

Analysis of equivalent temperatures in the area of Zlatibor in the function of outdoor tourism

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Abstract

Bioclimatic research is an important source of data for the tourism industry because climate is one of the most important factors in tourism. Knowing the bioclimatic characteristics of a tourist destination can contribute to its better valorization. The paper discusses the equivalent temperatures in the area of Zlatibor. In this study equivalent temperatures are analysed for the period 1991-2020. The analysis of the obtained results based on Krieger's anthropoclimatic classification showed that Zlatibor has favorable values of equivalent temperatures throughout the year. The positive influence of the climate on the psychophysical state of man, numerous tourist contents and complementary tourist values have made Zlatibor the leading center of mountain tourism in Serbia, which has the status of an air spa.

1. Introduction

The stabilization of socio-political conditions in the world after the Second World War enabled tourism to become a global phenomenon and gain the character of mass and a certain level of standardization. In the last decades of the 20th century, tourism has become the fastest growing industry and a very important factor in the overall development of a destination, region or country (Godde, Price, Zimmermann, 1999; Šušić, 2017).

The most widespread type of continental tourism is mountain tourism, and after coastal tourism, it is the most important form of recreational tourism. Tourist valorization of mountains for recreational purposes is done on the basis of their morphological, climatic, hydrological and biogeographical characteristics that provide an opportunity to organize various recreational activities. The main motive for visiting the mountains is the climate that is conditioned by altitude, while other natural and different anthropogenic values affect the increased attractiveness of mountains, their impact increases with decreasing altitude (Jovičić, 2009; Šušić, 2017).

Climate has a great influence on human behavior, his body and mental health. The performance of many economic activities depends on the climate: the manner of construction of residential and other facilities, the structure of agricultural production, the formation of tourist destinations, etc. In areas with polluted air such as urban and industrial centers, climate appears as an initial factor in tourist movements, while in places with preserved natural environment, one of the elements of which is clean and fresh air, which can have a sedative or stimulating effect on tourists as a receptive factor. As a need of the society for knowledge of the influence of climate on living beings and vice versa, a new scientific discipline appeared - bioclimatology. Bioclimatology studies the interaction of organisms and perennial atmospheric conditions. In its research, bioclimatology uses different combinations of climatic elements, i.e. based on their values it calculates bioclimatic indices used to determine the bioclimatic characteristics of the studied area (Stanković, 1995; Unkašević, 2003; Pecelj, Milinčić, Pecelj, 2007; Stojićević, 2016). Numerous authors have analyzed the various bioclimatic indices of urban centers (Pecelj et al., 2020; Bursać Martić, Stričević, Gocić, 2021; Lukić et al., 2019; Milentijević et al., 2018), spa (Pecelj, Błażejczyk, Vagic, 2021;

Stevanović, 2019; Stojićević, Basarin, Lukić, 2016; Maćejka, 2003), mountains (Pecelj et al., 2017; Basarin et al., 2018; Vujević, 1961) but also regional units of Serbia (Basarin et al., 2017; Stojićević, 2016; Malinović Milićević, 2013) and certain places in its surrounding (Šušnjar, Pecelj, 2014; Trbić, 2005).

The subject of this paper is the analysis of equivalent temperatures in the area of Zlatibor, and the aim is to consider the impact of the mentioned bioclimatic index in the function of tourism and recreation.

With the help of equivalent temperatures, we can determine thermal comfort zones, which are represented by physiological sensations of heat in this bioclimatic index. Thermal comfort represents a set of microclimatic conditions in which a person feels comfortable, which is very important when choosing a vacation destination, as well as planning the tourism industry.

2. Study area

Zlatibor occupies larger parts of the vast Starovlaška plateau, located in the northern part of Stari Vlah, which regionally belongs to Southwestern Serbia. The administrative district of Serbia to which Zlatibor belongs is named after it. The head office of the Zlatibor administrative district is in the city of Užice (Figure 1). In morphological terms Zlatibor rep-

resents a spacious undulating surface with an average altitude of about 1000 m, from which several peaks rise: Čigota, Brijač, Čuker, Liska, Konjoder, etc. The highest peak of Zlatibor is Tornik (1496m). It stretches in the northwest-southeast direction for about 30 km in length and about 12 km in width. Due to its position between two large natural units, the Pannonian Plain and the Adriatic coast, Zlatibor is exposed to the influences of continental air masses coming from the northeast and beneficial and modified maritime influences from the southwest. The area of Zlatibor has a temperate-continental and subalpine climate at higher altitudes. Winters are moderately cold, summers are fresh, and autumns are warmer than springs. The snow cover lasts for about four months on average (Jovičić et al., 2013; Dragović, Filipović, Nikolić, 2009; Ršumović, Milojević, Lazarević, 1991).

The natural resources of Zlatibor have been adequately explored and used. Based on its values, Zlatibor was declared a Nature Park in 2017. The geological composition consists of igneous rocks which are considered to have a recreational-therapeutic effect on humans with their specific radiation. The landscape of this mountain is represented by the change of pastures and groves of coniferous forests in which pine is the most numerous and this landscape aesthetic has a relaxing effect on visitors. Apart from recreational and health

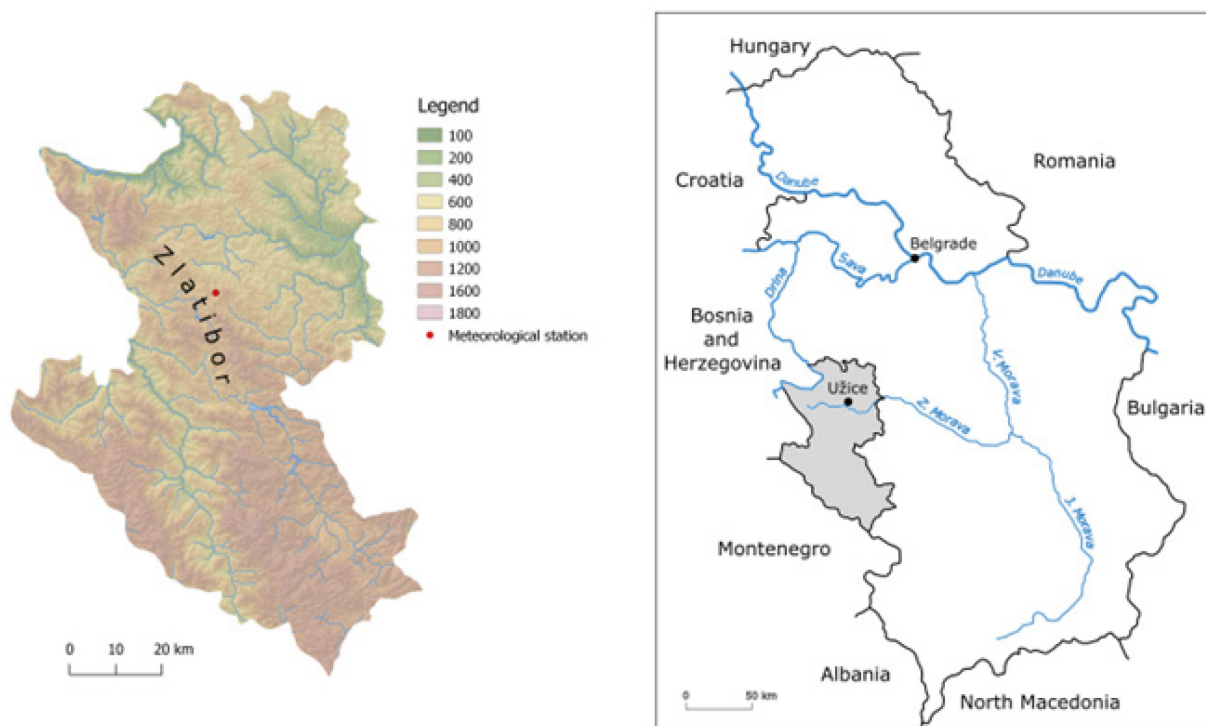


Figure 1. Geographical position of Zlatibor on the relief map of Zlatibor district (left) and geographical position of the Zlatibor district in the Republic of Serbia (right).

tourism, Zlatibor is becoming an increasingly important center of congress tourism in our country. Complementary tourist values that can enrich a visit to Zlatibor are Stopića Cave, Gosilje Waterfall, Shargan-Mokra Gora Nature Park, Perućac and Zaovine lakes, Tara, Zlatar, Pribojska Spa, ethnic village Drvengrad, outdoor museum Sirogojno, Rača and Mileševa monasteries, etc. In addition to tourist values, visitors have at their disposal various tourist facilities that can make their stay more dynamic: riding quads, horseback riding, wellness and spa centers, zipline, gondola rides, etc. Zlatibor has the longest panoramic gondola in the world, the Golden Gondola, which is 9000m long. It connects the center of Zlatibor with the ski resort Tornik (Ršumović, Milojević, Lazarević, 1991; Bučić, Cimbaljević, Janković, 2015).

3. Material and method of work

Equivalent temperature (E_t) is a bioclimatic index that correlates the values of air temperature (t) and water vapor pressure (e):

$$E_t = t + 2e$$

This is the temperature that would occur if all the water vapor from the humid air condensed without cooling it, and all the heat released was transferred to the dry air. The equivalent temperature is a purely theoretical quantity because condensation is impossible without simultaneous cooling of the air, its values are mainly used for bioclimatic research (Vujević, 1956; Dukić, 1998).

The analysis of equivalent temperatures is performed on the basis of Krieger's anti-climatic classification. For the needs of bioclimatic research in our area, the supplemented Krieger scale is used, which contains three weather types and nine physiological sensations of heat (Table 1) (Burić, Ivanović, Mitrović, 2007).

For the needs of the paper, the mean daily values of air temperature and water vapor pressure recorded at the meteorological station Zlatibor for the period of thirty years, from 1991 to 2020, which are collected and published by the Republic Hydrometeorological Institute, were used. Meteorological station Zlatibor is located at 43°44'N latitude, 19°43'E longitude and 1029 m above sea level (RHMS).

4. Results and discussion

Bioclimatic research in tourism is important because data on the climate of a place can be an important element of tourist propaganda and contribute to better marketing of destinations on the tourist market. Also, climatic conditions influence the decision of potential tourists on the choice of a place where they will spend their free time. The modern tourist is characterized by increasingly pronounced recreational needs, including sports, rehabilitation, prevention, active rest, spa or climate treatment, etc. He tries to realize these needs in tourist places with a preserved natural environment and favorable climatic conditions, i.e. places that will provide him with optimal conditions for satisfying his recreational needs (Stanković, 1995; Šušić, 2017).

The average annual temperature on Zlatibor is 8.3°C, the coldest month is January (-1.7°C), the warmest August (18.3°C), and the annual amplitude is 20°C. The annual temperature flow is regular. Temperatures rise from January to August and then fall until January (Table 2). The second half of the year is warmer than the first, which indicates that autumn is warmer than spring. There is more heat in the second part of the year, so the transition from summer to winter is slower than the transition from winter to summer, which has a favorable impact on the tourism industry (Ršumović, Milojević, Lazarević, 1991).

The annual flow of water vapor pressure also has one minimum and one maximum. Unlike the annual air temperature flow, water vapor pressure values increase from January to July, when the maximum (14.4 hPa) is recorded, and then decrease until January when, as at air temperature, the minimum water vapor value is read in January (4.7 hPa). The average annual value of water vapor pressure is 8.9 hPa, and the annual amplitude is 9.7 hPa. In terms of the period, summer is wetter than winter, and autumn is wetter than spring, which tells us that the second half of the year is wetter than the first (Table 2).

According to Rakićević, Zlatibor belongs to the Starovlak climate region, which covers southwestern Serbia, and is the region with the highest humidity and clouds in Serbia. Heavy

Table 1. Classification of physiological sensations of heat and weather types according to Krieger.

E_t (°C)	<5	5-18	18-22	22-30	30-40	40-50	50-58	58-70	>70
Physiological sensations of heat - class	very cold	cold	very cool	chilly	warm	hot	little humidity	humid	very humid
Weather type		cold		pleasant			overheated		

Source: Burić, Ivanović, Mitrović, 2007

Table 2. Annual flow of air temperature, water vapor pressure and equivalent temperatures on Zlatibor (1991-2020).

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	year
t (°C)	-1,7	-0,6	2,9	7,8	12,4	16,2	18,1	18,3	13,4	9,1	4,3	-0,9	8,3
e (hPa)	4,7	4,8	5,6	7,2	10,2	13,4	14,4	14,2	11,4	9,1	6,8	5,1	8,9
Et (°C)	7,7	9,0	14,1	22,2	32,8	43,0	46,9	46,7	36,2	27,3	17,9	9,3	26,1

Source: The data in the table are result of the authors calculations based on data from the RHMS

rainfall, which is characteristic of this region, is mostly excreted in the mountains, about 1000 mm on average (Pavlović, 2019).

The geographical position enabled the climate of Zlatibor to be characterized by lower temperatures, higher ventilation and sunshine, lower air pressure and drier air, which has a refreshing and invigorating effect on the human body (Ršumović, Milojević, Lazarević, 1991).

Based on the analysis of equivalent temperatures, it was determined that the cold weather type (5°C<Et<22°C) occurs from November to March. The only physiological sensation of heat that is blunted in this weather type is “cold” (5-18°C). The classes “very cool” (18-22°C) and “very cold” (<5°C) are not present, which is a favorable circumstance for tourism, especially when it comes to the class “very cold”. The minimum value of equivalent temperature is recorded in January and is 7.7°C. Pleasant weather type (22°C<Et<50°C) occurs from April to October and is represented by all three classes. The “chilly” class (22-30°C) occurs in April and October. The “warm” class (30-40°C) is present in May and September. The physiological feeling of warmth “hot” (40-50°C) coincides with the summer months - June, July, August. The highest value of equivalent temperature is July - 46.9°C. Overheated weather type (50°C<Et<70°C) is not represented by any class, which is a feature and advantage of the mountain climate,

especially in the summer months when people seek escape from overheated urban centers. The average annual equivalent temperature for Zlatibor is 26.1°C and belongs to a pleasant weather type, ie a physiological feeling of “chilly” (22-30°C), which could be expected at this altitude (Figure 2).

Zlatibor belongs to the mountains of medium height, based on that we can assume that the summer season is more pronounced than the winter season. This assumption is confirmed by the recorded number of tourist arrivals from 2016 to 2020 by the Statistical Office of the Republic of Serbia (Table 3). The number of tourist arrivals by season was calculated as the sum of three-month values. The winter season includes the months of January, February and December of the previous year. The spring season includes the period from March to May, the summer season includes June, July and August, and the autumn season the remaining three months - September, October and November. There is an irregularity in the spring season of 2020, during which a curfew was introduced in Serbia due to the corona virus pandemic. Due to this irregularity in the five-year total, the spring season is the least visited, but looking at the trend of tourist arrivals during this season from 2016 to 2019, if the movement of people had not been restricted from March to May 2020, the spring season would have been in second place in terms of attendance.

If we compare all seasons, we will see that the differences in attendance are not drastic. We can look for answers in seasonal values of equivalent temperatures (Table 4). The winter season belongs to the cold weather type, while all three other seasons belong to the pleasant weather type. The physiological feeling of heat “cold” (5-18°C) is present during the

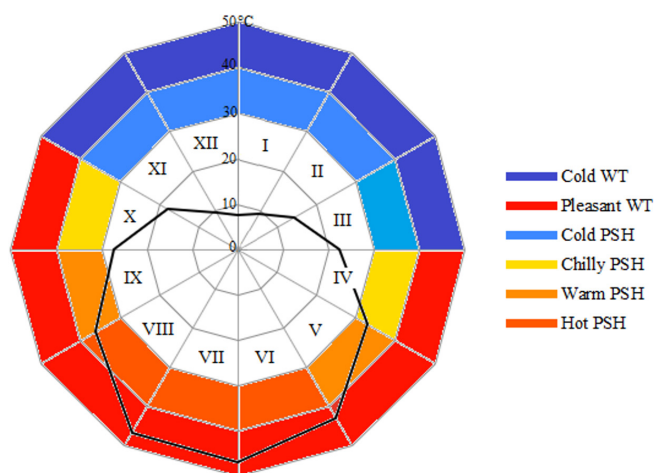


Figure 2. Classification of weather types (WT) and physiological sensations of heat (PSH) according to the equivalent temperatures index on Zlatibor for the period 1991-2020.

Table 3. Number of tourists at Zlatibor by season (2016-2020).

	winter (DJF)	spring (MAM)	summer (JJA)	autumn (SON)
2016	40452	45858	52037	38760
2017	45528	48092	55619	44298
2018	48033	55537	62192	51204
2019	49851	61885	64931	58354
2020	61041	11174	54383	37916
Σ	244905	222546	289162	230532

Source: The data in the table are the result of the author's calculations based on data from the SORS

Table 4. Value of equivalent temperature on Zlatibor by seasons (1991-2020).

	winter (DJF)	spring (MAM)	summer (JJA)	autumn (SON)
Et (°C)	8.7	23	45.5	27.1

Source: The data in the table are the result of the author's calculations based on data from the RHMS

winter season and provides optimal conditions for practicing winter sports. The spring and autumn seasons belong to the “chilly” class (22-30°C), and the summer season to the “hot” class (40-50°C). Seasonal values of equivalent temperatures on Zlatibor are favorable for tourist movements during all seasons and provide the opportunity to engage in various activities.

Błażejczyk A. with associates (2021) examined the suitability of weather conditions for different forms of outdoor tourism in Serbia, Poland and Ukraine. One of the meteorological stations from which the values of climatic elements were used was Zlatibor. It was found that only January and December are not suitable for sunbathing on Zlatibor. Very suitable periods for sunbathing are during spring and autumn. The period suitable for air bathing lasts all year round. For mild physical activity, the most optimal period is from November to February, while for active recreation, the most favorable conditions are from October to April. For skiing tourism is only suitable the winter season, which can be extended to the month of March.

Urban centers are the biggest generators of tourist demand. The largest number of annual vacations is realized during the summer season. According to the research of equivalent temperatures in Kragujevac (Milentijević et al., 2018) and Niš (Martić Bursać, Stričević, Gocić, 2021) during June, July and August in these cities there is an overheated weather type with the “little humidity” class (50-58°C). In the summer months, people look for vacation destinations where the climate conditions are more pleasant than those prevailing in their places of permanent residence. More favorable climatic conditions during the summer in our country are offered precisely by mountain tourist centers, among which Zlatibor stands out with its offer.

Comparing human heat load (HL) and the Universal Thermal Climate Index (UTCI) during July in Belgrade and Zlatibor for the period from 2000 to 2010 confirmed that during July Zlatibor offers much more favorable conditions for recreation than Belgrade. The degrees of comfort that dominate the heat load in Belgrade are “extremely hot” and “hot”, while the degree of comfort “warm” prevails in Zlatibor. Regarding the Universal Thermal Bioclimatic Index, “strong

heat stress” and “moderate heat stress” are the most prevalent in Belgrade, and “moderate heat stress” in Zlatibor with a significant number of “no thermal stress” days (Pecelj et al., 2017). A comparative analysis of the Universal Thermal Index during July, August and September for the period from 1998 to 2017 in Nis, Novi Sad and Zlatibor again showed that the mountain has the most pleasant bioclimatic conditions. In Niš during these three months, when heat waves occur in Serbia, the categories “strong heat stress” and somewhat less often “very strong heat stress” dominate. Novi Sad has slightly more favorable values of the Universal Thermal Index, which belong to the class of “moderate heat stress”, while in Zlatibor, for the entire observed period, the most represented class is “no thermal stress” (Pecelj et al., 2020).

Well-visited tourist places in Serbia are also spas, however, according to Stevnović's (2019) analysis of the equivalent temperatures of the Vranjska spa, during the two summer months, July and August, the “overheated” weather type occurs, represented by the “little humidity” class (50-58°C), which from the aspect of tourism it is not favorable because this class also occurs in the cities that represent the emitting areas of the largest number of tourists. Also, an analysis of the Universal Thermal Index of the Vranjski region, to which the Vranjska spa belongs, for the period from 2000 to 2017 found that during July, August and September the class of “strong moderate stress” occurs, which is not the case in Zlatibor (Pecelj, Błażejczyk, Vagic, 2021).

In the geographical study of Zlatibor, Dr. Miso Lazarević states that one meteorological station located on a hill in the northern part of the Zlatibor plateau cannot truly represent the climate of the whole plateau, but that it is necessary to perform measurements at several locations that would give a more complete bioclimatic picture of Zlatibor as a recreational and the air-health center (Ršumović, Milojević, Lazarević, 1991).

The difficulty in bioclimatic research in our country is the lack of necessary data, ie the low density of meteorological stations where the values of climatic elements required for this type of research are recorded. Increasing the number of observation systems would create conditions for more detailed bioclimatic research. This problem could be overcome by installing automatic meteorological stations, as they already exist in the area of Novi Sad. Stations automatically measure values, sending data to the main server every ten minutes, creating a database that can later be used for climate research (Šećerov et al., 2015).

5. Conclusion

Tourism on Zlatibor has a long tradition. The recreational and therapeutic influence of Zlatibor on the mental and physical health of man has long been determined by ordinary people based on their intuition and experience gained in contact with this mountain. Today, Zlatibor is developing as a modern tourist center with a high degree of comfort of catering facilities. In recent years, it has attracted more and more visitors and ranks first among our mountain centers in terms of the number of tourists and the number of their overnight stays.

The analysis of equivalent temperatures performed in the paper represents a small part of the bioclimatic picture of Zlatibor, but it speaks in favor of the favorable climatic characteristics of this vast plateau which has the status of an air spa. The cold weather type with the class "cold" appears in November, covers the winter months and continues to the first spring month. It is followed by a pleasant weather type that is dominant on Zlatibor. It occurs continuously from April to October and is represented by all three physiological sensations of heat. The "chilly" and "hot" classes include one spring and one autumn month, while the "warm" class is blunted during the summer. A special advantage of the climate for tourist movements is that the physiological sensations of heat "very cold", as well as overheated weather type are not present on this mountain.

The review of research on equivalent temperatures and other bioclimatic indices gives preference to the climatic characteristics of Zlatibor in the function of outdoor tourism compared to other places for which analysis of the same indices were made. More favorable climatic conditions stand out in the summer months, which explains the highest attendance in the summer season. Despite the low altitude and higher mountains in the surroundings, which offer better natural conditions for outdoor winter sports, Zlatibor has managed to establish itself as a winter sports and recreation center that attracts a significant number of tourists in the winter part of the year. In addition to the favorable climatic characteristics, this is also due to the construction of modern ski infrastructure and other accompanying tourist facilities. The natural and anthropogenic tourist values of Zlatibor are well visited in the spring and autumn seasons when this mountain center offers many different tourist contents for rest and recreation.

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