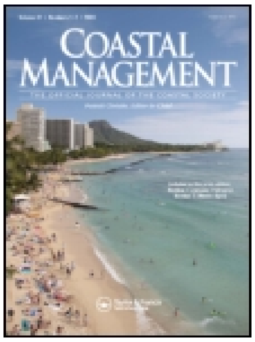

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Climate Change and Tourist Comfort on Europe's Beaches in Summer: A Reassessment

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Major impacts of climate change have been projected for tourism in Europe. Typically, these projections took general tourism activities such as sight-seeing and their climate requirements as their point of reference. The purpose of this study is to reassess the impact of climate change, by looking specifically at beach tourism in summer, a crucial market segment in Europe and more specifically in the Mediterranean. As beach tourism requires relatively high temperatures, relatively modest shifts in attractiveness are found. With respect to climate, the Mediterranean is likely to remain Europe's prime region for summer-time beach tourism for at least the next 50 years. Coastal managers in Mediterranean destinations are advised to focus some of their attention on other climate change impacts such as sea-level rise or water availability, and include environmental quality and diversification of activities in their deliberations. In non-Mediterranean regions, a promising strategy may be to focus on short- and medium-distance visitors who can take advantage of the new opportunities for beach tourism, and to explore the merits of seasonal climate forecasting.

Keywords beach climate index, beach tourism, climate change, Europe

Introduction

Since the 1950s tourism has experienced a tremendous growth, driven by socioeconomic changes such as the increase in free time and wealth, as well as by other factors such as improved and more accessible means of transport. Tourism is now one of the largest economic sectors worldwide, with international tourism receipts reaching US$856 billion (US$ 1 trillion including international passenger transport) and total international arrivals reaching 903 million in 2007 (UNWTO, 2008). According to the projections of the United Nations World Tourism Organization, the number of international arrivals is expected to reach 1.6 billion by 2020 (UNWTO, 2001).

International tourist flows are unevenly distributed between the different world regions. Europe is currently the world's leading destination, with a total of 488.5 million international arrivals (a market share of 53%) in 2008 (UNWTO, 2009). The popularity of the Mediterranean is a predominant factor in Europe's leading position. Accounting

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for 179 million international arrivals in 2008 (UNWTO, 2009), it is the world's single most important regional destination in the world, outnumbering entire world regions such as the Americas. Most of the international arrivals in the Mediterranean originate from Europe itself, in particular from Northern Europe (Todd, 2003). Multiple elements can explain this north to south flow of tourists, including the historical attractions and cultural manifestations in the southern countries. The number one factor, however, is the search for warm weather and sunshine by the seaside (Todd, 2003), making the beach one of the Mediterranean's main attractions (Bramwell, 2003).

Until relatively recently, the relationship between climate and tourism was not a major area for research. Climate was considered a more or less stable property of destinations (Abegg et al., 1997), which could not account for any long-term trends in tourism demand. This position is gradually being abandoned because of the increasing evidence that the global climate is changing. According to the International Panel on Climate Change (IPCC, 2007), the global mean temperature is likely to increase by 1.1 to 6.4°C (best estimate: between 1.8 and 4°) over the course of this century. Global average sea level is projected to rise by 18 to 59 cm or more in the same period.

These projections have led to a renewed interest in the relationships between the weather and tourism and recreation activities, and the impact that different climate conditions could have on the tourism sector (see Scott et al., 2008 for an overview). In recent years, a range of impact assessments have been produced. Some of these studies are global in nature (Agnew & Viner, 2001; Amelung et al., 2007; Hamilton et al., 2005), whereas others focus on specific countries of origin (Hamilton, 2003; Maddison, 2001), or destination types, such as ski areas (Elsasser & Bürki, 2002; Scott et al., 2001, 2003), parks (Jones & Scott, 2006a, 2006b), and coastal zones (Amelung & Viner, 2006; Moreno & Becken, 2009; Perry, 2005, 2006).

It is commonly agreed that the relationship between weather and recreation is highly dependent on the kind of activity that is assessed, with beach recreation, city visits, or hiking requiring different weather conditions (de Freitas et al., 2008; Mieczkowski, 1985). This feature has been ignored in many previous assessments, which may have led to over- and under-estimations of the impact of climate change for specific tourism segments. In this vein, Moreno et al. (2008) claim that tourism in the Mediterranean may not suffer as much from climate change as has been suggested by Amelung and Viner (2006) and others, because of the relatively high temperatures preferred by beach tourists.

Based on the work by Mieczkowski (1985), Morgan et al. (2000) developed a user-based climate index to assess the climate suitability of coastal destinations specific for beach recreation. They used a large number of empirical observations to improve and fine-tune the original index to beach activities. This article follows up on Morgan et al.'s (2000) work, exploring the climate suitability for beach tourism of all coastal zones in Europe, both at present and in a future scenario of climate change. In addition, it discusses the important policy and management implications that this suitability assessment has. The results can assist long-term destination planning in coastal zones, reducing the vulnerability to impacts, and facilitating adaptation.

The article is organized as follows. The next section provides a general introduction to climate indices for tourism, followed by a more detailed discussion of Morgan et al.'s beach climate index (BCI). The third section details the methodology and data used in this study. The fourth section presents the results. The fifth section compares these to outcomes from previous studies and puts them in a wider context, discussing their management implications and limitations. Finally, the sixth section concludes the article.

In the context of this article, the terms "recreation" and "tourism" refer to the same kind of activities and are therefore used interchangeably. The term "beach tourism" refers to the light activities that belong to the 3S tourism (sand, sea, and sun), for example, sunbathing.

Tourism Climate Indices

Establishing the influence of climate and weather conditions on tourism is a complex matter. According to de Freitas (1990) there are three distinct aspects of climate that are relevant to tourism: thermal, physical, and aesthetic aspects. The thermal component is primarily physiological in nature and determines the comfort of tourists. The physical component refers to climate features, such as rain and wind, which may cause physical annoyance. Finally, the aesthetic component represents climate features (e.g., sunshine) that may influence the tourist's appreciation of a view or landscape. Ideally, climate suitability assessments for tourism should take account of each of these three components.

Thermal indices, such as Physiologically Equivalent Temperature (PET) were originally developed to assess human comfort in general (Matzarakis et al., 1999), and later applied to tourism by Cegnar and Matzarakis (2004), Morabito et al. (2004), and others. An advantage of thermal indices is that they are rooted in the long tradition of physiological research; a major drawback is that they disregard important non-thermal aspects of weather and climate. For a proper assessment of the suitability of climate and weather conditions for tourism purposes, the use of composite measures is to be preferred.

Several composite indices have been proposed, and employed in a number of studies. The Tourism Climate Index (TCI), developed by Mieczkowski (1985), is arguably one of the most sophisticated and commonly used. The index incorporates thermal components as well as physical and aesthetic features. It was developed with the "typical" tourist in mind, who engages in light physical activities, such as sight-seeing, shopping, and relaxing.

While being widely used (Nicholls & Amelung, 2008; Amelung et al., 2007; Amelung & Viner, 2006; Scott et al., 2004), the TCI presents a number of limitations, some of which apply to all climate indices. First of all, the TCI has been considered too coarse an indicator, as it is insensitive to the large variety of weather requirements that are posed by tourist activities. Mieczkowski (1985) explicitly mentioned the possibility to tailor the rating and weighting system to specific activities, but this flexibility has hardly been used so far. A second point of criticism is that the empirical validation of the index is relatively weak. In particular, there is very little known about the influence on tourism of the physical and aesthetic components of the climate. To a large extent, Mieczkowski's rating and weighting scheme is based on his personal views, expert opinion, and existing biometeorological literature, the accuracy of which has so far not been tested extensively. Other, more subtle points of criticism are that the TCI does not take potential overriding effects of, for example, rain into account, and that it does not correct for potential intercultural and geographical differences in climate preferences as suggested by de Freitas et al. (2008).

Progress has been made in addressing these issues and improving the climate indices for tourism. De Freitas et al. (2008) proposed a new index that accounts for the overriding properties of some weather aspects and acknowledges the existence of intercultural differences in climate preferences. Morgan et al. (2000) developed a tailor-made climate index for beach tourism, based on Mieczkowski's TCI, but fine-tuned with empirical information. Morgan's framework is at the basis of this study, and is introduced in more detail in the following section.

Beach Tourism Climate Index

Morgan et al. (2000) devised a specific climate index for beach tourism that contained the same elements as Mieczkowski's (1985) TCI except for the daily (24-hour average) thermal component (i.e. thermal sensation, precipitation, sunshine and wind).[1] The main difference between the two indices is in the rating and weighting schemes. While Mieczkowski (1985) based his schemes heavily on expert judgment, Morgan et al. (2000) based theirs on the stated preferences of actual beach users. These preferences were elicited from questionnaires, filled out by a total of 1,354 north European beach users while spending their holidays in Wales, Malta, and Turkey in 1994 and 1995.

Similar to Mieczkowski's TCI, Morgan et al.'s beach climate index (BCI) is made up of smaller components (sub-indices) that, after weighting, add up to a maximum score of 100 (ideal conditions). The weights are based on the importance that the beach users attached to each of the four components. Beach users expressed the importance values on a Likert scale between 1 (not important) and 9 (very important). The Likert scores for each component were added, and these aggregated scores were subsequently scaled so that they added up to 1.

As Table 1 shows, this procedure results in weights that differ substantially from those proposed by Mieczkowski (1985), with precipitation, wind, and sunshine becoming more relevant at the expense of thermal comfort.

The resulting equation is as follows:

$$BCI = 0.18 \cdot TS + 0.29 \cdot P + 0.26 \cdot W + 0.27 \cdot S \tag{1}$$

In which *BCI* is the beach climate index, *TS, P, W,* and *S* are the components of thermal sensation, precipitation, wind, and sunshine, respectively. Each of the four components is itself represented by an index, with values ranging from 0 to 100. These values are the beach users' evaluation of the underlying weather conditions.

To assess beach users' preferred thermal sensation, Morgan et al. (2000) adopted an approach proposed by de Freitas (1990), who found that descriptors of subjective thermal sensation ("very hot," "cool," etc.) are strongly correlated to skin temperature. Skin temperature in turn is a function of the effective air temperature, proportion of sunshine, and wind speed, in addition to several individual characteristics (Green, 1967 as cited by Morgan et al. 2000), which were set to representative values for North Europeans.

Table 1
Weightings (in % of total maximum score) for the different components used by Morgan et al. (2000) and Mieczkowski (1985)

	Climate index (Morgan)	TCI (Mieczkowski)
Thermal sensation	18[a]	50[b]
Precipitation	29	20
Wind	26	10
Sunshine	27	20

[a]Skin temperature (see thermal sensation below); [b]Effective temperature (40% of the weight corresponds to Daytime Thermal Comfort Index and 10% to Daily Thermal Comfort Index).

Table 2
Relationship between thermal sensation, skin temperature (T_s), and the scoring systems (adapted from Morgan et al., 2000). Temperatures below 21.0 and above 36.5°C were allotted 0 points reflecting very cold and extremely hot conditions

Thermal sensation	T_s	Index
Cold	21.0–25.9	2
Cool	26.0–28.9	21
Neither cold nor warm	29.0–32.4	39
Warm	32.5–34.4	100
Hot	34.5–35.4	77
Very hot	35.5–36.4	24

Respondents were asked to rank six thermal descriptors in order of preference: three, two, and one points were allotted to the first, second, and third most preferred thermal sensation, respectively. For each of the descriptors, scores were then aggregated and subsequently scaled, setting the value for the highest-scoring descriptor to 100 (Table 2).

Morgan et al. (2000) adopted Mieckowski's rating scheme for precipitation. The maximum index value of 100 was assigned to instances of less than 15 mm/month, decreasing in linear fashion by 10 points for each additional 15 mm of precipitation. Amounts of precipitation exceeding 150 mm/month were given an index value of 0.

Morgan et al.'s (2000) scheme for wind contains three categories. Wind speeds of less than 4 m/s receive the maximum index value of 100, whereas wind speeds greater than 6 m/s correspond to an index value of 0. A value of 50 is allotted to wind speeds of between 4 and 6 m/s. In Morgan et al.'s scheme for sunshine, continuous sunshine was allocated the maximum index value of 100, falling in linear fashion to 0 for a situation of complete absence of sunshine.

The final Beach Climate Index (BCI) can attain values ranging from 0 to 100. Morgan et al. (2000) divides this range as suggested by Mieczkowski (1985), with values below 40 seen as unfavorable, the range between 40 and 60 as acceptable, values from 60 to 70 as good, between 70 and 80 as very good, and scores above 80 as excellent for beach tourism.

Data and Methods

Morgan's beach climate index is applied without any changes in the original calculation schemes. Different from Morgan et al. (2000), who took their data from weather stations, the input data are taken from grid-based sets of observed and projected climate data. The CRU TS 1.2 dataset (New et al., 2002) is used to represent observed climate conditions. It contains mean monthly values for five climate variables (temperature, diurnal temperature range, precipitation, cloud cover, and vapor pressure) for the 20th century (1901–2000). The dataset has a spatial resolution of 10 arcmin longitude-latitude, which in Europe corresponds to approximately 16 km × 16 km.

Projected climate data are taken from the TYN SC 1.0 dataset (Mitchell et al., 2004), which is based on outputs from transient coupled atmosphere–ocean General Circulation Models (GCMs). It contains all relevant climate variables at the same temporal and spatial resolutions as the CRU TS 1.2 dataset, except for wind speed. The TYN SC 1.0 dataset covers the whole of the 21st century (2001–2100) for 16 climate change scenarios representing all possible combinations of four Intergovernmental Panel on Climate Change (IPCC) emissions scenarios described in the Special Report on Emissions Scenarios (SRES (Nakicenovic et al., 2000)), and four GCMs. Together, these 16 scenarios cover 93% of the range of uncertainty in global warming in the 21st century as established by the IPCC (Mitchell et al., 2004).

It is generally advocated to use a wide range of scenario–GCM combinations to express uncertainty in future projections (Viner, 2002; IPCC-TGICA, 2007).To get an idea of the maximum impact of climate change on beach tourism, this article sets out to explore the implications for tourist well-being of scenarios in which the room for tourism growth is largest, and increases in emissions are highest. The SRES A1FI scenario meets these two criteria. It assumes rapid growth of global GDP and on-going globalization with increased mobility, both of which contribute to tourism growth; and it results in the highest emissions of all SRES scenario families. It is also the scenario that resembles the actual path of emissions most closely. In fact, the latest evidence suggests that "the emissions growth rate since 2000 was greater than for the most fossil-fuel intensive of the Intergovernmental Panel on Climate Change emissions scenarios" (Raupach et al., 2007, 10288).

Climate models differ in their assumptions about the sensitivity of the climate system to changes in greenhouse gas concentrations. At the top-end of the spectrum is the HadCM3 model, which projects an increase in summer temperature of 5.4°C, and a decrease in summer precipitation of 17.9% in Europe at the end of the century under the A1FI scenario. At the bottom-end of the spectrum is the CSIRO Mk2 model (+3.1°C, –0.1% precipitation under the same scenario). Together, the HadCM3-A1FI and CSIRO-A1FI integrations cover a large share of the spectrum of climate projections for Europe (see Figure 1).

Except for wind, all variables required for the calculations were either directly available from the climate models or could be inferred with some straightforward data transformations. Skin temperature (thermal component) was calculated based on effective temperature (°C) and humidity (%) using the formula proposed by Green (1967, cited in Morgan et al., 2000). The effective temperature was established with a nomogram as mentioned in the previous section. Humidity values were calculated from vapor pressure data as proposed by Bloutsos (1976, as cited in Balafoutis et al., 2004, 28), and sunshine values were inferred from cloud cover data. As wind speed is not a variable in the projected climate datasets, it was kept constant at the baseline value.

Baseline conditions are represented by the 1961–1990 ("1970s") timeslice of the CRU TS 1.2 dataset. The 2051–2080 ("2060s") timeslices of the TYN SC 1.0 dataset are used to represent climate conditions two generations from now. The analysis is seasonally limited to changes in summer conditions (i.e. conditions in June, July, and August), as this is by far the dominant season for beach tourism in Europe. Spatially, the analysis is limited to Europe's coastal zone, which is defined as the area within 100 km from the shoreline.

Results

Results are presented in three main parts. In the first part, the baseline case is depicted. The second section explores the effects of climate change on the distribution of climate suitability some 50 years from now ("2060s"). The third part explores the differences

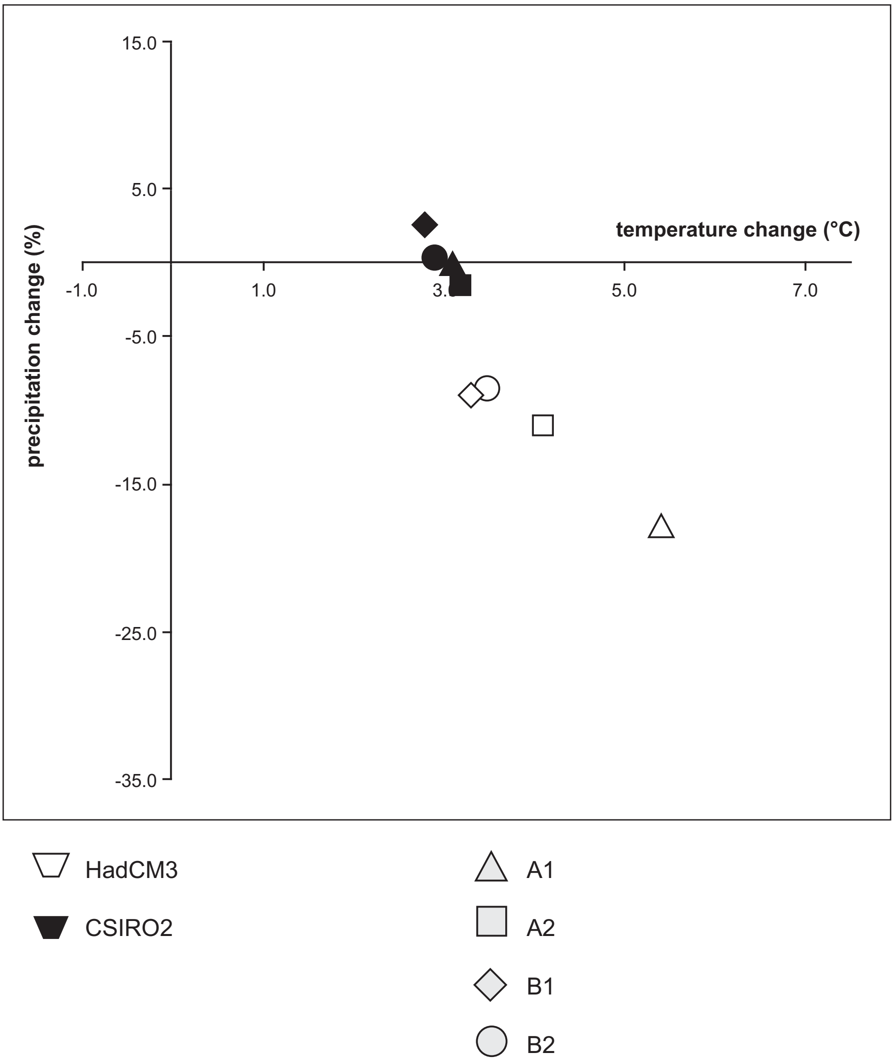


Figure 1. Changes in average summer temperature and precipitation in Europe between the baseline and the 2060s, according to the integrations of two climate models (HadCM3, CSIRO2) and four scenarios (SRES A1FI, A2, B1, B2).

between the baseline case and projected future conditions, to address issues of uncertainty and thresholds of change.

Baseline

Figure 2 depicts the climatic conditions for beach tourism in the summer season of the baseline period. Very good and excellent conditions (BCI $\geq$70) can be found along the Mediterranean coasts, from Portugal in the west to Turkey in the east. Good conditions (BCI $\geq$60) are found in the north of Spain and the southwest of France, while the rest of the European coasts attain acceptable scores at best (index values below 60).

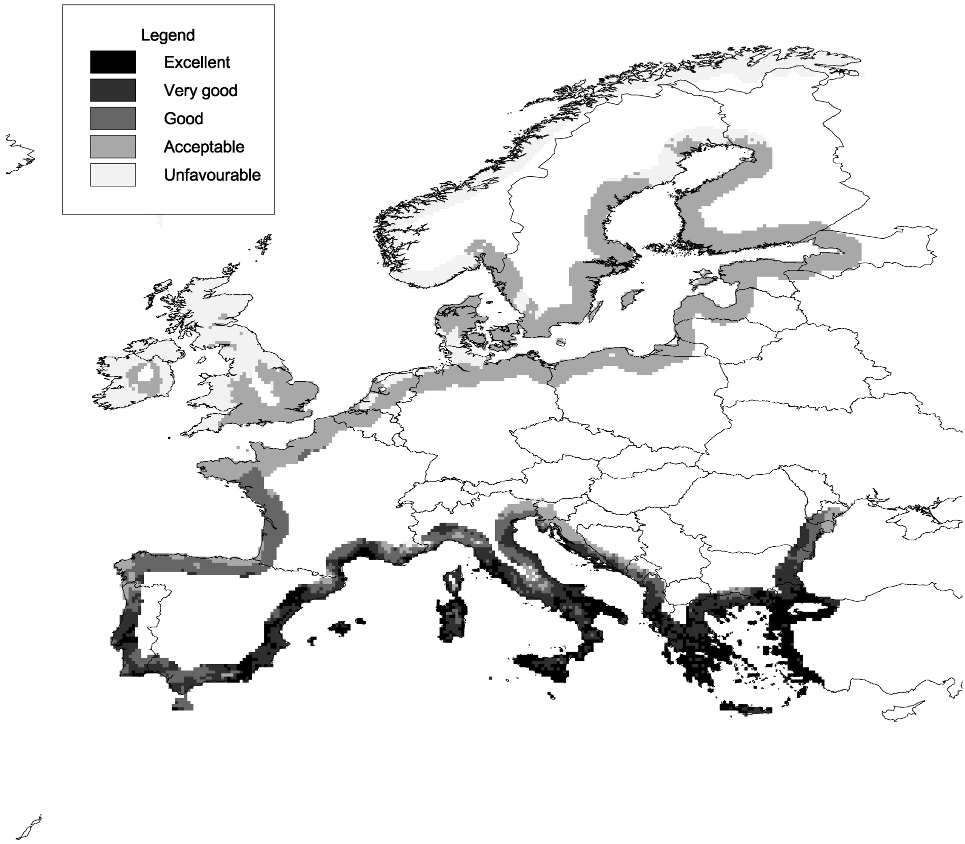


Figure 2. Beach tourism climate index for current summer conditions.

Projected Change and Future State

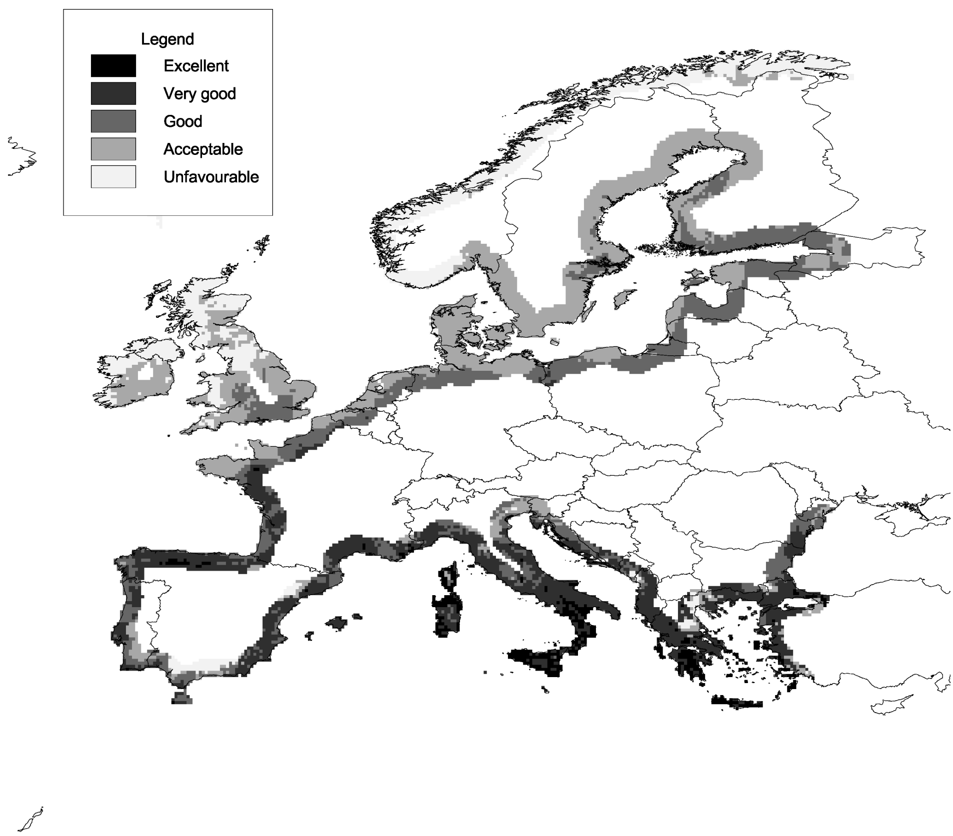
Under the A1FI scenario of the HadCM3 model (Figure 3a), parts of the Mediterranean, including most of the Spanish southern coast, are projected to suffer a significant decrease in their suitability for beach tourism. Other highly popular destinations in the same region, including Italy and Greece, and the Mediterranean islands, however, are projected to maintain their high climate ratings. Another salient implication of this scenario is the notable improvement in climatic conditions around the Baltic Sea and along the Atlantic coast of Europe. In particular the northern coast of Spain and the western coast of France are projected to attain very good conditions by the second half of the century.

In the more moderate scenario CSIRO–A1FI the Mediterranean remains an excellent destination in terms of climate for sun and beach tourism (Figure 3b). Some regions, such as the south coast of Spain (Guadalquivir Valley), could see their climate resources for beach tourism deteriorate, but in general the ratings remain very good or better. In the rest of Europe, only the northwest of the Iberian Peninsula, and the southwest (Pays de la Loire, Poitou-Charentes, Aquitaine) and southeast (Côte d'Azur, Languedoc-Roussillon) of France reach very good ratings. Good ratings are projected only for parts of the northwest of France and for isolated areas along the southern and south-eastern shoreline of the Baltic

Sea (Poland, Lithuania, Latvia). The conditions in the southeast of the United Kingdom, the North Sea region, and the northern shoreline of the Baltic remain unchanged.

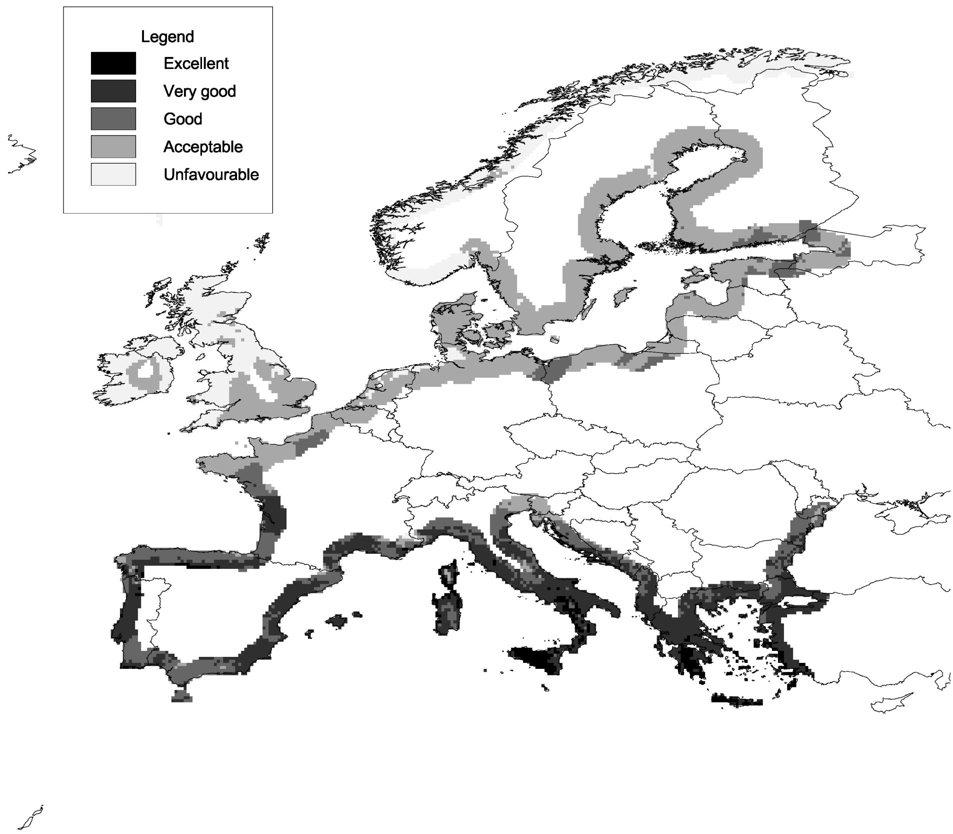
Agreement and Disagreement between Scenario Results

To explore the potential range of change with respect to current conditions, the level of agreement between the maps for the current and the two future states is assessed. A BCI of 70 is used as the cut-off score for pleasant beach conditions. In general, the two models produce very similar maps projecting what areas will attain scores above 70 in the 2060s and what areas will not. In a relatively limited number of cases, they disagree (see Figure 4a). A possible explanation may be that the relatively "cooler" parts of the Mediterranean warm up just fast enough to become too hot for comfort according to the HadCM3 model, but not according to the CSIRO model. More toward the north, some of the relatively "warmer" regions warm up too slowly for comfort according to the CSIRO model, whereas they just exceed the minimum values in the HadCM3 model. The rest of the section focuses on the cases for which the two models are in agreement.



(a)

Figure 3. Beach tourism climate index during summer in the 2060's (a) according to the HadCM3-A1FI and (b) according to the CSIRO2-A1FI. *(Continued)*



(b)

Figure 3. (Continued)

A first category of interest is made up of coastal regions that enjoy very good conditions (BCI $\geq$70) at present and continue to do so in both scenarios considered. Most of the Mediterranean area falls into this category. A second category includes those coastal regions that at present have values of BCI below 70 and that will also not attain very good conditions during this century. This category encompasses all coasts in the northern half of the continent as well as some isolated areas in the Mediterranean (see Figure 4b).

A third important category is formed by the regions that currently have a BCI lower than 70, but that will attain scores in excess of 70 in both scenarios considered, that is, even if the moderate CSIRO2–A1FI scenario materializes ("winners"). The northwest of the Iberian Peninsula and the French regions of Poitou-Charentes and Aquitaine are in this category (see Figure 5a).

The fourth category considered is the group of areas that currently enjoy very good or better conditions, but that will see their climate resources deteriorate to levels under 70 even if the moderate CSIRO2–A1FI scenario materializes ("losers"). Various regions in the south of the Iberian Peninsula (Algarve, Andalucía, Valencia) as well as a few other areas in the Mediterranean basin belong to this category (see Figure 5b).

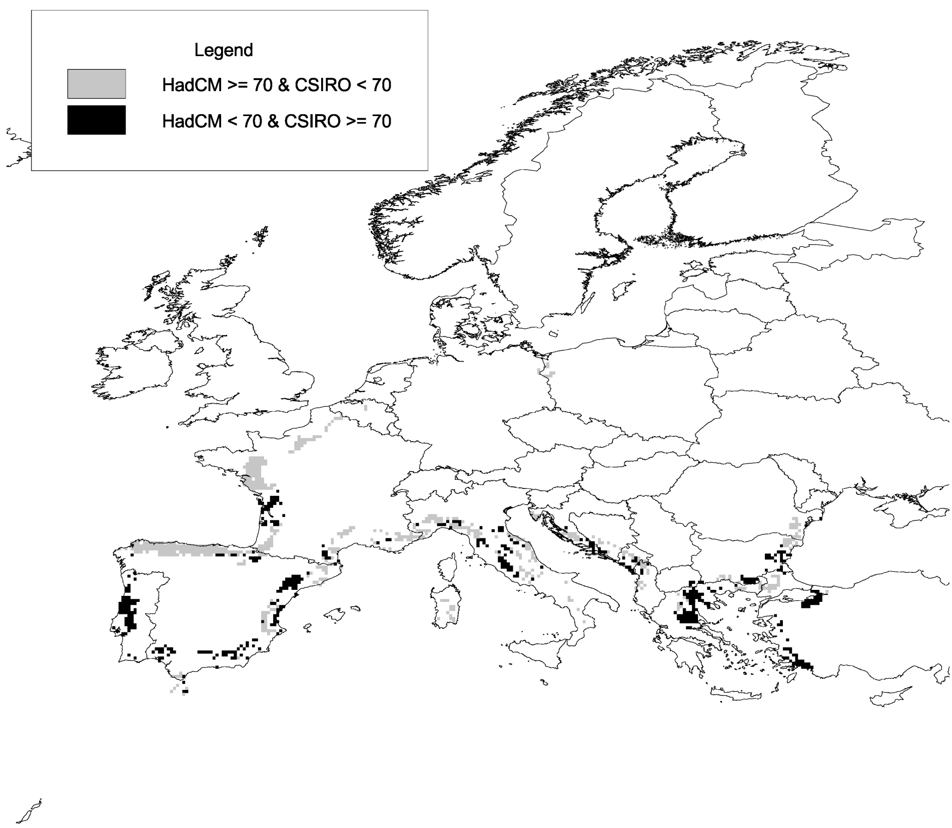
Finally, Figure 6 presents a summary of the findings for five aggregated coastal segments in Europe: Atlantic North, Atlantic South, Baltic South, Mediterranean, and Scandinavia. These segments are defined in the Appendix.

The aggregated losses in climate suitability in the Mediterranean are relatively modest, and smaller than the gains in the other regions, in particular the Atlantic North and Scandinavia. The Atlantic South region is projected to attain values similar to those found in the Mediterranean with climate change.

Discussion

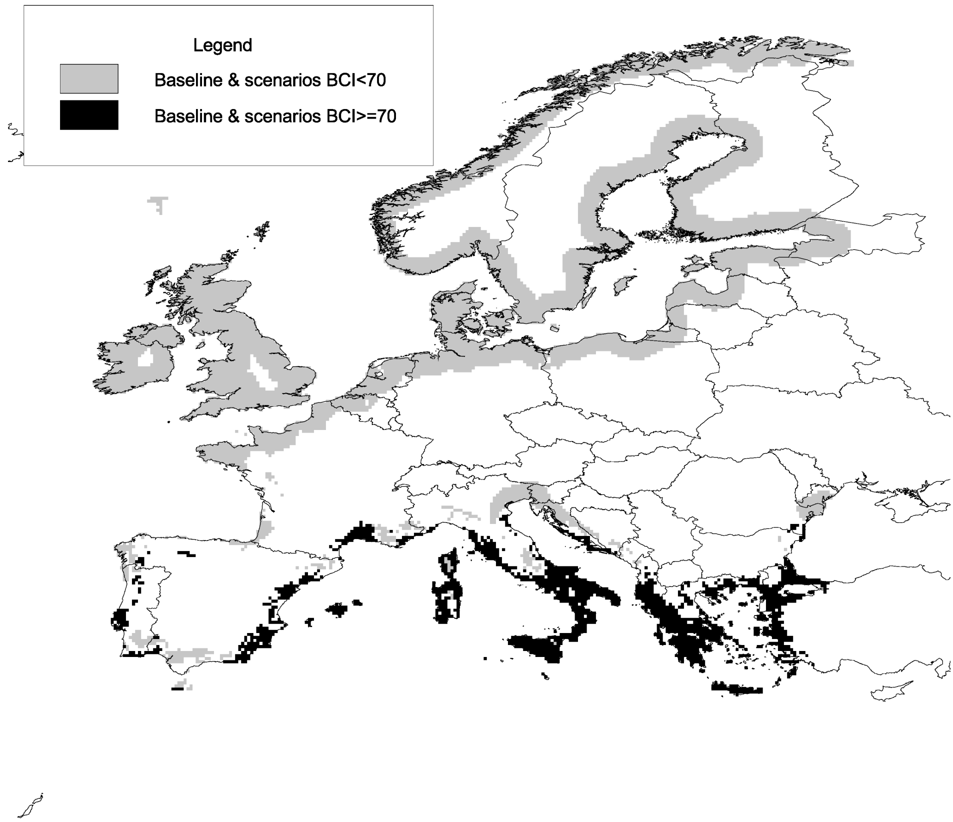
Implications for Research and Management

The analyses presented thus far map the spatial patterns of climatic suitability for beach tourism purposes now and in the future. Based on observed climate data, the most suitable summer destinations are situated along the Mediterranean coast. In the course of the century, the band of prime conditions expands to the north, in particular into northern Spain and southern France. The speed at which this happens varies according to the model used:



(a)

Figure 4. Beach tourism climate index (a) disagreement between climate change scenarios and (b) agreement between baseline and the two climate change scenarios. *(Continued)*



(b)

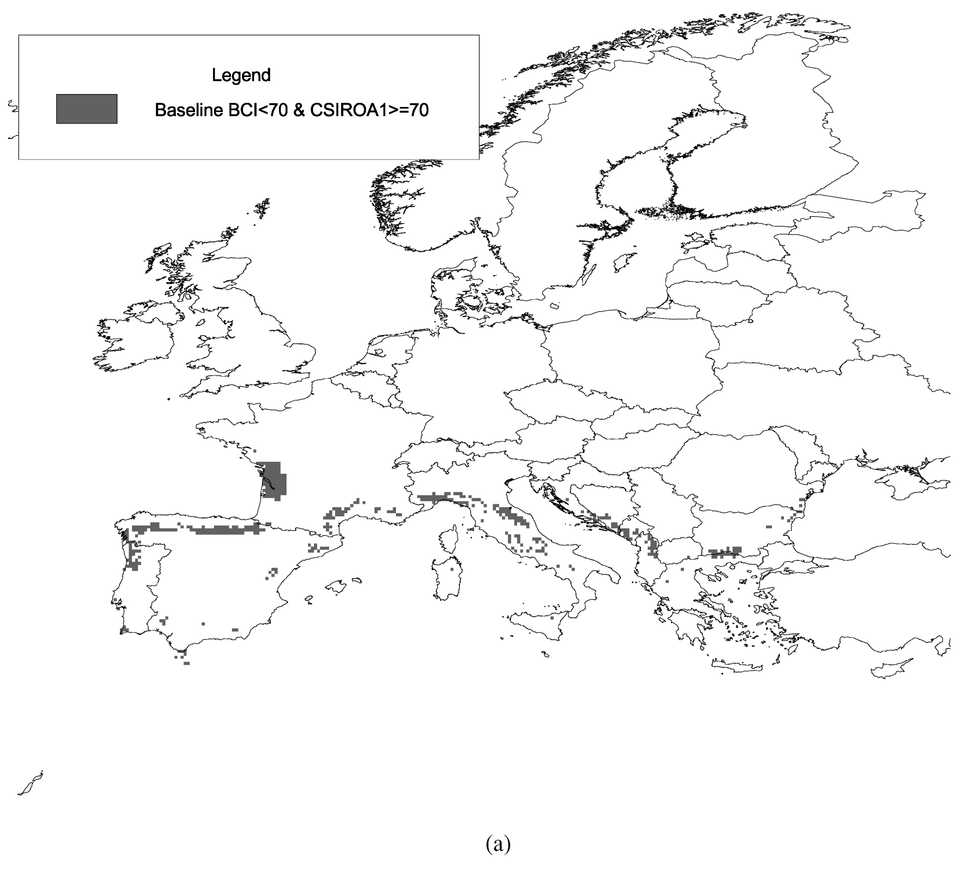
Figure 4. (Continued)

the HadCM3 model projects much higher rates of change than the CSIRO2 model. The exploration of thresholds in Figure 4 has shown that even when the high impact scenario materializes (HadCM3–A1FI), most of the Mediterranean will retain BCI scores above 70 (very good conditions). Similarly, this scenario does not show a remarkable improvement of conditions in most of northern Europe.

A crucial finding is that the rate of change in climatic suitability is much lower than the rates found in earlier studies. Several of these studies have used Mieczkowski's Tourism Climate Index to explore the implications of climate change for tourism in Europe (Amelung et al., 2007; Amelung & Viner, 2006; Nicholls & Amelung, 2008). They indicated a marked improvement of conditions in northern Europe and a sharp deterioration of climatic suitability in the Mediterranean in the second half of the century. These results are not confirmed in the present study, which focuses specifically on beach tourism. As beach tourism is a major market segment for Mediterranean tourism, claims that the Mediterranean will lose its attractiveness for tourism (Perry, 2005, 2006; Amelung & Viner, 2006) appear overstated. There is also little chance that specific areas of northern Europe will be able to compete with the Mediterranean in the market segment of beach tourism before the end of the century. However, the new areas attaining good BCI values (e.g., north of Spain and southwest of France) might compete with the traditional destinations in the Mediterranean area.

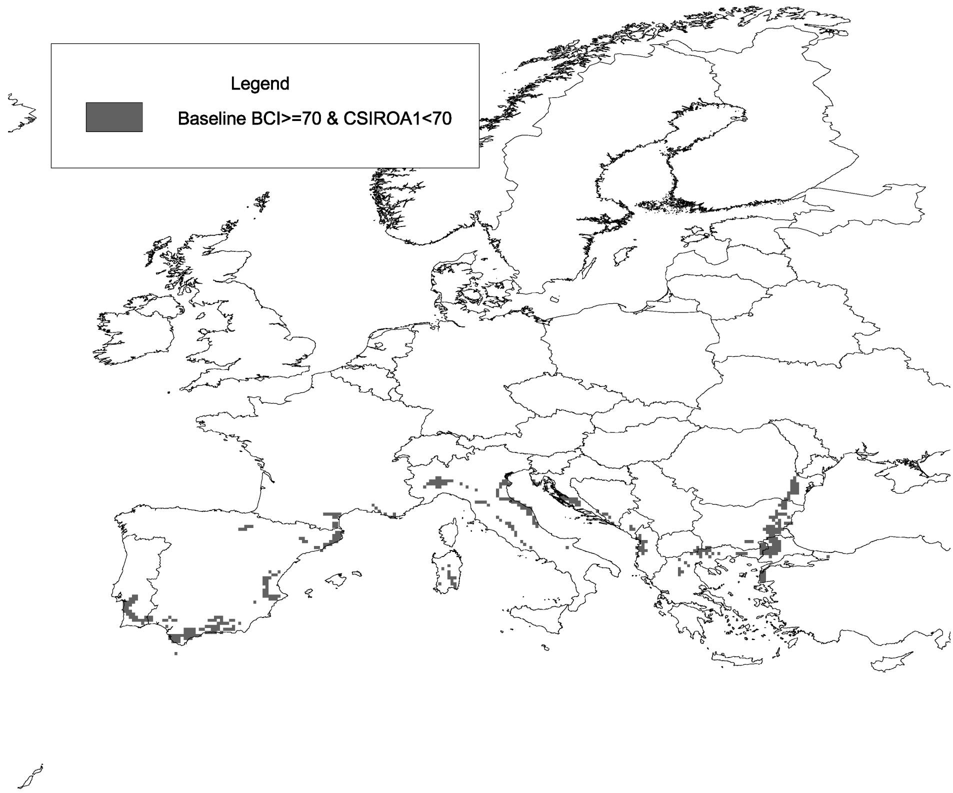
In this context, it should be noted that the BCI was intended as a tool to aid in the identification of climatically optimal destinations for beach vacations, rather than as a predictor of inbound travel. Even though appropriate climate conditions are a *condicio sine qua non* for beach tourism, a high score on the BCI does not necessarily translate into a high level of visitation. Successful destinations must exhibit a range of qualities, including adequate transportation links and infrastructure, appropriate numbers and kinds of accommodations and attractions, and a safe and pleasant environment, in addition to offering an appealing climate.

Climate change impacts many of these qualities. Assessing the vulnerability of tourism destinations and individual tourism enterprises to not only the impacts of climate change on tourist comfort, but also to the indirect impacts of climate change is therefore of paramount importance. The implications of water shortages, sea-level rise, and environmental changes for tourism have to date hardly been investigated. In particular for the coastal destinations in the Mediterranean, these issues should be high on the research and policy agendas for



(a)

Figure 5. Areas with BCI (a) below 70 in the baseline case and above 70 even with the moderate emission scenario (CSIRO2-A1FI) ("winners") and (b) above 70 in the baseline case and below 70 even with the moderate emission scenario (CSIRO2-A1FI) ("losers"). *(Continued)*



(b)

Figure 5. (Continued)

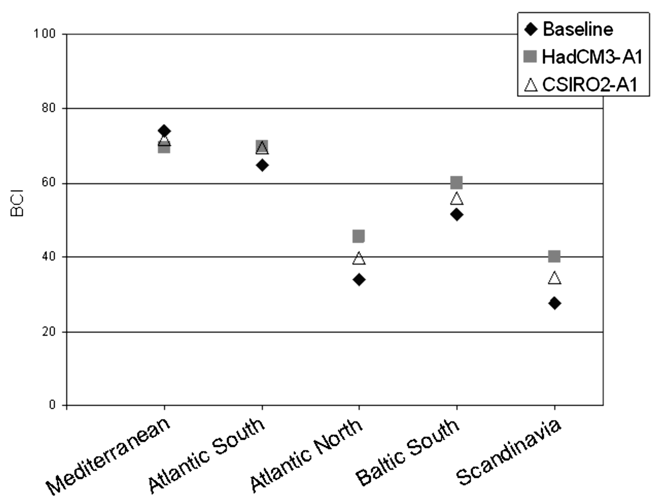


Figure 6. Change in BCI in different European coastal regions (including only the first 100 km inland from the shoreline).

the coming years. It is recommendable for tourism and coastal managers to actively work together in the elaboration of policies and development plans that address these issues.

Coastal and tourism managers in the non-Mediterranean parts of Europe will also need to take into account the biophysical transformations climate change will bring about. Climate change may not turn these regions into perfect destinations for beach tourism, but their climatic conditions are projected to improve very significantly. Two main trends are a longer season with suitable weather for general tourism, and an increase in the average number of days per year with suitable weather for beach tourism. Management strategies can be developed for coastal regions to capitalize on these trends. Beach towns, for example, may try to benefit more fully from the increased potential for beach tourism by disseminating tourism-specific weather information through new technologies such as webcams. Target groups may be short- and medium-distance visitors, who can respond quickly when good weather conditions occur. The development of seasonal climate predictions (see, e.g., Scott et al. 2008) may broaden the scope of such strategies to include longer-distance visitors. Market differentiation is another possible strategy managers could consider, specializing and marketing tourist products according to the climate of the region (e.g., kite-surfing in windy destinations).

Methodological Limitations

When evaluating the results, a number of limitations and uncertainties associated with the methodology employed in the study must be recognized. First of all, the calculations in this study were calculated based on the climate preferences of Northern European tourists, as recorded by Morgan et al. (2000). The generalization of these results may be limited as a result of possible intercultural differences in climate preferences (see, e.g., de Freitas et al. 2008), a point that is also stressed by Morgan et al. (2000). Climate preferences may also change in time (e.g., through acclimatization to a warmer climate).

Second, results may be sensitive to the evaluation of precipitation. Whereas Morgan et al. (2000) assume that low scores on precipitation can be compensated by high scores on other variables, others (e.g., de Freitas, 1990; de Freitas et al., 2008) have suggested that it has overriding properties: precipitation renders the other factors irrelevant. The implications of this latter conviction could not be tested with the monthly normals that were used.

Third, a limited set of two contrasting climate models and one emissions scenario were used to explore climate uncertainties. This was deemed adequate in this study, as its emphasis was on investigating the effects of a maximum (“worst case”) scenario. Nevertheless, in future studies it could be worthwhile to consider more scenarios, and a wider range of models in order to increase the robustness of the outcomes.

Fourth, the analysis was limited to the summer season, and shifts in the seasonal distribution of tourist comfort were therefore not explored. However, large seasonal shifts in tourist flows as a result of strong improvements of the relative conditions in the shoulder seasons (see Amelung & Viner, 2006) are considered unlikely for beach tourism, as our analysis revealed significant dips in future summer conditions for only a few areas in Europe.

Finally, calculations in this study are based on monthly climate normals and they do not allow identification of possible increases in the frequency and/or intensity of extreme weather events, such as heat-waves and floods. Although hard to predict, these extreme events may nevertheless be highly relevant for tourism activity, perhaps even more important than the changes in mean conditions projected by climate models. This is because people experience actual weather conditions rather than climate (“average weather”), and as a result they are more likely to react to sudden, extreme events that severely impact the physical environment and can cause substantial damage to tourism infrastructure.

Conclusions and Further Research

This article presents an analysis of the potential impacts of climate change on beach tourism in Europe during the summer season, based on projected shifts in climatic attractiveness over the coming 50 years. Our results suggest that non-Mediterranean coastal zones will likely benefit from climate change, although the improvements will not be enough to attain the climatic suitability of the Mediterranean. Coastal managers in these regions may still benefit from improving suitability, and promote coastal and marine recreation in accordance with the new climate conditions. For Mediterranean beach tourism, the impacts of climate change on tourist comfort may be less severe than previously anticipated, even in the SRES–A1FI scenario of rapid change. For some of the more active types of tourism, the Mediterranean may become "too hot for comfort" in the course of the century, but our findings suggest that this is not the case for beach tourism. Given the prominence of beach tourism on the Mediterranean coasts, this has important policy implications. Coastal and tourism managers may do well to shift some of the attention away from the impacts on tourist comfort toward other impacts of climate change, such as sea-level rise, water availability, and biodiversity.

Nevertheless, additional research on tourist comfort is also urgently needed. There is very little known about tourists' likely behavioral reactions to the projected climatic changes, a topic that can be addressed using a qualitative or traditional survey-based approach. New studies should take into account recent trends indicating that tourists expect the traditional formula of "sun, sea, and sand" to be complemented by other elements such as diversity in activities and environmental quality (EC, 2000). For other tourism segments requiring higher levels of physical activity (e.g., adventure tourism), new impact assessment studies are necessary to reflect the specific climate requirements. A better integration of suitability assessments and tourism demand models is also warranted, to increase the economic relevance of the results.

Note

1. Morgan et al. (2000) also included bathing water temperature but it was considered separately from the other parameters and it has not been included in this research as it was not available for the climate change scenarios.

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Appendix: NUTS 2 Regions Included, and Composition of the Aggregated Coastal Segments

The five aggregated coastal segments together encompass all NUTS 2 regions included in the study. All of the listed countries' coastal NUTS 2 regions are included, unless specified otherwise (as is the case for France, Germany, and Spain).

Atlantic North

Belgium, Denmark, France (Basse-Normandie, Bretagne, Haute-Normandie, Nord-Pas-de-Calais), Germany (Lüneburg, Schleswig-Holstein, Weser-Ems), Ireland, Netherlands, United Kingdom

Atlantic South
France (Aquitaine, Poitou-Charentes, Pays de la Loire), Portugal, Spain (Cantabria, Galicia, País Vasco, Principado de Asturias)
Baltic South
Estonia, Germany (Mecklenburg-Vorpommern), Latvia, Lithuania, Poland, Russia
Mediterranean
Albania, Bosnia & Herzegovina, Bulgaria, Croatia, France (Languedoc-Roussillon, Provence-Alpes-Côte d'Azur), Greece, Italy, Romania, Serbia, Slovenia, Spain (Andalucía, Cataluña, Comunidad Valenciana, Illes Balears, Región de Murcia), Turkey
Scandinavia
Finland, Norway, Sweden