

VARIATIONS OF AIR TEMPERATURE AT 850 hPa IN NORTH-WEST ROMANIA

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ABSTRACT. – **Variations of air temperature at 850 hPa in North-West Romania.** The 850 hPa air pressure level is situated about 1.5 km above sea level. This means that the surface does not influence the temperature at this altitude, so the diurnal temperature variations are small. They are about 2-3 degrees, or they do not exist, at all. This is why temperature of the 850 hPa level is used for identification of air masses and location of warm and cold fronts. Moreover, temperature variation of the 850 hPa level can be analysed in themselves, as indicators of climate 1500 meters above the sea level. The 1973-2014 period, analysed in this study, was chosen as the longest available series in Cluj-Napoca. The results, concerning the evolution of temperature at this standard isobaric level pointed at strong warming in the last 10-15 years. In the last 7 years the highest temperatures were higher by one degree at the 850 hPa level than in the preceding years. The heating at the analyzed isobaric level overlaps the growing of ground temperature, analyzed the medium annual temperature in the period 1973-2014.

Keywords: temperature, 850 hPa, climate change.

1. INTRODUCTION

The global warming is not questioned by the scientific community. The instrumental observations in the last 157 years show that the surface temperatures increased in global average, with important regional variations.

A high heating rate took place in the last 25 years and the tenth warmest years were registered in the last 14 (Busuioc et al., 2007).

Besides the global warming on the regional scale, other agents can influence the future environmental changes, like the variation in atmospheric circulation and local geography (Papagiannaki et al., 2014).

In Romania, different studies show that some modifications occurred in the air temperature and their relation with the modifications in circulation on a large scale. Since 2000, dry and hot summers have become more and more common in Romania (Busuioc et al., 2007).

The point of this research is to analyze the variation of temperature at 850 hPa level. The data and methods used are presented in Section 2. In Section 3, the results of this research are presented: a comparative study between air temperature at isobaric surface of 850 hPa and ground mean annual temperature in Cluj-Napoca was made. Conclusions are in Section 4.

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2. DATA AND METHODS

The data used in this study have been extracted from sounding data surveys archive in Transilvania Nord Regional Meteorological Center for Cluj-Napoca location. The data have been collected each day at 00:00 UTC, between 01.01.1973 and 31.12.2014.

Over this period there were some gaps with no direct measurements. These gaps were filled up by the data downloaded from the NCEP/NCAR reanalysis program interpolated above the horizontal coordinates of Cluj-Napoca (www.esrl.noaa.gov/psd/data/). The daily temperature data were analyzed at the 850 hPa level, deriving multi-annual, annual, monthly and daily averages, to point at their extremes, too. Also, averages on 10 years and 5 years were calculated to show longer periods of heating and cooling. For the annual mean air temperature in Cluj-Napoca, daily mean temperature data were used. In addition to the data on temperature of the 850 hPa, temperature at 2 meters above the surface were included from the same location, Cluj-Napoca. Semi-decadal averages were calculated for the intervals 1973-1980 (1981-1990, 1991-2000, 2001-2010) and 2011-2014. Similarly, averages were also built for some different intervals: 1973 - 1975, 1976 - 1980... 2006 -2010, 2011 - 2014. These averages were applied to point out the extreme temperatures recorded in some intervals from the analyzed period.

3. THE DATA ANALYSES

In the '70s and at the beginning of the '80s, the mean annual temperature at the 850 hPa level was 3.6 - 3.7 °C, while since 1985 the air temperature has increased with 0.4-0.5 °C (Fig. 1).

This increase was pointed out by using the 5 years average values. Over the period 1981-1985, the change was of 3.7 °C and reached 4.1 °C over the interval 1986-1990. The 10 year average (1981-1990) was 3.9 °C. The interval between 1991 and 2005 remain constantly at an average value of 4.0 °C. Analyzing the 2006-2014 period, we can notice a shift of 1 °C between 2006 and 2010, while between 2011 and 2014, another shift of 0.2 °C was detected. The survey on 10 years has got mild increase, so the intervals 2001-2010 indicated an increasing of 0.5 °C compared to the '90s mean values, while the period 2011-2014 registered an increasing of 0.6 °C above the values of 2000 (Fig. 1).

Among the coldest years, 1985 was pointed out with an average of 3.0 °C, whereas the years 1973, 1976, 1980, 1991 recorded 3.1 °C. The hottest year was 2014 with an average of 5.6 °C. This rate was greatly influenced by the first 4 months of the year, when the mean temperature was with 5.2 °C higher than the multiannual mean temperatures of those months. Other years, warmer than the normal, were 2007 and 2012 with mean temperatures of 5.4 °C, 2008 and 2009 with mean annual temperatures of 5.1 °C (Fig. 1).

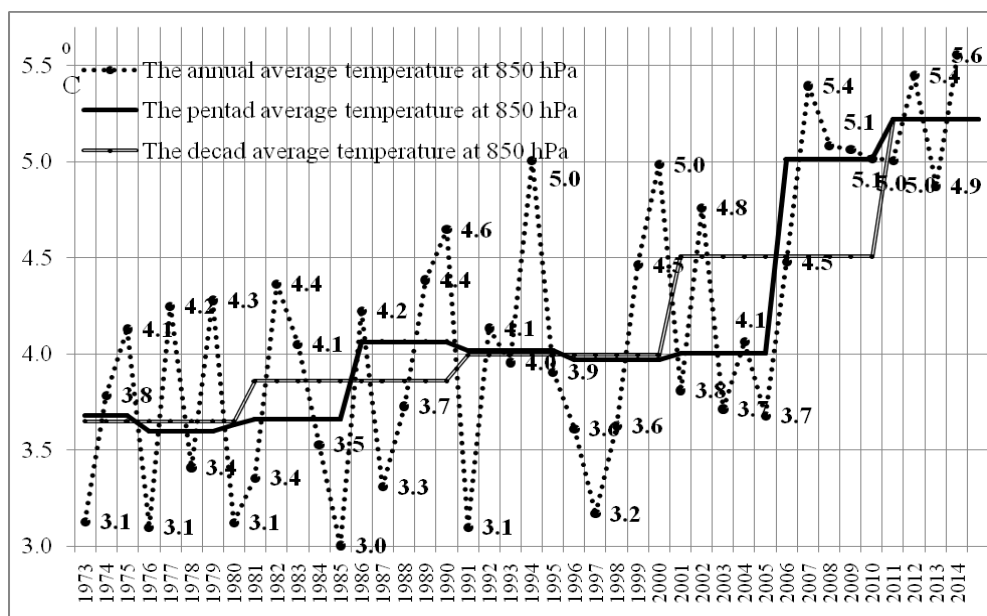


Fig. 1. The fluctuation of annual, pentad and decade medium temperature between 1973-2014 at 850 hPa level

The annual cycle of temperature at isobaric surface of 850 hPa keeps its classical shape with the highest values during summer with more than 10 °C (June, July and August, 12.8 °C) and the lowest mean monthly temperatures registered in January, February (- 4.3 °C) and March and December with values below 0 °C (Fig. 2).

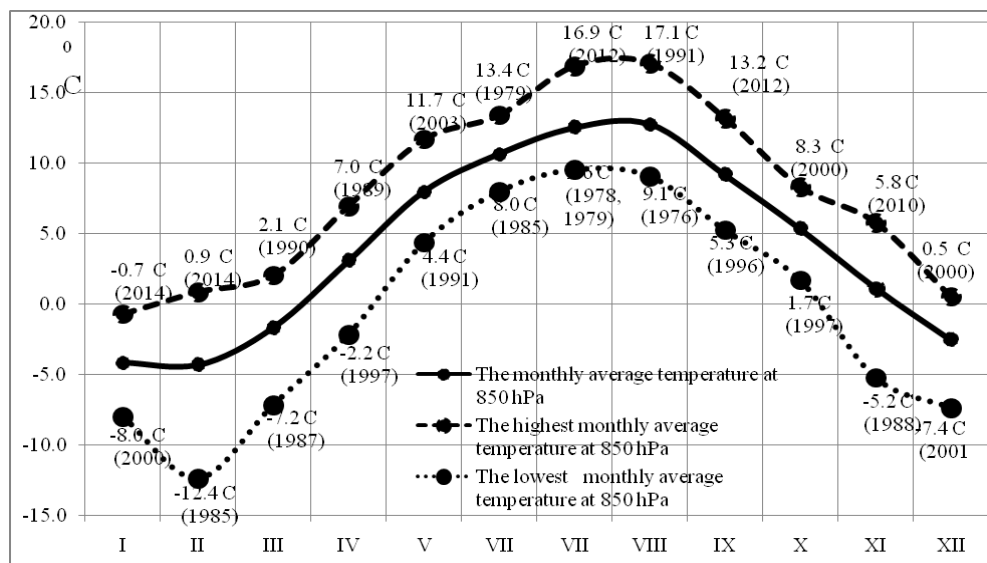


Fig. 2. The mean monthly temperature over the period 1973-2014

Concerning the temporal distribution of 850 hPa isobaric surface extreme monthly temperature one can notice that most of the years when all the 12 values were the highest (8) were after 2000, while the lowest extreme values occurred only in two years after 2000 (Fig. 2).

The increasing temperature registered at isobaric surface of 850 hPa mainly between 2007-2014 can be observed in Table 1. Thus, between the years 1973-2006 the negative deviations are in 50 % of the cases over the whole year. There are still two exceptions: 1982 and 1994. Between 2007-2014 the negative deviations are only in few months and they have lower amplitude.

Table 1. Deviations of the monthly mean temperatures form the 41 years' average (1973-2014) at the isobaric surface of 850 hPa

year month	'73	'74	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93
1	0.1	-1.3	1.3	-3.4	2.2	-0.8	-0.2	-3.0	-0.4	-1.0	0.3	0.3	-3.9	-0.4	-2.5	3.3	0.3	1.0	0.9	0.5	0.2
2	0.3	3.5	-1.7	-1.0	4.0	1.2	0.2	-0.3	-2.1	-2.0	-2.6	-0.9	-8.1	-2.1	1.6	2.1	2.9	4.1	-2.6	-1.5	-1.3
3	-2.7	2.4	3.1	-3.5	3.2	1.2	2.9	-0.8	0.7	-0.8	1.4	-1.7	1.5	0.7	-5.5	-1.1	2.4	3.8	1.6	-0.4	-1.7
4	-0.7	-2.4	-0.6	1.0	-1.8	-0.8	-2.0	-2.4	3.1	-3.1	2.3	-1.6	0.6	3.1	-1.9	-1.8	3.9	0.5	-2.6	0.6	-1.8
5	-0.4	-2.0	1.3	-1.2	0.3	-2.6	0.5	-2.7	1.0	0.8	1.7	0.7	1.0	1.0	-0.9	-0.3	-1.3	-0.1	-3.6	-1.3	1.1
6	-0.8	-1.6	0.6	-1.8	-0.6	-0.8	2.8	-1.1	-0.2	0.3	-0.5	-2.3	-2.7	-0.2	0.2	-0.9	-1.4	-1.3	0.4	0.2	-0.3
7	-0.8	-1.6	-0.7	0.3	-0.9	-3.0	-3.0	-1.6	-1.4	-1.4	0.1	-2.3	-1.0	-1.4	2.4	1.7	-1.0	-0.1	1.0	0.4	-1.5
8	-1.4	1.0	-0.8	-3.7	-1.1	-2.8	-1.2	-1.6	1.2	0.0	-0.6	-1.9	0.6	1.2	-2.8	0.6	0.2	0.0	-1.9	4.3	0.0
9	2.4	0.2	1.9	-1.1	-3.1	-2.1	0.6	-1.5	0.6	3.3	0.4	0.8	-0.8	0.6	1.6	-0.1	-0.6	-2.9	-0.4	-1.1	-0.3
10	-1.2	-1.8	-0.9	2.0	1.6	-0.3	-1.3	1.0	-0.5	1.8	-1.1	1.4	-1.4	-0.5	-0.9	-0.8	-0.3	0.6	-2.4	-0.9	2.7
11	-5.1	-1.0	-1.8	0.5	-0.4	1.6	-0.8	-1.0	0.3	1.7	-3.1	0.7	-2.0	0.3	-0.6	-6.3	-2.0	0.9	0.9	-0.6	-1.1
12	-2.0	0.2	-2.0	-0.7	-2.4	0.1	2.9	2.7	-1.3	2.9	0.5	-0.6	2.3	-1.3	-0.8	-1.6	-0.3	-0.6	-4.0	-0.4	1.6
year month	'94	'95	'96	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11	'12	'13	'14
1	3.4	-1.6	0.5	3.1	1.6	3.2	-3.9	1.7	1.3	-0.4	-2.8	-0.6	-1.0	-2.1	1.9	1.3	-1.1	0.2	-2.1	0.5	3.5
2	1.2	4.1	-1.0	1.0	2.4	-2.0	0.5	0.4	5.0	-4.4	-0.1	-1.6	-1.1	-3.7	1.3	-0.6	1.6	0.7	-3.4	0.8	5.2
3	1.1	0.3	-4.1	-2.5	-4.2	0.3	-0.9	3.0	1.8	-2.3	0.1	-2.7	-0.5	0.3	1.4	-0.6	-0.1	0.9	0.3	-1.2	3.1
4	1.3	-1.1	-0.7	-5.2	1.0	0.7	2.8	-0.5	-1.4	-2.9	0.9	0.7	1.3	2.1	0.9	3.1	0.4	0.3	2.1	1.5	1.0
5	-0.7	-1.1	2.1	0.2	-1.6	-1.5	0.8	-0.4	1.7	3.7	-1.6	0.3	-0.3	1.3	0.0	0.1	1.1	0.5	1.3	1.8	-0.6
6	-0.5	0.5	0.9	-0.3	0.6	1.8	0.2	-2.2	0.3	1.5	-0.4	-1.1	-0.3	2.5	1.4	0.8	1.8	1.2	2.5	1.1	-0.7
7	0.9	1.5	-1.9	-1.8	0.2	1.2	-0.9	0.7	1.4	-0.3	0.6	0.0	1.3	4.3	0.0	1.4	1.6	0.9	4.3	-0.3	0.3
8	0.4	-1.0	-0.5	-1.3	0.2	-0.6	1.5	0.7	-0.3	1.0	0.2	-0.2	-0.6	2.0	1.5	0.7	2.2	1.7	2.0	0.7	0.3
9	3.7	-2.0	-3.9	-2.4	-1.4	1.4	-0.8	-1.3	-1.4	-1.7	-1.4	1.0	0.2	4.0	-1.4	1.8	1.8	3.5	4.0	-2.7	0.3
10	-1.0	0.7	-1.2	-3.6	0.6	-0.8	3.0	1.6	-1.4	-3.3	1.2	0.0	2.1	2.7	1.3	0.0	-2.6	-1.3	2.7	1.4	1.4
11	-0.4	-3.2	2.4	0.9	-3.6	0.1	4.5	-3.0	2.1	1.7	0.1	-0.7	0.8	2.5	1.7	1.8	4.7	0.4	2.5	2.1	1.3
12	0.6	0.1	0.8	0.2	-2.3	0.0	3.1	-4.8	-1.9	2.0	2.1	-0.9	2.1	-0.7	1.2	0.9	-0.9	1.3	-0.7	2.9	1.7

The months with the highest negative deviations are February 1985 (-8.1 °C) and November 1988 (-6.6 °C). The months with the strongest positive deviations are February 2014 (5.2 °C) and February 2002 (5.0 °C) (Table 1).

In Fig. 3 and 4, mean annual air temperature series at ground level and at the 850 hPa level are presented. So we can notice that the temperature increase registered at ground level is present also at the 850 hPa levels.

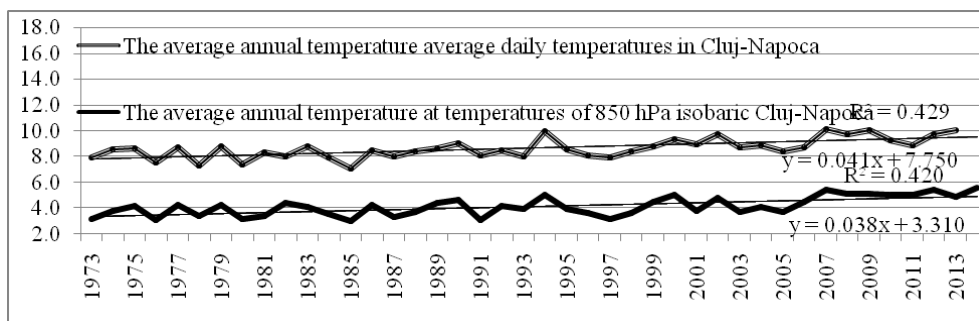


Fig. 3. The mean annual temperature variation at 850 hPa level and at the ground level, at Cluj-Napoca weather station over the period 1973-2014

The increasing trend of annual mean temperature expressed in 10 years averages is presented in Fig 4. At Cluj-Napoca weather station, the warming is 1.4 °C at ground level and 1.5 °C at 850 hPa isobaric surface level.

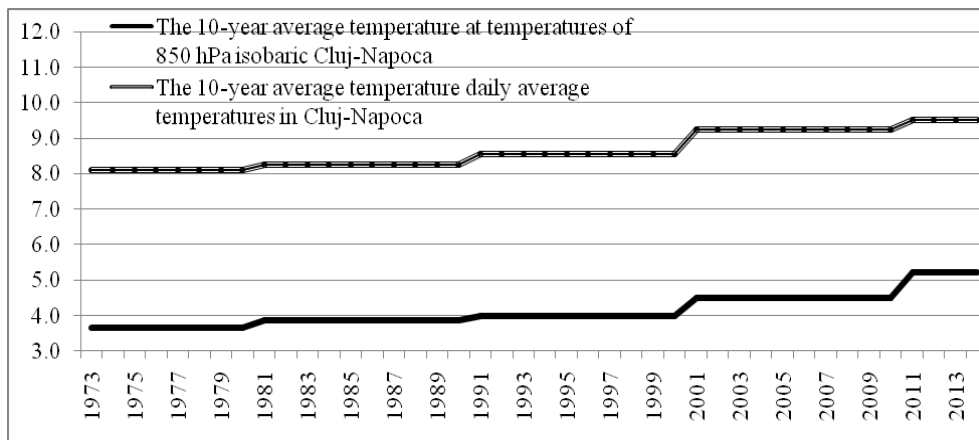


Fig. 4. The mean temperature variation on 10 years at 850 hPa level at Cluj-Napoca weather station between 1973-2014

4. CONCLUSIONS

The 850 hPa isobaric surface temperature is a good indicator of temperature evolution, because it is located generally around 1,500 meters above the sea level and the topography influence on temperature is minimum.

The temperature analysis at 850 hPa level replenished the picture about heating registered at ground level of weather stations. The warming signs were at their lowest value at the end of the XXth century: the variation of temperature was 0.3, 0.5 °C at ground level and at 850 hPa isobaric surface level. Starting at the beginning of the XXIst century, the warming has been higher; the temperature has increased with 1.1 - 1.2 °C since the early '70s.

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