Answers to the referee 2

23-Jun-2017

Thank you very much for your competent and creative comments. Please find below your comments repeated again and our answers. With the help of your advices, we have prepared a new version of our manuscript.

General Comments:

1. The thrust of the paper implies that the presence of statistical correlation implies causation, which is not the case. It is important for the authors to further explore the identified relationships by placing them in a climatological context and examining various potential atmospheric processes that may help explain the correlation results.

To have a more focused paper we reduced the number of parameters, for that we made a general table of correlations with all our parameters and then chose only 3 for subsequent analysis: temperature, SLP and we added geopotential heights. We separated cold and warm winters (based on Baffin Bay region), similar to Sato et al, (2014); and added following analysis to reveal possible physical mechanisms why the Baltic Sea and the BB winters are in opposite phase relying on 1000 hPa temperature. We look atmospheric circulation differences using SLP, 700 hPa and 500 hPa geopotential height differences between warm and cold winters. We added also a cross-section of geopotential heights (up to 100 hPa) along the 60W vertical slice and plots of annual evolution of 500-hPa height differences at 60N, 70N and 75N (similar to Wu et al., 2013). See figures below:

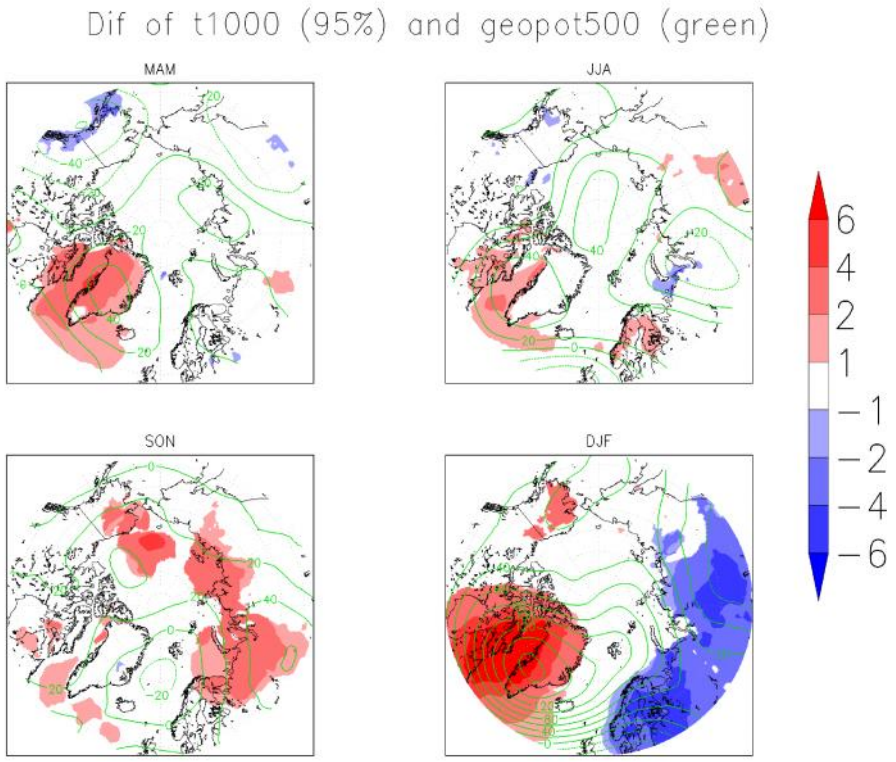

Figure 1. Seasonal difference maps (years with mild winters years with cold winters) in air temperature at 1000 hPa level (shading with confidence level of 95%), and (b) geopotential height at 500hPa level (contours).

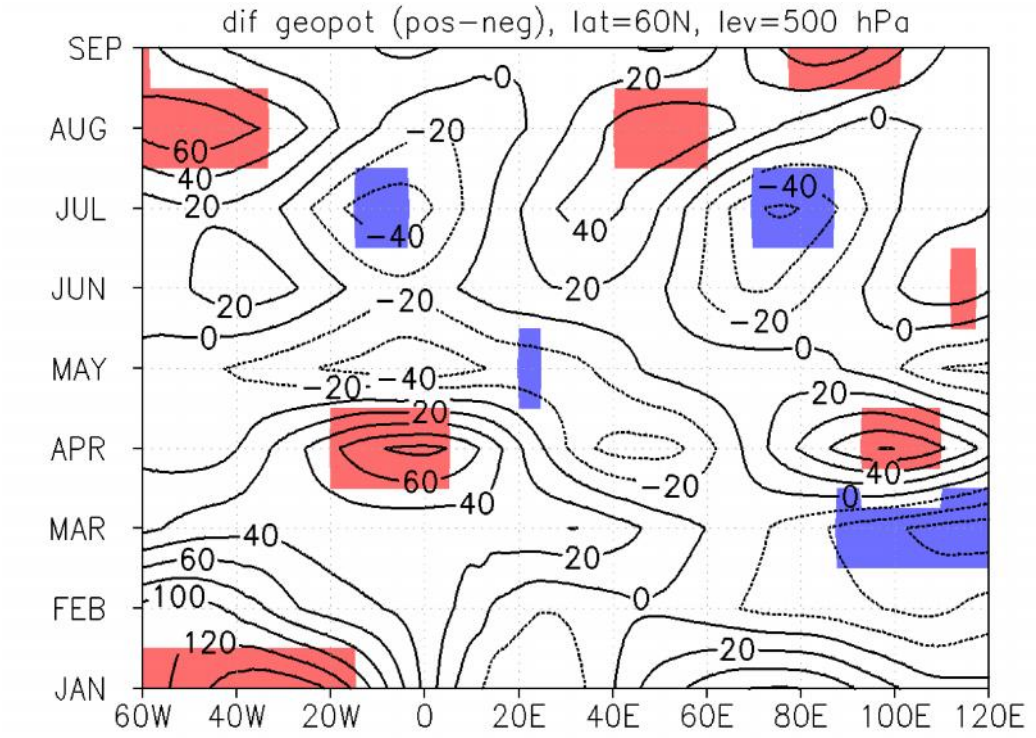

Figure 2. Evolution of 500-hPa height differences between mild and cold winters at 60N; red and blue shading indicates differences at the 95% significance levels for positive and negative height, respectively.

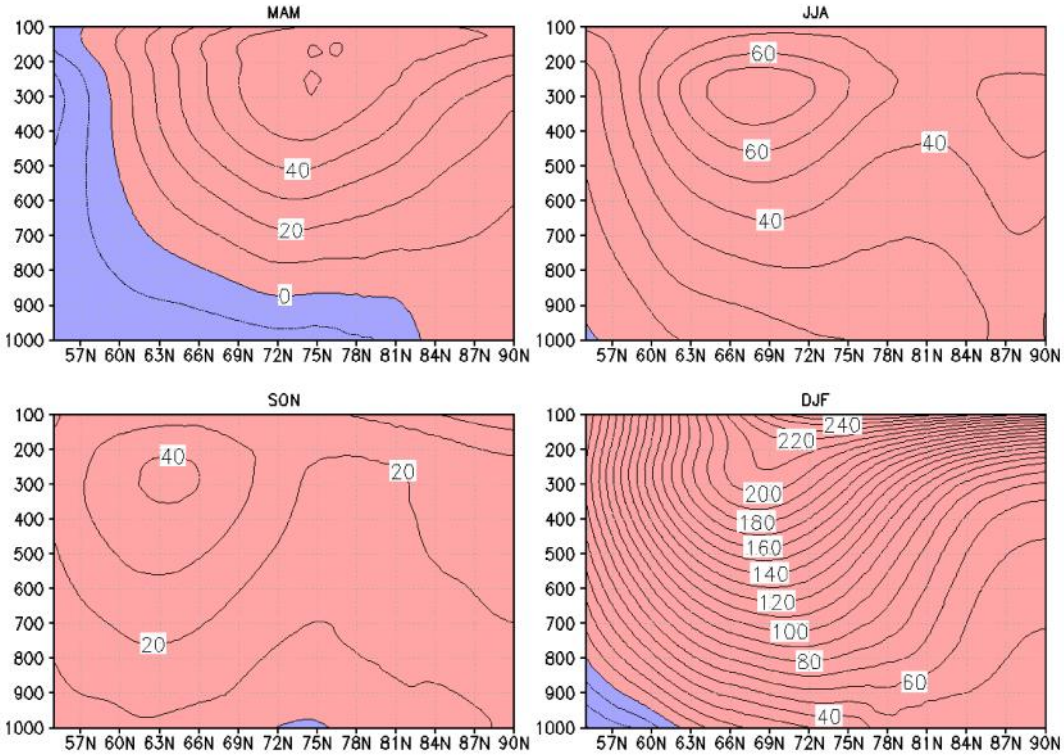

Figure 3. Differences in the mean heights between mild and cold winters along the 60W vertical slice. Contour intervals are 10 gpm; blue represent negative height differences and red positive height differences.

In discussion paragraph we added:

The large scale atmospheric circulation pattern in Figure 1 shows that the geopotential heights of 500 hPa are more than 100 gpm higher in mild winters than in cold ones, and the maximum of this height anomaly is centred over the maximum of the 1000 hPa temperature difference. It means that the whole column (up to 500 hPa) of the air in the Baffin Bay region is warmer than at cold years. Coming down to the lower surfaces (700 hPa, not shown), the maximum height anomaly is shifted to the east, what could be due to warmer sea surface of the Northern Atlantic compared to the regions that lay to west of it. The positive temperature anomaly (with the 500-hPa height anomalies) shifts towards east during the next seasons, reaching to Scandinavia/Baltic Sea region in summer (Figure 2). By Wu et al (2013) proposed mechanism, that associates the summer atmospheric circulation anomalies in the northern Eurasia with the previous winter ice conditions west of Greenland, supports our idea.
Figure 3 exhibit baroclinic structure of spring atmosphere north of 55N due to positive height anomalies in the lower troposphere below the 850 hPa and with further higher the negative ones. Similarly to Wu et al (2013) the vertical distribution of spring height anomalies differs from that of the previous winter when height anomalies show dominantly quasi-barotropic structure (not shown). With regression analysis they show the validity of their hypothesis of eastward propagation of the 500 hPa height anomalies. The same could be followed from Figure 2, where the evolution of 500 hPa height differences between mild and cold winters at 60 N is presented. Also at 65 N the similar pattern is present. At higher latitudes (70N and 75 N) this kind of signal propagation is missing.

2. The authors present a great amount of results that need to be better interpreted, synthesized and placed in to a climatological/ atmospheric context supported by existing literature.

To reduce the number of correlations we made a general table with all our parameters and then chose only 3 for subsequent analysis (temperature, SLP and we added height of geopotentials). We made extra analyses and supported our results with existing literature (see previous answer).

3. The authors use simple linear correlation analyses to explore atmospheric teleconnections. I assume that they are speaking of the Pearson Correlation Coefficient. I have some concerns about this given that the areas of concern are in middle-to-high latitudes where teleconnections are known to be of non-linear nature. Also, the correlation method is applied to climate parameters such as wind and specific humidity that may not be normally distributed and significantly influence the results.

We added the word "Pearson" to clarify which correlation we use in the manuscript. Teleconnections (like most physical processes) can often have non-linear nature, but until the process real relation functions are unknown, linear estimates are the most reasonable ones. We added to the text: "in this paper we use only linear correlations, non-linear correlations are not included".
To be statistically correct, our methods indeed assume normal distributions for all inputs. Still, as we are seeking not exact numbers but rather general patters, small violation of normal distribution assumptions should not have considerable effect. Also – as we use mostly seasonal

mean values – central limit theorem also gives us credit to assume that our data is at least in some extent normally distributed.

4. The entire Baltic Sea region is represented by one single station located in southern Estonia (TP). The authors claim that the information provided in Figure 1 (i.e., Correlations between air temperatures at this location with locations across the greater Baltic Sea region during various season) shows that TP's climate represents the climate of the greater region very well. This may be the case for surface temperature, but I strongly doubt that same would hold true for the other variables such as wind characteristics. This can be seen in Figure 2 for JJA, for instance.

We reduced the parameters of analysis. Temperature at 1000 hPa, SLP and geopotential heights at 700 hPa and 500 hPa are analysed. For SLP we prepared a similar figure as for temperature in manuscript (see below Figure 4).
To be more precise we renamed our title as the 'Atmospheric teleconnections between the Arctic and the Eastern Baltic Sea regions'.

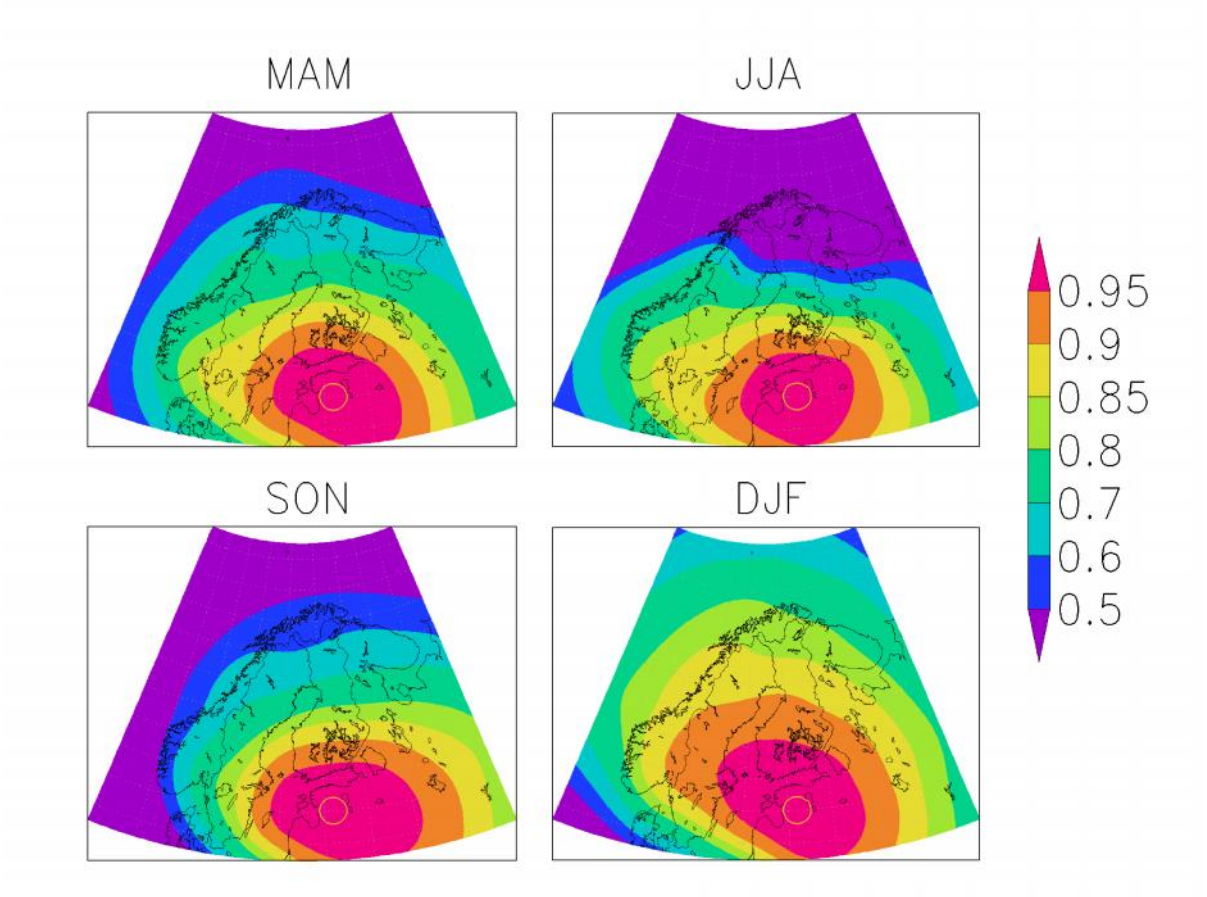

Figure 4. Correlation maps of SLP for the testing point in the Eastern Baltic Sea region.

5. For their analyses, the authors chose four atmospheric variables including air temperature, specific humidity, wind speed, and sea level pressure. Why did they choose these variables and not just sea level pressure, or the more typical 700 hPa geopotential heights for exploring atmospheric teleconnections?

We have left out specific humidity and wind speed and have added 700 hPa and 500 hPa geopotential heights.

6. What methods were used to remove the trends from the data?

For detrending, firstly we calculated linear trend (k) and intercept (b) for each parameter every season in every grid point. Using these parameters linear detrending was done also for each parameter every season in every grid point:
$Y_i = X_i - (k \cdot y \quad + b - X_a \quad)$.
We added the formula with explanations in the manuscript.

7. What methods were used to assess statistical significance?

We used F-test for testing the significance of correlations. For comparison of averages (difference between warm and cold winters, was not included in the previous version), we used t-test assuming equal variances.

$$F = \frac{(N-2) \cdot R^2}{1 - R^2}$$

8. The overall manuscript is clearly written baring some oddities in grammar and general use of the English language. I would recommend a more careful proof-reading of the revised manuscript. Some (not all) recommendations are included below.

Specific Comments:

Line 90: The authors mention several atmospheric teleconnections including the AO, NAO, PDO, SCA, EA, and EA/WR but do not explain what each of these are and on what basis they were included in the conversation. They also do not explain why most these were discounted up front and not addressed again even in the discussion section.

To expose the role of different teleconnection indices we reorganized the analysis of teleconnection indices as follows (based on the suggestions of our referees):

we explained our choices of indices based on geographical position of the centres of action of the teleconnection patterns in data paragraph (see the segment 1 beneath);

we added to Results paragraph the table about the influence of teleconnection indices to correlations between the Baffin Bay region and the Eastern Baltic Sea region (see the table 1 below);

we added the analysis of PEU and found that the strength of influence is larger than all other teleconnection indices except much more larger impact of AO and NAO (see table 1);

we added to our discussion paragraph a new segment about the role of teleconnection indices, the possible reasons why other indices showed much less impact than AO and NAO indices, based on literature: Uotila et al, 2015; Lim, 2015; Comas-Bru and McDermott, 2014; Vihma et al., 2014; Moore et al., 2013.

Table 1. *The partial correlations of teleconnection indices between 1000 hPa temperature at TP and the Baffin Bay-Greenland region (20-80W; 55 – 80). Smaller (than regular) values show higher impact of the index.*

index	DJF	MAM	JJA	SON
regular	*-0.41*	*-0.23*	*0.15*	*-0.02*
AO	**-0.07**	**-0.10**	0.19	0.08
NAO	**-0.10**	**-0.11**	0.23	0.04
PDO	-0.45	-0.26	0.06	-0.11
CAI	-0.41	-0.21	0.15	-0.01
PEU	-0.42	-0.18	0.19	-0.02
EA	-0.43	-0.27	0.06	0
EA/WR	-0.41	-0.22	0.12	-0.12
SCA	-0.25	-0.23	0.21	-0.01

Segment 1 of new version:
"The teleconnection indices we applied in our analyses were chosen according to the possible influence due to the geographical position of the centres of action of the teleconnection patterns over the North-Atlantic-Eurasian region. The following indices were chosen: 1) The North Atlantic Oscillation (NAO), which is the dominant mode of atmospheric variability in the North Atlantic sector throughout the year (Barnston and Livezey, 1987); 2) The Arctic Oscillation (AO), which is usually defined as the first EOF of the mean sea level pressure field in the Northern Hemisphere (Ambaum et al., 2001); 3) The Scandinavian Pattern (SCA), which consists of a primary circulation centre over Scandinavia, with two other weaker centres of action with the opposite sign, one over the north eastern Atlantic and the other over central Siberia to the southwest of Lake Baikal (Bueh and Nakamura, 2007); 4) The East Atlantic Pattern (EA), which consists of a north-south dipole of anomaly centres spanning the North Atlantic from east to west (Barnston and Livezey, 1987); 5) The East Atlantic/West Russia Pattern (EA/WR), which consists of four main anomaly centres: Europe, northern China, central North Atlantic and north of the Caspian Sea; 6) The Polar/ Eurasia Pattern (PEU) consists of height anomalies over the polar region, and opposite anomalies over northern China and Mongolia.; 7) Additionally, Pacific Decadel Oscillation (PDO), which is the dominant year-round pattern of monthly North Pacific sea surface temperature (SST) variability was included. Although its geographical centres are far from the Baltic Sea region, Uotila et al (2015) found that PDO correlated significantly with the ice concentration and temperature of Baltic Sea. All indices were downloaded from the NOAA-CPC database (http://www.cpc.noaa.gov)."

Line 105: The authors mention that they detrended the seasonal time series "to avoid the correlations to be caused by mutual trends in input variables." They also claim that the detrended and original correlation results were very similar. For this reason, they only show correlation results from "regular data". The results surprise me (i.e., similar correlations from original and detrended data), especially given the large recent temporal trends in many of the variables that are explored (i.e.,temperature)in the high latitudes of the northern hemisphere. It is also important to note that the conclusions regarding teleconnections that one can reach from the original series versus detrended series may be different. Are the authors exploring the connections that include long term climatic trends such as global warming, or are they interested in understanding the relationships as they may exist independently of such trends?

Thank you especially for the last sentence, it ended our hesitations should we present results with or without trend. In the upgraded version, we show only results without detrending, to focus connections that are present in our world that is influenced by global climate change

trends. We include discussion about detrended data to clarify that presented correlations are not because of trends. Our sentence "differences between the areal averages of correlations were up to 0.02 in both directions" is indeed a bit misleading, as there are small regions where the difference is larger than 0.4, we replaced it with "detrending did not change general patterns of correlations with TP, only intensified negative correlation in the Greenland region ".

Line191: The authors claim that"...,the winter mean temperature is not dependent on weather conditions during the previous seasons." But on line 199 they proceed to make the following claim: "Winter temperature at the TP has a strong negative correlation in the Taimyr region in the previous summer." To me, these statements seem to contradict themselves.

Thank you for asking, there was indeed conflict between these sentences. We upgraded the text as follows: " At the same time, the winter mean temperature has almost no dependent on weather conditions during the previous seasons, there is only small region with strong negative correlation in the Taimyr region in the previous summer (lag=6).

Line 235: The authors state that "To avoid false correlations, only the results that were present in both the regular and the detrended data were discussed." I am not sure what is meant by "false correlations". Like I mentioned earlier, detrended data for instance, may hold a different story, not a false story.

You are correct, we just remove this sentence (we explained reasons two comments above).

Line 25: find another word for "disconfirm"

We replaced "disconfirm" with "disagree".

Line 26-27: It is not clear what "both" is referring to in the sentence starting with "They found that from...."

We changed the sentence as follows: "They found that from October to December, the main factors responsible for the Arctic deep tropospheric warming are: 1) the recent decadal fluctuations and 2) long-term changes in sea surface temperatures. These two factors are located outside the Arctic."

Line 33: "Arctic amplification" should be Arctic Amplification

Corrected

Line 67: It is not customary for sentences to begin with "But"

We changed the sentence as follows:

There is no clear understanding about the reasons for the changes in these indices or climatic parameters in the Baltic Sea region in most recent time.

Line 68: I would suggest replacing "last decades" with most recent?

Corrected.

Line 71: Rework the sentences starting with “Therefore, our aim is to....

We changed the segment as follows: "Our aim is to clarify how the climatic parameters in the Eastern Baltic Sea and Arctic regions are associated. Knowledge of such connections helps to define regions in the Arctic that could be with higher extent associated with the Baltic region climate change."

Line 123: Replace the word “huge” with large

Corrected

Line 132: Can the word “distinguished” be replaced with different or distinct?

Replaced with distinct.

Thank you once more,

Sincerely yours,

Liisi Jakobson
Erko Jakobson
Piia Post
Jaak Jaagus

References (If we use in our answers references that were already given in our article then we will not give the reference here again):

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