Mediterranean Tourism: Exploring the Future with the Tourism Climatic Index

Bas Amelung
International Centre for Integrative Studies (ICIS), Maastricht University, The Netherlands

David Viner
Climatic Research Unit (CRU), University of East Anglia, Norwich, UK

This paper examines future climate change scenarios for the Mediterranean region using the Tourism Climatic Index. Currently, an estimated 100 million tourists visit the Mediterranean region annually, largely because of its favourable climate. Experiments with climate change scenarios suggest likely changes, with the Mediterranean becoming too hot in summer, with northern Europe having a more attractive climate, and with the Mediterranean becoming a more pleasant destination in spring and autumn. These spatial and temporal changes in climatic attractiveness could have major impacts on the sustainability of tourism development. Preliminary results for the case study of the Balearic Islands suggest that changes are likely to be detrimental from an economic and social point of view, and neutral or favourable from a resource management and biodiversity perspective.

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Introduction

The Mediterranean region is one of the most visited tourist destination areas in the world. Currently, an estimated 100 million tourists visit the Mediterranean region on an annual basis, spending close to 100 billion US dollars (Mather *et al.*, 2005). An estimated 84% of the international tourists that visit the Mediterranean come from Europe, mostly from northern and western countries. Germany is the largest market followed by the United Kingdom. Spain, France, Italy and Greece receive almost 80% of Mediterranean tourism arrivals.

The Mediterranean tourist sector has traditionally been characterised by strong seasonality, with large differences in occupancy rates between winter and summer. For example, in Spain in the early 1990s, tourist expenditures were around 50% higher in the peak month of August than in an average month, and around 30% lower in February (González & Moral, 1995). In Spain, in 2003, more than three times as many hotel nights were spent in August as in December (INE, 2004).

Climatic factors, such as temperature, sunshine hours, and (the absence of) rain determine a large share of the international tourism flows within Europe. Statistical analyses by Maddison (2001), Lise and Tol (2002), and Hamilton (2003), and a

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simulation study by Hamilton *et al.* (2003) show the relevance of climatic factors as determinants of tourist demand. According to Maddison (2001) the maximum daytime temperature should ideally be close to 30ºC, while Lise and Tol (2002) estimate the optimal 24-hour mean daily temperature to be around 21ºC. In tourism, climatic conditions have long been taken for granted because of their supposed long-term stability (Abegg *et al.*, 1998). There is now overwhelming evidence, however, that the global climate is changing as a result of emissions of greenhouse gases.

Climate change may well alter the relative climatic conditions for tourism in Europe. Agnew and Viner (2001) explored the impacts of climate change on a range of different destinations, which was the first attempt to examine the multi-sectoral and global changes in tourism flows as a result of climate change. Viner and Amelung (2003) report on the wider issues that surround the interactions of climate change with tourism and the environment. Several studies that specifically targeted the Mediterranean region (Perry, 2000a, 2000b, 2001; Rotmans *et al.*, 1994) suggest that in the future, the summer season's climatic conditions will deteriorate in this region and improve in western and northern Europe (currently the major source region of Mediterranean tourists) as a result of human-induced climate change. In contrast, conditions in autumn and spring (the shoulder seasons) are expected to improve in the Mediterranean region.

This paper examines the suitability for tourism of current and future climatic conditions in the Mediterranean. The Tourism Climatic Index (TCI), devised by Mieczkowski (1985) to rate climatic conditions, is used to accomplish this. It encompasses ratings for thermal comfort, sunshine, precipitation and wind. This paper pioneers the application of the TCI concept to future climatic conditions. To capture some of the uncertainties around climate change, scenario analysis is applied, based on the work of the Intergovernmental Panel on Climate Change (IPCC). IPCC undertook an exploration of the possible changes in socioeconomic conditions and population that resulted in the Special Report on Emissions Scenarios (SRES) (IPCC, 2000). This report presented a range of future plausible scenarios from which greenhouse gas emissions and atmospheric concentrations of these gases were estimated. These emissions and concentrations have in turn been used to explore the response of the climate system. It is estimated that the global mean temperature will increase by 1.5 to 5.8°C during the 21st century, taking into account uncertainties regarding future emissions and the functioning of the climate system. The effects of the four main SRES scenarios (i.e. the A1f, A2a, B1a, and B2a scenarios) are explored in this paper.

The analysis covers the whole of the Mediterranean, as well as north-western Europe, the Mediterranean's major visitor source region. On this large scale it is not feasible to test the relevance and validity of the TCI because tourism data of sufficient spatial and temporal detail are lacking. It is possible, nevertheless, to test the performance of the TCI for individual regions for which the necessary data are available. In this paper, the Balearic Islands are used as a regional case study. The Balearics are made up of Majorca, Minorca, Ibiza and Formentera. For this Spanish region, TCI scores are plotted against levels of visitation, and the implication of climate change for sustainable tourism development is explored in a qualitative way. Several factors make this group of islands an excellent study area: it is among the most important regions for tourism in Spain, climate is a major attraction and it is clearly delimited geographically.

The structure of the paper is as follows. In the second section, the concept of the tourism climatic index is discussed, addressing key issues such as factors included and weighting. The third section gives a brief overview of the analysis and the data that were used, followed by a presentation of the results in the fourth section. The case study of the Balearics is presented in the fifth section. In the sixth section, a discussion of the results is combined with the main conclusions and policy recommendations.

Tourism Climatic Indices

The tourism climatic index as a concept has evolved from more general knowledge about the influence of climatic conditions on the physical wellbeing of humans. In the 1960s and 1970s systematic research in this field yielded many insights, ranging from preferred temperatures, and the role of relative humidity to the appreciation of wind effects. It should be noted that the appreciation of climatic conditions is also dependent on a host of non-climatic factors, such as the level of activity, clothing, and genetic setup.

Mieczkowski (1985) was among the first to apply the general findings about human comfort to the specific activities related to recreation and tourism. He devised a tourism climatic index consisting of five sub-indices, describing daytime thermal comfort, daily thermal comfort, precipitation, hours of sunshine, and wind speed. The mapping of raw data to sub-index values depends on the kind and level of tourist activity. Beach holidays require climatic conditions different from ski holidays; in his article, light activities, such as touring, are used as a reference.

Values for all variables are mean monthly values. The thermal comfort sub-indices are based on effective temperature,[1] which is a measure of temperature that takes the effect of relative humidity into account. According to the latest bio-meteorological literature, both short and long wave radiation are essential for deriving modern thermal indices (Matzarakis, 2001a, 2001b; Skinner & De Dear, 2001). Information on these environmental parameters is, however, not generally available in observed climate datasets. The wind sub-index combines information about wind speed and temperature. The other sub-indices are based on single variables and reflect either the empirical findings of physiological research or qualitative assessments of tourist preferences, for example in relation to precipitation. For a detailed description of the set of variables, and the calculation of the sub-indices, see Mieczkowski (1985). All sub-indices have a maximum value of 5. Mieczkowski proposed the following equation for calculating the TCI for outdoor recreational activities:

$$TCI = 2 \cdot (4 \cdot ThC_{DT} + ThC_{DL} + 2 \cdot Sun \cdot Prec + Wind) \qquad \text{Equation (1)}$$

TCI = Tourism Climate Index
ThC_{DT} = Daytime Thermal Comfort Index
ThC_{DL} = Daily Thermal Comfort Index
Sun = Index of the amount of sunshine
Prec = Index of the amount of precipitation
Wind = Index of the appreciation of wind

The weights used in the equation are ultimately subjective, although they do have a basis in scientific knowledge. In the equation proposed by Mieczkowski, the highest weight is given to the daytime comfort index to reflect the fact that tourists are generally most active during the day. The amount of sunshine and the amount of precipitation are given the second-highest weights, followed by daily thermal comfort and wind speed. After summing the weighted individual components, the result is multiplied by two, so that the maximum TCI score is 100.

Mieczkowski proposed a classification of TCI scores, with values in excess of 60 corresponding to 'good' conditions, scores exceeding 70 representing 'very good' climatic conditions, levels of over 80 corresponding to 'excellent' conditions, and scores of 90 or more standing for 'ideal' circumstances.

While the Mieczkowski index, and other indices such as the one developed by Hatch (1988), were not originally devised to explore the impacts of climate change on tourist comfort, they can be used for that purpose: see Rotmans *et al.* (1994) for a grid-based application to Europe, and Scott and McBoyle (2001) for a case-based application to various cities in North America.

In this paper the Mieczkowski index is used to explore the changes in the climatic resources for tourism brought about by climate change in the Mediterranean region. The aim is to identify possible major shifts in the climatic attractiveness of various regions in the world in different seasons. The implications for the distribution of TCI values over the year are also considered, following the example of Scott and McBoyle (2001).

Data and Methods

This section briefly describes the steps taken to gather and prepare the data, to do the scenario runs, and to analyse the results.

Two datasets underlie the results presented here: the CRU CL 1.0 dataset, containing 0.5 × 0.5 degree 1961–1990 Mean Monthly Climatology data, assembled by the Climatic Research Unit in Norwich (New *et al.*, 1999); and results from an integration of the Global Circulation Model (GCM) HadCM3 forced (2.5 × 3.75) with a range of greenhouse gas emissions scenarios (Johns *et al.*, 2003). This paper aims to explore the implications of various emissions scenarios, rather than the model uncertainties in the different GCMs. It uses the Hadley Centre's HadCM3 model, the most widely used GCM. The use of the standard SRES scenarios does and will allow comparison with other studies.

The CRU CL 1.0 grid-based dataset was constructed from a dataset of station 1961–90 climatological normals, numbering between 19,800 for precipitation and 3615 for wind speed (New *et al.*, 1999). This data set is the best available and most commonly used. The station data were interpolated to obtain a 0.5º lat × 0.5º long grid-based dataset, covering the entire landmass of the earth except for Antarctica; ocean space is not included. Values for all the component variables of the Mieczkowski index can be extracted from the CRU dataset, either in unmodified form or after some straightforward manipulation.

For the construction of the dataset of future climatic states, results were used from a climate change integration performed with HadCM3 (a coupled ocean-atmosphere Global Climate Model) forced with the SRES emissions scenarios.

The spatial resolution of these gridded data is 2.5° latitude × 3.75° longitude. The HadCM3 dataset consists of monthly normals[2] for four time slices: 1961–1990 (the 1970s); 2010–2039 (the 2020s); 2040–2069 (the 2050s); 2070–2099 (the 2080s). These time slices were available for a number of scenarios; in the analyses underlying this paper attention was limited to the four most commonly used SRES scenarios: A1F, A2A, B1A, B2A; for details regarding the scenarios see IPCC (2000). The analyses showed that the direction of change was similar in all scenarios considered, while rates of change varied considerably. In this paper, the discussion is, therefore, limited to the A1F and B1A scenarios, characterised by a rapid[3] and a moderate pace of climate change, respectively. By taking this approach, the outer limits of the range of consequences implied by the set of SRES scenarios are explored.

A standard approach for constructing projections is to calculate the differences between a simulated future state and the simulated baseline state and to add those to the observed baseline state. This standard practice is followed here. For temperature, absolute change (°C) is used, while for the other variables, relative change (%) is preferred to avoid negative values. The drawback of this procedure is that relative changes can be very large if the initial value is close to zero; in this paper increases are therefore limited to a maximum of 100%.

Values for mean and maximum temperature are computed by adding the simulated changes to the observed historical values. Values for the other variables are computed by increasing the observed historical values by the corresponding percentage of change. The differences in spatial resolution between the two datasets imply that data on the coarse HadCM3 grid must be added to data on the finer CRU baseline dataset. The value that is added to a particular baseline cell depends on the location of that cell. If the cell can be uniquely mapped to one HadCM3 land cell, the value of this cell is used. If the cell is right on the border between two HadCM3 cells, the average value of these two cells is used, if either or both of these cells are land cells. In all other cases, an average is used of the land cells at a distance of less than one HadCM3 cell. Only land cells are used, since many climatological phenomena are very different over land and over sea; it would be misleading to use the sea dynamics from the HadCM3 model for projections related to land cells in the CRU grid.

The projected values for the component variables are subsequently converted into the five sub-indices, with one adjustment: the effective temperature concept is replaced by the more recent apparent temperature concept, following Scott and McBoyle (2001).

To analyse seasonal TCI patterns, a classification of TCI distributions is used, adapted from Scott and McBoyle (2001). Table 1 shows the details.

A distribution qualifies as 'optimal' if all monthly ratings are 80 or higher; it qualifies as 'poor' if all monthly ratings are 40 or lower. If these conditions do not apply, there are four other options. The summer and winter peak distributions apply if the highest TCI ratings occur in summer or winter respectively. If the scores in spring and autumn are higher than in both summer and winter, the bimodal distribution applies. The 'dry season peak' is somewhat ambiguous, because the dry season can coincide with either the spring or the autumn season. Therefore, in this paper, the 'dry season peak' distribution is split up into spring peak and autumn peak. In a spring peak (autumn peak) distribution, the

Table 1 Classification of TCI distributions

	All months	*Spring*	*Summer*	*Autumn*	*Winter*
Optimal	≥ 80	–	–	–	–
Poor	≤ 40	–	–	–	–
Summer Peak	–	–	1st highest TCI	–	–
Winter Peak	–	–	–	–	1st highest TCI
Bimodal	–	1st or 2nd highest TCI	–	1st or 2nd highest TCI	–
Dry season Peak	–	1st highest TCI (or Autumn)	–	1st highest TCI (or Spring)	–
Spring Peak	–	1st highest TCI	–	3rd or 4th highest TCI	–
Autumn Peak	–	3rd or 4th highest TCI	–	1st highest TCI	–

Source: Adapted from Scott and McBoyle (2001): Dark shaded original category replaced by light shaded new categories

highest TCI scores occur in the spring (autumn) season, with autumn (spring) not coming in second place; otherwise the bimodal distribution would apply.

Note that the relationship between months and seasons is adjusted for the hemisphere that is considered. For example: in the northern hemisphere, the spring season is taken to encompass the months of March, April and May, while in the southern hemisphere, it is taken to encompass the months of September, October and November.

Results

To get an overview of the historical situation, the TCI values are calculated for the baseline period of 1961–1990 (referred to as the 1970s). These calculations have been made for the whole world, but in this paper, attention is focused on the Mediterranean region, complemented by Western Europe, which generates the largest flow of tourists to the Mediterranean.

Located at considerable distance from the equator, Europe features large differences between the seasons. According to the classification of TCI distributions described in Table 1, the dominant seasonal distribution in the Mediterranean region and the whole of Europe is the summer peak distribution: the mean score in the summer months of June, July and August, is higher than in any other season (see Figure 1).

In North Africa, the bimodal distribution is most common, which is characterised by a situation in which scores in both spring and autumn are higher than those in summer. Large parts of the Moroccan and Algerian coastal areas have a summer peak distribution as a result of the cooling effect of altitude in the Atlas mountain range. Further away from the coast, there is a narrow strip of land with a spring peak distribution, marking the transition towards a winter peak distribution that is dominant in most of the African continent.

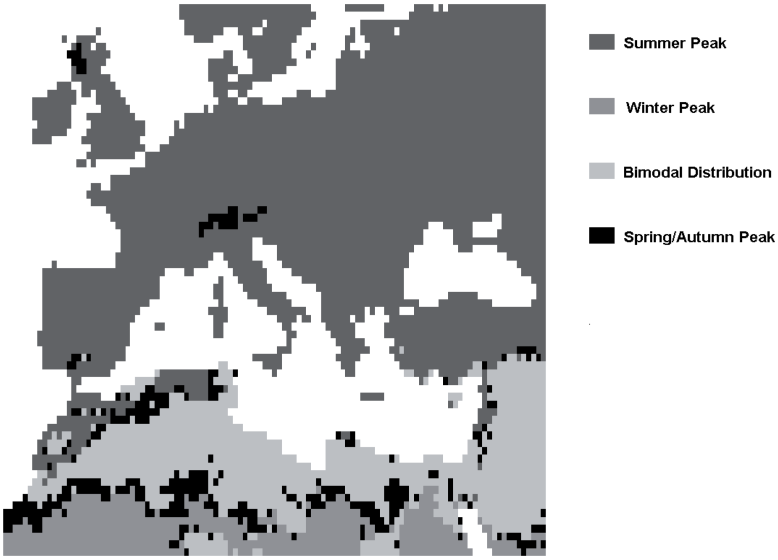

Figure 1 Seasonal distributions of tourism climatic index (TCI) values in Europe and North Africa in the 1970s

In the summer season, the northern Mediterranean region achieves excellent scores on the TCI, while scores in the northern parts of Europe are considerably lower, yet still good. In North Africa there is a marked distinction between the coastal zone and the rest of the area, with scores decreasing rapidly with increasing distance from the Mediterranean Sea and the Atlas mountain range. In wintertime, scores are consistently low in the whole of Europe. Only in parts of Spain and Italy are winter TCI scores acceptable. Winter conditions are much better in the south-eastern section of the Mediterranean region comprising Libya and Egypt.

The exploration of future conditions begins with an analysis of shifts in seasonal distributions. Seasonality is a key issue in tourism, and it is of major importance for the profitability of tourism in the Mediterranean region. Figure 2 shows the pattern of seasonal distributions across the Mediterranean and the rest of Europe in the 2020s, 2050s, and 2080s, according to the A1F and B1A scenarios.[4]

The general trend emerging from the six maps is that the whole pattern shifts northwards. The bimodal distribution slowly moves up into the northern Mediterranean region, while the winter peak distribution becomes dominant in most of North Africa. In Europe, changes are still relatively small in the 2020s. The TCI distribution changes only in parts of the Spanish interior and along the Spanish east coast. In the decades to follow, changes become much more dramatic. In A1F's 2050s (rapid change) and B1A's 2080s (moderate pace of change), the bimodal distribution dominates large sections of the northern Mediterranean coastal zones. By the 2080s in the A1F world, almost all of Portugal, Spain, Italy, Greece, Turkey, and the Balkans will be characterised by a bimodal distribution. In contrast, in North Africa, the influence of the bimodal distribution becomes

Figure 2 Seasonal distributions of tourism climatic index (TCI) values in Europe and North Africa in the 2020s (top), 2050s (middle), and 2080s (bottom), according to the A1F (left) and B1A (right) SRES scenarios

more and more restricted, until by A1F's 2080s it only dominates the mountainous northern parts of Morocco and Tunisia.

Looking at the four seasons individually, TCI values change dramatically in summer and spring. The Mediterranean changes from being a region with very good or excellent summer conditions up to the 2020s into being a region with only good or acceptable conditions in B1As 2080s, and even marginal conditions in A1Fs 2080s (see Figure 3). Northern Europe, in contrast, changes into a region that is characterised by very good or even excellent summer conditions. Changes for the United Kingdom in particular are remarkable. Also please note the changes in the Alps. While this region currently achieves low TCI values in summer, it will have one of the highest scores by A1F's 2080s.

With respect to TCI conditions in spring, the northern Mediterranean region

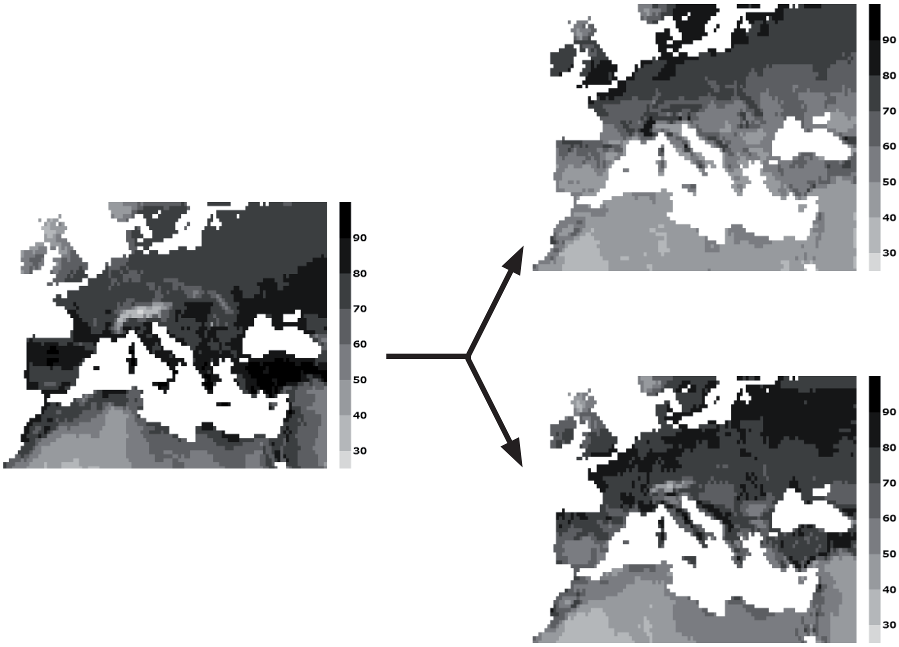

Figure 3 Mean tourism climatic index (TCI) values for Europe and North Africa in the summer season of the 1970s (left), the 2080s according to the A1F SRES scenario (top right), and the 2080s according to the B1A SRES scenario (bottom right)

will improve considerably (see Figure 4). While in the 1970s the region achieved marginal or acceptable scores of around 60, future conditions are projected to become good or even very good. The most southern countries, i.e. Spain, Greece and Turkey, will benefit most from these developments. Spring conditions will remain excellent in large stretches of the coastal zone of North Africa, although this strip will become narrower and narrower. In the coastal zones of Morocco and Algeria TCI scores will improve significantly.

For individual destinations, or rather cells, detailed monthly variations in TCI scores can be graphically represented, in addition to the TCI distribution, which is a rather coarse indicator. To illustrate this, results are plotted for two major tourist destinations in Europe: the Balearics in Spain and Blackpool in the UK. The Balearics are a typical location in the Mediterranean region, while Blackpool, a major UK seaside resort, is illustrative of the changing conditions in the temperate zones in north-western Europe.

According to the A1F and B1A scenarios, the annual TCI pattern for the Balearics will change drastically. This is not due to a change in the mean TCI score, which remains stable (–0.4 points), but to a change in the TCI distribution (see top panels of Figure 5). While optimal conditions in the Balearics are currently associated with the summer season, the optimum will shift to the shoulder seasons, i.e. autumn and spring.

For Blackpool, the changes are of a different nature. In contrast to the Balearics, the type of distribution remains firmly 'summer peak'. However, the mean TCI

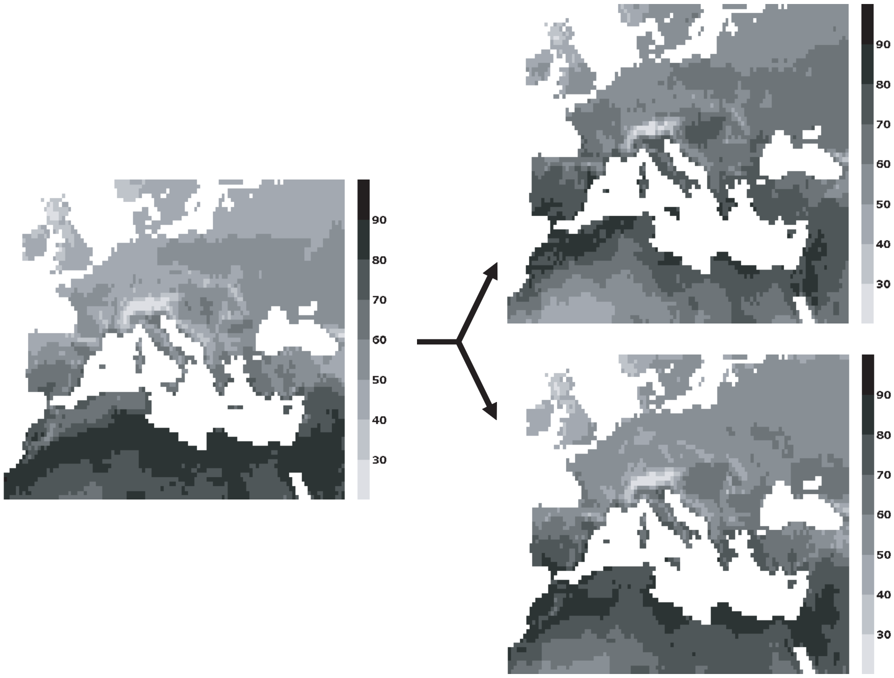

Figure 4 Mean tourism climatic index (TCI) values for Europe and North Africa in the spring season of the 1970s (left), the 2080s according to the A1F SRES scenario (top right), and the 2080s according to the B1A SRES scenario (bottom right)

rating will improve considerably (see bottom panels of Figure 5). In summer, climatic conditions will change from fair to very good or even excellent. Blackpool is an example of the significant improvements in TCI scores projected for the northern regions of Europe.

The Balearics Case Study

TCI-based analyses are sometimes criticised for being too subjective and for having little empirical basis. Partly as a result of data shortages, empirical validation of the predictive power of the TCI measure has so far been limited. This section attempts to address this issue by relating TCI scores to actual tourist behaviour in the major tourist destination of the Balearics. The results are subsequently put into the perspective of sustainable tourism development.

In 2002, some 47.4 million nights were spent in hotels in the Balearic Islands; another 11.6 million nights were spent in tourist apartments (INE, 2004). The number of nights spent in other types of accommodation was insignificant. Foreign tourists dominate, with almost 53 million nights spent: the British (42%) and Germans (37%) combined account for almost 80% of these.

Foreign tourist demand in the Balearics features a high level of seasonality. While from November to April the Balearic Islands account for less than 20% of total foreign tourist demand in Spain, this percentage rises to over 40% in the summer months of June, July and August. Domestic demand is distributed more evenly.

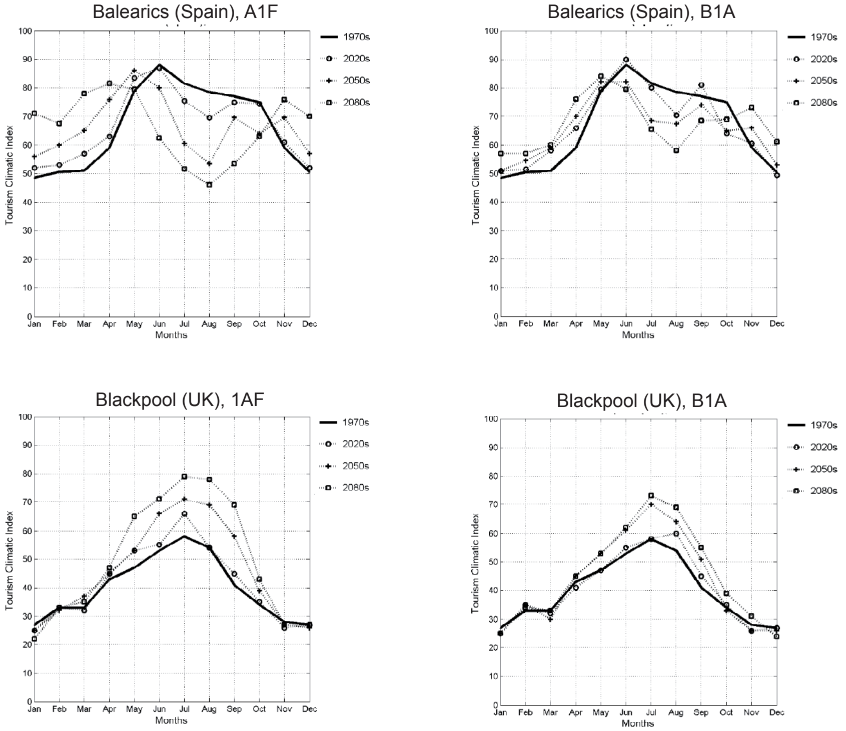

Figure 5 Developments in tourism climatic index (TCI) distributions for the Balearics (top) and Blackpool (bottom) in the 1970s, 2020s, 2050s, and 2080s, according to the A1F (left) and B1A (right) SRES scenarios

Aguiló *et al.* (2005) report on the motives for visiting the Balearics that tourists mentioned over the period 1993–2000. The climate is ranked highest (76.2%), followed by the beaches (51.2%), and price (36.4%). The authors assert that empirical data do not support the claims of either decreasing interest in 'sun and sand' mass tourism (Knowles & Curtis, 1999) or the reduced importance of a destination's climate and beaches (Weiermair, 2001). Package holidays remain one of the most common forms of travel in Europe: 86% of all high-season tourists in the year 2000 visited the Balearic Islands on a package holiday (Aguiló *et al.*, 2005).

The dominance of climate and beaches over potential other tourist attraction factors, such as cultural heritage sites, makes the Balearics a prime region for applying and testing the TCI. For this purpose, monthly visitation statistics for the 1999–2003 period have been plotted against the monthly TCI values that were calculated from climatic data for the two cells covering the Balearics in the CRU 1.0 dataset of 1961–1990 climate normals. The objective was not to link weather conditions in specific years to visitation levels in those same years; rather, its function was to illustrate the link between average climatic conditions and average visitation levels in each month. Results were encouraging: high visitation levels coincide with high TCI values. More than 88% of the annual nights spent by foreign tourists correspond to the six months with TCI scores exceeding

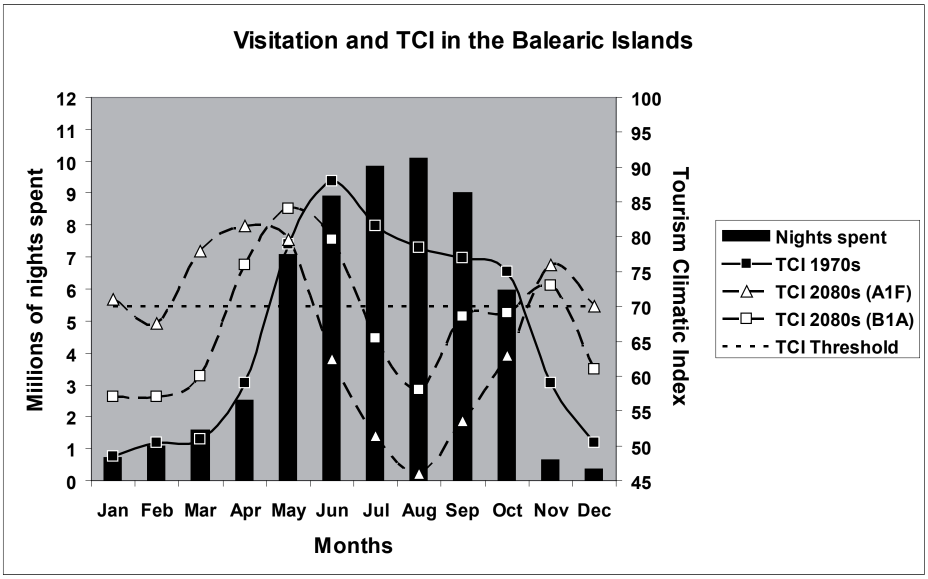

Figure 6 Exploration of future TCI scores in the Balearics
Source: Based on INE (2004)

70 or even 75, i.e. May to October (see Figure 6). Outside of these six months, both TCI scores and visitation levels are sharply lower. These results seem to support Mieczkowski's classification of TCI scores, with values over 70 'very good' climatic conditions, and with lower scores being much less attractive.

In order to illustrate the potential effects of climate change, TCI values have been calculated for the Balearics for three future time slices: the 2020s, 2050s and 2080s, and for the four most common SRES emissions scenarios. Consistent with the other analyses in this paper, only the results for A1F and B1A are discussed, which together represent a plausible range of possible speeds of climate change. TCI scores for the 2080s for both A1F and B1A were added to Figure 6, to illustrate the starting point and end state for both scenarios.

Our exploratory analysis suggests that up to the 2020s, projected changes will be relatively modest. In July and August in particular, TCI scores will decrease significantly, but stay above the (imaginary) threshold of 70. By the 2080s the situation will have changed completely. The three months that are currently the most popular ones (July, August and September), rating highest on the TCI scale, will by then be characterised by the lowest TCI scores. Of the current six high-season months only May attains a score of more than 70, accompanied by June in the B1A scenario. Spring conditions in the 2080s will be very good or excellent, in particular in the A1F scenario. This change represents a sharp contrast with the current 'acceptable' levels of the TCI in spring.

Provided that climatic conditions will remain important push and pull factors for tourism in the future, these preliminary results point at important implications for tourism in the Balearics. The remarkable seasonal concentration of today, with 88% of all nights spent in the six months from May to October, will be likely to change. Not only do TCI scores in all but one or two of these months drop below the 70-threshold in the Balearics; in the source countries the opposite will happen. In the summers of the 2080s, potential tourists in the UK and Germany will be able to find much better climatic conditions in their own country (e.g. Blackpool, see Figure 5) than in the Mediterranean region.

Simultaneously, climate change seems to offer possibilities for expansion in early spring (March and April), in particular for the domestic market in Spain. Only 7% of nights spent by foreign tourists in 2002 were associated with these two months, compared to 36% in July and August. For the Spanish tourists, these percentages were 20% and 31% respectively. Higher revenues in spring may offset part of the economic losses that are caused by the deteriorating summer climate. Given the rigidity of the institutions that favour summer as the main tourism season, however, this compensation will likely be partial at best. Given the fact that in the Balearics, tourism accounts for over 60% of GDP (Batle, 2000), the impacts may be substantial.

Employment patterns closely follow tourist demand, with hotels employing almost 46,000 in August and 5000 in December of 2003, and the tourist apartment industry employing 8500 in August and only a few hundred in December (INE, 2004). In August, the accommodation sector alone accounts for almost 14% of employment in the Balearics; almost 75% of the active population is employed in the service sector, a large share of which is tourism related. The need to accommodate seasonal employment in the tourist industry places great demands on the economic and social structures of the Balearics. The employees that the tourist industry needs in summer are partly absorbed by the islands' other industries in winter, and partly 'imported' from other Spanish regions or abroad. Between 1960 and 2001, the resident population of the Balearics rose from some 360,000 to over 700,000, which is a clear indication of the demographic response to the tourist boom (Essex *et al.*, 2004). Given the scale of these seasonal migration patterns, social consequences may be large. Drastic changes in the situation, such as those painted by the A1F and B1A scenarios, will undoubtedly change the social dynamics on the Balearics.

The availability of drinking water and sewage systems has been a problem in the Balearics for a long time (Aguiló *et al.*, 2005). The annual influx of tourists increases the demand for water well beyond the normal requirements of the resident population and the capabilities of local water sources (Essex *et al.*, 2004). Moreover, tourists typically use relatively more water than local inhabitants (Holden, 2000); the amount of water that is used to irrigate Majorca's golf courses would be enough to supply the populations of the major resorts of Calvià and the capital city of Palma with drinking water (Essex *et al.*, 2004). Water demand for tourism and irrigation is highest in the main holiday season, which coincides with the driest weather. In contrast, virtually all precipitation on the largest island of Majorca occurs in the autumn and winter months, with the wettest months typically being October to December (Kent *et al.*, 2002). The rising demand for water has been met by increased extractions of ground water. Around Palma, the water table has fallen by about 100 metres between 1973 and 1994 (Wheeler, 1995). Large water shortages are forecast for the future (Palmer & Riera, 2003) and climate change is expected to exacerbate the situation by reducing precipitation even further (Essex *et al.*, 2004; Kent *et al.*, 2002). Perhaps the expected reduction in tourist visitation levels in summer could bring some relief.

Table 2 Qualitative assessment of the impact of climate change (A1F scenario) on sustainable tourism development in the Balearics in the 21st century

	Spring	Summer	Autumn	Winter	Net effect
Revenues	↑↑	↓↓↓	↓↓	↑↑	↓↓
Occupancy	↑↑	↓↓	↔/↓	↑↑	↑
Employment	↑↑	↓↓↓	↓↓	↑↑	↓↓
Migration	↑	↓↓↓	↓↓	↔	↓↓
Water use	↑↑	↓↓↓	↓↓	↑↑	↓
Impact on Biodiversity	↑↑↑	↓↓↓	↓↓	↑	↓

↑ denotes an increase, ↓ denotes a decrease, ↔ denotes little or no change

The Mediterranean basin is considered a 'hyper-hot' candidate for conservation support in the light of its exceptional numbers of endemic plants (Myers *et al.*, 2000). Furthermore, the Mediterranean Sea is rich in marine biodiversity, and a healthy marine ecosystem is appreciated for bathing, tourism or simply aesthetic enjoyment (Bianchi & Morri, 2000). The Mediterranean biome is expected to experience a relatively large change of diversity as a result of climate change (Chapin III *et al.*, 2000). The impact of tourism on biodiversity is difficult to assess, but given tourism's significant claims on key conditions for biodiversity (i.e. the availability of land and water resources) in the Balearics, it can be safely assumed to be substantial. If the shift in tourist demand from summer to spring materialised, this would greatly reduce pressure on biodiversity in summer, but increase pressure in spring, the mating season for many species.

The results of the qualitative assessment of the implications that climate change may have for sustainable tourist development are summarised in Table 2, based on the points made above. The results are split up into the four seasons of the year, acknowledging the great differences in outcome between the seasons.

Discussion and Conclusions

In this paper the impact of climate change on the TCI is explored for the Mediterranean region. This impact is potentially very large, albeit not just in a negative sense. The projections indicate that particularly in spring, TCI scores will improve in most of the Mediterranean region, in particular in Spain, Greece and Turkey. Improvements are also projected for the autumn season. According to the explorations based on the SRES A1F and B1A scenarios, TCI ratings in the Mediterranean in the summer season will deteriorate markedly, whereas in the source countries of the North of Europe, conditions will improve.

It is important to note that in this paper, the results from just two of the SRES scenarios are taken into account. The other scenarios yield intermediate results between the A1F and B1A scenarios, and the direction of the changes is identical. All scenarios considered indicate that the Mediterranean will slowly adopt the bimodal distribution of TCI scores. Until the 2020s, these shifts occur only in the interior of Spain and along the Spanish east coast. After that, almost the entire region will come under the influence of the bimodal distribution, with the rate of change depending on the scenario.

The described changes need not be detrimental for tourism in the Mediterranean *per se*. Occupancy rates associated with a long tourist season with evenly spread demand tend to be higher than those associated with a very short tourist season consisting of just a few weeks of very high demand. It is by no means certain, though not impossible, that a situation of more evenly spread tourism demand can be easily reached; there are both unfavourable and favourable forces at work. On the one hand, current holiday seasons are geared to school holidays in the source countries, and these are subject to strict government legislation in the whole of Europe; this pattern is difficult to change. On the other hand, with the ageing of the population and the individualisation of society, families have ceased to be the dominant group in tourism. Pensioners and couples without small children, for example, have considerable flexibility in choosing when to go on holiday.

Furthermore, the climatic conditions of the Mediterranean are by no means the only attraction in the region. Attractive landscapes, cultural heritage, traditional lifestyles and beaches are among the other factors that have made the Mediterranean basin one of the most popular tourist destinations in the world. The results should thus be put in this perspective. Moreover, tastes and fashion are not stable over extended periods of time. The modern habit of sunbathing, for example, was not part of popular culture until relatively recently. Many things may change over the next decades that increase or decrease the relevance of the climatic resources for tourism in general and of the TCI in particular. Sunbathing is for example now seen as a potential health risk.

In addition to the general analyses described above, a few sites were studied in more detail. The differences between the effects of climate change on the Mediterranean and northern Europe were illustrated with the TCI distributions of the Balearics and Blackpool. In the Balearics the annual mean TCI hardly changes, in spite of the large shift towards a bimodal distribution. In Blackpool, on the other hand, the TCI distribution remains solidly summer peak, while mean TCI values increase dramatically.

The performance of the TCI as a predictor of tourist demand was tested for the Balearics, with encouraging results. The six months with TCI scores over 75 accounted for 88% of total nights spent in 2002. In the remaining six months, for which scores did not exceed 60, visitation levels were very low. These results are in agreement with findings from tourist surveys from which the climate emerged as the Balearics' single most important attractor. This climate dependence may be an important weakness in the face of climate change, because according to the A1F and B1A scenarios, by the 2080s TCI scores will have dropped below the threshold of 70 in all but one or two of the months that currently form the high season. The potential implications of these changes for sustainable tourism development were qualitatively explored. These preliminary results indicate that the net effect on economy and society will probably be detrimental, while pressures on the environment and ecosystems will decrease in summer.

It is as yet far from clear, however, if climate change will be a dominant or even significant factor in the grand scheme of tourist development. This issue of the significance of climate change is an important direction for additional study.

Tourist developments are shaped by an amalgam of factors, including political stability, economic growth, technological advances, and demography. In the day-to-day practice of the tourist industry, climate factors are overwhelmed by all kinds of other influences that require immediate action: SARS, fashion trends, terrorism, etc. Climatic effects on the climatic resources for tourism will perhaps not be so evident, but the compound effect of years of creeping change can have quite dramatic long-lasting effects.

In addition to climate change itself, mitigation policies to tackle greenhouse gas emissions are expected to have significant effects on tourism. Most of the tourism-related greenhouse gas emissions are linked to transport, which is also one of the fastest growing sectors in terms of emissions: people travel further, more frequently and for shorter periods of time than a few decades ago. In order to meet the (post-) Kyoto objectives of emission reduction, it is likely that specific measures targeting transportation will be implemented. Any restrictions to transport or significant increases in transportation prices would have a major impact on tourism. Aviation, which is currently subject to a very mild fiscal regime and uses low taxed kerosene, may be particularly hard hit. After a period in which low fuel prices and transport costs made distance less relevant, distance may start to matter again. For the Mediterranean, this would be an unfavourable development, since the region's tourism depends largely on air transport, and the popular charter flight/package tour market is extremely price sensitive. Fuel price rises, whether because of taxation or market forces, could seriously depress visitor numbers.

In this paper, the focus has been on monthly and annual means of climatic variables. Perhaps even more important than means are extreme events, such as heat waves, torrential storms, and gales. As the frequency of these extreme events is expected to increase due to climate change, their effects may provide the first signs that climate change is having an effect on the climatic resources for tourism.

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Correspondence

Any correspondence should be directed to Bas Amelung, Maastricht University, International Centre for Integrative Studies (ICIS), P.O. Box 616, Maastricht 6200 MD, The Netherlands (b.amelung@icis.unimaas.nl).

Notes

1. In this paper's analyses, the slightly different measure of 'apparent temperature' is used, as explained in the next section.
2. A climatic normal is the arithmetic average of a climate element such as temperature over a prescribed 30-year interval.

3. Whilst this is the most extreme scenario of the four standard SRES scenarios, it is the emissions pathway that global society is currently following.
4. Please note that due to the procedure for combining the CRU data with the HadCM3 projections, some coastal areas and islands (e.g. southern Italy) are not displayed on the maps that visualise the future projections. This is a technical issue that is totally unrelated to any expected changes in the real world, such as sea level rise.

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