Тринадцатая сессия Климатического форума стран СНГ
по сезонным прогнозам (СЕАКОФ-13)

О предсказуемости межгодовой изменчивости климата в Арктике

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On predictability of interannual climate variability in the Arctic

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Moscow
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OUTLINE

- Роль меридионального атмосферного и океанского переноса в формировании межгодовой изменчивости климата в Арктике;
- The role of meridional atmospheric and ocean transport in the formation of Interannual variability of climate in the Arctic

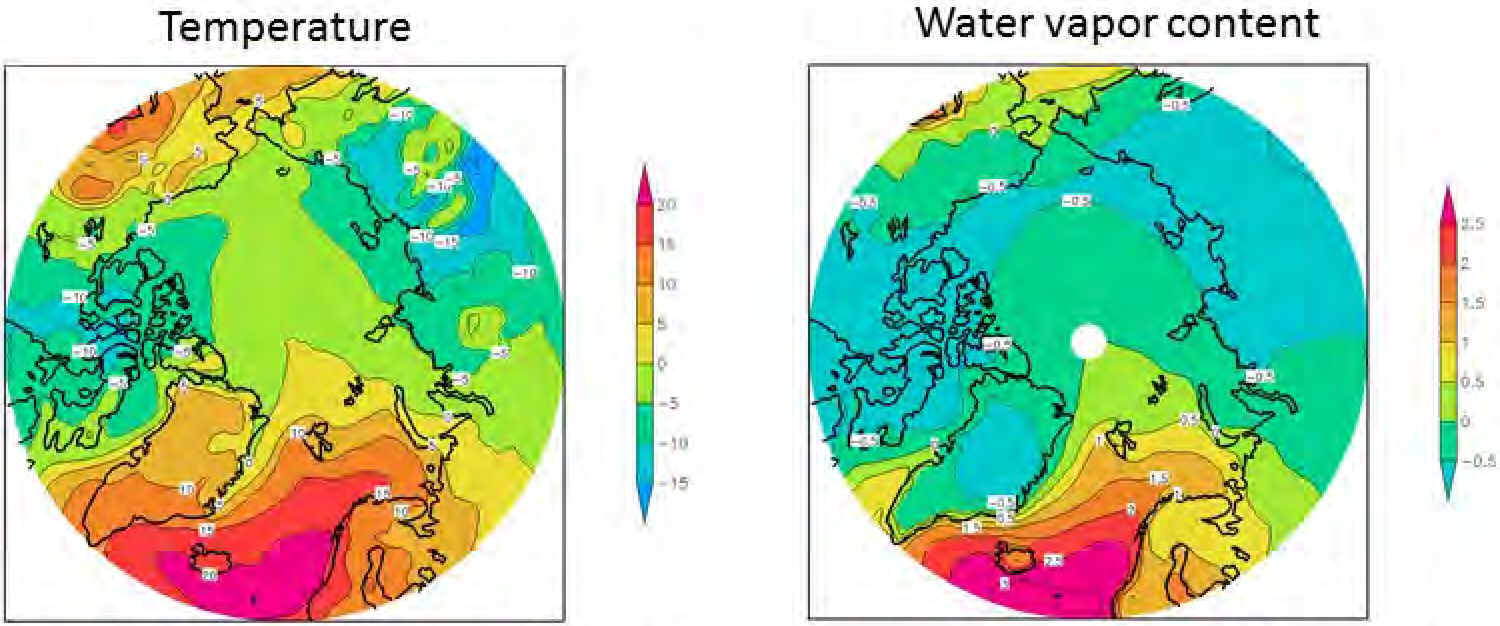
- Удаленное влияние ТПО в низких широтах океана на переносы тепла в Арктику
- Remote influence of SST in the low latitudes on the heat transport to the Arctic

- Предсказуемость колебаний климата Арктики в связи с удаленным влиянием
- Predictability of Arctic climate variations due to remote impact

Роль атмосферного переноса тепла и влаги
The role of atmospheric transport of heat and moisture

Calculation of the meridional atmospheric heat transport (MAHT) on base ERA/Interim data (Dee et al., 2011) for the 1979-2014 shows two regions corresponded to pars of 70ºN circle across which the heat and moisture enter 70-90ºN area.

Atlantic (0-80E) and Pacific (200-230E) "gates" for MAHT into 70-90°N area

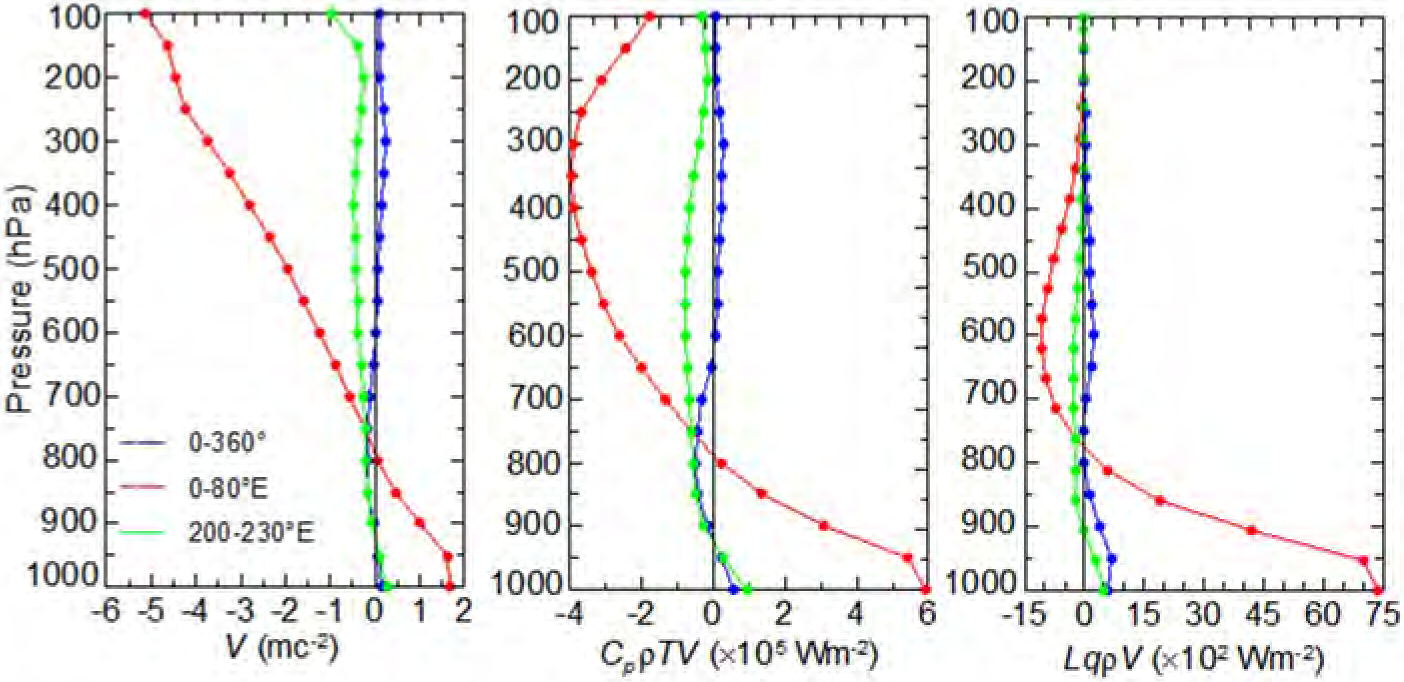


Temperature

Water vapor content

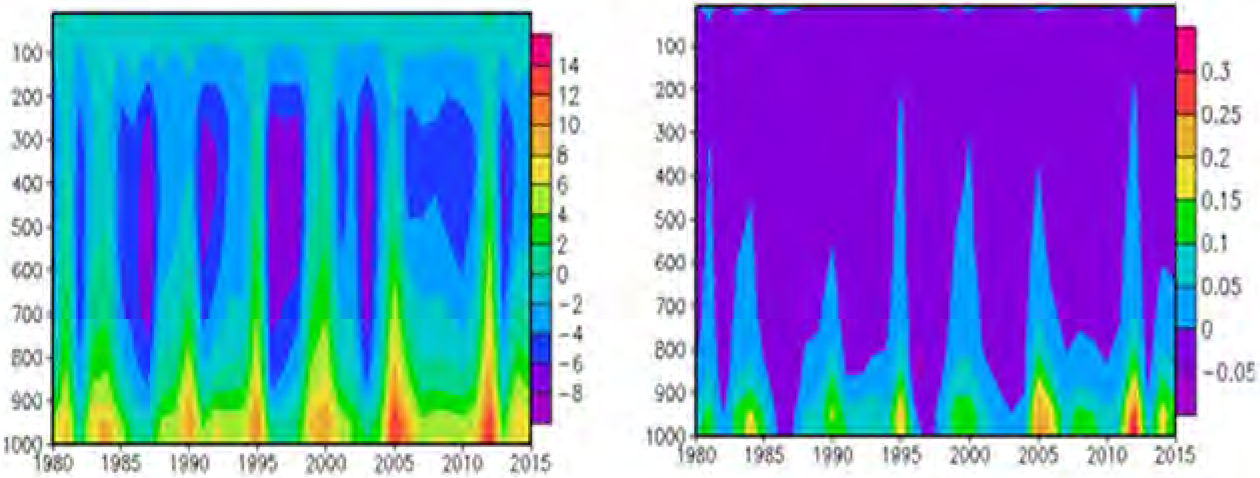
Anomalies of mean air temperature and water vapor content at 1000 hPa in January for 1979-2014

The vertical profiles of V, J_T, J_Q averaged along 70° N, Atlantic and Pacific “gates’ in winter (DJF)

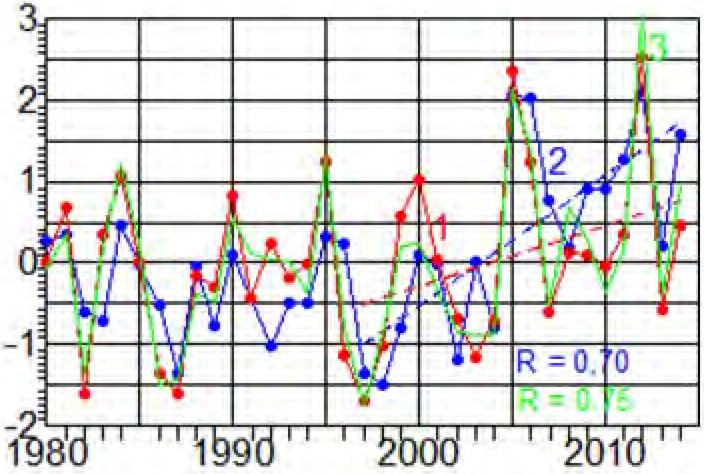


Profiles show that the average atmospheric inflows of sensible and latent heat through the 70°N concentrate in the lower layers of the atmosphere (up to 750 hPa) and their main part passes into the high latitude Arctic through the Atlantic "gate"

Winter MAHT into the Arctic across Atlantic “gate” includes a rise during 1979-2014 and varies significantly with 5-7 year cyclicity

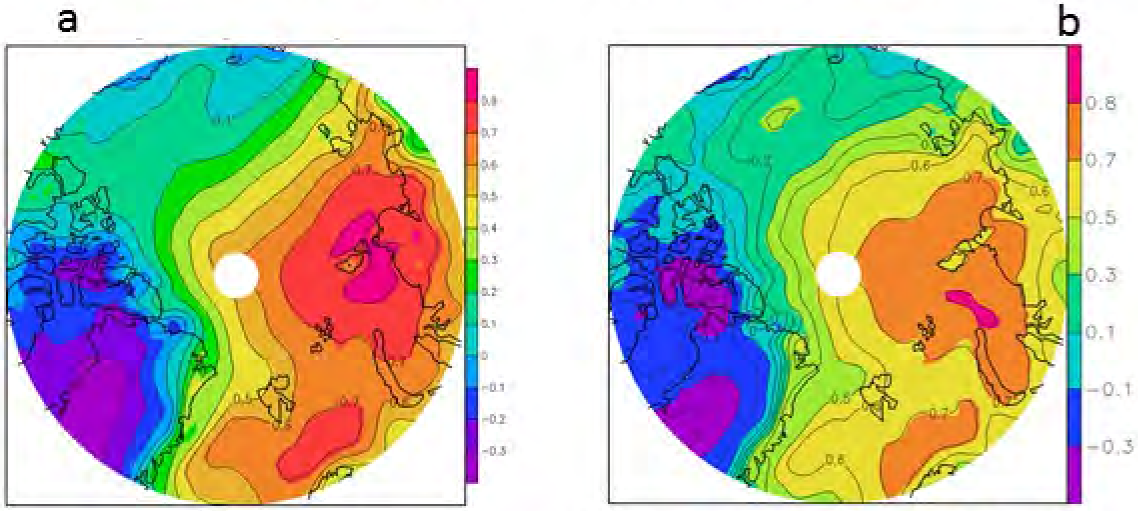


Winter MAHT of sensible (a, 10^5 Wm^{-2}) and latent (b, 10^5 Wm^{-2}) heat across Atlantic “gate”

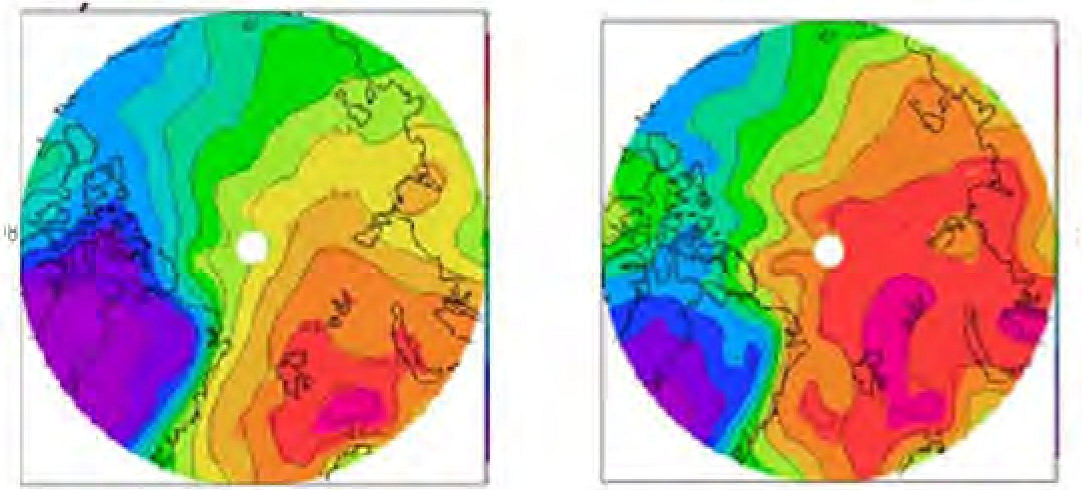


Standardized values of averaged winter SAT in 70-90°N area (1), MAHT of sensible (2) and latent (3) heat across Atlantic “gates” at 1000 hPa. R – correlation between SAT and MAHT.

The spatial distribution of the impact of heat influx through the Atlantic "gate" on the winter air temperature in the Arctic

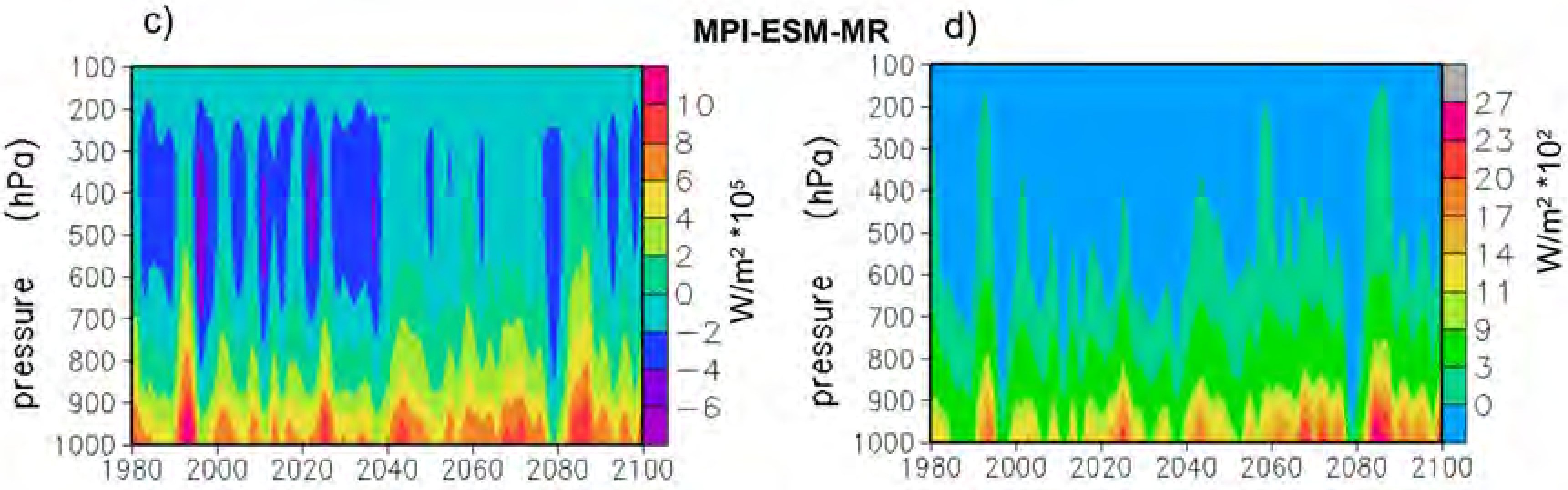


Correlation between winter MAHT of sensible (a) and latent (b) heat and SAT at 1000 gPa



The same for MAHT and SAT calculated from MPI-ESM-MR model simulations data in CMIP5

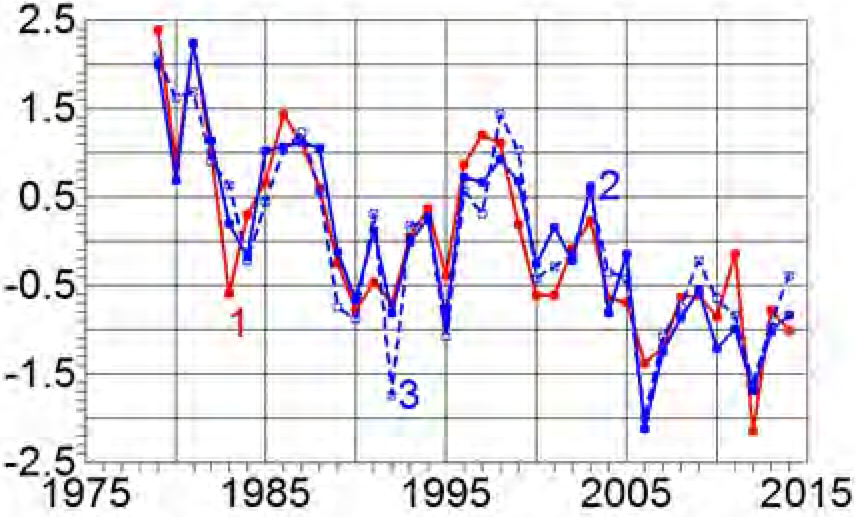
The model data from experiment with RCP8.5 emission scenario for 1980-2100 showed the increase of atmospheric heat transport to the Arctic across the Atlantic “gate” in accordance with the growth of projected air temperature in the Arctic



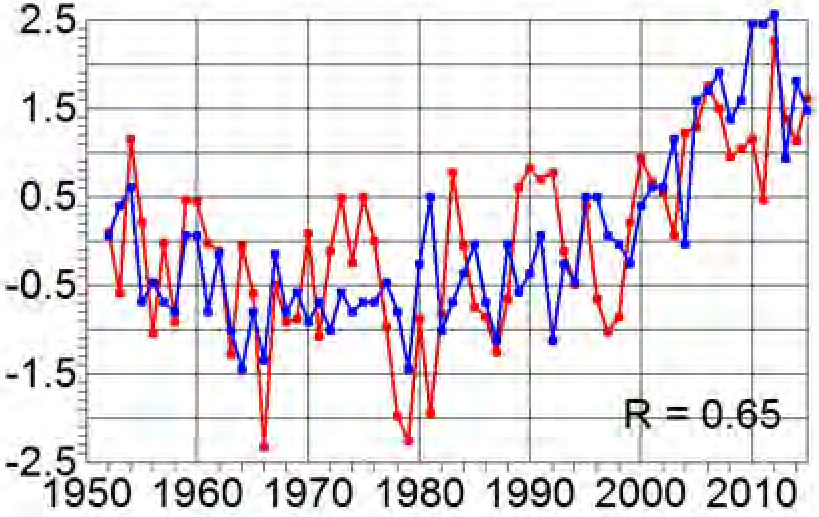
Winter MAHT of sensible (c) and latent (d) heat across Atlantic “gate” at the different isobaric levels cflculated on base the MPI-ESM-MR model data with RCP8.5 emission scenario up to 2100

The role of meridional ocean transport

Interannual changes in ocean heat transport from the North Atlantic are reflected in fluctuations in water temperature in the Kola meridian section in the Barents Sea, data on which have been available since 1901 (average for the year) and since 1951 (average for the month). We use this data to compare with the interannual changes in the sea ice extent in the Arctic and in the Barents Sea and the air temperature in the marine Arctic



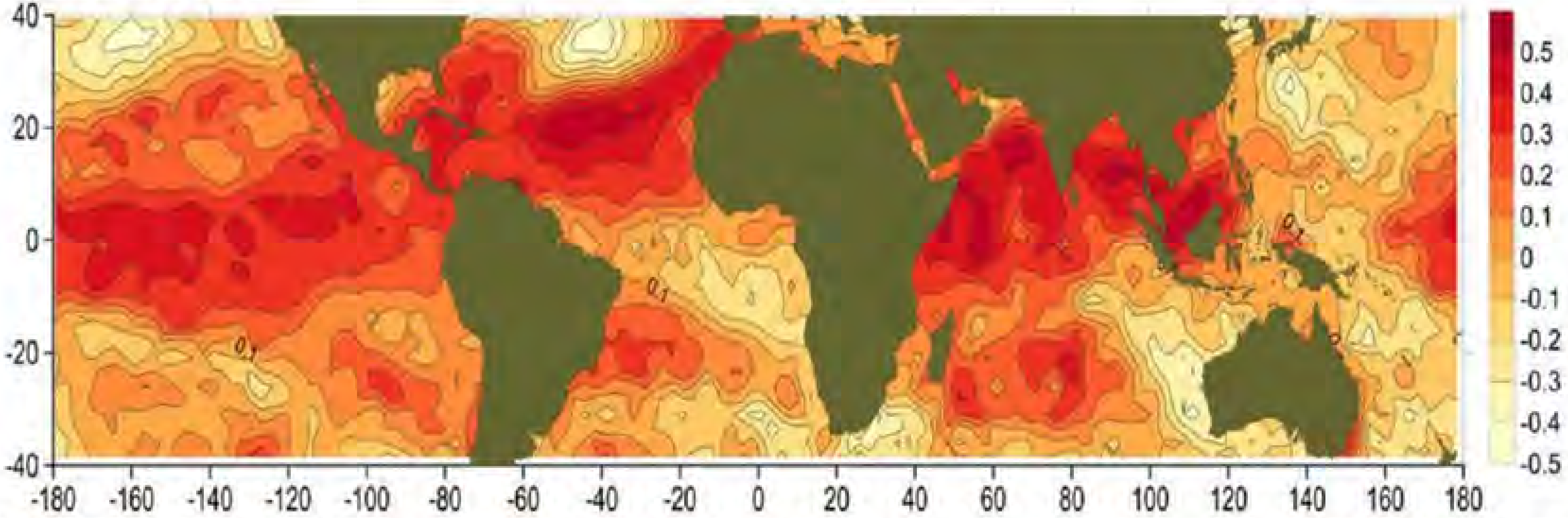
Normalized values of water temperature at the Kola section (1), PML in the Arctic (2) and in the Barents Sea (3) in May. The correlation coefficient between (1) and (2) is -0.92 (-0.83), between (1) and (3) is -0.87 (-0.76). Sign of water temperature anomaly was changed



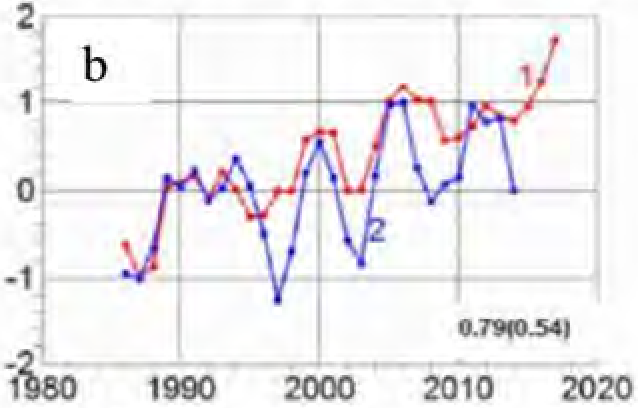
The normalized values of the average for a year water temperature on the Kola section (1) and air temperature in the marine Arctic (2). R is the correlation coefficient between (1) and (2)

Remote influence of SST in the low latitudes on the heat transport to the Arctic

To inspect an assumption about remote influence of SST on transport the area and month with maximal correlation between SST and winter MAHT, as well as the respective lag were found for the each ocean



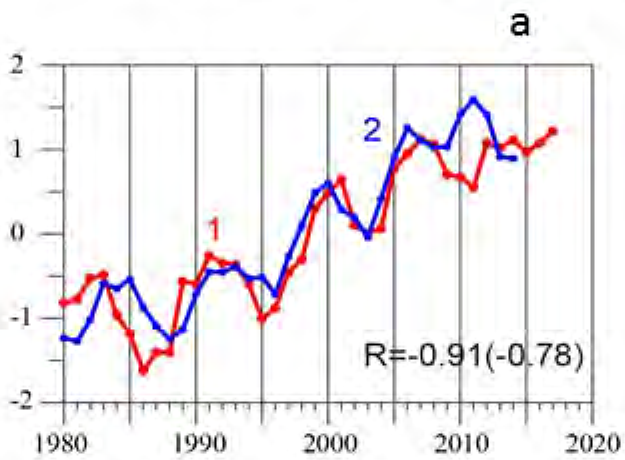
Correlation coefficients between SST anomalies in October in low latitude areas of the Pacific, Atlantic and Indian oceans and anomalies of winter MAHT with a 27-month lag



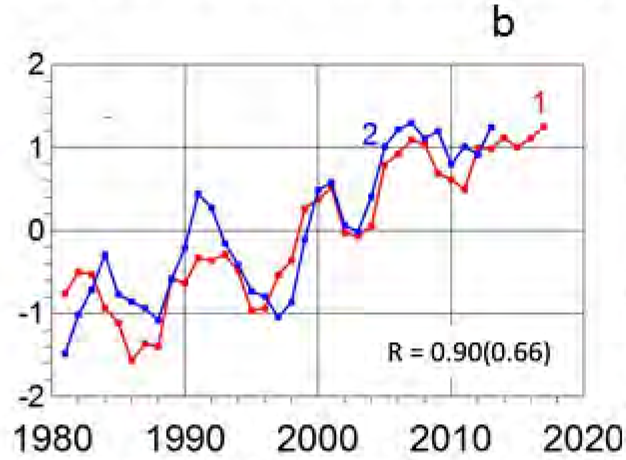
Anomalies is normalized and smoothed with a 3- year window

b – SSTA in the Atlantic, Indian, Pacific Oceans in October and winter MAHT after 27 months

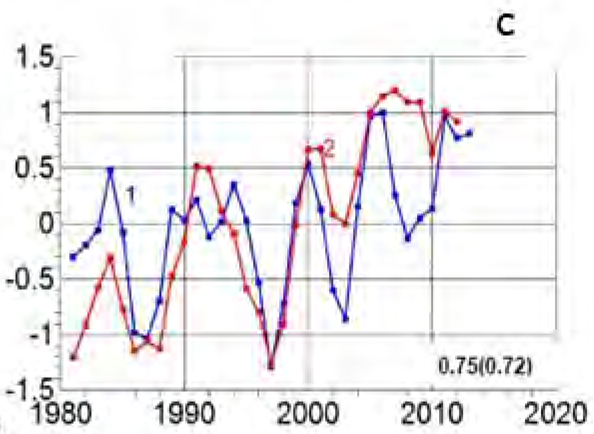
Examples of the influence of SST anomalies in the low latitudes of the North Atlantic on sea ice and water temperature in the Arctic



a - SSTA in October (1) and December SIE (2) over 38 months.

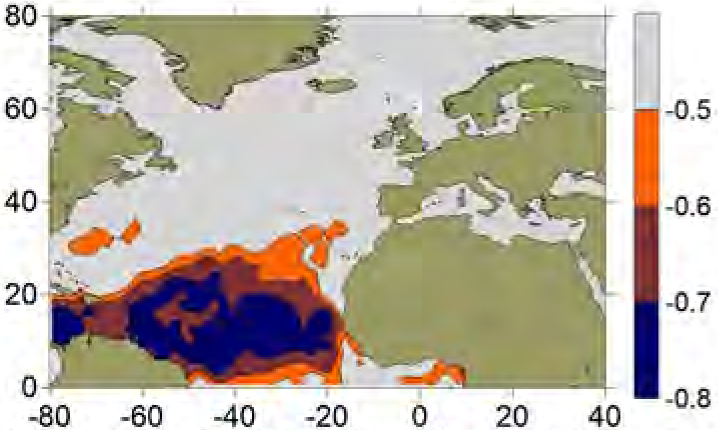


b - SSTA in October (1) and the water temperature at Kola section in January-February (2) over 27 months



c – normalized winter MAHT (1) and winter water temperature at Kola section (2)

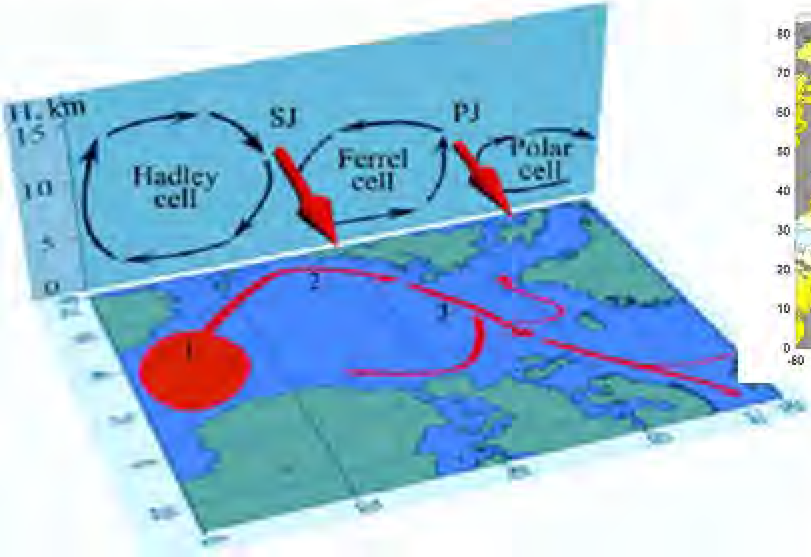
All series were smoothed by 3 years averaging. In brackets is correlation between detrended series.



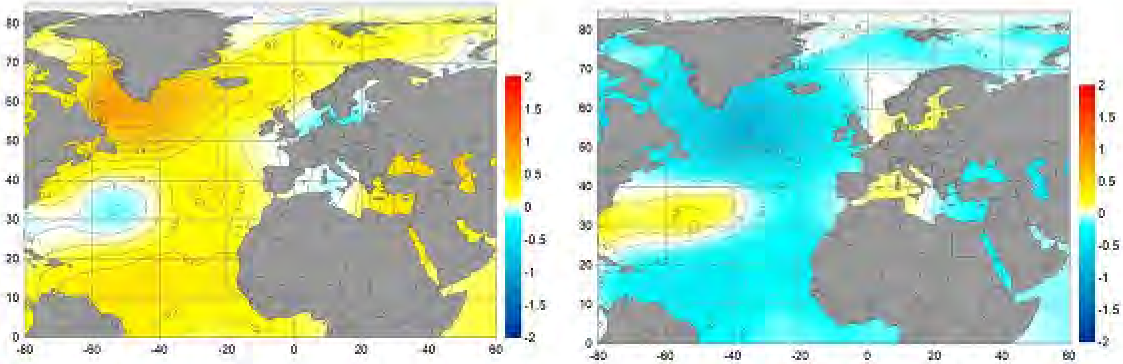
Area in the low latitudes of the North Atlantic. Correlation between SSTA and SIE in (a)

Haw influence of SSTA in low latitudes transferred to the Arctic

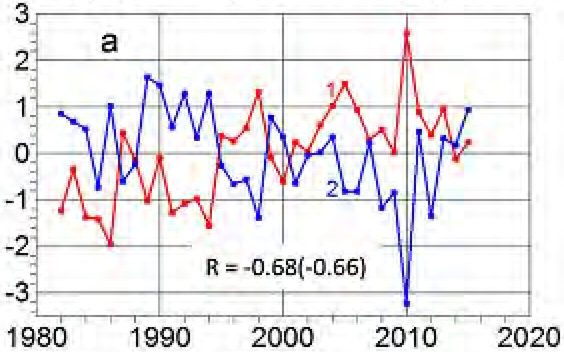
It is assumed that SST anomalies at low latitudes intensify the Hadley and Ferrell atmospheric circulation cells , reflecting the increase of meridional atmospheric circulation, weaken the NAO, that reduces the heat losses by the ocean and all this together increases the oceanic heat transfer by system including the Gulf Stream, Atlantic, West Spitsbergen and Norwegian currents



The scheme of the SST anomaly effect on the Arctic. 1 – SST anomaly, 2 – Gulfstream, 3 – North Atlantic, Norwegian and West Spitsbergen currents, SJ – Subtropical jet, PJ – polar jet.

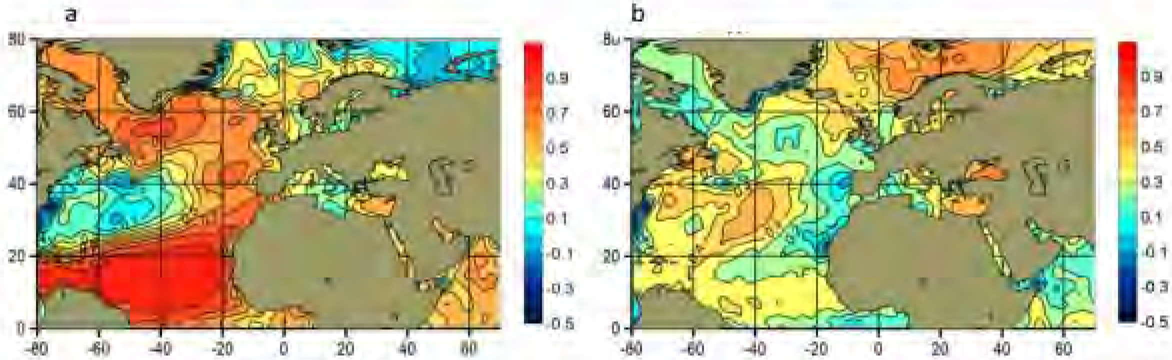


Composites of anomalies annual SST under strong negative (a) and positive (b) annual NAO



Series of normalized annual SST in the Atlantic (1) and annual NAO (2) anomalies

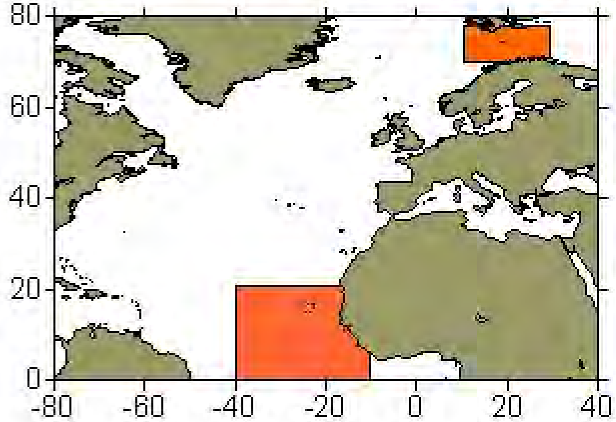
Positive anomaly SST to north 40°N that correspond to positive SST anomaly in low latitudes of the North Atlantic and negative NAO index appears through 3 years in the Norwegian and Barents sea



Correlation between annual SSTA in low latitudes and in whole area of the North Atlantic for 1980-2015. a – timed correlation; b – over 3 years

The mechanism of remote influence of SST anomalies to the Arctic includes interaction between atmospheric and oceanic circulation modes that drive the heat transport to high latitudes. Thus, the predictability of interannual variability of climate in the Arctic follows from its dependence on fluctuations in the influx of atmospheric and oceanic heat from low latitudes. Participation of the ocean circulation leads to a delay in the response of climate characteristics on the SSTA in low latitudes for several years.

The example of predictability: SIE in the Barents Sea

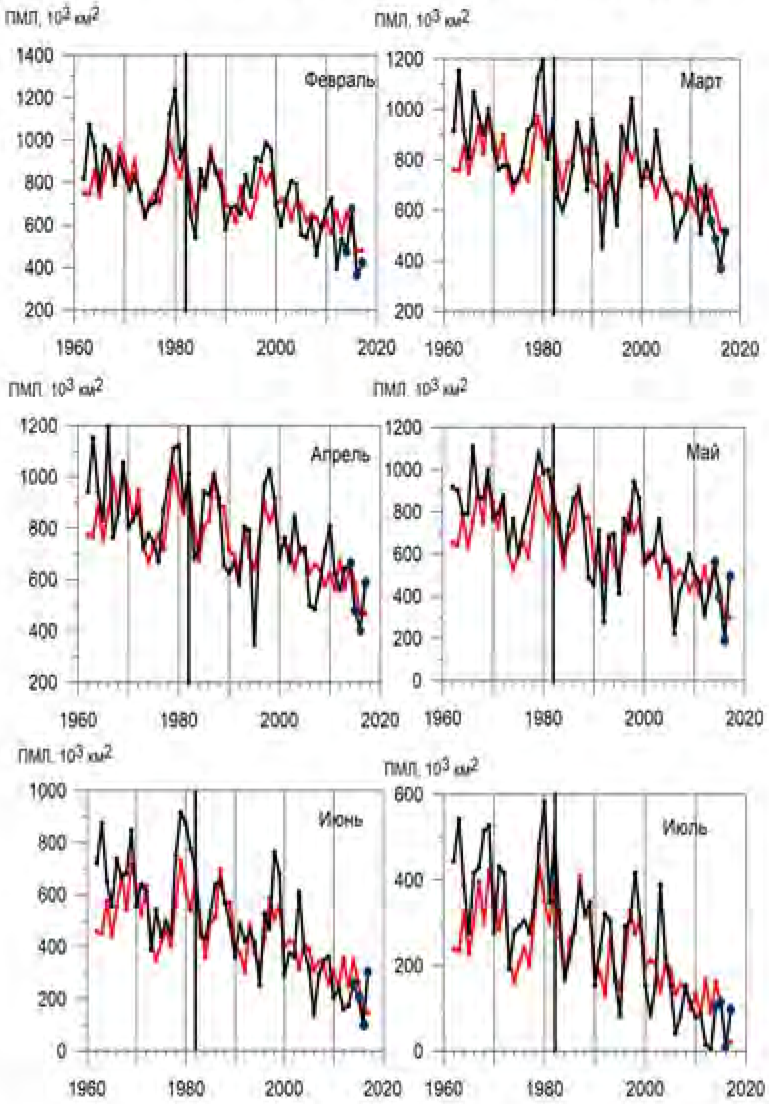


Justification of the forecast for 1982-2013 (%)
(cross-validation method)

II	III	IV	V	VI	VII
83	77	80	81	90	87

Justification of the forecast for 1962-1981(%)
(by independent data)

II	III	IV	V	VI	VII
90	70	75	70	60	75



Forecast SIE in the Barents Sea from February to July
with a lead time of 10 to 15 months

Publications

- G. V. Alekseev, S. I. Kuzmina, A. V. Urazgildeeva, L. P. Bobylev. Impact of atmospheric heat and moisture transport on Arctic warming in winter. Fundamental and Applied Climatology. 2016, v1, p 43–63 (in Russian).
- G. V. Alekseev, S. I. Kuzmina, N.Glok. Influence of water temperature anomalies in the low latitudes of the ocean on the atmospheric transport of heat to the Arctic. Fundamental and Applied Climatology. 2017, №1, p. 106-123 (in Russian).
- G. V. Alekseev, S. I. Kuzmina, , L. P. Bobylev, A. V. Urazgildeeva, N.V. Gnatuk. Influence of the atmospheric heat and moisture transport on summer warming in the Arctic. Problemi Arctici i Antarctici, 2017, N3, 67-68 (in Russian).
- Blue book 2017 issue at the WGNE web-site http://wgne.meteoinfo.ru/ (In English)
- Alekseev G.V., Glok N.I., Smirnov A.V., and Vyazilova A.E. The Influence of the North Atlantic on Climate Variations in the Barents Sea and Their Predictability // Russian Meteorology and Hydrology. 2016. Vol.41 . No.8. P. 544–558. Allerton Press Inc., 2016.
- Alekseev G.V., Kuzmina S.I., Glock N.I., Vyazilova A.E., Ivanov N.E., Smirnov A.V. The influence of the Atlantic on the warming and reduction of the sea ice cover in the Arctic. Ice and Snow. 2017; 57 (3): 381-390.