Sensitivity of the surface air temperature in different NH latitudes to changes in anthropogenic forcing and natural climate modes

Mokhov I.I.[1,2], Smirnov D.A.[3]

[1]A.M. Obukhov Institute of Atmospheric Physics RAS, Moscow, mokhov@ifaran.ru
[2]Lomonosov Moscow State University, Moscow
[3]Saratov Branch of V.A. Kotel'nikov Institute of RadioEngineering and Electronics RAS, Saratov, smirnovda@yandex.ru

Estimates of the sensitivity of the surface air temperature in different latitudinal belts of the Northern Hemisphere (NH) to the radiative forcing of greenhouse gases (GHG) and changes in the modes of natural climatic variability, including the Atlantic Multidecadal Oscillation (AMO) and El-Nino / Southern Oscillation (ENSO), have been obtained similarly to [1-3] (see also [4,5]). Three-component autoregressive (AR) models were used for surface temperature anomalies T with a year lag:

$$T_n = a_0 + a_1 T_{n-1} + a_2 I_{GHG,\mathrm{n-1}} + a_3 I_{m,\mathrm{n-1}} + \xi_n. \qquad (1)$$

Here n is the discrete time (years), ξ_n is the noise (residual model errors), I_{GHG} is the radiative forcing of greenhouse gases, a_0, a_2, and a_3 are the model coefficients, $I_{m,\mathrm{n-1}}$ is the climate mode index (AMO or ENSO).

Table 1. The coefficients (with the doubled standard deviations Δ) of empirical models (1) for different latitudinal belts in the Northern Hemisphere.

Northern Hemisphere degrees of latitude	Coefficients of empirical models (1)			
	AMO		ENSO	
	$a_2 \pm \Delta a_2$ $K{\cdot}W^{-1}{\cdot}m^2$	$a_3 \pm \Delta a_3$	$a_2 \pm \Delta a_2$ $K{\cdot}W^{-1}{\cdot}m^2$	$a_3 \pm \Delta a_3$
60 – 90	0.35±0.10	0.70±0.50	0.30±0.10	0.09±0.12
30–60	0.21±0.06	0.44±0.25	0.16±0.05	0.03±0.05
0 – 30	0.15±0.05	0.23±0.20	0.14±0.05	0.04±0.05

The estimates of the coefficients of the model (1) characterizing the sensitivity of temperature anomalies in different latitudinal belts to changes of I_{GHG} and I_m for the period 1880-2012 are given in Table 1. The analysis used annual long-term data for surface temperature for different latitudinal belts (ftp://ftp.ncdc.noaa.gov/pub/data/). To characterize the key modes of natural climatic variability, we used the AMO index (http://www.esrl.noaa.gov/psd/data/) and ENSO index Nino 3.4 (http://www.esrl.noaa.gov/psd/data/).

Estimates of the coefficients in Table 1 are statistically significant at the 95% level if they exceed the doubled standard deviation. According to them, the temperature sensitivity to the GHG radiative forcing in Arctic latitudes is more than twice as large as that in the tropical latitudes, both when accounting for AMO and for ENSO. The errors in the estimates of the sensitivity coefficients in Arctic latitudes are twice as large as in the tropical ones.

The estimates of temperature sensitivity to changes in AMO and ENSO indices are generally less significant than to changes in GHG radiative forcing. Estimates of the temperature sensitivity to AMO changes are more significant than those to ENSO changes in all latitudinal belts of the NH. The temperature sensitivity to changes in AMO and ENSO indices is greatest in the Arctic latitudes. The corresponding errors in the estimates of the temperature sensitivity are greatest in Arctic latitudes. The temperature sensitivity to changes in the AMO index in Arctic latitudes is three times higher than that in the tropical latitudes, and more than one and a half times higher than that in the middle latitudes. The estimates of the temperature sensitivity and their errors in Arctic latitudes to changes in the ENSO index are more than twice as large as those in the tropical and middle latitudes.

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References

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