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ESTIMATION OF TOURISM CLIMATE IN THE LAKE BALATON REGION, HUNGARY

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Abstract

Lake Balaton is one of the most important and best-known tourist destinations in Hungary. Although in the last few years, several efforts were implemented to increase the length of the tourist season, the highest visitor turnover occurs in the summer months. We mostly regard the Lake Balaton as a bathing place, despite of the fact that the region offers more and more tourism products. The beach tourism and other lakeside activities are highly dependent on weather and climate. In order to know that a region's climate what extent is suitable to the given tourism activities, the tourism climate potential must be determined. This study aims to illustrate observed changes of the tourism climate potential of Lake Balaton Region during the last half century, by using Tourism Climatic Index (TCI) and Climate-Tourism-Information-Scheme (CTIS). The analysis is based on the long-term measured datasets of Siófok synoptic station. Based on the TCI, the tourism climate potential of the examined region is barely changed over the past 50 years; significant changes can be detected only in February and June. By using the CTIS, smaller changes can also be detected. Such changes are: moderate improvement of the thermal comfort in spring and autumn, slight increase in sunny hours in the tourism season, as well as the sultriness becomes more frequent in the summer months. The results may represent useful background information to the policy decision-makers.

Keywords: tourism climatic index, climate-tourism-information-scheme, tourism climatology, climate change, Lake Balaton

INTRODUCTION

Despite of the economic crisis, tourism is one of the major economic sectors in Hungary. In 2011 tourism produced 1115.7 billion Hungarian forints (about 5.1 billion USD) revenue, which means second-third place in industry-wide comparison. The contribution to the gross domestic product (GDP) is approximately 6%. In addition, more than 8% of the all employees are working in tourism sector. The Lake Balaton Region plays an important role in Hungarian tourism. The Lake Balaton or as the Hungarians call it, the “Hungarian Sea”, is the largest fresh water lake in Central Europe with significant lakeside tourism. The southern shore of Balaton is ideal for small children because of the shallow water, but on the north shore the water gets deep faster. In summer the water temperature is around 26 °C, which is warmer than the average air temperature in the morning and in the evening. It can be said that the water and the climate are the main attractions of this region. According to Kéri (1974), meteorological point of view this means that if the weather does not hamper the tourists for enjoying the water, they do not even realize that the weather is good. The weather, as a factor, comes to people's mind when it goes wrong.

The weather and the climate is a key factor in tourism (Perry, 1997). There are multiple interactions between tourism and climate systems. First, the weather and climate can be *limiting factor in tourism* (de Freitas, 2003; Matzarakis, 2006). All regions have a tourism potential and appeal determined by the weather and climate. If a region’s climate is optimal for tourism, the area has great appeal (*Fig.1*). This also means that there are some areas on the world where the climate is unsuitable for tourist activities. The most tourist activity has climatic constraints or limiting factors (as an example, the appropriate quantity and quality of snow are essential for ski-tourism). This implies that those areas where the terms of tourism activities are lacking have lower appeal. In such areas the tourism is more or less risky. This risk can be either financial or physical.

Secondly, the climate and weather can be also *dominating factor in tourist demand* (de Freitas, 2003; Matzarakis, 2006). The climatic conditions affect the tourists’ decision on destination selection and mainly their time of travelling. However, the actual meteorological conditions influence the tourists what activities will be carried out in reality.

Finally, the climate and weather can be *risk factor for human health* because the trips in extreme climate areas may cause health problems (heat stroke, sunburn, asthma attack caused by air pollution, frostbite or other cold-related injury, etc.) (Matzarakis, 2006).

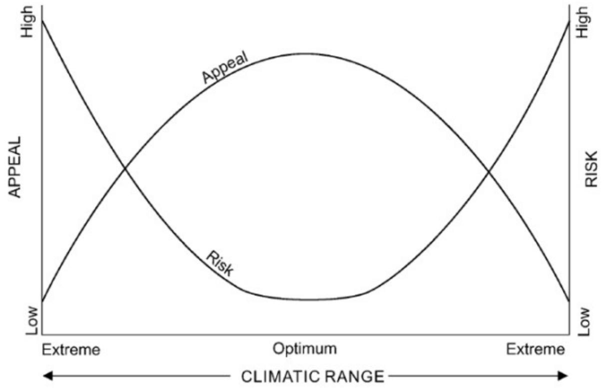

Fig. 1 Schematic representation of relationship between a climatic range and tourism potential. The climate potential of a particular location is a function of its climate and of the risks that weather may impose. (de Freitas, 2003 after Perry, 1997).

Tourism climate of a given area can be approached from several aspects. Some climate parameters are evaluated by physical (e.g. rain, air pollution), some by aesthetic or psychological (e.g. "clear blue sky"), while others by physiological (e.g. air temperature) aspect. One might think that the thermal component is the most important factor in terms of the tourism climate. But, if a region's temperature is in an acceptable range, the importance of the other factors increases in the tourism climatological evaluation. Let's examine some of these factors.

Physical factors are those meteorological parameters which affect the tourists' satisfaction directly or indirectly. As an example, the occurrence of a heavy rainfall during holidays has a direct impact on tourists which causes inconvenience (e.g. getting clothes or luggage wet), or affect indirectly the level of satisfaction (e.g. poor quality photos can be made). Physical factors include wind, ice and snow, severe weather conditions, or even the UV-rays.

The *aesthetic* (or psychological) aspects influence especially the attractiveness of the region and the enjoyment of holiday. This category includes the visibility, the cloudy or sunny day determined by the synoptic situation, and the length of the day.

The *thermal* aspects play role on the characterization of thermal comfort during the holidays. This means not only the air temperature, but the combined effect of temperature, humidity, solar radiation and wind.

The tourism climatology aims to examine and clearly demonstrate the above-mentioned characteristics for both tourists and tourism operators. Determining the tourism climate, simple climatic or bioclimatic indices were formerly used. Nowadays, more than 200 such indices exist. According to Matzarakis (2006), the tourism climatic indices can be divided into three categories. For calculating the *elementary indices,* one or more meteorological data are needed which do not contain any thermo-physiological information thus they do not really work in practice. The *bioclimatic* and *combined indices* include several climatic and bioclimatic parameters and their combined effect is taken into consideration. Some examples of the tourism climatic indices are shown in Table 1.

Table 1 Examples of tourism climate indices (after Matzarakis, 2006)

Category	**Parameters included**
Elementary	Air temperature, sunshine duration, precipitation
Bioclimatic	Windchill (air temperature and wind speed) Bioclimatic indices (based on human energy balance) – e.g. Predicted Mean Vote (PMV)*, Standard Effective Temperature (SET)*, Physiologically Equivalent Temperature (PET)*
Combined	Combination of parameters: daytime comfort index**, daily comfort index**, precipitation, sunshine duration, wind speed, PMV, PET

* definitions of these bioclimatic indices are in Fanger (1970), Gagge et al. (1986), Mayer and Höppe (1987)
** for definitions of these indices see Section "Tourism Climatic Index"

MATERIALS AND METHODS

Used data

In this study the measured meteorological data of the Storm Warning Observatory in Siófok (46°54'N, 18°02'E, 108 m asl) were used (*Fig. 2*). The measurements take place at the same location since the 1950's, so the data series do not have displacement-caused inhomogenity. This is particularly important for analyzing the long-term data series. The meteorological station is located right at the lakeside, thus it is ideal for tourism climatology. In the calculations the following measured data (for period 1961–2010) were utilized: hourly air temperature, relative humidity, vapour-pressure, wind speed, cloudiness; daily precipitation sum, average sunshine duration and daily maximum of wind speed.

Applied methods

1) Tourism Climatic Index (TCI)

There are several ways to determine the extent of the suitability of an area for tourism purpose in a climatic point of view. Several attempts have been made to identify the best or the optimal climate conditions for a tourism activity. Two of such methods were utilized in the present study.

First, one of the best-known and most widely used combined indices, the Tourism Climatic Index (TCI) was used. The TCI is favoured as an index because it is one of the most comprehensive metrics, integrating all three facets of climate considered relevant for tourism (Perch-Nielsen et al., 2010). The TCI was originally devised by Mieczkowski (1985) to exactly evaluate the climatic variables which are the most relevant for the quality of tourism experience of the "average" tourist. This work is based on the previous researches on relation between climate classification

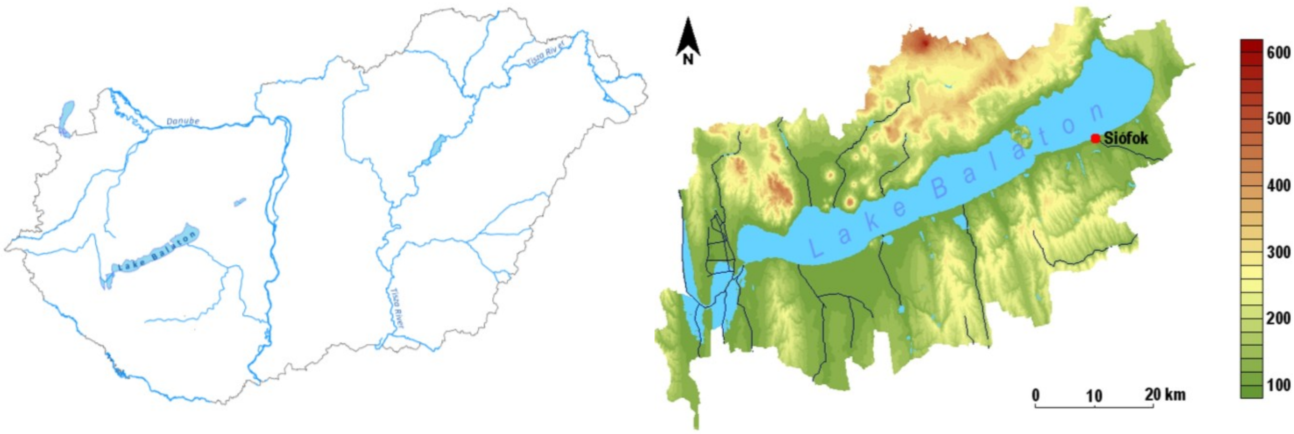

Fig. 2 Geographical location of the Lake Balaton Region in Hungary and the examined meteorological station (Siófok)

and recreation, and applied the human comfort-related outcomes too (Amelung and Moreno, 2012). The original index included 12 monthly climate variables. The final version of TCI was integrated only seven climatic variables (more precisely monthly averages of them): daily mean temperature, daily maximum temperature, daily mean relative humidity, daily minimum relative humidity, daily precipitation sum, daily sunshine duration and daily mean wind speed. These seven climatic variables were combined into five sub-indices (*Table 2*). A standardized rating (from the very bad of –3 to the very good of 10) system was devised to provide a common basis of measurement for each of the sub-indices.

In human biometeorological practice, many comfort indices exist for characterizing thermal comfort. Accordingly, the calculation of daily and daytime comfort index, which is included in the equation, can be done in several ways. The thermal comfort – in a subjective approach – is a kind of positive opinion (satisfaction), which expresses our relationship to the ambient thermal conditions. This subjective sensation is influenced basically by four meteorological factors: air temperature, relative humidity, wind speed and solar radiation. However, the *effective temperature (ET)* in its original form – which was applied by Mieczkowski (1985) for calculating the TCI – determines the combined effect only of the air temperature and air humidity (Hajek and Espinosa, 1982). ET is defined as the temperature of the saturated and stationary air mass which results the same total heat loss from the skin, and therefore the same thermal comfort sensation, as the actual environment. A serious problem with this definition of effective temperature is that it makes no special allowance for radiation.

The Tourism Climatic Index is calculated as follows:

$$TCI = 8 \cdot CID + 2 \cdot CIA + 4 \cdot P + 4 \cdot S + 2 \cdot W \qquad (1)$$

where:

CID = daytime comfort index
CIA = daily comfort index
P = precipitation
S = sunshine
W = wind speed

Based on a location's index value, its suitability for tourism activity is then rated on a scale from –30 to 100 (*Table 3*). Mieczkowski (1985) divided this scale into

Table 2 Sub-indices and their relative contribution to the TCI

Sub-index	**Climate variables**	**Influence on TCI**	**Weight ing in TCI**
Daytime Comfort Index (CID)	maximum daily temperature and minimum daily relative humidity	Represents thermal comfort when maximum tourist activity occurs	40%
Daily Comfort Index (CIA)	mean daily temperature & mean daily relative humidity	Represents thermal comfort over the full 24-hour period, including sleeping hours too	10%
Precipitation (P)	daily precipitation sum	Reflects the negative impact that this element has on outdoor activities and holiday enjoyment	20%
Sunshine (S)	daily hours of sunshine duration	Acknowledged can be negative because of the risk of sunburn and added discomfort on hot days	20%
Wind (W)	daily averaged wind speed	Variable effect depending on temperature (evaporative cooling effect in hot climates rated positively, while 'wind chill' in cold climates rated negatively)	10%

ten categories, ranging from “ideal” (90 to 100), “excellent” (80 to 89) and “very good” (70 to 79) to “extremely unfavourable” (10–19) and “impossible” (–30 to 9). In this study, a TCI value of 70 or higher is considered attractive for the “typical” tourist engaged in relatively light activities such as sight-seeing and shopping.

Table 3 Tourism Climatic Index rating system (Mieczkowski 1985)

Numeric value of TCI	Description of comfort level for tourism activity
90 – 100	Ideal
80 – 89	Excellent
70 – 79	Very good
60 – 69	Good
50 – 59	Acceptable
40 – 49	Marginal
30 – 39	Unfavourable
20 – 29	Very unfavourable
10 – 19	Extremely unfavourable
Below 9	Impossible

2) Climate-Tourism-Information-Scheme (CTIS)

Although the Mieczkowski's TCI distributed worldwide as a tourism climate index, it has numerous limiting factors while using it. The most serious limitation of the TCI is its subjectivity and lack of verification (Perch-Nielsen et al., 2010). The effective temperature which is used to determine the daily and daytime comfort index is an outdated bioclimatic index. On the other hand, the TCI gives information about tourism climate in very poor temporal resolution. Therefore it has become necessary to develop a system, which can characterize a region's tourism climate in fine temporal resolution by using a modern, energy balance-based bioclimatic index.

One of the latest possibilities for the integration of climate/bioclimate information for tourism purposes is the Climate-Tourism-Information-Scheme (Matzarakis, 2007; Zaninović and Matzarakis, 2009). It represents frequencies and probabilities of different bioclimatic and tourism climatic factors from all facets. This method is particularly suitable for the analysis of selected destinations and therefore the tourist practice – policy makers and planners – in high spatial and temporal resolution climate information. Therefore the CTIS is not a tourism climatic index. Actually, the CTIS is a graphical representation of the tourism-relevant climatic information in high temporal resolution of 10 days – each month is divided into three time intervals (Matzarakis et al., 2012). The advantage of 10-day intervals is that it is roughly equal to the average duration of vacation time. Meanwhile the CTIS is a flexible system. In this case, the flexibility means that it can be selected one by one those climatic parameters which are relevant for a specific tourism sector in a specific region. For tourism in Lake Balaton Region the next CTIS factors are selected: cold stress (physiologically equivalent temperature i.e. PET<0°C), heat stress (PET>35°C), thermal comfort (18°C<PET<29°C), sunshine/cloud cover conditions in terms of the number of days with a cloud cover < 5 octas, vapour pressure > 18 hPa, relative humidity > 93%, precipitation < 1 mm as well as precipitation > 5 mm, and wind speed > 8 ms^{-1} as well as wind speed > 17 ms^{-1}. In general, the definitions of the several threshold values do not necessarily correspond to the universal meteorological threshold values and are adjusted to applied tourism climatology and human health applications.

For the calculation of the thermal component of CTIS, the Physiologically Equivalent Temperature (PET) was used. It is one of the most common bioclimate indices, which is derived from the Munich Energy-balance Model for Individuals (MEMI) (Höppe, 1984, 1999). The MEMI models the thermal conditions of human body in a physiologically way. Beside of meteorological parameters (air temperature, relative humidity, wind speed and cloudiness) some physiological and geographical inputs are required for calculating PET. For the calculation the RayMan software was used (Matzarakis et al., 1999, 2007). The calculation was taken on a 35 years old, 75 kg weight and 175 cm high man, who is sitting and wears normal clothing (0.9 clo). The categories of PET values were defined according to different thermal perceptions for temperate climate (*Table 4*).

Table 4 Categories of Physiologically Equivalent Temperature (PET) for different levels of physiological stress and thermal sensation (Matzarakis and Mayer, 1996)

PET (°C)	Grade of physiological stress	Thermal sensation
above 41	extreme heat stress	very hot
35 to 41	strong heat stress	hot
29 to 35	moderate heat stress	warm
23 to 29	slight heat stress	slightly warm
18 to 23	no thermal stress	comfortable
13 to 18	slight cold stress	slightly cool
8 to 13	moderate cold stress	cool
4 to 8	strong cold stress	cold
below 4	extreme cold stress	very cold

RESULTS AND DISCUSSION

Fig. 3 shows the monthly values of TCI for three climatological normal periods (1961–1990, 1971–2000 and 1981–2010) in Siófok. The many-years averages of TCI were 60.5, 61.5 and 61.8 in the three examined periods. Based on this, the region's tourism climate potential is good. The diagrams show clearly, that the tourism climate of the Lake Balaton has a summer peak. The high-

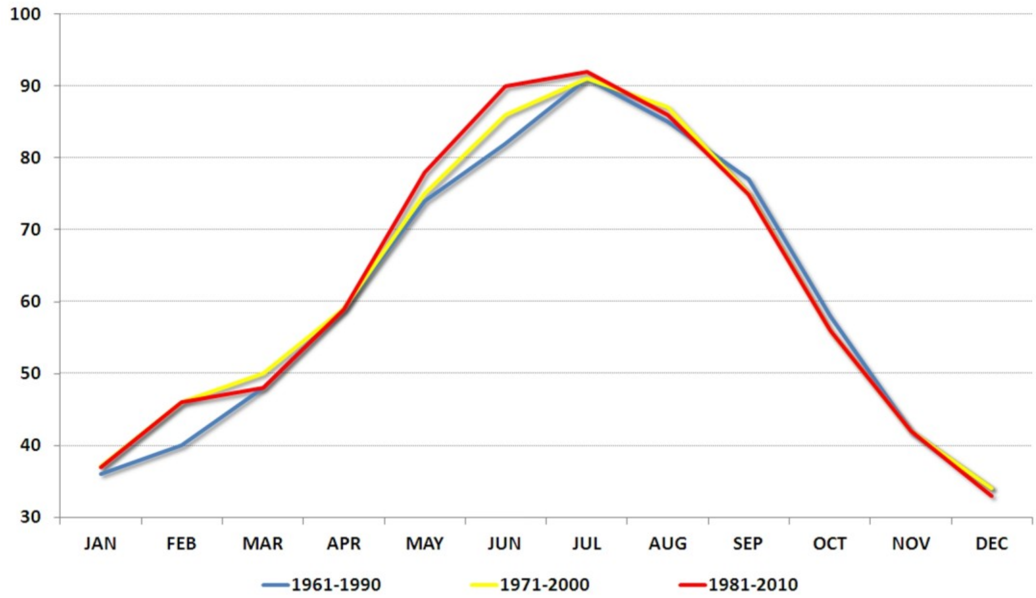

Fig. 3 The 30-year averages of the monthly means of Mieczkowski's Tourism Climatic Index in Siófok

est values (TCI ≥ 80) occur during the summer months, but altogether, the period from "good" to "ideal" lasts from May to September. The climatic requirements of tourism are not appropriate ("unfavourable") only in two months (December and January), but the TCI values do not go below 30 in these months.

Examining each climate periods it can be concluded, that there was no significant change in the climatic terms of the tourism in the last half-century in the studied region. The averages of TCI increased significantly only in February and June. The latter means the prolongation of the bath season in summer.

The change of TCI can be examined in more detail by analyzing the changes of sub-indices. Significant differences could not be explored between the two 30-year periods with 20-year difference by examining *Fig. 4*. However, some small characteristics can be observed. In February, the more favourable daytime comfort and precipitation conditions cause higher values of the TCI. This change in climate comfort can also be observed in May. In June, however, especially the aesthetic and physical components of the tourism climate changed favourably. The greatest change occurs in the wind conditions – this sub-index increased by 4 points.

Based on the CTIS diagrams (*Fig.* 5 and *Fig. 6*), from a thermal point of view, the favourable period (when the PET value is between 18 and 29°C) lasts from early May until the first third of October. Interesting that in contrast to the TCI graphs, we can talk about two-peak tourism season based on CTIS. The highest frequency of thermal comfort occurs in the end of May and in the middle of September. The rate of the comfort periods decreases temporarily during the summer months; this ratio is close to 30% in late July and early August. Heat stress (PET>35°C) should be expected typically in the summer months. The warmest period lasts from middle of July until beginning of August, when the highest frequency of heat stress occurs. Although, it should be noted, that the bathing potential of the area offset or makes it easier to endure these circumstances. The cold-stressed periods are frequent between mid-December and the end of January. The sultriness which is an important parameter in the thermal aspect reaches its maximum in early August, when the probability of these weather conditions is 50–60%. Comparing the period of 1961–1990 and

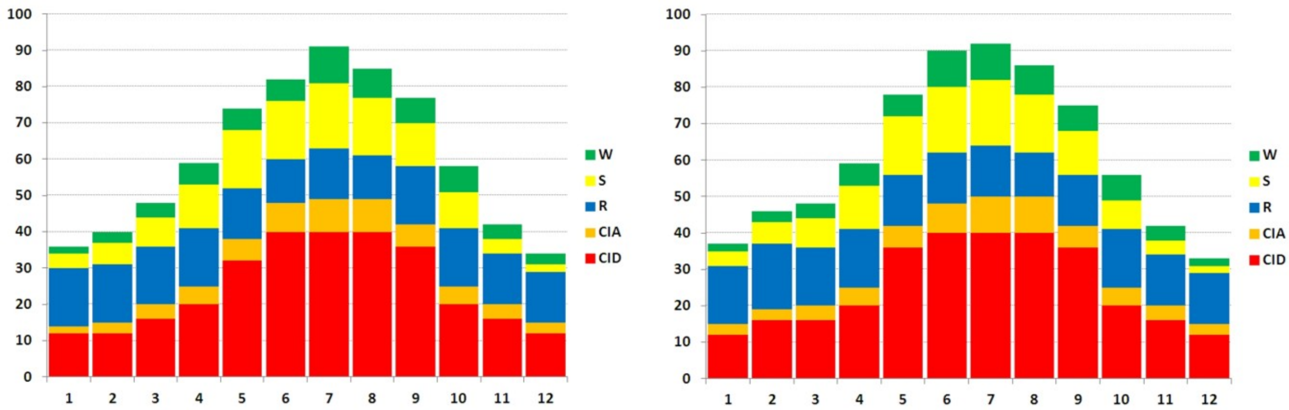

Fig. 4 The 30-year averages of the monthly means of sub-indices of TCI in Siófok for the period of 1961–1990 (left) and 1981–2010 (right)

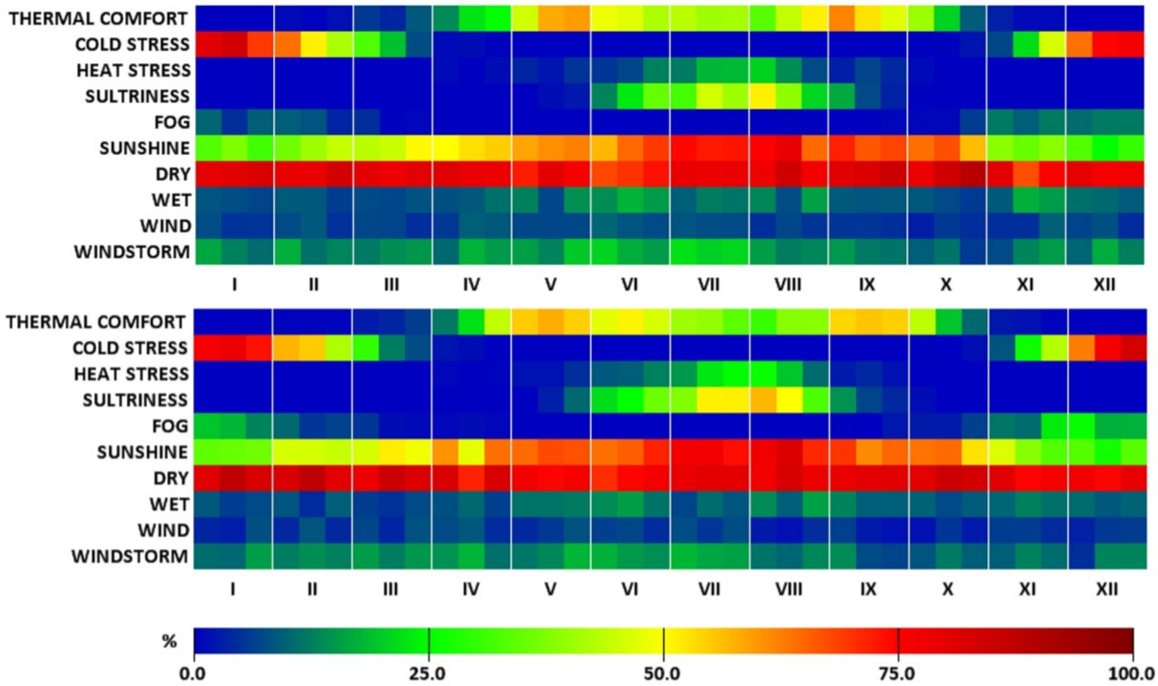

Fig. 5 CTIS (percent-type) in Siófok for the period of 1961–1990 (upper) and 1981–2010 (lower)

1981–2010, the above mentioned characteristics have become stronger, but the length of the tourism season did not change significantly.

The frequency of sunny days (according to the criteria) is favourable in terms of waterside tourism. Its ratio is above 50% during the period from April to October, but in July and August this ratio is close to 70–80%. Foggy weather can be expected from September to April, but its relative frequency of more than 20% is only in December and the first half of January. Examining the two 30-year periods, significant change can be seen especially in sunny days. The period of the sunny days increased in all seasons except in winter. This indicates the positive changes in the aesthetic component of the region's tourism climate.

The physical factors influence the region's tourism climate in a positive direction as a general rule. The precipitation and wind do not worsen the comfort sensation of the tourists. In this regard, there is no significant change between the two climate normal periods. The CTIS diagrams confirm the empirical fact that the climate of Lake Balaton is appropriate for lakeside tourism and other outdoor activities in the warmer half of the year.

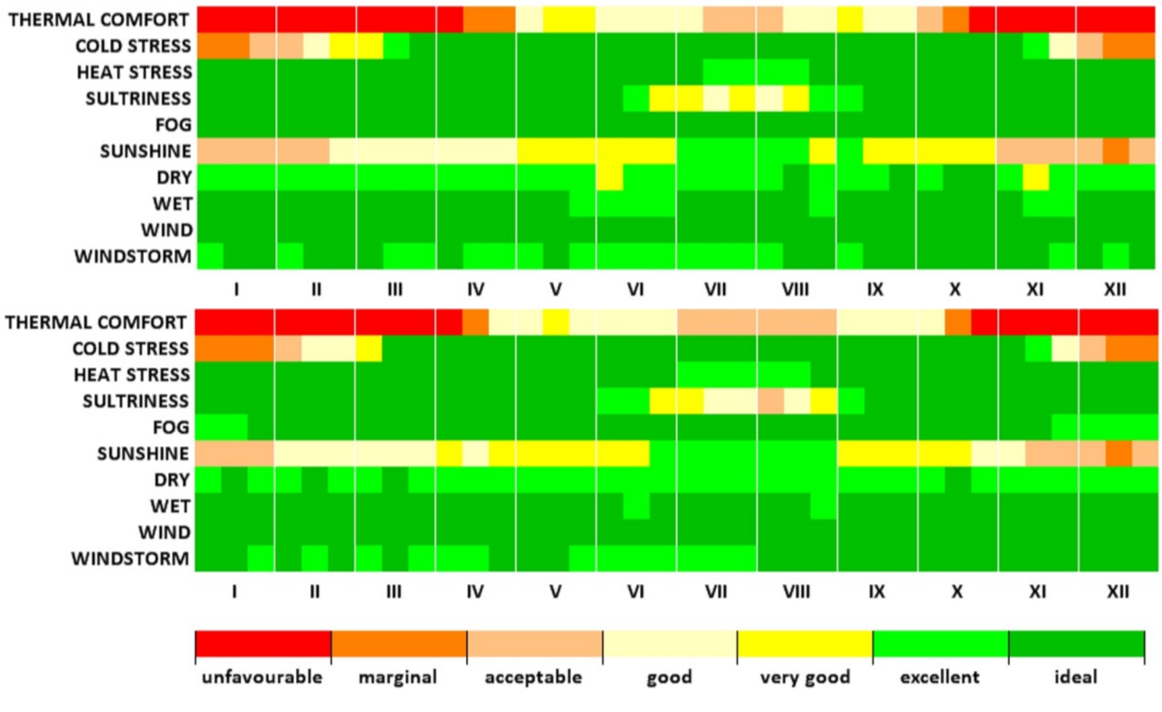

Fig. 6 CTIS (assessment-type) in Siófok for the period of 1961–1990 (upper) and 1981–2010 (lower)

CONCLUSIONS

Tourism climate is generally described by air temperature, precipitation and sunshine duration. Although these parameters are important, they do not describe the tourism climate potential of an area appropriately. Therefore, the tourism purpose examinations necessary to use such integrated indices or rating systems which take into account all the components of the tourism climate (physical, aesthetic and thermal). This paper means a step forward in this regard, because tourism climatological analyses with similar approach are not made previously. The results presented here can be easily interpreted for the travelling public and tourism operators.

The Mieczkowski's TCI index shows that the Lake Balaton Region's climate potential is favourable. The region has a positive climate for the lakeside tourism and other outdoor activities, especially in summer. The observed changes are insignificant over the past half-century; the climate potential only hardly changed. However this does not means that the future changes in the climate does not may cause a marked changes in the region's tourism climate. These analyses have to be carried out towards sustainable tourism development. Recent studies have shown that the region's climate supports only slightly the possibility of extending the tourist season.

Although the TCI is primarily developed for the analysis of urban tourism, it can be used almost in all sectors of the tourism industry. The TCI can be widely used because easy to calculate and does not require specific input data. In the future, however it would be advisable to examine that instead of the thermal comfort index (effective temperature), which is used in TCI, can be applied to other, modern bioclimatic index based on human energy balance (eg. physiologically equivalent temperature).

Based on CTIS, the region's tourism climate potential pattern is slightly different, it is rather bimodal. This is probably due to the CTIS factors were selected accordingly the tourism of this region (beach or lakeside tourism). Over the past 50 years, changes were appeared in the thermal and aesthetic (sunshine duration) components. In summer, the change in heat stress and sultriness may affect negatively to the tourism in the region. At the same time, the increase in sunshine duration assists to the beach tourism. On the whole, the tourism climate potential of Lake Balaton Region rose slightly over the past 50 years due to the changing climate.

Comparing the classic TCI with the CTIS, it should be highlighted the better temporal resolution and a more detailed criteria-system of the CTIS. The 10-days resolution of CTIS is near to the average length of stay of visitors.

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