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CONSIDERATIONS ON TEMPERATURE INVERSIONS IN THE LOWER TROPOSPHERE IN THE 2001-2002 COLD SEASON, SOUTH OF THE CARPATHIAN MOUNTAINS.

Bărcăcianu Florentina[1], Apostol Liviu[2]

Key words: troposphere, radiosounding, negative gradients, standardized temperature, termoisanomale, kriging, interpolation.

Abstract. Temperature inversions are characterized by negative vertical thermal gradients (Donciu, 1953, Ţâştea, 1965, Bogdan, 1971, Neacşa, Frimescu, 1981). The most frequent manifestation is in the depression areas because in addition to radiative cooling and better possibility to store cold air invasion, it also takes place the accumulation and of air flow of cold air due to gravity. The area south of the Carpathians, shows depression features, gaining titles like: carpathian-balkanic bucket (Bălescu, 1962), carpathian-balkanic sink (Ion-Bordei, N. 1988). In this space the inversions occupy the entire area, proof being the values from low altitude stations similar to those from mountain peaks, while the middle part of the slope remains wormer.

Introduction

Normally, the atmosphere is characterized by a decrease in temperature of the air proportional to the elevation, there are few cases where the temperature tends to rise in altitude, which is characterized by vertical thermal gradients that are negative or null (Apăvăloae et. al. 1994). The extra-Carpathian area shows climatic differences between north and south, set by latitude (Mihăilă, 2006, Machidon et al., 2012), and the higher areas, take the characteristics of the upper atmosphere, cooled by the increasing distance from the thermal source and increased effective radiation. Bellow the average altitude of the Carpathians, air circulation is strongly influenced by them , so blocking the eastern circulation results in outlining a negative thermal anomaly (Apostol, 1990, 2004) determining

[1] PhD. student, Alexandru Ioan Cuza Univrsity, Iasi, Romania
[2] Prof. PhD. Alexandru Ioan Cuza University, Iasi, Romania

a stable vertical distribution of air with a thickness of 600-800m (Clima României, 2008).

The contribution of specific synoptic structures specific in the formation of these phenomena manifest themselves as some cold reservoirs in the winter season (Apostol, 2004, Ştefan, 2004, Rao et al., 2010), less intese than those in the Romanian Plain due to the heat generated by friction with the slopes. In any sinoptic situation, the carpathian chain restructures the baric field from the surface in the way that it favors cold air from northern Europe, from Moldova towards central Romanian Plain, where it takes place the ”circulations interference” (Bordei-Ion, N, Bordei-Ion, Ecaterina, 1981, 1984), and the amplification is due to relief and also due to the Coanda effect.

1. Methodology and data base

The data base used was made of data from radio sounding, complemented by temperatures recorded at 28 meteorological stations south of the romanian Carpathians. The termic values were recorded at 00 UTC and 12 UTC at Bucureşti-Băneasa aerological station and 1^{00} and 13^{00} for the rest of the meteorological stations.

Only 23 stations are included in the studied area, the rest being used for better results of the interpolation method, and also for a detailed calculation of the mean termal gradient of the 2001-2002 cold season.

Quantification of the reversed atmospheric stratification was done by analyzing temperatures, thermal gradients and standardized temperature, that suffered altitude and latitude corrections. Therefore, it was sought changes in temperature and negative gradients vertically over Bucharest. The increased diversity of radion sounding data, forced us to mediate the successive data recorded and to establish thermal values corresponding for each 100 m, up until 3000 m, above which the underlying active surface influence is insignificant.

The city, through its specific topoclimate, favors the registration of higher values in the lower layers than in free atmosphere, these conditions being favorable for the manifestations of local thermal inversions, so it was analyzed the horizontal thermal inversions in the area south of the Carpathians. The variables that prevent thermal value comparison and analysis, as well the researched phenomenon is represented by latitude and altitude, which were eliminated by reporting to the difference of 0,86°C/1 degree northern latitude (Apăvăloae et al, 1988, Apostol, 1990) and bringing thermal values to sea level, respectively 0 m, by applying horizontal thermal gradient of the 2001-2002 cold season.

Tab. 1. Meteorological stations located in the southern Carpathians

Meteorological stations	**Altitude**	**Latitude**
Bisoca	833	45,55
Campulung Muscel	679	45,28
Polovragi	532	45,18
Curtea de Arges	449	45,16
Pitesti	315	44,85
Targoviste	297	44,93
Patarlagele	289	45,31
Dragasani	282	44,67
Tg Jiu	206	45,03
Craiova	195	44,31
Ploiesti	178	44,95
Titu	160	44,65
Videle	109	44,28
Caracal	107	44,1
Rosiorii de Vede	103	44,1
Buzau	97	45,13
Drobeta T S	79	44,63
Alexandria	76	43,98
Calafat	63	43,98
Fetesti	61	44,37
Slobozia	52	44,55
Bechet	40	43,78
Zimnicea	34	43,66
Turnu Magurele	31	43,75
Oltenita	16	44,07

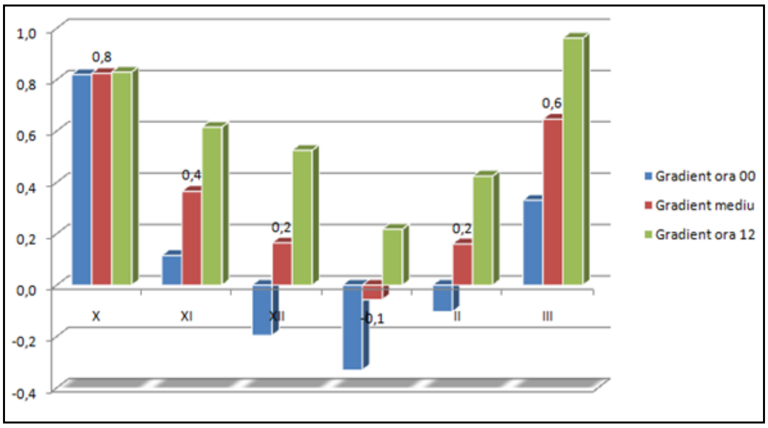

Fig. 1: The values of gradients featurea for cold season 2001-2002 over aerological station București-Băneasa

The thermal gradient was calculated from values recorded at weather stations analyzed and altitude differences between them, respectively 0,39°C(see fig. 1). By applying the method of spatial interpolation of standardized values were obtained distribution maps of termoisonomals of the cold season characteristic of each month, for the two time periods studied, 0^{00} and 1^{00} and also 12^{00} and 13^{00}.

2. Results and discussion

The air stratification model south-east of Curvature Carpathians during winter (Apostol, 1986), with some modifications, can be generally applied to the entire area studied in this paper, for the winter season. A model on the distribution with altitude in the atmosphere for all Romania and in detail for the area south of Southern Carpathians was elaborated by Bâzâc Gh. in 1983. Observations relevant to the ground temperature distribution in the cold season were presented by Bacinschi et al, 1990; Bogdan Octavia, 1969, 1980, 2007; Bogdan, Iliescu, 1971, Clima României, 2008, with numerous references and studies on the thermal inversions phenomenon, analyzed on data from the meteorological stations from ground level south of the Southern Carpathians. The major role of the Southern Carpathians and the Curvature Carpathians in shaping the thermal characteristics of the regions south and south east, has been studied by Bordei-Ion, N. şi Bordei-Ion, Ecaterina, 1988.

2.1. Analysis of temperatures in the lower troposphere above Bucureşti-Băneasa

Temperature decreases with altitude and in some cases is the opposite of the usual stratification and characterizes thermal inversions situations (fig. 2.). In this case, the downward trend of the temperature in the first 3000 m of the troposphere, the thermal inversions produces inflections of the evolving curves with large clusters in February-March in the case of the values at 00 and January-February in the case of the 12 values.

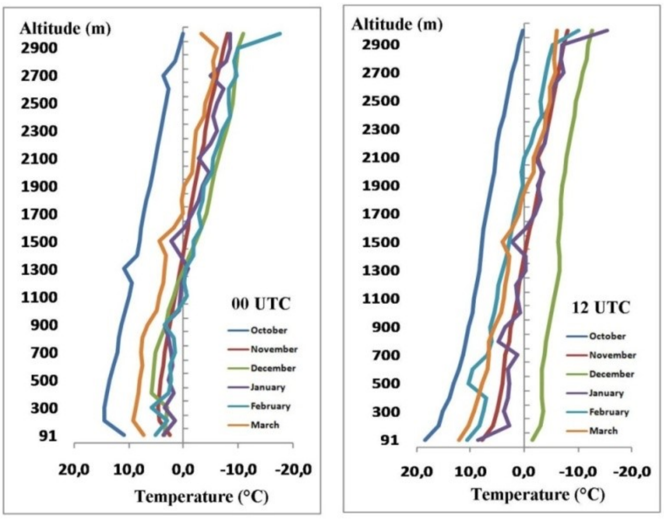

Fig.2.Distribution of cold season 2001-2002 average temperatures, at
00 UTC and 12 UTC over Bucureşti-Băneasa aerological stations

The high variability of the thermal regime in altitude does not reflect or confirm the presence of thermal inversions, these are more clear by analyzing statistical and mathematical the negative thermal gradients.In case of the values registered during night, those characteristic for the altitudinal interval of 200 - 800 m exceed the temperature at ground level (91 m). The downward trend is interrupted by the values characteristics for intervals 2000-2200 m and 2600 and 2800 m. Values at noon (12 UTC) shows a maximum at ground level, due to solar radiation and the variations are much lower than the nocturnal, the isotherm of 0°C placing it in both observation cases around the altitude of 1600 m.

2.2. Analysis of negative gradients in the lower troposphere above Bucureşti-Băneasa

Concentration of thermal inversions respectively the negative gradients is achieved mainly by the end of the cold season in case of data from 00 hour, with a gap towards mid-season for those at noon.

The maximum frequency occurred for values at 00 below 200 m altitude, a main interval with high frequency ranges between 91 and 600 m and the secondary between 1100 and 1600. In the case of the noon records, the maximum frequency is recorded in the 300-600 m interval and intervals with high frequency but with small thickness occur at 1200-1600, 1900-2100 and 2400 m, the increased variability being associated to diurnal values (see tab.2).

In 2001-2002 cold season maximum frequency of over 70 % occur bellow 400 m in all six months analyzed and in the interval 300-500 m for those at 12. At night occurs temperature inversions at ground level and by day through strong insolation at ground level these remain only in upper levels.

3.3. Correlation between inversions recorded in the free atmosphere with those at ground level, south of the Carpathians

Applying the Pearson correlations between monthly mean values recorded at same heights as those of the meteorological stations, led to the making of some hypotheses, according to which we can state there is a similar trend between the free atmosphere and temperatures from the station level. Very high correlation characterizes the 150-300 m level and above 400 m the correlation is weak, except for altitudes above 2500 m where the correlation increases, reflecting the uniformity of weather and climatic conditions of the Carpathian Mountains.

For the correlation between temperature values recorded at noon, theese are very high of more than 0,86°C, with the mention that under 100 m the coefficient has the lowest values due to the differential heating of the underlying active surface and also in the interval between 300 and 700 m, where it still persist the inverse thermal stratification. Above this altitude the correlation coefficient values are high.

Tab.2. Relative frequency of thermal inversions in cold season 2001-2002 above the upper-air station București-Băneasa

00 UTC	**X**	**XI**	**XII**	**I**	**II**	**III**	**12 UTC**	**X**	**XI**	**XII**	**I**	**II**	**III**
altitude (m)	**relative frequency (%)**						**altitude (m)**	**relative frequency (%)**					
91	81	53	35	55	62	73	**91**	6	3	3	16	17	13
200	71	47	35	68	72	60	**200**	0	0	6	26	3	3
300	45	37	35	55	52	40	**300**	0	3	16	39	7	0
400	10	27	42	48	34	17	**400**	0	13	35	61	21	7
500	16	17	39	45	28	3	**500**	0	20	35	42	41	10
600	3	13	19	35	21	7	**600**	3	30	29	32	24	3
700	10	17	3	32	28	7	**700**	6	27	19	23	17	3
800	13	7	6	13	10	7	**800**	10	3	16	23	10	17
900	0	17	3	13	3	7	**900**	3	10	16	10	14	13
1000	3	10	6	10	7	0	**1000**	6	7	13	16	10	10
1100	6	7	0	16	3	3	**1100**	10	13	10	23	14	0
1200	19	10	0	13	3	3	**1200**	13	10	3	19	7	3
1300	6	10	3	32	3	0	**1300**	13	13	6	23	3	10
1400	6	7	6	26	10	3	**1400**	16	10	13	16	10	10
1500	6	7	26	16	10	0	**1500**	10	10	29	13	17	7
1600	23	17	13	6	7	3	**1600**	13	10	19	10	3	17
1700	19	20	13	6	10	10	**1700**	10	3	29	10	7	17
1800	0	20	10	0	10	7	**1800**	6	3	23	10	7	3
1900	13	10	16	6	7	0	**1900**	6	3	16	13	3	10
2000	10	10	16	6	7	3	**2000**	10	13	13	23	0	10
2100	6	3	13	3	7	3	**2100**	10	17	16	19	7	7
2200	6	7	16	6	7	3	**2200**	10	17	6	13	3	0
2300	6	13	3	3	3	13	**2300**	10	10	6	19	3	13
2400	3	10	6	6	10	7	**2400**	0	7	13	19	3	10
2500	6	3	3	16	10	7	**2500**	10	13	6	16	14	10
2600	10	7	6	6	14	7	**2600**	10	7	0	10	3	3
2700	10	3	10	6	7	7	**2700**	6	10	3	6	0	3
2800	6	0	10	6	3	3	**2800**	0	7	0	0	3	3
2900	6	3	6	16	7	7	**2900**	0	7	6	0	3	7
3000	3	3	10	10	0	0	**3000**	6	7	6	0	7	10

3.4. Standardized temperatures - applying latitude and altitude corrections. South of the Carpathians it were eliminated the differences caused by latitude and altitude, namely modifying temperature values and level them to the corresponding values for 0 m and 45° 00′00″. Use of temperature values from analyzed stations was conducted with the aim of a better interpolation, the values of the stations inside the studied area being insufficient and irrelevant.

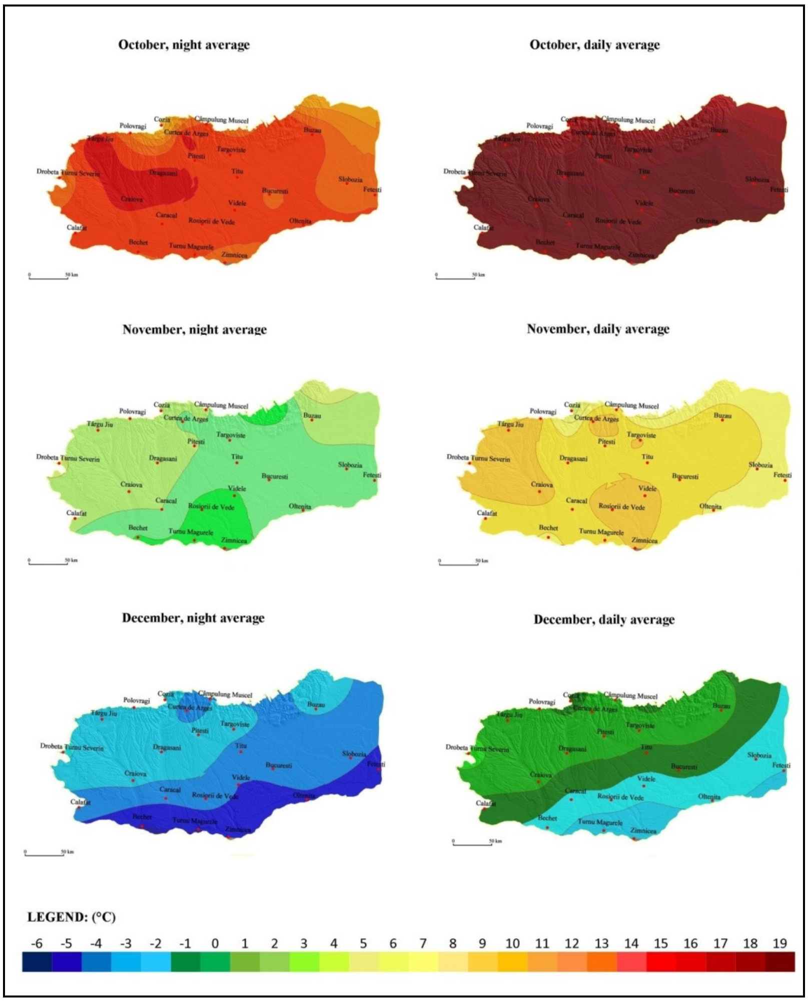

Fig.3. Spatial distribution of spatial distribution of October, November and December termoisanomales in the 2001-2002 cold season, south of the Carpathian mountains

The latitude corrections were performed according to the thermal horizontal gradient for the temperate climate area of northern hemisphere, 0,86°C/1°lat, the extremes being 45°55´ (Bisoca meteorological station) and 43°66´ (Zimnicea meteorological station), the corrections ranging between +0,47°C and -1,15°C. Temperature differences caused by altitude were corrected by applying the average thermal gradient of the 2001-2002 cold season, computed between all stations in the study area, respectively 0,39°C. Corrections were between the values of + 8.8 ° C for the meteorological station at Omu Peak and 0.52°C for the Braila.

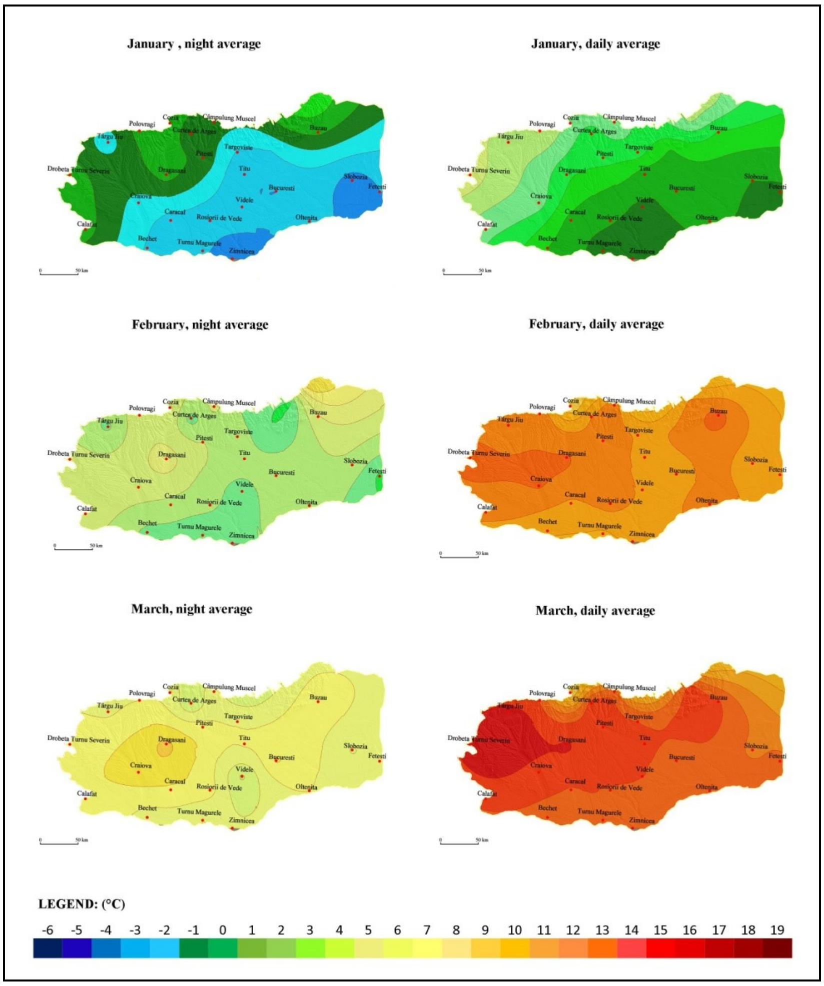

Fig. 4. Spatial distribution of spatial distribution of January, February and March termoisanomales in the 2001-2002 cold season, south of the Carpathian mountains

The results obtained by applying the latitude and altitude corrections were used to perform spatial interpolation (ordinary kriging), resulting in 12 maps(see fig. 3 and 4), classified by applying spatial simulation languages with the spatial distribution of thermoisonomals characteristic for each month of the 2001-2002 cold season for the observation intervals 00 and 1 and also for 12 and 13.

Conclusions

This study is useful in that it underlies many results obtained from ground data and gives some explanationson on the characteristics of thermal inversions in this area and their genesis.

Considerations regarding thermal statifications in altitude are of a real use in analyzing the air pollution phenomena (Haagen, 1959; Apostol, Pîrvulescu, 1988; Apăvăloae, Apostol, 1995), analysis required for the entire lower atmosphere, as in the studied area are many cities, among them Bucharest, industrial platforms, intense car traffic, and air pollution is a current issue.

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