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Atmospheric teleconnections between the Arctic and the Baltic Sea regions

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Abstract. The teleconnections between meteorological parameters of the Arctic and the Baltic Sea regions were analysed based on the NCEP-CFSR reanalysis data for 1979–2015. The Baltic Sea region was characterised by meteorological values at a testing point (TP) in Southern Estonia (58N, 26E). Temperature and specific humidity at the 1000 hPa level at the TP have a strong negative correlation with the Greenland region during all seasons except summer. The strongest teleconnections between the same parameter at the Baltic Sea region and the Arctic are found in winter, but they are clearly affected by the Arctic Oscillation (AO) index. After removal of the AO index variability, correlations in winter were below ±0.5, while in other seasons there remained regions with strong ($|R|>0.5$) correlations. Strong correlations are present between different climate variables at the TP and the Arctic. Temperature and wind speed at the 1000 hPa level in the Baltic Sea region have a significant positive correlation with sea ice concentration in Baffin Bay and in regions between the North Pole and Greenland during all seasons except summer. These teleconnections cannot be explained with the AO index variability. The most permanent lagged correlations in 1000 hPa temperature are in summer at the TP with the Baffin Bay region in the previous spring, winter and even autumn. At every season there are some regions in the Arctic that has strong teleconnections ($|R|>0.5$, $p<0.002$) with temperature, specific humidity, wind speed and air pressure in the Baltic Sea region. These relationships can be explained by the AO/NAO index variability only in winter.

1 Introduction

Over the past half a century, the Arctic has warmed at about twice the global rate (IPCC, 2014), a phenomenon called the Arctic Amplification. At the same time, a significant decrease in sea ice extent has occurred in all calendar months since 1979 (Simmonds, 2015), which has been declared to have a leading role in recent Arctic temperature amplification by some scientists (e.g. Screen and Simmonds, 2010; Francis and Vavrus, 2012). On the other hand, Perlwitz et al. (2015) disconfirm the common assumption that sea ice decline is primarily responsible for the amplified Arctic tropospheric warming. They found that from October to December, the main factors responsible for the Arctic deep tropospheric warming are the recent decadal fluctuations and long-term changes in sea surface temperatures, both located outside the Arctic. Screen et al. (2012) found that sea ice concentration and sea surface temperature explain a large portion of the observed Arctic near-surface warming, whereas remote sea surface temperature changes explain the majority of observed warming aloft. As the energy budget of the Arctic is highly dependent on energy exchange with lower latitudes, then the changes in atmospheric and oceanic circulation play an important role in all kinds of heat conservation changes in the Arctic. Therefore, the observed enhanced warming of the Arctic, referred to as the Arctic amplification, is expected to be related to further changes that impact mid-latitudes and the rest of the world (Jung et al., 2015; Walsh, 2014).

These Arctic influences could be direct, as the advection of cold and dry air from over the ice-covered areas to the neighbouring territories, but it could also be through teleconnections – the large-scale patterns of pressure and circulation anomalies that cover vast geographical areas and reflect the non-periodic oscillations of the climate system. Teleconnection as a term was first used by Ångström (1935). Wallace and Gutzler (1981) defined teleconnections as significant simultaneous correlations between the time series of meteorological parameters at widely separated points on the Earth; the essence of a teleconnection is that a climatic process may influence the Earth's system elsewhere (Liu and Alexander, 2007).

Teleconnections between the Arctic and mid-latitude regions have been the focus of research for many years and several reviews about the Arctic sea ice impact on the global climate (Budikova, 2009; Vihma, 2014) or Eurasian climate (Gao et al., 2015) have been published. Budikova (2009) stated that the size of the response of the climate of remote regions to changes in the Arctic has been found to be linked linearly, but the forcing direction nonlinearly. Less ice in the Arctic results in a significant decrease in the speed of the westerlies and the intensities of storms poleward of 45°N (Budikova, 2009). Many studies suggest that the Arctic sea ice decline increases the probability for circulation patterns resembling the negative phase of the Arctic Oscillation (AO) and North Atlantic Oscillation (NAO) indexes in winter (Vihma, 2014). However, there is a debate as to whether the reduction in the autumn Arctic sea-ice-induced negative AO/NAO index can persist into winter (Gao et al., 2015). Some researchers suggest that winter atmospheric circulation is more closely associated with changes in the winter Arctic sea ice (Gao et al., 2015). Several studies have demonstrated the relationships between warming and/or ice decline, and mid-latitude weather and climate extremes (Coumou et al., 2014; Tang et al., 2013; 2014; Petoukhov et al., 2013; Francis and Vavrus, 2012; Petoukhov and Semenov, 2010).

The Baltic Sea region features very variable weather conditions due to its location in the climatic transition zone between the North Atlantic and the Eurasian continent. The region is also close to the Arctic or even part of it (depending on defining the borderlines) and certainly has a direct Arctic influence. The weather in the region depends highly on the position of the polar front: it can be located northward as well as southward of the area. According to the Second Assessment of Climate Change for the Baltic Sea Basin (BACC II, 2015), significant changes have occurred in climate parameters, which could be associated to large-scale atmospheric circulation. Intensity of the zonal circulation, i.e. the westerlies, has increased during the cold period, especially in February and March. There has been an overall warming of the Baltic Sea region, which has not been equal throughout a year, nor over the whole region. The highest increase in air temperature is typical for spring (MAM) season. Although a remarkable warming has been present also in winter (DJF), it is not significant due to a very high temporal variability (Jaagus, 2006). A tendency of increasing precipitation in winter and spring was detected in the Baltic Sea region during the latter half of the 20th century, possibly increasing the risk of extreme precipitation events. There is some evidence that the intensity of storm surges may have increased in some parts of the Baltic Sea in recent decades, and this has been attributed to long-term shifts in the tracks of some cyclone types rather than to a long-term change in the intensity of storminess.

It is known that fluctuations of the climatological parameters in the Baltic Sea region are strongly affected by the atmospheric circulation variability described by the teleconnection indices of NAO and AO (BACC II, 2015). But there is no clear understanding about the reasons for the changes in these indices or climatic parameters in the Baltic Sea region in last decades. One of the reasons is the non-stationarity of the NAO spatial pattern and the temporal correlations (Lehmann et al., 2011; 2017). On the other hand, it is natural to assume that changes in the Arctic climate system have an effect on the Baltic Sea region and vice versa. Therefore, our aim is to find out how could the climatic parameters in the Baltic and Arctic regions be associated. Knowledge of such connections helps to define the specific geographic distribution of the resulting anomalies in surface climate parameters such as air temperature, precipitation or wind speed.

Our analysis is designed as follows. We selected one grid point (the testing point TP) to represent the Baltic Sea region and to find the correlations between climate parameters at this point and in the Arctic cap to find the regions of mutual connections. Next, we calculate the partial correlations with various teleconnection indices as control factors to get rid of the known atmospheric circulation variability. Due to longer memory of non-atmospheric components of climate system we compute by season lagged correlations between climate parameters.

The objective of this paper is to indicate the relationships between meteorological parameters of the Arctic region and the TP. By tracking down the teleconnections between the rapidly changing Arctic region and the TP we can get valuable information about possible future trends in the Baltic Sea region even if the changes in both regions were caused by a third factor.

2 Data and methodology

We used monthly mean reanalysis data from the Climate Forecast System Reanalysis (CFSR) on a 0.5º×0.5º horizontal grids provided by the National Centers for Environmental Prediction (NCEP). For the period 1979–2010, 6-hourly data of CFSR version 1 were used (Saha et al., 2010) and for the period 2011–2015, 6-hourly data of CFSR version 2 were used (Saha et al., 2014). The following parameters were analysed: temperature at 1000, 850, 500 and 250 hPa level; specific humidity and wind speed at 1000 hPa; sea-level pressure (SLP) and sea ice concentration (SIC). Monthly means and seasonal means (MAM, JJA, SON, DJF) were calculated from the 6-hourly data. Monthly mean wind speed was calculated as a scalar average.

The following teleconnection indices – North Atlantic Oscillation (NAO), Arctic Oscillation (AO), East Atlantic Pattern (EA), Scandinavia Pattern (SCA), East Atlantic/West Russia Pattern (EA/WR), and Pacific Decadal Oscillation (PDO) were downloaded from the NOAA-CPC database (http://www.cpc.noaa.gov). The first two indices had the largest effect on the Arctic – Baltic Sea region atmospheric teleconnections and are investigated in more detail in this article.

We assume that because of a high spatial correlation between meteorological conditions in the whole Baltic Sea region it is reasonable to choose one testing point (TP) that represents the whole region. Lehmann et al. (2011) used the same method by selecting Hamburg-Fuhlsbüttel to represent the temperature evolution of the Baltic Sea area as correlation coefficients for the seasonal mean air temperature between Hamburg and different sub-basins ranged from 0.8 to 0.9. We selected TP in Southern Estonia with coordinates 58°N, 26°E. The correlation coefficient for the seasonal mean air temperature at 1000 hPa between the TP and different sub-basins of the Baltic Sea is mostly higher than 0.85 (Fig. 1). The highest correlation is observed in winter and the lowest in summer.

We analysed the reanalysis data with the Grid Analysis and Display System (GrADS). We calculated linear correlation coefficients to reveal teleconnections between the Arctic region and the TP of the Baltic Sea region. We define the Arctic region here as the region northward of 55 N. For correlations with the TP, the first correlation input was taken at the TP and the second in the Arctic region. Two lowest correlation levels in Figures are ±0.17 and ±0.32, representing 68% and 95% confidence levels of the correlations; only strong correlations $|R|>0.5$ (at least 99.8% confidence level) are discussed in this paper.

Detrending of seasonal time-series was done to avoid the correlations to be caused by mutual trends in input variables. Therefore, linear trends for each parameter at each grid point were calculated for each season and all correlations were calculated twice – at first using the regular and later the detrended data. Detrending changed the correlations only slightly: differences between the areal averages of correlations were up to 0.02 in both directions. We show only the correlation coefficients of the regular data, but the detrended correlations were also significant in all discussed results.

The next step in the analysis was to remove from the correlations the effect of atmospheric teleconnections which could be described by known teleconnection indices. For that purpose, partial correlations between various atmospheric variables with the controlling effect of AO were calculated.

The last phase of the analysis was to calculate the lagged correlation coefficients with the purpose of revealing the possible delayed dependences between the atmospheric variables of the Arctic region and the TP. For the lagged correlation, the second parameter was taken by lag months earlier than the first parameter.

3 Results

3.1 Spatial correlations of climatic variables

Climatic variables at separate gridpoints are usually not independent, but correlations in space depend highly on the distance and climatic variables. For example, for temperature, the dependence in space stays significant for longer distances than for precipitation as the processes of their formation are different. But besides the short distance correlation of climatic parameters between the TP and the surrounding gridpoints, there are also vast areas far from the TP, still having significant correlations (Fig. 2). The strongest correlations are detected in winter when temperature at the 1000 hPa level at the TP has a positive correlation over a huge area, covering nearly the whole northern Eurasia, with the maximum (R>0.5) in northern Europe, on the Eastern European Plain and Central Siberia. At the same time, an area of a strong negative correlation is found in the Greenland region. A similar correlation pattern, but of less magnitude, is also present for spring and autumn. These patterns are very similar to the correlations between temperature and the AO index (Fig. 3). The pattern of spatial correlation for temperature at the 1000 hPa level in summer is different. The area of positive correlation is much smaller than in winter, mostly covering only Europe, but a negative correlation is detected in the central Arctic and western Siberia (Fig. 2).

Specific humidity at the 1000 hPa level has a similar pattern of correlations as temperature at the same seasons. The largest differences are observed in Siberia in spring with about 20% higher correlation in temperature than in specific humidity. Wind speed at the 1000 hPa level at the TP has the highest correlation in winter, while the areas of a positive correlation in Europe and North Atlantic and of a negative correlation in the central Arctic and Greenland are strictly distinguished. During the other seasons the spatial correlation is much lower. It is interesting that a strong positive correlation in wind speed in summer exists between the TP and the Canadian Arctic Archipelago and the Bering Sea region. SLP at the TP has a significant negative correlation with SLP in Greenland and at Baffin Bay region in summer and autumn (Fig. 2).

3.2 Correlations between the teleconnection indices and climatic parameters

Correlation coefficients between seasonal mean temperature, specific humidity and wind speed at the 1000hPa level and SLP at the TP, and the NAO and AO indices are presented in Table 1. The highest values are found for both the NAO and AO indices in winter, where all the correlations are statistically significant. The AO indices mostly have higher correlations, while correlations with temperature are significant in all seasons. Only SLP in summer and autumn has a significantly higher correlation with the NAO index.

Correlation maps between the seasonal mean values of the AO index and temperature, specific humidity and wind speed at the 1000hPa level, and SLP are presented in Fig. 3. There are patterns similar to Fig. 2, especially for temperature and specific humidity. The field of wind speed at the 1000 hPa level shows a diverse picture in both Figures. As it follows from the definition of the AO index, there is a strong negative correlation between the AO index and SLP in the whole Arctic region in all seasons.

3.3 Spatial correlations between the same parameters without the effect of the AO and NAO indices

Partial correlations with the controlling factor AO index reduce the area with a statistically significant correlation around the TP in all parameters and in all seasons (Fig. 4 in comparison with Fig. 2). This effect on the remote areas depends on the season. In spring, the differences between partial correlations with the AO or NAO indices are small compared to the regular correlations between the TP and the Arctic. Differences are below 0.2 in the whole region. In summer and autumn, the differences are even smaller. The effects of the AO and NAO indices on spatial correlations are the strongest in winter, up to 0.5, while the AO index has a stronger controlling effect than the NAO index in all parameters. Partial correlation with the AO index as a controlling factor reduced the TP correlation (absolute value) with temperature and specific humidity in Central Siberia and the Baffin Bay region by 0.3–0.5, compared with the regular correlation. At the Gulf of Alaska, the difference exceeds by 0.3 as the regular correlation is negative there, but the partial correlation is positive.

In winter, the absolute values of partial correlations with the controlling factor the AO index are below 0.5 everywhere beyond the TP region, though the regular correlations are the strongest. In other seasons, regions with stronger partial correlations than ±0.5 remain. In temperature and specific humidity, there are strong positive partial correlations from spring to autumn in North-Eastern Siberia. In wind speed, there are still strong positive partial correlations in the Canadian Arctic Archipelago and the Bering Sea region.

Next, correlations in the higher atmosphere are investigated. Temperature correlations with the TP on four isobaric levels – 1000, 850, 500 and 250 hPa – are shown in Fig. 5. Generally, a spatial correlation decreases on higher levels and the area of significant correlation around the TP also decreases. The positive correlation in winter and spring in Central Siberia weakens with height and becomes a negative correlation at the 250 hPa level in winter. Partial correlation in temperature, removing the influence of the AO index, is below ±0.5 on all levels in winter (not shown).

In summer, there is a strong positive correlation with temperature in the Laptev Sea region on all levels below 250 hPa and in Canada on the above 850 hPa level. In autumn, correlation is strongly positive in the Kamchatka region below the 500 hPa level. In summer and autumn, the AO or NAO indices have no significant influence on correlations on higher altitudes, similarly to the 1000 hPa level.

3.4 Spatial correlations between different parameters

Climatic variables have close relationships between themselves. If there is a climatic change in one parameter, for example in temperature, then it causes changes also in other parameters connected with it, for example in snow cover. Similarly to correlations of the same climate variable at the TP and the Arctic (Fig. 1, 2 and 5), there are strong correlations ($|R|>0.5$) between different climate variables at the TP and the Arctic (Fig. 6). Correlation between the 1000 hPa temperature at the TP and SLP show the expected results with a positive correlation in summer and negative in winter. The largest areas of negative correlations, controlled by variations of the AO index (not shown) are present in winter and spring. In summer, the temperature at the TP is negatively correlated with SLP in Siberia and North America, while in autumn it is negatively correlated in the North Atlantic and positively correlated in the Canadian Arctic Archipelago.

Correlations between the temperature at the TP and wind speed at the 1000 hPa level in the whole Arctic have a negative correlation in winter above Greenland and the East Siberian Sea, but it is missing in the partial correlation with the controlling factor AO index (not shown). Correlation between the 1000 hPa temperature at the TP and sea ice concentration is positive around Greenland in spring, in the Central Arctic in summer and around Greenland and in the Canadian Basin in winter. Correlation between the 1000 hPa wind speed at the TP and ice concentration is negative in the Canadian Basin in summer and positive at the coastal areas of north-eastern Siberia in autumn and around Greenland in winter. Partial correlations between ice concentration and temperature or wind speed with the controlling factor AO index do not differ much from regular correlations even in winter.

3.5 Teleconnection using lagged data

There is a large inertia in the atmosphere causing lag effects. It means that weather conditions in a previous period can have an effect on the weather during the following weeks, months and seasons. For finding the effect of the previous seasons on weather conditions at the TP, lagged correlations were calculated for the 1000 hPa temperature (Fig. 7). The results show that the previous winter season has a strong effect on temperature during the following seasons. At the same time, the winter mean temperature is not dependent on weather conditions during the previous seasons. There is a strong ($R>0.5$) positive correlation between the 1000 hPa temperatures at the TP in spring and in Eurasia during the previous winter (lag = 3 months). However, the spring temperature is not determined by the temperature of the previous autumn (lag=6) nor of the previous summer (lag=9). This means that not only the TP, but the whole Eurasia average spring temperature is highly controlled by the previous winter average temperature, which is responsible for more than 25% of the variability. Summer temperature at the TP has a strong positive correlation in the Baffin Bay region with the previous spring (lag=3), winter (lag=6) and autumn (lag=9). Autumn temperature at the TP has a strong negative correlation with the region between Greenland and Svalbard in the previous summer (lag=3). Winter temperature at the TP has a strong negative correlation in the Taimyr region in the previous summer (lag=6).

4 Discussion

There are vast areas in the Arctic far from the Baltic Sea region that show significant correlations with meteorological parameters at the TP. Temperature at the 1000 hPa level at the TP has a strong positive correlation (R>0.5) with the Eastern European Plain up to Central Siberia and a strong negative correlation with the Greenland region during all seasons except summer (Fig. 2). These patterns are similar to the correlations with the AO index (Fig. 3) and are probably partly induced by the general circulation of the atmosphere. These correlations can be considered as an effect of stronger westerlies that carry relatively warm and moist air from the North Atlantic into Eurasia and, at the same time, cold and dry air from the central Arctic to Greenland and the Canadian Arctic Archipelago. As specific humidity and temperature are strongly coupled, specific humidity has a similar pattern of correlations as temperature. Warmer air can hold much more water vapour. The exceptional summer season may be caused by a less effective large-scale circulation. Also, the circumstances are different in summertime: positive atmospheric energy budget, more specific humidity and clouds, the melting ice temperature is conserved by the melting energy of ice. Consequently, we assume that weather conditions in summer are more influenced by local factors, such as differences in local radiation and heat balances determined by local geographical peculiarities, and less affected by large-scale atmospheric circulation.

Partial correlation analyses were used as the control for the potential effects of different teleconnection indices on correlations between meteorological parameters at the TP and the Arctic. Partial correlations with the controlling factors of the AO and NAO indices had the strongest influence on the correlations between meteorological parameters between the TP and the Arctic region; other teleconnection indices had smaller influence. According to the review article by Bader et al. (2011), the NAO is the most important teleconnection index for investigating the impact of the Arctic sea-ice changes on teleconnection patterns. The study of Ambaum et al. (2001) suggests also that the NAO paradigm may be physically more relevant and robust for the Northern Hemisphere variability than is the AO paradigm. On the other hand, Thompson and Wallace (1998) declared that the AO index is actually more strongly coupled to the Eurasian winter surface air temperature than the NAO index. We analysed different meteorological parameters, including sea ice. Our results are more consistent with Thompson and Wallace – for the Baltic Sea region, the AO index mostly had the highest correlations in every season, only SLP in summer and autumn had a significantly stronger correlation with the NAO index.

The strongest teleconnections between the same parameter at the Baltic Sea region and the Arctic region can be found in winter, but they are clearly affected by the AO index. After the removal of the influence of the AO index, the correlations were below 0.5 in winter, while in other seasons there remained regions with strong correlations. It means that climatic teleconnections, i.e. significant spatial correlations of climatic parameters between regions located long distance from each other, in winter are mostly caused by large-scale atmospheric circulation described with the AO index.

5 Conclusions

Rapid warming and reduction of sea ice is going on in the Arctic. In this article, the relations between meteorological parameters of the Arctic region and the Baltic Sea region are investigated, using the NCEP-CFSR reanalysis data for 1979–2015. The Baltic Sea region is characterized by meteorological values at the testing point (TP) in southern Estonia (58N, 26E). To avoid false correlations, only the results that were present in both the regular and the detrended data were discussed.

There are vast areas in the Arctic, far from the Baltic Sea region, that show significant correlations with climatological parameters at the TP. The most spectacular findings about the Arctic teleconnections with the Baltic Sea region are as follows:

- The strongest teleconnections between the same parameter in the Baltic Sea region and the Arctic are in winter, but they are clearly affected by the Arctic Oscillation index (AO index). After removal of the AO index variability, correlations in winter were below 0.5, while in other seasons strong ($|R|>0.5$) correlations mostly remain.

- Strong teleconnections are present in temperature profiles from 1000 to 250 hPa. Similarly to the 1000 hPa level, teleconnections on higher levels are connected with the AO index variability in winter.
- Strong teleconnections are present between different climate variables at the TP and the Arctic. Temperature and wind speed at the 1000 hPa level in the Baltic Sea region have in all seasons strong teleconnections with the sea ice concentration in some regions of the Arctic Ocean. These teleconnections cannot be explained with the AO index variability.
- In all seasons there are strong teleconnections in temperature at 1000 hPa at the TP with some Arctic regions from the previous seasons. The most permanent lagged correlations in 1000 hPa temperature are in summer at the TP with the Baffin Bay region in the previous spring, winter and even autumn.

In conclusion, every season there are some regions in the Arctic that has strong teleconnection ($|R|>0.5$, $p < 0.002$) with temperature, specific humidity, wind speed and air pressure in the Baltic Sea region. These relationships can be explained by the AO/NAO index variability only in winter. In other seasons there has to be other influencing factors. Also, the previous season's weather in some Arctic regions has a statistically strong effect on the Baltic Sea region. Results of this study are valuable for selecting regions in the Arctic that have statistically the largest effect on climate in the Baltic Sea region.

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Table 1. Correlation coefficients between seasonal mean NAO and AO indices and meteorological parameters in the Baltic Sea region testing point (TP): temperature (t1000), specific humidity (q1000) and wind speed (s1000) at 1000 hPa and sea-level pressure (SLP). Statistically significant values (*p*<0.05) are marked with bold.

	NAO				AO			
	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF
t1000	0.31	**0.38**	0.15	**0.70**	**0.47**	**0.35**	**0.34**	**0.76**
q1000	0.01	–0.10	0.08	**0.71**	–0.02	–0.09	**0.32**	**0.80**
s1000	**0.34**	–0.27	–0.06	**0.73**	**0.57**	–0.13	0.22	**0.82**
SLP	0.15	**0.52**	**0.37**	**–0.51**	0.00	**0.33**	–0.06	**–0.48**

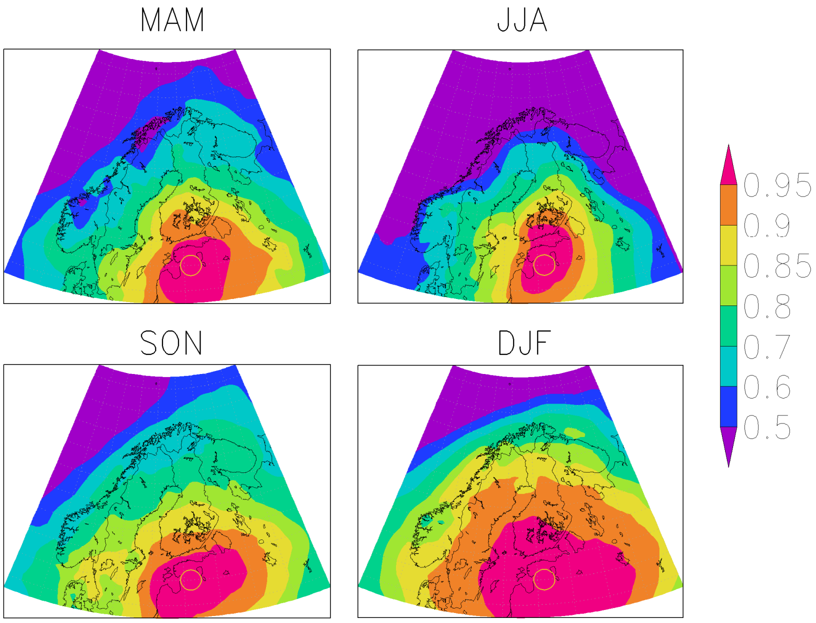

Figure 1: Correlation maps of air temperature on 1000 hPa level for the testing point in the Baltic Sea region.

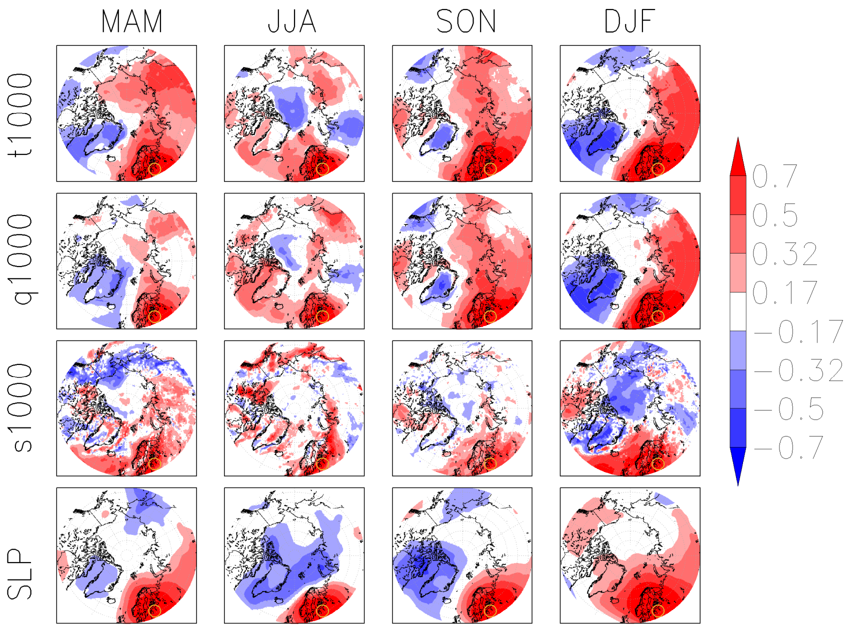

Figure 2: Correlation maps between seasonal mean 1000 hPa temperature (t1000), specific humidity (q1000), wind speed (s1000) and SLP measured at the TP (the yellow circle) and in the whole Arctic region. Columns represent seasons, shading levels ±0.17 and ±0.32 represent correlation significance at the confidence levels 68% and 95%. 330

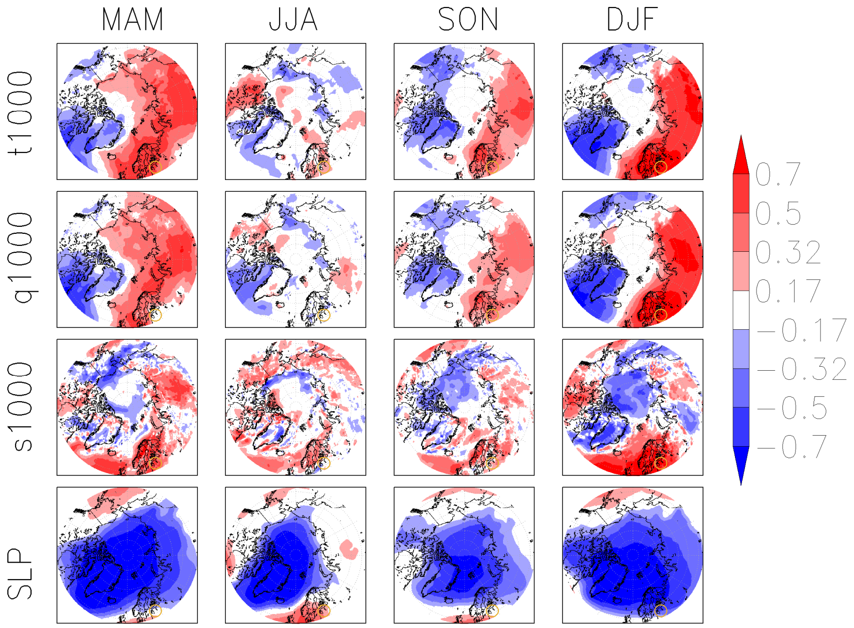

Figure 3: Correlation maps of seasonal mean AO index with 1000 hPa temperature (t1000), specific humidity (q1000), wind speed (s1000) and SLP. Columns represent seasons, shading levels ±0.17 and ±0.32 represent correlation significance at the confidence levels 68% and 95%.

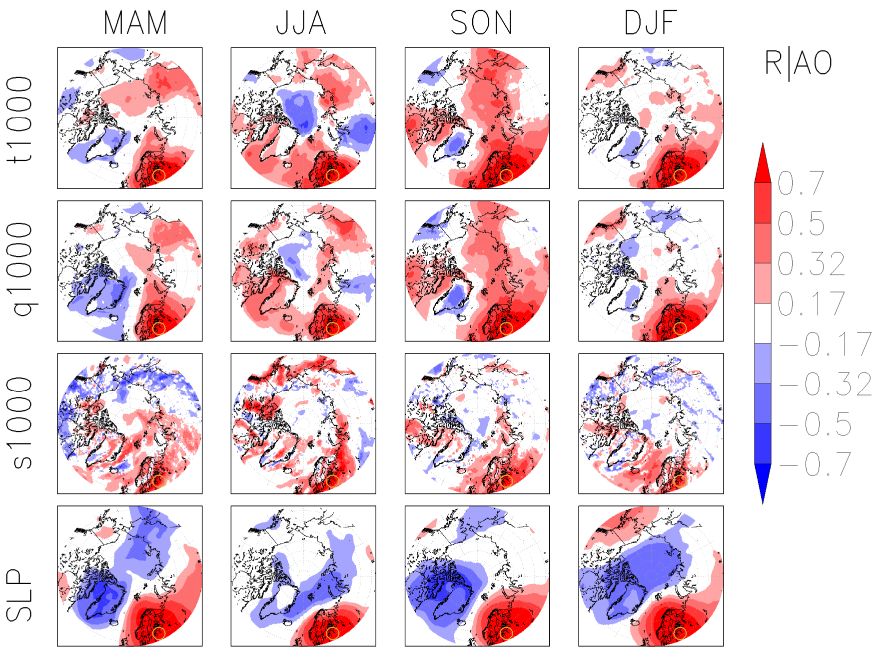

Figure 4: Partial correlation maps between seasonal mean 1000 hPa temperature (t1000), specific humidity (q1000), wind speed (s1000) and SLP measured at the TP (the yellow circle) and in the whole Arctic region while the controlling factor is the AO index. Columns represent seasons, shading levels ±0.17 and ±0.32 represent correlation significance at the confidence levels 68% and 95%.

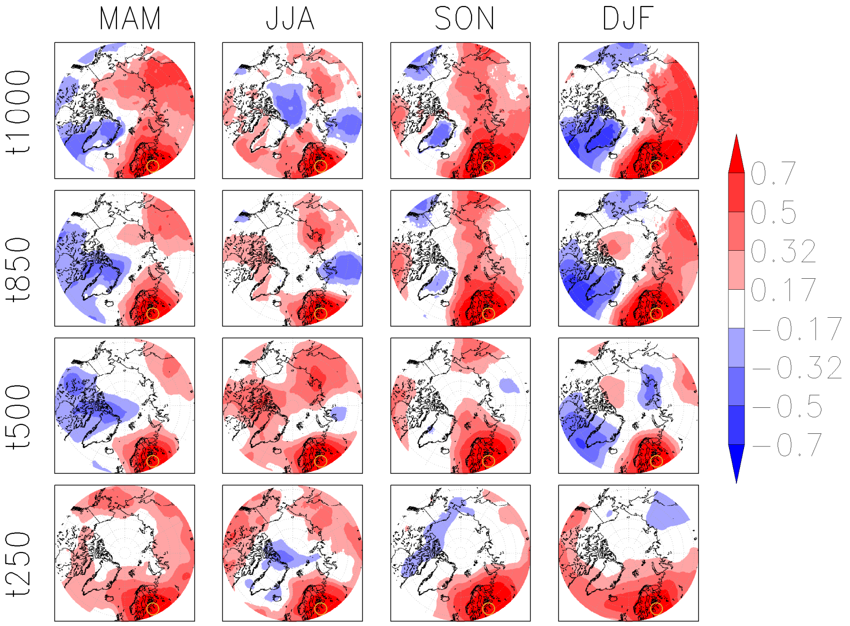

Figure 5: Correlation maps between seasonal mean temperature on the 1000 hPa, 850 hPa, 500 hPa and 250 hPa levels measured at the TP (the yellow circle) and in the whole Arctic region. Columns represent seasons, shading levels ±0.17 and ±0.32 represent correlation significance at the confidence levels 68% and 95%.

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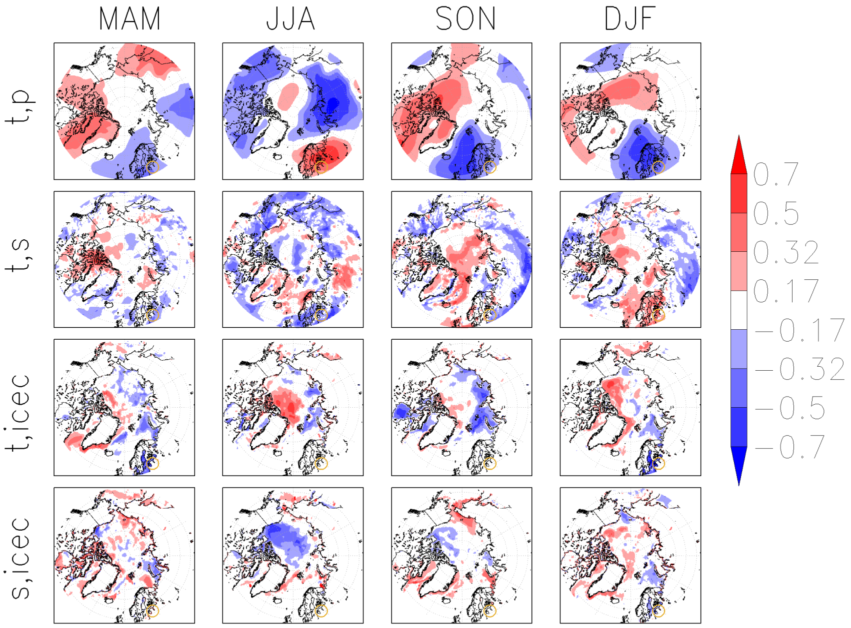
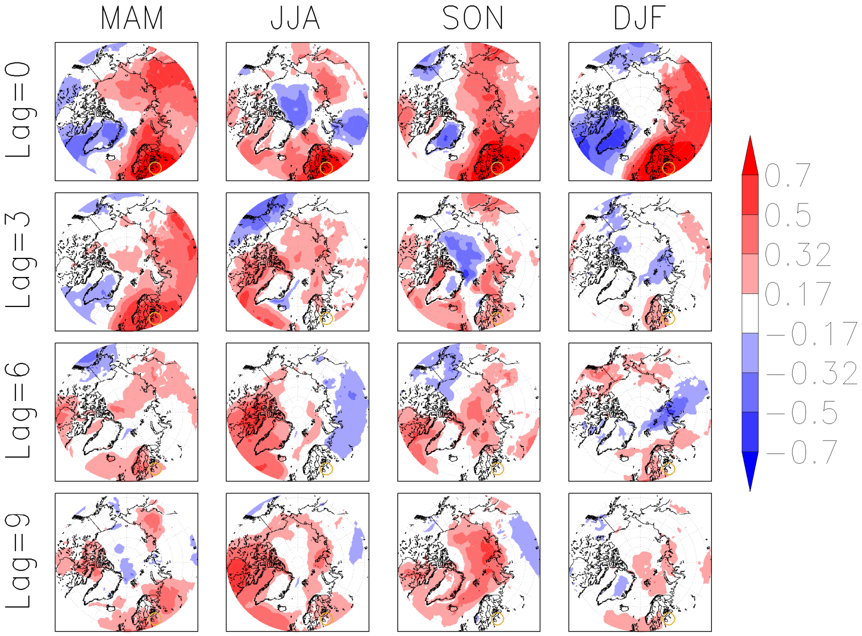


345 **Figure 6: Correlation maps between seasonal mean values measured at the TP (the yellow circle) and in the whole Arctic region. 1. row: temperature on the 1000 hPa level at the TP and SLP; 2. row: temperature on the 1000 hPa level at the TP and wind speed on the 1000 hPa; 3. row: temperature on the 1000 hPa level at the TP and sea ice concentration; 4. row: wind speed on the 1000 hPa level at the TP and sea ice concentration. Columns represent seasons, shading levels ±0.17 and ±0.32 represent correlation significance at the confidence levels 68% and 95%.**



350 **Figure 7: Lagged correlation maps between the TP (the yellow circle) and Arctic 1000 hPa temperature: 1. row: lag is 0 months (no lag); 2. row: lag is 3 months; 3. row: lag is 6 months; 4. row: lag is 9 months. Columns represent seasons shading levels ±0.17 and ±0.32 represent correlation significance at confidence levels 68% and 95%.**