Temporal differences of urban-rural biometeorological factors for planning and tourism in Szeged, Hungary

Ronja Vitt[1], Ágnes Gulyás[2], Andreas Matzarakis[1]

[1] *Albert-Ludwigs-University of Freiburg, 79095 Freiburg, Germany*

2 Department of Climatology and Landscape Ecology, University of Szeged, P.O. Box 653, 6701 Szeged, Hungary

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1. Introduction

There are several factors which affect the potential for tourism activity of a city or area, for example culture, landscape, leisure possibilities, geographical position, but also weather and climate (Hall 1992, 1998). The climatic conditions of a city or area are crucial to maintain tourism and can be altered by urban planning, which is important as the tourism sector has an important influence on the Hungarian gross domestic product. The climate of a city can be considerably different than the climate of the rural surrounding. Among others, the topographic background, height of the buildings, surface structure, sealing and street width affect the urban climate (Matzarakis 2001). One of the most displeasing effects is the increase of heat storage of the surfaces during the day and a reduced cooling during the night, which affects well-being and recreation of tourists and locals. Since tourists prefer to avoid any kind of stress during their vacation, it is necessary to prepare information about the biometeorological conditions during their stay (Matzarakis 2006, 2007a). Therefore the seasonal and diurnal probability of heat or cold stress and other crucial biometeorological factors for tourism are analyzed for Szeged and the rural outer conurbation area (Vitt et al. 2015).

2. Methods

The meteorological and biometeorological conditions of Szeged, a mid-sized city in southern Hungary, were analyzed for its urban and rural areas. The Hungarian Meteorological Service and the University of Szeged provide an urban and a rural weather station. In this study, the period between 2000 and 2011 is used. The urban weather station is located in the heavily built-up city center of Szeged, including measurements on the roof and a lawn beneath the university building. The rural area is represented by the synoptic weather station to the west of Szeged, which is located in grassland area.

In order to evaluate the influence of meteorological parameters on human beings, the biometeorological index Physiologically Equivalent Temperature (PET) is used (Höppe 1999, Matzarakis et al. 1999, Mayer and Höppe 1987). PET is defined as the assessed air temperature under complex outdoor conditions, at which the human energy budget is balanced at typical indoor conditions. The meteorological input variables air temperature, wind velocity, relative humidity or vapor pressure and global radiation are mandatory to calculate PET (Matzarakis et al. 1999). This index is easy to understand and interpret also for non-experts, as its unit is given in °C. The course of PET during the year is illustrated in a frequency diagram at 14 CET for urban and rural areas. The representation of the data is chosen in ten days intervals, as this time span is close to the mean vacation duration (Gulyás and Matzarakis 2009).

The precipitation in Szeged is also presented in frequency classes, to show not only the total monthly amount, but also the intensity classes of precipitation events. Insolation is given when the global radiation exceeds the threshold value of 180 W/m². The mean daily hours of insolation per day and the mean total cloud cover per decade are shown for the rural area (Zaninović and Matzarakis 2009).

In the Climate-Tourism/Transfer-Information-Scheme (CTIS), more detailed tourism relevant meteorological and biometeorological information are presented (Lin and Matzarakis 2008, Matzarakis 2007b, 2012). The probability of thermal acceptance (18.0 °C < PET < 29.0 °C), heat stress (PET > 35.0 °C), cold stress (PET < 4.0 °C), cloudiness (cloud cover clct < 4), fog (relative humidity RH > 93 %), sultriness (vapor pressure VP > 18 hPa), windy (wind velocity v > 8 m/s), dry days (precipitation RR < 1 mm) and wet days (RR > 5 mm) are analyzed for 7, 14 and 21 CET. These thermal, aesthetic and physical facets of climate are shown in ten days intervals as absolute frequencies.

3. Results

The frequency diagrams of PET for urban and rural areas at 14 CET are shown in Figure 1 and 2. The probability of cold stress, thermal comfort and heat stress are easy to identify for each ten days interval of the year. The mean annual PET value of the urban area amounts 19.3 °C and 17.8 °C in the rural areas. The range of minimum and maximum values is larger in the rural areas and extends from -20.8 °C to 50.6 °C, while there are PET values between -15.8 °C and 48.9 °C in the city of Szeged.

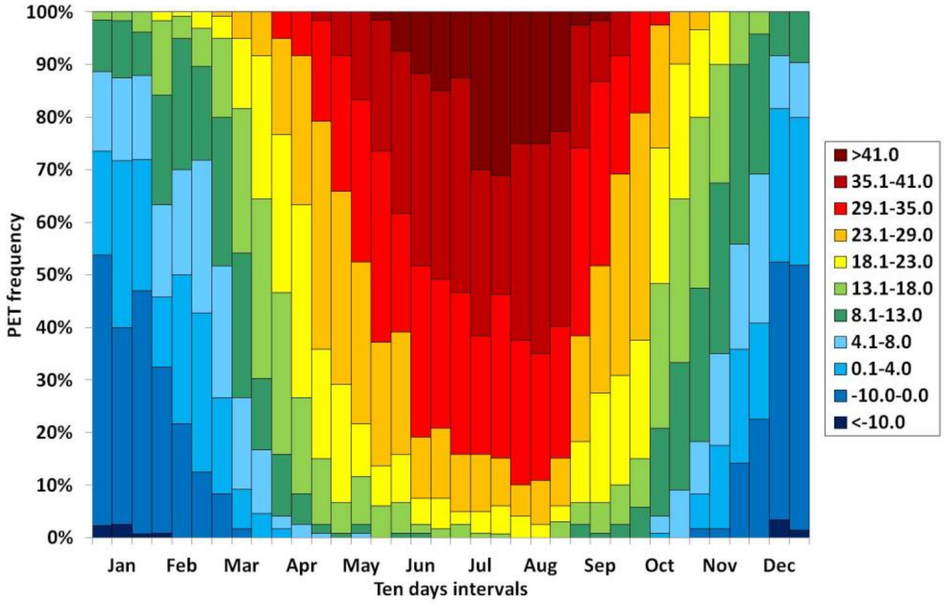

Fig. 1 Frequency diagram of PET at 14 CET for urban areas based on ten days intervals

The highest probability of cold stress is given between December and February with 62.0 % and 69.4 % and a mean PET of 2.4 °C and 0.8 °C for urban and rural areas, respectively. Throughout the year, there are 67 days of cold stress with PET values < 4 °C in the urban areas and 78 days with cold stress in the rural areas. Cold stress can generally occur between October and April with a minor probability. There is no chance of thermal acceptance in December and January neither in urban nor in the rural area around Szeged. Generally, the probability of thermal acceptance is higher in the city of Szeged during spring and autumn, while thermal acceptance is less frequent during summer and early autumn than in the rural areas. About every second day is assumed to be thermally comfortable in April, May, September as well as October, and 84 days of thermal comfort during the whole year at both sides.

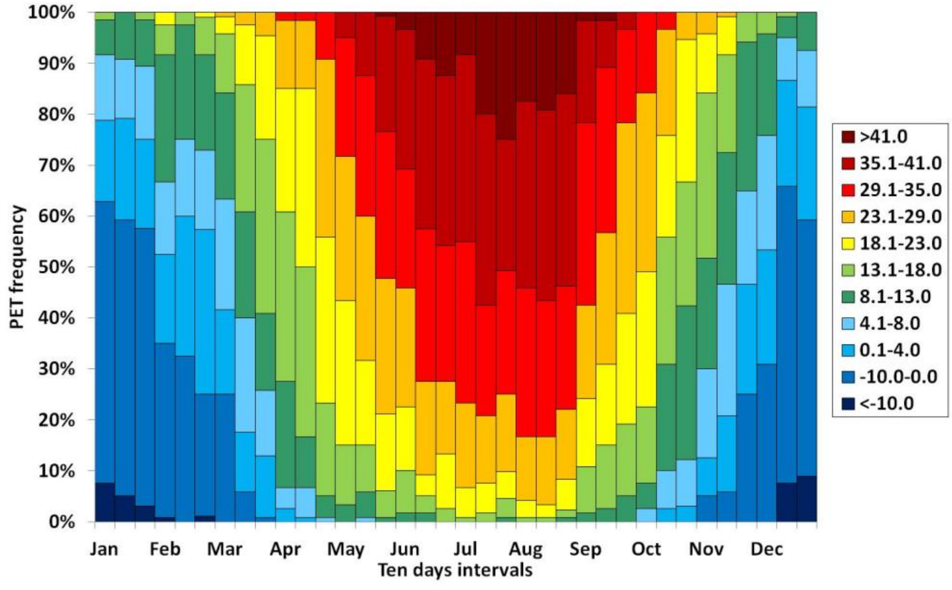

Fig. 2 Frequency diagram of PET at 14 CET for rural areas based on ten days intervals

Between April and September, heat stress can occur in the city of Szeged and its surrounding rural area. Even though heat stress is slightly less frequent in rural areas during summer, every second day of the season exceeds the threshold PET value for heat stress of 35.0 °C. In the same period, the probability of thermal acceptance amounts 16.0 % and 21.9 % for urban and rural areas, respectively. The average PET during summer is 34.9 °C in the city, while the rural mean PET is 1.2 °C lower. There are less heat stress days in rural areas (53 days) than in the urban areas (61 days).

The difference of precipitation between urban and rural areas is negligible, therefore only the urban situation is presented. Szeged has a total annual amount of 520 mm and about 73 days of precipitation per year (Fig. 3). The highest amount of precipitation falls during summer with a total of 180 mm. The maximum monthly amount of precipitation is detected in June (82 mm), which has an average of 8 rain days, while January has the least amount of 25 mm and about 5 rain days. The precipitation events during summer are more intense than during winter.

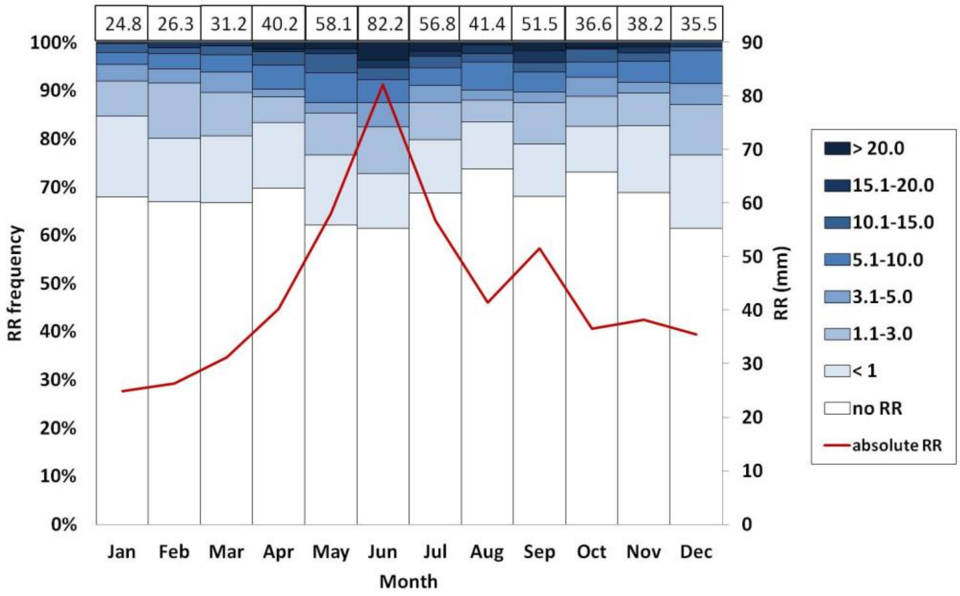

Fig. 3 Frequency diagram of precipitation intensity classes and total amount of the mean monthly precipitation (RR)

Szeged has more than 2100 hours of sunshine with a global radiation > 180 W/m² and therefore it is known in Hungary as the “city of sunshine” (Fig. 4). During summer months, Szeged has averaged 9.3 hours of sunshine per day, which drops to averaged 2.3 hours of sunshine per day in winter. The mean annual cloud cover is 4.6 octas with a higher cloudiness of averaged 5.7 octas during winter and 3.6 octas during summer.

The probabilities of the thermal, physical and aesthetic facets of climate are analyzed for every decade of the year at 7, 14 and 21 CET for urban areas (Fig. 5). The differences of the probability of the facets between the urban and rural areas are illustrated in Figure 6.

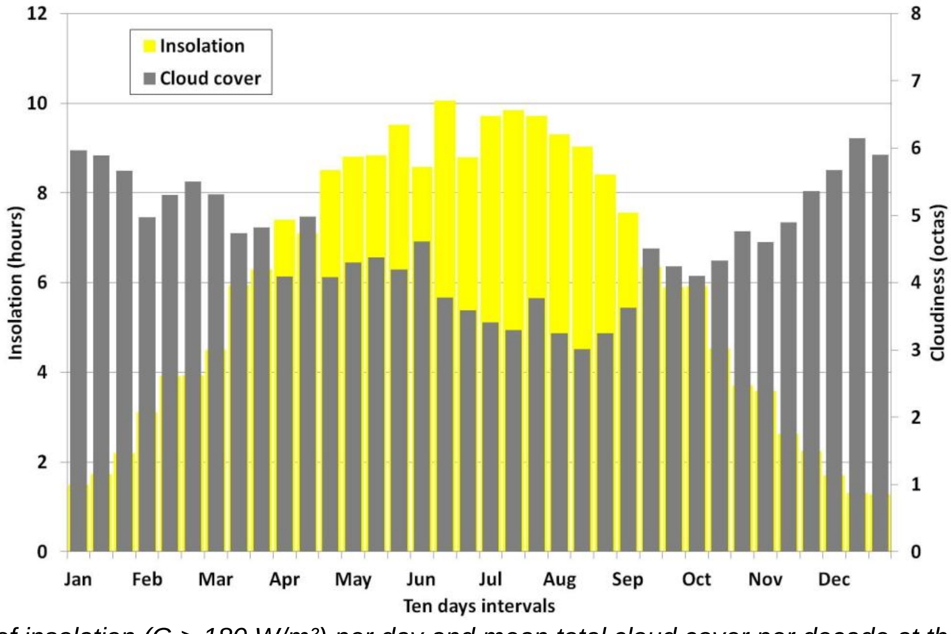

Fig. 4 Hours of insolation (G > 180 W/m²) per day and mean total cloud cover per decade at the rural station

In the urban areas thermal acceptance is very likely between March and August at 7 CET and slightly less frequent at 21 CET, while thermal acceptance at 14 CET predominantly appears in the transitional months (spring and autumn) and not during summer. There is almost no chance of heat stress in the morning and evening hours throughout the year, whereat there is a high probability of heat stress at 14 CET during summer. In this diagram, it is easy to detect that cold stress is very likely in winter at any time of day. A cloud cover < 4 °C occurs more frequent in summer than in winter, and is even more probable in the evening hours at 21 CET. In the winter months, two of ten days are foggy at 7 CET, which decreases during the day. Between 1 % up to a maximum of 5 % of the days are foggy in summer for all the analyzed hours. Vapor pressure values > 18 hPa can occur from May until September with a possibility of about one third at 7 and 21 CET in July and August and about one fourth at 14 CET. The averaged wind velocity and wet days are insignificant, as they seldom exceed the threshold values of v > 8 m/s and RR > 5 mm, respectively. Since the daily amount of precipitation is observed, the frequency of wet and dry days is the same at any time of the day. Almost two third of the days in the first decade of June and nine out of ten days in the second decade of January are assumed to be dry days.

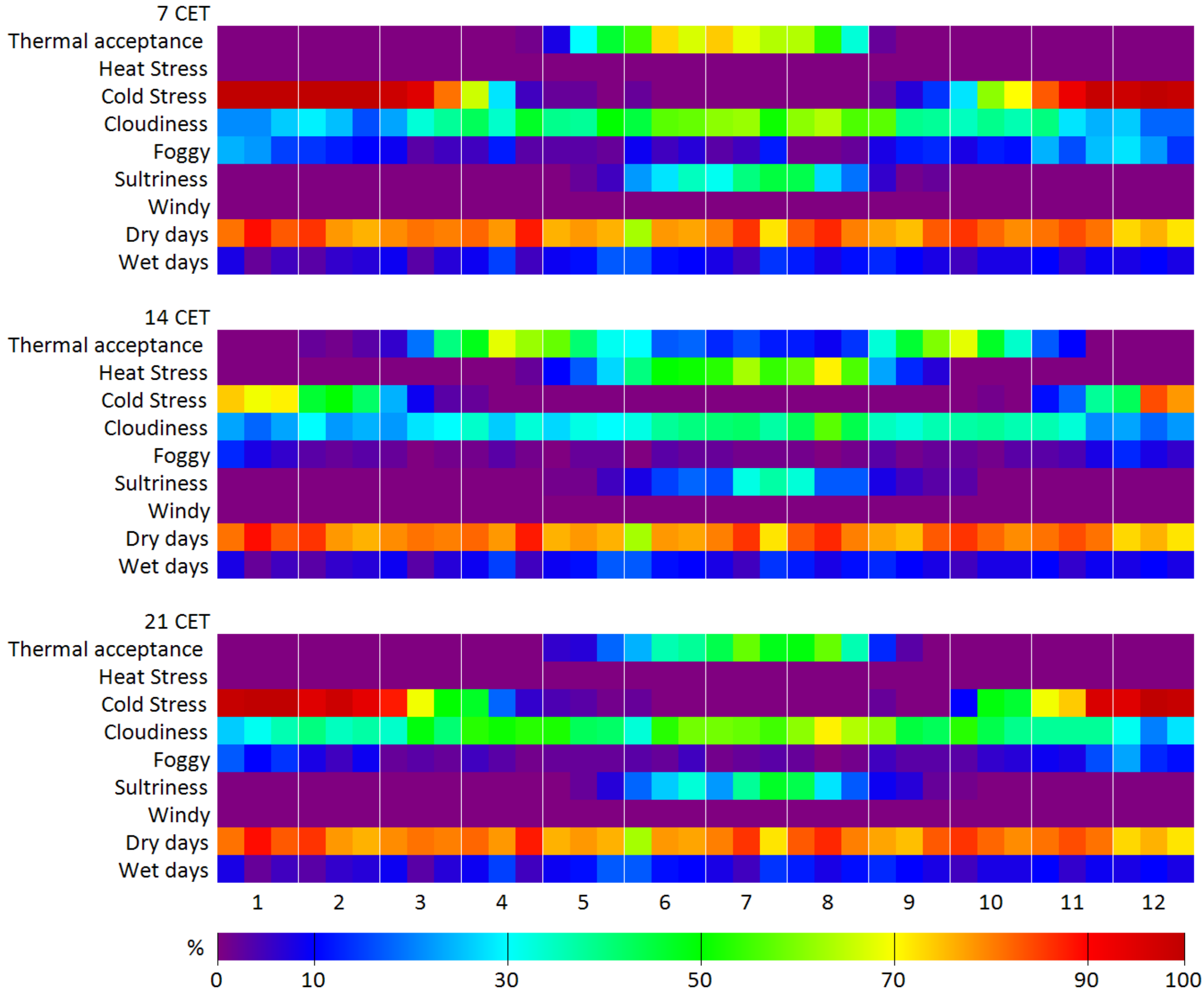

Fig. 5 Climate-Tourism-Information-Scheme in decades at 7, 14 and 21 CET at the urban station with frequency categories of the parameter Thermal acceptance (18 °C < PET < 29 °C), Heat stress (PET > 35 °C), Cold stress (PET < 4 °C), Cloudiness (clct < 4 octas), Foggy (RH > 93 %), Sultriness (V P > 18 hPa), Windy (v > 8 m/s), Dry days (RR < 1 mm) and Wet days (RR > 5 mm)

The bioclimatological conditions of the urban and rural areas are similar, but the expected differences can easily be recognized in Figure 6. Thermal acceptance is more frequent in urban areas during the summer in the morning and evening hours. In the afternoon at 14 CET, thermal acceptance is more likely in some decades of March, April and October in the city of Szeged, whereat in summer there is a 10 % higher chance of thermal acceptance in the rural areas. Heat stress also occurs more frequent at 14 CET in urban areas during summer than in the rural surroundings. There is less cold stress throughout the days in spring and autumn in the city, as well as less fog during the whole year and less sultriness in summer.

In this kind of diagram, the bioclimatological conditions of destinations can be shown in a simple and well-arranged way, to inform tourists about the predominant weather conditions during their stay.

4. Discussion and Conclusion

The temporal differences of meteorological and human biometeorological conditions between urban and rural areas of Szeged were analyzed. The urban climate is influenced by the anthropogenic urban structures, e.g. degree of sealing, street orientation, street width and height of building (Matzarakis 2001). On the one hand, the increased surfaces absorb and emit more radiation and on the other hand wind speed is reduced due to a higher roughness length in cities. Therefore the mean annual PET value is generally higher in urban than in rural areas around Szeged, but higher short-term extreme values are identified in rural areas. Gulyás et al. (2010) and Gulyás and Unger (2010) came to the same conclusions in their studies.

In the morning and evening hours, thermal acceptance is more likely in urban areas, due to the heat storage of the buildings in cities, while in rural areas thermal acceptance becomes more frequent and heat stress less frequent around noon compared to the urban areas. There are marginal differences of the large-scale weather

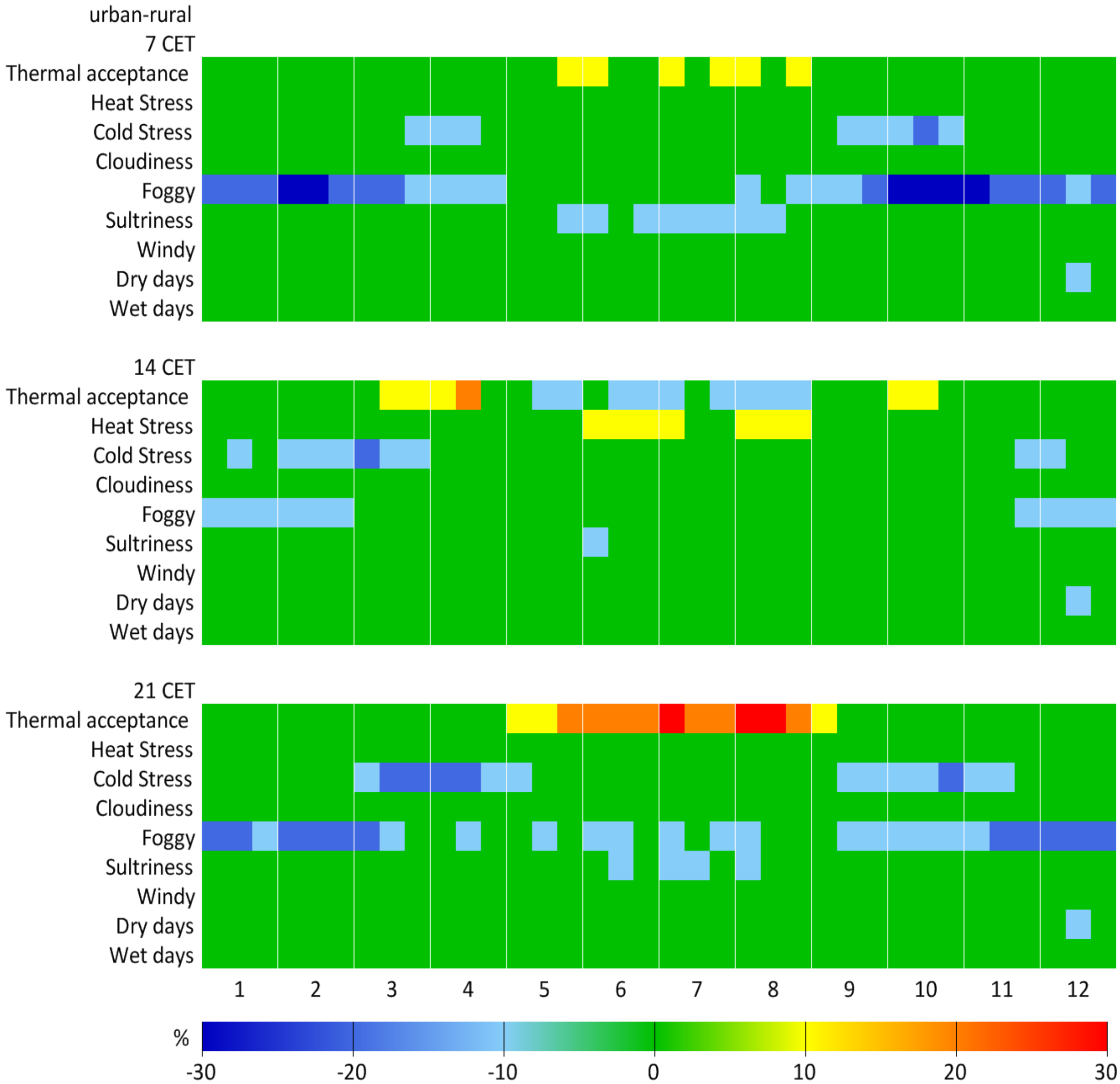

Fig. 6 Climate-Tourism-Information-Scheme in decades at 7, 14 and 21 CET for the difference of frequency between the urban and the rural station, for the parameter Thermal acceptance (18 °C < PET < 29 °C), Heat stress (PET > 35 °C), Cold stress (PET < 4 °C), Cloudiness (clct < 4 octas), Foggy (RH > 93 %), Sultriness (V P > 18 hPa), Windy (v > 8 m/s), Dry days (RR < 1 mm) and Wet days (RR > 5 mm)

events precipitation, insolation and cloud cover, as the horizontal distance between the urban and rural weather station is a few kilometers.

The combination of selected meteorological and biometeorological parameters in the Climate-Tourism/Transfer-Information-Scheme gives a brief and highly informative overview of the frequency of the facets of climate (Matzarakis 2012, 2014). Tourists can easily detect the most favorable climatic conditions, which are preferred for an individual stay. Leisure activities can be adapted and planned according to the expected weather situation, in order to avoid thermal stress conditions which can provoke health issues. According to the results, it is advisable for tourists to visit the city of Szeged or its rural areas either in spring or autumn. In these seasons, the least probability of heat and cold stress is given, while thermal acceptance is very likely at noon.

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