Review of egusphere-2025-2973

Piracha et al., 2025

Ocean Science

General comments

In this study, Piracha et al. use satellite observations of sea surface quantites over the period 2011–2020 to analyze the variability of "density flux" in the Atlantic. Density flux is a concept akin to water mass transformation and represents the change in seawater density due to processes such as air-sea buoyancy fluxes, mixing, and mixed layer entrainment. The authors produce maps of annual and seasonal mean density flux, including a decomposition into temperature and salinity contributions, as well as an attribution to annual and sub-annual periodicity. Finally, the study looks at changes in the density flux in the subpolar North Atlantic over recent years, and identifies anomalous conditions in 2019 that were not seen in previous years.

Overall, I believe that this study presents valuable results concerning density fluxes in the Atlantic over the recent past. The analysis itself is not especially novel or groundbreaking, but it seems that the methodology is robust, the calculation of the density flux using these datasets is novel in itself, and the results regarding recent changes in 2017–2020 are interesting. It is unfortunate that the analysis stops in 2020, just when a potential "regime shift" is detected (Ln. 14) — it would be ideal to extend the analysis to 2024/5. In some places, the conclusions are based on speculation and not necessarily supported by the results or by cited literature.

I believe that this manuscript could be suitable for publication in Ocean Science after the comments below have been addressed.

Having read the comments of reviewer #1 after having written my comments, I can say that I fully agree with their assessment, I differ only in my recommendation to the editor (revision instead of rejection).

Specific comments

Ln. 1 The abstract should begin with a sentence introducing the "density flux" concept and a motivation of why we should care about it.

Ln. 14 "regime shift": given the importance of this result, it would be good to extend the analysis further in time. I assume that the time period 2011–2020 has been chosen due to the availability of the chosen datasets, but surely there are other sea surface salinity datasets that could be used to see if a regime shift has actually taken place over recent years.

Ln. 45 "Atlantic Thermohaline Circulation": this term may be a bit outdated, I would suggest using "AMOC" (which is already used further up in the Introduction)

Ln. 57 Since the datasets have yet to be introduced, it can be confusing to read "All datasets provide..." at the beginning of the paragraph. You could include a general first sentence along the lines of "We use observational datasets of XYZ. These datasets provide..."

Section 2 (Datasets) Instead of the division into "satellite datasets" and an "in-situ/satellite blended dataset", it might be more useful to simply divide this section into one subsection (or bullet point) per dataset, i.e. one paragraph each for the SSS, SST, SSC, and MLD datasets.

Ln. 75 What is the spatial (and temporal) native resolution of the SSC product?

Ln. 81 MLD definition: do you use a density threshold or a temperature threshold to compute MLD? The way I understand it, you compute the density change that would result from a 0.2K cooling of the water at 10m depth and use that as a density threshold. Due to the non-linear equation of state of seawater, that would imply that the density threshold itself depends on temperature and salinity, correct? For example, a quick calculation shows that at a reference salinity of $S = 35\,\mathrm{g\,kg^{-1}}$, the density threshold at $T = 25\,^\circ\mathrm{C}$ is $0.06\,\mathrm{kg\,m^{-3}}$ and at $T = 2\,^\circ\mathrm{C}$ it is $0.01\,\mathrm{kg\,m^{-3}}$. Does this lead to substantially different MLDs compared to a fixed density threshold (e.g. $0.03\,\mathrm{kg\,m^{-3}}$), and does this influence your results?

Ln. 85 The paragraph on the 3D T/S dataset used for the calculation of MLD is too detailed; assuming the dataset has been shown to be trustworthy, you can simply cite its reference. More imporant is the calculation of the MLD itself, as mentioned in the previous comment.

Section 3.2 (Anomalies) This subsection feels overly complicated since the calculation of deseasonalized anomalies is fairly standard. It could be reduced to a single sentence, e.g. "We calculate monthly time series of deseasonalized anomalies by subtracting the 10-year mean seasonal cycle from the full time series". The latitude-longitude definition for the subpolar gyre can be mentioned in the text and figure caption.

Ln. 143 "driving dense water formation": Fig. 1 shows the whole Atlantic basin, not only the high latitude where actual dense water formation occurs. Of course, positive density fluxes occur across all latitudes as shown in Fig. 1, but this is not commonly called "dense water formation".

Ln. 170–172 This sentence needs one or several references.

Ln. 201 "winter peak": on Ln. 181, the timing is instead characterized as "boreal autumn". This should be made consistent.

Ln. 214 Figure 4 should already be referenced in the first paragraph of this subsection.

Ln. 263 What does the importance of low-frequency variability imply for the results of your study, which are based on a short (10-year) observational record?

Ln. 284 The last paragraph reads a bit too much like an advertisement for the Arctic-Flow project. Instead, you should state more generally how future work should build on your findings in this paper.

Ln. 294 "significant": significant under which statistical test? From Fig. A1 it seems that uncertainties in the density flux are generally smaller than 10% of the seasonal amplitude, is this the heuristic of significance used? Furthermore, the significance testing detailed in this appendix section should be referenced or briefly summarized in the main text.

Anywhere It should be mentioned at least once in the manuscript that the increased influence of salinity on density at high latitudes is due to the non-linear equation of state of seawater (specifically the dependence of α on T). This is a key fact and should be used to interpret some of the findings.

Throughout In the following places, statements in the text should be supported by citing the relevant literature:

- Ln. 144–146
- Ln. 152
- Ln. 170–172

- Ln. 173–174
- Ln. 196–197
- Ln. 256 (what potential weakening mechanism?)

Technical corrections

All figures Please avoid the use of the "jet" or "rainbow" colormap (Figs. 3, 4, A1). See this reference for a critique of this colormap: `https://doi.org/10.1109/MCG.2007.323435`

All figures In general, it would be useful to include column (and row) headings in the figures, e.g. column labels saying "net, thermal, haline" in all figures except Fig. 5, as well as row labels saying "amplitude" and "phase" in Fig. 3, and so on.

All figures It would be useful to make the panel labels (A/B/C/etc.) bold for better visibility.

All figures The units should be used as colorbar labels directly in the plots, not only mentioned in the figure captions.

Figure 1 Increase the size of the panel labels.

Figure 5 Do not use decimals (e.g. 2015.0) for years on the x-axis. Increase the size of all axis and tick labels.

Figure 5 caption lightning → lightening

Figure 6 Increase the size of the colorbar, maybe make it horizontal.

Affiliation The word "Oceanography" should likely be capitalized.

Units In all figure captions and elsewhere in the text, units should be typeset without italics (e.g. 1 kg instead of $1kg$). In the egusphere template, this can be done using the \unit{} command.

Ln. 29 within *the* ML

Ln. 39 over *the* ML

Ln. 101 "one-two": replace by "one to two" or similar.

Ln. 114 (Eq. 4) remove the $f(m)$ at the end of the line.

Ln. 114 (Eq. 4) "mod" should probably not be in italics (use \mathrm{} or similar)

Ln. 135 R^2 statistics → R^2 statistic

Ln. 139 Instead of calling σ the "standard deviation operator", you could simply replace σ^2 by "var" (for variance) in Eq. 6.

Ln. 144 "respectively" is misplaced, instead say "...shown in Figures 1 and 2, respectively."

Ln. 150 the citations should be in parentheses

Ln. 158–159 "strait" should be capitalized since Fram Strait and Davis Strait are proper nouns

Ln. 172 "Figure" is repeated

Ln. 219–223 The reference should be to Figure 4, not 5.

Ln. 240 There unit is not typeset correctly.

Ln. 291 There is a superfluous newline in the last sentence.

Ln. 298 The reference should not be in parentheses.

Ln. 299 "standard deviation": the standard deviation is not a measure of difference between datasets. I assume you are instead referring to root mean squared error (RMSE), or a similar metric? In addition, the values (0.35 and 0.4) should have units (presumably K or K^2).

Ln. 300 boy → buoy

Acknowledgements There is a missing closing parenthesis and a missing period in the Acknowledgements section.