About Warming in Troposphere over North-West of Russia

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At present time the study of climate change in Arctic region, in particular Russian part of Arctic, is very actual by reason of sensible warming in the region and absence of clear understanding of the reason of the warming. The research of climatic changes of temperature at the standard isobaric levels in Arctic troposphere over period 1964-10.2007 years is presented on base of radiosonde sounding data from dataset CARDS [Eskridge et al, 1995] for two stations: Murmansk and Nar'jan-Mar, placed in North-West of Russia. The method based on the using of hourly observations with taking into account the possible time correlations of observations [Alduchov and Chernykh, 2008] was used for calculating linear trends in time series of temperature anomalies at the standard isobaric levels. The method was developed especially for estimate of trends for Polar Regions with probably not full time series of observations. It is shown that warming for year with significance not less than 95% was detected over Murmansk only in low troposphere and over Nar'jan-Mar at most levels of troposphere. The largest warming for both stations was detected at level 925 hPa for January with decadal changes 0.71ºC/dec. and 0.95ºC/dec. for Murmansk and Nar'jan-Mar correspondently.

It is known, the estimations of trends are partly dependent from homogeneity and quality data. Note, that number of observations for 00 and 12 GMT is practically the same for both stations. Numbers of observations before and after running of complex quality control procedure [Alduchov and Eskridge, 1996] are presented in tables 1 and 2 for different months, seasons and year for level 850 hPa. Number of rejected observations foot up to 0.7% (Murmansk) and 0.9% (Nar'jan-Mar) from all soundings (table 2).

TABLE 1. Number of T observations before and after complex quality control for level 850 hPa for different months.

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Murmansk	2552	2329	2526	2468	2574	2356	2283	2343	2431	2459	2404	2509
	2543	2309	2500	2456	2563	2341	2242	2324	2413	2442	2396	2496
Nar'jan-Mar	2393	2224	2426	2381	2356	2359	2424	2344	2204	2304	2169	2328
	2382	2205	2398	2354	2329	2337	2395	2318	2189	2285	2149	2313

TABLE 2. The same as TABLE 1 for seasons and for year.

Station		Winter	Spring	Summer	Autumn	Year	Year (%)
Murmansk	Before control	7390	7568	6982	7294	29234	100
	After control	7348	7519	6909	7251	29027	99.3
Nar'jan-Mar	Before control	6945	7163	7127	6677	27912	100
	After control	6900	7081	7050	6623	27654	99.1

The multiannual means of temperature are presented for different months, seasons and for year at figure 1a. Corresponding linear trends in time series of temperature anomalies at the standard isobaric levels in troposphere are presented at figure 1b-1d. Due continuity of climatic changes in atmosphere 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-1d.

Figure 1b demonstrates the inhomogeneous of climatic changes in Arctic troposphere. Warming is detected only in low troposphere over Murmansk for all months, seasons and year in total. Only for autumn's months and autumn in total the warming is detected in middle and high troposphere too. Small cooling was detected in middle and/or high levels of troposphere for other months and for year in total. Warming over Nar'jan-Mar is detected for all months (with exception February, August and December), seasons (with exception winter) and year at all levels in troposphere. Cooling is detected in middle troposphere over Nar'jan-Mar for February and for winter, in low troposphere - for August and at all levels - for December. Figure 1c shows that not all determined trends were detected with significance more than 50% for both stations.

The warming with significance not less than 95% was detected over Murmansk only for January, April, spring, autumn and year only in low troposphere and over Nar'jan-Mar - only for June and autumn in middle and high troposphere, for spring – in low troposphere and for year - at most levels of troposphere (Fig. 1d).

Linear trends values for temperature anomalies for levels 925 hPa, 850 hPa and 700 hPa are presented in Table 3 for January, spring, autumn and year. Table 3 shows the largest warming for both stations was detected at level 925 hPa for January. For Murmansk it was detected with decadal changes 0.71ºC/Dec. and for Nar'jan-Mar it was detected with decadal changes 0.95ºC/Dec. For year largest warming was detected at level 925 hPa for Murmansk and for Nar'jan-Mar with decadal changes 0.42ºC/Dec. and 0.38 ºC/Dec. correspondently.

The results can be used for modeling of climate change, in study of climate change in Arctic region.

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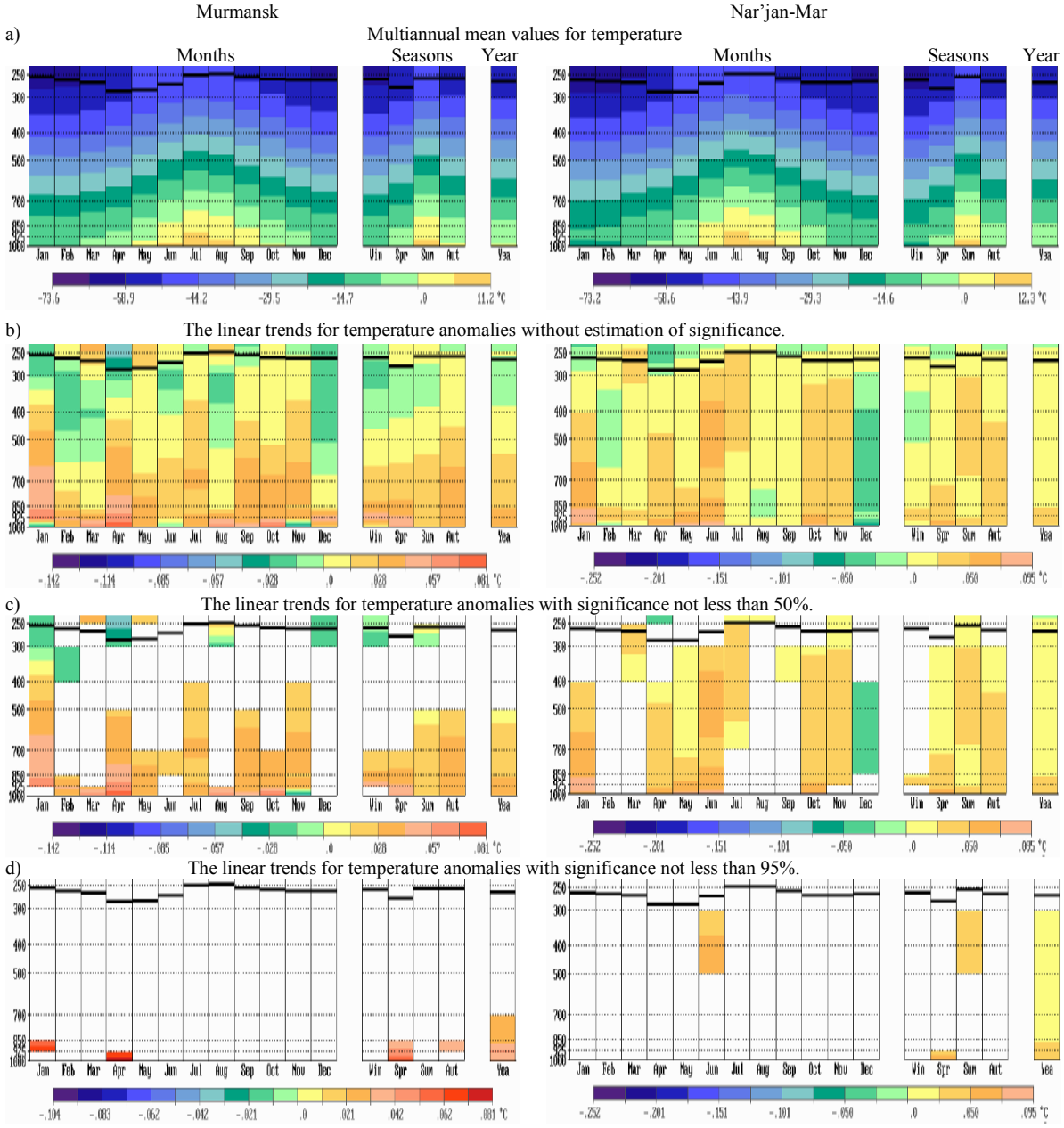

Fig. 1. Multiannual mean values for temperature (a) and linear trends for temperature anomalies (ºC/year) for the isobaric levels calculated on the base of hourly observations with taking into account the time correlations of observations for different months (in the left), seasons (in the center) and for year (in the right) without estimation of significance (b), with significance not less than 50% (c) and 95% (d). The first tropopause is marked by black line. Stations: Murmansk (left column) and Nar'jan-Mar (right column). CARDS. 1964 – 10.2007.

TABLE 3. Linear trends for temperature anomalies (ºC/decade) for standard isobaric levels 925 hPa, 850 hPa and 700 hPa, calculated on the base of hourly observations with taking into account the time correlations of observations, for January, spring, autumn and year. Trends with significance 99% are marked by Italic. Significance of other trend is not less than 85%.

Station	January			Spring			Autumn			Year		
	Standard isobaric levels, hPa											
	700	850	925	700	850	925	700	850	925	700	850	925
Murmansk	.50	.53	*.71*	.20	.32	.45	.34	.32	-	*.24*	*.28*	*.42*
Nar'jan-Mar	.58	.67	*.95*	.24	.30	.45	.27	.31	.38	*.21*	*.23*	*.38*

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