suggestions**

Table 1: maybe the CTD data could also be added in Table 1.

Figure 1: I would have found it helpful if the figure was also including a map of the bathymetry with the location of the Vema Channel and a rough schematic of the circulation.

Sections 2.3-2.5: To avoid the repetition about the atmospheric forcing, the 3 models could be under the same subsection 'Reanalysis models'

Table 3: the authors could consider adding the mooring mean and trend in the table.

Section 3: A table summarising what each model is able or not to represent would be very valuable.

Section 4: A table summarising the results would also be great!