# SPATIOTEMPORAL DISTRIBUTIONS OF GLOBAL TRENDS OF HUMIDITY AND TEMPERATURE IN THE LOW TROPOSPHERE

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## Introduction

The estimations of long-term changes in humidity and temperature (T) distributions in the low troposphere obtained on the basis of hourly values are necessary for investigations of global climate change. The paper presents the series of the 1-st and 2-nd order trends [1] of temperature, absolute (AH) and relative (RH) humidity in the global layer 0-2 km above the surface for different months and seasons in the Northern hemisphere for the period of 1964–2018.

## Data and methods

Reported observations from the CARDS global aerological dataset [2] that were updated by current data from RIHMI-WDC for the period of 1964–2018 were used in this research. The computations are based on the radiosonde dataset from 774 appropriate stations with relatively homogeneous observations. The necessary condition for including a station in the research was 15-year observations from the full period including 2018.

The Akima cubic spline interpolation method was used to calculate AH, RH, T values and their variations (σ) in the layer 0–2 km over the surface taking into account standard levels and specific points of vertical profiles. The trends were estimated for each station by using the least squares method. The anomalies were calculated with respect to the corresponding long-term mean values for the period of 1964–2018. The values obtained for all stations were averaged taking into account the area of the station influence.

## Results

Figure 1 shows that the spatiotemporal distributions of the 1-st order trends (classical linear trends) for anomalies and variations of the studied parameters are nonuniform in the layer 0–2 km above the surface. The annual changes of the 1-st order trends of the long-term monthly means anomalies in the 0–2-km layer range from -1.54 to 5.68 100·g/m$^3$ per decade for AH, from -0.69 to 0.11 %/decade for RH, and from 0.08 to 0.16 C°/decade for T. The global absolute humidity in this layer increases mainly at 0.4–1.1 km for all months, at 1.1–1.7 km in summer, and near the surface in summer and autumn. The temperature increases mainly at 1.5–2 km above the surface for all months and at 0–0.1 km in winter and autumn. The relative humidity increases only at 0.5–0.9 km, the largest decrease of RH is detected from October to April at 1.6–2 km.

The 1-st order trends of variability (σ) of all studied parameters are negative for all months in the entire 0–2 km layer. The most intense decrease of variability is detected for AH at 0.0–1.2 km in summer, for RH near the surface (0-50 m) and at 0.8–1.4 km, and for T throughout the layer 0–2 km in winter and at 0.6–2 km in spring and autumn.

Time series of the 1-st order trends for the different starting year and the 2-nd order trends for AH (a), RH (b), T (c) for the whole period of 1964-2018 at the 0.6 km level are presented in Figure 2. The 2-nd order trends for all parameters are positive, which means the acceleration of changes for all values with the year 2018 approaching. Figure 2 also shows critical changes of the 1-st order trends in 2002 for all parameters and in 1980 and 2008 for humidity.

## Conclusions

The spatiotemporal distributions of the linear trends of absolute and relative humidity and temperature anomalies are not uniform in the tropospheric layer 0–2 km over the Globe. The absolute and relative humidity increases mainly at the heights of 0.4–1.1 km for all months, and temperature grows near the surface in winter and autumn and at 1.5–2 km above the surface for all months.

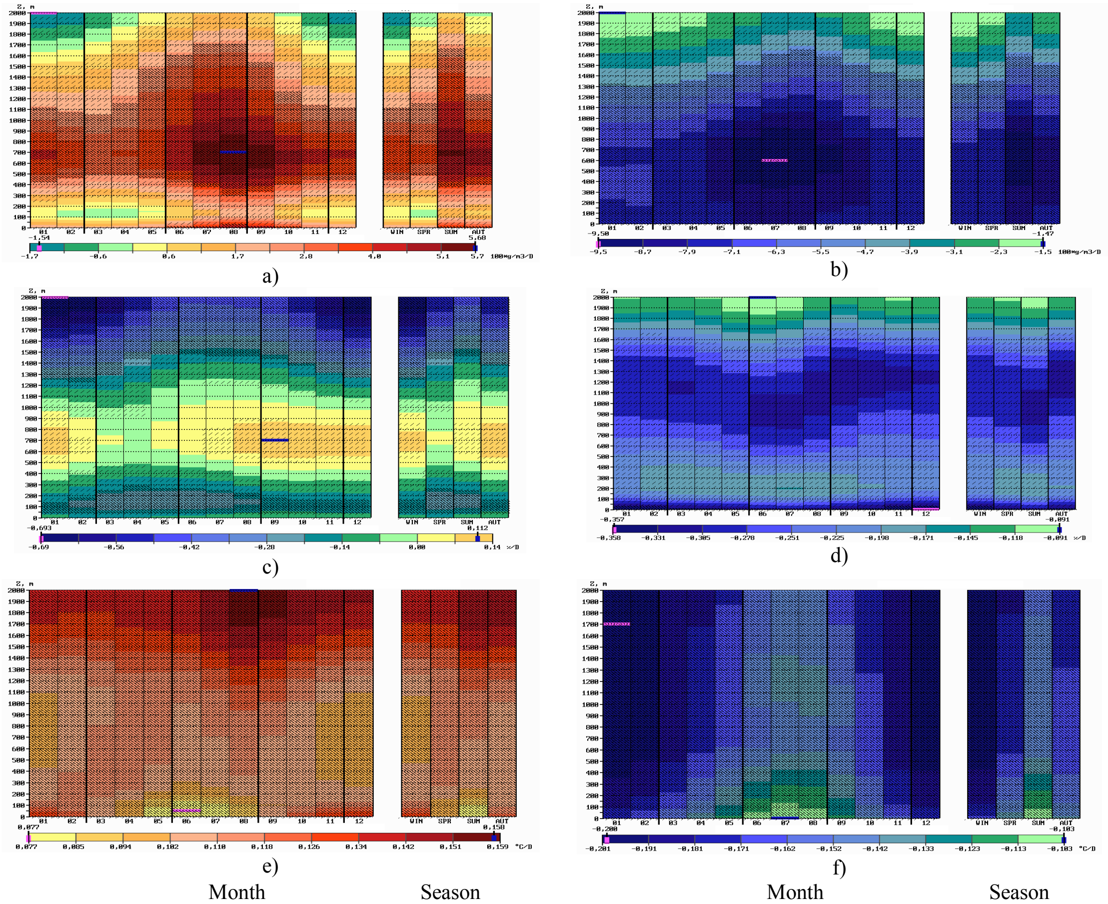


Figure 1. First-order trends of anomalies of long-term means (a, c, e) for AH (a, 100·g/m$^3$ /decade), RH (b, %/decade), T (e, C°/decade) and first-order trends of variability (b, d, f) for AH, RH, T in the low tropospheric layer 0–2 km for every month and season. The global statistics for months and 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 with significance of not less than 95% – by lattice. Blue and pink segments correspond to maximum and minimum values. 1964–2018.

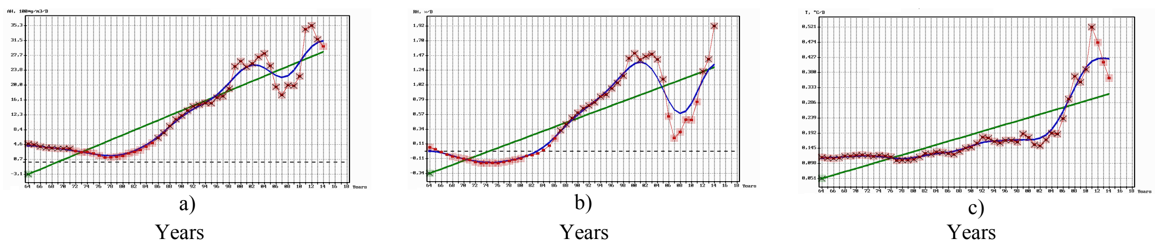


Figure 2. First and 2-nd order annual trends for AH (a), RH (b), T (c) at 0.6 km. Red lines and red points are the time series of the 1-st order trends for the corresponding periods with the one-year step, blue lines are the corresponding smoothed approximation of time series, green lines are the 2-nd order trends.

## References

1. Aldukhov O.A., Chernykh I.V. First and second-order trends of air temperature at the surface level from global radiosonde data // This edition, pp. 2-03-2-04.
2. Eskridge R.E., et. al. A comprehensive aerological reference dataset (CARDS): rough and systematic errors // Bull. Amer. Meteor. Soc. 1995. **76.** 1759-1775.