National Hydrometeorological Service – Skopje

ANALYSIS OF THE RESULTS FROM THE MESOMETEOROLOGICAL MEASUREMENTS IN THE SKOPJE VALLEY FOR THE PERIOD 2011-2020

Skopje, March 2021

ANALYSIS OF THE RESULTS FROM THE MESOMETEOROLOGICAL MEASUREMENTS IN THE SKOPJE VALLEY FOR THE PERIOD 2011-2020

MICROCLIMATE IN URBAN ENVIRONMENTS

Urban areas affect the environmental microclimate by increasing air temperature, reducing the intensity of solar radiation, reducing wind speed, increasing the occurrence of foggy days and their intensity and duration and so on. In summer, urban areas are a "source of heat" compared to green grassy areas. On the other hand, due to air pollution in the cities, the effective radiation is reduced, which diminishes cooling of the ground air layers. This is very important because urban areas have a higher heat capacity compared to green areas.

Several factors affect the thermal regime of cities. One of them is the change of meteorological elements and phenomena (for example, the processes of fog formation, etc.). The occurrence of fog in the cities is 10 - 20% more common than in the surrounding areas. This is due to the appearance of city impurities of hygroscopic particles that absorb water vapor, as well as the condensation and sublimation processes and the appearance of so-called smog. Aerosols absorb long-wave ground radiation which reduces night cooling. Due to that, the ground air layer temperature in the cities is higher.

Besides this, solid and gaseous impurities in the city air affect the direct solar radiation, especially in the winter months. Under those conditions, in the polluted atmosphere the ultraviolet radiation is weakened. Visibility in cities is reduced by up to two times. Transparency coefficients in cities are 2-5% lower than in surrounding areas. The albedo in the cities is reduced compared to the rural areas due to the impact of the urban environment.

Many scientific papers conclude that the urban areas impact local climate, which is the situation in the city of Skopje and the Skopje Valley as well, by increasing air temperature, decreasing wind speed, increasing fog frequency, reducing visibility, reducing intensity of solar radiation and reducing effective radiation.

AIR TEMPERATURE AND AIR THERMAL REGIME IN THE URBAN AREA

With the development of the city of Skopje as an administrative, cultural and industrial center of the Republic of North Macedonia, it is evident that the thermal regime of the urban environment causes local changes of weather and climate, and It affects the components comprising the condition of ground air layer. On the other hand, the local influences of the air thermal regime affect local circulation conditions, the hygric regime, the pluviometric regime as well as the

energy balance of above the ground solar radiation (in the urban environment). All these mesoclimatic conditions in the urban environment affect in their own way the cryptoclimate of closed premises: apartments, basements, attics and other facilities: hospitals, cinemas, libraries and offices, etc.

MESOMETEROLOGICAL MEASUREMENTS AND OBSERVATIONS IN THE CITY OF SKOPJE IN THE PERIOD 2011-2020

Mesometeorological measurements present a complex analysis of meteorological elements and phenomena, such as the urban structure of the city of Skopje and the physical and geographical characteristics of the Skopje Valley. These meteorological and mesometeorological measurements in the past period were interrupted and in 2011 they were restored jointly by the National Hydrometeorological Service (NHMS) and the City of Skopje. The mutual cooperation between the two institutions is beneficial for the citizens since it relates to environment protection, public health, tourism and recreation.

The main goal of the mesometeorological measurements and observations is through climatological and statistical processing of the obtained results to determine the basic indicators for the weather conditions during the year, and with multi-year continuous measurement to obtain indicators of climate change in the Skopje Valley. The need to establish a mesometeorological monitoring system in urban areas is even more significant because of climate change and their negative impact on various economic and social sectors. Particularly vulnerable to climate change in urban areas are people and their health, especially in event of extreme temperatures, i.e. warm spells and long periods with the creation of so called "cold air lakes", when there is significant air pollution and the so-called smog occurs.

The City of Skopje requires the data from the meteorological and mesometeorological measurements and observations in the urban environment and beyond, in the Skopje Valley, in order to implement its legal, strategic and planning obligations. These are as follows:

- The City administration is obliged to declare an alarming condition in case of ambient air pollution above the prescribed limit values, or when there is a real risk of exceeding the limit values as a result of certain meteorological factors (temperature inversions and inversion fogs in the Skopje Valley);
- The Climate Change Health Adaptation Strategy and the Action Plan, adopted by the Government of the Republic of Macedonia in March 2011, prescribes that the City of Skopje has to establish microclimate monitoring in cooperation with the National Hydrometeorological Service and establish gradient measurements and research of the temperature inversions in

Skopsko Pole, in order to take measures for protection of human health and for early warning in case of warm spells;
• The City has to obtain results that will be used to research the impact of the urban environment on the climatic conditions in the city;
• It has to obtain relevant data at the micro-location level, which together with the data from the monitoring of the environmental media and environment, should be a starting point for urban spatial planning.

Basic preconditions for full implementation of all activities planned in the Action Plan on the impact of climatic and mesoclimatic conditions in the City of Skopje and in the Skopje Valley is to design a special and comprehensive monitoring system for research of the so-called "cold air lakes", temperature inversions, inversion fogs and urban heat islands, which is a complex task.

In order to monitor the climatic characteristics of the Skopje Valley, the NHMS within its legal competencies, as well as in agreement with the City of Skopje and the Center for Development of the Skopje Planning Region, performs continuous and occasional meteorological measurements and analyses of meteorological elements and phenomena in the Skopje Valley.

MEASURING NETWORK

In the period 2011-2020, measurements and observations were performed at the measuring points of the permanent and occasional measuring network of meteorological stations located in the City of Skopje and in the Skopje Valley, where the number of measuring points increased over the years. The permanent measuring network of meteorological stations consists of the main meteorological station Skopje - Zajchev Rid, the climatological station Gjorche Petrov, the precipitation station Lisiche, and in the past period four automatic meteorological stations have been set up in the Skopje Valley, at Creshevo, in the Municipality of Karposh, on Zajchev Rid and in the Municipality of Gazi Baba.

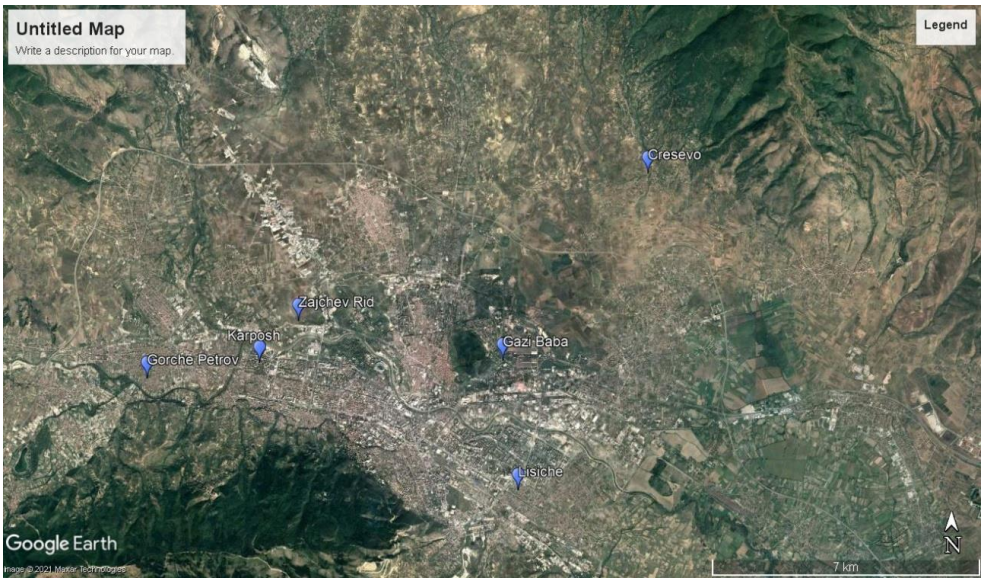


Figure 1. Permanent measuring points

Also, during the analyses, data from the mesometeorological measurements and observations performed at the following occasional measuring points are used:

1. Gjorche Petrov
2. Taftalidze – Pedagoshka
3. Centar
4. Centar - AMS
5. Zhdanec
6. Lisiche 1
7. Lisiche 2
8. Kisela Voda
9. Hotel Panorama
10. Avtokomanda
11. Butel 1
12. Dolno Lisiche
13. Sredno Vodno-AMS

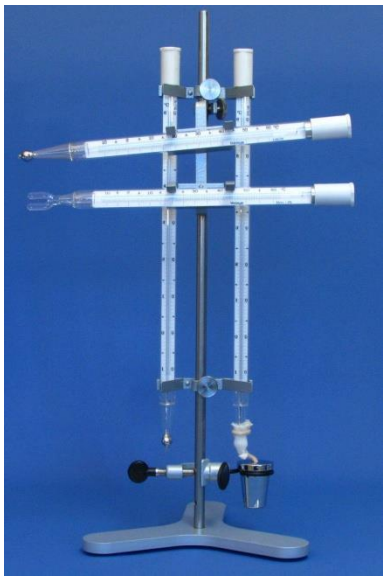
Figure 2. Occasional meteorological measuring points

MEASUREMENT METHODS

Continuous meteorological measurements and observations are performed at the permanent measuring points. At the main meteorological station Skopje - Zajchev Rid, 24-hour measurements are performed, seven days a week, of all meteorological elements: temperature and relative humidity, precipitation, air pressure, insolation, wind direction and speed. The meteorological phenomena are monitored visually, and since 2015 in the meteorological park on Zajchev Rid an automatic meteorological station has been installed which ensures contemporary continuous measurements of meteorological elements. The measurements at the measuring points Karposh, Gazi Baba and Creshovo are also performed with an automatic meteorological station, and the data are processed in the NHMS.

The permanent measuring point Gjorche Petrov is a climatological station, where the measurements of the basic meteorological elements are performed three times during the day in the so-called climatological terms (07:00, 14:00 and 21:00 local time), and the phenomena are observed visually. The measuring point Lisiche is a precipitation measuring station, where once a day (at 07:00) the type and amount of precipitation from the previous 24 hours are measured.

At the mentioned occasional measuring points, measurements were performed at certain synoptic-aerological conditions in different seasons of the year, in climatological terms (07:00, 14:00 and 21:00 local time), as well as every full hour from 07:00 to 20:00 in 2-day periods. Meteorological measurements and observations are made in days of anticyclonic weather conditions in the wider region (highlighting the local influences of the city on the climate conditions in a meso-scale). At the occasional measuring points, meteorological measurements of air temperature were performed per dry thermometer-Ts and per wet thermometer-Tv, as well as monitoring of certain atmospheric phenomena: fog, cloudiness, wind and their duration. The instruments used for temperature measurements were with a conventional set of thermometers at the permanent measuring points and for the simultaneous mesometeorological measurements (Asman aspiration psychrometer) are shown in Figure 3.



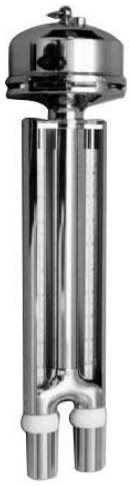


Figure 3. Conventional set of thermometers and Asmanov aspiration psychrometer

Based on the measured air temperatures per dry and wet thermometer, different components of air humidity were calculated, such as: maximum water vapor pressure at Ts, maximum water vapor pressure at Tv and water vapor pressure at appropriate temperature.

The data from the measurements and the registration of the instruments were subjected to logical control and statistical processing, and they were used for analyzing the characteristics of the weather in the Skopje Valley in the period 2011-2020.

RESULTS OF THE MESOMETEROLOGICAL MEASUREMENTS

AIR TEMPERATURE

During 2011-2020, 24 series of 2-day mesometeorological measurements and observations were performed (Table 1) at the already mentioned permanent and occasional measuring points.

Table 1. Mesometerological measurements and observations in the City of Skopje (period 2011-2020)

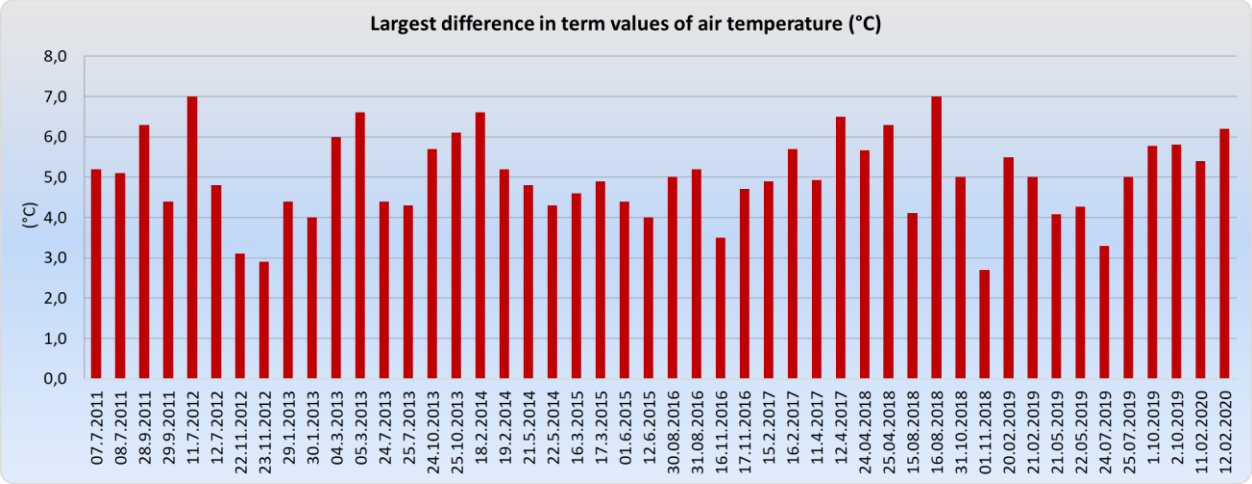
2011	07.07.-08.07.2011	28.09.-29.09.2011		
2012	11.07.-12.07.2012	22.11.-23.11.2012		
2013	29.01.-30.01.2013	04.03.-05.03.2013	24.07.-25.07.2013	24.10.-25.10.2013
2014	18.02.-19.02.2014	21.05.-22.05.2014		
2015	16.03.-17.03.2015	01.06.-02.06.2015		
2016	30.08.-31.08.2016	16.11.-17.11.2016		
2017	15.02.-16.02.2017	11.04.-12.04.2017		

2018	24.04.-25.04.2018	15.08.-16.08.2018	31.10.-01.11.2018	
2019	20.02.-21.02.2019	21.05.-22.05.2019	24.07 - 25.07.2019	1.10 - 2.10.2019
2020	11.02.-12.02.2020			

According to the data from the measurements performed every full hour from 07:00 to 20:00, during all series in the period 2011-2020, the air temperatures ranged in absolute limits from the lowest measured value -4,0°C (at 07:00), measured at the measuring point Gazi Baba AMS on 16.2.2017, up to the highest measured value of 38.4°C which was registered at the measuring point Zajchev Rid (at 15:00) on 12.07.2012. During the measurements the lowest values of temperature were measured in the early morning hours (at 07:00), with small exceptions when the lowest temperature was also measured at 20:00, while the maximum values were reached in the period from 14:00 to 16:00.

The largest differences in the term values of the air temperature from the measurements performed every full hour from 07:00 to 20:00 range from 2,7°C to 7,0°C (Graph 1).

Graph 1. Largest difference in term values of air temperature (°C)

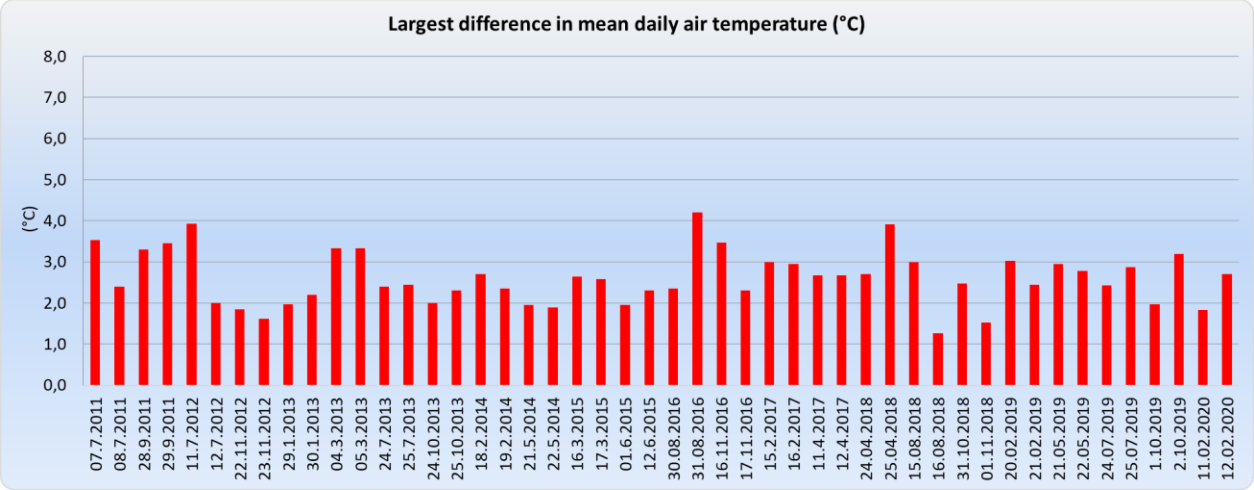


The mean daily air temperatures from the measurements in climatological terms, calculated according to the formula Tsr = (T_{07}+ T_{14}+ 2xT_{21}) / 4, range from 0,6°C at the measuring point Sredno Vodno (16.11.2016) and 0,9°C at the measuring point Zhdanec (29.01.2013), up to 30,0°C in Avtokomanda, 30,1°C in Pedagoshka and 30,2°C at the measuring point Hotel Panorama (12.07.2012).

According to the data from all measuring stations, the biggest difference in mean daily air temperatures of 4,6°C was noticed on 12.4.2017 between the measuring points Centar and Sredno Vodno, while with regard to the measuring stations with lower altitude the biggest

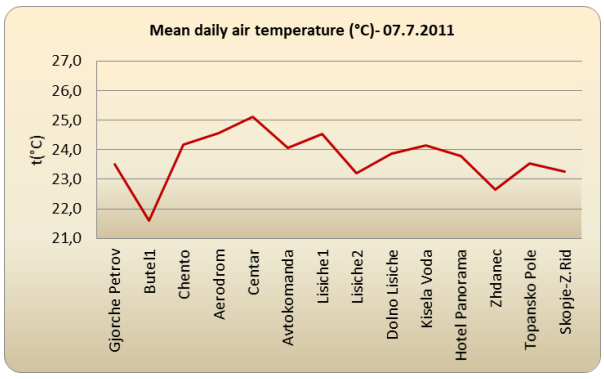
difference of 4,2°C is observed between the measuring points Centar and Butel 1 on 31.08.2016. The smallest difference of mean daily air temperatures of 1,3°C was observed between the measuring points Centar AMS and Butel 1 on 16.08.2018.

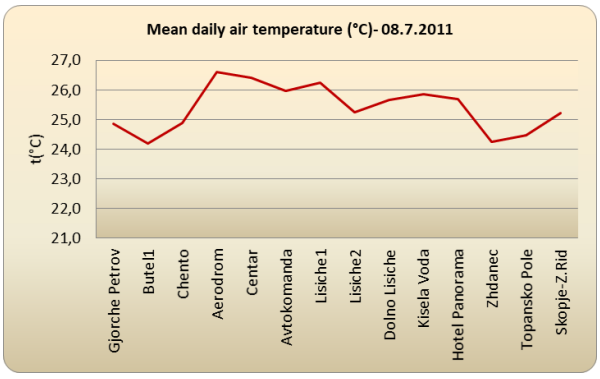
Graph 2. Largest difference in mean daily air temperature (°C)

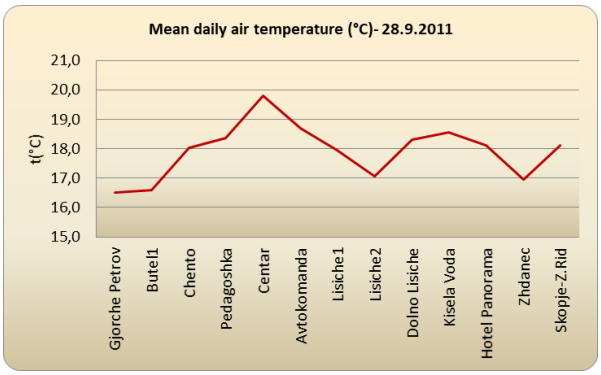


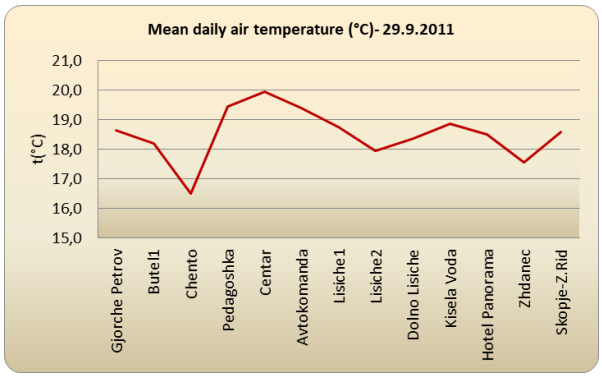
As can be generally seen from Graph 3 which shows the mean daily air temperature values for all series of measurements, the highest mean daily air temperatures are measured in the downtown area, while the lowest values are measured at peripheral measuring points such as Gjorche Petrov and Butel 1 and in the places with higher altitude such as Zhdanec, Hotel Panorama and Sredno Vodno.

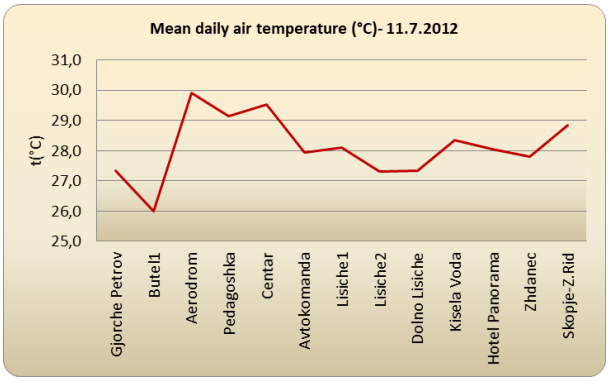
Graph 3. Mean daily air temperature (°C)

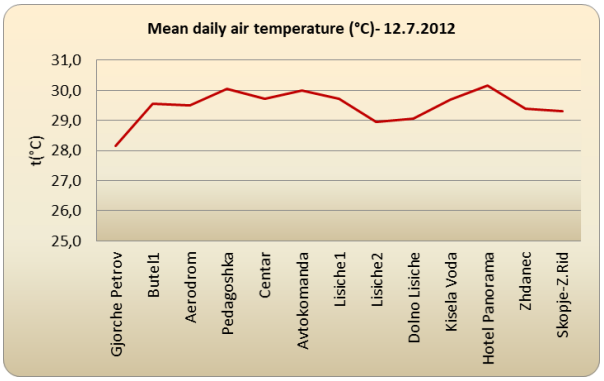


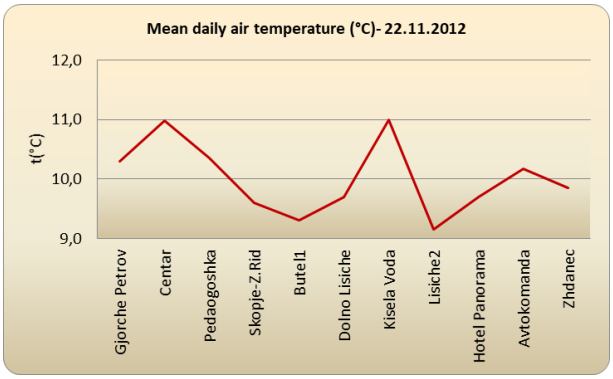


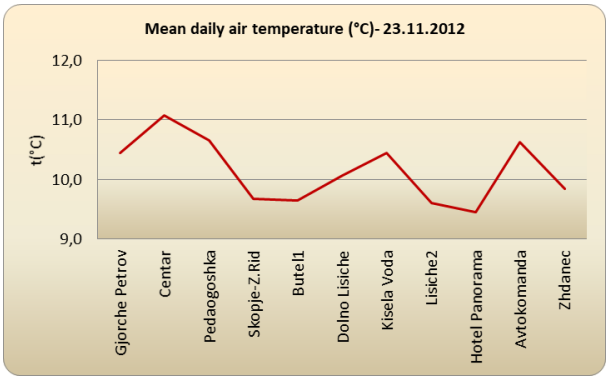

Mean daily air temperature (°C)- 28.9.2011
t(°C)
21,0
20,0
19,0
18,0
17,0
16,0
15,0
Gjorche Petrov
Butel1
Chento
Pedagoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

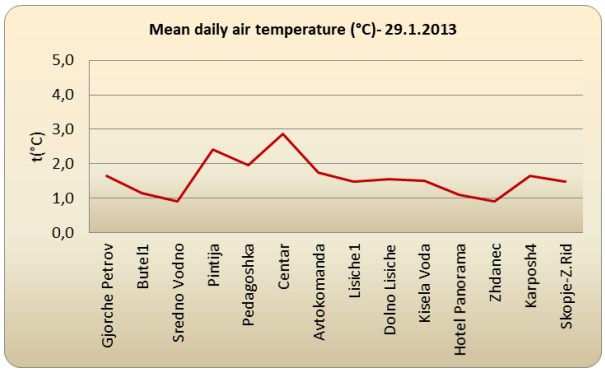

Mean daily air temperature (°C)- 29.9.2011
t(°C)
21,0
20,0
19,0
18,0
17,0
16,0
15,0
Gjorche Petrov
Butel1
Chento
Pedagoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

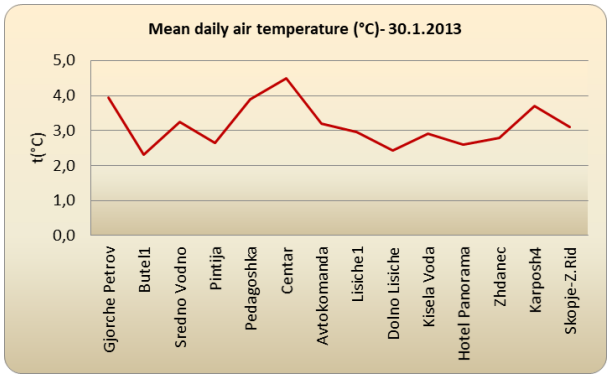

Mean daily air temperature (°C)- 11.7.2012
t(°C)
31,0
30,0
29,0
28,0
27,0
26,0
25,0
Gjorche Petrov
Butel1
Aerodrom
Pedagoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

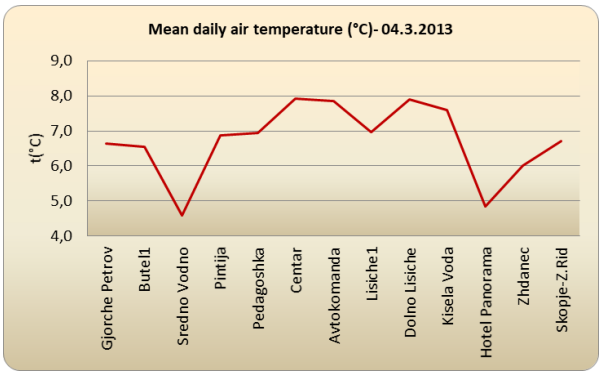

Mean daily air temperature (°C)- 12.7.2012
t(°C)
31,0
30,0
29,0
28,0
27,0
26,0
25,0
Gjorche Petrov
Butel1
Aerodrom
Pedagoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

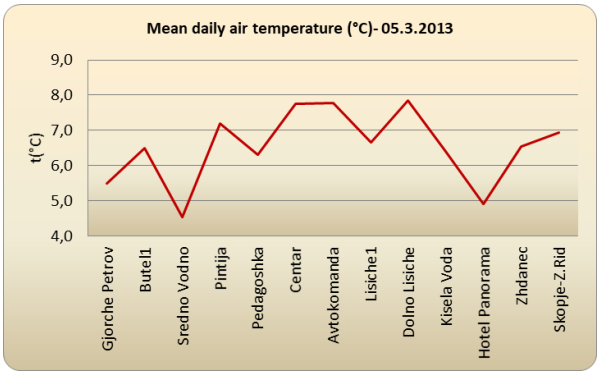

Mean daily air temperature (°C)- 22.11.2012
t(°C)
12,0
11,0
10,0
9,0
Gjorche Petrov
Centar
Pedaogoshka
Skopje-Z.Rid
Butel1
Dolno Lisiche
Kisela Voda
Lisiche2
Hotel Panorama
Avtokomanda
Zhdanec

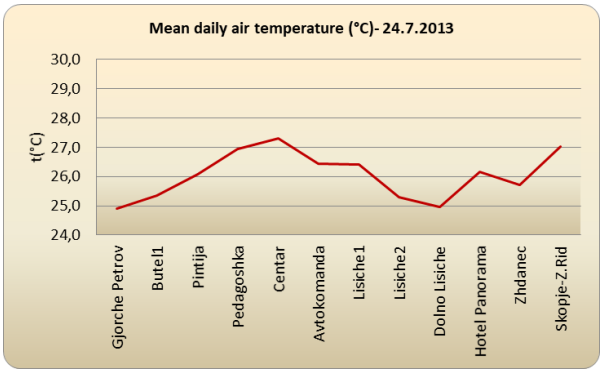

Mean daily air temperature (°C)- 23.11.2012
t(°C)
12,0
11,0
10,0
9,0
Gjorche Petrov
Centar
Pedaogoshka
Skopje-Z.Rid
Butel1
Dolno Lisiche
Kisela Voda
Lisiche2
Hotel Panorama
Avtokomanda
Zhdanec

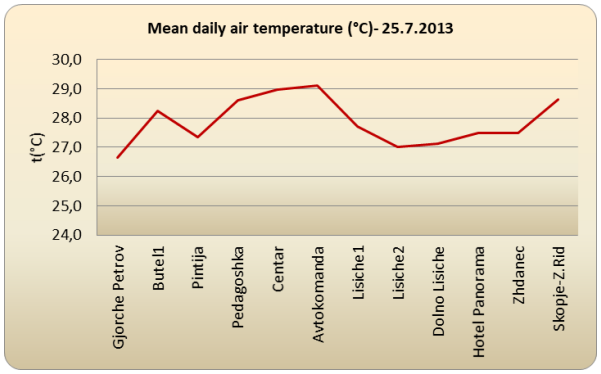

Mean daily air temperature (°C)- 29.1.2013
t(°C)
5,0
4,0
3,0
2,0
1,0
0,0
Gjorche Petrov
Butel1
Sredno Vodno
Pintija
Pedagoshka
Centar
Avtokomanda
Lisiche1
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Karposh4
Skopje-Z.Rid

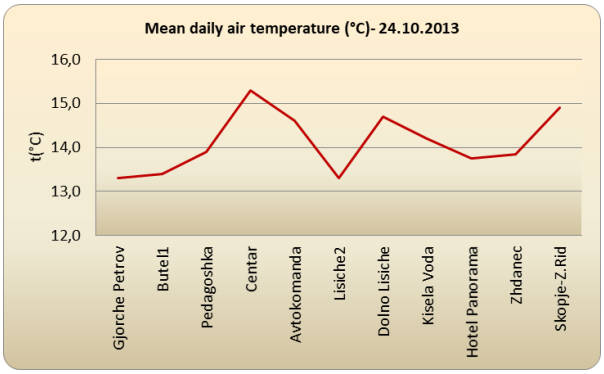

Mean daily air temperature (°C)- 30.1.2013
t(°C)
5,0
4,0
3,0
2,0
1,0
0,0
Gjorche Petrov
Butel1
Sredno Vodno
Pintija
Pedagoshka
Centar
Avtokomanda
Lisiche1
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Karposh4
Skopje-Z.Rid

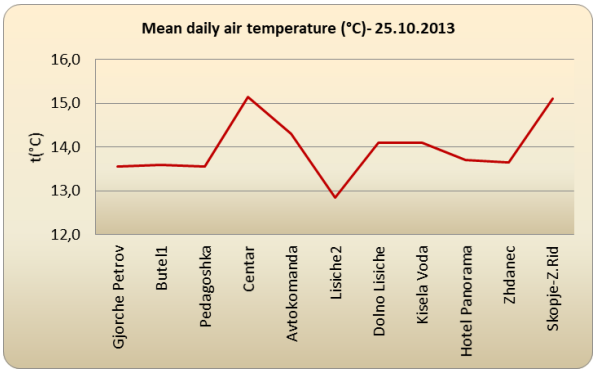

Mean daily air temperature (°C)- 04.3.2013
t(°C)
9,0
8,0
7,0
6,0
5,0
4,0
Gjorche Petrov
Butel1
Sredno Vodno
Pintija
Pedagoshka
Centar
Avtokomanda
Lisiche1
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

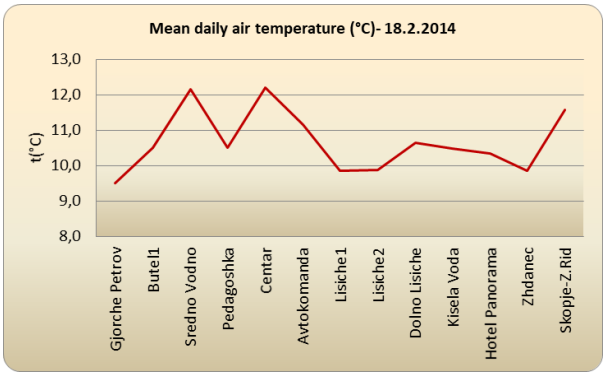

Mean daily air temperature (°C)- 05.3.2013
t(°C)
9,0
8,0
7,0
6,0
5,0
4,0
Gjorche Petrov
Butel1
Sredno Vodno
Pintija
Pedagoshka
Centar
Avtokomanda
Lisiche1
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

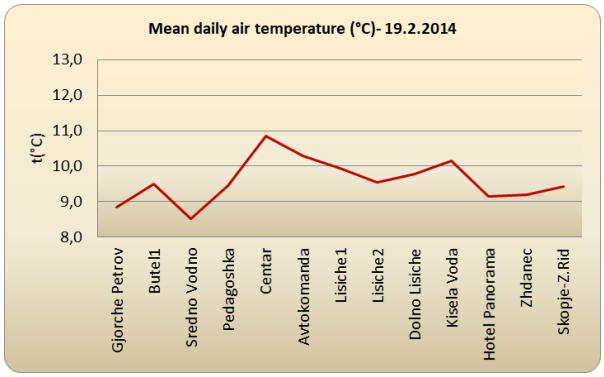

Mean daily air temperature (°C)- 24.7.2013
t(°C)
30,0
29,0
28,0
27,0
26,0
25,0
24,0
Gjorche Petrov
Butel1
Pintija
Pedagoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Hotel Panorama
Zhdanec
Skopje-Z.Rid

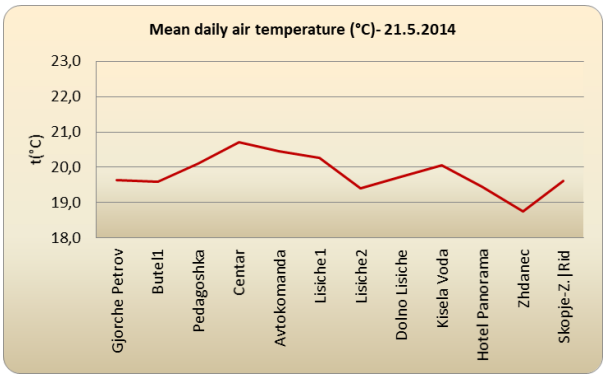

Mean daily air temperature (°C)- 25.7.2013
t(°C)
30,0
29,0
28,0
27,0
26,0
25,0
24,0
Gjorche Petrov
Butel1
Pintija
Pedagoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Hotel Panorama
Zhdanec
Skopje-Z.Rid

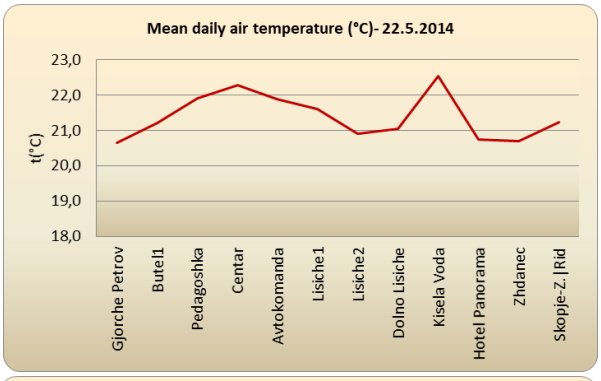

Mean daily air temperature (°C)- 24.10.2013
t(°C)
16,0
15,0
14,0
13,0
12,0
Gjorche Petrov
Butel1
Pedagoshka
Centar
Avtokomanda
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

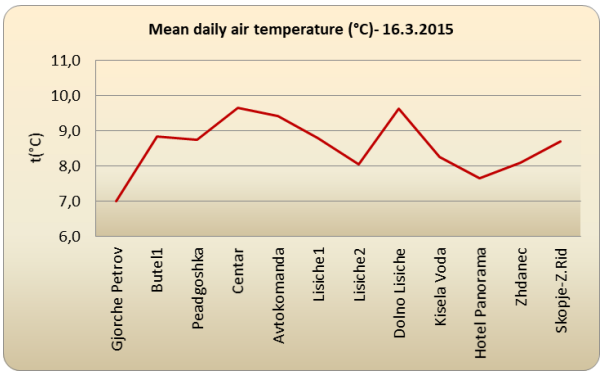

Mean daily air temperature (°C)- 25.10.2013
t(°C)
16,0
15,0
14,0
13,0
12,0
Gjorche Petrov
Butel1
Pedagoshka
Centar
Avtokomanda
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

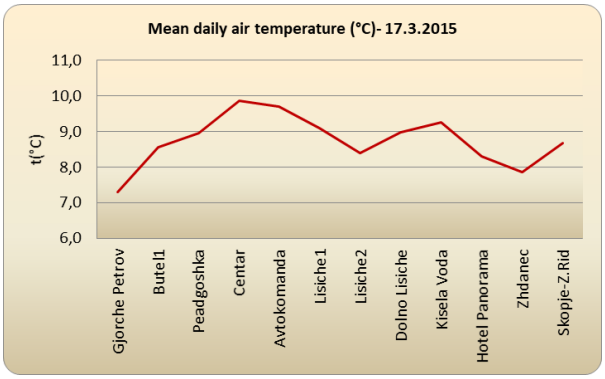

Mean daily air temperature (°C)- 18.2.2014
t(°C)
13,0
12,0
11,0
10,0
9,0
8,0
Gjorche Petrov
Butel1
Sredno Vodno
Pedagoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

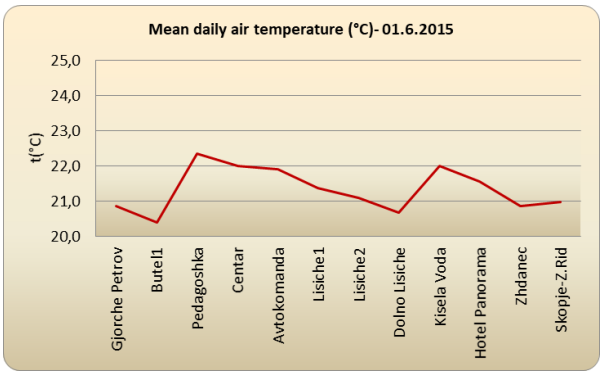

Mean daily air temperature (°C)- 19.2.2014
t(°C)
13,0
12,0
11,0
10,0
9,0
8,0
Gjorche Petrov
Butel1
Sredno Vodno
Pedagoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

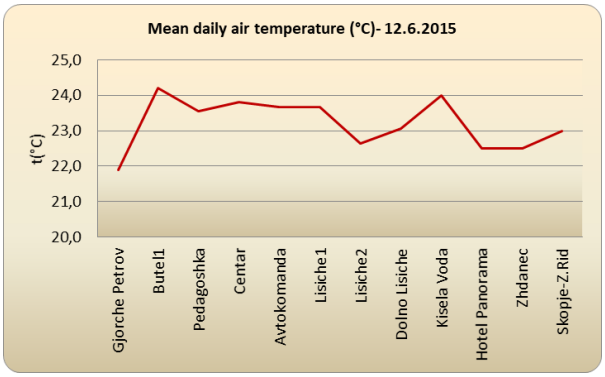

Mean daily air temperature (°C)- 21.5.2014
t(°C)
23,0
22,0
21,0
20,0
19,0
18,0
Gjorche Petrov
Butel1
Pedagoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z. |Rid

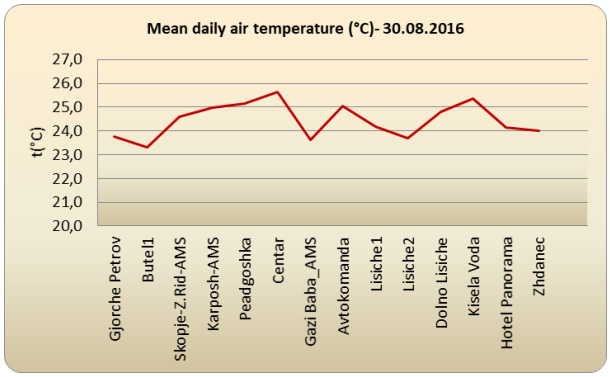

Mean daily air temperature (°C)- 22.5.2014
t(°C)
23,0
22,0
21,0
20,0
19,0
18,0
Gjorche Petrov
Butel1
Pedagoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z. |Rid

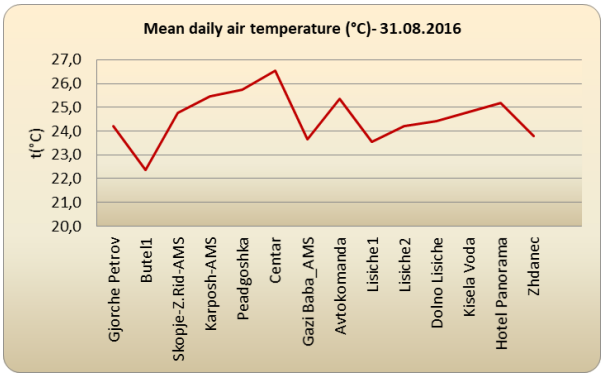

Mean daily air temperature (°C)- 16.3.2015
t(°C)
11,0
10,0
9,0
8,0
7,0
6,0
Gjorche Petrov
Butel1
Peadgoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

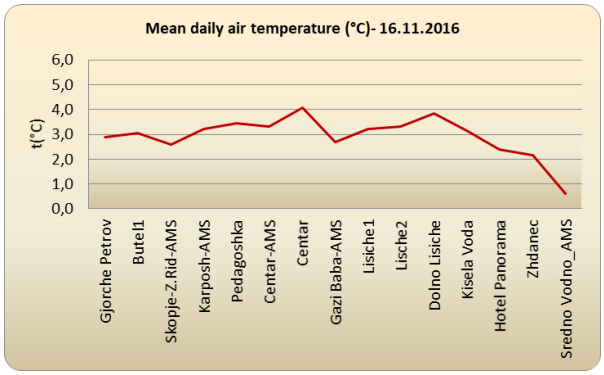

Mean daily air temperature (°C)- 17.3.2015
t(°C)
11,0
10,0
9,0
8,0
7,0
6,0
Gjorche Petrov
Butel1
Peadgoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

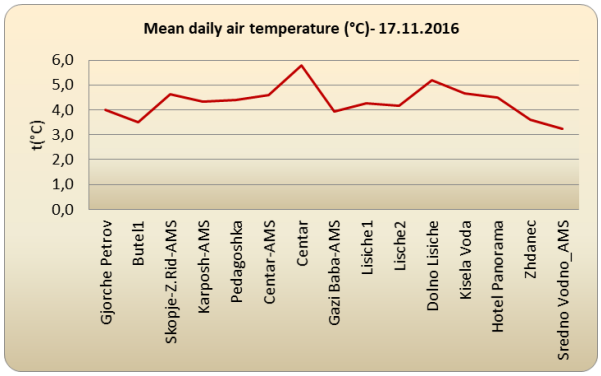

Mean daily air temperature (°C)- 01.6.2015
t(°C)
25,0
24,0
23,0
22,0
21,0
20,0
Gjorche Petrov
Butel1
Pedagoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

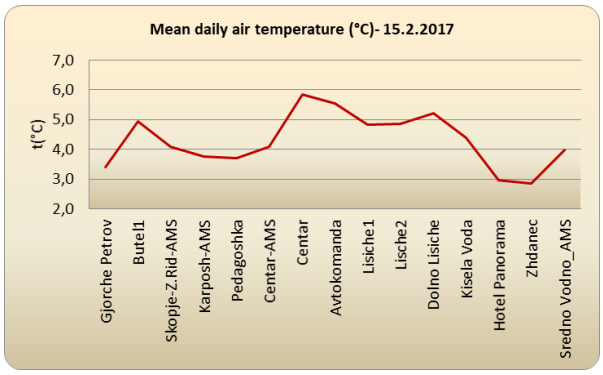

Mean daily air temperature (°C)- 12.6.2015
t(°C)
25,0
24,0
23,0
22,0
21,0
20,0
Gjorche Petrov
Butel1
Pedagoshka
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Skopje-Z.Rid

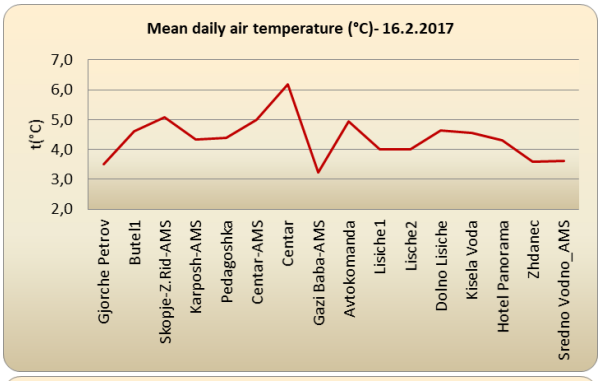

Mean daily air temperature (°C)- 30.08.2016
t(°C)
27,0
26,0
25,0
24,0
23,0
22,0
21,0
20,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Peadgoshka
Centar
Gazi Baba_AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec

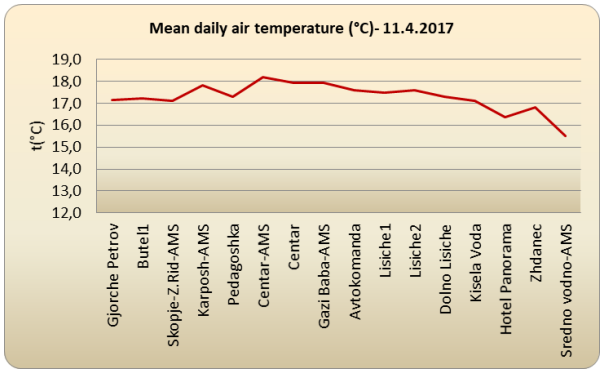

Mean daily air temperature (°C)- 31.08.2016
t(°C)
27,0
26,0
25,0
24,0
23,0
22,0
21,0
20,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Peadgoshka
Centar
Gazi Baba_AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec

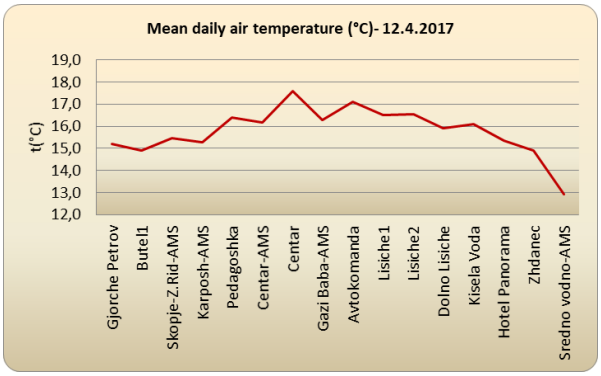

Mean daily air temperature (°C)- 16.11.2016
t(°C)
6,0
5,0
4,0
3,0
2,0
1,0
0,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno Vodno_AMS

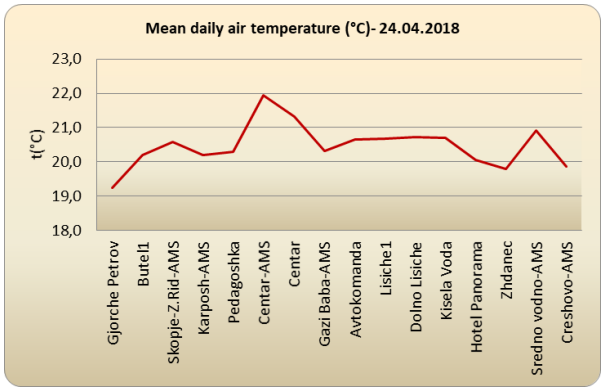

Mean daily air temperature (°C)- 17.11.2016
t(°C)
6,0
5,0
4,0
3,0
2,0
1,0
0,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno Vodno_AMS

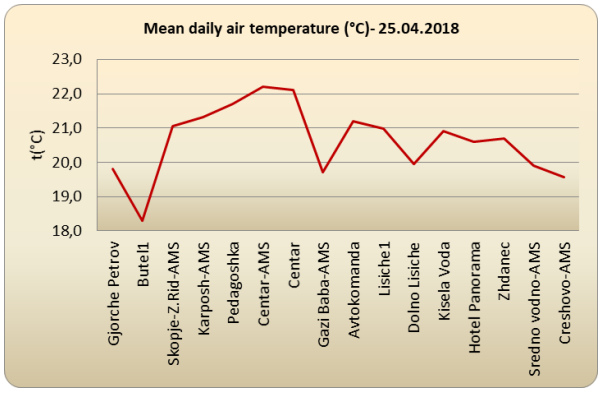

Mean daily air temperature (°C)- 15.2.2017
t(°C)
7,0
6,0
5,0
4,0
3,0
2,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno Vodno_AMS

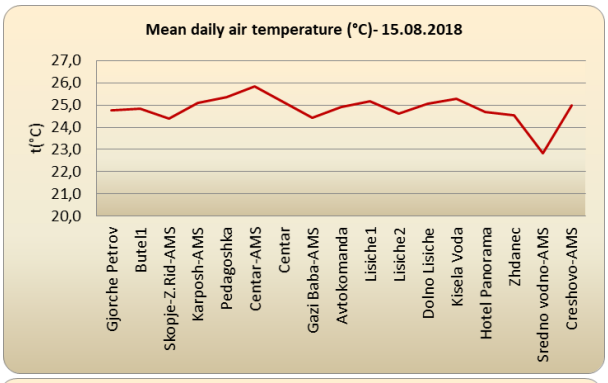

Mean daily air temperature (°C)- 16.2.2017
t(°C)
7,0
6,0
5,0
4,0
3,0
2,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno Vodno_AMS

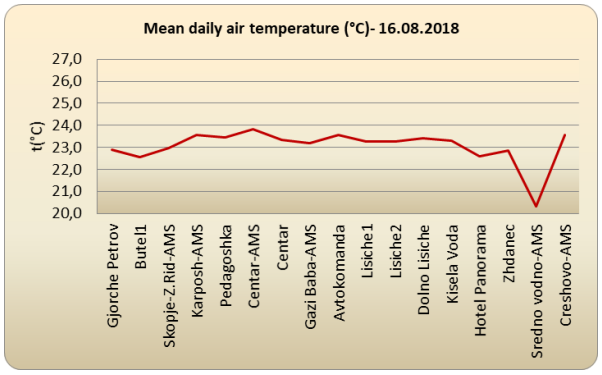

Mean daily air temperature (°C)- 11.4.2017
t(°C)
19,0
18,0
17,0
16,0
15,0
14,0
13,0
12,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno vodno-AMS

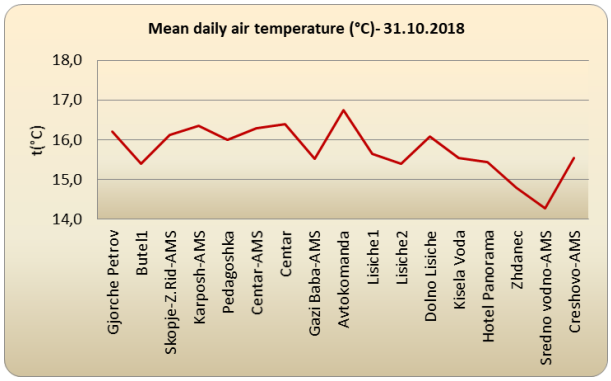

Mean daily air temperature (°C)- 12.4.2017
t(°C)
19,0
18,0
17,0
16,0
15,0
14,0
13,0
12,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno vodno-AMS

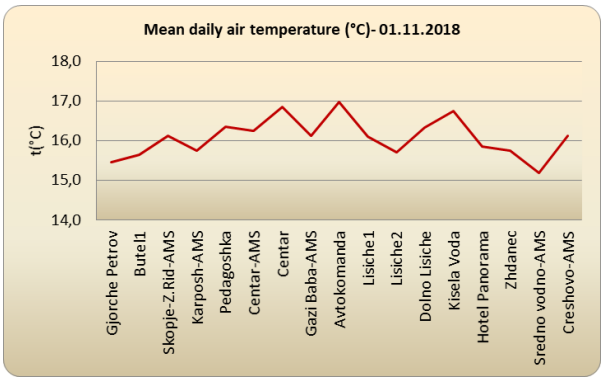

Mean daily air temperature (°C)- 24.04.2018
t(°C)
23,0
22,0
21,0
20,0
19,0
18,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno vodno-AMS
Creshovo-AMS

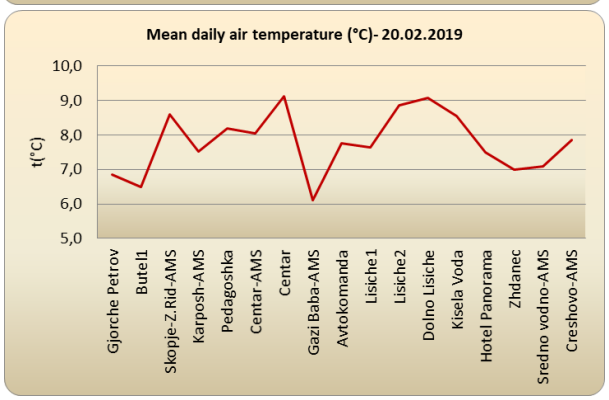

Mean daily air temperature (°C)- 25.04.2018
t(°C)
23,0
22,0
21,0
20,0
19,0
18,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno vodno-AMS
Creshovo-AMS

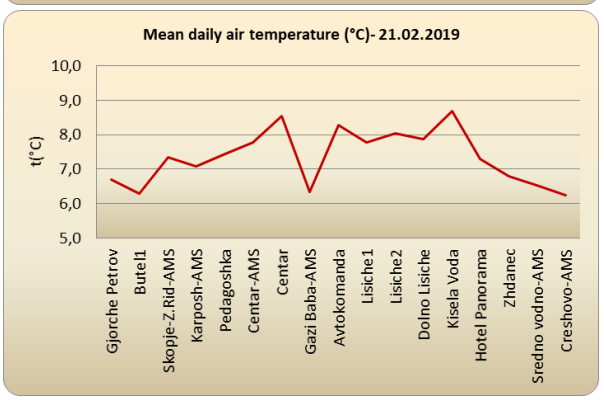

Mean daily air temperature (°C)- 15.08.2018
t(°C)
27,0
26,0
25,0
24,0
23,0
22,0
21,0
20,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno vodno-AMS
Creshovo-AMS

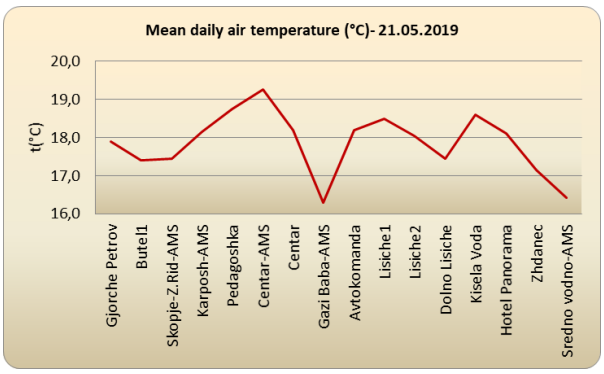

Mean daily air temperature (°C)- 16.08.2018
t(°C)
27,0
26,0
25,0
24,0
23,0
22,0
21,0
20,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno vodno-AMS
Creshovo-AMS

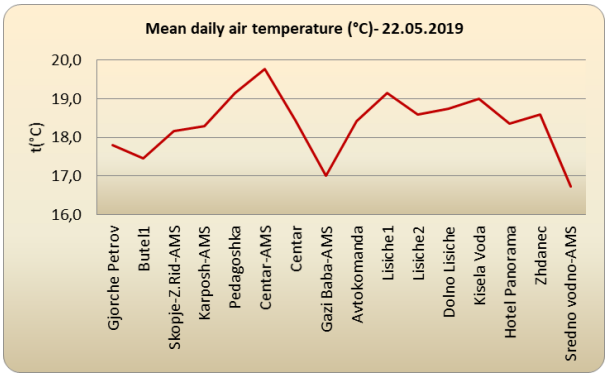

Mean daily air temperature (°C)- 31.10.2018
t(°C)
18,0
17,0
16,0
15,0
14,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno vodno-AMS
Creshovo-AMS

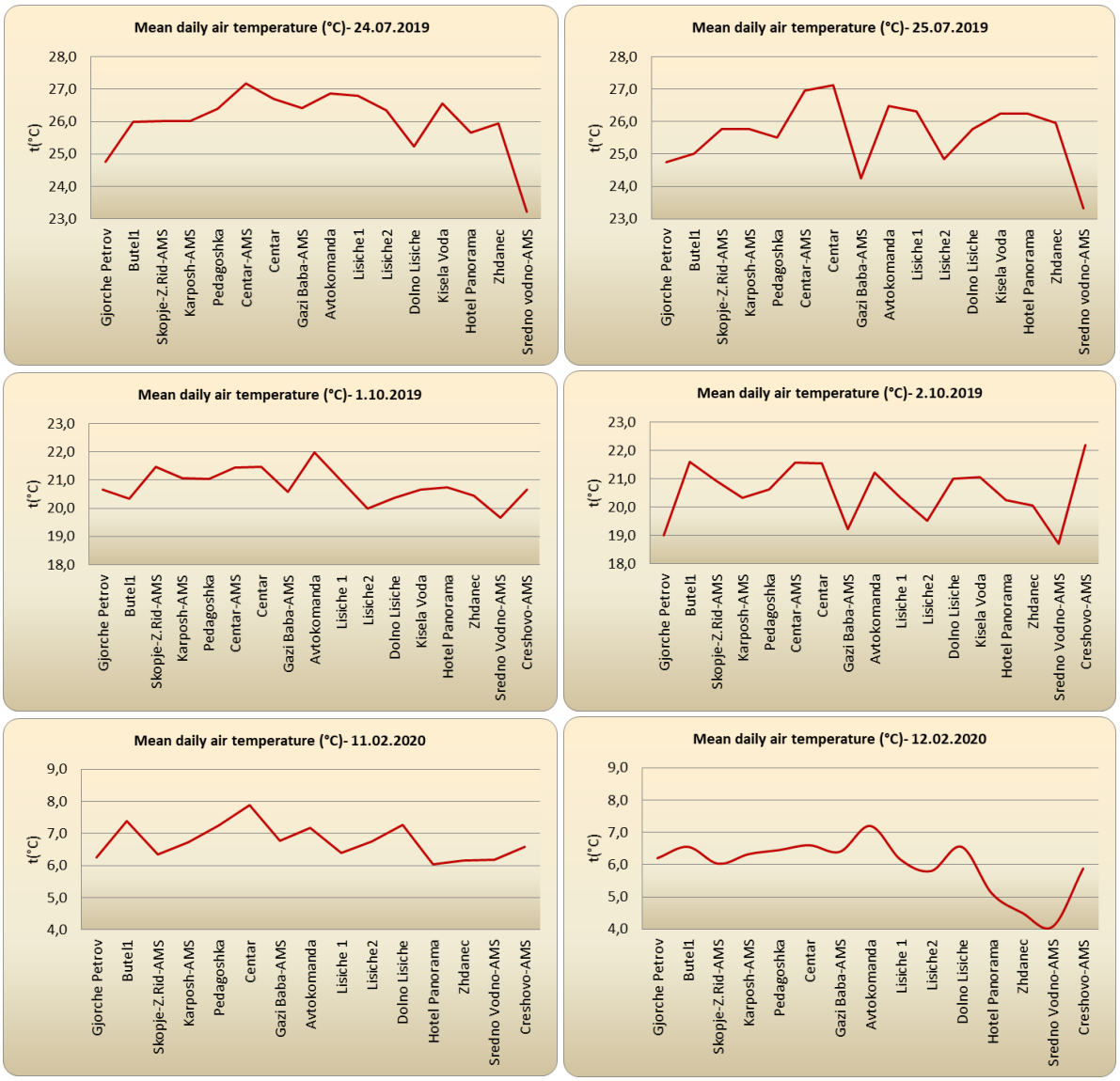

Mean daily air temperature (°C)- 01.11.2018
t(°C)
18,0
17,0
16,0
15,0
14,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno vodno-AMS
Creshovo-AMS


Mean daily air temperature (°C)- 20.02.2019
t(°C)
10,0
9,0
8,0
7,0
6,0
5,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno vodno-AMS
Creshovo-AMS


Mean daily air temperature (°C)- 21.02.2019
t(°C)
10,0
9,0
8,0
7,0
6,0
5,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno vodno-AMS
Creshovo-AMS


Mean daily air temperature (°C)- 21.05.2019
t(°C)
20,0
19,0
18,0
17,0
16,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno vodno-AMS

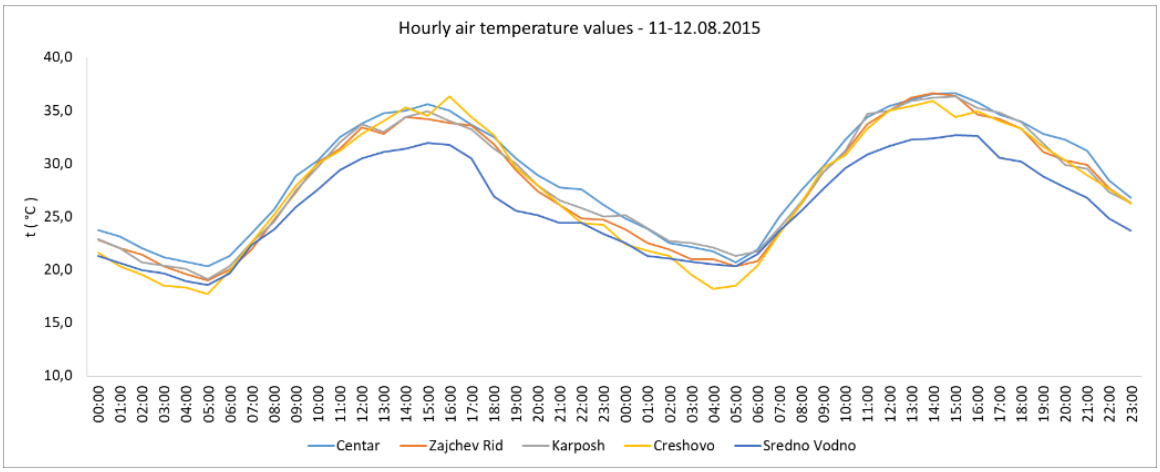

Mean daily air temperature (°C)- 22.05.2019
t(°C)
20,0
19,0
18,0
17,0
16,0
Gjorche Petrov
Butel1
Skopje-Z.Rid-AMS
Karposh-AMS
Pedagoshka
Centar-AMS
Centar
Gazi Baba-AMS
Avtokomanda
Lisiche1
Lisiche2
Dolno Lisiche
Kisela Voda
Hotel Panorama
Zhdanec
Sredno vodno-AMS

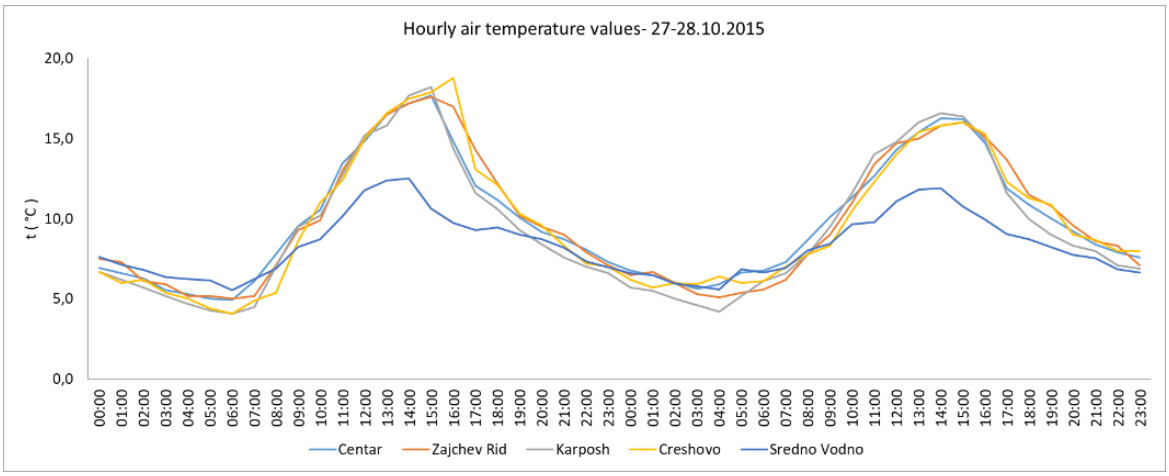


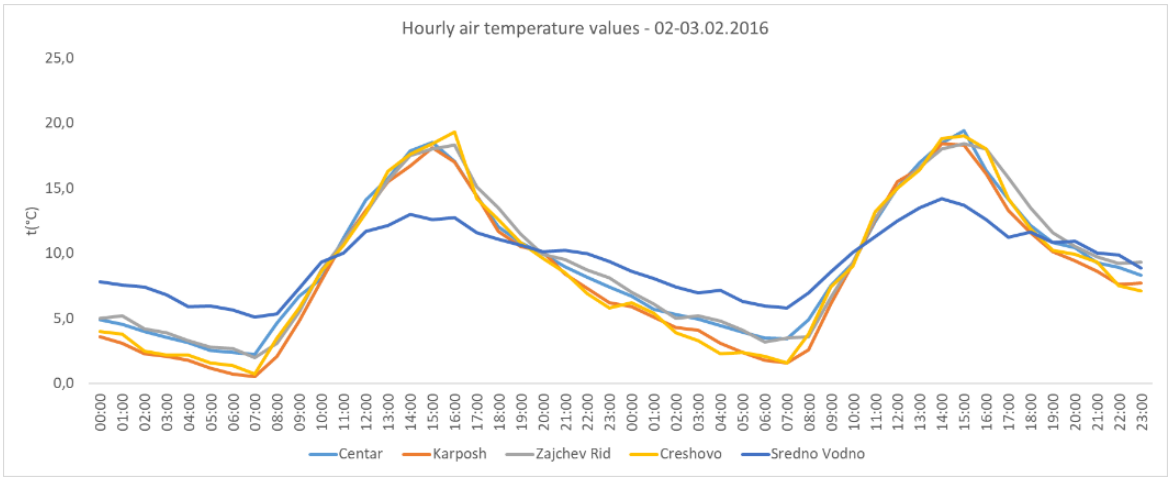
ANALYSIS OF 48-HOUR AIR TEMPERATURE VALUES FROM AUTOMATIC METEOROLOGICAL MEASUREMENTS

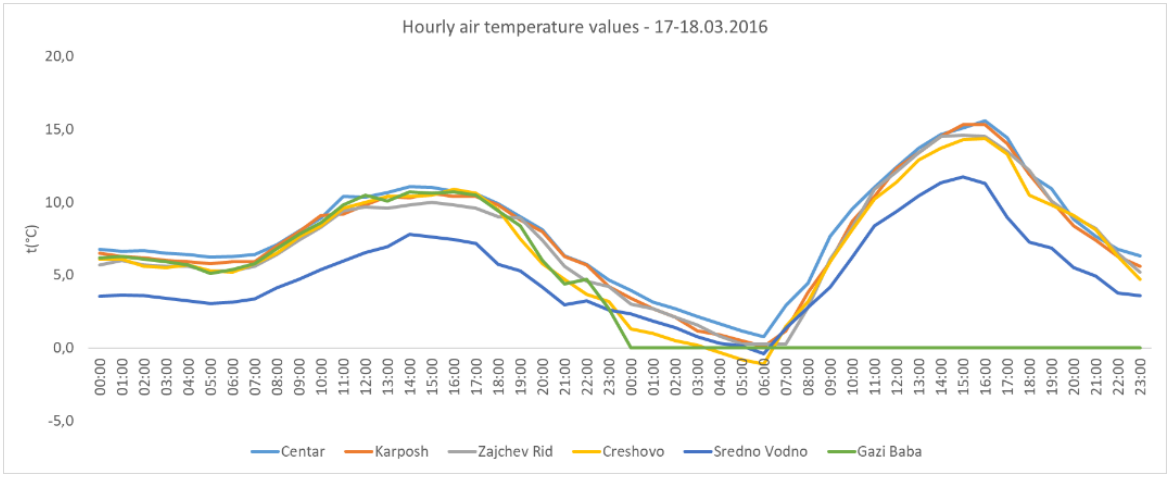
In the series of measurements performed in the period 2015-2020, in addition to mesometeorological measurements and observations in climatic terms, in every full hour from 07:00 to 20:00 hours, 48-hour automatic meteorological measurements of air temperature were performed at the permanent measuring points Zajchev Rid, Karposh, Creshovo and Gazi Baba and at the occasional measuring points Centar and Sredno Vodno. In general, as it can be concluded from the automatic meteorological measurements of air temperature, the highest temperature values were registered at Centar, while the lowest temperature values were registered at Sredno Vodno, which is especially pronounced during the day (Graph 4).

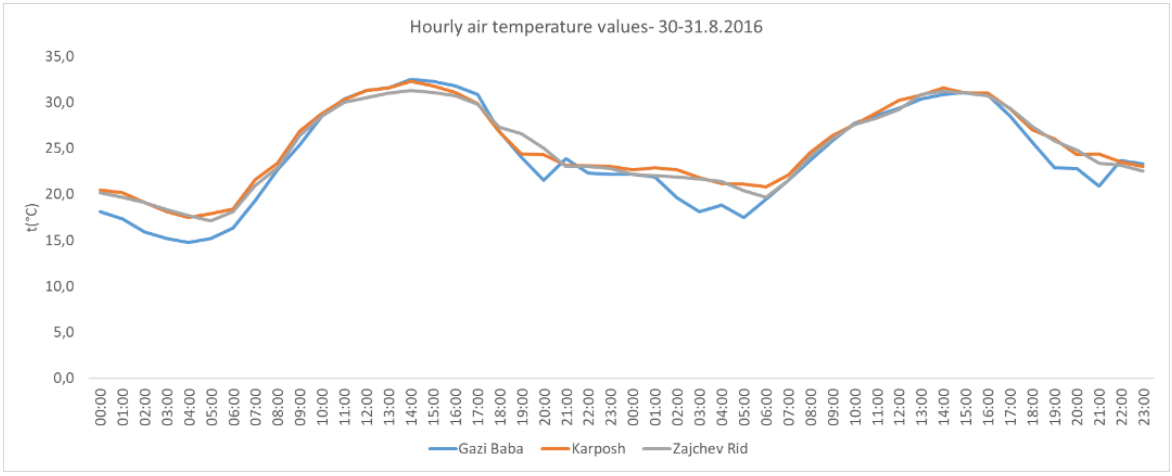
Graph 4. Hourly air temperature values (°C)

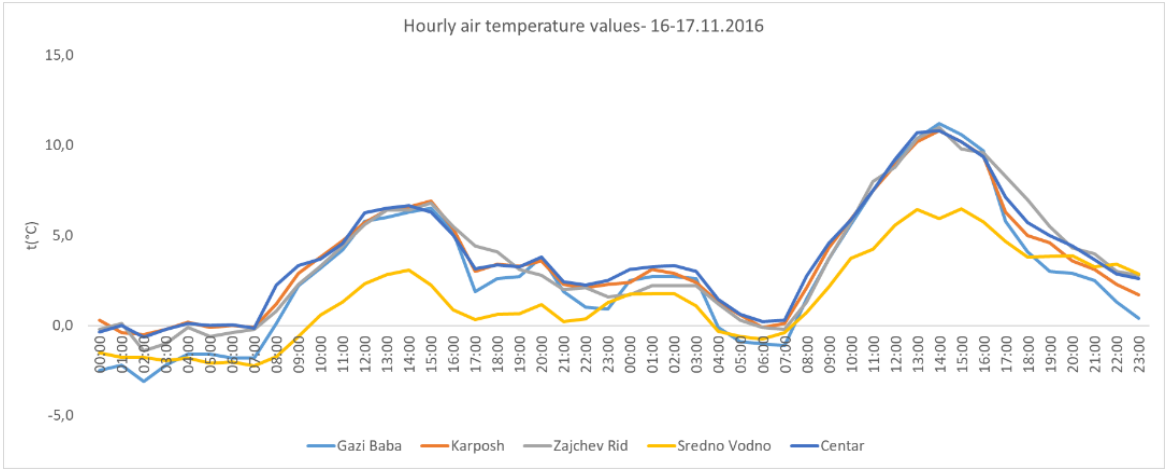


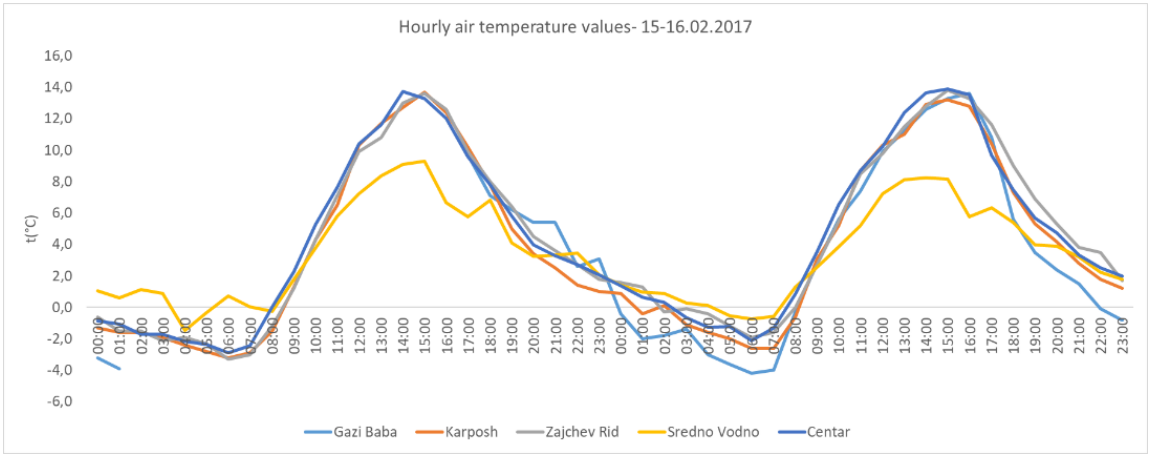


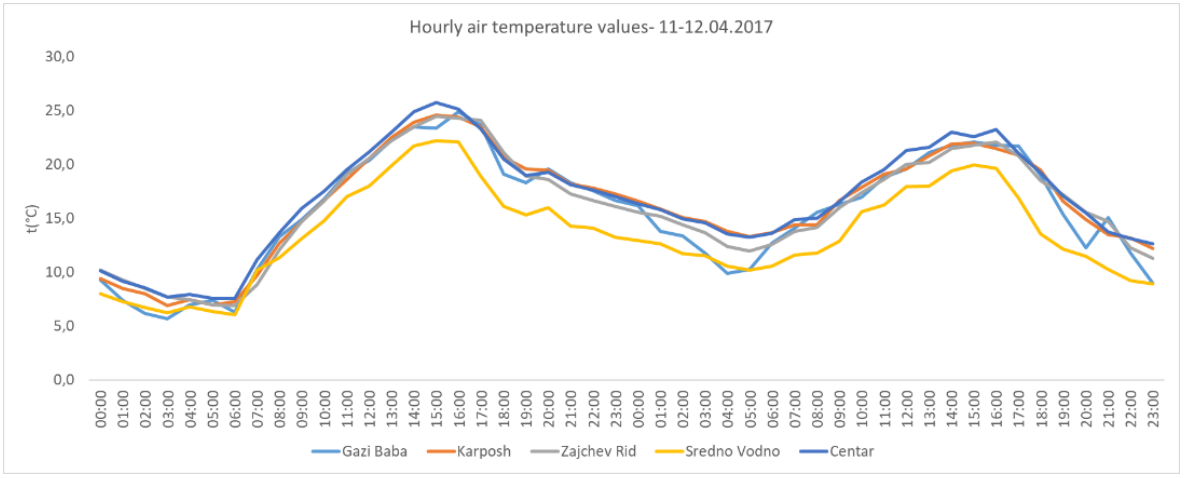


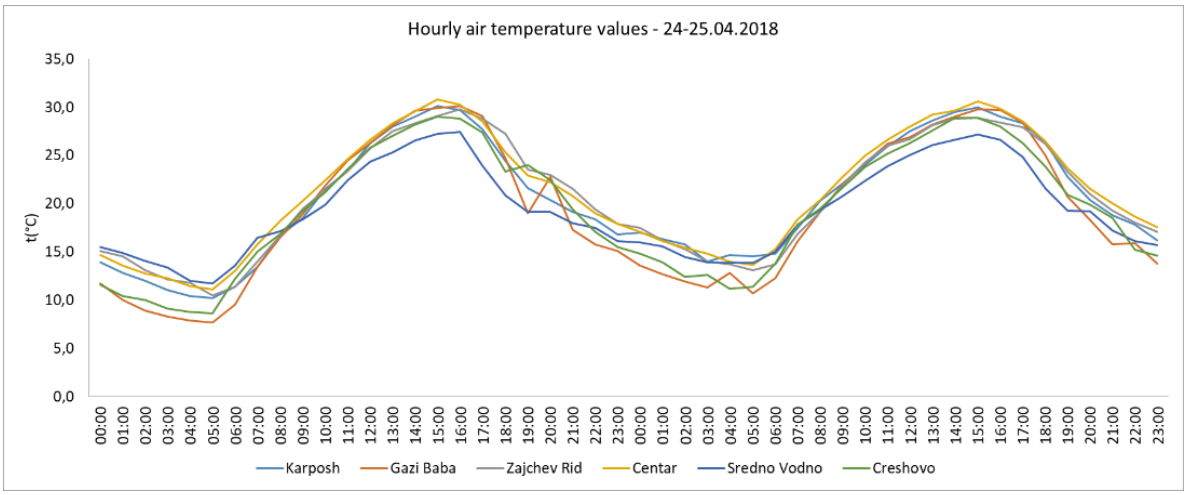

Hourly air temperature values - 17-18.03.2016
t(°C)
Centar
Karposh
Zajchev Rid
Creshovo
Sredno Vodno
Gazi Baba

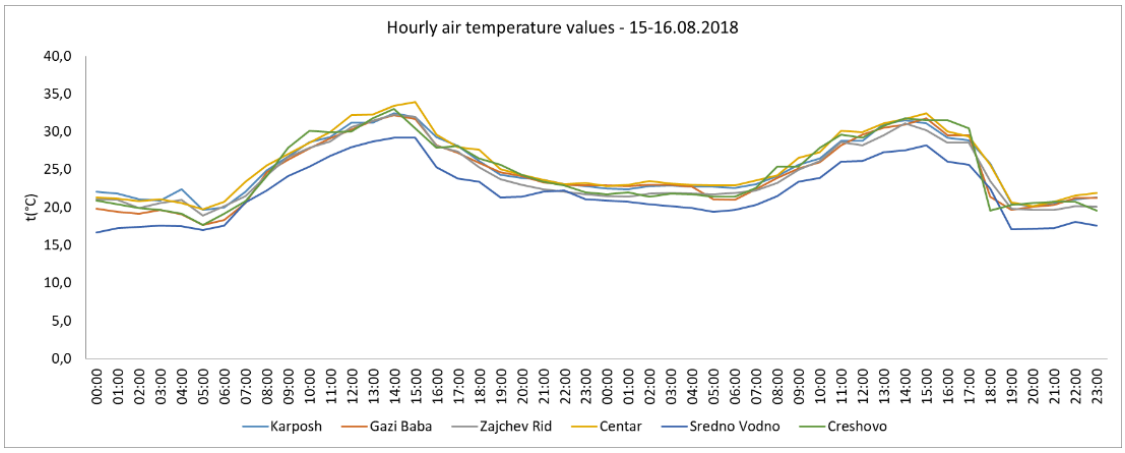

Hourly air temperature values- 30-31.8.2016
t(°C)
Gazi Baba
Karposh
Zajchev Rid

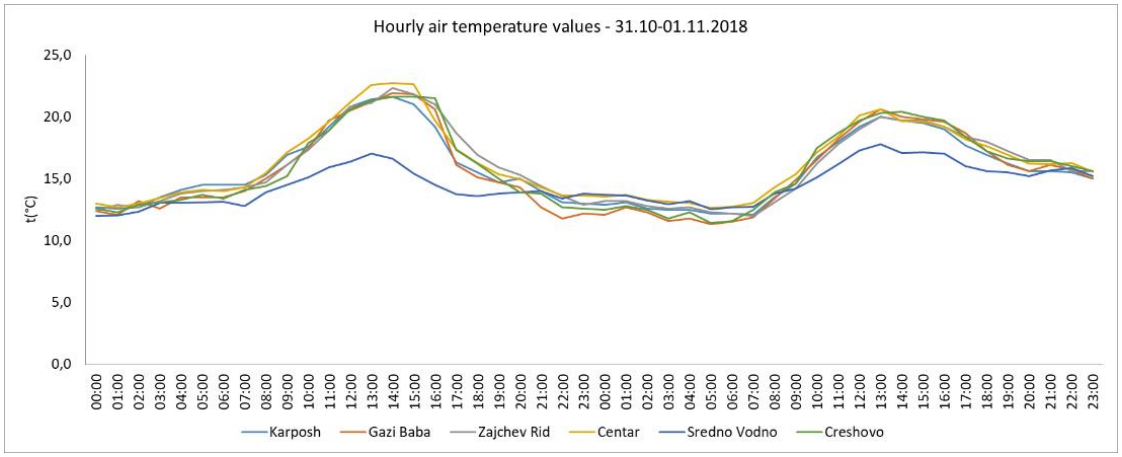

Hourly air temperature values- 16-17.11.2016
t(°C)
Gazi Baba
Karposh
Zajchev Rid
Sredno Vodno
Centar

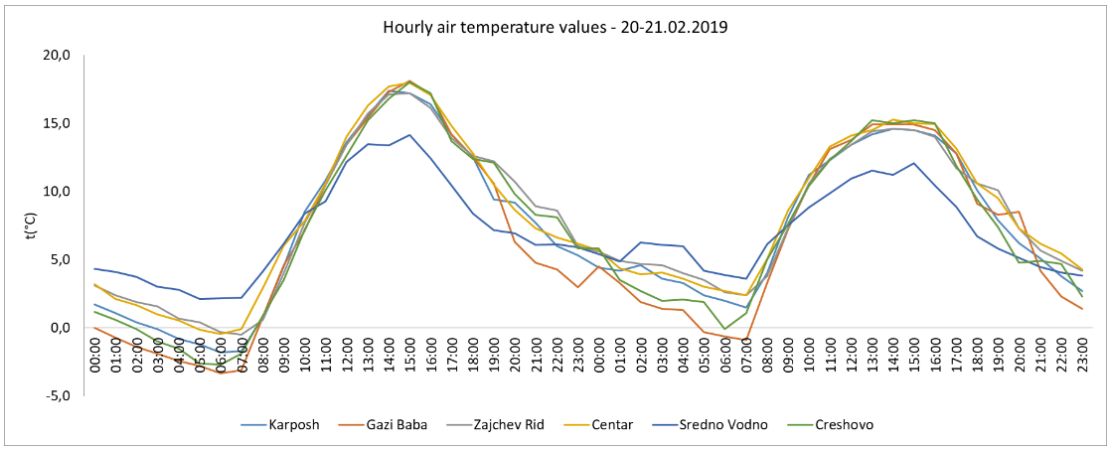

Hourly air temperature values- 15-16.02.2017
t(°C)
Gazi Baba
Karposh
Zajchev Rid
Sredno Vodno
Centar

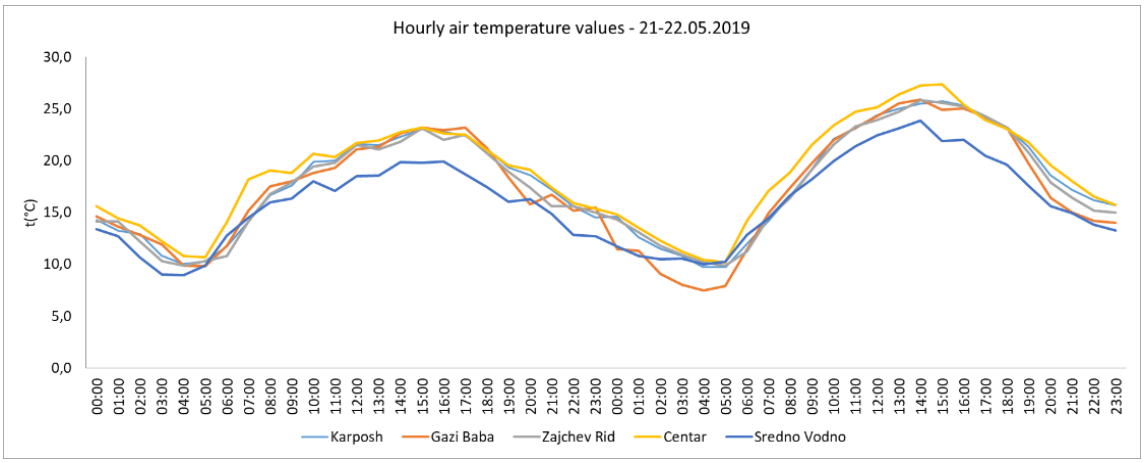

Hourly air temperature values- 11-12.04.2017
t(°C)
Gazi Baba
Karposh
Zajchev Rid
Sredno Vodno
Centar

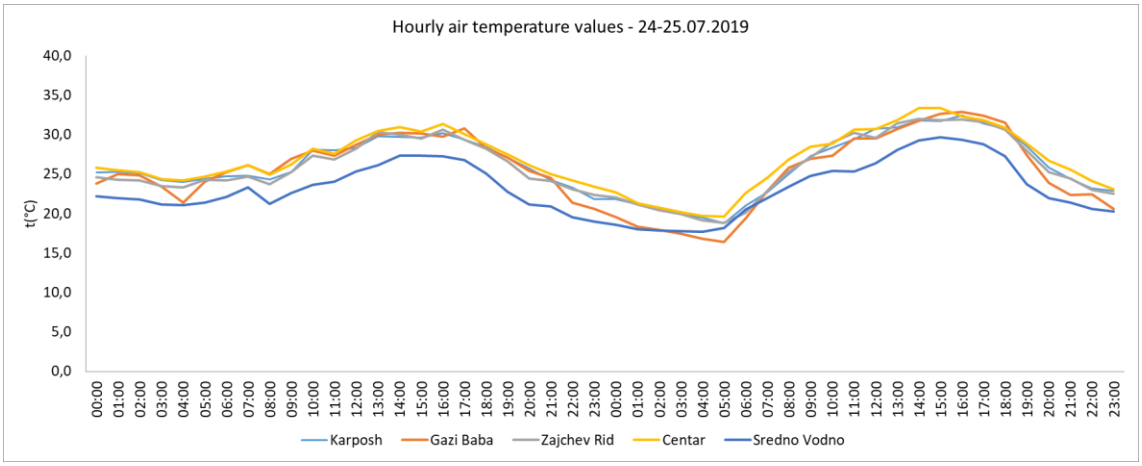

Hourly air temperature values - 24-25.04.2018
t(°C)
Karposh
Gazi Baba
Zajchev Rid
Centar
Sredno Vodno
Creshovo

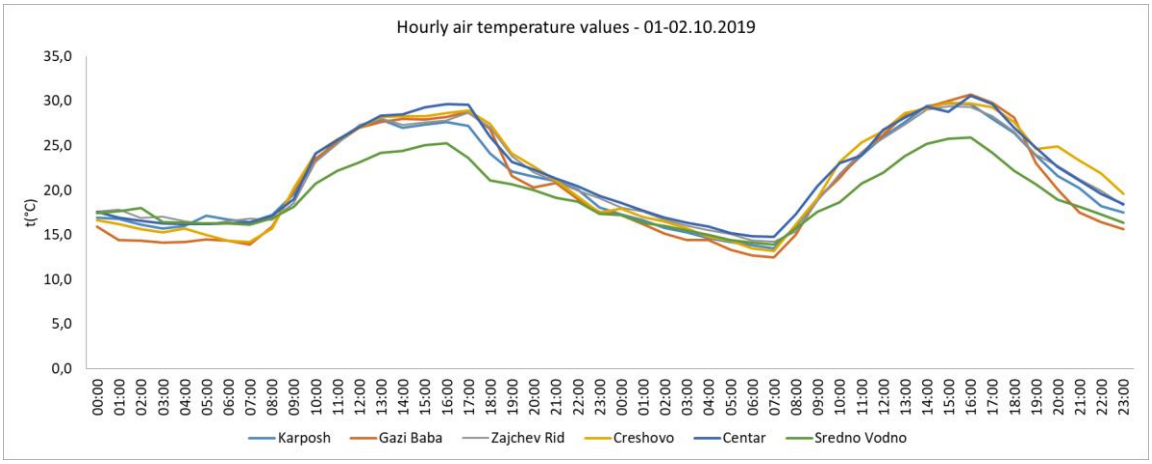

Hourly air temperature values - 15-16.08.2018
t(°C)
Karposh
Gazi Baba
Zajchev Rid
Centar
Sredno Vodno
Creshovo

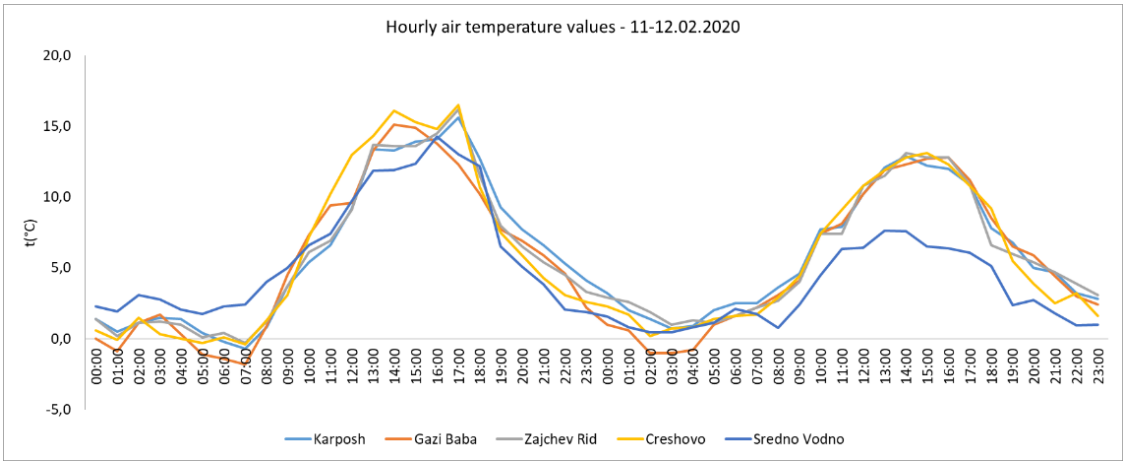

Hourly air temperature values - 31.10-01.11.2018
t(°C)
Karposh
Gazi Baba
Zajchev Rid
Centar
Sredno Vodno
Creshovo


Hourly air temperature values - 20-21.02.2019
t(°C)
Karposh
Gazi Baba
Zajchev Rid
Centar
Sredno Vodno
Creshovo


Hourly air temperature values - 21-22.05.2019
t(°C)
Karposh
Gazi Baba
Zajchev Rid
Centar
Sredno Vodno


Hourly air temperature values - 24-25.07.2019
t(°C)
Karposh
Gazi Baba
Zajchev Rid
Centar
Sredno Vodno


Hourly air temperature values - 01-02.10.2019
t(°C)
Karposh
Gazi Baba
Zajchev Rid
Creshovo
Centar
Sredno Vodno



The lowest air temperature values were measured at night and in the morning, while the highest in the period between 14:00 and 16:00 (Table 2).

Table 2. Lowest and highest 48-hour air temperature values (°C)

	Tmin (°C)	hour / date	Measurement point	Tmax (°C)	hour / date	Measurement point
11-12.08.2015	17.7	05:00/ 11 August	Creshovo	36.6	14:00/ 12 August	Zajchev Rid Centar
27-28.10.2015	4.1	06:00/ 27 October	Karposh and Creshovo	18.8	16:00/ 27 October	Creshovo
02-03.02.2016	0.5	07:00/ 02 February	Karposh	19.4	15:00/ 03 February	Centar
17-18.03.2016	-1.2	06:00/ 18 March	Gazi Baba	15.6	16:00/ 18 March	Centar
30-31.08.2016	14.8	04:00/ 30 August	Gazi Baba	32.5	14:00/ 30 August	Gazi Baba
16-17.11.2016	-3.1	02:00/ 16 November	Gazi Baba	11.2	14:00/ 17 November	Gazi Baba
15-16.02.2017	-4.2	06:00/ 16 February	Gazi Baba	13.9	15:00/ 16 February	Centar
11-12.04.2017	5.7	03:00/ 11 April	Gazi Baba	25.7	15:00/ 11 April	Centar
24.04.-25.04.2018	7.7	05:00/ 24 April	Gazi Baba	30.8	15:00/ 24 April	Centar
15.08.-16.08.2018	16.7	00:00/ 15 August	Sredno Vodno	33.9	15:00/ 15 August	Centar
31.10-01.11.2018	11.3	05:00/ November 1	Gazi Baba	22.7	14:00/ October 31	Centar
20.02-21.02.2019	-3.3	06:00/ 20 February	Gazi Baba	18.1	15:00/ 20 February	Gazi Baba

21-22.05.2019	7.5	04:00/ 22 May	Gazi Baba	27.3	15:00/ 22 May	Centar
24-25.07.2019	16.4	05:00/ 25 July	Gazi Baba	33.4	15:00/ 25 July	Centar
1-2.10.2019	12.5	07:00/ 2 October	Gazi Baba	30.7	16:00/ 2 October	Gazi Baba
11-12.02.2020	-1.8	07:00/ 11 February	Gazi Baba	16.5	17:00/ 12 February	Creshovo

The biggest differences in the term values of air temperature between the measuring points range from 2,4°C (Centar / Creshovo) to 4,5°C (Zajcev Rid / Gazi Baba).

Table 3. Biggest differences in air temperature between measuring points (°C)

11-12.08.2015	3.5°C	Centar / Creshovo
27-28.10.2015	2.4°C	Centar / Creshovo
2-3.02.2016	2.5°C	Centar / Karposh
17-18.03.2016	2.7°C	Centar / Creshovo
30-31.08.2016	3.7°C	Gazi Baba / Karposh
16-17.11.2016	2.9°C	Gazi Baba / Zajchev Rid
15-16.02.2017	3.6°C	Gazi Baba / Zajchev Rid
11-12.04.2017	3.9°C	Gazi Baba / Karposh
24-25.04.2018	4.5°C	Zajchev Rid/Gazi Baba
15-16.08.2018	4.4°C	Karposh/Gazi Baba
31.10-01.11.2018	2.6°C	Zajchev Rid/Gazi Baba
20-21.02.2019	4.4°C	Zajchev Rid/Gazi Baba
21-22.05.2019	4.1°C	Centar / Zajchev Rid Centar / Karposh
24-25.07.2019	3.3°C	Centar / Gazi Baba
1-2.10.2019	3.7°C	Zajchev Rid/Gazi Baba
11-12.02.2020	3.9°C	Zajchev Rid/Gazi Baba

ANALYSIS OF AIR TEMPERATURE FROM THE PERMANENT AUTOMATIC METEOROLOGICAL MEASUREMENTS FOR THE PERIOD 2017-2020

The introduction of an automated meteorological and climate monitoring system in the Skopje Valley in recent years has enabled the collection of meteorological data in a database which serves as a basis for more detailed analysis of the impacts of the city on the climate conditions on a meso-scale. Tables 4,5,6,7 and 8 show the data for the mean monthly and annual air temperature, mean monthly and annual maximum and minimum air temperature and monthly and

annual absolute maximum and minimum temperature of air obtained from the automatic meteorological stations Gazi Baba, Karposh and Zajchev Rid for the period 2017-2020.

The highest values of mean annual and monthly air temperature for most of the months were recorded at AMS Karposh (Table 4). The highest absolute and mean annual maximum air temperature was recorded at AMS Gazi Baba (Tables 5 and 6). Also the lowest absolute and mean annual minimum temperature was recorded also at AMS Gazi Baba (Tables 7 and 8).

Table 4. Mean monthly and annual air temperature (°C)

	Tavg	1	2	3	4	5	6	7	8	9	10	11	12	Year
Gazi Baba	2017	-4.7	4.7	11.2	12.9	17.7	22.9	25.4	25.4	19.1	12.3	6.8	2.9	13.0
Karposh	2017	-3.6	5.4	11.6	13.2	18.4	23.6	26.2	25.8	19.7	12.9	7.3	3.9	13.7
Zajchev Rid	2017	-4.0	5.3	11.5	12.9	17.9	23.1	25.9	25.7	19.6	13.2	7.2	3.6	13.5
Gazi Baba	2018	2.6	4.0	8.0	16.9	19.4	21.0	23.5	24.2	19.7	14.2	8.0	1.4	13.6
Karposh	2018	3.5	4.4	8.4	17.4	20.2	21.6	24.1	24.7	20.1	14.6	8.4	2.2	14.1
Zajchev Rid	2018	3.5	4.0	8.1	17.3	19.6	21.0	23.3	24.4	20.0	15.0	8.5	1.8	13.9
Gazi Baba	2019	-0.6	4.6	10.4	13.7	16.2	23.3	24.4	26.3	20.3	14.7	11.4	4.4	14.1
Karposh	2019	0.1	5.4	/	/	16.5	23.8	25.0	26.9	20.9	15.3	11.6	4.9	/
Zajchev Rid	2019	-0.5	5.2	11.1	13.7	16.1	23.5	24.7	26.9	20.7	16.1	11.7	4.5	14.5
Gazi Baba	2020	0.9	5.5	8.4	12.0	17.1	21.1	24.4	23.2	20.6	13.4	5.9	5.6	13.2
Karposh	2020	1.8	6.0	8.9	12.7	17.5	21.4	25.0	23.6	20.9	13.7	6.8	5.9	13.7
Zajchev Rid	2020	1.8	6.0	8.5	12.6	17.3	21.3	24.7	23.5	21.0	13.9	7.2	5.6	13.6

Table 5. Monthly and annual absolute maximum air temperature (°C)

	Tmax_aps	1	2	3	4	5	6	7	8	9	10	11	12	Year
Gazi Baba	2017	7.1	21.2	26.7	29.4	31.8	39.7	41.0	40.9	36.3	26.9	17.1	16.4	41.0
Karposh	2017	6.5	19.9	26.7	28.7	32.0	39.3	40.9	40.3	35.0	26.7	15.8	15.8	40.9
Zajchev Rid	2017	7.0	20.2	26.3	28.5	31.9	39.0	40.5	40.9	35.4	/	16.7	15.5	40.9
Gazi Baba	2018	14.9	15.0	23.4	30.8	31.9	33.7	36.7	35.7	34.2	27.0	25.2	12.2	36.7
Karposh	2018	14.4	14.3	23.3	30.4	31.1	33.3	36.7	34.7	33.0	26.4	23.6	10.9	36.7
Zajchev Rid	2018	15.6	14.5	23.4	30.2	30.5	33.3	36.0	34.8	33.5	26.7	24.1	10.8	36.0
Gazi Baba	2019	9.1	18.5	25.6	29.3	29.3	35.6	38.8	40.5	35.7	31.0	25.9	14.0	40.5
Karposh	2019	8.5	17.5	/	/	29.2	35.4	38.1	39.4	34.7	29.9	24.3	14.3	39.4
Zajchev Rid	2019	8.6	17.6	25.0	28.3	29.8	34.9	38.5	39.7	34.9	30.3	25.7	14.4	39.7
Gazi Baba	2020	11.1	20.7	25.7	28.1	36.8	36.0	39.4	37.1	35.3	30.4	22.5	17.4	39.4
Karposh	2020	10.7	19.3	24.7	27.9	36.4	34.9	38.9	35.6	33.9	29.4	21.2	16.3	38.9
Zajchev Rid	2020	10.9	19.5	25.3	27.5	36.2	34.4	38.8	36.2	35.2	29.3	21.9	15.7	38.8

Table 6. Mean monthly and annual air temperature (°C)

	tmax_avg	1	2	3	4	5	6	7	8	9	10	11	12	Year
Gazi Baba	2017	-0.1	10.4	18.7	20.5	25.1	30.9	34.2	34.8	27.5	21.4	12.2	8.1	20.3
Karposh	2017	0.0	10.7	18.3	20.0	24.6	30.4	33.6	34.1	26.8	21.0	11.8	7.9	19.9
Zajchev Rid	2017	-0.2	10.7	18.4	19.8	24.3	30.2	33.6	34.3	26.9	/	11.9	8.0	/
Gazi Baba	2018	8.2	8.6	14.2	25.3	27.5	28.7	31.3	32.9	28.7	22.8	14.3	6.5	20.7
Karposh	2018	8.0	8.2	13.8	24.8	27.0	28.4	30.6	32.0	27.9	22.2	13.7	6.3	20.2
Zajchev Rid	2018	8.1	8.3	13.7	24.4	26.3	27.9	30.1	32.0	28.1	22.5	13.8	6.2	20.1
Gazi Baba	2019	3.2	11.3	19.2	20.7	23.3	31.5	32.6	35.8	29.5	24.8	17.0	7.9	21.4
Karposh	2019	3.3	10.8	/	/	22.4	30.7	32.0	34.9	28.4	24.1	16.1	7.7	/
Zajchev Rid	2019	3.1	10.9	18.7	19.9	22.3	30.5	32.1	35.2	28.6	24.5	16.4	7.6	20.8
Gazi Baba	2020	6.8	13.3	15.2	20.1	24.8	29.1	33.1	31.8	29.5	21.3	13.5	9.4	20.7
Karposh	2020	6.7	12.5	14.8	19.7	24.2	28.2	32.2	31.0	28.5	20.6	13.0	9.2	20.0
Zajchev Rid	2020	6.9	12.7	14.7	19.4	24.0	28.1	32.3	31.0	28.8	20.8	13.1	9.0	20.1

Table 7. Monthly and annual absolute minimum air temperature (°C)

	tmin_aps	1	2	3	4	5	6	7	8	9	10	11	12	Year
Gazi Baba	2017	-19.2	-5.4	-1.8	-0.4	4.5	10.3	12.4	9.0	5.9	-2.4	-18.8	-8.6	-19.2
Karposh	2017	-16.1	-4.4	0.2	1.7	6.2	12.5	14.8	11.6	8.2	0.5	-4.5	-5.7	-16.1
Zajchev Rid	2017	-16.7	-4.4	0.2	0.8	5.4	12.2	14.2	11.6	7.9	/	-5.4	-6.9	-16.7
Gazi Baba	2018	-7.5	-8.7	-11.4	1.3	8.6	10.4	13.5	13.3	1.0	-1.1	-4.1	-7.7	-11.4
Karposh	2018	-5.7	-7.4	-9.9	3.6	10.8	12.9	15.6	15.8	3.6	0.4	-2.2	-5.4	-9.9
Zajchev Rid	2018	-6.7	-8.2	-11.0	3.5	10.3	12.0	14.4	16.0	3.7	0.8	-2.8	-5.7	-11.0
Gazi Baba	2019	-11.6	-6.2	-3.9	1.1	2.9	11.1	11.4	11.9	3.7	1.4	1.5	-6.9	-11.6
Karposh	2019	-9.6	-5.4	/	/	5.6	12.9	13.6	15.1	5.9	3.1	5.0	-4.0	-9.6
Zajchev Rid	2019	-9.8	-6.7	-1.5	3.2	5.3	12.2	-3.0	14.4	6.0	3.9	5.0	-5.4	-9.8
Gazi Baba	2020	-8.8	-5.9	-4.3	-3.0	3.3	4.1	11.4	13.1	6.9	0.9	-6.0	-8.1	-8.8
Karposh	2020	-6.8	-3.7	-1.7	-1.5	5.3	6.4	14.4	14.7	8.3	2.4	-4.4	-6.3	-6.8
Zajchev Rid	2020	-6.8	-3.6	-1.7	-2.1	4.5	5.9	12.8	14.8	8.2	2.6	-4.2	-5.6	-6.8

Table 8. Mean monthly and annual minimum air temperature (°C)

	tmin_avg	1	2	3	4	5	6	7	8	9	10	11	12	Year
Gazi Baba	2017	-8.9	0.1	4.1	5.7	10.8	15.2	16.7	15.8	11.8	5.6	1.9	-1.0	6.5
Karposh	2017	-7.2	1.0	5.8	7.2	12.4	17.0	18.9	18.0	13.5	7.2	3.5	0.6	8.1
Zajchev Rid	2017	-7.6	0.7	5.5	6.6	11.7	16.5	18.3	17.7	13.1	/	3.2	0.0	/
Gazi Baba	2018	-1.5	0.2	2.6	8.7	12.4	15.1	17.1	16.7	11.9	7.7	3.7	-2.9	7.6
Karposh	2018	-0.1	1.3	3.8	10.5	14.1	16.5	18.9	18.6	13.8	9.0	4.8	-1.3	9.2
Zajchev Rid	2018	-0.4	0.7	3.3	10.2	13.5	15.9	18.1	18.1	13.5	9.0	4.8	-1.8	8.7
Gazi Baba	2019	-4.3	-0.6	1.9	6.9	9.2	16.1	16.3	17.0	12.7	7.4	7.5	1.1	7.6
Karposh	2019	-2.8	1.0	/	/	10.7	17.7	18.4	19.2	14.7	8.9	8.5	2.2	/
Zajchev Rid	2019	-3.4	0.5	4.1	7.9	10.3	17.1	17.3	18.7	14.3	9.4	8.4	1.8	8.9
Gazi Baba	2020	-3.5	-1.0	2.4	4.2	10.0	13.5	16.1	16.5	13.6	7.8	0.9	1.9	6.9
Karposh	2020	-2.0	0.6	3.9	6.1	11.5	15.1	18.4	17.8	15.4	8.7	2.4	2.9	8.4
Zajchev Rid	2020	-2.1	0.6	3.5	5.8	11.1	14.8	17.8	17.6	15.2	8.8	2.5	2.7	8.2

CONCLUSION

The current climate change and their manifestations have shown that there is a need to reactivate mesometeorological measurements in the Skopje Valley, thus starting from 2011 every year several series of 2-day mesometeorological measurements are performed. In the past period, in addition to the regular meteorological and occasional mesometeorological measurements and observations with classical instruments and equipment, a modern automated meteorological-climate monitoring system was established in the Skopje Valley (in accordance with the standards of the World Meteorological Organization).

As part of this activity, four automatic meteorological stations have been set up in the Skopje Valley. The process of establishment of an automated meteorological monitoring system in the Skopje Valley started in 2012 with the installation of an automatic meteorological station in Creshovo as a result of the participation of the HMO in the Twinning project of the Ministry of Environment and Physical Planning and the Finnish Meteorological Institute, "Strengthening the Capacities at Central and Local Level in Environmental Management in the Area of Air Quality". Within the Agreement of HMO, the Skopje Planning Region and the City of Skopje for realization of the "Program for Mesometeorological Measurements in the Skopje Valley and its Implementation", three automatic meteorological stations were installed, in 2013 in the Municipality of Karposh (in the primary school Petar Pop Arsov), in 2015 at Zajchev Rid and in 2016 in the Municipality of Gazi Baba.

The results of the occasional mesometeorological measurements performed so far as well as the data from the established automated meteorological observation system in the Skopje Valley feed into a meteorological database that serves as a basis for more detailed research of local impacts of the city on the climate. The website of the HMO https://uhmr.gov.mk/aktuelni-podatoci/ contains current data taken from the automatic meteorological stations in the Skopje Valley which are part of the established national automated observation system.

As stipulated in the Strategy for Establishment of an Automated Meteorological Monitoring System in the Skopje Valley, the installation of an automatic meteorological station in the downtown area is a priority. For complete and continuous future monitoring of the components of the meso-scale climate system in the Skopje Valley it is necessary to continue the activity by setting up automatic meteorological stations of different types at several points in the Skopje Valley, which will be permanent measuring points for carrying out continuous meteorological measurements.

PICTURES OF OCCASIONAL MEASURING POINTS

Gjorche Petrov

Butel 1

Taftalidze-Pedagoshka

Centar

Avtokomanda

Lisiche1

Kisela Voda

Hotel Panorama