Temperature Analysis in Bucharest (2009-2015)

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Abstract: *In this paper we have analyzed seasonal mean temperatures, semi-annual, annual number of days that exceed certain thresholds, thermal hourly average temperatures, temperature extremes absolute in Bucharest in the winter season; period under review is 2009-2015.*

Keywords: *Seasonal mean temperatures, schedules, absolute extreme, semestrials*

1. Introduction

Temperature variations influence the dispersion and transport of pollutants and have health effects. Temperature decreases with altitude, when a layer of cold air is absorbed in a layer of warm air, there is a thermal inversion, and the pollutants accumulate on the surface of the earth. Once this happens and ozone depletion. This layer serves to filter out ultraviolet radiation. When ultraviolet radiation are not stopped occurs greenhouse effect, increases the average temperature of the planet. Thermal inversion layer acts as a cap preventing the dispersion and transport of pollutants.
Characteristics of general circulation of the atmosphere, manifested through intensification or permanent reductions of atmospheric circulation over Bucharest together with changes in the direction of being transported air masses with physical properties different, plus the fluctuations of solar radiation in a year or from one year to another, leading to irregular variations of air temperature, observable both in the monthly averages and at the annual media (Sterie Ciulache, 1997).
General circulation of the atmosphere prints a dynamic climate; it is often characterized by temperate oceanic air masses with frequencies especially during summer synoptic and two synoptic transition periods. Azores anticyclone Ridge at the transition between autumn and winter brings moisture, precipitation and moderate temperatures in summer cooler air drives that determine rainfall.
Tropical maritime air masses are involved in hot and humid tropical-maritime movements from the south-west and south. They are moving to the Balkans bringing rainfall in the first half of the year and cold sudden and massive warming. And summer rainfall causes changeable weather.
Tropical continental air masses are common in summer; they are due to movements from the south and southeast. These hot, dry air masses cause high heating.
In this paper, the data are processed monthly, Seasonal, half yearly air temperature at the weather station at the Biotechnical Faculty of Engineering, Polytechnic University of Bucharest the range 2009-2015. Bucharest appears as an urban heat island due fuels burned in the city, because of the heating surfaces of asphalt, bricks, due to the number of inhabitants (Gugiuman and Contrău, 1975). Comprising mostly horizontal section and vertical assumes the shape of a bell urban (phenomenon horn) climbing in altitude up to several times the height of the assembly building (Iojă, 2009). Urban heat island presents seasonal and diurnal variations in temperature and ratio values of the area affected (Iojă, 2009). In Bucharest with the expansion of built areas (especially in the north of the city) at the expense of green areas (potential consumer of thermal energy through processes of evapotranspiration), witnessing an increase in thermal values to the suburbs. This contributes to the fact that in the last 20 years has increased the volume of traffic (the explosion fleet); heat island effects are higher where the green has the lowest percentage. The air temperature may be important for some chemical reactions that cause pollutants to be transformed into other sometimes much more dangerous than those from which they originated. If Bucharest concentrations of ozone exceed since March and April, thanks to the intensification of solar radiation under the influence that certain pollutants (especially nitrogen oxides resulting from

activities in industry traffic) reacts with atmospheric oxygen causing photochemical reactions, from which the ozone.

2. Results and discussion

Average temperatures in the winter season have been analyzed.

Bucharest is located in a temperate continental climate; the four seasons are underway normal. Atmospheric temperature was monitored weather station: AWS / EV from the Biotechnical Faculty of Engineering measurement range from -30 ^{0}C to + 60 ^{0}C.
We analyzed term average temperatures in Bucharest being analyzed period 2009-2015 (data processed based on data from the weather station of the Biotechnical Faculty of Engineering, Polytechnic University of Bucharest. We analyzed the evolution of the multi-annual average temperatures of winter. It is noted that the trend of development is increasing, except for 2012, which has a tendency of decreasing trend (Figure 1).
Average yearly temperature in winter season is calculated from the monthly averages between December and February.
We analyzed the average temperatures of the winter months: December - the current year and January, February next year. These temperatures were statistically analyzed individually, each string separately, then string sets of values we calculated average temperature of winters. The string average temperatures of winters we performed statistical processing as (Figures 1, 2, 3, 4). For every season we calculated the annual average, standard deviation, range. We calculated the difference between the highest and the lowest value of average temperatures string Seasonal called amplitude (Figure 5).
Averages multi positive average temperature of winter were obtained in Bucharest in years: 2011 (0.5 ^{0}C), 2013 (0.8 ^{0}C) 2014 (0.9 ^{0}C), 2015 (2.3 ^{0}C), the smallest term average were obtained years: 2009 (-0.2 ^{0}C), 2010 (-0.2 ^{0}C) 2012 (-2.1 ^{0}C). It is noted that the standard deviation does not exceed 1.6ºC, the lowest of which is 0.1 ºC. (Figure 4) The lowest temperature in winter was recorded in January 2009 being - 19.7 ^{0}C, and the highest temperature value in the winter season, was recorded in December 2012 was 19.4 ^{0}C. The amplitude ranges from 1.0 ^{0}C in 2014 and 2.8 ^{0}C in the winter season (Figure 5).
The warmest winter in 2015 (4.4 ^{0}C) followed by 2011 (3.9 ^{0}C). The lowest average winter temperature was recorded in 2012 (-5.3 ^{0}C), followed by 2009 with -2.8 ^{0}C, 2010 ^{0}C -2.7 (coldest winters in Bucharest in the period under review).
The thermal regime winters at all the analyzed period (2009-2015) had periods of increased temperature and lowering it. The trend is to increase the average temperature of winters, warmer winters so in Bucharest than in the 1994 2008. Given the wide variability of the thermal regime, we can expect, as before, on winters, severe or moderate.

Average temperatures in spring season

It is observed in Figure 1 Spring season considering that the lowest values of average temperature were obtained in Bucharest in years: 2011 (12.1 ^{0}C), 2013 and 2015 (12.3 ^{0}C). The highest average temperature values were obtained in spring season in Bucharest in years: 2012 (14 ^{0}C) followed by 2010 (13.3 ^{0}C), 2009 (13 ^{0}C).
Spring season peak in January 2009 was 35.4 ^{0}C, while the minimum was recorded in March 2012 being -5.2 ^{0} C (Figure 3). Analyzing square standard deviation values, it is noted that it has lower values than the winter season, which is between 0.5 ºC and 1.3 ºC (Figure 4).
By analyzing the amplitude values, it notes that are higher than in the winter season, with values between 7.5 ºC 14 ºC in 2013 and 2014. Looking at the variation and evolution trend of the average temperature of the spring season it is observed that the trend for this season is the temperature rise (Figure 5).

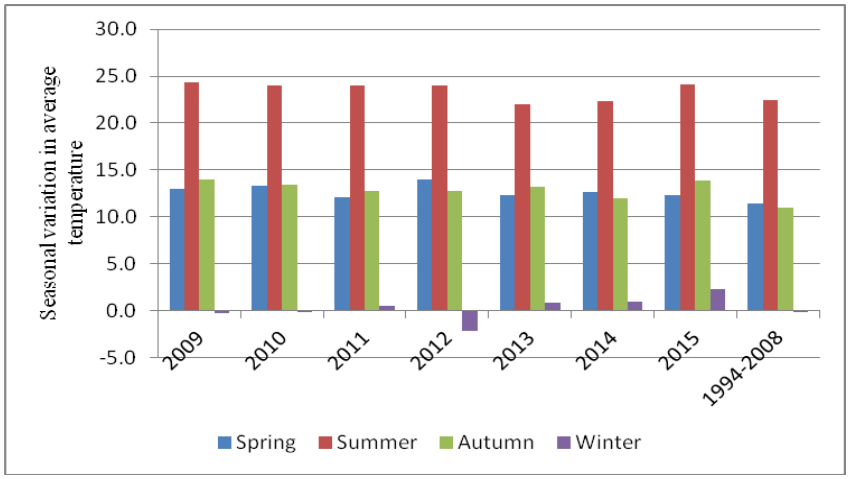

Fig. 1. Seasonal mean temperatures in Bucharest; analyzed period 2009-2015 compared to the period 1994-2008

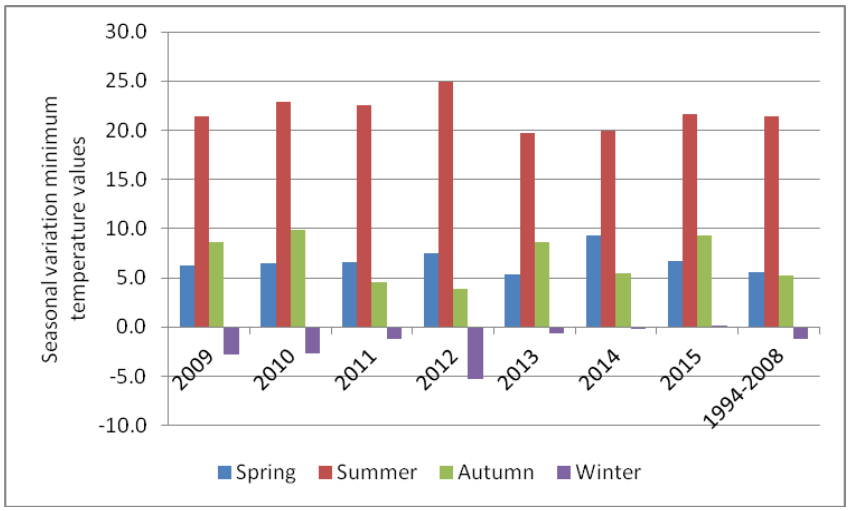

Fig. 2. Seasonal variation minimum temperatures in the range from 2009 to 2015 in Bucharest, compared to the period 1994-2008

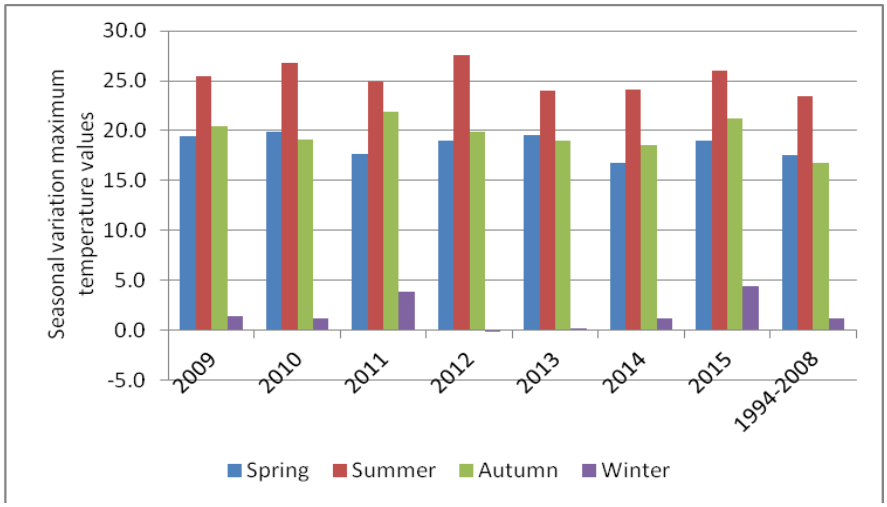

Fig. 3. Seasonal variation in maximum temperatures in Bucharest between 2009-2015 compared to the period 1994-2008

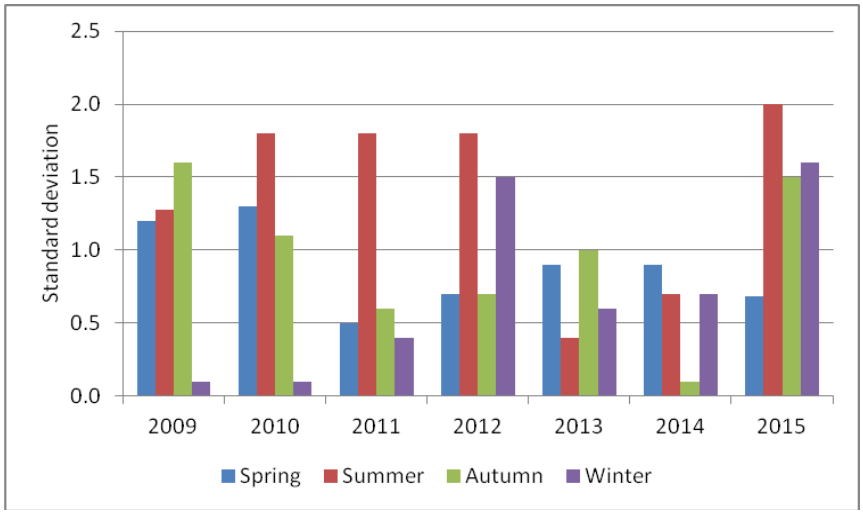

Fig. 4. Standard deviations from Bucharest temperatures between 2009-2015 compared to 1994-2008

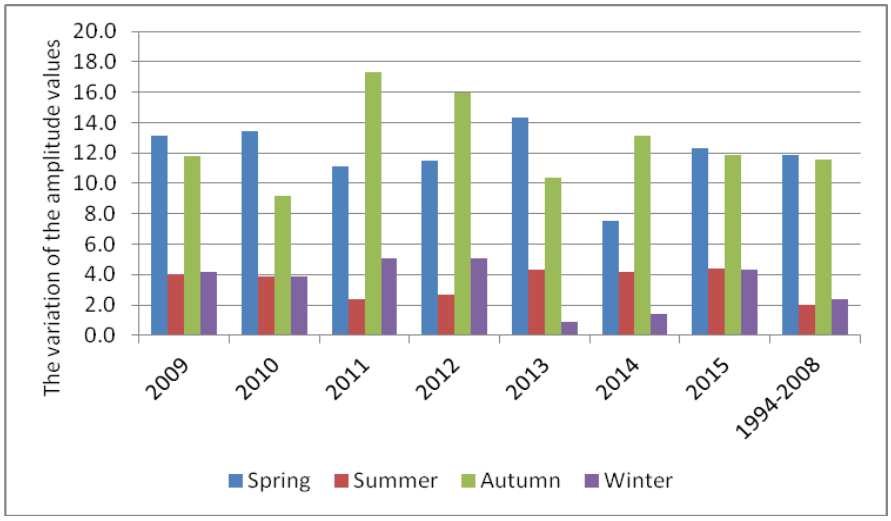

Fig. 5. Variations amplitudes in Bucharest between 2009-2015 compared to 1994-2008

Average temperatures in summer season

It is noted that the average annual values of summer temperatures are about two times higher than the spring season.
It is noted that the standard deviation is between 0.4 ^{0}C and 1.8 ^{0}C in summer season. The lowest values of average temperature of the summer season are observed in Bucharest in years: 2013 (21.9^{0}C) 2014 (22.4^{0}C). The highest values of average temperature of the summer season are observed in Bucharest in years: 2009 (24.3^{0}C), followed by years: 2010, 2011, and 2012 (24.^{0}C) (Rusănescu, 2016).
Warmest summer was in 2012 (27.6 ^{0}C) followed by 2010 (26.8^{0}C), 2015 (26^{0}C), 2009 (25.4^{0}C). These years were years of extremely hot under (Sandu, 2013).
The maximum recorded temperature in the range 2009-2015 summer seasons was in August of 41.5 ^{0}C, followed by July 2014, all of which is 40.9 ^{0}C, while the lowest temperature was 10.3 ^{0}C in June 2013 (Figure 3).
Evolution of the average temperature of the summer season is growing in the years 2012, 2010, 2015.

Average temperatures in the autumn season

Notice in figure 1 that averages multiannual average temperatures of winter season ranges from 11.9 ^{0}C in 2014 and 13.9 ^{0} C in 2015. The standard deviation is between 0.1-1.6ºC (Figure 4).

Annual mean air temperatures

The average annual temperature of the air has variable heat changes caused by the movement of air, hot or cold fronts. Above the plains, the average annual temperature is relatively evenly distributed. Average annual temperatures are influenced by local factors such as altitude, the layout of landforms, ridges orientation, inclination slopes, vegetation coverage, showing an uneven distribution.
In the first half cold temperature is regulated by the atmospheric circulation (air advection). Average yearly temperature semester cold, calculated from monthly averages over the interval from October to March has turned positive, reaching values between 3.3-5.7 °C. The average temperature hot semester calculated from the monthly averages between April and September is between 19.1 °C - 21.4 °C.
The variation in average temperatures, maximum and minimum year in Bucharest in 2009, 2010, 2011, 2012, 2013, 2014, 2015 - In the period under review there has been a slight increase in annual average air temperature compared to the annual average standard 1961 1990. During the year the average monthly air temperature records a maximum in July and a minimum in January and one in February.

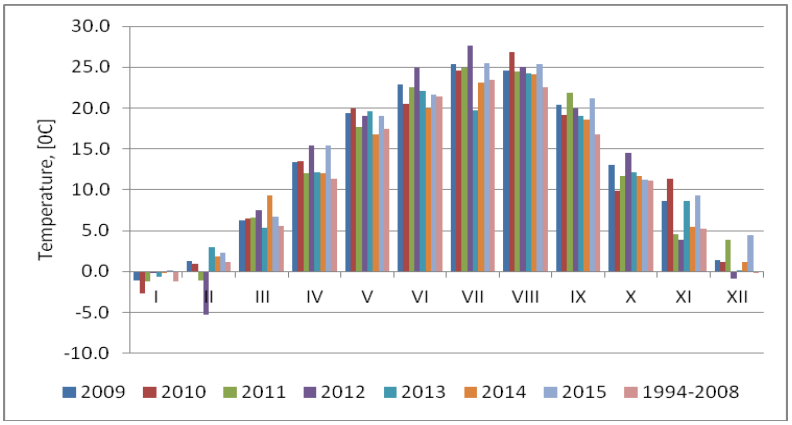

Fig. 6. Variation in average annual temperatures range from 2009 to 2015 in Bucharest, compared to the period 1994-2008

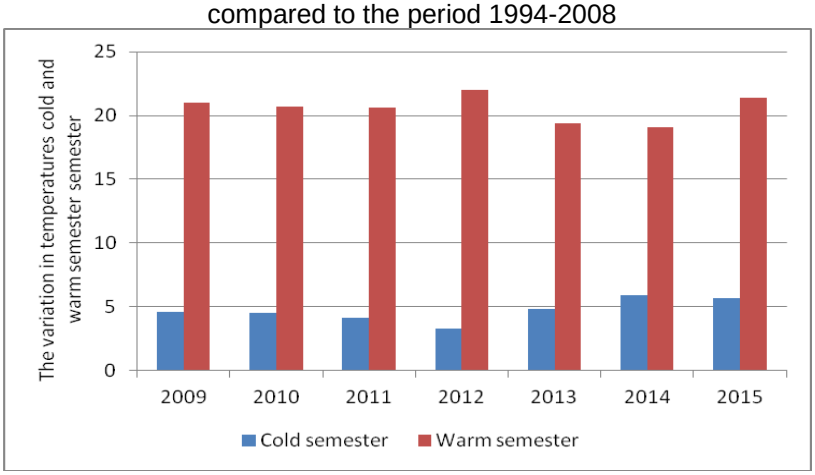

Fig. 7. Semester average temperatures in Bucharest, analyzed period 2009-2015

Average annual amplitude is an indicator that reflects the value of thermal contrast between the warmest month and coldest of the year and that express the degree of continentalism climate of a region. As obvious from Figure 5, the amplitude of the annual average air temperature in Bucharest increases in 2012 (32.9 ^{0}C), the lowest being in 2014 (23.3 ^{0}C).
The annual change resulting from the analysis of monthly air temperature averages denoted the continental climate, with a minimum in February (-5.3 °C), followed by a rise in values until August where heat peaks (26.8 °C) after lowering temperatures on a downward trend since January.

Temperatures average hourly

Hourly average air temperature values are influenced by the movement of air and surface characteristics of assets, against which produce heat and cool air in 24 hours.
In January, the lowest values of average temperature zones in Bucharest are after sunrise (8pm) reaching the maximum at around 15 when solar radiation intensity begins to decrease (Figures 8-11).
In July the temperatures drop hourly until around May, after growing highs at 14-17 when solar radiation intensity begins to decrease.
For any local temperature variation has a daily phenomenon called diurnal variation. After reaching a minimum around sunrise sunlight, temperature increases, reaching the maximum value from 14 and 17 of that afternoon, then it falls to sunrise the following day (Figure 3). Control of the diurnal cycle is provided by the sun. There appear sudden changes in weather deviations of daily variation in air temperature [6]. Studying the evolution of air temperature during the day we made the observations in the time range 1-24 in two days in different seasons. At noon (13 pm), air temperature throughout the year remains positive (Figure 3).

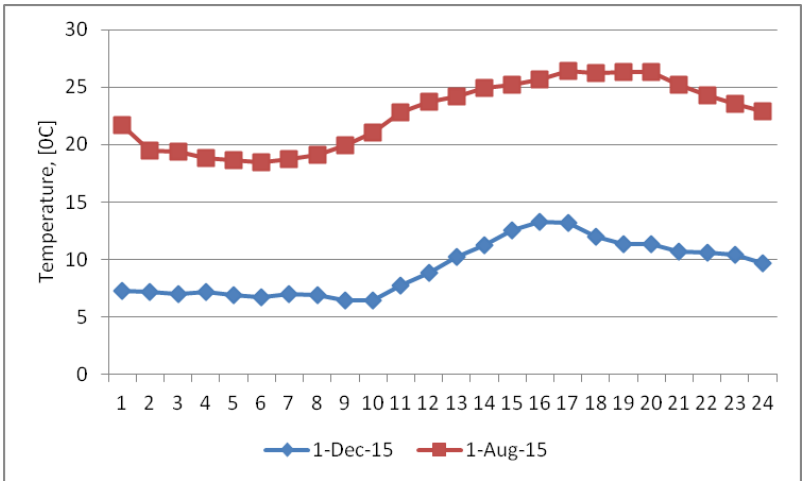

Fig. 8. Temperature variation days December 1, August 1, 2015
(a winter day, a summer day)

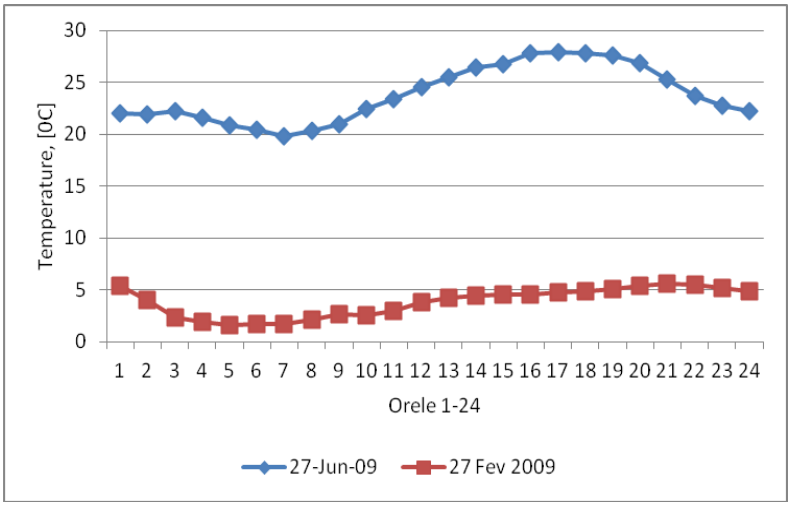

Fig. 9. Variation of temperature in the days June 27, February 27, 2009
(a summer day, a winter day)

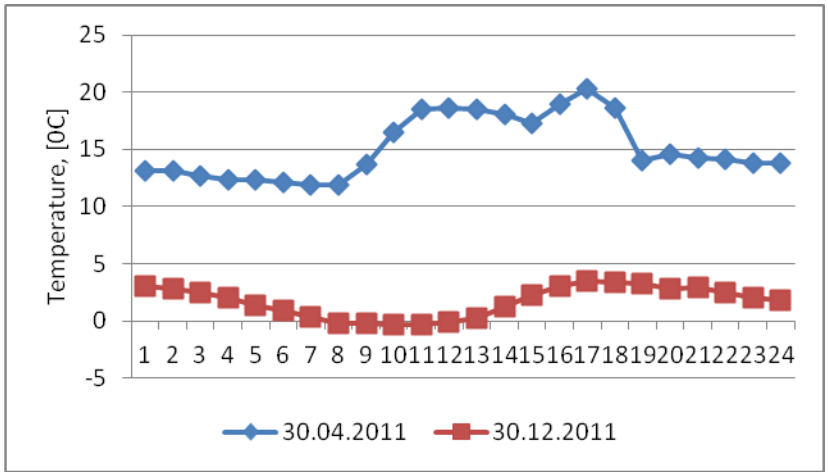

Fig. 10. Variation in temperature days 30.04.2011, 30.12.2011

If the soil is covered with vegetation, diurnal temperature variations amplitude changes in that rich vegetation decreases the amplitude of these variations.
Negative temperature values begin to appear during the night (1 am), at this time in December and the shift towards positive values occurs in March (Figure 11).

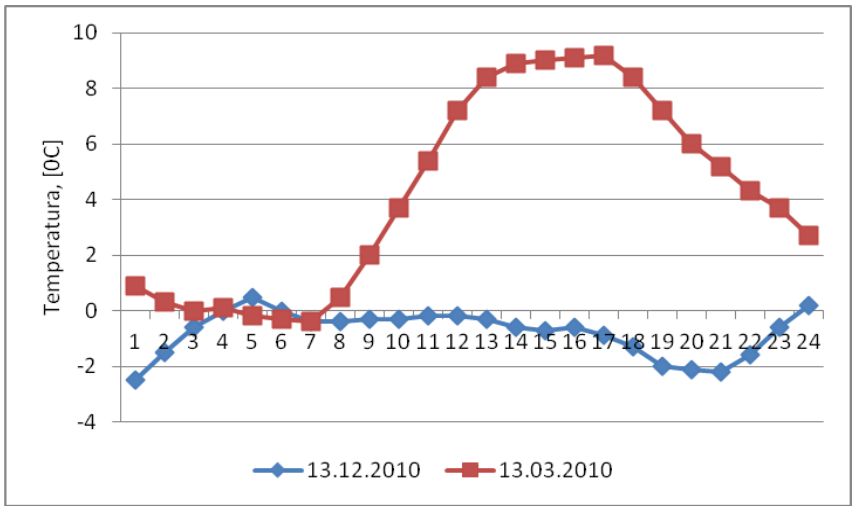

Fig. 11. Changes in air temperature on 13.12.2010 and 13.03.2010 in Bucharest

Negative temperature values begin to occur in the morning (hour 7) at this time, also in December, moving towards positive values occurs one month later in April;
In the evening (hour 19), negative values reappear temperature between December and February (Figure 10).

Absolute extreme temperatures

Highs and lows are achieved instant values of air temperature, with unique character in the history of meteorological station analyzed, occurring at a time. Extreme temperatures are recorded at intervals of extremely high, this parameter indicates the real limits between oscillating actual values of the air temperature in a certain place on a long period of years, so that has great theoretical and practical importance in assessing climate of regions.
Bucharest geographical position at the junction with the tropical air polar determines the contrasts between winter and summer. Thermal amplitudes grow (Figure 5).
Lows absolute regime annually produced in the winter months due to advections cold air home Arctic or continental moved from the eastern outskirts of anticyclones develop over Europe Northern the Arctic and North Atlantic, while installing above the Mediterranean, Aegean and Black Sea baric low pressure systems (cyclones). Due to these invasions of cold air, continentalized,

there is a sudden increase in air pressure, which leads to the establishment of the anticyclone regime in Romania. Nocturnal radiative cooling, the regime intensified anticyclone conditions (for clear, cold air, low in water vapor) and the presence of snow, the emergence of temperature inversions in winter nights. Absolute minimum air temperature in January 2009 was recorded at the weather station at the Biotechnical Faculty of Engineering of the Polytechnic University of Bucharest, with a temperature of -19.7 ^{0}C, followed by January 2010 with a temperature of -19.2 ^{0}C, with a temperature January 2015 by -16.1 ^{0}C under the influence of a thick layer of snow (Figure 2)
Absolute maximum temperature values were recorded in Bucharest: August 2012 (41.5 ^{0}C), 2012 (40.9 ^{0}C); in April 2013 (32.2 ^{0}C), May 2009 (35.4 ^{0}C), October 2012 (32.7 ^{0}C) - Figure 3.
The highest recorded temperature variations winter days, and the lowest recorded temperature variations on summer days.
Fluctuations in the general circulation of the atmosphere are much lower average temperatures in July variation of July compared to the annual average of this month is in the range of 19.7 ^{0}C and 25.5 ^{0}C compared to 22.15 ^{0}C.

The number of days with temperatures some

Knowing the number of days with certain temperatures is important for agriculture; offer a snapshot of the air temperature in Bucharest.
The number of days below freezing (t ≤0 ^{0}C) of the analyzed period 2009-2015 was 427 in Bucharest, the temperature was below 0 ^{0}C in the months from December to February, in March were fewer days with this temperature.
The number of summer days (t ≥25 ^{0}C) in the analyzed period from 2009 to 2015 in Bucharest was 627. Most summer days with temperatures above 25 ^{0}C were 2015 (134 days) months: June, July, August, September, and sometimes into May.
The number of tropical days (t ≥30 ^{0}C) in the analyzed period from 2009 to 2015 in Bucharest was 317 days with temperatures above 30 ^{0}C were in June, July, August, and September.
In the analyzed period were 49 hot days (t max≥35 ^{0}C) in August 2012 were recorded and three days with temperatures above 40 ^{0}C (Figure 12).

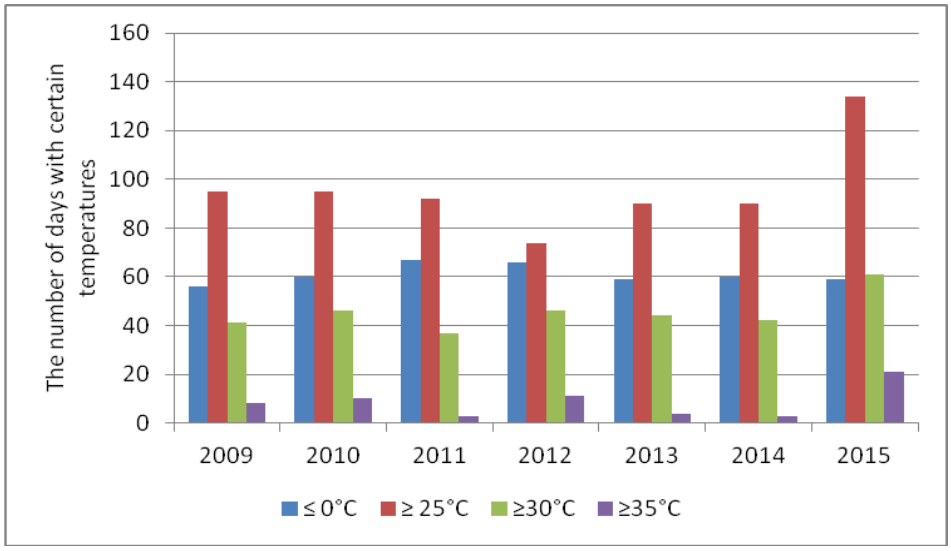

Fig. 12. The frequency of days with different temperatures characteristic Bucharest in 2009-2015

3. Conclusions

By analyzing the thermal variation of the seasonal air temperature observed annual average air temperature increase in winter season, spring, summer and autumn.
An important feature of the trends in the thermal regime in the mid-latitudes is warming, highlighted value growth in average annual regime. Another feature is that the springs and autumns start

earlier. After processing temperatures average values per year, it is observed that if the annual values are very close together (12.1-13.5 °C).
It appears that the warming trend manifested in mean annual temperatures largely due to trend more pronounced warming of the cold season. The increasing trend of annual average temperature of the planet is a topic of current research specialists from around the world, which became apparent at the end and beginning of the new century in our country, but this state is actually considered much of specialists as a normal, non-periodic oscillations being the effect of air temperature, conclusion resulting from the processing undertaken on a large number of weather stations with long strings of data.

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