MESOPAUSE TEMPERATURE VARIATIONS UNDER GLOBAL CLIMATE CHANGES FROM OBSERVATIONS DURING LAST 5 DECADES

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Detection of global climate changes from observations at the surface and in the low atmosphere (troposphere) should be accompanied by observations in the middle and upper atmosphere (Beig et al., 2003). Here, variations of temperature (T_m) at the mesopause from measurements during 1960-2012 at the Zvenigorod Scientific Station (56N, 37E) of the A.M. Obukhov Institute of Atmospheric Physics (ZSS IAP RAS) (Semenov et al., 2002) are analyzed in comparison with the global climate changes. Global climate changes during last decades are characterized by a global surface air temperature anomalies (relative to the 1961-1990 conditions) T_{gs} (http://www.cru.uea.ac.uk/cru/data/temperature/).

Dataset for Tm (at 87 km) at the ZSS IAP RAS is the longest one in the global NDMC (Network for the Detection of Mesopause Change, http://wdc.dlr.de/ndmc/) system. These data are obtained by measurements on the hydroxyl rotational temperature records at the ZSS since 1957 (Golitsyn et al, 1996).

Interannual variations on Fig. 1 show strong general T_m decrease during last half a century from observations in winter (December-January-February) at the ZSS IAP RAS with a significant slowing of this cooling during last 3 decades. Total range of T_m variations for last 53 winters is 35K (from 242K to 207K). Mean linear trend dT_m/dt for this period equals to -0.7 K/yr (with coefficient of correlation r=0.93).

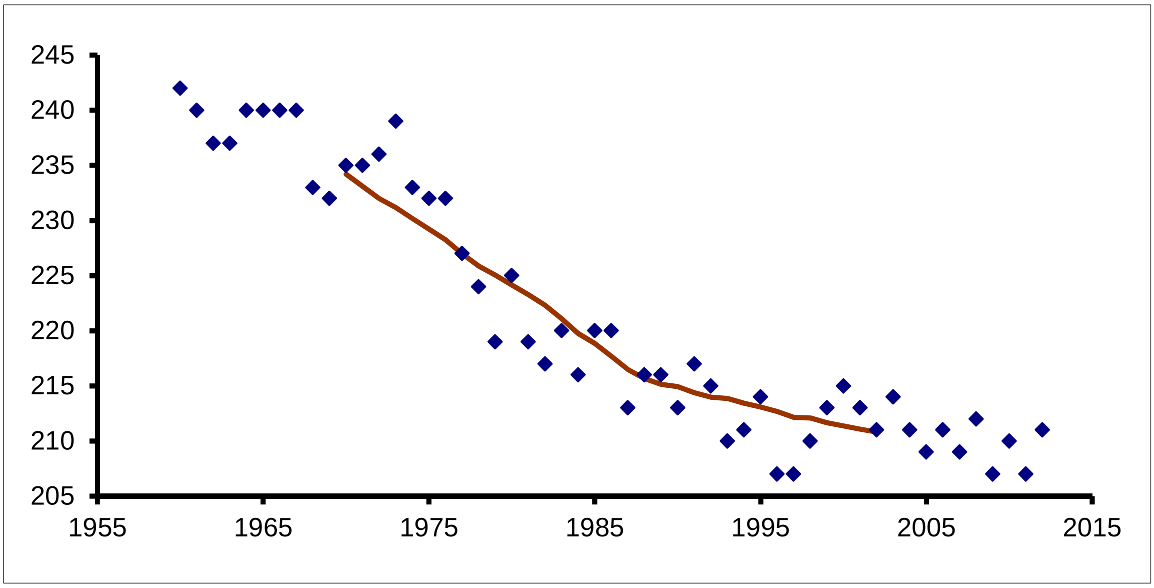

Fig. 1. Interannual T_m variations (K) from observations in winter at the ZSS IAP RAS during the period 1960-2012 (bold line - smoothed with 21-year averaging).

Smoothed T_m variations on Fig. 1 display quite clear decrease in the slope of the bold line after 1987. Linear trend of T_m for the first 27 years (1960-1986) is equal to -1.0 K/yr (r=0.92), while for the second 26 years (1987-2012) dT_m/dt=-0.24 K/yr (r=0.58) – more than 4 times less. It should be noted abrupt T_m decrease on 13K during 3 years from 1976 to 1979 (on 5K, 3K and 5K for 1976-1977, 1977-1978 and 1978-1979 transitions, respectively). For the first 17 years of analyzed dataset (1960-1976) before the abrupt T_m decrease the linear trend equals to -0.49 K/yr

(r=0.72), for the period 1978-1994 dT_m/dt equals to -0.67 K/yr (r=0.82), but for the last 17 years (1996-2012) it is one order less (-0.07 K/yr) and statistically insignificant (r=0.13).

The abrupt T_m decrease between 1976 and 1979 with a transition to new conditions since 1980s is quite clear from Fig. 2 for dependence of T_m variations at the ZSS IAP RAS on T_{gs} anomalies during 1960-2012. According Fig. 2 there is a significant general T_m decrease accompanying the general T_{gs} increase during last decades. Relative changes of T_m and T_{gs} can be assessed from corresponding linear regression: dT_m/dT_{gs}= -35.0 (r=0.75) for the total period 1960-2012. For the first 27 years (1960-1986) the value of dT_m/dT_{gs} was assessed to be equal to -21.0 (r=0.43), while for the second 26 years (1987-2012) dT_m/dT_{gs} =-3.2 (r=0.17) – almost 7 times less (and less significant). For the first 17 years of analyzed dataset (1960-1976) before the abrupt T_m decrease the dT_m/dT_{gs} value was assessed to be equal to 7.2 (r=0.33), for the period 1978-1994 it equals to -5.5 (r=0.17), and for the last 17 years (1996-2012) it was estimated to be equal to 2.8 (r=0.16).

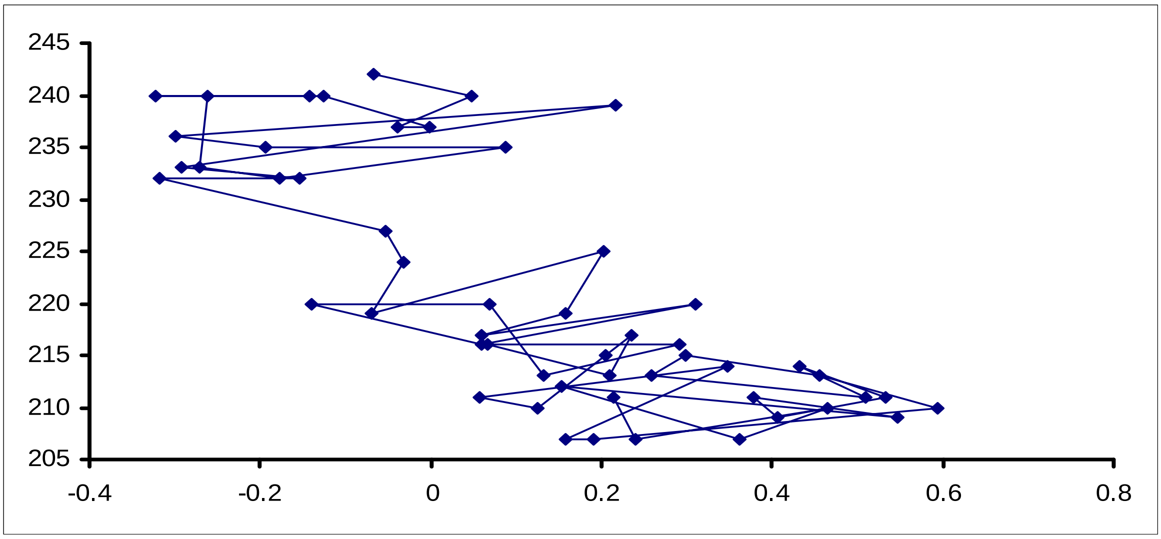

Fig. 2. Dependence of T_m variations (K) at the ZSS IAP RAS on T_{gs} anomalies (K) in winter (DJF) during 1960-2012.

The most significant relationship for T_m with T_{gs} was obtained for the total analyzed time interval (1960-2012). For shorter analyzed intervals such relationship is less significant and there are essential differences for various decadal-scale intervals. Cross-wavelet analysis exhibits significant differences in local coherence between T_m and T_{gs} for interannual and decadal variations and for various time intervals. Results of similar analysis of long-term model simulations show long-term negative coherence of T_m and T_{gs} variations with periods larger than 3 decades. To display such a coherence from observations it is necessary to have twice longer data set for T_m.

References

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