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Bioclimatic and climatic tourism conditions at Zlatibor Mountain (Western Serbia)

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Abstract— This study presents the climatic and bioclimatic conditions at Zlatibor, as well as their modification and distribution over the year. Zlatibor Mountain is a popular tourist destination in Serbia, and it stands out as a mountain of exquisite natural and anthropogenic values. Information about climate and bioclimate is presented by using physiologically equivalent temperature (*PET*), and universal thermal climate index (*UTCI*) over 10-day periods. The Climate-Tourism/Transfer-Information-Scheme (*CTIS*) was also used as it displays climate and bioclimate information for tourism purposes based on thresholds of relevant parameters and the frequency of occurrence. The weather suitability index (*WSI*) was calculated as well, because it provides synthetic information about suitability of weather for different forms of recreational and tourism activities. The results obtained in this study were used to develop a bioclimatological leaflet for Zlatibor, which could be very useful to the tourism industry and stakeholders in decision-making, but also it will enable tourist to choose the best time for holiday depending on personal preferences and requirements.

Key-words: bioclimate, *PET*, *UTCI*, *CTIS*, climatological leaflet, Zlatibor, Serbia

1. Introduction

The environmental resources that are the foundation for tourism/recreation are influenced by weather and climate which also affect the length and quality of tourism and recreation seasons, the health of tourists, and even the quality of tourism experiences (Scott *et al.*, 2004; Katerusha and Matzarakis, 2015; Stojšavljević *et al.*, 2016). Information about climate that is provided to tourists and tourism industry should include not only its general features (mean monthly and annual values of particular climate elements), but also detailed information about thermal comfort as well as aesthetic and physical weather factors (de Freitas, 2003). Several studies used bioclimate information and focused on diverse spatial and temporal distributions (Scott *et al.*, 2006; Scott and Lemieux, 2010; Matzarakis and Amelung, 2008), but also investigated the ways to incorporate them in tourism sector (Hall and Higham, 2005; Matzarakis, 2006; Matzarakis and de Freitas, 2001; Matzarakis *et al.*, 2007a; Amelung *et al.*, 2007; Gössling and Hall, 2006; Gössling *et al.*, 2010; Jopp *et al.*, 2010).

During the last three decades, various climate indices for tourism were developed. The widely known and applied is the tourism climate index (TCI) (Mieczkowski, 1985), which combines seven meteorological parameters but without taking human energy balance into account. From a human-biometeorological point of view, it is necessary to assess the thermo-physiology of human organisms, and consequently their comfort and discomfort, because they are important factors for tourists and their satisfaction during vacations (Matzarakis, 2006). Physiologically equivalent temperature (PET) is found to be a very useful bioclimatic index for tourism purposes. PET uses degree Celsius as a unit, which makes it a good indicator of thermal stress. It also evaluates the thermal conditions in a human physiological manner (Mayer and Höppe, 1987; Matzarakis *et al.*, 1999; Höppe, 1999). Another advantage of PET is that it can be applied in different climates and all year round (Matzarakis *et al.*, 2007b; Lin and Matzarakis, 2008; Zaninović and Matzarakis, 2007; Gulyás and Matzarakis, 2009; Çalışkan *et al.*, 2011).

PET was used to estimate bioclimatic conditions in different places around the world (e.g., Gulyas *et al.*, 2006; Kovács *et al.*, 2017; Thorsson *et al.*, 2007; Grigorieva and Matzarakis, 2011). Additionally, PET was used to evaluate bioclimatological potential for tourism and recreation in various destinations in different climate zones (e.g., Matzarakis *et al.*, 2013; Katerusha and Matzarakis, 2015; Çalışkan *et al.*, 2011; Brosy *et al.*, 2014; Zaninović and Matzarakis, 2009). The first results of biometeorological parameters in Serbia (Vojvodina, northern part of Serbia) were given by Basarin, *et al.*, (2014). Respective authors presented a detailed analysis of climate and weather conditions for tourism purposes (for two special nature reserves “Gornje Podunavlje” near

Sombor and “Carska bara” near Zrenjanin), including important parameters such as *PET* and tourism climate index (*TCI*). The latest study based on *PET* analysis in Serbia is published by *Stojićević et al.*, (2016), which conducted a detailed bioclimate analysis of Banja Koviljača (Serbia) using *PET* index.

Together, with *PET*, Universal thermal climate index (*UTCI*) (*Jendritzky et al.*, 2012) is being used for the assessment of the physiological thermal response of the human body to climatic conditions (*Blazejczyk et al.*, 2012). *UTCI* has been applied in order to determine bioclimatic conditions in cities (e.g., *Idzikowska*, 2010; *Lindner*, 2011), but also to observe the modification of thermal conditions due to the relief features (*Kunert*, 2010). These results are very important for planning different recreational activities, especially at mountain tourism destinations.

The Climate-Tourism/Transfer-Information-Scheme (*CTIS*) (*Matzarakis*, 2007; *Lin and Matzarakis*, 2008; *Zaninović and Matzarakis*, 2009; *Matzarakis*, 2014) is a recent development in tourism climatology. It displays climate and bioclimate information for tourism purposes based on thresholds of relevant parameters and their frequency of occurrence. Furthermore, it can be adapted to different types of touristic activities. According to *de Freitas* (2003), the three facets of tourism are thermal, physical, and aesthetic, which are combined in *CTIS*. The temporal resolution of *CTIS* is 10 days (*Lin and Matzarakis*, 2008). Another index that gives supplementary information about weather suitability for different tourism activities is the weather suitability index (*WSI*) (*Blazejczyk and Matzarakis*, 2008). The *WSI* provides information about usefulness of weather for different forms of recreational and tourism activities: passive (sun and air bathing) and active (mild and intensive) (*Blazejczyk and Matzarakis*, 2008).

Zaninović and Matzarakis (2009) developed a climate leaflet containing climatological and bioclimatological information for tourists. This scheme is valuable for tourists, because it enables them to choose the most suitable time period for holidays depending on personal preferences and requirements. Climate pamphlet is also useful to stakeholders and decision-makers (*Zaninović and Matzarakis*, 2009). It includes thermal indices, but also climate facets such as thermal, aesthetical, and physical (*Matzarakis*, 2006), which represent a combination of important factors using mean values and extreme conditions (*Lin and Matzarakis*, 2008; *Matzarakis*, 2010).

The bioclimatic analysis in this study concerns Zlatibor Mountain, a popular tourist destination in Western Serbia. Zlatibor Mountain stands out as a mountain of exquisite natural and anthropogenic values, and as such, it is significant for the development of tourism (*Jovanović et al.*, 2015). The tourism started to develop at the end of the 19th century and in the beginning of the 20th century, with the substantial increase of tourists since then (*Dragović et al.*, 2009). The climate of the investigated area is typical subalpine, with more than 2000 hours of sunshine per year, which makes it one of the most desirable

tourist destinations in Serbia. It is characterized by relatively warm summers and mild winters with abundant snow cover (*Dragović et al., 2009; Stojsavljević et al., 2016*).

2. Material and methods

2.1. Study area

Zlatibor Mountain is located in Western Serbia. It spreads between 17° 14' and 17° 28' E and 43° 36' and 43° 48' N. It covers greater parts of the widespread plateau of Starovlaška (*Fig. 1*). The average elevation of Zlatibor is 1000 m. Zlatibor Mountain is often called the “Serbian capital of mountain tourism”. The touristic center of Zlatibor is in its central part at an average elevation of 1000 m, and is surrounded by peaks Tornik (1496 m), Čigota (1422 m), and a number of lower ones. Number of tourists during both the summer and winter season, is quite high (*Dragović et al., 2009; Stojsavljević et al., 2016*). Tornik ski resort is located at an elevation of between 1110 – 1490 m, 9 km from the tourist resort of Zlatibor. The total capacity of the ski area is about 5400 skiers per hour. Four runs, Čigota, Tornik, Ribnica, and Zmajevac are covered by an artificial snowing system, so this ski resort no longer depends on snowy weather conditions.

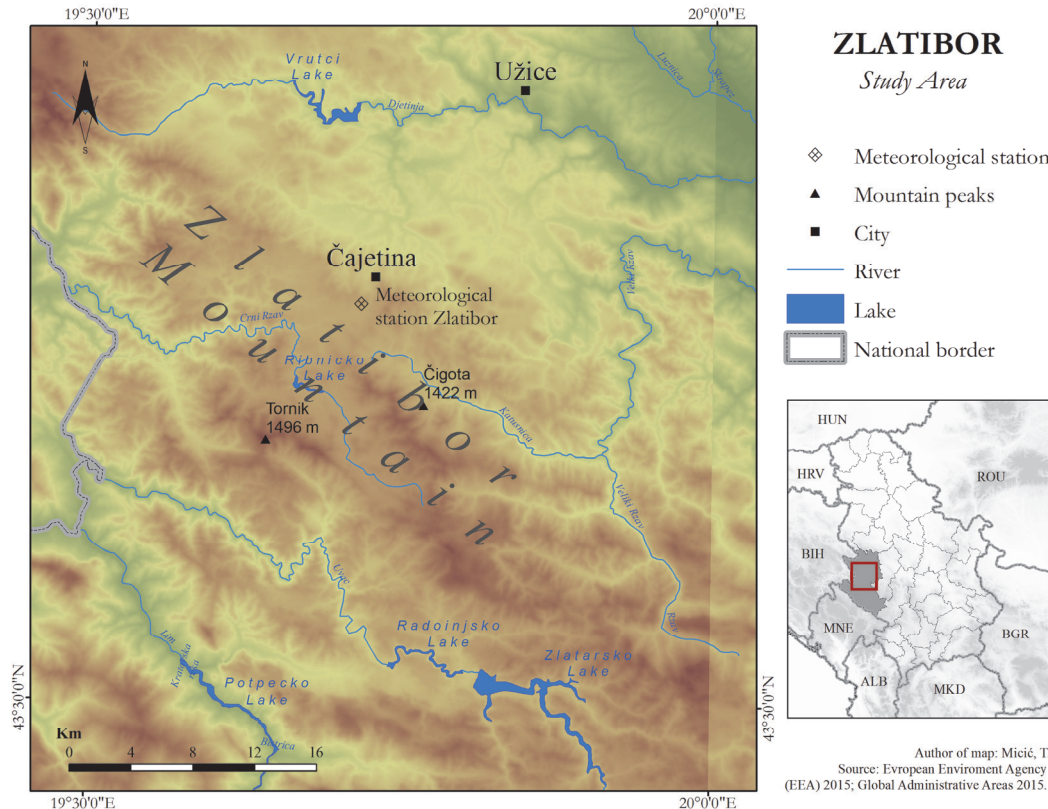


Fig. 1. Physical map of Serbia with the investigated area.

2.2. Data and methods

The climatic and bioclimatic conditions of Zlatibor have been analyzed by using daily data from the Zlatibor meteorological station (43°44'N, 19°43'E, and elevation of 1028 m) during the period between 1992 and 2013. This data is recorded and provided by the Hydrometeorological Service of Serbia in accordance with standards recommended by the World Meteorological Organization (WMO).

Before the calculation of bioclimatological indices, the homogeneity of the meteorological datasets was examined according to the *Alexandersson* (1986) test. The homogeneity analysis indicated that the data for the observed station is homogeneous. There are several methods based on the human energy balance that have been used for the calculation of thermal comfort for tourism (*Matzarkis*, 2006). Commonly used indices that measure the effect of the thermal environment on humans are *PMV* (predicted mean vote) (*Fanger*, 1972), *PET* (physiologically equivalent temperature) (*Mayer and Höppe*, 1987; *Höppe*, 1999; *Matzarakis et al.*, 1999), *SET* (standard effective temperature) (*Gagge et al.*, 1986), *PT* (perceived temperature) (*Staiger et al.*, 2012), and *UTCI* (universal thermal climate index) (*Jendritzky et al.*, 2012). These thermal indices require input from the same meteorological variables (air temperature, air humidity, vapor pressure, wind speed, short- and long-wave radiation fluxes), but having a detailed thermophysiological basis. *PET* and *UTCI* are seen as preferable to other thermal indices because of their units (°C), which make results more comprehensive (*Matzarakis et al.*, 1999).

The *PET* values represent several meteorological parameters that influence the human energy balance such as air temperature, air humidity, wind speed, and short- and long-wave radiation. The calculation of *PET* also considers the heat transfer resistance of clothing and internal heat production (*Matzarakis et al.*, 1999; *Lin and Matzarakis*, 2008; *Zaninović and Matzarakis*, 2009). The RayMan model was used to calculate *PET* (*Matzarakis et al.*, 2007b, 2010; *Matzarakis and Endler*, 2010). The threshold values for *PET* have been developed in the form of a graded index (*Matzarakis and Mayer*, 1996) (*Table 1*). The *PET* (°C) is based on a complete heat budget model of the human body (*Höppe*, 1999), and it provides the equivalent temperature of isothermal reference environment with a water vapor pressure of 12 hPa (50% at 20 °C) and less air (0.1 m/s), at which the heat balance of a reference person is maintained with core and skin temperature equal to those under the conditions being assessed (*Höppe*, 1999). The variables needed and used for calculation include air temperature (*T_a*), vapour pressure (*VP*), wind velocity (*v*), and mean radiant temperature (*T_{mrt}*). Activity, clothing insulation, height, and weight that are usually standardized in Munich Energy Balance Model for Individuals (*MEMI*) represent human parameters that have a great influence on *PET* values (*Matzarakis et al.*, 2011). A typical indoor setting, for the reference person, is selected with work

metabolism of 80 W added to basic metabolism and with clothing insulation of 0.9 clo (Matzarakis *et al.*, 1999; 2007b; Matzarakis and Ender, 2010). The *PET* values are calculated based on meteorological parameters measured at 7.00 a.m., 2.00 p.m., and 9.00 p.m.

UTCI is defined as the ambient temperature corresponding to a reference environment that provides the same physiological response of a reference person as the actual environment (Bröde *et al.*, 2012). The calculation is based on a multi-node model of human thermoregulation (Fiala *et al.*, 2001), associated with a clothing model. The meteorological reference frame consists of the mean radiant temperature that is equal to the ambient temperature and the wind speed observed at 10 m above ground set at 0.5 m/s. The reference humidity is set at 50% for ambient temperatures of the reference ≤ 29 °C and at 20 hPa above. The non-meteorological reference is set at a metabolic rate of 135 W/m² and a walking speed of 1.1 m/s. Additionally, by adjusting static clothing insulation to the ambient temperature reflecting seasonal clothing adaptation habits of Europeans, human perception of the outdoor climate is depicted (Havenith *et al.*, 2012). The *UTCI* assessment scale is presented in Table 2. It is worth mentioning, that while the *PET* scale represents thermal sensations of thermal environment experienced by specific population, the *UTCI* scale was made to represent heat/cold stress intensities regardless the population type. The *UTCI* scale can be applied to a very wide range of temperatures, from -70 to $+50$ °C (Bleta *et al.*, 2014). For the calculations of *UTCI*, the RayMan model was used.

Table 1. Physiological equivalent temperature (*PET*) for different grades of thermal sensation and physiological stress on human beings (Matzarakis *et al.*, 1999)

<i>PET</i> (°C)	Thermal sensation	Physiological stress level
<4	Very cold	Extreme cold stress
4–8	Cold	Strong cold stress
8–13	Cool	Moderate cold stress
13–18	Slightly cool	Slight cold stress
18–23	Comfortable	No thermal stress
23–29	Slightly warm	Slight heat stress
29–35	Warm	Moderate heat stress
35–41	Hot	Strong heat stress
>41	Very hot	Extreme heat stress

Table 2. UTCI assessment scale: UTCI is categorized in terms of thermal stress (Bröde et al., 2012)

UTCI (°C)	Physiological stress level
< -40	Extreme cold stress
(-40) – (-27)	Very strong cold stress
(-27) – (-13)	Strong cold stress
(-13) – 0	Moderate cold stress
0 – 9	Slight cold stress
9 – 26	No thermal stress
26 – 32	Moderate heat stress
32 – 38	Strong heat stress
38 – 46	Very strong heat stress
> 46	Extreme heat stress

The bioclimatic conditions, *PET* and *UTCI* values are analyzed by means of the annual course of the 10-day mean values of thermal sensation at 7.00 a.m., 2.00 p.m., and 9.00 p.m. during the year. The likelihood of occurrence of mean daily thermal sensation during the year is also included together with the likelihood of occurrences in the morning, afternoon, and evening. This presents a more complete picture of the bioclimatic conditions, and enables everyone to choose the most convenient period for a holiday, considering their personal preferences. The presentation using the temporal resolution of 10 days is very appropriate for tourism, as holidays usually last a week or two, rather than a whole month (Zaninović and Matzarakis, 2009).

All of the above mentioned parameters are calculated for Zlatibor Mountain, in order to present the climate and bioclimate information to tourists. Furthermore, the results could be presented in a form of bioclimatological leaflet (Zaninović and Matzarakis, 2009). It is imagined to contain the annual cycle of meteorological variables that are important for tourism and recreation based on 10-day periods (Zaninović, 2001; Lin and Matzarakis, 2008). Parameters that affect tourism on thermal (air temperature, thermal perception), physical (precipitation, snow, wind), and aesthetic dimensions (daylight and clouds) were treated together and were evaluated in a 10-day time resolution (de Freitas, 1990; de Freitas and Matzarakis, 2005). Additionally, annual distribution of mean, mean minimum, and mean maximum temperatures, as well as the number of days with different temperature threshold, representing ice days ($T_{max} < 0$ °C),

frost days ($T_{min} < 0\text{ }^{\circ}\text{C}$), warm days ($T_{max} \geq 25\text{ }^{\circ}\text{C}$), tropical days ($T_{max} \geq 30\text{ }^{\circ}\text{C}$) were presented. Cloudiness and the number of clear and overcast days, as well as number of foggy days are included in the aesthetic part of the analysis. Physical factors incorporate the number of days with precipitation, rain, and snow cover. In addition to climatological and bioclimatological parameters, *CTIS* (Matzarakis, 2007a, 2007b; Lin and Matzarakis, 2008; Zaninović and Matzarakis, 2009; Matzarakis, 2014) and *WSI* were used for more successful representation of tourism and recreational conditions in the investigated area (Zaninović and Matzarakis, 2009; Blazejczyk and Matzarakis, 2008).

CTIS is very useful in providing information on the frequency of various features of weather in consecutive 10-day periods of the year. Thus, *CTIS* makes the analysis which weather properties would be useful for specific tourism activity very easy. The *CTIS* diagram includes thermal, aesthetic, and physical components of weather as follows:

- Thermal comfort ($18.0\text{ }^{\circ}\text{C} < PET < 29.0\text{ }^{\circ}\text{C}$);
- Cold stress ($PET < 0.0\text{ }^{\circ}\text{C}$);
- Heat stress ($PET > 35.0\text{ }^{\circ}\text{C}$);
- Sultriness ($VP > 18.0\text{ hPa}$);
- Sunshine days (cloud cover < 4 octas);
- Dry conditions, dry day (precipitation (RR) ≤ 1 mm per day);
- Wet conditions, rainy day ($RR > 5$ mm per day);
- Foggy days (relative humidity (RH) $> 93\%$);
- Windy days ($v > 8$ m/s);
- Skiing potential (snow cover > 10 and 30 cm).

For parameters 1, 2, 5, 6, 7, 9, greater probability means less favorable conditions, while for parameters 3, 4, 8, greater probabilities indicates more favorable conditions.

Additionally, *WSI* provides synthetic information about the suitability of weather for different forms of recreational and tourism activities: passive (sun and air bathing) and active (mild and intensive) (Blazejczyk, 2007a; 2007b). *WSI* describes weather conditions using seven digits: thermal sensations (due to Subjective temperature – *STI*), radiation stimuli (due to absorbed portion of radiation), physiological strain (due to the physiological strain index – *PhS*), sultriness (due to the heat stress index – *HSI*), daily thermal contrast (due to the temperature amplitude), rain (snow) fall (> 1 mm), and snow cover (> 10 cm) (Blazejczyk, 2007a; 2007b).

Every weather condition was assigned a specific code based on particular forms of recreation: sun baths (*SB*), air baths (*AB*), mild recreational activity (e.g., walking, light plays, shopping – *MR*), intensive recreation and summer tourism (e.g., football, biking, climbing, jogging, etc. – *AR*), and ski tourism (*ST*). Every weather condition was estimated using *WSI* as follows: 0 – unfavorable, 1 – favorable with limitations, 3 – favorable without limitations (*Blazejczyk and Matzarakis, 2008*). Calculation of all of the above mentioned parameters is adopted from the approach given by *Basarin et al. (2014)*.

3. Results

3.1. Air temperature (*T_a*), humidity (*RH*), vapor pressure (*VP*), precipitation (*RR*), snow, and wind (*v*)

The frequency distribution of air temperature (*T_a*) for the period from 1992 until 2013 is shown in *Fig. 2*.

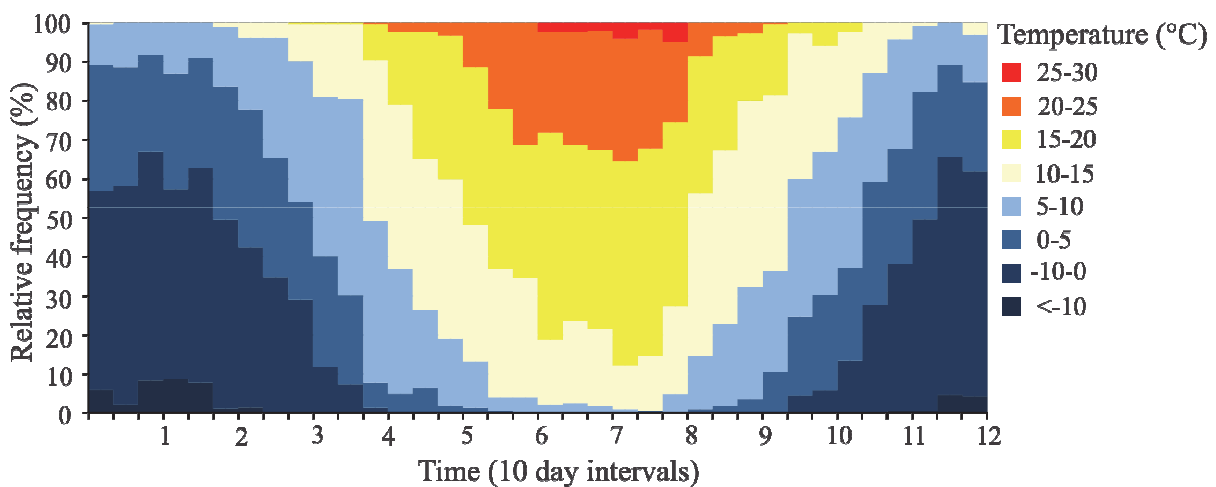


Fig. 2. Relative frequency diagrams of mean daily air temperature for Zlatibor for the period from 1992 to 2013.

Hottest days occur during the summer months with up to 5% of values ranging from 25–30 °C in July and August. The highest percentage was observed in the third period of August. Coldest days can be observed from the second ten-day period in October until the beginning of April. In December and January, more than 50% of days display temperatures ranging between –10.0 and 0.0 °C. Days <–10 °C are rare and show the highest amount (8%) in the third ten-day period in January and February.

Air temperature is also analyzed by means of the annual course of the 10-day mean values measured at 7.00 a.m., 2.00 p.m., and 9.00 p.m. during the year (Fig. 3). The mornings and late afternoons are very cold ((-5)–0 °C) from November until the end of February. From the second ten-day period in April until the third ten-day period in August, mornings and late afternoons are pleasant with temperatures ranging from 10 to 20 °C. During noon in summer months, temperatures could be very high with average values ranging between 20–25 °C.

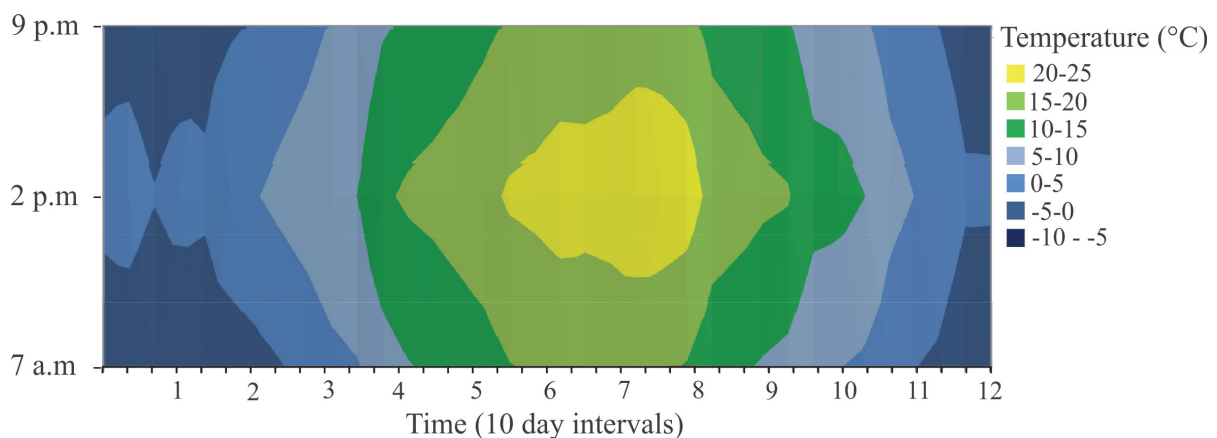


Fig. 3. Annual course of 10-day mean air temperatures at 7 a.m., 2 p.m., and 9 p.m. in Zlatibor for the period from 1992 to 2013.

The same kind of frequency diagram was produced for *RH* and *VP* (Figs. 4 and 5). Values of *RH* show a high variability with atypical annual cycle. More than 50% of the values in the range between 85 and 95 and above 95% *RH* or even higher are observed during the winter months, December, January, and February. During the same period *RH* between 65% and 85% take up approximately 50% of values. In the summer months, values of *RH* between 45% and 75% occur in approximately 50% of the cases. Values lower than 45% as well as values higher than 85% are rare and take up 10 to 15% of all the cases.

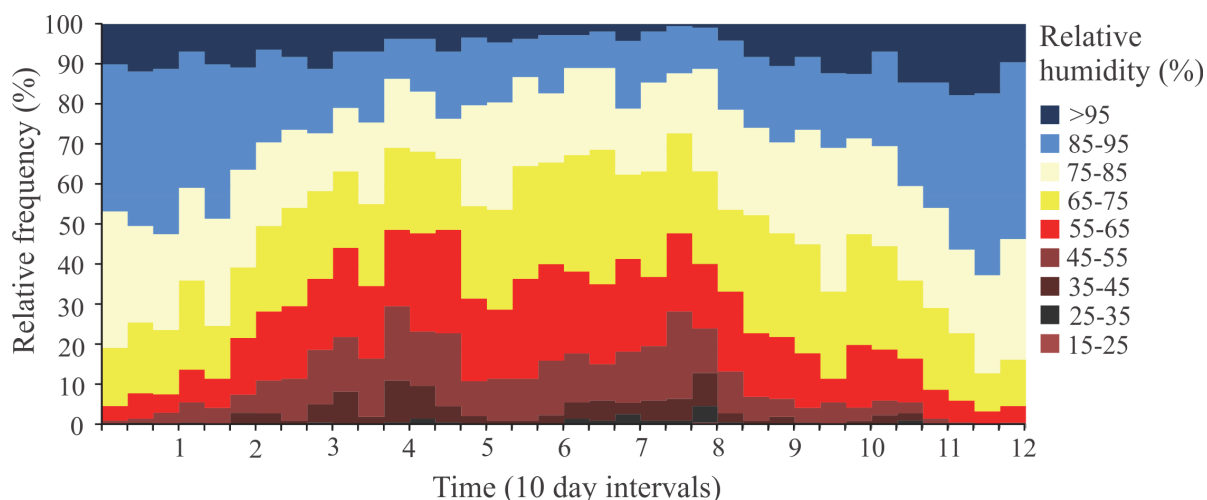


Fig. 4. Relative frequency diagram of relative humidity based on 10-day periods for mean daily values for Zlatibor for the period 1992–2013.

Fig. 5 shows the relative frequency diagram for *VP*. *VP* values equal or higher than 18 hPa, that characterize sultriness, occurs on the average from June until August. The highest amounts occur during July with approximately 10% of the cases. This number makes sultry events very rare at Zlatibor Mountain during the summer months.

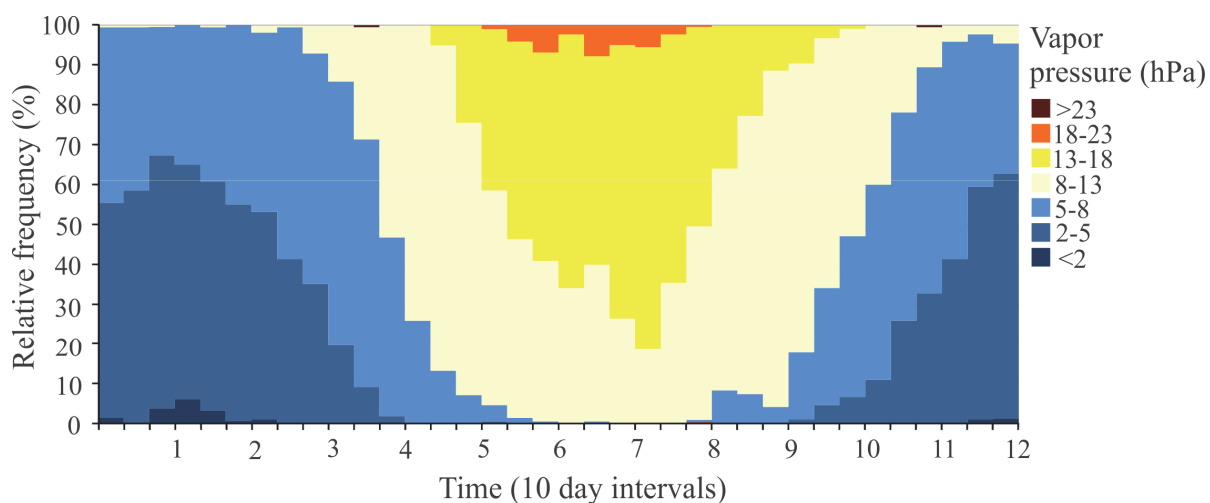


Fig. 5. Relative frequency diagram of vapor pressure based on 10-day periods for mean daily values for Zlatibor for period 1992–2013.

Average number of days with *RR* per year for Zlatibor during the investigated period was 178, days with no rain occur on average for 187 days, while the days with precipitation higher than 5 mm could be observed for 72 days. The frequency distribution of *RR* for Zlatibor was analyzed in order to characterize the rainy periods (*Fig. 6*). Rain events of low intensity (*RR* 0–1 mm) occur all over the year in approximately 5–15% of the cases. Heavy rainfalls also appear throughout the year, but it seems that they are concentrated during late spring and summer months, respectively. The class of most intensive rainfall (*RR* > 20.0 mm per day) was also recorded during the year, but in winter months at only 1–3% of the cases.

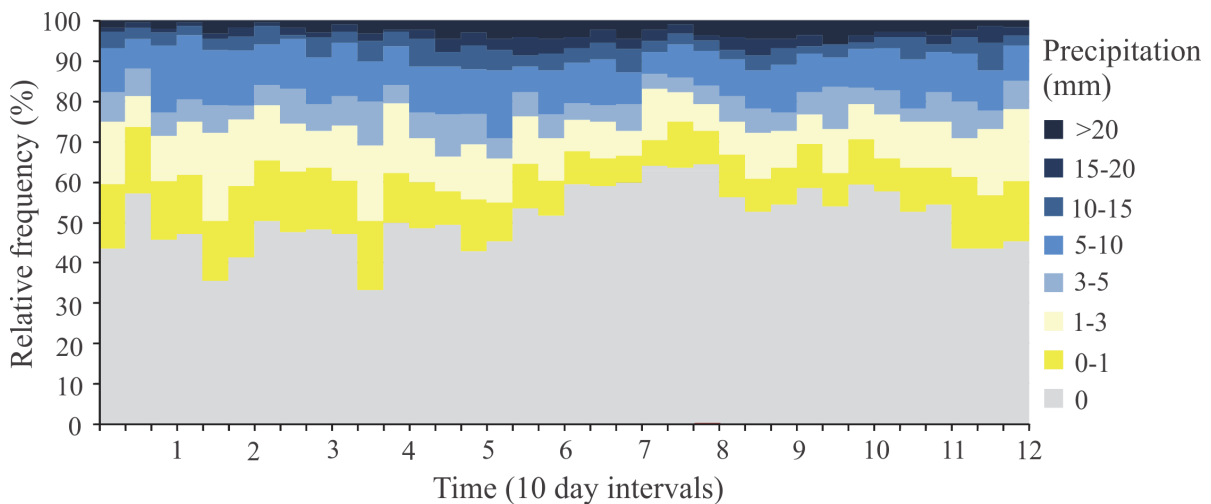


Fig. 6. Frequency diagram of precipitation classes for Zlatibor Mountain for the period 1992–2013.

A snow cover ≥ 1 cm can be expected at Zlatibor Mountain from the first half of October until the second half of April. Snowy winter lasts on average for more than five months (not with a continuous snow cover). *Fig. 7* depicts the annual course of the mean monthly number of days with snow cover of different depth classes (≥ 1 cm, ≥ 10 cm, ≥ 30 cm, and ≥ 50 cm). It can be seen that autumn months (September – November), as well as the first part of winter (December) experience a rarer appearance of snow than the second half of the snow season (January and February).

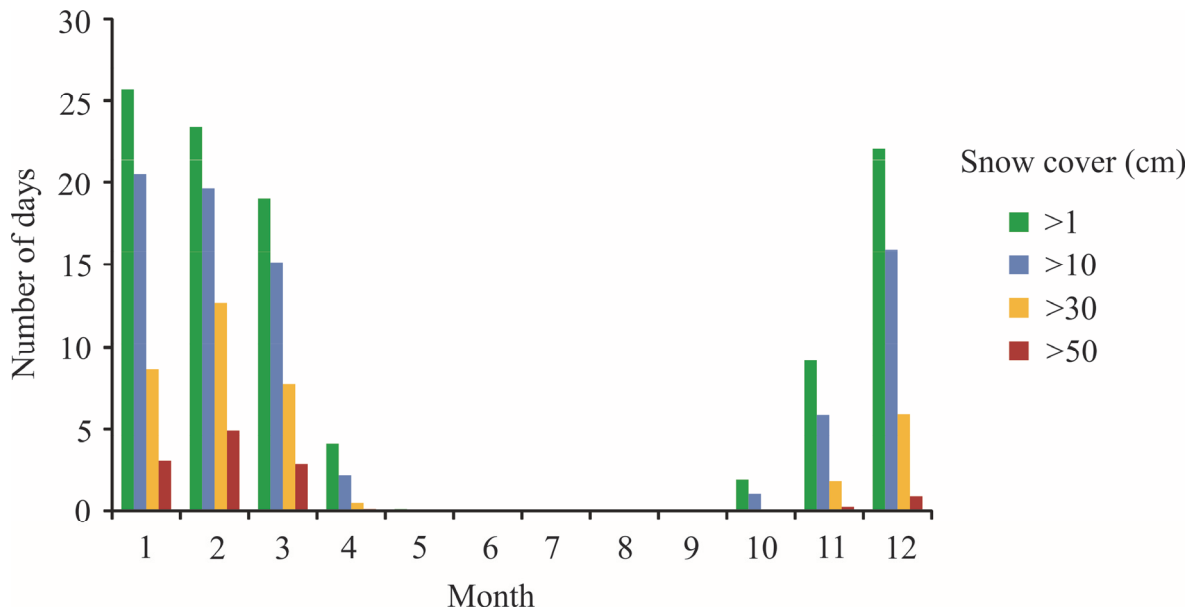


Fig. 7. Annual course of mean monthly number of days with snow cover of different depth classes for Zlatibor Mountain in the period between 1992 and 2013.

Wind direction distribution is visualized by the use of wind charts based on mean values measured daily at 7 a.m., 2 p.m., and 9 p.m. (Figs. 8a–c). The prevailing wind directions are SW for all values. During mid-day, the N direction becomes dominant. Wind speeds between 1 and 3 m/s could be observed in approximately 20% of the cases registered at 7 a.m. During noon, the prevailing winds are N and SW with speeds ranging between 0.5–1 m/s in 10% of the cases. In the evening, the dominant winds have speeds in the same range as the ones in the noon (0.5–1 m/s).

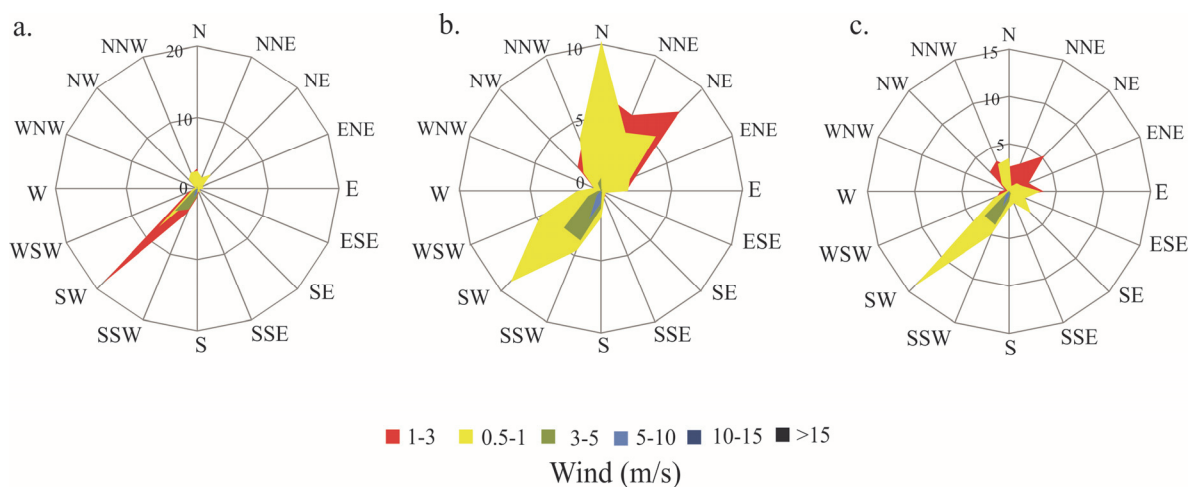


Fig. 8. Wind roses for Zlatibor Mountain based on daily values, for the period from 1992 to 2013 (excluding calms); a) values measured at 7 a.m. (calms=9.7%), b) values measured at 2 p.m. (calms=3.7%), and c) values measured at 9 p.m. (calms=11.9%).

3.2. Bioclimatological conditions

The different thermal sensations according to *PET* and *UTCI* values at 7 a.m., 2 p.m., and 9 p.m. in ten-day periods are shown in *Fig. 9*. An analysis of Zlatibor's 10-day mean *PET* values between 1992 and 2013 shows, that extreme cold stress may be experienced in morning and evening hours during the colder part of the year (from the end of October through the second ten-day period of March). The extreme cold stress is relatively less observed during afternoons. Better thermal comfort conditions are seen during spring and autumn. The second half of April, May, September, and the first half of October are characterized by *PET* values that seem to be comfortable mostly throughout the day. During summer, June, July, and August experience comfortable thermal conditions in the morning and in late afternoon. During noon in these months, a hot stress can be experienced (*Fig. 9a*). Similar thermal sensations concerning *UTCI* were observed (*Fig. 9b*). The extreme cold stress is observed during whole day in November, December, January, February, and even March. From the second ten-day period in April until July, and from the third ten-day period in August to the end of September, comfortable thermal conditions prevail throughout the day. The heat stress is only present during midday in July and August (*Fig. 9b*).

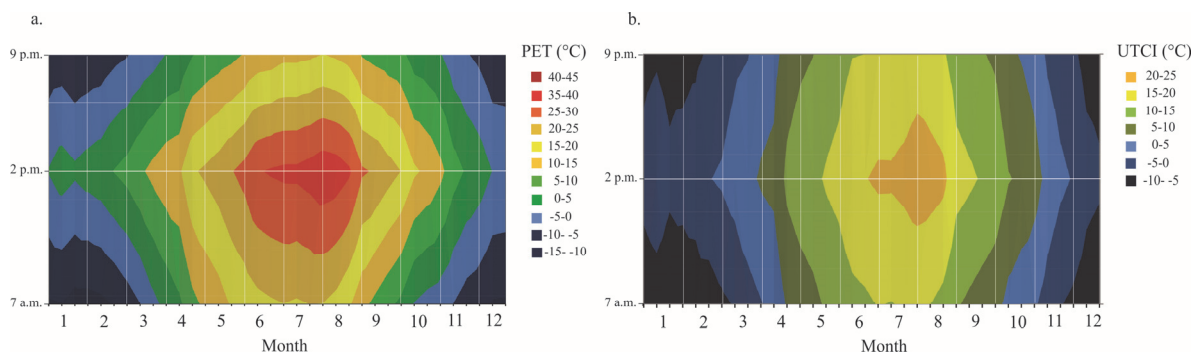


Fig. 9. Annual course of 10-day mean values of thermal sensation a) *PET* b) *UTCI* at 7 a.m., 2 p.m., and 9 p.m. at Zlatibor Mountain for the period 1992–2013.

Relative frequencies for *PET* values divided into 11 classes are presented in *Fig. 10a*. Special thermal conditions are presented by specific class for ten-day intervals at 2 p.m. throughout the year during the period 1992–2013. Similarly, the frequencies of *UTCI* are also shown for ten-day periods at 2 p.m. for the entire year during the investigated period (*Fig. 10b*). Thermal comfort occurs throughout the entire year according to both *PET* and *UTCI*. *PET* values

between 18 and 23 °C with highest probability (>25%) occur in the third ten-day period in April and May, as well as in the end of September and October. Comfortable thermal class of *UTCI* occurs mostly during spring and autumn months with the highest probability of more than 50%. *PET* classes that indicate cold stress (<0 °C) conditions can be observed from October to the end of March, with highest frequencies (~50%) from December until the end of January. During the same period, the *UTCI* values lower than 0 °C can be seen from September to May. The highest frequencies of extreme cold stress (>50%) are present from December until the end of February. Days with strong heat stress, defined as *PET* values >35 °C, can be observed from the third ten-day period in April until the end of September with maximum frequencies (~30%) during June until August. *UTCI* values >26 °C are recorded from the end of May until the end of September with the highest frequencies in the beginning of August (~20%).

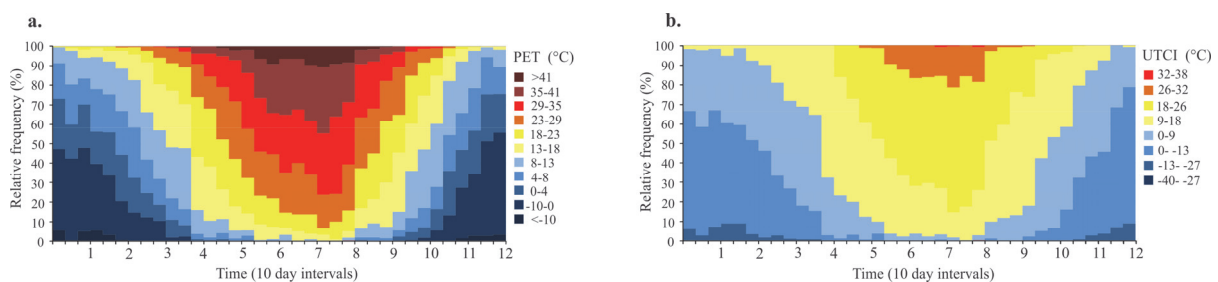


Fig. 10. The probability of occurrence of different thermal sensations a) *PET* and b) *UTCI* at 2 p.m. at Zlatibor Mountain for the period 1992–2013.

3.3. Climate-Tourism Information Scheme (CTIS) and Weather Suitability Index (WSI)

The annual courses of different parameters and factors that are described earlier are summarized clearly in the *CTIS* for Zlatibor Mountain (Fig. 11). Following the frequency of thermally unsuitable *PET* classes, the highest percentage of days with cold and heat stress is found in the monthly decades with a high proportion of cold or heat stress. Thus, the months with low percentage of these unfavorable *PET* classes are thermally favorable. The highest amount of thermally comfortable days is found in June, July, and August. When comparing the percentage of days with sunshine duration (>5h) to dry days, it can be seen that all over the year there are positive values. The lack of days with high wind speed contributes to the suitability of Zlatibor’s bioclimatological conditions

during summer months. Snow cover, which is an advantage in touristic terms, concentrates mostly at the end of December, during January, and February, which is recognized as the month with the highest occurrence of the days with snow cover higher than 10 cm.

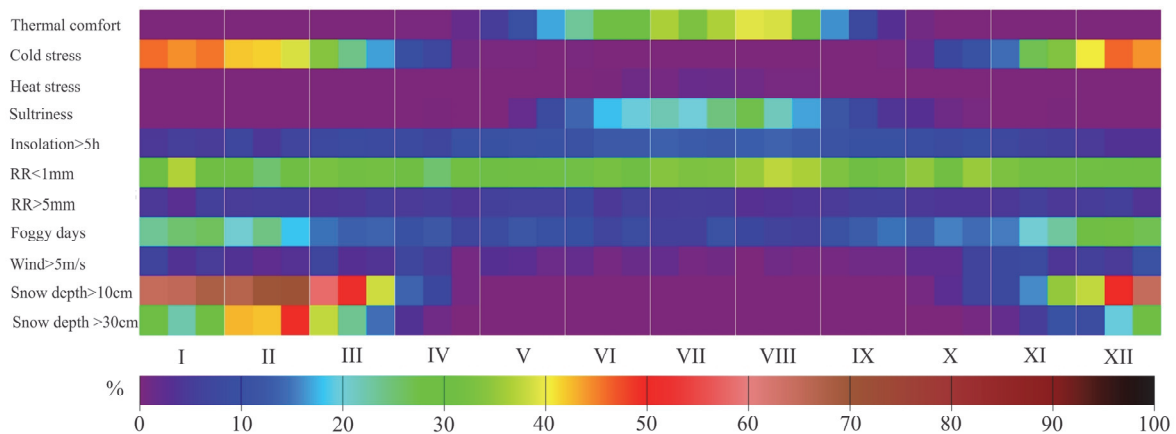


Fig. 11. CTIS for Zlatibor Mountain (frequency of occurrence in the period 1992–2013 in percent).

Weather suitability index (*WSI*) provides another important clue about bioclimatological conditions for tourists and recreationists. It is used to assess the usefulness of particular weather conditions for different forms of activity. Fig. 12 shows patterns in annual variability of *WSI*. It can be seen that the weather conditions most favorable for passive recreation (sun and air baths, *WSI_SB* and *WSI_AB*) occur during summer months. However, the conditions for mild recreational activity (e.g. walking, light plays, shopping – *WSI_MR*) are best during the warmer part of the year from the 150th day (end of May) until the 300th (end of October) of the year. On the other hand, intensive forms of active recreation (*WSI_AR*) can be practiced throughout the whole year. The weather conditions for ski tourism (*WSI_ST*) are favorable during winter due to the snow cover and snow cover duration. The ski season is prolonged using artificial snowing system installed at Tornik ski resort.

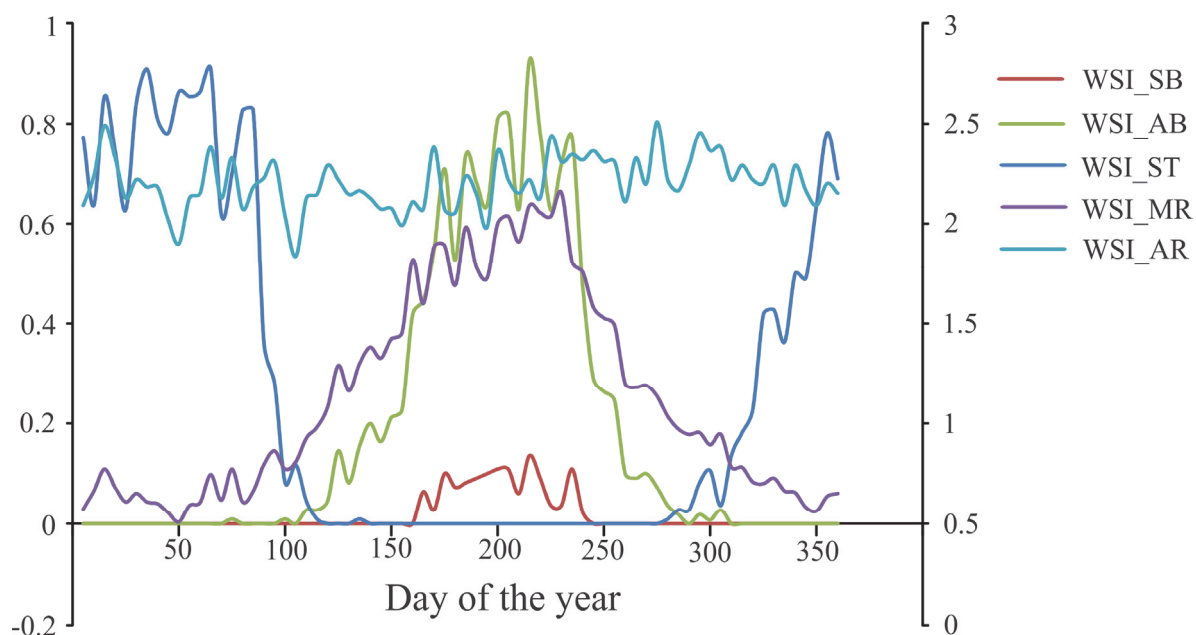


Fig. 12. Annual variations of weather suitability index for Zlatibor Mountain based on five-day intervals for the period between 1992 and 2013. The abbreviations are as follow: *WSI_SB* - sun baths (right y-axis), *WSI_AB* - air baths (right y-axis), *WSI_ST* - ski tourism (left y-axis), *WSI_MR* - mild recreational activity (left y-axis), *WSI_AR* - intensive recreation and summer tourism(left y-axis); index values refer to 0 – unfavorable, 1 – favorable with limitations, 3 – favorable without limitations.

4. Discussion

Results of the earlier studies showed that bioclimatological indices such as *PET* and *UTCI* reflect the thermal condition better than air temperature, relative humidity, and other individual meteorological elements.

This study assesses the bioclimate potential for tourism of one of the most important tourism destinations in Serbia. Recently, the leaflet as a mean of presenting the climate and bioclimate information for tourists was introduced (*Zaninović and Matzarakis, 2009*). Similarly, in this study a climatological and bioclimatological brochure was proposed as a “tool” that could help tourists to learn more about the climate of the destination and choose the best time to travel. It evaluates the aesthetic, physical, and thermal conditions for Zlatibor Mountain in order to reveal its potential for tourism and recreation.

The bioclimatic indexes such as *PET* and *UTCI* are more understandable for people, which use their experience in an indoor environment to assess the outdoor thermal condition. Furthermore, the *PET* and *UTCI* frequencies for 10-day intervals combined with the results of the analysis of aesthetic weather

components, as well as physical variables, display the likelihood of certain perceptions in detail for the whole year (Lin and Matzarakis, 2008).

Similarly to Bursa's (Çalışkan *et al.*, 2012) and Hvar's (Zaninović and Matzarakis, 2009) bioclimatological leaflet for Zlatibor mountain, in the left hand column, temperature conditions given in annual course of mean, mean minimum, and mean maximum values and annual course of relative humidity could be presented. Days with extreme temperature values suppose to be classified (hot days, tropical days, frost days, and tropical nights), and their annual distribution should be given in 10-day intervals. The components of aesthetic weather conditions such as cloudiness, insolation, as well as the number of clear and overcast days could be presented as well. Thermal parameters must be analyzed using *PET* and *UTCI* values in 10-day intervals. The number of days with precipitation (snow and rain) should also be included, as well as days with different classes of snow depth. In addition, the brochure can also include precise information about the mean wind speed and direction over the year for the investigated area. For tourists that are fond of different recreational activities during their holiday, *WSI* could be included in the leaflet.

Lin and Matzarakis (2008) showed that the number of tourists visiting the Sun Moon Lake in Taiwan is not significantly affected by climatic and bioclimatic factors. They argued that the most frequently visited periods are not the best time for visit, as tourists may suffer from cold stress or rainy periods. According to the Statistical Office of the Republic of Serbia, more than 106,000 people, mainly domestic tourists visited The Zlatibor Mountain. As shown by Stojsavljević *et al.* (2016), an increase in the number of tourists can be observed in the period 2001–2014. Using the monthly data about tourist visits for the period between 2000 and 2013 and the average monthly *PET* values for the same period, the correlation coefficient is 0.6, and it is statistically significant ($p < 0.05$) (Fig. 13). Comparing the mean monthly *UTCI* values, the Pearson correlation coefficient is even higher, it is 0.7 ($p < 0.05$). It could be seen that the highest number of tourists visit Zlatibor during May, June, August, and September, when the thermal comfort conditions occur on more than 30% of the cases for *PET* and more than 50% for *UTCI*, as the comfort range for *UTCI* scale is considerably higher.

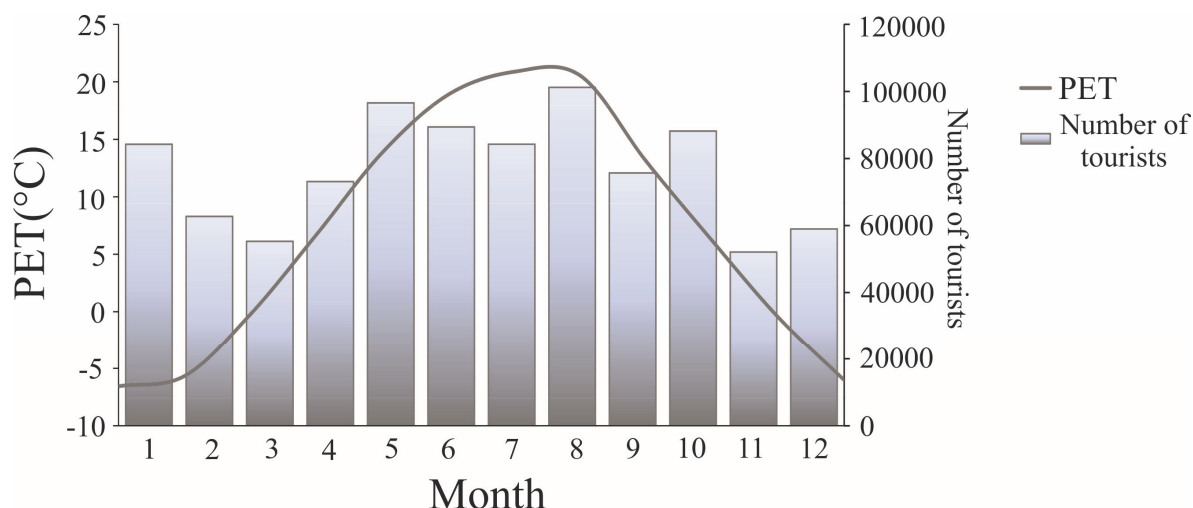


Fig. 13. Annual and seasonal number of tourists who visited Zlatibor during the period between 2000 and 2013.

5. Conclusion

The aim of this study was to analyze Zlatibor's climatic and bioclimatic conditions, as well as their variability and distribution over the year in order to provide substantial information for the tourism and tourism industry in general. The results were the basis for the creation of a bioclimate and tourism climate brochure, which is user-friendly and understandable by everyone. It is produced to be used as part of tourism promotions, and it is very important for the evaluation of various natural resources and alternatives. Since Zlatibor offers thermo physiologically comfortable conditions during spring and autumn, but also during morning and late afternoons in summer, the mountain resort is suitable for different health, recreation, and other tourism activities from May to September. The number of days with snow cover higher than 10 cm enhanced with artificial snowing system enables the continuous ski-season from December until April. One advantage of Zlatibor's climatology is that insolation during the day in summer is higher than 10 hours, which makes it one of the sunniest destinations in Serbia. Snowy winters, thermos-physiologically comfortable spring and autumn, as well as warm summers, provide favorable bioclimatological conditions, thus allowing year-round touristic activities. Monitoring of detailed bioclimate parameters and their variability on the local, regional, and national level can contribute to the creation of the suitable platform for the strategic planning and adaptation of tourist destinations in Serbia and neighboring countries as well.

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