SPATIOTEMPORAL DISTRIBUTIONS OF GLOBAL TRENDS OF WATER VAPOUR AMOUNT IN THE 0-30 KM ATMOSPHERIC LAYER

O.A. Aldukhov and I.V. Chernykh

Russian Institute of Hydrometeorological Information – World Data Center, Obninsk, Russia, E-mail: aoa@meteo.ru, civ@meteo.ru

Introduction

Water vapour is one of greenhouse gases. The knowledge about long-term changes in water vapour amount (VA) distributions in the atmosphere based on hourly values is necessary in studying global climate change. The paper presents the series of the 1-st and 2-nd order trends [1] of water vapour amount at standard heights in the 0-30-km atmospheric layer over sea level for different months, seasons and the year as a whole.

Data and methods

The CARDS global aerological dataset [2] updated by current data [3] for the period 1964–2018 was used in this research. The computations are based on the dataset from 770 stations with relatively homogeneous observations. The necessary condition for including a station in this study was 15-year observations for the full observation period including 2018.

The Akima cubic spline interpolation method was used to compute VA values and their standard deviations (σ_{VA}) in the 0–30-km layer above sea level on the basis of standard pressure levels and specific points of vertical profiles.

The trends were calculated for each station by using the classic least squares method. The values obtained for all stations were averaged considering the area of the station influence. The anomalies were calculated with respect to the long-term means for the full period 1964–2018.

Results

The Figure shows spatiotemporal distributions of long-term monthly means and standard deviations (σ_{VA}), the 1-st and 2-nd order trends for anomalies of water vapour amount and σ_{VA} in the 0–30-km atmospheric layer for different months, seasons and the whole year.

The annual changes of the long-term monthly means in the 0–30-km layer range from 4.23 to 27.11 kg/m^2 for VA. The annual changes of the 1-st order trends of the long-term monthly means anomalies in the 0–30-km layer range from -0.040 to 0.143 kg/m^2/decade for VA. The global water vapour amount in this layer increases mainly at 0–3 km for all months, while at 0–30 km it increases from June to September.

The annual changes in standard deviations σ_{VA} range from 3.05 to 16.69 kg/m^2. The 1-st order trends of σ_{VA} are negative for all months in the entire 0–4-km layer and throughout the 0–30-km layer from July to September. The most intense decrease of σ_{VA} is detected at 27–29 km in winter and autumn. The most intense increase of σ_{VA} (with significance of more than 95%) is detected in the entire 9–13-km layer for February and March. Significant increase of σ_{VA} is detected throughout the 0–2-km layer for all the months.

The 2-nd order trends for VA are positive for all months in the entire 0–30-km layer, which implies the acceleration of changes for VA with the year 2018 approaching. The annual changes in the 2-nd order trends of the long-term monthly means anomalies in the 0–30-km layer range from -0.018 to 0.257 kg/m^2/decade^2 for VA. The highest positive accelerations of changes for VA were detected at 8-26 km for winter and autumn and at 6-26 km, for spring.

The 2-nd order trends of standard deviations σ_{VA} are positive in the 8-30-km layer for all the months. The annual changes in the 2-nd order trends of standard deviations σ_{VA} in the 0–30-km layer range from -0.002 to 0.163 kg/m^2/decade^2. The highest positive accelerations of changes in σ_{VA} were detected at 18–26 km for spring.

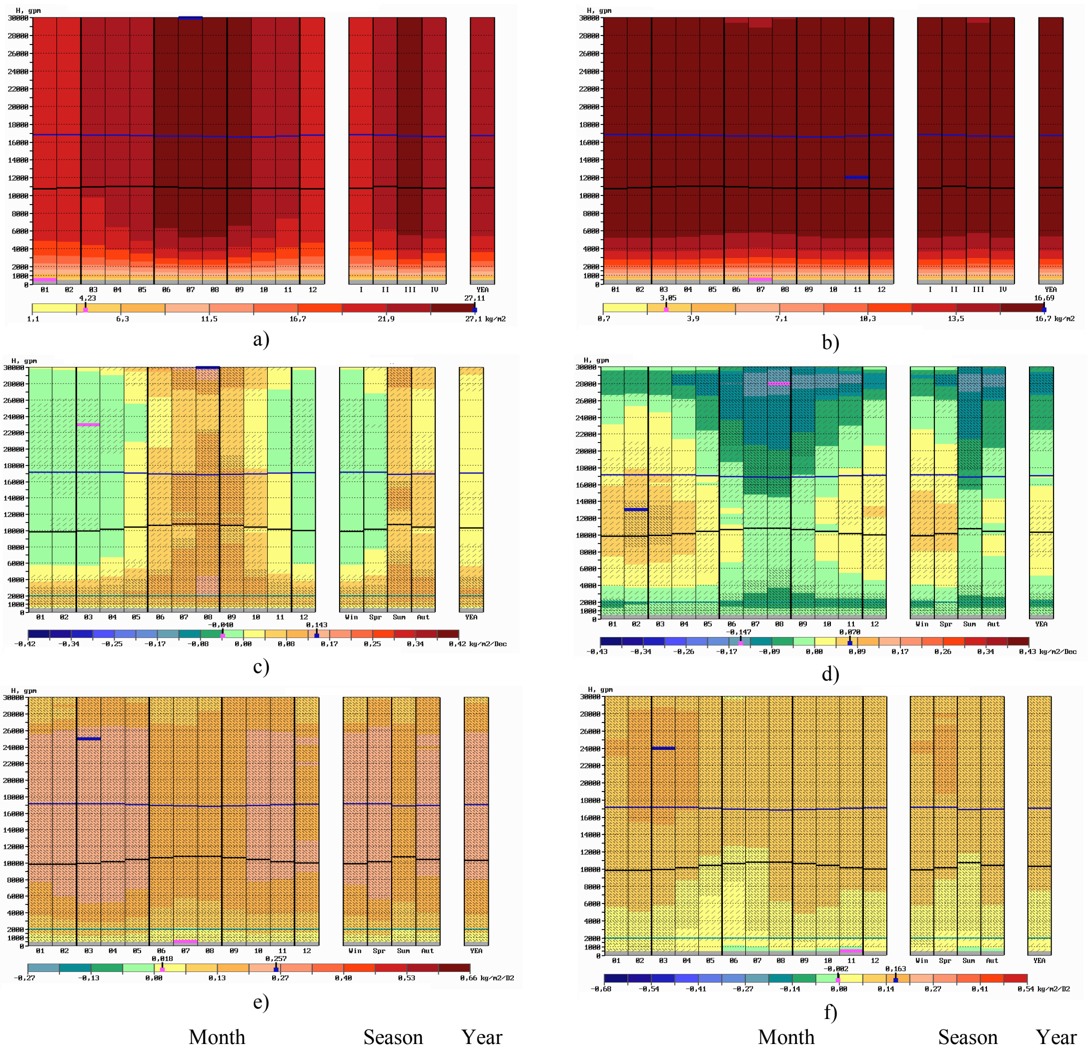

Figure. Long-term means (a), first-order trends of anomalies of long-term means for VA (c, kg/m^2/decade), second-order trends of anomalies of long-term means for VA (e, kg/m^2/decade^2), and standard deviations σ_{VA} (b), first-order (d) and second-order (f) trends of σ_{VA} in the 0–30-km atmospheric layer for the year as a whole, for each month and season. Blue and pink segments correspond to maximum and minimum values. The global statistics for months and seasons were subject to twofold smoothing. 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. Grey color marks areas with insufficient data for calculations. 1964–2018.

Conclusions

Spatiotemporal distributions of the linear trends of water vapour amount anomalies are not uniform in the 0–30-km atmospheric layer above sea level. The water vapour amount increases mainly in the entire 0–3-km layer for all the months and throughout the 0–30-km layer from June to September.

References

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