WEATHER AND CLIMATE RISK FACTORS FOR TOURISM

J. MIKA, K. ZANINOVIC, L. SRNEC, M. PERCEC-TADIC, A. NÉMET

ABSTRACT. Weather and Climate Risk Factors for Tourism. The paper comprehended weather and climate risk factors for tourism with the main focus on the present climate also with some attention to the expected changes in Central Europe which are not at all advantageous and which affect the business in question both directly and indirectly. The paper intends to specify these meteorological factors and effects also in terms of the different types of touristic activities. Climate services are introduced from the experience of the Croatian partners, whereas an example on what the recent climate shift mean in terms of human bioclimate is presented in terms of a Hungarian analysis. In both investigations the so called Physiologically Equivalent Temperature plays a key role. Other examples, helping the tourism industry are presented parallel from both countries. They include high precipitation and high relative humidity information for the capital cities as examples. The paper also lists the possible adaptation measures to extreme events and also their likely changes in time.

Key words: extreme weather, tourism, climate service, climate change, adaptation, Croatia, Hungary

1. Introduction

Weather and climate, together with natural resources such as geographical location, orography and landscape play a vital role in tourism and recreation (de Freitas 2003). Because outdoor recreation is very sensitive to weather, weather and climate, although amongst the most important features attracting tourists, are also limiting factors (Perry, 1972). Health tourism is even more sensitive to climate conditions, especially to thermal conditions (Didaskalou et al. 2004; Zaninović 1998), and health tourism operators should pay particular attention to thermal conditions to avoid adverse consequences for visitors to health resorts.

Unfortunately, the role of climate in determining the suitability of a region for recreational or health tourism is often assumed to be self-evident and therefore to require no elaboration (de Freitas 2003; de Freitas and Matzarakis 2005). Misleading or selective climate information may give the tourist a false impression of their destination (Perry, 1993). However, climate-related information is often very poor and barely helps tourists in planning and scheduling their holidays or in the promotion of a tourist destination in publicity campaigns.

Though some recent publications provide overviews of the climate issue in relation to tourism and leisure (Hall, et al., 2005; Gössling and Hall, 2006; Becken and Hay, 2007; Scott et al., 2008), the effects of climate change on tourist flows and recreation patterns, these views are still far from finally established. The issue is rather complex since mountain tourism, lakes and streams, forest ecosystems, coastal and marine environment, savannah regions, urban areas, biodiversity, disease and biosecurity all comprehend series of mutually interacting direct and indirect effects of climate variations and weather extremes. In the following Sections we also try to give an overview mainly focusing on the weather and climate extremes as risk factors for tourism.

2. Weather extremes and tourism

2.1 Weather extremes

Extreme weather event is an event that is rare within its statistical reference distribution at a particular place. Definitions of "rare" vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile. By definition, the characteristics of what is called "extreme weather" may vary from place to place. An "extreme climate event" is an average of a number of weather events over a certain period of time, an average which is itself extreme (e.g., rainfall over a season). The longer-term, precipitation- and temperature-driven set of extremities contain drought, wildland fires, heat-waves, temperature extremes, melting of permafrost and occurrence of snow avalanches, etc.

Specific concern in tourism at the middle latitudes are caused by thunderstorms, tornadoes, hail, dust storms and smoke, fog and fire weather. These small-scale severe weather phenomena are weather events that are sparse in space and time and may have important impacts on societies, such as loss of life and property damage. Their temporal scales range from minutes to a few days at any location and typically cover spatial scales from hundreds of meters to hundreds of kilometers. These extremes are accompanied with further hydrometeorological hazards, like floods, debris and mudslides, storm surges, wind, rain and other severe storms, blizzards, lightning.

For example, mudslides disrupt electric, water, sewer and gas lines. They wash out roads and create health problems when sewage or flood water spills down hillsides, often contaminating drinking water. Power lines and fallen tree limbs can be dangerous and can cause electric shock. Alternate heat sources used improperly can lead to death or illness from fire or carbon monoxide poisoning.

Extreme events are often the consequence of a combination of factors that may not individually be extreme in and of themselves. Complex extreme events are often preconditioned by a pre-existing, non-extreme condition, such as the flooding that may result when there is precipitation on frozen ground. In addition, non-climatic factors often play a role in complex extreme events, such as air quality extremes that result from a combination of high temperatures, high emissions of smog precursors, and a stagnant circulation.

Very often there is a possibility to predict quite accurately the probability of severe weather events and issue warnings, or even close the endangered region temporarily. But, tourists often do not speak the language of the country in which they are spending vacation. They do not know the local signs of danger and some of them do not respect warnings and prohibitions to enter the endangered areas.

2.2 Weather relatedness of the tourism business

The famous cities are attracting many tourists. For this *urban tourism* the highest risk is the heat island effect that enhances the sometimes otherways high temperatures during the day and even until late evenings. In the big cities is already of the same magnitude as the expected climate change in the next hundred years. Cities in tropics and middle latitudes are likely to become more unpleasant for tourists during the hottest months. In middle latitudes heat waves will become more intensive and more frequent. Severe heat stress can result in deterioration in health including heat illness. Direct health effects would include increases in heat-related mortality and illness resulting from an anticipated increase in heat waves, although offset to some degree in temperate regions by reductions in winter mortality.

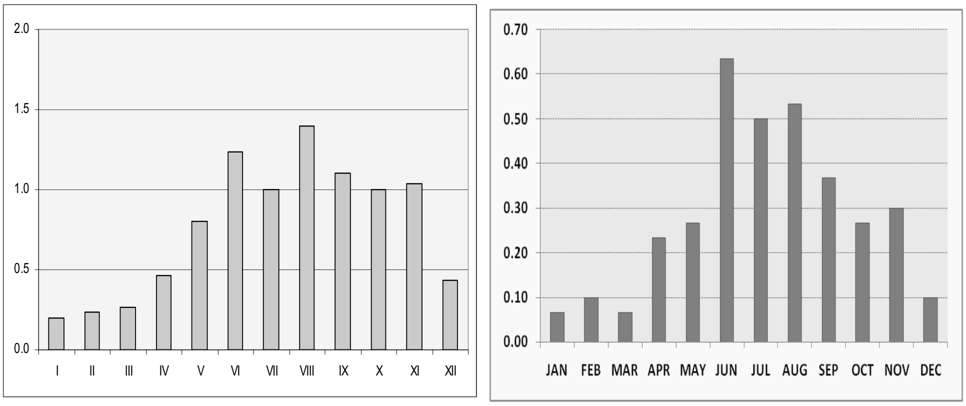
Selection of season for visiting the towns is also season-dependent due to the duration of the daylight and sunshine for sightseeing and taking pictures. There are also several humidity factors which exhibit parallel annual cycles, but which are not always considered by the visitors (or considered erroneously, based on their home - based climate experience).

Figures 1 and 2 present such variables for capital cities of Croatia and Hungary. The first one is the probability of precipitation ≥ 20 mm in 24 hours and the second one is the average number of days with relative humidity ≥ 80% at 2 p.m. in Zagreb, and 12 UTC in Budapest.

The pair of figures indicates that even within this not very big distance between the two capital cities, the extreme precipitation probability may considerably differ not only in its detailed annual cycle but also in the overall probability of the event.

Rural tourism, particularly in the mountainous areas, has traditionally been popular among free-time spenders all over the world. In summer for hiking and other recreation activities, including spas, and in winter largely based on typical winter sports. Since many locations lie on lower altitudes, their vulnerability to warmer winter and less snow cover is considerably higher (Agrawala 2007).

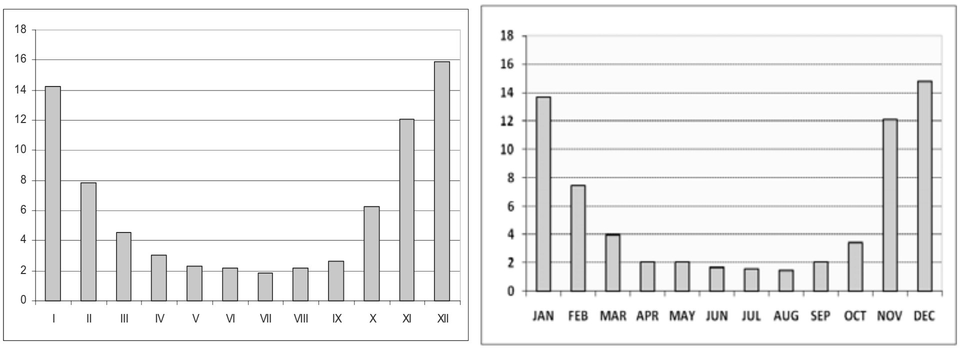
Mountain environment is very sensitive to weather. For many alpine areas winter tourism is the most important income source, snow-reliability is one of the essential elements of touristic offer. As the temperature increases also in the mountains, this also causes problems to ski slopes on glaciers in winter and



Zagreb **Budapest**

Figure 1. *The annual course of monthly number of days with precipitation ≥ 20 mm in Zagreb and Budapest*

summer skiing. Rising temperatures also cause melting of permafrost, consequently mountain areas are vulnerable to landslides, infrastructure becomes instable and hiking and climbing are more dangerous due to increasing rockfall, putting under risk even the summer activities in mountain area (hiking, trekking, biking).



Zagreb **Budapest**

Figure 2. *The annual course of number of days with relative humidity ≥ 80% at 2 pm in Zagreb and at 12 UTC in Budapest*

Islands, coasts and beaches are the pleasant sites for *beach tourism*. Different impacts on this environment tend to be the most threatening. The rise in sea level will cause coast and beach erosion, inundation of flood plains, destruction of coastal ecosystems, water-table rising, aquifer salinisation and submersion coastal plains. Since the coastal zones have often fertile soils, and are in favour for housing near the sea (ports, fisheries), the pressure on the yet undisturbed coastal zone is great.

There are many coastal activities laying their own claims to the coastal zone. Main activities are transport, aquaculture fishery, agriculture, forestry, human settlement, mining, recreation and tourism. Some major problems encountered in coastal development are the deterioration of coastal resources by destruction, over-exploitation and un-economical use; development activities along the coast, which create adverse affects on coastal resources; upland development activities having negative impact upon the downstream coastal areas and, finally, sea level rise and land fall resulting in inundation of coastal lowlands.

Health tourism is the sum of all the relationships and phenomena resulting from a change of location and residence by people in order to promote, stabilize and restore their physical or mental well-being, using health services (Kaspar, 1996).

One can divide it into two forms: medical tourism and wellness tourism. The hearts of the medical tourism are the healing and rehabilitation. The therapy is the most important among the medical and tourist services which based on natural medicinal factors (thermal water, cave, medical mud, and microclimate), and the general tourist services complement it only. The guests have resort to these services with medical prescriptions, generally. The subalpine bioclimate, for example, plays an important part inhealing and prevention of different respiratory and thyroid disease, cardiac and circulatory disease, anaemia or exhaustion at our climatic health resorts (Németh, 2008). Weather and climate have a considerable influence on asthma, hay fever and other respiratory disorders caused by various allergens, pollens and pollutants, so spending a holiday in places with healthy climate could result in enhanced work efficiency and help to prevent illnesses.

Finally let us briefly specify some *sport activities*, from the risk point of view, that are parts of various touristic activities tackled above. Need for meteorological data of some of them goes beyond information provided on regular basis in the frame of weather forecasts. Extreme sports require even better meteorological support. Some tourists may expose themselves to risk (surfing, waterskiing, winter sports, hanggliding, etc.) which make them particularly vulnerable. No tourist season is complete without the sad news of accidents befalling tourists engaged in some particular form of sporting or mountaineering activity and who are surprised by a sudden onset disaster or simply an adverse change in weather conditions. There will always be a group of "hazarders" searching for high adrenalin levels, challenging nature and the limits of possible. No information, warnings, regulations will prevent them in their intention. Let us list the weather effects on sporting individuals through one frequent way of free-time sport.

This is the *distance running* in which the individuals are mostly subject to the ambient environment. In case of bad weather conditions as high temperature, low atmospheric pressure, high humidity or strong wind, heavy rain, etc., many runners would even find it difficult to perform the planned number of kilometres. The higher the temperature is, the more physical strength will be consumed. In a hot environment, the energy supply of the human's anaerobic metabolism will increase relatively. In addition, sunshine is also an important factor, since the sunlight will increase the athletes' body temperature, and more importantly the solar infrared radiation will reduce one's capacity to dissipate body heat. Cloud amount reflects how much the sunlight, so cloudy day is most favourable for long distance running. The impact of precipitation on it is the two sides of a coin. On one hand, heavy rain will affect the performance. On the other hand, a slight rain is most advantageous for keeping the runner fresh. Although the athletes will feel uncomfortable if their clothes get wet, the rainwater on body surface will lead to faster sweat evaporation and body heat dissipation, which is favourable for performing longer distance or doing it in shorter time period.

3. Climate change and tourism

IPCC WG-I (2007), the FAQ. 3.3 states: "Since 1950, the number of heat waves has increased and widespread increases have occurred in the numbers of warm nights. The extent of regions affected by droughts has also increased as precipitation over land has marginally decreased while evaporation has increased due to warmer conditions. Generally, numbers of heavy daily precipitation events that lead to flooding have increased, but not everywhere. … In the extra-tropics, variations in tracks and intensity of storms reflect variations in major features of the atmospheric circulation, such as the North Atlantic Oscillation."

In more details one can further read the following "inconvenient" statements related to the Central European region in the appropriate pages of IPCC WG-II (2007): *Central and eastern Europe:* more temperature extremes, less summer precipitation, more river floods in winter, higher water temperature, higher crop yield variability, increased forest fire danger. *Mountain areas:* high temperature increase, less glacier mass, less mountain permafrost, upwards shift of plants and animals, less ski tourism in winter, higher soil erosion risk, high risk of species extinction. *Mediterranean region:* decrease in annual precipitation, decrease in annual river flow, more forest fires, lower crop yields, increasing water demand for agriculture, less energy by hydropower, more fatalities by heat waves, more vector-borne diseases, less summer tourism, higher risk of biodiversity loss.

None of them are advantageous, but all of them are somehow related to tourism, since climate is a principal resource for tourism. It co-determines the suitability of locations for a wide range of tourist activities, is a principal driver of global seasonality in tourism demand, and has an important influence on operating costs, such as heating-cooling, snowmaking, irrigation, food and water supply, and insurance costs (Simpson et al, 2008). Studies indicate that a shift of attractive climatic conditions for tourism towards higher latitudes and altitudes is very likely. Uncertainties related to tourist climate preference and destination loyalty require attention if the implications for the geographic and seasonal redistribution of visitor flows are to be projected (UNWTO-UNEP-WMO 2008).

4. Climate information for tourism

4.1 Climate services

Tourism sector (i.e. decision makers, tourism industries and tourists) need accurate climatological information for their decisions. There are three kinds of end users:

- the short perspective user, who wants to know the conditions or weather situation for the next days (usually from a few days to 3 weeks of vacation);
- the tourism planner, who needs information about the recent season; and
- the tourism industry and decision makers, who require information for a longer time span to adjust infrastructure or to plan micro-climate shelters.

Also, physicians should warn their patients what periods are inconvenient for them and suggest the best period for improving their health. For example, the people who difficulty bear summer heat, like elder and deceased people, could choose the period of pleasant biometeorological conditions ideal for hiking or riding, which prevail at the Adriatic coast during spring and autumn or at the mountains during the summer. For sportsmen, who prefer an active vacation, pleasant or even cool conditions may be more convenient than summer heat.

The Meteorological and Hydrological Service of Croatia issues a so called „bioclimatological leaflet" (Fig. 3), to provide climatological information that enables decision-making regarding holiday time and destination. It contains the of meteorological variables that are important for tourism and recreation based on 10-day periods (Zaninovic 2001; Lin and Matzarakis 2008, Zaninovic and Matzarakis, 2009).

The meteorological parameters are selected taking into account the thermal, physical and aesthetic facets of the tourism climate (de Freitas 1990, de Freitas and Matzarakis 2005). More specifically, the leaflet contains the following information:

	1. Thermal stress (PET>35°C)
Thermal components:	2. Cold stress (PET<0°C).
	3. Thermally acceptable (PET between 18 and 29 °C)
	4. Cloudiness (cloud cover<5 octals)
Aesthetic components	5. Fog (relative humidity>93%)
	6. Wind (wind speed>8 m/s).
	7. Long rain (precipitation>5 mm)
Physical factors:	8. Dry days (precipitation<1 mm)
	9. Sultriness (vapour pressure>18 hPa)

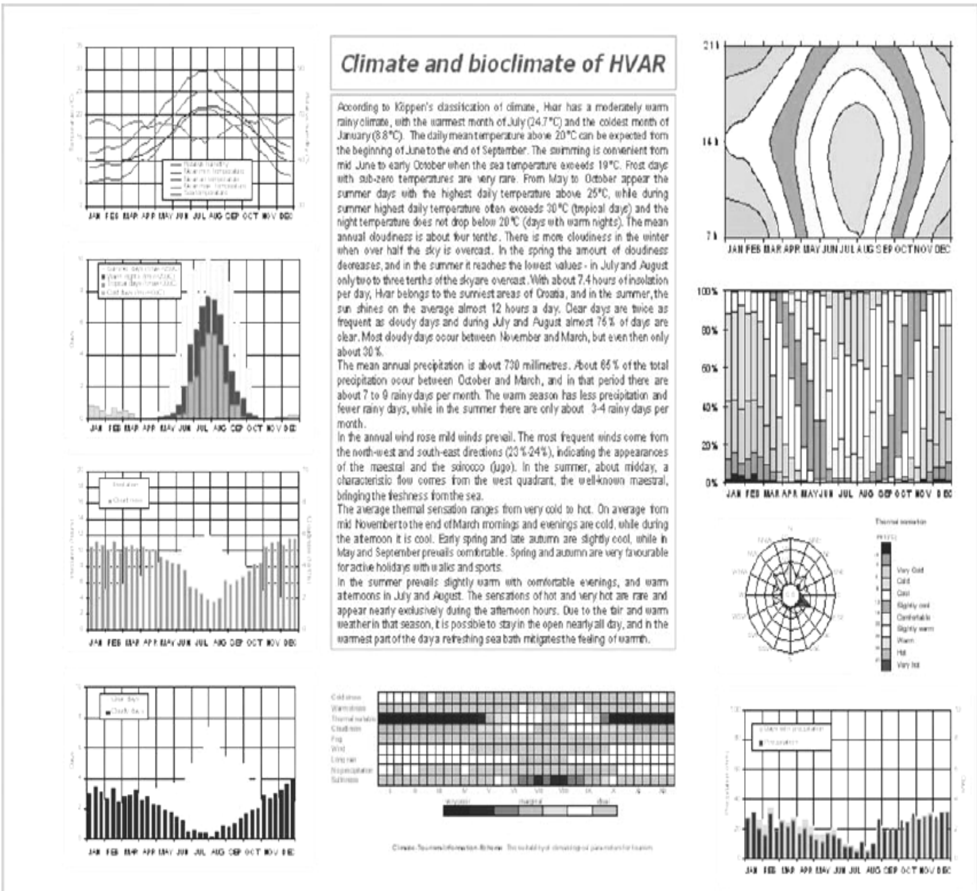


Figure 3. *Bioclimatological leaflet for tourists issued by the Meteorological and Hydrological Service of Croatia (Zaninović et al., 2009).*

4.2 Bioclimatic indices to characterise the thermal environment

The thermal comfort index is calculated by means of the physiologically equivalent temperature PET as the physiologically significant assessment of the thermal environment based at the human energy balance (Matzarakis and Mayer, 1997, Höppe, 1999 and Matzarakis et al., 1999). For calculating PET the RayMan model can be used, using four meteorological parameters (air temperature, relative humidity, wind speed and cloudiness) as well as some assumed physiological parameters (age, genus, bodyweight and height, average clothing and working).

Zagreb **Budapest**

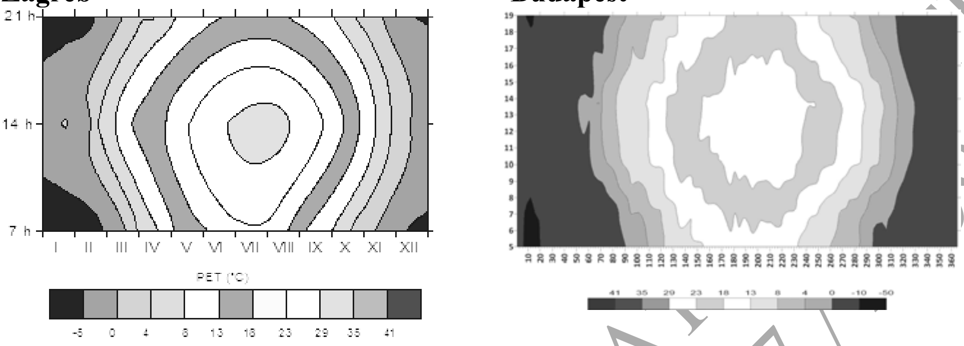


Figure 4. *Average annual and diurnal cycle of PET in Zagreb and Budapest (1961-1990). Both stations are located out of the city.*

In Figure 4 we demonstrate the average annual and diurnal course of this variable in Zagreb and Budapest. In order to identify the changes during the day, the index for observed climate has been calculated for observation terms 7 a.m., 2 p.m. and 9 p.m. local time. (Coordinates of the two capital cities and six other stations from Croatia and Hungary used below are collected in Table 1.)

Table 1. Horizontal and vertical coordinates of the Hungarian and Croatian stations for Figs 4-5.

Station	Country	Latitude (deg. N)	Longitude (deg E)	Altitude (m a. s. l.)
Kékestető	Hungary	47°52’	20°01’	1011
Budapest	Hungary	47°26’	19°11’	138
Siófok	Hungary	46°55’	18°02’	112
Szeged	Hungary	46°15’	20°07’	79
Parg	Croatia	45°36’	14°38’	863
Zagreb	Croatia	45°49’	16°02’	123
Rovinj	Croatia	45°05’	13°38’	20
Split	Croatia	43°31’	16°26’	26

These climate normal-based diagrams do not properly indicate the danger of temperature extremes especially in the summer period. Hence, we also demonstrate the probability of PET>35 °C (Figure 5). This value is already significant from health point of view in case of touristic leisure. Besides that, in Table 2 one can also find the probabilities of overshooting the even more dangerous threshold PET>41 °C. For convenience, these numbers are expressed in the unit of occurrence per month.

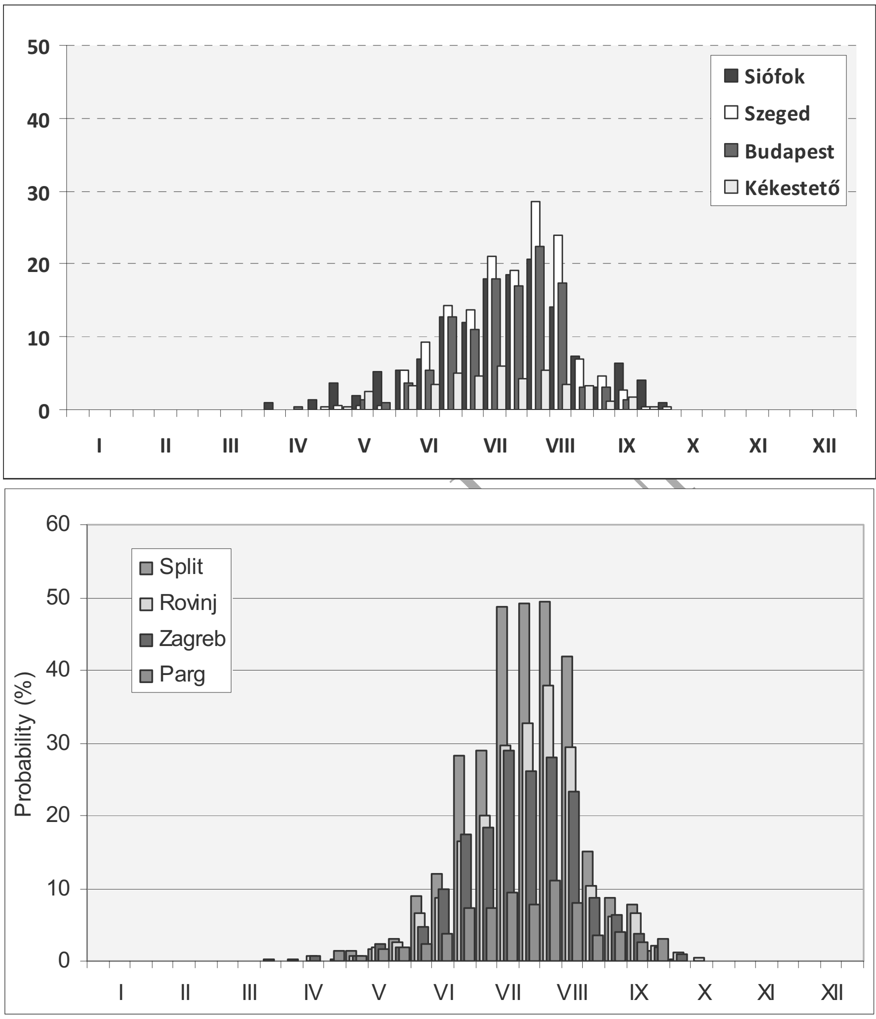


Figure 5. *Probability of occurrence of PET >35°C in ten-day periods during the year at 2 PM. The figures clearly indicate the marked spatial difference and the intra-seasonal differences.*

Table 2. Average number of days overshooting the PET>41 °C in the affected months at four selected sites at 2 pm in Hungary and Croatia.

PET >41°C	Kékestető, HU	Budapest, HU	Siófok, HU	Szeged, HU	Parg, CR	Zagreb, HU	Rovinj, HU	Spit, CR
MAY	0,0	0,0	0,5	0,0	0,0	0,1	0,5	0,0
JUNE	0,1	0,4	2,1	0,8	1,7	1,2	0,6	1,2
JULY	0,3	0,4	4,4	1,7	1,9	2,9	2,4	5,2
AUG.	0,1	0,7	2,7	2,3	2,3	2,1	1,5	5,1
SEP.	0,0	0,0	0,7	0,1	0,4	0,2	0,4	0,3

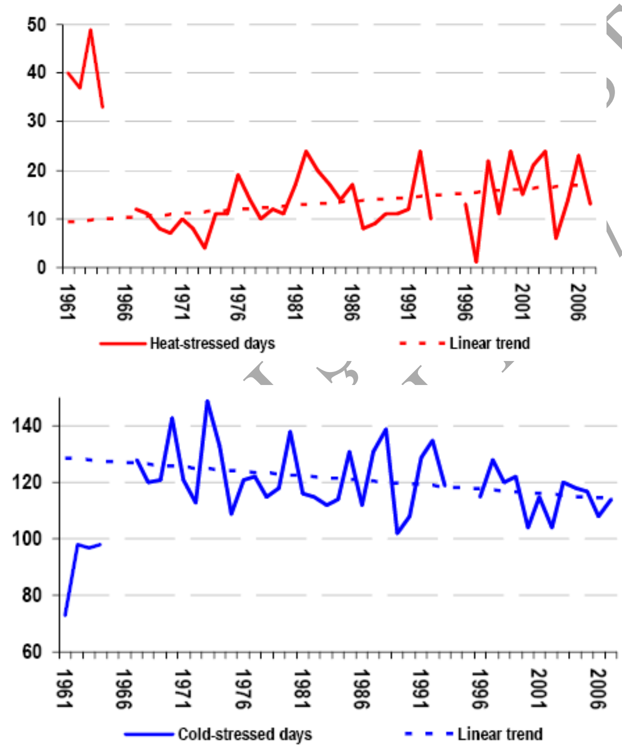


Figure 6. *Variation of number of heat-stressed days (left) and cold-stressed days (right) (the linear trend calculated for 1967-2007)*

The same PET index can also be used to detect climate changes in a given site. For demonstration of this possibility, the PET values were computed from the

12 UTC data series (for selected hours) of the Kékestető synoptic station. In its previous position before 1966 the station was just about 990 m above the see-level, hence the trends are computed after this time, only. According the data series the number of heat-stressed days (when the PET > 29°C) increased whilst the number of cold-stressed days (PET < 0°C) decreased in the examined period (Fig.6.).

5. Adaptation to the weather and climate extremes

The application of disaster preparedness to tourism will involve a number of measures. Tour operators and the tourists should be involved in the process of dissemination of warnings, in the response to the warnings and any evacuation process.

Adaptation strategies include technical measures, sometimes with preliminary research efforts, such as snowmaking, slope contouring, rainwater collection and water recycling, reservoirs, water conservation plans, desalination plants at the shores, or introduction of new site locations (e.g. north facing slopes, higher elevations for ski areas, high snow fall areas). Another group of measures is the adapting regulations, such as fee structures for water consumption, compulsory prediction in case of risk of avalanche or enhanced UV radiation, advanced building design and prescription of given (e.g. fire-resistant) material standards for insurance, convention- or event insurance for the case of danger, insurance premiums or, simply, restriction of high-risk business operations, etc.

Development of an early warning system should be specific to the vulnerable groups. Tourists can be particularly vulnerable, because in case of a general warning in a region, they are unlikely to know what specific actions to take and may be difficult to inform because of the language barriers.

REFERENCES

1. Agrawala, S. (ed) (2007) *Climate Change in the European Alps. Adapting winter tourism and natural hazards management*, OECD Publishing – ISBN 92-64-03168-5
2. Becken, S., Hay, J. (2007), *Tourism and Climate Change – risks and opportunities*. Clevedon: Channel View Publications.
3. de Freitas CR (1990), *Recreation climate assessment*. Int J Climatol 10:89–103
4. de Freitas CR (2003), *Tourism climatology: evaluating environmental information for decision making and business planning in the recreation and tourism sector*. Int J Biometeorol 48:45–54
5. de Freitas CR, Matzarakis, A. (2005), *Recent developments in tourism climatology*, Bulletin of the German Meteorological Society 1/2005:2–4
6. Didaskalou, E.A., Nastos, P., Matzarakis, A. (2004) *The development prospects of Greek health tourism and the role of the bioclimatic conditions of Greece*. Ber Meteor Inst Univ Freiburg 12:149–157

7. Gössling, S., Hall, C.M. (eds.) (2006), *Tourism and Global Environmental Change. Ecological, Social, Economic and Political Interrelationships*. London. Routledge.
8. Hall, C.M., Higham, J. (eds) (2005), *Tourism, Recreation and Climate Change*, Clevedon: Channel View Publications.
9. Höppe, P.(1999), *The physiological equivalent temperature—a universal index for the biometeorological assessment of the thermal environment*, Int J Biometeorol 43:71–75
10. IPCC, WG-I, (2007), *Climate Change 2007: The Physical Science Basis. Contribution of WG-I to the Fourth Assessment Report of the IPCC*, Cambridge Univ. Press, 996 pp.
11. IPCC, WG-II (2007), *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of WG-II to the Fourth Assessm. Report of the IPCC*, Cambridge Univ. Press.
12. Kaspar, C.(1996), *Gesundheitstourismus im Trend*, In: Institut für Tourismus und Verkehrswirtschaft.Jahrb. Schweizer Tourismuswirtschaft. 1995/96, St. Gallen p. 53-61.
13. Lin,T.P., Matzarakis, A. (2008), *Tourism climate and thermal comfort in Sun Moon Lake*, Taiwan. Int J Biometeorol 52:281–290
14. Matzarakis, A., Mayer, H. (1997), *Heat stress in Greece*, *Int. J. Biometeorol.* **41,**
15. Matzarakis, A.; Mayer, H., Iziomon, M. G.(1999), *Applications of a universal thermal index: physiological equivalent temperature*, Int. J. Biometeorology 43: 76-84.
16. Németh, Á. (2008), *Bioclimatology*. In: Holicska, Sz. [ed.]: Weather that stresses people. Medical meteorology for everyone. Athenaeum 2000. pp. 180-200. (in Hungarian).
17. Perry, A.H. (1972), *Weather, climate and tourism*, Weather 27:199–203
18. Perry, A.H. (1993), *Climate and weather information for the package holiday-maker*, Weather 48: 410–414
19. Scott, D., Amelung, B., Becken, S., Ceron, JP., Dubois, G., Gossling, S., Peeters, P., Simpson, M. (2008), *Climate Change and Tourism: Responding to Global Challenges*, World Tourism Organization, Madrid – United Nations Environment Programme, Paris.
20. Simpson, M.C, Gössling, S., Scott, D., Hall, C.M., Gladin, E. (2008), *Climate Change Adaptation and Mitigation in the Tourism Sector: Frameworks, Tools and Practices*, UNEP, University of Oxford, UNWTO, WMO: Paris, France, pp. 136
21. UNWTO and UNEP and WMO (2008), *Climate Change and Tourism: Responding to Global Challenges*, (prep. by Scott, D., Amelung, B., Becken, S., Ceron, J.P., Dubois, G., Gössling, S., Peeters, P. and Simpson, M.C.) UNWTO, Madrid – UNEP, Paris.
22. Zaninović, K. (1998), *Bioclimatic preferences of Hvar for the development of health tourism* (in Croatian). In: Health and tourism. Split/Hvar, pp 63–67
23. Zaninović, K. (2001), *The bioclimatic potential of Croatian Adriatic coast*, In: Matzarakis A, de Freitas CR (eds) Proceedings of the First International Workshop on Climate, Tourism and Recreation, pp 257–265.
24. Zaninović K, Gajić-Čapka M, Perčec Tadić M. et al (2009) The climate atlas of Croatia 1961–1990, DHMZ, Zagreb, p. 130.
25. Zaninović, K., Matzarakis, A.(2009), *The Bioclimatological Leaflet as a means conveying climatological information to tourists and the tourism industry*, Int. J. Biometeorol, 53:369–374, http://www.springerlink.com/content/1ru557j437321614/fulltext.pdf