

Review

I conducted a thorough review of the manuscript titled "Contribution of satellite sea surface salinity to the estimation of liquid freshwater content in the Beaufort Sea" by Marta Umbert et al. In summary, these findings highlight that the incorporation of SMOS SSS data while employing TOPAS4b reanalysis data into the calculation of freshwater content in the Beaufort Gyre region during 2011-2019 summer months. Three different depths were used to combine SMOS SSS in freshwater content (FWC) depending on a constant mixed layer depth which significantly enhances the accuracy of FWC estimates. This enhancement is manifested through the reduction of bias, an increased slope, and improved coefficient of determination when compared to in-situ estimates.

General Recommendations:

- Maintain consistency in the use of "in-situ" terminology, either hyphenated without italics or not hyphenated with italics, as long as it is applied uniformly throughout.
- Strive for conciseness and directness in many areas of the text. Specific values can replace vague sentences to enhance precision.
- Clarify a major concern regarding the measurement of freshwater content. It should be noted that mixed layer depth can be calculated, and the study is concerned with the amount of freshwater within this depth while testing different constant MLD values. The justification for this approach, represented by adding SMOS SSS data up to 16 m (green line), 25 m (orange line), and up to 29 m (blue line), should be provided. Additionally, address the potential for overestimation of FWC due to SMOS measurements being confined to the melting season, which can create a freshwater film at the surface.
- I have reservations to these results, one of which is related to alias biasing of in-situ data based on their horizontal and vertical resolution. The FWC product is integrated which can introduce more bias and thus may not represent 'true FWC' without further explanation of the product or related works. Emphasize that the estimation of FWC remains subject to limitations when insufficient data is available, as comparisons to direct in-situ measurements allows for validation of salinity but not the integration of freshwater.
- Acknowledge concerns about the region tested, particularly the influence of downwelling on freshwater accumulation, which could be the reason for the improvement using SMOS SSS to 29 m depth. Concluding that combining SMOS SSS and reanalysis data could enhance the entire Arctic's FWC should be cautioned as this has not been tested in your research while it may be a useful avenue for future exploration.

Abstract

Authors specify their use of satellite data to better assess SSS in the Arctic. Such retrievals are known to have substantial limitations and large errors near the sea ice edge and in cold waters due to the L-band retrievals becoming less sensitive to salinity at cold sea surface temperatures. Can the authors justify this in text?

Line 4: "Sea Surface Salinity" does not need capitalization

Line 5-6 "That is because... increase/decrease of one entails a decrease/increase of the other." The authors should specify this point for clarity. As in "an increase (decrease) of salinity entails a decrease (increase) of freshwater content". "That is because" is not needed.

Line 8: Specify type of reanalysis product you are using as your study does not analyze more than one reanalysis product.

Line 11: “The improvements are significant, especially in areas close to ice melting.”
Too vague, give a more quantitative value from results to back this.

Line 13-14: “Our research demonstrates....that regulates Earth’s Climate.”

This sentence should be rewritten for clarity. Some areas are vague (“a key process”, which one?) and the research does not address the implications towards the global circulation system that regulates the Earth’s Climate. Add further details in the introduction to justify this connection.

Introduction

- Address the significance of atmospheric conditions and climate patterns in relation to the retention of FWC in the Beaufort Gyre, which currently lacks explanation in the introduction.
- It might be best to describe what liquid freshwater content is since its not just a layer of freshwater on top of salt water, but a ratio of salt content that is lower than a certain standard. The salinity reference is also not agreed upon between scientists and may need to be defended on your part for why you chose that salinity reference (simply stating that you match the salinity reference with Proshutinsky et al. (2009) as you compare your results to their gridded FWC. It would also be beneficial to clarify the concept of FWC within the context of the Arctic. Emphasize that "freshwater" does not necessarily mean complete absence of salinity; there exists a salinity threshold that varies in Arctic research.

Line 17: Be more specific, the Arctic has experienced rapid changes more than just recent years, it has arguably been occurring over decades or at least since 2007. This statement could be improved by adding specific rate or timeframe that would enhance the importance of Arctic changes.

Line 21: “(referred to as FWC)”
Change to “(FWC)”

Line 23: Please provide a references for these contributions of FWC as it may differ between time periods or methodologies.

Line 28: This sentence is a bit misleading, the Beaufort Gyre itself isn’t necessarily at the ‘heart’ of the Arctic’s climate, its highly influenced by climatic systems and atmospheric processes. It is also located in the Beaufort Sea and may extend northward but this statement makes it sound like it is not in the Beaufort Sea.

Line 29-30: This is a personal opinion but will clarify for the reader: “...strong anticyclonic (counterclockwise) winds...powerful cyclonic (clockwise) circulation”.

Line 32-33: This transition between sentences seems random, you started introducing the Beaufort Gyre then talk about the Arctic's freshwater flux influence on a global scale without stating how. You could emphasize that the Beaufort Gyre consists of a large portion of the entire Arctic Ocean's FWC and where the connection is between the Arctic and the thermohaline circulation comes in.

Line 35: I'm assuming "change" could be clarified as "increase"? This sentence also seems random and would benefit with explanation of the importance of the time between 2012 and 2016.

Line 40: Only within the last decade (2013-2023)? Also, is sea surface height capitalized for a reason?

Line 47-49: It would be much simpler to state that FWC is the integral of salinity differences between measurement and a constant. I understand the way you are introducing different ways of measuring FWC but you don't describe what FWC really is upfront. This paragraph can be conveyed more directly and concise.

Line 56-57: One-day repeat cycle does not seem accurate. Data can be generated at daily intervals, but that is not the same as a satellite's repeat cycle. Typically, its 3-8 days unless you can clarify what you mean. I also believe Aquarius's spatial resolution is much greater.

Line 62: Change "sea surface salinity" to "SSS". Also in lines 70, 228.

Line 86: Change "resolution" to "spatial resolution"

Line 90: "ranging from surface to bottom". Can you be more specific on what 'surface' is in meters?

Data

Line 70: State the level of the satellite product (level 3 product?)

Line 71: Specify month and year range of SMOS data and which timeframe you took the data from here.

Line 80-81: You use the OSI-SAF acronym then the name but should it come after "Ocean and Sea Ice Satellite Application Facility" in parenthesis?

Line 96: Change "sea ice concentration" to SIC. Also in line 139.

Line 99: "...surface to 4000 m depth.", is this near surface or skin-surface? Might be best to note top layer in meters.

Line 105: Do the in-situ data exceed 300 meters as well or is this referring to the region's depths exceed 300 m defined by Proshutinsky. If the latter, then clearly define the depths that the in-situ measurements cover.

Line 109: Specify the time intervals that these data are provided or that you used (hourly, daily, monthly?)

Eq.1: Define equation symbols through text explanation.

Line 121: Justify the use of 16, 25, and 29 meters for the MLD. Can you use profile data to estimate the MLD? You mention using a constant value of MLD throughout the year but are only assessing melt season, which is confusing.

Results

Line 131: As a predominantly anticyclonic gyre, isn't it more characteristic for the Beaufort Gyre to have downwelling occur instead of upwelling as this line suggests (i.e. "surfaced")? Or are you discussing waters pulled from the surrounding water or characteristics in general?

Figure 1: Why these two years (2011 & 2016)? You mention the greatest and quickest change in salinity between 2012-2016, but do you choose 2011 since is the beginning of the period you are examining? Stating the uppermost level of TOPAS4b would be helpful in analyzing the difference between the skin-salinity that the satellite measures and the depth of what TOPAZ4b measures.

Line 137: Should the references be in parentheses?

Line 155-156: Repeat of the description of the Beaufort Gyre region as in lines 104-105, could further describe why you use the same region as Proshutinsky et al.

Figure 3. Note the acronym for freshwater content and its unit in the caption (i.e. FWC [m]). The colorbar for (c,f) seems to emphasize regions over or under a ~2psu difference, is there a reason for this or can the colorbar be changed to detail the region and make different values clearer?

Line 182: Parenthesis around reference.

Line 182-184: How does TOPAZ4b assimilate variables associated with freshwater inputs? Are there estimations on its certainty to capture these signals accurately?

Section 3.2

Figure 5. Label [b] colorbar as "FWC error [m]". Last sentence of caption is not complete.

Line 198: You mention "several studies" but only cite one, can you provide more studies to back this claim? Otherwise reword.

Figure 6.: Define more reasons why there are large discrepancies in FWC between in-situ data and other products. Could in-situ be overestimating due to lack of spatiotemporal coverage? The in-situ based FWC product is integrated so this could pose it's own errors or overestimation/underestimation.

Line 228: Change “sea surface salinity (SSS)” to “SSS”

Line 230: Change “...freshwater content..” to “FWC”

Lines 251-252: “This integrated approach could allow for the identification of patterns, trends, and anomalies in SSS..”