

EVALUATION OF BIOCLIMATE CONDITIONS IN TWO SPECIAL NATURE RESERVES IN VOJVODINA (NORTHERN SERBIA)

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Abstract: For some tourism destinations, climate represents a natural resource on which the tourism industry is predicated. Data covering the period from 1949 to 2012 for two meteorological stations, Sombor and Zrenjanin was used to compute the Physiologically Equivalent Temperature (*PET*) and Tourism Climate Index (*TCI*) for two special nature reserves in Vojvodina, North Serbia, “Gornje Podunavlje” near Sombor and “Carska bara” near Zrenjanin. Information on thermal comfort/stress conditions as well as aesthetical and physical parameters is considered. Before calculation of *PET* and *TCI*, homogeneity test was applied for the detection of possible abrupt changes in the climate records. The monthly *PET* values were produced using the RayMan Model. The distribution of comfortable condition with no thermal stress occurred in April, May, September and October, with 3.2%, 76.2%, 60.3% and 6.3% respectively for Sombor meteorological station. For Zrenjanin meteorological station distribution of comfortable condition with no thermal stress occurred in April, May, June, September and October, with 14.0%, 70.7%, 7.8%, 59.3%, 3.1% respectively. The investigated sites have a summer peak distribution of *TCI* with maximum values ranging from 85 to 98. The frequency distribution of mean monthly climatological parameters for the period from 1950 until 2012 for Special nature reserves “Gornje Podunavlje” (meteorological station Sombor) and “Carska bara” (meteorological station Zrenjanin) was used to assess the climate conditions. Additionally Climate Tourism Information Scheme CTIS is a used for a graphical description of analysed tourism-related parameters and frequency classes on monthly time scale.

Keywords: bioclimate, Vojvodina, Physiologically Equivalent Temperature, Tourism Climate Index, Tourism

1. INTRODUCTION

Climate is an important part of the region's tourism resource base. Information about climate for tourists, tourism industry, tourism organizers, agents, tourism planners, and investors are vital and very useful. Coherence of climate and tourism activities has led to a development of new branch of climatology, tourism climatology. It is based on applied climatology and human biometeorology (de Freitas, 2003; Matzarakis 2006; Matzarakis & Endler, 2010).

Location, natural and environmental

components of destination are usual factors that influence decisions regarding areas to be visited. Two additional factors are weather and climate (Abegg, 1996; de Freitas, 2003). Climate, tourism and recreation are interconnected in diverse ways. Therefore tourists, tour organizers, travel agencies, tourism planners, and stakeholders need to be informed properly about the role of weather and climate (Matzarakis, 2006). The climate could be seen as a resource for tourism activities, and this resource can be measured. Thus climate could be seen and treated as an economic asset for tourism (de Freitas, 2003).

Climate indices have been applied to measure climate suitability for tourism. One way of representing multifaceted nature of climate is index approach. Tourism Climate Index (*TCI*) proposed and developed by Mieczkowski (1985) is the most widely known and applied index (Scott & McBoyle, 2001; Scott et al., 2004). However, the *TCI* has been criticized by many authors as being subjective and not been validated with tourists (de Freitas et al., 2004; Scott et al., 2004; Amelung & Viner, 2006; Frarajzadeh & Matzarakis, 2009; Perch-Nielsen et al., 2010). Indeed, an important limitation of most existing climate indices for tourism is that their rating schemes and the weighting of climate variables were based on the subjective opinion of the researchers and were not empirically tested on tourists or within the tourism marketplace (de Freitas et al., 2008). But on the other hand, the broad nature of the *TCI*, the possibility to apply it on general tourism activities, and data availability make the *TCI* well suited to a macro-scale analysis of potential future changes in climate resources for tourism (Pierch-Nielsen et al., 2010). Also, there are several methods based on the human energy balance that have been used for the calculation of thermal comfort for tourism (VDI 1998). 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 & Höppe, 1987; Höppe, 1999; Matzarakis et al., 1999), *SET** (standard effective temperature) (Gagge et al., 1986), the Perceived Temperature (PT) (Staiger et al., 2012) and the Universal Thermal Climate Index (UTCI) (Jendritzky et al., 2012). These three 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* is preferable to other thermal indices of its units (°C), which make results more comprehensive.

PET evaluates the thermal conditions in a physiologically significant manner (Höppe, 1999; Matzarakis et al., 1999). It is defined as the air temperature at which the human energy budget for the assumed indoor conditions is in balance with the same skin temperature and sweat rate as under the actual complex outdoor conditions to be assessed. Meteorological parameters influencing the human energy balance, air temperature, air humidity, wind speed and short- and long-wave radiation, are represented in the *PET* values, but it also considers the heat transfer resistance of clothing and internal heat production (Matzarakis et al., 1999; Lin &

Matzarakis, 2008; Zaninović & Matzarakis, 2009).

The current study assesses the human thermal comfort conditions of tourism bioclimate in two special nature reserves in Vojvodina, Northern Serbia, based on the Physiologically Equivalent Temperature (*PET*) using the RayMan Model (Matzarakis et al., 2007; Matzarakis & Endler, 2010). Additionally, the *TCI* was used to quantify climate for tourism.

In Vojvodina and Serbia climate change has been investigated using minimum and maximum temperatures, daily temperature range and precipitation (e.g. Tošić, 2004; Knežević et al., 2013; Unkašević & Tošić, 2011, 2013; Kržić et al., 2011). However, the changes in thermal comfort have never been calculated before. This study presents the first results of thermal comfort and climate indices for tourism in Vojvodina. Two main meteorological stations near the protected areas were chosen to illustrate climate and bioclimate trends and variability, Sombor on the Danube River and Zrenjanin on Begej River. Both have the same monitoring protocol and similar instruments. Because of their surroundings, the data from both stations are extremely valuable for studying changes in sensitive wetland ecosystems on both sites.

2. STUDY AREA

Vojvodina is the province in Northern Serbia and it is well known for numerous protected wetlands with swamps and marshes. In Serbia there are 10 Ramsar sites, eight of which are located in Vojvodina. In this study main focus is on the Special Nature Reserve “Gornje Podunavlje” and “Carska bara” (Fig. 1). Special nature reserves are placed on the banks of big rivers in Vojvodina – the Danube, and the Begej respectively. The importance of the ecosystems in those reserves is in direct relationship with rivers that created them, both in the present - through floods, and in the past – through the evolution of their basic characteristics. Those are mainly “wetlands”, where marshes and swamps prevail. Special nature reserves belong to the Ramsar areas (Stojanović, 2005).

Special Nature Reserve “Gornje Podunavlje” is located in the northwestern part of Vojvodina, 45°31'30"N, 19°07'35"E, and at an elevation of 80 to 88 m (Fig. 1). With National park “Danube-Drava” in Hungary and Nature reserve “Kopački rit” in Croatia, forms bigger, international protected area. It has been recorded as a Special nature reserve 2001 (Official Gazette of the Republic of Serbia No. 45/2001).

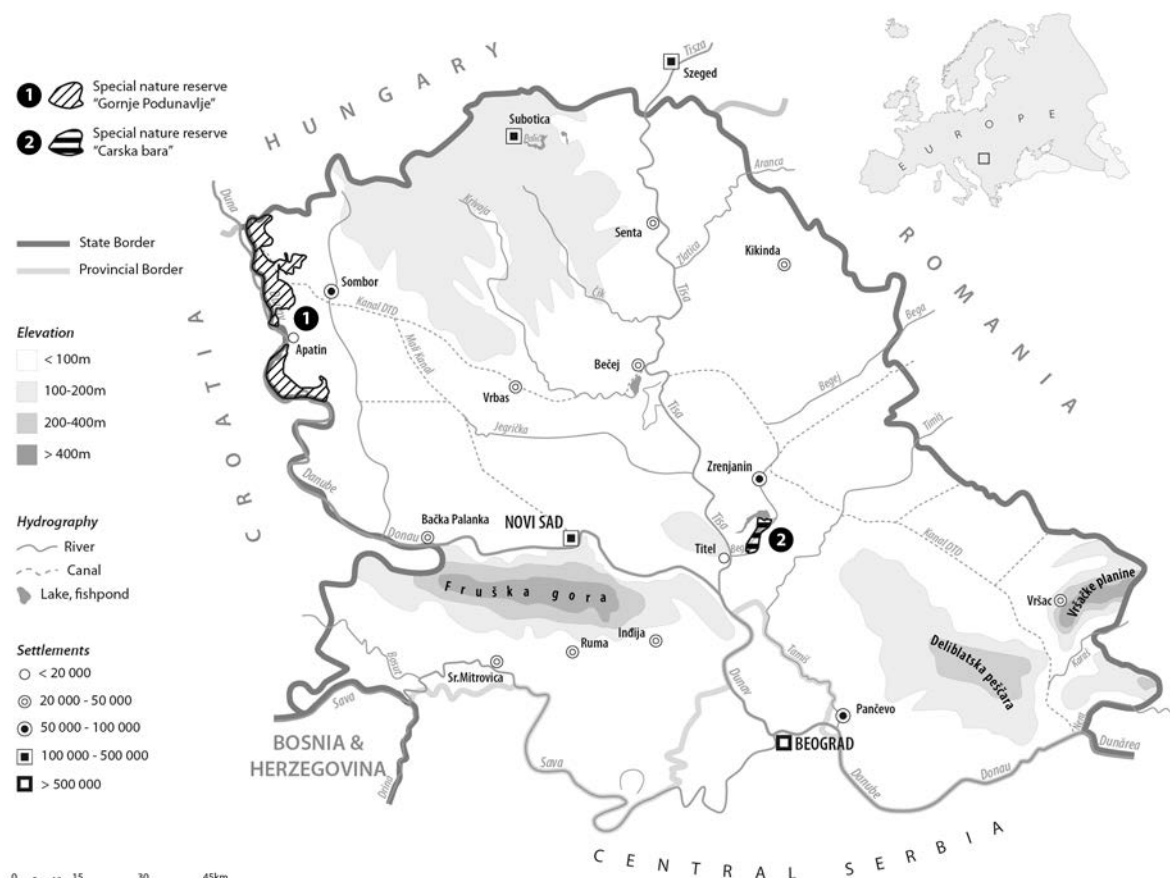


Figure 1. Map of Vojvodina (North Serbia) with the location of Special nature reserves 1. "Gornje Podunavlje" and 2. "Carska bara"

"Gornje Podunavlje" spreads on the area of 19648 ha, comprising the areas of the municipalities of Sombor and Apatin. The Special nature reserve was declared as a Ramsar site in 2002. The lake sustains more than 55 species of freshwater fish. Special nature reserve "Gornje Podunavlje" is considered to be one of the largest natural habitats of Vojvodina, which serve as food source for the migratory birds. In this area approximately 250 species of birds are registered (Stojanović, 2014, Stojanović & Mijović, 2008). Annual precipitation amount ranges from 280 (for 1950) to 1040 mm (for 2011) and mean annual air temperature from 9.3°C (for 1956) to 12.8°C (for 2000).

Special nature reserve "Carska bara" is located in the central part of Vojvodina, 45° 15' 46" N and 20° 23' 56.4"E, and at an elevation of 80 m (Fig. 1). Firstly, Special nature reserve of "Carska Bara" was proclaimed in 1955, but its status was revised in 1995. "Carska bara" spreads on the area of 7532 ha comprising the area of the municipality of Zrenjanin. The Special nature reserve was declared as a Ramsar site in 1996 (Stojanović et al., 2009). The wetland sustains more than 25 species of freshwater fish, more than 500 plant species, including 30 that are natural

rarities. Special nature reserve has great ornithological values as there are recorded more than 250 species of birds, of which 140 are conditional nesting (Stojanović, 2005). Annual precipitation amount ranges from 300 (for 1999) to 900 mm (for 2010) and mean annual air temperature from 9.6°C (for 1956) to 13°C (for 2000).

3. DATA AND METHODS

Climate data used in this study were obtained from meteorological stations Sombor (45°47'N, 19° 5'E and elevation of 88 m) for Special nature reserve "Gornje Podunavlje" and Zrenjanin (45°14'N 20°13'E and elevation of 80m) for Special nature reserve "Carska bara" (Fig. 1). These stations are operated by the Republic Hydrometeorological Service of Serbia. Data sets were analyzed for the period 1949–2012 for Zrenjanin and 1950–2012 for Sombor (Meteorological Yearbook of Serbia, 1949–2012). Data used for calculation included monthly minimum, maximum and mean temperature, monthly minimum, maximum and mean relative humidity, sunshine duration, cloud cover, wind speed and precipitation.

Data sets for each station were complete, except sunshine duration. For Zrenjanin meteorological measurements of sunshine duration started in 1954, and in Sombor 1961. The missing values were estimated from cloud cover data (which were available) and day length. Day length is determined by latitude and time of year, which are both known. From day length and cloud cover data, the number of hours without cloud cover could be calculated. The equation used for this calculation is:

$$\text{uncloudedHours} = \text{DayLength} \times (1 - \text{cloudCover})$$

(Eq. 1)

Using the least squares linear regression method and Pearson's correlation coefficient (later Pearson's R) we tested the relationship between calculated number of unclouded hours per day and observed number of sunshine hours per day.

Pearson's R and multiple regression method showed the results $R = 0.93133042$, $R^2 = 0.86737636$,

Adjusted $R^2 = 0.86716314$ with $p < 0.0000$ for Sombor. The R^2 and p values indicate strong correlation (Fig. 2). Based on this high correlation coefficient, the estimated hours of sunshine were used to calculate TCI for both sites.

Before calculation of PET and TCI , homogeneity test was applied for the detection of possible abrupt changes in the climate records. The standard normal homogeneity test (SNHT) Alexandersson (1986) implemented in software AnClim (Štěpánek, 2008) was used. The performance of the test to the time series of the mean annual temperature suggested discontinuities between 1980 and 2000, marginally significant at the 1 % level. For example, figure 3a–b depicts the results of the SNHT test applied to the mean annual temperature for Sombor and Zrenjanin. The statistics of the test reveal a maximum around 1998, indicating a break point at this period.

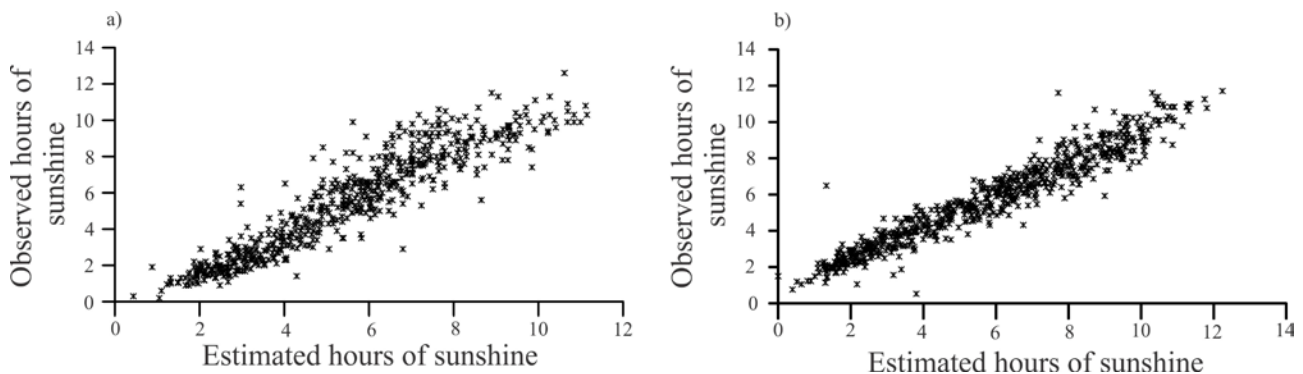


Figure 2. Correlation between the estimated and observed hours of sunshine for Special nature reserve a) "Gornje Podunavlje", b) "Carska bara"

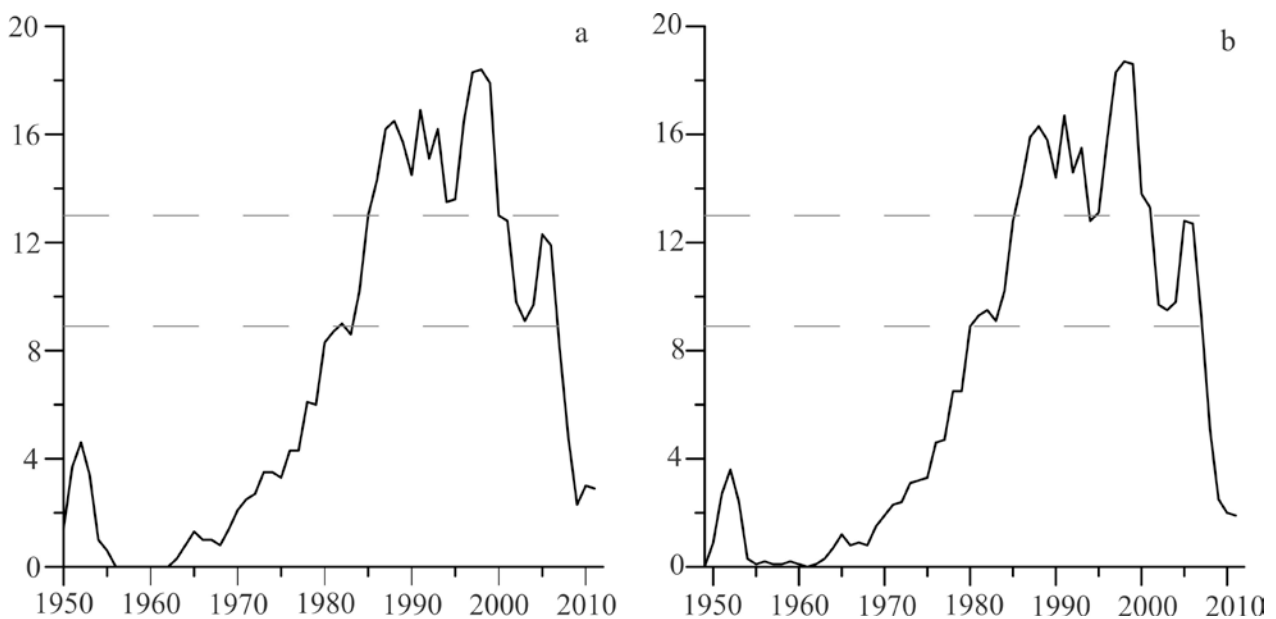


Figure 3. Application of Alexandersson absolute homogeneity tests on the mean annual temperature of a) Sombor and b) Zrenjanin. Dashed lines indicate 1 % and 5 % confidence levels

However, maximum statistic values are very close to the 1% critical values of the test. Given that: (a) according to metadata information and Savić et al., (2012), no documented changes as significant site relocations or observational practice changes are registered at the stations during this period, (b) discontinuities were identified during the same period at both stations, and (c) absolute homogeneity tests are sensitive in true, abrupt changes in climate; we concluded that detected break points are likely to represent a real climate signal (Fig. 3). As far as the other parameters are concerned the above-mentioned reasons could not be employed, thus the absolute homogeneity test was used to adjust time series.

3.1. TCI and PET calculations

In this study, two indices, the *TCI* and *PET* have been applied. For *TCI* calculations monthly means of maximum daily air temperature, mean daily air temperature, minimum daily relative humidity, mean daily relative humidity, monthly total precipitation and total hours of sunshine and monthly mean wind speed were used. These seven climate variables were combined into five sub-indices that comprise the Mieczkowski's *TCI* (Mieczkowski, 1985). *TCI* takes on the following expression:

$$TCI = 8 \times Cld + 2 \times Cla + 4 \times R + 4 \times S + 2 \times W$$

Eq.(2)

Where the five sub-indices are: daytime comfort index, *Cld*, consisting of the mean maximum air temperature (°C) and the mean minimum relative humidity (%), daily comfort index, *Cla*, consisting of the mean air temperature (°C) and the mean relative humidity (%), the precipitation index, *R*, consisting of total monthly precipitation (mm), insolation index, *S*, comprised of the daily sunshine duration (h) and the wind index, *W*, which is actually the mean wind speed (ms^{-1}). In this equation, the highest weight is given to the daytime comfort index due to the fact that tourists are generally most active during the day. The insolation and precipitation index are given the second highest weights, followed by daily thermal comfort and wind index. Maximum *TCI* score is 100. The total

range of *TCI* values is -20 to 100. (Mieczkowski, 1985; Farajzadeh & Matzarakis, 2009). The *TCI* rating scale is divided into ten qualitative, descriptive, categories (Table 1). Although devised on the basis of available biometeorological literature, the rating systems of the five sub-indices and their relative weightings within the *TCI* are ultimately subjective (Scott & McBoyle, 2001).

Scott & McBoyle (2001) theorized that the tourism climate resource of every destination could be classified into one of six annual distributions of *TCI*. Their tourism climate typology ranged from an 'optimal' year-round tourism climate with *TCI* scores higher than 80 for each month of the year to the point of a 'poor' year-round tourism climate with *TCI* scores less than 40 throughout the year. The 'summer' and 'winter peak' distribution curves are quite similar, but distinguished by the season in which more favourable climate conditions occur. A 'summer peak' occurs in destination where summer is the most pleasant period of the year for tourism but on the other hand 'winter peak' would occur at locations where cooler and/or lower humidity conditions in winter are more comfortable for tourists compared to hot and/or humid summer conditions. Where spring and fall months are more suitable for tourist activity a 'bimodal' or 'shoulder peak' distribution occurs (Scott et al., 2004; Farajzadeh & Matzarakis, 2009).

PET is defined as thermal index that quantifies the effect of the thermal environment on humans. Additionally, there are *PMV* (predicted mean vote) and *SET* (standard effective temperature), indices with similar characteristics. Standard climate data, such as air temperature, air humidity and wind speed, are needed to calculate and quantify thermal bioclimatic conditions (Höppe, 1999; Matzarakis, 2001). *PET* is based on the Munich Energy-balance Model for Individuals (MEMI), which models the thermal conditions of the human body in a physiologically relevant way (Höppe, 1999). *PET* can be applied on the indoor and also on the outdoor environment. In the calculations of *PET* RayMan model was used (Matzarakis et al., 2007; Matzarakis & Endler, 2010).

Table 1. Rating categories for the Mieczkowski tourism climate index (Mieczkowski, 1985; Scott & McBoyle, 2001)

<i>TCI score</i>	<i>Category</i>	<i>TCI score</i>	<i>Category</i>
Marginal	40–49	Ideal	90–100
Unfavourable	30–39	Excellent	80–89
Very unfavourable	20–29	Very good	70–79
Extremely unfavorable	10–19	Good	60–69
Impossible	-20 to 9	Acceptable	50–59

To calculate *PET*, meteorological variables that are used include air temperature (T_{avg}), relative humidity (*RH*), wind velocity (*W*) and radiant temperature (T_{mrt}) (calculated based on cloud cover (*C*)). Human parameters influencing *PET*, such as activity, heat resistance of clothing, height, and weight are usually standardized in MEMI (Matzarakis & Endler, 2010). The threshold values for *PET* have been developed in the form of a graded index (Matzarakis & Mayer, 1996) (Table 2). In order to define the conditions under which tourists feel most comfortable it is necessary to define “thermal comfort range”. Thermal sensations differ amongst different regions, thus “thermal comfort range” has been defined for Western/Middle European classes of *PET* but also for different regions (Lin & Matzarakis, 2008).

In this study monthly minimum, maximum and mean values of meteorological parameters were used to calculate values of monthly minimum *PET* (PET_{min}), maximum *PET* (PET_{max}), and mean *PET* (PET_{avg}). Also we used the mean values of meteorological parameters measured at 14 h to calculate the climate index (PET_{14}). The reason behind this is that people are most active during this part of the day on their vacation, excursion or short field trip.

3.2 CLIMATE–TOURISM/TRANSFER–INFORMATION–SCHEME

CTIS is a used for a graphical description of analysed tourism-related parameters and frequency classes on monthly time scale. The scheme is suitable for analysing climate stations or grid points and describes the corresponding frequency of single parameters and factors based on thresholds (Matzarakis et al., 2007; Matzarakis et al., 2013; Zaninović & Matzarakis, 2009). The following factors are selected and included:

- Cold stress ($PET < 0\text{ }^{\circ}\text{C}$),
- Heat stress ($PET > 35\text{ }^{\circ}\text{C}$),
- Thermal comfort ($18\text{ }^{\circ}\text{C} < PET < 29\text{ }^{\circ}\text{C}$),
- Sunshine $> 5\text{h}$

- Vapor pressure $> 18\text{ hPa}$ (sultriness),
 - Relative humidity $> 93\%$ (foggy days),
 - Precipitation $< 1\text{ mm}$ (dry days)
- Precipitation $> 5\text{ mm}$ (wet days).

4. RESULTS

4.1. Tourism climate index

The five sub-indices of the *TCI* contribute differently to the *TCI* score at each location. Fig. 4a and 4b illustrate how the contributions of the sub-indices change from month to month. The highest contribution to *TCI* scores has *Cld*, especially in summer months. The high contribution is also observed for precipitation index for both locations. Insolation index has considerable role for “Gornje Podunavlje’s” *TCI* in summer months while for Special nature reserve “Carska bara” precipitation index influences more the score of the *TCI*.

For Sombor meteorological station, near “Gornje Podunavlje” nature reserve, the predominantly a summer peak distribution was found with highest *TCI* values from May till September (Fig. 4a). For Zrenjanin meteorological station near “Carska bara”, the results exhibit an initial the bimodal-shoulder peak class and the highest *TCI* values are recorded in May and September (Fig. 4b). The most suitable months for tourism activities in the *TCI* descriptive category ‘excellent’ climatic conditions ($TCI > 80$) were found in May, June, July, August and September at both sites (Fig. 4a and b). The frequency distribution of *TCI* show that relevant *TCI* scores (> 60) at both sites make from 90 to 100 % *TCI* scores during summer months (Fig. 5). The “Ideal” conditions (> 90) are recorded in only 5 to 10 % of the distribution during summer on both sites, while “excellent” category is predominant during summer. During winter “unfavorable” and “marginal” categories are principal category. Interestingly, “very unfavorable” conditions are present in extremely small percentages and other negative marginal categories are not recorded.

Table 2. Thermal sensations and PET classes for Western/Middle European classes (Matzarakis & Mayer, 1996)

Thermal sensation	PET range for Western/Middle European ($^{\circ}\text{C PET}$)
Very cold	4
Cold	8
Cool	13
Slightly cool	18
Neutral	23
Slightly warm	29
Warm	35
Hot	41
Very hot	

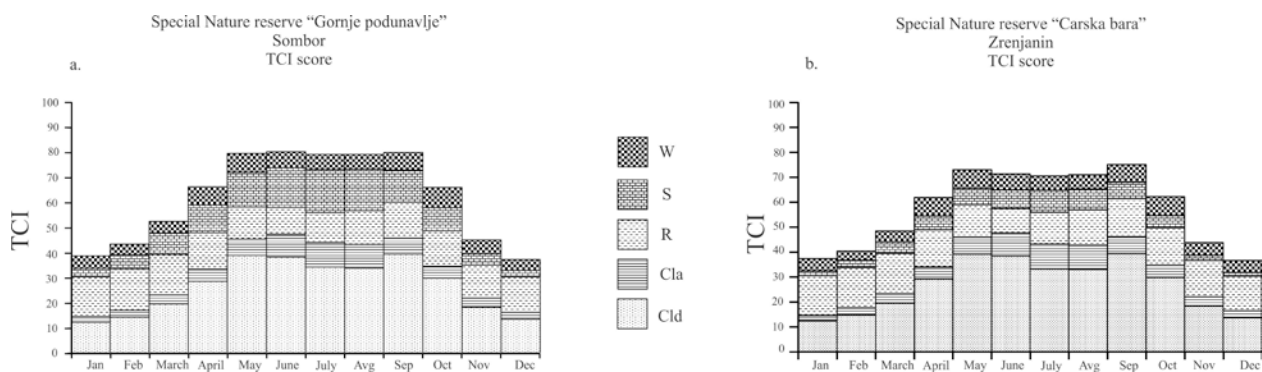


Figure 4. TCI scores for a. "Gornje Podunavlje" b. for "Carska bara"

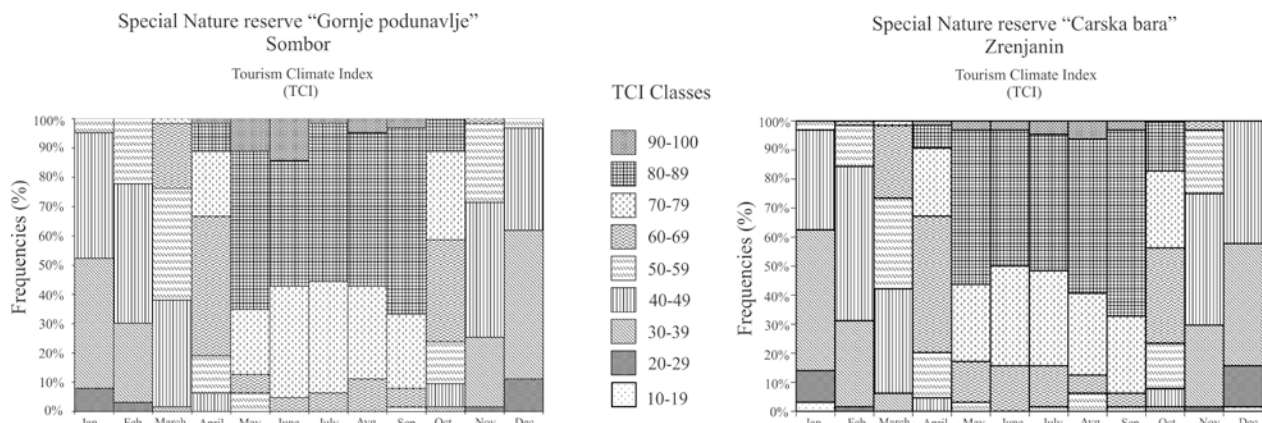


Figure 5. TCI frequencies for "Gornje Podunavlje" and "Carska bara", for 1950–2012 and 1949–2012 respectively. The frequencies are calculated using mean monthly values of meteorological data

TCI curves appear to reflect tourism demand as general information, it is readily interpretable by the travelling public. Also it is designed to measure suitability of the climate resource for the most popular tourism activities in cities – sightseeing and shopping (Farajzadeh & Matzarakis, 2009). The *TCI* values calculated for Special nature reserves "Gornje Podunavlje" and "Carska bara" stand in good agreement with tourism offer at the site. The most suitable time for the visit according to *TCI* is summer, when migratory birds inhabit the sanctuaries.

4.2. Air temperature, relative humidity, sunshine duration and wind conditions

The frequency distribution of mean monthly (T_{avg}), mean monthly maximum (T_{max}) and mean monthly minimum (T_{min}) air temperature for the period from 1950 until 2012 for Special nature reserves "Gornje Podunavlje" (meteorological station Sombor) and "Carska bara" (meteorological station Zrenjanin) is shown in figure 6. The hottest periods occur during summer months with mean monthly temperatures between 20 and 25°C. The highest percentages are recorded in July 81%, August 61% and June 48% for "Gornje Podunavlje" and in July 89%, August 70% and June 53% for

"Carska bara". Coldest months can be observed from December until February with mean temperatures ranging between -10 to 0°C. Highest percentages (more than 50%) are observed in January for both sites. Mean maximum monthly temperatures have highest values (between 30 and 35°C) in August (21% for "Gornje Podunavlje" and 12.7 % for "Carska bara") but lowest temperature range (-10 to 0°C) is observed in December, January and February with percentages of approximately 4%, 14% and 9% respectively for both sites. Mean minimum monthly temperatures show shift of coldest months from December to November and February to March. The hottest months are June, July and August with temperature range between 15 and 20°C.

The frequency diagram for the monthly mean (RH_{avg}), maximum (RH_{max}) and minimum (RH_{min}) relative humidity values given in figure 7 and it show a high variability with a typical annual cycle. In the meteorological winter months December, January and February RH_{avg} more than 50% of the values are in the range between 85 and 95%, whereas values 45% RH are rare and are mainly concentrated in spring and summer. In the summer months, values $RH > 65\%$ occur in 50% of the cases for both investigated sites.

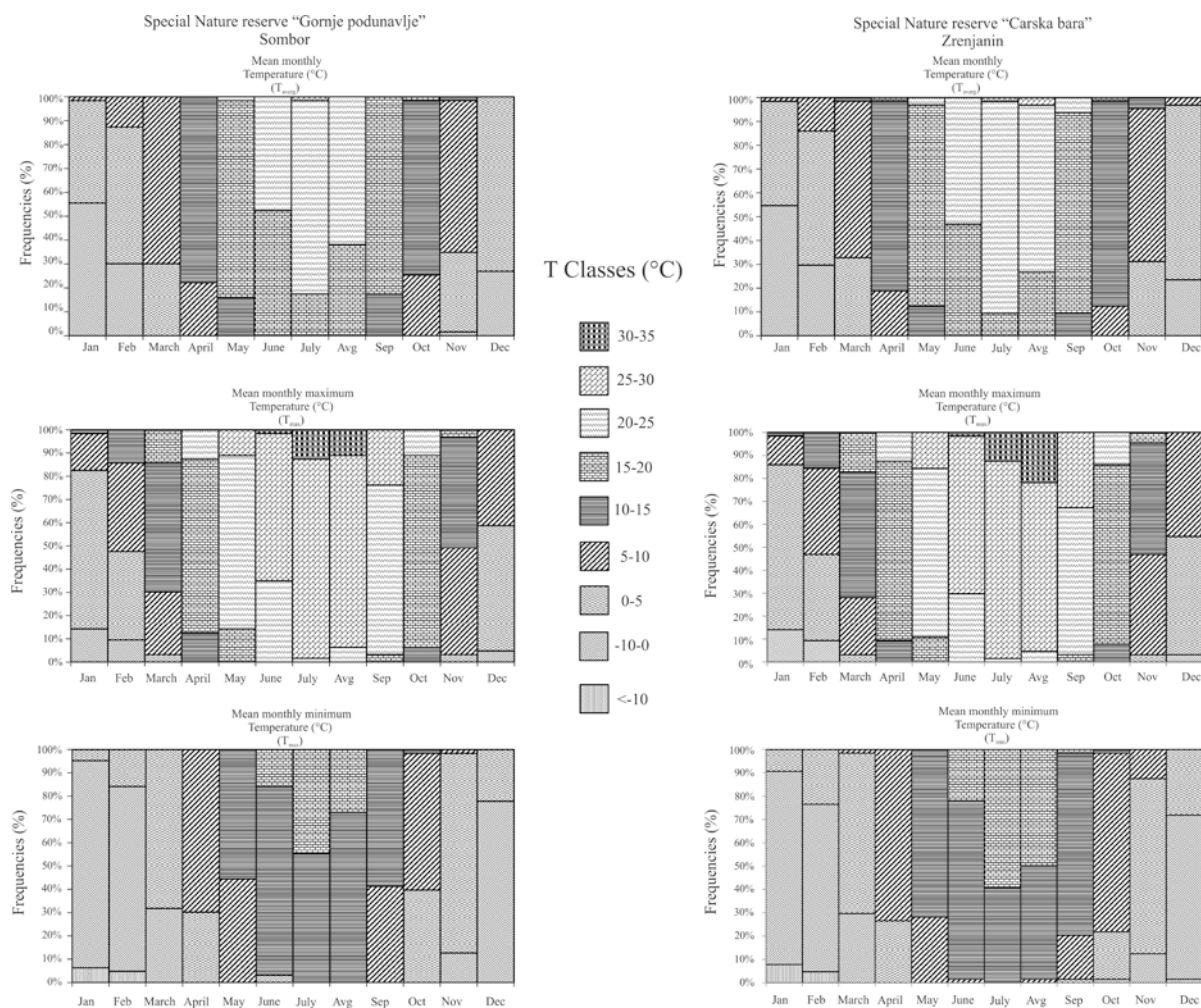


Figure 6. Air temperature frequencies for investigated sites. The frequencies of air temperature are calculated using mean monthly data from 1950–2012 and 1949–2012.

Mean monthly maximum relative humidity (RH_{max}) shows highest values in December and January with more than 90% of values in the range between 85 and 95%. Lowest values (55–65%) are observed in June and July (about 3%) for “Gornje Podunavlje” and in May, June, July and August for “Carska bara” (1.5% and 9% for August).

In the meteorological winter months December, January and February RH_{min} approximately 40% of the values are in the range between 45 and 55%, and whereas values 85–90% RH are rare and are mainly concentrated in December, January and May (for “Carska bara”). In the summer months, values between 25 and 30% occur in more than 50% of the cases for both investigated sites.

To account for aesthetic aspects, the factors visibility (cloud cover) and sunshine are presented as frequency diagrams (Fig. 8). The highest percentage of days with highest amount of sunshine (more than 10 h) is observed during summer, with July (31.3% and 20%) being the sunniest month in “Gornje Podunavlje” and “Carska bara” respectively. The lowest values for summer months are between 6 and

7 hours of sunshine indicating that June, July as well as August are most favorable from aesthetic aspects. Contrastingly, months with highest amount of sunshine are the ones with lowest cloud cover.

Regarding the precipitation diagram for “Gornje Podunavlje” and “Carska bara” (Fig. 9), the annual course follows again the seasons. While events with low rain amounts occur all over the year, heavy rainfalls concentrate in summer and autumn but it is also visible in winter (more than 120 mm). The class of 30–45 mm was found throughout the year, but at a lower frequency in summer months similarly to the frequency class of 45–60 mm.

Wind direction distribution is visualized via different wind charts based on mean monthly values for the period from 1949 until 2012 (Fig. 10). The prevailing wind directions are easterly and westerly with wind speeds between 1 and 3 m/s. Wind speeds lower than 0.5 m/s could not be observed at the two meteorological stations. Winds coming from south and north have higher speed in the range between 3 and 5 m/s.

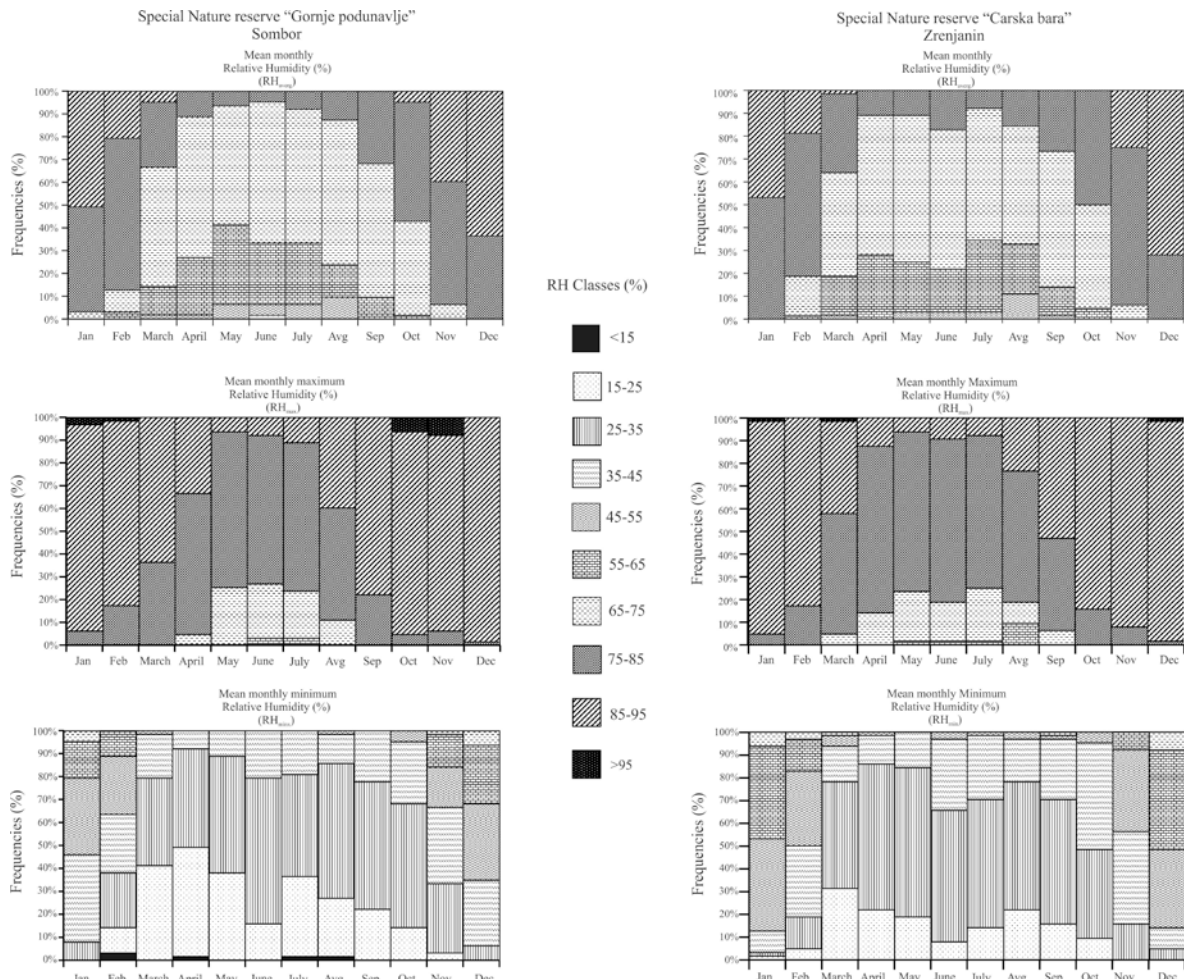


Figure 7. Relative humidity frequencies for investigated special nature reserves "Gornje Podunavlje" and "Carska bara". The frequencies of relative humidity are calculated using mean monthly data from 1950–2012 and 1949–2012.

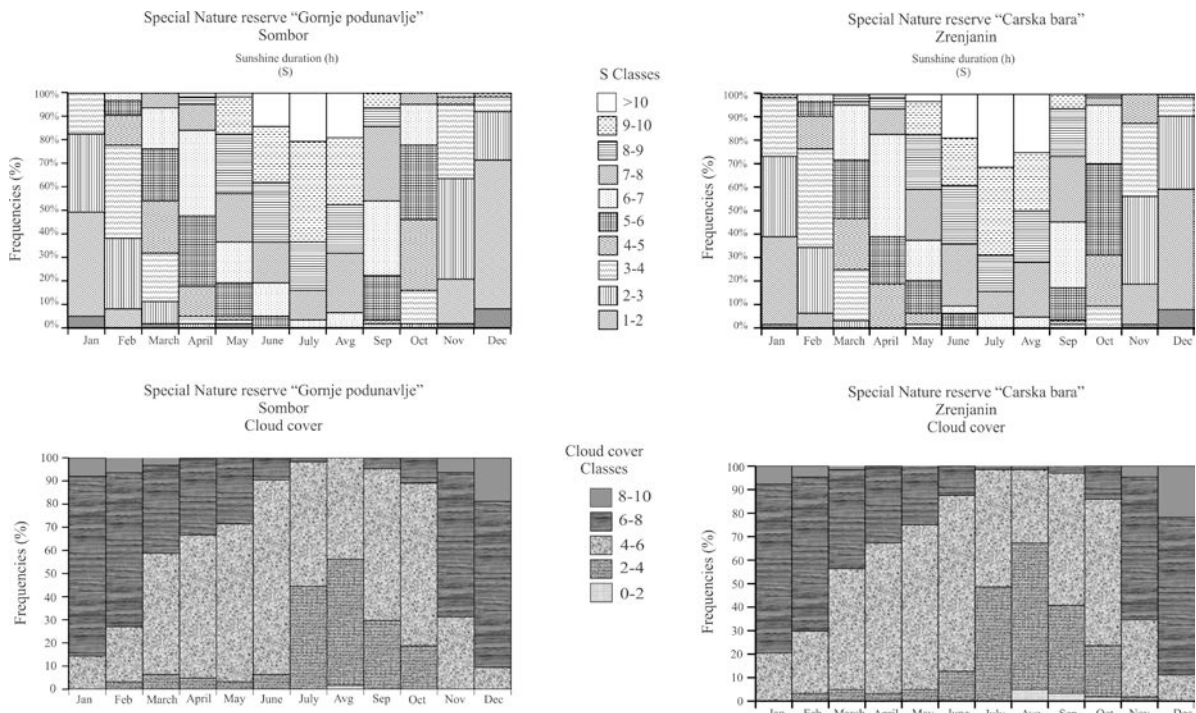


Figure 8. Sunshine duration hours frequencies and cloud cover frequencies for investigated special nature reserves "Gornje Podunavlje" and "Carska bara". The frequencies of sunshine duration are calculated using mean monthly data from 1950–2012 and 1949–2012.

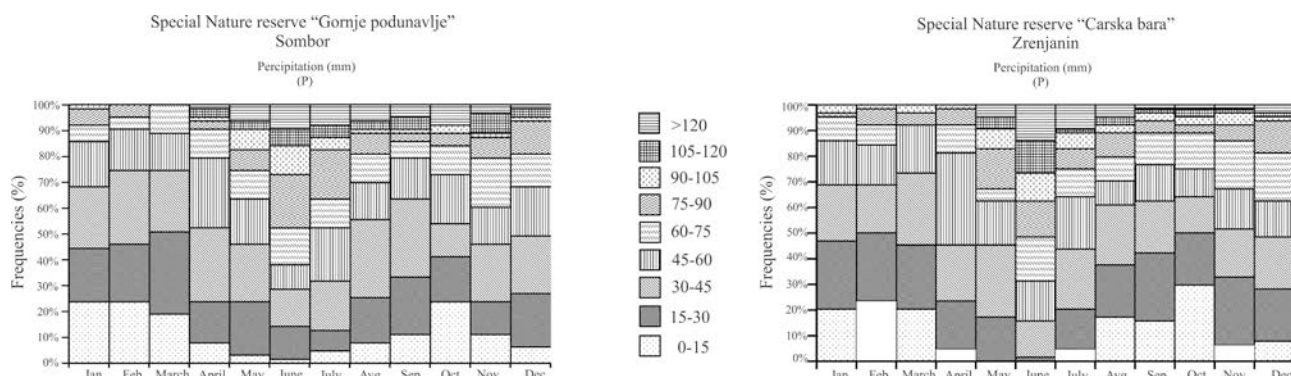


Figure 9. Precipitation frequencies for investigated special nature reserves "Gornje Podunavlje" and "Carska bara". The frequencies of precipitation are calculated using mean monthly data from 1950–2012 and 1949–2012.

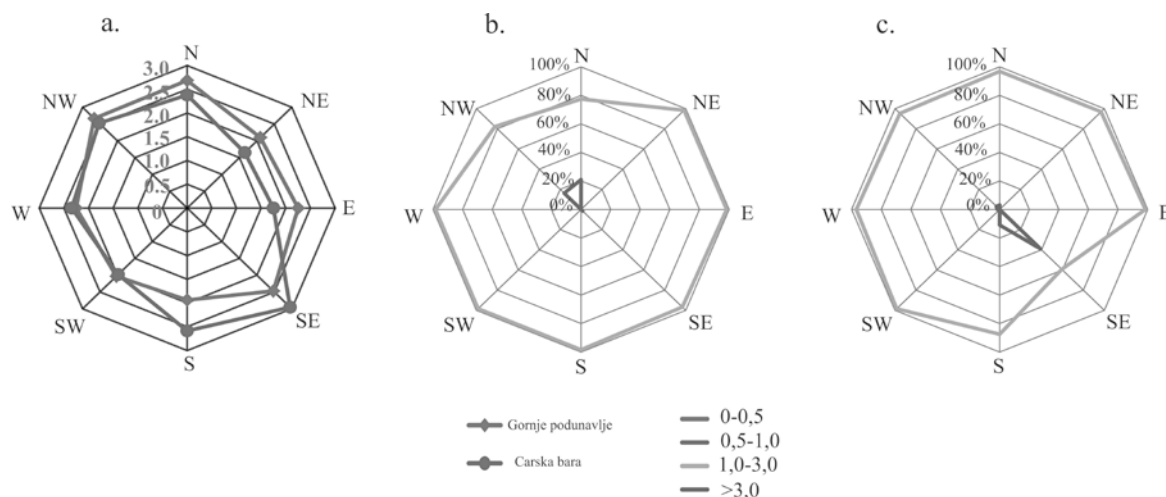


Figure 10. a. Wind rose for the investigated special nature reserves based on mean monthly values for the periods 1950–2012 and 1949–2012 excluding calms. b. Frequency diagram for special Nature reserve "Gornje Podunavlje" c. Frequency diagram for special Nature reserve "Carska bara"

4.3. Pet values

The above-described parameters are important for the calculation of the PET in order to describe the thermal bioclimate. Detailed information of air temperature, air humidity and wind speed are of relevance including their variability and the covered range.

The PET values, which describe the effect of the thermal environment on humans, are shown in figure 12 as bioclimatic diagrams (Matzarakis, 2006). For the mean monthly PET_{avg} extreme cold stress ($PET < 4^{\circ}C$) was found in the period from December to February at both sites with the highest percentage in January (more than 80% in Sombor and 90% in Zrenjanin). Correspondingly, the moderate heat stress ($PET 29-35^{\circ}C$) was observed in the period from June to August with the highest percentages in July, about 80 % in Sombor, while in Zrenjanin the highest percentages are observed in August (approximately 70%). It could be seen that the distribution of comfortable condition with no thermal stress occurred in April, May, September

and October, with 3.2%, 76.2%, 60.3% and 6.3% respectively for Sombor meteorological station. For Zrenjanin meteorological station distribution of comfortable condition with no thermal stress occurred in April, May, June, September and October, with 14.0%, 70.7%, 7.8%, 59.3%, 3.1% respectively. For mean maximum monthly values of PET_{max} for both locations it can be seen that the extreme heat stress and strong heat stress are present during summer months, and comfortable condition with no thermal stress are shifted toward earlier spring months and late autumn. For PET_{min} , which was calculated using mean minimum monthly values, comfortable conditions with no thermal stress are observed during summer, with highest percentages in July for Sombor and August for Zrenjanin. The lowest PET_{min} values that correspond to extreme and strong cold stress have highest percentages during winter and spring (Fig. 11). As tourists are most active during midday we used mean values of meteorological parameters measured at 14 h to calculate PET_{14} .

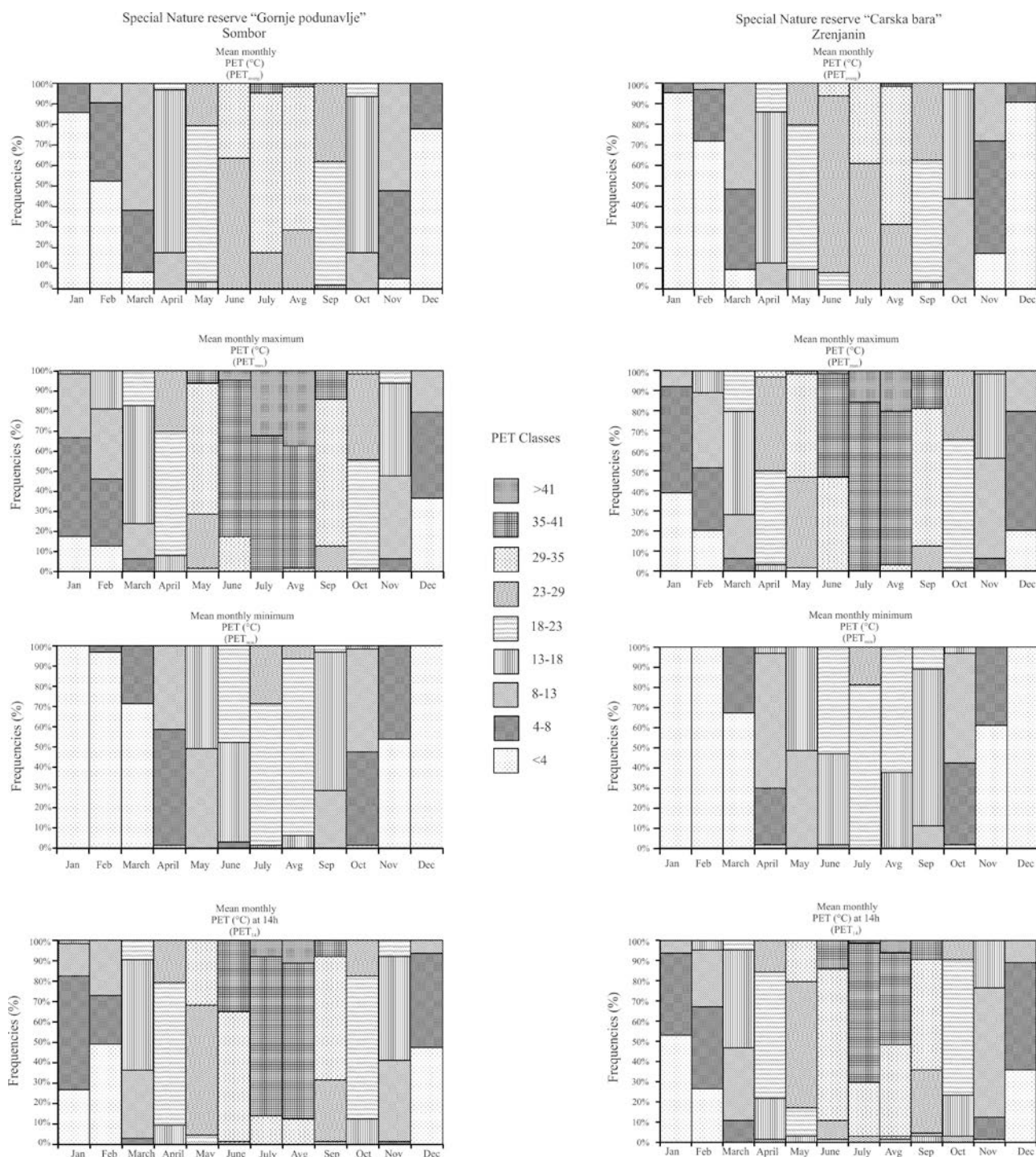


Figure 11. PET frequencies with Western/Middle European Scale for “Gornje Podunavlje” and “Carska bara” for period 1950–2012 and 1949–2012.

The results of bioclimatic diagram show that percentages of extreme cold stress ($PET < 4^{\circ}\text{C}$), found in the period from December to February at both sites, are considerably smaller than for PET_{avg} . The moderate heat stress (PET 29–35 $^{\circ}\text{C}$) was observed in the period from May to September and comfortable conditions with no thermal stress occurred are mainly concentrated in April and October. Smaller occurrence of comfortable conditions is also seen in March, May and

November (for Zrenjanin meteorological station) (Fig. 11).

4.4. Climate-tourism/transfer-information-scheme

In order to analyze of present climate conditions for tourism The Climate–Tourism–Information–Scheme (CTIS) is used. CTIS is a tool that combines meteorological and tourism-related

components in order to give detailed specific climate information to improve destination's tourism potential. The diagrams (Fig. 12a and 12b) offer sufficient climate information for tourists, based on which they can choose their preferred travel period. A particular color is always associated with the same frequency class of the selected climatological variables, making it easier to understand and use.

For the investigated period, thermal comfort/acceptance is given for April and May and for September and October. During June, July and August, the highest amounts of heat stress occur (up to 50%). During these months, the highest amount of sunshine can be also detected. Cold stress occurs with more than 60% during November and December until February. Frequencies of Foggy days occur during fall and winter until the middle of March with amounts from 10–30% showing highest amounts in December.

The results presented as CTIS are of basic interest for the most relevant kinds of tourism and recreation. In addition, in CTIS there could be different combinations of factors relevant for a region under investigation (Matzarakis et al., 2013).

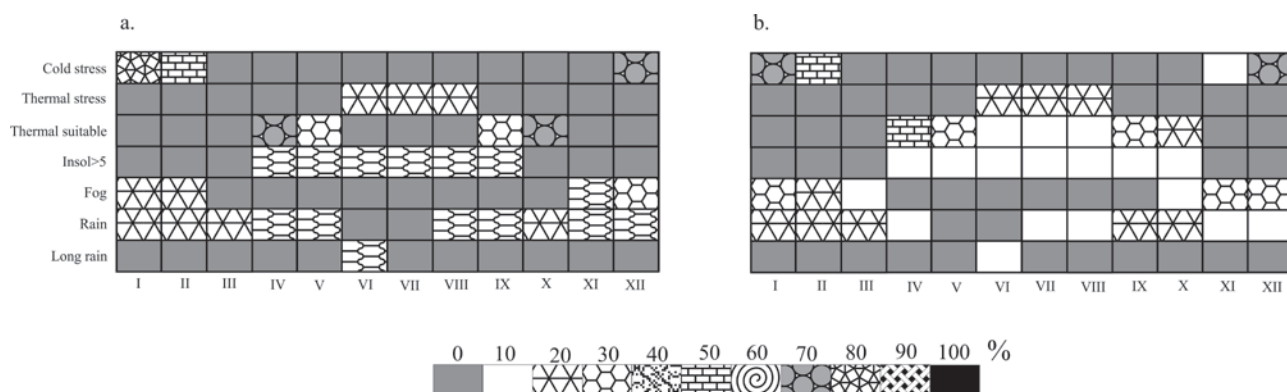
5. DISCUSSIONS

Vojvodina region (North Serbia) currently lies at the border between Atlantic, Continental and Mediterranean climate zones. The climate of Vojvodina is characterized as moderate continental, with cold winters and hot and humid summers with huge range of extreme temperatures and non-equal distribution of rainfall per month (Hrnjak et al., 2014).

When discussing the thermal characteristics of climate in protected wetlands one must choose suitable thermal index in order to present climate potential for tourism activities. Special nature reserves “Gornje Podunavlje” and “Carska bara”

according to Ramsar convention are a unique mosaic of aquatic, wetland, and terrestrial ecosystems and important centers of ecosystem, species, and genetic diversity. A large number of rare and nationally or internationally threatened plant species and their communities are supported, as well as vulnerable habitats. Given this, it is important to provide information about climate and bioclimate conditions for visitors and nature lovers. The use of *PET* for thermal sensations rather than only information about single meteorological parameters provide more detailed knowledge about the thermal comfort of humans and how atmospheric conditions affect human bodies (Lin & Matzarakis, 2008; Farajzadeh & Matzarakis, 2009; Brosy et al., 2013; Zaninović & Matzarakis, 2009; Bleta et al., 2013).

In this study *PET* scale for Western/Middle European countries was used. The scale is frequently used (Matzarakis et al., 1999) in order to estimate bioclimatic conditions in different areas and cities, such as Istanbul and Paris (Bouyer et al., 2007), Goteborg (Svensson et al., 2003; Thorsson et al., 2004), Szeged (Gulyas et al., 2006), Matsudo, Japan (a satellite city near Tokyo, Thorsson et al., 2007), Far-Eastern Federal District of the Russian Federation (temperate monsoon climate zone, which is characterized by an extreme continental regime of annual temperatures, Grigorieva & Matzarakis (2011)). A recent study by Zaninović & Matzarakis, (2009) and Brosy et al., (2013) confirmed our initial assumption, revealing that the acceptable comfort range of *PET* for this part of Europe is in comfort range of *PET* for Western/Middle European countries. The advantage of these sites is best seen in spring and autumn when best bioclimate conditions with no thermal stress or slight heat stress prevail (e.g. PET_{avg} and PET_{14} , Fig. 12). This is also the time when migratory birds come to the nature reserves.



This period could be seen as the best for different kind of activities such as hiking or boat tours for bird watching for example. Visiting “Gornje Podunavlje” and “Carska bara” during summer would result in moderate and extreme heat stress and during winter months in extreme cold stress and strong cold stress (e.g. PET_{avg} and PET_{14} , Fig. 11). In the period of no thermal or slight heat stress the diagram of precipitation classes show that the highest percentage is between 45 and 70 mm per month as well as that a heavy rainfall is present in only 5 to 10%. For nature lovers, bird watchers and hikers the aesthetic factor is very important. Sunshine duration hours for spring and autumn are between 5 and 8 h (Fig. 9) indicating that good conditions for different activities in “Gornje Podunavlje” and “Carska bara” do exist.

Compared with previous studies of tourism climate in specific regions, e.g., Spain (Gómez Martín, 2004), Austria (Matzarakis et al., 2004; Matzarakis et al., 2012), Phoenix, Arizona (Hartz et al., 2006), Lisbon, Portugal (Alcoforado et al., 2004), Slovenia (Cegnar & Matzarakis, 2004), and Florence, Italy (Morabito et al., 2004), the advantage of the method employed in this research is that the PET index is more understandable for tourists who can assess the outdoor thermal condition based on their experience in an indoor environment. In this study, mean monthly values of meteorological parameters are used for the calculations of PET and for the development of TCI . For better understanding of different bioclimate conditions it would be better to use daily values or even hourly values of air temperature, relative humidity, wind speed, wind direction, precipitation and cloud cover similar to Matzarakis et al., (2013).

Different climate indicator for tourism activities is TCI . The distribution of TCI (Fig. 6) shows that the most suitable period to visit special nature reserves is during late spring, summer and early autumn. Calculating modified TCI for Europe Perch-Nielsen et al., (2010) concluded that the most regions can be classified as “summer peak” distributions, such as the investigated sites, with the exception of the Iberian Peninsula and the Mediterranean that tend towards “bimodal shoulder peaks” caused by maximum temperatures rising too high in summer to be comfortable for sightseeing activities. Using the daily data from five regional climate models and comparing the reference period 1961–1990 to the A2 scenario in 2071–2100 authors argued that most parts of Northern and Central Europe would experience an increase in mean number of good days with favorable values of TCI accompanied by a decrease in seasonality. On the

other hand, the mean number of good days would decrease on average in most parts of Southern Europe (Perch-Nielsen et al., 2010).

With regard to climate change which will affect the tourism and other economic sectors as well as ecology and society (IPCC, 2007; UNWTO, 2007; Scott, 2011) it is very important to take a closer look at the current climate situation but also to future changes and climate change mitigation strategies. Generally, some regions will become more attractive as touristic destinations at the expense of others (Abegg, 1996; Perry, 2000; 2001). In the IPCC report (2007) it is stated that wetland are the most vulnerable to climate change, and the limits to adaptations were indicated due to the dependence on water availability controlled by outside factors. Special nature reserves “Gornje Podunavlje” and “Carska bara” with their main characteristics present one of the best wetland areas in Europe and therefore deserve our special attention. Therefore, adaptation to climate change is important not only for tourists but also for other groups involved in the tourism sector such as tour operators (Scott et al., 2009).

6. CONCLUSIONS

This study presents the first results of biometeorological parameters for Vojvodna, North Serbia. A detailed analysis of climate and weather for tourism purposes is suggested, which should draw on detailed data and include important parameters. Analysis and assessment of the climate tourism potential (PET analysis) at the investigated sites showed that present summer conditions are already hot for several touristic activities. This is not only the case during summer, for PET_{avg} , but also in spring and in autumn for PET_{max} and PET_{14} .

Based on the results for recreation and health reasons, the group of tourist that would probably visit the reserves could be offered to come to the sites in times with more convenient bioclimatic conditions, such as those that prevail in May and September. But, with regard to climate change which will affect the tourism and other economic sectors as well as ecology and society it is necessary to adapt and be prepared to future changes. The attractiveness and climate tourism potential of destinations will change, and to remain competitive on the tourism market a wider offer of activities should be provided. The methods presented here would allow a time-series assessment of climate with high temporal resolution if the daily data of different meteorological parameters are used. So, the use of long term climate data and the grouping of months in 10-day intervals provide some solution.

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