Comparing the ‘Tourism Climate Index’ and ‘Holiday Climate Index’ in Major European Urban Destinations

by

Mantao Tang

A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Master of Environmental Studies
in
Geography - Tourism Policy and Planning

Waterloo, Ontario, Canada, 2013

AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this 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.

Abstract

Tourism is one of the largest economic sectors globally. It is a climate sensitive sector, with climate being one of the most important attributes for a destination. The Tourism Climate Index (TCI), developed by Mieczkowski (1985), is the most widely used index for assessing a destination's climatic suitability for general tourist activities. Major deficiencies such as the subjectivity of its rating system and component weightings have been identified in the literature, and the need to develop a new index has been identified by researchers for almost a decade. This study aims to fill the research gap by developing a new index, the Holiday Climate Index (HCI), for the purpose of overcoming the deficiencies of the TCI. The HCI was compared with the TCI in rating both current (1961-1990) and future (2010-2039, 2040-2069 and 2070-2099) climatic suitability for tourism of the 15 most visited European city destinations (London, Paris, Istanbul, Rome, Barcelona, Dublin, Amsterdam, Vienna, Madrid, Berlin, Stockholm, Warsaw, Munich, Athens and Venice). The results were also compared with monthly visitation data available for Paris to assess whether the HCI ratings more accurately represent visitation demand than the TCI. The results show that there are key differences between the HCI and TCI in rating the tourism climate suitability of the selected European city destinations, in particular in the winter months of the northern, western and eastern European city destinations where the performance of the TCI had been questioned in the literature. The comparison with leisure tourist visitation data in Paris also revealed that the ratings of the HCI were more reflective of seasonal pattern of tourist arrivals than the TCI ratings. Because the TCI has been widely applied (15 studies), these findings hold important implications for future research in assessing current and future climatic suitability for tourism.

Keywords: Climatic Suitability for Tourism; Climate Index for Tourism (TCI); Holiday Climate Index (HCI); Urban Tourism

Acknowledgements

There are a lot of people I want to thank during the past two years of my graduate study. Without them, I could not complete this long journey and fulfill my one of the dreams in my life. First and foremost, I want to thank the most important person in this whole research experience, my advisor, Dr. Daniel Scott. I thank him for his patience, expertise and insightful guidance during the entire graduate research in leading me through this journey. Words cannot express my sincere gratitude to him. Second, I want to take this opportunity to thank another important person in this research process, Dr. Bas Amelung (Wageningen University) who provided the climate data and assisted with climate change modeling. Without his help and expertise in climate change, this research project could not being conducted and carried out so smoothly. Third, I want to take this opportunity to thank Dr. Jean Andrey and Dr. Peter Johnson for being in my committee. Finally, I also want to thank all my family and friends who gave me constant support for the past two years and to walk with me with courage and confidence through the whole period.

Dedication

This thesis is dedicated to my parents.

Thank you for your unconditional love and support.

Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Study Context

Tourism has become one of the largest global economic sectors in the world and contributes significantly to national and local economies (United Nations World Tourism Organization [UNWTO] 2009). As one of the largest industries in the world, tourism is directly responsible for an estimated 5% of the world's gross domestic product (GDP), 6% of total exports, and one out of every 12 people employed worldwide (UNWTO 2012a). The latest UNWTO report forecasted that international tourism will reach a historic level of one billion arrivals in 2012 and that, in a single year, one seventh of the world's population will cross international borders for tourism purposes (UNWTO 2012a). Among all regions, Europe was most visited by international tourists in 2011, accounting for 51% (503 million) of the total worldwide inbound tourists (UNWTO 2012a). Countries in Europe also dominate the top places in the travel and tourism competitiveness ranking, which measures the attractiveness of developing business in the travel and tourism industry of individual countries, with all top five places taken by European countries and 14 of the top 20 countries from the region (World Economic Forum 2011). When exploring what motivates tourists to visit Europe, climate has been revealed to be one of the main reasons for tourists to visit the region, in particular to travel to the Mediterranean region (Hu and Ritchie 1993, Moreno 2010).

The close relationship between climate and tourism has been explored extensively, in particular the influence of climate on tourist motivation and destination choice (Mintel 1991, Ryan and Glendon 1998, Wilton and Wirjanto 1998, Maddison 2001, Elsasser and Burki 2002, Lise and Tol 2002, Fukushima et al. 2002, Burki et al. 2005, Hamilton 2005, Hamilton and Lau

2005, Agnew and Palutikof 2006, Gossling et al. 2006, Shih et al. 2009 and Scott and Lemieux 2010) and the impact of climate on destination attractiveness (Mayo 1973, Gearing et al. 1974, Ritchie and Zins 1978, Hu and Ritchie 1993, Wall and Badke 1994, Lohmann and Kaim 1999). Climate has a significant influence for tourists' decision-making process, and it is a key factor considered by the tourists either explicitly for the purpose of travel planning or as a primary motivator (Scott et al. 2012). For many, climate is one of the main reasons to travel (Mintel 1991, Ryan and Glendon 1998, Maddison 2001, Lise and Tol 2002, Hamilton 2005, Hamilton and Lau 2005, Gossling et al. 2006 and Scott and Lemieux 2010). The influence of climate on tourists' decisions of where to travel has a subsequent effect on tourist destination choice and expenditures, in particular for climate-dependent destinations (Wilton and Wirjanto 1998, Elsasser and Burki 2002, Fukushima et al. 2003, Burki et al. 2005, Agnew and Palutikof 2006, Shih et al. 2009).

Climate is a free and renewable primary resource in attracting tourists to a destination (Gomez-Martin 2005, Scott et al. 2012). Climate as an important nature resource for destinations plays a key role in determining the attractiveness of a destination to tourists, as climate has been rated as either the most influential factor (Ritchie and Zins 1978, Wall and Badke 1994) or one of the most important attributes that influence destination attractiveness (Mayo 1973, Gearing et al. 1974, Hu and Ritchie 1993, Lohmann and Kaim 1999).

Climate change is considered "the defining challenge of our generation" by some high-level decision makers in government and business (United Nations Environment Programme 2008, p.14). The National Oceanic and Atmospheric Administration (NOAA) (2012a) revealed that:

The year 2012 was the 10th warmest year since records began in 1880. The annual global combined land and ocean surface temperature was 0.57°C (1.03°F) above the 20th century average of 13.9°C (57.0°F). This marks the 36th consecutive year (since 1976) that the yearly global temperature was above average. Including 2012, all 12 years to date in the 21st century (2001–2012) rank among the 14 warmest in the 133-year period of record.

The impacts of climate change also have been observed on mountain glaciers, snow cover and sea levels (NOAA 2012b). When exploring the shrinking of the sea ice in Arctic, the NOAA (2012) revealed that:

> Arctic summer sea ice is shrinking much more rapidly than the rate at which Antarctic winter sea ice is expanding. Over the 1979-2012 record, the Arctic has experienced significant ice loss, while the growth of Antarctic sea ice has been slight.

The IPCC has also predicted that it is 'very likely' (>90% probability) that warmer and more frequent hot days and nights in late 20th century will occur, and extreme events such as heat wave and heavy precipitation will continue to become more frequent. The IPCC (2007b) has predicted the heat wave will become more intense and longer lasting in the future.

Climate change has become "one of the most important challenges to tourism in the 21st century" (UNWTO 2008, p.38). For the tourism sector, the impact of climate change was claimed to pose a greater risk than the threat of terrorism (Rashid and Robinson 2010). For destinations, "the impacts of climate change on tourism are anticipated to be widespread, with no destination unaffected" (Scott et al. 2012, p.190). There are four broad categories of climate change impacts on tourism destinations, including direct climatic impacts, indirect environmental change impacts, impacts of mitigation policies on tourist mobility and indirect societal change impacts (UNWTO 2008). The UNWTO (2008) identified five destination vulnerability hotspots that are most at-risk for the mid- to late-21st century, including the Caribbean, the Mediterranean region, Australia/New Zealand, small nation islands in the Pacific Ocean and Indian Ocean.

In Europe, the impacts of climate change were predicted to negatively affect nearly all European regions including southern, northern, central and eastern Europe (IPCC 2007a). The predicted changes of European climate conditions could also have a major impact on some of the top European tourist destinations. A number of studies revealed that a major improvement in climatic conditions was expected in the summer months of northern Europe and the shoulder seasons (spring and fall months) of the Mediterranean region, while climate conditions of the summer months were projected to deteriorate in the Mediterranean (Morgan et al. 2000, Hamilton et al. 2005, Amelung and Viner 2006, Amelung et al. 2007, Hein 2007, Nicholls and Amelung 2008, Amengual et al. 2010, Perch-Nielsen et al. 2010, Rutty and Scott 2010).

Due to the close link between climate and tourism sector and the impacts of climate variability on many facets of tourism sector, reliable climate information is useful for all stakeholders involved in the sector (Scott and Lemieux 2010 and Becken et al. 2010). Scott and Lemieux (2010) revealed that the use of climate information within the tourism sector is tremendous and identified three major users of climate information in the sector, including tourists, tourism developers (operators and destinations), government agencies. For tourists, local weather forecast at their intended destination and weather information along the way are useful, in particular for business travelers; for tourism developers, historical climate information is useful for strategic planning of tourism infrastructure; for government agencies, climate information is useful to assist tourism sector to assess risk of climate change and manage potential natural disasters (Scott and Lemieux 2010). Efforts have been devoted to assess climate as a resource, in particular to assess climate suitability for tourism development. With the emergence of the mass tourism industry in the 1950s, there was a need for a human-oriented climate assessment tool which could satisfy the needs of temporary visitors interested in climatic conditions during specific times of the year (Mieczkowski 1985). The assessment of climate resources for tourism purposes was dominated by two major approaches: generalized approaches that "portrayed climate for tourists in simple descriptive terms" and numerical indices (de Freitas 2003, p.50). The concept of devising numerical climate indices specifically for tourism purposes was considered as more appropriate for assessing a destination's climatic suitability for tourism, because climate as a tourism resource is multifaceted and involves a complexity of weather variables (de Freitas et al. 2008). The purpose of developing multi-faceted numerical indices for assessing tourism climate, is to facilitate a holistic interpretation of destination climate and facilitate objective comparisons among destinations.

The first attempt to develop a numerical index for evaluating climate for tourism purposes was by Mieczkowski (1985) who designed the 'Tourism Climate Index' (TCI). The purpose of the TCI was to present a quantitative composite measure to evaluate the world's climate for general tourism activities by integrating all climatic variables relevant to tourism into a single index (Mieczkowski 1985). A total of seven climatic variables were used to form five main sub-indices in the TCI's calculation including: 1) daytime comfort index (CID) - combination of maximum daily temperature (ºC) and minimum daily relative humidity (%); 2) daily comfort index (CIA) – combination of mean daily temperature (ºC) and mean daily relative humidity (%); 3) precipitation (mm); 4) sunshine (hrs); and 5) wind (km/h or m/s). The TCI has been the most widely applied index for assessing climate suitability for tourism over the past 25 years (Scott et al. 2012). The TCI has been used to assess the current climate suitability and future climate changes for many individual destinations as well as with geospatial data for the entire world (Scott and McBoyle 2001, Scott et al. 2004, Amelung and Viner 2006, Amelung et al. 2007, Hein 2007, Cengiz et al. 2008, Nicholls and Amelung 2008, Moreno and Amelung 2009, Farajzadeh and Matzarakis 2009, Hein et al. 2009, Roshan et al. 2009, Yu et al. 2009a and 2009b, Perch-Nielsen et al. 2010, Whittlesea and Amelung 2010).

Despite the TCI's wide application, it has been criticized by several authors. The identified deficiencies of the TCI focus on three main areas. First, the TCI's rating system of climatic variables and its weightings of components are subjective, as they were designed solely based on Mieczkowski's (1985) own expert opinion and the limited available biometeorological literature at the time. No validation with tourists' preferences of climatic conditions on secondary tourism data was undertaken (de Freitas et al. 2004, 2008). Second, no overriding effects of physical facets (e.g. rain, wind) were taken into account in the TCI's calculation (de Freitas et al. 2004, 2008). Physical facets like strong rain and wind could override otherwise suitable thermal and aesthetic facets in influencing tourist overall climatic comfort. Third, the original TCI has a low temporal resolution, as monthly average climatic data was all that was widely available to Mieczkowski in the early 1980s (Scott et al. 2004, de Freitas et al. 2008, Yu et al. 2009a and 2009b, Perch-Nielsen et al. 2010).

1.2 Research Needs and Expected Outcomes

Despite its recognized limitations, the TCI has been the most widely used index in assessing a destination's climatic conditions since its introduction in 1985. A more conceptually sound index, which can overcome the identified deficiencies of the TCI, has been called for by de Freitas (2003), Scott et al. (2004), de Freitas et al. (2008) and Denstadli et al. (2011).

This study introduces a new index, the Holiday Climate Index (HCI), that is designed to overcome the above mentioned limitations of the TCI and is consistent with the design principles set out by de Freitas et al. (2008). It will be used to first assess tourism climatic suitability for some of the top-visited European destinations. It will also be compared with the original TCI to determine if there are substantial differences in relative rating of climate resources between the HCI and TCI. The broad ratings of the two indices are also compared against available tourism demand data to evaluate validity in the market place. No previous study has compared the ratings of different tourism climate indices for the same study areas with the same climatic data to examine whether conceptual improvements result in different and more accurate climate ratings.

The outcomes of this study are expected to offer several contributions to the research field. First, this research will advance the growing literature of tourism climate index studies by designing a new index, based on recent literature on the climate preferences of tourists, to assess climatic suitability for general tourism activities in urban destinations. Second, this thesis is expected to advance the research area by providing the first comparison between two conceptually different tourism climate indices. This comparison will reveal how the differential treatment of individual variables (e.g. overriding variables) affects rating outcomes. In addition, the development of the new tourism climate index provides benefits in particular for the decision makers of the tourism sector, as appropriate use of climate information about past, present and future climate can help individuals make proper decisions (World Meteorological Organization 2009).

1.3 Study Goals and Objectives

This thesis is expected to fulfill some of the research needs identified in the literature above by exploring whether there is a meaningful difference in ratings among different tourism climate indices when applying the same climatic data. The main goal of this thesis is to conduct the first known inter-comparison study to evaluate whether improvements in the construction of the HCI results in appreciably different and more accurate ratings than the TCI by assessing current climatic conditions (1961-1990) of 15 climatically diverse European cities (including London, Paris, Istanbul, Rome, Barcelona, Dublin, Amsterdam, Vienna, Madrid, Berlin, Stockholm, Warsaw, Munich, Athens and Venice) (Figure 1.1). The future climatic conditions of the selected European cities, as projected by ECHAM5 Global Climate Model (GCM) under the SRES A1B greenhouse gas (GHG) emission scenario for the 2020s (2010-2039), 2050s (2040-2069), 2080s (2070-2099), will also be examined. In order to achieve the main research goal, four objectives have been formulated for this study:

1) Develop a new climate index for tourism purpose that overcomes the limitations of the TCI.
2) Compare the HCI with the TCI to examine what spatial and temporal differences result in the rating of climate for tourism across a sample of 15 leading European urban destinations.
3) Compare the HCI and TCI scores against visitation data to see whether the HCI has a more accurate performance in rating of climatic suitability for tourism.
4) Compare the HCI findings to previous TCI-based analyses of the impacts of climate change on climate resources for tourism in Europe to determine whether any different spatial or temporal patterns emerge.

Figure 1.1 Map of Europe with 15 Urban Destinations Selected for This Study

Source: worldatlasbook.com (2011)

1.4 Structure of Thesis

The thesis has been organized into five chapters: Introduction, Literature Review, Methods, Results, and Discussion and Conclusions. Chapter one explains the study context, research needs and the research goal and objectives. Chapter two presents a review of past studies discussing the interrelationship between climate and tourism, the climate information utilized by tourists, and the application of the Mieczkowski's Tourism Climate Index (TCI). Chapter three describes the newly designed Holiday Climate Index (HCI) and the method used for conducting this study. Chapter four presents the key results for the HCI and index-intercomparison. Chapter five and six discuss how the research objectives have been met by exploring the contributions of this research to the study area of tourism climate indices, and presents some recommendations for future research on the assessment of climatic suitability for tourism.

Chapter 2

Literature Review

2.1 Introduction

This chapter focuses on reviewing the literature related to the relationship between climate and tourism and the development and application of climate indices for tourism. The chapter is divided into four sections: climate and tourism, tourist climatic preferences, assessment of tourism climatic suitability and climate change. The first section discusses the interrelationship between climate and tourism, including climate and destinations attractiveness, climate as tourist motivation, seasonality and relationship between climate and tourist flow and expenditures. The second section presents an overview of the literature of tourist climatic preferences that were obtained by three research approaches: expert-based, revealed and stated approach. The third section focuses on reviewing the application and criticisms of the most widely used index, the Mieczkowski's Tourism Climate Index (TCI). The fourth section describes the impacts of climate change in the tourism sector, in particular on European destinations.

2.2 Climate and Tourism

Tourism has a multifaceted and highly complex relationship with climate, and it is widely agreed that climate plays an important role in influencing many facets of the tourism sector (Gomez-Martin 2005, Scott and Lemieux 2010, Becken and Hay 2012, Scott et al. 2012). All tourism sectors and products are weather/climate sensitive to a degree and climate acts both as a resource and a limiting constraint for tourists' activities, tourism operations and destination development (Scott et al. 2012). The importance of climate to the tourism sector is reflected from its influence on destination attractiveness, tourists' decision-making process, length of holiday season and tourists' flow and expenditures.

2.2.1 Climate and Destination Attractiveness

From the perspective of tourism supply, climate has been identified as an important natural resource for the tourism sector (Hu and Ritchie 1993, de Freitas 2003, Gomez-Martin 2005, Scott et al. 2012). Some of the key characteristics of climate as a tourism resource include: it is free, renewable and non-degradable, as well as cannot be transported or stored (Gomez-Martin 2005). Three climate facets, the thermal, physical and aesthetic components were defined by de Freitas (2003) as comprising climate resources for tourist destinations. The thermal component relates to the thermal comfort of tourists; the physical component includes precipitation and wind, and may act as limiting factor for tourist activities, but is necessary for others. The aesthetic component includes sunshine, cloud cover, fog and sky color. However, climate is not always a beneficial resource for destinations, it may also act as a constraint, as the distribution of climate resources vary seasonally and is not homogeneous across earth surface (Andriotis 2005 and Gomez-Martin 2005).

The close relationship between climate and a destination's level of attractiveness to tourists has been revealed by many studies (Mayo 1973, Gearing et al. 1974, Ritchie and Zin 1978, Hu and Ritchie 1993, Wall and Badke 1994, Lohmann and Kaim 1999, Kozak 2002 and Moreno 2010). A destination's overall attractiveness was regarded as 'pull' factors which generally include the tangible characteristics such as climate, accommodation, historical and cultural resources (Crompton 1979). Climatic variables, such as sunshine and temperature, were regarded as important 'pull' factors for attracting tourists to travel to a specific destination (Dann 1981). Several studies revealed that climate is one of the main destination attributes to influence destination attractiveness (Mayo 1973, Gearing et al. 1974, Hu and Ritchie 1993, Lohmann and Kaim 1999). Mayo (1973) conducted a nationwide survey in the US to determine auto travelers' attitudes toward a holiday. The results from the survey revealed that climate is one of the most critical criteria respondents use in evaluating destination attractiveness along with scenery and price. Hu and Ritchie (1993) conducted a survey in western Canada to examine the relative importance of touristic attributes in contributing to the attractiveness of a selection of five destinations (Hawaii, Australia, Greece, France and China) in regard to two different types of vacation experiences – recreational and educational experiences. The survey results showed that climate is among the four most important attributes for destination attractiveness for a recreational vacation experience. Another study on destination attractiveness was conducted by Lohmann and Kaim (1999), the surveys revealed that weather factor is particularly important to the attractiveness of a destination for Germans. In addition, Gearing et al. (1974) examined industry experts' opinions on what the determined factors are for destination attractiveness. The industry experts from the Turkish government also revealed that natural beauty and climate are the two most important factors for a region's touristic attractiveness. The study of Wall and Badke (1994) also assessed whether climate is a major determinant of destination attractiveness in any given country by sending letters to 192 government tourism and meteorological organizations. The findings revealed that the majority (81%) of respondents felt that climate is a major tourism determinant for a country's tourism attractiveness.

Furthermore, some studies have claimed that climate is the most important factor in determining destination attractiveness (Ritchie and Zin 1978, Wall and Badke 1994, Kozak 2002, Moreno 2010). Ritchie and Zin (1978) conducted mailed questionnaires in Quebec, Canada, to assess the relative importance of criteria in influencing the overall attractiveness of a tourism region. The results revealed that the criterion ‘natural beauty and climate’ is the most important determinant of the attractiveness for Quebec. In the study of Kozak (2002), weather was revealed as the most powerful destination attribute to attract tourists for summer vacation; and countries with good climate being very attractive for outdoor activity seekers. Another study by Moreno (2010), focused on obtaining tourists’ views of the Mediterranean region by conducting surveys on people traveling to the region. The study revealed that out of total 14 attributes, climate was considered by the majority of respondents (61%) as the attribute contributing the most to the attractiveness of the region.

2.2.2 Climatic Motivation

Since climate forms an important part of destination attractiveness, tourists’ choice of where to travel is the result of a decision-making process which is closely linked to a destination’s overall attractiveness and its image (Hamilton and Lau 2005, Scott and Lemieux 2010). Climate was revealed to be an important motivator and plays a key role in motivating tourists to travel during key stages of the travel decision making process (Dann 1981, Mintel 1991, Ryan and Glendon 1998, Morgan et al. 2000, Limb and Spellman 2001, Maddison 2001, Kozak 2002, Lise and Tol 2002, Bansal and Eiselt 2004, Hamilton 2005, Hamilton and Lau 2005, Bigano et al. 2006, Gossling et al. 2006, Eugenio-Martin and Campos-Soria 2010, Scott et al. 2008). Crompton’s (1979) ‘push’ and ‘pull’ model revealed that climate represents both a ‘push’ and ‘pull’ factor in motivating tourists to take holiday. Mintel (1991) claimed that 73% of respondents to a UK survey specified ‘good weather’ as the main reason to travel. Ryan and Glendon (1998) also analyzed the relative importance of holiday motivations on British holidaymakers, and found that all respondents rated ‘nice’ climate as an important factor. Limb and Spellman (2001) conducted the research for revealing how tourists’ decisions can be affected by climate conditions, especially focusing on those affected by their own climate perceptions for the planned holiday destinations. Their study used a qualitative methodology of in-depth discussion groups to investigate the importance of tourist memories and experiences in relation to climate. The findings showed that people sometimes can be affected by their own perceptions of climate, even they have very ambivalent attitudes towards weather conditions, and their decisions would change dramatically according to the changes in their perceived destination climate. The importance of climate on tourists' destination choice is also supported by several multivariate analyses of tourist arrival data (Maddison 2001 and Hamilton et al. 2005).

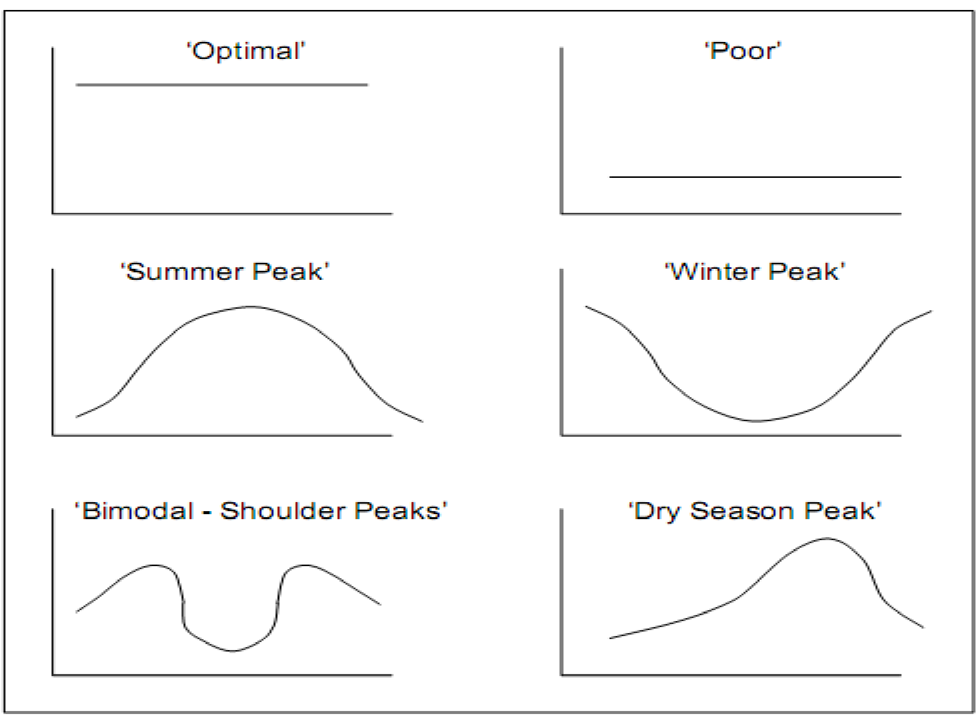
In addition, several studies (Bansal and Eiselt 2004, Hamilton and Lau 2005, Gossling et al. 2006, Scott et al. 2008 and Gossling et al. 2012) used surveys and interviews to reveal from tourist perspective of how climate acts as an influential factor in tourist decision making process. Bansal and Eiselt (2004) conducted surveys in the Province of New Brunswick in Canada to discuss what factors influencing tourist decision-making. The survey results showed that climate was one of the five major motivators for tourists to taking a trip. In the surveys conducted by Hamilton and Lau (2005) in Hamburg Airport in Germany, climate was ranked by the respondents as the most popular factor. The tourist perceptions of climate change and the importance of climate for travel decisions were explored by Gossling et al. (2006) by conducting interviews on tourists traveling in three major tourism areas in Zanzibar, Tanzania: Stonetown, the North of Zanzibar and the East Coast. Specific climate variables such as rain, storms and higher humidity was revealed by Gossling et al. (2006) as the most important weather variable influencing tourists' comfort. A more recent study of Gossling et al. (2012) also explored tourist perceptions to climate change, and in particular how tourist perceptions on climate change could influence their decision-making process. Tourist perceptions and reactions to the impacts of climate have been revealed to be helpful in "anticipating the potential geographic and seasonal shifts in tourism demand, changes in specific tourism markets, and the overall competitiveness of businesses and destinations" (Gossling et al. 2012, p. 37).

At the same time, the choice of destination was also revealed as having close relationship with tourists' home climate (Lise and Tol 2002, Eugenio-Martin and Campos-Soria 2008). People from regions with poorer climates have a higher propensity to travel to destinations with warmer and sunnier climates and have more chances to take international trips, whereas better climate in the regions of residence is related to a higher probability of traveling domestically (Eugenio-Martin and Campos-Soria 2008). However, different views exist regarding the preferred climate and people's residence climate, as Bigano et al. (2006) argued people's preferred destination climate is the same for all tourists, independent of their home climate (Bigano et al. 2006).

2.2.3 Seasonality

The variation of tourist demand throughout the year is defined as seasonality, and it has been identified as one of the most intrinsic and prominent features of tourism, as well as one of the biggest challenges faced by the tourism industry (Hartmann 1986, Baum and Hagen 1999, Higham and Hinch 2002, Jang 2004). One broadly accepted type of categorizing seasonality is to group it into two categories based on cause factors: institutionalized seasonality and natural seasonality (BarOn 1975, Hartmann 1986). Institutionalized seasonality refers to the holiday seasons following an established social calendar to reflect social norms and practices. Natural seasonality is related to the variability in climatic conditions throughout a year both at destination and source markets. Climate is usually considered as the primary cause of a destination's natural seasonality (Butler 1994, Higham and Hinch 2002). Seasonality caused by climate negatively impacts fluctuations of tourism demand and approaches have been encouraged in order to mitigate the level of seasonality (Jang 2004, Andriotis 2005). In consideration of seasonality caused by climate, Scott and McBoyle (2001) introduced six conceptual distributions of annual tourism climate resource to describe the seasonality type of every destination, including ‘optimal’ year-round tourism climate, ‘poor’ year-round tourism climate, ‘summer peak’, ‘winter peak’, ‘bimodal-shoulder peaks’ and ‘dry season peak’ (Figure 2.1). A ‘summer peak’ or ‘winter peak’ climate indicates that summer or winter has the most pleasant climate for tourism compared to other seasons of the year. In contrast, a ‘bimodal’ climate occurs when spring and summer months are more suitable for tourism than summer months. The ‘dry season peak’ typology refers to the places with wet and dry season which is determined by precipitation and the peak time occurs when the amount of precipitation is the most suitable for tourism in the dry season.

Figure 2.1 Six Conceptual Tourism Climate Distributions



Source: Scott and McBoyle (2001)

2.2.4 Climate and Tourist Flow and Expenditure

In addition to the influence of climate on destination attractiveness, tourist motivation and seasonality, climate variability also influences tourism flows and expenditure. Agnew and Palutikof (2006) investigated the impacts of climate variability on the sensitivity of UK tourism in terms of domestic as well as international tourist flows. The results showed a close link between interannual climate variability in the UK and tourism flows, since weather of previous year has an impact on tourist flow in the current year; in addition, wetter or cooler-than-average conditions of the first quarter of a year encourage more international holidays taken in the rest of the year. The study also revealed that certain climatic parameters such as rainfall and sunshine were found to have a greater impact on international tourism than temperature. In a study of winter tourism, Shih et al. (2009) modeled the influence of weather variation on daily downhill ski lift ticket sales in Michigan and the findings showed that weather has a significant impact on ticket sales of ski resorts, and climatic variables such as temperature, snow depth and wind chill are all essential factors determining tourism expenditures for winter tourism.

The changing number of tourists caused by interannual climate variability has a consequent influence on tourism expenditures (Wilton and Wirjanto 1998, Subak et al. 2000, Elsasser and Burki 2002, Fukushima et al. 2002, Shih et al. 2009). Wilton and Wirjanto (1998) analyzed the impact of a seasonal pattern on Canada's tourism demand, supply and employment from 1986 to 1997. Canadian tourism expenditures were found to be influenced greatly by seasonal variations, as seasonality was reported to explain 75% of the statistical variation in tourism expenditures and one degree Celsius above normal summer temperatures increased domestic tourism expenditures by 4% (Wilton and Wirjanto 1998). Subak et al. (2000) suggested that relationship between climate and tourism expenditures is complex, and requires further investigation.

2.3 Tourist Climatic Preferences

Climate has been revealed as having a close link with various aspects of tourism. Thus to understand tourists' preferences of optimal and unacceptable climatic conditions on a holiday is crucial for destination development, marketing and programing. Defining the 'ideal' climatic conditions preferred by tourists on thresholds is critical to decision making, in particular preferences of specific climate parameters, such as the amount of rain or hours of sunshine, are both essential for understanding the role of climate in tourist decisions and challenging. It is challenging because people's response to climate is considered a matter of perception (Yapp and McDonald 1978, de Freitas 2001, Gomez-Martin 2006, Gossling et al. 2012). Tourists are thought to respond to the integrated effects of the atmospheric environment (thermal, physical and aesthetic aspects) rather than to climatic averages (Mieczkowski 1985, de Freitas 2003). A comprehensive summary of approaches in examining tourists' preferred climate was made by Scott et al. (2008), who identified three distinct research approaches to examine tourists' climatic preferences over the past thirty years: expert-based, revealed preference and stated preference.

2.3.1 Expert-Based Preference

The most widely known study which used the expert-based approach to define the optimal climatic conditions for urban tourism was conducted by Mieczkowski (1985). He proposed an index designed for assessing climate suitability for tourism purpose on a global scale for the first time. Five climatic variables, including air temperature, relative humidity, sunshine, precipitation and wind were considered by Mieczkowski as essential factors influencing overall tourist holiday experience. The thermal comfort, a combination of air temperature and relative humidity, was considered the most influential on tourists' comfort level. The optimal climatic conditions for urban tourism were set by Mieczkowski (1985) as follows: between 20°C to 27°C, precipitation less than 15mm per month, mean monthly hours of sunshine per day equal to 10 hours or more, and wind speed below 2.88km/h. However, the expert-based presumption of tourists' preferred climatic conditions has been repeatedly criticized as subjective and not validated by tourists themselves on appropriate tourism indicators (de Freitas et al. 2004, Scott et al. 2004, Amelung and Viner 2006, Frarajzadeh and Matzarakis 2009, Perch-Nielsen et al. 2010).

2.3.2 Revealed Preference

The second approach, the revealed preference, was used by several studies (Maddison 2001, Lise and Tol 2002, Hamilton 2005, Hamilton et al. 2005, Bigano et al. 2006) to measure tourist preferred climatic conditions through statistical models. Maddison (2001) used the Pooled Travel Cost Model (PTCM) based on microeconomic theory and destination characteristics to examine the impact of climate change on various facets of destinations management. The optimal maximum daytime temperature for urban tourism was identified as around 30.7°C. Lise and Tol (2002) also adopted Maddison's (2001) Pooled Travel Cost Model (PTCM) to examine tourists' destination choice as well as their preferred climate conditions from the OECD (Organization for Economic Cooperation and Development) destinations. The optimal temperature was said to be a daytime mean of 21°C during the hottest month of the year. The study also emphasized that tourists from different nationalities have different climatic preferences. One shortcoming of the study is that it used capital cities to represent the whole countries, thus limiting the accuracy of the results. Another study used the PTCM to explore the changes of climate conditions on tourists' destination choice is Hamilton (2005). The study in

Germany revealed that for temperatures above zero, the optimal mean monthly temperature is 24°C. Hamilton et al. (2005) also constructed a simulation model to estimate the impacts of global changes on tourism demand by using annual arrival and departure data of 207 nations in 1995. The model suggested that the highest optimal temperature is around 14°C. Furthermore, Bigano et al. (2006) used a similar statistical model to analyze the relationship between climate and holiday destination choice on tourists from 45 countries, and the results showed that the estimated optimal annual temperature is 16.2°C. It is worth noting that the study claimed no matter which country tourists come from, a similar climatic condition is preferred. Opposite views were proposed by Lise and Tol (2002) and Scott et al. (2008), who suggested that tourists' climate preferences are related to their origins.

2.3.3 Stated Preference

The third approach used to assess tourists' preferred climate conditions is through stated preference. Its main strength is it is not subjective like expert-based studies and allows much greater depth of analysis regarding tourist's preferences (by market segment, destination type, etc.) than revealed preference approach (Scott et al. 2008). The common methods used in stated preference approach include questionnaires, interviews and observations, as seen in the studies of Morgan et al. (2000), Mansfeld et al. (2004), Gomez-Martin (2006), Gossling et al. (2006), de Freitas (2008), Scott et al. (2008), Moreno (2010), Rutty and Scott (2010) and Jacobsen et al. (2011). Gossling et al. (2006) conducted an in-situ study to investigate tourist perceptions of climate conditions in Zanzibar, Tanzania. Tourist perceptions of comfort level were found to be affected by a set of climate variables including temperature, rainfall, humidity, and storms. Ranking of relative importance of climatic parameters indicates that temperature is not the most influential climatic variable in affecting tourist's comfort level as variables such as rain, storms might have more impacts than temperature. Scott et al. (2008) also used the stated preference approach to determine tourist preferences of climatic conditions in three major tourism environments (urban, beach and mountain) by obtaining views from university students in Canada, New Zealand and Sweden. The survey results indicate that the optimal climatic conditions in an urban environment include a temperature of 22°C, 25% cloud cover and 1-9 km/h wind speed. Temperature was also revealed as the most important parameter for urban tourists, followed by rain, sunshine and wind. Scott et al. (2008) also revealed three key findings for climatic preferences for urban tourism; first, ranking of relative importance of major climatic parameters (temperature, precipitation, sunshine, wind) is different for major tourism environments (beach, urban, mountain); second, climatic preferences are also different among major tourism environment; third, tourists from different nationalities would have different preferences. The study of Rutty and Scott (2010) also used surveys on university students across Europe to reveal their preferences of optimal climatic conditions for Mediterranean urban and beach holidays. The survey results showed that majority of respondents (>50%) define optimal temperature between 20-26°C for a Mediterranean urban holiday. A study conducted by Jacobsen et al. (2011) also assessed tourists' preferences of summer climatic conditions for sightseeing, by conducting interviews in two Arctic archipelagos in northern Scandinavia. Eight climatic elements were included in the survey (clear sky, rather cool weather, windy, occasional rain, frequent rain, low visibility, high sea wave, frequently changing weather), and the survey results indicated that clear sky is the most preferred climate variable for a summer season trip, followed by rain, visibility, sea wave and wind.

Tourists' climatic preferences for beach holidays have also been revealed in a number of studies using the stated preference approach (Morgan at el. 2000, Mansfeld et al. 2004, de Freitas et al. 2008, Scott et al. 2008, Moreno 2010 and Rutty and Scott 2010). Different from urban tourism, temperature was not the most important weather parameters for beach tourism (Morgan et al. 2000, de Freitas et al. 2008, Moreno 2010). Morgan et al. (2000) assessed beach users' optimal climate conditions by conducting surveys in Wales, Malta and Turkey, in particular their preferences for thermal sensation and bathing water temperature. The survey revealed both optimal climate conditions for beach users and ranking of relative importance of the main climatic parameters (temperature, sunshine, rain, wind). The majority of beach users (29%) in Wales, Malta and Turkey ranked absence of rain as the most important parameter for a beach holiday, followed by sunshine (27%), windiness (26%), and temperature (18%). Although the study revealed ranking of relative importance of climatic parameters as well as preferred bathing water temperature (22-26°C), preferences for specific climatic parameters (e.g. strong of wind, duration of rain and sunshine) were not defined. The study of Moreno (2010) also assessed the optimal climatic conditions for beach users by questionnaires with people travelling in Belgian and Dutch airports to the Mediterranean region. Similar to Morgan et al.'s (2000) study, the absence of rain was ranked as the most important climatic parameter for a beach holiday. However, for the rest of the climatic parameters (temperature, sunshine and wind), the ranking was in different orders from Morgan et al. (2000) with temperature ranked second instead of sunshine. The cause of difference in ranking of climatic parameters was found to link with respondents' origin climate.

The exploration of the relationship between tourists' origins and their climate preferences has been conducted by Mansfeld et al. (2004) and Scott et al. (2008). In Mansfeld et al.'s (2004) study, by interviewing beach users at Eilat, Israel, domestic tourists were found to have different climatic preferences than international tourists for a beach holiday. Different from Morgan et al.

(2000) and Moreno (2010), in Mansfeld et al.'s (2004) study, wind was ranked as the most influential parameter for a beach holiday. Scott et al. (2008) also revealed a relationship between climate preference and tourists' nationalities, by surveying students from three countries, Canada, New Zealand and Sweden. The survey results showed that sunshine is the most important climate parameter for a beach holiday, followed by temperature, absence of rain and wind.

Tourist preferred climatic conditions in mountains were assessed by the stated approach (Gomez-Martin 2006, Scott et al. 2008). The survey results from Gomez-Martin's (2006) study presented a number of findings for mountain activities in summer: 1) tourists have high expectations for daily sunshine, but it is not an impeding factor for outdoor activities; 2) precipitation is an impeding factor; 3) maximum temperature is the most important parameter; 4) wind is the most irritating element, even more than precipitation. At the same time, surveys from Scott et al.'s (2008) study showed that the optimal climatic conditions for mountain environment include temperature around 20°C, with slightly cloudy sky and no wind or light breeze preferred.

By reviewing the literature about tourist climatic preferences obtained through three approaches (expert-based, revealed and stated preferences), one can conclude that differences exist on the ranking of relative importance of climatic parameters, as well as preferences of optimal climatic conditions for different tourism segments (Table 2.1). There are four major findings revealed from reviewing the literature: (1) no single optimal climatic conditions for all forms of tourism was agreed upon, (2) tourist preferences of climate conditions are different in major holiday environments (urban, beach and mountain), (3) tourist comfort level is an individual perception, and while it is hard to define an universal-accepted standard, only general preference patterns (zones of satisfaction) are observable, (4) tourist climatic preferences relate to their home climate. In addition, different views exist regarding to the ranking of climate variables in assessing tourist comfort level. Temperature was regarded as the most influential variable for tourist comfort by macro-scale economic modeling studies (Maddison 2001, Lise and Tol 2002, Hamilton 2005, Hamilton et al. 2005, Bigano et al. 2006) and studies of Mieczkowski (1985) and Gomez-Martin (2006). However, survey based studies with tourists found that temperature is not always the most important climate variable influencing tourist decisions, so that an integration of climatic variables should be considered when assessing tourists' preferred climatic conditions (Morgan et al. 2000, de Freitas et al. 2008, Scott et al. 2008, Moreno 2010).

Table 2.1 Tourist Preferences of Climate Conditions

Approach	Author	Region	Ranking of Relative Importance				Optimal Climate Conditions				
			1	2	3	4	Temperature (°C)	Precipitation (mm)	Sun (hrs)	Cloud (%)	Wind (km/h)
Expert-based	Mieczkowski (1985)	Global	Thermal	Rain	Sunshine	Wind	20-27°C	<15	>10	_	<3
Revealed	Maddison (2001)	UK	Thermal	_	_	_	30.7°C	_	_	_	_
	Lise & Tol (2002)	OECD Nations	Thermal	_	_	_	21°C (Tmean of hottest month of year)	_	_	_	_
	Hamilton (2005)	Germany	Thermal	_	_	_	24°C	_	_	_	_
	Hamilton et al. (2005)	Global	Thermal	_	_	_	14°C (annual mean)	_	_	_	_
	Bigano et al. (2006)	Global	Thermal	_	_	_	16.2°C	_	_	_	_
Stated (Urban)	Gossling et al. (2006)	Tanzania	Rain	Storm	Humidity	Temperature	_	_	_	_	_
	Scott et al. (2008)	Canada, New Zealand, Sweden	Thermal	Rain	Sunshine	Wind	22°C	_	_	25	1-9
	Rutty & Scott (2010)	Canada	_	_	_	_	20-26°C	_	_	_	_
	Jacobsen et al. (2011)	Northern Scandinavia	Sky	Rain	Visibility	Seawave	_	_	_	_	_
Stated (Beach)	Morgan et al. (2000)	UK & Mediterranean	Rain	Sunshine	Wind	Thermal	22-26°C (bathing water)	_	_	_	_
	Mansfeld et al. (2004)	Israel	Wind	Sky	Thermal	RH	20-25°C	_	_	1/8	<2-3m/s
	de Freitas (2008)	Canada	Thermal	Sunshine	Rain	Wind	20-24°C	_	_	_	_
	Scott et al. (2008)	Canada, New Zealand, Sweden	Sunshine	Thermal	Rain	Wind	27°C	_	_	25	1-9
	Moreno (2010)	Mediterranean	Rain	Thermal	Sunshine	Water Temp	_	_	_	_	_
	Rutty & Scott (2010)	Canada	_	_	_	_	27-32°C				
Stated (Mountain)	Gomez-Martin (2006)	Spain	Thermal	Rain	_	_	22-28°C	>3	>11	_	<5.5-7.9
	Scott et al. (2008)	Canada, New Zealand, Sweden	Rain	Thermal	Sunshine	Wind	20°C	_	_	25	1-9

2.4 Assessment of Tourism Climate Suitability

Information about a destination's climatic suitability for tourism is used by both tourists and tourism service providers. To develop a method to determine a destination's climatic suitability for tourism and to present the information in a more easily interpretable way to tourists is essential for all stakeholders involved in the tourism sector.

In an attempt to accurately assess a region's climatic suitability for tourism, various methods have been developed. Due to the complex nature of climate, an index which integrates all facets of climate relevant to tourism, uses standard data and is objectively verified, was considered by de Freitas (2003) as the most appropriate approach to facilitate interpretation of climatic elements.

2.4.1 Climate Information for Tourists

Climate is an important factor to influence tourist decisions on where to travel and a number of studies reveal that tourists seek weather and climate information most often during holiday planning stage (Smith 1981, Hamilton and Lau 2005, Becken et al. 2010, Scott and Lemieux 2010). In the study of Smith (1981), a survey was conducted on northern European travelers to the Mediterranean region, and results revealed that 81% of respondents would obtain information before making travel reservations. Hamilton and Lau (2005) also revealed a similar result that 42% of German outbound tourists inform themselves of destination climate conditions before booking holidays. The study of Becken et al. (2010) even showed that 94% international travelers to New Zealand responded they would obtain climate information before traveling. However, the studies about the use of weather and climate information by travelers are still limited and areas of uncertainty exist regarding what specific type of climate information tourists consult and how tourists interpret the obtained forms of climatic information (Scott et al. 2012).

The common climate information provided to tourists includes daily air temperature, humidity, precipitation, sunshine duration, wind speed, UV-radiation and air pollution. However, climate information provided to tourists by weather stations was considered insufficient to satisfy tourists' growing needs and is hard to understand by the users, as they are usually presented in the form of climatic averages, which is less meaningful to most tourists (Matzarakis 2001, de Freits 2003, Hamilton and Lau 2005, Zaninovic and Matzarakis 2009, Scott and Lemieux 2010). Matzarakis (2001) assessed the climate information for tourism in Greece, pointing out that detailed temporal and spatial bioclimatic analysis of the thermo-physiological parameters should be included. The type of climatic information sought by the tourists has been also explored by de Freits (2003) and Hamilton and Lau (2005). de Freitas (2003) pointed out that climate data should be presented in a form that can be readily interpreted and easily understood by the users, and data should convey the likelihood of the occurrence of a specific condition rather than average values with no physiological or psychological meaning. To present climatic information in the format of an index was considered by de Freitas (2003) as the most appropriate way to present climate information to the tourists. This also agreed by Hamilton and Lau (2005) who conducted surveys at Hamburg Airport to analyze further on what type of specific climatic information is sought by tourists, as well as when tourists active seek information and how information should be presented. The survey results indicated that numerical data is the most popular option (57%) for presenting climatic information to tourists, followed by diagrams (36%), maps and satellite image (33%), and text is the least preferred option (27%).

In addition, how weather and climate information is communicated to tourists and how different kinds of communication channels have been used to deliver such information are still unexplored (Scott et al. 2012). Only one study, Scott and Lemieux (2010), presented a comprehensive analysis of different providers of climate information and services. By exploring current and emerging application of climate services in the tourism sector, four climate information providers were identified: the National Meteorological Services (NMSs), private sector providers, tourism operators and destinations. The NMSs and tourism operators offer relatively limited services compared to the private sector. In recent years, private sector has become an innovative leader in providing a variety of climate information and services by adopting emerging technological advancements to deliver specialized climate information to tourists and other end-users. However, existing climate information were insufficient to satisfy different end-users' needs; misleading climate information also can be found in various communication materials. Barnes (2002) stressed that travelers have expressed they feel misled by travel operators and marketers about destination climate. Since there is no evaluation of the quality and accuracy of climate information provided to the tourists, the reliability of the information is highly questionable. At the same time, tourism operators and destination marketers in several countries have expressed frustration with NMS weather forecasts and the impact on tourism (Becken et al. 2010, Scott and Lemieux 2010).

2.4.2 Tourism Climate Indices

The early climatic indices were not developed for the purpose of leisure and tourism, but for applied climatology and human-biometeorology. The research of tourism climatic index and the provision of tourism climatology information were originally traced from the applied climatology and human-biometeorology fields (Mieczkowski 1985).

Becker (1998) developed the 'Beach Comfort Index' (1998) to evaluate the thermal conditions of beach holiday resorts in South Africa based on human energy balance calculation. The calculation was based on the heat loss by radiation for a person lying on the beach, and factors taken into calculation include air temperature, humidity, wind speed, direct sun radiation, diffuse radiation and long-wave atmospheric counter radiation. However, the major weakness of this type of bioclimatic index is that it singles out the thermal comfort as the most important facet, but ignores other variables which may have potential effects on people's overall comfort level. The other weakness is that a bioclimatic index cannot be easily understood by the general public as complex climatological information is presented. Morgan et al. (2000) also developed an index, the Beach Climate Index (BCI), to assess the climatic conditions of beach for beach users featuring thermal sensation, precipitation, sunshine, and wind speed by using survey results obtained from beach users' responses on-site for their climatic preferences.

As noted, the most widely used index is Mieczkowski's (1985) 'Tourism Climate Index' (TCI). It is the most widely applied index to assess climate resources for tourism (Scott et al 2004, 2012). However, as indicated the TCI has been criticized by many authors as being subjective and not been validated with tourists (de Freitas et al. 2004, Scott et al. 2004, Amelung and Viner, 2006, Frarajzadeh and Matzarakis, 2009, Perch-Nielsen et al. 2010). Therefore, in order to overcome the deficiencies of the TCI, de Freitas et al. (2008) developed a conceptually new index for tourism climate assessment, the Climate Index for Tourism (CIT). However, the CIT was only designed for 3S (sun, sea and sand) tourism, but not for general tourist activities. Yu et al. (2009a) modified the TCI to develop a Modified Climate Index for Tourism (MCIT) using climatic data from more than 50 years in Florida and Alaska. The index used the hourly observation on temperature, wind and added two new variables deemed relevant to tourism in these study areas (visibility and significant weather event data).

Neither of these newer indices (CIT or MCIT) made use of tourist climatic preferences findings from revealed preference studies. A universal accepted climate index for tourism was urged by researchers to be developed for the purpose of application to different kinds of climate conditions, regions and seasons of the year (Jendritzky et al. 2001) and facilitate improved destination comparisons and marketing in the global tourism market place (Scott et al. 2008).

2.4.3 Mieczkowski's Tourism Climate Index (TCI)

The first attempt to develop an index to assess a destination's climatic suitability for tourism was by Mieczkowski in 1985, who designed the Tourism Climate Index (TCI) to integrate all climatic variables deemed relevant to tourism into a single index to measure the climatic well-being of tourists engaged in general tourism activities (e.g. sightseeing). The TCI was designed based on existing literature related to climate classifications for tourism and recreation, and its theoretical considerations were from the biometeorological literature related to human comfort (Scott et al. 2004). Seven climatic variables have been used in the TCI (maximum air temperature, mean air temperature, minimum relative humidity, mean relative humidity, amount of precipitation, hours of sunshine and average wind speed). The TCI has been identified to have two main strengths: its integration of three essential climatic facets (thermal, aesthetic and physical) into a single index, and it has widespread applicability as the required climatological data for climatic variables are commonly available from weather stations with simple data provision and calculations (Scott and McBoyle 2001, Perch-Nielsen et al. 2010). In addition, the TCI can be easily interpreted by the general public (scale of -30 to 100), and it was designed to measure the most common tourism activities, sightseeing and shopping.

Although the TCI was designed nearly three decades ago, it is still the most widely used climate index in assessing a destination's climatic suitability. The TCI has been used in studies to assess a destination's current climatic conditions and potential (Cengiz et al. 2008, Farajzadeh and Matzarakis 2009, Roshan et al. 2009), as well as to examine future climatic resources by combining with climate change scenarios (Scott and McBoyle, 2001, Scott et al. 2004, Amelung and Viner, 2006, Amelung et al. 2007, Hein 2007, Nicholls and Amelung 2008, Amelung and Moreno 2009, Hein et al. 2009, Yu et al. 2009a and 2009b, Perch-Nielsen et al. 2010, Whittlesea and Amelung 2010).

2.4.3.1 Application of Mieczkowski's TCI

The TCI has been applied in studies to assess a place's climate suitability for tourism on a global (Amelung et al. 2007), regional (Scott and McBoyle 2001, Scott et al. 2004, Amelung and Viner 2006, Hein 2007, Nicholls and Amelung 2008, Amelung and Moreno 2009, Hein et al. 2009, Perch-Nielsen et al. 2010) and country/destination scale (Cengiz et al. 2008, Farajzadeh and Matzarakis 2009, Roshan et al. 2009, Yu et al. 2009a and 2009b, Whittlesea and Amelung 2010). Among the 15 identified TCI studies, both current and future conditions of climatic resources for urban tourism have been explored. To use the TCI to assess current climate conditions and tourism potentials would provide two types of information: locations with good climate conditions and months with the most suitable climate to visit. The combination of the TCI and climate change projection is also beneficial for tourism climate studies and has profound implications for exploring the impact of climate change on tourism climate resources.

Amelung et al. (2007) combined two climate change scenarios (B1A and A1F) with the TCI to examine the potential changes of climatic conditions for global tourism. The findings showed that in Europe, climate of both northern Europe and the countries of the northern Mediterranean coast are expected to change. A substantial improvement in summer climatic conditions of the northern European countries has been projected. In contrast, for the Mediterranean countries including Spain, France, Italy, Greece, Turkey and others, summer months are likely to become too hot for tourism activities and a 'bimodal shoulder peaks' climate distribution is also projected, suggesting a shift in their peak season from summer months to shoulder periods.

Several studies have conducted research on the climatic suitability for tourism in a regional scale, mainly focused in North America and Europe. Scott and McBoyle (2001) used a modified version of TCI to explore the impact of projected climate change on climate resources of 17 North American cities; at the same time, the issue of whether the TCI can reflect tourism demand was validated in the study by comparing seasonal TCI scores with accommodation costs. Six conceptual tourism climate distributions (optimal, poor, summer peak, winter peak, bimodal-shoulder peak and dry season peak) were developed for the purpose of assessing any location's annual climate distribution. Although only one demand indicator (accommodation cost) was measured, positive results were achieved as the TCI was revealed to be a useful tool to measure the relationship between climate and tourism demand. Based on the study of Scott and McBoyle (2001), Scott et al. (2004) went further to use the TCI to examine the potential changes of climate resources of 143 North American cities (90 in the USA, 44 in Canada, and 9 in Mexico) under 2 climate change scenarios (CGCM2-B2 and HadCM3-A1F1) for the 2050s and 2080s. The results from both studies indicated that climate resources of the destinations in the USA and Canada will improve in both 2050s and 2080s.

Besides North American region, a number of studies have also assessed the projected changes of tourism climatic resources with the application of the TCI in major European regions and destinations including the Northern Europe (Nicholls and Amelung 2008, Amelung and Moreno 2009 and Perch-Nielsen et al. 2010) and the Mediterranean region (Amelung and Viner 2006, Hein 2007 and Hein et al. 2009). Nicholls and Amelung (2008) used the TCI and the IPCC SRES A1F and B1 scenarios to examine the projected changes in climatic suitability for tourism in a number of northwestern European countries including the UK, Ireland, north France, Belgium, the Netherland, Germany, Denmark, and the southern portions of Norway and Sweden. By using the same climate change scenarios (A1F and B1), the findings of Nicholls and Amelung (2008) showed a similar result to the study of Amelung et al. (2007) regarding the projected changes of climatic resources in northern European region. The climate conditions of summer months were projected to improve in the coming century and the length of peak season was also expected to extend from summer to spring and fall which will make the region more competitive to the Mediterranean summer season.

The study of Perch-Nielsen et al. (2010) assessed the suitability of European climate for sightseeing by combining the TCI with the A2 climate change scenario. The study is the first and the only one of all identified TCI studies to address the TCI deficiency of low temporal scale by using daily climate data instead of monthly average. By assessing major Europe regions (northern, central and southern Europe), the findings indicated that climatic conditions of northern and central European destinations will improve in most seasons whereas southern Europe is expected to experience deteriorate summer climate conditions in the coming century. However, the drops in suitability of the Mediterranean summer months will be compensated by improvements in spring and fall months.

The studies of Amelung and Viner (2006), Hein (2007) and Hein et al. (2009) used the combination of the TCI and climate change scenarios to assess future climate conditions of the Mediterranean region. Amelung and Viner (2006) used the TCI to measure possible changes of climatic resources in the Balearic Islands under climate change scenario. The six conceptual climate distributions developed by Scott and McBoyle (2001) were used in the study. The results of the study showed that changes of climate resources will be small in the 2020s in the

Mediterranean region, but dramatic in the 2050s and 2080s. The TCI scores suggested that climate conditions in spring and fall will improve in the Mediterranean region, but summer climate will deteriorate, which will make the Mediterranean region a ‘bimodal-peak’ destination. Similar to the study of Scott and McBoyle (2001), Amelung and Viner (2006) also tested the performance of the TCI as a predictor for tourist demand by plotting monthly visitation statistics of 1999-2003 periods against monthly TCI values of the Balearic Islands. Again, positive results were achieved, with a high visitation level coinciding with a high TCI value. This indicates that a close link between TCI values and tourist demand exists.

Hein (2007) also used the TCI to analyze the effects of climate change on Mediterranean region’s future climate suitability for tourism. Both current and future climate suitability was predicted in five Spanish regions (Andalucia, the Mediterranean coast, Central Spain, Northern Spain and the Balearic islands). The study presented a similar result to Amelung and Viner (2006) that summer conditions of top-visited destinations in the Mediterranean region such as Spain will suffer substantial index score decrease, but spring and fall’s climate will improve. In the study of Hein et al. (2009), the suitability of climate in Spain at present and in 50 years was analyzed by the TCI and study also showed the changes in the attractiveness of the climate for tourism at major European tourism regions. The results of the analysis showed that climatic conditions in summer months of almost the entire Mediterranean region will deteriorate, but climate in the northern half of the continent is expected to be very good. Amelung and Moreno (2009) used the TCI to examine current and future climatic suitability and changes of the whole Europe. The study focused on two tourism segment, the light tourism activities and winter sports. Similar to the previous studies on changes of climate conditions in Europe, the findings of Amelung and Moreno (2009) showed that summer of southern Europe will experience less favourable conditions for tourism, but there will be better summer conditions in the countries of the northern Europe.

The studies of Cengize et al. (2008), Farajzadeh and Matzarakis (2009), Roshan et al. (2009) and Whittlesea and Amelung (2010) have used the TCI to assess tourism climate suitability on a country/destination basis. Cengiz et al. (2008) used the TCI to evaluate tourism potential in Canakkale, a northwest province of Turkey and monthly TCI values of Canakkale were displayed in order to reveal the best time to visit. In addition, the relation between each climatic variable and the TCI score has also been investigated. Furthermore, both Farajzadeh and Matzarakis (2009) and Roshan et al. (2009) assessed the current climatic conditions in Iran. Farajzadeh and Matzarakis (2009) used the combination of the TCI and the Physiologically Equivalent Temperature (PET) to determine current climate conditions in the northwest Iran and the most suitable months to visit. Roshan et al. (2009) combined the TCI with the study of urban sprawl to identify the effects of the urban sprawl of cities on tourism-climate index (TCI) oscillation in Tehran. By determining the quantitative coefficient between monthly TCI values and urban sprawl components (population, area, density and number of automobiles) for three 18-year periods in Tehran, the authors revealed that the urban sprawl of cities had a negative effect on the TCI index. Within the urban sprawl components, transportation and the increase in the rate of ownership of a personal car have a significant effect on the annual and monthly TCI coefficient.

By improving Mieczkowski's (1985) TCI, Yu et al. (2009a) and Yu et al. (2009b) developed and applied the Modified Climate Index for Tourism (MCIT) to assess a place's climate suitability for tourism. Yu et al. (2009a) developed and tested the MCIT in the climate-contrasting regions, Florida and Alaska, to measure climate as tourism resource by using hourly climatic data. The major improvements of the MCIT over the TCI include the usage of hourly data instead of daily average and incorporate variables that are more relevant to tourism activities such as visibility and significant weather variables (e.g. rain, lightning). The study went a step forward from past TCI studies to use hourly data rather than daily average to climate suitability for tourism that allows the assessment of suitability of a day's weather for tourism activities. In another study conducted by Yu et al. (2009b), the MCIT was adopted to examine seasonal patterns at two Alaska destinations, King Salmon and Anchorage.

In a more recent study conducted by Whttlesea and Amelung (2010), the TCI was used to explore the impact of climate change on tourism comfort and seasonality in the southwest England. The TCI results showed that climate conditions in the shoulder season are expected to improve and climate of summer months could become excellent and even ideal for tourism.

2.4.3.2 Deficiencies of Mieczkowski's TCI

Despite the TCI's wide application, its deficiencies have been noted, with criticisms mainly focus on three areas: (1) inapplicable to all climate-sensitive tourism activities; (2) subjectivity in choosing climatic variable and assigning weighting component in the index; (3) and over-concentrating on thermal comfort component. First, although the TCI was designed to assess the most common tourist activity (sightseeing), it still has limitation as weather-sensitive activities such as beach tourism cannot be assessed by the TCI without modification (Scott et al. 2004, Amelung et al. 2007, de Freitas et al. 2008). Second, the central weakness of the TCI is the subjectivity of its rating and weighting system, as no verification of tourists' views were obtained (de Freitas et al. 2004, Scott et al. 2004, Amelung and Viner 2006, Frarajzadeh and Matzarakis 2009, Perch-Nielsen et al. 2010). The importance of incorporating tourists' stated preferences of optimal climatic conditions was regarded as essential for a comprehensive climate index (Gomez-Martin 2005). Third, over-emphasis of thermal component in TCI's calculation by giving it the highest weighting may not correctly reflect tourists' overall perception of climatic suitability (Gomez-Martin 2005, Scott et al. 2008). It should also be noted that the TCI does not take any potential overriding effects of physical variables into consideration (de Freitas et al. 2008).

Another deficiency of the TCI has been revealed as low-temporal scale by Matzarakis (2007) and Perch-Nielsen et al. (2010). Matzarakis (2007) criticized TCI's data selection by claiming that climatic data used by the TCI are mean monthly values, and it only consider basic climate elements. This was further addressed by Perch-Nielsen et al (2010) by saying that the TCI has a low temporal resolution. The temporal scale of the variables used in TCI – monthly averages, was considered as insufficient for tourism purposes, as tourists react to an integrated effect of the different climatic variables on each single day. However, both Matzarakis (2007) and Perch-Nielsen et al. (2010) ignored the fact that the TCI was developed during the pre-internet era in which the availability of climatic data was limited.

2.5 Anticipated Changes of European Climate Conditions

According to the IPCC (2007a), eleven of the twelve years from 1995 to 2006 have been observed among the warmest years in the instrumental record of global surface temperature since 1985; global temperature was predicted an increase of 0.2°C per decade for the next two decades under a range of SRES emission scenarios. For the tourism industry, climate change has even been argued to pose a greater security threat to tourists than terrorism (Rashid and Robinson 2010).

Climate has been considered as an important natural resource for European tourism industry and the effects of climate change have brought influences on European climatic conditions. According to the Intergovernmental Panel on Climate Change (IPCC) (2007a), an average increase of 0.1 to 0.4°C for next decade in Europe has been predicted, despite the rate of warming is not uniform across the region. The areas with the most intense warming prediction include the southern (Spain, Italy and Greece) and northeast (Finland and western Russia) Europe; the summer warming is going to be more noticeable in the southern Europe (0.2 and 0.6°C per decade) than in the northern Europe (0.08 and 0.3°C per decade) (IPCC 2007a).

The impacts of warming temperature on tourism have already been seen in climate-sensitive activities such as ski in some of European top-visited resorts. The study of Koenig and Abegg (1997) examined the impacts of snow-deficient winters on tourism sector in Switzerland at the end of the 1980s and suggested that unfavorable snow condition have direct impact on ski demand in Switzerland. Elsasser and Burki (2002) evaluated specifically the impacts of climate change on ski resorts in the Alps to assess how tourism industry should cope with the changing of snow-reliability under current climate change scenarios. The study concluded that the changing of climate poses a challenge for tourism as the predicted climate change phenomenon may cause ski resorts becoming less snow-reliable, and subsequently influencing tourist flow and expenditures. In addition, a tourist survey also showed that during snow-poor seasons, 49% of the skiers would change to other ski resorts that are more snow-reliable, and 32% of the skiers would ski less often (Burki et al. 2005). Moreover, drops in snow depth caused by changes of air temperature were reported to have an inevitable effect on income level of ski industry. In the Alps, shortage of snow at the end of the 1980s' winter makes earnings of the cable-way companies dropping by 20% (Elsasser and Burki 2002).

Current climatic conditions of major European destinations in different regions and their suitability for tourism are predicted to change. Several studies have predicted that summer in northern Europe is expected to have a more pleasant climate, while the Mediterranean summer will become ‘too hot’ for tourists and climate of spring and fall months in the Mediterranean region will improve (Morgan et al. 2000, Hamilton et al. 2005, Amelung and Viner 2006, Amelung et al. 2007, Hein 2007, Nicholls and Amelung 2008, Amengual et al. 2010, Perch-Nielsen et al. 2010). The studies of Morgan et al. (2000), Hein (2007), and Amelung and Viner (2006) revealed that many southern and eastern Mediterranean beach destinations will become ‘too hot’ for beach users during July and August. Summer months in some of the popular Spanish islands will become unpleasant for tourists in 2080 because of excessive temperature, and tourist flow will decrease substantially as a consequence of climate change. Another study predicting future climate conditions in Spain was conducted by Amengual et al. (2010), who measured future climatic conditions for sun, sea and sand (3S) tourism in the System of Platja de Palma (SPdP). The results of the study showed that current ‘ideal’ summer climate conditions in Spanish island will deteriorate and a shift of optimal climate from peak season to shoulder season in the Spanish coast was also predicted. Furthermore, Amelung and Viner (2006) used combinations of climate change scenarios and the Tourism Climate Index (TCI) to predict future climate conditions in Europe. The Mediterranean summer climate was predicted to drop from ‘excellent’ conditions to only ‘good’ or ‘acceptable’ conditions in the 2080s when being rated by the TCI. A projection on future climatic conditions of global scale conducted by Amelung et al. (2007) also showed that by the 2080s, the most comfortable summer conditions (June, July and August) will shift from the Mediterranean coastlines of Spain, France, Italy, Greece and Turkey to the countries in the northern Europe including northern France, southern parts of the UK, Germany and southern Scandinavia. In addition, the traditional Mediterranean beach resorts will change to a climate with the ‘bimodal shoulder peaks’ with more pleasant climate in spring and fall. In contrast, climate conditions of northern, western and eastern Europe are projected to improve in the coming century (Amelung and Viner 2006, Nicholls and Amelung 2008 and Perch-Nielsen et al. 2010). Climate in summer peak season will improve, with peak season extending to spring and fall.

2.6 Chapter Summary

This chapter focused on reviewing the literature related to the role climate plays on tourism, specifically on topics of the climatic motivations, tourists' climatic preferences for different environment, and the method of using an index to assess climatic suitability for tourism. Existing studies have agreed that climate is an important factor in influencing tourists' own holiday experience in many aspects, but no consensus has been reached on what the optimal climatic conditions are for tourists in specific environment as research on this question is fairly new and developing. Only a few methods have been developed specifically to assess climatic suitability for tourism purpose, even fewer which use the index method to assess objectively and present the information in an easy-interpretable way. Only one study, Mieczkowski (1985) designed an index, the Tourism Climate Index (TCI), to measure climatic suitability for general tourism activities which has been applied widely in climate potential and change studies. However, the TCI has been identified to have deficiencies mainly on its subjective design of rating and weighting system. Therefore, after nearly three decades since the TCI was developed in 1985, a need has been identified to design a new index which could overcome the identified deficiencies of the TCI.

Next chapter will describe both the newly designed index and the methods used to conduct an inter-comparison study to assess whether the new index, informed by recent advances in tourist stated climate preferences, performs differently than the TCI.

Table 2.2 Application of TCI in Existing Studies

Region	Author	Study area	Study goals	Data type
Global	Amelung et al. (2007)	Global	Potential implications of climate change on tourism climate resources	Monthly
Regional (North America)	Scott & McBoyle (2001)	17 North American cities	Impact of climate change on tourism climate resources	Monthly
	Scott et al. (2004)	143 North American cities	Current and future climate resources distributions under 2 climate change scenarios	Monthly
Regional (Europe)	Amelung & Viner (2006)	Mediterranean Region	Impacts of climate change on tourism climatic resources	Monthly
	Hein (2007)	Spain, Mediterranean, Northwest Europe	Impacts of climate change on tourism climate resources and tourist flow	Monthly
	Nicholls & Amelung (2008)	Northwest Europe	Future climate conditions in Northwest Europe	Monthly
	Amelung & Moreno (2009)	Europe	Examine changes of climate conditions in whole Europe under climate change	Monthly
	Hein et al. (2009)	Spain & Europe	Assessed suitability of Spanish climate and major European destinations in 50 years	Monthly
	Perch-Nielsen et al. (2010)	Europe	Presented tourism climate resources distribution under projected climate change scenarios	Daily
Country/Destination	Cengiz et al. (2008)	Canakkale, Turkey	Current climate conditions and potentials	Monthly
	Farajzadeh & Matzarakis (2009)	Northwest Iran	Current climate conditions and potentials	Monthly
	Roshan et al. (2009)	Tehran, Iran	Effects of urban sprawl of metropolis on tourism-climate index oscillation	Monthly
	Yu et al. (2009a)	Florida and Alaska	Developed and tested the Modified Climate Index for Tourism (MCIT)	Hourly
	Yu et al. (2009b)	Alaska	Use MCIT to examine seasonal patterns at two Alaska destinations, King Salmon and Anchorage	Hourly
	Whittlesea & Amelung (2010)	South West England	Impacts of climate change on tourism comfort and seasonality under UK Climate Projections	Monthly

Chapter 3

Methods

3.1 Introduction

This chapter presents the methods used to assess the differences of the two tourism climate indices, the Tourism Climate Index (TCI) and the Holiday Climate Index (HCI) in rating the climatic suitability of the selected 15 European city destinations, as well as to examine future climatic suitability for tourism in Europe under projected climate change. The rationale for selecting the European cities for this study, a description of the TCI rating and weighting system, the design of the HCI and its improvements over the TCI, as well as data collection for climate change study are described in the following sections.

3.2 Selection of Study Area

Europe has been chosen as the study region for this study because of its primary importance as a global tourism destination and the availability of higher temporal resolution geospatial data needed for this study. Among all popular tourism destinations, Europe is the most visited region in the world. In 2011, Europe was the most visited by international tourists, accounting for 51% (503 million) of the total number of worldwide inbound tourists (United Nations World Tourism Organization 2012). The tourism industry generates more than 10% of the European Union's GDP and provides about 12% of its employment (European Commission 2012). In addition, countries in Europe were also dominate the top 20 places in the travel and tourism competitiveness ranking, which measures the attractiveness of developing business in the tourism industry, with 14 of the top 20 countries from the region (World Economic Forum 2011).

Within the 27 EU nations, 15 European cities covering the majority of European climatic types were selected for this study (Table 3.1), including six of them (Istanbul, Rome, Barcelona, Athens, Venice and Madrid) located in southern Mediterranean region, three (London, Dublin and Stockholm) in northern Europe, five (Paris, Amsterdam, Vienna, Berlin and Munich) in western Europe, and one (Warsaw) in eastern Europe.

Table 3.1 European Cities Included in the Study

	City	Latitude	Longitude	Mean Temperature (°C)				Mean Monthly Rainfall (mm)	
				summer (Jun,Jul,Aug)		winter (Dec,Jan,Feb)		summer (Jun, Jul, Aug)	winter (Dec, Jan, Feb)
				min	max	min	max		
Southern Europe	Istanbul	41°N	28.58°E	17.7	27.6	3.7	9.6	24.2	88.4
	Rome	41.53°N	12.29°E	17.4	27.6	4.4	13.5	21.4	81.7
	Barcelona	41.23°N	2.10°E	17.9	26.6	5.1	14.1	41	40.3
	Athens	37.58°N	23.44°E	19.9	32.6	5.8	13.4	7.5	57.6
	Venice	45.26°N	12.2°E	17	26.4	0	6.9	74.2	55.3
	Madrid	40.25°N	3.42°W	17.2	29.6	3.4	10.6	16.7	42.7
Northern Europe	London	51.3°N	0.7°W	12.9	21.5	2.8	7.7	50.7	48.7
	Dublin	53.2°N	6.16°W	10.7	18.2	2.7	7.8	58.7	65
	Stockholm	59.19°N	18.3°E	12.3	21	-4.3	-0.3	61	37.3
Eastern Europe	Warsaw	52.13°N	21°E	12.2	23	-3.9	1.4	67.8	26.2
Western Europe	Paris	48.51°N	2.21°E	14.7	23.6	3	7.6	53.6	52
	Amsterdam	52.22°N	4.53°E	11.7	20.8	0.9	6	64.9	60.1
	Vienna	48.12°N	16.22°E	14.7	24.8	-1.1	4	65.4	40.3
	Berlin	52.31°N	13.24°E	13.6	23	-1.3	3.8	60.8	43.6
	Munich	48.08°N	11.34°E	11.8	22.2	-3.1	3.6	123.2	51.3

Source: World Meteorological Organization (WMO) (2013)

The 15 European cities were also chosen on the basis of being among the Euromonitor International's (2011) top-visited destination ranking. All selected cities were among the top 20 visited cities in Europe. In addition, the 15 cities represent diverse climatic zones in Europe, including: semiarid (Madrid), subtropical dry summer (Barcelona, Rome, Venice, Athens, Turkey), humid subtropical, humid oceanic (London, Dublin, Paris, Amsterdam) and humid continental (Stockholm, Berlin, Warsaw, Vienna, Munich) (Figure 3.1).

Figure 3.1 Climate Zones in Europe

Source: Greekvoyager.com (2012)

3.3 Index Design and Comparison

In this study, two tourism climate indices, the Tourism Climate Index of Mieczkowski (1985) and newly designed Holiday Climate Index have been applied. Daily data of air temperature, relative humidity, precipitation, cloud cover and wind speed were obtained to calculate both indices.

3.3.1 Tourism Climate Index (TCI)

Both current and projected future climatic conditions of the 15 selected European cities were assessed via application of Mieczkowski's (1985) TCI. The TCI was designed by Mieczkowski (1985) as a method to quantitatively evaluate a specific location's climate suitability for general tourism activities. The TCI assesses a location's climate suitability for tourism by grouping seven climatic variables relevant to tourism (maximum air temperature, mean air temperature, minimum relative humidity, mean relative humidity, amount of precipitation, hours of sunshine and average wind speed) into five sub-indices (Table 3.2). It should be noted that in Mieczkowski's original design, mean monthly climate data is required for index input. In this study, daily climatic data was used as the TCI's input for the purpose of comparing the rating differences between the two tourism climate indices and so that the probability of rating higher than specific threshold score couldI be calculated, instead of only average conditions. In addition, hours of sunshine has been replaced by percentage of cloud cover for the aesthetic facet because of data availability.

Table 3.2 Components of Tourism Climate Index (TCI)

Sub-index	Climatic variable	Influence on TCI	Weighting (%)
Daytime Comfort Index (CID)	Maximum daily air temperature (°C) Minimum daily relative humidity (%)	Thermal comfort when maximum tourist activity occurs	40
Daily Comfort Index (CIA)	Mean daily air temperature (°C) Mean daily relative humidity (%)	Thermal comfort over 24 hours period including night time	10
Precipitation (R)	Total precipitation (mm)	A negative factor on overall experience	20
Sunshine (S)	Total hours of sunshine (hours)	A positive factor on overall experience	20
Wind (W)	Average wind speed (km/h or m/s)	Highly depends on air temperature (evaporative cooling effect in hot climates rated positively, while 'wind chill' in cold climates rated negatively	10

Source: Adapted from Mieczkowski (1985)

The TCI is calculated as follows:

$$TCI = 2*(4CID + CIA + 2R + 2S + W)$$

The Daytime Comfort Index (CID) is a combination of maximum daily temperature and minimum daily relative humidity to assess the level of daytime climate conditions when maximum tourists' activities occur. The Daily Comfort Index (CIA) is a combination of mean daily temperature and mean daily relative humidity to assess the thermal comfort over the 24 hours. The highest weight is given to the Daytime Comfort Index (CID) (40%) to reflect the fact that tourists are most active during the day. The variables of sunshine and precipitation are given the second highest weight (20% each), followed by the Daily Comfort Index (CIA) (10%) and wind speed (10%).

As for the original TCI design, each of the sub-indices was assigned a highest rating score of 5.0 to make the maximum TCI score 100 and the minimum score is -30 (when both CID and CIA were rated a score of -3). The rating scheme of TCI climatic variables are outlined in Table 3.3.

Table 3.3 TCI's Rating Scheme

Rating	Effective Temperature (°C)	Mean Monthly Precipitation (mm)	Mean Monthly Sunshine (hrs/day)	Wind Speed (km/h)			Wind Chill Cooling (watts/ms/hr)
				Normal	Trade Wind	Hot Climate	
5.0	20 - 26	0.0 - 14.9	≥10	<2.88	12.24-19.97		
4.5	19 27	15.0 - 29.9	9	2.88 - 5.75			
4.0	18 28	30.0 - 44.9	8	5.76 - 9.03	9.04 - 12.23 19.80 - 24.29		<500
3.5	17 29	45.0 - 59.9	7	9.04 - 12.23			
3.0	16 30	60.0 - 74.9	6	12.24 - 19.79	5.76 - 9.03 24.30 - 28.79		500 - 625
2.5	10 - 15 31	75.0 - 89.9	5	19.8 - 24.29	2.88 - 5.75		
2.0	5 - 9 32	105.0 - 104.9	4	24.30 - 28.79	<2.88 28.80 - 38.52	<2.88	635 - 750
1.5	0 - 4 33	105.0 - 119.9	3	28.8 - 38.52		2.88 - 5.75	750 - 875
1.0	-5 - -1 34	120.0 - 134.9	2			5.76 - 9.03	875 - 1000
0.5	35	135.0 - 149.9	1			9.04 - 12.23	1000 - 1125
0.25							1125 - 1250
0.0	>36 -10 - -6	>150.0	<1	>38.52	>38.52	>12.24	>1250
-1.0	-15 - -11						
-2.0	-20 - -16						
-3.0	<20						

Source: Mieczkowski (1985)

The index score calculated according to the TCI formula was then adapted to the classification scheme designed by Mieczkowski (1985) to describe a location's climate suitability for tourism (Table 3.4). There are eleven categories in the TCI's scheme, ranging from "ideal" (90 – 100) to "impossible" (-30 – +9).

Table 3.4 Rating Categories of Tourism Climate Index (TCI)

TCI score	Descriptive category
90 -100	Ideal
80 - 89	Excellent
70 - 79	Very good
60 - 69	Good
50 - 59	Acceptable
40 - 49	Marginal
30 - 39	Unfavourable
20 - 29	Very unfavourable
10 - 19	Extremely unfavourable
9 - -9	Impossible
-10 - -30	Impossible

Source: Mieczkowski (1985)

3.3.2 Design of the Holiday Climate Index (HCI)

A new tourism climate index, the Holiday Climate Index (HCI) was designed for this study with the purpose of overcoming all identified deficiencies and limitations of the Tourism Climate Index. The word 'holiday' was chosen to more accurately reflect what the index was designed for. The UNWTO's (2012b) definition of tourism is much broader than 'leisure tourism':

Tourism is a social, cultural and economic phenomenon which entails the movement of people to countries or places outside their usual environment for personal or business/professional purposes.

The word 'holiday' better reflects that the index is designed specifically for the outdoor activities of leisure tourists. Similar to the TCI, the HCI was designed specifically for sightseeing and other general tourism activities in an urban destination. A major advancement of the HCI is that its variable rating scales and the component weighting system (Table 3.5) were designed based on the available literature on tourist climatic preferences that have been obtained from a range of surveys over the last ten years. This overcomes the main criticisms of the TCI that its design was subjective and not validated in the tourist market place.

The HCI uses five climatic variables related to the three facets essential to tourism: thermal comfort (TC), aesthetic (A), and physical (P) facet. The five climatic variables used for the HCI input are maximum air temperature and relative humidity (TC), cloud cover (A), precipitation and wind (P) (Table 3.5).

Table 3.5 Components of Holiday Climate Index (HCI)

Facet	Climatic Variable	Index Weighting (%)
Thermal Comfort (TC)	Dry-bulb Temperature (°C): Maximum Temperature (°C)	40%
	Relative Humidity (%): Mean RH	
Aesthetic (A)	Cloud Cover (%)	20%
Physical (P)	Amount of Rain (mm)	30%
	Wind Speed (km/h)	10%

The HCI score is calculated according to the following formula:

$$HCI = T*4 + A*2 + (R*3 + W*1)$$

For comparability to the TCI, the HCI uses the effective temperature, a combination of air temperature and relative humidity to determine the thermal comfort. The evening temperatures were eliminated from the HCI in consideration of the high implementation rate of air conditioning in tourist accommodations in developed countries and major tourist destinations in developing countries since the time the TCI was developed in the early 1980s. The maximum daily air temperature was chosen as the variable for thermal comfort. The purpose of choosing maximum temperature is because it represents the thermal conditions during the time of day when the maximum tourists' activities happening.

A major advancement of the HCI is that its variable rating scales and the weighting component system were designed based on the available literature on tourists' climatic preferences that have been obtained from a range of surveys from the last 10 years. The survey results used to assist designing the HCI include Scott et al. (2008), Moreno (2010), Rutty and Scott (2010) (Table 3.6). This overcomes the main criticism of the TCI that its design was subjective and not validated on the tourist market place. The weighting of each variable is re-assigned in order to overcome TCI's deficiency of subjectivity in weighting its components.

Table 3.6 Information of Surveys Used for HCI Design

Author	Study region	Sample size	Target group	Market segment
Scott et al. (2008)	Canada, New Zealand and Sweden	863 (333 from Canada, 207 from New Zealand, 291 from Sweden)	university students	young-adult segment
Moreno (2010)	Belgian and Dutch airport	115	air travelers	adult
Rutty & Scott (2010)	Northern European countries	850 (230 from Austria, 303 from Germany, 163 from Netherlands, 81 from Sweden, 89 from Switzerland)	university students	young-adult segment

One of the major criticisms of the TCI is its over-emphasis on the thermal comfort (see Table 3.2 for TCI component weighting). The TCI assigns half of its weight (50%) to the thermal comfort component, consisting of two separate indices – the Daytime Comfort Index (CID) and Daily Comfort Index (CIA), to emphasize its importance in influencing tourist comfort level.

The over-emphasis of the thermal component will result in the downplay of the impact of other climatic elements on overall tourist holiday experiences, and overlook the potential overriding effect of physical facet. Thus, by giving the physical facet (precipitation and wind) equal weight (40%) to the thermal comfort (40%), the overriding effect can be achieved when poor physical climatic conditions occur (e.g. rain or wind storm) as a sufficient weighting in physical facet can ensure a high HCI score cannot be achieved when the physical component rating is low. In order to capture the overriding effect when the physical facet is so poor, it overwhelms even pleasant thermal and aesthetic conditions (e.g. during rain storm of very high winds), the precipitation and wind rating schemes decline rapidly and have sufficient weighting in the index that a high HCI score cannot be achieved with low physical facet score.

Each climatic variable is rated on a scale of 0 to 10, and the overall HCI index score is 0 to 100 (Table 3.7). The HCI uses the same descriptive category scheme as the TCI (Table 3.4).

Table 3.7 HCI's Rating Scheme

Rating	Effective Temperature (°C)	Daily Precipitation (mm)	Daily Cloud Cover (%)	Wind Speed (km/h)
10	23 - 25	0	11 - 20	1 - 9
9	20 - 22 26	<3	1 - 10 21 - 30	10 - 19
8	27 - 28	3 - 5	0 31 - 40	0 20 - 29
7	18 - 19 29 - 30		41 - 50	
6	15 - 17 31 - 32		51 - 60	30 - 39
5	11 - 14 33 - 34	6 - 8	61 - 70	
4	7 - 10 35 - 36		71 - 80	
3	0 - 6		81 - 90	40 - 49
2	-5 - -1 37 - 39	9 - 12	>90	
1	<-5			
0	>39	>12		50 - 70
-1		>25		
-10				>70

The HCI uses daily climatic data for its calculation in order to overcome the TCI's identified deficiencies of low temporal scale and allow probability calculations for threshold conditions instead of only average ratings. In consideration of the time when the TCI was designed, the reason of adopting monthly average data was probably because the lack of international daily data. This use of daily resolution data as important for all variables, but especially of precipitation, as tourists not only want to know the amount of rain in a given month of a place, it is also critical for tourists to know the occurrence and intense of the rain. The use of daily climatic data in the index can provide this information. Thus, the HCI was designed to use daily climatic data and estimate both average monthly index ratings as well as probabilities of specific rating categories (very high or low score).

In summary, three main deficiencies that have been identified in the TCI by the past studies (de Freitas *et al*. 2004, 2008, Scott, *et al*. 2004, Amelung and Viner 2006, Frarajzadeh and Matzarakis 2009, Moreno and Amelung 2009, Perch-Nielsen, *et al*. 2010) have been addressed in the HCI design, including: (1) over-concentrating on thermal comfort component with no overriding effects were taking into consideration; (2) subjectivity on index variable weighting and variable rating systems; (3) low temporal scale. A summary of the HCI`s three main areas of improvements can be seen in Table 3.8. Although the HCI was designed to overcome the subjectivity of the TCI, its assigned weightings are subjective to some extent as the weighting of each climatic variable was assigned based on the ranking of relative importance of tourist preferences of climatic variable, and the actual percentage was assigned by the author. In considering of this limitation on the HCI design, the HCI is more objective than the TCI in terms of component weighting and rating system, but is subjective to some extent on the actual percentage assigned to each component weighting.

Table 3.8 Design Improvements of HCI over TCI

Main Areas of Improvements	Limitations of TCI	HCI
Index Variable Weightings (Overriding Effect)	Subjective: *weightings were assigned based on limited (non-tourism) available literature and expert opinion* No overriding effect: *weighting of physical facet is too low (30% in total)*, so that a physically impossible day for tourism can still be rated as acceptable, good, even very good	Evidence-based: weighting of each variable is assigned based on tourist ratings of relative importance of each variable Overriding effect: assigning physical facet an equal weight (40%) to thermal facet
Variable Rating Schemes	Subjective: *variable rating is based on physiological research and limited (non-tourism) available literature* No overriding effect: *rating scheme of physical facet does not adequately reflect how poor physical conditions can dominate (e.g. storm or high wind/rain)*	Evidence-based: results of tourist climatic preferences of each variable were obtained for designing the rating scheme. Surveys used include Scott et al. 2008, Wirth 2009, Rutty and Scott 2009, Moreno 2010 Overriding effect: ratings of physical facet (rain and wind) decline rapidly when conditions are poor and can dominate overall rating scores
Temporal Scale	Low temporal resolution: *mean monthly data is used, only average climatic conditions can be reported*	Higher temporal resolution: daily climatic data is used so that probability of specific conditions along with average conditions can be calculated

3.3.3 Variable Rating Comparison between TCI and HCI

Although both HCI and TCI require the same climatic variables to assess the climatic suitability of a destination for tourism, the rating scheme of each climatic variable is different between the two indices. The HCI rating scheme was designed based on tourist stated preferences of specific climatic conditions from the available studies, which is the major advancement over the TCI, and aims to overcome the subjectivity of TCI's expert-based ratings.

In both TCI and HCI calculations, five climatic variables (air temperature, relative humidity, cloud cover, precipitation and wind) are used to represent three climatic facets (thermal, aesthetic and physical). In the original published paper of Mieczkowski (1985), the TCI uses a scale of 1 to 5 to rate each of its components, including Daytime Comfort Index (CID), Daily Comfort Index (CIA), precipitation (R), sunshine (S) and wind (W). Because the entire TCI score is multiplied by two at the last stage (see equation on p.47), effectively each component is rated out of ten. The HCI was designed to use a ten point scale for each of its five climatic variables. In this section, for the purpose of comparing the rating differences for each climatic variable between the two indices in terms of differences in score position of rating scales, the TCI rating scales were standardized from a 5-point scale to a 10-point scale for each variable rating system by multiplying rating score of each rating score category by two (as they are done at the last stage of TCI calculations).

In the thermal facet, both HCI and TCI use effective temperature (ET) that consists of air temperature and relative humidity to measure the thermal comfort for general tourism activities in an urban destination. By comparing the thermal rating of two indices, it can be seen from Table 3.9 that major rating differences appear at categories of extreme hot (>34°C) and extreme cold (<-5°C); for the rest temperature categories, ratings of the two indices are fairly consistent . When effective temperature is higher than 34°C, the HCI assigns double to four times the scores of the TCI. Based on stated tourist preferences, the HCI ratings for the thermal facet are more reflective of tourist's preferences for the thermal comfort as leisure tourists show a greater tolerance for hot temperature. The rating difference at the hot end could play a major role when exploring topics such as whether climatic conditions of a destination (e.g. cities in the Mediterranean region) may become 'too hot' under climate change as the TCI ratings could lead to a result that the region may be 'too hot' for general tourist activities by giving low rating scores. Furthermore, the TCI assigns a broader ideal temperature (20-27°C) range than the HCI (23-25°C).

What causes the score difference in the thermal comfort facet between the two indices is how the variable scale was assigned. It should be noted that the HCI rating scale was designed according to tourist stated preferences of the thermal comfort from obtained surveys whereas the TCI rating categories are based only on available literature.

Table 3.9 Comparison of Rating Systems for the Thermal Facet

Rating	TCI Effective Temperature (°C)	HCI Effective Temperature (°C)	Rating
0	>36	>39	0
		37 - 39	2
1	35	35 - 36	4
2	34		
3	33	33 - 34	5
4	32		
5	31	31 - 32	6
6	30		
7	29	29 - 30	7
8	28	27 - 28	8
9	27	26	9
10	20 - 26	23 - 25	10
9	19	20 - 22	9
8	18	18 - 19	7
7	17	15 - 17	6
6	16		
5	10 - 15	11 - 14	5
4	5 - 9	7 - 10	4
3	0 - 4	0 - 6	3
2	-5 - -1	-5 - -1	2
0	-10 - -6	< -5	1
-2	-15 - -11		
-1	-20 - -16		
-6	<-20		

In the ratings of the aesthetic facet, the TCI uses hours of sunshine as variable input and percentage of cloud cover is used in the HCI rating scheme. In this study, cloud cover is used as data input for the aesthetic facet of both indices because hours of sunshine is not widely available as a daily variable. It should be noted that two main differences in ratings again occur in the highest and lowest rating of cloud cover. The TCI gives the highest score to the daily sunshine hours at more than 10 hours, and rating scores become higher with the increase of sunshine hours (Table 3.10). The highest rating score of the HCI aesthetic scheme reflects tourist preferences obtained from surveys, that indicates most tourists prefer a 11-20% cloud cover as an 'ideal' aesthetic experience instead of completely a clear blue sky. For the lowest rating of the aesthetic facet, the TCI assigns a score of 0 to daily sunshine hours less than one hour, whereas the survey results used for the HCI ratings show that 30% of respondents stated even all cloud cover conditions are suitable for urban holidays. Thus, no 0 score is assigned in the HCI scale.

Table 3.10 Comparison of Rating Systems for Aesthetic Facet

Rating	**TCI**	**HCI**	Rating
	Sunshine (hrs/day)	Cloud Cover (%)	
10	>10	11 - 20	10
9	9	1 - 10 21 - 30	9
8	8	0 31 - 40	8
7	7	41 - 50	7
6	6	51 - 60	6
5	5	61 - 70	5
4	4	71 - 80	4
3	3	81 - 90	3
2	2	90 - 99	2
1	1	100	1
0	<1		0

In the rating of precipitation, the TCI and HCI show major differences in rating certain amounts of precipitation. In the original paper, mean monthly amount of precipitation is used for TCI rating scheme. In this study, for the purpose of comparing the ratings of two indices, the monthly amount is converted to daily amount by dividing each rating category by 30. This is a limitation of using monthly data, as it is unknown if the rain is evenly distributed across the months (frequent light rain) or concentrated in short, intense events that tourists find easier to adapt to. In this study, amount of precipitation was used instead of hours of precipitation used in the original TCI calculation because the availability of climatic data from available sources. Except the assigned score for the lowest amount of daily precipitation (0-0.49mm), the HCI assigns higher score for all other amounts up to >25mm (Table 3.11). In the rating of daily precipitation less than 3mm, the HCI gives a score of 9 whereas the TCI assigns scores ranging from 5 to 9. The biggest rating difference occurs when daily precipitation ranges from 3 to 5mm. The HCI gives a score of 8 to any daily rain amount within the range of 3 to 5mm; the TCI, on the other hand, assigns a much lower score as only 1 to 4 score was given to the same daily amount.

Furthermore, the TCI considers any amount of daily precipitation higher than 5mm as the most unfavorable condition for urban tourism activities and a score of 0 is given. However, a score of 5 is assigned by the HCI to daily rain amount of 6 to 8mm. Only when daily amount of precipitation is more than 12mm, is a score of 0 is given by the HCI. The reason for the differences in assigned rating scores for each precipitation amount is because the HCI assigns rating scores based on tourist climatic preferences obtained from available surveys, whereas the TCI designed its rating scheme only based on expert knowledge. By objectively designing rating categories of climatic variables, the HCI rating are more reflective of real impact of precipitation on overall tourist holiday experience because it takes rain intensity into consideration.

Table 3.11 Comparison of Rating Systems for Precipitation

Rating	TCI	HCI	
	Daily Precipitation (mm)	Daily Precipitation (mm)	Rating
10	0.00 - 0.49	0.00	10
9	0.50 - 0.99	<3.00	9
8	1.00 - 1.49		
7	1.50 - 1.99		
6	2.00 - 2.49		
5	2.50 - 2.99		
4	3.00 - 3.49	3.00 - 5.00	8
3	3.50 - 3.99		
2	4.00 - 4.49		
1	4.50 - 4.99		
0	>5.00	6.00 - 8.00	5
		9.00 - 12.00	2
		>12.00	0
		>25.00	-1

For wind, the TCI includes four separate rating systems, including normal, trade wind, hot climate and wind chill system to rate wind speed. The rationale of developing four rating systems for wind for the TCI is that the effects of wind on tourist comfort level change with temperature. The four wind schemes are used separately for different temperature ranges. The normal system is used when mean daily maximum temperature is between 15-24°C; the trade wind system is used when there is a high temperature of 24-33°C; when temperature is higher than 33°C, the hot climate system is adopted; in the situation of a wind chill in which temperature is lower than 15°C and wind speed is faster than 8km/h, the wind chill rating system is used. In contrast, the HCI uses one rating system for wind because tourists did not distinguish the differential impact of wind on thermal comfort, but rather focused on its physical impact (e.g. blowing clothing and hair, disrupting outdoor dining and markets, blowing sand and other particles).

When comparing the rating scales of wind between the TCI and HCI, none of the four systems of the TCI has similar rating with the HCI rating system (Table 3.12). Similar to the other climatic variables included in the index, the HCI uses the tourist stated preferences of climatic variables from the available surveys, including Scott et al. (2008) and Rutty and Scott (2010), to develop the rating categories for wind speed. In contrast to the evidence-based ratings, the TCI's four wind schemes were developed based on author`s expert views and available non-tourism biometeorology literature.

Table 3.12 Comparison of Rating Systems for Wind

	TCI				HCI	
Rating	Normal (15 - 24°C)(km/h)	Trade Wind (24 - 33°C)(km/h)	Hot Climate (>33°C)(km/h)	Wind Chill Cooling (<15°C & >8km/h) (watts/ms/hr)	Wind Speed (km/h)	Rating
10	<2.88	12.24 - 19.79			1 - 9	10
9	2.88 - 5.75				10 - 19	9
8	5.76 - 9.03	9.04 - 12.23 19.80 - 24.29		<500	0 20 - 29	8
7	9.04 - 12.23					7
6	12.24 - 19.79	5.76 - 9.03 24.30 - 28.79		500 - 625	30 - 39	6
5	19.8 - 24.29	2.88 - 5.75				5
4	24.30 - 28.79	<2.88 28.80 - 38.52	<2.88	635 - 750		4
3	28.8 - 38.52		2.88 - 5.75	750 - 875	40 - 49	3
2			5.76 - 9.03	875 - 1000		2
1			9.04 - 12.23	1000 - 1125		1
0.5				1125 - 1250		0.5
0	>38.52	>38.52	>12.24	>1250	50 - 70	0
-2						-2
-4						-4
-6						-6
-10					>70	-10

3.4 Data

The dataset for present climate (1961-1990) and future climate change scenarios were obtained from the EU-funded ENSEMBLES project. The ENSEMBLES project's main goal is to produce probabilistic climate projections for Europe to help researchers, decision makers, businesses and the public with climate information of the latest climate modelling and analysis tools (ENSEMBLES 2009). It also aims to develop an ensemble climate forecast system which can be used across a range of timescales and spatial scales (see the report ‘Six Framework Programme Priority 1.1.6.3: Global Change and Ecosystems 2008’). In consideration of the scope and coverage for (all western Europe) and characteristics (daily data for multiple variables) of the data necessary for this thesis, data offered by the ENSEMBLES project were most appropriate to fulfill the requirements of this research. Another important reason for choosing ENSEMBLES data is because it is one of the biggest downscaled climate change datasets available, and is used by a wide range of climate change studies in Europe. It is currently the standard for climate change scenarios for impact studies in western Europe.

The Research Theme 2B (RT2B) is one of the ENSEMBLE project’s 10 interlinked Research Themes (RTs) and was used for this study. The purpose of the RT2B is to:

“construct probabilistic high-resolution regional climate scenarios using dynamical and statistical downscaling methods to add value to the model output from RT1 and RT2A and to exploit the full potential of the Regional Climate Models (RCMs) developed in RT3” (ENSEMBLES 2009, p.5).

For the climate change analysis, the Global Climate Model (GCM) ECHAM5 is combined with Regional Climate Models (RCMs) to generate daily climate data in four time periods: the 1970s (1961-1990); 2020s (2010-2030); 2050s (2040-2069); and 2080s (2070-2099). The RCMs use a 25 km horizontal grid-length resolution that covers all of Europe (Table 3.13). This is one of the major improvements of this study on previous studies that examined the climate change impacts as high resolution RCM based scenarios were used instead of course-scale GCMs which better reflect local physiology (e.g. elevation, bodies of water).

Table 3.13 Model Chosen for Present Analysis

Scenario	RCM	Driving GCM	Acronym	Institute	Resolution
A1B	RegCM	ECHAM5	ICTP-REGCM	ICTP	25km

The IPCC developed four major emission scenarios families: the A1, A2, B1 and B2 family to describe the relationship between the forces driving emissions and their evolution and to evaluate climatic and environmental consequences of alternative future GHG emissions (IPCC 2007a) (Table 3.14). The IPCC SRES (Special Report on Emissions Scenarios) A1B scenario was adopted for climate change analysis in this thesis. The A1B scenario belongs to the A1 storyline and scenario family which results in the warmest scenarios. The A1 storyline describes a future world of very rapid economic growth, global population peaks in mid-century and declines afterwards, as well as the rapid introduction of new and more efficient technologies (IPCC 2007a). Three groups are included in the A1 family, the A1FI, A1T and A1B, which are distinguished by their technological emphasis. The A1B assumes balanced energy consumption across all sources where no one particular energy source is relied too heavily, and a similar improvement rates apply to all energy supply and end-use technologies. The reason of choosing the A1B scenario is because it is the most consistent with observed emissions through to 2012.

Table 3.14 Summary of Intergovernmental Panel on Climate Change (IPCC) (2007a) Scenario

Storyline/Scenario Family	Description
A1	Represents a future of rapid economic growth, with global poplucation peaking midcentury, and the rapid introduction of new and more efficient technologies. Subdivided into three groups based on their primary technological emphasis: fossil intensive (A1FI), non-fossil intensive (A1T), and balanced (A1B).
A2	Based on regionally oriented economic development in which both per capita economic growth and technological change are slower and more fragmented than in other storylines, but in which global population continues to increase
B1	Recognizes the same midcentury peak in global population as the A1 storyline but based on a far more resource-efficient, service/information-oriented economy, and on a world in which economic, social and environmental sustainability are emphasized at a global level.
B2	A locally/regionally oriented storyline that is based on a continuously increasing global population (but at a rate lower than A2), intermediate levels of economic development, and less rapid and more diverse technological change than B1 or A1.

3.5 Chapter Summary

In summary, a new tourism climate index, the Holiday Climate Index was designed and its component and structure were compared with the Tourism Climate Index to demonstrate how the newly-designed HCI is more valid for assessing the climate suitability for tourism in urban destinations. Both current and future climate suitability of the selected European city destinations will be assessed using the TCI and HCI. The results and any rating difference between the HCI and TCI are presented in the next chapter.

Chapter 4

Results

4.1 Introduction

The results and comparison of the ratings of the TCI and HCI are presented in four sections. The first section describes both TCI and HCI ratings of the selected 15 European destinations. The mean monthly score, seasonal score difference and seasonal probability of ‘suitable’ conditions are presented for the 1961-1990 period. The discussion is organized by region, results for the northern, western, eastern Europe were presented first, followed by the southern Europe. The second section compares both TCI and HCI scores with recent visitation data to compare the climate ratings with an indication of tourism demand. The third section presents the differences between the TCI and HCI in rating of specific climatic conditions (e.g. heavy rain) for the three climatic facets: thermal, aesthetic and physical. Section four shows the projected future climatic ratings for tourism in the selected destinations rated by both TCI and HCI.

4.2 TCI and HCI Ratings of Current Climatic Conditions (1961-1990) for Tourism

Current climatic conditions (1961-1990) of the 15 European city destinations were rated using both TCI and HCI. The climatic conditions are assessed using two variables: mean monthly index score and seasonal probability of ‘suitable’ conditions. The ‘suitable’ conditions are defined as ratings of 49 and higher for winter, spring and fall months (as scores in these seasons are relatively lower than scores in summer months), and ratings of 59 and higher for summer months. The seasons are defined as spring (March, April and May), summer (June, July and August), fall (September, October and November), winter (December, January and February).

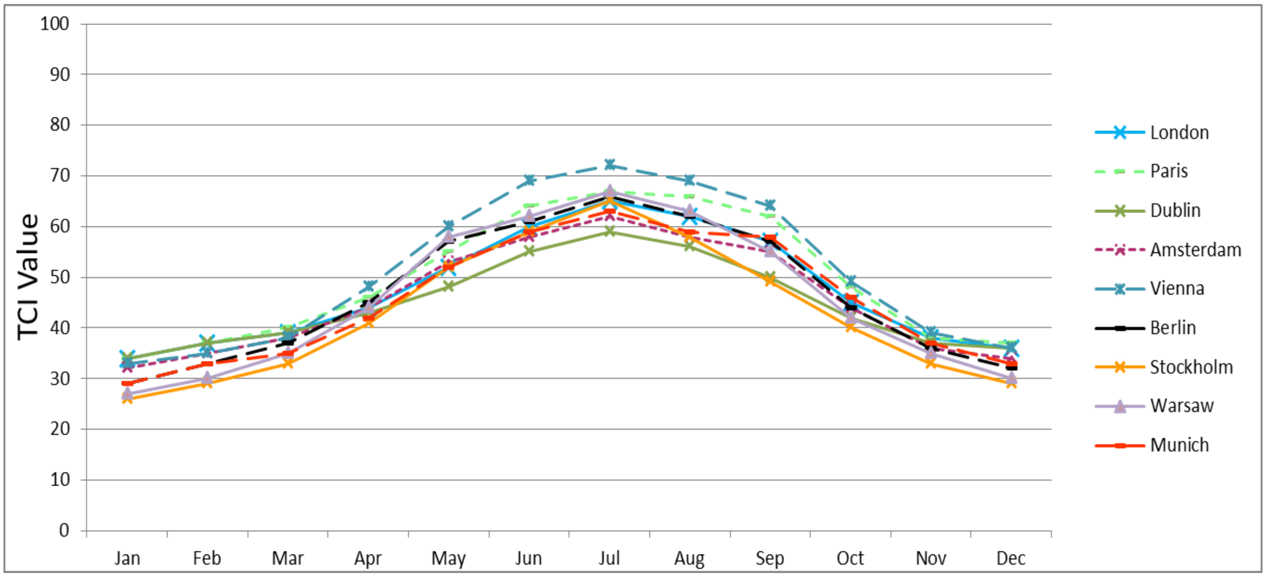
4.2.1 Mean Monthly and Seasonal Ratings

4.2.1.1 Northern, Western and Eastern Europe

All selected destinations located in northern, western and eastern Europe (London, Paris, Dublin, Amsterdam, Vienna, Berlin, Stockholm, Warsaw and Munich) have a ‘summer peak’ climate distribution (see Figure 2.1 for six conceptual tourism climate distributions) when rated by the TCI (Figure 4.1). This means that summer months (June, July and August) have the most suitable climate for urban tourism. The summer months in all destinations have a TCI score of 55-70, which are in the categories of ‘marginal’ (40-49), ‘acceptable’ (50-59) and ‘good’ (60-69) for urban tourism (see Table 3.4 for TCI rating categories). The ratings show that summer months in all selected northern, western and eastern European city destinations are suitable for urban tourism. The summer months in Vienna have the best climate conditions for urban tourism (June=69, July=72, August=69) whereas Dublin has the lowest TCI scores in summer months (June=55, July=59, August=56) (Figure 4.1).

In winter months (December, January and February), the TCI scores show that all selected northern, western and eastern European destinations have a score of below 40, and all destinations are in the score range of 27-37 which means winter months in these regions are ‘unfavorable’ (30-39) or ‘very unfavorable’ (20-29) for urban tourism activities.

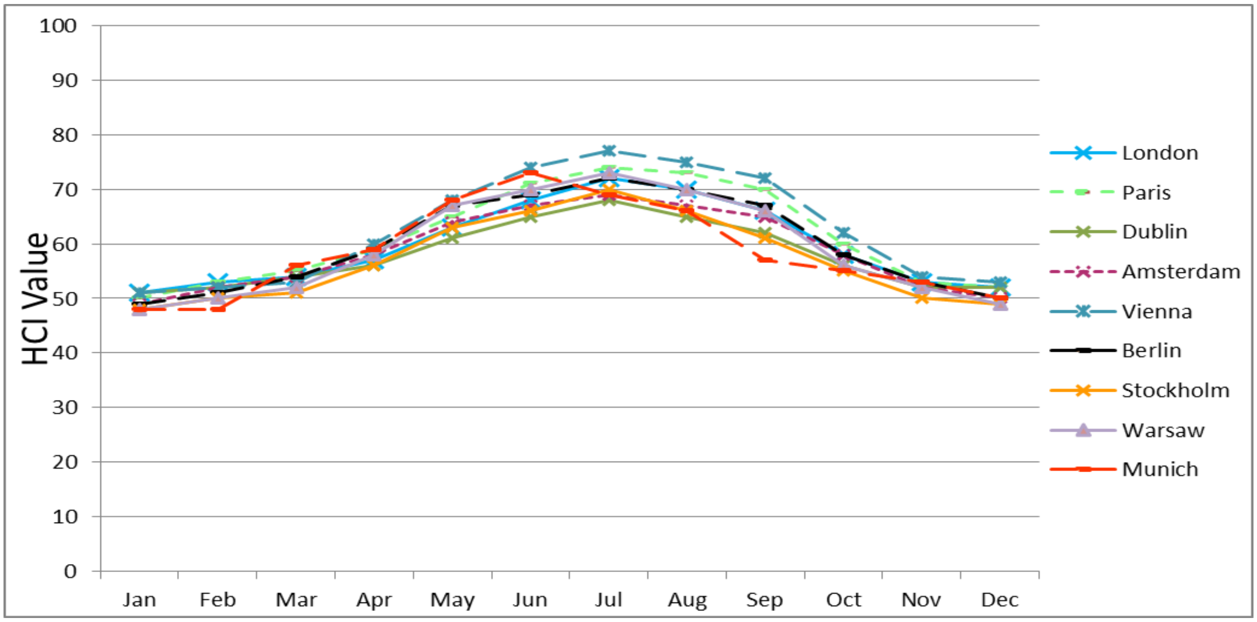
Figure 4.1 Monthly TCI Values of Northern, Western and Eastern Europe



Similar to the TCI ratings, all selected city destinations located in northern, western and eastern Europe (London, Paris, Dublin, Amsterdam, Vienna, Berlin, Stockholm, Warsaw and Munich) have a 'summer peak' climate distribution when rated by the HCI (Figure 4.2). In summer, when the highest HCI scores occur, all destinations in these regions have a score range of 65-77 which is in the categories of 'good' (60-69) to 'very good' (70-79). Throughout all months of the year, the HCI scores are above 50 in these regions, indicating that climate conditions are 'suitable' for urban tourism in all four seasons.

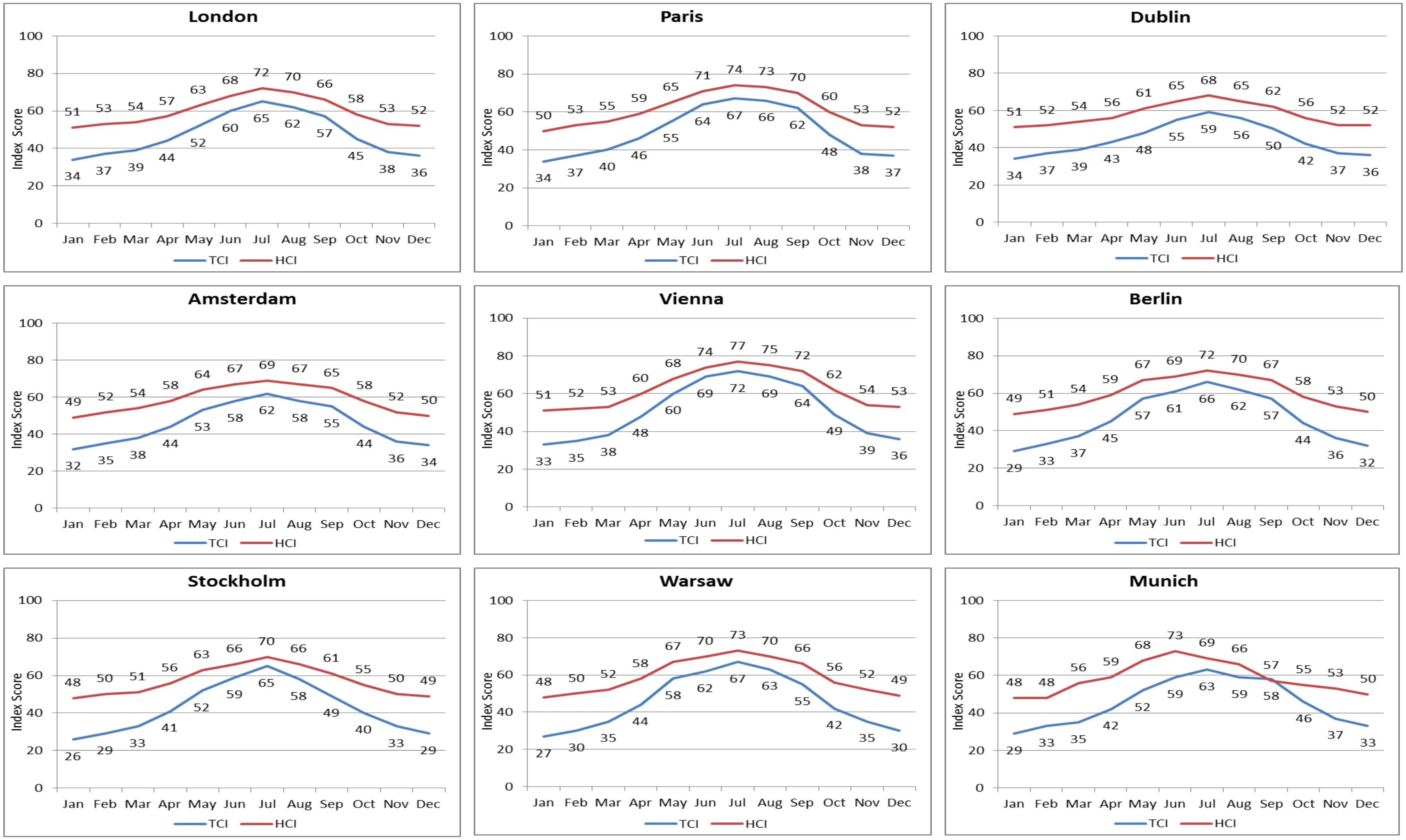
The HCI scores indicate that climatic conditions of winter months in these regions are not 'unfavorable' to 'very unfavorable' as the TCI ratings. All selected northern, western and eastern European destinations have scores higher than 45 (ranges from 48 to 53). In this case, winter climate is 'marginal' (40-49) to 'acceptable' (50-59) for urban tourism.

Figure 4.2 Monthly HCI Values of Northern, Western and Eastern Europe



By comparing the HCI and TCI monthly scores of the selected northern, western and eastern European city destinations, it can be seen from Figure 4.3 that rating differences between the two indices are more prominent in winter months, and that the HCI rates the climate for tourism higher in all of those destinations.

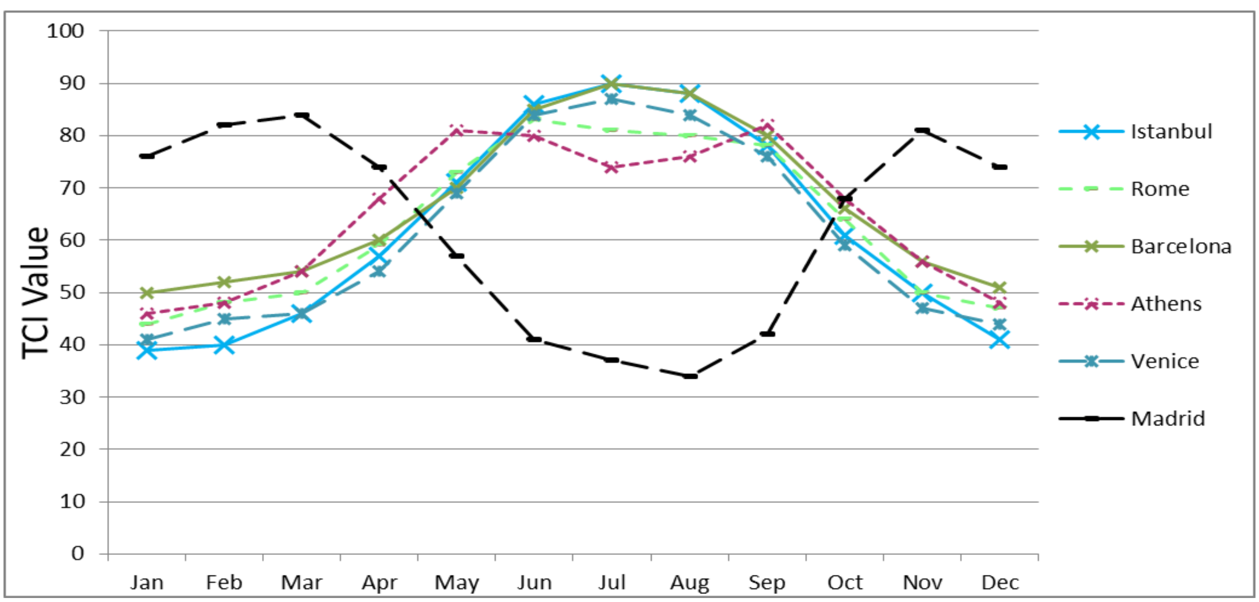
Figure 4.3 Rating Comparison of Current Climatic Conditions (1961-1990) for Tourism between TCI (blue) and HCI (red) for Northern, Western and Eastern European city destinations



4.2.1.2 Southern Europe

In southern Europe, most destinations also have a ‘summer peak’ climate distribution, while Madrid, Rome and Athens have a ‘bimodal shoulder peak’ distribution when rated by the TCI (Figure 4.4). Summer climatic conditions of the southern European destinations are better than those located in northern, western and eastern European regions, as the TCI rates half of the destinations in the region (Istanbul, Barcelona and Venice) in the score range of 84-90 in summer (‘excellent’: 80-89, ‘ideal’: 90-100). Climate conditions in Rome, Athens and Madrid show a different distribution, a ‘bimodal-shoulder peak’ distribution can be seen as TCI scores in late spring (May) and early fall (September) are higher than scores of the summer months. Madrid has the most pronounced difference, with the best climatic conditions in March and November. Summer is the least suitable time climatically to visit Madrid, when it has an ‘unacceptable’ climate (<40) according to the TCI. In contrast to northern, western and eastern Europe, winter in the southern European cities is only ‘marginal’ (40-59) to ‘acceptable’ (50-59) for urban tourism when rated by the TCI.

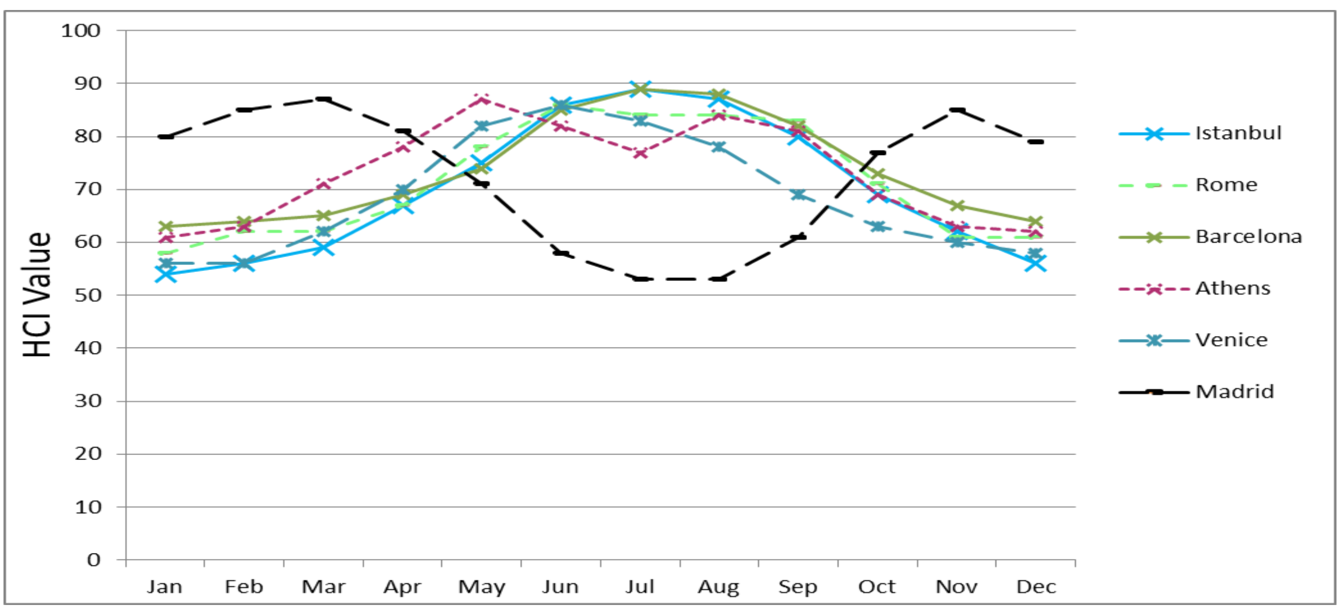
Figure 4.4 Monthly TCI Values of Southern Europe



Similar to the TCI ratings of southern European city destinations, most destinations (Istanbul, Rome, Barcelona and Venice) have a 'summer peak', while Athens and Madrid have a 'bimodal-shoulder peak' climate distribution when rated by the HCI (Figure 4.5). Istanbul, Barcelona and Venice have a 'summer peak' climate distribution with an 'excellent' (80-89) summer climate. An early 'summer peak' distribution can be seen in Rome, with the highest HCI rating score (86) in June. Compared to other destinations in the region, the HCI scores show a 'bimodal-shoulder peak' distribution in Athens and Madrid, indicating that spring (March, April and May) and fall months (September, October and November) are more suitable than summer in these destinations for urban tourism activities.

Different from the TCI ratings of winter climate in the southern Europe that rate winter climate as 'marginal' (40-49) to 'acceptable' (50-59), the HCI scores indicate that climatic conditions of winter months in the region are 'acceptable' (50-59) to 'good' (60-69) in all six selected destinations.

Figure 4.5 Monthly HCI Values of Southern Europe



The rating differences between the HCI and TCI in the southern European city destinations are more prominent in winter, and the score gap is narrower during summer months for all selected destinations except Madrid (Figure 4.6). The score differences in summer months of Istanbul, Rome, Barcelona, Athens and Venice are less than 10 which indicate that no major difference in rating category occurs when rated by both indices. In contrast, score differences between the TCI and HCI in rating winter climate conditions are more prominent as score differences are more than 10.

Seasonally, winter has the wider rating difference between the two indices for all 15 European city destinations, while the rating difference is smaller in summer months with the exception of Madrid (Table 4.1 and 4.2). When comparing the seasonal differences between the TCI and HCI rating of the selected 15 European destinations, it is evident that the colder the season, the wider the gap between the ratings of the two indices. Winter has the widest rating difference and the gap becomes the narrowest in summer, suggesting the way the thermal comfort facet is rated and weighted in the index is the primary difference in the index results.

Figure 4.6 Rating Comparison of Current Climatic Conditions (1961-1990) for Tourism between TCI (blue) and HCI (red) for Southern European city destinations

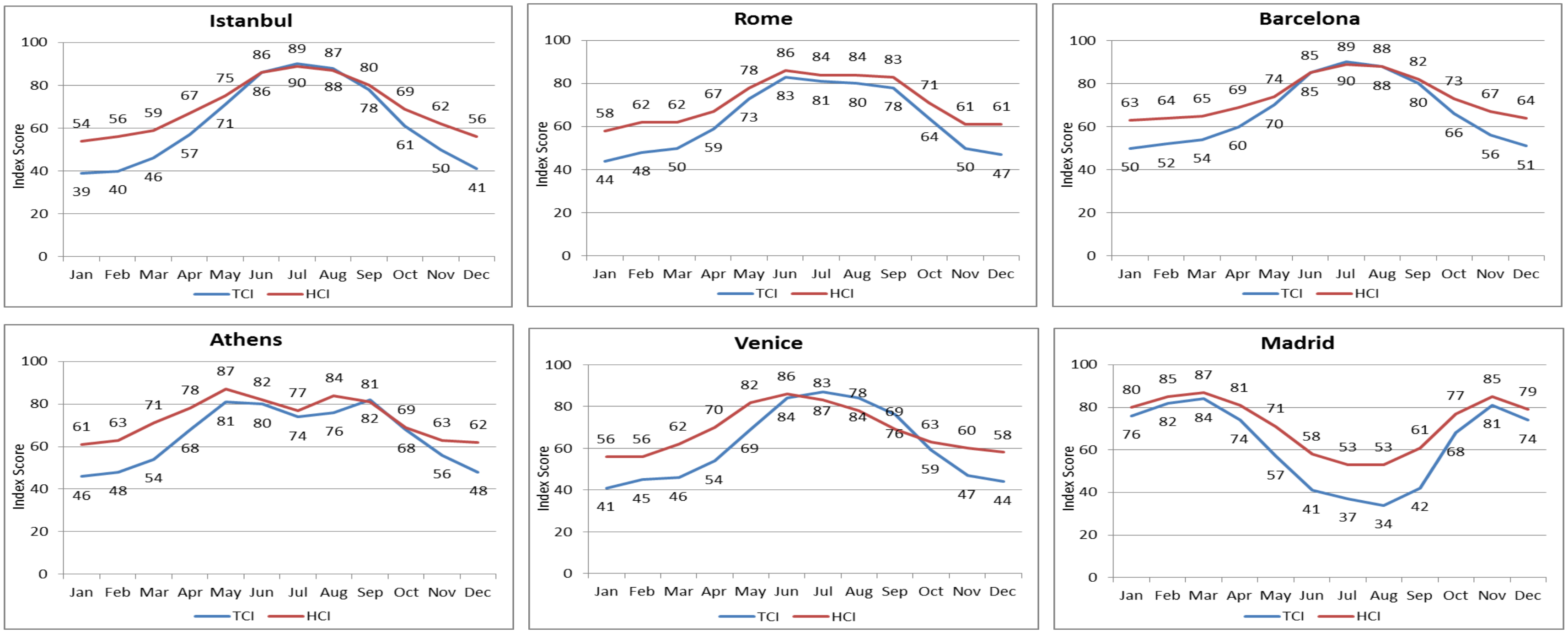


Table 4.1 TCI and HCI Rating Score for Winter Months

Index	Season	1970s															
		Month	London	Paris	Dublin	Amsterdam	Vienna	Berlin	Stockholm	Warsaw	Munich	Istanbul	Rome	Barcelona	Athens	Venice	Madrid
TCI	Winter	Dec	36	37	36	34	36	32	29	30	33	41	47	51	48	44	74
		Jan	34	34	34	32	33	29	26	27	29	39	44	50	46	41	76
		Feb	37	37	37	35	35	33	29	30	33	40	48	52	48	45	82
HCI	Winter	Dec	52	52	52	50	53	50	49	49	50	56	61	64	62	58	79
		Jan	51	50	51	49	51	49	48	48	48	54	58	63	61	56	80
		Feb	53	53	52	52	52	51	50	50	48	56	62	64	63	56	85

Table 4.2 TCI and HCI Rating Score for Summer Months

Index	Season	1970s															
		Month	London	Paris	Dublin	Amsterdam	Vienna	Berlin	Stockholm	Warsaw	Munich	Istanbul	Rome	Barcelona	Athens	Venice	Madrid
TCI	Summer	Jun	60	64	55	58	69	61	59	62	59	86	86	85	80	84	41
		Jul	65	67	59	62	72	66	65	67	63	90	84	90	74	87	37
		Aug	62	66	56	58	69	62	58	63	59	88	84	88	76	84	34
HCI	Summer	Jun	68	71	65	67	74	69	66	70	73	86	86	85	82	86	58
		Jul	72	74	68	69	77	72	70	73	69	89	84	89	77	83	53
		Aug	70	73	65	67	75	70	66	70	66	87	84	88	84	78	53

- Ideal (90-100)
- Excellent (80-89)
- Very good (70-79)
- Good (60-69)
- Acceptable (50-59)
- Marginal (40-49)
- Unfavorable (30-39)
- Very unfavorable (20-29)
- Extremely unfavorable (10-19)
- Impossible (9 - -9)
- Impossible (-10 - -20)

4.2.2 Seasonal Probability of 'Suitable' Climate Conditions

In this section, seasonal probability of 'suitable' climate conditions refers to how likely the 'suitable' climate conditions (index scores higher than 49 for summer months and scores higher than 59 for winter, spring and fall months) will happen. The seasonal probability was obtained by calculating how many times daily index scores in the 'suitable' categories appeared from 1961 to 1990 for the selected 15 European urban city destinations. A 'suitable' climate for urban tourism is defined differently for different seasons in this study. Climate conditions in any given day with a score higher than 49 are considered 'suitable' for general tourism activities (e.g. sightseeing and shopping) in winter, spring and fall months as scores in these seasons are relatively lower than scores in summer months. This includes rating categories of 'acceptable' (50-59), 'good' (60-69), 'very good' (70-79), 'excellent' (80-89) and 'ideal' (90-100) (as scores in these seasons are relatively lower than score in summer months). Daily climate conditions with a score higher than 59 are considered 'suitable' climate in summer months, including rating categories of 'good' (60-69), 'very good' (70-79), 'excellent' (80-89) and 'ideal' (90-100) (see Table 3.4 in Chapter 3 for full rating schemes of the TCI and the HCI).

In the winter months (December, January and February), the probability of experiencing a 'suitable' climate (>49) on any given day under the TCI and HCI are substantially different, in particular in the northern, western and eastern European regions. The TCI ratings show the probability of experiencing 'suitable' climatic conditions in winter months for urban tourism activities in the selected northern, western and eastern European city destinations is less than 15% (Table 4.3). In Berlin, Stockholm and Warsaw, the probability is too low (<5%) to conduct any tourism activity in urban environment, which is clearly not the case. The HCI ratings, in contrast, indicate that winter months in northern, western and eastern European region are more suitable for urban leisure trips, as there is a high probability (50-77%) of having a ‘suitable’ climate in winter months of most cities (London, Paris, Dublin, Amsterdam, Vienna, Berlin and Munich).

For the selected southern European city destinations, the differences in the probability of experiencing ‘suitable’ climate conditions between the TCI and HCI are smaller than the differences in the northern, western and eastern Europe. The TCI ratings show that all selected southern European destinations, except Madrid, have a 21-67% probability of having a ‘suitable’ climate for urban tourism (Table 4.3). Barcelona is the only city that has a 60-67% probability in winter months, and all other cities have a 21-50% probability. The HCI ratings are higher than the TCI, with a 75-92% probability of have a ‘suitable’ climate in winter months in the region.

Table 4.3 Seasonal Probability (%) of ‘Suitable’ (>49) Climate Conditions in Winter Months

Index	Season	1970s															
		Month	London	Paris	Dublin	Amsterdam	Vienna	Berlin	Stockholm	Warsaw	Munich	Istanbul	Rome	Barcelona	Athens	Venice	Madrid
TCI	Winter	Dec	3	6	2	2	5	1	0	0	7	26	49	65	48	36	96
		Jan	2	2	1	1	2	1	0	0	4	21	39	60	43	26	96
		Feb	8	14	6	8	8	4	2	1	12	27	51	67	50	36	99
HCI	Winter	Dec	75	75	74	70	73	62	53	54	60	78	86	91	89	85	100
		Jan	70	68	70	63	66	52	39	39	52	75	78	92	90	80	100
		Feb	77	73	74	70	69	63	49	51	58	77	87	92	88	86	100

The difference in the probability of experiencing ‘suitable’ climate conditions (>59) on any given day for urban tourism in summer months (June, July and August) under the TCI and HCI are smaller compared to the difference in winter months, with a 30-40% probability difference on average (Table 4.4). All selected northern, western and eastern European cities, except Vienna, have a 33-68% probability in summer of experiencing ‘suitable’ climate conditions for tourism when rated by the TCI. Vienna is the city that has the highest probability (73-79%) of having a ‘suitable’ climate for urban tourism activities in summer months. The HCI ratings indicate higher probabilities with a 73-92% probability of experiencing ‘suitable’ conditions in northern, western and eastern European summer.

In the selected southern European city destinations, with the exception of Madrid, the probability differences between the TCI and HCI are very low (<10%) (Table 4.6). Both TCI and HCI ratings indicate that there is a 94-98% probability of experiencing ‘suitable’ climate conditions in summer months. Athens is the only city which has a 79% probability in July and August when rated by the TCI. In Madrid, the TCI ratings show that there is almost 0% probability of having a ‘suitable’ climate for urban tourism activities which does not fit with observed summer tourism patterns. The HCI ratings indicate that a 10-33% probability of ‘suitable’ climate can be expected for sightseeing tourists.

Table 4.4 Seasonal Probability (%) of ‘Suitable’ (>59) Climate Conditions in Summer Months

Index	Season	1970s															
		Month	London	Paris	Dublin	Amsterdam	Vienna	Berlin	Stockholm	Warsaw	Munich	Istanbul	Rome	Barcelona	Athens	Venice	Madrid
TCI	Summer	Jun	47	61	33	41	73	51	47	55	49	95	94	96	86	94	4
		Jul	61	68	47	54	79	65	60	65	58	98	96	98	79	97	0
		Aug	53	65	34	44	73	54	44	55	50	96	92	98	79	94	0
HCI	Summer	Jun	85	86	78	76	90	82	80	83	73	98	98	97	98	95	33
		Jul	89	89	84	84	92	89	88	88	79	99	98	98	97	97	10
		Aug	90	89	82	80	90	88	81	85	73	97	97	97	98	94	11

In the spring months (March, April and May), the differences in probability between the TCI and HCI are still prominent in northern, western and eastern European region (Table 4.5). In March and April, a low probability (<50%) of having ‘suitable’ climate conditions (>49) was rated by the TCI. May has a higher probability (46-73%) which means May is the only months in spring that has a ‘suitable’ climate for urban tourism. In contrast, the HCI ratings show that all three months in spring are ‘suitable’ for urban tourism activities, as nearly all selected cities in the regions have more than 70% probability. The only exception is March in Stockholm, where a 61% probability was rated by the HCI.

For the selected southern European city destinations, there is a small probability difference (<20%) between the TCI and HCI ratings in April and May (Table 4.5). March, on the other hand, has a bigger probability difference (20-36%) between the TCI and HCI.

Table 4.5 Seasonal Probability (%) of ‘Suitable’ (>49) Climate Conditions in Spring Months

Index	Season	1970s															
		Month	London	Paris	Dublin	Amsterdam	Vienna	Berlin	Stockholm	Warsaw	Munich	Istanbul	Rome	Barcelona	Athens	Venice	Madrid
TCI	Spring	Mar	16	22	17	16	16	11	8	9	16	47	55	71	67	48	100
		Apr	31	37	30	34	46	36	27	33	36	70	72	81	86	67	94
		May	55	59	46	56	73	67	60	65	54	87	88	91	96	86	62
HCI	Spring	Mar	80	78	78	75	75	77	61	70	65	83	85	91	91	79	100
		Apr	83	83	83	84	86	86	79	83	75	90	86	94	97	85	100
		May	89	88	88	88	90	93	90	92	82	95	93	96	98	90	99

In the fall months (September, October and November), probability differences between the TCI and HCI are prominent in the selected northern, western and eastern European city destinations, but not in the selected southern European cities. The difference is significant in all three months in fall, in particular in October and November (Table 4.6). According to the TCI ratings, September is a suitable month to visit for sightseeing tourists as all selected northern, western and eastern European cities, with the exception of London, have a 52-75% probability of having ‘suitable’ climate conditions (>49) for urban tourism. London is the only city in the regions that has a low probability (37%) of experiencing a ‘suitable’ climate in September when rated by the TCI. In October and November, the TCI probability suggests that urban tourists should avoid traveling in October and November, as a low probability (<50%) of experiencing ‘suitable’ conditions was rated by the TCI. The probability of London is too low (0-7%) to take any urban tourism activity. In comparison to the TCI ratings of probability in fall months in the northern, western and eastern European region, the HCI ratings show a very different rating. All fall months have a high probability (>70%) of having a 'suitable' climate in all selected cities in the region.

Table 4.6 Seasonal Probability (%) of 'Suitable' (>49) Climate Conditions in Fall Months

Index	Season	1970s															
		Month	London	Paris	Dublin	Amsterdam	Vienna	Berlin	Stockholm	Warsaw	Munich	Istanbul	Rome	Barcelona	Athens	Venice	Madrid
TCI	Fall	Sep	37	75	52	60	81	67	52	61	62	93	98	90	99	95	22
		Oct	7	43	21	32	49	33	17	24	44	77	80	88	88	78	82
		Nov	0	12	4	6	16	5	1	3	18	56	54	76	69	49	99
HCI	Fall	Sep	92	93	87	89	93	94	88	93	85	96	96	97	100	96	90
		Oct	85	84	82	80	91	87	81	84	79	90	87	93	96	88	100
		Nov	78	75	77	75	79	81	65	75	70	86	80	92	92	81	100

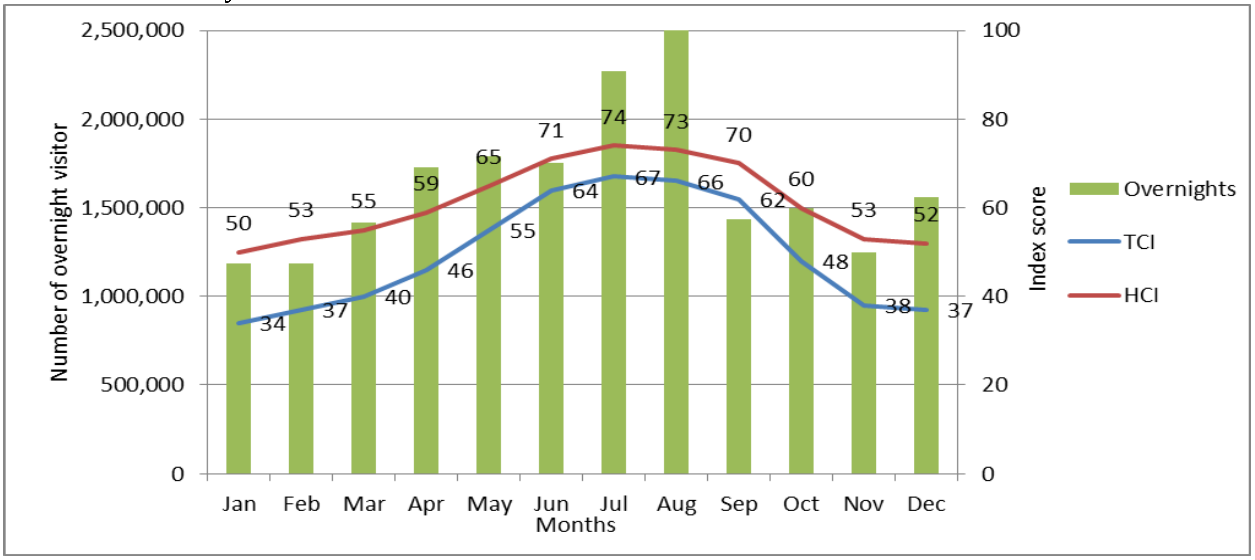
4.3 Comparison of the HCI and TCI with the Tourist Demand Indicator

This section aims to compare ratings of the TCI and HCI with visitation data, to provide some additional insight into their relative ability to consumer decisions of destination. It is recognized that climate is far from the only determinant of tourist travel decisions and that other motivation and 'push-pull' factors could overcome poor climatic conditions. Nevertheless, it is helpful to compare actual visitation patterns to climatic ratings to better understand the relative merits of the two indices.

Both the TCI and HCI mean monthly scores were compared with monthly tourist arrivals from the only city destination such information was available for (Paris). Monthly arrivals of leisure tourists in one of the northern, western and eastern European cities were compared with both the TCI and HCI ratings, as results of rating score comparison in section 4.2 showed that the rating differences are more prominent in northern, western and eastern European region than southern Europe, in particular during winter months of the regions.

Figure 4.7 shows the comparison of mean monthly numbers of leisure visitors from 2000 to 2010 who stayed overnights in Parisian hotels and mean monthly TCI and HCI scores of Paris. The seasonal variation of leisure arrivals in Paris showed a similar summer peak trend with both TCI and HCI ratings of climatic conditions in Paris. Major differences in rating climate suitability for urban tourism between the TCI and HCI occur in winter months (December, January and February) in the northern, western and eastern European regions in which the TCI rated winter climate as ‘unsuitable’ (<40) for general tourism activities whereas the HCI ratings showed that climate conditions in winter months still can be considered as ‘acceptable’ (50-59) for urban tourism. The mean monthly leisure tourist arrivals show that during winter months in which a very low tourism season is expected, the number of leisure tourists was high, and maintained a steady number of higher than 1,000,000 from 2000 to 2010. This implies that climate conditions in the traditional low tourist season of northern, western and eastern European region, in particular during winter months, could still be considered as ‘acceptable’ for leisure tourists. By comparing the rating scores of both indices against the leisure tourist arrivals in Parisian winter, the HCI ratings are more reflective of visitation trend with respect to the suitability of climate conditions for urban tourism as numbers of tourist arrivals in winter months indicate climate of low season is ‘suitable’ and preferred by leisure tourists in the regions.

Figure 4.7 Comparison of Monthly Leisure Tourist Overnights in Parisian Hotels from 2000 to 2010 and Monthly TCI and HCI Scores



Source: parisinfo.com (2005) (2009)

4.4 TCI and HCI Rating Differences of Three Specific Conditions

This section presents the results of TCI and HCI rating differences for illustrative climatic conditions (e.g. days with cold/hot temperature, heavy rain, high speed wind etc.) to demonstrate how the thermal, aesthetic and physical facets compare under marginal conditions. The purpose of comparing the rating differences in each climate facet using illustrative conditions is to show the effects of different index construction (e.g. rating scales and weighting component) on overall rating scores, in particular the overriding effects of the physical facet in the HCI. In order to compare the rating differences in each climatic variable, the rating scales were standardized to a 10-point scale for both indices. However, in order to make correct calculations, the overall rating scores (shading section of examples) for the 3 climate facets (thermal, aesthetic and physical) are still calculated based on original rating scales (TCI 5-point and HCI 10-point scale).

4.4.1 Thermal Facet

The two examples below show the rating differences between the TCI and HCI in situations when effective temperature is low (<10°C) and high (>15°C). When comparing the rating differences in the thermal facet, other climatic variables of the aesthetic and physical facet (cloud cover, precipitation and wind) are kept constant in order to show both the rating score differences in the thermal facet and its relationship with overall score difference. Table 4.7 presents an example of rating differences between the TCI and HCI when effective temperature is lower than 10°C. The rating differences between the two indices are small, which means that the assigned ratings for the thermal category are similar between the two indices (see Chapter 3 for rating scale comparison for the thermal facet). When mean air temperature is 4°C, the TCI rates a score of 4 for its Daytime Comfort Index (CID) and 3 for the Daily Comfort Index (CIA), the HCI rates a score of 3. Although a similar score was assigned, the calculated scores for the thermal facet between the two indices are different (TCI-19, HCI-12). This is caused by the assigned weightings of the thermal facet as the TCI over-emphases the thermal comfort by giving it a 50% of total weights whereas the HCI only assigns a 40% weight.

Table 4.7 Example of Rating Differences between TCI and HCI when Temperature is Low

Index	RH (%)	Tmax (°C)	Tmean (°C)	Cloud (%)	P (mm)	Wind (km/h)	Thermal (T)		Aesthetic (A)	Physical (P)		Total Score
							CID (Tmax & RH)(°C)	CIA (Tmean & RH)(°C)	Cloud (%)	Pricipitation (mm)	Wind (km/h)	
TCI	92	6	4	100	1	27	4 (2)	3 (1.5)	0 (0)	8 (4)	2 (1)	37
							2*(4CID + CIA) = 19		2*2S = 0	2*2R = 16	2*W = 2	
HCI	92	6	4	100	1	27	3		2	9	8	51
							4T (Tmax & RH) = 12		2A = 4	3R = 27	W = 8	

*( ) represents scores used in TCI calculations based on original 5-point scale

A similar result also can be seen when comparing rating differences between the TCI and HCI when a day has a relatively higher effective temperature (>15°C) (Table 4.8). The differences in thermal ratings between the TCI and HCI are small when both indices were compared in a 10-point scale (TCI: CID-6, CIA-5; HCI: 6), but the higher weighting component of the thermal facet gives the TCI a higher thermal rating score than the HCI (TCI=29, HCI=24).

Table 4.8 Example of Rating Differences in Thermal Facet when Temperature is High

Index	RH (%)	Tmax (°C)	Tmean (°C)	Cloud (%)	P (mm)	Wind (km/h)	Thermal (T)		Aesthetic (A)	Physical (P)		Total Score
							CID (Tmax & RH)(°C)	CIA (Tmean & RH)(°C)	Cloud (%)	Pricipitation (mm)	Wind (km/h)	
TCI	92	16	14	100	1	27	6 (3)	5 (2.5)	0 (0)	8 (4)	4 (2)	49
							2*(4CID + CIA) = 29		2*2S = 0	2*2R = 16	2*W = 4	
HCI	92	16	14	100	1	27	6		2	9	8	61
							4T (Tmax & RH) = 24		2A = 4	3R = 27	W = 8	

*( ) represents scores used in TCI calculations based on original 5-point scale

In both cases the total HCI score is still higher because of differential rating and weightings of the aesthetic and physical facets. This demonstrates that urban tourists are highly adapted to the greater sensitivity of the TCI to thermal conditions. Tourist surveys used by the HCI reveal greater tolerance for high and low temperature than the TCI expert-based rating scale indicates. This explains why summer has the smallest rating difference and winter has the biggest as a high thermal score of TCI plays a major role in reducing the gap of overall score between the HCI and TCI.

4.4.2 Aesthetic Facet

The two examples below illustrate two aesthetic conditions, a day with percentage of cloud cover extremely high (100%) and extremely low (0%). When all other climatic variables (temperature, relative humidity, precipitation and wind) are kept constant, ratings of the aesthetic facet between the TCI and HCI are different than when there is 100% cloud. A score of 0 is given by the TCI to suggest that a day with the highest percentage of cloud cover is considered the worst climatic condition for urban tourists' aesthetic perceptions (Table 4.9). However, the

HCI gives a score of 2 based on results from tourist surveys, that a day with a 100% cloud cover is considered by mainly urban tourists as ‘suitable’ for general tourism activities.

Table 4.9 Example of Rating Differences in Aesthetic Facet when Cloud Cover is High (100%)

Index	RH (%)	Tmax (°C)	Tmean (°C)	Cloud (%)	P (mm)	Wind (km/h)	Thermal (T)		Aesthetic (A)	Physical (P)		Total Score
							CID (Tmax & RH)(°C)	CIA (Tmean & RH)(°C)	Cloud (%)	Pricipitation (mm)	Wind (km/h)	
TCI	92	16	14	100	1	27	6 (3)	5 (2.5)	0 (0)	8 (4)	4 (2)	49
							2*(4CID + CIA) = 29		2*2S = 0	2*2R = 16	2*W = 4	
HCI	92	16	14	100	1	27	6		2	9	8	61
							4T (Tmax & RH) = 24		2A = 4	3R = 27	W = 8	

*( ) represents scores used in TCI calculations based on original 5-point scale

When a maximum level of sunshine (0% cloud cover) occurs, aesthetic ratings of the TCI and HCI are also different. The TCI gives the highest score of 10 to a day with 0% cloud cover, whereas only a score of 8 is given by the HCI (Table 4.10). The reason why the HCI does not give the highest score to a day with no cloud cover is because the survey results show that not all urban tourists prefer a 0% cloud cover during holidays, and a 11-20% cloud cover was most preferred condition by leisure tourists.

Table 4.10 Example of Rating Differences in Aesthetic Facet when Cloud Cover is Low (0%)

Index	RH (%)	Tmax (°C)	Tmean (°C)	Cloud (%)	P (mm)	Wind (km/h)	Thermal (T)		Aesthetic (A)	Physical (P)		Total Score
							CID (Tmax & RH)(°C)	CIA (Tmean & RH)(°C)	Cloud (%)	Pricipitation (mm)	Wind (km/h)	
TCI	92	16	14	0	1	27	6 (3)	5 (2.5)	10 (5)	8 (4)	4 (2)	69
							2*(4CID + CIA) = 29		2*2S = 20	2*2R = 16	2*W = 4	
HCI	92	16	14	0	1	27	6		8	9	8	75
							4T (Tmax & RH) = 24		2A = 16	3R = 27	W = 8	

*( ) represents scores used in TCI calculations based on original 5-point scale

4.4.3 Physical Facet

Table 4.11 and 4.12 present the rating differences between the TCI and HCI for two conditions of precipitation: a day with a light rain and a day when a heavy rain occurs. These two examples demonstrate how the HCI recognizes the overriding effect of the physical facet of precipitation, but high winds would have the same effect. The rating differences in precipitation between the two indices are significant when there is a light rain. When daily amount of precipitation is 5mm, the TCI considers it to be the least satisfactory condition for urban tourism, giving a score of 0. In contrast, the HCI gives a score of 8 to a day with a 5mm rain as urban tourism is less rain sensitive than other tourism segments (e.g. beach tourism), and city holidays provide many alternative shelters and activities to ‘wait out’ short rainfall, such as restaurants, museums, shopping, without significantly impacting holiday satisfaction. A more important factor to consider when rating precipitation, is the duration and intensity of rain. A 5mm rain can be a 1 hour moderate rain or 30 minutes heavy rain, which is not a major preventative factor for urban tourism activities taking place. It can be seen from the examples that major rating differences in precipitation between the TCI and HCI play a major role in influencing overall score differences (HCI=72, TCI=53).

Table 4.11 Example of Rating Differences in Physical Facet when Precipitation is Light

Index	RH (%)	Tmax (°C)	Tmean (°C)	Cloud (%)	P (mm)	Wind (km/h)	Thermal (T)		Aesthetic (A)	Physical (P)		Total Score
							CID (Tmax & RH)(°C)	CIA (Tmean & RH)(°C)	Cloud (%)	Pricipitation (mm)	Wind (km/h)	
TCI	92	16	14	0	5	27	6 (3)	5 (2.5)	10 (5)	0 (0)	4 (2)	53
							2*(4CID + CIA) = 29		2*2S = 20	2*2R = 0	2*W = 4	
HCI	92	16	14	0	5	27	6		8	8	8	72
							4T (Tmax & RH) = 24		2A = 16	3R = 24	W = 8	

*( ) represents scores used in TCI calculations based on original 5-point scale

When a day has heavy precipitation, its impact on overall holiday experience can be seen in both indices (see example in Table 4.12). When there is a 25mm precipitation in a day, both TCI and HCI rate it as the worst physical condition for urban tourism. Although both TCI and HCI give very low score to conditions of heavy precipitation, the impact of heavy precipitation on overall climatic suitability versus the same day with only light precipitation only can be seen in the ratings of the HCI. The HCI captures the overriding effect of heavy rain by reducing rating scores of the precipitation when physical thresholds were exceeded to make sure physical scores contribute negatively to overall index score. From the example in Table 4.14, it is clear that both negative rating of precipitation and its higher weighting (30%) assigned by the HCI contribute to the lower overall rating. With the introduction of the physical override effect in the HCI, a high overall score cannot be achieved with a low physical score, better reflecting the impact of physical conditions on overall tourist experiences.

Table 4.12 Example of Rating Differences in Physical Facet when Precipitation is Heavy

<table>
<tr><th rowspan="2">Index</th><th rowspan="2">RH (%)</th><th rowspan="2">Tmax (°C)</th><th rowspan="2">Tmean (°C)</th><th rowspan="2">Cloud (%)</th><th rowspan="2">P (mm)</th><th rowspan="2">Wind (km/h)</th><th colspan="2">Thermal (T)</th><th>Aesthetic (A)</th><th colspan="2">Physical (P)</th><th rowspan="2">Total Score</th></tr>
<tr><th>CID (Tmax & RH)(°C)</th><th>CIA (Tmean & RH)(°C)</th><th>Cloud (%)</th><th>Pricipitation (mm)</th><th>Wind (km/h)</th></tr>
<tr><td rowspan="2">TCI</td><td rowspan="2">92</td><td rowspan="2">16</td><td rowspan="2">14</td><td rowspan="2">0</td><td rowspan="2">25</td><td rowspan="2">27</td><td>6 (3)</td><td>5 (2.5)</td><td>10 (5)</td><td>0 (0)</td><td>4 (2)</td><td rowspan="2">53</td></tr>
<tr><td colspan="2">2*(4CID + CIA) = 29</td><td>2*2S = 20</td><td>2*2R = 0</td><td>2*W = 4</td></tr>
<tr><td rowspan="2">HCI</td><td rowspan="2">92</td><td rowspan="2">16</td><td rowspan="2">14</td><td rowspan="2">0</td><td rowspan="2">25</td><td rowspan="2">27</td><td colspan="2">6</td><td>8</td><td>-1</td><td>8</td><td rowspan="2">45</td></tr>
<tr><td colspan="2">4T (Tmax & RH) = 24</td><td>2A = 16</td><td>3R = -3</td><td>W = 8</td></tr>
</table>

*( ) represents scores used in TCI calculations based on original 5-point scale

For the variable of wind, the rating differences between the TCI and HCI were compared by two wind speed: moderate and strong wind. When a day has a moderate wind speed, as seen in the example of daily wind speed is 27km/h, the ratings are different between the two indices. In the same 10-point rating scale, the TCI only rates a low score of 4 to a day with wind speed of 27km/h, but the HCI gives a high score of 8 (Table 4.13). The reason for the HCI's assigned ratings is the results of obtained tourists' surveys on their preferences of wind.

Table 4.13 Example of Rating Differences in Moderate Wind

Index	RH (%)	Tmax (°C)	Tmean (°C)	Cloud (%)	P (mm)	Wind (km/h)	Thermal (T)		Aesthetic (A)	Physical (P)		Total Score
							CID (Tmax & RH)(°C)	CIA (Tmean & RH)(°C)	Cloud (%)	Pricipitation (mm)	Wind (km/h)	
TCI	92	16	14	0	1	27	6 (3)	5 (2.5)	10 (5)	8 (4)	4 (2)	69
							2*(4CID + CIA) = 29		2*2S = 20	2*2R = 16	2*W = 4	
HCI	92	16	14	0	1	27	6		8	9	8	75
							4T (Tmax & RH) = 24		2A = 16	3R = 27	W = 8	

*( ) represents scores used in TCI calculations based on original 5-point scale

When a day has a strong wind (>70km/h), the TCI considers it having no contribution to the overall score by giving a score of 0 when daily wind speed stronger than 38.52km/h. In contrast, the HCI ratings capture the overriding effect of physical facet by assigning a negative score for the purpose of reflecting the effect of severe physical conditions on overall holiday experience. As seen in Table 4.14, when daily wind speed is 71km/h and becomes a physical danger to outdoor activities, a score of -10 is given to ensure a high rating score cannot be achieved when a physical score is so low.

Table 4.14 Example of Rating Differences in Strong Wind

Index	RH (%)	Tmax (°C)	Tmean (°C)	Cloud (%)	P (mm)	Wind (km/h)	Thermal (T)		Aesthetic (A)	Physical (P)		Total Score
							CID (Tmax & RH)(°C)	CIA (Tmean & RH)(°C)	Cloud (%)	Pricipitation (mm)	Wind (km/h)	
TCI	92	16	14	0	1	71	6 (3)	5 (2.5)	10 (5)	8 (4)	0 (0)	65
							2*(4CID + CIA) = 29		2*2S = 20	2*2R = 16	2*W = 0	
HCI	92	16	14	0	1	71	6		8	9	-10	57
							4T (Tmax & RH) = 24		2A = 16	3R = 27	W = -10	

*( ) represents scores used in TCI calculations based on original 5-point scale

4.5 Climate Change Analysis (ECHAM5 A1 Scenario 2020s, 2050s and 2080s)

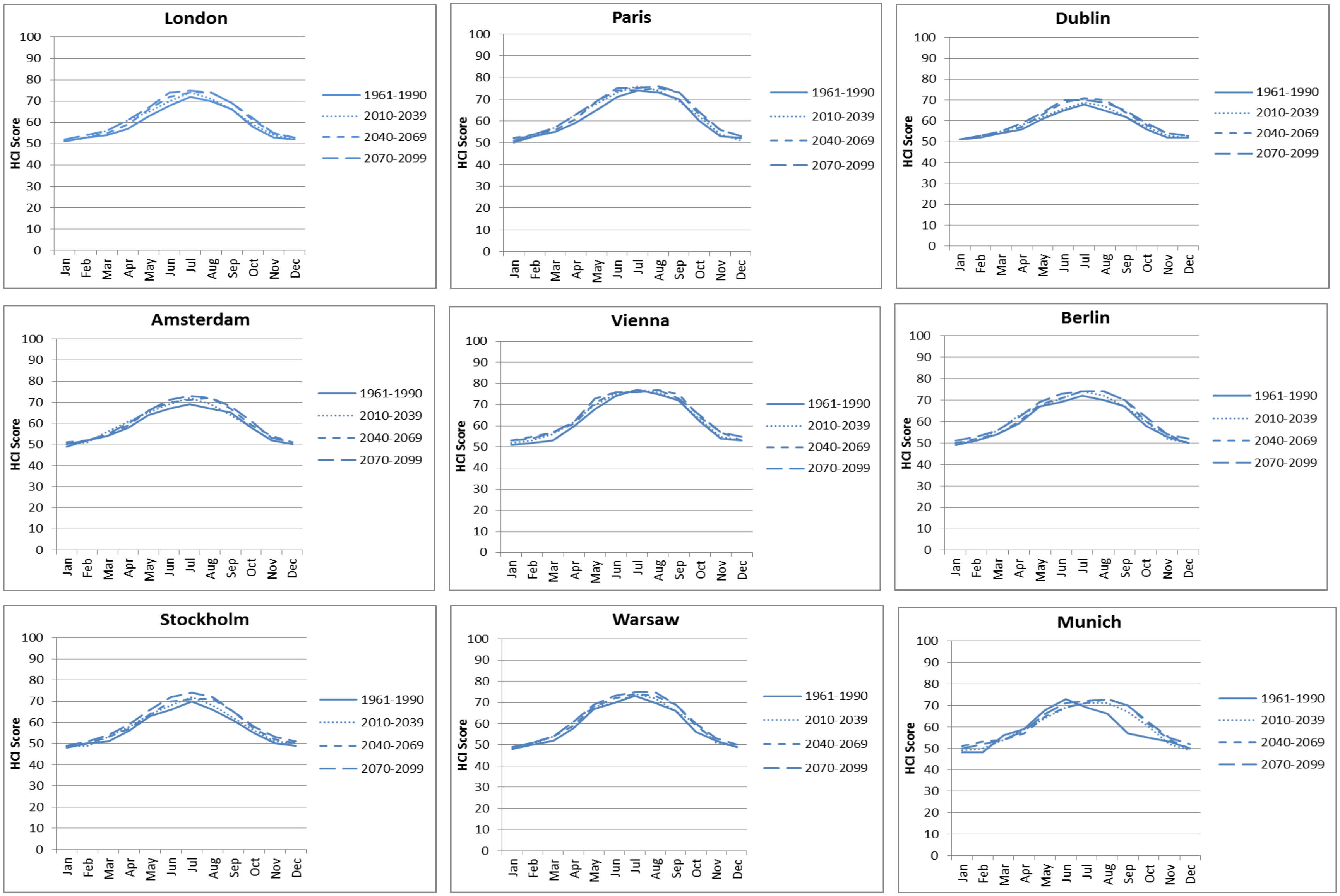
This section analyses future tourism climatic conditions of the selected 15 European destinations as projected by both the newly-designed Holiday Climate Index (HCI) and the TCI in three time periods: 2020s (2010-2039), 2050s (2040-2069) and 2080s (2070-2099). The climate resources analyzed were those projected by the ECHAM5 model under the SRES A1B emission scenario. The projected HCI mean monthly scores were compared with the TCI scores to see the types of seasonal climate changes of the selected 15 European city destinations in the 2020s, 2050s and 2080s, and importantly, how the future HCI ratings different from the TCI ratings which have been cited in several government assessment reports and media stories.

4.5.1 HCI Mean Monthly Score

4.5.1.1 Northern, Western and Eastern Europe

For the selected nine northern, western and eastern European city destinations (London, Paris, Dublin, Amsterdam, Vienna, Berlin, Stockholm, Warsaw and Munich), the projected climatic suitability for tourism will improve for almost all months of the year in the future time periods: 2020s (2010-2039), 2050s (2040-2069) and 2080s (2070-2099) when rated by the HCI (Figure 4.8). Climatic conditions of the northern, western and eastern Europe are expected to improve the most in spring, summer and fall months. A steady increase in HCI scores in summer months was expected for most cities. Vienna is the only exception, as there is hardly any change of HCI scores in any season. In Munich, the projected changes of climate conditions vary across seasons. In the summer and fall months, Munich was projected to have the biggest improvement in climatic conditions of all the selected cities in these regions.

Figure 4.8 Projected HCI Mean Monthly Scores of Northern, Western and Eastern European Cities



When examining the changes of the HCI scores in the northern, western and eastern Europe regions, major changes of climate conditions were expected to occur in spring, summer and fall months (Table 4.15). Climate conditions of winter months (December, January and February) are only ‘marginal’ (40=49) and ‘acceptable’ (50-59) in these cities, and no major change was expected from 2020s to 2080s. In March and April, most cities will continue to have ‘good’ conditions (60-69) for urban tourism activities in 2020s, 2050s and 2080s. There will be more months in summer to become ‘very good’ (>69) for tourism, and all selected cities in the regions could have at least one month in summer higher than a score of 69 by the 2080s.

Table 4.15 Changes of Seasonal HCI Scores in Northern, Western and Eastern Europe

	Month	London				Paris				Dublin				Amsterdam				Vienna				Berlin				Stockholm				Warsaw				Munich			
		Pre	20s	50s	80s	Pre	20s	50s	80s	Pre	20s	50s	80s	Pre	20s	50s	80s	Pre	20s	50s	80s	Pre	20s	50s	80s	Pre	20s	50s	80s	Pre	20s	50s	80s	Pre	20s	50s	80s
Winter	Dec	51	51	51	52	50	52	52	51	51	51	51	51	49	50	51	50	51	52	53	53	49	50	50	51	48	49	49	49	48	48	49	49	48	49	51	50
	Jan	53	53	53	54	53	53	54	54	52	52	53	53	52	51	52	52	52	53	55	54	51	51	52	53	50	49	50	51	50	50	51	51	48	50	53	52
	Feb	54	56	55	56	55	57	56	57	54	55	54	55	54	56	54	55	53	56	57	57	54	56	54	56	51	53	53	54	52	54	54	54	56	54	54	54
Spring	Mar	57	61	59	61	59	63	61	63	56	58	57	59	58	61	59	60	60	62	61	62	59	63	60	62	56	58	57	59	58	61	59	61	59	59	57	58
	Apr	63	65	66	67	65	68	69	69	61	62	63	64	64	65	66	66	68	70	71	73	67	67	68	69	63	64	64	66	67	68	68	69	68	64	65	66
	May	68	70	72	74	71	73	74	75	65	66	69	70	67	69	70	71	74	75	76	76	69	71	71	73	66	68	70	72	70	70	72	73	73	69	69	71
Summer	Jun	72	74	74	75	74	76	74	75	68	69	71	70	69	72	71	73	77	77	76	76	72	74	74	74	70	72	71	74	73	74	74	75	69	71	71	72
	Jul	70	71	74	74	73	74	75	76	65	67	70	69	67	69	72	72	75	76	77	77	70	72	74	74	66	68	71	72	70	72	73	75	66	71	73	73
	Aug	66	66	69	69	70	69	73	73	62	62	64	65	65	64	67	68	72	72	75	73	67	67	70	70	61	62	65	65	66	66	69	69	57	67	70	70
Fall	Sep	58	59	61	62	60	62	63	64	56	57	58	59	58	58	59	61	62	63	64	65	58	60	60	62	55	56	57	58	56	60	59	60	55	60	61	62
	Oct	53	54	55	55	53	54	56	56	52	53	54	54	52	52	54	53	54	55	57	57	53	52	54	54	50	51	52	53	52	51	52	53	53	52	54	55
	Nov	52	52	53	53	52	51	53	53	52	52	53	53	50	50	51	51	53	53	53	55	50	50	50	52	49	50	50	51	49	49	49	50	50	49	50	52

(‘very good’ 70-79)

4.5.1.2 Southern Europe

In the selected southern European city destinations (Istanbul, Rome, Barcelona, Athens and Venice), a major deterioration of climatic conditions in peak summer holiday season was projected while shoulder seasons (spring and fall) could have major improvements in climatic suitability for tourism (Figure 4.9). Rome, Barcelona and Athens were expected to experience a more prominent deterioration in climatic conditions in the summer months than Istanbul and

Venice in the future time periods: 2020s, 2050s and 2080s when rated by the HCI. A major shift of peak season from summer months to spring and fall months was expected to occur in Istanbul, Rome, Barcelona and Venice, making these cities no longer ‘summer peak’ destinations. In the future three time periods, all selected southern European cities, with the exception of Madrid, will become ‘bimodal-shoulder peaks’ destinations and spring and fall months will be the most suitable time to visit the region for general tourism activities. Madrid is the only city in the region that has a decrease in HCI scores throughout all months of the year.

Figure 4.9 Projected HCI Mean Monthly Scores of Southern European Cities

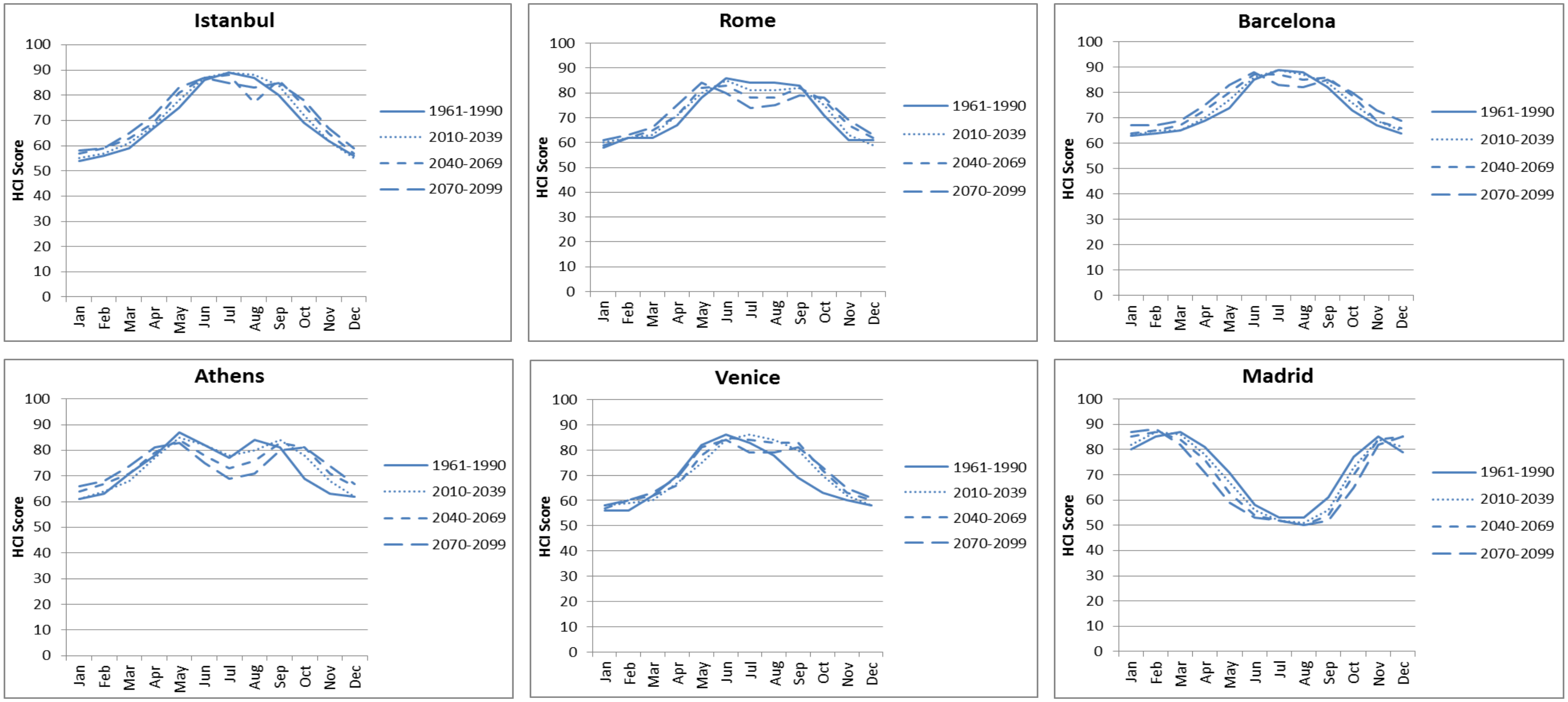


Table 4.16 shows the changes in the HCI scores for the selected southern European cities in the 2020s, 2050s and 2080s. Winter months in the southern European region were projected to remain as ‘acceptable’ (50-59) to ‘good’ (60-69) conditions for tourism in Istanbul, Rome, Barcelona, Athens and Venice from 2010 to 2099. A continuous increase in HCI scores was projected in spring and fall months. In the early spring (March) and early fall (September) of Istanbul, Rome and Barcelona, climate conditions are expected to improve from ‘good’ (to ‘’very good’ for tourism. Summer climatic conditions were projected to deteriorate from current ‘excellent’ conditions (80-89) to ‘very good’ conditions (70-79) in Rome, Athens and Venice.

Table 4.16 Changes of Seasonal HCI Scores in Southern Europe

	Month	Istanbul				Rome				Barcelona				Athens				Venice				Madrid			
		Pre	20s	50s	80s	Pre	20s	50s	80s	Pre	20s	50s	80s	Pre	20s	50s	80s	Pre	20s	50s	80s	Pre	20s	50s	80s
Winter	Dec	54	55	57	58	58	60	59	61	63	63	64	67	61	61	64	66	56	58	57	58	80	82	85	87
	Jan	56	57	59	59	62	62	62	63	64	65	65	67	63	64	67	68	56	59	60	60	85	87	87	88
	Feb	59	61	63	65	62	63	65	66	65	65	67	69	71	68	71	74	62	60	62	63	87	86	84	82
Spring	Mar	67	68	69	72	67	71	71	75	69	70	73	75	78	77	79	81	70	67	66	69	81	78	76	71
	Apr	75	78	81	83	78	80	82	84	74	77	80	83	87	85	84	83	82	75	78	81	71	67	63	59
	May	86	87	87	87	86	85	83	80	85	86	87	88	82	82	78	75	86	84	85	84	58	56	54	53
Summer	Jun	89	89	88	85	84	81	78	74	89	89	87	83	77	78	73	69	83	86	84	79	53	52	52	52
	Jul	87	88	77	83	84	81	78	75	88	87	85	82	84	80	76	71	78	84	83	79	53	51	50	50
	Aug	80	84	86	85	83	82	82	79	82	84	86	85	81	84	83	80	69	80	83	81	61	56	54	52
Fall	Sep	69	72	76	78	71	75	77	78	73	76	79	80	69	78	81	81	63	70	72	73	77	73	70	65
	Oct	62	62	65	67	61	63	67	69	67	69	69	73	63	68	71	74	60	62	63	65	85	84	84	82
	Nov	56	55	57	59	61	59	62	63	64	65	66	69	62	62	66	67	58	58	60	61	79	81	85	85

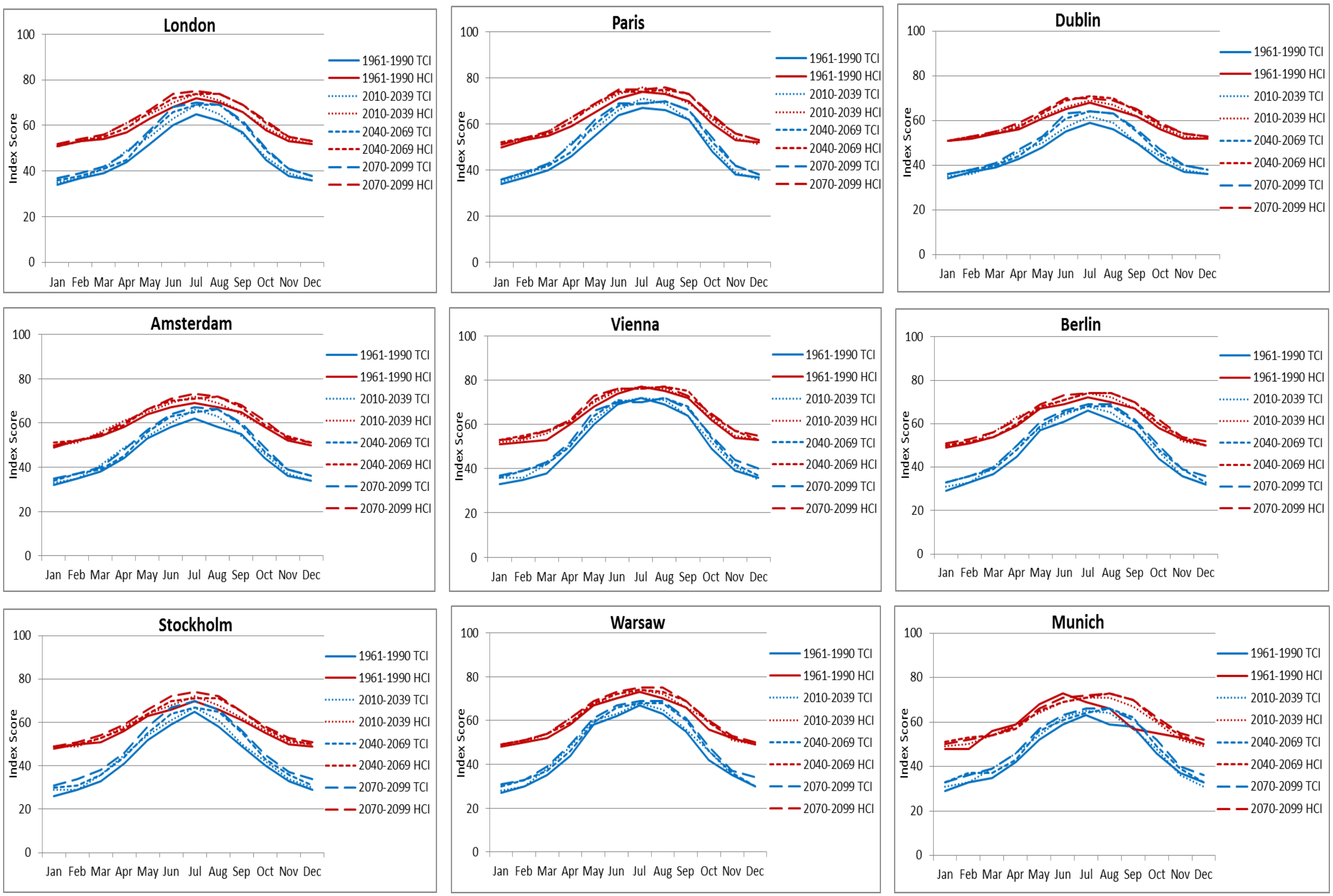
(‘excellent’ 80-89, ‘very good’ 70-79)

4.5.2 Seasonal Score Differences between HCI and TCI

4.5.2.1 Northern, Western and Eastern Europe

The TCI scores were also calculated for the selected 15 European city destinations using the ECHAM5 model under the SRESS A1 emission scenario. The HCI mean monthly scores of the 15 European city destinations were compared with the projected TCI mean monthly scores to see whether the HCI ratings show similar types of seasonal changes to the TCI ratings. For the selected northern, western and eastern European cities, the TCI ratings show similar seasonal changes to the HCI ratings in the 2020s, 2050s and 2080s (Figure 4.10). Both TCI and HCI ratings indicate that there will be an all-year-round improvement in climatic suitability for tourism in the regions, and summer months will have the most prominent improvement in climatic conditions. The difference between the TCI and HCI ratings is the projected ratings in winter months of Stockholm, Warsaw, Berlin, Vienna and Amsterdam. The TCI scores show an improvement in climate conditions in winter months, while the HCI scores indicate that the projected improvement will not as big as the TCI ratings suggest. However, winter climatic conditions in the regions were still rated as 'unacceptable' (<40) by the TCI in the 2020s, 2050s and 2080s, while HCI scores indicate that climate in winter months will continue be 'acceptable' for urban tourism. In addition, the HCI ratings for Munich are also different from the TCI. During spring months (March, April and May) of Munich, the TCI projected an improvement in climatic conditions for urban tourism, but the HCI scores show a slight decrease in the same season. Munich is also the only city in the regions that was projected to have deteriorated climate conditions in spring when rated by the HCI.

Figure 4.10 Projected TCI and HCI Mean Monthly Scores of Northern, Western and Eastern European Cities

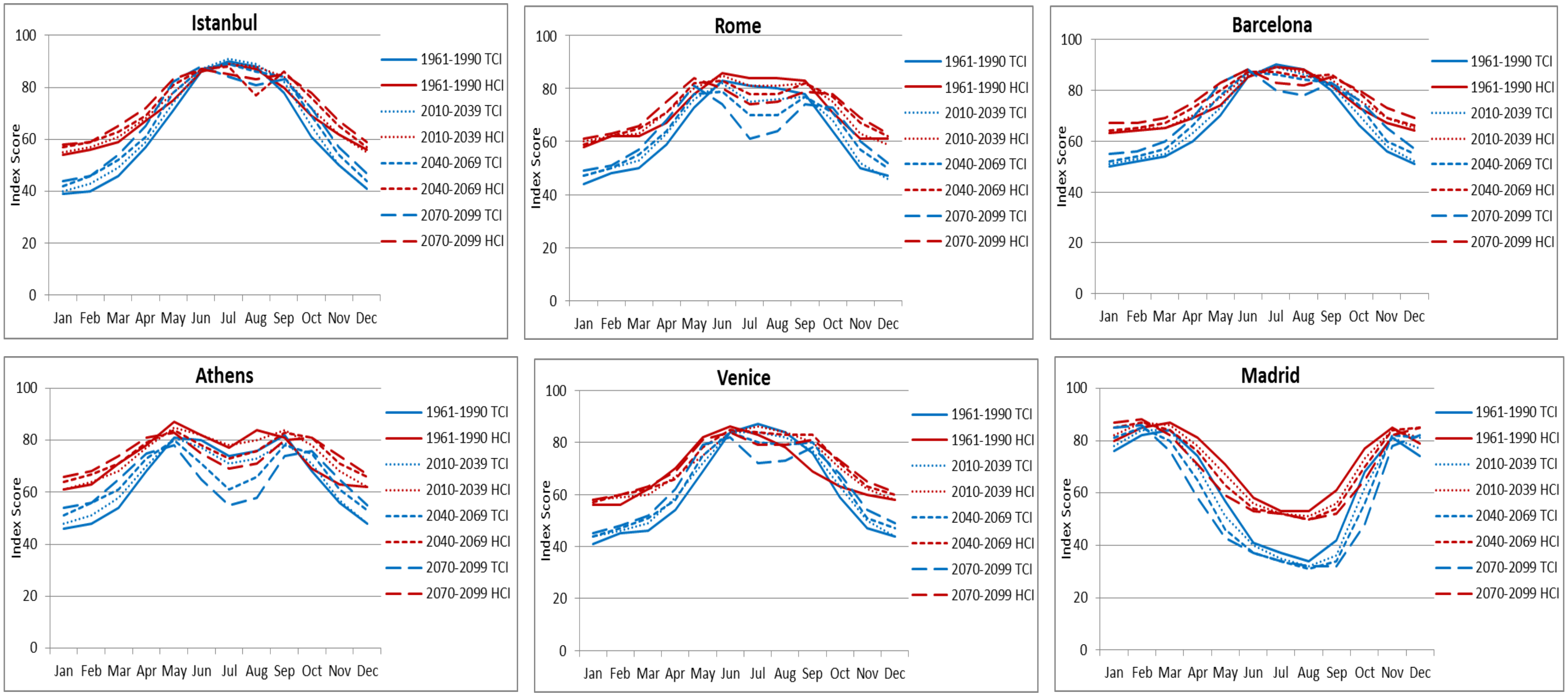


4.5.2.2 Southern Europe

For the six selected southern European city destinations (Istanbul, Rome, Barcelona, Athens, Venice and Madrid), the TCI and HCI ratings of projected changes of climate conditions in 2020s, 2050s and 2080s vary across different seasons. The HCI ratings show similar types of changes with the TCI ratings in winter, spring and fall months of Istanbul, Rome, Barcelona and Athens, as both indices projected a continuous improvement in climatic suitability for urban tourism (Figure 4.11). The prominent rating difference between the HCI and TCI in future ratings occurs in the summer months for Rome, Barcelona, Athens and Venice. Although both HCI and TCI projected a major deterioration in climatic conditions in summer months, the TCI ratings showed a faster pace of deterioration (2050s to 2080s) in summer climatic conditions than the HCI ratings in Rome, Barcelona, Athens and Venice. The HCI ratings also imply that summer climate conditions in the Mediterranean urban destinations may still be at least ‘suitable’ for urban tourism and not ‘unacceptable’ as the TCI indicates.

Madrid was projected by the HCI and TCI to have a different score changes from the other cities in the region. Both HCI and TCI ratings show that a major decrease in rating scores is expected in spring, summer and fall months, in particular in spring and fall whereas climatic conditions in winter months will improve throughout the 2020s to 2080s.

Figure 4.11 Projected TCI and HCI Mean Monthly Scores of Southern European Cities



4.6 Chapter Summary

This chapter presented the results in areas: (1) comparison of monthly index scores and probability of 'suitable' climate conditions of the selected European city destination between the HCI and TCI, (2) compare TCI and HCI scores with monthly visitation data, (3) present examples of rating differences between the two indices in thermal, aesthetic and physical facet and (4) conduct climate change analysis. From the results, a better understanding of how the newly-designed HCI differed from and improved upon the TCI is obtained.

Chapter 5

Discussion and Conclusion

5.1 Introduction

The goals of this thesis were to introduce a newly-designed climate index for tourism, the HCI, compare the HCI ratings with the highly used TCI, and consider whether the HCI is a more accurate index in rating of climatic suitability for tourism. A quantitative approach was adopted to analyze mean monthly index scores and seasonal probability of ‘suitable’ (>70) climate conditions. This chapter presents the main findings of this thesis and implications for future research by considering each of the four objectives in order. In addition, recommendations on future research raised by this thesis are also provided.

5.2 Main Findings

5.2.1 Objective One

Develop a new climate index for tourism purpose that overcomes limitations of the TCI.

The TCI is the most widely used tourism climate index for the assessment of climatic suitability for tourism (Scott and McBoyle 2001, Scott et al. 2004, Farajzadeh and Matzarakis 2009, Moreno and Amelung 2009, Perch-Nielsen et al. 2010). However, with design deficiencies which may affect its accuracy, the need to design a new climate index for tourism have been identified by a number of studies (de Freitas 2003, de Freitas et al. 2008 and Denstadli et al. 2011). Major deficiencies of the TCI have been criticized by a number of studies (Amelung et al. 2007, de Freitas et al. 2004, Scott et al. 2004, Gomez-Martin 2005, Amelung and Viner 2006, de Freitas et al. 2008, Frarajzadeh and Matzarakis 2009, Perch-Nielsen et al. 2010) and focus on three areas: 1) subjectivity in index weighting and rating systems; 2) over-concentrating on thermal component and lack of overriding effect of severe physical conditions; 3) low temporal resolution. The central limitation has been the subjectivity of index weighting and rating system which are not tested against tourist ranking of relative importance of climatic variables and preferences of climatic conditions (de Freitas 2003 and Gomez-Martin 2006).

All identified studies that assessed a destination's current and future climatic suitability for tourism have adopted the TCI in its original form or with minor modifications (Scott and McBoyle 2001, Scott et al. 2004, Amelung and Viner 2006, Amelung et al. 2007, Hein 2007, Cengiz et al. 2008, Nicholls and Amelung 2008, Amelung and Moreno 2009, Farajzadeh and Matzarakis 2009, Hein et al. 2009, Roshan et al. 2009, Yu et al. 2009a, b, Perch-Nielsen et al. 2010, Whittlesea and Amelung 2010). Although studies, such as Perch-Nielsen et al. (2010), addressed some of the TCI limitations including using high temporal resolution data, its central deficiency of subjective rating and weighting has not been addressed. However, with its identified deficiencies, the reliability of the results from past TCI studies in exploring current and future climatic suitability for tourism under climate change has been questioned.

de Freitas et al. (2008) stated that the key characteristics of a new comprehensive tourism climate index should include six elements: (1) theoretically sound; (2) integrates the effects of all facets of climate; (3) simple to calculate; (4) easy to use and understand; (5) recognize overriding effect of certain weather conditions; (6) empirically tested. The HCI was designed to overcome the identified deficiencies of the TCI as well as to meet de Freitas et al.'s (2008) six essential elements of a tourism climate index, thus achieving the Objective One (Table 5.1).

Table 5.1 HCI Design Improvements for Achieving de Freitas et al. (2008) Six Elements

Elements	HCI Design Improvements
theoretically sound	Integration of climatic facets relevant to tourists and design of index facets was based on recent literature of tourism thermal comfort and tourism climate indices
integrates effects of all facets of climate	Five climatic variables were used to form the three climate facets (thermal, aesthetic and physical) essential to tourist overall holiday experience
simple to calculate	Only standard data needed for calculation
easy to use and understand	Simple rating system and descriptor of climate conditions
recognize overriding effect of weather conditions	Physical facets have been assigned an equal weighting (40%) to thermal facet and ratings of physical facet decline rapidly when conditions are poor
empirically tested	The mean monthly HCI scores have been compared with mean monthly visitation data of Paris to test its validity

5.2.2 Objective Two

Compare the HCI with the TCI to examine what spatial and temporal differences resulted in the rating of climate for tourism in a sample of 15 leading European urban destinations.

Although the HCI was designed to overcome the identified deficiencies of the TCI and conceptually better than the TCI in terms of objective rating and weighting design based on stated tourist preferences, it still need to be compared against tourist demand indicators to further test its validity. This is the first known tourism climate index inter-comparison study to examine how different climate suitability ratings can be.

Existing studies (Amelung and Viner 2006, Amelung et al. 2007, Hein 2007, Nicholls and Amelung 2008, Amelung and Moreno 2009, Hein et al. 2009, Perch-Nielsen et al. 2010, Whittlesea and Amelung 2010) using the TCI to assess the current climatic resources of most-visited European regions for tourism have found that the dominant seasonal climate resource distribution of the top-visited European destinations in the northern, western and eastern Europe is 'summer peak'. Winter months in the regions were not considered climatically suitable for tourism (index score <40). The TCI ratings in this study were consistent with the literature.

When the HCI was compared with the TCI in assessing climatic conditions of the 15 top-visited city destinations in Europe, rating differences were observed both from temporal (seasonal) and spatial aspects. For the selected 15 European destinations, the HCI ratings are generally higher than the TCI ratings in most months of the year. Seasonally, a major disagreement between the two indices exists in the rating of winter climate conditions, as winter has the widest gap in ratings between the TCI and HCI. When temperatures become warmer, the gap between the two indices becomes narrower. The difference is particularly prominent in the northern, western and eastern European destinations. In London, Paris, Dublin, Amsterdam, Vienna, Berlin, Stockholm, Warsaw and Munich, the climate was rated as 'unacceptable' (<40) by the TCI, but the HCI scores indicated that winter climate in these destinations is 'acceptable' (40-69) for urban tourism (see section 4.2.2 for seasonal rating score comparison) which reflects the reality of visitation patterns. Spatially, although a rating difference also exists in winter months in the selected southern European destinations, the gap is relatively smaller than in the northern, western and eastern European destinations.

The causes of the rating differences between the two indices are the structural design of facet weightings and rating systems. One important issue to consider for discussing the design of rating system is the objectivity. The importance of incorporating tourists' stated preferences of climatic conditions in designing an index's rating system to ensure its objectivity has been proposed by a number of past studies (Gomez-Martin 2005, de Freitas et al. 2008). The assigned weighting and rating system not validated with tourists has been central criticism of the TCI in past studies, which urged the need for a new 'market tested' tourism climate index (de Freitas et al. 2004, de Freitas et al. 2008, Scott et al. 2004, Amelung and Viner 2006, Frarajzadeh and Matzarakis 2009, Perch-Nielsen et al. 2010). In this study, the HCI rating systems for all three climatic facets were developed based on tourists' stated preferences of various weather conditions. Therefore, the higher ratings from the HCI that caused rating differences between the two indices are justified, and in this case, more reflective of real tourist ratings of climatic suitability for each climatic facet.

The assigned weighting of the thermal facet explains the identified seasonal rating differences. Both TCI and HCI adopt effective temperature (ET) for the thermal facet and the TCI gives half of its total weighting (50%) to the thermal component which makes it the most important factor in determining climatic suitability of a destination for tourism. However, this over-emphasis on thermal component by the TCI has been criticized by several studies (Gomez-Martin 2005, de Freitas et al. 2008, Scott et al. 2008, Amelung and Moreno 2009, Jacobsen et al. 2011). de Freitas (2003) claimed that in the moderate thermal conditions, thermal comfort should not be the determined factor in influencing overall holiday experiences, other factors assume greater importance for tourist pleasantness rating. It can be seen from the rating comparison that the TCI rating of thermal component changes substantially with temperature, with high temperature in summer dramatically increasing its thermal rating because of the assigned weighting. This is one of the main factors explaining why winter has the widest rating gap between the two indices. The HCI assigned weighting (40%) for the thermal facet is based on tourist perceptions of the relative importance of each facet and assigns greater importance to other variables.

From the results of comparing the ratings of both HCI and TCI when applying same climatic data of the top-visited European city destinations, it is concluded that different results have been achieved both from temporal (seasonal) and spatial perspective when re-designing an index for the purpose of overcoming the identified TCI deficiencies. This has implications for past studies that used the Mieczkowski's (1985) TCI to assess European climatic suitability for urban tourism activities, in particularly those exploring the northern, western and eastern European cities (Amelung and Viner 2006, Amelung et al. 2007, Hein 2007, Nicholls and Amelung 2008, Amelung and Moreno 2009, Hein et al. 2009, Perch-Nielsen et al. 2010, Whittlesea and Amelung 2010).

5.2.3 Objective Three

Compare the HCI and TCI scores against visitation data to see whether the HCI has a more accurate performance in rating of climatic suitability for tourism.

By comparing the rating differences between the two indices under specified weather conditions and comparing the ratings against visitation data, a reasonable conclusion could be drawn regarding to whether the HCI is a better index than the TCI in rating the climate suitability for tourism and whether existing studies using the TCI to assess tourism climate resources should be reassessed. The rating scores of the TCI have been validated against tourist demand indicators such as tourist arrivals (Amelung and Viner 2006) and accommodation costs (Scott and McBoyle 2001). Positive results have been achieved which prove that the TCI can be used as an indicator of relationship between climate and tourism demand. Although there are many other factors that influence tourist demand, the suitability of climatic conditions have been revealed as an important and essential factor affecting demand of leisure tourists. Therefore, ratings of tourism climate index should resemble the temporal distribution of tourist demand throughout the year.

In response to the requirement of testing the accuracy of a tourism climate index (de Freitas 2003), both HCI and TCI ratings were compared with leisure tourist demand. Monthly leisure visitor overnight stays in Paris were compared with both monthly HCI and TCI scores of Paris. The results showed that during winter months in Paris, the HCI ratings more accurately reflected tourist demand (see section 4.3). Although the data required to conduct a similar analysis in other northern, western and eastern European cities was not available, it is thought that similar performance improvement exists in these cities as well.

5.2.4 Objective Four

Compare the HCI findings to previous TCI-based analyses of the impacts of climate change on climate resources for tourism in Europe to determine whether any different spatial or temporal patterns emerge.

In this study, future climatic conditions of the selected 15 top-visited European city destinations were projected by the ECHAM5 climate change model under the IPCC SRES A1B emission scenario and both HCI and TCI were used to project seasonal changes of climatic resources for tourism in three time periods: 2020s (2010-2039), 2050s (2040-2069) and 2080s (2070-2099). Both HCI and TCI ratings indicate that destinations in northern, western and eastern European region (London, Paris, Dublin, Amsterdam, Vienna, Berlin, Stockholm, Warsaw and Munich) could experience a major improvement in tourism climate conditions of summer months. Southern European destinations (Istanbul, Rome, Barcelona, Athens, Venice) will have a 'bimodal shoulder peak' climate distribution, with spring and fall months being climatically more suitable for leisure tourism than summer months.

Comparing HCI and TCI ratings of projected climatic conditions in 2020s, 2050s and 2080s under the same climate change scenario, differences in changes of future tourism climatic conditions in Europe were found. In the selected northern, western and eastern European cities (Stockholm, Warsaw, Berlin, Vienna and Amsterdam), although both TCI and HCI scores show a continuous improvement in climatic conditions in winter months, the TCI scores indicate that winter climate in the regions is ‘unacceptable’ (<40) for urban tourism in the 2020s, 2050s and 2080s, while ‘acceptable’ winter climatic conditions were expected when rated by the HCI (see Figure 4.12). For destinations in southern Europe, although both indices revealed that summer climate conditions would deteriorate, the TCI ratings showed a much worse deterioration than the HCI ratings (see Figure 4.13). The pace of deterioration is prominent in Rome, Barcelona and Venice when rated by the TCI. However, the HCI scores imply that although some level of deterioration will occur, summer climatic conditions in the Mediterranean region may still be at least ‘suitable’ for urban tourism in the future.

Although different climate change scenarios have been used in previous studies that used the TCI to assess changes of future climatic conditions in Europe (Amelung and Viner 2006, Amelung et al. 2007, Hein 2007, Nicholls and Amelung 2008, Amelung and Moreno 2009, Hein et al. 2009, Perch-Nielsen et al. 2010), the results also revealed a consistent northward shift of favorable tourism climate and that the Mediterranean regions will change from traditional ‘summer peak’ climate distribution to ‘bimodal shoulder peak’ distribution in the coming decades. The study of Amelung et al. (2007) showed that by the 2080s, the most ideal conditions for summer tourism will occur in the countries of northern Europe with the most climatically suitable regions including northern France, southern parts of the UK, Germany and southern Scandinavia. Substantial improvements in summer climatic conditions were also projected in the countries of northern Europe. Perch-Nielsen et al. (2010) also found that most part of northern and central Europe will become “winners” under the impacts of climate change when rated by the TCI and projected climate change will enhance the region’s competitiveness relative to the Mediterranean region in the summer months..

In the southern European region, where the traditional 'sun, sand and sea' tourism takes place, future summer climate conditions in the region were reported by existing studies (Amelung et al. 2007, Nicholls and Amelung 2008, Amelung and Moreno 2009, Perch-Nielsen et al. 2010) using the TCI as 'too hot' for leisure tourism. Studies like Amelung and Moreno (2009) revealed that TCI scores of summer climate conditions would drop enormously from 'excellent' or 'ideal' conditions (TCI>80) to only 'marginal' conditions (TCI between 40-50). The TCI results for the Mediterranean region were consistent with these findings. Other studies (Rutty and Scott 2010, Moreno 2010) have questioned these findings. The HCI ratings showed that the pace of deterioration in summer months of the selected Mediterranean city destinations (Rome, Barcelona, Athens and Venice) will not be as significant as the TCI ratings projected.

Given the HCI is founded on tourists stated preferences and was found to more accurately represent monthly visitation patterns in Paris, this raises questions about the reliability of past studies using the TCI to explore future climate conditions of the European regions.

5.3 Recommendations for Future Research

A number of future research directions emerge from the findings. First, future research may apply the HCI in other geographical locations other than Europe, such as those with different climate conditions and cultures. An inter-comparison study may also be conducted in other places to further confirm that the HCI produces quantitatively different ratings than the TCI when same climatic data is applied and under what regionally important conditions their ratings differ. Second, further efforts to compare HCI ratings with observed visitation patterns at the city or attraction scale would be valuable to evaluate the performance of the HCI. Third, the results from Scott et al.'s (2008) study revealed that tourists' climatic preferences differed somewhat by the residence's climate. Therefore, additional cross cultural studies of tourists' stated preferences of climatic conditions from other regions to compare them with existing European, North America and New Zealand samples are needed. Fourth, this research also paves the ways for future research on designing of a tourism climate index for other tourism segments. Since the HCI was developed for general tourist activities such as sightseeing and shopping in urban areas, future studies may seek ways to develop an index to assess climatic index for other weather-sensitive types of tourism, such as beach tourism or ski tourism, based on the conceptual design of the HCI. Fifth, nearly all studies exploring tourist preferences of optimal climatic conditions have used surveys or interviews as main approach, other methods could also be considered by future researchers to explore tourist climatic preferences. Observation has rarely been used in the past literature as a way of revealing and recording tourist behaviors under specific climatic conditions (e.g. strong wind, heavy rain). Further studies exploring the optimal climatic conditions for tourists may consider using observation as the main approach to examine how tourists react under certain climatic conditions. Sixth, future research could use the concept of the HCI design to apply to other climate indices for other types of leisure tourism. There are currently many types of climatic indices used for a variety of leisure activities such as those used for golf and fishing, but how these indices were constructed and whether they have been verified by the users are questionable. The stated opinions and preferences of holiday takers of other tourism segments should be obtained as the basis for the index design and any validation of index results with visitor demand indicator should be conducted to further verify the index validity and reliability.

5.4 Conclusion

In assessing a destination's climatic suitability for tourism, the Tourism Climate Index (TCI) has a dominant place literature (Scott and McBoyle 2001, Scott et al. 2004, Farajzadeh and

Matzarakis 2009, Moreno and Amelung 2009, Perch-Nielsen et al. 2010). However, the need for a more conceptually sound index that overcomes the TCI's deficiencies has been called for by many authors (de Freitas 2003, Denstadli et al. 2011, Jacobsen et al. 2011). An ideal tourism climate index would integrate the effects of all facets of climate, simple to calculate, easy to use and understand, recognize overriding effect of certain weather conditions and most importantly, based on actual tourist preferences (de Freitas et al. 2008). This thesis intended to fill this gap by designing a new tourism climate index, the Holiday Climate Index (HCI), to assess climatic suitability for tourism purposes in urban area. An inter-comparison study was conducted as a first attempt in the research area to determine whether improved index design would lead to different and more accurate ratings when applying the same daily climate data. There are two major results from this inter-comparison study of the HCI and TCI in the 15 selected European city destinations. First, different ratings exist between the HCI and TCI in specific seasons of the year indicating evaluation of climate resources for tourism is sensitive to index design. Given the conceptual improvements of the HCI, this further implies that reassessment of current and future climate resources for tourism in Europe as well as North America may be needed. This study holds other implications for future research on the topics of tourism climate index design and the assessment of climate suitability for tourism. From conceptual perspective, the rating differences between the HCI and TCI reveals the need to reassess the reliability of the TCI as the most widely applied index in assessing climatic suitability for tourism, in particularly for those assessing the potential and changes of European climate resources. The HCI introduced by this study provides a new and more reliable method to assess tourism climate suitability for those involved in tourism industry, including tourism planners, government officials and researchers in tourism sector. The results from existing studies exploring current and future tourism climate suitability in some of the top-visited European destinations should be questioned in consideration of the identified deficiencies of the TCI and the results of rating differences between the two indices in this study. Reassessment of future climate conditions of European regions, in particular the summer climate conditions of the Mediterranean region and winter conditions of northern, western and eastern European city destinations is needed.

Second, by comparing the HCI against visitation data, the results showed that the HCI is a more reliable index to use than the TCI as it more accurately assesses a place's climatic suitability for leisure tourism and also objectively reflects tourists' preferences of 'ideal' climatic conditions in its calculations. The monthly numbers of leisure visitor staying overnight in Paris from 2000 to 2010 have been used to compare with both HCI and TCI rating scores of Paris. Although only one tourist demand indicator was used, the results illustrated that the TCI is not as reliable as the HCI in rating the destination's climate suitability for tourism.

Based on the results of this study, it is concluded that an improvement in index design could lead to a more accurate measurement of climatic suitability, and the newly-designed HCI is a better index than the TCI in assessing climate suitability. However, this study is only a starting point for index comparison research; more efforts are needed in the future to conduct research on comparison of indices in other climatic locations and market test their validity with tourists and tourism industry performance indicators.

Bibliography

Agnew, M. & Palutikof, J. (2006). Impacts of Short-term Climate Variability in the UK on Demand for Domestic and International Tourism. *Climate Research*, 31, 109-120.

Amelung, B. & Moreno, A. (2009). Impacts of Climate Change in Tourism in Europe. PESETA-Tourism Study, JRC Scientific and Technical Reports, European Commission, Joint Research Centre, Institute for Prospective Technological Studies, Seville. Retrieved June 3, 2012 from http://ftp.jrc.es/EURdoc/JRC55392.pdf.

Amelung, B., Nicholls, S. & Viner, D. (2007). Implications of Global Climate Change for Tourism Flows and Seasonality. *Journal of Travel Research*, 45(2), 285-296.

Amelung, B. & Viner, D. (2006). Mediterranean Tourism: Exploring the Future with the Tourism Climatic Index. *Journal of Sustainable Tourism*, 14(4), 349-366.

Amengual, A., Homar, V., Romero, R., Alonso, S. & Ramis, C. (2010). Projections of the Climate Potential for Tourism at Local Scale: Application to Platja de Palma, Spain. GIRA 2010 Conference: Corporate Governance, Innovation, Social and Environmental Responsibility. 9-10 September. Lisboa, Portugal.

Andriotis, K. (2005). Seasonality in Crete. Problem or a Way of Life? *Tourism Economics*, 11(2), 207-227.

Bansal, H. & Eiselt, H.A. (2004). Exploratory Research of Tourist Motivations and Planning. *Tourism Management*, 25, 387-396.

BarOn, R. (1975). Seasonality in Tourism: A Guide to the Analysis of Seasonality and Trends for Policy Making. London: Economist Intelligence Unit.

Barnes, B. (2002). The Heat Wave Vacation. The Wall Street Journal, 2 August 2002.

Baum, T. & Hagen, L. (1999). Response to Seasonality: The Experiences of Peripheral Destinations. *International Journal of Tourism Research*, 1(5), 299-312.

Becken, S., Wilson, J. & Reisinger, A. (2010). Weather, Climate and Tourism: A New Zealand Perspective. Land Environment and People – Technical Report 20. Lincoln University, Lincoln, NZ.

Becken, S. & Hay, J. (2012). *Climate Change and Tourism – From Policy to Practice*. Routledge, Oxon, UK.

Becker, S. (1998). Beach Comfort Index – A New Approach to Evaluate the Thermal Conditions of Beach Holiday Resorts Using a South African Example. *GeoJournal*, 44(4), 297-307.

Bigano, A., Hamilton, J.M. & Tol, R.S.J. (2006). The Impact of Climate on Holiday Destination Choice. *Climatic Change*, 76, 389-406.

Burki, R., Elsasser, H., Abegg, B. & Koenig, U. (2005). Climate Change and Tourism in the Swiss Alps. In: C.M. Hall and J. Higham (eds). *Tourism, Recreation and Climate Change*, Clevedon: Channel View Publications.

Butler, R.W. (1994). *Seasonality in Tourism: Issues and Problems.* In: T. Baum and S. Lundtorp (eds). *Seasonality in Tourism*. Pergamon, UK: Wiley.

Cengiz, T., Akbulak, C., Caliskan, V. & Kelkit, A. (2008). Climate Comfortable for Tourism: A Case Study of Canakkale. BALWOIS, Ohrid, Macedonia. Retrieved March 23, 2011 from http://www.balwois.com/balwois/administration/full_paper/ffp-1184.pdf.

Crompton, J. (1979). Motivations for Pleasure Vacation. *Annals of Tourism Research*, 6(4), 408-424.

Dann, G. (1981). Tourist Motivation: An Appraisal. *Annals of Tourism Research*, 8(2), 187-219.

de Freitas, C.R. (2001). Theory, Concepts and Methods in Tourism Climate Research. International Society of Biometeorology Proceedings of the First International Workshop on Climate, Tourism and Recreation. Retrieved March 13, 2012 from http://www.mif.uni-freiburg.de/isb/ws/report.htm.

de Freitas, C.R. (2003). Tourism Climatology: Evaluating Environmental Information for Decision Making and Business Planning in the Recreation and Tourism Sector. *International Journal of Biometeorology*, 48, 45-54.

de Freitas, C.R., Scott, D. & McBoyle, G. (2004). A Second Generation Climate Index for Tourism (CIT). Proceedings of the International Society of Biometeorology Commission on Climate, Tourism and Recreation. Kolimbari, Crete, Greece, 9-12 June.

de Freitas, C.R., Scott, D., & McBoyle, G. (2008). A Second Generation Climate Index for Tourism (CIT): Specifications and Verifications. *International Journal of Biometeorology*, 52, 399-407.

Denstadli, J., Jacobsen, J. & Lohmann, M. (2011). Tourist Perceptions of Summer Weather in Scandinavia. *Annals of Tourism Research*, 38(3), 920-940.

Elsasser, H. & Burki, R. (2002). Climate Change as a Threat to Tourism in the Alps. *Climate Research*, 20, 253-257.

ENSEMBLES (2009). ENSEMBLES: Climate Change and its Impacts at Seasonal, Decadal and Centennial Timescales. ENSEMBLES Project Office, Exeter, UK. Retrieved June 23, 2012 from http://ensembles-eu.metoffice.com/docs/Ensembles_final_report_Nov09.pdf.

European Commission (2012). *Supporting European Tourism*. Retrieved October 22, 2012 from http://ec.europa.eu/enterprise/sectors/tourism/index_en.htm.

Euromonitor International (2011). *Euromonitor International's Top City Destinations Ranking*. Retrieved January 5, 2012, from http://blog.euromonitor.com/2011/01/euromonitor-internationals-top-city-destinations-ranking.html.

Eugenio-Martin, J.L. & Campos-Soria, J.A. (2010). Climate in the Region of Origin and Destination Choice in Outbound Tourism Demand. *Tourism Management*, 31(6), 744-753.

Farajzadeh, H. & Matzarakis, A. (2009). Quantification of Climate for Tourism in the Northwest of Iran. *Meteorological Applications*, 16(4), 545-555.

Fukushima, T., Kureha, M., Ozaki, N., Fujimori, Y. & Harasawa, H. (2002). Influence of Air Temperature Change on Leisure Industries – Case Study on Ski Activities. *Mitigation and Adaptation Strategies for Global Change*, 7(2), 173-189.

Gearing, C.E., Swart, W.W. & Var, T. (1974). Establishing a Measure of Touristic Attractiveness. *Journal of Travel Research*, 12(4), 1-8.

Gomez-Martin, B. (2005). Weather, Climate and Tourism. A Geographical Perspective. *Annals of Tourism Research*, 32(3), 571-591.

Gomez-Martin, M.B. (2006). Climate Potential and Tourist Demand in Catalonia (Spain) during the Summer Season. *Climate Research*, 32, 75-87.

Gossling, S., Bredberg, M., Randow, A., Svensson, P. and Swedlin, E. (2006). Tourist Perceptions of Climate Change: A Study of International Tourists in Zanzibar. *Current Issues in Tourism*, 9 (4-5), 419-435.

Gossling, S., Scott, D., Hall, C.M., Ceron, J. & Dubois, G. (2012) Consumer Behaviour and Demand Response of Tourists to Climate Change. *Annals of Tourism Research*, 39(1), 36-58.

Greekvoyager.com (2013) Location and Climate. Retrieved July 20, 2012 from http://www.greekvoyager.com/pagesen/europe_clima.html.

Hamilton, J. (2005). *Climate and the Destination Choice of German Tourists.* Centre for Marine and Climate Research, Hamburg University, Hamburg, Germany. Retrieved February 14, 2012, from http://www.fnu.zmaw.de/fileadmin/fnu-files/models-data/htm/climtour.pdf.

Hamilton, J.M. and Lau, M.A. (2005). The Role of Climate Information in Tourist Destination Choice Decision-making. In S. Gossling and C.M. Hall (eds) *Tourism and Global Environmental Change*. London: Routledge.

Hamilton, J.M., Maddison, D.J. & Tol, R.S.J. (2005). Climate Change and International Tourism: A Simulation Study. Global Environmental Change, 15, 253-266.

Hartmann, R. (1986). Tourism, Seasonality and Social Change. *Leisure Studies*, 5(1), 25-33.

Hein, L. (2007). *The Impact of Climate Change on Tourism in Spain*. CICERO Working Paper, 2007:02. Center for International Climate and Environmental Research, Oslo, Norway. Retrieved 6 September 2011, from http://www.cicero.uio.no/media/5119.pdf.

Hein, L., Metzger, M.J. & Moreno, A. (2009). Potential Impacts of Climate Change on Tourism: A Case Study for Spain. *Current Opinion in Environmental Sustainability*, 1(2), 170-178.

Higham, J. & Hinch, T. (2002). Tourism Sports and Seasons: The Challenges and Potential of Overcoming Seasonality in the Sport and Tourism Sectors. Tourism Management, 23(2), 175-185.

Hu, Y. & Ritchie, J. (1993). Measuring Destination Attractiveness: A Contextual Approach. *Journal of Travel Research*, 32(20), 25-34.

Intergovernmental Panel on Climate Change (IPCC) (2007a). *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. [Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J. & Hanson, C. E. (eds)]. Cambridge University Press, Cambridge, UK, 7-22.

Intergovernmental Panel on Climate Change (IPCC) (2007b). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* [Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. & Miller, H.L. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1-18.

Jacobsen, J.K.S., Denstadli, J.M., Lohmann, M. & Forland, E.J. (2011). Tourist Weather Preferences in Europe's Arctic. *Climate Research*, 50, 31-42.

Jang, S.C. (2004). Mitigating Tourism Seasonality: A Quantitative Approach. *Annals of Tourism Research*, 31(4), 819-836.

Jendritzky, G., Maarouf, A. & Staiger, H. (2001). Looking for a Universal Thermal Climate Index UTCI for Outdoor Applications. Windsor-Conference on Thermal Standars. Moving Thermal Comfort Standards into the 21st Century, Windsor, UK, 2001.

Koenig, U. & Abegg, B. (1997). Impacts of Climate Change on Winter Tourism in the Swiss Alps. *Journal of Sustainable Tourism*, 5(1), 46-58.

Kozak, M. (2002). Comparative Analysis of Tourist Motivations by Nationality and Destinations. *Tourism Management*. 23(3), 221-232.

Limb, M. & Spellman, G. (2001). *Evaluating Domestic Tourists' Attitudes to British Weather: A Qualitative Approach*. Proceedings of the First International Workshop on Climate, Tourism and Recreation. Greece, 5-10 October 2001. Retrieved 13 March 2012, from www.mif.uni-freiburg.de/isb/ws/papers/02_spellman.pdf.

Lise, W. and Tol, R. (2002). Impact of Climate on Tourist Demand. *Climatic Change*, 55(4), 429-449.

Lohmann, M. & Kaim, E. (1999). Weather and Holiday Destination Preferences Image, Attitude and Experience. *Tourism Review*, 54(2), 54-64.

Maddison, D. (2001). In Search of Warmer Climates? The Impact of Climate Change on Flows of British Tourists. *Climatic Change*, 49(1-2), 193-208.

Mansfeld, Y., Freundlich, A. & Kutiel, H. (2004). *The Relationship between Weather Conditions and Tourists' Perception of Comfort: The Case of the Winter Sun Resort of Eilat*. In: Amelung, B. & Viner, D. (eds) Proceedings NATO Advanced Research Workshop on Climate Change and Tourism, Warsaw, Poland.

Matzarakis, A. (2001). *Climate and Bioclimate Information for Tourism in Greece*. In: Matzarakis, A. and de Freitas, C.R. (eds). Proceedings of the First International Workshop on Climate, Tourism and Recreation. International Society of Biometeorology, Commission on Climate Tourism and Recreation. December 2001. 171-183.

Matzarakis, A. (2007). *Assessment Method for Climate and Tourism based on Daily Data*. In: Matzarakis, A., de Freitas, C.R. & Scott, D. (eds.), Developments in Tourism Climatology. German Meteorological Society, 52-58.

Mayo, E.J. (1973). *Regional Images and Regional Travel Destinations*. In: Proceedings of the Fourth Annual Conference of TTRA. Sun Valley, ID: *Travel and Tourism Research Association*, 211-218.

Mieczkowski, Z. (1985). The Tourism Climatic Index: A Method of Evaluating World Climates for Tourism. *Canadian Geographer*, 29(3), 220-233.

Mintel (1991). *Special Report – Holidays*. Leisure Intelligence. Mintel International Group, London, England.

Moreno, A. & Amelung, B. (2009). Climate Change and Tourist Comfort on Europe's Beaches in Summer: A Reassessment. *Coastal Management*, 37(6), 550-568.

Moreno, A. (2010). Mediterranean Tourism and Climate (Change): A Survey-Based Study. *Tourism and Hospitality Planning & Development*, 7(3), 253-265.

Morgan, R., Gatell, E., Junyent, R., Micallef, A., Ozhan, E. & Williams, A. (2000). An Improved User-based Beach Climate Index. *Journal of Coastal Conservation*, 6, 41-50.

National Oceanic and Atmospheric Administration (NOAA) (2012a) National Climatic Data Center, State of the Climate: Global Analysis for Annual 2012, published online December 2012, retrieved on March 26, 2013 from http://www.ncdc.noaa.gov/sotc/global/2012/13.

National Oceanic and Atmospheric Administration (NOAA) (2012b) National Climatic Data Center, State of the Climate: Global Snow & Ice for Annual 2012, published online December 2012, retrieved on March 26, 2013 from http://www.ncdc.noaa.gov/sotc/global-snow/2012/13.

Nicholls, S. & Amelung, B. (2008). Climate Change and Tourism in Northwestern Europe: Impacts and Adaptation. *Tourism Analysis*, 13, 21-31.

Parisinfo.com (2005) Tourism in Paris in 2005: Key Figures. Retrieved Jan 28, 2013 from http://en.parisinfo.com/uploads/93//Chiffres_cles_2006.pdf.

Parisinfo.com (2009) Tourism in Paris in 2009: Key Figures. Retrieved Jan 28, 2013 from http://asp.zone-secure.net/v2/index.jsp?id=1203/1515/7436&lng=fr.

Perch-Nielsen, S., Amelung, B. & Knutti, R. (2010). Future Climate Resources for Tourism in Europe Based on the Daily Tourism Climatic Index. *Climate Change*, 103(3-4), 363-381.

Rashid, T. & Robinson, N. (2010). Crisis and Risks in Tourism: Death Takes a Holiday – Debunking the Myth of Terrorism and its Psychological Impact on the Tourism Industry. *International Journal of Tourism Policy*, 3(4), 348- 353.

Ritchie, B. & Zins, M. (1978). Culture as Determinant of the Attractiveness of a Tourism Region. *Annals of Tourism Research*, 5(2), 252-267.

Roshan, G., Rousta, I. & Ramesh, M. (2009). Studying the Effects of Urban Sprawl of Metropolis on Tourism – Climate Index Oscillation: A Case Study of Tehran City. *Journal of Geography and Regional Planning*, 2(12), 310-321.

Rutty, M. & Scott, D. (2010). Will the Mediterranean Be "Too Hot" for Tourism? A Reassessment. *Tourism and Hospitality Planning & Development*, 7(3), 267-281.

Ryan, C. & Glendon, I. (1998). Application of Leisure Motivation Scale to Tourism. *Annals of Tourism Research*, 25(1), 169-184.

Scott, D., Gossling, S. & de Freitas, C.R. (2008). Preferred Climates for Tourism: Case Studies from Canada, New Zealand and Sweden. *Climate Research*, 38, 61-73.

Scott, D., Hall, C.M. & Gossling, S. (2012). *Tourism and Climate Change: Impacts, Adaptation and Mitigation*. Oxon, UK: Routledge.

Scott, D. & Lemieux, C. (2010). Weather and Climate Information for Tourism. *Procedia Environmental Sciences*. 1, 146-183.

Scott, D. & McBoyle, G. (2001). *Using a 'Tourism Climate Index' to Examine the Implications of Climate Change for Climate as a Tourism Resource.* In: Matzarakis, A., de Freitas, C.R. (eds.) Proceedings of the 1st International Workshop Climate, Tourism and Recreation, International Society of Biometeorology. Porto Carras, Neos Marmaras, Halkidiki, Greece, 5 to 10 October 2001. Retrieved 6 July, 2011, from http://www.mif.uni-freiburg.de/isb/ws/papers/full_report.pdf.

Scott, D., McBoyle, G. & Schwartzentruber, M. (2004). Climate Change and the Distribution of Climatic Resources for Tourism in North America. *Climate Research*, 27(2), 105-117.

Shih, C., Nicholls, S. & Holecek, D. (2009). Impact of Weather on Downhill Ski Lift Ticket Sales. *Journal of Travel Research*, 47(3), 359-372.

Smith, K. (1981). The Effect of Weather Conditions on the Public Demand for Meteorological Information. *Journal of Climatology*, 1(4), 381-393.

United Nations Environment Programme (UNEP) (2008) Annual Report. Retrieved July 20, 2012 from http://www.unep.org/PDF/AnnualReport/2008/AnnualReport2008_en_web.pdf.

United Nations World Tourism Organization (UNWTO). (2008). *Climate Change and Tourism: Responding to Global Challenges*. Davos, Switzerland, 1-3 October 2007. Madrid, Spain: United Nations.

United Nations World Tourism Organization (UNWTO). (2009). *From Davos to Copenhagen and Beyond: Advancing Tourism's Response to Climate Change – UNWTO Background Paper*. Retrieved November 23, 2011, from http://sdt.unwto.org/sites/all/files/docpdf/fromdavostocopenhagenbeyondunwtopaperelectronicversion.pdf.

United Nations World Tourism Organization (UNWTO). (2012a). *International Tourism to Reach One Billion in 2012*. Retrieved October 3, 2012 from http://media.unwto.org/en/press-release/2012-01-16/international-tourism-reach-one-billion-2012.

United Nations World Tourism Organization (UNWTO) (2012b). Understanding Tourism: Basic Glossary. Retrieved 27 December, 2012 from http://media.unwto.org/en/content/understanding-tourism-basic-glossary.

Wall, G. & Badke, C. (1994). Tourism and Climate Change: An International Perspective. *Journal of Sustainable Tourism*, 2(4), 193-203.

Wilton, D. & Wirjanto, T. (1998). *An Analysis of the Seasonal Variation in the National Tourism Indicators*. Department of Economics, University of Waterloo. Canadian Tourism Commission. Ottawa, Canada. Retrieved 23 December 2012, from http://torc.linkbc.ca/torc/downs1/SeasonalVariation.pdf.

Wirth, K. (2009). Auswirkungen des Klimawandels auf den Tourismus im Mittelmeerraum. Prognosen anhandeiner Umfrage in Munchen [Impacts of climate change on tourism in the Mediterranean. Forecasts based on a survey in Munich]. Unpublished undergraduate thesis, pp. 1–83. Ludwig Maximilian University, Munich, Germany.

Whittlesea, E. & Amelung, B. (2010). Cost-a South West: What Could Tomorrow’s Weather and Climate Look Like for Tourism in the South West of England?, National Case Study. Exeter, UK: South West Tourism.
Ukclimateprojections.defra.gov.uk/images/stories/Case_studies/CS_SWTourism.pdf

Worldatlasbook.com (2011). Europe Map. Retrieved 20 June 2012, from www.worldatlasbook.com/europe/europe-map.html.

World Economic Forum (2011). *Travel & Tourism Competitiveness Report 2011*. Retrieved 13 June 2011, from http://www3.weforum.org/docs/WEF_TravelTourismCompetitiveness_Report_2011.pdf.

World Meteorological Organization (2009). Climate Knowledge for Action: A Global Framework for Climate Services – Empowering the Most Vulnerable, WMO No. 1065. Geneva: World Meteorological Organization. Retrieved June 23, 2012 from www.wmo.int/pages/publications/showcase/documents/1055_en.pdf.

World Meteorological Organization (2013) World Weather Information Service – Europe.

Retrieved March 13, 2013 from http://www.worldweather.org/062/c00194.htm.

Yapp, G.A. & McDonald, N.S. (1978). A Recreation Climate Model. *Journal of Environment Management*, 7, 235-252.

Yu, G., Schwartz, Z. & Walsh, J.E. (2009a). A Weather-resolving Index for Assessing the Impact of Climate Change on Tourism Related Climate Resources. *Climate change*, 95, 551-573.

Yu, G., Schwartz, Z. & Walsh, J.E. (2009b). Effects of Climate Change on the Seasonality of Weather for Tourism in Alaska. *Arctic*, 62(4), 443-457.

Zaninovic, K. & Matzarakis, A. (2009). The Bioclimatological Leaflet as a Means Conveying Climatological Information to Tourists and the Tourism Industry. *International Biometeorol*, 53, 369-374. 22