

Review of “Arctic freshwater fluxes: sources, tracer budgets and inconsistencies”, by Forryan et al.

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General comments

The authors present a reconciliation the two prevailing methods for determining the freshwater budget of the Arctic Ocean, namely the control-volume based approach (based on salinity and velocity fields at the ocean boundary) and the geochemical tracer approach (where Nitrate/Phosphate ratios and $d^{18}O$ are used to determine water origins). I found the paper to be educational and interesting, it is very well-written in general and succinctly conveys its main points. As such my comments are mostly suggestions to improve the presentation. I would note that, while I am broadly familiar with aspects of the Arctic freshwater cycle, I am no expert in geochemical tracers and their interpretation so I cannot fairly judge the merits of that aspect of the paper. From what I have seen I think the manuscript only needs some minor changes before publication. I do question the choice of The Cryosphere as a venue for the paper, since ice only really plays a minor supporting role as a source/sink/vehicle for freshwater. The equivalent EGU journal Ocean Science might be a better choice, or J Physcial Oceanography or JGR: Oceans. But I leave it to the editor to decide in their recommendation.

Specific comments

P2L2 and p23L11 – “traditionally divergent” to me implies that the divergence is somehow inevitable, or done on purpose historically. Maybe use “generally divergent” instead.

P2L3 – split the sentence: “...reconcile. The...”

P3L4-10 – I’m not sure the discussion of mid-latitude linkages and AMOC disruption by Arctic FW are really warranted here. Also, my (admittedly limited) understanding of both of these phenomena is that they are highly contentious, and an accurate mention of them would have to also say that some researchers claim there is no evidence that they are occurring or will occur.

P8L5-7 – could you give some indication of the uncertainty associated with the optimal interpolation of the geochemical data?

P9L5 – What is a Redfield nutrient ratio? Certainly my lack of knowledge, but I’m probably fairly representative of the Cryosphere audience...

Figure 2 – (caption) I think the gateways are shown anticlockwise from Davis i.e., Davis, Fram, BSO, Bering? I think you should write on all of these Figures (2 and 5-10) which opening is which, for clarity and ease of interpretation.

P11L4-6 and Figure 3a/b – the fits to the green points (Fram) are poor, or rather the data are clearly not linear, which you attribute to the presence of Greenland Ice Sheet meltwater. Is there a way to exclude the Greenland water masses from your data in order to improve the fits? The linear regression to the green points in fig 3A especially is clearly not suitable and shouldn't be used for further analysis.

P13L25 and Figure 6 – is flux positive in or out/positive or negative? Say explicitly early on for ease of interpretation.

P14L1 – “positive fluxes indicating an export of high-salinity waters”, is this equivalent to an import of freshwater? Seems more intuitive to talk about freshwater fluxes as that's the main focus of the paper.

P14L11-17 and Tables 3-8 – I find reading data off tables pretty unhelpful in general, but especially when we are trying to compare data between different tables as here. I think you could easily summarise the budgets presented in tables 3-8 in one figure with multiple panels, or in a couple of separate figures. Personally I would use bar charts with error bars, and you could also include the Fram Strait break down as 'sub-bars' of the Fram bar. Would highly recommend this as it would make interpretation/comparison between the model runs much easier.

P14L27 – the ice-modified water in the WSC is from recirculation, right? State this here

P15L26 – “large uncertainty”, the uncertainty is actually smaller than for the 3EM/4EM models, the relative uncertainty is larger though if that's what you mean.

Section 4.1 – Is the apparent consistency between the 3EM and 4EM models a surprise given that the difference between them is just the use of the geochemical data to partition the seawater into Atlantic/Pacific fractions? In Figures 11, 12, and 13 I can see no difference between the 3EM/4EM fluxes. In other words, are the 3EM/4EM fluxes consistent just by construction? If so you should say this, as it is misleading to say they are “consistent” when they are simply the same by construction. Perhaps my misunderstanding.

P22L8-12 – while you cannot ascertain exactly the source of this water transformation, could you speculate at all? At least on the classes of processes that might cause this?

Section 4.3 – I was wondering if you could also provide a paragraph with some perspectives on 1) future research using these methods/datasets, and 2) implications for Arctic Ocean climate monitoring in terms of observation systems and optimal approaches at analysis/modelling.