

Weather and Climate for Coastal Tourism

by

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AUTHOR'S DECLARATION

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

Exceptions to sole authorship:

Chapter 3:

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Chapter 4:

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Chapter 5:

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I hereby declare that as a lead author on all three manuscripts, I was responsible for the conceptualization of the research, including writing the proposal for the research project and served as the principal investigator for the research that forms the basis of this PhD. I was also responsible for data collection, data analysis and the drafting of all three manuscripts. I was also responsible for submitting the manuscripts to each respective journal, addressed the comments from the peer-reviewers and reviewing the article proofs. My supervisor and co-author, Dr. Daniel Scott, offered intellectual insight, feedback and suggestions, as well as editorial changes.

Abstract

Weather and climate serve as an important travel motivator, influencing destination choice, the timing of travel, travel expenditures and overall trip satisfaction. Climatic resources are a defining factor in destination attractiveness and are a key element of the natural resource base of a destination that can be classified along a spectrum from ideal to unacceptable. A growing literature has sought to measure, evaluate and assess climate resources for tourism, both generally and for specific tourism market segments.

A direct impact of climate change on tourism will be the global redistribution of climatic resources. This would change the length and quality of climate-sensitive tourism seasons, affecting both the temporal and spatial distribution of domestic and international tourism flows and spending. Studies have revealed a generally consistent temporal and geographical pattern of climate change impacts on global tourism. As the 21st century progresses, there is anticipated to be a pronounced shift in thermal comfort (and thereby tourism demand) towards higher latitudes and away from sub-tropical and tropical destinations. This would have a substantial impact on the tourism-intensive economy of the Caribbean, as the vast majority of the region's attractions are based on weather- and climate-dependent 3S (sun, sea, sand) tourism.

However, the assertion that major coastal tourism destinations, such as the Caribbean, will become seasonally 'too hot' for tourism has been questioned because the literature has not established what tourists to these regions perceive to be thermally unacceptable for coastal tourism activities. In addition, existing climate and tourism assessments do not account for the microclimatic conditions where tourism activities take place. With the inextricable dependency between 3S tourism and favourable weather conditions in the coastal zone, it is important to understand both how tourists perceive and evaluate climatic resources, particularly those conditions that are most preferred or avoided (i.e., trigger behavioural responses), as well as examine the adaptive climatic range tourists' can experience within a coastal setting. Such information is a prerequisite if accurate projections

are to be made about changes in tourism demand as a result of climate variability or future climate change.

This dissertation proposes a conceptual framework that integrates the multiple facets known to influence tourists' evaluation of climatic resources, as well as tourists' responses to holiday weather conditions. The research advances weather and climate resource assessments for tourism by improving our understanding of the complex relationship between personal and meteorological parameters that influence tourists' climatic preferences and thresholds for coastal tourism. This was achieved through concurrent meteorological measurements and in situ surveys with 472 beach tourists in the Caribbean islands of Barbados, Saint Lucia and Tobago. The results from this study reveal that tourists' optimal and unacceptable climatic conditions are dependent on several interpersonal factors, with statistically significant differences ($p < 0.05$) found based on gender, age, and climatic region of origin. Thermal comfort expectations and perceived thermal control were also found to be key contextual considerations that enable beach tourists' to not only be exposed to, but to prefer, thermal conditions that elicit strong to very strong heat stress. This indicates that conventional evaluation systems of thermal comfort (e.g., PET, UTCI) cannot be applied to 3S tourists without modification. This research also highlights the importance of microclimatic conditions when evaluating weather and climate for tourism, with thermo-physiological comfort varying up to 4°C within a coastal resort setting. The results from this research can be incorporated into existing climate indices and climate change assessments to allow for more robust projections of tourism demand, as well as used in various decision-making contexts by both tourists (e.g., plan best time/place to travel, plan appropriate accommodation, attire, transportation and activity schedule) and the tourism industry (e.g., marketing strategies, risk assessment, operational decision making, infrastructure planning and development).

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Dedication

For the two most important women in my life—my mother Susan and sister Lisa.

Additional adoration and catnip to Chicka and Sophie.

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List of Abbreviations and Acronyms

3S	Sun, Sea, Sand
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BCI	Beach Climate Index
d ⁻¹	Per Month
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
h	Hour
h ⁻¹	Per Hour
IPCC	Intergovernmental Panel on Climate Change
km	Kilometres
m	Metre
mm	Millimetre
m ⁻¹	Per Month
OECD	Organization for Economic Co-Operation and Development
PET	Physiological Equivalent Temperature
PTCM	Pooled Travel Cost Model
RH	Relative Humidity
s ⁻¹	Per Second
T _a	Ambient Temperature
TCI	Tourism Climate Index
T _g	Globe Temperature
T _{mrt}	Thermal Mean Radiant Temperature
UNEP	United Nations Environmental Programme
UNWTO	United Nations World Tourism Organization
UTCI	Universal Thermal Climate Index
V _a	Wind Speed
WMO	World Meteorological Organization
WTTC	World Travel and Tourism Council
yr	Year

Glossary

Climate	“In the narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The [typical] period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation and wind” (IPCC 2012, p. 557).
Climate Change	Refers to “a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal process or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use” (IPCC 2012, p. 557).
Coastal Tourism	“Embraces the full range of tourism, leisure and recreationally-oriented activities that take place in the coastal zone and offshore coastal waters. These include coastal tourism development (accommodation, restaurants, food industry, and second homes) and the infrastructure supporting coastal development (e.g., retail businesses, marinas, and activity suppliers). Also included are tourism activities such as recreational boating, coast- and marine-based ecotourism, cruises, swimming, recreational fishing, snorkeling and diving” (Hall 2001, p. 602).
Perception	Weather perceptions refer to an “understanding of atmospheric conditions (including perception of the weather and/or of the different variables of which it is comprised, such as temperature, sunshine, precipitation, etc.) or of a specific atmospheric phenomenon or event (e.g., perception of climate change or of an extreme weather event) as perceived by the senses. Perception is selective and influenced by various mechanisms and factors that explain (or help to explain) why individuals perceive things differently and why some phenomenon are perceived by some but go unnoticed by others” (Gomez-Martin & Martinez-Ibarra 2012, p. 136).
Preferences	Weather preferences refer to the “predilection or inclination for certain weather conditions or conventions in response to given

atmospheric questions or problems” (Gomez-Martin & Martinez-Ibarra 2012, p. 136).

Projection	“A potential future evolution of a quantity or set of quantities, often computed with the aid of a model. Projections are distinguished from predictions in order to emphasize that projections involve assumptions concerning, for example, future socioeconomic and technological developments that may or may not be realized, and are therefore subject to substantial uncertainty” (IPCC 2012, p. 562).
Thermal Comfort	The condition of mind that expresses satisfaction with the thermal environment (ASHRAE 2013).
Tourism	Refers to the activity of tourists (UNWTO 2008).
Tourist	A traveler/visitor taking a “trip to a destination outside his/her usual environment, for less than a year, for any main purpose (business, leisure or other personal purpose) other than to be employed by a resident entity in the country or place visited” (UNWTO 2008, p. 10).
Weather	The state of the atmosphere with respect to wind, temperature, cloudiness and moisture at a given point in time (NOAA 2013).

Chapter 1:

Introduction to Dissertation

1.1 Problem Context

Tourism has become one of the largest economic sectors in the world and is a significant contributor to many national and local economies. The growth of international tourist arrivals has been virtually continuous over the past 60 years, increasing on average 6.5% annually from 1950 to 2005 (United Nations World Tourism Organization [UNWTO] 2013). In 2012, international tourist arrivals exceeded one billion for the first time in history, reaching a record US\$1 trillion in international tourism receipts. Importantly, international arrivals represent only a fraction of total trips, with an estimated six billion domestic tourists in 2012. Tourism contributes an estimated 9% to the world's Gross Domestic Product (GDP) (direct, indirect and induced), provides one in 11 jobs globally and accounts for 6% of the world's exports (US\$1.3 trillion) (UNWTO 2013). By 2030, international arrivals are expected to reach 1.8 billion, with four times as many tourists traveling domestically (UNWTO 2011).

Coastal tourism is the largest segment of global leisure tourism, with much tourism development concentrated along coastlines for the past 60 years (Hall 2001, Honey & Krantz 2007, UNEP 2009, Jones & Phillips 2011). Coastal tourism is founded on the unique resource combination at the interface of land and sea, with high demand amenities including beaches, rich marine and terrestrial biodiversity, scenic beauty, and very often highly sought after climate conditions (UNEP 2009). Coastal tourism embraces a range of activities that take place within the coastal zone and offshore coastal waters, including recreational boating/sailing, coast- and marine-based ecotourism, cruises, swimming, beachcombing/walking, surfing, recreational fishing, snorkeling and diving (Hall 2001).

Southern/Mediterranean Europe is an important coastal tourism region, receiving the greatest share of global international tourist arrivals (18.5%) (UNWTO 2013), with other important coastal tourism sub-regions including South-East Asia (8.2%), the Caribbean (2%), and Oceania (1.2%) (UNWTO 2013). In the United States, which is ranked second behind France for the most international tourist arrivals (UNWTO 2013), more than half of arrivals are to the coastal states of Florida (22.1%), California (20.2%) and the Hawaiian Islands (9.5%)

(OTTI 2012). The popularity of these and other 3S (sun, sea, sand) international destinations can be linked to natural seasonality, which serves as a primary stimulus for the world's largest regional tourism flows (i.e., Northern and Western Europe to Southern/Mediterranean Europe, and northern USA and Canada to southern USA coastal states and the Caribbean). Weather and climate therefore represent a key element of a coastal destination's natural resource base, influencing global travel patterns (seasonality and destination choice) and tourism expenditures.

Weather and climate are important features in defining destination attractiveness (Mayo 1973, Crompton 1979, Echtner & Ritchie 1993). They are also important travel motivators (Lohmann & Kaim 1999, Kozak 2002, Hübner & Gössling 2012), influencing destination choice (Hamilton & Lau 2005, Gössling et al. 2006, Moreno 2010, Hübner & Gössling 2012), the timing of travel (e.g., Eugenio-Martin & Campos-Soria 2010, Hadwen et al. 2011), spending and overall trip satisfaction (e.g., Bardón 1991, Smith 1993, Agnew 1995, Williams et al. 1997, Coghlan & Prideaux 2009, Becken et al. 2010, Becken & Wilson 2013). Climatic resources are therefore a key contributor to the overall appeal of a destination and can be characterized as a resource which, at various times and locations, can be classified along a spectrum from ideal to unacceptable (Gomez-Martin 2005, Scott et al. 2012b). As such, weather and climate are important tourism resources that can be measured, evaluated and assessed (de Freitas et al. 2008).

Until relatively recently, there was limited research interest into the climate and tourism relationship. Up until the early 1980s, tourism studies were focused largely on documenting the rapid growth of domestic and international tourism and understanding its economic and social implications (Scott et al. 2012a). Abegg et al. (1998) and Amelung et al. (2007) suggest that climate and tourism was not a major research focus because climate was considered a rather stable property of destinations that could not account for any long-term trends in tourism demand. This 'stability bias' has gradually been reconsidered as increasing evidence of the impacts of weather extremes, climate variability and global climate change has intensified interest in the links between weather/climate and tourism (Scott et al. 2004, Scott et al. 2012a, Becken & Wilson 2013). A direct impact of climate change on tourism will be the global redistribution of climatic resources (Scott et al. 2008b, Scott et al. 2012b). This could change the length and quality of climate-sensitive tourism seasons, affecting the temporal and spatial distribution of international and domestic tourism flows and spending. Understanding the

implications of climate change for tourism demand has been identified as a research priority by scholars (e.g., Hamilton et al. 2005, Dubois & Ceron 2006, Scott & Lemieux 2010, Gössling et al. 2012, Scott et al. 2012a) and the tourism industry (e.g., UNWTO et al. 2008, WTTC 2009).

While progress has been made with respect to understanding the significance of climate for tourism demand, the climate-related criteria tourists use to make decisions about tourism remains a prominent research gap in the literature (Gössling et al. 2006, Scott et al. 2008a, Shaw & Loomis 2008, Ruddy & Scott 2010, Gössling et al. 2012, Scott et al. 2012b). With the inextricable dependency between 3S tourism and favourable weather conditions in the coastal zone, it is important to understand both how tourists perceive and evaluate climatic resources, particularly those conditions that are most preferred or avoided (i.e., trigger behavioural responses), as well as examine the adaptive climatic range tourists' can experience within a coastal setting. Such information is a prerequisite if accurate projections are to be made about changes in tourism demand as a result of climate variability or future climate change.

1.2 Methodological Approach

The methodological approach of a study can have important implications for the research findings. Meze-Hausken (2008) concluded that the treatment of thresholds associated with human responses to climate can be addressed by two lines of questioning; (1) "Can climate thresholds for society be established or measured?"; and (2) "Can human thresholds to climate be established or measured?" (p. 300). The key difference between these questions is the goal of the research. The former approach is more common to a natural science origin, emphasizing the measurement and need to define a physical threshold value for a climatic variable(s) that influences the well-being of a society. The latter question accentuates a broader social-cultural understanding, investigating the social sensitivity of people to climate stimuli(s).

In terms of assessing climate as a resource for tourism, the majority of studies has followed the former line of questioning, where the driver for a particular response is due to a variation or change in climate (e.g., climate indices, macro-scale econometric models). These approaches run the risk of being overly climate deterministic, as climate is isolated and used as the explanatory factor that predicts human behaviour/response and thereby tourism demand. Largely absent from the tourism literature are assessments where the climatic driver of the tourist response accounts for variation in socio-demographic or socio-cultural conditions that influence

how a specified climatic condition is interpreted. Tourists' evaluation of optimal and unacceptable climate conditions are dependent on numerous factors (e.g., tourism environment and nationality) (Scott et al. 2008a, Ruddy & Scott 2010), and studies that have generalized these perceptions into universal climate thresholds for all market segments and geographic regions ignore this complexity.

The three manuscripts presented in this dissertation follow the latter line of questioning. The methodological approach aims to empirically examine the personal and socio-demographic factors that influence tourists' climatic preferences and perceptions. This is achieved with a multi-method approach that included concurrent meteorological measurements and in situ tourist surveys to compare visitors' predilections and sensations with recorded weather conditions. This method was applied in three Caribbean islands, including Barbados, Saint Lucia and Tobago.

A Caribbean case study was selected for three main reasons. First, the region's tourism is highly weather- and climate-dependent, with the vast majority of its attractions based outdoors (mainly coastal/3S tourism). Second, the region has been repeatedly ranked as one of the global tourism regions most vulnerable to climate change (Deutsche Bank Research 2008, Hall 2008, Scott et al. 2008b, Perch-Nielsen et al. 2010, Scott et al. 2012a). Third, the Caribbean has the most tourism-intensive economy (i.e., tourism represents the greatest proportion of the regional economy) among the 12 regions ranked by the World Travel and Tourism Council (2011), with tourism representing 14% of GDP and 13% of employment (2.2 million jobs).

The methods utilized are novel, integrating approaches from geography, tourism and biometeorology to advance understanding of outdoor thermal comfort and its implications for decision making in the tourism sector. The study area and tourist sample also reveal new insights into a broader range of socio-demographic variables, with significant differences revealed among previously unrepresented sample groups.

1.3 Research Goal and Objectives

The overarching goal of this research is to advance weather and climate resource assessments for the tourism sector. The specific goal is to understand the complex relationship between personal and meteorological parameters that influence tourists' climatic preferences and thresholds for coastal tourism and to gain insight into how this influences holiday decision

making. To achieve this, three main objectives were established, each with specific research aims.

Objective 1: Understand the climatic preferences and thresholds for 3S tourism in the Caribbean.

Aim 1: Identify ideal and unacceptable threshold conditions for a 3S holiday (temperature, rain, cloud cover, wind) and compare these geographically specific results with the ideal conditions identified by beach climate preference studies in other tourism regions to determine if more generalizable beach tourists' climatic preferences exist.

Aim 2: Examine whether these ideal and unacceptable climate conditions differ significantly across major tourism market segments (i.e., age, nationality, climatic region of origin).

Objective 2: Examine the relationship between microclimatic conditions and tourists' bioclimatic comfort.

Aim 1: Explore beach tourists' in situ thermal bioclimatic comfort perceptions, preferences and acceptability.

Aim 2: Assess whether the thermal comfort range from existing outdoor bioclimatic studies can be applied within a coastal tourism setting or whether coastal tourists' hold fundamentally different thermal comfort perceptions, preferences and acceptability.

Aim 3: Identify personal parameters (i.e., gender, age, climatic region of origin) that influence beach tourists' bioclimatic comfort.

Objective 3: Identify the range of microclimatic thermal conditions available at a sample of coastal tourism settings and explore how these conditions influence tourists in thermo-physiologically relevant ways.

Aim 1: Measure the thermal conditions available at a coastal resort during peak tourist use periods at varying outdoor areas.

Aim 2: Based on recorded micrometeorological measurements, calculate and apply the Universal Thermal Climate Index (UTCI) to estimate the bioclimatic conditions coastal tourists could experience at the site-level.

Aim 3: Quantify the site-level adaptive thermal range available to coastal tourists and assess bioclimatic comfort within the context of tourists' thermal preferences and thresholds for 3S tourism.

1.4 Outline of Dissertation

This dissertation follows a manuscript format and consists of three manuscripts that are published (Chapter 3 and Chapter 4) or in press (Chapter 5) in peer-reviewed academic journals. Collectively, the purpose of the three manuscripts is to achieve the overarching goal of this research, as well as the specific objectives and aims set forth in this study.

The introductory chapter outlines the problem context for this research, introduces the methodological approach, establishes the purpose, objectives and aims of the study, and outlines the structure of the dissertation. The second chapter reviews existing scholarship on climate assessments for tourism, identifying important research gaps and opportunities for multidisciplinary contributions that are relevant to all three manuscripts. Each manuscript also provides a more specific literature review. Chapter three focuses on the first objective of this dissertation through a paper titled, "Differential climate preferences of international beach tourists," which has been published in *Climate Research* (Rutty & Scott 2013). In this chapter, the results of the beach tourism survey are presented, which was used to identify ideal and unacceptable threshold conditions for a 3S holiday (temperature, rain, cloud cover, wind). Major coastal tourism market segments were examined, including a comparison across age cohorts, nationality, and climatic region of origin. Chapter four focuses on objective two, through a paper titled, "Bioclimatic comfort and the thermal perceptions and preferences of beach tourists," which has been published in the *International Journal of Biometeorology* (Rutty & Scott 2014a). This paper examines the relationship between recorded microclimatic conditions and tourists' stated bioclimatic comfort. Thermal comfort perceptions, preferences and acceptability are explored, identifying personal parameters that influence thermal comfort. Chapter five concentrates on the third objective through the manuscript entitled, "Thermal range of coastal tourism resort microclimates," which has been accepted in *Tourism Geographies* (Rutty & Scott 2014b). This paper examines the range of thermal microclimates available in high-demand areas of a coastal resort. The results are presented using the UTCI and discussed in the context of tourists' climatic preferences and thresholds. Chapter six summarizes the research findings,

highlighting the complex relationships that influence tourists' climatic preferences and thresholds. Significant findings are discussed, including the implications for assessing current and future climate resources for tourism, and a proposed agenda for future research.

Chapter 2:

Literature Review: Assessing Climate as a Resource for Tourism

This chapter discusses the proposition that weather and climate represent a resource and constraint for tourism. It reviews the current state of knowledge on climate resource assessments for tourism demand and provides a critical synthesis of the different assessment approaches in the literature. A discussion of the strengths and limitations of each approach are provided, highlighting important research gaps and the value of continued research. This chapter also acknowledges the multidisciplinary nature of the topic, reviewing research in geography, tourism, environmental and climatological journals, while further identifying opportunities to integrate climate assessment research from biometeorology, engineering, architecture, planning, psychology, and health literature. The chapter concludes with a discussion of the diverse and highly valuable tourism applications that stem from climate assessment research.

2.1 Characteristics of Climate Resources for Tourism

Weather and climate represent a key element of the natural resource base of a destination for tourism. Weather and climate denote different temporal scales of the same phenomenon and are of interest to tourists at different stages of their travel (Figure 2-1). The activities that tourists engage in are often dependent on climate as a basic resource (e.g., winter sports, golf, swimming, sunbathing) or climate as a complimentary resource for activities (e.g., sightseeing, fishing, hiking). Smith (1993) distinguishes between these two types of destinations as ‘climate-dependent,’ whereby climate is the principal resource upon which tourism is predicated, and ‘climate-sensitive,’ whereby climate resources do not directly generate tourism but either facilitates or constrains tourist activities. Given that leisure tourism is a voluntary activity, with people freely participating for personal satisfaction or pleasure, a leisure tourist must perceive the weather or climate to be suitable for undertaking the types of activities they desire at a specific destination. Unsuitable climatic conditions may thereby limit tourists’ destination choice or range of activities sought (de Freitas 2003).

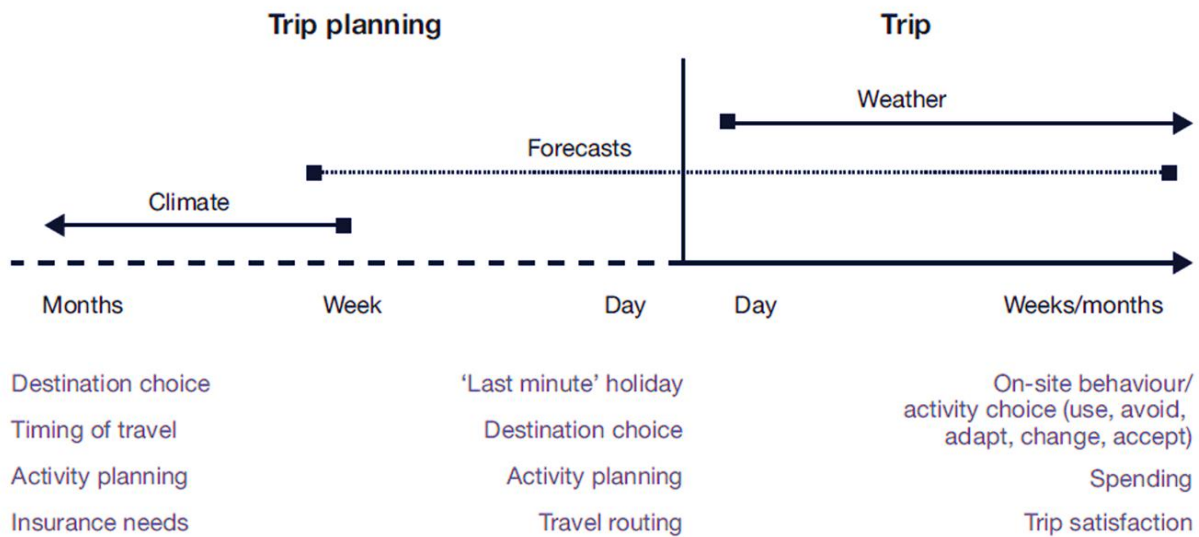


Figure 2-1 Weather-climate information for leisure tourist decision making (Scott et al. 2011)

Climate resources for tourism can be characterized in several ways. First, the distribution of climate resources vary geographically and temporally (e.g., seasonally, inter-annually) (Figure 2-2). As a result, the supply and demand of climate resources fluctuates, affecting the demand and prices for holidays. For example, the demand and perceived value of sunshine and warm temperatures at a particular destination (e.g., Caribbean) will be higher when the supply of sunshine and warm weather is limited in the source markets (e.g., during the winter months in temperate regions such as Northern USA or Canada).

Second, climate is a resource that cannot be transported or stored. Individuals must travel to the location at a specific time to experience the resource in situ (Scott et al. 2012b).¹ Third, climate is a free common resource (i.e., does not require market or regulatory mechanisms for equitable or sustainable allocation). It is also renewable (i.e., the amount of the resource used by a tourist does not affect availability of the resource for other tourists or the future availability of the resource) and non-degradable (i.e., regardless of the exploitation of the resource by a tourist it does not degrade the resource available for the future) (Gomez-Martin 2005).

¹ It is possible to capture and transport freshwater or snow resources from precipitation. However, once they are on the ground, these resources are considered part of the hydrosphere and cryosphere and no longer atmospheric resources.

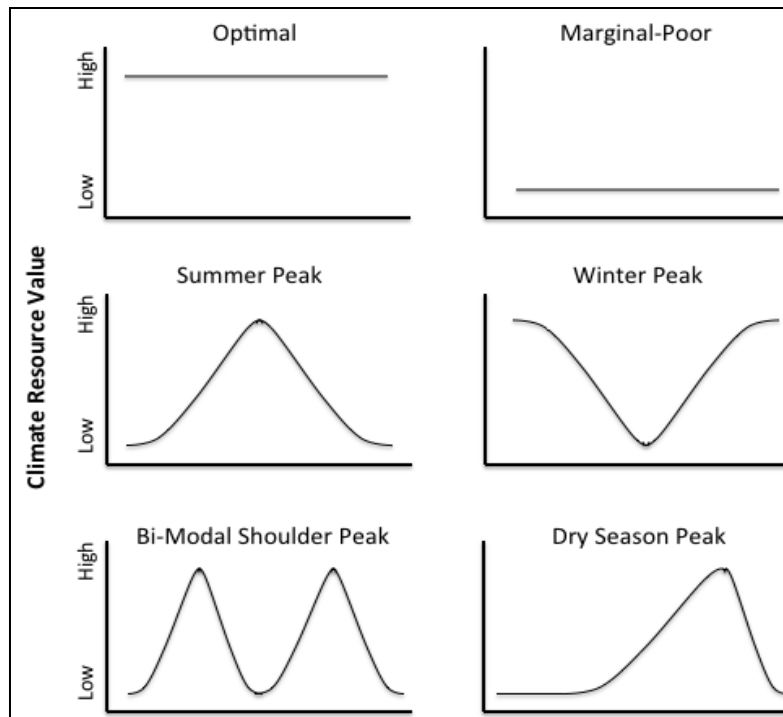


Figure 2-2 Conceptual typology of annual tourism climate resource distribution (Scott et al. 2004)

Perhaps the most important characteristic of climate resources is that they are culturally and socially defined. Resources are not fixed, but are rather based on what a society wants or needs. For example, a suntan became a symbol of leisure and wealth in the 20th century in the developed world, which was a shift from the 18th century when tanned skin was regarded as an indicator of being a lower class, outdoor labourer (Gomez-Martin 2005, Scott et al. 2012b). Similarly, the climate resources of today may not be evaluated in the same way decades in the future. Social norms regarding dark tans from sun exposure have begun to change over the last decade of the 20th century and early 21st century due to increasing risk of skin cancer and premature ageing (Albert & Ostheimer 2003, Cokkinides et al. 2006). Only human “appraisal” turns the “neutral stuff of the earth” into resources (Zimmerman 1951, p. 14).

de Freitas (2003) defines three facets of climate as a resource for tourism: thermal, physical and aesthetic (Table 2-1). The thermal dimension refers to the integrated climatic elements that influence the body’s thermal state. The physical component describes the non-temperature climatic elements that may act as a physical annoyance and/or limit the possibility for tourists to engage in activities. The aesthetic facet denotes the climatic elements that

influence tourists' appreciation of the quality of a view/landscape. The potential for tourists to travel to a destination is a function of perceived appeal of the climate resources to tourists (physiologically, physically, psychologically) and its constraints on tourist activities (including health and safety risks). A representation of this relationship, developed by Perry (1993) and modified by de Freitas (2003) and Scott et al. (2011) is provided in Figure 2-3.

Table 2-1 Facets of climate and the significance for tourists (adapted from de Freitas 2003)

Facet of Climate	Climatic Elements	Significance for Tourists
Thermal	Air temperature, wind, solar radiation, humidity	Thermal comfort
Physical	Wind, rain, snow, ice, air quality, ultraviolet radiation	Annoyance; Constraint
Aesthetic	Sunshine, cloud cover/blue skies, visibility/fog, day length	Attractiveness of site

The optimal level of thermal climate appeal (solid line) occurs when the risks or constraints of thermal extremes (dashed line) are the lowest, and the lowest thermal appeal occurs when the thermal extremes are highest, as the conditions become less suitable for tourism activities, even posing a health and safety risk to tourists. The transition between appeal and constraint represent thermal thresholds, whereby tourism demand will be affected because participation would either no longer be possible or satisfaction would decline to the point where the specific type of tourism activity was no longer desired (Perry 1993).

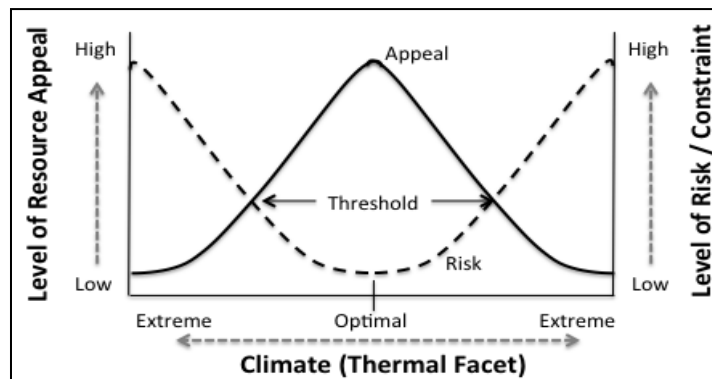


Figure 2-3 Representation of thermal thresholds for tourism (Scott et al. 2012b)

In contrast to the thermal facets, the physical and aesthetic facets of climate have a more unidirectional distribution (Figure 2-4). The appeal (solid line) of physical and aesthetic climate resources rapidly declines as the risk or constraints (dashed line) increases. For example, even a small increase in rain or wind can quickly reduce the appeal of the destination. The rate of decline for aesthetic climate resources may be more gradual (e.g., from the initial optimal of sunshine to cloudiness) and the constraining factor is limited (unless integral to a destination’s appeal) in that it does not represent a risk to tourist health or safety. It is important to note that the appraisal of climate resources as a resource/constraint varies by tourist and tourism environments (discussed further in Section 2.2). As a result, these transitions from resource appeal to resource risk are likely to be zones of transition rather than highly precise thresholds.

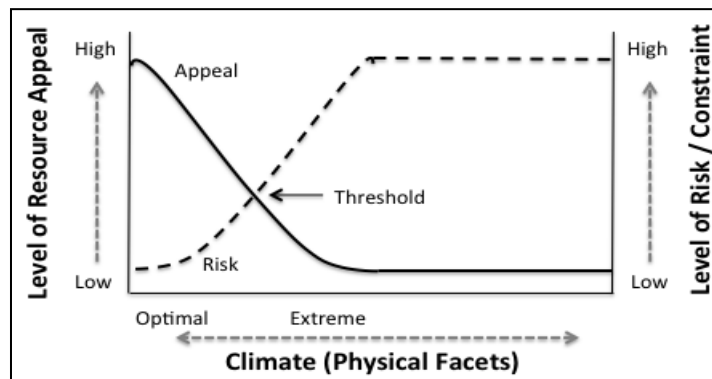


Figure 2-4 Representation of physical and aesthetic thresholds for tourism (Scott et al. 2012b)

2.2 Evaluating Climate as a Resource and Constraint for Tourism

The evaluation of climate as a resource or constraint for tourism has been approached using a variety of methods that endeavor to quantify the optimal and unacceptable climate conditions for tourism, both generally and for specific tourism segments or activities. The methods can be categorized into three types of approaches: expert-based, revealed preferences, and stated preferences (Scott et al. 2008a). A critical review of each approach is provided, with a summary of the optimal climates identified by each type of study in Table 2-2.

2.2.1 Expert-Based Approach

Among the first to assess climate as a resource for tourism was the Canadian Atmospheric Environment Service in the early to mid-1970s (Crowe et al. 1973, Gates 1975).

Producing tourism and outdoor recreation handbooks, these studies consulted tourism professionals to classify the duration of a season based on the minimum climatic conditions required for a range of outdoor recreational activities.

In the late 1970s, ‘weather typing’ was developed as a climate-preference research tool. Yapp and McDonald (1978) combined four thermal comfort classes with four weather types (rainy, windy, overcast or sunny) to rate weather conditions for outdoor recreation-tourism activities in Australia that included pleasant, indifferent or unsuitable. Besancenot et al. (1978) and Besancenot (1985) combined five meteorological parameters (sunshine, cloud cover, rainfall, temperature, wind speed) to establish eight weather types for summer tourism that range from ideal (type 1) to unsuitable (type 8). The major limitations of these studies are that they generalize the climatic requirements for tourism to be the same for all destinations, tourism segments (i.e., socio-demographics), and activities. Moreover, the defined thresholds are based on the opinions of the consultants or the authors and are not empirically validated against the ratings of tourists.

Integrative climate indices are another form of expert-based studies that holistically assess the climate suitability of tourism destinations. The most widely cited index is the Tourism Climate Index (TCI), developed by Mieczkowski (1985). The TCI encompasses five weighted sub-indices (daytime thermal comfort—40% of the index, daily thermal comfort—10%, precipitation—20%, hours of sunshine—20%, wind speed—10%) that are rated from optimal (Table 2-2) to extremely unfavourable. Although the TCI is theoretically based in biometeorological literature on weather and thermal comfort, like weather typing, the central limitation of this approach is that the rating and weighting scheme of the sub-indices are not empirically tested against the preferences of tourists (Scott & McBoyle 2001, de Freitas 2003, Gomez-Martin 2006). Other limitations include the insensitivity of the index to the large variety of weather requirements posed by various tourism segments (e.g., beach sunbathing, mountain trekking), reliance on monthly climate means without consideration of variability or probability of key weather conditions, and neglecting the possibility of the over-riding effect of physical and aesthetic parameters (de Freitas et al. 2008).

Two other integrative climate indices, the Beach Climate Index (BCI) (Morgan et al. 2000) and the Climate Index for Tourism (CIT) (de Freitas et al. 2008), have since been developed to address some of these limitations of the TCI. The BCI is a climate index to

specifically assess the suitability of coastal destinations for beach activities. Using survey responses from actual beach users from northern Europeans in Wales, Malta and Turkey, the weighting and rating scheme of the TCI was modified. Results revealed absence of rain to be the most important (contributing to 29% of the BCI index), followed by sunshine (27%), wind (26%) and temperature (18%), with optimal climate conditions varying from that of the TCI (Table 2-2). The CIT is designed to account for the overriding effect of physical climate parameters, as well as allow for standard daily climate data to be utilized, enabling values to be expressed as probability estimates for likelihood of occurrence. Nevertheless, the empirical testing of both the BCI and CIT has been limited, restricting generalizations of the results because of possible differences in the climatic preferences of tourists (discussed further in Table 2-2).

The private sector is also increasingly developing climate indices that are customized for types of tourism destinations, events and activities. The Weather Channel®, a major private climate service provider in the USA, produces indices relevant to individual tourists. For example, the ‘Spectator Index’ calculates temperature, probability of precipitation, humidity, wind speed and cloud cover to provide a comfort rating value from 1 to 10 (poor to ideal) to signify how comfortable tourists would feel while watching a sporting event (e.g., Major League Baseball and National Football League games). The ‘Ski Index,’ incorporates surface snow conditions, average snow depth, new snow accumulation, temperature, precipitation and wind speed to rate conditions from 1 (dangerous) to 10 (ideal) and a ‘Golf Index’ incorporates extreme temperatures, high dew points, low visibilities, thunderstorm risk, high winds and precipitation to rate a golfing day on a scale from 0 (unfavourable) to 10 (excellent). While the parameters included in each of the Weather Channel® indices are outlined, the evaluation method and the calculation of the parameters within the indices (e.g., weighting and rating of each climate variable) are not disclosed. Empirical validation against tourists’ preferences has yet to be demonstrated for these tourist climate decision tools.

2.2.2 Revealed Preference Approach

A second approach to evaluating climate as a resource for tourism is revealed preference studies. These studies analyze the relationship between climate and empirical measures of aggregate tourism demand (e.g., visitation data, tourist arrivals, occupancy rates) to evaluate tourists’ climatic preferences and optimal climatic conditions. Multiple linear regression models

have been employed to examine the effect of daily/monthly weather variables (e.g., temperature, precipitation, sunshine hours) on daily/monthly visitation/attendance numbers at tourist attractions or destinations. In chronological order, this literature includes studies of beaches in The Netherlands (Van Lier 1973), Kissimmee River Basin in Florida (USA) (Gibbs & McGuire 1973), Cleveland Zoological Park (USA) (Emmons et al. 1975), Chicago swimming pools (USA) (Tolley et al. 1986), an urban forest in Chicago (USA) (Dwyer 1988), Franz Josef Glacier visitor center in New Zealand's Westland National Park (Meyer & Dewar 1999), Rocky Mountain National Park (USA) (Richardson & Loomis 2004), Ontario and Canadian National Parks (Jones & Scott 2006a and 2006b), and golf resorts across Canada (Scott & Jones 2006, Scott & Jones 2007) and the State of Michigan in the USA (Nicholls et al. 2008).

Results from these revealed preference studies show temperature and sunshine hours to be statistically significant and positively correlated to visitation numbers, while precipitation and cloud cover are negatively correlated. Moreno et al. (2009) also noted precipitation has an overriding effect, with even low quantities of rain during the morning discouraging people from going to the beach. While demonstrative of the general influence of weather and climate for tourism, the revealed-climate preferences in these studies should not be considered representative of comparative tourism destinations or tourism segments without replication in several other locations (Scott et al. 2008a). As a result, they are not included in Table 2-2.

Moreno et al. (2009), Martinez-Ibarra (2010), and Gomez-Martin and Martinez-Ibarra (2012), used a slightly different technique to 'reveal' tourists' climatic preferences, capturing beach visitation levels by elevated webcams. The images were then used in combination with real-time weather data to estimate the relationship between beach visitation and atmospheric conditions. While the two former studies both found that the density of beach users steadily increases with higher temperatures, the temperatures are not provided. However, the latter study identified optimal conditions for beach tourism, based on density of beach users, to be 29-31°C, with a maximum physiological equivalent temperature (PET) of 35-39°C, wind speeds of <8m s⁻¹, and no rainfall.

International tourism arrivals data has also been used to 'reveal' tourists' climatic preferences and optimal climate conditions. With a Pooled Travel Cost Model (PTCM), Maddison (2001) used aggregate data on the number of visits (e.g., number of return visits) and the cost of these visits (e.g., average return fare paid and daily expenditures) to estimate a

demand function of British tourists. Lise and Tol (2002) used a slightly modified PTCM (due to data restrictions) to analyze a cross section of OECD (Organization for Economic Cooperation and Development) destinations and Hamilton (2003) modeled German tourists' demand. The results from these studies reveal preference differences across nationalities, including Lise and Tol (2002) who found minor preference differences across tourists from OECD nations (e.g., optimal temperatures ranged from 21.8°C for French tourists to 24.2°C for Italian tourists based on mean temperature for the warmest month of the year). This contrasts with the results of Hamilton et al. (2005), calculating a globally averaged optimal temperature for tourism to be 14°C (based on annual temperatures) using an econometric model of bilateral tourist flows². Bigano et al. (2006) similarly used an econometric model with international tourism flows for 45 countries and concluded that “people from any country prefer the same climate [of 16.2°C] for their holidays” (p. 399) (based on annual temperatures). The optimal temperatures provided by these international revealed preference studies are summarized in Table 2-2.

Primary among the limitations of these revealed preference studies is the coarse spatial and temporal resolutions of the models. For instance, the PTCM of Maddison (2001) and Lise and Tol (2002) assume the temperature of capital cities to be representative of the entire nation, inferring that the mean temperature of Washington, D.C. is representative of the United States, which contains 10 different climate zones (Scott et al. 2008a). This information is likely irrelevant for tourists, as the destination to which they are traveling may have a climate that is quite different from that of the national average. Also problematic is the coarse temporal scale of the models. Tourists' vacation periods are often limited to one or two weeks at a destination. Therefore, selecting the maximum daytime temperature across a monthly (Lise & Tol 2002, Hamilton 2003), quarterly (Maddison 2001) or annual (Hamilton et al. 2005, Bigano et al. 2006) time scale is unsuitable for tourists. Moreover, tourists experience and respond to the combined effects of weather elements that comprise climate, but these macro-scale models focus only on temperature and omit the physical and aesthetic facets. Therefore current studies that examine macro-scale tourism patterns are utilizing incomplete constructs of climate which have little meaning for tourists (Scott et al. 2012b).

² The data set is based on total arrivals and total departures; there is no data on the origin of the arrivals or the destination of the departures. Therefore a database was constructed on bilateral tourism flows for all pairs of countries.

Furthermore, the validity of the international tourism arrivals data has also been questioned (Gössling & Hall 2006a). First, the data provided by the UNWTO does not distinguish between leisure, business, and VFR (Visiting Friends and Relations) tourists. The latter two types of travelers can be assumed to travel irrespective of reasons related to climate. Second, none of the databases are consistent for all countries, with many important national destinations with missing or incomplete data. As a result, projecting travel flows based on generalized data bases is likely to have a substantial influence on the results of the model, with missing data constituting one substantial error and the non-distinction between leisure and business travelers constituting another error.

Conventional demand indicators, such as visitation or arrivals/departures numbers, do not necessarily provide to an accurate measure of tourists' climatic preferences because tourism demand is also driven by institutional seasonality (e.g., state, religious or school holidays) and not simply natural seasonality (climate) (Butler 2001). Various studies support this contention, identifying optimal climate conditions outside of peak tourism demand periods (e.g., de Freitas 1990, Morgan et al. 2000, Gomez-Martin 2006). This is particularly true for the models of Hamilton et al. (2005) and Bigano et al. (2006) that account for climate on an annual basis, thereby producing results that may be calibrated to non-optimal temperatures (Scott et al. 2008a).

It is also important to note that climate data for tourism are frequently based on meteorological observation networks operated by state meteorological organizations, which are often located many kilometres away from the location where tourists' actually holiday. Studies have revealed that climate station data does not present an accurate reflection of the microclimatic conditions tourists encounter (e.g., at resorts, beaches, parks or ski hills) and can create substantial challenges for tourism marketers and operators (Scott & Lemieux 2010). For example, Wilson and Becken (2011) found deficiencies in currently available climate and weather information for tourists in New Zealand, with poor regional images generated by inaccurate and poorly presented climate and weather data. The study underscores the ongoing and recurring discontent among tourism operators, with many towns and regions disagreeing with the daily temperature highs recorded by the MetService, noting that it is the location of weather stations rather than the accuracy of the readings that result in a misrepresentation of weather and climate information. Höpfe and Seidl (1991) compared the recorded weather conditions on a beach resort in Lido degli Estensi on the Adriatic coast of Italy with the recorded

weather conditions at the nearest official meteorological station. The study found that the beach location was consistently lower in air temperature, with higher air velocity near the seaside. Hartz et al. (2006) similarly compared state weather data from Phoenix (from the National Weather Service) with resorts across the metropolitan area. Temperatures and dew points were consistently lower at the resort, whereby tourists could expect to find a more hospitable microclimate than official reporting would infer, resulting in a longer comfort season. Overall, the extent to which distant weather stations or even coarser gridded climate data accurately represent the climatic conditions where tourism activities take place remains relatively unknown. It is also unclear whether the results of climate change impact assessments would differ when microclimates are considered.

2.2.3 Stated Preference Approach

A third approach to evaluating climate as a resource for tourists is a stated preference approach, which consults tourists directly (either through surveys or interviews) about their climatic preferences. de Freitas (1990) and Mansfield et al. (2004) surveyed tourists' satisfaction with on-site atmospheric conditions in Australia and Israel, respectively. de Freitas (1990) found the immediate thermal environment to be the key contributing factor to tourist satisfaction, followed by non-thermal effects of cloud and wind, with rainfall events of 30 minutes or longer having an overriding effect. Mansfield et al. (2004) similarly found the importance of multiple weather parameters, with wind velocity and cloudiness exerting a strong negative influence on satisfaction. Mansfield et al. also noted that domestic (Israeli) tourists were more sensitive to weather conditions than those international tourists, as well as increased sensitivities for those who come to Israel primarily for beach activities. This suggests that tourists have different climate preferences or tolerances depending on origin and travel motivation. Other in situ studies include the previously discussed Morgan et al. (2000) survey in Wales, Malta and Turkey to assess the relative importance of climate parameters for 3S tourism to modify the TCI for beach users and Gomez-Martin's (2006) survey of tourists in Catalonia (Spain) to refine Besancenot's (1985) eight weather types. The optimal climates identified through these in situ studies are summarized in Table 2-2.

Table 2-2 Summary of optimal climates for tourism as identified in the literature

Study	Sample Region	Tourism Segment	Temporal Scale	Optimal Climate Conditions			
				Temp (°C)	Precip	Sun/Cloud	Wind (km/h)
Besancenot et al. (1978)	France	General	Daily	25-33	0mm	> 9hrs sunshine, 25% cloud cover	< 29
Mieczkowski (1985)	Global	General	Monthly	20-27 ^(a)	<15mm	> 10hrs sunshine	< 3
Morgan et al. (2000)	Wales, Malta, Turkey	Beach	Monthly	27-30	<15mm	> 10hrs sunshine	< 3
Maddison (2001)	UK	General	Quarterly	30.7	-	-	-
Lise & Tol (2002)	OECD Nations	General	T _{mean} for warmest month of the year	21	-	-	-
Hamilton (2003)	Germany	General	Monthly	24	-	-	-
Gomez-Martin (2006)	Spain	Beach	Daily	22-28	0mm	> 11hrs sunshine, 25% cloud cover	< 29
Hamilton et al. (2005)	Global	General	Annual	14	-	-	-
Bigano et al. (2006)	Global	General	Annual	16	-	-	-
Scott et al. (2008)	Canada, New Zealand, Sweden	Beach	-	27	-	25% cloud cover	1-9
		Urban	-	23	-	25% cloud cover	1-9
		Mountain	-	21	-	25% cloud cover	1-9
Moreno (2010)	Belgium, The Netherlands	Beach	-	28	-	> 8hrs sunshine 0% cloud cover	1-9
Rutty & Scott (2010)	Europe	Beach	-	27-32	0min	25% cloud cover	1-9
		Urban	-	20-26	0min	25% cloud cover	1-9
Wirth (2010)	Germany	Beach	-	27-32	0min	25% cloud cover	1-9
		Urban	-	25-32	0min	25% cloud cover	1-9
Gomez-Martin & Martinez-Ibarra (2012)	Spain	Beach	Daily	29-31 35-39 ^(b)	0min	-	< 29

* Results from thermal indices are not included because they are not based on tourist's preferences, but rather thermal preferences generally.

(a) 21-32°C when relative humidity of 0% and 19-24°C when relative humidity of 100%

(b) PET

A common limitation of surveys that explore tourists' satisfaction with current weather conditions is the high personnel costs of doing so, reducing the range of weather conditions that can be examined (Scott et al. 2008a). For example, the results of Mansfeld et al. (2004) are based on four days of interviews in the month of March. Moreover, these studies have all focused on beach tourism and, cannot therefore be generalized to other major tourism environments or destinations. In-situ surveys also run the risk of response bias, as surveys administered on days with marginal weather conditions can produce artificially high ratings, since those visitors who are not onsite because they found the conditions unacceptable will not be available to be surveyed (Scott et al. 2008a).

An ex-situ study, where respondents are in an indoor controlled climate setting, limits this potential bias and allows for respondents to express their perceived satisfaction with a wide range of climate conditions for a range of tourism settings. Scott et al. (2008) was the first to conduct an ex-situ study of tourists' stated climate preferences, administering surveys to university students in Canada, Sweden and New Zealand. Optimal climate conditions varied across both tourism destination types (Table 2-2) and by nationality. For example, respondents from Sweden stated 29°C as ideal for beach tourism, whereas Canadian respondents stated 27°C and New Zealand respondents stated 25°C. Ruddy and Scott (2010) similarly examined the climate preferences for beach and urban tourism among university students in northern Europe (Austria, Germany, The Netherlands, Sweden and Switzerland). Results also revealed that optimal climate conditions are different across tourism destination types (Table 2-2) and by nationality. For example, Swedish respondents rated 0% cloud cover and 28-32°C as ideal for beach tourism compared to Swiss respondents who rated 25% cloud cover and 26-32°C as ideal for beach tourism. Recent ex-situ studies have since surveyed a broader (public) sample of tourists and found similar results to that of the university samples. Moreno (2010) surveyed tourists waiting to board flights to a Mediterranean destination at a Belgian and Dutch airport and found ideal conditions for beach tourism to be 0% cloud cover and 28°C. Wirth (2010) compared a public sample of German travelers with the results of Ruddy and Scott (2010) and found no significant differences across the two sample groups.

Stated-preference studies have also begun to empirically validate climate resources as a constraint for tourism. Ruddy and Scott (2010) found temperatures of less than 22°C/17°C as unacceptably cool for a beach/urban sightseeing holiday and temperatures greater than

37°C/30°C as unacceptably hot for a beach/urban sightseeing holiday. Wirth (2010) found too hot conditions for a beach holiday to be 36°C and 34°C for university students and respondents aged 56 years and older, respectively, with no significant differences across the sample groups for unacceptably cool temperatures for a beach holiday or for unacceptably cool/hot temperatures for an urban sightseeing holiday. In a survey commissioned by the Government of France (Credoc 2009), respondents stated that summer tourism would be too hot in France if temperatures exceeded 32°C, with significant differences found by age (e.g., 18-25 years old stated 34°C, ≥60 years stated 30°C) and by activity (e.g., beach 34°C, outdoor sports 33°C, walking 32°C, camping 34°C, mountain 30°C). Too cold for summer tourism in France was identified as 14°C, with significant differences by age (≥ 60 years stated 12°C), and by activity (beach 17°C, camping 17°C, urban 9°C, mountain 9°C).

Stated-preference research, albeit limited, has begun to reveal differences for specific tourism segments or activities, as well as interpersonal differences, both confirming and contradicting aspects of revealed preference studies. Tourists' optimal and unacceptable climate conditions are dependent on several factors, and those studies that have tried to generalize this complex relationship into universal thresholds (e.g., climate indices, macro-scale models) may be too simplistic. Given the factors that are involved, climate parameters for tourism have only been partially quantified on a destination or segment-specific basis, at best. Moreover, the focus thus far has primarily been on European climate preferences, with no known international study sample from a broad range of climate regions (e.g., monsoon, tropical, semi-arid). With an incomplete understanding of the range of climate preferences among tourists, as well as how these preferences may differ by cultural, regional or market segments (Gomez-Martin 2005, Scott et al. 2008a, Moreno 2010, Ruttty & Scott 2010), existing studies outside of the conventional climate and tourism disciplines (i.e., geography, tourism, climatology) may lend important insights to inform these knowledge gaps.

2.3 Multidisciplinary Insights into Climatic Preferences

Much empirical research on the thermal aspect of human optimal and critical threshold conditions have been conducted by engineers, particularly as it relates to the indoor internationally accepted American Society of Heating Refrigeration and Air-Conditioning

(ASHRAE) 55 standard—*Thermal Environmental Conditions for Human Occupancy*.³ Based almost exclusively on data from climate chamber experiments performed in mid-latitude climatic regions, researchers have increasingly sought to validate the recommended indoor standard of 21-23°C (with relative humidity between 40-60%). Based on interviews (stated preference) with concurrent physical indoor climatic measurements of building occupants located in humid-tropical climates have failed to support the results from laboratory-based models, with findings indicating different thermal comfort ranges based on the occupants' climatic origin of residence. For example, in Bangkok, Thailand, the majority of occupants in an indoor work environment felt thermally comfortable at temperatures between 28-31°C (Busch 1990), which is up to 10°C higher than the comfort range identified by the ASHRAE 55 standard. Findings from Hong Kong identified thermally comfortable conditions at 23°C (Chan et al. 1998), Townsville (Australia) 23-24°C (de Dear & Fountain 1994), Taiwan 24-26°C (Hwang et al. 2006) and Singapore 24-28°C (de Dear et al. 1991).

Examination of thermal comfort in an outdoor environment is much more limited, but differences have nevertheless been recorded. A survey of locals using an outdoor space in Taiwan stated comfortable temperatures to be 26-30°C, which is much warmer than that identified by similar outdoor space users in Germany at 18-23°C (Lin 2009). Knez and Thorsson (2006) revealed that Swedish subjects perceived the same air temperature of an outdoor urban square as colder than Japanese subjects, suggesting that regional cultures perceive outdoor temperatures differently. These differences could translate into diverse climatic preferences while on holiday as well.

Increasing research in psychological adaptation can also inform climate assessments for tourism, with studies indicating that thermal perceptions and preferences cannot be fully explained by the energy balance of the human body (e.g., Physiologically Equivalent Temperature [PET]), which is what the thermal component of tourism indices are based on. Humans are also affected by behavioural factors, including thermal experience, comfort expectations, perceived thermal control, duration of exposure, and culture (e.g., Paciuck 1990, Brager & de Dear 1998, Nikolopoulou et al. 2001, Lin et al. 2010). Rohles (1980) found that simply telling occupants that the temperature was higher than it really was during a chamber

³ The purpose of ASHRAE Standard 55 is to “specify the combination of indoor space environment and personal factors that will produce thermal environmental conditions acceptable to 80% or more of the occupants within a space” (ASHRAE 2013).

experiment made them feel warmer. Lack of perceived control has also been found to explain why the number of people who state they are thermally comfortable in an outdoor setting is much higher than that predicted by human heat balance models (e.g., PET and Predicted Mean Vote [PMV]). For example, Nikolopoulou and Steemers (2003) predicted 66% of the people sitting in an outdoor urban space in the UK should theoretically be dissatisfied with the thermal conditions based on PMV, but the actual percentage (based on in situ stated preference) was only 11%. Therefore studies that evaluate the suitability of a location for tourism based solely on standard thermo-physiological indices (i.e., PET, PMV) (e.g., Matzarakis 2006, Lin & Matzarakis 2008, Zaninovic & Matzarakis 2009, Endler et al. 2010, Matzarakis et al. 2010, Lin & Matzarakis 2011, Caliskan et al. 2012, Brosy et al. 2013, Matzarakis et al. 2013, Matzarakis et al. 2014) not only exclude the physical and aesthetic facets of climate, but also fail to consider the psychological factors of the thermal component, which may substantially alter the range of thermal conditions tourists' deem acceptable.

In the health sciences literature, seasonal adaptation has been found to influence thermal comfort. For example, heat/cold waves early in the summer/winter, when physiological processes and dressing habits have not adjusted to the occurrence of these temperature extremes, can have a more drastic impact on discomfort and health than heat/cold waves occurring later in the season (e.g., Baranowska & Gabryl 1981, Sheridan & Kalkstein 2004, Koppe & Jendritzky 2005). The threshold for initiating heat alerts (when the 'critical air temperature'⁴ has been exceeded) through public health authorities and national meteorological services varies geographically (Meehl & Tebaldi 2004, Robinson 2001). Due to cultural site specificity, there is no international standard threshold temperature at which heat/cold alerts are initiated through the public health authorities and national meteorological services (Cubash & Meehl 2001, Koppe et al. 2004, Koppe & Jendritzky 2005). For example, studies have found that the Kalahari Bushmen, Bantu peoples in South Africa, and the indigenous peoples in central Australia, have physiologically adapted to thermal stress, with a lower susceptibility to heat collapse than their non-native fellows due to lower perspiration and heart rates (Meze-Hausken 2008). Vigotti et al. (2006) found that a person's place of birth can influence their heat tolerance, with Italians born

⁴ The point at which an unclothed person at rest can maintain body temperature by balancing heat production and heat loss.

in the southern regions of the country having a higher minimum mortality temperature⁵ at 23.6°C versus 19°C for Italians born in the northern regions.

The preceding literature highlights that a broader body of scholarship has much to offer in terms of filling existing gaps within climate-tourism assessments. Based on the differences identified in thermal conditions for indoor occupancy, outdoor urban space use, as well as evidence of cultural climate adaptation in the health sciences literature, it is very possible that differences in tourists' climatic preferences and thresholds may exist. The findings from these diverse studies support the cultural differences identified in the limited tourism stated-preference literature (e.g., Morgan et al. 2000, Scott et al. 2008a), while further questioning the veracity of studies that aim to identify universal tourism climate ideals (e.g., Mieczkowski 1985, Hamilton 2005, Bigano et al. 2006). It also highlights the need to examine cross-cultural variations in tourists' responses, with the aim of sampling tourists from a range of different geographical contexts and climatic zones.

Moreover, the multidisciplinary evidence suggests that climate assessments for tourism need to be calibrated to account for psychological adaptation, as individuals assess climate based on personal perceptions, expectations and experience. It is therefore likely that human psychology of leisure travel will influence a tourists' level of weather and climate acceptability and unacceptability before, during, and after travel. At present, a large proportion of the climate-tourism assessments have focused exclusively on tourists' macro-scale response (i.e., top-down model) to climatic parameters (e.g. revealed preference studies), thereby excluding the subjective perceptions of tourist climatic preferences. This lends further support to the need for additional stated-preference studies (i.e., bottom-up approach) that will address the importance of psychological adaptation among tourists.

2.4 Application of Climate Assessments for Tourism

The motivations for evaluating weather and climate for tourism are diverse and valuable for a number of applications. Assessment studies can be used as a demand or supply-side decision-making tool. Tourists can use climate assessment information to select the best time and place to travel, to plan appropriate accommodation, attire, transportation and activity schedule

⁵ The point at which mortality reaches its minimum at an optimal temperature value, which is taken as a rough measure of the population's heat tolerance.

(i.e., selecting activities and scheduling them during periods with the most optimal weather). This is particularly true for those tourists with health concerns to minimize possible risks (e.g., heat stress). For tourism operators and destinations, this type of research can be utilized in marketing strategies (e.g., objective promotion of attractive climate conditions or conditioning tourists' expectations of climate), risk assessment (e.g., severe weather events, avalanche risk), operational decision making (e.g., when to commence snow making, staffing requirements), infrastructure planning and development (e.g., resort micro-climate design and landscape). The insurance industry (i.e., weather insurance or weather derivative contracts) can integrate climate assessment research to better customize its products to the climate preferences of tourists in different types of destinations or to develop financial products for tourism operators and destinations to manage weather risk (e.g., weather guarantees). Figure 2-5 outlines the temporal scale at which tourism operators and planners can use weather and climate assessments for a range of decision-making contexts.

The results from climate assessment research can also be incorporated into existing climate indices (Mieczkowski 1985, Morgan et al. 2000, de Frietas et al. 2008), demand models (e.g., Lise & Tol 2002, Hamilton et al. 2005, Bigano et al. 2006) and climate change assessments (e.g., Scott et al. 2004, Amelung et al. 2007, Moreno & Amelung 2009, Moore 2010) to allow for more robust projections of tourism demand. Such projections can help the tourist industry in developing plans for climate change adaptation, minimizing associated risks and capitalizing on new opportunities posed by changes in the competitive relationships among destinations.

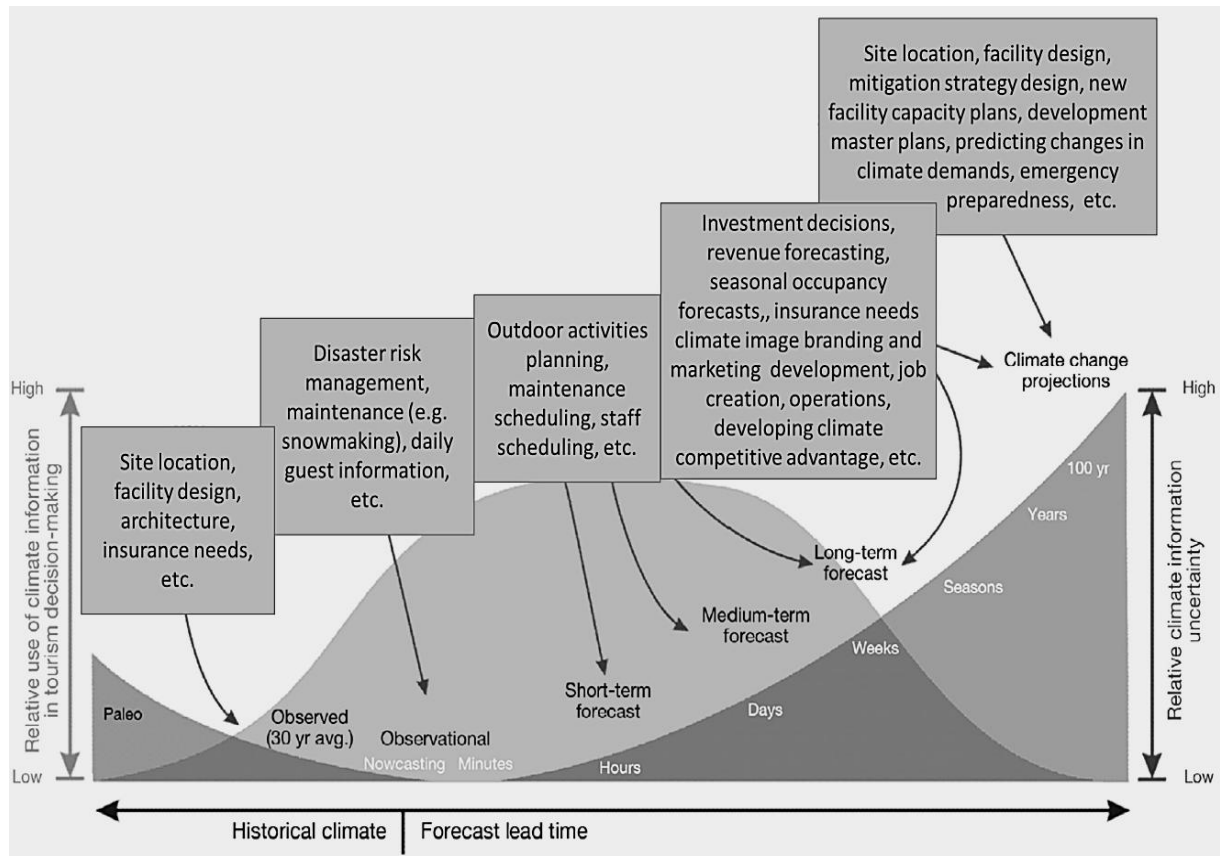


Figure 2-5 Application of weather and climate assessments by tourism operators and travel planners (Scott et al. 2012b)

2.5 Conclusion

While the focus on tourism climate assessments has increased over the last several decades, our knowledge of tourists' climatic preferences and thresholds remains incomplete. This chapter highlights the many fields that are working toward a similar objective—understanding and evaluating human climatic preferences and thresholds, and draws attention to the opportunities to capitalize on multidisciplinary insights. With climate change projected to alter the temporal and spatial distribution of climate resources for tourism, with some destinations speculated to become 'too hot' for tourism and others openly anticipating the rewards of improved climate conditions, there is a greater need for more informed assessments. This is particularly true given that tourists have the greatest capacity to adapt to climate change by altering the destination (e.g., change locations), timing (e.g., go another day) and intensity

(e.g., go less often) of their holidays, or by substituting their intended travel activity for another (e.g., go on an urban sightseeing holiday instead of a winter sports holiday). The ease with which tourists can alter their travel plans is of concern for tourism-recreation businesses, as well as nations heavily dependent on tourism, as they cannot adapt as easily to climatic impacts because of large capital investments in immobile infrastructure (e.g., hotels, shopping facilities) (Scott et al. 2008b). Like other areas of climate change research, tourism has seen its share of early speculation and contrasting perspectives, which demand careful consideration and reassessment as research advancements occur (Scott et al. 2012a).

Chapter 3:

Manuscript #1: Differential Climate Preferences of International Beach Tourists

Rutty M, Scott D (2013). Differential climate preferences of international beach tourists. *Climate Research*, 57: 259-269.

Weather and climate are a principal resource and constraint for tourism that directly and indirectly influence global demand patterns. Against the background of rapidly expanding literature on climate and tourism, this study sheds needed insight into the complexities of tourist climate preferences and the implications for rating current and future climate resources for tourism. A survey of 472 beach tourists is the basis for comparing the climatic preferences of diverse tourism market segments on the Caribbean islands of Barbados, Saint Lucia and Tobago. Key findings include warmer temperature preferences and tolerances for tourists originating from tropical regions, with lower heat preferences and tolerances for tourists from temperate regions. Statistically significant differences ($p < 0.05$) were also found between temperate and tropical residents for every climate variable examined (temperature, rain, cloud cover, wind). The results are discussed with regard to their implication for the construction of tourism climate indices, demand models and climate change assessments.

3.1 Introduction

A number of tourism studies have explored the similarities and differences between socio-demographic and cross-cultural groups in relation to tourism demand patterns. Understanding these differences is important for tourism operators and managers, providing insight into effective decision making and market-segmentation strategies. Such research has revealed that tourist behaviour and perceptions, travel motivations, satisfaction levels and activity selections, all vary according to age and country of origin (e.g., Pizam & Sussmann 1995, Crofts & Erdmann 2000, Moscardo et al. 2001, Kozak 2002, Lee et al. 2004, Diaz-Perez et al. 2005, Kang & Moscardo 2006, Vespestad & Mehmetoglu 2010, Prayag & Ryan 2011, Correia et al. 2011, Thrane & Farstad 2012).

Weather and climate are principal resources and constraints for tourism; they directly and indirectly influence global demand patterns (de Freitas 2003, Scott & Lemieux 2010, Scott et al. 2012a). For tourists, weather and climate are considered consciously or implicitly throughout the travel planning process (Scott et al. 2012b), serving as an important travel motivator (e.g., Lohmann & Kaim 1999, Kozak 2002), influencing the timing of travel (e.g. Eugenio-Martin & Campos-Soria 2010), the destination(s) selected (e.g., Hamilton & Lau 2005, Moreno 2010), spending and overall trip satisfaction (e.g., Bardón 1991, Williams et al. 1997, Becken et al. 2010). Recognizing the importance of weather and climate for tourism, researchers have sought to quantify the optimal and threshold (i.e., unacceptable, point of behavioural adaptation) climatic conditions for tourism, both generally (i.e., sight-seeing) and for specific tourism environments or activities (i.e., beach, urban, mountain) (Mieczkowski 1985, Morgan et al. 2000, Maddison 2001, Scott & McBoyle 2001, Lise & Tol 2002, Scott et al. 2003, Hamilton et al. 2005, Bigano et al. 2006, Gomez-Martin 2006, Scott et al. 2008a, Credoc 2009, Moreno 2010, Ruddy & Scott 2010, Denstadli et al. 2011). A noted gap in this literature is a lack of empirical studies that compare climatic preferences for major tourism market segments (e.g., socio-demographic and cultural groups) and tourists originating from different climatic regions (e.g., temperate versus tropical) (Scott et al. 2008a, Ruddy & Scott 2010, Gössling et al. 2012). Revealed preference studies have not

explored market segment differentiation in climate preferences because of the aggregated nature of tourism arrivals data (Scott et al. 2012b), while studies using stated climatic preference techniques have either not included demographic characteristics or have captured a narrow range of tourists (e.g., Morgan et al. 2000, Gomez-Martin 2006, Moreno 2010, de Freitas et al. 2008, Scott et al. 2008a, Ruddy & Scott 2010). It is therefore unclear whether, and to what degree, climate preferences and key thresholds vary. Furthermore, existing studies are geographically restricted to relatively similar cultures and temperate climate zones (Europe, North America and Australasia) (Morgan et al. 2000, Gomez-Martin 2006, Scott et al. 2008a, Moreno 2010, Ruddy & Scott 2010). Differences in climatic preferences among these limited samples have nevertheless been recorded, raising the question whether differences would be larger in more climatically diverse tourist groups.

This study addresses these two knowledge gaps by evaluating climate resources for beach tourism using an in situ survey of climatic preferences from a sample of tourists in Barbados, Saint Lucia and Tobago. Three central research questions guided this study:

1. What are the ideal and unacceptable threshold conditions for a beach holiday (temperature, rain, cloud cover and wind)? How do the results compare with the optimum conditions identified by beach climate preference studies in other regions (e.g., Morgan et al. 2000, Gomez-Martin 2006, Scott et al. 2008a, Moreno 2010, Ruddy & Scott 2010, Wirth 2010)?
2. Do ideal and unacceptable threshold climate conditions differ by age cohort? Have previous convenience samples of university students (Scott et al. 2008a, Ruddy & Scott 2010) satisfactorily represented the broader tourism market?
3. Do ideal and unacceptable threshold climate conditions differ cross-culturally? Lise & Tol (2002) and Bigano et al. (2006) concluded that temperature preferences varied little among tourists of different nationalities, while Morgan et al. (2000) and Scott et al. (2008a) found significant differences among tourists from different nations. If cross-cultural differences exist, does the

degree of difference increase across more climatically diverse nations (e.g., residents from temperate regions compared to those from tropical regions)?

3.2 Assessing Climate Preferences for Beach Tourism

Beach tourism is strongly related to climatic conditions, with many coastal tourists largely, or in some cases entirely, motivated by climatic considerations when selecting their holiday destination (Kozak 2002, Mansfeld et al. 2004, Gomez-Martin 2005, Uyarra et al. 2005, Moreno 2010). Major intra-regional tourism demand patterns highlight the influence of weather and climate for this market segment, with millions of North Americans and northern Europeans annually travelling south to the warm and sunny coasts of the Caribbean and Mediterranean, respectively. The sensitivity of beach users to weather is also apparent given that the activity takes place in the open natural environment, where tourists are generally exposed to weather and oceanic conditions with little clothing (i.e., a swimsuit) as protection. Weather sensitivities have been recorded, with sunshine and higher temperatures correlated with crowded beaches, and cool temperatures, rain and wind conditions deterring users and resulting in low levels of beach use (e.g., de Freitas 1990, Moreno et al. 2008, Martinez-Ibarra 2011). A number of studies have examined beach tourists' climatic preferences, with the identified optimal and unacceptable climate conditions discussed below and summarized in Table 3-1.

Using survey responses from beach users (northern Europeans) holidaying in Wales, Malta and Turkey, Morgan et al (2000) adapted Mieczkowski's (1985) tourism climate index (TCI) to formulate their beach climate index (BCI) to develop the rating and weighting schemes of the index. Absence of rain was rated as the most important for a beach holiday (29%), followed by sunshine (27%), wind (26%) and temperature (18%). Respondents were also asked to rank their preferred thermal sensations from 'very hot,' 'hot,' 'warm,' 'neither cold nor warm,' 'cool' and 'cold,' with a temperature range later assigned to each sensation category using skin temperature values from de Freitas (1985). A 'warm' skin temperature of between 33 and 35°C was rated as most preferred. Respondents were not surveyed regarding

their preferred conditions for precipitation, wind or sunshine, but instead the highest ranked optimal condition was either adopted or prescribed ($<15\text{mm mo}^{-1}$ of rain, winds of 4 m s^{-1} , and $>10\text{ h}$ of sunshine).

Modifying Besancenot et al.'s (1978) weather-types method, which catalogs eight types of suitable weather for general tourism activities from Type 1 (very good weather) to Type 8 (bad weather), Gomez-Martin (2006) surveyed tourists in Catalonia (Spain) to assess their preferences for weather types specifically for beach tourism. The results were then applied to present and future climate scenarios, with the goal of evaluating climate-tourism potential in the region. Respondents selected $22\text{-}28^{\circ}\text{C}$ as ideal and $16\text{-}22^{\circ}\text{C}$ as least favourable (as chosen from $16\text{-}22^{\circ}\text{C}$, $22\text{-}28^{\circ}\text{C}$, and $28\text{-}33^{\circ}\text{C}$). Optimal precipitation conditions were assumed to be no rain, with respondents stating that $>3\text{ h}$ of rain would 'totally ruin' the tourism experience. On the Beaufort scale from 0 to 8, the majority of respondents stated a wind level of 4 ($5.5\text{ to }7.9\text{ m s}^{-1}$) to be the maximum tolerated, and therefore wind velocities $<8\text{ m s}^{-1}$ were specified as ideal. The majority of respondents stated an ideal 'sunny day' was when the sun shines for at least 77% of the daylight hours ($\geq 11\text{ h d}^{-1}$).

Scott et al. (2008a) conducted the first ex-situ study of tourists' stated climate preferences for multiple tourism environments, administering surveys to university students in Canada, Sweden and New Zealand. Respondents were asked to specify an ideal temperature for beach tourism, resulting in a median preferred temperature of 27°C . Based on 5 wind speed categories, the majority of respondents stated a light breeze was ideal ($1\text{-}9\text{ km h}^{-1}$). Five sky condition categories were also provided, with the majority of respondents selecting 25% cloud cover as ideal for a beach holiday. The study found significant differences for temperature and cloud preferences among these national samples, with the Swedish sample preferring slightly warmer temperatures and no cloud cover.

Moreno (2010) surveyed Belgian and Dutch tourists at an airport waiting to travel south to the Mediterranean for a beach holiday. Using the same question format as Scott et al. (2008a), the results indicated a preferred temperature of 28°C , a light breeze ($1\text{-}9\text{ km h}^{-1}$), >8

h of sunshine and 0% cloud cover. Respondents were also asked which weather elements had the greatest negative impact on beach tourism experience, with precipitation being rated the highest (76%), followed by strong winds (57%), low temperatures (44%), cloudy skies (26%), high temperatures (20%), high humidity (17%) and low humidity (5%).

Rutty and Scott (2010) also conducted an ex-situ study of university students in Europe (samples from Austria, Germany, The Netherlands, Sweden, Switzerland). It was the first to examine key climatic thresholds in addition to the most preferred (optimal) climate conditions. Scott et al. (2008a) noted that clusters of responses in their data were visible at 15, 20, 25 and 30°C, suggesting that these values may be key perceptual thresholds. Recognizing that tourists may have a range of ideal temperatures (e.g., 27°C may be preferred equally to 26 or 28°C), the survey asked respondents to indicate the range of temperatures that is ideal for beach tourism, as well as to indicate threshold temperatures that are unacceptably hot or cold for beach tourism. The survey found that 27-32°C is ideal for more than half (>50%) of beach tourists, with temperatures <22°C and >36°C being given as unacceptable for the majority of respondents. Ideal conditions also include a light breeze, 25% cloud cover and no rain. Conversely, unacceptable conditions include strong winds (41-60 km h⁻¹), ≥75% cloud cover and >2 h of rain a day.

Using the same survey as Rutty and Scott (2010), Wirth (2010) explored whether there was a difference in climate preferences between university students and other demographic groups (i.e., 26-35, 36-55, 56+ yr olds) in Germany. Ideal beach tourism conditions for all demographic groups included no rain, a light breeze and 25% cloud cover. A slightly different ideal temperature was recorded between the student sample (27-32°C) and the oldest demographic group (25-32°C). All demographic groups identified > 2.5 h d⁻¹ of rain, strong winds and ≥75% cloud cover as unacceptable, as well as temperatures <22°C. However, similar to ideal temperatures, unacceptably hot temperatures differed between the youngest (>36°C) and oldest age cohort (>34°C).

Table 3-1 Daily climatic optimal and unacceptable threshold conditions for beach tourism

Sample Region	Temperature (°C)		Precipitation		Sun/Cloud Conditions		Wind (km h ⁻¹)		Source
	Ideal	Unacceptable	Ideal	Unacceptable	Ideal	Unacceptable	Ideal	Unacceptable	
Wales, Malta, Turkey ^(b)	33-35 ^(d)	-	<15mm mo ⁻¹	-	>10 h sun	-	<14	-	Morgan et al. (2000)
Spain ^(b)	22-28	16-22	-	>3 h	>11 h sun ≤25% cloud	≤5 h sun	<8	>8	Gomez-Martin (2006)
Canada ^(a)	27				25% cloud				
New Zealand ^(a)	25	-	-	-	-	-	1-9	-	Scott et al. (2008a)
Sweden ^(a)	29				0%				
Belgium ^(b)	28	-	-	-	>8 h sun 0% cloud	-	1-9	-	Moreno (2010)
Europe ^(b)	27-32	<22; >37	0 h	≥2 h	25% cloud	≥75% cloud	1-9	≥41	Rutty & Scott (2010)
Germany ^(b,c)	27-32 25-32	<22; >36 <22; >34	0 h	≥2.5 h	25% cloud	≥75% cloud	1-9	≥41	Wirth (2010)

(a) Youth traveller market segment (i.e., student sample);

(b) Public traveller market segment (i.e., all age cohorts);

(c) Senior traveller market segment (i.e., 56+ yr old);

(d) Skin Temperature

3.3 Methods

Self-administered questionnaires were distributed to beach users on the Caribbean islands of Barbados (Accra, Amaryllis, Dover and Holetown beaches) Saint Lucia (Gros Islet and Rodney Bay beaches) and Tobago (Crown Point and Pigeon Point beaches). This study area was chosen because tourism in the Caribbean is predominantly based on a 3S market. This market segment depends on favourable weather conditions in the coastal zone. The Caribbean also has the most tourism-intensive economy among the 12 regions ranked by the World Travel and Tourism Council (2011) (i.e., tourism represents the greatest proportion of the regional economy), with tourism representing 14% of GDP and 13% of employment (2.2 million jobs).

A pre-test of the survey was conducted in Canada, with slight modifications made to improve the clarity of some questions in March 2012. A total of 472 persons agreed to participate in the survey, which provided a strong response rate of 89%. Of the completed surveys, 216 were completed in Barbados, 126 in Saint Lucia and 130 in Tobago. The survey was conducted in English in all three countries. Respondents were asked to circle the range of temperature(s) they deemed ideal and unacceptable for their beach holiday. For the variables rain, wind and sky conditions, respondents were asked to select the most preferred and unacceptable daily conditions from a list of five available options. The data collection extended over 18 days in March and April 2012, with every available person/group on the beach approached and asked to participate. In this period, a daily mean and maximum temperature between 27 and 30°C were recorded, which correspond to long-term averages in the region.

A few limitations should be borne in mind when considering the results of this study. A common drawback of in situ surveys is the time limitations for data collection (without significant personnel costs). In the same vein, there is the possibility of response bias, as those beach users who prefer weather conditions not available during the days when surveys were disseminated may not be represented in the sample. It is possible that visitors arriving in the Caribbean during the shoulder season (i.e., June-November) may have different weather

preferences than those reported here. However, average daily maximum and minimum temperatures in the region vary only slightly throughout the year (1-2°C) and may therefore be less of a concern in this study. The survey was also distributed to beach users on the ‘dry’ part of the beach, which means tourists in the water at the time of the survey were not captured. As such, those who often engage in water sports may be somewhat under-represented in the sample. The extent of these biases is unknown.

3.4 Results

The survey sample is composed of slightly more females than males (57 and 43%, respectively), with the largest share of respondents falling into the 45-54 age group (22%), followed by 25-34 (20%), 55-64 (19%), ≥65 (16%), 35-44 (15%), and under 25 (8%). The greatest numbers of respondents were from the United Kingdom (UK) (28%), followed by Canada (26%), the United States (US) (16%), Trinidad and Tobago (16%) and Germany (4%), with the remaining respondents from other European (5%), Caribbean (3%) and South American (2%) countries. Based on the Köppen climate classification scheme (Peel et al. 2007), the majority of respondents originate from a temperate/summer continental climate region (75%), followed by tropical (21%), subtropical (3%) and other (1%) climate regions. Most respondents (87%) had travelled to the Caribbean at least once before, with 20% having travelled to the region 10 or more times, and only 13% were first-time visitors.

Figure 3-1 shows the distribution of unacceptably cool, ideal and unacceptably hot temperatures for beach tourism. The greatest share of respondents (>30%) defined ideal temperatures for beach tourism as 27-30°C. This is within the range of optimal temperatures identified in the literature, with the exception of Scott et al.’s (2008a) New Zealand sample, which identified 25°C as ideal. The majority of respondents (>50%) identified a temperature of <23°C as unacceptably cool for a beach holiday and >34°C as unacceptably hot. The unacceptably cool threshold is 1°C warmer than that identified by Gomez-Martin (2006), Ruddy & Scott (2010) and Wirth (2010), and the unacceptably hot temperature is 3°C cooler than that identified by Ruddy & Scott (2010) and 2°C cooler than that identified by Wirth

(2010). Therefore, the range of acceptable temperatures for a beach holiday (i.e., 23-34°C) was found to be somewhat narrower than that found in previous studies.

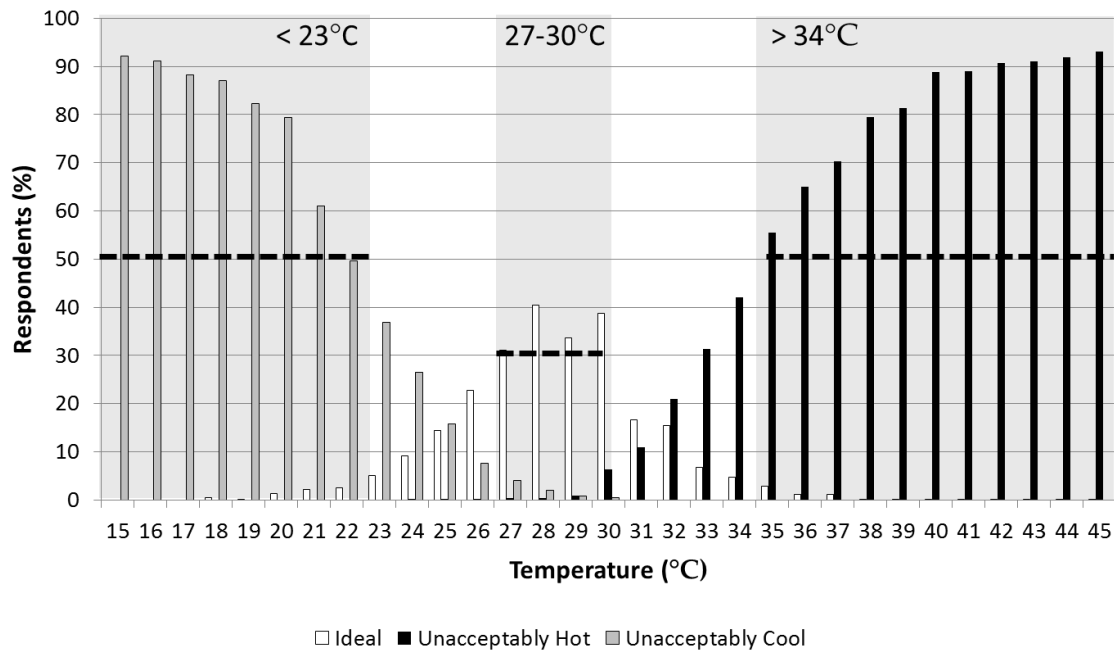


Figure 3-1 Temperature preferences and thresholds for beach tourism
Dashed lines: greatest share of respondents

As highlighted in Table 3-2, the majority preference for rain is 15 minutes or less per day (52%), with 2 h of rain being unacceptable (59%). As such, this sample has a lower rain tolerance compared to the studies by Gomez-Martin (2006) (3 h) and Wirth (2010) (2.5 h). The majority (73%) of respondents identified ideal sky conditions as 25% cloud cover (Table 3-3), which is consistent with much of the literature, but different than the preferred 0% cloud cover identified by Moreno’s (2010) Belgian sample and Scott et al.’s (2008a) Swedish sample. This study also found that the majority (59%) of respondents think $\geq 75\%$ cloud cover is unacceptable (Table 3-3), which is consistent with the existing literature (Table 3-1). Also consistent with the literature is the majority preference for a light breeze, with strong winds considered unacceptable for a beach holiday (82 and 70%, respectively) (

Table 3-4). These findings suggest that optimal and unacceptable climate conditions for beach tourism may differ depending on the sample being analysed and the holiday/travel circumstances specific to in situ samples.

Table 3-2 Ideal and unacceptable daily rain conditions

	No Rain	≤15 min	30 min–1 h	2-4 h	≥5 h
Ideal					
Complete Sample	27	52	19	2	0
Temperate	24	56	20	0	0
Tropical	41	38	16	5	0
Unacceptable					
Complete Sample	9	3	20	59	96
Temperate	7	3	21	64	97
Tropical	12	6	21	41	91

*data are percent of respondents

Table 3-3 Ideal and unacceptable cloud cover according to the percent of sky cover

	Percent cloud cover				
	0	25	50	75	100
Ideal					
Complete Sample	12	73	14	1	0
Temperate	13	76	11	0	0
Tropical	6	64	28	1	1
Unacceptable					
Complete Sample	7	2	21	59	91
Temperate	5	1	22	62	93
Tropical	12	3	20	49	83

*data are percent of respondents

When comparing demographic groups, ideal temperature preferences were found to be very similar across the six age groups, with 28-30°C ideal for 18-24 and 45-54 yr olds, and 27-30°C ideal for the remaining groups. However, unacceptably cool temperatures differed up to 2°C, with the youngest group (18-24) the least tolerant of cool temperatures (<24°C), followed by 45-64 yr olds (<23°C), and 25-44 and 65+ yr olds (<22°C). Unacceptably hot thresholds also differed by up to 2°C, with the 18-24 and 35-44 yr olds having the highest temperature tolerance (>36°C), followed by 25-34 and 45-54 yr olds

(>35°C), with the oldest age groups (55-64 and 65+) having the lowest heat tolerance (>34°C). However, differences across age groups are not statistically significant for ideal ($F(5,410) = 0.358$, $p = 0.655$), unacceptably cool ($F(5,403) = 0.814$, $p = 0.540$), or unacceptably hot ($F(5,404) = 1.877$, $p = 0.097$) temperatures.

Table 3-4 Ideal and unacceptable daily wind conditions

	No wind (0 km h ⁻¹)	Light breeze (1-9 km h ⁻¹)	Moderate wind (10-40 km h ⁻¹)	Strong wind (41-60 km h ⁻¹)	Very strong wind (61-90 km h ⁻¹)
Ideal					
Complete Sample	1	82	16	0	0
Temperate	0	87	13	0	0
Tropical	2	64	31	3	0
Unacceptable					
Complete Sample	22	1	25	70	92
Temperate	19	0	28	75	95
Tropical	33	3	16	50	80

*data are percent of respondents

For the other climatic variables: rain, sky conditions and wind speeds, the majority of respondents (>50%) in all six age groups selected the same ideal and unacceptable conditions, with no statistically significant differences found ($p < 0.05$).

To examine whether tourists from climatically diverse regions have different climate preferences for beach tourism, the city of origin for the sample was classified. Using the Köppen climate classification scheme (Peel et al. 2007), respondents ($n = 472$) were classified into temperate/summer continental (75%) (henceforth shortened to temperate), tropical (21%), subtropical (3%) and other (1%). The latter two groups were considered too small for statistical comparisons ($n < 20$), and were not included in this analysis.

As summarized in Table 3-5, some differences in climatic preferences were observed. Ideal temperatures for temperate residents were between 27 and 30°C, with tropical residents preferring 30°C. This difference in ideal temperature is statistically significant ($F(1,447) =$

39.419, $p = 0.000$), with temperate residents preferring a cooler ideal temperature than tropical residents. Unacceptably cool temperatures differed by 1°C , with temperate residents less tolerant of cool temperatures ($<23^{\circ}\text{C}$) compared to tropical residents ($<22^{\circ}\text{C}$), but this difference was not statistically significant ($p = 0.229$). Unacceptably hot temperatures also differed by 1°C , with temperatures $>34^{\circ}\text{C}$ too hot for temperate residents and $>35^{\circ}\text{C}$ too hot for tropical residents; this was statistically significant ($F(1,438) = 7.062$, $p = 0.008$).

Table 3-5 Comparison of temperature preferences and thresholds ($^{\circ}\text{C}$) by climate region

	Unacceptably Cool	Ideal	Unacceptably Hot
Temperate	$<23^*$	27-30	>34
Tropical	$<22^*$	30	>35

*Not statistically significant ($p \geq 0.05$)

Optimal conditions identified by the temperate sample match those of existing studies (Table 3-1). However, the sample of tourists from the tropical region, which has not been previously examined, reveals a warmer temperature preference, which is outside of the range identified by Gomez-Martin (2006), Scott et al. (2008a) and Moreno (2010) and is in the upper temperature range identified by Ruddy & Scott (2010) and Wirth (2010). The unacceptably hot temperature for both samples is $2\text{-}3^{\circ}\text{C}$ lower than previous assessments, but, importantly, revealed that tropical residents stated a higher temperature tolerance, with a greater heat sensitivity among tourists' originating in cooler temperate climates.

A majority of responses from both climate region groups selected <15 min of rain as ideal, with no statistically significant differences ($p = 0.673$). However, a majority of temperate residents stated >2 h of rain was unacceptable (64%), while tropical residents stated that >5 h was unacceptable (91%) (Table 3-2), which is outside the threshold currently reported in the literature. Tropical residents are therefore more tolerant of rain than temperate residents, resulting in statistically significant differences at the 2-4 h rain threshold ($\chi^2 = 15.918$, $df = 1$, $p = 0.000$) and the >5 h threshold ($\chi^2 = 7.971$, $df = 1$, $p = 0.005$).

The majority (76 and 64%, respectively) of temperate and tropical region residents selected 25% cloud cover as the ideal sky condition for beach tourism, but statistically

significant differences were found ($p = 0.003$). This can be explained by the additional 28% of tropical region residents that selected 50% cloud cover as ideal. Unacceptable sky conditions differed by climate group, as the majority of temperate residents stated $\geq 75\%$ cloud cover as unacceptable (62%) and the majority of tropical residents stated 100% cloud cover as unacceptable (83%) (Table 3-3). Temperate residents are therefore less tolerant of cloud cover compared to tropical residents, with statistically significant differences recorded at the 0% ($\chi^2 = 4.469$, $df = 1$, $p = 0.035$), $\geq 75\%$ ($\chi^2 = 4.879$, $df = 1$, $p = 0.027$) and 100% ($\chi^2 = 7.701$, $df = 1$, $p = 0.006$) cloud cover thresholds. The results from the temperate sample correspond to the results currently recorded in the literature, but the cloud cover preference and thresholds for tropical residents is different.

A majority of temperate and tropical region residents selected a light breeze as ideal for beach tourism (87 and 64%, respectively) (

Table 3-4), but statistically significant differences were found ($p < 0.001$). This can be explained by the additional 31% of tropical residents that stated a preference for moderate wind speeds. Unacceptable wind speeds were the same for both groups, with the majority of temperate and tropical region residents stating strong winds were unacceptable (75 and 50%, respectively). However, statistically significant differences were found for all wind speed thresholds, with tropical residents less tolerant of no wind and more tolerant of higher wind speeds: no wind ($\chi^2 = 7.771$, $df = 1$, $p = 0.005$), light breeze ($\chi^2 = 6.880$, $df = 1$, $p = 0.009$), moderate wind ($\chi^2 = 5.903$, $df = 1$, $p = 0.015$), strong wind ($\chi^2 = 22.467$, $df = 1$, $p < 0.001$), and very strong winds ($\chi^2 = 20.228$, $df = 1$, $p < 0.001$). Once again, the temperate sample matches existing research, but the tropical sample reveals new insight into potential regional differences.

To determine whether differences also exist within climatically similar regions, a comparison of responses among the temperate countries of Canada, the UK, the USA and Germany was examined. All four countries had similar ideal temperatures for beach tourism, with Canada and the UK preferring 27-30°C; the USA, 28-30°C; and Germany, 30°C. The unacceptably cool threshold was $< 23^\circ\text{C}$ for all but Germany, which was 1°C warmer. The

unacceptably hot threshold was $>33^{\circ}\text{C}$ for the UK and the USA, with Canada and Germany 1°C warmer. No statistically significant differences were found for temperature preferences or thresholds ($p < 0.05$). These results differ somewhat from those of Scott et al. (2008a), which showed lower optimal temperatures for New Zealand (25°C), but comparable temperatures for Canada (27°C) and Sweden (29°C).

Ideal and unacceptable conditions for the climate variables rain, sky conditions, and wind were the same for all four temperate countries. The majority prefer <15 min of rain, 25% cloud cover and a light breeze, and unacceptable were >2 h of rain, 75% cloud cover and strong winds. No statistically significant differences were found for these climate variables ($p < 0.05$), with the exception of ideal wind ($\chi^2 = 21.607$, $df = 6$, $p = 0.001$). Almost all respondents from the UK and the USA prefer a light breeze (92 and 96%, respectively), while nearly one-quarter of Canadian and German respondents prefer a moderate wind (23 and 19%, respectively). These results also differ somewhat from the data of Scott et al. (2008a), which showed statistically significant differences for cloud cover, with the Swedish sample preferring 0% cloud cover to Canadians preferring 25% cloud cover (similar to our Canadian sample), but no statistically significant differences for wind preferences.

3.5 Discussion

A number of studies have found that differences exist in climate preferences for holidays among market segments. This study has confirmed some of the results of earlier studies and identified a number of differences among previously unrepresented sample groups. The unacceptable climate conditions identified for this public sample of beach users in the Caribbean reveals a lower tolerance for many climate variables, including a narrower range of acceptable temperatures ($23\text{-}34^{\circ}\text{C}$), a lower acceptance for cool and warm conditions, as well as a lower tolerance for rain (<2 h). Consistent with existing studies are wind speed preferences (light breeze as ideal, strong winds as unacceptable), cloud cover preference (25% as ideal, $\geq 75\%$ as unacceptable), with the exception of Moreno's (2010) 0%

cloud cover, and ideal temperatures are also within the range of existing studies (27-30°C). These examples indicate that tourists' threshold conditions are less homogenous than ideal conditions. The lower tolerance for climate variables may be the result of surveying respondents in situ, whereby respondents have paid for and are experiencing current weather conditions rather than being asked to envisage climatic conditions for a future holiday. This study sample may therefore have higher expectations for optimal climate conditions, with less tolerance for unacceptable climate conditions. The extent of the heterogeneity requires further study, but has implications for the design of tourism climate indices and associated rating scales.

The Caribbean public sample was then analysed by age cohort to better gauge whether a convenience sample (i.e., university student samples in Scott et al. 2008a and Rutty & Scott 2010) is representative of the broader tourism market (i.e., all age cohorts). For all climate variables examined (i.e., temperature, rain, cloud cover, wind), no statistically significant differences were found for ideal and unacceptable conditions. These results are inconsistent with the statistically significant findings of Wirth (2010), in which the youngest age cohort (18-25 yr) both prefers and is more tolerant of warmer temperatures than the oldest age cohort (56+ yr). Although not specifically examining beach preferences, Credoc (2009) also found that older (60+ yr) domestic tourists in France were more sensitive to heat than younger people (18-24 yr). Limb and Spellman's (2001) qualitative interviews with UK travellers found suitable weather conditions differed based on family status, with single professionals more resilient to a range of weather conditions than families with children. These results reinforce that the interaction between climate preferences and age or other socio-demographics (e.g., travelling with children) remains insufficiently understood.

Perhaps the most notable finding from this study is the significant differences in climatic preferences and thresholds for tourists' residing in temperate versus tropical climate zones. Previous studies have found that among countries with similar climates (e.g., Morgan et al. 2000, Scott et al. 2008a, Denstadli et al. 2011), and even within the same country (Credoc 2009), tourists climatic preferences vary. While such differences were not found

among tourists from Canada, Germany, the UK, and the USA, statistically significant differences were found between tourists originating from temperate and tropical climate regions. The results show that tropical residents have a slightly higher tolerance for certain climate conditions, accepting temperatures between 22 and 35°C, up to 5 h of rain and 100% cloud cover, compared to 23-34°C, up to 2 h of rain and 75% cloud cover for temperate residents. Both climate groups stated a light breeze and 25% cloud cover as ideal, but the tropical residents were more likely to prefer moderate wind speeds and up to 50% cloud cover. Tropical residents also prefer a slightly warmer temperature than temperate residents. Perhaps the temperate sample has a narrower range of preferred climate conditions for a beach holiday because of higher expectations that may result from travelling long distances south, investing a lot of time and money, to experience idealized Caribbean weather that is different from the temperate winter weather conditions experienced at home. Respondents originating from tropical regions are not only travelling much shorter distances, but most (96%) live in Caribbean countries and would be accustomed to, and be expecting, weather conditions that are similar to home. For example, tropical residents would be familiar with frequent late afternoon rains that characterize many Caribbean islands, presumably increasing their tolerance for rain events. Tropical residents also preferred climate conditions that offer more cooling effects—increased cloud cover and higher wind speeds both reduce the thermal influence of the sun, allowing for warmer temperatures to be tolerated. Depending on tourists' climatic origins, preferences and thresholds for beach tourism can vary. There remains much scope to better understand this influence, with future research needed to examine preferences from additional climate zones, such as dry (arid and semiarid), tropical monsoon, boreal, and polar climates.

An important caveat with respect to comparing studies is the multiple ways tourists' have been asked about their climatic preference(s). For example, temperature preference has advanced from a list of predetermined temperature ranges (Morgan et al. 2000, Gomez-Martin 2006) to a single temperature (Scott et al. 2008a, Moreno 2010) to circling a range of temperatures (Rutty & Scott 2010, Wirth 2010, present study). Also, Morgan et al. (2000)

refer to optimal temperatures in terms of skin temperature, not ambient temperature. As such, it can be difficult to make definitive statements on temperature similarities and differences between studies. Moreover, the literature is very limited with regards to unacceptable climatic thresholds for tourism, further compounding the difficulty of identifying generalizable thresholds at the present time. To further our understanding, continued research with a more standardized method to enable comparisons across studies is strongly recommended.

The results from this study also raise an important methodological consideration regarding context dependency. The unacceptably hot temperature for beach tourism was lower in all of the analyses performed (i.e., total Caribbean sample, by age, by climate region and by nationality) when compared to existing temperature threshold studies. Ruddy & Scott (2010) and Wirth's (2010) ex-situ studies were conducted at the end of the winter season, with the possibility that the sample perceived a warm/hot climate to be more desirable/acceptable (Gössling et al. 2012). Conversely, this study was conducted in situ, while respondents were experiencing warm temperatures (27-30°C), so that even warmer temperatures may have been perceived as less desirable/unacceptable. Similarly in the Scott et al. (2008a) study, the New Zealand sample preferred 25°C for a beach holiday and the Swedish sample preferred 29°C, with the former surveyed at the end of summer and the latter during mid-winter. As previously noted, surveying respondents in situ versus ex-situ may affect identified ideal and unacceptable climate conditions. The contextual influence of climatic conditions during the time of the survey has yet to be explored as a source of preference differences (Gössling et al. 2012).

It is also unclear to what degree tourists are able to accurately estimate temperatures and other weather parameters either in situ or ex-situ (Gössling et al. 2012). This relates to both single parameters, such as temperature, and whether tourists can distinguish the influencing effect of other parameters, such as the cooling effect of wind and cloud cover on temperatures felt. Studies that examine the role of such complexities and evaluate the accuracy of tourists' perceived versus experienced preferences and thresholds are needed.

While some studies have explored these questions (e.g., Oliveira & Andrade 2007, Lin 2009, Andrade et al. 2011), it has been exclusive to the human biometeorology and engineering literature and has yet to be examined in a tourism context.

3.6 Conclusions

Against the background of rapidly expanding literature on climate/climate change, the present study sheds needed insight into the complexities of tourist climate preference and the implications of rating current/future climate resources for tourism. Overall, the research indicates that tourists' preferences and thresholds for beach holidays can differ for certain climate variables. This is primarily evident with respect to tourists' climatic zone of residence, even in a simplified framework that examines but one tourism segment. With weather and climate serving as a key travel motivator, influencing the timing of travel, destination(s) selected and overall trip satisfaction, advancing our understanding of tourists' climatic needs is both a challenging and fundamental research area if accurate climate change assessments of tourism demand patterns (seasonally and geographically) are to be possible. The results from this study provide relevant insight into existing climate indices (e.g., Mieczkowski's 1985, Morgan et al. 2000, de Freitas et al. 2008), demand models (e.g., Lise & Tol 2002, Hamilton et al. 2005, Bigano et al. 2006), and climate change assessments (e.g., Scott et al. 2004, Amelung et al. 2007, Moreno & Amelung 2009, Moore 2010), particularly with respect to claims that some tourism regions (e.g., Mediterranean and the Caribbean) will become seasonally 'too hot' for tourism (Rutty & Scott 2010, Scott et al. 2012b). Important research gaps nonetheless remain, and the next steps should involve continued assessments of the similarities and differences across broader tourist market segments and tourism environments, as well as the integration of field work that aims to validate tourists' actual perceptions of, and behavioural responses to, weather and climate.

Chapter 4:

Manuscript #2: Bioclimatic Comfort and the Thermal Perceptions and Preferences of Beach Tourists

Rutty M, Scott D (2014a) Bioclimatic comfort and the thermal perceptions and preferences of beach tourists. *International Journal of Biometeorology*. DOI:10.1007/s00484-014-0820-x

The largest market segment of global tourism is coastal tourism, which is strongly dependent on the destination's thermal climate. To date, outdoor bioclimatic comfort assessments have focused exclusively on local residents in open urban areas, making it unclear whether outdoor comfort is perceived differently in non-urban environments or by non-residents (i.e., tourists) with different weather expectations and activity patterns. This study provides needed insight into the perception of outdoor microclimatic conditions in a coastal environment, while simultaneously identifying important psychological factors that differentiate tourists from everyday users of urban spaces. Concurrent micrometeorological measurements were taken on several Caribbean beaches in the islands of Barbados, Saint Lucia and Tobago, while a questionnaire survey was used to examine the thermal comfort of subjects (n=472). UTCI conditions of 32°C to 39°C were recorded, which were perceived as being “slightly warm” or “warm” by respondents. Most beach users (48% to 77%) would not change the thermal conditions, with some (4% to 15%) preferring even warmer conditions. Even at UTCI of 39°C, 62% of respondents voted for no change to current thermal conditions, with an additional 10% stating that they would like to feel even warmer. These results indicate that beach users' thermal preferences are up to 18°C warmer than the preferred thermal conditions identified in existing outdoor bioclimatic studies from urban park settings. This indicates that beach users hold fundamentally different comfort perceptions and preferences compared to people using urban spaces. Statistically significant differences ($p \leq .05$) were also recorded for demographic groups (gender, age) and place of origin (climatic region).

4.1 Introduction

Tourism has expanded and diversified to become one of the world's largest economic sectors. In 2012, international tourist arrivals exceeded one billion for the first time in history, contributing 9% to global GDP, US\$1.3 trillion in exports and provided one in 11 jobs globally (United Nations World Tourism Organization 2013). Coastal tourism is the largest market segment of global tourism (Hall 2001, Honey & Krantz 2007, United Nations Environment Programme 2009), with "coastal destinations, beaches and beach resorts synonymous with tourism, tourism growth and economic success" (Jones & Phillips 2011, p. xvii).

Coastal tourism is strongly dependent upon a destination's natural resources, including beach quality and extent, as well as climate. This is evidenced by some of the world's largest international tourism flows travelling from cooler regions to warmer regions in search of 3S holidays (e.g., North America to the Caribbean, Northern Europe to Southern Europe and the Mediterranean, Australia to Southeast Asia). Behavioural observations of tourists reveal that microclimatic conditions have a substantial effect on the usage of coastal areas, with tourists responding to the combined effects of weather elements (i.e., thermal, physical, aesthetic) (de Freitas 2003). Sunshine and higher temperatures are correlated with crowded beaches, while cool temperatures, rain and windy conditions deter users and result in low levels of beach use (de Freitas 1990, Moreno et al. 2009, Martinz-Ibarra 2011, Gomez-Martin & Martinez-Ibarra 2012). Studies of stated climatic preferences have found that tourists' ideal conditions for a beach holiday range from 27°C to 32°C (Scott et al. 2008a, Moreno 2010, Rutty & Scott 2010, Rutty & Scott 2013). Studies also have found that tourists' thermal preferences can vary by nationality, climatic region of origin, and age (Scott et al. 2008a, Credoc 2009, Wirth 2010, Rutty & Scott 2013). This study focuses exclusively on the thermal aspect of tourism climate.

Recent assessments of bioclimatic comfort in outdoor areas have sought to understand the complex links between meteorological and personal factors in the perception of the atmospheric environment (Thorsson et al. 2004, Knez & Thorsson 2006, Oliveira &

Andrade 2007, Knez et al. 2009, Lin 2009, Lin et al. 2010, Andrade et al. 2011). This body of research has focused exclusively on local residents in open urban areas. It is therefore unclear whether outdoor thermal comfort is perceived differently in non-urban environments or by non-residents (i.e., tourists) with different weather expectations and activity patterns. The aim of this study was to assess whether existing outdoor comfort studies can be used for tourism purposes or whether coastal tourists' hold fundamentally different thermal comfort perceptions and preferences. To achieve this goal, beach users were surveyed with concurrent micrometeorological measurements on several Caribbean beaches in the islands of Barbados, Saint Lucia, and Tobago in order to (1) examine the relationship between outdoor microclimatic conditions and the thermal perception and preference of beach tourists (domestic and international) and (2) identify personal parameters (i.e., gender, age, climatic region of origin) that influence tourists' bioclimatic comfort.

4.2 Materials and Methods

4.2.1 Study Area

The Caribbean was selected because the region's economy is highly tourism-intensive, contributing 14% to regional GDP and 13% of employment (WTTC 2011). Caribbean tourism is also predominantly based on a 3S market, which depends on favourable weather conditions in the coastal zone. High-profile tourism beaches in the Caribbean islands of Barbados (Accra, Amaryllis, Dover and Holetown beaches) Saint Lucia (Gros Islet and Rodney Bay beaches), and Tobago (Crown Point and Pigeon Point beaches) were chosen for this study.

4.2.2 Micrometeorological Measurements

Ambient temperature (T_a), relative humidity (RH), and wind speed (V_a) were measured every 30 seconds concurrently with the field surveying. The instrument height was set at 1.1m above the ground, corresponding to the average height of the centre of gravity for a standing adult (Mayer & Höppe 1987). The thermal influence of the radiant fluxes was

measured with a globe thermometer painted in matt black (Bedford & Warner 1934). From the globe temperature measurements (T_g in degrees Celsius), the globe's emissivity (ϵ_g) and the globe's diameter (D in millimetres), mean radiant temperature (T_{mrt} in degrees Celsius) was calculated according to ISO 7726 (ISO 1998) for forced convection. This approach has been used in other bioclimatic studies (e.g., Thorsson et al. 2007, Bröde et al. 2012).

A thermo-physiological index was calculated to estimate the combined influence of atmospheric variables on thermal sensation and preference votes. The Universal Thermal Climate Index (UTCI) was selected for this task because it aims to be the international methodological standard for characterizing the human thermal environment (Jendritzky et al. 2012). The UTCI is based on the most advanced multi-node model of thermoregulation. It is derived conceptually as an equivalent temperature, so that for any combination of ambient temperature, wind, radiation and humidity, the temperature provided by the UTCI can be defined as “the isothermal air temperature of the reference condition that would elicit the same dynamic response (strain) of the physiological model” (Jendritzky et al. 2012, p. 421). The UTCI requires the input of wind speed at 10 m above the ground, so the wind speed values were scaled-up by a factor of 1.4 according to the formula $\log(10/0.01)/\log(1.5/0.01)$ as proposed by the operational procedure of Bröde et al. (2011).

4.2.3 Field Surveys

Field surveys were distributed over three weeks between March and April, 2012 (tourism high season), from 11 a.m. to 5 p.m. (local time). At this time of the day, the beaches have the highest number of tourists and both ambient temperature and solar radiation reach their daily maximum. Beach users who were sitting or lying down on the sand were approached to participate. A total of 472 persons agreed to fill out the survey, resulting in a high response rate of 89%. Of the completed surveys, 216 were completed in Barbados, 126 in Saint Lucia and 130 in Tobago. Based on these sample sizes, the reported percentages can be interpreted as being accurate to within $\pm 3\%$, 95 times out of 100. The survey was conducted in English in all three countries.

Information about the personal characteristics of respondents (i.e., age, gender and geographical origin/residence), the perception and preference of current thermal and wind conditions, as well as acceptability for both temperature and wind parameters, were obtained using the survey. First, perceptions were examined by asking respondents to report their thermal sensation vote on the basis of a seven-step scale from hot (+3) to cold (-3) based on the seven-point ASHRAE scale. Respondents were also asked to report their wind sensation on a five-point scale from no wind (0) to very strong wind (+4). Second, preferences were examined by asking respondents to indicate how they would prefer to feel on a three-point McIntyre scale from feel warmer (+1), feel cooler (-1), to no change (0) (de Dear and Brager 2001). This was similarly done for wind preferences: feel stronger winds (+1), weaker winds (-1) and no change (0). Third, acceptability was evaluated by asking respondents to rate current ambient temperature and wind parameters on a seven-step scale from very unacceptable (1) to very acceptable (7). The answers to these questions reveal the subjective evaluation of the atmospheric conditions by the individuals (Parsons 1993) who relate to their state of thermal comfort (Andrade et al. 2011).

The results and analysis focus on the summary statistics related to the above themes (i.e., perception, preference, acceptability). One-way analysis of variance (ANOVA) was used to determine whether there were any significant differences between the response patterns for thermal/wind perceptions and preferences versus experienced UTCI/wind conditions, thermal/wind preferences versus thermal/wind perceptions, and ambient temperature/wind acceptability versus experienced ambient temperature/wind conditions. Independent *t* tests were used to compare response patterns for climatic region of origin (temperate versus tropical residents) and gender (male versus female), and ANOVA was used to compare response patterns for the different age groups.

When considering the results of this study, there is the possibility of sampling bias that has been noted for such in situ surveys (Scott et al. 2008a, Ruttly & Scott 2013). Beach users with a preference for weather conditions that were not available during the days when the surveys were conducted may not be represented in the sample. It is possible that visitors

arriving in the Caribbean during the touristic low season (i.e. June–November) may have different weather preferences than those reported here. However, daily maximum and minimum temperatures in the region vary only slightly throughout the year (1–2°C), and this potential sampling bias is less of a concern in this study than in temperate regions with more variable seasonal conditions. The survey was also distributed to beach users on the “dry” part of the beach, which means tourists in the water at the time of the survey were not approached. As such, those who often engage in water sports may be somewhat under-represented in the sample. The extent of these potential sampling biases is uncertain.

4.3 Results

4.3.1 Recorded Meteorological Conditions

Table 4-1 summarizes the recorded meteorological conditions during the days on which the surveys were administered (March 17, 2012 to April 1, 2012). The weather condition throughout the 18-day study period was absent of rainfall, with cloudless or near cloudless skies. During the study, ambient temperatures (T_a) averaged 30.0°C, reaching a minimum of 27.0°C and a maximum of 35.1°C, corresponding to long-term averages in the region. Average relative humidity (RH) was 64.8%, reaching a minimum of 48.6% and a maximum of 76.1%. Wind speeds (V_a) averaged 6.5km/h, ranging from 0.7km/h to 19.7km/h. On average, mean radiant temperature (T_{mrt}) was 41.0°C, reaching a minimum of 29.2°C and a maximum of 53.6°C. UTCI temperatures averaged 33.5°C, reaching a minimum of 27.8°C and a maximum of 39.9°C.

Table 4-1 Meteorological conditions (11a.m. to 5 p.m.) during the days on which surveys were administered

Date (2012)	Beach	Air temp (T_a) (°C)			Relative humidity (RH) (%)			Wind speed (V_a) (Km/hr)			Mean radiant temp (T_{mrt}) (°C)			UTCI (°C)		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
17 March	Accra ^a	27.0	32.7	30.5	48.6	68.7	58.2	0.7	15.4	4.7	29.7	53.6	43.3	29.8	36.8	34.5
18 March	Dover ^a	27.7	31.4	29.6	53.3	69.3	60.6	3.3	16.7	8.7	31.4	50.7	42.0	29.0	39.9	35.2
19 March	Amaryllis ^a	27.4	29.8	28.8	61.0	68.0	64.2	8.7	10.6	9.9	29.2	40.5	36.0	27.8	32.1	30.3
20 March	Amaryllis ^a	27.5	29.2	28.7	64.8	72.1	67.9	5.3	14.2	8.7	30.0	39.5	34.9	28.7	31.6	29.6
22 March	Holetown ^a	27.9	32.6	30.8	58.7	70.6	63.5	1.3	8.0	3.7	32.3	47.2	42.1	31.8	36.6	35.0
24 March	Crown Point ^b	27.8	32.9	30.7	62.3	76.1	67.8	1.3	8.0	3.7	31.3	52.9	43.8	31.7	37.9	35.8
25 March	Pigeon Point ^b	27.9	35.1	30.9	59.5	75.4	68.2	0.7	14.7	2.8	30.3	35.1	42.4	31.9	39.6	36.3
27 March	Pigeon Point ^b	29.4	31.3	30.3	64.4	68.5	66.0	3.0	5.1	3.8	36.0	45.5	41.4	32.9	36.3	34.6
31 March	Gros Islet ^c	28.3	32.9	31.0	57.1	70.2	62.6	2.0	18.0	8.5	34.0	49.2	43.6	30.9	35.0	33.7
01 April	Rodney Bay ^c	27.4	30.9	29.0	60.2	72.3	68.9	3.3	19.7	10.7	32.1	46.4	40.5	29.0	31.1	30.3

^aBarbados, ^bTobago, ^cSaint Lucia

4.3.2 Respondent Characteristics

Females represented 57% of the sample and males represented 43%. The most frequent age group was 45 to 54 years (23%), followed by 25 to 34 years (20%), 55 to 64 years (19%), 65+ years (16%), 35 to 44 years (14%), and 18 to 25 years (8%). For 13% of respondents, it was their first trip to the Caribbean, with the remaining respondents (87%) having travelled to the Caribbean at least once before or originating from a Caribbean country. The largest share of respondents (75%) originate from temperate regions (e.g., UK, Canada, northern USA, Germany), followed by tropical regions (21%) (e.g., Trinidad and Tobago, Barbados, Venezuela, Guyana) and subtropical regions (4%) (e.g., southern USA, southern India). The latter group was considered too small for statistical comparison ($n \leq 20$) and has not been included in the statistical analyses that examine differences based on climatic region of origin. At the time of the survey, all respondents were either sitting or lying down on the sand (not in the water), with 89% having been on the beach for more than one hour, 8% for 30 minutes to one hour, and 3% for 15 to 30 minutes.

4.3.3 Thermal and Wind Sensation (Perceptions)

During the study period, a relatively small thermal range was recorded, with UTCI temperatures between 30°C and 39°C, which is typical of tropical islands in this region. Due to small sample sizes of surveys completed when thermal conditions of 30°C ($n=9$), 31°C ($n=5$) and 35°C ($n=1$) were recorded, these surveys were not included in the thermal perception or thermal preference analyses. Figure 4-1 plots the mean thermal sensation vote for the remaining seven UTCI temperatures (32°C to 34°C and 36°C to 39°C). Respondents indicated that they felt slightly warm (+1) or warm (+2) for all but 37°C, to which respondents stated that they felt warm (+2) or hot (+3). There was a statistically significant difference between respondents experiencing different UTCI conditions, as determined by one-way ANOVA ($F(9, 460)=2.981, p=.002$). At a UTCI of 37°C, respondents mean thermal vote was significantly warmer (2.13) compared to those respondents experiencing a UTCI of 32°C (1.41) and 39°C (1.24). This statistically significant difference is likely explained by

differences in the tourist profiles under different conditions. At 39°C, 70% of the surveyed sample originated from tropical countries; this is not surprising since Tobago has largely a domestic market. Residents of tropical countries felt statistically cooler for all recorded UTCI temperatures (.95) compared to residents from temperate regions (1.88) ($t(445) = 7.146$, $p = .000$). Statistically significant differences were not found for gender or age ($p \geq .05$).

Wind speeds ranged from a light (1 to 9km/h) to moderate breeze (10 to 20km/h) during the study period. When the current wind conditions were a light breeze (+1), the mean wind sensation vote was 1.47. When the current wind conditions were moderate (+2), the mean wind sensation vote was 1.75. No statistically significant differences were found between respondents from different climatic regions, nor by gender or age ($p \geq .05$). There was also no statistically significant relationship between thermal perceptions and recorded wind speeds ($p \geq .05$).

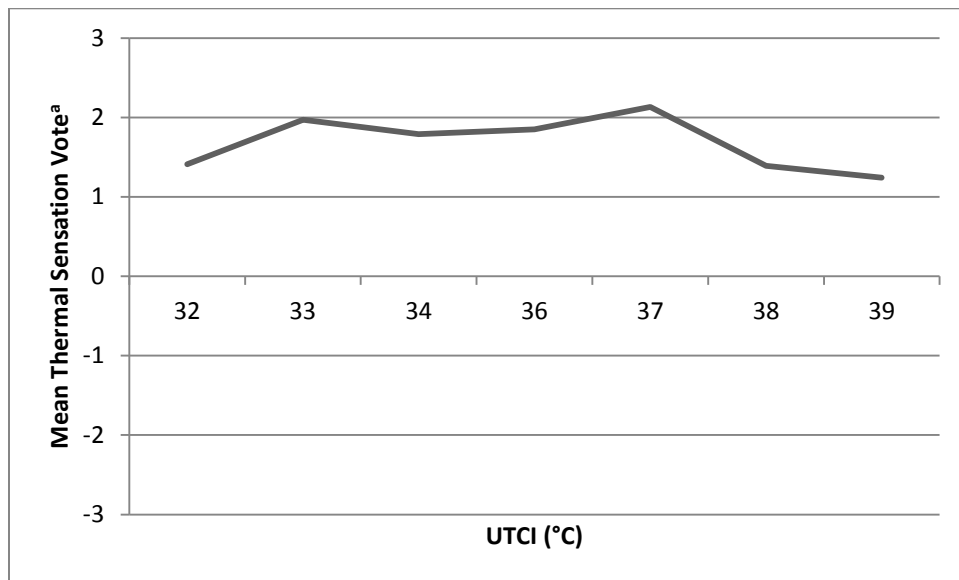


Figure 4-1 Mean thermal sensation vote at recorded UTCI temperature.
^a(-3 cold; -2 cool; -1 slightly cool; 0 neutral; 1 slightly warm; 2 warm; 3 hot)

4.3.4 Thermal and Wind Preference (Preferences)

Figure 4-2 highlights how respondents would prefer to feel when experiencing each UTCI temperature. The majority of respondents (62% to 77%) preferred to feel no change in the thermal conditions. The one exception was at UTCI of 38°C, where 48% of respondents voted to feel no thermal change and 42% voted to feel thermally cooler. Few respondents would prefer to feel warmer than the current thermal conditions (4% to 15%) and approximately one-quarter of respondents would prefer to feel cooler (15% to 30%) at all UTCI temperatures (except 38°C at 42%). Statistically significant differences between temperate and tropical residents were found ($t(416)=4.011, p=.000$), with the latter preferring to feel cooler (-.33) compared to the former (-.09). Statistically significant differences were also found between genders ($t(412)=.975, p=.028$), with females preferring to feel slightly cooler (-.17) than males (-.11). Statistically significant differences were also found between age groups ($F(5, 364)=4.119, p=.001$). Respondents 65+ years prefer to feel warmer (.05) than 18-25 years (-.39) and 25 to 34 years (-.23). Respondents aged 55 to 64 years also prefer to feel warmer (-.04) than 18 to 25 years (-.39).

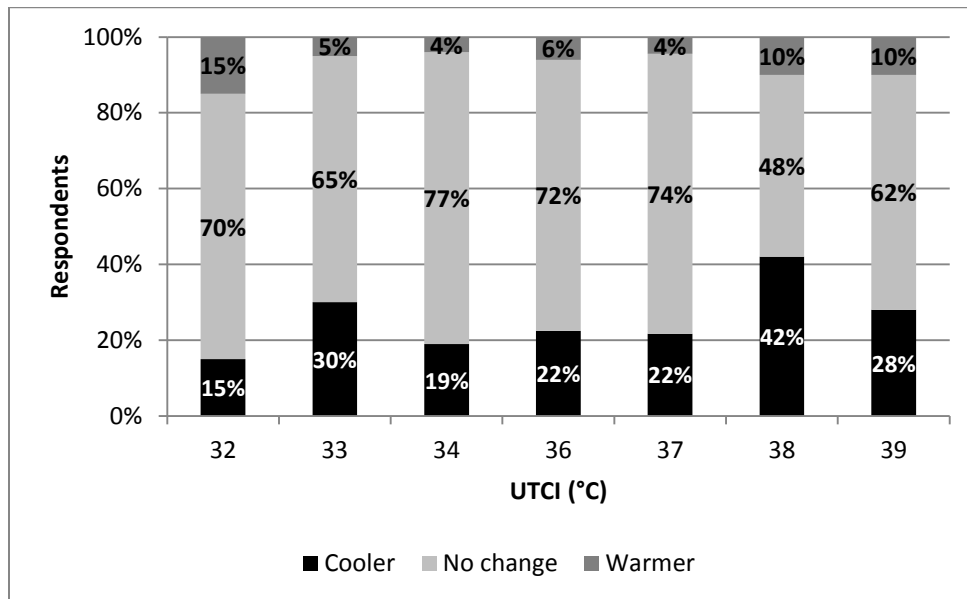


Figure 4-2 Thermal preference votes for recorded UTCI temperature
^a(0 neutral; 1 slightly warm; 2 warm; 3 hot)

Thermal preference votes were also compared against thermal perceptions (Figure 4-3). Due to small sample sizes in the thermal sensation votes for cold (-3) ($n=1$), slightly cool (-2) ($n=14$), and cool (-1) ($n=17$), these categories were not included in this analysis. Over 70% of respondents who perceived the current conditions as neutral (0) or warm (+2) would prefer to feel no thermal change. Of the respondents who felt slightly warm (+1) and hot (+3), an almost equal percentage of respondents (66%) would prefer to feel no thermal change. Preference votes to feel warmer decreased as thermal sensation increased, with statistically significant differences found ($F(3, 389)=10.346, p=.000$). Respondents who perceived the temperature as hot were statistically more likely to prefer to feel cooler (-.39) compared to respondents who feel neutral (.04), slightly warm (-.07) and warm (-.07) ($F(3, 389)=10.346, p=.000$).

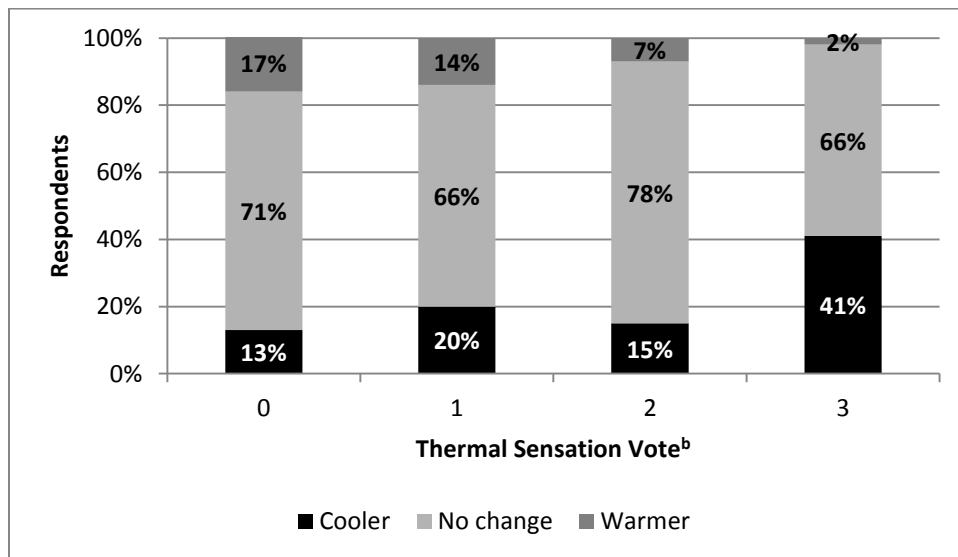


Figure 4-3 Thermal preference votes based on perceived thermal sensation
^b(0 neutral; 1 slightly warm; 2 warm; 3 hot)

Wind preference votes revealed that with a light breeze (+1), the majority (64%) did not want the wind conditions to change, with 18% preferring stronger winds and 18% weaker winds. When the current winds were moderate (+2), the majority (75%) wanted no change in the wind conditions, with the remaining 25% preferring less winds. None of the respondents

preferred to have stronger winds when the wind conditions were moderate. Statistically significant differences were found between temperate and tropical residents, with the former preferring weaker winds (-.08) than the latter (.32) ($t(445)=-5.949, p=.000$). No statistically significant preference differences were found for gender or age ($p \geq .05$). There was also no statistically significant relationship between thermal perceptions and wind preference votes ($p \geq .05$).

4.3.5 Ambient Temperature and Wind Ratings (Acceptability)

During the field surveying with tourists, ambient temperature (T_a) ranged from 28°C to 32°C. Table 4-2 summarizes the acceptability rating for each T_a interval. For all five ambient temperatures that occurred during surveying, 81% to 93% of respondents rated the temperature between slightly acceptable and very acceptable. The highest rated temperature was 30°C, with 93% acceptability, followed by 31°C and 32°C, with 87% acceptability. The most unacceptable ambient temperature was the coolest (28°C), with 19% rating it between very unacceptable and slightly unacceptable. Few respondents (0% to 8%) rated the ambient temperature conditions as neutral. No statistically significant rating differences were found for respondents from temperate or tropical climatic regions, gender or age ($p \geq .05$). There was also no statistically significant relationship between thermal perceptions and temperature ratings ($p \geq .05$), nor between thermal perceptions and recorded ambient temperature ($p \geq .05$).

Table 4-2 Acceptability rating for recorded ambient temperature (T_a) and wind speed

	28°C	29°C	30°C	31°C	32°C	Light Breeze (1-9km/h)	Moderate Breeze (10-20km/h)
Very Unacceptable	8	4	2	5	3	2	0
Unacceptable	0	1	2	1	2	2	0
Slightly Unacceptable	12	2	2	1	2	6	8
Neutral	0	8	2	3	5	7	8
Slightly Acceptable	4	8	5	6	8	9	50
Acceptable	39	39	34	36	36	40	0
Very Acceptable	39	37	54	48	43	33	33

*data are percent of respondents

Table 4-2 also summarizes the acceptability rating for a light and moderate breeze. The majority (82% to 83%) rated both wind conditions as acceptable, with slightly more respondents finding the light breeze unacceptable (11%) compared to moderate winds (8%). Statistically significant differences were found between temperate and tropical residents, with temperate residents rating the wind conditions as more acceptable than tropical residents (5.82 and 5.33, respectively) ($t(445)=2.993, p=.005$). No statistically significant differences were found for gender or age ($p \geq .05$). There was also no statistically significant relationship between thermal perceptions and wind ratings ($p \geq .05$).

4.4 Discussion

During this study, recorded UTCI temperatures between 32°C and 39°C were experienced by beach tourists surveyed on Caribbean beaches in Barbados, Saint Lucia and Tobago. Based on the UTCI thermal stress categories, respondents should have felt “strong” to “very strong thermal stress” (Bröde et al. 2012). However, when beach tourists were asked whether they would prefer different thermal conditions, the vast majority of respondents voted for no change. Even at a UTCI of 39°C, 62% of respondents voted for no change to the current thermal conditions, with an additional 10% stating that they would prefer to feel even warmer. These preferred thermal conditions are well outside the findings reported in existing outdoor bioclimatic studies in urban areas. For example, urban square users in Lisbon and

Taiwan identified 21°C to 23°C PET⁶ and 27°C to 29°C PET as preferred, with a strong increase in people who voted for change when temperatures were below or above these ranges (Andrade et al. 2011, Lin et al. 2010). Beach tourists not only willingly exposed themselves to thermally stressful conditions but also preferred conditions that are up to 18°C warmer than urban respondents in Lisbon and 10°C warmer than in Taiwan.

Moreover, existing outdoor thermal comfort studies have defined “acceptable thermal conditions” as sensation votes within the three central thermal categories (i.e., slightly cool, neutral, slightly warm) (e.g., de Dear & Fountain 1994, Matzarakis & Mayer 1996, Lin 2009). However, evidence from this study suggests that acceptable thermal conditions for beach tourism are well outside these categories. Unlike studies in urban environments, when beach tourists stated that they felt warm, the vast majority (78%) voted no change, with an additional 7% stating that they wanted to feel even warmer. Even when beach tourists stated that they felt hot, 66% voted no change, with an additional 2% stating that they would like to feel even warmer. This study reveals that when assessing outdoor thermal comfort for a beach tourism environment, acceptable thermal conditions as currently defined in the human biometeorology literature cannot be applied. While this is an intuitive finding, the magnitude of difference is surprising. The thermal preferences of tourists are also likely to vary for other key market segments, which deserves further examination.

This study also found personal characteristics influenced thermal perceptions and preferences. Results indicated that climatic region of origin matters. Respondents from tropical countries perceived the thermal conditions on the beach to be cooler than respondents from temperate countries. Tropical residents also preferred to feel cooler and rated the acceptability of wind conditions lower than temperate residents. This is opposite to the findings of Lin (2009) and Lin et al. (2010), whereby residents from Taiwan (i.e., humid region) preferred warmer thermal conditions compared to people from Western Europe (Matzarakis et al. 1999, Andrade et al. 2011). This conflicting evidence may be the result of

⁶ PET is similarly derived from human heat budget models and correlates “very well” with UTCI (Blazejczyk et al. 2012, p. 533).

the thermal environment (i.e., beach versus urban environment) or perhaps due to the difference in climatic region of origin (i.e., tropical versus hot and humid). Tourism studies have also found that stated climatic preferences vary by temperate countries (Scott et al. 2008a, Moreno 2010, Ruttu & Scott 2010).

The results also show that preferences vary by gender, with females preferring to feel cooler than males. This finding is novel relative to results reported in other outdoor comfort assessments where similar differences were not found (Knez & Thorsson 2006, 2008, Knez et al. 2009, Lin 2009, Oliveira & Andrade 2007, Andrade et al. 2011). While a strong correlation between satisfaction with wind conditions and gender has been recorded in Portugal (Oliveira & Andrade 2007, Andrade et al. 2011), wind was not rated differently by males and females in this study. These conflicting results may be attributable to the environmental context (i.e., beach tourist versus urban user), level of clothing (i.e., cover of men's bathing suit versus women's bathing suit) or perhaps due to the higher thermal conditions examined in this study ($UTCI \geq 32^{\circ}\text{C}$) and the limited wind conditions experienced (1 to 20km/h). Tourism studies have not yet examined the relationship between climatic preferences and gender.

It was also found that older beach tourists (55+ years) preferred to feel warmer than younger beach tourists (18 to 25 years). This is opposite to the findings of Andrade et al. (2011), whereby in urban areas, respondents 25 to 34 years preferred higher temperatures and were more likely to vote for warmer conditions than respondents 55+ years. Credoc (2009) and Wirth (2010) similarly found that older tourists' (60+ years) stated that "too hot" temperature for beach tourism was 2°C to 4°C lower than the "too hot" threshold temperature identified by younger respondents (18 to 25 years). Interestingly, Knez et al. (2009) found thermal comfort increased with age for "open-air persons" (i.e., find pleasure in the sea, the woods and nature) but decreased with age for "urban persons" (i.e., find pleasure in the street-life, the shops, the amusements of the city). Given that this study was conducted by the sea, it is likely that respondents would consider themselves open-air persons. The findings

lend further support to the importance of understanding psychological and place-related emotions when assessing outdoor bioclimatic comfort.

Thermal comfort theory suggests that psychological factors significantly influence the thermal perception of outdoor spaces and how these spaces are evaluated (Brager & de Dear 1998, Nikolopoulou et al. 2001, Nikolopoulou & Steemers 2003, Spagnolo & de Dear 2003). The bioclimatic comfort literature indicates that thermal perceptions and preferences cannot be fully explained by physical measures or thermophysiological indices (e.g., UTCI, PET). Psychological factors such as comfort expectations and perceived thermal control help to explain why different people perceive the environment in a different way and why the human response to a climatic stimulus is not in direct relationship to the magnitude of change (Nikolopoulou & Steemers 2003). Accordingly, people may well have divergent thermal perceptions and preferences when they are exposed to different contexts, despite having identical thermal balances as indicated by the heat balance of comfort indices. It is within these contextual factors that beach tourists' preference and acceptability for thermally stressful conditions need to be understood.

Studies have found that people adjust their thermal perceptions based on comfort expectations. For example, preferred temperatures are higher in the summer season than in the winter season as a result of seasonal expectations (Nikolopoulou et al. 2001, Spagnolo & de Dear 2003, Lin 2009). Importantly, seasonality in tourism is primarily driven by climate (natural versus institutional seasonality) (Butler 2001). Weather and climate, both at home and at the destination, are important travel motivators (e.g., Lohmann & Kaim 1999, Kozak 2002), influencing the timing of travel (e.g., Eugenio-Martin & Campos-Soria 2009, Hill 2009), and the destination selected (e.g., Hamilton & Lau 2005, Moreno 2010). Tourists leaving temperate regions for tropical holidays are investing significant time and money with the expectation of leaving cooler regions to experience warm and sunny beaches. Such warm weather expectations are not only well-formed given that the vast majority of tourists' gather weather information prior to their trip (e.g., Gamble & Leonard 2005, Hamilton & Lau 2005, Ruddy & Scott 2010, Hübner & Gössling 2012, Ruddy & Andrey 2013), but also because of

the prominence of weather and climate in marketing the image of coastal destinations like the Caribbean (Besancenot 1991, Perry 1993, Gomez-Martin 2005).

Perceived thermal control can also markedly impact a person's perception and satisfaction within an outdoor space. Unlike an indoor environment where people can directly control thermal conditions (e.g., with a thermostat or air conditioning), in an outdoor environment there is more limited control over thermal conditions (i.e., can alter clothing, relocate into/out of sun/wind/rain/snow). Subsequently, outdoor conditions are regarded as satisfactory over a wider thermal range, with the perceived control over the source of discomfort becoming more important than the actual physical conditions (Paciuck 1990, Spagnolo & de Dear 2003, Nikolopoulou & Lykoudis 2006). Nikolopoulou and Steemers (2003) found that people feeling uncomfortable and dissatisfied with the thermal environment were higher among those who were in the park simply to meet someone (i.e., obligation), rather than for other reasons (e.g., rest/relaxation). By arranging to meet someone, the termination of your exposure to the thermal conditions is dependent on the arrival of the other person. Lin (2009) similarly found that respondents who were using an urban square as thoroughfare were most likely to be thermally uncomfortable, particularly in comparison to those using the square for leisure purposes. Free choice becomes of prime importance in outdoor spaces, where actual control over the microclimate is minimal so perceived control has the biggest weighting (Nikolopoulou & Steemers 2003). Tourists have a high level of autonomy, choosing the timing and location of their holidays, as well as the activities pursued while at a destination. Being at a beach is a discretionary activity and should thermal conditions become personally unsuitable, the option is available to move to the shade, cool off in the water, or leave the beach altogether. This perceived control over the thermal environment would theoretically enhance beach users' tolerance for high temperatures.

4.5 Conclusion

The results indicate that beach users thermal comfort perceptions and preferences are markedly different than what has been reported for users of outdoor urban spaces, with beach tourists' thermal preferences up to 18°C warmer. Based on thermophysiological indices such as the UTCI, 32°C to 39°C would be considered to cause “strong” or “very strong thermal stress”⁷. However, the large majority of beach tourists rated these thermally stressful conditions as acceptable, with some respondents wanting even warmer conditions. Perceptions and preferences also varied based on personal characteristics, including climatic region of origin, gender, and age.

These results have important implications for bioclimatic evaluations of tourism climate resources, as well as for the design of climate indices for tourism (e.g., Mieczkowski 1985, de Freitas et al. 2008), particularly those designed for beach tourism (e.g., Morgan et al. 2000, Gomez-Martin 2006, Moreno & Amelung 2009). Outdoor thermal ratings (be they measured by UTCI or PET) clearly cannot be applied to coastal tourism without specific knowledge of what climatic conditions tourists desire. The simple application of thermal ratings based on thermo-physiological indices may be similarly inappropriate for other major tourism market segments. Past studies of thermal climate resources for tourism (e.g., Lin and Matzarakis 2008, Matzarakis et al. 2010, Lin and Matzarakis 2011, Caliskan et al. 2012, Matzarakis et al. 2013) should be re-evaluated given these findings. Climate assessments that assert that major coastal tourism destinations (i.e., Caribbean and Mediterranean) will become thermally unsuitable for tourism as a direct result of climate change (Maddison 2001, Scott & McBoyle 2001, Lise & Tol 2002, Scott et al. 2004, Hamilton et al. 2005, Amelung & Viner 2006, Bigano et al. 2006, Berritella et al. 2006, Amelung et al. 2007, Nicholls & Amelung 2008, Hein et al. 2009, Moore et al. 2010, Perch-Nielsen et al. 2010) should also be re-evaluated. This study reinforces the results of previous evaluations that coastal destinations are unlikely to become “too hot” for summer tourism (Rutty & Scott 2010, Scott

⁷ PET thermal sensation of 35°C to 41°C is classified as “hot (extreme caution)” (Blazejczyk et al. 2012).

et al. 2012a), as coastal destinations are more resilient to temperature increases due to the tolerance of beach tourists to stressfully high thermal conditions.

We believe that this study provides an initial basis for understanding the perception of outdoor microclimatic conditions in a coastal environment, while simultaneously identifying important psychological factors that differentiate tourists from everyday users of urban spaces. This study has focused on bioclimatic comfort as it relates to the thermal component of climate, with similar research on the physical (i.e., rain) and aesthetic (i.e., clear skies) facets of climate needed. Complementary studies in other coastal tourism environments, as well as in other key tourism market segments, are important avenues for future research.

Chapter 5:
Manuscript #3: Thermal Range of Coastal Tourism Resort
Microclimates

Rutty M, Scott D (2014b) Thermal Range of Coastal Tourism Resort Microclimates, *Tourism Geographies*. Accepted

With considerable evidence demonstrating the intrinsic importance of weather and climate for tourist decision making, the projected redistribution of climatic resources as a result of climate change is anticipated to have important consequences for temporal and spatial patterns of tourism demand. Some of the world's leading coastal tourism destinations (Mediterranean and Caribbean) have been identified in the literature and media as becoming 'too hot' for tourism. However, neither tourist defined thresholds of 'too hot' or the microclimates of coastal tourism areas have been considered by such assessments. With a focus on thermo-physiologically relevant climatic parameters, this paper examines the adaptive range of microclimatic conditions available in two coastal resort settings in the Caribbean islands of Barbados and Tobago. Recorded weather parameters include air temperature, black globe temperature, relative humidity and wind speed. The microclimatic results, which are presented using the Universal Thermal Climate Index (UTCI), show that hourly thermal conditions can range up to 4°C in different outdoor areas of the resort property. The results are discussed in the context of tourists' thermal preferences and thresholds to better assess the implications of climate change for thermal comfort and coastal tourism demand.

5.1 Introduction

Climate is a principal resource for tourism and represents a key element of the natural resource base of a destination (de Freitas 2003, Gomez-Martin 2005, Scott & Lemieux 2010). Climate not only determines the suitability of a location for tourist activities, but it is the principal driver of seasonality in tourism demand—a defining characteristic of global tourism (Butler 2001). Seasonality of tourism is driven largely by major market countries of the Northern Hemisphere, with natural seasonality serving as a primary stimulus for some of the largest tourism flows (northern Europe to southern Europe/Mediterranean, northern USA and Canada to southern USA/Caribbean, Australia to southeast Asia). According to Smith (1993), all tourism destinations are either climate-dependent, whereby climate is the principal resource on which tourism is predicated (e.g., snow for winter sports tourism, sunshine and warm temperatures for coastal tourism) or climate-sensitive, whereby climate resources do not directly generate tourism but either facilitate or constrain tourist activities (e.g., sightseeing) (Smith 1993, Gomez-Martin 2005, Scott & Lemieux 2010). Climate resources therefore influence the overall appeal of a destination, with potential visitation to a destination representing a function of perceived value of climate to tourists and its constraint on tourist activities (Perry 1993, de Freitas 2003, Scott et al. 2012a). Climate, both at source markets and at destinations, is a principal motivator for leisure tourism (Kozak 2002, Lohmann & Kaim 1999), influencing the timing of travel (e.g., Eugenio-Martin & Campos-Soria 2009, Hill 2009, Hadwen et al. 2011), the destination(s) selected (e.g., Kozak 2002, Hamilton & Lau 2005, Moreno 2010), spending patterns throughout the destination(s) (e.g., Agnew 1995), and overall trip satisfaction (e.g., Bardón 1991, Williams et al. 1997, Becken & Wilson 2013, Tervo-Kankare et al. 2013)

A direct impact of climate change on tourism destinations will be the global redistribution of climatic resources (Scott et al. 2004, Scott et al. 2012b). This will alter the length and quality of climate-dependent and climate-sensitive tourism seasons and affect the distribution of international tourism flows and regional economic contributions (Scott et al. 2012a). Studies have revealed a generally consistent temporal and geographical pattern; as

the 21st century progresses, there is a pronounced shift in thermal comfort and other parameters suitable for tourism (and thereby tourism demand) towards higher latitudes and away from sub-tropical and tropical destinations (Maddison 2001, Scott & McBoyle 2001, Lise & Tol 2002, Scott et al. 2004, Hamilton et al. 2005, Amelung & Viner 2006, Bigano et al. 2006, Berrittella et al. 2006, Amelung et al. 2007, Nicholls & Amelung 2008, Hein et al. 2009, Moore 2010, Perch-Nielsen et al. 2010). However, these assessments have not been without criticism (Gomez-Martin 2005, Gössling & Hall 2006a and 2006b, de Freitas et al. 2008). The assertion that major coastal tourism destinations (i.e., the Mediterranean and Caribbean) will become seasonally ‘too hot’ for tourism (Perry 2006, Amelung & Viner 2006) has been questioned because what tourists perceive to be ‘too hot’ for coastal tourism activities is unknown (Scott et al. 2008a, Moreno et al. 2009, Rutty & Scott 2010, Rutty & Scott 2013 and 2014a).

While the above studies provide valuable insight into the future macro-scale redistribution of climate resources for tourism, they do not account for the microclimates where tourism activities often take place. Tourism microclimates create substantial challenges for tourism marketers and operators (Scott & Lemieux 2010, Becken & Wilson 2013). The extent to which distant weather stations or even coarser gridded climate data accurately represent climatic conditions at tourism destinations remains unknown and represents a key research gap in the tourism and climate change literature. It is unclear the extent to which microclimates influence the thermal conditions at tourism destinations, and whether the results of climate change impact assessments would differ when more sophisticated tools are used to measure human thermal conditions (e.g., Universal Thermal Climate Index) (Scott et al. 2012a). To accurately assess the potential impact of climate change on coastal tourism destinations, there is a need to better understand the existing influence of microclimatic conditions, and how these conditions influence people in thermophysiological ways.

This study examines the range of microclimatic conditions available in two coastal resort settings in the Caribbean islands of Barbados and Tobago. This study is the first to

apply the Universal Thermal Climate Index (UTCI) within a tourism context to examine the bioclimatic conditions tourists would experience in a coastal setting. The results are discussed in the context of tourists' thermal preferences and thresholds for coastal tourism to better assess the potential impact of projected climate change.

5.2 Evaluating Climate for Tourism

The evaluation of climate as a resource or constraint for tourism has been approached with a variety of methods to quantify optimal and threshold climate conditions, both generally and for specific tourism segments or activities (e.g., coastal or ski tourism). Approaches include expert assessments to develop 'weather typing' classifications (Besancenot et al. 1978, Besancenot 1985) and integrative climate indices such as the Tourism Climate Index (TCI) (Mieczkowski 1985). Statistical analyses have also been employed to estimate the relationship between weather variables and measures of aggregate tourism demand, such as visitation data and occupancy rates (e.g., Van Lier 1973, Gibbs & McGuire 1973, Emmons et al. 1975, Tolley et al. 1986, Meyer & Dewar 1999, Jones & Scott 2006, Scott & Jones 2007, Nicholls et al. 2008, Serquet & Rebetez 2011, Day et al. 2013). International tourism arrivals data has also been used to 'reveal' tourists' climatic preferences and optimal conditions on a regional and global scale (Maddison 2001, Lise & Tol 2002, Hamilton 2003, Hamilton et al. 2005, Bigano et al. 2006, Berrittella et al. 2006). Stated preference approaches using in situ and ex-situ surveys or interviews (Lohmann & Kaim 1999, Morgan et al. 2000, Gomez-Martin 2006, Scott et al. 2008a, Moreno 2010, Ruttty & Scott 2010, Denstadli et al. 2011, Ruttty & Scott 2013 and 2014a), as well as tourist behavioural observation (de Freitas 1990, Mansfeld et al. 2004, Moreno et al. 2009, Martinez-Ibarra 2011, Gomez-Martin & Martinez-Ibarra 2012) have also been used to identify tourists' preferred climatic conditions.

Many of the aforementioned studies have also been used to assess the impact of climate change on tourism destinations. For example, Mieczkowski's (1985) TCI has been used to describe the redistribution of climate resources globally (Amelung et al. 2007) and

regionally, including North America (Scott & McBoyle 2001, Scott et al. 2004), Europe (Perch-Nielsen et al., 2010), the Mediterranean (Amelung & Viner 2006, Hein et al. 2009), Northern Europe (Nicholls & Amelung 2008) and the Caribbean (Moore 2010). A pooled travel cost model (PTCM), which uses aggregate data on the number of visits (e.g., number of return visits) and the cost of these visits (e.g., average return fare paid and daily expenditures) to estimate a climate demand function, has also been used to describe the impact of climate change on the flow of tourists originating from Britain (Maddison 2001) and the Organisation for Economic Co-operation and Development (OECD) countries (Lise & Tol 2002). As previously noted, these studies project a shift of climatic resources, most frequently thermal conditions for tourism, towards higher latitudes and elevations, and away from sub-tropical and tropical regions. As such, tourism demand is projected to shift away from the presently popular coastal tourism destinations of the Caribbean, Mediterranean/southern Europe, and southern United States, towards the climatically cooler regions of the Baltics, Canada, northern Europe, and Scandinavia.

However, these studies have been subject to two main critiques that raise questions regarding the accuracy of such demand projections. First, these analyses are insensitive to the diverse weather requirements of tourism market segments and they do not use evidence-based thresholds of tourists' upper/lower acceptable thermal conditions (de Freitas 2003, Scott et al. 2004, Gomez-Martin 2006, de Freitas et al. 2008, Scott et al. 2008a, Ruttly & Scott 2010, Scott et al. 2012a). To account for these limitations, Moreno and Amelung (2009) modified the TCI on the basis of surveys done by Morgan et al. (2000) to tailor the index to the preferences of beach tourists, and re-examined the distribution of climatic resources for coastal tourism across Europe. The study concluded that the Mediterranean would remain climatically 'very good to excellent' through the 2060s, contradicting previous studies (Amelung & Viner 2006, Perry 2006) by stating that the Mediterranean would likely remain Europe's prime region for summertime coastal tourism for the next 50 years. Ruttly and Scott (2010) were the first to define thermally uncomfortable conditions on the basis of consultations with tourists, similarly finding that several Mediterranean destinations (e.g.,

Barcelona, Costa Brava, Marseilles, Milos, Nice, Venice) would not be considered ‘too hot’ even under the warmest climate change scenario until the mid- to late twenty-first century, if at all.

Regardless of the climate change assessment approach, an important second limitation remains: how climate at the destination is represented spatially and temporally. For example, Maddison (2001) and Lise and Tol (2002) used coarse spatial resolution where the temperature of the capital city is to be representative of an entire nation. As Scott *et al.* (2008a) point out, this infers that the mean temperature of Washington, D.C. is representative of the United States, which contains 10 different climate zones using the Köppen classification scheme. Also problematic is the coarse temporal scale of the model, selecting the maximum daytime temperature across quarterly (Maddison 2001) and annual (Hamilton *et al.* 2005, Bigano *et al.* 2006) time scales. The coarse temporal and spatial scales that climate is represented by in these studies is irrelevant to tourist decision making (Scott *et al.* 2012a). Assessments by Scott and McBoyle (2001), Scott *et al.* (2004), Hein *et al.* (2009) Moore (2010) and Rutty and Scott’s (2010) were completed at city scale using national weather station data (e.g., monthly normal for average daily maximum temperature). However, questions have been raised about the suitability of weather stations to represent tourism climate as they may be up to 100 km away from where tourism operators are located (Scott & Lemieux 2010, Becken & Wilson 2013). The recorded weather data may differ substantially from the prevailing local conditions (i.e., be warmer or cooler), particularly since tourism activities are highly localized, often in better than average microclimate conditions (e.g., snow rich mountain valleys, along coasts or small lakes) (Scott *et al.* 2012a). Moreover, official weather stations often lack important biometeorological information, specifically thermal mean radiant temperature, which is a key environmental parameter that influences human thermal comfort. Höppe and Seidl (1991) took weather measurements along the beach of Lido degli Estensi in the Adriatic coast of Italy and compared the results with that of the official weather station located two kilometres inland. The results indicated that thermal stress (based on the physiological equivalent temperature) was significantly

lower on the beach (up to 5°C cooler). Hartz et al. (2006) similarly found that recorded air temperatures and dew points were lower at seven resorts in the countryside near the major metropolitan area of Phoenix (Arizona, USA), with energy budgets and percentages of comfortable conditions (based on the OUTCOMES model) substantially greater (on an hourly and monthly basis) when compared to official national weather service data recorded at the Phoenix airport. Existing destination specific climate change assessments are therefore further limited in that thermal conditions at tourism micro-climates, a difference which may be equal to or exceed projected climate changes, has not been sufficiently measured and accounted for.

5.3 Materials and Methods

This study is based on measurements of weather parameters taken at two different coastal resorts in the Caribbean. The climate of the Caribbean, as described by the Köppen climate classification scheme (Peel et al. 2007), belongs to Group A; tropical/megathermal climates, which is characterized by high temperatures, with an average annual temperature of 18°C or higher (at sea level and low elevations). Much of the region is characterized by pronounced bimodal rainfall, with the dry season (winter) occurring from approximately December until May, which is also the tourism high season, and the wet season (summer) (with increased humidity and higher maximum temperatures) occurring from approximately June until November.

Caribbean study areas were chosen for three reasons. First, the region's tourism is predominantly based on the natural environment, with 3S tourism by far its largest market. This tourism product therefore depends on favourable weather conditions in the coastal zone to attract millions of international tourists. Second, the region has been repeatedly ranked as one of the global tourism regions most vulnerable to climate change (Deutsche Bank Research 2008, Hall 2008, Scott et al. 2008b, Perch-Nielsen et al. 2010, Scott et al. 2012a). Third, the Caribbean has the most tourism-intensive economy (i.e., tourism represents the greatest proportion of the regional economy) among the 12 regions ranked by the World

Travel and Tourism Council (2011), with tourism representing 14% of GDP and 13% of employment (2.2 million jobs).

5.3.1 Study Area

To understand the climatic conditions tourists experience most while outdoors on their beach vacation, microclimatic measurements were collected in high traffic areas of two coastal resort settings in the Caribbean; Amaryllis Beach Resort in Barbados and Pigeon Point Heritage Park in Trinidad and Tobago. The Amaryllis Beach Resort, Barbados (13.076577° N 59.604644° W, 7 m elevation), is located in the south-western region of the island (St Matthias), 5 km south of the capital city Bridgetown. Microclimatic data were collected at three locations at 10 metre intervals along a linear transect that was perpendicular to the shoreline. Data was collected on the beach (i.e., 10 m from the shoreline), in the tropical gardens (i.e., 20 m from the shoreline), and beside the outdoor swimming pool (i.e., 30 m from the shoreline). Pigeon Point Heritage Park, Trinidad and Tobago (11.170349° N 60.840513° W, 7 m elevation), is located in southern Tobago (Crown Point), approximately 40 km northeast of Trinidad. The park is considered by locals to be the best beach in Tobago, and is a popular area for beach visitors, as well as for large events on the island (e.g., Tobago's Culinary Festival). Measurements were similarly taken along a linear transect perpendicular to the shoreline at 10 metre intervals. Data was collected on the beach (i.e., 10 m from the shoreline), in a thatched beach cabana (i.e., 20 m from the shoreline), and in a garden/picnic area (i.e., 30 m from the shoreline).

5.3.2 Microclimatic Measurements

Micrometeorological measurements were taken on March 20th, 2012 at Amaryllis Beach Resort (Barbados), and March 27th, 2012 at Pigeon Point Heritage Park (Tobago). The resort weather data were collected as part of a larger coastal tourism study which examined weather data throughout March and April 2012 at beaches across both islands. During this period, temperatures between 27°C and 31°C were recorded, corresponding to long-term

daily mean and maximum temperatures in the region. The temperatures on observed days represent normals for March and April, and with only a 1°C difference in maximum mean temperature from March to November, they are representative of nine months of the year.

Data were collected using a laboratory grade HOBO H21-Pro weather station with automated sensors manufactured by Onset Computer Corporation. The location of the weather station at each resort was kept as similar as possible, by selecting and then placing the station in the three outdoor open areas with the highest density of users. Air temperature (T_a), black globe temperature (T_g), relative humidity (RH), and wind speed (V_a) were sampled every 30 seconds between 11am and 5pm (local time), and stored on a HOBO data logger. The data collection time, 11am to 5pm, was chosen based on peak tourist use periods. The station was set up each hour in all three measurement sites for 15 minutes, allowing 10 minutes for the station to calibrate to its new location and 5 minutes of data collection, with the remaining 15 minutes used to move the equipment between the three measurement sites. The measurement height for air temperature, black globe temperature, and relative humidity was 1.1m above the ground, corresponding to the average height of the centre of gravity for a standing adult (Mayer & Höppe 1987).

The mean radiant temperature (T_{mrt} in degrees Celsius) sums all short and long wave radiation fluxes (both direct and reflected), to which the human body is exposed to. It can be defined as the ‘uniform temperature of an imaginary enclosure in which the radiant heat transfer from the human body equals the radiant heat transfer in the actual non-uniform enclosure’ (ASHRAE 2001). The thermal influence of the radiant fluxes was measured with a globe thermometer painted in matt black (Bedford & Warner, 1934). From globe temperature measurements (T_g in degrees Celsius), the globe’s emissivity (ϵ_g), and the globe’s diameter (D in millimetres), T_{mrt} was calculated according to ISO 7726 (1998) for forced convection (Eq. 1). For calculations of T_{mrt} , the value of T_g measured at 1.1 m was used, corresponding to the measurement height of the other quantities. This approach has been used by Thorsson et al. (2007) and Bröde et al. (2012).

$$T_{mrt} = \left[(T_g + 273.15)^4 + \frac{1.1 \times 10^8 V_a^{0.6}}{\varepsilon D^{0.4}} \times (T_g - T_a) \right]^{1/4} - 273.15 \quad (1)$$

Given that tourists experience the integrative effects of weather (de Freitas 2003), the human thermal environment cannot be represented adequately with just a single parameter (i.e., air temperature). Therefore a thermo-physiological index was calculated to evaluate the combined effect of atmospheric variables on the average tourist. The Universal Thermal Climate Index (UTCI) was selected for this task because it aims to be the international methodological standard for characterizing the human thermal environment (Jendritzky et al. 2012). The UTCI is based on the most advanced multi-node model of thermoregulation. It is derived conceptually as an equivalent temperature, so that for any combination of air temperature, wind, radiation, and humidity, the temperature provided by the UTCI can be defined as “the isothermal air temperature of the reference condition that would elicit the same dynamic response (strain) of the physiological model” (Jendritzky et al. 2012, p. 421). The UTCI requires the input of wind speed at 10 m above the ground, so the wind speed values, which were measured at 1.5 m, were scaled-up by a factor of 1.4 according to the formula $\text{LOG}(10/0.01)/\text{LOG}(1.5/0.01)$ as proposed by the operational procedure (Bröde et al. 2011).

5.4 Results

Figure 5-1 represents horizontal profiles of the climatic parameters collected at Amaryllis Beach Resort in Barbados on March 20, 2012. The results indicate that air temperature (Figure 5-1a) varies only slightly between 11am and 4pm, and vary only slightly between the three areas of the resort. The pool deck was the warmest, ranging from 27.7°C to 29.6°C, followed by the beach, ranging from 27.5°C to 29.2°C, and the garden, ranging from 27.4°C to 28.6°C. The greatest temperature difference between the three resort areas occurred in the mid-afternoon (2pm) between the pool (29.6°C) and garden (28.2°C).

However, the air temperature provides only a broad indicator of the thermal environment, and does not represent the integrative weather affects that tourists would experience.

When temperature is considered thermo-physiologically, the thermal range between the three resort areas increased. Using the UTCI (Figure 5-1b), the thermal range increased between 11am and 4pm, as well as between each of the three resort areas. The pool remains the warmest throughout the recorded period, while the beach is only warmer than the garden until 1pm, and then the garden becomes warmer as onshore sea breeze continues through the afternoon. The UTCI for the pool ranges from 29.3°C to 32.8°C, the beach ranges from 28.7°C to 31.6°C, and the garden ranges from 29.2°C to 30.6°C. The greatest difference occurs at 2pm, when the pool reaches 32.8°C, which is almost 4°C warmer than the thermal conditions experienced at the beach (29.1°C), and 3°C warmer than the thermal conditions in the garden (29.8°C). UTCI temperatures, when compared to air temperatures, are higher in all three areas (+1.1°C to 3.6°C), highlighting the important influence of wind speed (Figure 5-1c), relative humidity (Figure 5-1d) and the intensity of thermal radiation (Figure 5-1e) on thermal comfort.

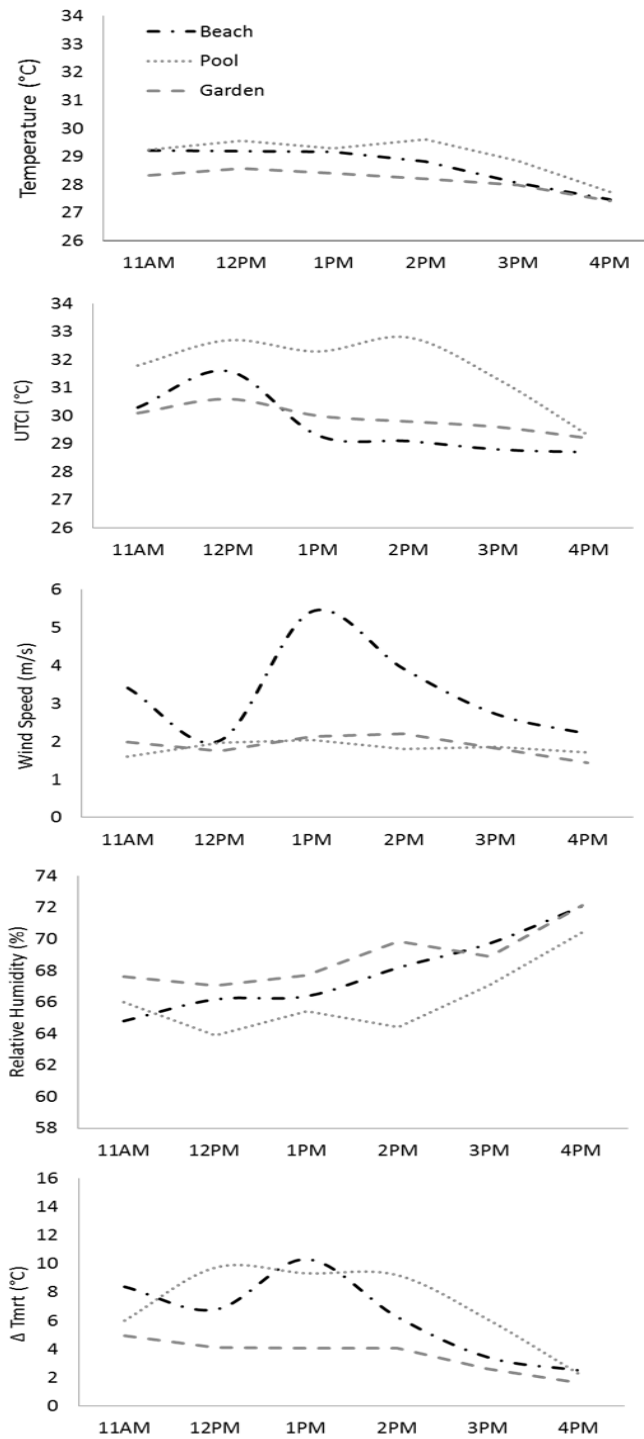


Figure 5-1 Hourly distribution of (a) air temperature, (b) UTCI temperature, (c) wind speed, (d) relative humidity, and (e) thermal radiation, expressed as difference in mean radiant temperature to air temperature (ΔT_{mrt}) at Amaryllis Beach Resort, Barbados

Wind speeds were similar by the pool and in the garden (1.4 to 2.2 m/s), with relatively little difference recorded between the two locations (≤ 0.4 m/s). The beach had the highest wind speeds (2.0 to 5.4 m/s), with the greatest difference recorded between the locations at 1pm (≥ 3.4 m/s). Relative humidity was similar across all three locations, with the garden having slightly higher relative humidity (67% to 72%), followed by the beach (65% to 72%) and the pool (64% to 70%). The intensity of thermal radiation, expressed as the difference of mean radiant temperature to air temperature (ΔT_{mrt}), had the highest recorded average by the pool (7.1°C), followed by the beach (6.3°C) and the garden (3.6°C). Both the beach and the pool were exposed to direct solar radiation, whereas the garden was shaded by palm trees. While the pool had the lowest relative humidity, it also had the lowest wind speeds and highest thermal radiation, resulting in the warmest UTCI temperature. The beach also had a high intensity of thermal radiation, but was offset by higher wind speeds, reducing heat stress. The UTCI rating for the beach and garden are similar, within 1°C throughout the recorded period, which is likely due to the counterbalance between the high wind speeds and lower relative humidity recorded on the beach and the low thermal intensity and higher relative humidity recorded in the garden.

Figure 5-2 represents horizontal profiles of the climatic parameters collected at Pigeon Point Heritage Park in Tobago on March 27, 2012. Similar to the data recorded in Barbados, the results indicate that air temperatures at each measurement site (Figure 5-2a) vary only slightly between 11am and 4pm, and vary only slightly between the three park sites. The beach was the warmest, ranging from 29.4°C to 31.3°C, followed by the cabana, ranging from 28.6°C to 30.0°C, and the garden, ranging from 28.5°C to 30.0°C. The recorded difference ranges from 0.3°C to 1.3°C, with the greatest difference observed between the beach and the garden from 11am to 1pm.

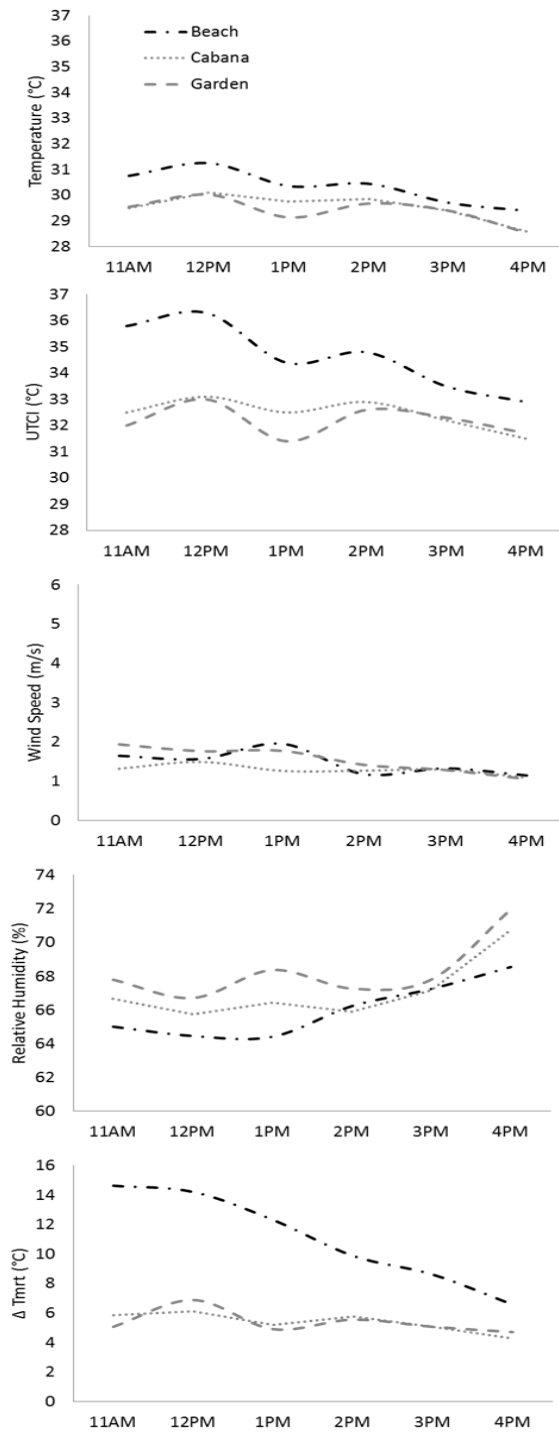


Figure 5-2 Hourly distribution of (a) air temperature, (b) UTCI temperature, (c) wind speed, (d) relative humidity) and (e) thermal radiation, expressed as difference in mean radiant temperature to air temperature (ΔT_{mrt}) at Pigeon Point Heritage Park, Tobago

Also similar to Barbados, when the UTCI temperatures are considered, the available thermal range increases throughout the recorded time periods, and across all three park areas (Figure 5-2b). The UTCI for the beach ranges from 32.9°C to 36.3°C, the cabana ranges from 31.5°C to 33.1°C, and the garden ranges from 31.4°C to 33.0°C. The greatest UTCI temperature range occurs at 11am, with the beach 3.8°C warmer than the garden, followed by a 3.3°C difference at 12pm. The cabana and garden remain thermally similar under the UTCI, but are an average of 3.1°C warmer compared to recorded air temperatures.

Unlike Barbados, where the Amaryllis beach was predominantly cooler based on UTCI temperatures, Pigeon Point beach in Tobago recorded the highest UTCI temperatures. Much of this can be explained by the wind profiles (Figure 5-2c). The difference in wind speed between the three Tobagonian park sites is very small (≤ 0.6 m/s), with the garden recording slightly higher wind speeds than the beach and cabana. Between 2pm and 4pm, the differences are the smallest (≤ 0.2 m/s), with no difference recorded at 3pm. Relative humidity was also similar across all three locations (Figure 5-2d), with the garden recording slightly higher relative humidity (67% to 72%), followed by the cabana (66% to 71%) and the beach (64% to 69%). The greatest difference in relative humidity was recorded at 1pm between the garden (68%) and the beach (64%). Large differences were however recorded for the intensity of thermal radiation (Figure 5-2e). The beach had the highest intensity of thermal radiation, with an average of 11.0°C, compared to the shaded cabana and garden, which both recorded an average of 5.4°C. Given that the wind speeds and relative humidity were similar for all three sites, but the beach was exposed to much higher thermal radiation, the thermal conditions experienced on the beach were the warmest.

5.5 Discussion

In both locations, for any given hour during the sampling period, a range of thermal conditions were recorded. In Barbados, hourly UTCI temperatures measured at the beach, garden, and pool differed by 1°C to 4°C, with the greatest range (4°C) recorded at 2pm

between the beach (29.1°C) and the pool (32.8°C). In Tobago, hourly UTCI temperatures recorded at the beach, cabana, and garden also differed by 1°C to 4°C, with the greatest range (4°C) recorded at 11am between the garden (32.0°C) and the beach (35.8°C). The adaptive range provided by resort scale microclimates is evident, with varying thermal opportunities available to meet tourists' individual comfort requirements throughout the day. Tourists' can change their location (e.g., move from the pool to the beach) providing an onsite adaptive range of 1-4°C, which could be further increased through personal changes (e.g., change clothing, swimming).

While the results presented are characteristic of the tourism high season, they are limited in that the meteorological measurements were taken at only two resorts in the Caribbean region. As such, the measurements should not be regarded as representative of Caribbean coastal resort climates in general, as other resorts or destinations may display greater or lesser micro-climate thermal range. Nevertheless, this study does reveal that thermo-physiological comfort can vary at the micro-scale of a coastal resort or park. Moreover, the results highlight that the thermo-physiologically relevant climatic parameters, presented here with the UTCI, provide a more precise estimate of the available range of thermal comfort than is inferred from air temperature alone. These two points are salient in terms of characterizing tourism destination microclimates and for climate change assessments.

Existing assessments of future changes in climate resources for tourism do not consider tourism microclimates, nor do they consider the thermal adaptive range at a property or destination scale. The relationship between thermal preferences and bioclimatic comfort has been researched, but this body of work has focused exclusively on local residents in open urban areas (Thorsson et al. 2004, Knez & Thorsson 2006, Oliveira & Andrade 2007, Knez et al. 2009, Lin 2009, Lin et al. 2010, Andrade et al. 2011). An exception is Rutty and Scott (2014a), who found that outdoor thermal conditions are perceived differently by tourists in a coastal environment. Specifically, beach users' thermal preferences, based on the UTCI, are

up to 18°C warmer than the preferred thermal conditions identified in bioclimatic studies from urban park settings. The study found that the largest share of respondents (48-77%) preferred thermal conditions between 32°C and 39°C during their beach holiday. Even at 39°C, the majority (62%) would prefer no change, with an additional 10% wanting even warmer thermal conditions. Therefore the range of UTCI conditions recorded at the resort in Barbados (29.2°C to 32.8°C) and Tobago (31.4°C to 36.3°C) are well within tourists' preferred thermal conditions. Importantly, none of the three areas within either resort exceed tourists' thermal threshold.

Additional studies have examined tourists' stated temperature preferences and thresholds for beach tourism (Morgan et al. 2000, Gomez-Martin 2006, Scott et al. 2008a, Ruddy & Scott 2010, Wirth 2010, Ruddy & Scott 2013). However, it is unclear whether the temperatures cited in this literature are based on tourists' perception of temperature alone (i.e., air temperature) or whether tourists' consider the influencing effect of multiple weather parameters (i.e., thermal conditions). Therefore in order to assess the current thermal suitability of these two coastal resorts for beach tourism, both the air temperatures and UTCI temperatures recorded in Barbados (Figure 5-3) and Tobago (Figure 5-4) are compared against the stated preference literature.

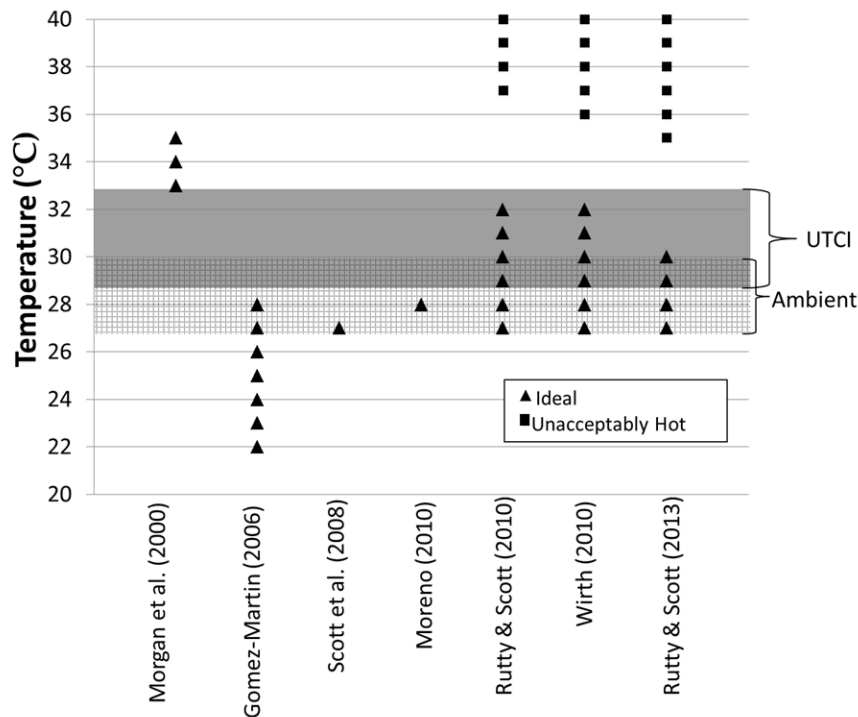


Figure 5-3 Recorded temperature range at Amaryllis Beach Resort, Barbados, compared to preferred and unacceptable temperatures for beach tourism

In Barbados, the recorded air temperatures would be considered ideal for beach tourism in six of the seven studies, with UTCI temperatures considered ideal in four of the seven studies (Figure 5-3). Recorded conditions in Barbados are not considered unacceptably hot for either air or UTCI temperatures. In Tobago, recorded air temperatures are ideal in three of the seven studies, with UTCI temperatures also ideal in three of the seven studies (Figure 5-4). Tobago's air temperatures are not considered to be unacceptably hot in any of the three sites (i.e., beach, cabana, garden), but the recorded UTCI temperatures reach 35°C and 36°C at the beach, exceeding the unacceptably hot threshold identified in Rutty and Scott (2013) and Wirth (2010), respectively. However, in the three timeframes where UTCI temperatures exceed 35°C (i.e., on the beach at 11am, 12pm, 2pm), both the cabana and garden are between 32.0°C and 33.1°C. Therefore the range of available onsite thermal microclimates not only allows tourists the opportunity to move to an area that no longer

exceeds thermal comfort, but to move to an area that has ideal thermal conditions based on the findings of Morgan et al. (2000), Ruddy and Scott (2010) and Wirth (2010). The results demonstrate that when a location becomes thermally uncomfortable, tourists' can move around a single resort property (let alone an entire destination).

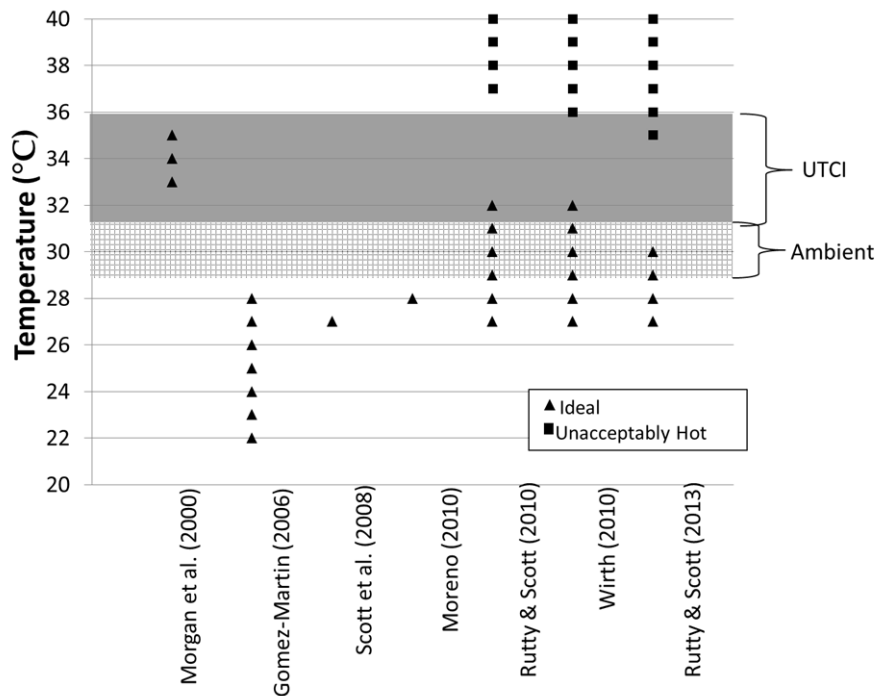


Figure 5-4 Recorded temperature range at Pigeon Point Heritage Park, Tobago, compared to preferred and unacceptable temperatures for beach tourism

Assessments that indicate a very likely shift of comfortable thermal conditions away from sub-tropical and tropical regions are calculated based on the recorded climatic normals, specifically average monthly/annual maximum temperature, from gridded weather data or official weather stations (Maddison 2001, Scott & McBoyle 2001, Lise & Tol 2002, Scott et al. 2004, Hamilton et al. 2005, Bigano et al. 2006, Amelung & Viner 2006, Amelung et al. 2007, Nicholls & Amelung 2008, Hein et al. 2009, Moore 2010, Perch-Nielsen et al. 2010, Ruddy & Scott 2010). In the Caribbean, as with many tourism destinations, official weather data is recorded at the international airport(s). This study has shown that a range of thermal

microclimates are available at a coastal resort level, indicating that a single temperature value from an airport is unlikely to capture the thermal conditions experienced by 3S tourists. It is therefore imperative to understand whether and to what degree microclimates differ from climatic normals if we are to accurately assess the impact of projected climate change. In all three resort areas of Barbados and Tobago, recorded temperatures (air and UTCI) were warmer than that reported from Grantley Adams (Barbados) and Crown Point (Tobago) airports. While more extensive data collection is needed, it suggests that coastal tourists in the Caribbean may experience warmer temperatures than is currently being used to represent the destination.

Perhaps the most limiting aspect of the current climate change assessments, and the subsequent media statements (e.g., Guardian 2006, Halifax Travel Insurance 2006) that sub-tropical and tropical regions will be ‘too hot,’ is that tourists may perceive this to be true, even if temperatures do not exceed thermal thresholds. Human response to climate is largely a matter of perception and in many cases the decision to travel to a destination can be based on a perception of a destination that is not accurate (Gössling et al. 2012). As motives for travel are interlinked with perception of destination attributes, climate change can affect destination attractiveness (Hall 2005). A more accurate reflection of the range of climatic conditions tourists are likely to encounter at coastal resorts at a particular time of year could be beneficial for tourism marketers and should be considered a goal of future climate change assessments.

5.6 Future Research and Conclusion

Since microclimates are affected by the general wind conditions and topographical situation (e.g., inland vegetation, distance of hills and mountains from the beach, orientation of the sun) of a location, future investigations are necessary to provide more comprehensive information on microclimates that tourists’ experience. Additional research is needed to provide a more representative estimate of available microclimates in Caribbean coastal resorts, as well as tourism destinations more generally. Assessing microclimate and

property/destination scale adaptive range across broader tourism market segments (e.g., urban and mountain destinations), as well as for a range of destination attractions (e.g., amusement parks, national parks, zoos) remains a productive avenue for future studies. These findings could then be used in impact assessments to more accurately determine whether a destination (in part or as a whole) could become thermally less optimal or unsuitable for tourism with projected climate change and what adaptive responses may be required (e.g., cooling stations, water/landscaping, adjusted seasonal operations).

While thermal comfort is strongly influenced by microclimatic conditions, it cannot fully account for the wide variation between individual's objective and subjective comfort evaluation. Thermal comfort studies must consider thermal adaptation, particularly psychological adaptation, as this alters the perception and assessments of thermal environments (Andrade et al. 2011). According to Nikolopoulou and Steemeres (2003), psychological adaptation includes the way in which a person perceives the thermal environment as a result of expectation (e.g., what the thermal environment should be like rather than what it actually is). This is particularly important for international tourism, as tourists' expectations of climatic conditions at a destination, whether well-or-ill-informed, may strongly influence relative acceptance and satisfaction with conditions experienced (Rutty & Scott 2013). Research that examines how tourists' evaluate thermal conditions as a result of their expectations is an important area for future research.

Climate change and its direct and indirect impacts on global tourism is a pressing issue (Scott et al. 2012b). Profound impacts are anticipated for the industry throughout the twenty-first century, including the spatial and temporal patterns of tourism demand (Gössling et al. 2012, Scott et al. 2012a). With the rapid increase in multidisciplinary tourism and climate change literature (Becken 2013), it can be a challenge to decipher the accuracy of assertions about the vulnerability of tourism. Studies often make assumptions about tourist perceptions of climate-resources, as well as climate change implications for changes in tourism demand for highly generalized tourism populations and market regions (Scott et al. 2008a, Gössling et al. 2012, Scott et al. 2012a). Like other areas of climate change research,

tourism has seen its share of early speculation and contrasting perspectives, which demand careful, information-based consideration (Scott et al. 2012a). With the inextricable dependency between 3S tourism and favourable weather conditions in the coastal zone, there remains an important need to improve current climate change assessments by basing them on both climate data that represents the localized conditions where such tourism activities take place, as well as providing considerations for thermo-physiological comfort. Such information is a prerequisite if projections are to be made about destinations becoming thermally unsuitable for tourism. This paper has provided additional insight into these questions for coastal destinations by demonstrating the thermal adaptive range tourists possess, even at the resort scale. As our understanding of climate thresholds that trigger behavioural changes among tourists improve, this knowledge can be applied to more accurately project changes in tourism demand under climate change.

Chapter 6: Dissertation Summary and Conclusion

This chapter begins with a summary of the significant findings of this research, through a discussion of the climatic preferences and thresholds of 3S tourists, including bioclimatic comfort (manuscripts one and two) and the range of thermal conditions available to 3S tourists in a coastal resort setting (manuscript three). The implications of the research findings are also discussed, followed by future research suggestions and concluding remarks.

6.1 Study Synopsis

The literature is clear that weather and climate represents a key element of the natural resource base of a tourism destination and an important consideration in tourist decision making. Climate not only determines the suitability of a location for tourist activities, but it is the principal driver of seasonality in tourism demand—a defining characteristic of global tourism (Butler 2001). Climate resources set limits to the overall appeal of a destination (destination image) and can be classified along a spectrum from ideal to unacceptable (de Freitas 2003, Gomez-Martin 2005, Scott et al. 2012b). A growing literature has sought to measure, evaluate and assess climate for tourism, both generally and for specific tourism market segments.

A direct impact of climate change on tourism will be the global redistribution of climatic resources. This could change the length and quality of climate-dependent and climate-sensitive tourism seasons, affecting the temporal and spatial distribution of domestic and international tourism flows and economic spending (Scott et al. 2012a). Studies have revealed a generally consistent temporal and geographical pattern of climate change impacts on global tourism. As the 21st century progresses, there is anticipated to be a pronounced shift in thermal comfort and other parameters suitable for tourism (and thereby tourism demand) towards higher latitudes and away from sub-tropical and tropical destinations (Maddison 2001, Lise & Tol 2002, Scott et al. 2004, Hamilton et al. 2005, Amelung & Viner

2006, Bigano et al. 2006, Berritella et al. 2006, Amelung et al. 2007, Nicholls & Amelung 2008, Hein et al. 2009, Moore et al. 2010, Perch-Nielsen et al. 2010).

However, these climate and tourism assessments have not been without criticism (Gomez-Martin 2005, Gössling & Hall 2006a and 2006b, de Freitas et al. 2008, Scott et al. 2012a). The assertion that major coastal tourism destinations (i.e., the Mediterranean and Caribbean) will become seasonally ‘too hot’ for tourism (Perry 2006, Amelung & Viner 2006) has been questioned because the literature had not established what tourists to these regions perceived to be ‘too hot’ for coastal tourism activities (Scott et al. 2008a, Moreno et al. 2009, Moreno 2010, Ruttty & Scott 2010). In addition, existing assessments do not account for the microclimate conditions where tourism activities take place. It is therefore unknown the extent to which distant weather stations or even coarser gridded or country level climate data accurately represent climatic conditions at tourism destinations. Understanding the implications of climate change for tourism demand has prompted a prioritization for additional research at the climate and tourism interface by both scholars (e.g., Hamilton et al. 2005, Dubois & Ceron 2006, Scott & Lemieux 2010, Gössling et al. 2012, Scott et al. 2012b) and the tourism industry (e.g., UNWTO et al. 2008, WTTC 2009).

The three manuscripts presented in this dissertation directly address this call by advancing weather and climate resource assessments for tourism, particularly the complex relationship between personal and meteorological parameters that influence tourists’ climatic preferences and thresholds for coastal tourism. This overarching goal was achieved through new insights gained by taking concurrent meteorological measurements and in situ surveys from 472 beach tourists in the Caribbean islands of Barbados, Saint Lucia and Tobago. The findings from each of the three main study objectives are summarized below.

6.1.1 Tourists’ Climatic Preferences (Objective 1)

While progress has been made in understanding the significance of climate for tourism (Mayo 1973, Crompton 1979, Bardón 1991, Echtner & Ritchie 1993, Agnew 1995, Williams et al. 1997, Giles & Perry 1998, Lohmann & Kaim 1999, Kozak 2002, Hamilton &

Lau 2005, Gössling et al. 2006, Eugenio-Martin & Campos-Soria 2010, Becken et al. 2010, Moreno 2010, Hübner & Gössling 2012), the weather and climate-related criteria tourists use to make decisions about tourism remains a prominent research need identified in the literature (Gössling & Hall 2006a and 2006b, Scott et al. 2008a, Ruddy & Scott 2010, Gössling et al. 2012, Scott et al. 2012b, Becken & Wilson 2013). With the inextricable dependency between coastal tourism and favourable weather conditions, it is important to both understand how tourists perceive and evaluate climatic resources, particularly those conditions that are most preferred or avoided (i.e., trigger behavioural changes). It is also important to examine the adaptive climatic range tourists' can experience within a coastal setting. Such information is a prerequisite if accurate assessments and projections are to be made about changes in tourism demand as a result of climate change.

The ideal climate conditions for beach tourism identified in this study are generally consistent with previous climate assessments (Gomez-Martin 2006, Scott et al. 2008a, Moreno 2010, Ruddy & Scott 2010, Wirth 2010), with ideal temperatures of 27-32°C, a light breeze, and 25% cloud cover. However, unacceptable climate conditions identified in this study revealed lower willingness to tolerate many climate variables compared to the literature, with a narrow range of acceptable temperatures, including a lower acceptance for cool (<23°C) and warm (>34°C) temperatures, as well as a lower willingness to tolerate rain (≥ 2 h) (consistent with existing studies were wind and cloud cover thresholds [strong winds, $\geq 75\%$, respectively]). This indicates that tourists' threshold conditions may be less homogenous than ideal conditions, particularly with respect to threshold temperatures. For all climate variables examined (temperature, rain, cloud cover, wind), no statistically significant differences were found among different age groups for ideal or unacceptable conditions. These results differ from the literature (Credoc 2009, Wirth 2010), which has found that younger age cohorts prefer and are more tolerant of warmer conditions compared to older age cohorts.

This study also revealed a number of new findings among previously unrepresented sample groups. Tourists originating from tropical regions have statistically significant ($p <$

0.05) warmer temperature preferences and tolerances than tourists originating from temperate regions, which is consistent with outdoor bioclimatic studies between temperate and hot-humid regions (Lin 2009, Lin et al. 2010). Statistically significant differences were also found between temperate and tropical residents for every climate variable examined (temperature, rain, cloud cover, wind). Temperate residents were found to have a narrower range of acceptable temperatures for a 3S holiday, with a lower acceptance for cool and warm conditions, as well as a lower tolerance for rain, cloud cover and wind.

6.1.2 Tourists' Bioclimatic Comfort (Objective 2)

To date, outdoor bioclimatic comfort assessments have focused exclusively on local residents in open urban areas, making it unclear whether outdoor comfort is perceived differently in non-urban environments or by non-residents (i.e., tourists) with different weather expectations and activity patterns. During the study, Universal Thermal Climate Index (UTCI) conditions of 32°C to 39°C were recorded. These conditions were perceived as being 'slightly warm' or 'warm' by respondents. Even at UTCI 39°C, 62% of respondents voted for no change to current thermal conditions, with an additional 10% stating they would like to feel even warmer. These results reveal that beach users' thermal preferences are up to 18°C warmer than the preferred thermal conditions identified in existing outdoor bioclimatic studies from urban park settings (Lin et al. 2011, Andrade et al. 2011).

This study also found personal characteristics influenced thermal perceptions and preferences. The statistically significant findings show that climatic region of origin matters. Respondents from tropical countries perceive the thermal conditions on the beach as cooler than respondents from temperate countries, which is consistent with the findings in the biometeorology literature (Lin 2009, Lin et al. 2011). However, tropical residents preferred to feel cooler at all recorded UTCI temperatures, as did females and younger beach tourists (18-25 years), which all stand in contrast to the findings of existing studies in the tourism and biometeorology literature (Credoc 2009, Knez et al. 2009, Lin 2009, Wirth 2010, Andrade et al. 2011, Lin et al. 2011).

Based on UTCI thermal stress categories, respondents should have felt ‘strong’ to ‘very strong thermal stress’ while at the beach (Bröde et al. 2012). However, the results indicate that beach tourists were not only willingly exposing themselves to thermally stressful conditions, but they prefer conditions that are thermally stressful. Thermal comfort theory suggests that psychological factors can significantly influence the thermal perception of outdoor spaces and how these spaces are evaluated. Tourists’ comfort expectations and perceived thermal control are both important contextual factors that enhance beach users’ tolerance for thermally stressful conditions. The results from this study indicate that beach users hold fundamentally different comfort perceptions and preferences compared to people using urban spaces. The findings indicate that when assessing outdoor thermal comfort for 3S tourism, acceptable thermal conditions, as currently defined in the human biometeorology literature (i.e., slightly cool, neutral or slightly warm [e.g., 18-28°C PET]), cannot be applied.

6.1.3 Coastal Tourism Microclimates (Objective 3)

Existing tourism and climate change assessments are based on distant weather stations or even coarser gridded or nationally averaged climate data. The extent to which these data accurately represents climatic conditions at tourism destinations and microclimates remains a gap in climate change vulnerability assessments of the tourism sector. Based on the recorded weather parameters at two coastal resort settings in the Caribbean, microclimatic results, which are presented using the UTCI, show that hourly thermal conditions can range up to 4°C in different outdoor areas of a resort property (beach, pool, cabana, garden). When a location becomes thermally uncomfortable, tourists’ can change their location (e.g., move from the pool to the beach), providing an onsite adaptive range between 1-4°C. This adaptive range can be further increased through personal changes (e.g., swimming, moving into the shade, alter clothing).

These results reveal that thermal conditions can vary at the micro-scale of a coastal resort or park, with the ability for tourists’ to attain thermally comfortable conditions even within a single resort property (let alone an entire destination). This is salient in terms of

characterizing tourism destinations for climate change assessments. This site level thermal adaptive range of up to 4°C is of the same scale as projected climate change at many coastal locations of the Caribbean and Mediterranean. Furthermore, based on the results from this study, the recorded UTCI conditions at both resorts are well within tourists' preferred thermal conditions and do not exceed tourists' thermal thresholds for 3S tourism.

6.1.4 Research Implications

Weather and climate significantly influences global tourism demand patterns and global economic expenditures. There is thus an inherent need to assess the suitability of weather and climate for tourism for use in various decision-making contexts by both tourists and the tourism industry (Figure 2-5). Tourists can use climate assessment information to aid with travel planning, including the best time and location to travel, to plan appropriate attire, as well as onsite activity scheduling. Tourism operators and destinations can use this research to inform marketing strategies, such as to promote attractive climatic conditions or to condition tourists' expectations to less favourable climatic conditions. This research can also be used for infrastructure planning and development, including microclimate design to optimize the range of available thermal conditions for tourists. The insurance industry can integrate climate assessment research to customize products (e.g., weather insurance or weather derivative contracts) to the climatic preferences of tourists in varying destination types or to develop financial products for tourism operators and destinations to manage weather risks (e.g., weather guarantees). The results of this research can also be incorporated into existing climate indices (e.g., TCI, BCI, CIT), demand models (e.g., Lise & Tol 2002, Hamilton et al. 2005, Bigano et al. 2006) and climate change assessments (e.g., Scott et al. 2004, Amelung et al. 2007, Moreno & Amelung 2009, Moore 2010) to allow for more robust projections of tourism demand. Such projections can then be used to help the tourist industry with developing plans for climate change adaptation, minimizing associated risks and capitalizing on new opportunities posed by changes in the competitive relationships among destinations.

Overall, the methodological approaches to assessing climate for tourism have evolved over the past several decades, becoming more diverse. Now studies include both top-down (i.e., expert-based and revealed preference studies) and bottom-up (i.e., stakeholder based, stated preference studies) approaches. The results from this study provide new insight into the complexities of assessing climatic resources for tourism, with important research implications for evaluating current/future climatic resources for tourism.

First, those studies that have tried to generalize tourism climate resources (optimal and threshold conditions) for all market segments including weather typing (Besancenot et al. 1978, Besancenot 1985, Gomez-Martin 2006), climate indices (Mieczkowski 1985, Morgan et al. 2000, de Freitas et al. 2008) and econometric demand models (Maddison 2001, Lise & Tol 2002, Hamilton 2003, Hamilton et al. 2005, Bigano et al. 2006) have not adequately captured the complexity of weather and climate preferences of tourists or the implications of diverse preferences for tourist decision making. Tourists' optimal and unacceptable climatic conditions not only differ based on specific tourism environments or activities (Scott et al. 2008a, Rutty & Scott 2010, Wirth 2010), but are dependent on several interpersonal factors. For the first time, climatic region of origin and gender were considered, revealing statistically significant differences in beach tourists' preferences and thresholds. These findings are largely supported by the biometeorology and health literature, which have similarly found differences among socio-demographic and socio-cultural groups (Knez & Thorsson 2006 and 2008, Vigotti et al. 2006, Meze-Hausken 2008, Knez et al. 2009, Lin 2009, Lin et al. 2011, Oliveira & Andrade 2007, Andrade et al. 2011). Age was also found to significantly influence thermal perceptions and preferences, which is also supported by both the tourism and biometeorology literature (Credoc 2009, Wirth 2010, Andrade et al. 2011). These interpersonal factors need to be considered when evaluating weather and climate as a resource or constraint for tourism.

Similarly, this research has important implications for meteorological indices developed by private-sector companies. The development of specialized climate products for the tourism industry, including customized decision support tools for tourism destinations,

events, and activities (e.g., Golf Index, Spectator Index and Ski Index developed by the Weather Channel® in the USA) require knowledge of the specific climatic conditions that tourists' desire. Without it, the validity and accuracy of such indices remain uncertain. Most of the specialized products from private meteorological companies lack transparency in the methods and data sources used to properly evaluate their application (Scott & Lemieux 2010). New self-defined climate indices for tourism are beginning to emerge that allow tourists to objectively compare climatic conditions of destinations they are considering. For example, Wetter Graubunden in Switzerland is an online website that allows users to self-define their climatic preferences for skiing and snowboarding (i.e., temperature, cloud cover, amount of fresh snow, visibility) (www.wetter-graubuenden.ch). The data base then lists those snow resort locations throughout Switzerland that meet the criteria based on the climatic preferences set by the user. Such an approach not only overcomes the lacking transparency of private meteorological indices, but also accounts for individual preference differences. Tourists' use of this application requires further evaluation.

Moreover, the thermal component of climate indices (Mieczkowski 1985, Morgan et al. 2000, de Freitas et al. 2008) are based on thermal comfort as defined by thermo-physiological indices (e.g., PET, UTCI), which cannot be applied to 3S tourists without modification. This study contributes to assessments of bioclimatic comfort in outdoor areas, which to date, have only considered residential use of urban environments. Psychological factors, including thermal comfort expectations and perceived thermal control, are key contextual considerations that enable beach tourists' to not only be exposed to, but to prefer, thermal conditions that elicit strong to very strong heat stress. While this is a somewhat intuitive finding considering the motives for 3S tourism, it has not been documented empirically and the degree of difference is substantial ($>18^{\circ}\text{C}$). This suggests that beach tourists' tolerances for thermal conditions may be much warmer than what is currently identified in the stated preference literature (Rutty & Scott 2010, Wirth 2010). Importantly, studies that have evaluated the suitability of destinations for tourism based on thermo-physiological indices need to be reassessed. For example, PET has been used to define the

‘climate tourism potential’ of destinations, with slight to moderate heat stress ($PET > 29^{\circ}\text{C}$) considered ‘unsuitable’ for coastal tourism in Greece (Matzarakis 2006), Croatia (Brody et al. 2013, Zaninovic & Matzarakis 2009) and Turkey (Caliskan et al. 2012). This threshold of ‘unsuitability’ for coastal tourism is up to 10°C lower than the thermal preferences recorded in this study, suggesting the results of these studies need to be fully reassessed. The evaluation of tourism destinations based on thermo-physiological indices may be similarly inappropriate for other major tourism market segments, with additional studies in the biometeorology literature requiring re-evaluation based on empirical considerations of tourists’ climatic preferences and thresholds (e.g., McGregor et al. 2002, Lin & Matzarakis 2008, Endler et al. 2010, Matzarakis et al. 2010, Lin & Matzarakis 2011, Matzarakis et al. 2013, Matzarakis et al. 2014).

Furthermore, it is important to consider the existing influence of microclimatic conditions when evaluating climate for tourism. Even at the micro-scale of a coastal resort or park, thermal comfort can vary, with greater variability likely on a destination scale. Importantly, thermo-physiologically relevant climatic parameters provide a more precise estimate of the available range of thermal comfort than is inferred from air temperature alone. Therefore when assessing climate for tourism, it is critical to acknowledge that thermal comfort varies at the micro-scale where the tourism activity is taking place.

Collectively, this research has important implications for the demand response of tourists to climate change. The results from this study suggest that a pronounced shift in thermal comfort and thereby tourism demand towards higher latitudes and away from sub-tropical and tropical destinations because of temperature (Maddison 2001, Lise & Tol 2002, Scott et al. 2004, Hamilton et al. 2005, Amelung & Viner 2006, Bigano et al. 2006, Berrittella et al. 2006, Amelung et al. 2007, Nicholls & Amelung 2008, Hein et al. 2009, Moore et al. 2010, Perch-Nielsen et al. 2010) is uncertain, especially where 3S tourism is the dominant market. Not only do beach tourists’ have high thermal thresholds (i.e., low sensitivity to increased temperatures), but they also have the ability to adjust their thermal environment by several degrees ($1-4^{\circ}\text{C}$) by simply changing locations within their coastal

setting (i.e., high adaptive capacity). This onsite thermal adaptive range is on the same scale as projected temperature increases under climate change in many coastal tourism regions. This research therefore supports the findings of Rutty and Scott (2010) and Scott et al. (2012b) that the Caribbean and Mediterranean are unlikely to become ‘too hot’ for coastal tourism even by the end of the 21st century. Rather, it is very likely that warmer climate change scenarios will impact these coastal tourism destinations through future sustainability challenges, including reduced water supply, sea level rise and beach erosion (Scott et al. 2012a, 2012b, 2012c).

Overall, this study advances our understanding of the complex relationships between meteorological parameters, personal factors, and tourists’ evaluation of climatic resources. Based on the findings from this study, a conceptual framework that integrates the multiple facets known to influence tourists’ evaluation of climate resources, as well as tourists’ responses to holiday weather conditions, was developed (Figure 6-1). The framework consists of a two key temporal travel phases; trip planning (i.e., pre-trip) and trip (i.e., onsite holiday), which is consistent with Figure 2-1. The arrows within the framework indicate lines of influence.

During the trip planning phase, *holiday type* (e.g., 3S, urban, mountain or adventure holiday) is influenced by both *personal factors* (i.e., socio-demographics) (Pizam & Sussmann 1995, Moscardo et al. 2001, Kozak 2002, Diaz-Perez et al. 2005, Prayang & Ryan 2011, Correia et al. 2011), and the *source region weather/climate* (i.e., the weather/climate at tourists’ region of origin) (Smith 1993, Agnew 1995, Jorgensen & Solvoll 1996, Giles & Perry 1998, Agnew & Palutikof 2006, Nadal et al. 2008, Hill 2009, Eugenio-Martin & Campos-Soria 2010). *Climate preferences* (e.g., temperature, rain, wind, cloud cover) are influenced by *holiday type* (e.g., temperature preferences differ for a 3S versus urban holiday) (Scott et al. 2008a, Rutty & Scott 2010, Wirth 2010), as well as influenced by *personal factors* including age (Credoc 2009, Wirth 2010, Andrade et al. 2011, Rutty & Scott 2014a), gender (Oliveira & Andrade 2007, Andrade et al. 2011, Rutty & Scott 2014a), and nationality (Morgan et al. 2000, Knez & Thorsson 2006 and 2008, Scott et al. 2008a, Knez et

al. 2009, Lin 2009, Lin et al. 2011, Oliveira & Andrade 2007, Moreno 2010, Andrade et al. 2011). *Destination choice* (i.e., the location of the holiday) is influenced by both the *holiday type* (Lohmann & Kaim 1999, Kozak 2002), as well as the tourists' *climate preferences* (Hamilton & Lau 2005, Moreno 2010). The destination chosen then influences *destination weather/climate expectations* (i.e., the weather/climate conditions the tourist expect at the chosen destination), which are well-formed given that the vast majority of tourists' gather weather information prior to their trip (Gamble & Leonard 2005, Hamilton & Lau 2005, Rutty & Scott 2010, Hübner & Gössling 2012, Rutty & Andrey 2013), as well as the prominence of weather and climate in marketing the image of destinations (Besancenot 1991, Perry 1993, Gomez-Martin 2005, Scott & Lemieux 2010). *Source region weather/climate* can also influence *destination weather/climate expectations* (e.g., seasonal expectations) (Nikolopoulou et al. 2001, Spagnolo & de Dear 2003, Lin 2009).

All of these preceding factors during the trip planning phase collectively influence the *evaluation of weather* during the trip itself (i.e., in situ acceptance and satisfaction with the weather conditions at the destination). *Perceived control* also influences the evaluation of weather, as it can markedly impact the perception and satisfaction of the weather conditions experienced (e.g., the ability to control thermal comfort by adjusting clothing and the outdoor activity or the ability to leave an outdoor area when the weather conditions become unsuitable) (Paciuck 1990, Nikolopoulou & Steemers 2003, Spagnolo & de Dear 2003, Lin 2009, Rutty & Scott 2014a). Based on a tourists' evaluation of weather, it can then influence the *behavioural response* to the weather. The response may be in situ and immediate, such as a verbal or emotional reaction (positive or negative) or physical movement (e.g., around the resort or destination, movement from outdoors to indoors) or the response to the weather may be ex-situ after returning home, influencing the decision on whether or not to return to the destination in the future.

It is important to note that this conceptual framework focuses exclusively on those factors that influence tourists' evaluation of weather and climate. There are other well established non-climate factors that influence holiday type and destination choice, including

social-psychological processes (e.g., motives, benefits sought, values, attitudes, images) and situational constraints (e.g., budget, time, cognitive distance, prior experience, knowledge) (Thompson & Cooper 1979, Spiggle & Sewall 1987, Woodside & Lysonski 1989, Um & Crompton 1990, Mansfeld 1992, Ankomah et al. 1996, Kemperman et al. 2000, Pearce 2005). This framework serves to encapsulate the complex relationships that influence tourists' evaluation of weather and climate resources and the important factors that need to be considered when analyzing tourists' climatic preferences and thresholds. The framework is conceptual, requiring further research to both confirm the relationships within the framework, as well as to further clarify the degree of influence each factor has on tourists' evaluation of weather and climate.

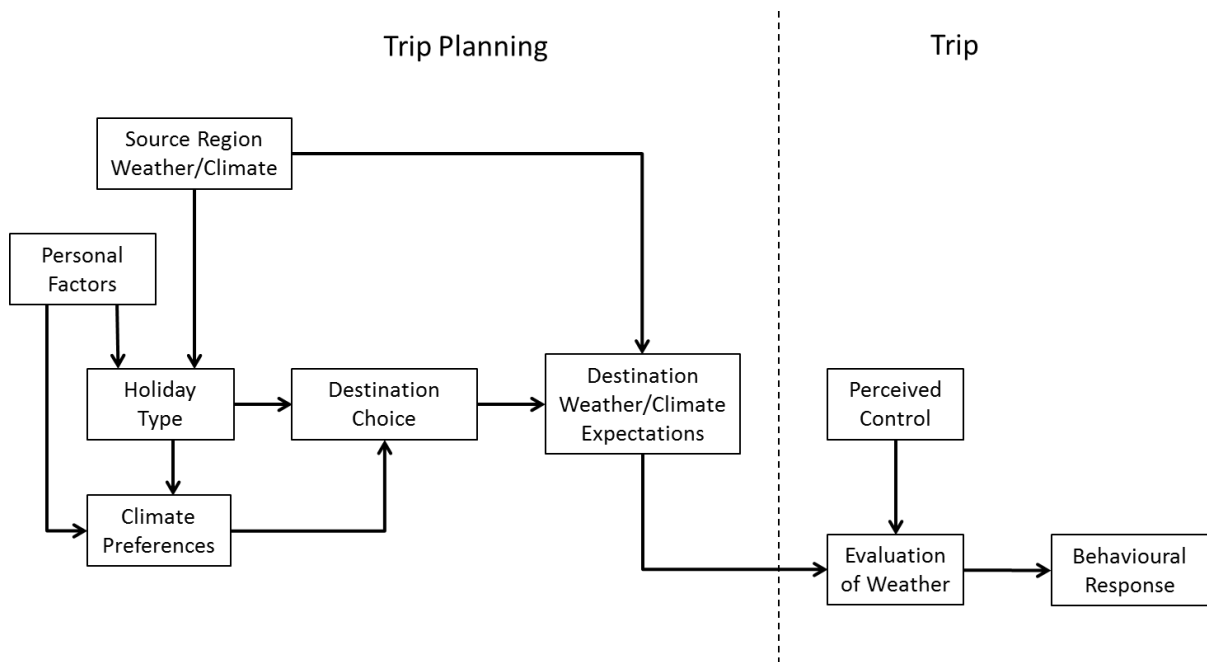


Figure 6-1 Conceptual framework to analyze tourists' climatic preferences and thresholds

6.2 Future Research

This study provides a comprehensive review of the growing literature on climate assessments for tourism, including those studies that have projected the impacts of climate change on global tourism demand patterns. Based on this synthesis, it is evident that the state

of the literature has improved markedly over the past decade, particularly with respect to the methodological approaches used for such assessments. Nevertheless, many of the studies make unsupported assumptions about tourists' climatic preferences and thresholds and thereby the resulting changes in future demand patterns are uncertain. While the empirical research presented here advances our understanding of these relationships, a number of uncertainties and research needs remain. Future research is needed to clarify in more detail the relationships within the conceptual framework (Figure 6-1).

This study did not find any differences among different age groups for ideal or unacceptable conditions for coastal tourism. However, Wirth's (2010) survey of German beach tourists found younger age groups prefer and are more accepting of warmer temperatures on average compared to older age groups, which is also supported by the findings of Credoc's (2009) survey of urban domestic tourists in France as well as Hewer and Scott's (2011) survey of overnight campers in Ontario (Canada) parks. Similarly, a survey by Andrade et al. (2011) found that in an urban park setting in Portugal, sensitivity to warmer summer temperatures decreased with age, with younger cohorts more likely to vote for a change in the thermal conditions than older age cohorts. Moreover, Limb and Spellman (2001) using qualitative interviews found suitable weather conditions for domestic UK travelers differed based on family status, with single professionals more resilient to a range of conditions than families with children.

In terms of gender, this study found females prefer to feel cooler on average than males, which is not supported by outdoor comfort studies in urban areas, whereby no preference differences have been recorded between males and females (Knez & Thorsson 2006 and 2008, Knez et al. 2009, Lin 2009, Oliveira & Andrade 2007, Andrade et al. 2011). This study also found no significant differences among tourists' from similar climatic regions (i.e., temperate nations), which contrasts with the tourism literature, with differences recorded among tourists' from Canada, Sweden and New Zealand (Scott et al. 2008a), as well as Austria, Germany, The Netherlands and Switzerland (Rutty & Scott 2010).

For the first time, tourists from climatically diverse origins were examined, with significant differences found. Tourists from tropical regions prefer cooler thermal conditions on average and are less tolerant of very warm thermal conditions, which is opposite to the survey findings of Lin (2009) and Lin et al. (2010), whereby Taiwanese people (i.e., humid region) in an urban park setting preferred warmer outdoor thermal conditions compared to people surveyed in urban parks in Portugal (Andrade et al. 2011). This difference is likely attributable to the fact that unlike the tourists from tropical region in this study (96% of whom live in the Caribbean) or the local residents in an urban park setting in Taiwan or Portugal, the tourists from temperate regions travelled long distances south to the Caribbean, investing a lot of time and money to experience thermal conditions that are significantly warmer than the winter conditions experienced at home (i.e., they paid for warmer temperatures and sunshine).

Overall, the above findings indicate that the interaction between climatic preferences and socio-demographics, including age, gender, and climatic region of origin, remains insufficiently understood. With only a handful of studies examining each socio-demographic variable, more studies are needed to ascertain detailed tourist weather sensitivities and preferences across broader tourism market segments and for specific tourism environments and activities.

Another important area for future research is to examine whether thermal comfort ratings, based on thermo-physiological indices (e.g., UTCI, PET) can be applied in other tourism environments. This study has found that acceptable thermal conditions, as currently defined in the human biometeorology literature, cannot be applied to coastal tourism without significant modification. Beach tourists' thermal preferences are markedly different than what has been reported for users of outdoor urban spaces. This may be similarly true for other major tourism environments, but without specific knowledge of what thermal conditions tourists' desire, this remains unknown. Complementary studies in other coastal environments, as well as in other key environments (e.g., urban, rural, mountain) are important avenues for future research.

This study has largely focused on the thermal component of climate, particularly as it relates to bioclimatic comfort. Global scale simulation models of tourism demand also focus on temperature as the proxy variable for climate (Maddison 2001, Lise & Tol 2002, Hamilton 2003, Hamilton et al. 2005, Bigano et al. 2006). However, tourists' respond to the combined effect of thermal, physical and aesthetic facets of climate (Table 2-1). Within a broad range of moderate to non-extreme thermal conditions, other factors may assume relatively greater importance in determining the pleasantness rating of a given weather or climate condition (de Freitas 2003). For a beach holiday, temperature was ranked second (Scott et al. 2008a, Moreno 2010) and third (Morgan et al. 2000, Rutty & Scott 2010) behind absence of rain (i.e., physical) and sunshine (i.e., aesthetic). Differences in the relative rankings have also been recorded for different tourism environments (Scott et al. 2008a, Rutty & Scott 2010, Hewer & Scott 2011), as well as between national samples (Morgan et al. 2000, Scott et al. 2008a) and within national samples (Credoc 2009, Hewer & Scott 2011). The physical facet has also been found to have an overriding influence on the thermal and aesthetic facets, with rain negatively impacting daily tourism demand at the beach, both during and after the event (de Freitas 1990, Moreno et al. 2009). It is important that future studies incorporate these considerations and examine the influence of multiple climatic variables in tourists' decision-making.

The influence of expectations on how climatic parameters are evaluated and perceived is another important area for future research. Psychological adaptation suggests that the way in which a person perceives the environment, and thereby their satisfaction with the climatic conditions, is a result of one's expectations (i.e., what the weather should be like rather than what it actually is) (Nikolopoulou & Steemers 2003). This is particularly important for international tourism, where traveler's expectations of a destination, whether well- or ill-informed, may strongly influence relative satisfaction with conditions experienced, impacting whether a tourist returns to the destination in the future (Pearce 2005, Denstadli et al. 2011, Becken & Wilson 2013). Expectations may vary based on socio-demographic factors, as well as whether one is travelling domestically or internationally

(e.g., Canadians travelling to a domestic beach in the summer versus Canadians travelling to the Caribbean in the winter). Different forms of holidays, such as daytrips, short trips, main annual holiday, or the ‘once-in-a-lifetime’ trip may also influence expectations, as weather will impact differently on a trip with a high degree of commitment and planning prior to the travel compared to a spontaneous day trip (Hall 2005). Also, depending on the type and length of trip, there may be varying degrees of resilience to climatic conditions, especially with respect to the degree that climatic extremes may be tolerated (Scott & Lemieux 2010).

The contextual influence of weather conditions at the time when tourists are being surveyed, has yet to be sufficiently explored as a source of preference and threshold differences among stated preference studies. This is true for both in situ and ex-situ studies. In the former case, if a tourist is feeling warm/hot at the time of the survey, their stated thermal preferences and thresholds may be lower and their wind preferences may be higher. The opposite may be true when surveying a tourist who is feeling cool/cold. In the latter case, if a tourist is filling out the survey during the winter/summer season, they may similarly state their thermal preferences and thresholds as higher/lower. Or if a tourist is experiencing a long dark winter, the importance of the aesthetic facet (i.e., sunshine, day length) may be higher than it would otherwise be in the spring, summer or fall. Future studies that account for seasonality and the climatic conditions at the time of study are warranted to quantify this influence.

It is also unclear to what degree tourists are able to accurately estimate temperatures or other weather parameters either in situ or ex-situ. This relates to both single parameters, such as temperature, and whether tourists can distinguish the influencing effect of other parameters, such as the cooling effect of wind and cloud cover on temperatures felt. This is of importance as it is generally expected that there is a linear relationship between increasing temperatures and changing travel flows (Maddison 2001, Lise & Tol 2002, Hamilton 2003, Hamilton et al. 2005, Bigano et al. 2006). Gössling and Hall (2006a) also question whether a tourist is capable of interpreting a 1°C temperature increase in terms of comfort. Even if tourists are capable of interpreting a 1°C temperature increase, the research presented in this

study has shown that tourists can find thermal relief up to 4°C within a coastal resort setting by relocating, raising further questions with respect to the linear relationship of moderate temperature increases. Consequently, it would be essential to carry out further studies to better understand the role of such complexities and the projections of existing studies with respect to altered geographic distribution of tourism demand (Gössling et al. 2012, Scott et al. 2012b).

Future investigations are also necessary to provide more comprehensive information on microclimates that tourist experience. Given that microclimates are affected by the topographical situations of a location, additional research is needed to provide a more representative estimate of the available microclimates in which tourism activities take place. Existing climate change assessments are based on either distant weather stations or even coarser gridded or nationally averaged climate data (Maddison 2001, Scott & McBoyle 2001, Lise & Tol 2002, Scott et al. 2004, Hamilton et al. 2005, Bigano et al. 2006, Amelung & Viner 2006, Amelung et al. 2007, Nicholls & Amelung 2008, Hein et al. 2009, Moore 2010, Perch-Nielsen et al. 2010, Ruttly & Scott 2010). A limited number of studies have confirmed that the weather conditions of the nearest meteorological station do not present an accurate reflection of the microclimates tourists encounter at beaches and urban resorts (Höppe 1991, Hartz et al. 2006) and this study has shown that thermal conditions can vary on a property scale. Collecting microclimate data and examining property/destination scale adaptive range across broader tourism market segments, as well as for a range of destination attractions, will provide valuable information that can improve current climate change assessments.

6.3 Concluding Remarks

The research presented here advances our understanding of the complex relationship between personal and meteorological parameters that influence tourists' climatic preferences and thresholds for coastal tourism. However, given the socio-cultural and geographic factors that are involved, assessing weather and climate as a resource for tourism has only been partially quantified on a destination and tourism environment-specific basis. While our

knowledge may be imperfect, the body of literature on climate and tourism continues to grow. In so doing, important knowledge gaps are highlighted, drawing attention to the opportunities to bridge different methodological approaches and disciplines. This study has drawn together a number of scholarly fields that are working toward a similar objective—understanding and evaluating human climatic preferences and thresholds, including geography, tourism, biometeorology, climatology, health studies, psychology, engineering, architecture and planning. This multidisciplinary perspective provides vital new insights and is recommended as the way forward to define ideal and unacceptable climatic conditions for tourism. This underscores the current missed opportunity for scholars to better communicate and collectively advance our understanding of human-climate relationships when it is most needed to adapt to the multifaceted challenges of anthropogenic climate change.

Appendix A: Survey Instrument



Weather & Climate Tourism Survey

This letter is an invitation to participate in a study being conducted by researchers at the Interdisciplinary Centre on Climate Change (IC3) at the University of Waterloo, Canada. Over the past few years the potential for climate change to negatively impact the tourism industry in the Caribbean has been widely discussed. To gain a better understanding of how sensitive Caribbean tourism is to climate change, it is necessary to better understand weather sensitivity of tourism in the region.

Your participation in this study is entirely voluntary and would involve completing a short survey. The survey would take approximately 5-10 minutes of your time. You may decline to answer any of the questions. The survey is completed anonymously and your responses will be summarized with those of hundreds of other tourists. The completed surveys will be securely stored in a locked office accessible only to the research team, and will be retained for 3 years, upon which the surveys will be shredded.

If you have any questions or would like additional information about the study to assist you in reaching a decision about participation, you may contact my supervisor, Dr. Daniel Scott at (519) 888-4567 ext. 35497, dj2scott@uwaterloo.ca. This study has received ethics clearance from the Office of Research Ethics at the University of Waterloo which can be contacted at (519) 888-4567 ext. 36005, ohrac@uwaterloo.ca.

Your opinions are very much appreciated. Thank you in advance for your assistance with this survey.

Sincerely,

Michelle Rutty
mkrutty@uwaterloo.ca



Date: _____ Time: _____ Location: _____

Code: _____

SECTION 1: Current Weather Conditions

1. What does the current **temperature** feel like to you right now? _____°C or ____°F
2. Is the current **temperature** what you expected for your Caribbean beach holiday?
 Yes No I didn't have any expectations
If NO, were you expecting the temperature to be:
 cooler slightly cooler slightly warmer warmer
3. Right now would you say you feel:
 cold cool slightly cool Indifferent/Neutral slightly warm warm
 hot
4. Right now would you prefer to feel:
 cooler slightly cooler no change slightly warmer warmer
5. What does the current **wind** conditions feel like to you right now?
 no wind light breeze moderate breeze strong wind very strong wind
6. Is the current **wind** condition what you expected for your Caribbean beach holiday?
 Yes No I didn't have any expectations
If NO, were you expecting the wind to be:
 weaker slightly weaker slightly stronger stronger
7. Right now would you prefer the **wind** to be:
 weaker slightly weaker no change slightly stronger stronger
8. How would you rate the current weather conditions for your Caribbean beach holiday?

	Very Unacceptable	Unacceptable	Slightly Unacceptable	Neutral	Slightly Acceptable	Acceptable	Very Acceptable
Temperature	1	2	3	4	5	6	7
Wind	1	2	3	4	5	6	7

SECTION 2: Climatic Preferences

1. Please circle the temperature(s) that are **IDEAL** for a Caribbean beach holiday (in °C or °F).
 15°C 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45°C
 60°F 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114°F
2. Please circle the temperature(s) that are **unacceptably HOT** for a Caribbean beach holiday
 ...**OR** if all temperatures are acceptable for a beach holiday then *check this box*
 15°C 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45°C
 60°F 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114°F

3. Please circle the temperature(s) that are **unacceptably COOL** for a Caribbean beach holiday ... **OR** if all temperatures are acceptable for a **beach** holiday then *check this box* .

15°C 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45°C
60°F 62 64 66 68 70 72 74 76 78 80 82 84 86 88 90 92 94 96 98 100 102 104 106 108 110 112 114°F

4. What are the **ideal** daily rain conditions for a Caribbean beach holiday? (*Check one box*)

- No rain
- Little rain (15 minutes or less)
- Some rain (30 minutes - 2 hours)
- Moderate rain (2 - 4 hours)
- A lot of rain (more than 5 hours)

5. What are the **unacceptable** daily rain conditions for a Caribbean beach holiday? (*Check all that are unacceptable*)

- No rain
- Little rain (15 minutes or less)
- Some rain (30 minutes - 2 hours)
- Moderate rain (2 - 4 hours)
- A lot of rain (more than 5 hours)

6. What are the **ideal** wind conditions for a Caribbean beach holiday? (*Check one box*)

- No wind
- Light breeze (1-9 km/h or 1-6mph)
- Moderate wind, when sand begins to be blown around (10-40 km/h or 6-25mph)
- Strong wind (41-60 km/h or 26-37mph)
- Very strong wind (61-90 km/h or 38-56mph)

7. What are the **unacceptable** wind conditions for a Caribbean beach holiday? (*Check all that are unacceptable*)

- No wind
- Light breeze (1-9 km/h or 1-6mph)
- Moderate wind, when sand begins to be blown around (10-40 km/h or 6-25mph)
- Strong wind (41-60 km/h or 26-37mph)
- Very strong wind (61-90 km/h or 38-56mph)
- All wind conditions are acceptable

8. What are the **ideal** sky conditions for a Caribbean beach holiday? (*Check one box*)

- 0% cloud
- 25% cloud
- 50% cloud
- 75% cloud
- 100% cloud

9. What are the **unacceptable** sky conditions for a Caribbean beach holiday? (*Check all that are unacceptable*)
- 0% cloud
 - 25% cloud
 - 50% cloud
 - 75% cloud
 - 100% cloud
 - All cloud conditions are acceptable

SECTION 3: Weather Information & Trip Planning

1. Did you look up weather/climate conditions for this destination when planning this holiday?

Yes No

If YES:

At what stage did you gather weather/climate information? (*Check all that apply*)

- Before booking transport tickets and/or accommodations
- After booking transport tickets and/or accommodations
- During my holiday

Where did you gather weather/climate information? (*Check all that apply*)

- TV weather channels
- Radio
- Newspapers
- Weather service webpages (e.g., Government or weather channel)
- Destination webpages
- Tourism guidebooks, magazines, brochures, etc.
- Family, friends, co-workers, etc.
- Travel agent
- Telephone weather information source
- Other: _____

2. How important are the following weather forecast elements when planning your trip?
 (Please circle your answer along this 5-point scale for each statement)

	Not Important	A Little Important	Somewhat Important	Very Important	Extremely Important
High Temperature	1	2	3	4	5
Low Temperature	1	2	3	4	5
Average Temperature	1	2	3	4	5
Time of day the high temperature will occur	1	2	3	4	5
“Feels like” temperature (e.g. heat index, heat stress, humidex)	1	2	3	4	5
Chance of precipitation	1	2	3	4	5
Amount of precipitation	1	2	3	4	5
Time of day the precipitation will occur	1	2	3	4	5
Wind speed	1	2	3	4	5
Relative Humidity	1	2	3	4	5
Sky conditions (cloud cover)	1	2	3	4	5
Visibility	1	2	3	4	5
UV index	1	2	3	4	5
Sunrise/Sunset (day length)	1	2	3	4	5

SECTION 4: About You

1. Are you: (Please check one box): Male Female
2. Where do you live? City: _____ Country: _____
3. What year were you born?: _____
4. Approximately how long have you been outside?
 <15min 16-30min 31min-1hour > 1hour
5. Is this your first holiday to the Caribbean? Yes No
 If NO, how many times have you holidayed in the Caribbean (including this trip)? _____
6. How many people are travelling with you? _____

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