Final Response

"Brief Communication: Trends in sea ice extent north of Svalbard and its impact on cold air outbreaks as observed in spring 2013", Tetzlaff et al.

All changes in the manuscript are marked in bold face.

Answer to Referee 1 (D. G. Barber)

We thank the referee for his constructive criticism which helped to improve the manuscript.

1. Paragraph -1 in introduction (P15). You state that there is evidence for negative trends outside of summer and fall – you should cite some of these papers.
The first paragraph reads now:
"Arctic sea ice extent has strongly decreased in the last decade (Stroeve et al., 2012; Meier et al., 2012). This is most pronounced in summer and early autumn, during the period of sea ice melt, but there is increasing evidence for a negative trend also during the remaining seasons (Stroeve et al., 2012)."

2. Last paragraph if section 2 you state - We define the polynya length as the cumulative open water path along the yellow area. You should state which value of SIC you used as your definition of open water.
To clarify the calculation method we write now:
"We define the polynya length as the cumulative open water path along the yellow area in Fig. 1a, starting at the northwestern edge of Svalbard. Here, we consider pixels with ice concentrations below 70% as open water areas. The polynya length is then the distance to the ice edge, i.e. the first pixel exceeding 70% ice concentration."

3. Figure 3D shows both a linear and a non linear fit between ERA 2m temps and mean polynya length. I would suggest you remove the linear relationship as it clearly is more a non linear relationship; the residuals for the linear will be biased upwards; it also fit with your text explanation better to just show the non linear.
Done.

4. I would have liked to have seen how far south this effect could be observed (i.e., what is the regional rather than just the local effect) – I suggest a short paragraph summarizing this would be useful – either in your discussion of the case studies or even just in the conclusions.
This is indeed an interesting point. Therefore, we expanded our analysis to two additional points east of Svalbard. These results are also included in Fig. 3d. The Spearman rank correlations gradually decrease from 0.76 to 0.52 and 0.42 further to the south-west. Further downstream, all air temperatures are nearly in equilibrium with the water temperatures and no significant correlations can be found. We describe these results in the last paragraph of Sect. 3 (, which is now in the newly introduced Sect. 4):
"To estimate how far south air temperatures are influenced by the polynya size, we repeat the calculations for two additional points further downstream. They are located north-west of Svalbard at 79.5° N, 4.5–7.5° E (P2 in Fig. 1a) and at 78.75° N, 2.25–5.25° E (P3 in Fig. 1a). The results are also shown in Fig. 3d. The Spearman rank correlation gradually decreases to rs = 0.52 at P2 and rs = 0.42 at P3. Thus, an effect is still visible more than 200 km downstream. At ERA-Interim grid-points even further to the south, the air temperatures are nearly in equilibrium with the water temperatures and no significant correlations can be found."

5. I would also suggest making reference to a similar work but in the Canadian Arctic – R. L. Raddatz , R. J. Galley , L. M. Candlish , M. G. Asplin & D. G. Barber (2013): Integral Profile Estimates of Sensible Heat Flux from an Unconsolidated Sea-Ice Surface, Atmosphere-Ocean, DOI:10.1080/07055900.2012.759900
We modified the introduction of the last paragraph in Sect. 3 (now new Sect. 4) and also included results from the recently published study by Onarheim et al. 2014:
"It is also interesting to consider the impact of polynyas on local atmospheric temperatures (e.g. Raddatz et al., 2013; Ebner et al., 2011; Fiedler et al., 2010). Using ERA-Interim data, Onarheim et al. (2014) found an air temperature increase of 7K in the Whaler's Bay Polynya between 1979 and 2012 associated with the observed decrease in sea ice cover. The close connection between the size of the Whaler's Bay Polynya and the local temperature in the polynya region can be seen in Fig. 3d."

Answer to Referee 2 (B. Brümmer)

We thank the referee for his constructive criticism which helped to improve the manuscript.

Conclusions: They may conclude a little bit further. A deeper boundary layer also means a deeper cloud layer and probably more snowfall. So, will there be more snowfall in the northern part of Svalbard? Could this lead to a growth of the glaciers?
Considering also changes in snowfall seems interesting. Unfortunately, snowfall measurements in the north of Svalbard are sparse. We tried to use the "convective snowfall" or the "total precipitation" predicted by ERA-Interim to conduct a similar analysis as for near-surface temperatures. However, the data is too scattered to find a significant correlation between polynya size and snowfall and therefore we do not present the plot in the paper. Thus we only discuss this topic in the conclusions:
"Increased boundary layer heights could also lead to a thicker cloud layer with enhanced precipitation. However, the analysis of ERA-Interim results did not show a significant correlation (not shown). It would be interesting to examine polynya related changes in snowfall and a possible impact on the surface mass balance of glaciers in northern Svalbard in the future."

1. P 3059, line 23/24: "referred to in the following as the Western Nansen Basin (WNB)". There is no further reference to this in the following text.
The term WNB is used again in the caption of Fig. 1. For an additional use, see question 7.

2. P 3060, line 7: "cumulative open water path". Explain the calculation in more detail.
To clarify the calculation method we write now:
"We define the polynya length as the cumulative open water path along the yellow area in Fig. 1a, starting at the northwestern edge of Svalbard. Here, we consider pixels with ice concentrations below 70% as open water areas. The polynya length is then the distance to the ice edge, i.e. the first pixel exceeding 70% ice concentration."

3. Section 2: The WBP in winter 2014 became smaller and smaller in the course of the three winter months J, F, M. The polynya is almost closed since April up to now (July 2014). You may add this specialty of the winter 2014.
Besides 2014, there were also other years with a nearly closed Whaler's Bay Polynya until July (e.g 1993, 2000, 2003, 2008). However, 2014 is special because the large polynya extent in January gradually decreased over spring. We now describe this observation at the end of Sect. 2:
"2014 is also a remarkable year because the polynya length decreased from more than 500km at the end of January to nearly 0km in mid-April. The polynya remained closed at least until the beginning of August (status on 1 August 2014, not shown)."

3.a) What causes the variability of the polynya extent?
Possible drivers for for the polynya extent have been examined by Onarheim et al. 2014, a study that was published shortly after submission of our manuscript. We would like to mention some of their findings and thus write in the introduction:
“Based on remote sensing data Ivanov et al. (2012) observed a decrease in the ice concentration north of Svalbard in winter and spring by more than 10% in the period between 1999 and 2011 compared to the period between 1979 and 1995. Using a similar method, Onarheim et al. (2014) found an ice reduction of 10% per decade north of Svalbard between 1979 and 2012. They identify a temperature increase of the inflowing Atlantic Water as a major driver for this long-term trend, while the year-to-year variability is also influenced by wind direction. Both studies also found an increase in the near-surface air temperatures in the ERA-Interim reanalysis in this area, which is in line with the decreasing ice concentration in the last decades.”

4. P 3060, line18: “roll convection”. I am not sure if this term is generally known.
To our knowledge, the term “roll convection” has been widely used in the literature (e.g. Gryschka and Raasch (2005)). Due to the limited extent of the “Brief Communication” format we would like to avoid an extensive explanation of the term. Therefore, we only slightly altered the phrase to:
“During that time, several strong CAOs occurred starting with convective rolls associated with cloud streets over the Whaler’s Bay Polynya clearly visible in satellite images.”

5. P 3061, line11: “the ABL height depends on wind direction”. Why wind direction? Do you mean fetch?
Yes, indeed, wind direction only has an influence by changing the fetch. Since we already discuss the fetch in the next sentence we drop the term wind direction and write:
“The ABL height in CAOs depends on wind speed and temperature conditions. Another possible reason for the extreme ABL height at this latitude can be found by considering the open water fetch.”

6. P 3061, line 18: “usual N-S orientation”. Replace “usual” by “most frequent”.
Done.

7. P3062, line 21: “general findings of Ivanov”. What are these findings?
We changed the sentence to:
“This is in line with the more general findings by Ivanov et al. (2012), who concluded
that air temperature trends in the Western Nansen Basin based on ERA-Interim data are consistent with the observed ice loss.”

8. P 3063, line 3: After the doi-number follow some non-understandable abbreviations.
These abbreviations are hyperlinks of page numbers and are specific for the TC discussion format.

9. Fig.1a: Encircle also the area for the ice extent calculation.
Done.

10. Fig. 3a: Minus sign missing for “64km”.
We checked the figure again and noticed that the minus sign is visible in the digital version of the paper.

11. Fig. 3d: How did you calculate the polynya length for 2014 because (see above) the length decreased in the course of the winter.
The data for 2014 have not been included in Fig. 3d so far since the ERA-Interim data was not completely available at the time of submission, yet. The data is now included in the final version of the manuscript. Your point of a gradually decreasing polynya length, however, is also valid for other years, such as 2013 for example.
We only consider data with a north-easterly wind direction and calculate the mean polynya length also

only using these data. Thus, the mean polynya length in Fig. 3d is not a monthly mean but rather a mean of the considered cases with north-easterly winds. Therefore, the impact of a decreasing polynya size with time is already included in this calculation. To clarify this calculation method we modify the description to:
“The relationship between the JFM mean temperatures during north-easterly winds and the mean polynya length of the considered cases is probably not linear ...”