



EGUsphere, referee comment RC1  
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## **Comment on egusphere-2022-354**

Alan Fox (Referee)

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Referee comment on "Interannual to decadal sea level variability in the subpolar North Atlantic: the role of propagating signals" by Denis L. Volkov et al., EGU sphere,  
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### **General comments**

The study uses satellite and hydrographic data to characterize the inter-annual variability of SSH, focusing on the subpolar North Atlantic (SPNA). Empirical orthogonal function (EOF), and complex EOF (CEOF) analysis, of the North Atlantic SSH show that the first two EOF modes do not represent independent processes, but a signal propagating from east to west in the SPNA. The study then adds analysis of wind forcing and surface buoyancy fluxes to examine whether SSH variability and the east-west propagation is driven by winds, local air-sea fluxes or ocean advection, and relate the results to those of previous studies in the region. I enjoyed reading this and find the study to be well-written and convincing and to comprise useful insight into subpolar North Atlantic variability. Below I have a few specific queries, and a few minor technical issues.

### **Specific comments**

Introduction and conclusions

Subpolar Gyre Index (SPGI)?

There exists extensive literature on the SPGI, which is often defined similarly, but not identically, to the EOFs used here. Generally, the SPGI had settled on the use of the first EOF (EOF1) of SSH variability (including the long-term trend I think) over the subtropical and subpolar gyres (about 30 to 65 N, contrasting to the larger area north of the equator up to 70N used here). Hatun and Chafik (2018, <https://onlinelibrary.wiley.com/doi/abs/10.1029/2018JC014101>), show that more recently EOF1 in this region has become dominated by the largescale linear trend in the SSH, with

subpolar gyre variability now in EOF2 (or a combination of EOF1 and EOF2). Superficially the first two EOFs in Hatun and Chafik appear similar to those presented here, but the time series in the principal components appear different. I think, given the focus on the SPNA, the present study needs more reference to the existing SPGI literature, highlighting the differences and similarities between 'classic' SPGI and the metrics used here, in both the introduction and in discussion. Does the study, for example, show that a single EOF is insufficient or inappropriate to characterise the major, propagating, variability in the SPNA?

#### Section 4. Results

I was occasionally confused about whether the authors were talking about their work in the current paper or previous published work by other authors. Examples are paragraph 1 of both sections 4.1 and 4.2. I think this may be due to a tendency to switch between describing results and figures in the past and present tenses.

Section 4.1, lines 236-245, Figure 5. As well as the west-east differences in variance explained by EOF1/EOF2, there are differences based on water depth, with EOF1 explaining the largest part of the variance in waters over 2000m deep (in the west) and EOF2 explaining more variance in waters less than 2000 m deep. What are the reasons for these differences? Are the warming/cooling signals associated with the SSH changes propagating in depth as well as space?

Section 4.2, lines 263-274, Figure 7. I was a bit surprised at the percentage of SSH variance explained by  $SSH_{ST}$  in the WSPNA, as there appears to be a larger misfit between the black and blue lines in Figure 7b? For the period described in the text,  $SSH_{ST}$  decrease of 5 cm was part of an SSH decrease of nearly 8 cm. What explains these differences? Changing barotropic flows? Please include some discussion of the part of the SSH signal which is not captured in  $SSH_{ST}$ .

Section 4.5. In the light of the previous sections on propagating signals, why were the periods here selected based separately on periods between maxima and minima of PC1 and PC2 (rather than phases of the propagating signal)? The first period (1994-2010) covers more than 2 periods of the propagating signal. And having chosen periods based on PC1 and PC2, why are they discussed in the order presented alternating PC1- and PC2-based periods? I think it would be useful to mark these periods on Figures 3 and 9.

Section 4.5. This section discusses absolute SSH changes, rather than those reconstructed from the EOFs or CEOFs. How much difference does this make? Does the west-east propagating SSH contain less local surface flux signal and more advection, for example? Or is this not possible to determine?

Section 4.6. While opening with the 2011-2015 cold blob in the Iceland Basin as an example of an advective feature, the discussion doesn't really consider the source of that feature, just its subsequent westward, downstream advection. Can your analysis say anything about the upstream source of this feature?

It should be explained why velocities at 1000-dbar from Argo/altimetry are used when the cited method of Schmidt produces horizontal velocity estimates throughout the upper 1000m. It isn't clear to me, either from the methods or this results section, what different information is provided by the velocities and the eddy propagation velocities, and why both are used. I couldn't find the time-span over which these mean currents are calculated.

Figures 10 and 11. These regressions are presumably come with an associated measure of significance? Perhaps consider including the arrows/colours only where they are significant?

## Technical corrections

### 3.1 EOF analysis

This section appears to have some errors in the equations:

Eq. 1:  $EOF_j$  is just a function of position (not position and time). You could use bold for the position vector,  $\mathbf{x}$ . Explain that  $N$  is the number of EOFs in the reconstruction and that  $SSH_R$  is reconstructed SSH

Eq. 2: I think the LHS of this equation is variance explained by the  $j$ th EOF, but the RHS is variance explained by the sum of the first  $N$  EOFs.

Eq. 3: LHS should make it clear it is the augmented complex SSH, perhaps call it  $\$SSH_C$  to differentiate it from  $\$SSH$ .

Figures: Panel labels should be formatted as (a), (b), etc.

Figure 3 caption refers to 'SSL' as opposed to SSH. I can't find reference to SSL in the text. Should SSL be  $SSH_{ST}$ ?

Figure 11. I was very confused by the reversal of the blue-red color scale compared to everywhere else in the manuscript (to red negative, blue positive here), for a long time thinking the figure showed exactly the opposite thing to that being described. I understood (eventually) that this was to help the comparison with the SSH patterns in Fig 8. This reversal of the scale needs to be made much clearer or, preferably, return to the conventional use of the scale. I think readers can still easily compare figures 8 and 11.

Figures 10 and 11. I think these regression maps are anomalies, it isn't always clear when the full variable is meant, and when it is the anomaly.

Figure 17. It is difficult to see the red, green and blue contours mentioned in the caption.