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A second generation climate index for tourism (CIT): specification and verification

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Abstract Climate is a key resource for many types of tourism and as such can be measured and evaluated. An index approach is required for this task because of the multifaceted nature of weather and the complex ways that weather variables come together to give meaning to climate for tourism. Here we address the deficiencies of past indices by devising a theoretically sound and empirically tested method that integrates the various facets of climate and weather into a single index called the Climate Index for Tourism (CIT). CIT rates the climate resource for activities that are highly climate/weather sensitive, specifically, beach "sun, sea and sand" (3S) holidays. CIT integrates thermal (T), aesthetic (A) and physical (P) facets of weather, which are combined in a weather typology matrix to determine a climate satisfaction rating that ranges from very poor (1 = unacceptable) to very good (7 = optimal). Parameter A refers to sky condition and P to rain or high wind. T is the body-atmosphere energy balance that integrates the environmental and physiological thermal variables, such as solar heat load, heat loss by convection (wind) and by evaporation (sweating), longwave radiation exchange and metabolic heat (activity level). Rather than use T as a net energy (calorific) value, CIT requires that it be expressed as thermal sensation using the standard nine-point ASHRAE scale ("very hot" to "very cold"). In this way, any of the several body-atmosphere energy balance schemes available may be used, maximizing the flexibility of the index. A survey (N=331) was used to validate the initial CIT. Respondents were asked to rate nine thermal states (T) with different sky conditions (A). They were also asked to assess the impact of high winds or prolonged rain on the perceived quality of the overall weather condition. The data was analysed statistically to complete the weather typology matrix, which covered every possible combination of T, A and P. Conditions considered to be optimal (CIT class 6–7) for 3S tourism were those that were "slightly warm" with clear skies or scattered cloud (≤25% cloud). Acceptable conditions (CIT=4–5) fell within the thermal range "indifferent" to "hot" even when the sky was overcast. Wind equal to or in excess of 6 m/s (22 km/h) or rain resulted in the CIT rating dropping to 1 or 2 (unacceptable) and was thus an override of pleasant thermal conditions. Further cross-cultural research is underway to examine whether climate preferences vary with different social and cultural tourist segments internationally.

Keywords Tourism climate index · Destination image · Tourism planning · Tourism marketing

Introduction

Climate is a salient resource for tourism and a dominant attribute of a tourist destination. The preferences of tourists for various aspects of climate have been explored in various ways. Several attempts have been made to identify most favourable or 'optimal' climate conditions for tourism

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generally and for specific tourism segments or activities (Crowe et al. 1973; Besancenot et al. 1978; Mieczkowski 1985; De Freitas 1990; Harlfinger 1991; Becker 1998; Morgan et al. 2000; Maddison 2001; Lise and Tol 2002; Hamilton and Lau 2005; Bigano et al. 2006). The reasons for evaluating climate in this context and identifying 'optimal' or 'ideal' climate conditions are diverse and sundry. Climate has a major effect on tourism demand and satisfaction, thus there is the need to assess the suitability of climate for tourism for use in decision-making by tourists and the tourism industry. Tourism planners could better assess a destination for tourism development and incorporate climate in infrastructure planning and programming. The insurance industry offers various forms of weather insurance (or weather derivative contracts) to the tourism industry. Tourists can take out insurance on likelihood of 'poor' weather conditions occurring while on vacation or during a specified operating period. A question arises as to how insurance companies define 'poor weather' and how it compares to perceptions of the quality of conditions by tourists themselves. The insurance industry could use this type of research to better tailor its products to the climate preferences of tourists in different types of destinations. Another approach might be to incorporate climate into generalised models intended to predict tourist demand and international tourism flows. Then there are the important implications of global climate change for altering the quality of climate conditions at destinations and thus altering the competitive relationships between destinations.

The above confirms that climate is an important resource for tourism that needs to be measured and evaluated. An index approach is required for this task owing to the multifaceted nature of weather and the complex ways the weather variables come together to give meaning to climate for tourism. Because of this complexity, considerable effort has gone into devising climate indices that integrate and rate the climate resource for tourism. These indices aim to facilitate interpretation of the integrated effects of a range of atmospheric elements and permit the measurement and rating of climate conditions for tourism. The concept of climate indices specifically for tourism evolved from more general development of climate indices in sectors such as health (e.g., UV index, Wind Chill, and Humidex) and agriculture (e.g. various drought indices).

With the appropriate quality controls in place, a good tourism climate index would provide a measure of the integrated effects of the atmospheric environment useful for both tourists and the tourism industry. Tourists and tour operators could use the index to select the best time and place for vacation travel or plan activities appropriate to the expected climate. Tourism planners and marketing agents could use the index to promote visitation outside the peak period and, if necessary, discourage it during the peak (to reduce tourism seasonality); or it could be used to assess the potential visitor numbers to assist in planning resort development programmes. Tourism marketers could use this information to objectively compare their tourism product to other more well known destinations, and to provide potential visitors with information to reduce the gap between expected (or promoted) and real weather conditions, so as to reduce the potential for dissatisfaction (and increase the potential for return visits). An index would also permit the climate of international tourism destinations to be objectively compared, which would be particularly valuable information for consumers purchasing 'winter getaway' holidays where climate is the principle commodity being purchased. The index, having validated the current climate preferences of tourists, could also be used to assess possible impacts of climate change on the climate resource of 'sun-sea-sand' (3S) tourism destinations worldwide.

Most of the tourism climate index work to date has produced rudimentary, single facet indices (e.g. Becker 1998), but there have been many others over the past 30 years (e.g. Mieczkowski 1985; Harlfinger 1991; Morgan et al. 2000). One of the most comprehensive schemes proposed so far is that of Mieczkowski (1985), who developed the 'Tourism Climate Index' (TCI). The TCI merges seven features of climate into a single climate index for general tourism activities, such as sightseeing. The highest rated conditions for each of the components of Mieczkowski's (1985) index were: daytime maximum temperature of 20–27°C (with a relative humidity between 30–70%), less than 15 mm of rain per month, 10 or more sunshine hours per day, and wind speeds of less than 3 km/h. A critical limitation of the TCI is that it is as an 'expert-based' index. Meaning attached to the index was secondarily derived from the biometeorology literature and Mieczkowski's subjective opinion, and was not validated against tourists' stated preferences or visitation data. In fact, an important limitation of most existing climate indices for tourism is that their rating schemes for individual climate variables and the weighting of climate variables in the index were based largely on the subjective opinion of the researchers and were not empirically tested on tourists or within the tourism marketplace. Other weaknesses of existing indices stem from their failure to address the essential requirements of a comprehensive index, which we describe below.

Mieczkowski's (1985) index has subsequently been used in a slightly modified form by Morgan et al. (2000) for beach environments, and in a number of recent studies that assess the potential impact of global climate change on the climate resources of destinations around the world (Scott and McBoyle 2001; Scott et al. 2003; Amelung and Viner 2006). Morgan et al. (2000) conducted in situ surveys with tourists in beach environments in Wales, Malta and Turkey (summers of 1994 and 1995) in order to modify Mieczkowski's (1985) tourism climate index for 3S tourism. The study found that ranking of the relative importance of four climate parameters to be: absence of rain, presence of sunshine, temperature sensation and wind speed. The authors also suggest they found differences in the preferences and rankings of individual climate parameters among respondents from Northern Europe and Mediterranean Europe, but did not elaborate on these differences. Both of these findings stand in contrast to those determined using real preference approaches.

A central limitation of existing climate indices for tourism is that, although theoretically grounded in the available biometeorological literature on weather and thermal comfort, the rating schemes for each component of the index and the weightings of each variable within the index are ultimately subjective, as they are based on the author's opinion and are not empirically tested against the preferences of tourists (De Freitas 2003; Gomez-Martin 2006). These indices suffer from other important limitations, including: insufficient temporal and spatial scale, reliance on climate means without consideration of variability or probability of key weather conditions, and they do not consider the over-riding effect of physical parameters [i.e. rain and wind] under certain conditions (De Freitas et al. 2005). Other index studies (Harlfinger 1991; Becker 1998, 2000; Matzarakis 2001; Blazejczyk 2001; Cegnar and Matzarakis 2004; Morabito et al. 2004; Zaninović and Matzarakis 2004) are even more limited in that they consider only the thermal aspect of climate. We reiterate the contention of De Freitas et al. (2005) that biometeorological indices that calculate only thermal conditions (e.g. Physiologically Equivalent Temperature and Predicted Mean Vote), regardless of their sophistication, cannot be used to evaluate the quality of climate for tourism because they do not account for the physical and aesthetic aspects of climate and have not been empirically tested to demonstrate their relationship with tourist satisfaction or decision-making. In the present study, we aim to address the deficiencies of past climate indices for tourism by devising a theoretically solid and practically useful climatic index called the Climate Index for Tourism (CIT).

Essential features of a second generation climate index for tourism

Rather than simply build on previous climate indices for tourism and recreation, we began this study by considering the essential characteristics of a theoretically sound and practically useful index (De Freitas 2003). Building on the work of De Freitas (2003), we propose that the key characteristics of a comprehensive tourism climate index that could be utilised by the tourism industry are:

1) Theoretically sound

A climate index for tourism must incorporate the results of recent multi-disciplinary research (climatology, tourism, biometeorology, resource management, psychology, geography) that has contributed to an improved understanding of tourism-climate relationships.

2) Integrates the effects of all facets of climate.

Various researchers (De Freitas 1990; Gomez-Martin 2005) have demonstrated that tourists respond to the combined effect of various facets of climate, namely, the thermal, physical and aesthetic (De Freitas 1990). Analysis of the thermal facet involves three steps: (1) integrate the factors that influence the body–atmosphere thermal state using a method that takes account of both the attributes of those exposed and the functional attributes of the environment. Ideally this would include the following variables: air temperature, humidity, wind speed, solar radiation and nature of the physical surroundings and, for the body, level of activity and clothing. (2) Provide a rational index with sound physiological basis that adequately describes the net thermal effect on the human body. (3) Identify relationships between the thermal state of the body and the condition of mind that expresses the thermal sensation associated with this state. There are a range of methods available to analyse the thermal facet. To maximize flexibility and potential application, the index should be able to accommodate input from any analysis of the thermal facet. To achieve this, the final output of the thermal facet of the index is expressed using the internationally standardised and recognised ASHRAE thermal sensation scale. The physical facet covers meteorological elements such as rain and wind that directly or indirectly affect tourist satisfaction other than in a thermal sense. The occurrence of high wind, for example, can have either a direct mechanical effect, causing inconvenience (personal belongings having to be secured or weighted down) or an indirect effect such as blowing sand along the beach causing decreased satisfaction. The aesthetic facet relates to the appealing attributes of the non-thermal and non-physical components of the atmospheric environment. Included within this category are factors such as sunshine or cloud. Note that the thermal effect of cloud cover via its impact on the solar heat load on the body is accounted for in the thermal facet.

3) Simple to calculate

To maximize application, the index should be simple to calculate and designed so that it can use standard, daily data. This allows for index values to be expressed as probability estimates of likelihood of occurrence (e.g. there is a 90% chance of experiencing 'ideal' conditions during each day of a specified holiday period and adequately represent climate variability at a location).

4) Easy to use and understand

Importance should be placed on the nature and form of the index output, which should be presented in a form that can be readily interpreted and understood by users in the tourism-recreation sector. Much research has been done on the international application and communication of the UV index (Repacholi 2000; Vanicek et al. 1999) and the lessons learned about the simplicity of the rating system and messaging are highly applicable to designing a climate index for the tourism-recreation sector. The final product of the index should be a rating system with five to seven classes, with clear descriptors of the quality of the climate conditions for the tourism activities the index was specifically designed for.

5) Recognise overriding effect of certain weather conditions

This requirement takes into account that the combined effect of a given weather or climate condition is not necessarily the sum total of its various facets. Under certain conditions and at certain thresholds, the physical facet has an overriding influence on the thermal and aesthetic facets. For example, heavy rain or high winds will cause people to leave the beach even if the thermal conditions are excellent and the sun is shining. No previous climate index for tourism and recreation recognised this overriding characteristic of the physical facet and thus tended to overrate days when rain or wind dominated.

6) Empirically tested.

The performance of the index and its thresholds should be validated against measures of tourist satisfaction with weather climate conditions. Index validation presents several challenges. Use of conventional demand indicators such as attendance/visitation numbers or occupancy rates may be unsuitable, because these are not necessarily a measure of tourist satisfaction with climate conditions. For example, peak demand is strongly influenced by state holidays ('institutional seasonality', e.g. school holidays, long weekends), not just climate (natural seasonality) (Butler 2001). In fact, peak demand is observed to sometimes occur outside of the period when optimal climate occurs (De Freitas 1990; Yapp and McDonald 1978). This means statistical models of climate and tourism demand can be calibrated to non-optimal climate and thus may not predict 'optimal climate for generating tourism'. Some studies have modelled climate-visitation relationships for peak and shoulder seasons separately to account for this (Jones and Scott 2006a, b). Self-reported tourist satisfaction with climate is argued here to be a more reliable 'validator' for a tourism climate index. It is also important that a climate index for tourism be cross-culturally validated, as climatic preferences might differ (although this has never been empirically shown).

Method

CIT is an integrated index for tourism and recreation that rates climate and weather along a favourable-to-unfavourable spectrum. It is defined as:

$$\mathrm{CIT} = f\,[(T,\ A) * P] \tag{1}$$

The variables T (thermal), A (aesthetic) and P (physical) are facets of the atmospheric environment that collectively determine CIT, except when certain thresholds are exceeded in P, at which time the effect is to override the other variables. T is a measure of the integrated body–atmosphere energy balance. This can be found using many well established models that integrate environmental and physiological thermal variables, such as solar heat load, heat loss by convection (wind), heat loss by evaporation (sweating) and longwave radiation to and from the body, and metabolic heat (activity level). Rather than express the T as a net energy (calorific) value, CIT requires that it be expressed as thermal sensation (TSN) using the standard nine-point ASHRAE scale shown in Table 1. In this way any of the several body–atmosphere energy balance assessment schemes may be used (e.g. Höppe 1999; Matzarakis et al. 1999; Matzarakis and Rutz 2005; McGregor et al. 2002). A is the aesthetic appeal of the sky condition ranging from clear to overcast (in tenths). P is the physical threshold of high wind (equal to or greater than 6 m s^{-1}) and rain (greater than or equal to 3 mm, or greater than or equal to 1 h duration). If either physical threshold is exceeded, then P over-rides T and A to affect the satisfaction rating. Thermal and aesthetic states are combined in a weather typology matrix to produce a climate satisfaction rating class, ranging from 1 to 7 (Fig. 1, Fig. 5).

Table 1 The thermal facet of climate (TSN) derived according to the internationally standardised recognised ASHRAE thermal sensation scale

TSN according to the ASHRAE scale	Numeric code
Very hot	+4
Hot	+3
Warm	+2
Slightly warm	+1
Indifferent	0
Slightly cool	−1
Cool	−2
Cold	−3
Very cold	−4

Fig. 1 Climate index for tourism (CIT) rating scale and interpretation of perceived satisfaction with weather conditions

The theoretical development of the climatic thresholds for *A* and *P* and satisfaction ratings for the CIT were based on the work of De Freitas (1985, 1990). In that work, beach users were interviewed on-site and their responses compared with detailed climate data monitored on-site. De Freitas (1990) showed that the contribution of the thermal component to the overall climate rating (C_{rate}) for S3 tourism was correlated with thermal sensation responses (TSN) such that CIT_{TSN} is given by:

$$C_{rate} = 6.4 + 0.4\ TSN\ - 0.281\ TSN^2 \qquad (2)$$

where C_{rate} varies over a seven-point scale from 1 (very poor) to 7 (very good). De Freitas (1990) showed that the most preferred atmospheric conditions are those producing "slightly warm" conditions in the presence of scattered cloud (i.e. ≤40% cover). Conditions during which rain occurred for 30 mins or longer wind speeds were over 6 m s^{-1} had an overriding effect (De Freitas 1990), reducing tourist satisfaction to a state perceived as unacceptable.

The work of De Freitas (1990) reported on the results of empirical field data used to identify the main components of tourism climate and climatic thresholds that affect tourist satisfaction for beach activities. Using the results of this work to examine how tourists discriminate between the finer amenity attributes of weather types, questionnaire surveys in controlled settings indoors were used to measure satisfaction for a range of hypothetical atmospheric environmental conditions. A prototype questionnaire was developed and pre-tested on 20 respondents for clarity, ease of use and timing. A revised survey instrument was then pre-tested on 34 adults in Waterloo (Ontario), Canada in May 2004. The final survey instrument was administered to in a controlled setting to students at the University of Waterloo in 2004 and 2005.

The respondents were briefed on the nature of the survey. It was explained they were to identify their perceptions of and preferences for various beach weather conditions assuming the purpose of the beach visit was for relatively sedentary pursuits such as a picnic or family out for a day at the beach. Respondents were then asked for their views on what they regard as the ideal temperature, cloud cover and wind conditions for 3S tourism destinations. Next, respondents were asked to give a rating (from 1–7) for each of the six thermal climate states (integrated thermal climate as expressed in the thermal sensation scale) for both cloudy conditions (cloud ≥50% cover), then, with same six thermal states, for clear sky or scattered cloud conditions (i.e. ≤ 40% cover). For example, wording of questions took the form: "Assume you are at the beach, how would you rate each of the following weather conditions using the scale: 1 = Poor...7 = Ideal". Further questions aimed to determine whether or not rain or high wind would result in them leaving the beach (i.e. thresholds for override of physical parameters). Respondents were also asked how long it must rain before conditions became unacceptable. Finally, respondents were asked to rate the importance of specific climate parameters (comfortable temperature, sunshine, and the absence of rain and /or wind).

Results

The first stage of the analysis focuses on the perceived importance of specific facets of 3S tourism weather, namely, sunshine, temperature and the absence of strong wind and rain. The results showed that all these facets of tourism weather are considered to be of high importance. Sunshine and comfortable temperature tied as the most important (Table 2). The detailed responses regarding the importance for each weather parameter are shown in Fig. 2. The results show that temperature and sunshine were tied as the most important followed by the absence of rain and finally the absence of wind (Table 2). The absence of strong wind had the highest variance, which reflects the fact that not everyone considered high wind to be an overriding determinant of the acceptability of on-site weather conditions. Detailed distribution of these perceptions along the seven-point scale of importance is shown in Fig. 2.

Phase two of the analysis set out to identify optimal conditions for 3S tourism and key override thresholds for

Table 2 The perceived importance of sunshine, comfortable temperature and the absence of rain and strong wind, where 1 is "not important" and 7 is "extremely important"

	Importance of absence of strong wind	Importance of sunshine	Importance of comfortable temperature	Importance of absence of rain
Mean	4.8	6.1	6.1	5.8
Median	5.0	6.0	6.0	6.00
Mode	5 and 6 [a]	6	7	6 and 7 [a]
Standard deviation	1.53	1.00	1.07	1.32

[a] Multiple modes exist

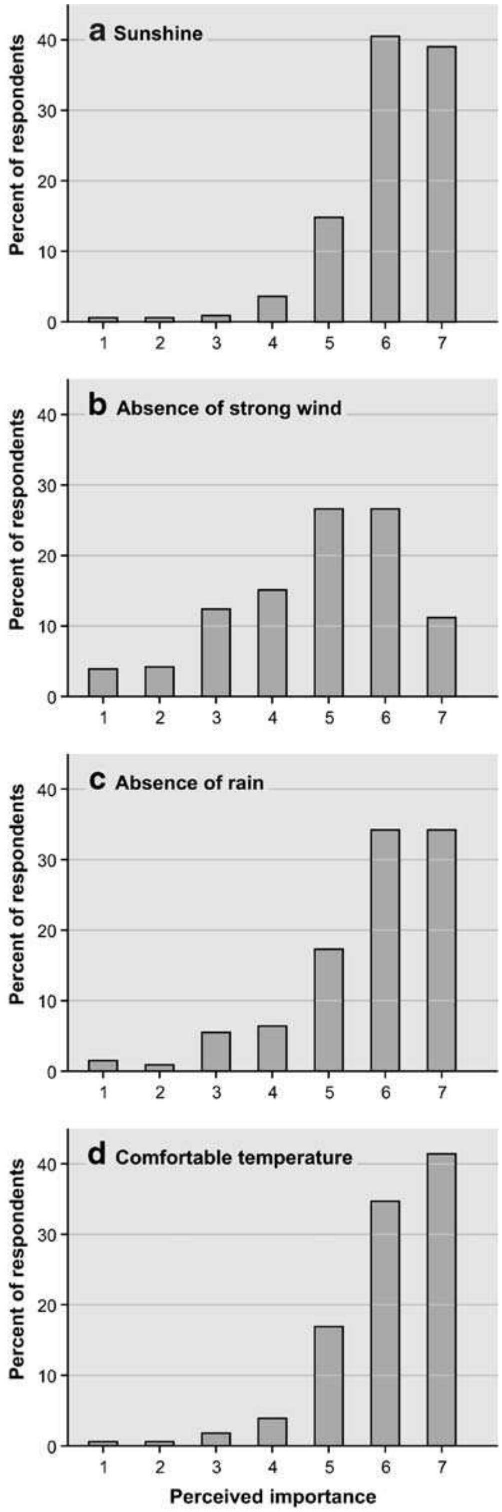

Fig. 2 The perceived importance (per cent of respondents) of sunshine (**a**), the absence of strong wind (**b**), the absence of rain (**c**) and comfortable temperature (**d**), where 1 is "not important" and 7 is "extremely important". N=331

the parameters that make up the physical facet. First, the preferred condition of the aesthetic facet was examined. The results confirm that scattered cloud rather than a clear sky is preferred by the majority of the respondents, which is consistent with De Freitas (1990). The results in Fig. 3 show that 67% of the respondents considered 25% cloud amount to be the ideal, while 26% of the respondents preferred clear sky conditions. A clear majority (83%) of the respondents considered the presence of a light breeze an essential facet of ideal weather conditions (Fig. 4). A majority of respondents said they would leave the beach if wind picked up and began blowing their personal belongings around or sand onto their beach towels and into food and drink.

The thermal (T), aesthetic (A) and physical (P) facets were combined in a holiday weather typology matrix of ratings in classes of 1 (worst) to 7 (best). Median and mean responses from the questionnaire survey were used to identify central tendencies and to complete the matrix, which covered every combination of T, A and P. The results (Fig. 5) show that conditions considered to be ideal (CIT=6–7) were those that are "slightly warm" or "warm" with clear sky or scattered cloud. Acceptable conditions (CIT 4–5) extended to TSN between "indifferent" and "hot" even when the sky was overcast. Overcast conditions reduce the rating, typically by one or two categories. The occurrence of wind greater than or equal to 6 m/s (22 km/h), or the occurrence of more than half an hour of rain had an overriding effect on CIT. Rain for greater than 1 h or wind in excess of 6 m s^{-1} resulted in rating dropping to the lowest level (CIT=1–2), that is, conditions considered to be entirely unacceptable.

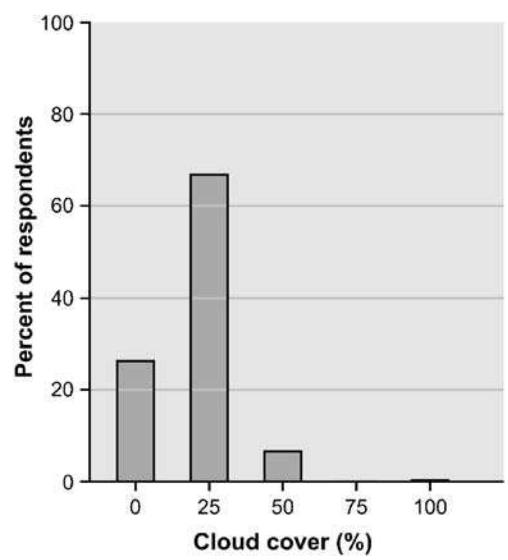

Fig. 3 Respondents' ranking of ideal (preferred) sky conditions (per cent of respondents): 0% cloud amount, 25% cloud amount (25% sky covered), 50% cloud amount (50% sky covered), 75% cloud amount (75% covered), and 100% cloud amount (100% overcast). N=331

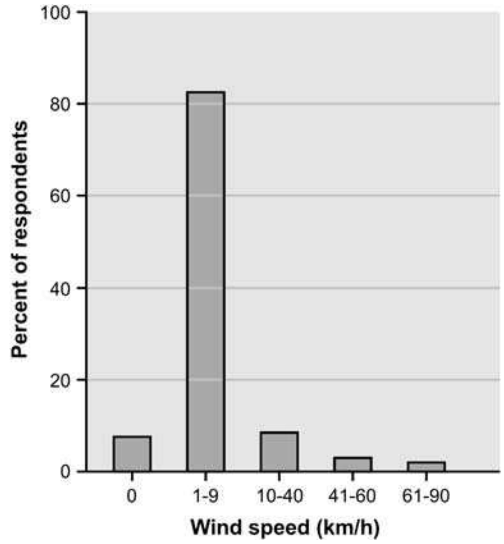

Fig. 4 Respondents' ranking of ideal (preferred) wind conditions (per cent of respondents): no wind, a light breeze (1–9 km/h), a moderate wind (10–40 km/h), strong wind (41–60 km/h), or very strong wind (61–90 km/h). N=331

Discussion

The concept of tourism climate recognises a climatically controlled resource that may be graded along a favourable-to-unfavourable spectrum; thus the asset can be measured and assessed (De Freitas 2003). However, there are numerous problems. One of them is selection of atmospheric criteria. For example, what exactly are the criteria for *ideal*, *suitable*, *acceptable*, or *unacceptable* conditions? Only after appropriate criteria have been clearly identified can key questions be answered. When is the best time to visit? What clothing or equipment is needed? What are the climate extremes likely to be?

Many writers on the subject of tourism climate single out the thermal component of climate as the most important and there has been a great deal of research on the energy balance and thermal comfort aspects of this element. But within a broad range of moderate or "non-extreme" thermal conditions, other factors assume relatively greater importance in determining the pleasantness rating of a given weather or climate condition. This raises the complex problem of integrating the various facets and interpreting the result. The work reported here approaches this complex but important problem.

The results of the work show that some combinations of atmospheric environmental parameters are preferred to others. It also identifies optimal conditions for 3S tourism, and goes one step further to examine the sensitivity to climate. However, CIT does not meet all the requirements of a universal index in that it has not been validated within a cross section of tourism activities, or even age groups. The tourism sector is diverse, and although university students are representative of a certain section of the market, it is not clear how their views reflect those of the tourism market at large.

The possibility of cross-cultural differences in climate evaluation is accepted. Further research is needed to examine this. The existence of cross-cultural differences would complicate the development of a uniform CIT for 3S tourism since, for the same climatic conditions, CIT scores would differ between cultures. If this was the case, CIT would have to be recalibrated to take these differences into account. Clearly this is a topic for future research.

CIT relies on actual observations of atmospheric conditions rather than on averaged or statistically processed climatic data. This is because a tourist responds to the combined effect of actual atmospheric environmental conditions at any given time. Therefore, an approach such as that favoured in this work can be used for only those locations or regions for which the required data are available. The approach will have to be modified to suit generalised applications, such as the incorporation of the index into models intended to predict tourist demand and international tourism flows. Further work is required to clarify how such large-scale applications, which may require using more generalised climatic data, could be realised.

One necessary requirement for a useful tourism climate index is that the index is specifically designed for and relevant to a type of tourism. The work reported deals only with 3S tourism. Clearly, the relative importance of different meteorological elements will be different in this context compared to, say, winter sports tourism. Therefore, CIT would need to be calibrated for different tourism contexts. How this may be approached is the subject of future research. Another issue to consider is the relationship between CIT and the ongoing work within the International

ASHRAE scale TSN [T]		Cloud (≤40%) [A]	Cloud (≥50%) [A]	Rain (>3mm or >1hr duration) [P]	Wind (≥6m/s at ground) [P]
Very hot	(+4)	4	3	2	3
Hot	(+3)	6	5	2	4
Warm	(+2)	7	5	2	4
Slightly warm	(+1)	6	4	1	4
Indifferent	(0)	5	3	1	2
Slightly cool	(-1)	4	3	1	2
Cool	(-2)				
Cold	(-3)				
Very cold	(-4)				

Fig. 5 Survey results giving climate index for tourism (CIT) ratings based on thermal conditions (T) expressed as thermal sensation (TSN) on the ASHRAE scale, aesthetic quality (A), and physical factors (P). CIT ratings 1 to 7 are described in the text and in Fig. 1. Further interpretation of the shading code is given in Fig. 1

Society of Biometeorology on a Universal Thermal Climate Index (UTCI). It is likely that the UTCI could provide a platform for the thermal aspect of CIT.

Conclusion

Rather than simply build on previous tourism climate indices, this study set out to develop a theoretically sound, new generation index that deals holistically with all the essential facets of tourism climate. For ease of application, the index has been designed so that it can be used with either climate data or forecasts of weather. The temporal resolution of climatic data must be daily in order that the index values can be expressed as probability estimates of likelihood of occurrence (e.g. there is a 90% chance of experiencing 'ideal' conditions during each day of a specified holiday period). Importance has been placed on the nature and form of the index output; namely, one that can be readily interpreted and understood by users in the tourism-recreation sector. Much research has been done on the international application and communication of the UV index and the lessons learned about the simplicity of the rating system and messaging are highly applicable to designing a climate index for the tourism-recreation sector. The end product of the index should be a rating system with five to seven classes, with clear descriptors of the quality of the climate conditions for the tourism activities the index was specifically designed for. In the case of CIT, the highly weather sensitive activities of 3S holidays are the focus.

This work has shown that CIT can be reliably used as an integrated index for beach-based tourism and recreation where the thermal (T), aesthetic (A) and physical (P) facets of weather collectively determine CIT, including occasions when certain thresholds are exceeded in P, namely continuous rain and high wind, where the effect is overriding. The thermal facet is a function of the net body-environment thermal state that can be accounted for by any number of integrated body–atmosphere energy budget schemes reported in the literature. However, instead of dealing with T as a net energy term, CIT expresses T as thermal stress using the well established and widely used nine-point ASHRAE thermal sensation scale, thus any one of numerous well tested schemes can be used to assess T depending on data availability. The results show that each of the seven CIT classes correspond to clearly identifiable weather conditions along a favourable-to-unfavourable spectrum. The product is an index with clear descriptors for the quality of climate for tourism.

This study was designed to examine the details of tourist climate preferences, including tourist rankings of climatic conditions, the relative importance of a range of climate parameters, and key weather thresholds, in order to validate the CIT. An important feature of CIT is that it recognises that the combined effect of a given weather condition is not necessarily the sum total of its various facets. Under certain conditions and at certain thresholds, the physical facet has an overriding influence on the thermal and aesthetic facets. For example, heavy rain or high winds will cause people to leave the beach even if the thermal conditions are ideal. No previous climate index for tourism recognised this, thus they tend to overrate days when rain or wind dominated. Finally, unlike most previous climate indices for the tourism-recreation sector, the performance of CIT and its thresholds have been validated against measures of tourist satisfaction with weather conditions. Validation has avoided the usual 'demand' indicators such as attendance/visitation or occupancy rates. These are inappropriate because they are not necessarily a measure of tourist satisfaction with climate conditions. For example, peak demand is strongly influenced by state holidays (institutional seasonality), not just climate (natural seasonality). In fact, peak demand is observed to sometimes occur outside of the period when optimal climate conditions occur. This means statistical models of climate and tourism demand can be calibrated to non-optimal climate and thus may not predict 'optimal climate for generating tourism'. Self-reported tourist satisfaction with climate is argued to be a more reliable 'validator' for a tourism climate index.

The main limitations of this study are the relatively narrow tourist market segment it examined (young adults) and the restricted spatial coverage of the survey (only one country). However, we believe this limitation is compensated for by the novel ability of the approach to explore the climate preferences of tourists in a detailed manner. Future research with a broader cross-cultural sample from more diverse climatic regions (tropical, temperate, monsoon and semi-arid) remains an important task to validate the CIT internationally. The cross-cultural validation and application of the CIT is planned in collaboration with members of the International Society of Biometeorology's Commission on Climate, Tourism and Recreation.

References

Amelung B, Viner D (2006) Mediterranean tourism: exploring the future with the tourism climate index. J Sustain Tourism 14 (4):349–366

Becker S (1998) Beach comfort index: a new approach to evaluate the thermal conditions of beach holiday resort using a South Africa example. GeoJournal 44(4):297–307

Becker S (2000) Bioclimatological rating of cities and resorts in South Africa according to the climate index. Int J Climatol 20:1403–1414

Besancenot J, Mouiner J, De Lavenne F (1978)Les conditions climatiques du tourisme littoral.Norois 99: 357–382

Bigano A, Hamilton JM, Tol RSJ (2006) The impact of climate on holiday destination choice. Clim Change 76(3–4):389–406

Blazejczyk K (2001) Assessment of recreational potential of bioclimate based on the human heat balance. In: Matzarakis A, de Freitas CR (eds) Proceedings of the first international workshop on climate, tourism and recreation. 5–10 October 2001, Greece. International Society of Biometeorology, Commission on Climate Tourism and Recreation, pp 133–152

Butler R (2001) Seasonality in tourism: issues and implications. In: Baum T, Lundtorp S (eds) Seasonality in tourism. Advances in tourism research series. Pergamon, London

Cegnar T, Matzarakis A (2004) Trends of thermal bioclimate and their application for tourism in Slovenia. In: Matzarakis A, de Frietas CR, Scott D (eds) Advances in tourism climatology. Berichte des Meteorologischen Institutes der Universtät Freiburg, Nr. 12, pp 66–73

Crowe RB, McKay GA, Baker WM (1973) The tourist and outdoor recreation climate of Ontario, vol 1: objectives and definitions of season. Report Number REC-1-73. Atmospheric Environment Service, Environment Canada, Toronto, Canada

De Freitas CR (1985) Assessment of human bioclimate based on thermal response. Int J Biometeorol 29:97–119

De Freitas CR (1990) Recreation climate assessment. Int J Climatol 10:89–103

De Freitas CR (2003) Tourism climatology: evaluating environmental information for decision making and business planning in the recreation and tourism sector. Int J Biometeorol 48:45–54

De Freitas CR, Scott D, McBoyle G (2005) Specification and verification of a new generation climate index for tourism. Ann Meteorol 41:600–603

Gomez-Martin MB (2005) Weather, climate and tourism—a geographical perspective. Ann Tourism Res 32(3):571–591

Gomez-Martin B (2006) Climate potential and tourist demand in Catalonia (Spain) during the summer season. Clim Res 32:75–87

Hamilton J, Lau M (2005) The role of climate information in tourist destiantion choice decision-making. In: Gössling S, Hall CM (eds) Tourism, recreation and climate change. Routledge, London, pp 229–250

Harlfinger O (1991) Holiday biometeorology: a study of Palma de Majorca, Spain. GeoJournal 25:377–381

Höppe P (1999) The physiological equivalent temperature in a universal index for the bio-meteorological assessment of the thermal environment. Int J Biometeorol 43:71–75

Jones B, Scott D (2006a) Climate change, seasonality and visitation to Canada's National Parks. J Park Recreat Admin 24(2):42–62

Jones B, Scott D (2006b) Implications of climate change for visitation to Ontario's Provincial Parks. Leisure 30(1):233–261

Lise W, Tol RSJ (2002) Impact of climate on tourism demand. Clim Change 55(4):429–449

Maddison D (2001) In search of warmer climates? The impact of climate change on flows of british tourists. Clim Change 49:193–208

Matzarakis A (2001) Assessing climate for tourism purposes: existing methods and tools for the thermal complex. In: Matzarakis A, de Freitas CR (eds) Proceedings of the First International Workshop on Climate, Tourism and Recreation. 5–10 October 2001. International Society of Biometeorology, Commission on Climate Tourism and Recreation, Greece, pp 101–111

Matzarakis A, Rutz F (2005) Application of RayMan for tourism and climate investigations. Ann Meteorol 41(2):631–636

Matzarakis A, Mayer H, Iziomon MG (1999) Applications of a universal thermal index: physiological equivalent temperature. Int J Biometeorol 43:76–84

McGregor GR, Markou MT, Bartzokas A, Katsoulis BD (2002) An evaluation of the nature and timing of summer human thermal discomfort in Athens, Greece. Clim Res 20:83–94

Mieczkowski Z (1985) The tourism climatic index: a method of evaluating world climates for tourism. Can Geogr 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 Frietas CR, Scott D (eds) Advances in tourism climatology. Berichte des Meteorologischen Institutes der Universtät Freiburg, Nr. 12, pp 56–64

Morgan R, Gatell E, Junyent R, Micallef A, Özhan E, Williams A (2000) An improved user-based beach climate index. J Coast Conserv 6:41–50

Scott D, McBoyle G (2001) Using a 'tourism climate index' to examine the implications of climate change for climate as a natural resource for tourism. In: Matzarakis A, de Frietas CR (eds) Proceedings of the First International Workshop on Climate, Tourism and Recreation. International Society of Biometeorology, Commission on Climate, Tourism and Recreation, Halkidi, Greece, pp 69–98

Scott D, McBoyle G, Mills B (2003) Climate change and the skiing industry in Southern Ontario (Canada): exploring the importance of snowmaking as a technical adaptation. Climate Res 23:171–181

Repacholi MH (2000) Global solar UV index. Radiat Prot Dosim 91:307–311

Vanicek K, Frei T, Litynska Z, Schmalwieser A (1999) UV- Index for the Public. A guide for publication and interpretation of solar UV Index forecasts for the public prepared by the Working Group 4 of the Cooperation in Science and Technology" (COST)COST-713 Action "UVB Forecasting" COST-713 Action Brussels, of the European Commission

Yapp GA, McDonald NS (1978) A recreation climate model. J Environ Manag 7:235–252

Zaninović K, Matzarakis A (2004) Variation and trends of thermal comfort at the Adriatic coast. In: Matzarakis A, de Frietas CR, Scott D (eds) Advances in tourism climatology. Berichte des Meteorologischen Institutes der Universtät Freiburg, Nr. 12, pp 66–73