CHARACTERISTICS OF THERMAL ANOMALIES OCCURRING DURING THE COLD SEASON ABOVE BUCHAREST, AS DETERMINED ON THE BASIS OF RADIO AND SATELLITE SOUNDINGS

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ABSTRACT. This paper uses the comparative method in order to highlight the thermal anomalies, the impact of atmospheric circulation and the air masses through specific situations. Our preliminary study employs radio sounding data from Bucharest-Băneasa weather station, and this method is applied for an altitude interval bounded by Earth's surface and the geopotential surface of 900hPa. Thus, the results have been obtained from radio soundings up to the 900 hPa level, which corresponds to an altitude of 1000 meters, because above this level, there is a tendency towards generalization due to the decreased influence of the subjacent active surface and the impact of the particularities of the general atmospheric circulation above Bucharest. The aim of the study was to explain the temperature distribution through statistical shape/form indices and to measure their degree of flattening and asymmetry. Processing the radio – soundings data complemented, when not measured, by the remote sensing data available after 2007, involved the statistical modeling of time series for the cold season (October to March), which meant analyzing the temporal variations and the prognosis for the evolution of meteorological and climatic elements. A comparison of the values taken by different parameters of the analyzed thermal regime could not be achieved without a more detailed presentation of the thermal regime up to 900 hPa, by entirely taking into account thermal anomalies, exceptional thermal gradients and the altitude/height of isotherms directly involved in the analyzed phenomenon, and also by directly correlating these elements with the characteristic synoptic situations.

Keywords: Radio soundings, isopotential levels, lower troposphere, satellite profiles, thermal inverse stratification

1. INTRODUCTION

The climatic analysis of the lower troposphere, whose upper limit is the isobaric level of 900 hPa, represents a median state that can be defined by a set of climatic averages and statistical parameters reflecting the variability and

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fluctuations over time of the climatic regime. The choices of the upper level was determined by the tendency towards generalization presented by the climatic elements found at certain isopotential levels and by the reduced influence generated by the topography and active subjacent surface (see sources).

In any synoptic situation, the Carpathian mountain arch acts by restructuring the baric/pressure field, favoring the penetration of cold air from Northern Europe via Moldova towards the centre of the Romanian Plain, where occurs both the “interference of Romanian circulations” (N. I. Bordei, Ecaterina Ion Bordei, 2008) and also the stagnation of warm Mediterranean or tropical air masses, particularities that are seen as main variables in the appearance of positive and negative thermal anomalies. In Bucharest location, the most frequent inversions are those of advection-type, caused by the movement of polar or arctic air over Romania, which penetrates and then remains in the Carpatian-Balcanic Depression (Mărinică, 2006).

The area of interference of atmospheric circulations where the Bucharest-Baneasa Aerologic Station is located determines in the temporal and spatial evolution of climatic elements and phenomena a number of deviations, irregular oscillations (Rahau Lidia et all., 1978) or anomalies (Apostol, 1990) that are more frequent than the multi-annual averages seen as normal.

A meteo-climatic phenomenon that is characteristic for the cold season, reversed thermal layering is confirmed by the presence of negative thermal gradients, when temperature increases with altitude (Țâștea 1965; Neacșa O., Popovici C., 1967, Bogdan Octavia, 1996, 1999; Cavazos, T. 2000, Devasthale, A. et al. 2010), and it manifests itself in all the analyzed seasons.

2. DATA AND METHODS

The documentation was mainly covered by the radio-soundings datasets for Bucharest – Băneasa weather station, for a 30 years period of daily records (1983 – 2013), twice a day, for 00UTC and 12UTC. Because the mean structure of atmospheric temperature profiles (1000 and 900 hPa levels) can also be achieved from ATOVS measurements (satellite profiles), depending on radio-sounding data availability beginning with 2007, the gaps in the dataset was filled, in many cases, with data from satellite soundings. However, because of some emissivity errors, such as the failure of low level cloud check, surface uncertainty, the retrieval may become subject to many errors, especially in low atmospheric levels (Wolf et al., 2000).

A set of intersource data comparisons was performed for both the radio and satellite soundings data, to check for any inconsistencies in the retrieved values of the temperature at the two levels mentioned above and there was a good agreement among the two datasets. For the satellite data, some technical details were considered necessary to be offered. Briefly describing it, the Advanced Technology Microwave Sounder represents a significant advance in the quality of the measurements injected into models for understanding and making atmospheric forecasts. The ATOVS (Advanced TIROS Operational Vertical Sounder) and

AVHRR (Advanced Very High Resolution Radiometer) Pre-processing Package (AAPP) is supplied and maintained by the NWP SAF , acronym for EUMETSAT Satellite Application Facility for Numerical Weather Prediction (***, 2011).

Once the datasets were established and pre-processed, an entire range of calculations and statistical operations were made in order to obtain the results of the climatological study, by using some statistical and designing programs, as follows: Panoply, Microsoft Excel, Systat (Mystat – student edition) and Inkscape.

The statistical methodology was used as a diagnostic tool to derive anomalous atmospheric patterns characteristic of inversion events, as extreme climatological phenomena.

3. RESULTS AND DISCUSSIONS

The altitudinal evolution of average temperature values during the cold seasons presents a tendency towards increasing up to the 975 hPa level, which is the equivalent of an altitude of 378 meters, the difference of 0.4ºC being generated by the thermal inversions occurring at ground level with great frequency and intensity during the cold season. A detailed analysis of values shows in the case of values recorded at 00 UTC that the multiannual seasonal thermal average of 3.7ºC is surpassed at all isobaric levels found above, and in the case of values recorded during the day, at 12 UTC, the radiative maximum determines the heating of the air layer from the base towards the top, the averages have a negative tendency of evolution, as it can be seen in Table 1.

Table 1. The multi-seasonal averages distribution (daily for 00UTC and 12 UTC) of the temperature according to isobaric levels 1983_2013 at the aerological weather station Bucharest-Băneasa

Data source: *http://weather.uwyo.edu/upperair/sounding.html, http://www.eumetsat.int/website/home/index.html*

Isobaric Level	Multiannual seasonal averages		
	Day	00 UTC	12 UTC
1000	3,7	1,4	5,8
975	4,1	3,5	4,1
950	3,4	3,1	3,2
925	2,7	2,4	2,6
900	1,9	1,7	1,7

In Romanian climatological studies (Clima României, 2000) are mentioned the years that present deviations from the temperatures considered as being normal, which are consistent with the results obtained by analyzing the vertical thermal deviations. The analyzed period, 1983-2013, presents a 54% frequency of positive thermal deviations which confirms the positive tendency of the thermal evolution above the Bucharest-Băneasa aerological station (Table 2).

Table 2. Maximum and minimum values of thermal deviations of seasonal multiannual averages according to the selected izobaric levels within 1983-2013 at Bucharest - Băneasa aerological weather station
Data sources: *http://weather.uwyo.edu/upperair/sounding.html, http://www.eumetsat.int/website/home/index.html*

Isobaric level	Maximum deviations	The season	Minimum deviations	The season
1000	3,62	2006_2007	-3,29	1995_1996
975	3,74	2006_2007	-3,79	1995_1996
950	4,07	2006_2007	-3,90	1984_1985
925	3,73	2006_2007	-3,24	1995_1996
900	2,64	1989_1990	-2,57	1995_1996

The groupings of positive deviations increase their interval of occurrence towards the end of the period, such as the 2000-2002 and 2006-2011 seasons, those with negative deviations generally presenting a temporal manifestation that lasts around 6 months, usually. The 2006-2007 season has the highest number of positive deviations for the first 4 isobaric levels that were analyzed, 1000-925 hPa, and the 1989-1990 season has the most deviations for the upper level of 900 hPa, and regarding negative deviations, remarkable are the 1995-1996 and 1984-1985 seasons, the latter being known for the frequency and intensity of its massive cold waves and the blizzard of January – February 1954 (Bogdan, O., Niculescu, E., 1999).

As a general rule, the amplitude of thermal deviations during the cold seasons for the 1983-2013 interval increases proportionally with altitude, fitting within the +4.07ºC – -3.9ºC.

The determination coefficient (R^2) of the simple linear regression line presents the highest values, 0.25, at the station level (1000 hPa, meaning 91 meters) and 0.22 at the median level of the analyzed interval. The percentage explanation of over 20% for the abovementioned levels found in the tendency prognosis is associated with the thermal deviations' regime (Fig. 1), and in the case of other levels, the deviations' regime varies greatly because of the complex variables that are integrated (Fig. 1).

The isobaric levels employed in the analysis, associated with the corresponding temperature values, were able to capture significant interannual differences. The analyzed period, 1983-2013, presents a 54% frequency of positive thermal deviations which confirms the positive tendency of the thermal evolution above the Bucharest-Băneasa aerologic station.

This phenomenon is frequent in areas with depressions, where the temperature in the first few hundred meters above the ground is equal to that found at the altitudes corresponding to the top of the mountains, the median portion remaining warmer (Mărinică, 2006).

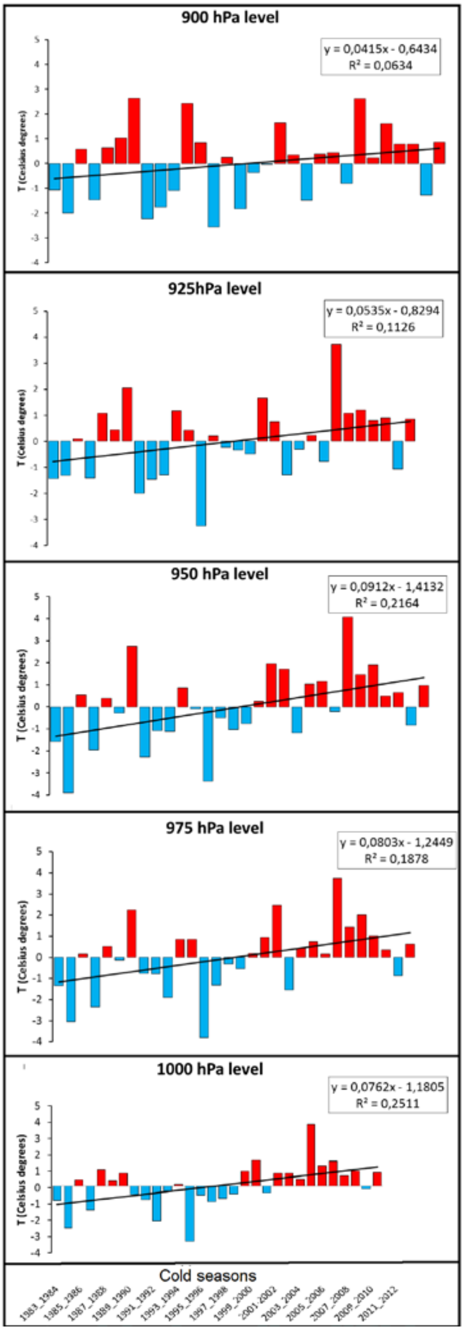

Fig. 1. The distribution of average multiannual thermal deviations during the cold season, according to the isopotential levels (1000-900 hPa interval), above Bucharest - Băneasa aerological weather station within 1983 – 20

Data sources:

http://weather.uwyo.edu/upperair/sounding, http://www.eumetsat.int/website/ home/index.html.

In order to present in detail the deviations or thermal anomalies (Apostol, 1990), the results have been achieved by applying the Hellman classification criterion, usually employed for the quantitative analysis pf atmospheric precipitations in studies made by Șt. Hepites, C. Donciu, N. Topor, N. Al. Rădulescu and Octavia Bogdan.

As altitude increases, so does the number of classes with extreme values and also the frequency of exceptionally warm or cold seasons, a result that confirms the intense manifestation of climatic variability with altitude increase (Fig. 2). Ground level anomalies are generally moderated by factors that increase the thermal intake generated by the thermal inertia of the subjacent active surface and also by the characteristics specific for Bucharest's topo-climate, seen as a thermal island (Ciulache S., 1971). At higher altitudes, the perturbations typical for the greater variability are mostly dictated by the altitude circulation and by the lack of influence from the active subjacent surface.

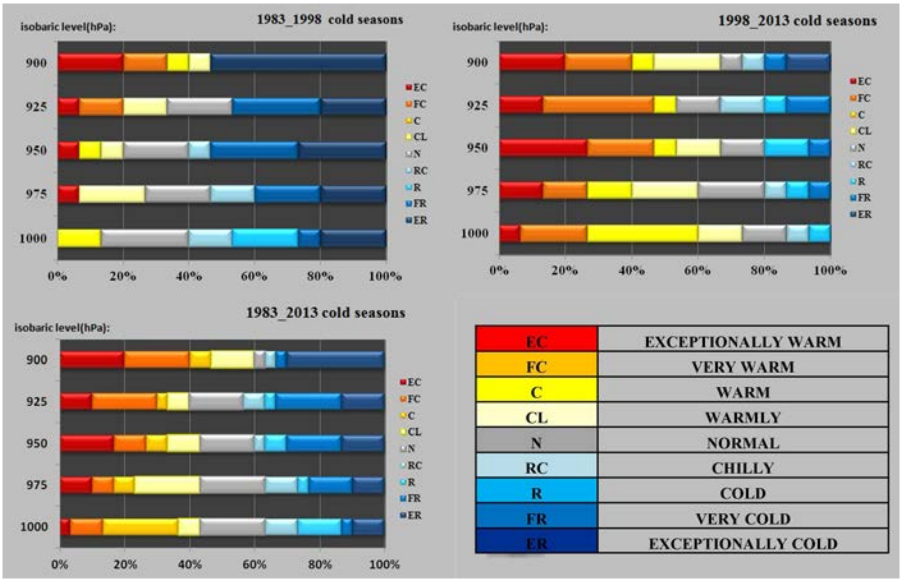

Fig. 2. Class distribution according to Hellman criterion of the average annual thermal deviations above Bucharest - Băneasa aerological weather station in the cold seasons of the period 1983 – 2013
Data sources: *http://weather.uwyo.edu/upperair/sounding.html,*
http://www.eumetsat.int/website/home/index.html

The reversed thermal layering, as a meteo-climatic phenomenon characteristic for the cold season, directly affects the averages recorded in the lower troposphere above Bucharest, bounded by the 1000 and 900 hPa isopotential levels.

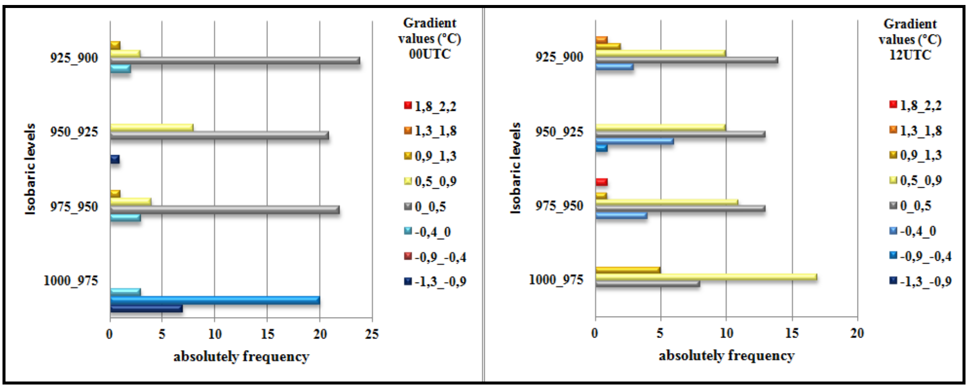

Fig. 3. Class distribution of multiannual average values of thermal gradients above Bucharest - Băneasa aerological weather station in the cold seasons within 1983 – 2013
Data sources: *http://weather.uwyo.edu/upperair/sounding.html,*
http://www.eumetsat.int/website/home/index.html

The classification of the distribution values for gradients, according to the Huntsberger and Brook Caruthers relations, reflects the uni-modal histograms where negative gradients have the highest frequency at ground level, below 975 hPa in case of values measured at 00 UTC (Fig. 3).

4. CONCLUSIONS

The characteristic thermal regime of the lower troposphere above the location of Bucharest - Băneasa aerological weather station is strongly influenced by the occurrence of the inverse thermal stratifications. Thus, the consequence of the reversal of normal behavior of temperature in the troposphere was highlighted by the multiannual average of the cold season within 1983 - 2013, reaching a value of 3,7 and being lower than the 4,1 , corresponding to the isobaric level of 975 hPa. The increasing trend with the altitude, both for the temperature and for the amplitudes of thermal deviations from the mean values, reflects the rise of the climatic variability.

Thermal anomalies manifest themselves through the high frequency of thermal inversions with altitude, having a significant weight overnight, at 00UTC observation hours and at 12UTC in the afternoon. Moreover, the prevalence of the negative deviations from the normal thermal field in the first 15 seasons are complemented by the positive deviations in the second part of the analyzed period.

The conclusive fact is that the increased frequency of thermal inversions above a location with such synoptic signatures characteristics, as it is the case of Bucharest - Băneasa aerological weather station, may be linked to the large-scale circulation anomalies in the whole eastern North Atlantic and Europe in the last most recent decades.

5. ACKNOWLEDGEMENTS

The authors gratefully acknowledge the meteorologists from Romanian National Meteorology Administration for their suppport and advice, especially Miss Anișoara Irimescu, Mr. Denis Mihăilescu and Mr. Ion Mărinică, whose suggestions and critiques helpfully clarified a number of points at the beginning of our research. We also wish to thank Miss Nicoleta Ionac, professor at the Faculty of Geography, University of Bucharest for her comments, information and guidance.

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