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Observation-based estimates of volume, heat and freshwater exchanges between the subpolar North Atlantic interior, its boundary currents and the atmosphere
by Sam C. Jones, Neil J. Fraser, Stuart A. Cunningham, Alan D. Fox, and Mark E. Inall

Great to see the revised version of this manuscript. I think that it is much improved and will form a significant contribution to our understanding of overturning in the subpolar North Atlantic. I only have a few remarks.

General comments:

My first general comment was only partially addressed. I understand and accept the reasoning for keeping the perimeter contour at the 1000 m isobath. As a consequence, the contour is for large parts of the domain oriented along the major boundary current system (particularly in the Irminger Sea along east Greenland and in the Labrador Sea, e.g., Figure 2). This implies that the dominant isopycnal slope along this depth contour is across the boundary current system and that the cross-contour component of the flow is a relatively small residual relative to the much stronger along-contour flow. I did not register that this issue was discussed in the manuscript.

Specific comments:

Line 20:
I am surprised to see that there is no evidence of the substantial export of freshwater from the Arctic Ocean (e.g., Haine *et al.*, 2015) in the subpolar gyre budget, that you can close the budget considering only the atmospheric fluxes.

Line 27:
Perhaps rephrase, dense-water formation is not considered a “driver” of the AMOC (Kuhlbrodt *et al.*, 2007).

Line 54:
Lozier *et al.* (2019) did not distinguish south and north of the Greenland-Scotland Ridge, they only concluded that most of the overturning occurs east of Greenland.

Line 127:
I think that the statement ”some profiles are used in more than one grid cell” is an understatement. If the minimal search radius is 150 km, which is the same as the distance between grid points, most of the profiles will be used in the two nearest grid cells. If you plot the search radius used for each grid cell on a map such as Figure 2a, I think this should be evident. Davis (1998) provides good justification for using a search radius that is reduced in the across-slope direction compared to the along-slope direction.

Line 299:
I think the statement that geostrophic flow is largely out of the subpolar gyre shallower than 500 db and opposite below 500 db should be elaborated on.

Lines 348 and 351:
Your estimates of the transport of Atlantic Water from the subpolar gyre into the Nordic Seas could be compared to the transport estimates from the monitoring efforts along the Greenland-Scotland Ridge (e.g., Østerhus *et al.*, 2019).

Line 421:
It appears that the values of 8 and 14 cm/s were simply estimated from Figure 2b. This could have been approached more quantitatively, for instance by making a frequency histogram of the speed between successive surfacings of individual floats within the basin perimeter.

Line 474:
East Greenland south of Denmark Strait is not a major overflow region. While the East Greenland Spill Jet may contribute some dense water to the lower limb of the AMOC (Pickart *et al.*, 2005), the Faroe Bank Channel/ Iceland-Scotland Ridge and Denmark Strait are the only major overflow regions.

Line 521:
Please elaborate on why there is substantial densification in summer, when the air-sea heat fluxes are very low or even warming the ocean.

Line 540:
There is an apparent inconsistency with line 34 (heat transport of 0.31 PW). The 0.27 PW quoted here may be more appropriate when considering only the Atlantic Water component, but the difference with the previously quoted heat transport should probably be explained.

Line 631 and elsewhere:
The uncertainty estimate in the overturning strength is provided in the conclusion (line 836), it should also be included in the discussion section.

Line 675:
Please explain how the surface Ekman forcing introduces a lag in the overturning.

Line 714:
The Atlantic Water inflow from the subpolar gyre to the Nordic Seas east of Iceland is roughly evenly split on either side of the Faroe Islands (Østerhus *et al.*, 2019). Hence it would be more appropriate to ascribe this flow to the Iceland-Scotland Ridge than to the Faroe-Shetland Channel.

Line 818:
Note that the magnitude of the overflows east of Iceland (including entrainment) are of similar magnitude as the Denmark Strait overflow (Johns *et al.*, 2021). This should be reflected in the discussion, even if the model does not fully capture that component of the overflows from the Nordic Seas.

Detailed comments:

Line 30:
Arctic Ocean or Arctic Mediterranean would be more appropriate than Arctic (which by itself is ill-defined and typically also includes surrounding land masses) alone.

Line 394:
For clarity, perhaps specify that you mean the OSNAP **West** crossing.

Figure 12:
A sign is probably missing from the magnitude of the downward fluxes (all of the other transports have signs).

References

Davis RE. 1998. Preliminary results from directly measuring middepth circulation in the tropical and South Pacific. *Journal of Geophysical Research* **103**: 24 619–24 639, doi:10.1029/98JC01 913.

Haine TW, Curry B, Gerdes R, Hansen E, Karcher M, Lee C, Rudels B, Spreen G, de Steur L, Stewart KD, Woodgate R. 2015. Arctic freshwater export: Status, mechanisms, and prospects. *Global and Planetary Change* **125**: 13–35, doi:10.1016/j.gloplacha.2014.11.013.

Johns WE, Devana M, Houk A, Zou S. 2021. Moored observations of the Iceland-Scotland Overflow plume from along the eastern flank of the Reykjanes Ridge. *Journal of Geophysical Research: Oceans* **126**: doi:10.1029/2021JC017 524.

Kuhlbrodt T, Griesel A, Montoya M, Levermann A, Hofmann M, Rahmstorf S. 2007. On the driving processes of the Atlantic Meridional Overturning Circulation. *Reviews of Geophysics* **45**: RG2001, doi:10.1029/2004RG000 166.

Lozier MS, Li F, Bacon S, Bahr F, Bower AS, Cunningham SA, de Jong MF, de Steur L, de Young B, Fischer J, Gary SF, Greenan BJW, Holliday NP, Houk A, Houpert L, Inall ME, Johns WE, Johnson HL, Johnson C, Karstensen J, Koman G, Le Bras IA, Lin X, Mackay N, Marshall DP, Mercier H, Oltmanns M, Pickart RS, Ramsey AL, Rayner D, Straneo F, Thierry V, Torres DJ, Williams RG, Wilson C, Yang J, Yashayaev I, Zhao J. 2019. A sea change in our view of overturning in the subpolar North Atlantic. *Science* **363**: 516–521, doi:10.1126/science.aau6592.

Østerhus S, Woodgate R, Valdimarsson H, Turrell WR, de Steur L, Quadfasel D, Olsen SM, Moritz M, Lee CM, Larsen KMH, Jónsson S, Johnson C, Jochumsen K, Hansen B, Curry B, Cunningham S, Berx B. 2019. Arctic Mediterranean exchanges: A consistent volume budget and trends in transports from two decades of observations. *Ocean Science* **15**: 379–399, doi:10.5194/os–15–379–2019.

Pickart RS, Torres DJ, Fratantoni PS. 2005. The East Greenland Spill Jet. *Journal of Physical Oceanography* **35**: 1037–1053.