Implications of Global Climate Change for Tourism Flows and Seasonality

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Tourism is a climate-dependent industry, and many destinations owe their popularity to their pleasant climates during traditional holiday seasons. This article explores the potential implications of climate change for global tourism, with special emphasis on seasonality. Combination of two climate change scenarios with the Tourism Climatic Index reveals that the locations of climatically ideal tourism conditions are likely to shift poleward under projected climate change. Whereas destinations such as the Mediterranean may see shifts in their peak seasons from summer months to current shoulder periods, regions in higher latitudes are likely to experience a lengthening of their summer seasons. The effects of these changes will depend greatly on the flexibility demonstrated by institutions and tourists as they react to climate change, with substantial implications for both spatial and temporal redistribution of tourism activities. The reader is referred to http://www.carrs.msu.edu/Main/People/faculty%20bios/extra/nicho210-journal.pdf to view the full series of color maps accompanying these analyses.

Keywords: *climate change; seasonality; Tourism Climatic Index (TCI)*

Climate change is now recognized by the majority of governments and scientists throughout the world as a significant social and environmental issue facing the global population and its resources. Similarly, events such as the European heat waves of 1998 and 2003 (Perry 2005), the increased incidence and severity of wildfires across the Mediterranean and the American West (Pinol, Terradas, and Lloret 1998; Westerling et al. 2003), and the recent increase in the frequency of intense hurricanes across the southeastern United States and Caribbean (Fossell 2005) have increased the public's awareness of and interest in the issue of climate change. Although none of these events can be proven to be the direct result of climate change, their occurrence, and their impacts on both local residents and temporary visitors such as tourists, adds considerably to the sense of urgency associated with this issue.

According to the Intergovernmental Panel on Climate Change (IPCC; 2001), the global average surface temperature has increased 0.6 ± 0.2°C since 1861. The 1990s were the warmest decade, and 1998 the single warmest year, since records began. Tide gauge data show that global average sea level rose 0.1 to 0.2 meters throughout the same period. Although estimates vary widely depending on the modeling procedures used, climate change scenarios suggest that the global average surface temperature will increase by between 1.4 and 5.8°C between 1990 and 2100. Projections regarding global mean sea level indicate a rise of between 0.09 and 0.88 meters throughout the same period. An increase in the frequency and intensity of extreme weather events (floods, droughts, heat waves, etc.) is also expected (IPCC 2001).

For large shares of the population, the projected changes in average climate conditions outlined above are in and of themselves somewhat irrelevant and meaningless. Rather, societal interest in climate change tends to center on its potential to affect our current way of life and living conditions. To assess this potential, an increasing number of climate change impact studies have been performed that focus specifically on the implications of climate change for society. To date, these impact assessments have tended to focus on industry and resource sectors such as water, forestry, and agriculture. Given the size and significance of the tourism industry, the relative dearth of studies assessing the implications of projected climate change for tourism is surprising. According to Hall and Higham (2005, p. 21), "[I]n terms of the future of tourism, as well as the societies within which we live, there are probably few policy and development concerns as significant as global climate change."

The purpose of this article is to assess the potential impacts of projected climate change on the global tourism industry. More specifically, it has two objectives: to (1) assess the potential implications of projected climate change on international and regional tourism flows throughout the coming century, and (2) assess the implications of projected climate change on tourism seasonality in the summer European market. The analysis is presented at the macro level, with a focus on regions and countries rather than individual destinations, and provides a broad overview of potential changes in tourism patterns throughout the next 100 years based on projected changes in climate. It is important to note that the methodology used can account only for the climatic conditions of

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Journal of Travel Research, Vol. 45, February 2007, 285-296
DOI: 10.1177/0047287506295937

tourism destinations; factors such as the number and attractiveness of natural and cultural attractions, political situations, and the threat of unrest or terrorism are not incorporated. Nevertheless, given the large proportion of leisure travel that is undertaken based in part on the expectation of (more) pleasant climatic conditions (according to Perry [1993], 70%-80% of U.K. holidaymakers cite better climate abroad as the primary reason for their trip), this limitation is not seen as unduly problematic. In the following sections, the topics of seasonality and the Tourism Climatic Index, the index used to assess the suitability of climatic conditions for tourism activity in this study, are reviewed. Methods, results, and discussion are then presented.

WEATHER AND CLIMATE AS MOTIVATIONS FOR TRAVEL

The literature on travel motivations is extensive. Some authors have developed tourist profiles that link tourist activities to personality types (Plog 1974). According to this view, motivational structures are relatively stable throughout time, although they may follow a "travel career" as a result of maturation of personality (Pearce 1990). This school of thought is closely linked to Maslow's hierarchy of needs (Maslow 1954), which has inspired a number of researchers to suggest that tourists typically have multiple motivations for traveling, related to friendship, prestige, self-actualization, and so on (Crompton 1979).

The way in which tourists attempt to address these motivations depends on their physical, financial, and other abilities, and on relevant "push" and "pull" factors. Push factors are origin related and refer to factors such as travelers' desires and the negative or undesirable aspects of the climate in their home region. Pull factors are attributes of destinations that determine their attractiveness, such as their natural resource base, cultural attractions, and climate (Kozak 2002).

Weather and climate can, hence, act as both push and pull factors (Hamilton, Maddison, and Tol 2005). Giles and Perry (1998) found a strong relationship between the weather in the United Kingdom and the propensity of the British to travel abroad. Climate considerations also play a major role when choosing specific holiday destinations. According to Lohmann and Kaim (1999), German citizens rank weather third on the list of important destination characteristics, after landscape and price. In view of this importance, surprisingly little is known about the empirical relationship between weather and climate on one hand, and tourism and recreation on the other. One explanation for the discrepancy between the importance of climate for tourism and the limited interest in it among academics may be that the climate has long been considered a more or less stable factor (Abegg et al. 1998; Baker and Olsson 1992), with little predictable and structural change from year to year. Similarly, unlike travelers' preferences and behaviors, weather and climate are typically considered unchangeable, that is, they may not be deliberately manipulated by tourism marketers.

A number of hypotheses about the role of weather and climate have been formulated, however. According to the International Institute for Sustainable Development (IISD; 1997), although available resources generally determine the set of possible recreational and tourist activities (e.g., it takes water to sail), the weather determines when these activities can best be scheduled. In this context, it is useful to make a distinction between tourism and recreation. Although tourists and recreationists often behave similarly (Wall 1998), there are marked differences in their decision-making processes. Recreationists can respond to the weather conditions on very short notice (IISD 1997) and quickly adjust their plans. In contrast, tourists spend at least one night outside their usual place of residence, according to common definitions of what constitutes a tourist. Therefore, tourists depend on planning for a longer time span.

Smith (1993) discriminated between climate-dependent and weather-sensitive tourism. In the case of climate-dependent tourism, the climate itself attracts visitors who expect favorable weather conditions in their holiday destination. A good example of a region with this type of tourism is the Mediterranean. In the case of weather-sensitive tourism, the climate is not a tourist attraction in its own right, but weather conditions do play a decisive role when specific activities are planned (Giles and Perry 1998; Harrison, Winterbottom, and Sheppard 1999).

Only very few tourist demand models have included climate as a factor (Maddison 2001; Wietze and Tol 2002; Hamilton 2003). In all cases, countries have been the basic unit of analysis, for which climate is represented by average annual temperature. The focus on countries and annual averages facilitates empirical validation against recorded visitor numbers. Under this approach, however, all regional variation is lost, which is a major drawback for large countries, and, even more importantly, seasonal variation is also ignored.

Climate change may lead to changes in climatic seasonality. This is crucial, because time is of the essence in tourism. To give an example: for many people, school holidays represent the "window of opportunity" for planning holiday activities. The demand models discussed above assume temporal indifference among tourists, which may be an important cause of their low estimates of the effects that climate change will have on the tourist industry, relative to factors such as economic development and population growth (Hamilton, Maddison, and Tol 2005).

TOURISM AND SEASONALITY

The issue of seasonality in tourism flows has attracted the attention of tourism researchers for several decades (e.g., BarOn 1975; Soesilo and Mings 1987; Butler 1994; Baum and Lundtorp 2001; Koenig and Bischoff 2004), and seasonality has been described as one of the most problematic yet least understood features of the tourism industry (Higham and Hinch 2002; Jang 2004). To date, seasonality research has tended to focus on the causes and consequences of this phenomenon, its measurement, and means of mitigation. The causes of seasonality can be divided into two broad groups of factors, natural and institutional (BarOn 1975; Hartmann 1986). Natural factors relate primarily to a destination's climate, including annual variations in variables such as temperature, precipitation, wind speed, humidity, and snow depth (Butler 1994). Institutional factors are those that reflect the social norms and practices of society, and include the timing of religious (e.g., Christmas and Easter), school, agricultural, and industrial festivals and holidays (Hinch and Hickey 1997). Butler (1994) added three additional causes to this initial pair—social pressure or fashion, sporting seasons, and inertia or tradition on the part of tourists—although all might be considered to fall under the institutional heading if considered at its broadest.

Seasonality has potentially significant consequences for destination regions, as summarized by Koenig and Bischoff (2004). From an economic perspective, excess seasonality, and the fluctuations between under- and overcapacity it generates, can negatively affect profits, the attraction of investment capital, and the employment situation. Environmentally, the peak season concentration of visitors can place a considerable strain on the local environment, with implications for water supply, trash disposal, congestion, and erosion, among others. Similarly, local people may also be disadvantaged by seasonal strains on community services and infrastructure.

Although it is important to recognize that seasonality may also have its advantages, most notably in the opportunities for ecological and community recovery provided during the off-season (as noted by, e.g., Butler 1994; Hartmann 1986), considerable research and policy attention has been placed on the reduction of tourism seasonality. Although the climatic causes of seasonality have traditionally been considered relatively stable and predictable, substantial policy-making and marketing energy has been devoted toward altering institutional factors such as the timing and length of school holidays, and human tradition and inertia. Tourism planners, developers, and managers, meanwhile, have focused on product and market diversification, extending the existing season into the shoulder periods, and offering new, year-round recreation opportunities, often in combination with reaching out to new market segments—such as senior citizens, conference and event planners, and special interest tourists—and aggressive pricing strategies (e.g., Baum and Hagen 1999). The relevance of climate change for seasonality, and for the urgency of improving our understanding of this phenomenon, has only very recently been recognized in the seasonality literature (i.e., Koenig and Bischoff 2004) and has yet to receive sufficient attention in empirical analyses.

THE TOURISM CLIMATIC INDEX

The Tourism Climatic Index (TCI), first developed by Mieczkowski (1985), allows quantitative evaluation of the world's climate for the purpose of general tourism activity. The TCI is based on the notion of "human comfort" and consists of five subindices, each represented by one or two monthly climate variables. The five subindices and their constituent variables are as follows: (1) daytime comfort index (maximum daily temperature [in ºC] and minimum daily relative humidity [%]), (2) daily comfort index (mean daily temperature [ºC] and mean daily relative humidity [%]), (3) precipitation (total precipitation, in mm), (4) sunshine (total hours of sunshine), and (5) wind (average wind speed, in m/s or km/h). The index is weighted and computed as follows:

$$\mathrm{TCI} = 4CID + CIA + 2R + 2S + W$$

where CID = daytime comfort index, CIA = daily comfort index, R = precipitation, S = sunshine, and W = wind speed. With an optimal rating for each variable of 5.0, the maximum value of the index is 100.

Based on a location's index value, its suitability for tourism activity is then rated on a scale from –30 to 100.

TABLE 1
COMPONENTS OF MIECZKOWSKI'S TOURISM CLIMATIC INDEX

Subindex	Variable(s)
Daytime comfort index	Maximum daily temperature (°C)
	Minimum daily relative humidity (%)
Daily comfort index	Mean daily temperature (°C)
	Mean daily relative humidity (%)
Precipitation	Precipitation (mm)
Sunshine	Daily duration of sunshine (hours)
Wind speed	Wind speed (m/s or km/h)

Source: Adapted from Mieczkowski (1985, pp. 228-29).

TABLE 2
TOURISM CLIMATIC INDEX RATING SYSTEM

Numeric Value of Index	Description of Comfort Level for Tourism Activity
90-100	Ideal
80-89	Excellent
70-79	Very good
60-69	Good
50-59	Acceptable
40-49	Marginal
30-39	Unfavorable
20-29	Very unfavorable
10-19	Extremely unfavorable
Below 9	Impossible

Source: Adapted from Mieczkowski (1985, pp. 228-29).

Mieczkowski (1985) divided this scale into 10 categories, ranging from *ideal* (90 to 100), *excellent* (80 to 89), and *very good* (70 to 79) to *extremely unfavorable* (10 to 19) and *impossible* (9 to –30). In this study, a TCI value of 70 or higher is considered attractive to the "typical" tourist engaged in relatively light activities such as sightseeing and shopping. It should be noted that the TCI applies only to these more general forms of tourism activity and is not applicable to more climate-dependent activities such as winter sports. Furthermore, the TCI cannot be used to predict tourist arrivals. The index is designed solely to indicate levels of climatic comfort for tourism activity and does not take into consideration the existence and quality of vital tourism infrastructure such as transportation and attractions. Thus, a region with a high TCI may experience low levels of tourism arrivals, and vice versa, because a multitude of other factors besides climatic conditions influence tourism activity. Tables 1 and 2 illustrate the components of the index and the rating scale for tourism comfort.

The combination of the TCI with projected scenarios of future climate conditions has been extremely limited. Indeed, only two such studies were identified by the authors (Scott and McBoyle 2001; Scott, McBoyle, and Schwartzentruber 2004), both of which focus on destinations in North America. These studies demonstrate both the utility of adoption of the TCI approach in analyses of potential climate change impacts, and the substantial impacts that such change might have on tourism patterns in Canada, the United States, and

Mexico throughout the coming century. Specifically, Scott, McBoyle, and Schwartzentruber (2004, p. 116) found that "a substantive redistribution of climate resources for tourism was possible as a result of projected climate change," with implications for domestic and international travel numbers, expenditures, and timing. Potential changes identified by the authors included a lengthened summer season for Canada; declining summer conditions in the urban centers of the United States; and enlargement of, and increased competition within, the winter sun destination market. The authors also presented a conceptual framework of annual TCI distributions into which the climatic resources of any location can be classified. This framework will be used to characterize current and projected future climate conditions in the analyses carried out here, and is summarized in table 3.

TABLE 3

CONCEPTUAL FRAMEWORK OF TOURISM CLIMATE DISTRIBUTIONS

Classification	Description[a]
Summer (June-August) peak	TCI indicates the most favorable climate conditions for general tourism activity occur in the (northern) summer months.
Winter peak (December-February)	TCI indicates the most favorable climate conditions for peak general tourism activity occur in the (northern) winter months.
Bimodal shoulder peaks	TCI indicates the most favorable climate conditions for general tourism activity occur in the spring and autumn (shoulder) months.
Dry season peak	TCI indicates the most favorable climate conditions or general tourism activity occurs in the dry season; applies, e.g., to the monsoon regions of Asia.

Source: Scott, McBoyle, and Schwartzentruber (2004).
Note: TCI = Tourism Climatic Index.
a. Optimal TCI indicates a favorable climate for general tourism activity on a year-round basis. Poor TCI indicates an unfavorable climate for general tourism activity on a year-round basis.

METHODS

Global pictures of tourism comfort based on calculation of the TCI were constructed for a series of current and future time spans. Current patterns were calculated based on historical weather data from 1961 through 1990, and three future periods were considered: the 2020s (representing 2010–2039), 2050s (2040–2069), and 2080s (2070–2099). Historical weather data representing mean monthly surface climate for all land areas (excluding Antarctica) were obtained from the Climatic Research Unit at the University of East Anglia, United Kingdom, on a 0.5° latitude × 0.5° longitude grid system (as per New, Hulme, and Jones 1999). Future climate scenarios were developed on a 2.5° latitude × 3.75° longitude grid using the HadCM3 coupled ocean-atmosphere Global Climate Model forced with standard IPCC SRES (*Special Report on Emissions Scenarios*; IPCC 2000) emissions scenarios. Although the IPCC does recognize four distinct groups of emissions scenarios (known as "storylines"), representing a range of future socioeconomic and technological conditions, only two, B1 and A1, were considered in these analyses. Specifically, the B1A and A1F scenarios were used.

The A1 storyline is based on rapid and successful economic development with an average annual growth rate of about 3% in the global economy (reaching around US$550 trillion [1990 dollars] by 2100) and a global population that grows to approximately 9 billion by 2050, declining to about 7 billion by 2100. The A1 storyline assumes a strong commitment to market-based solutions; high savings and commitment to education at the household level; high rates of investment and innovation in education, technology, and institutions at the national and international levels; and international mobility of people, ideas, and technology. The B1 storyline suggests a much more environmentally and socially conscious future on the part of governments, businesses, the media, and the public, with a globally coherent approach to sustainable development. In a B1 world, incomes are distributed more effectively, resources are used more efficiently, and economic growth is more balanced (IPCC 2000).

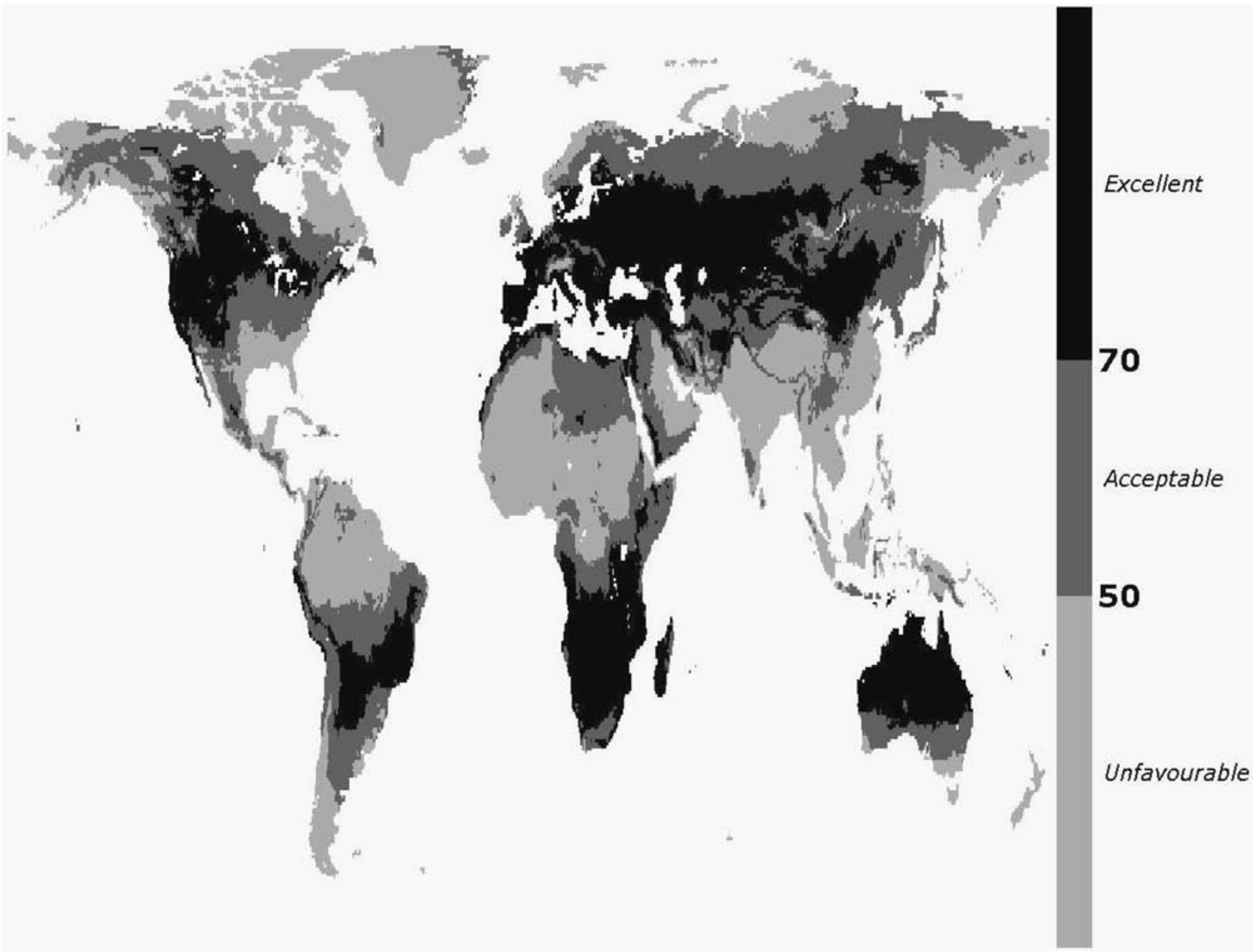
RESULTS

The TCI was calculated for each grid cell across the land surface of the earth for the 1970s (representing current conditions and based on historical weather data) and the 2020s, 2050s, and 2080s (representing future conditions under the B1A and A1F scenarios). Although values could be presented for each and every month of the year, in this article we concentrate initially on the northern hemispheric summer (June, July, and August). As an indication of overall changes in conditions on an annual basis, however, we also include a set of results that illustrate the number of "good" months (i.e., months with a TCI value greater than 70) each location currently experiences and is projected to experience according to the two climate change scenarios. Given that the figures could only be presented here in black and white, in which format a large amount of detail is lost, and given space limitations, we provide only six figures in this article. The reader is, however, directed to http://www.carrs.msu.edu/Main/People/faculty%20bios/extra/nicho210-journal.pdf, where he or she may view the entire series of 14 figures, which are in full color and based on the full range of comfort categories. In the discussion of results that follows, we refer to both sets of results so as to maximize the reader's insight into the trends suggested.

TCI, June-August, 1970s–2080s

Figure 1 (in text and on the Web) illustrates global TCI values for the current climatological period for the months of June, July, and August. As expected, it illustrates that the most comfortable areas for general tourism activity during the northern summer months include the countries of the

FIGURE 1
TOURISM CLIMATIC INDEX VALUES FOR JUNE, JULY, AND AUGUST, 1970s



northern Mediterranean coast from Spain to Turkey, the western portion of the United States, the central portion of southern Africa, and northern Australia. It should be noted that this map depicts tourist comfort, as based on Mieczkowski's index, only and that it is not representative of actual visitation numbers. Nevertheless, the strong correlation between currently popular summer destinations such as France, Spain, Italy, and Greece and the TCI map does suggest that the index performs quite well as a predictor of summer visitation.

Figures 2 and 3 (in text) illustrate global TCI values for June, July, and August for the 2050s under the A1F and B1A scenarios, respectively. They suggest a definite poleward shift in the zones of maximum tourism comfort as compared to the historical (1970s) period, although this shift is less dramatic under the B1A scenario than the A1F, as anticipated.

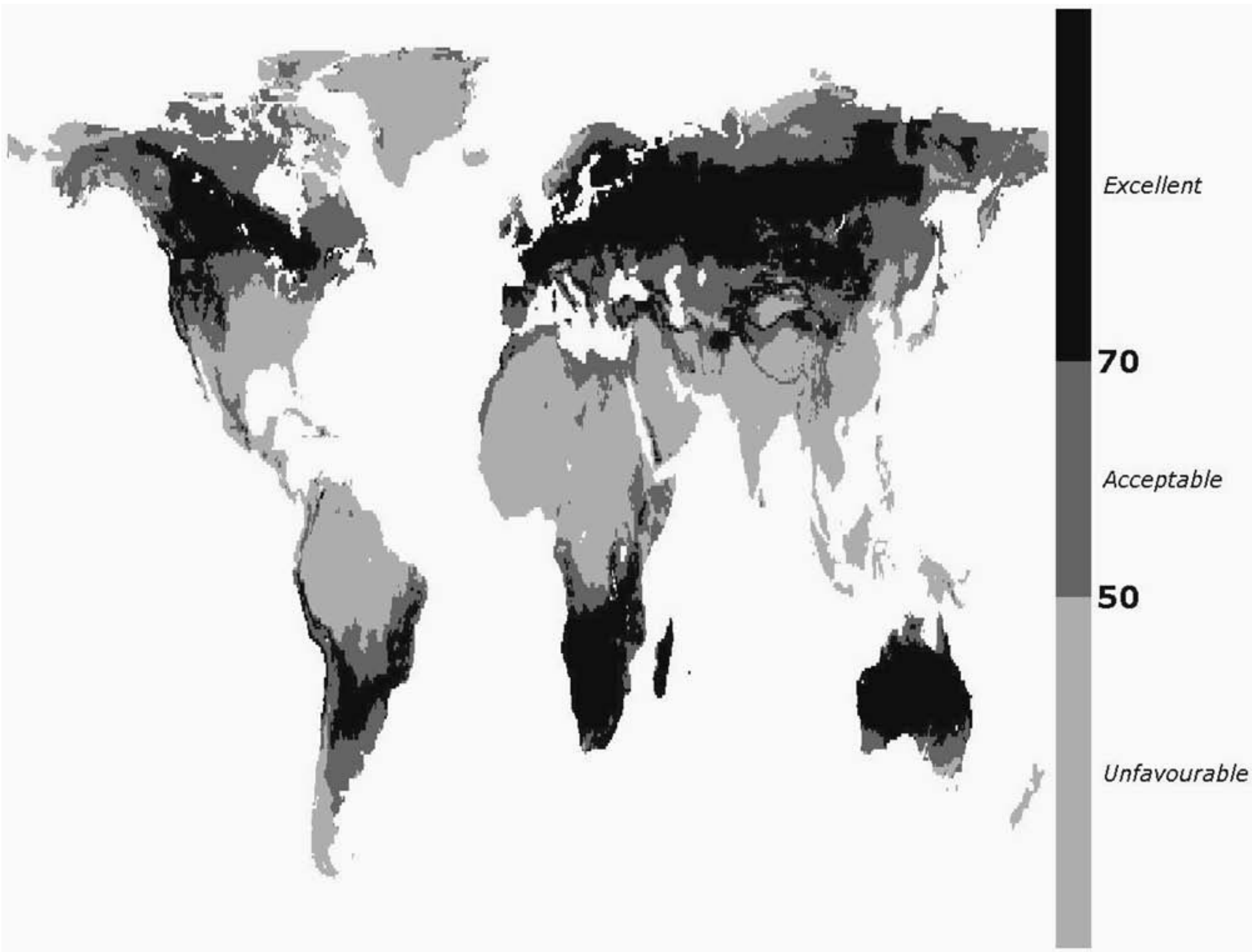
Figures 2-4 (on the Web) illustrate global TCI values for June, July, and August for the 2020s, 2050s, and 2080s, respectively, under the A1F scenario. As a series, they suggest a pronounced poleward movement in tourism comfort as time progresses, such that, by the 2080s, the most ideal conditions for tourism activity in the northern hemisphere will have shifted to the countries of northern Europe and Canada. Similarly, the band of tourism comfort in the southern hemisphere is projected to move southwards. The only region that appears to maintain its "ideal" level of tourism comfort throughout the entire period is that centered on the country of Tajikistan in central Asia.

Figures 5-7 (Web) illustrate global TCI values for June, July, and August for the 2020s, 2050s, and 2080s, respectively, under the B1A scenario. Given the nature of this scenario, the less dramatic poleward shift in comfort zones as compared to that under the A1F scenario is as expected. Nevertheless, even this scenario does suggest that, by the 2080s, the most comfortable regions for summer tourism in the northern hemisphere will have shifted from the Mediterranean coastlines of Spain, France, Italy, Greece, and Turkey to include northern France, southern parts of the United Kingdom, Germany, the Low Countries, and southern Scandinavia. Similarly, the most comfortable regions of North America are projected to have shifted northwards, with the concomitant reverse, a southwards shift, in the southern hemisphere.

TCI, "Good Months" (TCI > 70), 1970s–2080s

Construction of a series of maps representing the number of "good" (TCI > 70) months per annum each grid cell currently experiences and may in future experience provides an

FIGURE 2
TOURISM CLIMATIC INDEX VALUES FOR JUNE, JULY, AND AUGUST, 2050s, A1F

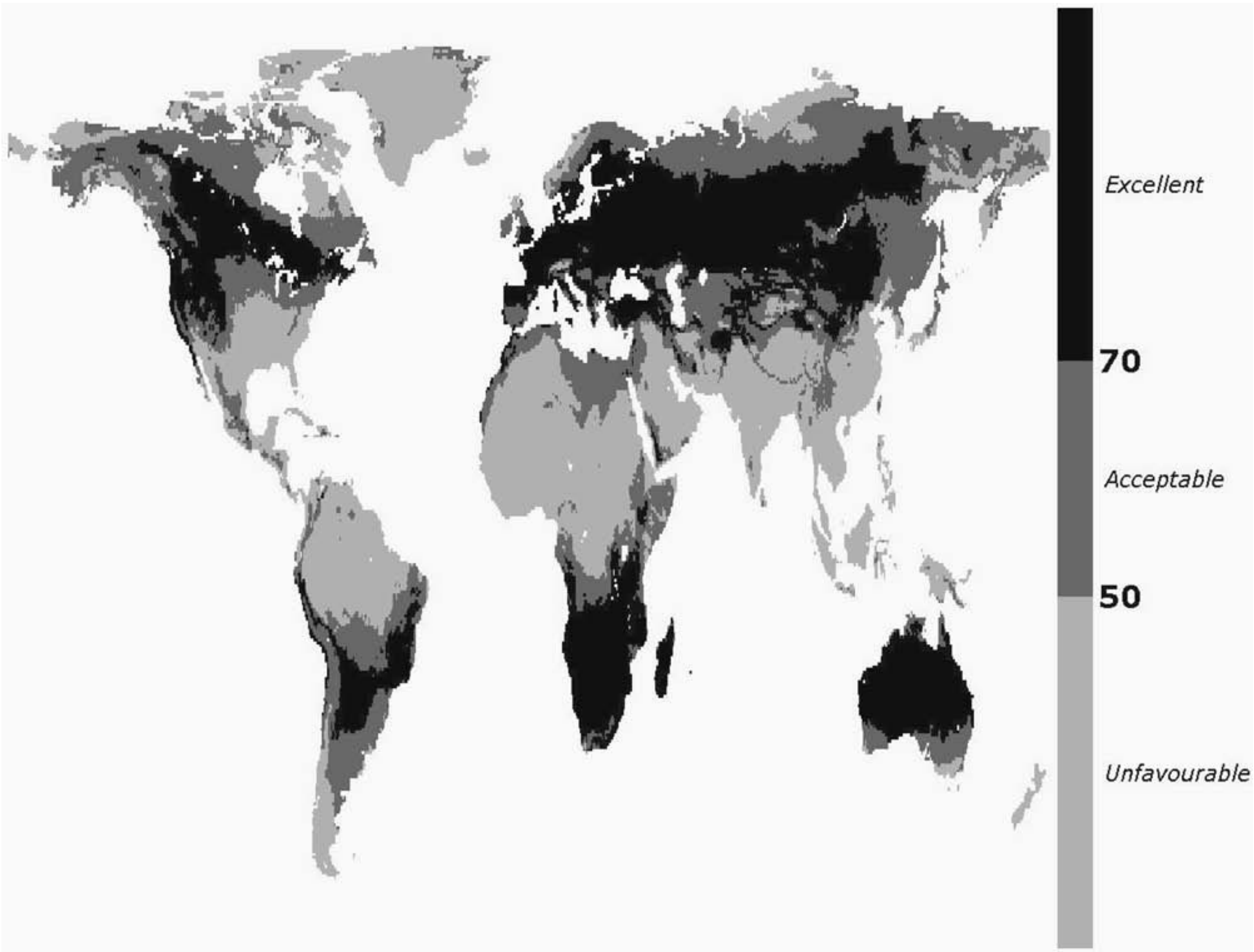


alternative picture of future global tourism comfort levels (figures 4-6 in this article and 8-14 on the Web). The regions that currently experience the highest number of months (more than 10) with comfortable conditions for general tourist activity include the Baja California region of Mexico, the coastlines of Peru and Morocco, much of Egypt, and most of Namibia, Botswana, and South Africa. Much of Australia, the northern and far southern portions excepted, experiences 7 or more months of comfortable climatic conditions, as does much of the eastern part of northern Africa, Yemen, and western Saudi Arabia. In Europe, the number of pleasant months per annum varies from 6 or 7 in the south, along the Mediterranean coast, to 2 or less in the far north, a clear reflection of this region's location in the temperate latitudes. Similarly, the equatorial nations also indicate a very low level of tourist comfort.

Projections of climate change suggest that the band of areas offering extremely low levels of tourist comfort associated with the equator is likely to widen as time progresses, such that by the 2080s, very few locations in Central America, the northern part of South America, the central band of Africa, or Southeast Asia will offer even a single month in which conditions are likely to be comfortable for general tourist activity. In the southern hemisphere, the regions of high comfort (10 or more months with a TCI greater than 70) are projected to shift southwards, from the coast of Peru to that of Chile, for example. Although the number of comfortable months in portions of South Australia may increase, those in the northern territories appear likely to experience a noticeable decline. These trends are repeated across both the B1A and A1F scenarios, although at a slower rate according to the former than the latter.

In the northern hemisphere, the analyses suggest that the number of locations offering high levels of tourism comfort (10 or more months with a TCI greater than 70) will decline progressively such that by the 2080s, there may be no such areas according to the A1F scenario and only a handful (in Egypt, Morocco, and [Baja] California) according to B1A. In Europe, however, the poleward shift of comfortable conditions may result in an evening out of the number of months with TCI levels greater than 70. Whereas current

FIGURE 3
TOURISM CLIMATIC INDEX VALUES FOR JUNE, JULY, AND AUGUST, 2050s, B1A



conditions tend to favor the Mediterranean coastline, which at present may experience up to 7 months of comfort as far as general tourism activity is concerned, in the future, rising summer temperatures may reduce this number to the range of 4 to 7 months. In northern Europe, in contrast, which currently enjoys only 1 to 4 months of comfortable conditions (depending primarily on latitude), the number of pleasant months may in future rise by several months.

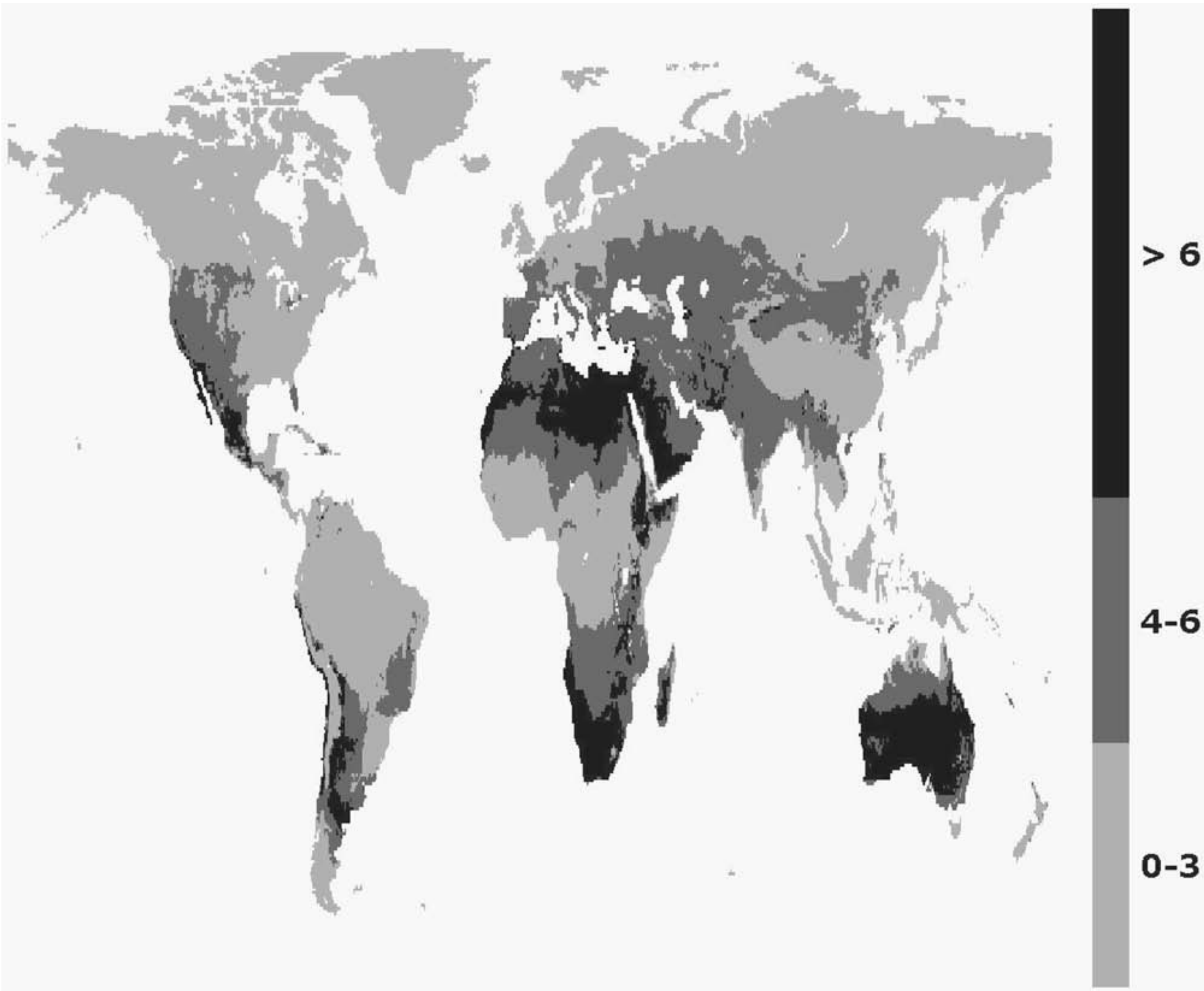
DISCUSSION AND CONCLUSIONS

The potential changes in tourism comfort levels suggested by combination of the Tourism Climatic Index with scenarios of climate change have profound implications for the global tourism industry. Whereas some locations are likely to experience substantial increases in attractiveness due to improvements in their weather conditions, others may become significantly less appealing to tourists, leading to shifts in the temporal patterns of visitation and/or actual declines in the number of visits.

Given the current dominance of Europe as an origin and destination market—Europe accounted for 54% of international arrivals and 52% of international receipts in 2004, according to the World Tourism Organization (2005), and approximately one-sixth of all international tourism trips made in 2000 were by northern Europeans to the countries of the northern Mediterranean coast (Travel Research International 2003)—the potential implications of climate change for tourism in this region are especially significant. According to the potential changes in tourism comfort levels outlined in figures 1 through 7, in future decades it appears likely that the countries of northern Europe, from which many of the Mediterranean's current summer visitors originate, may experience substantial improvements in summer climatic conditions. This bodes well for both increased domestic travel and international visitation from southern Europe and further afield.

Meanwhile, the regions of Spain, France, Italy, Greece, Turkey, and others that currently attract the traditional "sun and sand" summer vacationer are likely to become too hot for comfort in the current "summer peak" season. The shift

FIGURE 4
NUMBER OF MONTHS WITH "GOOD" (> 70) TOURISM CLIMATIC INDEX VALUES, 1970s

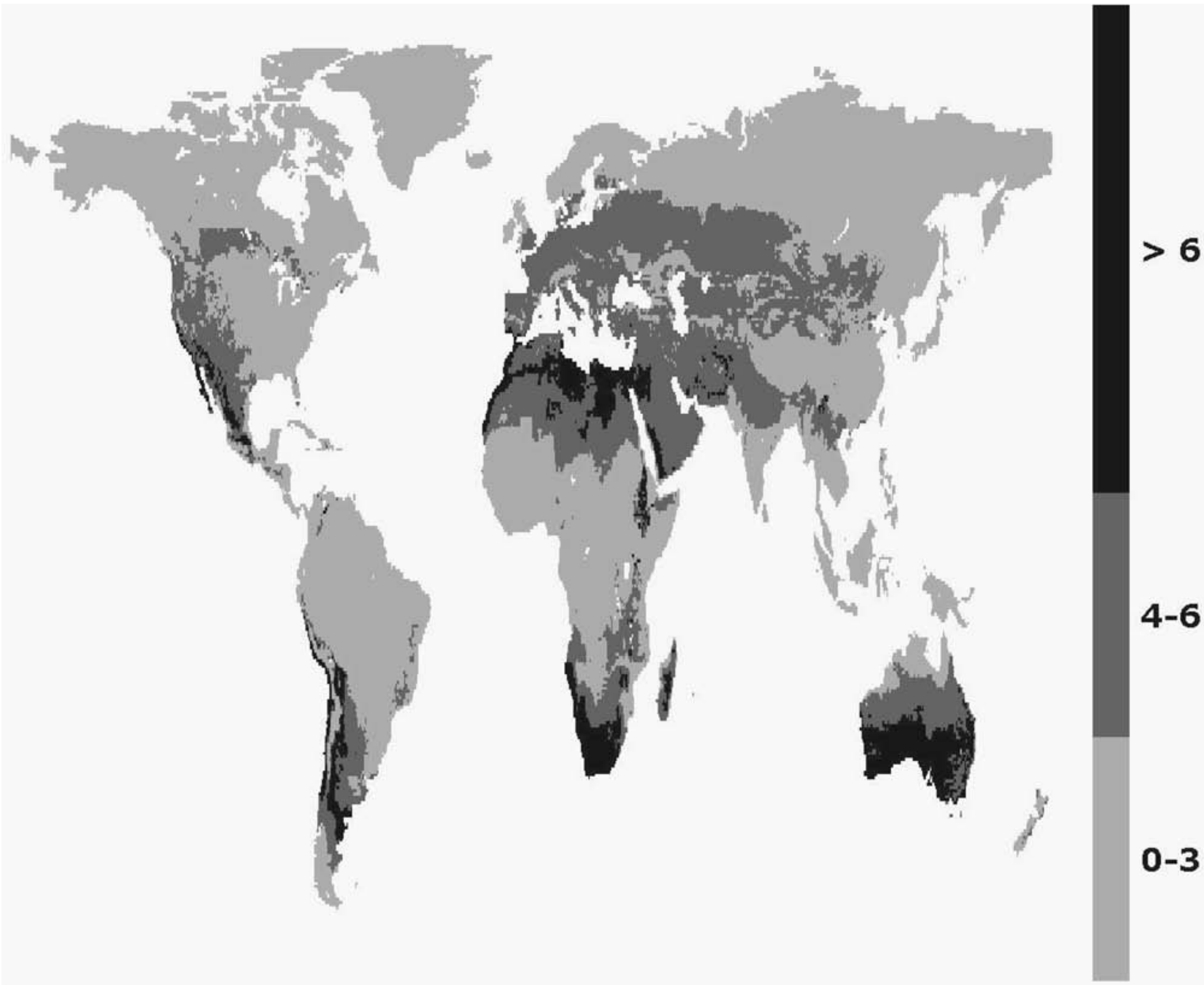


in TCI patterns to "bimodal shoulder peaks" in these regions does, however, imply more pleasant spring and autumn months. The crucial question is the extent to which the demand side can adapt to or take advantage of these climatic improvements in the shoulder seasons, that is, to what extent institutional seasonality can be overcome. Among the main institutional causes of seasonality is the timing of school holidays, in particular summer holidays. The original economic motivation of the long summer holiday was to allow children to help with agricultural chores on the family farm in the busy summer season during which weather conditions were most amenable (Butler 1994). This reason has today lost its significance in many countries, yet the tradition lives on, placing a substantial constraint on family vacation planning.

In tourist destinations such as the Mediterranean, climate change will help disentangle the climatic and institutional causes of seasonality. The consequences of this process will depend on the relative strength of climatic and institutional seasonality factors, and the level of their interdependence, but information on these issues is currently scarce. Although the broad causes of seasonality are well-known, as discussed above, their interactions and causal chains are not well understood (Hinch and Jackson 2000), and the area lacks a sound theoretical framework (Koenig and Bischoff 2004).

Given this lack of theoretical guidance, the implications of two extreme assumptions regarding the flexibility of holiday-related institutions are considered here. In the first case, climatic factors dominate seasonality, and institutional settings prove to be flexible in the longer term, for example as a result of ageing, the increased mixing of working and leisure time, and the staggering of school holidays. This perspective provides ample room for adaptation to climate change, because it accommodates both the temporal and spatial redistribution of tourism activity as a result of shifts in climate. Europeans, for instance, would be able to extend their tourism activities throughout a longer period, with

FIGURE 5
NUMBER OF MONTHS WITH "GOOD" (> 70) TOURISM CLIMATIC INDEX VALUES, 2050s, A1F

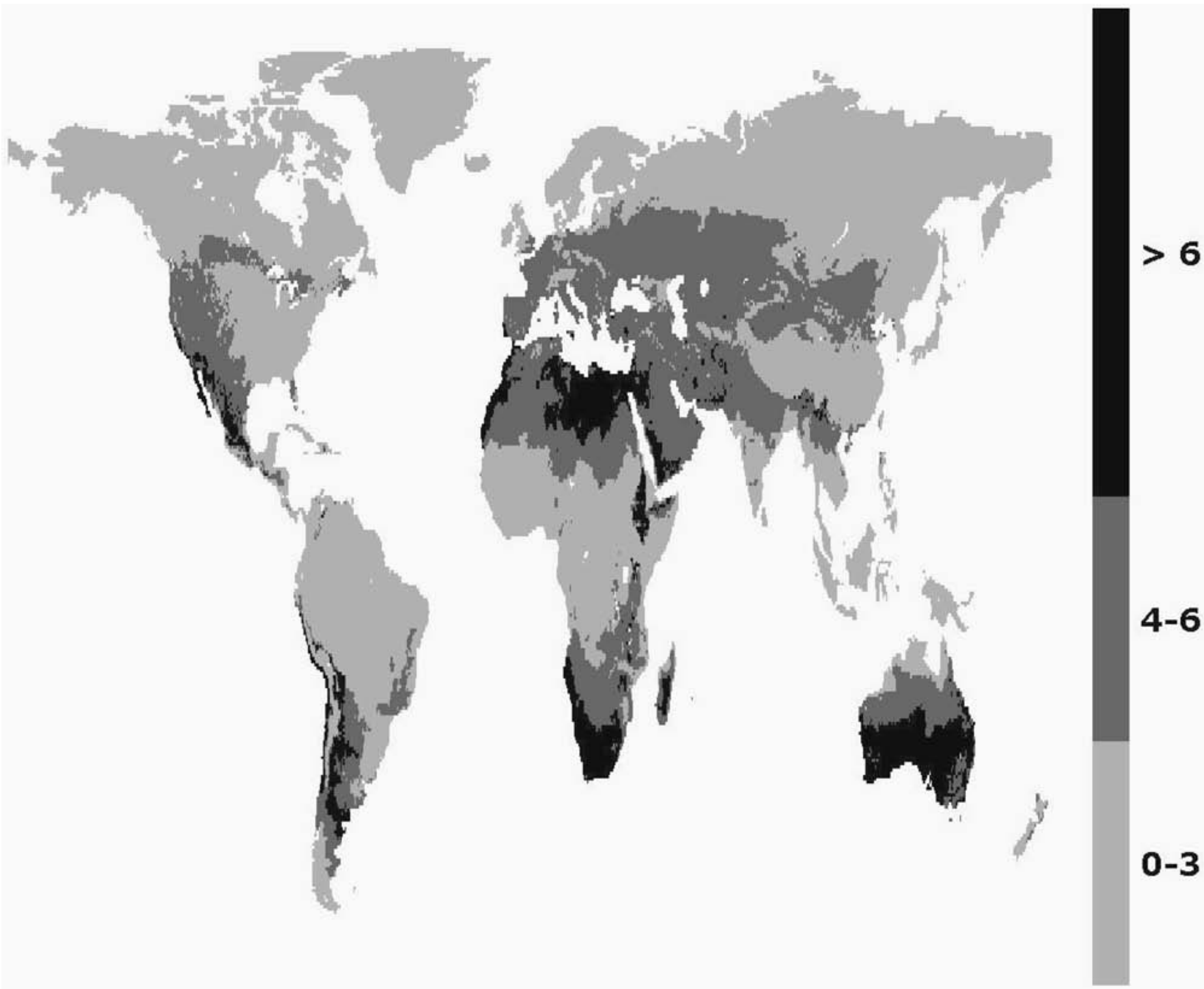


activities in the spring and autumn concentrating on the Mediterranean region and those in the summer months concentrating on the more pleasant northerly regions. From this perspective, the overall contribution of climate change to seasonality is likely to be one of evening out visitation levels across a larger number of months, without any necessary decline in overall visitation levels.

In the second case, however, the institutional context proves to be rather rigid and inert, for example, as a result of people's inability to find travel companions outside the traditional holiday season or a mismatch between the actual and the perceived effects of climate change. From this perspective, adaptation on the part of tourists is limited to spatial redistribution. This would leave the destinations that become uncomfortably hot in summer with a large decrease in visitation, with little or no compensation in the shoulder seasons. The countries that experience better summer conditions, in contrast, would face large increases in visitation without being able to shift some of this additional demand to the (also improved) shoulder seasons. In this case, the contribution of climate change to seasonality would be one of intensified temporal and spatial concentration of tourist activity rather than the reduction of seasonality.

The answer to which of the above two cases is valid, or what combination of the two, has potentially substantial consequences for the impact of climate change on the viability of the tourism industry in Europe and elsewhere, and for its adaptation options. Climate change may bring some relief to extreme cases of seasonality, but only if institutions and tourists are sufficiently flexible; if they are not, climate change may even cause seasonality to intensify. As discussed above, to avoid and mitigate the adverse effects of seasonality, many destinations have tried to reduce seasonality by increasing (decreasing) demand or reducing (increasing) supply in the off- (peak) season. These efforts have typically met with only limited success (Baum and Hagen 1999), perhaps partly due to insufficient insight into the true nature of seasonality. Factors thought to reduce the

FIGURE 6
NUMBER OF MONTHS WITH "GOOD" (> 70) TOURISM CLIMATIC INDEX VALUES, 2050s, B1A



impacts of seasonality include a destination's level of diversification and its proximity to urban areas offering a wide range of less seasonal attractions such as art galleries and museums (Baum and Hagen 1999; Fernandez-Morales 2003). For example, seasonality patterns on the relatively remote Balearics, known almost exclusively for their sun, sea, and sand tourism, are very acute (Rosselló Nadal, Riera Font, and Sansó Rosselló 2004), more so than those in the coastal area around Barcelona.

Projected climate change will further complicate these patterns because it will alter conditions in both origin and destination regions, and modify the current balance between climate-related push factors in generating regions and pull factors at destinations. Unfortunately, tourists' potential reactions to both the perceived and actual impacts of climate change on tourism destinations and, hence, their impacts on travel patterns are underresearched areas, so statements about effects on tourism flows remain highly speculative. It seems probable, nevertheless, that successful adaptation strategies will not necessarily be limited to the supply side of this issue but will also include changes in the marketing of destinations, both at home and abroad. Adjusting tourists' perception of destinations, for example, may prove more effective than providing new and expensive attractions. For regions likely to experience an increase in season length, at least from the perspective of their climatic attractiveness, it is also important to remember that seasonality can have beneficial effects, as noted above. Any lengthening of the season would reduce these economic, social, and environmental benefits, and social consensus about its desirability should, therefore, not be taken for granted (Butler 1994).

As stressed above, the TCI provides a picture of climatic resources for general tourism activity only. It is not applicable to activities that are dependent on specific sets of climatic conditions, notably winter activities such as skiing, nor does it take into consideration the wide range of other factors (economic, social, cultural, political, etc.) that may influence the duration, timing, and location of tourism activity, although the climate change scenarios with which the TCI has been integrated do include broad consideration of future socioeconomic, demographic, and technological trends. In particular, it is important to note that a high score on the TCI does not necessarily translate into a high level of visitation, as demonstrated by, for example, the high scores received for the 1970s period by Angola and Namibia. To sustain large numbers of tourists, a destination must at a minimum possess adequate transportation links and infrastructure, a wide range of accommodations and attractions, and a safe and pleasant environment, in addition to an appealing climate. Similarly, a low score on the TCI does not necessarily preclude high levels of visitation, most notably in the case of destinations offering exceptionally high-quality natural and/or cultural tourism resources. Combination of climatic variables with other relevant explanatory factors into regression analyses using visitation as the dependent variable would enable the relative influence of these factors to be explored and more accurate assessments of the likely impacts of projected climate change to be completed. Nevertheless, the TCI does enable macrolevel analysis of potential shifts in climatic conditions, which, when combined with our current knowledge of tourism flows, does allow broad statements of future patterns to be conjectured.

The analyses presented here are based on a single, general, global climate model (the HadCM3) and two of four available emissions scenarios. The A1F scenario, based on rapid, fossil fuel–intensive economic growth, does represent one of the more extreme futures because it is based primarily on a "business-as-usual" approach rather than allowing for any significant response to the global warming problem. Nevertheless, it is the trajectory on which the world is currently headed (UK Climate Impacts Programme 2001). Further analysis, using additional combinations of climate models and emissions scenarios, would provide a broader picture of the potential climatic conditions for tourism activity. Analysis at a finer geographic scale would also enable more in-depth investigation of potential implications at a regional rather than global level. In addition, this article has focused primarily on implications for the world's major tourism origin and destination region, Europe; climate change is likely to have just as significant an impact on tourism in other areas of the world, most notably those peripheral areas with a heavy dependence on an already highly seasonal tourism industry such as the Caribbean.

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