

Interactive comment on “Freshwater in the Arctic Ocean 2010–2019” by Amy Solomon et al.

Anonymous Referee #1

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Summary

This manuscript presents a useful updated freshwater budget for the Arctic Ocean. All components of the Arctic freshwater budget are reviewed, and some aspects that are lacking in the literature, such as the vertical redistribution of freshwater, are discussed in an interesting manner. The discussion of the meaning of “ocean freshwater flux” in the introduction is particularly useful. The text is generally clear and comprehensive, however several of the main points that are made in the abstract, introduction, and summary are not effectively conveyed in the manuscript or shown in the figures that are presented. This study will be a useful contribution to the literature after a major revision that synthesizes results from the literature in a more consistent manner, and supports its conclusions in a clear fashion.

Major comments

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Discussion paper



The authors argue that the trend in Arctic freshwater content stabilized in the 2010s due to increased compensation between the Beaufort Gyre and the remaining Arctic. However, that is not immediately apparent in any of the figures. Only one of the reanalysis products presented in Figure 2 shows a compensating pattern in the freshwater anomaly, but it also does not reproduce the observed storage trends. The multi-model mean shows a small amount of compensation on the shelves, but it is not clear that this balances the large storage in the Beaufort Gyre. The fidelity of the reanalysis products, or what we can learn from them, is not really discussed in the text. From Figure 3 it appears that the freshwater content in the Beaufort Gyre stabilized in the 2010s, at the same time as the freshwater content of the full Arctic stabilized: no compensation is apparent in this figure.

The two time series presented in Figure 3 are from different data products and use different reference salinities. This is not justified or discussed in the text. Why not also show the Beaufort Gyre freshwater content from the hydrographic observations, as it is a subset of the full Arctic?

The definition of the study region varies throughout the manuscript, which makes it difficult to interpret the numbers that are presented. For example, at Line 88, the authors state “in this study, the reference salinity used is 34.8 psu and freshwater content is calculated over the area north of 70N”. However, in the Figure 3 caption a different domain and reference salinities are used. At Line 188, the authors give the impression that the Nordic Seas should be included in the analysis, but it is unclear that they have done this.

Runoff from the Greenland Ice Sheet has been considered in previous assessments, such Haine et al. 2015, Proshutinsky et al. 2015, so it is not particularly compelling to say that this aspect has been overlooked previously. It is also not made clear how freshwater fluxes from Greenland enter the budget, since much of Greenland is to the south of the Arctic (Mediterranean).

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In the abstract and the summary the authors state that the import of subpolar waters into the Arctic has increased, yet this is not discussed substantially in the manuscript.

In general, it would be useful to include summary sentences at the end of each section.

Minor Comments

L26: You could specify “Arctic freshwater content” rather than “Arctic freshwater” here.

L41: This first sentence could be split into at least two.

L55: There may be a formatting issue here, but it seems S is being used for both salinity and salinity anomaly.

L58: What do you mean by “verbal”?

L81: This clause is confusing, starting from “inverse imprint”

L89: Can you comment a little bit more on why you choose 34.8 and how to interpret freshwater content and fluxes in this framework? Another significant freshwater framework that is missing in this discussion is that presented in Wijffels et al. 1992.

L167: Not sure this is a fair comparison, as Morison et al. 2007 present a very different time span. What is meant by “complex variability?”

L173: Which “difference in annual cycle” are you referring to?

L211: It is a bit confusing to include river discharge in this section after discussing river discharge in the previous section. Please clarify the links between these sections and which trends may be consistent between them. Boisvert et al. 2015, 2018 could also be referenced in this section.

L239: Could you clarify how sea ice age is converted into volume and how to interpret these results?

L255: Spall 2019 “Dynamics and Thermodynamics of the Mean Transpolar Drift and Ice Thickness in the Arctic Ocean” may be a useful reference to include here.

L260: Typo, should read “on par”

L265: Might add “before reaching the Transpolar Drift” to the end of the sentence.

L268: Please clarify this sentence. Does the decrease in sea ice extent cause a delay of freeze up?

L272: Was the snow depth greater than the climatology? Please clarify this sentence.

L299: In this section , you could also discuss the trends in Atlantic Water entering the Arctic as shown in Tsubouchi et al. 2020, for example.

L315: What is the “but” referring to here? Please rewrite this long sentence.

L316: Isn't the freshwater gradient in the Arctic caused by the difference in salinity between the Pacific and the Atlantic? It seems odd to credit the circulation with this gradient. Please clarify.

L321: May want to swap word order to “yet unreached”.

L334: What is meant by more effective? Please explain and/or provide a reference.

L337: Please expand and clarify the synthesis of the Janout et al. 2017 study.

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