Analysis of relationship between the Arctic climate and intensity of thermohaline circulation from model simulations

Mokhov I.I.[1], Artamonov A.Yu. [1,2], Bezverkhny V.A.[1], Karpenko A.A. [1], Muryshev K.E. [1,2], Khon V.Ch. [1], Roeckner E.[3]

[1]A.M. Obukhov Institute of Atmospheric Physics RAS, Moscow, Russia
[2]Moscow Institute for Physics and Technology, Russia
[3]Max-Planck Institute for Meteorology, Hamburg, Germany
mokhov@ifaran.ru

Relationships between intensity of thermohaline circulation I_{THC} in the North Atlantic and Arctic climate characteristics are studied. The analysis is based on the ECHAM5/MPI-OM general circulation model simulations (Marsland et al., 2003; Roeckner et al., 2003) with the SRES B1 scenario (IPCC, 2001) for 2001–2100 and with the greenhouse gases concentrations in the atmosphere (GHG) from observations for 1860–2000. Different methods are used including two methods of cross-wavelet analysis (CWA): CWA-1 (Bezverkhny, 2001; Mokhov et al., 2005) and CWA-2 (Jevrejeva et al., 2003; Grinsted et al., 2004).

Figure 1 shows coefficients of correlation r between the I_{THC} and averaged over the Arctic and sub-Arctic latitudes (60-90N) surface air temperature T_A (a), salinity S_A (b) and total sea ice area in the Arctic Ocean I_A (c) for 100-year moving intervals. According to Fig.1 correlation between I_{THC} and S_A is always positive with a general increase from about 0.2÷0.35 in the 19th-20th to about 0.7 and later decrease to 0.6 in the 21st century. Correlation between I_{THC} and T_A changes the sign from the relatively low positive values to the negative values growing by absolute value and then stabilizing at the level about -0.65. The correlation between I_{THC} and I_A is almost symmetric relative 0 in comparison to the correlation between I_{THC} and T_A. It is related to the strong negative correlation between T_A and I_A with the increase of r from about -0.8 in the 19th-20th centuries to about –(0.98÷0.99) in the 21st century. Correlation between I_{THC} and Siberian rivers runoff was also analyzed but this correlation is quite weak with maximum r about 0.2 by absolute value.

Corresponding correlation analysis with shorter moving intervals (with 50- and 30-year moving intervals, in particular) shows more unsteady evolution of relationships. Even more complicated dynamics of relationships displays CWA. Coherency of I_{THC} and S_A is different for various periods and changes essentially in time. In particular, significant changes were noted for coherency and phase lags between I_{THC} and S_A for variations with periods about 20-50 years at the end of the 20th century and in the 21st century (especially in its first half) both with CWA-1 and CWA-2. Differences were obtained for variations with periods larger and smaller than 20-30 years.

According to this analysis phase lags between I_{THC} and characteristics of the Arctic climate can be of different sign for various periods of variations. In particular, it was noted that variations of T_A can lead variations of I_{THC} at periods about 30 years while can lag at periods about 60 years.

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Figure 1. Coefficients of correlation between THC intensity I_{THC} and climate characteristics for the Arctic region (60-90N) (for 100-year moving intervals): surface air temperature T_A (a), salinity S_A (b) and sea ice area I_A (c). Horizontal lines show minimum values of coefficients of correlation necessary for statistical significance at the 90, 95 and 99% level.