Intra-annual Changes of Trends of the Number of Reconstructed Cloud Layers for the Northern and Southern Hemispheres from Radiosounding Data

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Introduction

The information about the cloud layer number is useful for studying the cloudiness vertical structure and climatic changes, and for assessing propagation conditions of electromagnetic waves. Different questions of research on the cloud layer number were discussed in [1–4]. The paper presents long-term estimates of the number (n) of reconstructed cloud layers with the cloud amount of 0–100% of the sky surface and trends of their anomalies for the Northern and Southern Hemispheres. Calculations were conducted for the atmospheric layers of 0–2, 2–6, 6–10 and 0–10 km above the surface level. Means and trends were found for each month, season (winter – DJF, spring – MAM, summer – JJA, autumn – SON) 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 with current data [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. The existence of several cloud layers with different cloud amounts was allowed. We did not consider cloud layers with thickness less than 50 m that was determined by CE-method.

Results

The Table presents annual mean values and trends of anomalies of the cloud layer number with cloud amount of 0–100% of the sky surface, as well as ranges of annual variations in monthly means and trends of their anomalies for the atmospheric layers of 0–2, 2–6, 6–10, 0–10 km over the Northern and Southern Hemispheres.

The means of the cloud layer number with cloud amounts of 0–100% of the sky surface and the corresponding trends estimated for atmospheric layers of 0–2, 2–6, 6–10, 0–10 km over the Northern and Southern Hemispheres are shown in the Figure for months, seasons and the year as a whole.

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 the stations placed in the Northern and Southern Hemispheres were averaged taking into account the area of the station influence. The statistics for the Northern and Southern Hemispheres for months and seasons were subject to twofold smoothing. The three-points smoothing was used.

The results show that the means of the cloud layer number and trends of their anomalies depend on the cloud level. Their values for the middle-level cloud layers are higher than those for the low- and high-level cloud layers. Their values for the low-level cloud layers are minimal. These statements are true for all months, seasons and the year as a whole for the both hemispheres.

Long-term monthly (seasonal) means of the number of cloud layers differ little for each atmospheric layer considered in this paper for the Northern and Southern Hemispheres. The minimum values of trends for cloud layers with cloud amount of 0–100% in the atmospheric layers of 0–10, 2–6 and 6–10 km are detected in the cold season and the maximum ones – in the warm season.

Table. The annual mean values and decadal trends of anomalies of the cloud layer number with the cloud amount of 0–100% of the sky surface and intra-annual variations ranges (Δ) of monthly averaged values and decadal trends of their anomalies for different atmospheric layers over the Northern and Southern Hemispheres; changes of cloud layer number for the period 1964–2018. N is the number of soundings.

Atmospheric layer, *km*	Mean, *n*	Trends, *n/Decade*	Changes of the cloud layer number for the period 1964–2018, *n*	Δ mean, *n*	Δ trends, *n/Decade*	N, *millions*
			Northern Hemisphere			
0–10	6,4	0,043	0,237	6,33–6,55	0,037–0,046	18,5
6–10	2,3	0,014	0,077	2,25–2,40	0,012–0,015	18,2
2–6	2,8	0,019	0,105	2,66–2,95	0,016–0,021	19,0
0–2	2,1	0,009	0,050	2,10–2,13	0,009	18,1
			Southern Hemisphere			
0–10	6,9	0,042	0,231	6,83–6,99	0,039–0,046	3,1
6–10	2,4	0,015	0,083	2,35–2,46	0,014–0,015	3,0
2–6	3,0	0,016	0,088	2,89–3,04	0,015–0,017	3,1
0–2	2,3	0,010	0,055	2,26–2,28	0,010–0,011	3,1

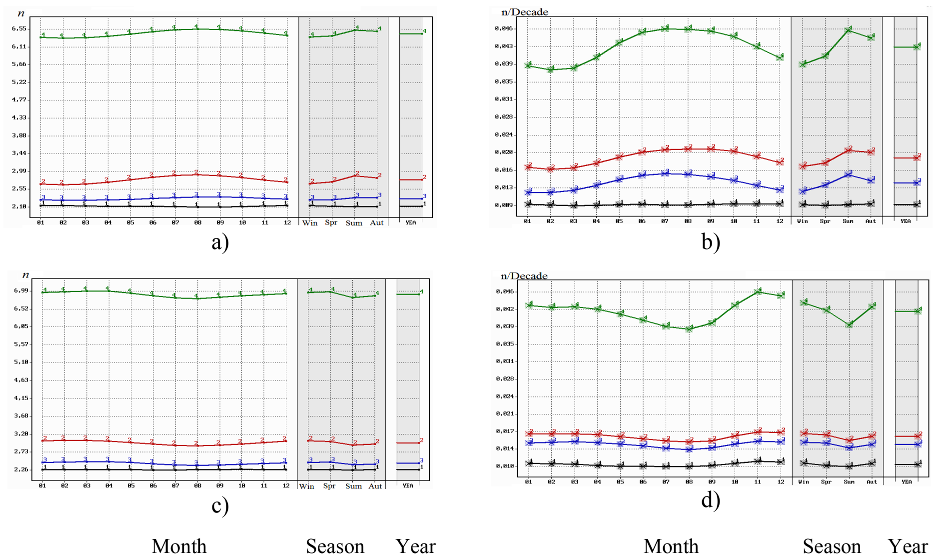

Figure. Long-term means (a, c) and trends of their anomalies (b, d; n per decade) of the number (n) of cloud layers with cloud amount of 0–100% of the sky surface for different atmospheric layers for each month, season and year. The trends with significance of not less than 95% are marked by a square with a cross. Black lines (1) – for 0–2 km, red lines (2) – 2–6 km, blue lines (3) – 6–10 km, green lines (4) – 0–10 km. (a, b) – Northern Hemisphere, (c, d) – Southern Hemisphere. 1964–2018.

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