Ocean Science Discussions

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Comment on os-2021-14

Anonymous Referee #2

Referee comment on "The potential role of Icelandic runoff in the extreme surface freshening event in the Iceland Basin around 2015" by Bogi Hansen et al., Ocean Sci. Discuss., https://doi.org/10.5194/os-2021-14-RC2, 2021

General comments

This paper uses observational data (satellite altimetry, trajectory of surface drifters, in situ salinity measurements) to suggest an overlooked freshwater source off the Iceland coast. The authors argue that this addition of low-salinity waters likely contributed to the recent freshening in the eastern subpolar North Atlantic that was described by a previous study (Holliday et al. 2020). Despite the title referring to "freshwater source", the manuscript does not argue for a source of freshwater, but rather a phenomenon where fresher surface waters off the coast of Iceland were diverted into the Iceland Basin due to an anomalous circulation pattern south of Iceland.

The analysis starts by evaluating satellite altimetry data to define the common characteristics of geostrophic flow in the easter subpolar gyre as well as its temporal variability in the recent years. By applying an EOF analysis on the satellite altimetry over the eastern SPG the authors identify an enhanced cyclonic circulation after 2014. They also use satellite-tracked drifter data and correlate it with the temporal variability of the principal component in the satellite altimetry EOF analysis. This is interpreted by the authors as that during the enhanced anticlockwise circulation the drifter trajectories originating from the Iceland shelf are preferably directed southwestwards (into a region of anomalous freshening). They then looked at various salinity observations from hydrographic sections in the region (Extended Ellett Line, OSNAP morning and sections over the south-Icelandic shelf) to describe a possible addition of freshwater into the eastern subpolar North Atlantic derived from the Icelandic coast via a change in the upper circulation.

The study includes a comprehensive analysis of various data sets and observations and I acknowledge the attempt to connect these diverse datasets with each other. However, these results do not convincingly show the relevance of such a freshwater source to contribute to the overall freshening. Therefore this complicates without suitable justification the story that Holliday et al. (2020) laid out to explain the freshening.

The main issue with this study is the lack of quantification. This type of analysis essentially requires a budget analysis in order to provide a clear freshwater estimate and establish that the redirection of low-salinity water off the Iceland shelf is a relevant signal in the eastern subpolar North Atlantic. The analysis presented here does not meet current standards given that there is now readily available data that goes beyond mooring and hydrographic ship data. In particular it is surprising that Argo profiling data has not been utilized to complement the other salinity observations. Especially for recent time periods, salinity profiles from Argo floats should provide a better picture of the spatiotemporal variability in that regions. There are also a number of gridded salinity products derived from Argo and other profile data as well as satellite-derived surface salinity estimates which are publicly and readily available. In particular, the use of ocean reanalysis products (e.g., SODA, ECCOv4) would be essential in such investigation as these allow closed budget analyses that can establish underlying mechanisms. It is essential to include these analyses, which then can be compared to the present hydrographic data to see if the picture is still consistent with the freshening and hypothesized pathway of freshwater over the Iceland Basin.

In summary, I am not able to recommend the manuscript for publication at this stage. Much more rigorous quantitative data needs to be presented in order to demonstrate that freshwater from the Iceland shelf is relevant in describing variability in the salinity and stratification in the eastern subpolar North Atlantic. This will require major revisions, with both new (and robust) analysis as well as substantial rewriting of the text.

Specific comments

Title: The title is misleading since it describes a "freshwater source", but in fact the hypothesized mechanism is a change in circulation.

Line 34: What is meant by the term "buffering region"?

Lines 43-46: This statement needs references. I am not aware that the subpolar North Atlantic is nutrient limited and would expect it to be largely light limited. Thus, a reduction in vertical mixing could also lead to higher productivity due to a decrease in light limitation.

Section 2: I think this section would read better without the different subsection and instead have a single section with complete paragraphs. Also, I feel there is a lot of important information missing. For example, the EOF analysis is a key method in this

study, but it is only described in the supplementary material. A shortened description should be included in the Method section too. As well, what is the calculation method for freshwater thickness? What analysis software has been used (Python, Matlab etc.)?

Line 128-129: How has potential density been derived?

Line 130-134: The location of these sections should be included in the map (Figure 1).

Line 135-137: This is confusing phrasing. ERA5 should be stated as the atmospheric reanalysis product and CDS the repository from which the data has been obtained.

Section 3: Instead of calling the subtitles by the data product, it would be better to have an actual subject that refers to the finding/processes etc. For example, instead of the title "satellite altimetry", it should be called something like "geostrophic flow pattern".

Line 157: Need to explain more how the spatial pattern in Figure 2 can be interpreted to identify the flow.

Line 159-163: I think the description of the EOF analysis fits better in Section 2.

Line 160: Please specify the spatial domain that has been used in the EOF analysis (cite lat and lon bounds).

Line 166: "Anomalous behaviour" is unnecessarily vague. Just describe what is anomalous about it.

Figure 3 b-d: Units are missing on the axis labels. Is it "cm" as in panel a?

Lines 174-176: How is the connection made between zero to negative PC values and enhanced clockwise circulation? This connection has not been clearly explained.

Line 203: I'm not sure if the term "streamlines" is appropriate here. This would set the EOF equivalent to a stream function, which I don't think is the case.

Lines 211-213: It is not obvious to me how a fairly weak correlation between the zonal drift and PC time series leads to that conclusion. Maybe it helps if the authors actually describe the process behind the apparent correlation.

Lines 224-226: The fact that the drop in salinity is confined to the middle of the basin indicates to me that the freshening is sourced from the south, as this region corresponds to the pathway of the northward flowing NAC.

Lines 248-249, Fig 7c: How's the freshwater content calculated? This needs to be included in Section 2.

Line 254: Cite the actual value that is chosen as the reference salinity.

Line 274: The freshwater flux of 5 mSv needs to be put in context. This is quite small compared to any other freshwater flux estimate over the subpolar North Atlantic.

Lines 276-277: Please clarify the relevance of this statement.

Section 4: A majority of the content of this section can be regarded as results. Usually, the Discussion is for bringing up previous studies, raising potential concerns and caveats, and restating the main findings.

Lines 296-299: If the freshening is explained by just deviation in the circulation, then shouldn't we expect salinification in the downstream region where the Icelandic source usually ends up?

Line 305: This statement need to be supported by quantitative analysis.

Line 308: The phrasing "more normal flow" is odd. It should be clarified what normal is.

Line 324: The phrasing "drained of freshwater" does not make sense in the context of oceanic freshwater content.

Line 332: Clearly describe the steps used to get to the estimate of 0.5 m.

Section 4.3 This suggest only a minor influence of the Icelandic freshwater source and thus contradicts the whole premise of this study.

Line 415: Statement "improves conditions for primary production" needs references.

Line 427: Specify a quantitative criterion to determine convection depth.

Page 20: This is a strange way to end the paper. A section containing Conclusions is missing.