Vertical Distribution of Trends of Relative Humidity in the 0-30-km Atmospheric Layer over the Northern and Southern Hemispheres from Radiosounding Data

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Introduction

The estimations of long-term changes in relative humidity (RH) distributions in the 0-30-km atmospheric layer obtained on the basis of hourly values are necessary for investigations of climate change. The paper presents the series of the first- and second-order trends [1] of relative humidity in the 0-30-km atmospheric layer above the sea level for the Northern (NH) and Southern (SH) Hemispheres for different months and seasons for the period 1964–2018.

Data and methods

Hourly observations from the CARDS global aerological dataset [2] that were updated by current data from RIHMI-WDC for the period 1964–2018 were used in this research. 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 RH values and their standard deviations (σ_{RH}) in the 0–30 km-layer above the sea level taking into account standard levels and specific points of vertical profiles. The linear 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 1964–2018. The statistics obtained for all stations were averaged for the Northern and Southern Hemispheres taking into account the area of the station influence.

Results

The Figure shows that the spatiotemporal distributions of the first- and second-order trends for the relative humidity anomalies and standard deviations σ_{RH} are nonuniform in the studied layer for the both hemispheres.

The annual changes of the first-order trends of the long-term monthly means anomalies in the 0–30-км layer range from -0.87 to 0.14 and from -0.99 to 0.42 % per decade for RH for the Northern and Southern hemispheres, respectively. The relative humidity decreases at 2–30 km over the Northern hemisphere for all months, the largest RH decrease is detected from December to February at 3–5 km. The relative humidity increases at 0–1 km and at 11–24 km and decreases at 2–8 km over the Southern hemisphere for all months; the largest RH decrease is detected at 3–4 km in summer; the largest RH increase is detected at 0–1 km and at 11–13 km in winter and autumn. The annual changes in the second-order trends of the long-term monthly means anomalies in the 0–30-km layer range from -1.354 to 0.421 and from -0.220 to 1.571 % per decade^2 for RH for NH and SH, respectively. The second-order trends of the long-term monthly means anomalies for RH are positive mostly in the 3–8-km and 0–18-km layers and negative in the 13–30-km and 26–30-km layers for NH and SH, respectively, with significance of more than 95% for all months. Positive values of the second-order trends imply the acceleration of increase in the relative humidity for the cases with positive values of the first-order trends, while this implies the weakening of RH decrease for the case with negative values of the first-order trends, with the year 2018 approaching.

The annual changes in the first-order trends of σ_{RH} in the 0–30-km layer range from -0.061 to 1.724 and from 0.027 to 2.005 % per decade for the Northern and Southern hemispheres, respectively. The first-order trends of σ_{RH} are positive for all months in the entire 2–30 km layer for the Northern hemisphere and in the entire 1–30 km layer for the Southern hemisphere. The most intense increase of σ_{RH} is detected at 9–11 km for the Northern hemisphere, and throughout the layer 10–12 km over the Southern hemisphere for all months. The annual changes in the second-order trends of σ_{RH} range from -0.822 to 0.617 and from -0.547 to 1.307% per decade^2 for the Northern and Southern hemispheres, respectively.

Conclusions

The spatiotemporal distributions of the first-order and second-order linear trends of relative humidity anomalies are not uniform in the 0–30-km atmospheric layer over the Northern and Southern Hemispheres. The relative humidity decreases mainly at the heights of 2–8 km over the both hemispheres for all seasons, the positive values of the second-order trends at these heights imply the weakening of the RH decrease, with the year 2018 approaching. The corresponding trends were mainly detected with significance of more than 95%.

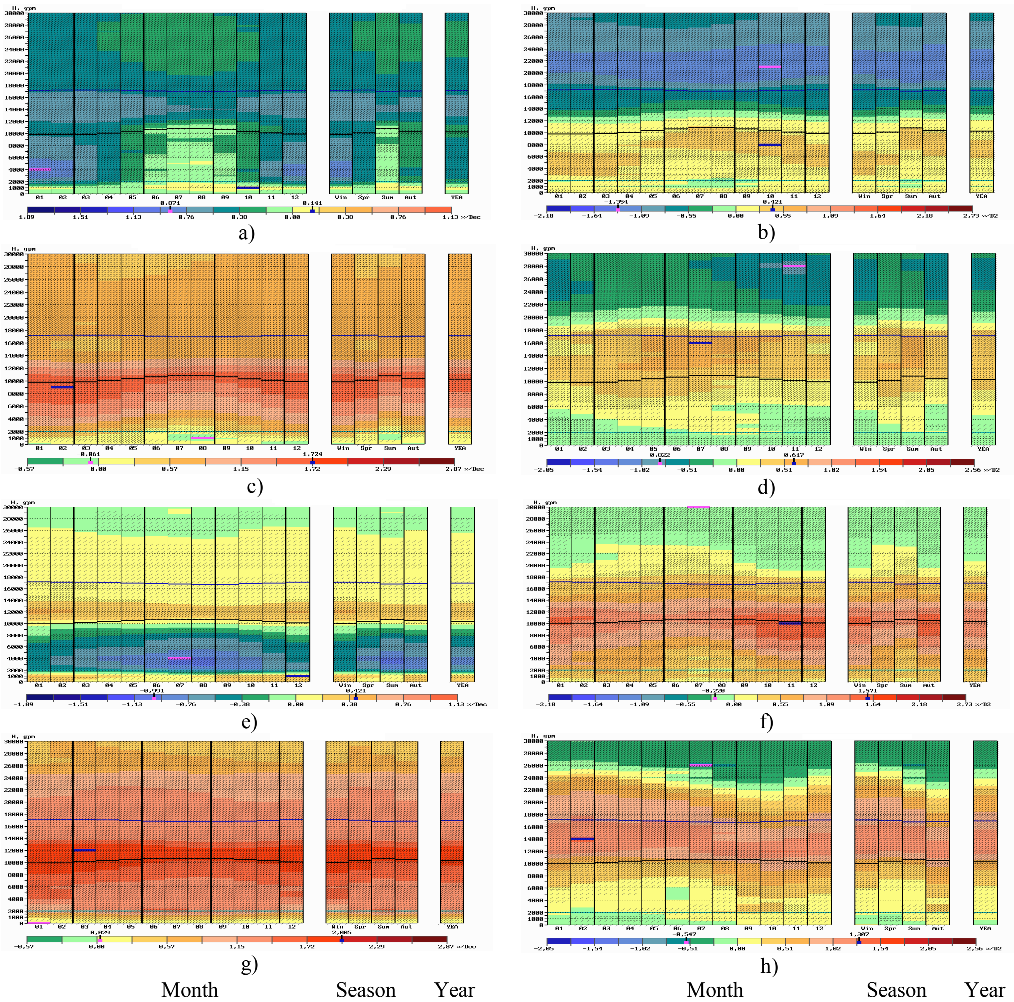

Figure. First-order trends of anomalies of long-term means (a, e) for RH (% per decade), second-order trends of anomalies of long-term means (b, f) for RH (% per decade^2), and first-order (e, g) and second-order (d, h) trends of standard deviations in the 0–30-km layer for the year as a whole, for each month and season. (a, b, c, d) – Northern Hemisphere, (e, f, g, h) – Southern Hemisphere. 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.

References

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