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Interactive comment on "The impact of atmospheric and oceanic circulations on the Greenland Sea iceconcentration" *by* Sourav Chatterjee et al.

Anonymous Referee #2

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Review of the manuscript ÂńThe impact of atmospheric and oceanic circulations on the Greenland Sea ice concentrationÂż, submitted to The Cryosphere

General comments This is a novel study that focuses on the dual influence and control that oceanic and atmospheric circulation have on several key parameters in the Greenland Sea. It aims to show how the complete system works together to shape the sea ice conditions, ocean stratification and upper ocean heat content, also aiming to explain why the characteristic sea ice shape 'Odden' tend to occur in some winters and not others. The latter through influence of Atlantic Water higher up in the water column and increased inflow of Atlantic Water during periods with an anomalous strong

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gyre. The paper largely succeeds in showing this interplay. The authors also show how their results fit into a bigger picture of processes through framing it well into published literature.

One of the strengths of the paper is the focus on both vertical and horizontal processes, both from the atmosphere to the ocean and sea ice, and from the ocean to the sea ice (the impact further from the ocean/sea ice on the atmosphere is less mentioned). The paper has a high and complex aim, trying to reveal a complex interplay, and it therefore needs to be very well written and have a tidy structure in order to give a clear presentation of the results. Unfortunately, this is not good enough in the current version. Sentences are mostly well written, but the organization of the paper needs improvement, and some parts are weak or even lacking, e.g. Ch. 1 lacks a clearly stated objective and Ch. 2 lacks a thorough description of the methods. Ch. 3 Results and Discussions appear messy since sentences that belong to the introduction and methods are blended in, and there are some repetitions in this chapter. This tends to preclude the key results and make it harder to follow the discussion. However, with a largely improved presentation of the findings, including a clearer focus on the objective, an addition of a thorough description of the methods and a model evaluation, the paper will be worthy of publication. Note that even if the numerical model has been evaluated previously, this is not equivalent to it being adequate for investigating the processes which are analysed here. A model evaluation is therefore needed in this paper, see comment below. It is also important to treat uncertainties better in the paper, to show that the results are significant.

My conclusion is that an improved version of the manuscript will be well-worthy of publication and deepen the insight on how the atmosphere and ocean act in tandem in the Greenland Sea. The paper gives rise to an improved understanding of the complex and important interplay that takes place between the ocean, sea ice and atmosphere, and the results can have value for understanding regions outside the Greenland Sea as well. I encourage the authors to add a discussion on how the complete set of results

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can be viewed schematically. My suggestion is a divergence/convergence situation or strong divergence (pos. GI periods) versus weak divergence (neg. GI periods) situation, see major point below.

Specific comments - It would improve the paper to include a discussion on the overall picture of processes towards the end (discussion), accompanied by a schematic illustration of the process described. What may be the overall picture of processes here? Is it strong divergence versus weak divergence with the associated Ekman transport and pumping? The analysis compares periods with a strong and weak gyre circulation and show that it corresponds to periods with sea ice transport towards the Greenland coast versus periods with sea ice transport towards the gyre and shaping of the characteristic Odden sea ice shape. Is this also valid for a larger domain encompassing the study area? I.E., is this comparable to a large divergence situation where low sea level pressure induces stronger cyclonic motion in the gyre, which in turn is associated with stronger Ekman drift of sea ice and surface water away from the gyre, inducing a lift of the interface between the fresher waters in the upper ocean and Atlantic Water below? And that this also involves Ekman pumping in the centre of the gyre, lifting the interface and inducing stronger inflow of Atlantic Water towards the gyre? When the gyre is more relaxed, there is less divergence and the sea ice can drift also towards the gyre region, particularly with the Jan Mayen Current and shape the characteristic 'Odden' tongue of sea ice. There is a need to summarize this at the end of Ch. 3 and to add schematics of the horizontal and vertical conceptual framework that the authors mention several times in the manuscript.

-Why use the smaller region to the west (72-75N, 18-10W) when investigating the covariability between stratification strength and gyre strength in Fig. 7? These two study regions are not similar. Why not use the same region as for the Gyre Index? It is logical to use the 72-75N, 18-10W for showing flow of AW upstream of the gyre, but for the stratification comparison I assume it is better to look at the actual response of the gyre. From reading the manuscript one gets the impression that the figure intends

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to show the change in stratification in the gyre itself, not upstream. -Present the Gyre Index thoroughly early on, as it is a key part of the analysis. This can be done by adding a time series of it in Fig. 1b and highlight the positive and negative time periods that are used for the analysis. A rationale for using the chosen threshold values 0.75 and -0.75 is needed (in the methods). The paper needs to show which time periods are used in the analysis, as the negative and positive periods are compared. Explain in the methods carefully how you have estimated the "composite differences". This explanation can refer to Fig. 1b, the time series of the Gyre Index. It can also be of good value to present maps showing the mean wind fields for the positive and negative periods as Fig 1c and d or add such maps to Fig. 4.

-The last paragraph of Ch. 1 needs a strong rewrite. Clearly state the objective of the paper and mention briefly in one or two sentences how the study is performed, which data have been used and how the rest of the paper is structured/organized. In the current version, the objective and hypothesis are mentioned indirectly in Ch. 3. -The Method section is poor. Ch. 2 Data and methods presents the data shortly but lacks a thorough description of the methods. Reorganize it to e.g. 2.1 Data, with three paragraphs on atmospheric, oceanic and sea ice data, and 2.2 Methods, with a careful explanation of what the authors did in this paper. An evaluation of the TOPAZ4 results are needed to show that the model results are appropriate for investigating the objective of the paper. Mention which oceanographic data are used for the data assimilation (how many, from which data sets and the distribution seasonally and through the time period). What are the typical discrepancies between the TOPAZ4 before and after the data assimilation? What are the parts of the ocean-sea ice system that the model performs well on and which is it not simulating well?

-The evaluation needs to show that the TOPAZ4 results simulate reasonably well the key variables investigated in this study, which include the ocean stratification, sea ice concentration and ocean circulation in the upper 500 m., in terms of the spatial pattern of the mean fields and their temporal variability. It is also important to show the vertical

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structure of the ocean in temperature and salinity to check that TOPAZ4 reproduces the change in these variables between positive and negative Gyre Index periods. Add a brief discussion on TOPAZ4's applicability, strengths and weaknesses that shows why the model is suitability for the purpose here. Even if there are discrepancies from reality in the model results, they can still be useful for the purpose here. However, the discrepancies need to be shown and mentioned explicitly and it is necessary to discuss the findings in consideration of these discrepancies at the end of the paper. E.G., from Fig. 2 is clear that TOPAZ4 has a higher sea ice concentration variability than the observations. Does this imply that it exaggerates the variability, which in the time series analysis could result in a higher significance than in reality?

-Ch. 3 Results and Discussion is messy and needs a strong tidying job. Having the results and discussion in parallel may work, but that demands a very well written, tidy and organized results and discussion chapter. As it is reads now, Ch. 3 is a mixture of results and discussion blended with introduction and methods sentences. Stick to a structure of starting each paragraph with briefly stating a result and referring to the companying figure. Then discuss briefly what the finding means and how it is interpreted by the authors and where applicable shortly if that is in line or not with published literature. The paper needs a broader, separate discussion of the findings before the conclusions are drawn. This can be a last paragraph of Ch. 3 that presents the flowchart in Fig. 8 and a new schematic in Fig. 8b that shows the process in the horizontal and vertical.

-Conceptual presentation: For this type of paper, that encompasses a complex and overarching picture of processes it is important to present the conceptual framework explicitly. Fig. 8 needs to be strengthened with a schematic of how the concept it is viewed from above, showing the case with the strong gyre/positive GI periods, with arrows showing the divergence of sea ice (and surface water) and stronger inflow of Atlantic Water, and a vertical sketch showing the lifted/raised pycnocline, with AW higher up in the water column. Then explain that during neg. Gyre Index periods, the gyre is

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more relaxed, there is less divergence/less Ekman transport and sea ice tends to be drifting more towards the gyre and the 'Odden' tongue of sea ice can be formed (helped by the JMC). In this way, the author's interpretation of the whole set of processes can be summarized and made easily accessible for readers and increase the impact of the paper.

-Seasonal aspects: The paper does the analyses for winter (Dec-Jan-Feb), presumably because winter has strong wind forcing, thus likely a stronger signal-to-noise ratio which increases the chances of tracing the signals under investigation, with significant correlation coefficients. This is a reasonable choice, but the authors need to provide a rationale for it and discuss if the investigated processes are in effect and significant in other seasons. It is necessary that the model simulations are good in winter. I assume there is less observational CTD data to assimilate the model with in winter. It is therefore necessary to show the seasonal distribution of the observational data and that the model performs well enough in winter (particularly, the change between winters with different forcing is essential here).

-It has not been shown that AW reaches the surface in response to the anomalously strong gyre circulation. In the analysis, this is checked for the upper 400 m and even if the mean temperature and salinity increases in the upper 400 m, this is not equivalent to showing that AW reaches the surface. Either modify the wording to e.g. "implying a lift of the AW" or "raising the AW" or similar or strengthen the analysis to show that it does occur. It will strengthen the paper if the analysis is made for more specific parts of the water column, e.g. for 0-100 m and 100-400 m separately, or other depth spans that the authors find more appropriate for investigating how AW is lifted in the water column in response to the strengthened gyre. Fig. 7 is informative in this manner, and should be expanded to include Hovmöller diagrams of temperature and salinity in the same way as panels b and c.

-There is a poor level of treatment of uncertainties in the manuscript. There are only a few years that goes into the statistical analysis (i.e. those with Gyre Index >0.75

or <-0.75) and it is important to show that the results are significant. Estimate the uncertainty and show it, in time series as e.g shading around each variable and in maps as shading or hatching over the significant areas. Write the p-value after each correlation coefficient. Why use the 95 % confidence level? Are the results valid on the 99 % confidence level?

Technical corrections TITLE -Remove the period at the end. -Consider a rewrite to highlight the finding, i.e. that there is a combined impact by the atmosphere and ocean. And since the ocean is the main focus here, consider mentioning it first, thus changing to "Combined impact of oceanic and atmospheric circulations on Greenland Sea ice conditions". -Since the authors investigate the effect not only on sea ice concentration but also on ocean stratification and AW inflow, the title could end with ". . .Greenland Sea conditions".

ABSTRACT -Regards the sentence "This in turn decreases the freshwater content and weakens the ocean stratification in the central GS". This may very well be true, but it has not been properly shown that the freshwater content declined in response to a stronger Gyre Index and the associated Ekman transport of sea ice and freshwater away from the gyre. Can you add figures to show this? Is the freshwater input reduced in response to less sea ice transported into the GS? But the effect of that would be seen after the following summer? Second last sentence: It has not been shown that AW is reaching the surface. It has been shown that there are warmer waters in the upper 400 m when the gyre is strong (GI>0.75). And how high up does the authors mean when they use the phrase "surface"? Upper 400 m is very large span and increased heat content in the upper 400 m probably reflect that the Atlantic Water is occupying more of the water column when the pycnocline is raised more (during periods with stronger divergence and increased Ekman transport of surface waters and sea ice away from the gyre).

CH. 1 INTRODUCTION Paragraph 40-45: -Last sentence: 'can also be important in terms of interactions' is unclear. Rephrase. Paragraph 50-55: -Second sentence:

rephrase ‘or the old sea ice’ to ‘or older sea ice’. The sentence reads as though there is either young or old ice. Can younger and older sea ice occur in the Odden region at the same time? Paragraph 60-65: -First sentence: change to ‘large-scale’. -Third sentence. Rewrite and add a hyphen between ‘NAO’ and ‘like’. Suggesting a rewrite to ‘The large-scale atmospheric circulation resembles the pattern of the North Atlantic Circulation (NAO), but the NAO-like pattern is not covarying significantly with the Odden ice extent (Comiso et al. 2001).’ Paragraph 70-75: -First sentence: Remove comma after parenthesis with references and add ‘and’. -Sentence starting with ‘Further, . . .‘ Add em-dash around the embedded clause: ‘Further, the eastward flowing JMCâĂŤoriginated from the EGCâĂŤconstitutes the . . .’ -Second last sentence: Change ‘this’ to ‘the’ in ‘this cold and fresh JMC’. -Last sentence: Remove ‘current’ in ‘JMC current’. Also, note that this sentence mentions indirectly the hypothesis of the paper. Rather write it explicitly (e.g. starting with ‘Our hypothesis is. . .’) or rewrite the sentence to e.g. ‘This implies that the GSG circulation . . .’ and add a sentence stating the hypothesis explicitly in the following paragraph, where also the objective needs to be clearly formulated. Paragraph 80-85 – last paragraph of the introduction: A clear ending of the introduction is needed. This is an important paragraph of the paper and needs to state explicitly the objective of the paper, the hypothesis, which now is mentioned indirectly in the paragraph above and in sentences in Ch. 3. Also mention briefly how aim is investigated and how the paper is structured. -First sentence: Be specific and explicit. Add what is investigated before stating the aim, e.g. ‘In this study, we investigate . . . with the aim to . . .’ -Add a sentence between the current first and second sentences stating the hypothesis: ‘Our hypothesis is that . . .’. -Second sentence: Add briefly the approach of comparing time periods with weak and strong forcing, e.g. ‘Using a combination of . . ., we compare time periods with strong and weak gyre circulation and show that . . .’ -Last sentence: ‘Further, it is shown that . . .’ is a rather vague and passive start of the sentence. Rewrite to e.g. ‘We also show that . . .’. Consider to rewrite ‘. . . helps setting up . . .’ to something more clear.

CH. 2 DATA AND METHODS Paragraph 100: -This is a too short introduction to the

atmospheric data. There is information missing. State all the atmospheric variables that were used in the study. Were they monthly means? What more did you do with the atmospheric data? What were they used for? This is completely missing from Ch. 2. -Use en-dash, not hyphen when stating the time period, i.e., '1991–2017'. -add a 'the' in front of 'ERA'. -Use past tense in the data and methods chapter, consistently. Paragraph 105-110: -Add which vertical resolution there is in the model simulation. This is important in order for it to be useful for studying the change in vertical structure of the water column and the changes in stratification between positive and negative Gyre Index periods. -Last sentence: add a comma after 'observations'. Remove 's' in 'temperatures' and 'sea ice concentrations'. -From where were the observations collected? Which data set? How many profiles, and from which years, seasons, etc. -Add an evaluation of the TOPAZ4. Is the model simulation suitable for the purpose here? This needs to be shown. Paragraph 115-120: -Rewrite to 'Following Chatterjee et al. (2018), we estimated the strength of the GSG circulation by area-averaging the winter-mean December-January-February (DJF) barotropic stream function within the 3000 m isobath in the region 73–78 °N, 12 °W–9 °E (Fig. 1).' Which depth span was used in the water column for this estimation? Add the 3000 m isobath as a thicker contour in Fig. 1 so that it is easily seen which contour this is referring to. -Second sentence: Rewrite to 'The area-averaged value was standardized over the complete time period 1991–2017 to . . .'. The phrase 'to get the' is a bit awkward. Consider refining it. Also, it would fit well to refer to a Fig. 1b with the time series of the Gyre Index here, as mentioned above. -Third sentence: A rationale is needed for choosing the thresholds 0.75 and −0.75. -Last sentence: Is this only for the oceanic data? This shows that it is tidier to have methods as a separate subchapter, not mention methods within the 2.2. Oceanic data. Paragraph in Ch. 2.3: Again, this is too brief. Add how the data was used in the analysis. -First sentence: Rewrite to 'Monthly mean sea ice concentration data . . . were obtained from . . .'. At which grid size? -Second sentence: Rewrite to 'Sea ice velocity data were obtained from . . .' *METHODS section is missing. What did you do here? Add a proper evaluation of TOPAZ4. Explain the methods, mentioning

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the time periods, study area, that you used winter-mean values (and why), that you used anomalies, etc. How many years actually went into the analysis. Highlight in bands with shading in new Fig. 1b so that it can be seen how many winters (DJF) had a positive Gyre Index > 0.75, and how many was <−0.75. This will allow for a higher transparency and clarity through the paper.

CH. 3 RESULTS AND DISCUSSION Use past tense when presenting the results. Use present tense when discussing them. Start each paragraph with presenting a result and refer to the appropriate figure. Then discuss what the results can imply towards the end of the paragraph. End Ch. 3 with a separate paragraph with a broader discussion of the results and the authors interpretation of them. Start this paragraph with presenting Fig. 8 (and add a conceptual sketch to it). Paragraph 125-130: -The first three sentences belong to Ch. 1. The rest of the paragraph belongs to the evaluation. I suggest moving them to Ch. 2. -Forth sentence: Move to evaluation part in Ch. 2. Refine to "The standard deviation of winter-mean DJF SIC shows high variability along the MIZ and the Odden region, in the observational and reanalysis data (Fig. 2)." -Last sentence: Move sentence to evaluation part in Ch. 2. Also, add that the figure shows that TOPAZ4 has a higher interannual variability in the winter-mean DJF sea ice concentration compared with the observations. Add how this discrepancy can or will influence the results and conclusions of this study. Is it exaggerating the interannual variability, thus giving a higher signal to noise-ratio, or is the additional variability not in phase with the observed variability? Please add a time series of the corresponding SIC variability of the observational and reanalysis SIC in the study area as a Fig. 2c. The model was assimilated with SIC data. Mention why it still has discrepancies from the observed SIC data. How often is the model assimilated (daily, monthly?). Paragraph 140-145: This paragraph is messy, it contains parts of the objective, results, methods and discussion, and it suffers from some poor, vague writing. It needs a strong rewrite, and the sentences that remain in this paragraph needs to be sharp "to the point". -First sentence is about the objective of the paper. Move it to the last paragraph of Ch. 1 and rewrite to a clear sentence. -Sentences 2-4 belong to this paragraph as they present the result and

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the accompanying brief discussion of the implication of the result, which is appropriate for the chapter. -Fifth and sixth sentences belongs to Ch. 1. I understand that the authors have a need to explain why they move on to investigating the atmospheric fields, but there is too much introductory text here, 'with full sentences simply stating the results of other references. Rather simply add a '. . ., in line with *REFS*' after the fourth sentence. -The last two sentences are a mixture of methods and discussion. I suggest taking them out and, if necessary, starting the following paragraph with a brief mentioning of why the atmospheric influence was investigated. Paragraph 155-175: Very long paragraph, which presents two different figures. Split into two paragraphs where Fig. 5 is presented for the first time. -The first sentence is unnecessary long and difficult to read. Rephrase it. The part "suggests that the large-scale circulation associated with the GSG circulation features a NAO-like meridional pattern although the SLP. . ." could be written as "shows a NAO-like atmospheric pattern associated with the GSG ocean circulation, but with centres of action north of their usual locations (Fig. 4a). " Further, it is not self-explanatory what is meant with the phrase "composite differences of anomalies of ". I understand from reading the paper that you have estimated the difference in winter SLP between the positive and negative Gyre Index periods, using anomalies from the long-term mean, but this should be explicitly written in the methods chapter and also understandable just from reading the figure caption and introduction of the figure in the Ch. 3. If you want to keep the phrase "composite differences of SLP anomalies" then explain its meaning explicitly in the methods. Write which time-period the anomalies are estimated based on, in the text and in the caption. -Sentence starting with "The GSG circulation responds to. . .": I suggest bringing it further up front in the paragraph, as the second sentence. Then say that the correlation coefficient with the static, traditional NAO-pattern is insignificant, showing the importance of taking spatial variability of NAO's centres of action into account. -The two sentences starting with "However, at the same time. . .": It is awkward and needs a rewrite, to e.g. "The associated wind stress can influence sea ice transport through Ekman transport, towards the central GS and Greenlands west-coast due Ekman transport" and "We find

anomalous northerly wind stress in the central GS during the positive Gyre Index periods, and vice versa for southerly wind stress." Comment: Is it a southerly wind stress or a weaker northly wind stress during negative Gyre Index periods? It would be clarifying to show the maps with the mean wind fields for the two different cases, strong and weak gyre. -Panels are introduced in the opposite sequence. Introduce Fig. 5a first, then 5b. -This last part around lines 170-175 contains key discussion that is important and may fit better in a separate paragraph for the broader discussion at the end of Ch. 3. Paragraph 185-190: -The entire paragraph is introductory text and includes what the paper investigates in the third sentence. Move this information to Ch. 1. Paragraph 195-200: -First and second sentences: Rewrite to state the result explicitly, then end with '(Fig. 6a)'. The term 'composite differences' is not very intuitive. Could this be rephrased to something more easily understood? The point is that the figure shows that the ocean temperature in the upper 400 m is higher during the positive Gyre Index periods, right? Please write this simply and explicitly and mention how much higher the temperature is during these periods compared with the mean of the negative Gyre Index periods. -Third sentence: Remove. This is repetition and another mentioning of introductory text that does not belong to Ch. 3. -Fourth sentence: Rewrite to start with bluntly presenting the result coming from Fig. 6b, i.e. 'There is a significant positive correlation between the Gyre Index and ocean heat transport in the upper 400 m in the smaller study area west of the main study area (r=0.7)'. (The phrase will improve when the two study areas are named and introduced in the same panel in Fig. 1a.) It is cluttering the structure to start with how a previous finding is confirmed here. This is not a proper way to introduce Fig. 6b. Again, stick to the pattern of first presenting the result, and secondly discuss briefly its meaning, implication, mention how it confirms a previous finding or the like. -Last sentence: If this is also for the upper 400 m then it mixes the signatures of variability in the AW with the upper water masses. It would be more appropriate to check separately for different parts of the water column, e.g. 0-100 m and 100-400 m, separately, as AW is typically in the latter whereas the surface waters and polar/Arctic waters occupies the upper part. That would allow for

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seeing if the surface water decrease in salinity in periods with negative Gyre Index and more sea ice drift towards the gyre and would give a stronger result on whether AW is influencing higher up in the water column during positive Gyre Index periods. The term 'surfacing' is too strong given that it is likely rising but not necessarily reaching the surface. Be specific about which region this is estimated for. Paragraph 210-215: The paragraph is messy and needs to be tidied up. It starts with discussing figures 4 and 5. Rather start it with 'The Gyre Index is covarying with the Brunt-Väisälä frequency (Fig. 7).' And add which depth span of the water column the stratification is estimated over. I suggest continuing with 'Our comparison shows that a weakening of the stratification in the upper part of the water column coincides with a stronger GSG circulation and vice versa.' -Sentence 4: Rewrite to 'This supports that . . . by the GSG can rise under a . . ., hence potentially also the SIC.' -Last sentence: Delete 'further' and 'eastward flowing'. Change 'EGC' to 'JMC'. Delete the clause starting with ', which constitutes' because it is repetition. *A summarizing paragraph with a broader discussion is needed here. This should start with presenting Fig. 8 and write up the complete picture of processes and how the authors interpret their findings.

CH. 4 CONCLUSIONS Please state if atmospheric or oceanic circulation when 'circulation' is mentioned in the conclusion, to avoid confusion. -First sentence: Unclear. Please rewrite. I suggest starting with e.g. 'Here, we investigate . . . and show that . . .'. -Second sentence: add 'the' before 'wind stress curl'. -Third sentence: Rewrite to be more specific, e.g. 'The large-scale atmospheric circulation pattern that influences the GSG circulation resembles a NAO-like pattern with its northern centre of action situated northeast of the typical NAO pattern.' -Fourth sentence: Add a 's' in 'sea ice conditions'. After 'Odden region', add 'in the GS'. Modify end of sentence to 'through Ekman drift of sea ice toward the Greenland coast during periods with northerly winds (Germe et al. 2011).' -Fifth sentence: The sentence is a bit messy. Rewrite it to e.g. 'During periods with anomalously low SLP and strong gyre circulation in the GS, northerly winds and associated Ekman drift causes sea ice drift towards the Greenland coast. This reduces the SIC in the central GS.' -Sixth sentence: Consider a rewrite to 'We show

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that this is associated with a weakening of the stratification in the upper water column.' or similar, to be more direct and specific. -Seventh sentence: Add a comma after 'into the central GS'. Modify the latter part of the sentence. It has not been shown that the AW reaches all the way to the surface, only that the upper 400 m become warmer and less saline. -Eight sentence: Presentation of Figure 8 is too short and should have been mentioned at the end of Ch. 3 and with a broader discussion of the conceptual view of the findings. -Last sentences after "...(Fig. 8)": This part is taking up too much space in the conclusion and gives the impression of dampening the value of the findings of the paper and the closure of the paper becomes too vague. Rather mention this clearly in the methods, that the impact of other smaller scale processes would largely cancel out or act to reduce the correlation coefficients in the processes studied here. But despite these smaller scale processes the results are significant. However, if mentioned in the conclusion it could be rephrased to e.g. "Despite the presence of smaller scale processes, such as eddies and wave interactions, our results on the larger scale processes are significant with high correlation coefficients. This implies that smaller scale processes largely cancel out over time or are not strong enough to dampen the larger scale processes, at least not when comparing periods with weak and strong gyre circulation in winter when the wind forcing is strong".

FIGURES In general, figure captions are lacking information and are not complete, and there are incomplete sentences, e.g. when explaining place names in Fig 1. Make sure all the information is given for each figure. The introduction of study areas should be made up front in Figure 1. In the current version of the manuscript the reader is asked to check for other figures to see which study region is meant. Rather include the two study regions and bathymetry in all the maps were those are needed in order to interpret the results from that figure. Be consistent. Consider to move the larger map from Fig. 4 to Fig. 1, as it fits with zooming in to the study area, and can be referred to in Ch. 1 Introduction. The term "composite differences" is used without further explanation, but is not self explanatory. Please be clear so the reader does not have to check the methods to understand what the figure shows. It can be written out

full without too much space, e.g. 'Difference in winter-mean SLP for DJF between time periods with strong and weak Gyre Index during 1991-2017', or something similar.

Figure 1: -Consider moving the larger map in Fig. 4a to here to zoom in early on. -Add the other smaller study region as well and name the two. -It is a bit misleading to show the larger study area as a box when in reality is following a bathymetry contour. Rather show it with the 3000 m bathymetry contour. Consider showing it in all the figures that have a map. It should be possible without cluttering the figures. -Add a time series of the Gyre Index as Fig. 1b, and highlight the positive and negative time periods and threshold values 0.75 and -0.75 as e.g. shaded bands and dotted lines. -Highlight the 3000 m isobath contour as e.g. a thicker contour line than the others, to show the region where the Gyre Index is estimated from.

Figure 2: -This figure belongs to the Methods section, showing the variability of the sea ice concentration fields in winter and is used for evaluation of TOPAZ4. Rather refer to it in Ch. 2. -Add label to the colorbar. -Rephrase 'winter (DJF) mean' to 'winter-mean DJF'. -Add more panels to evaluate the model thoroughly. It is important to show that it simulated the ocean stratification and temperature and salinity well.

Figure 3: -Caption: Explanation of the red square is missing. -This can also be part of the evaluation and mentioned for the first time in Ch. 2. Why is the co-variability between SIC and the Gyre Index stronger in TOPAZ4 compared with the observations? How can this influence the results and the interpretation of them? This should be discussed in the methods section. -Fig. 3b: Panel is denoted as (a). -Interpretation of Fig. 3: The authors conclude on causality when the figure only shows inverse co-variability. It could be that SIC and the Gyre Index are both affected by the atmospheric wind forcing? Sentence in paragraph 140-145 could be rephrased to e.g.: "This indicate that the GS SIC variability is covarying with the GSG circulation." -Correct the first sentence of the caption to '. . . (a) satellite observations and (b) the TOPAZ4 reanalysis. . .'.

Figure 4: -Show also the mean wind fields of positive and negative Gyre Index periods,

not only the anomalies to show the differences between the positive and negative periods. Is the mean of the negative periods a weaker northerly wind field compared to the mean of the positive periods, or is it a southerly wind field, with wind from the south? I assume it is not a mean southerly wind field in the negative periods, but a weaker northerly wind field, and that the anomalies show southerly wind because they are less northerly compared with the temporal mean for the whole study period. But this needs to made clear for the reader. Showing the mean fields would make the interpretations more intuitive and the paper easier to follow. -In the caption, add which time period the anomalies are estimated from. Add which data set the SLP is from. -Consider to add similar maps as b and c for Ekman pumping to make a stronger argument for the "lift of AW" during positive Gyre Index periods. -This figure has different coastlines compared with the other maps. Please be consistent.

Figure 5: -In caption, delete 'vectors'. -Again, showing only the anomalies means it is not entirely clear if the positive Gyre Index periods are associated with weaker southward sea ice drift or if the mean sea ice drift is from the other direction, i.e., northward sea ice drift. It would be more intuitive and easier to follow the manuscript if the mean field is shown for sea ice drift in positive and negative Gyre Index periods.

Figure 6: -Panel 6a: Add outlines for the study areas from which the variables in 6b are estimated from. -Panel 6b: Add line for y=0. Add bands of shading showing the positive and negative Gyre Index periods, from which the map in 6a is estimated from. -Consider adding a similar map as that of panel 6a for the upper 100 m or even the upper 50 m. This could be very interesting and give information that helps make the interpretation of the complete picture of processes (i.e., regards Ekman transport of surface water). -First sentence in caption is unclear. Rephrase to 'Difference in average potential temperature anomalies in the upper 400 m of the water column between positive and negative Gyre Index periods during 1991–2017.' -The term 'temperature advection' is perhaps better phrased as 'heat transport'. Explain in the methods how it was estimated. -Second sentence in caption is unclear. Rephrase to 'Time series of

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Discussion paper

the Gyre Index (blue curve) and standardized anomalies of the salinity and temperature advection in the upper 400 m.' Please do not use the term 'surface salinity' for the salinity in the upper 400 m, as 'surface' is typically associated with the upper 0-50 m or so.

Figure 7: -Add similar panels for temperate and salinity in ocean and increase the depth span to show the lift of AW. This can help justify the conclusions regards the lifting of AW in periods with positive Gyre Index. -Why is the Brunt-Väisälä frequency not estimated for the same region as the Gyre Index? Using the other smaller region outside the gyre makes the interpretation harder. The main response regards the lifting of the interface between the upper polar water masses and AW is occurring most strongly in the centre of the gyre?

Figure 8: -Flip the diagram on the side, with the atmospheric pathway on top and the oceanic pathway below. -Add schematics of how the authors interpret the process in the horizontal (showing divergence of sea ice and freshwater due to Ekman transport in response to stronger wind forcing and related increased AW recirculation and inflow to the GS) and vertically (showing the Ekman pumping and lift of the AW in response).

USAGE OF TERMS -use the term "winter-mean (DJF)" instead of "winter time (DJF)". -Avoid abbreviations as much as possible for easy reading. -the term "northerly" is used for both wind direction and sea ice drift. To avoid confusion, consider using "northerly" and "southerly" only for wind, and "northward" for sea ice drift and oceanic currents. See e.g. second sentence at the beginning of page 8, where the usage of "northerly" for both wind and sea ice drift is confusing. It is not clear if the sea ice drift is from the north or from the south from this sentence. -use apostrophes only when introducing a new term, like 'the Gyre Index'. Then refer to it simply as the Gyre Index without apostrophes on later mentions. The same goes for the Odden region. -Present the two study regions in the methods section, new Ch. 2.2., in Fig. 1a and Fig. 1 captions. Name the two study regions and use these names consistently throughout the paper. Write in the methods what you have estimated for each study area. -Which depth range

is the surface salinity anomaly estimated for? Write this in the methods. If this is the upper 400 m then “upper ocean salinity” is more appropriate. -The term ‘validation’ is used in section 2.2. ‘Evaluation’ is a better suited term because it reflects that all models have strengths and weaknesses, no models are perfect, and a key point is to make sure that the model results are useful for investigating the objective of the paper with the chosen approach.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-127, 2020.

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