

**Second round: review of “Sea ice volume variability and water temperature in the Greenland Sea” by Selyuzhenok, V. et al.**

**Summary:**

The authors have significantly improved the content and structure of the manuscript, but I still have three major comments (listed under general comments) that I think the authors need to elaborate on before the paper is ready for publication.

I have also included several specific comments and technical corrections on the updated text. Most of these are related to unclear text and English grammar.

**General comments:**

I still think that you need to include a statement in the paper about the data availability in the MIZ (especially the generally sparse data coverage on the shelf/shelf break), even though you are not able to address the temperature uncertainty. You can also add, as you mentioned in the previous response, that the additional use of satellite sea-surface data is very relevant and makes your analysis of the ML properties more robust than only including in situ observations, which is a strength of the ARMOR dataset.

Without discussing or investigating the role of increased atmospheric temperature and changes in ocean-atmosphere heat fluxes you cannot really make the conclusions on page 13 – lines 14-15, page 15 – lines 8-9, and page 16 – lines 10-12. You have shown that an increase in AW heat flux CAN contribute to sea ice volume loss, but not that it actually does. The correlation and trend estimates support your hypothesis, but does not imply causation. I understand that a thorough investigation of the atmospheric component requires some work, and could be an entire separate study. However, if you want to make the conclusions above, you cannot avoid to include some discussion on changes in the atmosphere and its potential role for the observed changes in sea ice volume. You do not necessarily need to include any new analysis, but could base a brief discussion on previous studies (ie. Moore et al. 2015 etc.).

The discussion on the link between the NAO index and the ocean circulation is improved in the current version of the paper, but since you already include the winter NAO index in fig. 7: what is the correlation between the winter NAO index and the water temperature at Svinøy? Some studies indicate that the ocean circulation has been decoupled from the NAO in periods during recent decades, and that it is more closely linked to the wind stress curl (Lohmann et al., 2009; Foukal and Lozier, 2017; Asbjørnsen et al., 2019).

**Specific comments:**

Page 1 – Line 16-17: Only refer to Marshall and Schott (1999) or find more appropriate references than Visbeck et al. (1995) and Brakstad et al. (2019) to this line/statement.

Page 1 – Line 18: I do not think that any of these references state that more than 50% of the deep AMOC originates from “the Greenland Sea”. It should be “the Nordic Seas” (ie. Chafik and Rossby, 2019). The fraction of contribution from the Greenland Sea to the Nordic Seas overflow water (the dense water that spill south across the Greenland-Scotland Ridge) is still not fully known. Some references looking at the origin of the Nordic Seas overflow waters are: Eldevik et al. (2009), Mastropole et al. (2017), and Jeansson et al. (2017).

Page 2 – Line 1-2: What drives the remaining 35% of the freshwater anomaly? Is this due to variability in the northward flowing AW?

Page 2 – Line 14-16: I would rather state that the Greenland Sea Intermediate Water and the Greenland Sea Deep Water (GSDW) are formed by wintertime convection in the central Greenland Sea. Note also that the GSDW has not been ventilated/formed since before the 1980s.

Page 2 – Line 17: Latarius and Quadfasel (2016) do not show MLDs exceeding 2000m. I think this statement is incorrect (see also Brakstad et al., 2019).

Page 5 – Line 9: It is still not clear from the text what you mean with “different weights”. Please add the information from your response to the text (ie: “taken with different weights based on the inverse distance and type of measurement (in situ observations were given higher weights).”).

Page 7- Line 19: There is a bias towards deeper mixed layers in the central Greenland Sea. The estimated MLDs in fig. 7 are always deeper than 600m, while both Latarius and Quadfasel (2016) and Brakstad et al. (2019) observe MLDs shallower than 500m in 2003 and 2012 for instance. This should be noted.

Page 8 – Line 7: What do you mean by “is conditioned by study of the role of heat fluxes on melting sea ice”?

Page 10 – Line 3: Tendencies in heat? Please clarify.

Page 10 – Line 8-9: Here you state that the ocean always melt sea ice in the MIZ. This sounds like a contradiction to line 12 on the same page where you state that sea ice is formed locally in winter. I know that you, in the first line (8-9), talk about the mean conditions over the upper 50m in the entire MIZ, but I would rephrase this line to avoid confusion. At least make it clear that the temperature can be well below 0 degrees C in certain regions of the MIZ, and that your average is affected by the defined area of investigation (you average over water temperatures > 1 degrees C in some places (ie. AW in the northeast, fig. 5) which is not representative for the real MIZ characteristics).

Page 11 – Line 25: Lauvset et al. (2018) do not examine the MIZ and heat fluxes toward the sea ice. They investigate how increased salinity and temperature in the northward flowing AW have led to deeper mixed layers in the Greenland Sea gyre. It would be more appropriate to include this reference in the next line (25-26).

Page 13 – Line 31: Clarify what you mean by “All the processes”.

Page 14 – Line 5-11: These lines are not necessary since the same information is repeated/elaborated in the next paragraph. Please remove these lines and make a smooth transition to the discussion of the NAO.

Page 14 – Line 15-16: Which regional studies? Please include reference.

Page 16 – Line 12-15: These lines repeat lines 7-12 and are therefore not necessary. Please remove.

#### **Technical corrections:**

Generally: Remove “the” in “through the Fram Strait/Denmark Strait”.

Page 1 – Line 3: Replace “sea ice volume (SIV)” with “SIV” since SIV is defined in line 1 already.

Page 1 – Line 18: Replace “originated” with “originates”.

Page 2 – Line 6: Use “The” instead of “A” before “general surface circulation”.

Page 2 – Line 7: Remove comma after “temperature” and add comma after “Polar Water (PW)” and before “and the Atlantic Water (AW)”.

Page 2 – Line 9-10: I would first state where the maximum PW is found then that it quickly decreases in the off shelf direction.

Page 2 – Line 11: Remove “s” in “centrals”.

Page 2 – Line 12 and 13: Do you mean “Greenland Sea Intermediate Water”?

Page 2 – Line 20: Use “are” instead of “is” before “primarily controlled”.

Page 2 – Line 23: Should be “winds that drive” not “drives” since it refers to “winds”. Single vs. plurals.

Page 2 – Line 24: Remove “between”. It is written twice.

Page 2 – Line 28: Replace “that” with “since it” before “explains a higher fraction”.

Page 2 – Line 35: Replace “is” with “was” after “the Odden sea ice tongue” since it is ~20 years since this last occurred.

Page 3 – Line 1: Remove “and” before “northwest of Jan Mayen”?

Page 3 – Line 5: Add “the” before “large”.

Page 3 – Line 15: Replace “The overall” with “An overall”.

Page 3 – Line 16: Add “In particular” or “particularly” to highlight the large changes in the Odden ice tongue area?

Page 3 – Line 21: Add “the” before “1990s”.

Page 3 – Line 22: Add “is” before “not possible”.

Page 3- Line 32: Use “daily sea ice concentration” instead of “sea daily ice concentration”.

Page 3 – Line 33: Remove “the” before “sea-surface temperature”.

Page 4 – Line 7: Remove “s” in “affects” and insert “sea ice” before “thickness and volume”.

Page 4 – Line 17: Remove “In the Greenland Sea” at the beginning of the sentence since it is written at the end of the sentence as well.

Page 4 – Line 30: Remove “In addition,” since “also” is used later in the sentence.

Page 4 – Line 31: Replace “timeliness” with “timing” and remove “the” before “satellite passes”.

Page 5 – Line 14: Remove “the” before “satellite altimetry”.

Page 5 – Line 21-23: Replace “However,” with “Since”, add comma after “2000s”, remove “. In this paper”, and use capital “C” in “West Spitsbergen Current”.

Page 5 – Line 25: Add “the” before “cold season”.

Page 5 – Line 28: Use “a” instead of “the” before “kriging”.

Page 5 – Line 28-29: Replace “over the months the most densely covered with data” with “over the months with densest data coverage”.

Page 6 – Line 20: “20E” should be “20W”.

Page 6 – Line 20: Replace “the” with “a” before “sea ice volume”.

Page 6 – Line 21: Replace “access” with “assess”.

Page 6 – Line 24: Use “gate locations” instead of “gates locations”.

Page 7 – Line 3: Replace “and boarder on the east” with “and by the boarder in the east”.

Page 7 – Line 8-9: There is something strange with this sentence. It makes more sense if “to” before “sea ice volume loss” is removed.

Page 7 – Line 17-18: Remove “the” before “weakly”, before “Dukhovskoy’s”, and after “mean distribution of”.

Page 7 – Line 25: Remove “a” before “new ice”.

Page 7 – Line 25: Replace “All these distant factors” with “All of these factors”.

Page 7 – Line 27-28: Replace “the ice volume in the sea” with “the sea ice volume”.

Page 7 – Line 28: Replace “define” with “examine” after “In this study we”.

Page 8 – Line 6: Insert “and” before “v is current velocity”.

Page 8 – Line 10: Remove “in region, PIOMAS” and add comma before “monthly”.

Page 8 – Line 12: Should be “values” instead of “value”.

Page 8 – Line 24: Replace “off” with “of”.

Page 9 – Line 9: Insert “the” before “long-term”.

Page 9 – Line 19: Remove “a” before “half of the years”.

Page 9 – Line 22: Remove “s” in “trends”.

Page 9 – Line 26: Remove “in” before “and sea ice volume flux”.

Page 9 – Line 29: Remove “s” in “shows” after “estimates of winter MLD”.

Page 10 – Line 6: Add “a” before “maximum”.

Page 10 – Line 7: Remove “a” before “somewhat weaker”.

Page 10 – Line 9: Remove “the” after “ocean melts”.

Page 10 – Line 12: Replace “formed by” with “at”, and add “the” before “winter cooling”.

Page 10 – Line 12: “localy” should be “locally”.

Page 10 – Line 12-17: I would first explain the evolution of the 2degC isotherm (lines 15-17), then explain that this evolution is consistent for different isotherms etc. (lines 12-15). The beginning of the first sentence (line 12) is also a bit confusing and unnecessary. I would rather start this sentence with “The tendency of the isotherm to approach the shelf break is consistent for different isotherms etc.”.

Page 10 – Line 16: Remove “s” in “westwards”.

Page 10 – Line 25: Remove comma after “area”.

Page 10 – Line 26: Rather start this sentence with: “The decreasing temperature in both of these areas is consistent with ....”

Page 10 – Line 30: Remove “s” in “trends”.

Page 11 – Line 10: Remove comma before “accumulated” and after “during summer”.

Page 11 – Line 15: Remove “effect”

Page 11 – Line 17: Remove “the” before “eddy formation” and replace “for the” with “during”.

Page 11 – Line 18: “northely” should be “northerly”.

Page 11 – Line 18: Replace “off” with “seaward”. Also replace “increase in bottom” with “increased bottom”.

Page 11 – Line 23: Remove “the” before “winter mixing”.

Page 11 – Line 25: Replace “of” with “in” before “MLD”.

Page 11 – Line 31: Add “and” before “the MIZ area”.

Page 11 – Line 31: Replace “computations show” with “computations give”.

Page 12 – Line 1: Replace “by” with “of”.

Page 12 – Line 3: Remove “of” after ice density.

Page 12 – Line 8: Replace “contacting with” with “to reach”. Also remove comma before “the autumn warming”.

Page 12 – Line 9: Replace “the amount heat far exceeding the amount, sufficient” with “more than enough heat to account”

Page 12 – Line 17: Use “than” instead of “that” after “the trend is lower”.

Page 12 – Line 19: Replace “be also” with “also be”.

Page 12 – Line 23: “myltiyear” should be “multiyear”.

Page 12 – Line 32: Replace “are the main gates” with “is the main gate”.

Page 13 – Line 6: Remove “the” before “sea ice volume” and add “the” before “Greenland Sea”.

Page 13 – Line 24: Remove “for” before “in the Nansen Basin”.

Page 14 – Line 14: Replace “leading to” with “which results in”.

Page 14 – Line 18: Remove “of” before “the cyclonic circulation”.

Page 14 – Line 22: Add “The” before “NAO phase”.

Page 14 – Line 25: Add “of” before “PW”.

Page 14 – Line 26: Remove parenthesis before “Blindheim et al.”.

Page 14 – Line 29: Remove “a” before “higher heat fluxes”.

Page 14 – Line 30: Insert “the” before “1970s”.

Page 14 – Line 34: Replace “of” with “on the” before “order of”.

Page 15 – Line 11: Replace “of” with “for” before “the shelf area”. Also remove parenthesis before “Alekseev et al.”.

Page 15 – Line 12-13: Replace “as well as along the EGC, as well as along the NwAC, increases during recent decades” with “as well as along the EGC and in the NwAC, has increased during recent decades”.

Page 15 – Line 13: Remove parenthesis around “d” in “(Fig. 5(d))”. Also the case on line 25.

Page 15 – Line 24: Insert “the” before “1990s”.

Page 15 – Line 28: Insert “the” before “1980s”.

Page 15 – Line 33: Replace “for” with “from” before “1979 to 2016”.

Page 16 – Line 1-2: Replace “It shows” with “We found”.

Page 16 – Line 3: Replace “ice SIF by” with “in SIF of”.

Page 16 – Line 5: Do you mean “thickness of thick sea ice”?

Page 16 – Line 5-6: Replace “the actual” with “a weaker” and remove “to be weaker” after “SIF trend”. Also replace “to” with “may” before “be stronger”.

Page 16 – Line 9: Replace “value of additional” with “amount of the”.

Page 16 – Line 11: Add “to” after “largely contribute”.

Figure 4: In the figure caption: Replace “and” with comma after “(December-April)” in the first sentence.

Figure 5: In the figure caption: The dotted lines are shown in all panels. Hence, remove “in panels (b) and (d)” in the last sentence. Also remove comma after “region” in the same sentence.

Figure 7: Please clarify which scale belongs to which graph.

Figure 7: You have plotted MLD in the Greenland Sea, but from the values I assume that you mean within the Greenland Sea gyre/interior basin and not an average over your entire domain/green box? Please clarify.

## References:

Chafik and Rossby (2019): <https://doi.org/10.1029/2019GL082110>

Eldevik et al. (2009): <https://doi.org/10.1038/ngeo518>

Mastropole et al. (2017): <https://doi.org/10.1002/2016JC012007>

Jeansson et al. (2017): <https://doi.org/10.1016/j.dsr.2017.08.013>

Asbjørnsen et al. (2019): <https://doi.org/10.1029/2018JC014649>

Lohmann et al. (2009): <https://doi.org/10.1029/2009GL039166>

Foukal and Lozier (2017): <https://doi.org/10.1002/2017JC012798>