

## VARIATIONS OF THERMAL BIOCLIMATE IN THE LAKE BALATON TOURISM REGION (HUNGARY)

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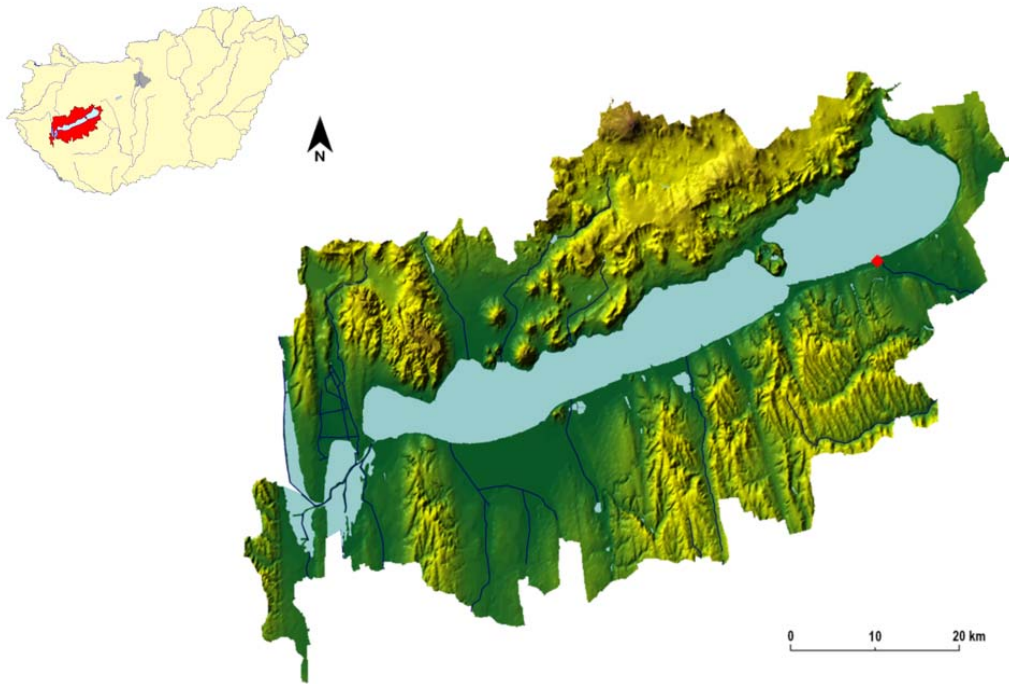
**ABSTRACT** Tourism is the most important branch of the service sector in Hungary. According to the Hungarian Tourist Authority, tourism in Hungary adds up to 8.7% of the GDP and 12% of the number of employees. Higher rate can only be found in the Mediterranean countries. Therefore it is important to provide satisfactory climatological information to this considerable economic sector.

In this paper at first we analyse the variations of some conventional climate parameters (temperature, precipitation, sunshine duration, etc.) at the Lake Balaton Tourism Region. Secondly we analyse the variations of PET, the thermal bioclimate indices based on the human energy balance models. For calculating PET indices we used measurements of Siófok synoptic station. According to our results, PET is applicable to examine climate change. Our most important results were that at winter bioclimate did not change significantly while in summer the frequency of days with strong and extreme heat stress increased widely during the last 40 years.

**KEYWORDS:** *Thermal bioclimate, Physiologically Equivalent Temperature, Climate change, Lake Balaton*

### INTRODUCTION

Lake Balaton is the largest freshwater lake in Central-Europe and represents one of the greatest environmental treasures and a unique ecological fortune of Hungary. The Lake Balaton's surface is about 600 km<sup>2</sup>; it is 77 km long and 14 km wide at its largest width. The deepest point of the lake is 11 m, but its average depth is only 2 to 3 meters. Its popularity results from the lake's favourable climate, its warm water in summer, and the nice landscape surrounding the lake. The Lake Balaton Tourism Region [LBTR] (Fig. 1) is part of three counties, three different statistical (NUTS-II) regions and involves 41 settlements situated right on the lakeside and 123 nearby. The total area of the LBTR is 3780 km<sup>2</sup>.



**Figure 1: Location of the Lake Balaton Tourism Region**

Although the LBTR is one of the most important tourism regions of Hungary its climate has been studied last time at the 70's (Béll and Takács, 1974). From the beginning of the 2000's the tourism of the LBTR went through a crisis. Because of the consecutive hot and dry years, water level of the lake decreased significantly, resulting in relatively large lands coming out of water in the southern coast. Some people visioned even about the total drying up of the lake. Even though the water-quality didn't fall off, more and more people chose the Adriatic and Aegean coast for their holidays instead of the Lake Balaton. This process turned our attention to the impact of the climate change on the lake's tourism. Previously, only conventional climatic parameters (e.g. air temperature and precipitation) have been examined in Hungary in connection with tourism. At the Climate Division of the Hungarian Meteorological Service in 2005 have been suggested that we should examine the thermal bioclimate of this region and variation of thermal bioclimate.

Although in the 70's the characteristics of Lake Balaton's bioclimate have been analyzed, these researches based on the empiric examines of the comfort-sense only. As far as we know, complex and exact tourism climate research based on calculation of bioclimatic indices has not been fulfilled in Hungary up till now.

## **METHODS**

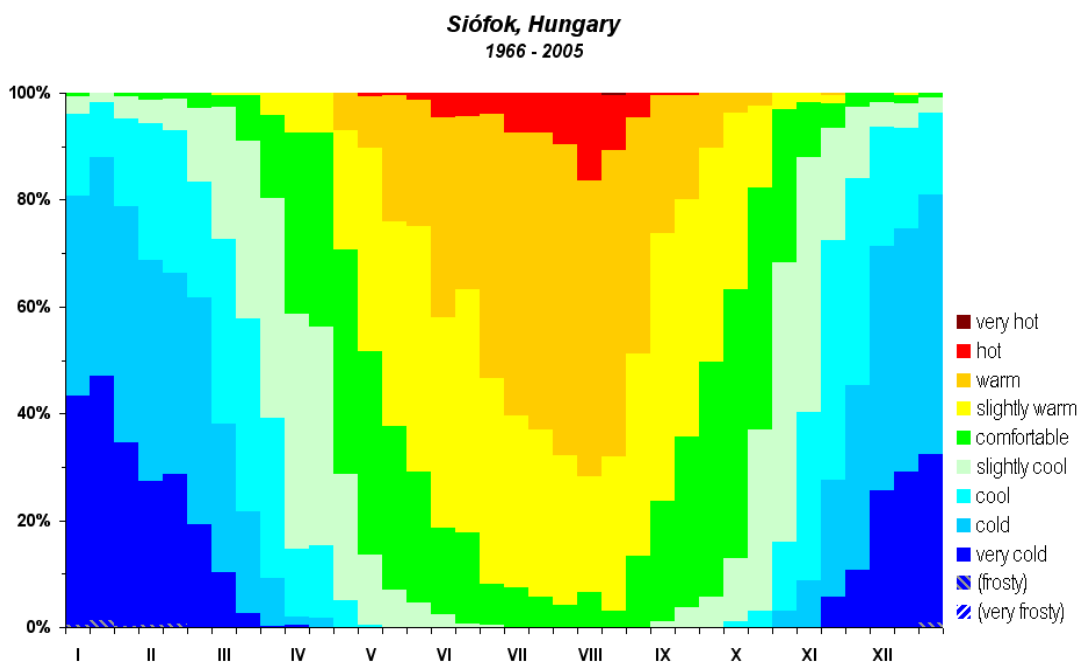
For analyzing general climatic conditions we used the daily data series of the Siófok synoptic station (46°54' N and 18°02' E; elevation: 108 m asl.). As this station operates continuously at the

same place since the end of the 50's, we considered this data series as homogeneous and accepted it without reservation.

For analyzing the thermal bioclimate we applied the physiologically equivalent temperature (PET), the well-known and one of the most frequently used bioclimate index based on the human energy balance models (Höppe, 1993, 1999, Matzarakis et al., 1999, VDI, 1998). For calculating PET we used the RayMan model (Matzarakis et al., 2001, Matzarakis and Rutz, 2005). For the calculation we need to possess four meteorological parameters (air temperature, relative humidity, wind speed and cloudiness) as well as some standard physiological parameters (age, genus, bodyweight, height, average clothing and working). We calculated the daily PET series (at 12 UTC) for the period 1966 – 2006.

## RESULTS

According to the 41-year mean annual and seasonal PET the thermal bioclimate of the Lake Balaton area is slightly cool ( $PET_a = 13.6 \text{ }^\circ\text{C}$ ), with very cold winters ( $PET_{\text{winter}} = -1.3 \text{ }^\circ\text{C}$ ) and slightly warm summers ( $PET_{\text{summer}} = 27.5 \text{ }^\circ\text{C}$ ).



**Figure 2: Bioclimate diagram for Siófok, period 1966-2005**

On the bioclimate diagram (Fig. 2) two noticeable characteristics are of the Lake Balaton's climate can be found. The first is the temporary temperature decrease at the beginning of summer. It is closely connected with the beginning of rainy period (it is also called "European monsoon"). The second characteristic can be found at the end of September, when the rate of comfortable days increases provisionally. This period is called Indian summer.

Analyzing the 41-years changes, in the examined period yearly mean of PET increased by 2.6 °C according to the linear trend. Hence, the annual mean rising was just above 0.06 °C, however the warming was not consistent during the observed 41 years. The warming was the most intensive in the 70's, while since the middle of the 80's the rising rate has been smaller.

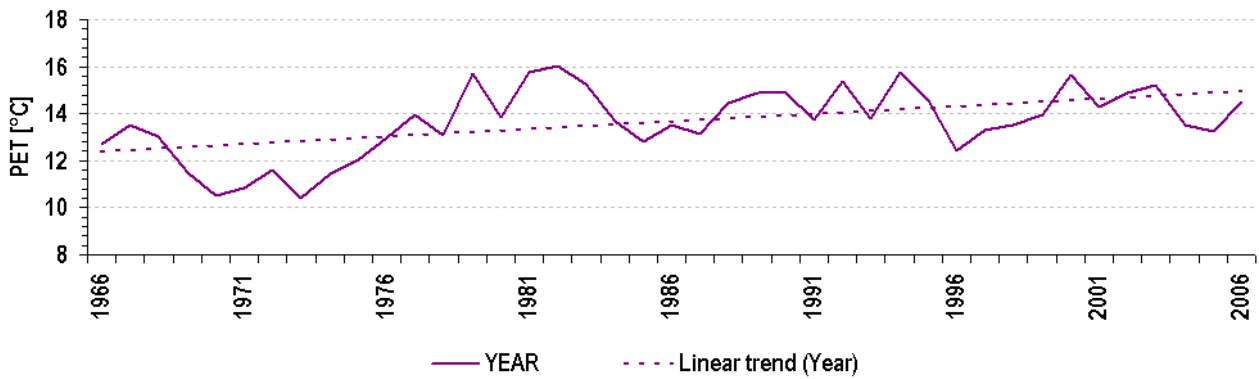


Figure 3: Mean annual PET for Siófok, period 1966-2006

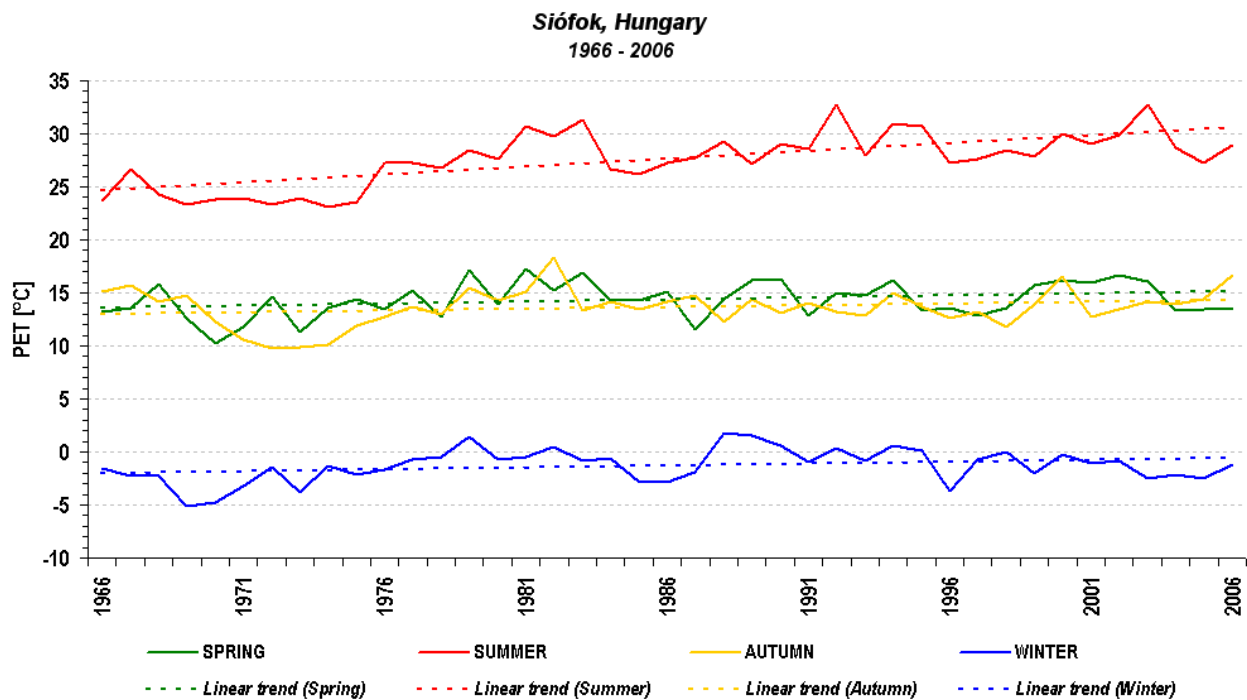


Figure 4: Mean seasonal PET for Siófok, period 1966-2006

The variation of seasonal means of PET (Fig. 4) shows very interesting characteristics. The change in PET values is the greatest in summer. This trend means more than 0.15 °C increase per year, which is 3 to 4 times bigger than in the other seasons.

Whilst the seasonal and yearly mean of PET increased, the number of heat-stressed days increased as well (Fig. 5.). Today the rate of days on which the PET exceeds 29 °C is twice as much than in the middle of the 60's.

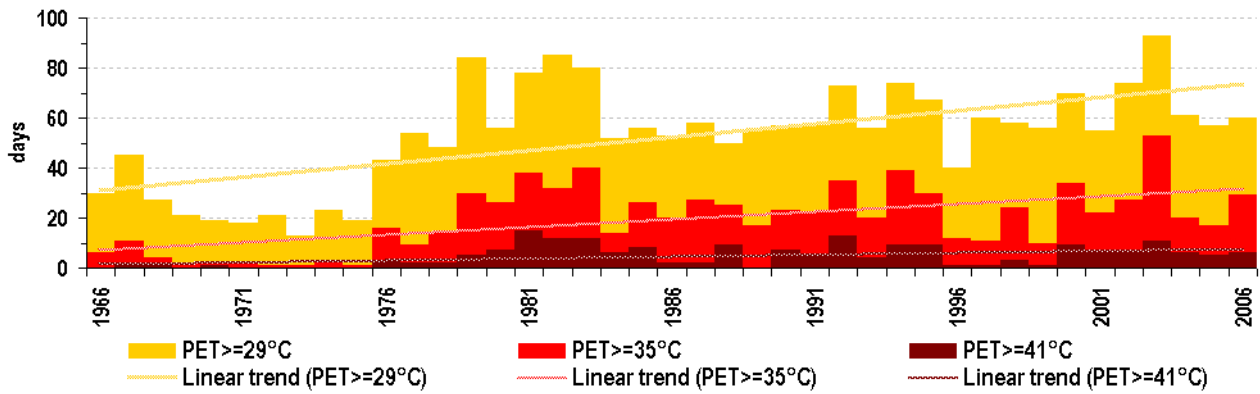


Figure 5: Variation of number of days when the PET ≥ 29; 35 and 41°C) for Siófok, period 1966-2006

The number of comfortable days (when the PET is between 18 and 23 °C) decreased simultaneously with the increasing ratio of heat-stressed days (Fig. 6). In the recent years the number of comfortable days are just third of their number in the middle of 60’s. This tendency is a remarkable phenomenon.

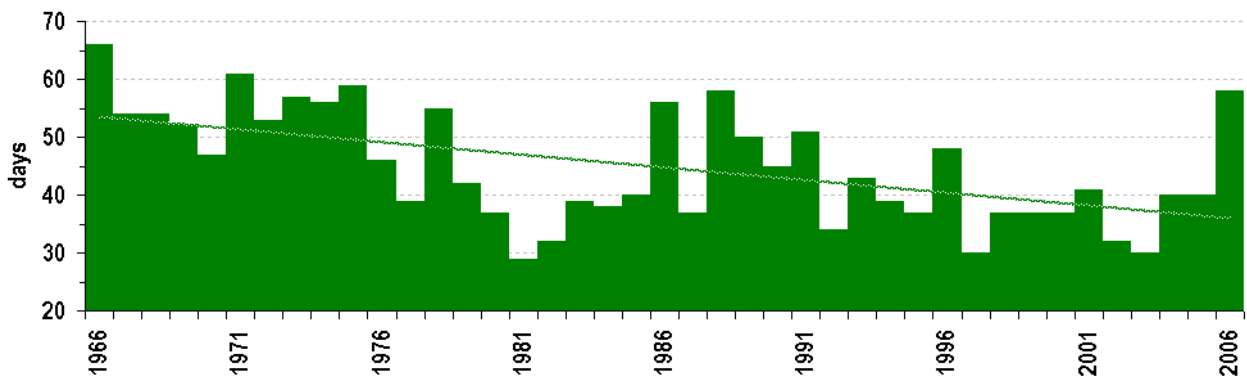


Figure 6: Variation of the number of comfortable days (18°C > PET > 23°C) for Siófok, period 1966-2006

## DISCUSSION

It is indisputable that the change of global climate is under way. The effects of climate change affect all participants of the global economy, as well as the tourism sector. For that very reason, it is important that we will be fully aware of the rate and direction of this change. The tourism sector expects the climatologist to do complex researches. We must not to be satisfied with examining only the variation of air temperature or precipitation sums. One of the possible ways is determine the thermal bioclimate using bioclimate indices. The bioclimate indices (e.g. physiologically equivalent temperature) are based on human energy balance models. For calculate this indices many different climatic parameters are needed. Therefore these indices are much more useful for the tourism than some conventional climatic parameters.

In our work we calculated the physiologically equivalent temperature at the Lake Balaton Tourism Region for period 1966 – 2006. In these 41 years we detected the variations of thermal bioclimate.

The annual and seasonal means of PET are on the increase. The number of comfortable days is on the decrease. On which way affects this change the tourism of Lake Balaton? If these trends will continue in the next years, we must expect some positive and some negative results. The increasing demand for the waterside as well as the increasing length of the tourism season are the possible positive results. Negative impacts may be the overflowing beaches, the ecological problems resulting from the crowd, and the increasing frequency of certain extreme weather events (heat-waves, storms, droughts, vegetation fires, etc.). These possible impacts mean that the tourism industry needs to draw up adaptation plans on behalf of the sustainable tourism.

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