



## ***Interactive comment on “A climate index for the Newfoundland and Labrador shelf” by Frédéric Cyr and Peter S. Galbraith***

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Dear Dr Berx,

Thank you for your exhaustive comments. Please find below a point-by-point reply to your comments. In order to better answer, the relevant part of your comments associated to our answer has been re- copied here in italic.

### **1) On the calculation of some of the sub-indices**

*- Section 2.1 NAO: The choice of the EOF-based NAO means that technically the time series will be slightly different each year (due to the nature of the analysis). Similar to the information highlighted in the Hurrell product, the users of the NLCI should be*

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*made aware that this means they do need to download the entire time series annually (rather than add a single value to the end of their time series). The authors could avoid this requirement by choosing the alternate NAO data product. If the current method is maintained, the caveat does need to be made explicit to ensure awareness with end-users.*

Very good point, thank you. We kept the EOF definition for consistency with other environmental studies in our group (AZMP, NAFO, etc.), but now clearly mention this caveat L.73

*- Section 2.2 Air Temperature: The inclusion of the more remote sites of Nuuk and Iqaluit needs some further explanation. How does weather at these remote sites impact ocean state on the Labrador and Newfoundland Shelf? Looking at Figure 3 (but please note my comment on the figures in point 4), it looks like the sign of anomalies at these sites is at times opposite to those more local to the Labrador and Newfoundland Shelf. The authors may want to consider giving the local and remote weather conditions separate weight in their combined index. The analysis of how the different component indices correlate may also show some stronger/clearer signals if this is done.*

The 5 sites used for air temperature have been kept because they represent both local and remote effect on the NL shelf. Also, since the stack bar plot of these 5 sites are provided, the reader can appreciate the relative consistency of all the sites in some years (generally during the coldest and warmest years), or the opposite in other years. Note that there is already more weight, however, on the NL portion with 2 sites in Newfoundland and one site in Labrador (and 4 sites out of 5 in Canada). Details on this choice have now been included L. 88 and 95.

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- *Section 2.3 Sea Ice: The language around the calculation of combining the 6 times series (2 variables over 3 regions) is somewhat ambiguous. My understanding is that normalised anomalies were calculated and then averaged (arithmetic mean), correct?*

Yes, correct. The text has been re-worded L. 110.

- *Section 2.4 Iceberg Count: The region where the measurement is made should be included in the map in Figure 1.*

Done.

- *Section 2.5 Station 27: The climatological conditions at Station 27 suggest the region stratifies to some extent throughout the year (see suggestion on isopycnals for Figure 7). The vertical average temperature and salinity may therefore be masking important variability in the near-surface and near- bed layer which may be driven by different processes. The authors also describe a three-layer system at the sampling location, which to me suggests that a vertical average is possibly not the most representative of on-shelf conditions. Could S27 surface and near-bed salinity and temperature be treated separately?*

We gave a lot of thought to this. In an earlier version of the NLCI, the anomalies of the near-surface, mid-water column and bottom were calculated before being averaged. The two methods did not lead to significant changes to the NLCI. We thus decided to go for the simple approach of averaging the whole water column. This is also the historical time series reported annually in the ICES Report on Ocean Climate (<https://ocean.ices.dk/core/iroc>).

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- *Section 2.5 Station 27: The complete lack of significant correlation of the S27 salinity is one indication to me that the choices here should be reconsidered. [...] Is one of these more/less relevant for the ecosystem of the region (for example, are there known links between fish stocks and recruitment success and one/several of these climate variables??*

Yes, salinity has been related, for example, to capelin dynamics, although no clear causal effect has been established (a hypothesis is through stratification and the timing of the spring bloom, but this is outside the scope of this study). But more importantly, salinity at Station 27 is a good indication of the freshwater fluxes on the Labrador shelf, one of the key pathways for Arctic freshwater exports. Therefore salinity has been kept for these reasons, but users can construct their own index and remove it since all subindices are provided. This is now explained in the Discussion L.260.

- *Section 2.5 Station 27: Could the strength of stratification (for example expressed as potential energy anomaly) or the size of salinity/temperature range in the year be more important (on lines 115-117 the authors highlight the importance of the salinity cycle, but this is not adequately reflected in the sub- index or eventual climate index). Generally, salinity is a good indicator of circulation change, and therefore I would have suspected it to play a more important role, particularly due to the sub-polar gyre's influence on the region (see also item 3 below).*

This is a very good point, but such analysis seems outside the scope of this study and would not be in line with the previous versions of the NL climate indices.

- *Section 2.8 Bottom temperature: What is the reason for choosing the 1000 m isobath to delimit the extent of the shelf? Most publications consider the boundary to be the 200*

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*or 500 m isobaths. Is it because this is what the fisheries assessments use? Does this definition mean that a significant portion of water masses from deeper in the Labrador Sea is included? How does this inclusion of deeper water (which is likely not influenced by the same processes as the shallow shelf region) significantly impact on the bottom temperature mean and its seasonal/inter-annual variability?*

Selecting 200m would be too shallow for the different channels on the shelf. While 500m might be a suitable choice, we would lose some areas in the deep Laurentian Channel in the south of our region. The isobath 1000m has then been chosen because some NL fisheries extent to the shelf break near these depths and because some oceanographic data that we used are limited to 1200m profile depths.

## **2) On the oceanographic understanding behind the combined index**

*This index will be very valuable to other marine scientists studying the ecosystem dynamics and productivity of the region. There is little interpretation of this throughout the manuscript (see item 5 below), but I also wonder if the combined index across so many components can provide a meaningful overview of the ocean state of the region. A good test is to see whether a schematic diagram could be drafted which indicates the generalised conditions of a positive/negative phase of the index. As mentioned below, the manuscript also lacks an indication of how the combined index (as well as the individual sub-indices) could be a driver of variability in the wider marine ecosystem of the region.*

In a hope to strengthen our explanation on the interpretation and the role of the NLCI for the ecosystem, and the interactions between the different subindices, we have expanded the Discussion. While some scientists already find meaningfulness with the NLCI (see review in the Introduction),

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we also provide the 10 subindices, so users can design their own index. While a schematic diagram would be an interesting addition, the amount of work required seems unrealistic as part of this review (especially that we already have 14 figures). Such a description could well be a dedicated study by itself.

*In addition, the choice of annual mean anomalies for some of the quantities also needs justification. The drivers of variability on shallow shelf environments can be different between winter-time and summer-time, therefore averaging across the year could be masking changes in one particular season. From the marine ecosystem impacts, consistent change in one season may be driving the variability of spawning/survival/recruitment... I would encourage the authors to review whether their choice of averaging periods is not masking such consistent differences in inter-annual change of the seasonal variability, and is therefore providing the most meaningful information for marine scientists researching the biogeochemical and ecosystem components of the region.*

We agree on this, and we now make this distinction in the Conclusion L.278. While it is difficult to have one single index that is representative of all seasons, our approach is to provide 10 subindices where some represent more the winter season (NAO, sea ice), some more the ice-free season (SST, CIL) and some the entire year (air temperature, S27 T-S). While the combination of all subindices in the NLCI is already in high demand among our colleagues, this new version with available 10 subindices is a significant addition for future ecosystem studies.

*3) The lack of an index on sub-polar gyre strength: There has been no consideration of sub-polar gyre strength in any of the indices considered. Did the authors consider*

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*its inclusion? Is this basin-scale driver unimportant of the Newfoundland and Labrador Shelf region?*

This is a good point, but available data for a “Labrador Current subindex” would only start in 1993 which is quite limiting to our time scale that aims to capture decadal variations. In addition, such an addition would differ with previous versions of the NL climate indices.

*4) Figures: I must admit I very much dislike the stacked bar graph as a method of visualising the anomalies (sorry!). I find it very difficult to see the common variability (or not) across the different component indices, and would recommend the authors instead create a grid of the anomalies [...] Such a grid would also make it more readily identifiable where the combine index is based on a smaller subset of the sub-indices due to the lack of data (see also my comment on an overview table below).*

We have modified Figure 12 to add such scorecards.

*5) The Climate Index and what it means: Within marine ecosystem research, the use of single indices by researchers beyond the native discipline is attractive. Ideally, these indices are a single time series that integrate the state of the physical environment. Such indices do also however need to have a clear summary of what it means when they are positive/negative. This should be summarised in an expert statement which non-expert users can understand and refer to in their own research and publications. I will try to explain this point with an example. [...] In my opinion, it is advantageous to release some of this expert guidance with the manuscript as it will aid the end user and will broaden the application the end product. As is, I think this additional expert guidance and interpretation is missing from the manuscript, and I would therefore recommend the authors consider including a “what the NLCI means for the state of the*

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*region's seas” section. I would also suggest that some of this is elaborated for each of the sub-indices too. In the end, I do think it is up to the authors to consider inclusion of such a section. They will need to make a decision on whether they consider this a data product which is freely available but where end-users will need to make contact and collaborate to aid in the meaningful interpretation of the end-user's data, or whether this is a data product which comes with a sufficient level of expert guidance that allows end-users to make their own attempts with interpretation (but where they may still approach the authors for expertise if desired). There is no correct answer here (and different authors/reviewers will have their own bias), but the NAO Index products provide an example of what could be achieved (and how to do it well).*

This comment looks like no.2 above. We have re-written the Discussion in hopes of providing a basic expert guidance on the NLCI. A complete description on the functioning of the NL shelf ecosystem in relation with the NW Atlantic conditions is however still a work in progress, and outside the scope of this study.

#### **Other minor comments:**

*General: consider adding an overview table with sub-index, data source, time period covered, calculation method.*

We now provide a table with the historical versions of the climate indices in Atlantic Canada.

*Line 16: Although an annual update is stated, the likely publication time within the year is not defined. Some end-users may want to know whether this update will be in Spring/Summer/Autumn/Winter to know whether they can expect it when they are undertaking their own annual assessments (for example, for inclusion in an annual*

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*stock forecast for stock assessments which may be undertaken at a specific time of year). Such a statement could be appropriately "hedged" to avoid over-committing (or unexpected set-backs): "An annual update of the NL CI will likely be available by early summer each year. "*

Such a sentence has been added in the data availability statement.

*Line 27-28: It may be worth consider for the future 2020 update to create versions referenced to both the 1981-2010 and the 1991-2020 period to highlight to end-users the possible impacts of the change in reference period (or include an expert guidance statement to provide this information).*

This new version of the manuscript is now based in the 1991-2020 climatology. A suite of relevant figures using the 1981-2010 climatology is also provided in the Appendix.

*Lines 130-131: Add reference to some of the recent papers documenting this fresh anomaly in the sub-polar North Atlantic (such as Holliday et al, 2020).*

Done L.182

*Line 143: The choice of BB as Bonavista is a little confusing, particularly as Baffin Bay is also part of the overall region, and generally abbreviated as BB.*

BB stands for Bonavista Bay (now stated in the text) And has been kept for historical reason (it has been sampled and named with this acronym since the 1950's)

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*Figure 7: Isopycnals on both panels could provide a good addition.*

Done

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Interactive comment on Earth Syst. Sci. Data Discuss., <https://doi.org/10.5194/essd-2020-350>, 2020.