Review on “Major sources of North Atlantic Deep Water in the subpolar North Atlantic from Lagrangian analyses in a high-resolution ocean model” by Fröhle et al.

Summary

Fröhle et al. investigated the major sources of the North Atlantic Deep Water transports at the southern exit of the Labrador Sea using Lagrangian particle experiments in a high-resolution ocean model. They quantified contributions from different processes, including diapycnal fluxes (in and out of the mixed layer) and overflow from the Greenland-Iceland-Scotland ridge, to the total deep water transports. For each source, the associated pathways and transit times were discussed.

Overall, I find results from the study quite interesting as they show, in a model, what the subpolar deep western boundary current is composed of from a Lagrangian perspective. The manuscript was overall clearly written and the particle experiments were reasonably designed, supporting the major conclusions. Therefore, I recommend this manuscript for publication after addressing the following comments.

Major comments

[1]. The method sections, especially section 2.3, are very dense and hard to understand without looking at the results. Could they be merged into the Results section, along with where the results/figures are presented?

[2]. Differences between current study and previous literatures need better explanations. In the Discussion section, it was mentioned that the LSW/lNADW transport ratio differed from 53N array observations because of a different water mass definition in this study. But I am having a hard time understanding the explanations. I thought the LSW and lNADW layers were defined using a fixed isopycnal 27.86 kg/m^3. In this sense, shouldn’t the LSW (26.7 Sv) and lNADW (3.4 Sv) transports derived from the particles equal the Eulerian transports in the corresponding density layer? Does this large transport ratio suggest a model bias in simulating the overflow waters?

A relevant comment is that the authors claimed the 5.7 Sv NADW from the Greenland-Iceland-Scotland ridge was consistent with overflow observations of 6 Sv. However, the NADW transport in the study is mostly contained in LSW layer, whereas the lNADW transport, which should be used to compare with the overflow observations, is as small as 0.6 Sv.

[3]. Finally, I am trying to understand the consistency/difference between diapycnal mass flux inferred from the Lagrangian particles and the classical diapycnal water mass transformation from a Eulerian perspective. I guess the two cannot be compared directly but they should be ultimately linked. For example, observations show that 7 Sv of lighter waters are transformed into denser layers by surface buoyancy loss in the Irminger and Iceland basins, as reported by Petit et al. (2020). Some of these waters might travel across the gyre and reach the boundary current at 53N, which will be counted as part of the diapycnal mass flux discussed in this study. This was only briefly mentioned in the Discussion. I suggest the authors to elaborate a little bit more.

Minor comments

[1]. Lines 3-4: Here you mentioned NEADW and DSOW. However, in the manuscript, the sources of NEADW and DSOW transports were not explicitly distinguished and discussed.

[2]. Line 8: It is better to first report the total transport at 53N in the model, i.e. 30 Sv, before quantifying different sources. Also, please specify in the Abstract that "diapycnal mass flux" refers to the diapycnal flux in the boundary.

[3]. Line 19: "a net downwelling *in density space* of upper AMOC water"

[4]. Lines 66-68: I am not sure if I understand this long sentence. What do you mean by "adding transformed water to a major volume of water…"?

[5]. Equation (1): What is "ceil"?

[6]. Lines 122-126: So the water mass definitions are based on mean density, but the particle release density varies on daily time scales, correct?

[7]. Line 130: What do you mean by "the same advection time"?

[8]. Line 172: Are signs or flow directions considered for the cumulative transport? If particles flow into the bin from different directions, then the cumulative transport should be zero.

[9]. Line 179: Is this binned transport (based on point of origin) also converted to the relative transport with respect to the 53N section? Again, are flow directions considered in the binning?

[10]. Lines 191-193: I do not understand how the "volumetric water mass transformations" are calculated here. Please elaborate.

[11]. Lines 254: The 5.7 Sv of NADW from the ridge is mostly in LSW layer. I am not sure why the authors compare this number with the overflow transport observations. Instead, it is the lNADW transport (as small as 0.6 Sv) that should be compared with overflow observations (6 Sv). Please also see my major comment [2].