Bulletin of Geography – **Physical Geography Series**
No 7/2014: 57–80 http://dx.doi.org/10.2478/bgeo-2014-0003

Małgorzata Świątek

Department of Hydrology and Water Management,
Institute of Marine Sciences, University of Szczecin, Poland
e-mail: malgorzata.swiatek@univ.szczecin.pl

SEASONAL VARIABILITY OF CLIMATIC CONDITIONS FOR TOURISM AND RECREATION ALONG THE SOUTHERN COAST OF THE BALTIC SEA

Abstract: This paper aims to indicate the periods within the year that are most and least suited to outdoor recreation along the southern coast of the Baltic Sea. The author indicates these periods based on the analysis of annual variability of several meteorological and bioclimatic parameters from the years 1981–2010 in Greifswald and Świnoujście, and from 1985 to 2010 in Hel and Gdynia. Passive recreation is favoured in July and the first half of August. The whole of the summer season has the most favourable conditions for active recreation. Good conditions frequently occur in May, and to a lesser degree in September. The advantages of May are that it has the highest sunshine duration and the lowest frequency of precipitation.

Key words: bioclimatology, seasonality, tourism and recreation, southern coast of the Baltic Sea

Introduction

Weather conditions are one of the main factors that limit recreation and tourism activity. In assessing bioclimatic recreational potential, both precipitation and such phenomena as e.g. fog, storms and thermal conditions (such as intensity of warm or cold) are very important (Błażejczyk 2004). The climate is an important factor in satisfying tourism and recreation demands. These demands feature, in particular: physiological and psychological needs, the necessity to change activity or geographical place, demand for entertainment and recreation, and safety and prestige needs (Gómez 2005; Becken 2010).

The facets of tourism have been divided in studies into the aesthetic (sunshine/cloudiness, visibility and day length), the physical (wind, rain, snow, ice, frequency of severe weather, air quality and ultraviolet radiation) and the thermal, affecting thermal comfort, which comprises the integrated effects of air temperature, wind, solar radiation, humidity, long-wave radiation, metabolic rate (de Freitas 2001; Becken 2010) and clothing insulation. Mass tourism continues to seek sun, sea and sand, and so is very sensitive to climate. Tourists prefer countries with a sunny yet mild climate, and shun climates that are too hot or too cold (Bigano et al. 2006). Beach users hold different comfort perceptions and preferences from those of people doing sightseeing in urban spaces or taking part in leisure in the form of physical activity. For example, Rutty and Scott (2014) demonstrated that beach tourists preferred conditions that are up to even 18°C warmer than urban respondents. Clearly, beach users–unlike urban environment users–have a definition of "acceptable" thermal conditions that goes beyond the common definition.

Interest in the interactions between climate, weather and tourism has increased in the last decade in response to climate change (Becken and Wilson 2013). The reduction of discomfort caused by cold conditions in cooler regions, and in winter in warmer regions, make conditions for tourist activity more comfortable. On the other hand, in some regions traditionally attractive for tourists (such as the Mediterranean region) summers will cause more frequent discomfort (excessively hot conditions), especially in urban spaces (Morabito et al. 2004). The current change in climate will affect the development of tourism in different parts of the world, because tourists will spend their holidays in different places than they currently do (Lise and Tol 2002). For example, a study of European holiday preferences finds that better climate and weather in the previous year in a holidaymaker's region of residence is related to a higher probability of travelling domestically (Hamilton et al. 2005; Agnew and Palutikof 2006; Hamilton and Tol 2007; Becken 2010; Falk 2014). Increased air temperature may offer additional opportunities for tourism even in the Arctic (Denstadli et al. 2011). Some of the biggest increases in attractiveness of summer climate among European countries are observed in Poland and Germany (Hamilton 2005; Hamilton and Tol 2007) particularly with regard to the southern Baltic Sea coast (Filies and Schumacher 2013).

Beach use was selected in a lot of studies as a highly weather-sensitive recreational activity (de Freitas 1990; Moreno 2007; Moreno et al. 2008). The positive effects of warmer and drier weather outweigh the combined negative influences of reductions in beach width due to sea level rise (Coombes et al. 2009) and an increase in some extreme events (Pierch-Nielsen 2010). Other forms of leisure activities and sport are also weather-sensitive, e.g. cycling (Brandenburg et al. 2007), sailing, some athletics disciplines and winter sports (Perry 2004).

Bioclimatic conditions are one of the most important values of coastal zones, because of the high potential of these areas for climatotherapy. Basic climatotheraupetical treatments sought by tourists and resort guests include sunbathing, swimming in the sea, enjoying the sea breeze, and inhaling natural marine aerosols (Koźmiński et al. 2013). Coastal areas provide a number of climatic stimuli, including radiation, temperature, humidity and high wind velocities.

The climatic conditions for the development of tourism and recreation in the coastal zone of the southern Baltic Sea have been analyzed several times (Kowalkowska et al. 2003; Koźmiński and Michalska 2011). The basic attraction for mass recreation in coastal areas is swimming. Therefore, the majority of local studies on climatic determinants of tourism and recreation in maritime resorts, including those located in the southern part of the Baltic Sea coast, focus on conditions that favour swimming (Chabior and Girjatowicz 1997; Girjatowicz 2006). The focus of other papers is the analysis of thermal experiences in various resorts (Chabior and Korpalska-Chabior 2006; Chabior 2008; Koźmiński and Michalska 2008, 2010a). A major problem faced by the many maritime resorts, especially at moderate latitudes, is the short duration of the tourist season (Manning and Powers 1988; Lundtorp et al. 1999), usually restricted to the period which allows swimming and sunbathing (note that in this paper, the term ‘sunbathing’ collectively refers to passive forms of recreation on the beach). In the Pomeranian Bay area, this period (of water temperature >15°C) lasts from mid-June to early September. In other parts of the Polish coast, the swimming season is even shorter: for instance, in Gdynia and Ustka it lasts only 61 days, from 4 July to 7 September (Girjatowicz 2006). Furthermore, even at the peak of the season in July and August, only approximately 23%

of days provide swimming conditions classified as ‘highly favourable’ (Chabior and Girjatowicz 1997), i.e., enabling even physically out of shape tourists to swim. Development of alternative forms of recreation (other than sunbathing and swimming) would result in an increased number of customers for the existing facilities (such as accommodation or catering). The importance of seasonality and suitable weather on the German Baltic Sea coast were described in Kammler and Schernewski’s study (2004). Among the activities that maritime resorts could benefit from are e.g. hiking and cycling. The pleasure and satisfaction from any given activity, and physical and mental relaxation, are determined by several factors, including weather conditions. Therefore, this paper aims to indicate the periods within the year that are most and least favourable for active, outdoor recreation, including in particular mild (i.e., non-professional) activities, e.g., lowland hiking, recreational lowland cycling, jogging, nordic walking, roller skating, go-karting or out-door team sports.

Materials and methods

In order to determine the seasonal variability of weather conditions in the study area, data on the following parameters were compiled from the period 1981–2010 in Greifswald and Świnoujście and from 1985 to 2010 in Hel and Gdynia: mean and maximum daily air temperatures, mean daily relative humidity, mean daily wind velocity and mean daily atmospheric pressure. The air temperature, relative humidity, precipitation and daily sunshine duration are, according to Matzarakis (2006), major meteorological factors affecting the quality of recreation. Wind speed was analyzed mainly because of its influence on temperature perceptibility. Day-to-day changes of air pressure were examined due to people’s perception of them as a negative influence on their sense of wellbeing (Błażejczyk 2006; Koźmiński and Michalska 2010b). The data were obtained from the National Oceanic and Atmospheric Administration (NOAA, USA) database.

The daily precipitation sums for Polish stations from the NOAA database were found to considerably deviate from the measurements carried out by the local branch of the Institute of Meteorology and Water Management (IMGW), and thus are here considered as non-credible. Therefore, daily precipitation totals from the period 1954–2003 were taken from the IMGW database in order to characterize the pluvial conditions along the Polish coast. Additional resources used in this study include published multi-annual, decadal mean values of real sunshine duration in Resko, Koszalin, Ustka, Lębork and Elbląg from the period 1971–2000 (Koźmiński and Michalska 2006). Based on arithmetic mean values of daily average and maximum temperatures, a seasonal variation in the probability of occurrence of days with thermoneutral conditions was designated.

Thermoneutral conditions are the range of ambient temperature at which temperature regulation is achieved without regulatory changes in metabolic heat production or evaporative heat loss (Mercer 2001). This range has been determined as temperatures ranging from 18 to 23°C (Kozłowska-Szczęsna et al. 2004). Since tourists generally do not perform outdoor activities at night or in the early morning (although some people practise sports such us jogging during the early morning hours) it was necessary to minimize the degree to which these calculations reflect night and early morning temperatures. To achieve this, only mean and maximum temperatures were considered, and minimum values were neglected.

In the paper, effective temperatures were also used. This is an expression of the temperature combined with humidity and wind speed (Mercer 2001). Effective temperature reflects the influence of these factors on the human thermal sensibility in the shade, both when fully clothed, and when stripped to the waist. It does not, however, consider solar radiation. Given a wind velocity of ≤ 0.3 ms^{-1}, the equation takes the form (after: Błażejczyk and Kunert 2011):

$$TE = t - 0.4 \cdot (t - 10.0) \cdot (1 - 0.01 \cdot RH) \qquad (1)$$

For higher wind speeds the formula takes the following form:

$$TE = 37.0 - \frac{37.0 - t}{0.68 - 0.0014 \cdot RH + \frac{1}{1.76 + 1.40 \cdot v^{0.75}}} - 0.29 \cdot t \cdot (1 - 0.01 \cdot RH) \qquad (2)$$

Where t is the air temperature (°C), being the average of mean daily temperature and maximum daily temperature in this study; RH is the relative air humidity (%), being the mean daily value in this study; and v is the wind speed (ms^{-1}), being the mean daily value in this study.

Throughout the paper, each value of daily air temperature was counted as the average of two values: the mean average daily air temperature and the maximum daily air temperature. Daily thermal comfort occurrence probability in a year was calculated based on effective temperature variations for: 1) lightly-clothed persons involved in intense recreation (effective temperature range: 9.0–16.9°C, Bajbakova et al. 1963), and 2) persons stripped to the waist, and not in motion (effective temperature range 17.3–21.7°C, Flach 1981).

The simplified formula of the Universal Thermal Climate Index (UTCI) has also been applied in this work. UTCI is defined as the equivalent air temperature at which the terms of reference of the body's basic physiological parameters take the same values as in the current conditions (Błażejczyk et al. 2010). In order to perform a quick calculation of UTCI, an approximating regression function was used. This function takes into account data on the daily air temperature (calculated as the average of mean and maximum daily temperature), daily average relative humidity and daily average near-surface wind speed (at a height of 10 m above the ground). In the absence of data on streams of solar and long-wave radiation, the mean radiant temperature is usually used to determine the regression function UTCI (Błażejczyk et al. 2010), so in this work mean radiant temperature is assumed to be equal to the air temperature.

Probabilities of the occurrence of at least 0,1 mm precipitation (measureable precipitation) and at least 10 mm (heavy precipitation) were derived from daily precipitation totals. Some of the studied parameters displayed strong fluctuations from day to day. To highlight the long-term trends in seasonal variability of these parameters, smoothing was applied by means of a 30-day moving average.

In bioclimatological studies, in order to quantify the evaluation of a climate for the purpose of tourism the Tourism Climate Index TCI (Mieczkowski 1985; Perch-Nielsen et al. 2010) and the Climate Index for Tourism CIT (Freitas et al. 2008) are used. These are very convenient measures for evaluating the climate conditions. In this study, however, they could not be used, mainly due to the lack of data on daily sunshine duration.

Results

Air temperature

The highest air temperature (averaged over the mean and maximum daily temperature) occurs from the beginning of the second decade of July to the beginning of August, when it is about 20°C (Fig. 1). The lowest mean daily temperature (approximately 1°C) was observed in the beginning of January. The daily temperature (values of mean and maximum daily temperature were included) equals slightly less than 3°C (Fig. 1), which is high in comparison to other parts of Poland (Woś 2010). Warm maximum air temperatures in winter do not favour winter sports. On the other hand, mild thermal conditions in winter are less encumbering for the human metabolism (Kozłowska-Szczęsna et al. 1997; Błażejczyk and Kunert 2011). The importance of the period during which thermoneutral conditions are most frequent is, e.g. the dependence of metabolic rates on air temperature. For instance, a lowering of air temperature by 5°C causes the basal metabolic rate (BMR) to increase by 17%, while a 15–20°C drop in temperature causes the BMR to increase by as much as 80%. The BMR value changes rapidly depending on the form of physical activity (Błażejczyk and Kunert 2011). When lying down, an average human produces approximately 50 Wm^{-2} of heat. However, walking without a load through a flat area at 4 km/h causes the body to produces approximately 115 Wm^{-2} of heat. Walking with a 10 kg load produces 195 Wm^{-2}, and walking at a pace of 8 km/h without load produces as much as 290 Wm^{-2} of heat (Błażejczyk and Kunert 2011). Therefore, lower temperatures favour tourism and active recreation, rather than passive recreation.

Thermoneutral conditions, determined on the basis of mean and maximum daily air temperatures, occur most frequently from approximately 20 July to mid-August. They are basically absent from mid-October to 10 April (Fig. 1). Even though the annual air temperature variability in the study sites is similar, there are considerable differences in the probability of occurrence of thermoneutral conditions. The probability of occurrence of thermoneutral conditions during late July through to early August in Hel is considerably higher than in other locations. The annual variations in the probability of occurrence of thermoneutral conditions indicate that the frequency at which optimum temperatures occur rises with air temperature (Fig. 1).

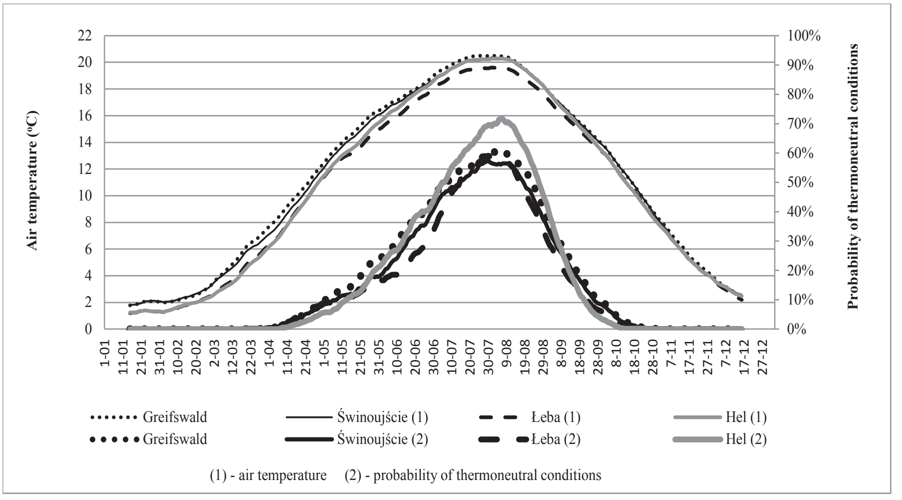

Fig. 1. Annual variations of averaged (over the mean and maximum) daily air temperatures (°C) and in probability of occurrence of thermoneutral conditions (%), derived from averaged mean and maximum air temperatures, smoothed by means of a 30-day moving average. Data coverage: 1981–2010 (Greifswald and Świnoujście) and 1986–2010 (Łeba and Hel)

Even mild forms of active recreation, including lowland hiking and cycling, can be hindered by weather experiences which are either too hot or too sultry in summer. On hot days, intense activity causes the circulation system to become overloaded due to increased heart rate. The latter increases both with intensifying physical strain, and increasing air temperature (which is usually accompanied by an increase in atmospheric water vapour pressure (Błażejczyk 2004)). Relatively low air humidity allows air to absorb additional water vapour volume, which in turn allows for increased evaporation of sweat from the skin. This process improves thermoregulation of the system, and at the same time prevents the sweat from remaining on the skin for too long. Air humidity also heavily influences humans' experience of heat. In temperatures below 12°C, an increase in water vapour pressure escalates the experience of cold, while in temperatures warmer than 12°C it promotes the experience of warmth (Kozłowska-Szczęsna et al. 1997). Air motion also has a great significance for human thermal sensibility. Wind velocity can be especially high in the marine coastal zone, hence its importance in the study sites. Bearing in mind these relationships, not only air temperature, but also relative humidity and wind speed were included in determining the variations in the probability of effective temperature that enable thermal comfort.

Comfortable effective temperatures for an undressed person lying down occur mainly in July and in the first half of August. The highest number of days characterized by these conditions occurs in Greifswald, and the fewest in Łeba (Fig. 2). Note, however, that these considerations do not regard the influence of sunshine duration, which on cloudless days significantly increases the effective temperature, especially in the highly-exposed coastal beaches. Effective temperatures favouring active recreation by lightly-clothed persons occur from April to September, and the most favourable conditions during the year are from approximately 20 July to 20 August. Within this period, Hel has the highest number of days characterized by such conditions, and Łeba the fewest.

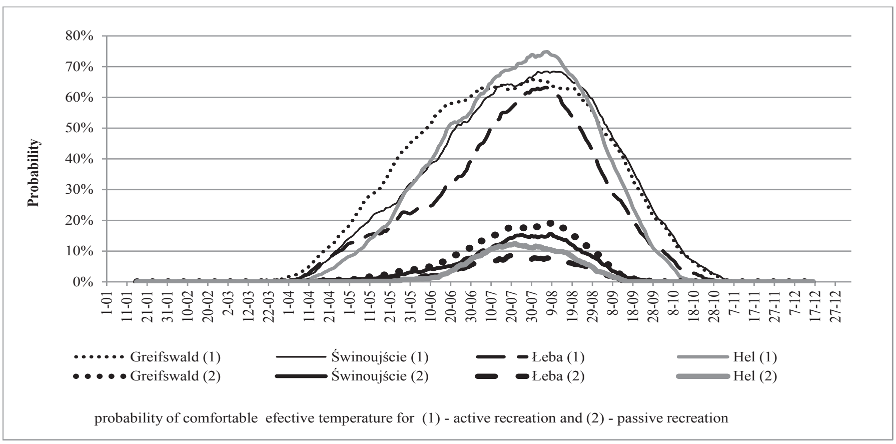

Fig. 2. Annual variations of probability of comfortable effective temperature, smoothed by means of a 30-day moving average. Data coverage: 1981–2010 (Greifswald and Świnoujście) and 1986–2010 (Łeba and Hel)

Universal Thermal Climate Index

Universal Thermal Climate Index UTCI describes human heat stress caused by a combination of weather parameters. Severe cold stress, when a person should intensify activity and protect face and extremities against cooling and use warmer clothing, covers the UTCI range between -27°C and -13°C; moderate cold stress is between -13°C and 0°C; slight cold stress is between 0°C and 9°C and no thermal stress (thermal comfort) is between 9°C and

26°C (Błażejczyk et al. 2010). Heat stress in the southern coast of the Baltic Sea (the mean and maximum daily temperature is included to calculate UTCI; mean radiant temperature is not included) is not present. These limit values of UTCI are marked on Figure 3.

The length of the period of no thermal stress (the period when human physiological thermoregulation are sufficient to keep thermal comfort) differ from place to place. The wind velocity has a very large impact on human heat balance so in Greifswald, located in a sheltered bay, the period of no thermal stress is much longer (from the middle of May to the end of September) than in Łeba, located on the open coast of the Baltic Sea (from about 20 June to about 5 September). For the same reason (the wind chill effect), in the winter there is severe cold stress in Łeba and Hel, while in Greifswald and Świnoujście there is not (Fig. 3). The determined values of UTCI may be slightly understated, especially in the period from the middle of May to the end of August, because of the omission of the mean radiant temperature. In the autumn and winter, the sunshine duration is very small so mean radian temperature is not important.

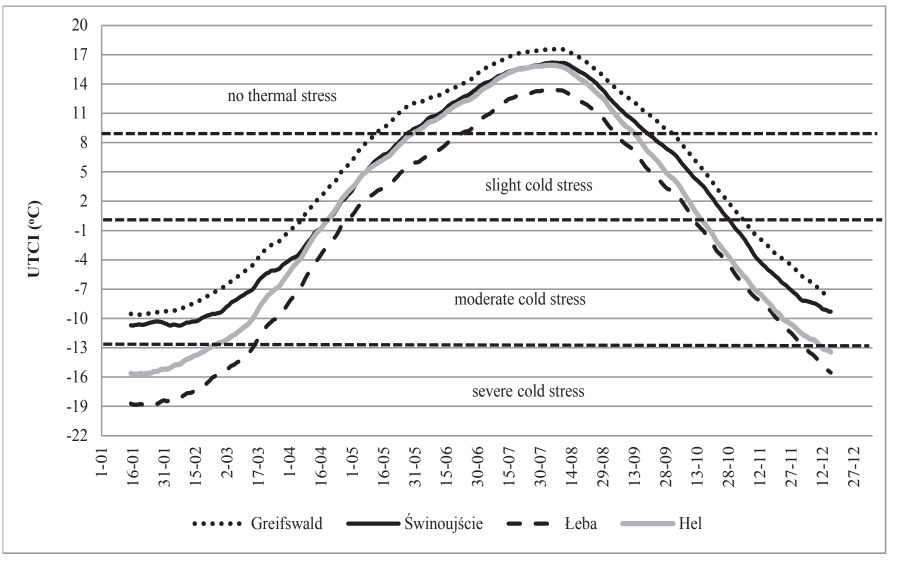

Fig. 3. Annual variations of UTCI (°C), smoothed using a 30-day moving average. Data coverage: 1981–2010 (Greifswald and Świnoujście) and 1986–2010 (Łeba and Hel)

Wind speed

Wind intensifies thermoregulation by increasing heat exchange between the human body and its surroundings. Thus, at high air temperatures, it favours active recreation. However, at low air temperatures, strong wind escalates the experience of cold and might lead to hypothermia (Kozłowska-Szczęsna et al. 2004). Due to increased air resistance, strong wind hinders cycling and–to a smaller extent–hiking. Additionally, the potential for physical strain becomes reduced as well. High speed wind can be accompanied by a sense of nervousness, and can even amplify mental disorders (Błażejczyk and Kunert 2011). Furthermore, seasonal variation in wind velocity directly influences safe and satisfying sailing conditions for a range of vessels.

Although high-velocity winds can hinder outdoor activities, wind is an important element of aerotherapy. As a mechanical stimulus it helps to strengthen health. It increases the atmospheric concentrations of marine aerosols containing chlorides of sodium, magnesium, calcium and iodine, as well as metabolic products of marine plankton. It is therefore a therapeutic stimulus characteristic of maritime resorts (Koźmiński et al. 2013).

A comparison between the plots of probability of comfortable values both of effective temperature and UTCI and seasonal variation in near-surface wind velocity at each study site indicates the high significance of wind velocity for thermal sensibility (Figs 2, 3 and 4). The location of study sites is reflected in the wind velocity differences and the related differences in effective temperature. Greifswald is located on the sheltered Greifswalder Bodden, Świnoujście on the open Pomeranian Bay, Hel on a semi-sheltered part of the Gulf of Gdańsk, and Łeba on the open coast of the Baltic Sea. The relatively low wind velocities in Greifswald make this area more suitable for passive recreation than the Polish part of the coast (Figs 2 and 3). However, the insufficient wind chill at Greifswald does not favour active recreation as much as in Hel or Łeba.

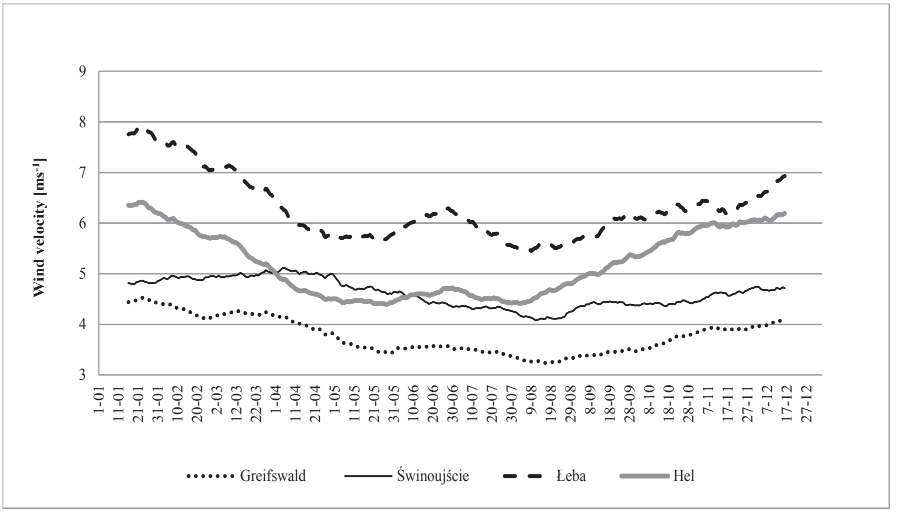

Fig. 4. Annual variations of wind velocity (ms^{-1}), smoothed using a 30-day moving average. Data coverage: 1981–2010 (Greifswald and Świnoujście) and 1986–2010 (Łeba and Hel)

The analysis of the available data shows that the variability of wind speed is inversely related to variability of measured air temperature (Figs 1 and 4). The highest wind velocity occurs in winter, in particular in January, and the lowest in summer, in August. There are some exceptions to this rule; the highest wind velocity in Świnoujście occurs in April, which is confirmed by Koźmiński and Michalska (2008), and in Hel the lowest value is observed in May (Fig. 4).

Relative humidity

Relative humidity also influences the experience of air temperature and well-being during recreation. Changes in relative humidity are inversely proportional to temperature variations (Figs 1 and 5). In addition to air temperature, relative humidity is also influenced by water vapour content in the air, which tends to be higher in autumn than in spring in coastal zones. The highest relative humidity values are recorded in December, even though the lowest air temperatures are typical of January. This causes a decrease in temperature experienced by humans, and thus enhances cold stress. For most of the year, the lowest relative humidity is observed in Greifswald.

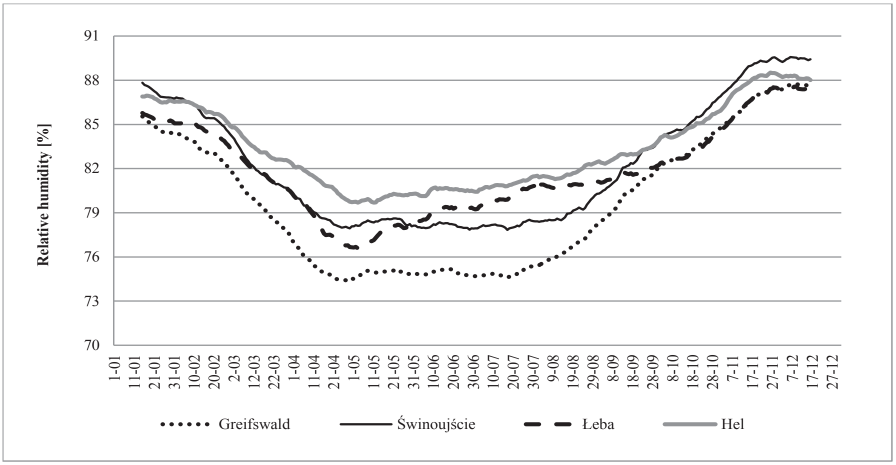

Fig. 5. Annual variations of relative humidity (%), smoothed using a 30-day moving average. Data coverage: 1981–2010 (Greifswald and Świnoujście) and 1986–2010 (Łeba and Hel)

Sunshine duration

The duration of sunshine does not directly affect the performance of outdoor recreation and tourism activities. However, it certainly influences the satisfaction that tourists experience from the respective activities. On the southern coast of the Baltic Sea the highest real sunshine duration values occur in the third decade of May and in the first and third decades of July (Fig. 6). In the end of May, effective sunshine duration in Koszalin and Ustka even exceeds 9 hours. These high real sunshine duration values are influenced both by the degree of cloudiness, and long daylight duration. Favourable solar conditions occur during the whole summer season. From the third decade of November to the first decade of January, effective sunshine duration values are very low (approximately 1 hour). This results in poor disposition and health deterioration, as low sunshine duration causes resistance to illness to decrease. Low sunshine duration also results in a reduction in the activity of internal glands, the production of vitamin D, and the activity of nervous and circulatory systems (Koźmiński and Michalska 2006). The low sunshine duration in this period is controlled not only by the short daylight duration, associated with the location of the study area in the north of Poland, but also exceptionally high cloudiness.

In the warm season, the western part of the Polish coast benefits from high sunshine duration values.

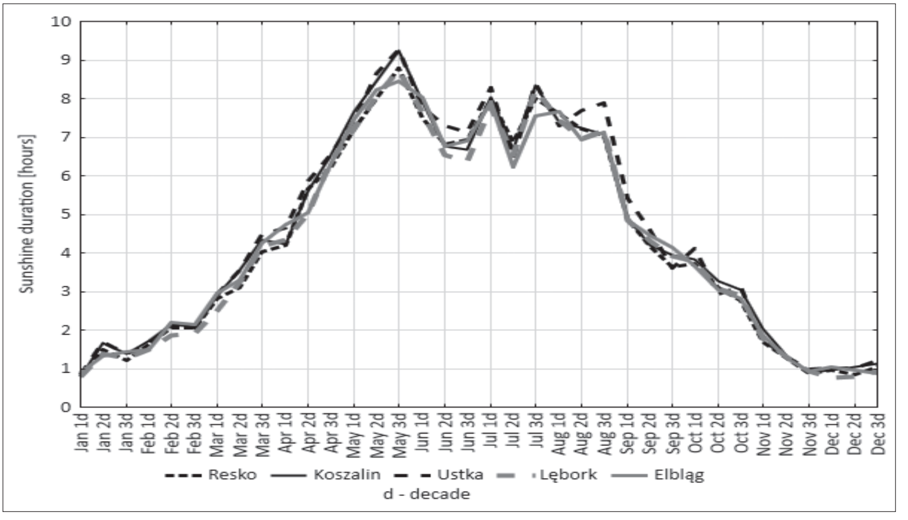

Fig. 6. Annual variability of a real sunshine duration values (hours) per decade. Data coverage: 1971–2000, d = decade. Data source: Koźmiński and Michalska (2006)

Atmospheric precipitation

Rainfall seriously hinders both hiking, cycling and other kinds of outdoor recreation and sightseeing. Heavy rainfall makes tourism virtually impossible, while light rainfall deteriorates the quality of experience for this type of recreation. Moreno et al. (2008) and Moreno (2007) suggest that precipitation has an overriding effect over other weather variables, especially for beach visitation.

Although generally the highest precipitation sums in the analyzed area occur during summer (Schönwiese and Rapp 1997; Świątek 2010), the probability of measurable rainfall (in excess of 0.1 mm) is higher in winter and late autumn, predominantly at the end of November and in December (Fig. 7). From November to February the long duration of rainfall hinders outdoor activity opportunities. Conversely, in June the number of hours with rainfall is relatively low (Jankowiak and Parczewski 1978). The probability of precipitation is lowest in May (in all stations) and in the first half of June (in Świnoujście and Łeba, see Fig. 7). Note that within the period from

May to September, which is characterized by a generally low probability of precipitation, there is a short-term peak in precipitation in the second week of July.

Highly unfavourable tourism and recreation days with precipitation totals exceeding 10 mm occur most frequently in late August to early September (in all stations) and in the beginning of July (Łeba and Hel, see Fig. 7). These trends are influenced by increases in frontal precipitation sums, clearly dominant over the Polish coast due to the high activity of thermal convection processes in summer (Świątek 2009). These two maxima are interrupted by a marked minimum at the end of July and the beginning of August. High precipitation totals are least frequent between January and March, in particular in the first half of February. This period is characterized by a high number of days with precipitation totals of more than 0.1 mm.

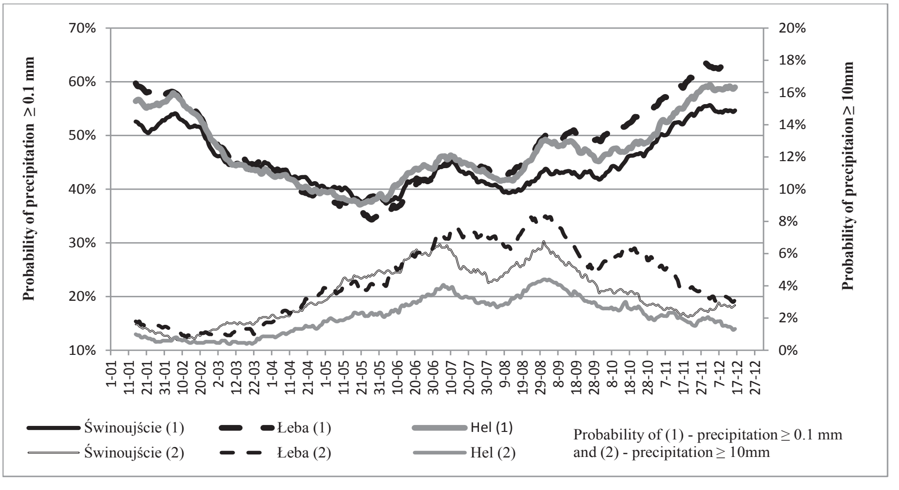

Fig. 7. Annual variation in the probability of occurrence of daily precipitation totals higher than 0.1 mm and 10 mm, smoothed by means of a 30-day moving average. Data coverage: 1954–2003

The highest probability of heavy precipitation in summer is in Łeba and the lowest in Hel. Daily precipitation totals in all resorts are similar in spring and summer, but in autumn are lower in Świnoujście (in the west part of the Polish coast) than in Łeba and Hel.

Day-to-day variability of air pressure

Interdaily changes of atmospheric pressure exceeding 8 hPa constitute a burden on human health and wellbeing. The variability of such changes is quite similar to the seasonal variability of air temperature. In the winter these unfavourable conditions are much more frequent (mainly about 28%) than in the summer (only 3–4%). The largest probability of big (>8 hPa) interdaily changes is in February, although in Świnoujście it is less frequent at that time than in other locations (Fig. 8).

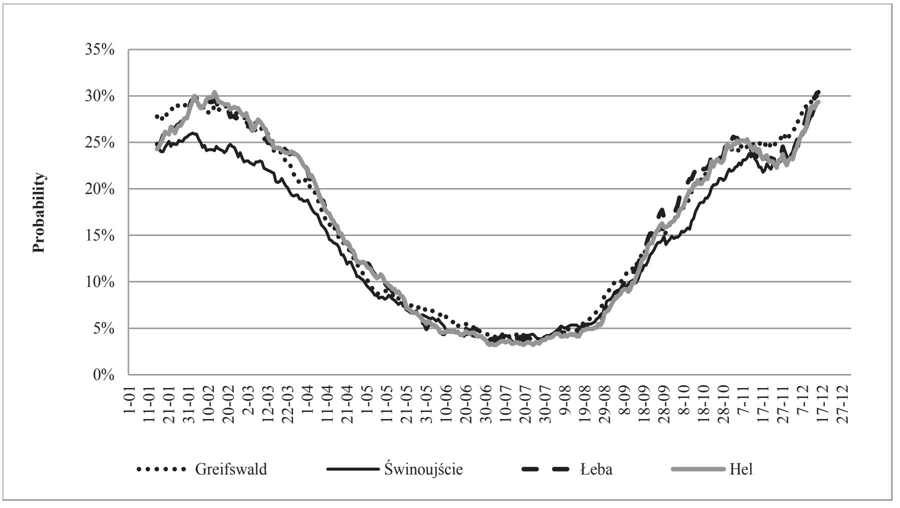

Fig. 8. Annual variations of probability of interdaily changes of air pressure > 8 hPa (%), smoothed using a 30-day moving average. Data coverage: 1981–2010 (Greifswald and Świnoujście) and 1986–2010 (Łeba and Hel)

The other important parameter for tourism and recreation in the coastal zone is the intensity of UV radiation. This was not analyzed in the study due to a lack of data on the beneficial effect of solar UV on the production of vitamin D. On the other hand, excessive exposure to solar UV radiation at first causes erythema and also acute and chronic effects on the skin, such as skin cancers (Morabito et al. 2014). The maximal time of solar exposition is strictly dependent not only on values of the UV index, but also on the skin phototype. The most sensitive skin, described by the smallest Minimal Erythemal Dose (MED), is specific for persons with red hair and blue eyes (Błażejczyk and Kunert 2011). The highest probability of erythema occurs on the south coast of the Baltic Sea on the sunniest days within the second half of May and in the summer months (JJA). Incidences of sunburn during childhood are especially dangerous for human health (Morabito et al. 2014).

Discussion and conclusions

The period from mid-July to mid-August in the southern coast of the Baltic Sea generally favours passive recreation, as it is characterized by conditions that provide an experience of thermal comfort. However, considering the increase in heat production by the human body depending on the intensity of physical activity, the thermal comfort range is reduced. The period of the most favourable conditions for active recreation also refers to the summer, but conditions of thermal comfort quite frequently occur both in May and in September. The analysis of UTCI showed that physiological thermoregulation is sufficient to keep thermal comfort generally only in the summer and in the beginning of autumn (in June, July, August and the first half of September) and the long of period is highly dependent on the wind chill connected with the location of the station.

Outdoor recreation in the summer is limited by a high probability of heavy rainfall in the summer (despite a slight decrease in the end of July and in the beginning of August). In spite of these drawbacks, summer days without extremely high temperatures and precipitation provide attractive conditions for recreation. Further advantages of the summer season are low variations in atmospheric pressure (observed from mid-May, they hit their lowest in July). The low wind velocities, particularly in August, might be considered as an advantage by some tourists. However, they reduce the therapeutical values characteristic of maritime resorts. Moreno (2007) noted that, in Spain, wind speed between 4 and 5 ms^{-1} is favourable to a high density of beach users, while a wind speed exceeding 7 ms^{-1} seems to be too large for ideal conditions. With respect to sunshine duration, the probability of precipitation and wind speed, weather conditions conducive to active forms of recreation occur in May. Recreation in May is favoured mainly by the peak in real sunshine duration values. In autumn, sunshine duration is considerably lower, it is cloudy and the probability of precipitation is higher than in spring. The lowest precipitation sums, which obviously favour tourism and recreation, occur in May and in the first half of June.

This is related to the low pressure field gradients over Europe in that period of the year.

The least favourable bioclimatic conditions for tourism prevail in winter and in late autumn, predominantly because of low air temperatures as well as the lowest sunshine duration and high probability of precipitation. Additionally, high wind speed and relative humidity in this period increase the experience of cold (cold stress). In Łeba and Hel people even experience severe cold stress in the winter, while in Greifswald and in Świnoujście they feel moderate cold stress. Large decreases and increases in atmospheric pressure from day to day in the winter also limited recreation because they negatively impact on a person's sense of wellbeing.

In each study site on the southern Baltic coast, the climatic variations are influenced by the variability of local conditions. In particular this refers to the wind velocity, and as a result, also the effective temperature. Of special importance is location, whether on a stretch of open coast or in a sheltered bay, and to what extent the coast is exposed to prevailing wind directions. This controls the force of friction limiting the wind velocity. Because of all this, the conditions at Greifswald are the most suitable for recreation on the beach.

Bioclimatic studies available to date for the southern coast of the Baltic Sea show similar results. However, they display a clear bias resulting from the types of bioclimatological indices applied. This causes the individual interpretations to differ, e.g., in the case of summer conditions. For instance, Koźmiński and Michalska (2008) indicate that there are no unfavourable conditions for hiking in the Świnoujście area throughout the year, while there are highly favourable conditions in April and May, and September and October. In the interpretation of Koźmiński and Michalska (2008), intense recreation is favoured within the period from the end of September to the second decade of April. Therefore, Świnoujście is worth visiting as a resort not only during the summer season. In Łeba, apart from the summer season, favourable bioclimatic conditions are observed in May and June, and–to a lesser extent–in September and October (Chabior and Korpalska-Chabior 2006). In Kołobrzeg, good weather occurs most frequently in May and from the second decade of June to the third decade of August (Chabior 2008). In Ustka (the central Polish coast) favourable weather conditions for walking and for slightly intensive outdoor recreation are recorded in the whole warm half-year (Koźmiński and Michalska 2010a) so this suggests a lengthening of the tourist season from the current mid-June to August to a period of at least the middle of May to the middle of September.

Both Amelung and Moreno (2009) and Perch-Nielsen et al. (2010) also indicate summer as the best season for most types of outdoor recreation for most, if not all, countries in Europe. Amelung and Moreno (2009) showed the climate conditions of the German and Polish Baltic coast to be good or excellent (depending on the model) in the summer, and marginal or acceptable in the spring and in the autumn. Błażejczyk (2007) noted that in the summer in northern and central Europe passive recreation is limited mainly by weak radiation stimuli and rain.

The determination of UTCI and analysis of the frequency of various classes of physiological stress at some selected meteorological stations in Poland, among others at coastal stations, were made by Błażejczyk and Kunert (2011). That study demonstrated similar but slightly higher values of UTCI than in this work because they take into account the air temperature at 12:00 UTC.

Very similar yearly variability of day-to-day air pressure changes in the southern coast of the Baltic Sea was demonstrated by Koźmiński and Michalska (2010b). The greatest monthly totals of sunshine duration in May (1971–1990) in Ustka (located on the central coast of the southern Baltic Sea) and Hel were shown by Błażejczyk (2006). Some results concerning seasonal thermal comfort are difficult to compare because of different ranges of preferred thermal conditions designated for warmer countries such as Australia or Spain (Zhang and Wang 2013).

The analysis of meteorological conditions for some stations in Poland (among others, the coastal stations of Świnoujście and Kołobrzeg) in the form of the Climate Tourism Information Scheme CTIS were made by Błażejczyk and Kunert (2011). Their work also demonstrated the occurrence of the worst weather conditions for tourism in the winter, when not only is it too cold (cold stress occurs), but also misty and not sunny. The most sunny days are approximately from mid-April to mid-August. Błażejczyk and Kunert, as in the present study, did not show the presence of excessively hot conditions (heat stress) on the Polish coast. The largest probability of thermal comfort was shown, however, not in summer (as in my study), but in spring and autumn. This difference is probably due to the designation of thermal comfort based on the value of another index–Physiologically Equivalent

Temperature (PET)–resulting from the solution of the formula of the human heat balance applied in the München Energy Model for Individuals (MEMI).

This paper aims to encourage the use of favourable climatic conditions not only for mass tourism in July and August, but primarily for physical activity in May and June, when there is relatively little rainfall, high sunshine duration and favourable thermal conditions. This period favours walking, cycling, jogging, nordic walking or out-door team sports. It should therefore be used to organize events such as training and social group trips. The results of the analysis contained in this paper can help to plan the organization of trips and tourism events within a certain period of the year depending on weather conditions. It is possible to adjust the time and place of planned events, depending on whether it is active or passive recreation.

Acknowledgements

The author would like to thank Barbara Wojtach, Institute of Meteorology and Hydrology, Warsaw, Poland; Peter Broede, Leibniz Research Centre for Working Environment and Human Factors at Dortmund Technical University, Germany; Gerd Jendritzky, Meteorological Institute at University of Freiburg, Germany, for the creation the UTCI calculator and making it freely available on the website.

References

AGNEW M. D. and PALUTIKOF J. P., 2006, Impacts of short-term climate variability in the UK on demand for domestic and international tourism, Clim. Res., 31 (1), 109–120.

AMELUNG B. and MORENO A., 2009, Impacts of climate change in tourism in Europe. PESETA –Tourism study, Universiteit Maastricht, 55 pp.

BAJBAKOVA E.M., NEVRAEV G.A. and ČUBUKOV L.A., 1963, Methods of analysis of climate resorts, Nauka, Moskva (in Russian).

BECKEN S. and WILSON J., 2013, The impacts of weather on tourist travel, Tourism Geographies, 15 (4), 620–639.

BECKEN S., 2010, The importance of climate and weather for tourism, Literature review. <http://www.lincoln.ac.nz/PageFiles/6750/WeatherLitReview.pdf > [accessed 10 01 2014].

BIGANO A., HAMILTON J. and TOL R., 2006, The impact of climate on holiday destination choice, Clim. Change, 76, 389–406.

BŁAŻEJCZYK K., 2004, Assessment of recreational potential of bioclimate based on the human heat balance, (in:) Matzarakis A., de Freitas C. R. (eds.), Proceedings of the First International Workshop on Climate, Tourism and Recreation, Commission on Climate Tourism and Recreation, Halkidiki (Greece), 133–152.

BŁAŻEJCZYK K., 2006, Climate and bioclimate of Poland, (in:) Degórski M. (ed.), Natural and human environment of Poland. A geographical overview, Polish Academy of Sciences and Polish Geographical Society, Warszawa, 31–48.

BŁAŻEJCZYK K., 2007, Weather limitations for winter and summer tourism in Europe, (in:) Matzarakis A., de Freitas C. R. Scott D. (eds.), Developments in Tourism Climatology, Commission Climate, Tourism and Recreation, International Society of Biometeorology, Freiburg (Germany), 116–121.

BŁAŻEJCZYK K., BROEDE P., FIALA D., HAVENITH G., HOLMÉR I., JENRITZKY G., KAMPMANN B., 2010, UTCI – nowy wskaźnik oceny obciążeń cieplnych człowieka, Przegl. Geogr., 82 (1), 49–71.

BŁAŻEJCZYK K., KUNERT A., 2011, Bioklimatyczne uwarunkowania rekreacji i turystyki w Polsce, s. Monografie, 13, PAN IGiPZ, Warszawa, 291 pp.

BRANDENBURG C., MATZARAKIS A. and ARNBERGER A., 2007, Weather and cycling – a first approach of the effects of weather conditions on cycling, Meteorol. Applications, 14 (1), 61–67.

CHABIOR M. and GIRJATOWICZ J.P., 1997, Warunki kąpieliskowe u polskiego wybrzeża Bałtyku, Czasopismo Geogr., 1, 25–37.

CHABIOR M. and KORPALSKA-CHABIOR G., 2006, Warunki bioklimatyczne Łeby, Balneologia Polska, 3, 182–189.

CHABIOR M., 2008, Wybrane aspekty bioklimatu Kołobrzegu, Balneologia Polska, 1, 68–74.

COOMBES E., JONES A. and SUTHERLAND W., 2009, The implication of Climate Change on Coastal Visitor Numbers: A Regional Analysis, J. of Coastal Res., 25 (4), 981–990.

de FREITAS C. R., 1990, Recreation climate assessment, Int. J. Climatol., 10 (1), 89–103.

de FREITAS C. R., 2001, Theory, Concepts and Methods in Tourism Climate Research, (in:) Matzarakis A., de Freitas C. R. (eds.), Proceedings of the First International Workshop on Climate, Tourism and Recreation, Commission on Climate Tourism and Recreation, Halkidiki (Greece), 3–20.

de FREITAS C., SCOTT D., MCBOYLE G., 2008, A second generation Climate Index for Tourism (CIT): specification and verification, Int. J. Climatol., 52 (5), 399–407.

DENSTADLI J. M., JACOBSEN J. K. S. and LOHMAN M., 2011, Tourist perceptions of summer weather in Scadinavia, Annals of Tourism Res., 38 (3), 920–940.

FALK M., 2014, Impact of weather conditions on tourism demand in the peak summer season over the last 50 years, Tourism Management Perspectives, 9, 24–35.

FILIES C. and SCHUMACHER S., 2013, Climate Change Impacts on Baltic Coastal Tourism and the Complexity of Sectoral Adaptation (in:) Schmidt-Thomé P. and Klein J. (eds.), Climate Change Adaptation in Practice: From strategy development to implementation, John Wiley & Sons, Ltd: Oxford.

FLACH E., 1981, Human bioclimatology, (in:) Landsberg H. E. (ed.), World Survey of Climatology, General Climatology, 3, Elsevier, Amsterdam-Oxford-New York, 2–187.

GIRJATOWICZ J.P. 2006, Zróżnicowanie przestrzenne warunków kąpielowych na wybrzeżu polskim, Przegl. Geofiz., 2, 117–125.

GÓMEZ MARTÍN B., 2005, Weather, climate and tourism. A geographical Perspective, Annals of Tourism Res., 32, (3), 571–591.

HAMILTON J. and TOL R., 2007, The impact of climate change on tourism in Germany, the UK and Ireland: a simulation study, Regional Environmental Change, 7, 161–172.

HAMILTON J., 2005, Tourism, Climate Change and the Coastal Zone, Dissertation, Uniwersität Hamburg, 181 pp.

HAMILTON J., MADDISON D. and TOL R., 2005, Climate change and international tourism: a simulation study, Global Environm. Study, 15 (3), 253–266.

JANKOWIAK J. and PARCZEWSKI W. (ed.), 1978, Bioklimat uzdrowisk polskich, IMGW, Warszawa, 429 pp.

KAMMLER M. and SCHERNEWSKI G., 2004, Spatial and temporal analysis of beach tourism using webcam and aerial photographs, Coastline Reports, 2, 121–128.

KOWALKOWSKA L., BŁAŻEJCZYK K., KYRCZ H., 2003, Bioclimatic conditions on the south coast of the Baltic sea in summer, (in:) Błażejczyk K., Adamczyk A. (eds.), The relationships climate-Man-Climate, Geographic Document., 29, Polish Academy of Sciences, Warszawa, 189–192 [in French].

KOZŁOWSKA-SZCZĘSNA T., BŁAŻEJCZYK K. and KRAWCZYK B., 1997, Bioklimatologia człowieka, Metody i ich zastosowanie w badaniach bioklimatu Polski, s. Monografie, 1, Polska Akademia Nauk, Warszawa, 200 pp.

KOZŁOWSKA-SZCZĘSNA T., KRAWCZYK B. and KUCHCIK M., 2004, Wpływ środowiska atmosferycznego na zdrowie i samopoczucie człowieka, s. Monografie, 4, Polska Akademia Nauk, Warszawa, 194 pp.

KOŹMIŃSKI CZ. and MICHALSKA B., 2006, Usłonecznienie rzeczywiste w strefie polskiego wybrzeża Bałtyku, Acta Agrophysica, 8 (1), 147–172.

KOŹMIŃSKI CZ. and MICHALSKA B., 2008, Ocena warunków pogodowych dla rekreacji i turystyki w rejonie Świnoujścia (in:) Dutkowski M. (ed.), Problemy turystyki i rekreacji, 1, Uniwersytet Szczeciński, 31–41.

KOŹMIŃSKI CZ. and MICHALSKA B., 2010a, Evaluation of bioclimate of the Ustka region for the needs of recreation and tourism, Acta Agrophysica, 184, 82–103.

KOŹMIŃSKI CZ. and MICHALSKA B., 2010b, Międzydobowe zmiany ciśnienia atmosferycznego w strefie polskiego wybrzeża Bałtyku, Przegl. Geogr., 82 (1), 73–84.

KOŹMIŃSKI CZ. and MICHALSKA B., 2011, Meteorologiczne uwarunkowania rozwoju turystyki i rekreacji w strefie polskiego wybrzeża Bałtyku, Acta Balneologica, 1, 68–74.

KOŹMIŃSKI CZ., MICHALSKA B., SZCZEPANOWSKA E. and GÓRNIK K., 2013, Zarys turystyki zdrowotnej i uzdrowiskowej, Uniwersytet Szczeciński, 200 pp.

LISE W. and TOL R., 2002, Impact of climate on tourist demand, Clim. Change, 55, 429–449.

LUNDTORP S., RASSING C.R. and WANHILL S., 1999, The off-season is 'no-season': the case on the Danish island of Bornholm, Tourism Economics, 5 (1), 49–68.

MANNING R. and POWERS L., 1988, Peak and off-peak use: redistributing the outdoor recreation/tourism load, Journal of Travel Res., 27, 43–45.

MATZARAKIS A., 2006, Weather- and climate-related information for tourism, Tourism and Hospitality Planning & Development, 3 (2), 99–115.

MERCER J. (ed.), 2001, Glossary of terms for thermal physiology, The Japanese Journal of Physiology, 51 (2), 254–280.

MIECZKOWSKI Z., 1985, The Tourism Climatic Index: a method of evaluating world climates for tourism, The Canadian Geographer, 29 (3), 220–233.

MORABITO M, CRISCI A, BARCAIOLI G, MARACCHI G., 2004, Climate change: The impact on tourism comfort at three Italian tourist sites (in:) Matzarakis A., de Freitas C. R., Scott D. (eds.) Advances in Tourism Climatol., Ber. Meteor. Inst. Univ. Freiburg (Germany), 12, 56–65.

MORABITO M., GRIFONI D., CRISCI A., FIBBI L., ORLANDINI S., GENSINI G.F., ZIPOLI G., 2014, Might outdoor heat stress be considered a proxy for the unperceivable effect of the ultraviolet-induced risk of erythema in Florence? J. Photochem. Photobiol. B: Biology, 130, 338–348.

MORENO A., 2007, The role of weather in beach recreation – a case study using webcam images (in:) Matzarakis A., de Freitas C. R., Scott D. (eds.), Developments in Tourism Climatology, Commission Climate, Tourism and Recreation, International Society of Biometeorology, Freiburg (Germany), 80–86.

MORENO A., AMELUNG B. and SANTAMARTA L., 2008, Linking Beach Recreation to Weather Conditions: A case Study in Zandvoort, Netherlands, Tourism in Marine Environments, 5, 111–120.

PERCH-NIELSEN S., 2010, The vulnerability of beach tourism to climate change: an index approach, Clim. Change, 100, 579–606.

PERCH-NIELSEN S., AMELUNG B., KMUTTI R., 2010, Future climate resources for tourism in Europe based on daily Tourism Climatic Index, Clim. Change, 103, 363–381.

PERRY A., 2004, Sport tourism and climate variability, Berichte Meteor. Inst. Univ. Freiburg, 12, 174–179.

RUTTY M., SCOTT D., 2014, Bioclimatic comfort and thermal perceptions and preferences of beach tourists, Int. J. Biometeorol., DOI 10.1007/s00484-014-0820-x [accessed 30.10.2014].

SCHÖNWIESE CH. and RAPP J., 1997, Climate trend atlas of Europe based on observations 1891–1990, Kluwer Academic Publishers, Dordrecht, Boston, London, 97 pp.

ŚWIĄTEK M., 2009, Opady frontowe na polskim wybrzeżu Bałtyku, Przegl. Geogr., 1 (81), 107–119.

ŚWIĄTEK M., 2010, Seasonal variability of precipitation on the Polish Baltic Sea coast, Acta Agrophysica, 183 (4), 38–49.

WOŚ A., 2010, Klimat Polski w drugiej połowie XX wieku, Uniwersytet A. Mickiewicza, Poznań, 478 pp.

ZHANG F., WANG X. H., 2013, Assessing preferences of beach users for certain aspects of weather and ocean conditions: case studies from Australia, Int. J. Biometeorol., 57, 337–347.