

## ***Response to reviewers on “The Sub-Polar Gyre Index - a community data set for application in fisheries and environment research” by Barbara Berx and Mark R. Payne***

We would like to thank the three anonymous referees for their constructive feedback on our manuscript submitted to Earth System Science Data Discussions. Below, we have addressed their comments, and have highlighted in our response how the manuscript has been modified (where appropriate). The referee comments are in grey, while our responses are in regular black font.

Please note that in light of the updated time series provided by the CMEMS delayed mode products (and as raised by Anonymous Referee #2), we have updated all figures with the time series to April 2016. Figures 2, 4, 5, 6, & 7 have all been updated. Some minor spelling and grammar corrections have also been made to the text.

### **Anonymous Referee #1**

The authors present a new dataset for general release that provides an index of North Atlantic subpolar gyre circulation. The index has been presented in journal articles in the past, but never freely distributed or updated before now. The index itself should prove very useful for applied research and monitoring, and for those who are not able to re-create the index from the original data. The manuscript gives a clear description of how the index is computed, assessing its sensitivity to the area over which is calculated, and the effects of the lengthening time series.

The manuscript is clearly written and provides good and appropriate figures. Overall my view is that it is suitable for publication with some revisions as follows.

In Section 3 you state that the index is EOF1 and explains 26.2% of the variance. It would be useful here to have a fuller explanation of what the EOF is in terms of the physical changes in the SPG (and cite some papers that are the origins of the information). For example, what does “weak” mean in this context? Can you plot composites or examples of what the SSH anomaly looks like under negative/weak conditions vs positive or “strong” conditions? Or SST to show the “westward retraction” (what does this retraction refer to?).

The introductory paragraph of Section 3 has been modified to a new subsection “Interpretation” which addresses the referee’s concerns and provides some help for readers on the physical meaning of the SPG-I. We have not created composites, but refer to a schematic in Hátún et al. (2009; Large bio-geographical shifts in the north-eastern Atlantic Ocean: From the subpolar gyre, via plankton, to blue whiting and pilot whales, *Progress in Oceanography*, 80, 149–162).

It would be interesting to know how much of the variance is explained by the second/third mode and what those patterns might represent? Could they be useful indicators of a different aspect of the SPG characteristics?

The second and third mode explain respectively 8.6 and 6.4 % of the variance, respectively. The interpretation of these has not been published, but the EOF spatial pattern suggests these are related to dynamics in the Irminger Basin and the Sub-Arctic Front, respectively. We are keen to present only established work and interpretation of the sub-polar gyre index. Some of this information has been added to the new “Interpretation” subsection.

On Line 125 you cite some numbers referring to Figure 4a, but I can't see what they refer to. In the same

paragraph you discuss the correlations between the indices over several different regions. Do the correlations decrease if you use de-trended series? This might highlight the differences between the subpolar and wider regions.

The numbers referred to the region numbers in Figure 4a. These were preceded by the letter R, and the text has been edited to correctly reference these time series.

The correlation coefficients do decrease after linearly detrending the time series prior to the analysis, however this does not change the main conclusion that the time series calculated on a domain focused solely on the sub-polar gyre have a stronger inter-annual variability.

The text and figures have been edited accordingly.

I wasn't very convinced by section 3.2, the sensitivity to length of time series. I think you are saying that you need a decent length of series to get a robust result. The statement on line 136 suggests that users need always to access the latest version of the index to use the "most accurate representation of sub polar dynamics", but then go on to say that we have now reached a series of sufficient length (which suggests that at some point that first statement stopped being true). Anyway it looks to me as those the length of the series is not a problem even for the shorter series; if those indices in Fig 5 were all overlain instead of being slightly offset at the start, their apparent difference would look even smaller. And since the value in the index is not its absolute value, but relative periods of high or low (as you say in the next paragraph), I think I would summarise this section as showing the form of the index is not at all affected by the number of years of data used.

We agree with the referee's observations. Our aim for this section was two-fold: to highlight the influence additional data points have on the SPG-I (i.e. small but potentially important, hence users need to download the entire time series after updates), and to show that the first EOF & PC of SLA have a dynamic meaning as the SPG-I, which is robust irrespective of time series length. We have re-written the section to bring more to attention the key conclusion from the reviewer.

In section 3.3 I noticed that you refer to your new index in Fig 7 as "yearly" data when there is clearly data at sub-annual time scales included in the red curve. In the text you described the data as annually filtered - you just need to be consistent with the terminology in Figure 7, or ideally, would present actual yearly values from your new index.

We have now calculated an actual yearly index, and text & figures have been modified accordingly.

## **Anonymous Referee #2**

This is probably a valuable effort and this index will be used by some. However, I would like to see major improvements in the paper for the following reasons: Among major reasons provided for this index work is a recommendation from a working group (WGOOFE) of ICES. This does not seem enough motivation, or at least this is not argued enough. How will this particular index help the Fisheries work? and how is it complementary to other indices that are published in delayed mode (based for example on atmospheric variables (NAO, EA, Arctic Oscillation...) or on CPR survey data...). Or, to take another example, on the time series and ocean analysis published by another ICE working group (WGOH)?

On the other hand, one can guess that this index might be interesting for fisheries work, as this community may not be used to manipulating large gridded datasets (such as the ones provided by Copernicus Marine Service, for example T-S 3D analyses either from data (for example ISAS or ARMOR products) or model

simulations).

We thank the reviewer for their comments. The introduction has been extended to highlight how the index could be useful for fisheries research, without being overly prescriptive in its use. As the review hints at, one of the key motivations for formalising this index is the need to bridge the gap between operational oceanographic products and the needs of fisheries and biological researchers: in a recent survey of this field (Berx et al., 2011, *Oceanography*), we showed that the technical skill levels of most potential users is poor and that they are not used to dealing with either the quantities of data associated with gridded data sets, the formats that they are presented in (e.g. netcdf) or the techniques required to summarise them (e.g. EOF). While this manuscript may seem overly unnecessary to those that are used to working with these datasets on a daily basis, we feel that it will open this data up to a new community of potential users.

We are confident that the Sub-Polar Gyre Index is an index-based time series of interest to researchers studying ecosystem variability in the North Atlantic Ocean. The time series provided by other working groups such as WGOH, provide the observed variability at a single point, and do not summarise the basin-scale dynamics in a single parameter. The WGOH aim to include this SPG-I product in their Ocean Climate Status Report (S. Hughes, WGOH co-chair, pers. comm., 2017). The NAO and SPG-I are somewhat related, and we have added some text on this to a new section on the interpretation/meaning of the SPG (section 3.1).

We disagree with the statement that the index will only be used by some. Since initial on-line publication in October 2016, the data website has been visited 188 times, from 140 unique visitors. Of those, 53 have proceeded to download the data (J. Rasmussen, Marine Scotland Data Manager, pers. comm., 2017). Statistics on the ESSDD website show the paper (in PDF form) to date has been downloaded more than 160 times.

I am also wondering about the interest to provide an index in a rather delayed mode (my understanding of the paper is that the 13-month smoothed index that is recommended ends in May 2015; on the web-site, the monthly non-smoothed files end up in December 2015, with the next 6-month release from Aviso just published this week). Is there a commitment of the Scottish Institute to update the index? Or should it be deferred once publication done to the Copernicus Marine Service (there is index work planned to be provided, but I don't think that it includes this index?); There also near-real time altimetric products that might be used to extend the time series to near-present (but this requires more work).

As stated in Section 4, we are committed to updating this time series on a regular basis (the revised MS now includes data up to May 2016), and this commitment has been made more explicit in Section 4. An additional motivation for this work is to attempt to standardise the calculation of the index and provide a step-by-step protocol for its derivation. While the reviewer suggests that this is a simple process, our experience with preparing this manuscript has showed that it is anything but and we have been unable to fully replicate the results of other researchers. By both writing this recipe down explicitly and providing the source code to make the calculation, we therefore provide a mechanism by which other providers (e.g. Copernicus Marine Service) or individual end-users can pick up our work and continue with it, if we do not provide regular updates ourselves.

Until other sources provide a reliable, operational time series of the Sub-Polar Gyre Index, we will continue providing updates, as and when the data is available from AVISO and within a reasonable time frame (i.e. six months after release). We believe this is an appropriate time frame for our target user group who generally work with fisheries stock data which are compiled annually and often with a lag of one to two years. A survey of the ICES community by Berx et al. (2011, *Oceanography*) shows annual updates to data products would meet the user requirements of nearly 50% of the respondents. The ICES WGOOFE has on many occasions

lobbied operational services, such as the Copernicus Marine Service, to provide index-based products, including a sub-polar gyre index. Unfortunately, these agencies have not yet acted on such requests, and therefore, until they do, we will gladly continue to provide a sub-polar gyre index to the community.

Maybe in the introduction, it could also be informative to add bibliography, for example from modeling work on this index such as in the Gao Yong-Qi and Yuh Lei 2008's paper or on variability in the subpolar gyre and connection to subtropical gyre? I am also wondering whether this first EOF of SSH is the only part of the SSH mapped data that might be interesting to the fisheries community (or climate community). If this is research in progress, it could be worth adding indices of intergyre transport and different gyre intensity... Combining with other indices that can be derived from easily accessible indices could also be helpful, but this requires more work (it could be an average T-S or density 0-1000m of the subpolar gyre?)

We thank the reviewer for the suggested alternative index-based products. We feel this is beyond the scope of our current manuscript. The ICES WGOOFE continues to work on developing index-based products for the community, and no doubt future developments will include some of those suggested. The community has been asking for a sub-polar gyre index for a number of years, and we would like to avoid further delays in providing this data product. We have added more information on the interpretation of the sub-polar gyre index in a new subsection ("3.1 Interpretation").

Then, different sensitivity tests are presented to show how stable and reliable is the index chosen. Work is presented on tests of size of domain and smoothing. I don't see tests on whether normalizing the variance in each (spatial) grid point before EOF analysis could have an effect, whether. Another point to test would be whether removing a time series of spatial mean before doing the EOF/PC analysis has an impact. There are also tests on time series length, but they all include the first part of the time series, where the largest changes occur in PC1. This is not very informative, and more sophisticated tests to provide information on the stability of the pattern. This could be done by extracting EOF1 by randomly selecting subsets of years, and providing tests of significance (how, does the proportion of variance explained by EOF/PC1 changes, whether patterns and regressed time series vary or not...). Even, doing the analysis separately on first and second halves of the record could be instructive (instead of figure 5)

This section has been revised in light of comments from the other referees. The sensitivity analyses suggested by the referee would lead into the realm of sub-polar gyre dynamics. This is beyond the scope of our work, and would be a subject more appropriate for a classical oceanography journal, rather than a data journal such as this.

Minor comment. The schematic circulation of Figure 1 could be modified/updated. Not that great from a physical point of view.

We thank the reviewer for their concern. The figure is meant to provide a schematic representation of currents and provide the reader with a general geographical reference. We have not made any changes.

## **Anonymous Referee #3**

In my opinion, the manuscript is suitable for ESSD but some revisions are needed, according to what listed below, to improve it before publication.

GENERAL COMMENTS Berx and Payne present a very interesting dataset of the North Atlantic sub-polar gyre index (SPG-1) and give a useful description of how it is computed from publically available SSH products.

This index has been already used and described in several papers; nonetheless, it needs to be routinely updated - because of the effects of the lengthening time series (as shown here by the authors). Thus a major advantage could be achieved if the authors will provide regularly updates of the SPG dataset; it would be worthy to understand if the authors have any commitment/ intention to do that and which is the expected timing (i.e., following SSH delayed time products release, using near-real-time products, . . .).

As originally alluded to in Section 4, we are committed to continue providing updates to the SPG-I, as and when updates are available from the data provider (CMEMS), and within a reasonable time frame (i.e. six months). We have changed the wording in Section 4 to make this commitment clearer. Code to recreate the index will also be made available shortly.

Data can be easily downloaded in ASCII format and a preview tool is included in the main page to facilitate the users. No doubt that this freely available dataset could limit mistakes and uncertainties for those not used to manage altimeter data and/or principal component and empirical orthogonal analyses.

The short manuscript that comes with the index estimations is carefully written and also provides i) a useful analysis of their sensitivity to the spatial extent of the area of computation and to the length of the considered time series, ii) a comparison with index values derived in previous studies. Finally, seven appropriate figures support these analyses.

SPECIFIC COMMENTS In the abstract, I am wondering why the authors say that the sensitivity to timeseries length is not an important factor; actually it is (to me) even though it does not affect this dataset. The authors discuss this aspect later in the manuscript (section 3.2) but again it is not completely clear if timeseries length represent an issue to be carefully considered or not. This aspect should be clarified and, eventually, the sentence in the abstract should be rephrased.

We have clarified the conclusions from the section on time series length, and have edited the abstract accordingly.

In the Introduction, it would be worthy to include information about similarities and differences with the NAO index and, possibly, their combined use. Still, although the fact that this index version is better than the previous ones is clearly highlighted, the manuscript lacks an explicit description of what this index can be used for. Suggestions about how fisheries could apply this SPG index could benefit the readers and improve the use of this dataset in future studies.

We have included several papers where sub-polar gyre dynamics are used as an explanatory factor for ecosystem dynamics. We, however, don't want to be prescriptive in how the index should be used, and encourage researchers to use the time series in their analyses as they see appropriate. We have re-worded the introductory paragraph of Section 3 to be a "interpretation" section, including the relation to the NAO.

In Section 3, it would be interesting to know something more about the second/third modes (how much variance they explain, what they could represent) and/or why we can neglect them when studying SPG. Generally, I would also appreciate more details about the first mode of the EOF and its physical interpretation in the SPG context.

The second and third mode explain respectively 8.6 and 6.4 % of the variance, respectively. The interpretation of these has not been published, but the EOF spatial pattern suggests these are related to dynamics in the Irminger Basin and the Sub-Arctic Front, respectively. We have added a new "Interpretation" subsection to include more information on the first mode and its physical meaning. All information is based on published work, and appropriate references have been added.

In Figure 7, I don't think that all data shown represent "yearly mean" values as described in the figure label. Please clarify.

We have now calculated a true annual index, and the manuscript and figures have been updated accordingly.