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The use of webcam images to determine tourist?climate aptitude: favourable weather types for sun and beach tourism on the Alicante coast (Spain)

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ORIGINAL PAPER

The use of webcam images to determine tourist–climate aptitude: favourable weather types for sun and beach tourism on the Alicante coast (Spain)

Emilio Martínez Ibarra

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Abstract Climate has an obvious influence on tourism as a resource and as a location factor for tourist activities. Consequently, the tourist phenomenon in general is heavily controlled by meteorological conditions—in short, by the climate. In this article, the author proposes a set of weather types with which to establish the climate aptitude for sun and beach tourism. To determine these types, the density of use of one of the beaches with the lowest seasonality in continental Europe, the Levante Beach in Benidorm (Alicante, Spain), was analysed. Beach attendance was monitored using a webcam installed by the "Agencia Valenciana de Turismo". The relationship between the density of use of the lower and upper beach areas on the one hand, and meteorological variables on the other, allowed comfort (physiological equivalent temperature) and enjoyment (fractions of solar radiation) thresholds to be established. The appropriate hydric comfort values were obtained by comparing the ranges proposed by Besancenot in 1989 [Besancenot (1989) *Clima et turismes*. Massom, París] with numbers of visitors to the beach. The wind velocity and precipitation thresholds were selected following consultation with the literature and considering the climatic characteristics of the environment under analysis. Based on a combination of these thresholds, weather types suitable for this specific tourist activity are defined. Thus, this article presents a method for assessing the extent to which a day on the beach can be enjoyed. This has a number of applications, for planners, the tourism business and consumers alike. The use of this (filter) method in climate databases and meteorological forecasts could help determine the tourist season, the suitability of setting up a business associated with sun and beach tourism, as well as help plan holidays and program a day's leisure activities. Thus, the article seeks to improve our understanding of the climate preferences of that tourist activity par excellence: sun and beach tourism.

Keywords Webcam image · Tourist–climate aptitude · Weather type · Sun and beach tourism · Benidorm's Levante Beach (Alicante)

Introduction

According to Scott et al. (2008), there are three procedures for calibrating the climatic preferences of tourists. First, there are those based on the consultation of experts or professionals; second, those based on the analysis of the relationship between meteorological conditions and demand behaviour; and, finally, those that involve surveys regarding tourist climate preferences, conducted either "in situ" or "ex situ". This study adopts primarily the second of these procedures: "revealed tourism climate preferences". Specifically, it examines the relationship between the number of tourists on a beach and the weather, thanks to the possibilities afforded by the study context.

The unprecedented technological progress experienced in recent years, thanks primarily to the internet, makes tourist-related information more accessible to potential clients and promotes individual travel planning. Furthermore, it makes new media and sources of tourist information available to researchers. In this sense, webcam images are of particular interest, especially those operating on ski slopes and on beaches. Webcam images make it possible to monitor both type and density-of-use data (Timothy and Groves 2001).

Webcam images allow us to observe beach-user behaviour and user responses to given atmospheric conditions.

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This analysis can be useful in examining the level of tourist satisfaction, as the length of time the tourist spends on the beach (the use) is taken to be associated with his or her enjoyment, since were this not the case the user would have abandoned the beach. Consequently, it is reasonable to propose that in this way it is possible to appreciate the degree of aptitude of different weather conditions for tourist activities. Here, beaches can be seen as laboratories for tourism climatology, in a context in which two factors of great importance merge. On the one hand, the activity undertaken is highly sensitive to meteorological conditions, and, on the other, the activity often presents very high concentrations of use. This latter characteristic makes the beach an ideal setting for studying a sample of significant population size.

Thus, in order to identify optimal thresholds of physiological equivalent temperature (PET) and percentage radiation for sun and beach tourism on the coast of Alicante, it was deemed adequate to analyse the level of daily occupation of the Levante Beach in Benidorm (Fig. 1)—a place considered an international reference point in the Fordist tourist model: Traditional Mass Tourism (Vera-Rebollo 2001). Similarly, to obtain values of hydric comfort, the author compared the thresholds set by Besancenot (1989) with the number of daily users on Benidorm's Levante beach. To analyse the beach's level of daily use, the author employed images from a webcam installed by the Agencia Valenciana de Turismo (the official tourist agency for the Comunidad Valenciana, Spain) at the westernmost point of this beach. Precipitation and wind values were obtained from the literature and were based on the climatic characteristics of the environment being analysed.

This study demonstrates how information obtained from a webcam can be used to contribute to the determination of classification of weather types for sun and beach tourism on the Alicante coast. First, the level of tourist use of Benidorm's Levante Beach was analysed in relation to the aesthetic and thermal facets of climate to which tourism responds. Then, the optimal thresholds of thermal and hydric comfort and the fraction of solar radiation were obtained. After that, taking into account findings in the literature and the climate characteristics of the zone, thresholds of precipitation and wind velocity (the physical facets of tourism climate) were determined. Finally, weather types were defined and classified in accordance with their aptitude for sun and beach tourism.

Methods

Among others, there are two specific problems that need to be tackled in tourism climatology. On the one hand, evaluating the tourism climate aptitude of a particular place (Besancenot 1989), i.e. determining the ideal climate for a particular tourist activity (Besancenot 1989; De Freitas 2003); and, on the other, developing a method for undertaking such an enterprise (Besancenot 1989). The task is particularly complex since, in addition to handling various meteorological and climatic parameters, it also requires an understanding of the human response to them in a given social and cultural context, in order to endow each atmospheric scenario with a meaning for tourism (De Freitas et al. 2008).

With these difficulties in mind, this study seeks to determine the tourist's climate preferences as regards sun and beach tourism, and then to present a method for evaluating the climate aptitude for this recreational activity (based on behaviour—use of the beach—it is possible to determine user preferences and, finally, we can assess the tourist climate aptitude). The methodology used is based primarily on an inductive-observational method. Thus, this study observes weather conditions and their relation to bathing and sunbathing. Of course, the relationship between

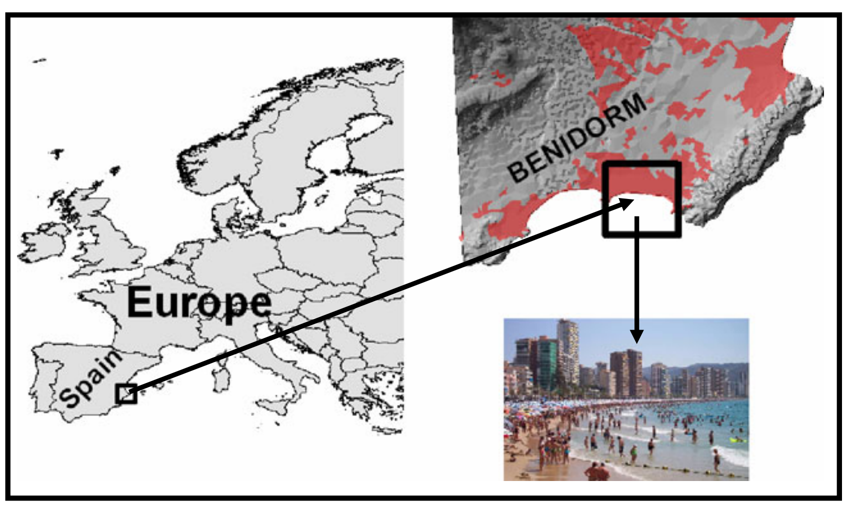

Fig. 1 Geographical location and appearance of Benidorm's Levante Beach

human behaviour and atmospheric and climatic conditions is intuitively obvious and has been widely recognised for many years (Brandenburg et al. 2007). In this regard, the analysis of an in situ phenomenon can be considered the most appropriate path for undertaking a study of tourism climatology, especially if the activity is largely determined by weather conditions, as is the case with the use and enjoyment of beaches. As such, beaches can be considered laboratories for tourist climatology. Indeed, an activity that is highly sensitive to meteorological conditions is practised on beaches and, moreover, this leisure activity is usually associated with high concentrations of use. What the author presents therefore is a method complementary to that provided by questionnaires enquiring into tourist climate preferences, since the conducting of surveys to establish tourist preferences can be problematic, particularly as regards interpretation of the questions posed (Suchman and Jordan 1990; Moreno et al. 2008). Thus, for example, providing responses regarding the climate thresholds that users prefer for taking part in a certain activity can be difficult. Thus, the author deems it more appropriate to ask about the weather being experienced. In other words, selecting as a sample those tourists that have enjoyed, for example, a day on the beach, and then asking them how they would evaluate the day (from a climatic perspective) for sunbathing and swimming in the sea.

The observations were made using webcam images, in line with Kammler and Schernewsky (2004) and Moreno et al. (2008). The densities of bathing and sunbathing practices were monitored. The webcam selected, which belongs to the Agencia Valenciana de Turismo, is located on Benidorm's Levante Beach. At this juncture, it is perhaps worth stressing why we chose this particular resort and, specifically, Levante beach. It should be remembered that Benidorm is one of the most prominent sun and beach resorts in the world. According to the "Top City Destination Ranking", compiled by the market research group Euromonitor International, in 2006 Benidorm received a total of 2,457 x 10^6 tourist arrivals. Benidorm was ranked 33rd among the most visited cities in the world. In this ranking, only one sun and beach tourist resort, Cancun (http://www.euromonitor.com/Top_150_City_Destinations_London_Leads_the_Way), was placed higher than Benidorm. Furthermore, the city of Benidorm, unlike other mid-latitudinal sun and beach resorts has managed, by and large, to overcome the problem of high seasonality. This is clearly reflected in Fig. 2, which shows that, among the main coastal resorts of Spain, only Adeje, in the Canary Islands (with a subtropical climate), has higher levels of hotel occupancy during just one winter month (January). This means that, throughout the year, Benidorm has a high customer potential. As most of this concentrates in the eastern sector of the municipality, Benidorm's Levante beach is one of the beaches with the lowest seasonality of use in continental Europe (Table 1). In this way, the possible effects of the lack of coincidence reported by Yapp and McDonald (1978), and De Freitas (1990) between peak tourist numbers and the period of optimum climate can be corrected for.

The beach was studied at midday (1200 hours local time) so that the tourist sample analysed[1] can be considered representative of the preferences of those tourists that frequent the Alicante coast.[2] This point in the day coincides with the highest use of the Levante Beach, as confirmed by this study as well as in those undertaken by Gaviria (1977) and Sellés (1999). Thus, different categories of densities of use (sunbathing and bathing), from 1 August 2002 to 31 December 2003, were established. More specifically, a file was set up containing webcam images (12:00 noon), classifying occupation as either null (0), low (1), medium (2) or high (3).[3] The determination of the degree of use did not involve an exhaustive headcount, but rather was based on a visual appraisal. To do this, and to be as objective as possible, the images were stored and the main classes of occupation density were established. Once determined, the level of use of each of the images was fixed. In this way, the codification of tourist frequency was more feasible.

Having established the daily tourist attendance at Benidorm's Levante Beach, this tourist variable was related to thermal comfort, hydric comfort, and the fraction of solar radiation. In the case of thermal comfort, a bioclimate index was used based on the human energy balance. For this purpose, one of the indices most frequently used at present was chosen, the physiological equivalent temperature (PET) (Höppe 1999; Matzarakis et al. 1999). This includes all the significant variables that influence thermal comfort (Matzarakis et al. 2007). In fact, the PET model was developed in accordance with norm 3787 of the German Society of Engineers (Knez and Thorsson 2006). Moreover, it is easy to interpret, being expressed in degrees Celsius (Lin and Matzarakis 2008; Matzarakis et al. 2009), and can be calculated using the RayMan model (Matzarakis and Rutz 2005). Moreover, in the case of the fraction of solar radiation, daily percentages were calculated based on mean 10-day period values. Subsequently, these were related to the number of people on Benidorm's Levante Beach. Likewise, the thresholds of hydric comfort were fixed on the basis of their relationship with the degree of use of the Levante Beach and the

[1] Paying attention to the volume of users, the low degree of seasonality and its heterogeneous composition.

[2] In search, particularly, of sun, sea and sand.

[3] Here, the aim has not been to analyse with an equal degree of precision the highest densities of use, on the understanding that these respond largely to the dynamics of demand (peak holiday periods, in particular at the weekends).

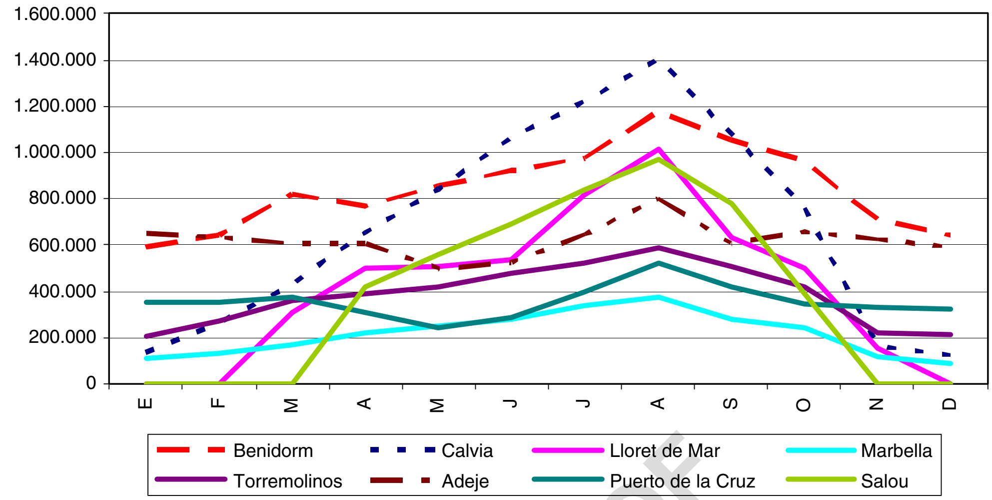

Fig. 2 Number of overnight stays each month in hotels in Spain's leading tourist resorts (2004) according to data from the Instituto Nacional de Estadística de España (INE): http://www.ine.es/

contributions of Besancenot (1989). By contrast, the thresholds of precipitation and wind velocity were determined by taking into consideration the climatic characteristics of the zone under study and references consulted in the literature and referred to in the sections discussing precipitation and wind velocity.

Having defined the thresholds corresponding to the basic requirements of tourism climate, in line with Besancenot (1989) and De Freitas (1990), the most appropriate procedure was chosen in order to evaluate the tourism-climate capacities of the atmosphere. Here, two methods are available: on the one hand, tourist-climate indices and, on the other, weather types (see Besancenot 1989), although what can be more strictly referred to as bioclimate indices have also been used (see Becker 1998, 2000; Mateeva 2001; Balafoutis et al. 2004; Cegnar and Matzarakis 2004; Blazejczyk and Matzarakis 2007).

The summary method, involving different weather types, was used back in the 1970 s and at the beginning of the 1980s by, among others, Gates (1975); Masterton et al. (1976); Crowe et al. (1977); Besancenot et al. (1978); Barbière (1981); Balafoutis et al. (1983); and Besancenot (1985). Besancenot's influence has meant that the method was again used in Portugal by Alcoforado et al. (1999) and Andrade et al. (2007), and in Spain by Gómez-Martín (2004). On the other hand, following the methodical approach proposed by De Freitas (1990), weather types have been used outside the Latin world by Blazejczyk (2005). This method reflects, as Cuadrat Prats (1983) and Andrade et al. (2007) point out, the state of the weather as actually perceived by the individual and, as such, shows in an effective way the characteristics of the atmosphere. Thus, and after combining the main meteorological parameters related to tourism, it is possible to establish a daily

Table 1 Days analysed and density of sunbathing greater than or equal to 2 on Benidorm's Levante beach

Year	Months	No. of days analysed	Density of sunbathing practices on Benidorm's Levante Beach ≥2		
			Total	Weekdays	Weekends and holidays
2003	January	26	0	0	0
2003	February	24	0	0	0
2003	March	27	0	0	0
2003	April	22	7	3	4
2003	May	29	23	15	8
2003	Jun	23	22	15	7
2003	July	28	28	21	7
2002 and 2003	August	31	30	22	8
2002 and 2003	September	56	52	39	13
2002 and 2003	October	59	29	21	8
2002 and 2003	November	53	0	0	0
2002 and 2003	December	51	0	0	0

classification. The ultimate goal is to show the frequency of each of the tourist-meteorological conditions defined.

Values from a meteorological database maintained by the Valencian Institute of Agrarian Research for two seasons were used. The two weather stations are located very near Benidorm: one to the north and the other to the south. Mean conditions were calculated based on the daily values from these two stations. These two weather centres were used for two reasons. First, because at the time of undertaking the study there was no suitable weather station in Benidorm and, second, because Benidorm's climate exhibits characteristics intermediate between the two areas. The variables included in the RayMan model for calculating the PET were: maximum temperature, relative humidity at 1300 hours, wind velocity at 1300 hours, and solar radiation at 1300 hours. As can be seen, only the hottest time of the day was evaluated. It should be borne in mind that, for reasons of operability, a simplification has to be made. De facto, it might be argued that this moment (the hottest) is the best reference point for assessing the climatic aptitude of the whole day.

Results

Thermal and hydric comfort

The relationship between PET values and the density of use of Benidorm's Levante Beach were examined, taking into consideration the degree of occupation of space on the beach both in and out of the water. Indeed, sun and beach tourism should be understood not solely as sunbathing but also as bathing in the sea. Fortunately, the webcam images used allowed both the upper and lower (waterline) beach areas to be visualised.

The comfort standard categories used are the same as those proposed by Matzarakis et al. (2009), with the exception of the class slightly cool. In this study, the lower limit was set at 16°C since lower values have not been recorded for mean densities of dry beach; neither were any recorded for values of occupation for the zone of shallow bathing. The classes very cold and cold were not considered here, as they were not recorded, not even for levels of occupation of low sun tanning. The class cool was not taken into consideration either, since it was only recorded on one occasion. Thus, the comfort classes identified are those included in Table 2.

The relationship between PET and occupation of Levante Beach was established by taking into account the activities of sunbathing and bathing, for the most representative densities of use (2 and 3). For these classes, the frequency percentages were calculated, considering the number of cases observed. According to the results obtained in Table 2, the following comfort categories can be identified by order of frequency: 35°C≤PET<41°C; 29°C≤PET<35°C; PET≥41°C; 23°C≤PET<29°C; 18°C≤PET<23°C; y, 16°C≤PET<18°C. In interpreting this categorisation, it is perhaps useful to recognise two points: first, that the values, despite being expressed in degrees Celsius, do not reflect temperatures but rather a comfort index (PET), which, normally, and especially in warm climates, tends to be much higher than the simple temperature reading; and, second, that they are not in themselves optimum values, but rather optimum daily maximum values.

Table 2 Percentage of cases for the various classes of thermal comfort defined by use densities awarded a value of at least 2, considering bathing and sunbathing jointly (from 1 August 2002 to 31 December 2003). *PET* Physiological equivalent temperature

PET values (°C)	Comfort categories	Density of use	Percentage of cases
16≤PET<18	Slightly cool	≥2	0.6
18≤PET<23	Comfortable	≥2	3.0
23≤PET<29	Slightly warm	≥2	13.4
29≤PET<35	Warm	≥2	22.5
35≤PET<41	Hot	≥2	43.7
PET≥41	Very hot	≥2	17.0

In the case of hydric comfort, it should first be pointed out that human body needs to maintain certain constant water levels. Thus, the body–atmosphere interaction occurs through the exchange of various gases, including water vapour, between the blood and the air, by means of the pulmonary alveoli, via osmosis. Besancenot (1989) considers values of partial water vapour pressure between 4 and 31.3 hPa as being acceptable, and those between 4 and 25 hPa as ideal. Comparing these limits with the most frequent densities of use (both for sunbathing and bathing), it has been calculated that in 98% of instances the water vapour pressure was between 4 and 31.3 hPa, and that the frequency of partial water vapour pressure between 4 and 25 hPa was 82.81%. Therefore, the limits of comfort are identical to those established by Besancenot (1989).

Solar radiation fraction

The radiation fraction thresholds[4] were obtained from the relationship between sun bathing and daily solar radiation. In this respect a database of percentage daily radiation was generated. The calculation of the radiation percentages was conducted as follows: first, the maximum daily radiation for each 10-day period (giving a total of 36 readings per year) for

[4] According to Scott et al. (2008) sunshine is the most important climate variable to take into consideration for sun and beach tourism.

the period 1999 to 2003 was found. Then, the percentage daily radiation with respect to that of the maximum observed for each 10-day period was calculated. Thus, for example, if on the 8 August 2002 there was a daily radiation of 226 w/m^2, this value was compared by taking into consideration the maximum value for the first 10-day period of August recorded between 1999 and 2003, that is, 306.7 w/m^2. Thus we obtained a value of 73.7% of daily radiation for that day. These percentage values of radiation were then matched against the densities of use observed between 1 August 2002 and 31 December 2003.

Next, the range of the solar fraction values was fixed by following a series of steps. First, the occupation level mean, maximum, minimum and mode were fixed for each month.[5] Based on these values, each day was classified as being: unfavourable, acceptable, good and ideal. The latter three were considered as favourable.[6] Then, for each of these degrees of relative potential,[7] the mean percentage value of radiation and its extremes were calculated. Finally, three ranges of solar radiation fractions were determined (unfavourable, acceptable and good/ideal), in accordance with their tourism-climate relative aptitude for sunbathing.

Based on the results obtained, in order to differentiate between suitable and unsuitable situations (from a tourist-climate point of view), a 50% threshold of daily radiation was selected. In fact, after the 50–60% daily radiation interval, the presence of acceptable contexts increased markedly (see Fig. 3). The distinction between acceptable and good/ideal days was fixed at a solar radiation level of 80% and above. Indeed, after this solar radiation value the number of cases defined as being good or ideal for sunbathing rose considerably. In short, the daily radiation fraction (Fr)[8] ranges were as follows: unfavourable $Fr<50\%$; acceptable $50\leq Fr<80\%$; and good/ideal $Fr\geq 80\%$ of radiation.

These values can be expressed as fractions of solar radiation (Fi). In this case, in line with a comparison of 1,263 pairs of data,[9] these categories are as follows: Fi<35% for unfavourable situations; 35≤Fi<75% for acceptable situations; while the situations are defined as ideal if Fi≥75%. In short, the categories are very similar to those identified by Ferreira et al. (1983).

Precipitation

Given the very few days with precipitation, the distinction between thresholds is made on the basis of the relationship between precipitation (mm) and the real daily solar fraction (%) recorded at the observatory in Alicante (Ciudad Jardín) belonging to the State Meteorological Agency.[10] These data were used as they were representative of the study zone, and were the only ones available for a sufficiently large period. This latter condition allowed us to establish acceptable relations.

The most notable aspect of the results is that when it rained, even though precipitation levels did not reach 1 l m^{-2} day^{-1}, days with a radiation fraction greater than 75% were very infrequent. This served to confirm the choice of the threshold of zero millimetres as the criterion for distinguishing ideal from acceptable weather types (Fig. 4).[11]

The distinction between unfavourable and acceptable situations was fixed at the threshold of 5 l m^{-2} day^{-1}. Indeed, on those days when this figure was reached, the radiation fractions above or equal to 35% were present on virtually 40% of the days analysed. Connected to this, and by way of an estimated approach, the unpublished expressions established by Martín-Vide and Peña in 2000, included in Gómez-Martín (2000), can be used in support of these figures. These authors studied the relationship between the daily amount of rainfall (x) and the duration of these precipitation episodes (y) in Barcelona[12]. The resulting equations were: $y=24.688\times^{0.6944}$ in spring; $y=20.68\times^{0.552}$ in summer; $y=25.825\times^{0.7236}$ in autumn; e $y=25.825\times^{0.8084}$ in winter. In keeping with these values for Barcelona, for an amount of rainfall equivalent to 5 mm, the duration of the episode would be: 1.26 h in spring; 0.84 h in summer; 1.38 h in autumn; and 1.74 h in winter. According to these equations, the 5-mm threshold is usually linked to the maximum precipitation considered as acceptable by many authors, that is, the precipitation time (Besancenot et al. 1978; Besancenot 1985, 1989; De Freitas et al. 2008).

[5] In all cases corresponding to the use of the upper beach area above the waterline of Benidorm's Levante Beach.

[6] However, for the months from June to September, inclusive, the distinction between good and ideal was disregarded. Both groups were classified simply as acceptable.

[7] Relative because in completing the calculations the potential is weighted in relation to the month under analysis.

[8] Calculated as indicated at the start of this section.

[9] For this reason we used 1,263 days with data for the two meteorological stations, with sunshine records at locations closer to the study zone (Alicante weather station, State Meteorological Agency) and solar radiation (San Vicente del Raspeig, Laboratory of Climatology, University of Alicante).

[10] The calculation of the fractions of solar radiation was performed based on a numerator comprising the maximum 10-day period in the series and a denominator comprising the daily value recorded.

[11] Criterion proposed by Besancenot et al. (1978), and later adopted by Besancenot (1985, 1989), Gómez-Martín (2000) and Batista and Matos (2004).

[12] The temporal concentration of rainfall events in Barcelona can be considered a point of reference for the study area. Despite the distance separating them, both zones have a Mediterranean climate, characterised by intense rainfall events of short duration (see Martín-Vide 2004).

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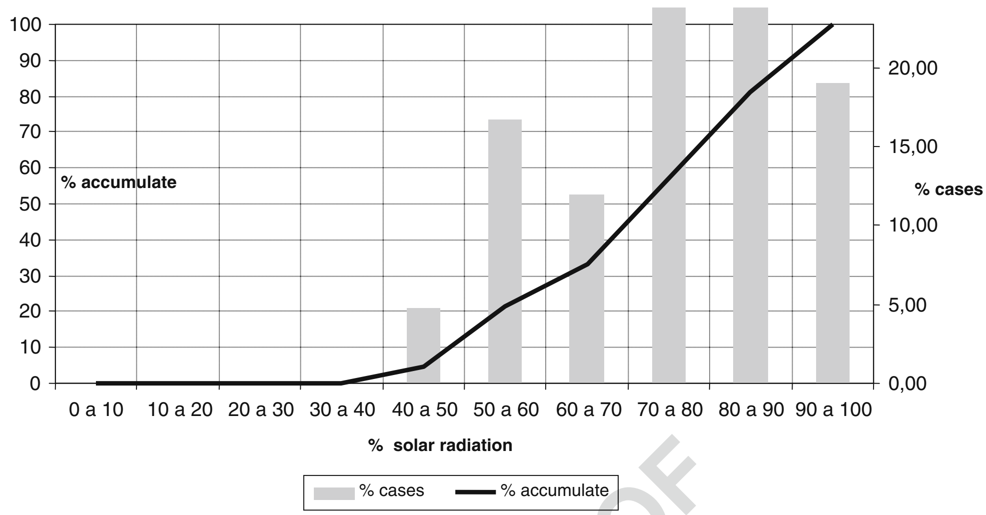

Fig. 3 Empirical frequency intervals for mean daily radiation for situations classified as acceptable, relative potential (from 1 August 2002 to 31 December 2003)

Wind velocity

In the case of this climatic element, it is necessary to take into consideration the work of Besancenot et al. (1978), Besancenot (1985, 1989), Gómez-Martín (2005) and Batista and Matos (2004), as well as the study published by De Freitas et al. (2008). Thus, while in the Latin world a limit of 12 m/s is established, in the latter study a somewhat more restrictive threshold of 6 m/s is proposed;[13] although the former identify two situations: the ideal, with values below 8 m/s, and the acceptable, with wind velocities between 8 and 12 m/s.

Here, in order to determine situations classed as acceptable the author has opted to use the first of the above proposals (8 m/s), since a moderate wind blowing at 1300 hours does not usually tend to be very inconvenient. Thus, in virtually all the cases analysed at the observatory in Alicante (*Ciudad Jardín*), the intensity at this time is usually accompanied by winds below 6 m/s at 0700 and 1800 hours (Table 3).

By contrast, the maximum wind value estimated as being acceptable is not the same as that considered by Besancenot et al. (1978), Besancenot (1985, 1989), Gómez-Martín (2005) and Batista and Matos (2004). Indeed, while the latter establish a threshold of 12 m/s, in this study the author opts for 10 m/s. This choice has two justifications: first, because such velocities can be inconvenient for sunbathing and bathing[14] and, second, because these wind speeds (greater than 10 m/s) have been recorded in Alicante on only one occasion with weather clearly suitable for sun and beach tourism (Table 3).

Estimation of favourable weather types for sun and beach tourism on the Alicante coast

On the basis of the above results, the following weather types can be defined as acceptable:

- First, sunny weather types, identified by radiation fractions (Fr) of at least 80%, zero precipitation (P), wind velocities (V) below 8 m/s, and a partial water vapour pressure (U) between 4 and 25 hPa. Six specific types can be differentiated based on PET values: Very nice sunny weather (35°C≤PET<41°C); Quite nice sunny weather (29°C≤PET<35°C); Nice sunny weather (23°C≤PET<29°C); Comfortable sunny weather (18°C≤PET<23°C); and Acceptable, slightly cool, sunny weather (16°C≤PET<18°C), as well as a weather type characterised by low osmotic pressure: Hot and sultry weather (PET>41 and U<31.3 hPa).
- Second, cloudy weather types, identified by Fr between 50 and 80%, albeit without any rainfall, V < 8 m/s and U between 4 and 31.3 hPa. Among these we can differentiate two on the basis of PET values: Acceptable weather with partial cloud cover (PET≥23°C) ,and Acceptable comfortable weather with partial cloud cover (18°C≤PET<23°C).
- Then, weather conditions characterised by rain. Here, there are three subtypes in total, depending on the amount of accumulated daily precipitation (P) and thermal conditions. Thus, in line with the amount of precipitation, there is Acceptable weather with brief

[13] The typical sand on the beach (with a grain diameter varying between 0.21 mm and 0.25 mm) starts to be moved and lifted by the wind at velocities of 5.6 m/s. This explains why some authors consider wind conditions over 6 m/s to be unfavourable (see Morgan et al. 2000).

[14] For its richness of expression, recall in this regard the Beaufort scale for velocities between 10 and 12 m/s.

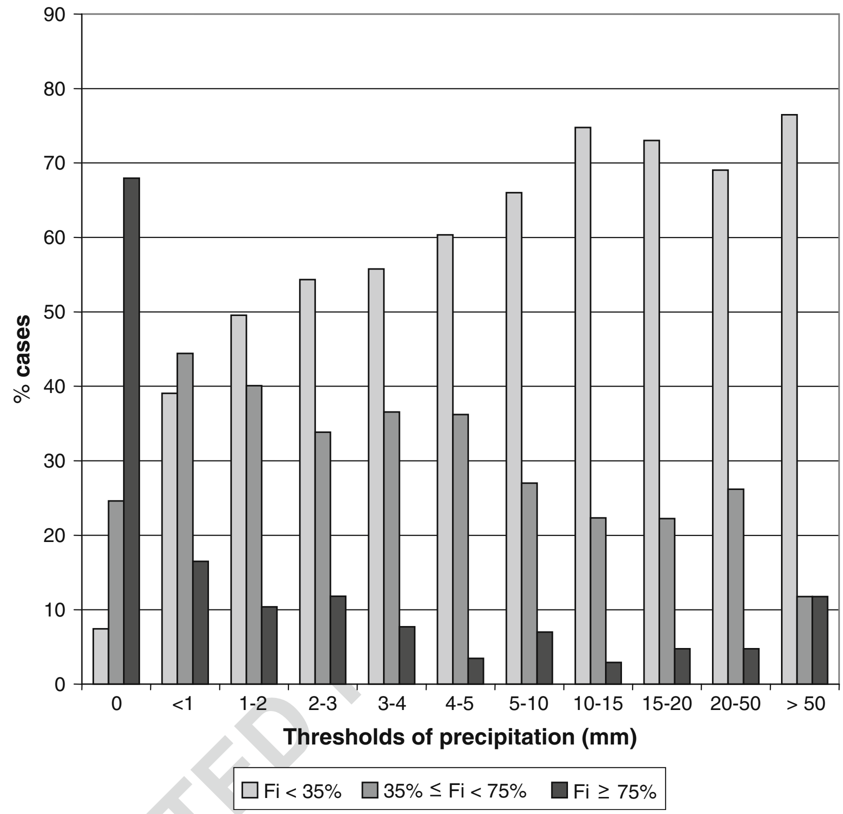

Fig. 4 Relationship between solar radiation and precipitation (1974–2003)

episodes of rain (0.1≤P<1 mm), and Acceptable weather with episodes of rain (1≤P<5 mm), both with Fr≥66%, PET≥23°C, V<8 m/s and a U between 4 and 31.3 hPa. In addition, there is a further weather type with lower temperatures, Acceptable comfortable weather with brief episodes of rain, whose defining characteristics are: Fr≥66%, 0.1≤P<1 mm, 18°C≤PET <23°C, V<8 m/s and 4<U<25 hPa.

– Finally, there are two variations on acceptable situations with relatively high winds (8<V≤10 m/s). Two types can be differentiated according to thermal comfort levels: Acceptable weather with strong winds (Fr≥80%, P=0 mm, 4<U<31.3 hPa and PET≥23°C), and Acceptable comfortable weather with strong winds (Fr≥80%, P=0 mm, 4<U<31.3 hPa and 18°C≤PET< 23°C).

Having established the thresholds of each of the weather types proposed, they now need to be ranked according to their tourism-climate aptitude for enjoying sun and beach tourism. Note that this ranking is based principally on the results contained in this study (Table 4). In addition, by way of support, the contributions of Besancenot et al. (1978), Besancenot (1985, 1989), Gómez-Martín (2005), Batista Tamayo and Matos Pupo (2004), De Freitas et al. (2008) and Scott et al. (2008) have also been taken into account.

As expected, Besancenot et al. (1978), Besancenot (1985, 1989), Gómez-Martín (2005), Batista Tamayo and Matos Pupo (2004), and De Freitas et al. (2008) agree in conferring greatest importance on sunny, quite hot weather types, but conditions that remain nevertheless relatively comfortable. Indeed, for Scott et al. (2008) sunshine and temperature are the first and second most important climatic parameters for being able to enjoy the sun and the beach. This level of agreement, together with the deductions reported above, allows us to identify the first and second most suitable weather types. The third most suitable type, based on the results reported here in Table 4, can be identified as that meteorological condition that has the sole inconvenience of presenting slight thermal stress.[15]

The next question that needs to be considered is under which thermal contexts cloudy conditions begin to acquire greater relevance than sunny conditions. Here, it is necessary to bear in mind that, under hypertonic conditions, then Besancenot et al. (1978) and Besancenot (1985, 1989) confer greater importance on sunshine than cloud cover. Thus, acceptable weather with some cloud cover is ranked after sunny weather that limits (in exclusively heat terms) conditions considered as being adequate. By contrast, under hypotonic conditions, sunshine cedes its importance to cloudy situations, even when accompanied marked by episodes of rainfall.

[15] Here, it is worth recalling that in the classification of Besancenot et al. (1978), the ideal weather type was limited by maximum temperatures below 33°C.

Table 3 Wind velocity (V) frequencies at 0700 and 1800 hours (1974–2003) for various atmospheric conditions. *GMT* Greenwich mean time

6≤V≤8m/s at 1300hours and PET≥16°C and Fi≥ 75%								
Frequencies	GMT	V<6 m/s	V<8 m/s	6≤V≤8 m/s	V>8 m/s	8≤V≤10 m/s	V>10 m/s	V>12 m/s
Absolute	0700 hours	447	462	15	4	4	0	0
	1800 hours	375	453	78	13	26	1	0
Relative	0700 hours	47.96	49.57	1.61	0,43	0.43	0.00	0.00
	1800 hours	39.64	47.89	8.25	1.37	2.75	0.11	0.00
6≤V≤8 m/s at 1300 hours and PET≥23°C and 35≤Fi≤75								
Frequencies	GMT	V<6 m/s	V<8 m/s	6≤V≤8 m/s	V>8 m/s	8≤V≤10 m/s	V>10 m/s	V>12 m/s
Absolute	0700 hours	42	44		1	1	0	0
	1800 hours	26	39	13	6	6	0	0
Relative	0700 hours	47.73	50.00	0.00	1.14	1.14	0.00	0.00
	1800 hours	28.89	43.33	14.44	6.67	6.67	0.00	0.00
6≤V≤8 m/s at 1300 hours and PET≥29°C and Fi≥75								
Frequencies	GMT	V<6 m/s	V<8 m/s	6≤V≤8 m/s	V>8 m/s	8≤V≤10 m/s	V>10 m/s	V>12 m/s
Absolute	0700 hours	54	56	2	0	0	0	0
	1800 hours	34	47	13	9	9	0	0
Relative	0700 hours	48.21	50.00	1.79	0.00	0.00	0.00	0.00
	1800 hours	30.36	41.96	11.61	8.04	8.04	0.00	0.00

Gómez-Martín (2005) confers less importance on sunshine. In fact, in her classification, both hot, sultry weather as well as cool weather types (respectively) are lower down the list than weather conditions whose sole inconvenience is the fact of being somewhat overcast. After the ideal weather type, therefore, greater importance is given to comfort than to sunshine. Batista Tamayo and Matos Pupo (2004) also show considerable permissiveness regarding the presence of cloud cover in their classification. Indeed, all weather types, with the exception of that considered ideal, may include a certain amount of cloud cover. Finally, in the classification proposed by De Freitas et al. (2008), cloudy conditions show greater or the same degree of aptitude as that presented by sunny settings only after very hot and cool weather types have been included.

The present study compares the density of use of the upper shore area of the Levante Beach in Benidorm and acceptable weather conditions. Thus, attention has been focussed on conditions with a solar radiation fraction of at least 80%, that is, sunny weather types, and on those that present a value between 50 and 80%, i.e. weather types with partial cloud cover. The first thing to underline, however, is the greater potential of clear or virtually clear skies compared to that of overcast skies.[16] Yet, at what threshold of PET values do the former cease to be more adequate for sun and beach tourism? Here, it should be noted that slightly hot weather with some cloud cover records a greater aptitude than comfortable sunny weather. Thus, after hot sultry weather would come the weather type classified as nice and sunny, followed by acceptable weather with partial cloud cover.

Having established the ranking up to this point, and taking into consideration the fact that, according to the study conducted by Scott et al. (2008), precipitation and wind are the third and fourth most important climatic parameters for sun and beach tourism, the question is whether comfortable sunny weather is more suitable than the weather type that presents the inconveniences of rain or wind but which offers relatively hot temperatures. The density of use of Benidorm's Levante Beach was greater during slightly hot weather with some rain (i.e. < 5 mm) than during comfortable sunny conditions. Consequently, the two weather subtypes that are slightly hot with rain can be ranked above comfortable sunny weather type.

Slightly hot and sunny weather types, and relatively windy are considered more suitable than comfortable sunny types. After this, based on the degree of use of the upper shore area of Benidorm's Levante Beach come comfortable sunny types and types characterised by PET values between 18°C and 23°C, with cloud cover, rain and wind in each case.

Finally, in keeping with its infrequent manifestation, comes slight cool sunny weather (Table 5).

Discussion

The importance of sun, sea and sand tourism is self-evident and even today the main tourist migrations continue to be

[16] In all the classifications consulted, cloud cover has been considered less inconvenient than episodes of rain or slight winds.

Table 4 Density of sunbathing and bathing recreational practices on Benidorm's Levante Beach under different atmospheric conditions (number of cases)

	Density of recreational practices on Benidorm's Levante Beach				
	Fr≥80%				
Thermal comfort	Sunbathing		Bathing		
	≥2	=3	≥1	≥2	=3
16≤PET<18	0	0	0	0	0
18≤PET<23	4	2	3	1	0
23≤PET<29	22	16	19	9	3
29≤PET<35	42	34	38	35	15
35≤PET<41	66	65	65	64	53
PET≥41	25	25	25	25	25
	50≤Fr<80				
Thermal comfort	Sunbathing		Bathing		
	≥2	=3	≥1	≥2	=3
16≤PET<18	1	1	0	0	0
18≤PET<23	6	2	3	3	1
23≤PET<29	15	9	12	10	3
29≤PET<35	8	6	9	9	3
35≤PET<41	4	4	4	4	4
PET≥41	0	0	0	0	0
	Fr≥50 and 0.1≤P<5				
Thermal comfort	Sunbathing		Bathing		
	≥2	=3	≥1	≥2	=3
16≤PET<18	0	0	0	0	0
18≤PET<23	4	2	3	3	1
23≤PET<29	6	3	6	5	1
29≤PET<35	3	2	3	3	1
35≤PET<41	12	12	12	12	10
PET≥41	0	0	0	0	1

driven by these two basic resources: sun and beaches. In Europe, the flow of these tourists from north to south is well defined, as new tourist products and typologies prove unable to overshadow sun and beach tourism. Despite its dominance, however, there are still major gaps in our understanding of the relationship between weather, climate and mass tourism. Thus, this study has sought to determine the ideal climate for sun and beach tourism.

Having made this initial incursion, analysis of the frequency use of tourist beaches has proved itself to be a suitable procedure for establishing tourism-climate relations. In this context, webcam images are a highly useful tool for recording the density of occupation, particularly in those zones in which the number of people on the beach is not always so clearly determined by extra-climatic factors (seasonality, peak holiday periods, concentration of beach-goers at weekends, etc.). A beach that presents these characteristics is the one studied here, Benidorm's (Spain) easternmost beach. It has been shown that this beach attracts a high number of tourists, has little seasonality and a marked diversity of users (in terms of age and climatic region of origin). The sample studied can be considered as being representative, as it is sufficiently wide and heterogeneous. Thus, when the numbers using a beach meet these criteria, the analysis of the density of its use constitutes a suitable way of defining ideal tourism-climate thresholds.

Having met these initial prerequisites, it can be concluded that the procedure described for evaluating optimal atmosphere conditions for sun and beach tourism is appropriate. In fact, the procedure considers thermal, physical and aesthetic facets of the meteorological conditions that most influence sun and beach tourism. Likewise, these meteorological qualities are assessed daily—the most appropriate time scale for evaluating the climate potential for certain recreational activities. However, this is not to say that an analysis of three further questions could have contributed to the study: an analysis of the frequency of use in the late afternoon; a separate study of weekdays, on the one hand, and weekends and holidays, on the other; and conducting surveys on the weather actually experienced. As regards the first of these potential areas for study, it should be recognised that a study of the time of maximum use in the early evening would have completed any assessment of the aptitude of the day in question for this type of tourist activity. And, in relation to the third question, I should point out that the surveys would have to be based on the tourist-climate evaluation of the day for enjoying the sun and the beach. The questions could then be put to those tourists that had been to the beach the day prior to administering the questionnaire. Such an opinion poll would be of particular use for determining the maximum thermal comfort threshold for beach-goers.

The results of this study stress the potential of hypotonic conditions compared to a state of thermal neutrality (recall that the author is dealing with maximum daily values). In fact, priority has been given here to "quite hot" and "hot" conditions with some slight inconvenience created by states of sunny and comfortable weather types. And this is because going to the beach in order to sunbathe and bathe in the sea makes little sense in thermally neutral environments or those with a slightly positive stress. In resorts characterised by the resources of sun and beach, this evidence might act as a cushion for the thermal effects of climate change. However, it should perhaps be borne in mind that, as the period of study included the heat wave that affected Europe in 2003, the category "very hot" and, consequently, "weather type 3", might have been granted greater importance than would otherwise have been the case under normal conditions.

Finally, using the method presented here it is possible to study the tourism-climate aptitudes for sun and sand t5.1 **Table 5** Weather types defined as suitable for sun and beach tourism on the Alicante coast

	Type	Description	Fraction of solar radiation (Fi) or radiation fraction (Fr)	Duration (D) and amount of precipitation (P)	PET	Wind speed (V)	Partial water vapour pressure (U)
t5.2	Type	Description	Fraction of solar radiation (Fi) or radiation fraction (Fr)	Duration (D) and amount of precipitation (P)	PET	Wind speed (V)	Partial water vapour pressure (U)
t5.3	1	Very nice sunny weather	Fi≥75%h or Fr≥80%	D=0 h or P=0 mm	35°C≤ PET< 41°C	V< 8 m/s	4<U<25 hPa
t5.4	2	Quite nice sunny weather	Fi≥75%h or Fr≥80%	D=0 h or P=0 mm	29°C≤ PET< 35°C	V< 8 m/s	4<U<25 hPa
t5.5	3	Hot and sultry weather	Fi≥75%h or Fr≥80%	D=0 h or P=0 mm	PET>41	V< 8 m/s	U<31.3 hPa
t5.6	4	Nice sunny weather	Fi≥75%h or Fr≥80%	D=0 h or P=0 mm	23°C≤ PET< 29°C	V< 8 m/s	4<U<25 hPa
t5.7	5	Acceptable weather with partial cloud cover	35%≤Fi<75%or 50%≤Fr< 80%	D=0 h or P=0 mm	PET≥ 23°C		4<U<31.3 hPa
t5.8	6	Acceptable weather with brief episodes of rain	Fi≥50% or Fr≥66%	0.1≤P<1 mm	PET≥ 23°C	V< 8 m/s	4<U<31.3 hPa
t5.9	7	Acceptable weather with episodes of rain	Fi>50% or Fr>66%	1≤P<5 mm	PET≥ 23°C	V< 8 m/s	4<U<31.3 hPa
t5.10	8	Acceptable weather with strong winds	Fi≥75%h or Fr≥80%	D=0 h or P=0 mm	PET≥ 23°C	8≤V≤	10 m//s
	4< U <	31.3 hPa					
t5.11	9	Acceptable comfortable sunny weather	Fi≥75%h or Fr≥80%	D=0 h or P=0 mm	18°C≤ PET< 23°C	V< 8 m/s	4<U<25 hPa
t5.12	10	Acceptable comfortable weather with partial cloud cover	35%≤Fi<75% or 50%≤Fr< 80%	D=0 h or P=0 mm	18°C≤ PET< 23°C	V< 8 m/s	4<U<25 hPa
t5.13	11	Acceptable comfortable weather with brief episodes of rain	Fi≥50% or Fr≥66%	0,1≤P<1 mm	18°C≤ PET< 23°C	V< 8 m/s	4<U<25 hPa
t5.14	12	Acceptable comfortable weather with strong winds	Fi≥75%h or Fr≥80%	D=0 h or P=0 mm	18°C≤ PET< 23°C	8<V≤	10 m//s
	4< U <	25 hPa					
t5.15	13	Acceptable, cool sunny weather	Fi≥75%h or Fr≥80%	D=0 h or P=0 mm	16°C≤ PET< 18°C	V< 8 m/s	4<U<25 hPa

tourism, and also to define the tourist seasons for these activities in any resort. This would be of great use in meeting the planning needs of the tourist sector, especially as this industry faces the uncertainty posed by climate change, and it would certainly be possible to use the filter proposed here in climate projection models. Likewise, meteorological forecasts for sun and beach resorts could adopt this classification for determining their daily meteorological aptitude. This would require reducing the 13 indices defined here as acceptable to a scale of values that ranged from 5 to 10, with those considered unsuitable being designated a value of 0. In other words, very nice, sunny weather would be designated a value of 10, while a day that did not coincide with the meteorological filter proposed here would receive a value of 0. A weather forecast drawn up along these lines would allow tourists to assess a day according to its aptitude for sun and beach tourism by reference to a single numerical value. This would provide quality to the product being offered and would meet the shortcomings of meteorological forecasts for tourism-climate purposes. Similarly, planners would be able, as far as this were possible, to match the tourist services offered by a certain resort to the weather conditions, and ultimately it would be possible to improve the degree of tourist satisfaction.

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