Referee #2

Dear referee,
Thank you for reviewing our manuscript. The provided references and comments has helped us to improve the text. We addressed all you comments below.

General comments:
Comment: The development of the sea ice volume in the Greenland Sea is investigated, but how is the Greenland Sea defined? The red box in Fig. 1 marks the entire Nordic Seas,which consists of the Norwegian Sea in the east and the Greenland + Iceland Seas aswell as the east Greenland shelf in the west. I would rather say that you study the seaice volume in the Nordic Seas or western Nordic Seas with a focus on the marginalice zone. The inconsistent use of “the Greenland Sea”, “the Nordic Seas”, and “the Greenland-Norwegian region” etc. makes the paper a bit confusing to read and it is notclear to me over which region you actually computed the sea ice volume.

Response: According to classification of the International Hydrographic Organization (IHO) the Greenland Sea extends from the Fram Strait to the Denmark Strait. Its eastern boundary goes along the western coast of Spitsbergen, from the south-eastern point of Spitsbergen to Jan Mayen and further south to the north-eastern extreme of Island. The term Island Sea, presently often used to define the southern part of the Greenland Sea from Jan Mayen to Island, is not a part of the standard oceanographic classification of ocean basins. We do not use this term in this paper.
In the previous version of Figure 1 the Norwegian Sea was included in the study region. In the new version the eastern boundary is corrected (see green boundary in the new version of Fig. 1). We slightly extend the eastern boundary of the Greenland Sea south-eastwards, compared to its classical definition in IHO in order to include the in the study region the entire area of the Odden ice tongue.
We also agree that “the Greenland-Norwegian region” is stylistically bad and replaced it with “The Nordic Seas”.

Comment: The authors start by introducing the Greenland Sea as an important area for deep convection and that the intensity of convection is controlled by buoyancy fluxes, in particular the input of freshwater (and sea ice). However, little is said about the observed changes in local sea ice formation, the retreat of the ice edge, winter-time heat loss, and their combined effect on convection in the Greenland Sea which has varied substantially over the past four decades. See e.g. Visbeck et al. (1995); Marshall andSchott (1999); Moore et al. (2015); Brakstad et al. (2019).

Response: We have added the proposed references to the text.. Further, the possible effect of deep convection on the advective process are briefly addressed in the Discussion. However, our study only marginally touches these questionable issues.

Comment: Some statements about the amount of available data in the MIZ (in the ARMOR dataset) are required. How does the generally sparse data coverage along the east Greenland shelf affect your results?

Response: The number of vertical profiles in the Greenland Sea between 1993 and 2016 vary from 50 to 300 per year, on average 150 casts per year. ARMOR dataset also favors from additional use of satellite sea-surface data, particularly relevant for our study. It is, however, difficult to assess the accuracy of the data, as ARMOR assimilates all available in-situ casts.

Comment: It would also be good to compare your mixed-layer properties with observations (i.e. Nilsson et al., 2008; Pawlowicz, 1995; Brakstad etal., 2019). All of these papers show ocean surface temperatures well below 0◦C during winter (in the MIZ and in the center of the Greenland Sea). This contradicts what you describe on Page 8 – Line 6-7, that the temperature is always above 0◦C

leading to sea ice melt. Furthermore, you have used the mean 15% sea ice concentration contour from 1979 to 2016 to define the MIZ. The position of the ice edge has varied substantially during this period (i.e. Moore et al, 2015). How does that affect your results?

Response: In order to justify the validity of average MIZ, we added the following information in the text (page 7 lines 21-34):

"The position of the real MIZ strongly varies in time and along the EGC, being a function of local direction and intensity of sea ice transport by wind and current, variation in the characteristics of ice transport from the Arctic and interaction of ice floes, local ice thermodynamics, etc. Presence of melting sea ice, in turn, affects the upper ocean and air temperatures. A warmer winter ocean warms up the air, which can further be advected over the sea ice causing its melt away from the sea ice edge. Furthermore, an anomalously warmer ocean may prevent (or delay) formation of a new ice. All these distant factors certainly affect the MIZ position. However, if we estimate ocean temperature variations only along the actual MIZ, we do not account for these effects. The considerations above show that defining the oceanic region directly and indirectly affecting the ice volume in the sea is not straightforward. In this study we define interannual variations of ocean temperature in a fixed region, which is defined as an area enclosed between the 500-m isobath, marking the Greenland shelf break, and the mean winter location of the sea ice edge (Fig. 11). Using the fixed region also assures compatibility of interannual temperature variations. For the computations, the sea ice edge was defined as the 15% mean winter NSIDC sea ice concentration for 1979-2016. For brevity we further, somewhat deliberately, call this region the MIZ area. We further will see that temperature trends remain positive and of the same order of magnitude all over the western Greenland Sea, except for a few limited areas along the shelf break. This assure robustness of the results to the choice of the study region."

Comment: It is interesting that the warming of the Greenland Sea and the MIZ can account for the sea ice volume loss in the area plus the increased sea ice export through FramStrait. However, as noted also in the specific comments, information about the role of the atmosphere is missing. This is crucial in order to obtain a more complete picture of the drivers for the observed development of the sea ice volume. As it stands, you assume that the atmosphere plays a minor role (Page 9 – Line 15 & Page 10 – Line 9).It is possible to quantify the fraction of heat released to the atmosphere, and the role of increased atmospheric temperature, using an atmospheric reanalysis product. I think that considering the atmosphere as well would make your conclusions more solid.

Response: We fully agree that solid conclusion about the oceanic input to the sea ice volume loss in the region can not be drawn without a proper analysis of the atmospheric data. However, the scope of this study, as stated in the last paragraph of the introduction, is to explore the linkage between sea ice and ocean. A consideration of the atmosphere requires a separate investigation, as the atmospheric heat content at the sea surface highly depends on the oceanic one (the sum of sensible and latent heat fluxes in the region is one of the main components of the lower atmosphere heat balance and is directed from the ocean to the atmosphere all year round). In this paper, we find an indication that the estimated increase in ocean heat content can solely be responsible for the additional sea ice volume loss. However, we do not state in the conclusions, that ocean is the only contributor to the sea ice loss.

Comment: I find the link between long-term variations in sea ice volume and the NAO a bit speculative. On page 11 – line 2 you write that several studies have shown that during positive NAO phase, the intensity of ocean heat flux to the Nordic Seas increases by 50%. However, neither of the studies referred to (i.e. Skagseth et al., 2004 and Raj etal., 2018) examines the oceanic heat flux/ heat transport into the Nordic Seas (rather velocity and volume transport). When Raj et al. (2018) discuss the increase of 50% they are talking about an increase in volume transport. What about

variations in temperature of the inflowing Atlantic Water? Based on the studies you refer to, I find the link between NAO and temperature/heat content in the MIZ exaggerated. Either focus less on the NAO link, or refer to literature that show the link more clearly, or investigate the link more thoroughly in this paper.

Response: This partly repeats the comments by reviewer 1. In fact, the increase of the volume flux leads to an increase of the heat flux in this region. We re-worked section 5.2, elaborating on the linkage between SIV and NAO and added a number of references. Please, see page 14 lines 12-35 -page 15 lines 1-11) in the new version of the manuscript.

Specific comments:

Comment: Page 1 - Line 16: What do you mean by “this region”? The Greenland Sea, the NordicSeas, or the North Atlantic? I do not think any of these papers state that 2/3 of thedeep AMOC originates from the Greenland Sea.

Response: We change the phrase to: “More than half of the deep AMOC water originated from the Greenalnd Sea (Yashayaev et al., 2007; Rhein et al., 2015).”

Comment: Page 2 - Line 1: Approximately 50% of the freshwater anomaly at the surface or of theentire water column? Also, what do you mean by “the Norwegian-Greenland region”.The Nordic Seas? Changes in salinity of the northward flowing Atlantic Water are alsoimportant (ie. Lauvset et al., 2018; Mork et al., 2019).

Response: In the cited works authors talk about the entire water column (Petterson et al. (2006) also adds ice FW flux). We agree that the Atlantic inflow is also important and indirectly is accounted for in the studies cited in the manuscript. We changed the phrase to:

“The freshwater anomaly in the upper Greenland Sea primarily originates from variations in the freshwater flux from the southern Fram Strait, which is formed by mixing of the Atlantic and the Polar water, as well as by solid ice transport (Serreze et al., 2006; Peterson et al., 2006; Glessmer et al., 2014; Lauvset et al., 2018).”

Comment: Page 2 – Line 6: Another very relevant reference for sea ice flux through Fram Strait, and for comparison with your results, is Smedsrud et al. (2017).
Response: Thank you, we are aware of this study. It is cited in the introduction page 3 lines 18

Comment: Page 2 – Line 14: Please clarify what you mean by “even stronger linked to the ArcticDipole pattern”. In addition, you should briefly introduce the Arctic Dipole pattern, as itmay not be clear to all readers what this is.
Response: We added the phrase, explaining the pattern. For furthert detailes the readers can consult the cited study:
“It is also argued that the interannual variations of the sea ice flux through the Fram Strait is even stronger linked to the Arctic Dipole pattern, that explains a higher fraction of the observed interannual variations in the sea ice area flux than either the AO or the NAO (Wu et al., 2006). The Arctic Dipole pattern is derived as the second sea-level pressure EOF over the Arctic, which has two centers of action: over the Laptev-Kara seas and over the Canadian Archipelago. The pattern represents an important mechanism regulating the ice export through Fram Strait (Wu et al., 2006).”

Comment: Page 2- Line 17: The Odden sea ice tongue has not been formed in the GreenlandSea since the early 2000s (ie. Moore et al., 2015). Since then, sea ice has been close to absent in the center of the Greenland Sea.

Response: Thank you, we added this information to the text.

Comment: Page 3 – Line 4: The detected variations of what?
Response: Thank you, corrected to : «the detected variabtions of sea ice mass balance»

Comment: Page 3 – Line 25: How is monthly sea ice thickness from the Cryosat-2 satellite data-set obtained?
Response: The Cryosat-2 satellite data-set contains monthly average sea ice thinkness informaition sonce Novemner 2010. We now provide references to the data description (Hendricks et al. (2016) and production Ricker et al. (2014). We also added a sentense to the data description (page 4, line 24-25):
"The CS2 retrieval is based on sea ice freeboard measurements that are converted into sea ice thickness assuming hydrostatic equilibrium".

Comment: Page 4 – Line 9: What do you mean by different weights? Please elaborate.

Response: Gridding is done using the standard Gaussian function, there the weight of each measurement decreases with the distance form the measurement point. However, for the equal distances the in-situ measurements are taken with a higher weights. The procedure is a multi-step complex algorithm, as for any gridded data-set. The details of the method for forming the data set an interested reader can find in the cited study.

We changed the phrase to: "The final monthly mean 3D temperature/salinity distributions are obtained through optimal interpolation of all observed in situ for this month together with the derived "synthetic" profiles, where in-situ profiles, in the vicinity of the point of the observations, are taken with a higher weights (Guinehut et al., 2012)."

Comment: Page 4 – Line 11: Include reference to the method used in the World Ocean Atlas data-set.
Response: The reference is added: "(as, for example, it is done in the World Ocean Atlas database, https://www.nodc.noaa.gov/OC5/WOD/pr_wod.html)."

Comment: Page 4 – Line 20-21: Interannual variations of what? In addition, replace " - the months the most densely covered with data" with "which are the months with densest data coverage".
Response: Thank you, corrected.

Comment: Page 5 – Line 10-11: Denmark Strait is between Greenland and Iceland, not all theway to 36E! Please use a different term for your meridional section (a section along the Greenland Scotland Ridge?), or separate it into several sections (ie. one west and oneeast of Iceland).
Response: There was a typo in the coordinates used to calulate flux thought he Denmark Strait. The gates are now illistrated in Figure 1 a.

Comment: Page 5 –Line 17: What do you mean by "due to thermodynamically within the Greenland Sea"? Please clarify.
Response: The sentence is corrected:
"In order to analyse the sea ice volume lost or gained due to local melt or freezing, we calculated the sea ice mass balance (MB) in the Greenland Sea."

Comment: Page 5 – Line 29: How were the density profiles filtered?
Response: The phase is changed to: "Before processing, the small-scale noise in the potential density profiles were filtered out with 10-m sliding means."

Comment: Page 6 – Line 3: How were you able to compare your MLDs with Kara et al. (2003)? None of their figures show MLDs in the Nordic Seas. de Boyer Montégut et al. (2004) are also looking at global mixed layers. I think it would be better to compare with observed MLDs from the Greenland and Iceland seas (Brakstad et al., 2019 and Vågeet al., 2015, respectively).

Response: In the text we refered to the methods suggested in Kara et al. (2003) and de Boyer Montégut et al. (2004). Instead of using figures we programmed the algorithms, described in paper and compared the results. We added the phrase:
"The obtained mean distribution of the MLD, seasonal and interannual variations of the MLD in the central Greenland Sea are consistent with observations (Vage et al., 2015; Latarius & Quadfase, 2016; Brakstad et al., 2019)"

Comment: Page 7 – Line 15-16: How does the negative trend in sea ice volume compare to those found in Moore et al. (2015) and Onarheim et al. (2018)?

Response: The studies Moore et al. (2015) and Onarheim et al. (2018) show the reduction of sea ice extent. In our study we look at the trends in sea ice volume. In general, the sea ice volume loss can be related to the loss of sea ice extent. The reduction in sea ice extent, including Odden tongue formation are partly described in the introduction and discussed in section 5.3. Now we added the references to Moore et al. (2015) and Onarheim et al. (2018) to the text.

Comment: Page 7 – Line 33: Unclear. Please expand. Atlantic-origin water in the EGC is capped by fresh/cold Polar Water and sea ice during winter, which will inhibit ventilation of theAtlantic Water. Våge et al. (2018) show that due to the retreat of the ice edge the last decades, Atlantic Water has been and is more likely to be ventilated in the EGC. However, we do not know if this takes place "regularly".

Response: Our estimates of the winter MLD shows this should happen quite regularly. The ice retreat is presumably one of the reasons. The phrases are changed to:
"A relatively warm AW is observed in the East Greenland Current (EGC), off the Greenland shelf break, below a thin upper mixed layer dominated by the cold PW. Our estimates of winter MLD shows that the AW should be regularly brought to the ocean surface by vertical winter mixing, which is consistent with observations (Håvik et al., 2017; Våge et al., 2018)."

Comment: Page 8 – Line 1-2: The temperature (and salinity) of the Atlantic Water in the EGC is not increasing downstream. Please clarify what you mean by "increasing southeastwards".

Response: We changed the phrase to: "The presence of the AW is observed in climatology as water temperature (and salinity) in the EGC increasing with depth from about 0 ^{o}C at the sea-surface to 2-4^{o}C at 500 m."

Comment: Page 8 – Line 4: "West Islandic Current" is not typically used. Rather use "North Icelandic Irminger Current". A better ref. here would be Jónsson and Valdimarsson(2005) or Hansen et al. (2008).
Response: Thank you, we added the reference to Hansen et al. (2008) and replaced the West Islandic Current by North Icelandic Irminger Current.

Comment: Page 8 – Line 6-7: As stated in the general comments, you need to compare your data with observations and discuss the temperature uncertainty due to limited data in the MIZ. Temperatures of 0.1-0.2◦C in winter seems unrealistically high.

Response: As reviewer correctly mentioned the data are limited in the region. The ARMOR data are based on in-situ data (where available) and interpolated data elsewhere. The temperature uncertainty is close to zero where the casts or the satellite data were obtained. The uncertainty is unknown in the areas where there are no data. However, temperatures above zero are often observed in winter in the region (Latarius & Quadfase, 2016; Brakstad et al., 2019). Here we remind that, for the reasons presented above, we use the fixed region to derive temperature variations, so the near-surface temperature mentioned here is not always in contact with ice, thus can be close to zero.

Comment: Page 8 – Line 14: Perhaps you should show the mixed-layer depth for comparison with previous work (ie. Brakstad et al., 2019 and Våge et al., 2015)
Response: In fact we do show it in Figure 6c, to which we refer now:
"Averaged over the upper 200-m, the typical depth of the winter mixed layer (Fig. 6c), the patterns of the mean distribution and of (a somewhat weaker) tendencies in temperature and salinity closely repeat those in Figure 5."
This value is consistent with Brakstad et al., 2019 and Våge et al., 2015, as now stated earlier in the manuscript.

Comment: Page 8 – Line 17: Clarify what you mean by "overall year mean increase of temperature".
Response: Changed to : "overall increase of annual mean temperature"

Comment: Page 8 – Line 19-22: These lines are confusing and hard to read. What do you meanby "decreasing the interannual trends to insignificant"? Please be more specific.
Response: Changed to: "We observe a growing difference between September and March temperatures (Fig. 5a) together with a decrease of temperature interannual trends to insignificant in winter, in spite of equal winter and summer trends in the heat inflow with the NwAC (see T_w and Q_Svinoy in Tab.3).

Comment: Page 8 – Line 28-29: Bondevik (2011) is gray literature (no peer review). I would encourage you to refer to peer reviewed literature. In addition, add "are" before "ob-served".
Response: Thank you, the typo is corrected. There is only one reference to grey literature and since it is relevant, we decided to keep it.

Comment: Page 8 – Line 28-30: Explain how this increases ice melt.
Response: We added a clarifing sentence:
" The eddies sweep sea ice and PW off and advect warm AW closer to the ice edge, resulting in increase in bottom and lateral sea ice melt"

Comment: Page 8 – Line 30-32: As stated in the general comments: How does your definition ofthe MIZ and the data coverage in the MIZ affect the results?
Response: The choice of the fixed region for defining interannual temperature variations is now justified in page 7 . Please, see the response to the related general comment.

Comment: Page 8 – Line 34-35: This corroborates the results of Lauvset et al. (2018) who examined the relationship between hydrography (and MLD) in the Greenland Sea and thetemperature/salinity of the northward flowing Atlantic Water.
Response: Thank you, we make a link to these study (page 11, lines 23-25):
"Since the winter mixing does not reach the lower limit of the warm Atlantic water at 500-700 m, the deeper the mixing, the more heat is uplifted towards the sea-surface, melting the ice in the MIZ, which is consistent with the findings of Lauvset et al. (2018)."

Comment: Page 9 – Line 6-7: The 20% depend on how you define the Greenland Sea.
Response: To avoid ambiguity,we replaced “Greenladn Sea” with the “study area”

Comment: Page 9 – Line 7: “additional heat release”: In addition to what?
Response: Here we mean the heat released due to an increse in 200-m layer temperature by 2^{o}C between 1993 and 2016. This should be clear from the equation and text above.

Comment: Page 9 – Line 13-14: It would be interesting to quantify the fraction of heat released to the atmosphere. This should be possible using atmospheric reanalyses.
Response: We agree, but this is not straightforward, as heat is consumed also by different processes (ice melting, mixing in vertical and horizontal). This will require a separate study. Please, also see the response to the related general comment.

Comment: Page 9 – Line 15-16: What about increasing atmospheric temperature?
Response: This repeats one of the general comments. Please, see the respond above. Here we do not state that the atmosphere does not play a role in the ice volume loss. We only compare the amount of oceanic heat to the lost volume of sea ice.

Comment: Page 9 – Line 28: Clarify what you mean by “the discussed above general PIOMAS tendency”
Response: We are not sure that we understand this comment. IN the text we mean “to the discussed above general PIOMAS tendency to underestimate sea ice thickness”, which is discussed few lines above in the same paragraph.

Comment: Page 9 – Line 29: Figure 2i does not exist.
Response: Thank you, corrected.

Comment: Page 10 – Line 6: This sentence is not in agreement with Page 8 – Line 6-7 where youstate that no sea ice formation occur and that the surface temperature is always >0.Here you write that sea ice is formed locally and that the atm. play a role.

Response: There is no contradiction. On p.8 we talk about the climatic seasonal means over the upper 50-m of the whole MIZ, including the warmer south-eastern part of the study region. Here we talk about the sea-surface and episodic formation of the ice tongue over a colder sea-surface (sometimes for a week or two). However, we agree with the reviewer that ice advection should also be important, although in the cited papers this factor was considered less significant.

Comment: Page 10 – Line 11-12: “almost twice of” what? Please clarify.
Response: The sentence was re-phrased:
“The surplus of the amount of the heat, released by the ocean at end of the study period, is more than twice of that necessary for bringing up the observed sea ice volume loss...”

Comment: Page 10 – Line 25-27: These two sentences are very confusing. Which inconsistency? What local peculiarities? Do you need these sentences at all? If so, please re-phraseand be more specific.
Response: The sentence was re-phrased: “The interannual variations in the vertical mixing intensity between the AW, the PW and the modified AW, returning from the Arctic through the southern Fram Strait, as well as variations in ocean-atmosphere exchange in that area leads to interannual variability of the AW advected by the EGC into the Greenland Sea (Langehaug and Falck, 2012).”

Comment: Page 10 – Line 30: Where did you obtain data (heat fluxes) from the Svinøy section? Please include reference.

Response: We computed the heat fluxes through the Svinoy section, using ARMOR dataset.

Comment: Page 11 – Line 2: Raj et al. (2018) show a 50% increase in volume transport not oceanic heat flux. (See general comment).
Response: We substantialy changed the section and added a number of references. Please see the new version of the manuscript, page 14.

Comment: Page 11 – Line 12: You have not really discussed any eastward advection of Polar Water to the southwestern Norwegian Sea. How does this relate to your results? Please elaborate.
Response: This region is out of the scope of our main line. We refer here to previous studies.

Comment: Page 11 – Line 23-24: This sentence contradicts line 19, where you state that the summer NAO is not important?
Response: We state that only winter NAO index should be taken into account for accessing the interannual variations, including those in the intensity of the AW advection. Summer NAO is of little relevance. Many studies in the region take into account only winter NAO index.

Comment: Page 11 – Line 25: What do you mean by "main currents in the Greenland Sea"? Be more specific.
Response: "In spite of the stronger ice melt, the upper ocean salinity in MIZ, as well as along the EGC, as well as along the NwAC, increases during recent decades (Fig. 5d)."

Comment: Page 12 – Line 5-7: Maybe better to refer to Brakstad et al. (2019), Lauvset et al.(2018), and Latarius and Quadfasel (2016) that all look at interannual changes in MLDin the Greenland Sea during your period. Lauvset et al. (2018) and Brakstad et al.(2019) both discuss the role of increased salinity on the mixed-layer depth.
Response: Thank you, know we refer to the suggested studies: "The on-going increase in salinity of the upper Greenland Sea (Fig. 5d) during the recent decades favors the deeper convection (see also Lauvset et al., 2018; Brakstad et al.,2019)."

Comment: Page 12 – Line 9: Smeed et al. (2014) show a weakened AMOC.
Response: Smeed et al. (2014) talks about a relatively small AMOC decline after 2004, on the top of the overall AMOC intensification since the 1970s-1980s (shown also in Smeed et al., 2014). We added a phrase:
"However, during the latest decade, a stagnation or a possible reversal of the tendency is observed (Smeed et al., 2014)"

Comment: Page 12 – Line 20: "govern" is too strong. Line 23-24: "Atlantic Water advection into the MIZ largely contributes to the SIV loss" is more appropriate.
Response: Thank you, corrected.

Comment: Page 12 – Line 28: In the last paragraph: The link to NAO is speculative, and you havenot shown this link in this paper.
Response: We agree with the reviewer. We now put this as a plausible hypothesis:
"This suggest that the simultaneous tendencies in the long-term increase of SIF and of the Atlantic water transport are both linked to a higher intensity of atmospheric circulation during the positive NAO phase, and, possibly, to the positive AMO phase, often linked to the intensification of the AMOC since the 1980s."

Technical corrections:

Comment: Page1 - Line 16: Replace "The 2/3" with "Two thirds"

Response: Replaced

Comment: Page 1 - Line 18: What do you mean by “to the sea”? Into the Greenland Sea?
Response: Re-phrased

Comment: Page 2 – Line 1: Replace “through the Fram Strait” with “through Fram Strait”. (Also the case for Page 2 - Line 6, 9 and 10 etc.)
Response: Replaced

Comment: Page 2 – Line 9: Should be “drive” not “drives”
Response: ‘divers’ is the correct form as it is related to the conditions of wind intensification.

Comment: Page 2- Line 11: The entire reference here should be within parenthesis. “(Kwok et al., 2004)” not “Kwok et al. (2004)”. Also the case for “Schweiger et al. (2011)” on Page 6 - line 25 in example. Please go through all references and make sure they are consistent.
Response: Thank you, corrected

Comment: Page 2 – Line 34: Replace “Oddin” with “Odden”.
Response: Thank you, replaced

Comment: Page 3 – Line 15: Singular vs plurals: Use either “the spatial pattern of PIOMAS icethickness agrees” or “the spatial patterns of PIOMAS ice thickness agree”.
Response: Thank you, corrected

Comment: Page 3 – Line 15: Remove comma after “those”.
Response: Thank you, corrected

Comment: Page 3 – Line 25: Should be “provides” not “provide”
Response: Thank you, corrected

Comment: Page 3- Line 26: Insert “the” before “CS2 data-set”.
Response: The sentence was re-phrased

Comment: Page 4- Line 3: Insert “the” before “ARMOR data-set”.
Response: Thank you, corrected

Comment: Page 4 – Line 7: Insert “depth” before “levels”.
Response: Thank you, corrected

Comment: Page 4- Line 9: Replace “all observed in situ” with “all in situ observations”.
Response: Thank you, replaced

Comment: Page 4 – Line 18: Remove comma before “used” and after “paper”.
Response: Thank you, corrected

Comment: Page 4 – Line 19: Replace “quire” with “quite”
Response: Thank you, replaced

Comment: Page 4 – Line 21: Use “a” instead of “the” in “kriging with the 30-km window”.
Response: Thank you, corrected

Comment: Page 4 – Line 25: Remove comma after “Note”.Page 5 – Line 9: Remove “s” in “months”.
Response: Thank you, corrected

Comment: Page 5 – Line 10: Denmark Strait should be with capital S.
Response: Thank you, corrected

Comment: Page 5 – Line 11: Replace “access” with “assess”.
Response: Thank you, replaced

Comment: Page 5 – Line 13: Should be “were adopted” not “was adopted”.
Response: Thank you, corrected

Comment: Page 5 – Line 13: Add “the” before “other”.
Response: Thank you, corrected

Comment: Page 5 – Line 14: Replace “also is” with “is also”.
Response: Thank you, corrected

Comment: Page 5 – Line 15: Should be “data-sets” not “data-set”.
Response: Thank you, corrected

Comment: Page 5 – Line 27: Add “the” before “ARMOR data-set”.
Response: Thank you, corrected

Comment: Page 6 – Line 3: Remove “de Boyer”. It is written twice.
Response: Thank you, removed

Comment: Page 6 – Line 19: Should be “underestimates” instead of “underestimate”.
Response: Thank you, corrected

Comment: Page 6 – Line 20: Remove “the” before CS2. Also the case on line 21.
Response: Thank you, removed

Comment: Page 6- Line 20: Remove “s” in “values”.
Response: Thank you, removed

Comment: Page 6 – Line 21: Remove “the” before “Spitsbergen”. Also the case on line 23.
Response: Thank you, removed

Comment: Page 6 – Line 23-24: Either use “PIOMAS tend to overestimate” or “PIOMAS overestimates”.
Response: Thank you, corrected

Comment: Page 6 – Line 24: Remove “thickness”.
Response: We believe that “thickness” is used correctly.

Comment: Page 6 – Line 26: “discrepancies” should be singular => “discrepancy”.
Response: Thank you, corrected

Comment: Page 6 – Line 30: Remove “the” before “PIOMAS”.
Response: Changed

Comment: Page 6 – Line 31: Replace “all are” with “are all”.
Response: Thank you, replaced

Comment: Page 6 – Line 31: Add “of” after “correlation”.
Response: Changed

Comment: Page 6 – Line 31: Add “the” before “Ricker et al. (2018) data”
Response: Changed

Comment: Page 7 – Line 16: Replace “comprises” with a more appropriate term (“was”?).
Response: Thank you, replaced

Comment: Page 7 – Line 22: Remove “for” before “about”.
Response: Thank you, corrected

Comment: Page 7 – Line 23: Should be “significant effect” rather than “significantly effect”. Alsoreplace “the sea” with “the Greenland Sea”.
Response: Thank you, corrected

Comment: Page 8 – Line 1: Add “the” before “climatology”.Page 8 – Line 9: “approaches” is an odd choice of tense when you talk about some-thing that happened from 1990s to 2000s. Replace with “approached” or “propagatedtowards”.
Response: Thank you, corrected

Comment: Page 8 – Line 10: It should be “Jan Mayen” not “Yan Mayen”.
Response: Thank you, corrected

Comment: Page 8 – Line 11: Replace “western” with “eastern”. In addition, do you mean “Frontal Current” instead of “Front Current” (same for Page 10 – Line 23)?

Comment: Page 8 – Line 12: The “tendencies” are shown in figure 5d. Replace “Fig. 4d” with “Fig.5d”.
Response: Thank you, corrected

Comment: Page 8 – Line 23: nearly doubles from 1993 to ?
Response: Changed to “from1993 to 2016”

Comment: Page 9 – Line 12: Remove “the” after exceeds. It is written twice.
Response: Thank you, removed

Comment: Page 9 – Line 22: Remove “thickness” after “thick ice”.
Response: We left the sentence unchanged as this wording is used in the cited study.

Comment: Page 9 – Line 25: Should be “appears” not “appear”. Also, replace “lower compared to know from literature fluxes” with “lower than those estimated by previous studies” orsomething similar.
Response: The entire paragraph is changed in response to another comment.

Comment: Page 9 – Line 27: Remove “the” before “data”.
Response: Thank you, corrected

Comment: Page 10 - Line 1: Remove “the” before “sea ice volume”.
Response: Corrected

Comment: Page 10 – Line 13: Replace “uptake” with “take up”.
Response: Corrected

Comment: Page 10 – Line 17: “brining” should be “bringing”.
Response: Thank you, corrected

Comment: Page 10 – Line 18: “later” should be “layer”.
Response: Thank you, corrected

Comment: Page 10 – Line 19: Write “Nansen Basin” with capital B.
Response: Thank you, corrected

Comment: Page 10 – Line 29: Replace “Further” with “Farther”.
Response: Thank you, replaced

Comment: Page 10 – Line 30: “Svinoy” should be “Svinøy”. Also the case on Page 10 - line 34 and Page 11 – line 16 and 17 etc.Page 10 – Line 31: Remove comma after “Barents Sea”.
Response: Thank you, corrected

Comment: Page 10 – Line 34: Remove “in” after “confirmed by”.
Response: Thank you, corrected

Comment: Page 11 – Line 1: Use capital S in “Nordic Seas”. Also the case for line 10 and 20.
Response: Thank you, corrected

Comment: Page 11 – Line 5: Remove “of” after “NAO phase increases”.
Response: Thank you, corrected

Comment: Page 11 – Line 10: “Fram Strat” should be “Fram Strait”.
Response: Thank you, corrected

Comment: Page 11 – Line 11: Replace “through” by “across” and use capital R in “Faroe-Shetland Ridge”.
Response: Thank you, corrected

Comment: Page 11 – Line 12: Inconsistent capitalization of “water”. Here you write “Polar Water”,while in line 6 you use “Atlantic water”. Please be consistent throughout the paper.
Response: Thank you, corrected

Comment: Page 11 – Line 28: Replace “is” with “was” after “more ice”.
Response: Thank you, corrected

Comment: Page 11 – Line 29: Add “the” before “Odden ice tongue”.
Response: Thank you, corrected

Comment: Page 12 – Line 7: Remove “the” after “favours”.
Response: Thank you, corrected

Comment: Page 12 – Line 22: “MID” should be “MLD”.

Response: Thank you, corrected

Comment: Page 12 – Line 23: Add “heat” before “necessary”.
Response: Thank you, corrected

Comment: Page 12 – Line 25: “Froe-Shetland ridge” should be “Faroe-Shetland Ridge”. This sentence is also incomplete. Please re-phrase.
Response: The paragraph was removed

Comment: Figure 1: The color in the right color bar is missing.
Response: Thank you, the figure was updated.

Comment: Figure 2: In the figure caption you describe panel (i) – “difference between mean PI-OMAS and CS2 effective ice thickness”, but panel “i” is not included in the figure (only panels a-h).
Response: Thank you, the caption for panel (I) is removed.

Comment: Figure 4: Please write out what the legends “w”, “s”, and “a” mean.
Response: The letters are replaced by full words

Comment: Figure 5: The color bar in panel “d” has the wrong units. The panel shows change in salinity, but have units of◦C.
Response: Thank you, corrected

Comment: Figure 6: In the figure caption: Remove parenthesis after “cold season”.
Response: Thank you, corrected

Comment: Figure 7: Is there missing a second y-axis for the normalized maximum MLD? If not,I do not understand what the values -1 to 1.5 in normalized maximum MLD mean.Please explain.

Response: MLD was notmalized in the standard way:
MLD(normalized)=(MLD-mean(MLD))/std(MLD))
To avoid confusions, the right y-axis now shows the non-normalized MLD (m).

Comment: Table 3: Explain all columns. (i.e. what is correlated in the column r2?)
Response: Now all columns are explained. R^2 is the coefficient of determintaion. It is a squared coefficient of correlation between the observed values and the ones modeld with the linear trend.

References:

please see the references in the updated version of the manuscript.