

We thank the two anonymous reviewers and the editor for the time and effort they invested in critically reviewing our manuscript. Please find answers to your very helpful comments and suggestions below.

## Report #1

1) In the abstract, for example, the words “off-ice flow” and “on-ice flow” suddenly appeared. I could not understand at first what these were, and also, I could not understand why the authors made this kind of analysis (I found them after I read on).

We rephrased the respective sentence in the abstract for clarity: *“As a next step, two typical flow directions for this region were studied: cold-air outbreaks with northerly winds originating from ice covered areas (off-ice flow) and warm-air intrusions with southerly winds from open ocean regions (on-ice flow).”*

2) While I respect the authors’ considerations, I still believe that in the sea-ice region, it is essential to consider the variability from the viewpoint of the coupled atmosphere-ice-ocean system. Of course, it is understandable that there are limits to the types and amount of data available in sea-ice covered areas. Even so, the authors should conduct the quantitative discussions from the viewpoint of the coupled system. As I noted earlier, the lack of these perspectives may be causing the difficulty in understanding.

Analyzing the coupled atmosphere-ice-ocean system is certainly important when studying large scale processes or to predict climate change impacts. However, we think that looking only at the isolated interaction of two components of the coupled system helps to deepen our understanding of specific processes and thus also has its value. The literature cited in our introduction also indicates that this is common in the field, with some studies focusing mainly on the relationship between sea ice cover and either atmospheric conditions (Dahlke et al., 2020; Isaksen et al., 2016) or ocean processes (Selyuzhenok et al., 2020). As the analyses in our paper are already rather extensive, we still think that including also the ocean impact should be the topic of future research, as we stated in the conclusions.

3) This study is quite regional as the authors described in “4. Summary and conclusions”, as “The goal of this study was to analyze recent regional trends in near-surface atmospheric variables in the Fram Strait region in winter and their connection to regional sea ice cover”. Also, my impression from reading the manuscript is that the analyses in this study are similar to those done in previous studies such as Tetz 14. In other words, I feel that this study can be regarded as a temporal extension of those by adding recent data. Of course, I can read and understand that various new findings have been obtained by adding the latest data.

Yes, our primary goal was to conduct a regional study, as we firmly believe that such studies are important alongside large-scale research. We are also not the first ones following the idea of

addressing the regional aspect, which has already been explored in numerous studies for both polar and mid-latitude regions. The results of our study are most important for the inhabitants of Svalbard, but regional change also has an impact on ship traffic, making it a matter of concern for various stakeholders.

While our study shares similarities with Tetz14, we acknowledge its influence as a basis for our work. However, our new research expands well beyond Tetz14, as explained in our response to comment 3b). We believe that our present study offers more than just the addition of new data. It sheds light on the continuous relevance of the trends identified in Tetz14, as they persist and are still relevant.

Combined with the editor's comments:

3a) There is a paragraph in the Conclusions section missing, widening your results and explaining what they mean for our understanding of Arctic sea ice decline.

We added the following paragraph to the conclusions:

*“Our study, though regional in scope, provides valuable insights into the strong connection of atmospheric and sea ice conditions. Some of the results can be transferred to other regions. Obviously, wind direction plays an important role for regional climate change near the marginal sea ice zones. This finding can most likely be generalized to all areas near the ice edge. Furthermore, our research highlights the large spatial variability of sea ice decline and its corresponding atmospheric response. The large trends near Svalbard align with previous studies that identify Svalbard as a hotspot in Arctic climate change. Our study contributes to a more comprehensive and detailed understanding of the ongoing changes in the Arctic.”*

3b) You could also more specific to what extent your results confirm previous studies such as Tetzlaff et al. (2014) or provide additional knowledge.

The main results of Sect. 3.3 are based on the correlation maps, which enable us to conduct a detailed spatial analysis of patterns and to identify regions in which a substantial part of atmospheric change can be attributed to sea ice changes. The extension of the time series by Tetz14 was mostly a prerequisite in order to introduce the method used for the calculation of the maps. We try to make this clearer by adding the following sentences to the third paragraph of Sect. 3.3: *“Consequently, we analyze in this section how atmospheric changes are related to sea ice changes. We use a method inspired by the study by Tetz14, who correlated air temperatures with upstream sea ice conditions. While their analysis focused only at three locations over the open ocean with increasing distance to the ice edge, we extend their analysis not only in time, but also present maps showing correlation coefficients for each reanalysis grid point. Looking at spatial patterns instead of single points has the clear advantage that we can identify specific regions in which a substantial part of atmospheric change can be attributed to sea ice changes.”*

## Report #2

### Minor comments

1) L191-197: Would probably be appropriate to add the more recent analysis by Isaksen et al 2022 (doi:10.1038/s41598-022-13568-5) to this discussion.

We now also include this paper in the discussion: *"In a recent study, Isaksen et al. (2022) presented air temperature trends based on weather station and reanalysis data averaged from December to February. Between 1991 and 2020, trends in the region north-east of Svalbard were in the order of 3 K per decade based on ERA5 data and even slightly larger values based on station data and the CARRA reanalysis, which is also in line with our findings."*

2) I was a little confused about c, g: What do the wind rose direction/amplitude (the shape, not the colours) represent in these panels? Based on the caption I was expecting them to show the \*trend\* in winds, but I guess it must be the 1992-2002 wind rose (?). Maybe clarify in the caption.

The first part of the caption now explains this in more detail: *"Wind roses based on ERA5 data in the WNB ATM box for the first ten years of the study period (a,e), the last ten years (b,f), and the whole period from 1992 to 2022. The length of the bars indicates the observed frequency of winds from each wind direction sector spanning 15°. The color denotes the average air temperature (a,b) and specific humidity (e,f) for the respective periods. The colors in panels (c) and (g) show the corresponding temperature and humidity trends over the whole 31 years."*

3) L216-17: "The situation..": Hard to see this in esp. Fig 6g..

The original aim was to use the same limits (0 and 0.4 g/kg/dec) for both regions. However, we agree with your point and adjusted the limits of the colormaps for Figures 5g and 6g separately. To clarify this, the following sentence was added to the caption of Fig. 6: *"Note that the colormap of panels (g) and (h) spans a smaller range than in Fig. 5."*

4) L283-285: Is this contrary to your results, then? ( $T_{\text{MERRA2}} > T_{\text{ERA5}}$ )? If so, warrants a comment.

The respective paper found biases of winter temperatures of 3 K for MERRA-2 and 3.4 K for ERA5. Thus, you are correct, and this somewhat contradicts our findings. Compared with biases for other reanalyses (e.g. 1.1 K for JRA-55), however, the biases for ERA5 and MERRA-2 are rather similar to each other. We rephrased the sentence to reflect these points: *"Graham et al. (2019) compared reanalysis data to meteorological observations during the N-ICE campaign in winter 2015 and found that both ERA5 and MERRA-2 overestimate winter temperatures by more than 3 K. Contrary to our results, however, biases are slightly larger for ERA5 than for*

*MERRA-2. They also found that among all the reanalyses considered, MERRA-2 has the largest overestimation of the downward longwave radiation flux.*

5) L288: “atmospheric flows” -> ? Should this be replaced with e.g. “temperature and humidity”?

We now write “*atmospheric variables*”, since besides temperature and humidity we also look at wind speed in this section.

6) Figure 11/paragraph around L315: Would be good to add an axis with month names for quick reference vs the text.

An axis with month names was added to the top of the figure.

7) Somewhere around L315: Recommend quickly repeating how you calculate fetch length (open water along green line o.s.).

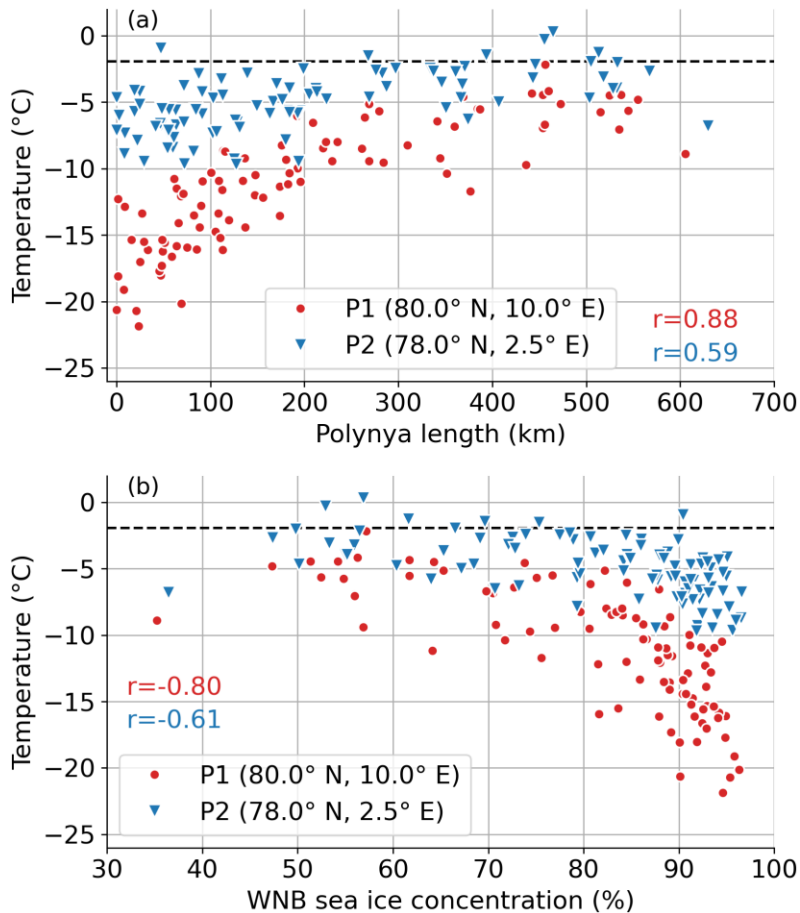
The following description was added: “*As described in Sect. 2.3, the WNB fetch is the distance along the green line in Fig. 1 over mostly open ocean (grid cells with a sea ice concentration below 70 %).*”

8) L327: “exemplarily” -> “for example”?

What we meant and write now is “*as an example*”.

9) Figure 12: Needs a legend and/or explanation in caption! Takes a while to figure out what blue triangles vs red circles are.

We now call the two considered locations P1 and P2 for clarity, added the legend also to panel a), and expanded the caption.



**Figure 12:** ERA5 air temperature at two locations (marked with triangles in Fig. 13) averaged monthly for January to March from 1992 to 2022 for periods with off-ice flow as function of WNB fetch (a) and of average sea ice concentrations in the WNB ICE box (b). P1 (red circles) is located close to the ice edge north-west of Svalbard and P2 (blue triangles) is located about 250 km further to the south-west over the open ocean region. Numbers are Spearman rank correlations. The dashed line indicates the freezing temperature of sea water

10) L331: “very similar”: Similar to each other or to the polynya length correlations? Best to rephrase.

The sentence was rephrased to: *“We performed a similar analysis to determine the relationship between average WNB sea ice concentration and atmospheric temperatures and found that correlations at the two considered points are very similar to those using open-water fetch.”*

11) Figure 13/14: Should make it clear what “difference” mean is (on-ice minus off-ice vs the other way around) in ylabel or caption – could help the reader by stating “red/blue colours mean that X/Y”.

We added a more detailed description to the figure captions. This is the text for Figure 13: *“Panels (e) and (f) show the corresponding differences of correlation coefficients between off-ice*

*and on-ice flow (panel (a) minus panel (c) and panel (b) minus panel (d)). Red colors mean that negative correlations are larger for off-ice flow compared with on-ice flow.”*

12) L346: “Over..”: And winds presumably also deflect around the steep land topography?

We agree and added the following sentence: *“On the one hand, the flow likely divides around Svalbard when winds deflect around the steep land topography. On the other hand, air masses from north-east do not experience any further warming and moistening over land and thus correlations decrease.”*

13) L349: It’s a little ambiguous what “differences” refers to here – seems to indicate difference between temp and hum patterns (leading me to look for differences between 13e and 13f), but I don’t think that is intended? Perhaps rephrase for clarity.

The sentence was rephrased for clarity: *“We also calculated the differences between the correlation maps for off- and on-ice flow for both temperature (Fig. 13e) and humidity (Fig. 13f). It is remarkable that the maps for temperature and humidity look almost identical, showing two areas of distinct differences between correlations for off- and on-ice flow.”*

14) L352: typo? (86N)

It should be 83° N and has been corrected.

15) L383: “although the effect was smaller” – phrasing seems strange, maybe “smaller but significant” or similar?

The sentence was rephrased to: *“While the impact of sea ice decrease was most pronounced during off-ice flow, smaller but significant negative correlations were also found during on-ice flow.”*

16) L422-L426: Look over these sentences for clarity (stray “with”, and what does “which” point to).

The sentences were rephrased to: *“In the GRL region, the negative sea ice trend is also significant but relatively smaller at -4.7% per decade compared to WNB. This discrepancy can be partially attributed to a higher proportion of open ocean within the GRL area already at the beginning of the analyzed period. The first half of the examined period shows the greatest inter-annual variability, likely influenced by the presence of the Odden ice tongue in certain years before 2006.”*

17) Section 4 is helpful, but I would suggest looking over it once more for clarity/language.

The respective section has been checked thoroughly and many sentences were rephrased for clarity. Please see the revised version for all improvements in this section.