

Ocean Sci. Discuss., referee comment RC1
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Comment on os-2021-100

Anonymous Referee #1

Referee comment on "Changes in Surface Salinity Gradient and Transport Quantify the Different Entrainment Rates Along the Irminger Current" by Nathan Paldor et al., Ocean Sci. Discuss., <https://doi.org/10.5194/os-2021-100-RC1>, 2021

Summary of review

This study presents a diagnostic, which is referred to as Freshening Length, to infer along-track changes in the Irminger Current transport around the South-Greenland coast. Based on the Freshening Length, the authors conclude that 20% of the original water mass in the Irminger Current at the eastern side are transported along the southern coast of Greenland to the western side, while 80% are dispersed into the ambient ocean.

Overall, I find this study quite thin. Further analyses may be needed to justify publication. From the current version, I am not able conclude that the study represents a substantial contribution to the journal.

For instance, the manuscript includes four figures and only two of these are original. Figure 1 contains maps adapted from other studies and Figure 2 shows climatological fields of the sea surface temperature and salinity from the publicly available SODA dataset, along with the points at the locations that were used to diagnose the transport changes.

I would recommend publication only if (1) additional analyses are added, or (2) the authors can demonstrate more clearly what the overall value of their analysis is.

Additional analyses could include an exploration of the processes along the current section by which the transport exchanges occur, such as eddies, or further dynamical implications of their study, or temporal changes over the investigated period and links to larger-scale ocean or atmospheric variability. In any case, I would recommend that the authors further demonstrate the potential information that can be gained from the Freshening Length.

General comments

1) The scientific writing could be improved. Some paragraphs are difficult to follow. In particular, many paragraphs could be shortened and the sentences could be written in a more concise way. Phrases like "*it appears*" (line 31) do not sound scientific. Overall, I think the amount of text is not in proportion to the amount of information it includes. Therefore, I would recommend shortening of the text.

2) I did not understand why the Freshening Length is important. The climatological map of the sea surface salinity (Figure 2b) already shows there is a gradual freshening along the current. This is expected since freshwater from the Greenland coastal currents is gradually added along its path. Given that the results are expected already from the climatology map, what information is gained from the additional quantification by the Freshening Length?

Other diagnostics, like the freshwater column, which is the integrated freshwater anomaly over depth relative to a pre-defined reference salinity, or the freshwater volume, have been used in numerous earlier studies. These diagnostics have been applied to distinct scientific questions. I am not convinced of the overall value of the Freshening Length unless the authors can demonstrate a clear use or application of the Freshening Length that other diagnostics or just visual inspection of the climatological sea surface salinity map are not able to provide.

3) Based on my understanding of this study, the main result is the statement that 20% of the water in the Irminger Current travel around the southern tip of Greenland. Yet, why is it important to know how much water travels around the southern tip of Greenland as a coherent current? I do not think that the analysis provides meaningful information about the AMOC since the loss of transport that is calculated may be compensated for by other currents and eddies. I cannot see a clear connection to the AMOC from this analysis.

4) The analysis is focused on grid point averages around selected points along the salinity maximum. Yet, the current may be broader at some locations than at others, in which case the diagnostic does not describe the transport in the Irminger Current but is sensitive to how the current is defined. A considerable fraction of the transport could also occur in eddies or in the boundary currents like the Greenland Coastal Currents. These are not captured by focusing on a narrow current with pre-defined width.

5) The analysis only considers the climatological mean over a 37-year period. I do not think there is a substantial gain in such an analysis. It would be more interesting to look at the time variability of the transport and investigate the involved dynamical processes.

6) Part of the freshwater transport around Greenland's coast occurs as sea ice. I am not sure if the authors accounted for this. Melting of sea ice along the way may also influence the salinity and hence the Freshening Length.

Specific comments

Title: I find the title misleading and difficult to understand. The study does not investigate *"changes in the surface salinity gradient"*. It should either read *"changes in the sea surface salinity along the current"* or *"the sea surface salinity gradient along the current"* but not *"changes in the gradient"* (which would correspond to the second rather than a first derivative). This mistake is repeated later, for instance in the abstract.

Also, I am not sure what is meant by *"the climate perspective"* in the title.

line 4, "surprising": I do not find it surprising that the Irminger Current can be identified based on salinity maxima, given that it represents a saline current system around the fresher subpolar gyre.

line 12: *"A temperature-salinity analysis shows that the Irminger Current east of Greenland is characterized by a compensating isopycnal exchange of temperature and salinity, while west of Greenland the horizontal convergence of less dense surface water is accompanied by downwelling/subduction."*

This sentence is misleading and confusing. It suggests that less dense water is subducted beneath denser water.

line 79: The SODA data set contains very irregular measurements in time. Thus, it is likely biased towards the recent period.

line 120: The title and figures refer to the sea surface salinity but the Freshening Length

itself seems to be integrated over the full current depth. I find this confusing. To avoid misunderstandings, it would be great if the authors could clarify this in the text and if necessary, adjust the title.

In case the analysis is restricted to the surface, the Freshening Length would not be a meaningful indicator of the transport fraction that travels around Greenland, as part of the freshwater could be mixed down to depth.

line 178: The conclusion, that the transport loss occurs in eddies is not supported by the preceding sentence. It is not clear from the sentence or the paragraph why the transport loss should occur in eddies. The writing here could be more precise.

line 193: I understand that the Freshening Length is only robust on climatological mean data. However, considering the large interannual and decadal variability in the subpolar region, it is questionable if the application of the Freshening Length to only the climatological average contains meaningful information.

line 195: *"...the Freshening Length estimate of the transport is much more robust and informative than direct estimates based on velocity profiles..."*

I strongly disagree with this sentence and the entire paragraph. Of course, the method used always depends on the question that needs to be answered. Still, I would argue that direct estimates based on velocity profiles are generally preferred to calculate transports.

Figure 1: in panel b, the labels are difficult to read

Figure 4: I am not sure why the red and blue lines are fitted to the points. What information is gained from doing this?