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The Impact of Climate Change on Tourism in Spain

Lars Hein

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CICERO
Center for International Climate
and Environmental Research
P.O. Box 1129 Blindern
N-0318 Oslo, Norway
Phone: +47 22 85 87 50
Fax: +47 22 85 87 51
E-mail: admin@cicero.uio.no
Web: www.cicero.uio.no

CICERO Senter for klimaforskning
P.B. 1129 Blindern, 0318 Oslo
Telefon: 22 85 87 50
Faks: 22 85 87 51
E-post: admin@cicero.uio.no
Nett: www.cicero.uio.no

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Abstract:
The tourism sector will be particularly affected by climate change, but there have been few studies specifying the impacts of climate change on tourism for a certain country. This paper considers the impacts of climate change on tourism in Spain. Tourism is a key economic sector in Spain, and it is strongly weather dependent. The paper analyses how the suitability of the Spanish climate for tourism will change, and how this will affect tourism flows to Spain. The suitability of the climate for tourists is expressed through an aggregated index, the TCI index. The impacts on tourist flows are modeled using a simple non-linear equation, calibrated on the basis of the current monthly tourism flows in Europe. The model shows that, *ceterus paribus*, climate change as forecasted with the Hadley model under the IPCC SRES A1 scenario would lead to a reduction of total annual tourist flow to Spain of 20% in 2080 compared to 2004. The effect would be entirely due to the much higher temperatures forecasted for the summer, which would make summer temperatures unpleasant for many tourists. In spring and autumn, there would be an increase in tourist flows.

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1 Introduction

Whereas there is increasing understanding of the potential changes in temperature and rainfall patterns that would occur in the coming century as a consequence of climate change, there is still much uncertainty regarding the societal costs of climate change (e.g. Tol, 2002; Stern, 2006). This uncertainty is due to the remaining uncertainty in climate change models, the difficulty of predicting economic processes and structures in the long term, and the complexities of linking physical impacts to economic processes. One of the sectors for which it has been particularly difficult to assess the impacts of climate change is the tourism sector (Nordhaus and Boyer, 2000). Nevertheless, it is likely that the tourism sector will be particularly affected by climate change, as many tourism activities are dependent on the weather conditions, and as most tourists have a high flexibility to adjust their holiday destinations. Various authors have related changes in climate to the suitability of the climate for tourism (e.g. Lise and Tol, 2002; Viner and Amelung, 2003), but a literature search did not reveal any studies that specifically analyzed how changes in the regional climate would affect the numbers of tourists visiting specific countries.

This paper focuses on the impacts of climate change on tourism in Spain. The tourism sector is of major economic importance in Spain. Spain is the country with the highest number of nights spent by foreign visitors in Europe (Schmidt, 2005). Total revenues from tourism amounted to € 37 billion, or 13% of the national GDP in 2002 (INE, 2006). Furthermore, the sector employs over 2 million people, also around 13% of the national total (INE, 2006). The attractiveness of Spain as a tourism destination can be related to the country's cultural heritage, its varying landscapes, and, above all, its pleasant climate compared to the Northern European conditions. Around 60% of the tourists coming to Spain have as a main motivation to enjoy the sun and beaches of Spain (IET, 2006). This makes the tourism sector in Spain potentially vulnerable to climate change.

The objective of the paper is to make a quantitative assessment of the potential impacts of climate change on tourist flows to Spain. In this study, tourists include only visitors from other countries (cf. Schmidt, 2005). The study involves an analysis of (i) the suitability of the Spanish climate for tourism in 2080, based on existing models and scenarios; and (ii) the potential changes in the number of tourists visiting Spain because of climate change.

The study follows a systems analysis approach, linking climate change to responses by tourists. It is based on grid cell climate change projections generated by the ATEAM project (Schröter et al. 2004), and builds on the work of Mieczkowski (1985) for the analysis of tourists' climate perceptions. The paper benefited from the availability of a spatial analysis of climatic change in relation to tourism by Moreno Sanchez (2005). A relatively simple, log linear model is developed to analyze tourism flows as a function of the suitability of the climate and the intrinsic (i.e. non-weather related) attractiveness of an area. The model is based on current monthly tourism flows to 5 regions in Spain as well as to the other EU Mediterranean countries and Northwestern Europe. Note that the methodology does not allow analysis of the subsequent economic impacts of changes in tourism flows, for which general equilibrium modeling should be applied (see e.g. Berrittella et al., 2004).

2 Methodology

2.1 Selection of the study regions

The study analyses the tourism flows to 5 Spanish regions, to other European Mediterranean countries (Italy, Greece and the French Mediterranean coast) and to Northwest Europe (including the French Atlantic coast, Belgium, the Netherlands, Denmark and the UK). The 5 considered Spanish regions are Andalucia, the Mediterranean coast, Central Spain, Northern Spain and the Balearic islands. The Spanish Canary islands receive around 18% of the annual foreign visitors to Spain (IET, 2006), but they are not part of the European continent and no climate data were available. Therefore, they have been excluded from this study.

Each Spanish region has its distinct climate, and climate data are derived from existing databases (see below) for one city within the region. Santander is located in the Atlantic coast, and represents the Spanish northern latitudes with mild temperatures during summer and abundant precipitation throughout the year. The other Spanish regions are characterized by temperate, wet winters and hot, dry summers characteristic of the Mediterranean climate. The climate for Northwest Europe has been approximated by averaging climate data for three seaside resorts: Deauville (France), Scheveningen, (the Netherlands) and Blackpool (the UK). For the rest of the Mediterranean Region, climate change has been analyzed on the basis of the averaged forecasted changes in Brac, Croatia and Lesbos, Greece.

2.2 Forecasts of climate change

To construct the climate change information, the study uses the set of high-resolution grids (gridded data sets) of monthly climate information constructed as part of the ATEAM project (Schröter et al. 2004). The grids are developed at a spatial resolution of 10 minutes for the whole of Europe and are based on climatological observations and on outputs from transient coupled atmosphere-ocean GCM simulations. In the grid, five climate variables are included: temperature, diurnal temperature range, precipitation, vapor pressure, and cloud cover. The set comprises the observed climate record (1901–2000), a control scenario (1901–2100) and 16 scenarios of projected future climate (2001–2100). The 16 climate change scenarios represent combinations of four SRES emissions scenarios and four global climate models (GCMs), covering 93% of the range of uncertainty in global warming in the 21st century published by the Intergovernmental Panel on Climate Change (Mitchell et al. 2004). From this set, the HADCM3-A1 model and scenario have been selected, as this was one of only two models (together with the CSIRO model) that provides the full set of variables necessary to calculate the TCI following Mieczkowski (1985). The A1 scenario assumes globalization as well as high importance attached to efficiency compared to solidarity, and has strong growths in CO2 emissions compared to the other SRES scenarios (Nakicenovic et al., 2000). For the HADCM3-A1 model and scenario, the climatic data for the period 2065-2095 has been extracted for the reference points described in 2.1 from Schröter et al. (2004).

2.3 Analyzing the suitability of the climate for tourism

The suitability of the climate for tourism can be expressed in the so-called TCI index (Tourist Climate Index, Mieczkowski, 1985). The TCI is a composite indicator that captures the climatic elements most relevant for the ‘average’ tourist, assuming that the tourist engages in light physical activities, such as beach recreation, sight-seeing, shopping and relaxing. It has been widely used in studies examining the impacts of climatic factors including climate change on tourism (e.g. Viner and Amelung, 2003). Currently, the TCI index is highly favorable for Spain during the period April-October, in particular compared to the rest of Europe. Only in August in the southern part of the country (Andalucia), temperatures are high enough to negatively affect the TCI. Climate change is forecasted to significantly raise the summer temperatures in Spain in the coming decades. This will influence the attractiveness of Spain's beaches to tourists, expressed through changes in the TCI. At the same time, the TCI of beaches and resorts in the central parts of Europe may increase.

The TCI includes seven climate variables: monthly means for maximum daily temperature; mean daily temperature; minimum daily relative humidity; mean daily relative humidity, total precipitation, total hours of sunshine, and average wind speed. These seven climate variables are combined into five indices that comprise the TCI. Each index is rated on a scale of -3 to 5. For instance, an effective temperature of 20 to 27 ^{o}C is rated 5, a temperature of 10-15 ^{o}C or 31-32 ^{o}C is rated 2.5, and a temperature of -15 ^{o}C Is rated -1 (see Mieczkowicz, 1985 for details). After summing the weighted individual components, the result is multiplied by two, so that the minimum TCI score is -20 and the maximum TCI score is 100. The methodology including the various underlying assumptions has been described at length in Mieczkowski (1985) and the reader is referred to the original paper for additional details pertaining to the conceptual and methodological development of the TCI. The current TCI is calculated for the seven regions distinguished in this study, based on the 1960-1990 weather patterns. The 2080 TCI values are calculated based on rainfall and temperature forecast of the A1 scenario, Hadley model, under the assumption that all other variables (wind, humidity) remain constant. This is a simplification as, for instance, rainfall and temperature will affect humidity, but climate change models are not yet detailed enough to account for these changes as well.

2.4 Modeling tourist numbers

A simple, stylized model is used to model tourism flows. It is assumed that tourism flows depend on (i) the intrinsic attractiveness of a region (dependent on landscape, nature, tourism facilities, cultural aspects, proximity to population centers, etc.) and (ii) the climate of the region. A log linear relation is used, as it is assumed that tourists chose their holiday destination based on a joint consideration of climatic factors and intrinsic attractiveness. The equation reflects that some substitution between the two is possible, i.e. a not so good climate can be partly compensated for by a high intrinsic attractiveness. The equation is presented below:

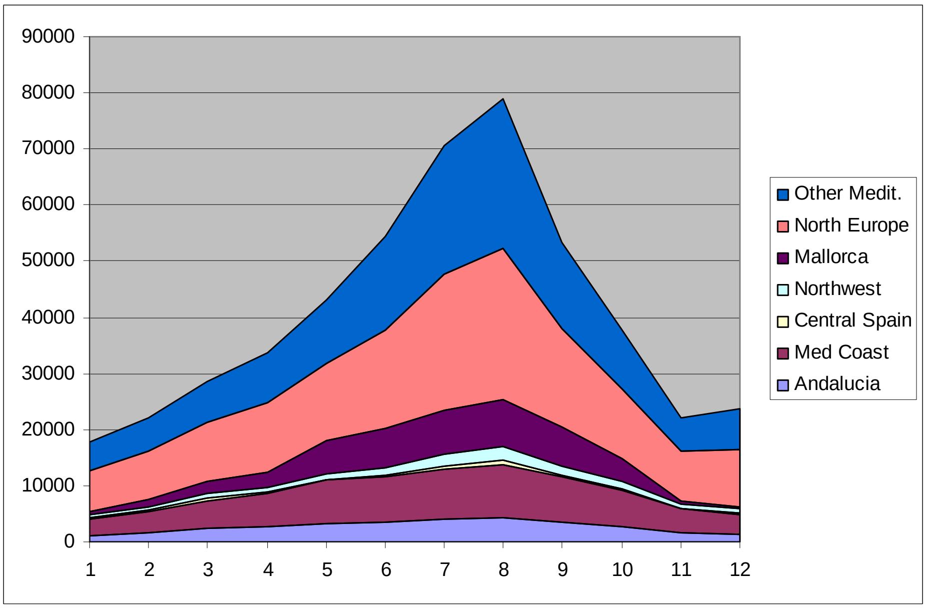
$$V_{r,m} = \lambda \cdot A_r^{\alpha} \cdot C_{r,m}{}^{\beta} \tag{1}$$

V is the number of visitor nights spent in a region (*r*) in a specific month (*m*); A is the attractiveness of a region independent of its climate; C is the monthly weather in a specific region, expressed as the TCI factor; λ is a scaling parameter; and α and β are coefficients. The coefficients α and β represent the preference of tourist for attractiveness versus climatic factors. The model is calibrated (i.e. λ, α and β are calculated) for the current monthly flows of tourists to the 7 distinguished regions. There is a high spread in the TCI values because the monthly flows are analyzed, which facilitates analyzing the climate dependency of tourism flows. It is assumed that A, and the coefficients α and β are constant over time. This presupposes that the preferences of tourists for cultural, natural and other sights do not change, and that there is no change in the relative attractiveness of areas because of different investments in tourism facilities. Furthermore, it is assumed that there is no change in preference for the timing of the holiday. This latter assumption was required because time preference could not be separately modeled. The uncertainties and methodological aspects of the modeling are further discussed in the Discussion section.

3 Results

3.1 The relation between climate and tourist flows

Figure 1 presents the current monthly visitor numbers, expressed as visitor-nights spent, to the 7 regions distinguished in this study. The amount of nights spent by foreign visitors in Spain approximately equals the amount of nights spent by tourists in the French Riviera, Italy and Greece together. Note however that, in France and in particular in Italy, the number of domestic tourists is much higher. Visitors for business reasons have been excluded in Figure 1. The share of business trips was only known for the whole year (from EU, 1998 and Schmidt, 2005), and it is assumed that the business visits are equally spread over the months. The numbers for Spain do not include the visitors to the Canary Islands and do therefore not add up to the total number of visitors to Spain.



Based on EU (1998) and Schmidt (2005).

Figure 1. Monthly tourism flows in 2004

The current suitability of the climates of the 7 regions, as expressed through the TCI index, is presented in Table 1. The TCI index is based on calculations of weather characteristics for the period 1960-1990. It is assumed that these characteristics are also representative for 2004, the reference year of the study.

Table 1. TCI values in 1960-1990

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Spain												
Andalucia	47	53	59	71	82	92	80	76	82	76	57	49
Med. Coast	60	60	68	79	81	84	80	73	72	75	71	60
Center	49	47	53	64	81	90	74	76	82	68	48	53
Northwest	33	37	40	41	53	73	79	75	73	54	33	33
Mallorca	50	53	59	63	83	90	78	70	76	75	64	56
Northwest Europe	33	36	39	46	57	67	74	73	62	44	33	32
Other Mediterranean	43	49	56	70	82	86	81	79	81	71	46	43

(adapted from Moreno Sanchez, 2005)

Based on the data presented above in Figure 1 and Table 1, the relation between monthly climate and tourism flows (Equation 1) has been analyzed. The function distinguishes two independent variables (i) the climate-independent, relative attractiveness of a region (compared to the other regions); and (ii) the regions monthly TCI value, indicating the suitability of the climate for tourism. The relative attractiveness (‘A’) is estimated by comparing the proportion of the monthly visitors that spends the holidays in each region in the month of July, when the differences in the TCI values are the smallest. With this method, a discrepancy occurs as the TCI values for the UK and Denmark in July (70) are significantly lower than those for Deauville, France (78), where the TCI value is much closer to those found in Spain in July. The implication of this discrepancy is that the relative attractiveness (A) of NW Europe is underestimated. Because the model is non-linear in both TCI and A, this means that the visiting rates to Northwestern Europe in 2080 will be underestimated by the model. Hence, the error causes an underestimation of the impact of climate change on tourism in Spain. The relative attractiveness is presented in Table 2. Clearly, the factor only indicates the attractiveness compared to the other regions distinguished in this study, and it can not be extrapolated to broader areas. It is also clear that the 7 regions are very different in terms of size as well as cultural and natural characteristics, and the factor A is only a tool developed for the specific purpose of this study.

Table 2. Relative attractiveness factor.

Region	A
Spain	
Andalucia	0.055
Med. Coast	0.129
Center	0.007
Northwest	0.030
Mallorca	0.081
North Europe	0.373
Other Mediterranean	0.325

Subsequently, the scaling parameter λ, and the coefficients α and β, which represent the preferences of tourists for relative attractiveness versus climatic factors, can be estimated. Based on the 2004 tourism flows, the equation is specified as follows: $\lambda = 0.001$; $\alpha = 1.09$; and $\beta = 1.02$. For 2004, the model is highly significant, with n=84 and $R^2 = 0.83$, $F = 411$, significant at $p<0.001$.

3.2 Implications of climate change for tourism flows

The HADCM3 A1 model/scenario combination results in significant increases in average temperature in the period 2070-2099. The average annual temperature in all mainland Spanish cities would increase by between 4.4 (Santander) and 5.6 (Barcelona) degrees ^{o}C. Only in Palma de Mallorca would the temperature increase be more modest, +3 ^{o}C. Somewhat lower temperature increases (in the order of 3.5 to 4 ^{o}C) are calculated for the other Mediterranean cities, where the cooling effect of the Mediterranean sea is stronger. In the three northwestern European cities, the temperature increase would be around 3 to 3.5 ^{o}C. The most marked changes in rainfall patterns occur in Northwestern Europe, where rainfall would increase during the summer months, thereby reducing the positive effect of higher temperatures on the TCI. The changes in temperature and rainfall strongly affect the TCI values for the 7 regions distinguished in this study. This is shown in Table 3.

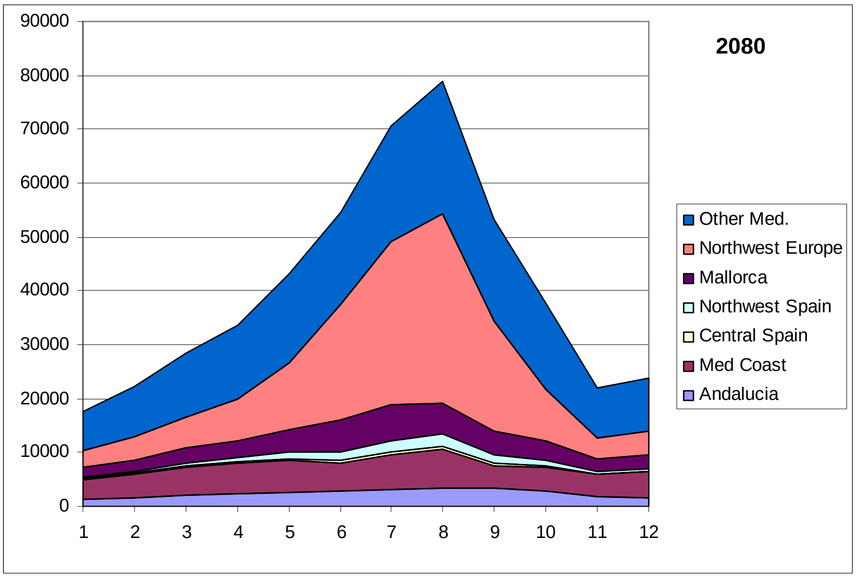
The table shows that there would be a very considerable drop in TCI values for most of Spain in the summer months. Summer temperatures would be too high to be attractive to tourists. The only exception is Santander, where a relatively high TCI value is maintained. The summer values of the TCI also drop, albeit to a lower degree, in the rest of the Mediterranean. To the contrary, the TCI value in the summer months increases in Northwest Europe. In spring and autumn, there will be a modest increase throughout Europe, but there will be a more pronounced increase in Spain where average mean temperatures will rise close to the optimum range (between 20 and 27 ^{o}C).

Table 3. Forecasted TCI values for 2070-2099.

Areas	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Spain												
Andalucia	59	65	76	80	80	54	44	40	62	84	74	59
Med. Coast	79	79	83	84	76	47	39	37	37	60	79	73
Center	46	53	68	81	84	49	45	45	55	84	64	54
North Spain	30	36	47	57	74	76	62	58	68	65	37	31
Mallorca	58	59	69	76	85	78	62	45	58	76	73	62
Northwest Europe	31	35	43	52	73	81	77	76	74	58	34	33
Other Mediterranean	62	65	75	82	83	57	50	49	61	84	70	60

(adapted from Moreno Sanchez, 2005)

The forecasted changes in TCI will have important impacts on the tourism flows in Europe in 2080. Spanish summer tourism will show a very considerable reduction in 2080, which will only partly be made up for by an increase in tourism in spring and autumn. The tourism flows in 2080 are presented in Figure 2 below, based on the assumptions that (i) the total numbers of European tourists do not change; (ii) the relative attractiveness of the regions does not change; and (iii) the monthly preferences of tourists are constant. It is very likely that these assumptions will not be fully adhered to, but analyzing changes in preferences over such a long-time period is next to impossible. Therefore, Figure 2 only presents the impacts of a change in climate on tourism flows, under the assumption that all other factors remain constant.



Source: this study

Figure 2. Projected monthly tourism flows in 2080

In total, the relative number of tourists visiting Spain will decrease with 20% in 2080 compared to 2004. In other words, if there would be no increase or decrease in the total number of tourists in Northwestern Europe, Spain and the rest of the Mediterranean, and if the preferences of tourists would not change, the total number of tourists to Spain would drop by 20% in the coming 80 years as a consequence of climate change.

4 Discussion

4.1 Key uncertainties in the model

There are a number of uncertainties in the model. The first major uncertainty relates to the rate and direction of climate change. Most models agree on temperature increases for the Mediterranean, but the rate varies as a function of the model and, of course, the emission scenario. Whereas the Hadley model predicts an average temperature increase for Spain of 4.5 ^{o}C, the CSIRO A1 model forecasts a temperature increase in Spain of some 3.5 ^{o}C. In general, the impacts on tourism would occur before or after 2080 if climate change proceeds respectively faster or slower than forecasted in the Hadley model.

The second uncertainty deals with the appropriateness of the simple model used in this study to examine tourist flows, and the statistical significance of the distinguished variables. Whereas the model is highly significant ($p<0.001$) for 2004, its validity for 2080 depends on the assumption that tourism preferences do not change. This is unlikely as the age structure of the European population, and their average income will change in the coming decades. Both factors have been found to influence the choice of holiday destinations of tourists (Schmidt, 2005). The impact of rising incomes on tourism in Spain can not be clearly be predicted *ex ante*, and will also depend on the response of Spanish tourism providers (in terms of offering different services such as higher quality accommodation). The aging of the European population will probably increase the aversion of tourists for high temperatures, which would further increase the impacts of climate change on tourism in Spain.

A third assumption is that the monthly preferences of tourists will not change over time. However, this preference will change with the changing population and the changing labor conditions in Europe and can not be expected to remain stable. Whereas many tourists will remain dependent on school holidays, there is a trend towards increasing flexibility in the timing of holidays (EU, 1998), which makes it easier for people to visit Spain in spring or autumn. However, where people find good summer conditions closer by, they may not be inclined to change the timing of their holiday as ample good beaches are also presents in France, Belgium, the Netherlands, UK, Denmark and South Sweden.

4.2 Adaptation options

Once the climate is too warm for beach or other tourism, few adaptation options are likely to exist. Alternative forms of tourism, e.g. golf courses, eco-tourism, etc., still require a pleasant climate. Elderly, who have moved to Spain in large numbers in recent years, may also be less willing to stay in Spain during the summer. In addition, water shortages may occur more frequently as a consequence of climate change. Most vulnerable is likely to be Mallorca, where water reservoirs are already under pressure (Garcia et al., 2003). It is therefore questionable if Mallorca would indeed be able to cope with an increase in the flow of tourists (as predicted in the model) because of its relatively modest temperature increase.

It would be interesting to also examine the impact of climate change on the agricultural sector, an important economic sector in the country and a second major employer in rural areas. The agricultural sector could provide alternative employment to people that may lose their job in the tourism industry. In view of the otherwise limited employment opportunities in Spanish rural areas, this constitutes an important potential adaptation option. Whereas temperature changes will evoke a shift in the growing season, increased evapotranspiration rates of crops are likely to increase water shortages and may negatively affect the sector. In addition, the returns to labor in the agricultural sector in Spain are considerably lower than in the tourism sector (INE, 2006). Hence, the potential contribution of the agricultural sector to provide adaptation options to the impacts of climate change in the tourism sector can not be assumed a priori and needs further examination.

5 Conclusions

This paper presents a first, quantitative assessment of the potential impacts of climate change on the tourism sector in Spain. The study is based on a simple model capturing tourist preferences with respect to climate as well as a basket of other area characteristics. Climate is expressed through the TCI (Tourist Comfortability Index), developed by Mieczkowski, (1985). The model was significant ($p<0.001$) for the base year of the study, 2004, and presents insights in the impact of climate change on tourism flows. The model assumes that the preferences of tourist do not change with respect to (i) the timing of their holiday; (ii) the perceived climate independent attractiveness of the 7 regions distinguished in this study; and (iii) the importance of climate versus other factors.

The model shows that, under these assumptions, tourism inflows to Spain will undergo major changes in the coming decades. Summer tourism will decrease substantially in 2080 compared to current situation because of excessive temperatures in most of Spain (throughout Spain except the Northern Coast and the Balearic Islands). Spring and autumn tourism would increase, but not enough to make up for the losses in the summer, in particular because tourists will be offered alternative destinations where the climate becomes much more appealing in Northern Europe. Furthermore, the impact of climate change will be much higher in mainland Spain, compared to the rest of the Mediterranean where the impact of the sea will moderate temperature increases to some extent. Under the assumptions specified above and all other factors being equal, tourism in Spain could be expected to decrease substantially as a consequence of climate change. In case the total number of tourists in Europe, which has not been modeled in the study, would remain equal, the forecasted decrease in annual tourist flows to Spain is 20%.

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