Analysis of Climatic Changes of Cloud Layers Vertical Structure in Atmospheric Layer below 250 hPa in Antarctica.

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Introduction

Cloudiness plays very important role in distribution of solar radiation and precipitation at the earth surface. Forming of different cloudiness types is viewing complex thermodynamic processes in different atmospheric layers. So knowledge of vertical structure cloudiness (VSC) trends will improve our understanding of recent climate changes.

As it was shown in previous researches [Chernykh and Alduchov, 2000a , 2000b; Chernykh, 2001; Chernykh et al. 2001], spatial distribution of trends for cloud layer vertical structure parameters are inhomogeneous. So it is interesting to make more detailed analysis of climatic changes for complex of atmospheric characteristics: cloudiness, temperature, humidity and wind parameters in troposphere for some specific regions with opposite sighting trends for surface temperature. In this paper Antarctic region was selected for researches, because it is one of most interesting, important and difficult for study, due low temperature, region. Trends in Antarctic surface temperature, calculated on base 20 and 45 years time series, obtained from surface and satellite measurements have shown different tendencies for some regions [Comiso, 2000]. The trends can to change sign for closely placed station [Comiso, 2000]. Increasing of cloud amount (up to 15-20%) in South Pole, detected by Neff (Neff, 1999) was classified in the documents of Intergovernmental Panel on Climate Change as “dramatic” [Climate Change 2001]. But, cloudiness regimes for western and eastern regions of Antarctica are very different [Warren et al. 1986]. So, two stations, Bellinsgshausen (1970.02-1999.01) and Mawson (1970.01-2001.12), placed in Eastern and Western Antarctica accordingly, were selected for research. Moreover, surface temperature anomalies trends calculated on base dataset Comprehensive Aerological Reference Data Set CARDS [Eskridge et al 1995] (see Table 1) have opposite sign for these stations. Besides, as was shown before [Comiso, 2000], for Mawson surface temperature anomalies trend, calculated on base other sources depends from period and sources of date (see Table 1). So this study is useful to gain insight into climate change of Antarctica and therefore into global climate change.

TABLE 1. Surface temperature anomalies trends °C/decade, calculated on base surface observation (45 yr), in suti (20 yr) (* - from Comiso, 2000) and on base CARDS (30yr) by using measured values with provision for correlation dependence in time.

Station name	Lat/Long	Trend (45yr)*	Trend (20yr)*	Trend (30yr)
Mawson	-67.60°S/ 62.9°E	-0.07±0.08	0.23 ±0.25	-0.25±0.12
Bellingshausen	-62.18°S/-58.9°W	0.19±0.06	0.01±0.21	0.40±0.13

Date and method

Research of climatic changes of cloudiness and temperature, water vapor amount and speed wind at surface and standard isobaric levels for different atmospheric layers (0-2 км, 2-6 км, 6-10 км, 0-10 км) are presented in this paper on base CARDS for period 1970-2001 years.

Chernykh and Eskridge method was used to determine cloud amount and boundaries from temperature and humidity profiles [Chernykh and Eskridge 1996; Chernykh et al. 2001].

Trends in anomalies for all parameters were calculated by using measured values with provision for correlation dependence in time.

Results

Surface temperature anomalies trends, calculated on base CARDS (30yr) by using measured values with provision for correlation dependence in time, show warming for Bellingshausen and cooling for Mawson with decadal changes 0.40±0.13 °C/decade and -0.25±0.12 °C/decade accordingly (Table 1). Detected trends are at the 99.7% significant level for Bellingshausen and 95.2% level for Mawson. These tendencies are in concordant with results obtained on base surface observation (45 yr) by Comiso. For Mawson, trends detected from different platform of observation, from surface and in suti (20 yr), have opposite signs (Table 1).

Mean and decadal changes for cloud layers number, total thickness, low and high boundaries are present in Table 2-Table 5 for cloud amount 0-100% of the sky.

In atmospheric layer 0-10 km for Mawson number of cloud layers with cloud amount 0-100% of the sky increases (Table 2) and total thickness, on the contrary, decreases (Table 3). For Bellingshausen, vice versa, decreasing of cloud layers number goes with increasing of theirs total thickness. Low boundaries decrease for both stations (Table 5). High boundary have opposite tendencies for the stations: increasing for Mawson and decreasing for Bellingshausen (Table 5).

Changes in cloudiness, temperature, humidity and wind are interdependent because forming of cloudiness is only a reflection of thermodynamic processes in different atmospheric layers. So, the means and trends of temperature, water vapor amount and wind speed anomalies are presented at Figure 1-Figure 6.

Analysis of trends for temperature anomalies have shown for Bellingshausen warming in the troposphere, increasing water vapor amount beginning from 700 hPa, decreasing wind speed at surface level and atmosphere.

For Mawson cooling below 700 hPa and higher 300 hPa, decreasing water vapor amount in atmosphere, decreasing wind sped in troposphere higher 925 hPa and below 200 hPa and increasing higher 150 hPa.

TABLE 2. *Mean* (m) *and decadal changes* (tr) for cloud layers number. Cloud amount 0-100% of the sky. Trends with significance level not less than 95% are marked by *. Other trends are with significance level not less than 50%.

Station name	Atmospheric layer							
	0-2 km		2-6 km		6-10 km		0-10 km	
	m	tr	m	tr	m	tr	m	tr
Mawson	2.1	0.33*	2.9	0.67*	2.8	0.77*	7.4	1.99*
Bellingshausen	1.9	-0.02	2.1	0.03	2.4	-	5.8	-0.17*

TABLE 3. *Mean* (m) *and decadal changes* (tr) for cloud layers total thickness. Cloud amount 0-100% of the sky. Trends with significance level not less than 95% are marked by *. Other trends are with significance level not less than 50%.

Station name	Atmospheric layer							
	0-2 km		2-6 km		6-10 km		0-10 km	
	m	tr	m	tr	m	tr	m	tr
Mawson	634	-41*	1083	-27*	1367	-	3078	-92*
Bellingshausen	587	14	968	-	1356	-	2781	60*

TABLE 4. Mean (m) *and decadal changes* (tr) for cloud layers low boundary. Cloud amount 0-100% of the sky. Trends with significance level not less than 95% are marked by *. Other trends are with significance level not less than 50%.

Station name	**Atmospheric layer**							
	0-2 km		**2-6 km**		**6-10 km**		**0-10 km**	
	m	**tr**	**m**	**tr**	**m**	**tr**	**m**	**tr**
Mawson	606	-35*	2551	-79*	6698	-181*	652	-28
Bellingshausen	488	-35*	2794	-	6850	-	723	-66*

TABLE 5. Mean (m) *and decadal changes* (tr) for cloud layers high boundary. Cloud amount 0-100% of the sky. Trends with significance level not less than 95% are marked by *. Other trends are with significance level not less than 50%.

Station name	**Atmospheric layer**							
	0-2 km		**2-6 km**		**6-10 km**		**0-10 km**	
	m	**tr**	**m**	**tr**	**M**	**tr**	**m**	**tr**
Mawson	1702	18*	5237	167*	9365	70*	9343	104*
Bellingshausen	1493	-10	5059	28	9463	-13	9402	-14

This study is useful to gain insight into climate change in Antarctica.
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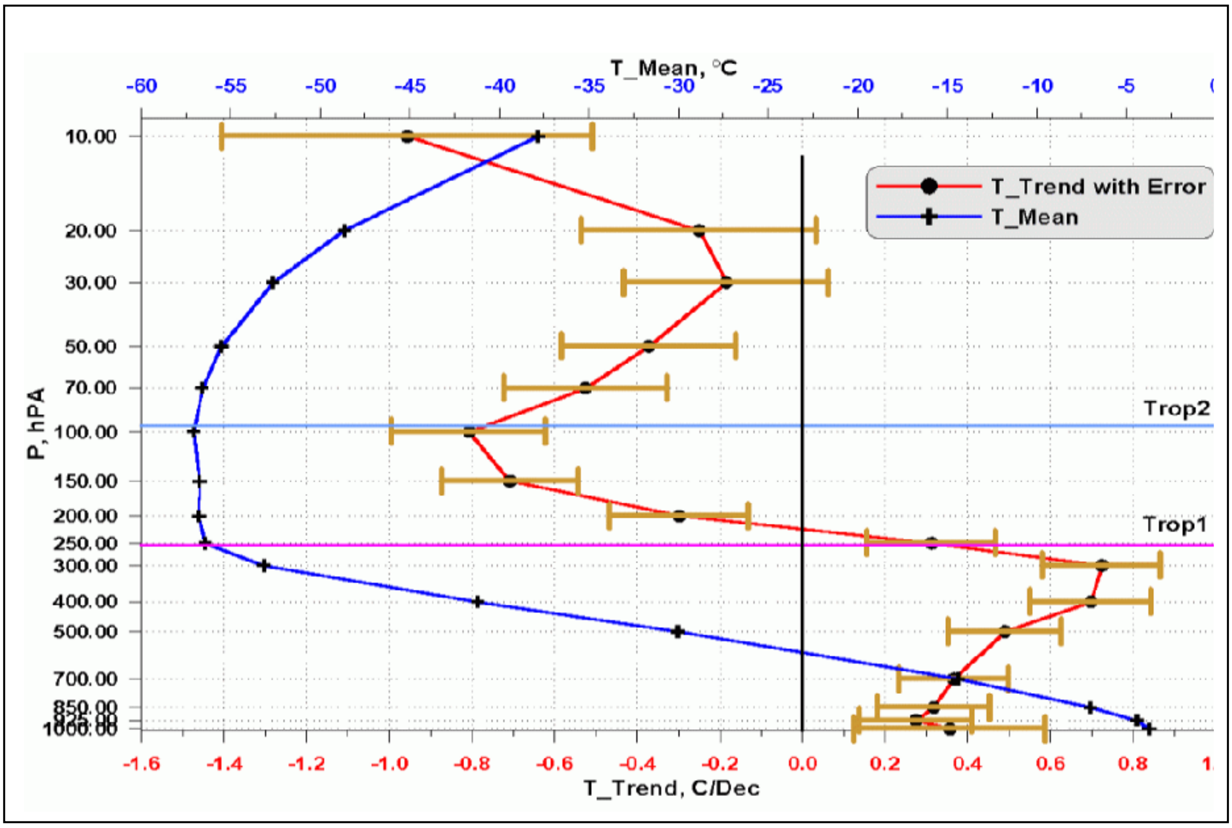

Figure 1 Mean and trends in anomalies of temperature T at standard isobaric levels for Bellingshausen. 1970-1999 years. CARDS.

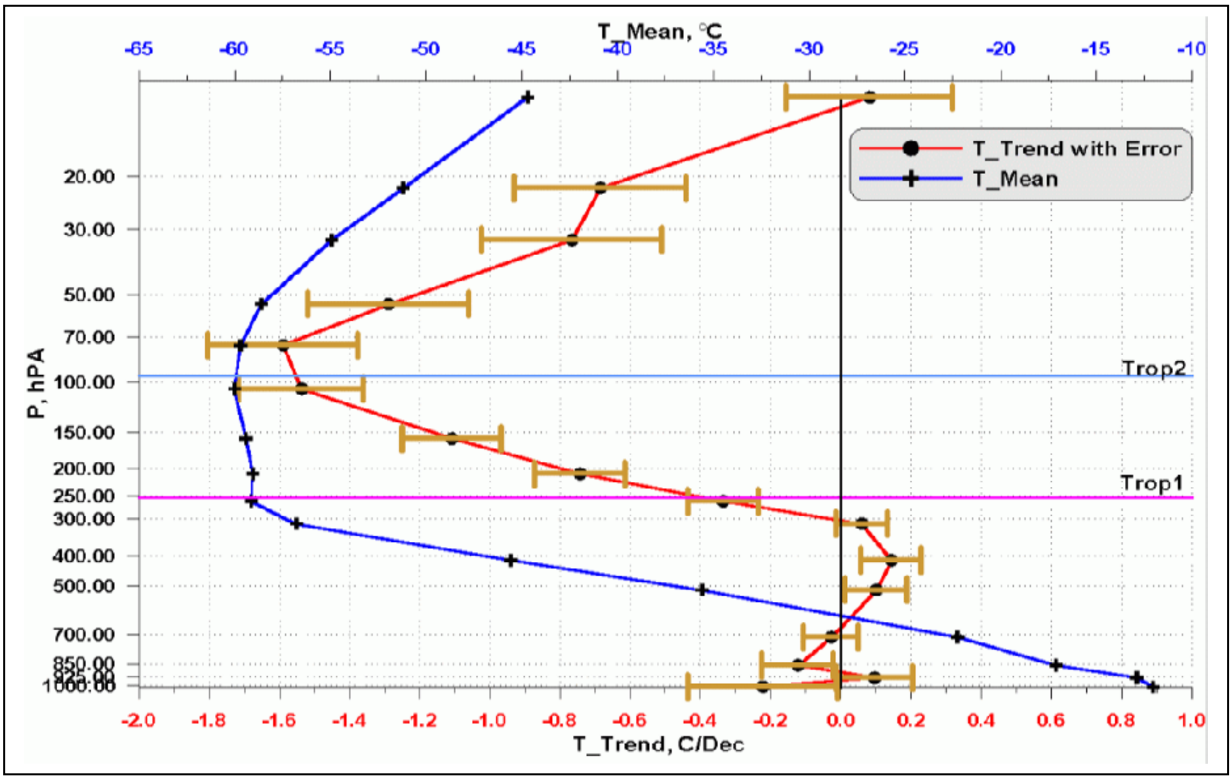

Figure 2. Mean and trends in anomalies of temperature T at standard isobaric levels for Mawson. 1969-2001 years. CARDS.

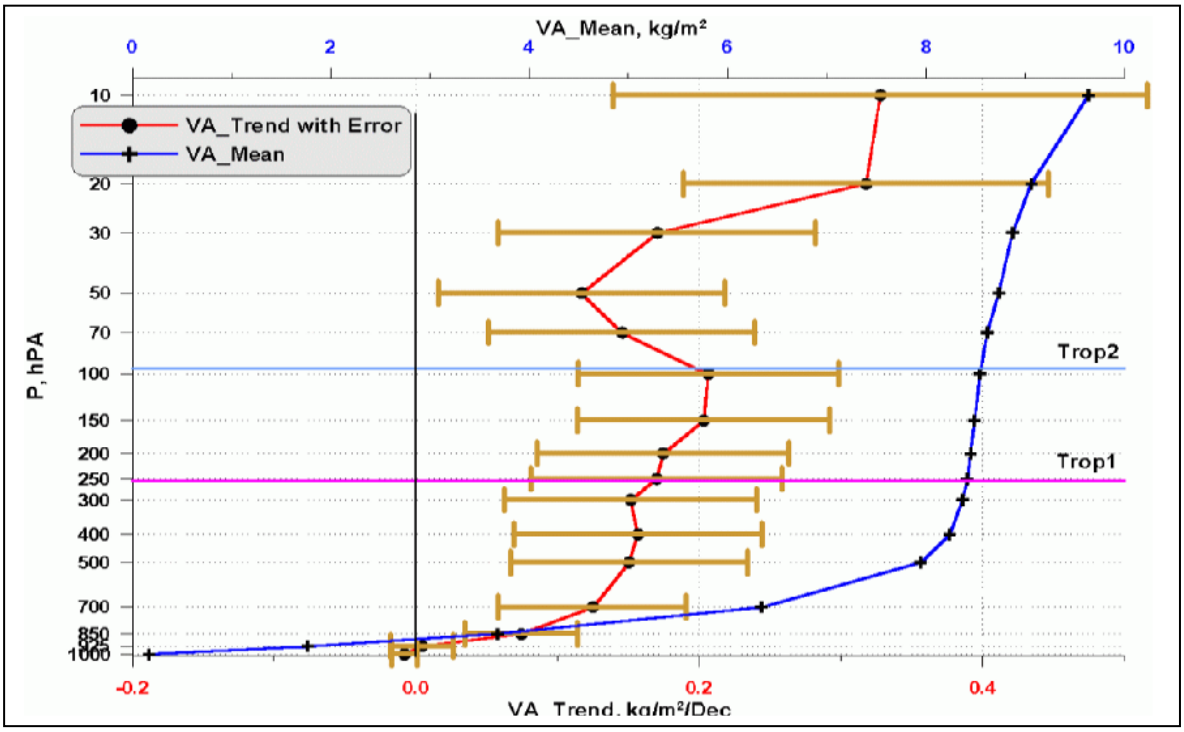

Figure 3. Mean and trends in anomalies of water vapor amount VA for standard isobaric levels for Bellingshausen. 1970-1999 years. CARDS.

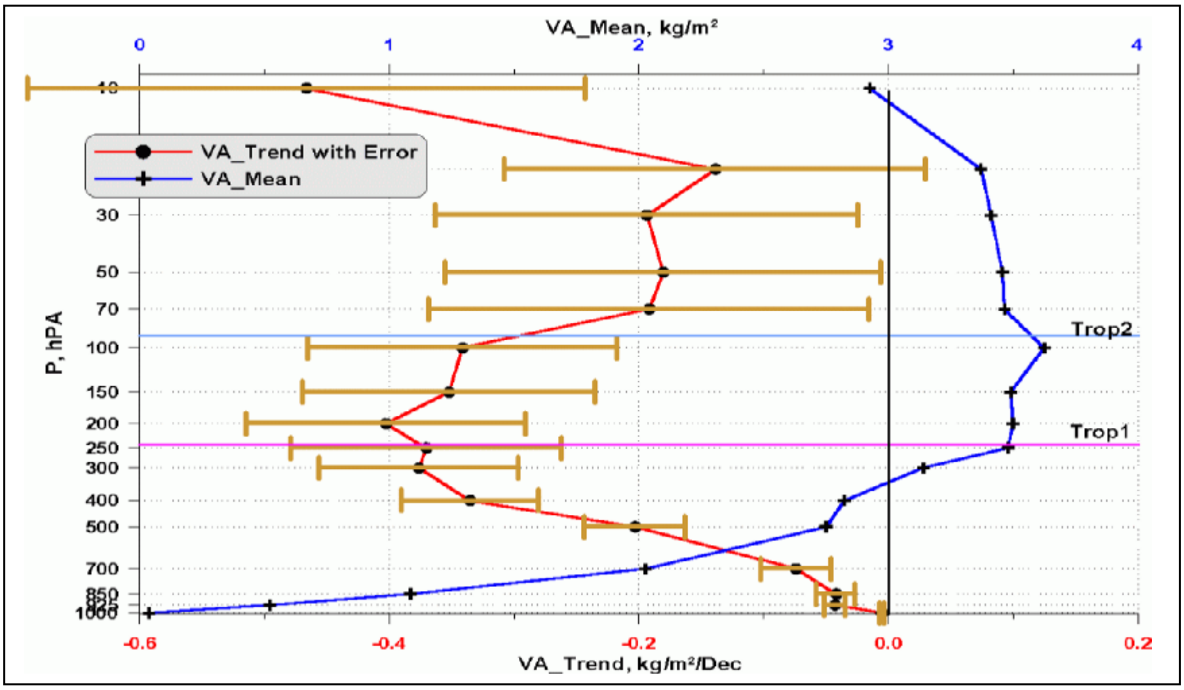

Figure 4. Mean and trends in anomalies of water vapor amount VA for standard isobaric levels for Mawson. 1969-2001 years. CARDS.

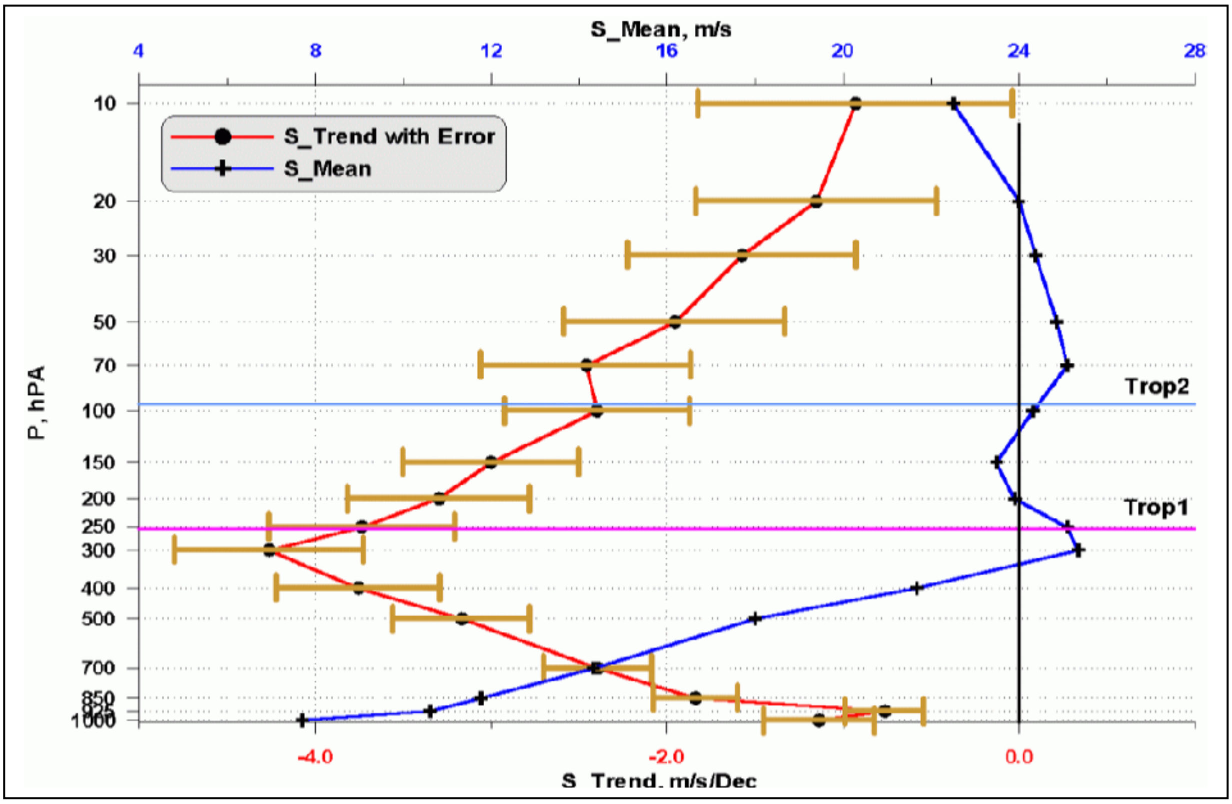

Figure 5. Mean and trends in anomalies of wind speed S for standard isobaric levels for Bellingshausen. 1970-1999 years. CARDS.

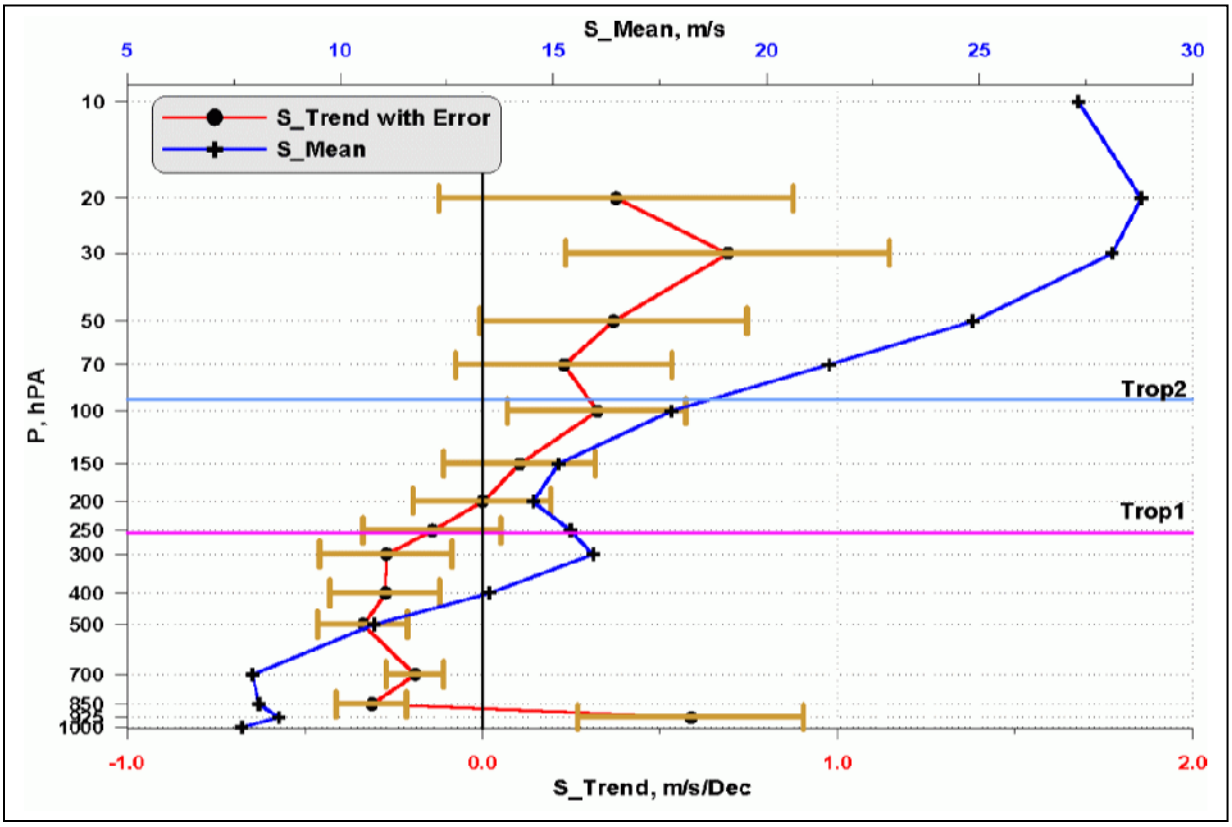

Figure 6. Mean and trends in anomalies of wind speed S for standard isobaric levels for Mawson. 1969-2001 years. CARDS.