SPATIOTEMPORAL STRUCTURE OF THE FIRST- AND SECOND-ORDER TRENDS IN AIR TEMPERATURE IN THE 0-30-KM ATMOSPHERIC LAYER FOR THE NORTHERN AND SOUTHERN HEMISPHERES FROM RADIOSONDE DATA

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Introduction

The information about the vertical structure of trends in air temperature in the atmosphere obtained from observations is necessary to study climate change. The paper presents the series of the first- and second-order trends [1] in air temperature (T) at standard heights in the 0–30- km atmospheric layer above sea level for different months, seasons and for the year as a whole for the Northern and Southern Hemispheres. The goal of this paper and of [1-4] is to show the longtime changes in the atmosphere for one period of radiosonde observations for the main aerological values. Calculations were made by Dr. O.A. Aldukhov.

Data and methods

Results of observations from the CARDS global aerological dataset [5] that were updated with the current data [6] for the period 1964–2018 were used in this study. The required condition for the station to be included into this study was the availability of 15-year observations from the full observation period including 2018. The Akima cubic spline interpolation method was used to calculate T values in the 0–30-km layer above sea level on the basis of standard pressure levels and specific points of vertical profiles. The linear trends were estimated for each station by using least squares method. The anomalies were computed with respect to the appropriate long-term mean values for the period of 1964–2018. The statistics obtained for all stations were averaged taking into account the area of the station influence.

Results

The Table presents ranges of intra-annual variations in monthly means for T and the first- and second-order trends in their anomalies in the 0–30-km atmospheric layer over the Northern and Southern Hemispheres, as well as, the months in which corresponding maximum/ minimum values were determined and the heights at which these values were determined. The corresponding maximum and minimum values were determined with significance of more than 95%.

Table. Ranges (Δ) of intra-annual variations of monthly averaged values for T *(C^o),* and the first- (*C^o per decade)* and second-order (*C^o per decade^2*) decadal trends in their anomalies in the 0–30- km atmospheric layer over the Northern and Southern Hemispheres for the period 1964–2018. N is the number of soundings. The numerator shows in brackets the month (mm) in which maximum/ minimum values were determined. The height (h) at which maximum/ minimum values were determined is given in the denominator.

Δ_{mean}, *C^o* (mm)/ h	$\Delta_{first\text{-}order\ trends}$, *$C^o$ per decade* (mm)/ h	$\Delta_{second\text{-}order\ trends}$, *$C^o$ per decade^2* (mm)/ h	N, *millions*
Northern Hemisphere			
-67.17 (12) / 17 км – 20.98 (08) / 00 км	-0.375 (06) / 20 км – 0.202 (04) / 1 км	-0.060 (06) / 25 км – 0.223 (05) / 10 км	20,7
Southern Hemisphere			
-68.79 (07) / 17 км – 18.47 (02) / 00 км	-0.526 (11) / 18 км – 0.164 (09) / 2 км	-0.057 (02) / 25 км – 0.159 (12) / 15 км	3,2

The Figure shows a vertical macrostructure of long-term means, the first- and second-order trends in anomalies in temperature in the atmospheric layer under study for different months, seasons and the whole year for the Northern and Southern Hemispheres. Table and Figure reveal that the vertical structures of the first- and second-order linear trends in air temperature anomalies are not uniform in time and space. The study founded that there were some differences in the Northern and the Southern hemispheres. The main of them are listed below. The minimum value of the first-order trends (-0.526

Cº per decade) was detected at 18 km for Southern hemisphere in November, while the maximum value (0.202 Cº per decade) was found at 1 km over the Northern hemisphere in April. An amplitude of intra-annual changes of first-order trends in anomalies of monthly averaged values for T in the 0–30-km layer for the Northern hemisphere (0.577 Cº per decade) is smaller than that for the Southern hemisphere (0.690 Cº per decade). At the same time an amplitude of intra-annual changes of second-order trends in anomalies of monthly averaged values for T in the 0–30-km layer for the Northern hemisphere (0.283 Cº per decade^2) is larger than that for the Southern hemisphere (0.216 Cº per decade^2).

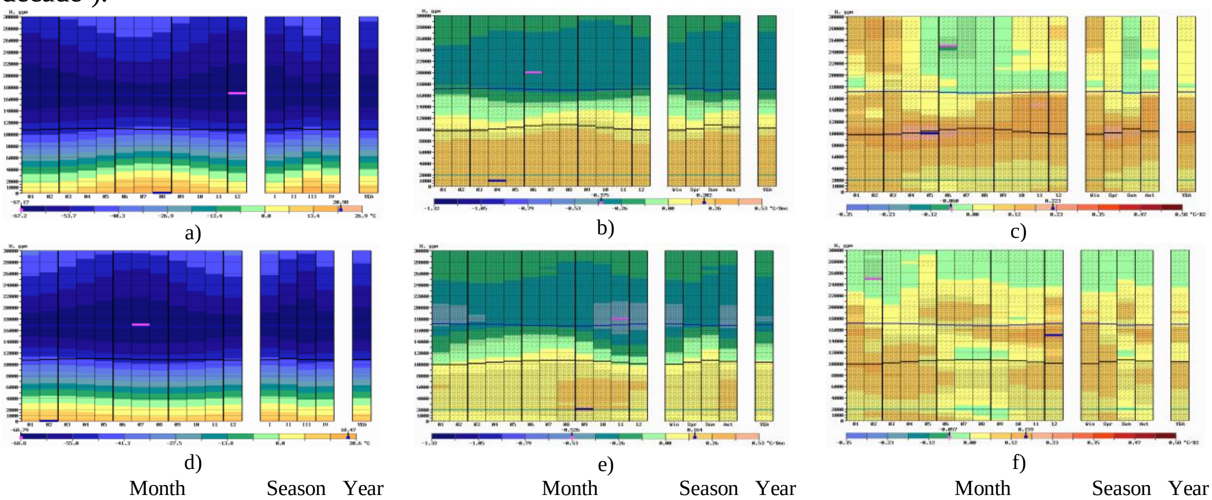

Figure. Long-term means (a, d, Cº), first-order trends in anomalies of long-term means for T (b, e, Cº per decade), second-order trends in anomalies of long-term means for T (c, f, Cº per decade^2) in the 0–30-km layer for the year as a whole, for each month and season. (a–c) – for the Northern and (d–f) – for the Southern hemispheres. Winter – DJF, spring – MMA, summer – JJA, autumn – SON. Blue and pink segments correspond to maximum and minimum values. The statistics for months and seasons were subject to twofold smoothing. The three–points smoothing was used. Trends with significance of not less than 50% are marked by the sloping line segments and those with significance of not less than 95% – by lattice. 1964–2018.

Conclusions

The computations are based on global aerological datasets for the period of 1964–2018. The following was found for both hemispheres. The vertical macrostructures of the first-order and second-order linear trends in air temperature anomalies are not uniform in the 0–30 km atmospheric layer above sea. Warming at 0–8 km and cooling at 16–30 km were detected for all months. With approaching to 2018 the highest acceleration in T changes was detected at 5-17 km in winter (DJF), at 0-1 km and at 4-13 km in spring (MMA), at 7-9 km and at 14-16 km in autumn (SON) and at 6-10 km and at 14-16 km for the year as a whole. The corresponding trends were detected with significance of more than 95%.

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