Comments on "Observed change and the extent of coherence in the Gulf Stream system" by Asbjørnsen et al.

In this manuscript, the authors present new evidence of a lack of coherence between the subtropical gyre, subpolar gyre and Nordic Seas in the North Atlantic, while also discussing possible trends in the strength of the circulation. They take advantage of the observational data available between 24N and 75N, also relying on models. Instead of focusing on AMOC transports, the authors have provided results using components of the Gulf Stream System along the three gyre structures. Moreover, they propose mechanisms of interannual to decadal variability linked to atmospheric forcing.

The authors have presented a well written paper with a clear methodology. Their new approach using certain components of the upper ocean circulation instead of the AMOC integrated view is of high interest for understanding the meridional coherence of the North Atlantic circulation.

As a result, I find this manuscript should be suitable for publication after addressing some minor comments given below.

Firstly, I recommend the authors to emphasize the main point of the results – gyre-specific meridional coherence, specially between SPNA and Nordic Seas. This disconnection between subtropics and subpolar gyres is not that new, but it is interesting to see these differences with the Nordic Seas, considering the great effort on providing the GSR, Svinøy and BSO time series.

Therefore, I would like to see a more extended discussion on gyre-specific coherence. On this topic, Buckley & Marshall (2016) in their review state that:

'Modeling studies [*Bingham et al.*, 2007], ocean state estimates [*Wunsch and Heimbach*, 2013b], and observations [*Mielke et al.*, 2013] indicate that the AMOC is not coherent between the subtropical and subpolar gyres on interannual timescales. Within the subtropical gyre interannual AMOC variability is dominant, while in the subpolar latitudes decadal AMOC variability is stronger [*Balmaseda et al.*, 2007; *Wunsch and Heimbach*, 2013b]. On decadal timescales models and state estimates generally exhibit meridionally coherent modes of AMOC variability.'

More recently, Zhao (2018) relay the importance of mesoscale processes on transporting MHT poleward across the SPNA using models. Zou (2019), similarly to this manuscript, investigate the coherence in the North Atlantic in deep layers through the equatorward NADW rather than AMOC and in Zou (2020), they re-examine the meridional structure of AMOC variability and diagnoses the associated forcing scenarios with three different models, showing that AMOC variability south of the Labrador Sea can be decomposed into a latitudinally coherent component and a gyre-opposing component, with different variabilities and forcing affecting each. And Han (2023) studies AMOC connection between OSNAP and RAPID in adiabatic terms using numerical models, where the Labrador Sea plays an important role as the origin of that adiabatic forcing that generates the SPNA variability.

Finally, I encourage the authors to add uncertainties to the values computed. Even if we know it is significant with a statistical test, knowing the uncertainties can help us interpret the results (such as the average mean value and trends for both observations and ECCO).

SPECIFIC COMMENTS

- Line 61. This is the first reference to the Norwegian Atlantic Current. Throughout the manuscript (text, figures and tables) there are references to both this and the Norwegian Atlantic Slope Current. I think it would be beneficial if the authors clarified both currents and maybe unified them in only just one.
- Table 1 provides a lot of information, but I find it could be useful if some of it were provided later in the manuscript.
    - For example, the trends are mostly discussed later, along with Table 3. The authors should consider moving these trends for observations to Table 3, so that it would be easier to follow the discussion in the text.
    - Please specify the uncertainties of the mean (or standard deviation of the mean), even after marking significant trends, as it provides an idea of the variability of the dataset.
    - Some of the naming don't follow the same structure (RAPID WBC and RAPID MOCz but GSR and GSR OW; Oleander GS but Svinøy) – do the authors want to specify the current part of the Gulf Stream System?
    - The values in Table 1 for mean and trend are not always reported in the literature cited. 'Data source' would be a more appropriate term than 'reference' to cite the works from which the datasets were obtained.
    - One of the points that I have not seen specified along the manuscript is the sensitivity of these computations on how the authors have defined the different currents studied, i.e., which are the horizontal and vertical boundaries of each current and what criteria were the authors following.
    - On another note, the instrumentation and methodology used for each monitoring observing system is quite diverse. The authors could consider adding columns for the instrumentation used for each timeseries and the frequency of the observations.
- Lines 98-99: 'the Oleander record has different temporal resolution than the other time series displayed in Figure 2'. This is the first mention of the time resolution of the time series, so to make this statement the authors should include that information when describing the rest of time series. This is related to the beginning of section 2.3, where it is stated that 'For the observational records with a higher-than-monthly temporal frequency…' and then they specify which ones those are. It can be a bit confusing, so I recommend specifying when describing each dataset.
- Figure 3. This is up to the authors, but I encourage them to add figure 3 as another column to figure 2, so that it will be referenced to the positions in the map and comparable to the individual currents.
    - For the GSR, there is a sharp difference in the behaviour of the overflow between the two intervals: could the authors briefly describe why is that? Are there any difference in instrumentation or methodology on all or any of the sections included in GSR? Why are there two intervals for the overflow (Figure 3) and not for the current (Figure 2)?
- Lines 107-115. This paragraph is about the GSR and each component. The description of IFR, FSC and DS can be complemented with a call for Figure S3a to show that the anomalies respond to that of FSC, even if the mean transport is larger over IFR.
- Line 162. The authors have normalized the datasets, which can be useful when comparing variables with different units. Could the authors discuss briefly this choice instead of just computing anomalies?
- Lines 218-226. This is a good paragraph discussing reconstructions of AMOC with observations. When discussing inverse models, the recent paper by Fu et al., (2020) could be included, where the authors find no trends in AMOC creating boxes between 24N and 55N.
- Table 3. As stated above, even if we don't have trends here for AMOC from ECCO, this is a better place for trends than Table 1. Also, these trends should be expressed with their uncertainties.

- Lines 317-322: This is a good discussion on the comparison between ECCO and observations. However, it has not been mentioned previously in the manuscript, so the authors may consider placing it above and not in the 'Summary and conclusions' section. One opportunity could be between lines 201 and 202, after discussing that ECCO finds more patterns than observations and before discussing the Ekman layer.

TECHNICAL CORRECTIONS

- Throughout the manuscript, please make sure that the main currents cited and discussed in the text are defined at their first mention and at the appropriate figures and tables.
- Please make sure that the figures in Supplementary Information are in order of appearance in the main text.
- Figure 1. I find this figure useful to illustrate the introduction, but the authors could include some extra details to make it more accessible.
    - On the schematic map in A, only the Gulf Stream is specified with its full name. However, that is not the case for DWBC, EGC, NAC and NwASC. I understand there's not much space in the figure, but it would be useful to define the acronyms at least in the figure caption. NAC, EGC and DWBC are common enough, but that's not the case for NwASC.
    - I suggest adding the A16 cruise track from subplot B to the map in A.
    - On subplot B, it could be helpful to employ the same colours for the arrows representing the upper (purple) and deep (black) circulation.
- Line 34. 'of which the Gulf Stream and **the** extensions' changed to 'of which the Gulf Stream and **its** extensions'
- Lines 53-54: the authors could describe shortly the location of the RAPID and OSNAP array (subtropical and subpolar or 24N and 55N). E.g.: The AMOC strength has been measured by cross-basin observing systems at 24N since 2004 (RAPID; Cunningham et al., 2007) and at 55N since 2014 (OSNAP; Lozier et al., 2017).
- Line 79. Please specify: 'The **mean** 32 Sv transported by the Florida Current and the, on average, 4.7 **± 7.5** Sv in the Antilles Current …'
- Figure 2. It could be very helpful to include the name of the observing systems in the map, with the color legend applied for the time series, even if it were just the acronyms and they were defined in the figure caption.
- Line 119: 'a single current meter at **100m** depth' is missing a space in '**100 m**'.
- Line 142: 'ECCOv4-r4 captures the observed peak in moc_σ in 2015/16 (Figure 3), but the observational time series is too short to get a fair assessment of how well interannual variability is represented at OSNAP.' I understand that this sentence refers to the peak in MOC observations from Figure 3, but it turns out a bit confusing, as there's no ECCO values to compare it against. I would refer readers only to Figure S2c, where the authors can specify the short overlap between both time series (2014-2017).
- Lines 151-152: 'compared to observations (0.9 Sv and 3.8 Sv **in observations**, respectively)'. The second 'in observations' is redundant: 'compared to observations (0.9 Sv and 3.8 Sv, respectively)'.
- Figure 4. The y-axis labels should include magnitude and unit following the same structure as before: a) STD and b) VT [Sv].
- Line 165. Reference to Figure S4 appears before Figure S3.
- Line 236. Reference to Figure S3c instead of only Figure S3.
- Line 258-259: 'onto the annual mean volume transport time series in ECCOv4-r4 (Figure 5, **Figure S7**) and

- in observations (**Figure S6**)'. I think the references for the supplementary information figures are wrong: 'series in ECCOv4-r4 (Figure 5, **Figure S8**) and in observations (**Figure S7**)'.
- Line 279: '**indecies**' changed to '**indices**'.

References for this review:

Buckley, M. W., & Marshall, J. (2016). Observations, inferences, and mechanisms of the Atlantic Meridional Overturning Circulation: A review. *Reviews of Geophysics*, *54*(1), 5–63. https://doi.org/10.1002/2015RG000493

Fu, Y., Li, F., Karstensen, J., & Wang, C. (2020). A stable Atlantic Meridional Overturning Circulation in a changing North Atlantic Ocean since the 1990s. *Science Advances*, *6*(48), eabc7836. https://doi.org/10.1126/sciadv.abc7836

Han, L. (2023). Exploring the AMOC Connectivity Between the RAPID and OSNAP Lines With a Model-Based Data Set. *Geophysical Research Letters*, *50*(19), 1–10. https://doi.org/10.1029/2023GL105225

Zhao, J., Bower, A., Yang, J., Lin, X., & Holliday, N. P. (2018). Meridional heat transport variability induced by mesoscale processes in the subpolar North Atlantic. *Nature Communications*, *9*. https://doi.org/10.1038/s41467-018-03134-x

Zou, S., Lozier, M. S., & Buckley, M. (2019). How Is Meridional Coherence Maintained in the Lower Limb of the Atlantic Meridional Overturning Circulation? *Geophysical Research Letters*, *46*(1), 244–252. https://doi.org/10.1029/2018GL080958

Zou, S., Lozier, M. S., & Xu, X. (2020). Latitudinal structure of the meridional overturning circulation variability on interannual to decadal time scales in the North Atlantic Ocean. *Journal of Climate*, *33*(9), 3845–3862. https://doi.org/10.1175/jcli-d-19-0215.1