INFLUENCE OF ATMOSPHERIC HEAT TRANSPORT ON AMPLIFICATION OF WINTER WARMING IN THE ARCTIC

Genrikh Alekseev[1)], Svetlana Kuzmina[2)], Aleksandra Urazgildeeva[3)] and Leonid Bobylev[2)]

[1] Arctic and Antarctic Research Institute (alexgv@aari.ru), [2] Nansen Centre, [3] St. Petersburg State University St. Petersburg, Russian Federation

Assessments of the energy budget show that the main part of incoming energy into the Arctic in winter enters with meridional atmospheric heat transport (MAHT) (Nakamura, Oort, 1988). However, global climate model simulations and calculations from reanalysis data indicate that MAHT has lesser importance than local feedbacks for explaining the Arctic amplification (Hwang et al., 2011). The objective of our investigation is to establish the link between the amplified winter warming in the high Arctic and the MAHT across 70 ° N.

Data from ERA/Interim (Dee et al., 2011) for 1979-2014 were used. The data included monthly air temperature, water vapor content, meridional component of the wind at grid points 1°×1° from 1000 to 100 hPa spaced-apart 50 hPa. The total values of meridional transport of heat and moisture through a unit vertical from the surface to 10 hPa and integral from the surface to 10 hPa water vapor content in each grid point were also used. The calculations of MAHT into 70°-90°N area based on the formulas presented in (Nakamura, Oort, 1988).

The total meridional atmospheric transport of sensible heat across the 70°N "wall" calculated from vertically integrated MAHT values in every grid point in ERA/Interim area is uncorrelated with mean air temperature in 70-90^{0}N area in every month. The total MAHT of latent heat correlates with the air temperature in winter months only. To understand the lack of correlation we construct the spatial distribution of anomalies of monthly mean air temperature and water vapor content at isobaric surfaces averaged for 1979-2014, which show two regions with maximal anomalies. These regions corresponded to the parts of the 70^{0}N circle across which the heat and moisture enter the 70-90^{0}N area. We referred to these parts as Atlantic (0-80^{0}E) and Pacific (200-230°E) "gates" [Alekseev et al., 2016]. Further, we estimated and analyzed MAHT across these "gates" for sensible (J_T) and latent (J_Q) heat fluxes across unit normal area at every isobaric surface as

$(JT)pgk = (C_p\rho\langle TV\rangle)pgk$ and $(JQ)pgk = (L\rho\langle QV\rangle)pgk$,

where C_p =1005 J(kgK)$^{-1}$; L = 2.50×10^{6}Jkg^{-1}; ρ is the air density, kgm^{-3}; Q is the water vapor content (kgkg^{-1}); V is the meridional wind, mc^{-1}; p denotes the isobaric surface, g is for year, m is month, and k = 1 or 2 for 0-80°E and 200-230°E, respectively.

Figure 1 shows the vertical profiles of V, JT , and JQ averaged along 70^0 N (blue), the Atlantic region (red), and the Pacific region (green). Winter MAHTs across 70°N into the Arctic take place up to 750 hPa and mainly through the Atlantic "gate". They show a positive transport's trend, 5-7 years cyclicity (Fig.2) and correlate with mean surface air temperature (SAT) in the 70-90°N area (Fig.3). MAHTs across the Atlantic "gate" influence the winter SAT at most part of the 70-90°N area with maximum at the Barents and Kara Seas (Fig. 4,a). The same correlation pattern results from ECHAM model control experiment data in CMIP5 (Fig.4,b) (Taylor et.al, 2012).

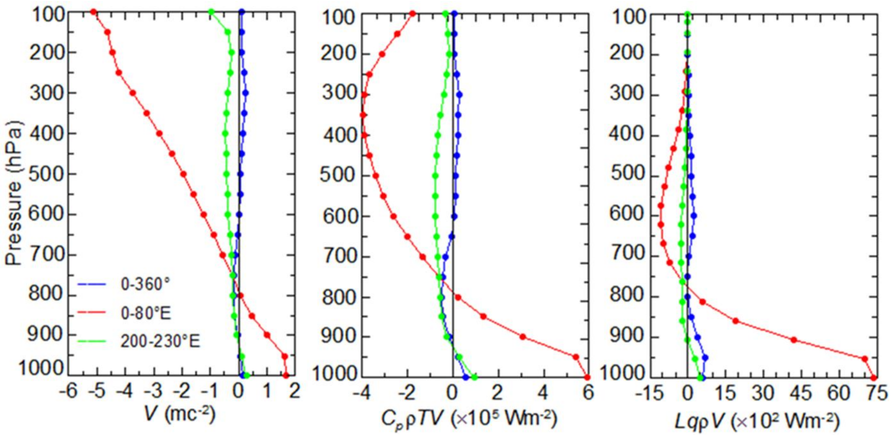

Figure 1. Vertical profiles of the meridional velocity wind component (a); the transport of sensible (b) and latent (c) heat averaged along 70N (blue), the Atlantic region (red), and the Pacific region (green).

p

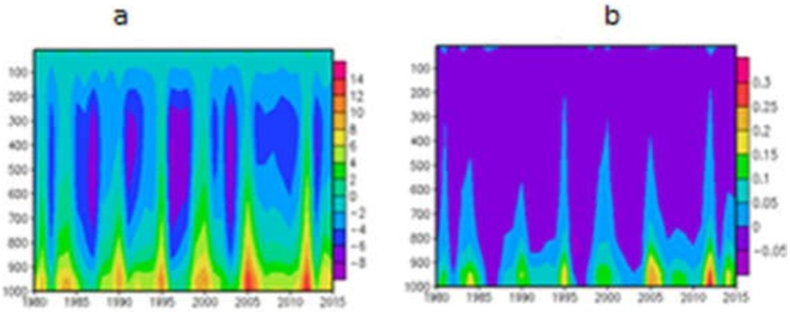

Figure 2. Winter MAHT of sensible (a, 10^5 Wm^{-2}) and latent (b, 10^5 Wm^{-2}) heat across the Atlantic "gate".

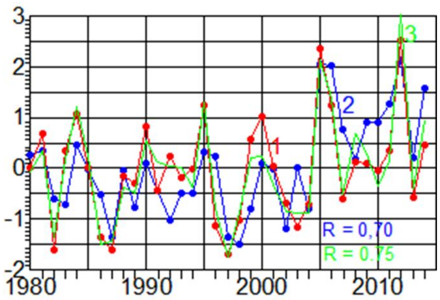

Figure 3. Standardized values of winter SAT in 70-90^{0}N (1), MAHT of sensible (2) and latent (3) heat across Atlantic "gate" at 1000 hPa surface. R are correlation coefficients between SAT and MAHTs.

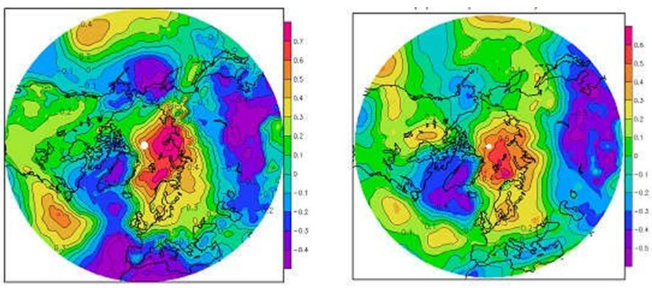

Figure 4. Pattern of correlation coefficients between winter sensible MAHT through Atlantic "gate" at 1000 hPa and winter SAT calculated on base of ERA-Interim 1980-2015 data (a) and control experiment data of ECHAM model from CMIP5.

This study is supported by RFBR grant 15-05-03512.

References

Alekseev G.V., 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, vol. 1, p. 43–63 (in Russian).

Dee,D. P., and 35 co-authors. 2011. The ERA-Interim reanalysis: Configuration and performance of the data assimilation system. - Quart. J. R. Meteorol. Soc., vol. 137, № 656, 553-597 p.

Hwang, Y.-T., Frierson D. M. W., Kay J. E. 2011. Coupling between Arctic feedbacks and changes in poleward energy transport. – Geophys. Res. Lett., vol. 38.

Nakamura, N., and A. H. Oort (1988), Atmospheric heat budgets of the polar regions, J. Geophys. Res., 93(D8), 9510 – 9524.

Taylor, K.E., R.J. Stouffer, G.A. Meehl: An Overview of CMIP5 and the experiment design." Bull. Amer. Meteor. Soc., **93**, 485-498, 2012.