TRENDS OF THE NUMBER OF CLOUD LAYERS FROM GLOBAL RADIOSOUNDING DATA

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Introduction

Estimates of the cloud layer number are useful for studying the atmospheric vertical structure and climatic changes, and for assessing propagation conditions of electromagnetic waves. Different aspects of research on the cloud layer number were discussed in [1–4]. The paper presents global long-term estimates of the number of reconstructed cloud layers with the cloud amount of 0–20, 20–60, 60–80, 80–100, 0–100% and trends of their anomalies. Calculations were conducted for the atmospheric layers 0–2, 2–6, 6–10 and 0–10 km above the surface level. Means and trends were found for each month, season and the year as a whole.

Data and methods

To determine cloud boundaries and cloud amount [5], we used CE-method and CARDS global dataset [6] supplemented by current data from AROCTAC dataset [7] for the 1964-2018 period. To compute the statistics, only observations including both temperature and humidity data from the surface to the 10-km height were applied. We did not consider cloud layers for which the CE-method gave thickness less than 50 m. The existence of several cloud layers with different cloud amounts was allowed.

Results

The Table presents global annual mean values and trends of anomalies of the cloud layer number with regard to the cloud amount gradation, as well as ranges of annual variations in monthly means and trends of their anomalies for the atmospheric layer of 0–10 km. The mean numbers of cloud layers with cloud amounts 0–100, 0–20 and 80–100% and the corresponding trends estimated for atmospheric layers 0–2, 2–6, 6–10, 0–10 km over the Globe are shown in the Figure for months, seasons and the year as a whole. The trends with significance of not less than 50% are marked by a square and those with significance of not less than 95% – by a square with a cross.

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 1964–2018. The values obtained for all stations were averaged taking into account the area of the station influence. The global statistics for months and seasons were subject to twofold smoothing. The three-points smoothing was used.

Table.

The global annual mean values and trends of anomalies of cloud layer number with taking into account the cloud amount gradation and intra-annual variations ranges (Δ) of monthly averaged values and trends of their anomalies for the atmospheric layer 0–10 km over the surface level.

Cloud coverage, %	Mean	Trends	Δ_{mean}	Δ_{trends}	Number of soundings, millions
0–20	4,2	0,023	4,25–4,36	0,021–0,026	15,4
20–60	1,5	0,004	1,51–1,52	0,003–0,005	7,7
60–80	1,2	0,003	1,19–1,20	0,003	4,1
80–100	2,8	0,017	2,67–2,88	0,016–0,019	12,3
0–100	6,62	0,036	6,59–6,65	0,033–0,038	17,9

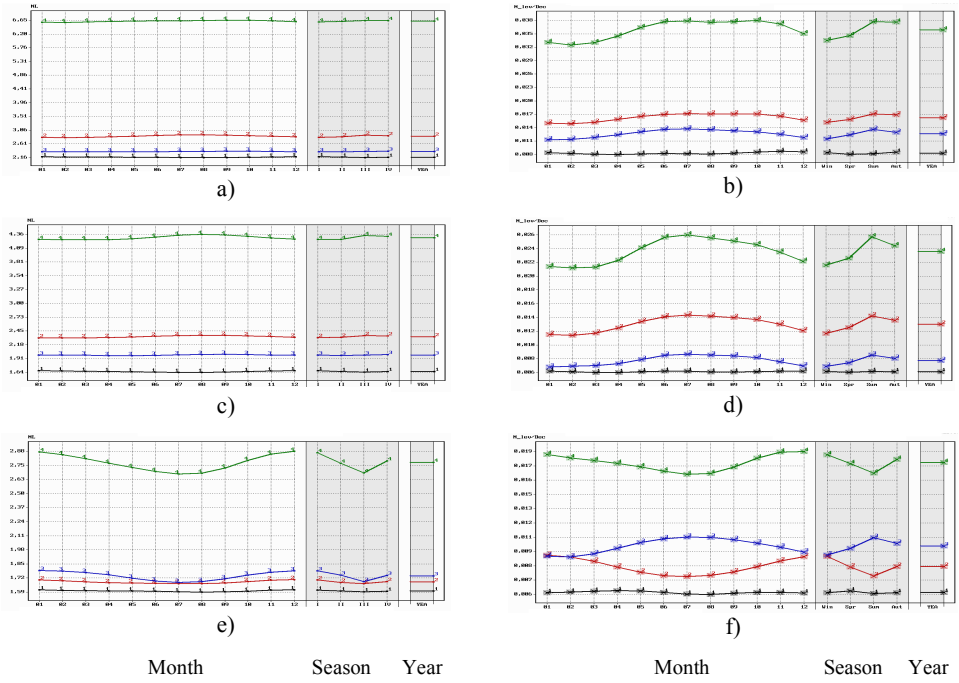

Figure. Global long-term means (a, c, e) and trends of their anomalies (b, d, f; n per decade) of the number (n) of cloud layers with regard to the cloud amount gradation for different atmospheric layers for each month, season and year. Black lines – for 0–2 km, red lines – 2–6 km, blue lines – 6–10 km, green lines – 0–10 km. (a, b) – 0–100%, (c, d) – 0–20%, (e, f) – 80–100% cloud coverage. 1964–2018.

Conclusions

The results show that the mean number of cloud layer and the trends of their anomalies depend on the cloud amount gradation. Their values for the gradations 0–20 and 80–100% are several times higher than those for the gradations 20–60, 60–80%.

Long-term monthly (seasonal) means of the number of cloud layers with the fixed cloud amount gradation differ little for each atmospheric layer considered in this paper.

The minimums of trends for cloud layers with cloud coverage 0–100% and 0–20% in the atmospheric layers 0–10, 2–6 and 6–10 km are detected in winter and the maximum – in summer. The cloud layer number increases in the 2–6-km atmospheric layer more than in the 6–10-km layer for all months and seasons.

The minimums of trends for cloud layers with cloud coverage 80–100% in the atmospheric layers 0–10 and 2–6 km are detected in summer and the maximums – in winter, while in the 6–10-km atmospheric layer, on the contrary, maximums – in summer and minimums – in winter.

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