

## Trends in Low Boundary of Overcast Clouds over North-West of Russia

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Cloudiness is one of main components of climatic system, but its climatic changes, in particular climatic changes of low boundary of overcast clouds over Arctic region, are not fully studied. Earlier it have been shown for Globe for the period 1964-1998 years that low boundary means for cloud layers with cloud amount 80-100% of the sky (overcast clouds) in atmospheric layer 0-10 km are decreasing for central months of the seasons (January, April, July, October) separately and in total with decadal changes of -27 m/decade, -27 m/decade, -19 m/decade, -25 m/decade and -24 m/decade correspondently [Chernykh, Alduchov, 2000; Chernykh et al, 2001]. The estimations of low boundary means for cloud layers with cloud amount 80-100% of the sky (LBO) and trends in LBO are presented in this paper for part of Arctic region, North-West of Russia, more particularly: for different months, seasons and for year for different atmospheric layers. Moreover, linear trends in time series of LBO anomalies were calculated by the method based on the using of observations with taking into account the possible time correlations of observations [Alduchov et al, 2006]. The results demonstrate inhomogeneous in the changes of LBO in time and space. It is shown the decreasing of LBO and the decreasing of annual and interseasonal variability for LBO in different atmospheric layers.

CE-method for cloud amount and boundaries reconstruction [Chernykh, Alduchov, 2004] and radiosonde sounding data from CARDS [Eskridge et al, 1995] for two stations: Murmansk and Nar'jan-Mar for period 1964-2007 years were used for this research. Number of detected cloud layers with cloud amount 80-100% of the sky in different atmospheric layers for period 1964-2007 years and number of sounding presented in the Table. It demonstrates some specific in vertical macrostructure of cloudiness over the stations.

TABLE. Number of cloud layers with cloud amount 80-100% of the sky in different atmospheric layer for period 1964-2007 years and number of sounding (N)

Station	Atmospheric layer					N	
	0-2 km	2-6 km	6-10 km	0-6 km	2-10 km		0-10 km
Murmansk	12916	12319	14947	15121	16910	15681	29234
Nar'jan-Mar	13054	10331	13774	13624	15002	13651	27912

The multiannual means and trends in time series of LBO anomalies for the atmospheric layers 0-2 km, 2-6 km, 6-10 km, 0-6 km, 2-10 km, 0-10 km over surface level are presented at figure 1. Due continuity of climatic changes in time and space all detected trends (with different significance), trends with significance not less than 50% and trends with significance not less than 95% are presented at the figure 1b, 1c, 1d correspondently.

For example (fig. 1a), multiannual averages for LBO in the atmospheric layer 0-2 km are 0.57 km for Murmansk and 0.5 km - for Nar'jan-Mar. In atmospheric layer 0-10 km they are about 2.4 km for Murmansk and 2.2 km - for Nar'jan-Mar.

Figure 1b shows decreasing of LBO for year for every of the atmospheric layers for both stations. Largest decreasing of LBO for year was detected in atmospheric layers 0-10 km and 2-10 km for Murmansk with decadal changes  $-0.39 \text{ km} \cdot \text{decade}^{-1}$  and  $-0.23 \text{ km} \cdot \text{decade}^{-1}$  and for Nar'jan-Mar - with decadal changes  $-0.43 \text{ km} \cdot \text{decade}^{-1}$  and  $-0.38 \text{ km} \cdot \text{decade}^{-1}$  correspondently.

Decreasing of the LBO in atmospheric layers 0-2 km and 2-6 km for year were detected for Murmansk with decadal changes  $-19 \text{ m} \cdot \text{decade}^{-1}$  and  $-42 \text{ m} \cdot \text{decade}^{-1}$  and for Nar'jan-Mar with decadal changes  $-40 \text{ m} \cdot \text{decade}^{-1}$  and  $-71 \text{ m} \cdot \text{decade}^{-1}$ , correspondently. Decreasing of the LBO go together with warming in low troposphere [Alduchov, Chernykh, 2009a], increasing of water vapour amount in troposphere [Alduchov, Chernykh, 2009b], increasing in the frequency of cloud layers in atmospheric layer 0-2 km and 2-6 km over the stations with decadal changes in  $4\% \cdot \text{decade}^{-1}$  and  $2\% \cdot \text{decade}^{-1}$  over Murmansk and  $6\% \cdot \text{decade}^{-1}$  and  $4\% \cdot \text{decade}^{-1}$  over Nar'jan-Mar. Significance of all trends for year is not less than 99%.

Figure 1b for different months and seasons demonstrates that climatic changes of LBO in Arctic atmosphere are inhomogeneous in the time and space. Figure shows the decreasing of annual and interseasonal variability for LBO in atmospheric layer 0-10 km, 6-10 km for both stations: maximum decreasing for LBO are detected for spring and/or summer, when mean values are largest (fig. 1a). Decreasing of annual and interseasonal variability for LBO in atmospheric layer 2-6 km follows from increasing LBO in summer, when mean values are lowest, and decreasing in other seasons.

The results can be used for comparison with estimations of cloudiness changes, obtained on base surface and satellites observations, in aviation needs, in study of climate change in Arctic region.

*Acknowledgment.* Study was supported by RBRF, project 07-05-00264.

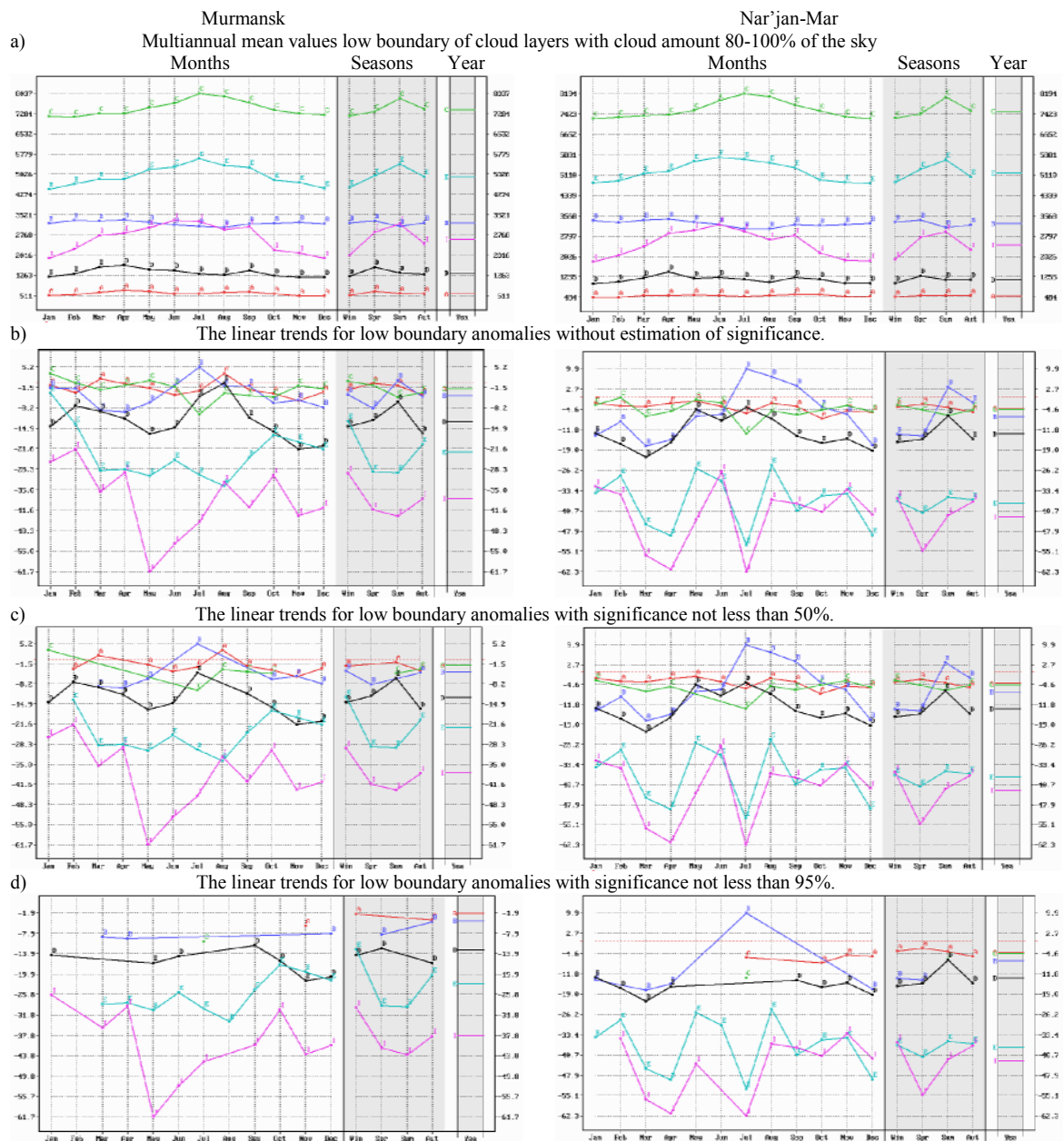


Figure 1. (a) Multiannual mean values (m) for low boundary of cloud layers with cloud amount 80-100% of the sky for different months, seasons and for year in different atmospheric layers: 0-2 km - (A, red lines), 2-6 km - (B, navy lines), 6-10 km - (C, green lines), 0-6 km - (D, black lines), 2-10 km - (E, blue lines), 0-10 km - (I, pink lines). (b) - (d) Corresponding linear trends for anomalies of low boundary (m/year), calculated on the base of hourly observations with taking into account the time correlations of observations. Stations: Murmansk and Nar'jan-Mar. CARDS. 01.1964 - 10.2007.

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