Climate Potential in Spanish regions: analysis and its relationship with tourism flows

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Abstract

The main objective of the paper is to analyze whether climatic factors have affected tourism flows in Spain and its regions. To achieve this, there is first a presentation of a complete quantitative characterization of the potential climate of Spain (and its eight climatic regions), based on constructing homogeneous territorial data relating to temperature, rainfall, sunshine hours and wind, for the period from 1951 to 2011. The analysis highlights the favourable condition of these vectors prevalent in Spain with the exception of the increase in average temperature experienced during the period analyzed. Second, an analysis was made of the relationship between these increases and tourism results during the sub-period 1999-2011 in the identified Spanish regions for the main summer months (July and August), along with overnight stays in hotels. Typically, it appears that hotel nights generally increase in Spain and the increase is largest precisely in the hottest months of the year (July and August). Beach tourism is particularly popular, mainly for international visitors. Hot weather, consequently, does not seem to affect the increasing rate of summer tourism, but the indirect impacts of climate change might threaten the capacity for maintaining a continuously high level of service in all resorts.

Keywords

climate change, climatic extremes, climatic impacts, hotel nights, beach tourism, Spain, strategic planning

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1. Introduction

Spain enjoys a very active tourism sector owing to its historical towns, its mountains and extensive coastlines. The maintenance of this activity and the promotion of tourists' satisfaction are of essential importance to the country, not only through the image it projects, but also because tourism makes a substantial contribution to Spain's economy (in last ten years, over 11% of its GDP according to the Spanish National Statistical Institute).

Surveys show that climate is generally the second most important factor in selecting holiday destinations (Shiue and Matzarakis, 2011). Consequently, favourable climate can contribute to the popularity of certain destinations, while the opposite might deter some potential visitors. In this study the Spanish climate is evaluated based on its potential to promote or hinder various kinds of tourist activity. A quantitative characterisation of the Spanish climate is presented using the observations of the Spanish Meteorological Agency for the period 1951-2011, as well as the relationship between climate and tourism activity using data on overnight stays by tourists in Spain between 1999 and 2010. Further characterisation of climate-related impacts on tourism is based on the selection of critical influencing factors. Tourism is generally influenced by a large number of economic, social, climatic and other environmental factors; therefore the selection of the critical factors of vulnerability is a recurring feature in studying the relationship between climate and tourism (Scott et al., 2004 or Vila et al., 2010).

Two main kinds of impact will be considered during the impact assessments: i) direct impacts of tourists' climate requirements, ii) indirect impacts through climate-generated effects on the capacity of tourist destinations and their maintenance costs. The results of our observational data are compared with findings of earlier studies, and the similarities and differences are discussed.

The organisation of the paper is as follows. The next section introduces the characteristics of the observational datasets and the quality controls applied. Also in that section the principles of the impact assessment method applied are described. The following sections deal with the climate's direct impacts on tourism activity. Section 3 presents some climatic characteristics of Spain. The key climatic characteristics for tourism demand are shown there and, based on them, the climatic potential of different regions of Spain is briefly evaluated. In section 4 a joint analysis of tourism activity data and climatic data is performed. There, the evidence of relationships between climate and tourism activity are discussed, examining the spatial and temporal variability of the observational data, and analyzes different ranges of optimal temperature for different kinds of tourism. In section 5 the predicted climate change for Spain and the risk of extreme climatic events are discussed in relation to the general requirements of tourism, relying on the last report of the Intergovernmental Panel on Climate Change (IPCC, 2007) and on other widely known climatic information, then this part is devoted to the characterisation of indirect climate impacts on tourism. Finally, in section 6, a summarising evaluation of the findings of the study and some concluding remarks are provided.

2. Data and methods

Monthly climatic time series of Spanish observing stations are used in the study. Six climatic variables are examined, namely monthly mean temperature (Tm), monthly mean of daily maximum temperatures (Tx), monthly amount of precipitation (Pt), number of precipitous days (Pd, Pt > 0.1 mm), ratio of sunshine duration to the astronomical potential (Ss), and monthly mean wind velocity (Vv). The raw data was downloaded from the homepage of the Spanish Meteorological Agency (ftp://ftpdatos.aemet.es/series_climatologicas/). Data from 114 observing stations was found there. The time period considered in this study is between January1951 and December2011.

Observations in the same settlement were sometimes performed at slightly different sites for different periods. In these cases the time series were merged. Time series with too few data were excluded. From parallel observation in the same settlement, redundant series were sometimes excluded to avoid excessive bias towards certain geographical locations and to achieve a spatially even distribution of observing sites. Data from high mountainous regions were not available in sufficient quantities to produce a separate characterisation of mountainous areas, and considering that these data are not comparable with those from low altitudes, the very few data available from above 1200m were excluded. Ultimately, 71 sites remained from the initial 114, 59 in the Iberian Peninsula, 4 in the Balearics and 8 in the Canary Islands.

Row data were checked for their physical reality. Data outside the ranges of -5°C < Tm < 33°C, 0°C < Tx < 40°C, 0mm < Pt < 3000mm, 0 < Pd < 31, 1% < Ss < 98% or 0.5 m/s < Vv < 12 m/s were checked individually. These controls only indicated serious quality problems with the wind speed data.

Climatic observations often have temporal, systematic biases due to technical errors or environmental changes (Brunet et al., 2006). When several time series are available for the same climatic region, these biases can be detected and corrected with homogenisation. The size of a climatic region depends on the climatic variable, and can be characterised with the spatial correlations of the observed data. Time series from 71 sites for a country like Spain compose a network of satisfactory spatial density for homogenising temperature data, but not for precipitation or wind. See more discussion about the conditions and options of time series homogenisation in Aguilar et al. (2003). For this study, only Tm and Tx data have been homogenised, but this step is important, because temperature is generally the most important explanatory variable in holiday destination choice among climatic characteristics (Bigano et al., 2006).

Before homogenisation, Spain was divided into eight regions: oceanic coast (OC), northwestern continental area (NW), central area (MD), southern continental area (SU), southern and southeastern Mediterranean coast (MS), eastern Mediterranean coast and Baleares (MN), northeastern continental area (NE), Canary Islands (CN). Each region contains 7-10 observing sites. In certain regions substantial differences occur between the climate of the western and eastern parts, but the number of time series does not allow a finer spatial distribution of regions.

The homogenisation was performed separately for each region. The ACMANT homogenisation method (Domonkos, 2011) was applied. It is a fully automatic method, and beyond homogenisation it filters outliers and fills in data gaps. Note that in an international blind test experiment funded by the European Union, ACMANT turned out to be one of the most reliable and most accurate homogenisation methods (Venema et al., 2012).

Tourism activity is characterised by the number of hotel nights (HN) spent by international and domestic tourists. The monthly data of HN is available for the 52 provinces of Spain between 1999 and 2010. The data came from the Spanish National Statistical Institute and, in particular, from the Hotel Occupancy Survey.

The joint analysis of HN and climate is performed taking into account the spatial-temporal variability of the data available. However, the time span of the HN-data is only 12 years and it limits its usability for statistical examinations. Another problem is that the indirect climatic impacts cannot be assessed in terms of the HN – climate relationship. Therefore further examinations are made that are based on the selection of critical influencing factors. The principles of the method of Moreno and Becken (2009) are adopted. That is a 5-stage activity of vulnerability assessments, spanning the examination of tourism activity together with its economic, environmental and social contexts up to the publication of results and making recommendations to policy makers. The present application is a somewhat reduced version of that package. The incorporation of economic analysis and discussion of concrete scenarios and adaptation options are omitted. The focus of the study is on the determination of critical climatic and climate impact related factors in the assessment of the vulnerability of tourism activities in Spain, and to point out some conclusions of great practical importance for tourism management.

3. Climatic potential of Spain for tourism

In this study the climate of Spain is evaluated from the point of view of its climatic potential for tourism. The most recent climatic data are involved, and several comparisons are made between the climate of the recent 3 decades (1981-2011) and that of the previous decades (1951-1980) to identify recent climatic tendencies. In Tables 1 and 2 the annual means and means for August are presented, respectively. August was chosen because it is the peak season for tourism activity in Spain. As previously mentioned, high mountain climates are not represented.

Firstly, the situation can be analyzed in terms of temperature vector. Thus, Spain has warmer climate than many other parts of Europe. From autumn to spring it is definitely a favourable characteristic for tourism, but summer temperatures can be too high (Table 2). The annual average temperature in the peninsula and Balearics is generally between 12 and 18°C, growing gradually from North to South. In the Canaries it is approximately 20°C. The annual mean of Tx is generally 18–23°C throughout the country. These temperatures are slightly lower than the optimal temperatures used in holiday destination choice (see, e.g., Lise and Tol, 2002). However, in the main tourist season, in August, the temperatures tend to be higher than the optimum. For Tx in August, the most frequent temperature is 28–31°C, but in the Canaries, and particularly in the oceanic coast, the mean Tx is lower. By contrast, in some lowland areas, particularly in the southern half of the country, a monthly mean Tx of 32–36 °C can also occur. The latter temperatures are generally known to be unfavourable (Maddison, 2001, Tobías et al., 2010, etc.).

Tables 1 and 2 also show the mean change of temperature between the periods 1951-1980 and 1981-2011. Warming was general in Spain both in daily main temperatures and daily maximum temperatures. The degree of warming was substantially larger than that of the global mean temperature, i.e. both August and annual means reached 0.7–1.0°C in most parts of the country. (The global average for warming over the same period was approximately 0.3°C.) The degree of warming was even larger in the annual mean for the Canaries, around 1.5ºC, the same figure as the August mean for several places in northern and eastern Spain. Summer warming is not favourable, but it does not so far seriously affect the climate potential for tourism in Spain.

Table 1. Annual mean climatic data (1951-2011) for eight regions of Spain.

	OC	NW	MD	SU	MS	MN	NE	CN
Tm (°C)	13.8	12.0	13.7	17.0	18.0	16.3	13.2	19.9
ΔTm (°C)	+1.0	+0.7	+0.8	+0.8	+0.7	+1.0	+1.0	+1.5
Tx (°C)	17.6	17.8	19.5	23.2	22.2	21.1	19.1	23.3
ΔTx (°C)	+0.8	+1.0	+1.1	+0.7	+0.5	+1.0	+1.1	+0.8
Pt (mm/month)	114.3	47.9	37.0	40.4	37.6	44.6	43.0	23.3
ΔPt (mm/month)	–9.6	–3.3	–0.9	–4.8	–4.4	–1.2	–4.2	–8.6
Pd (day/month)	14.0	9.5	7.8	5.8	5.0	6.3	8.6	4.0
ΔPd (day/month)	+0.6	+0.5	+0.2	+0.7	+0.5	+0.5	+0.4	+0.5
Ss (%)	40.7	52.7	58.2	62.8	63.4	58.0	53.5	58.7
Vv (m/s)	3.5	2.9	2.4	3.1	4.1	3.1	3.2	5.1

Notes: Tm = daily mean temperature, Tx = daily maximum temperature, Pt = precipitation total, Pd = day with precipitation, Ss = ratio of sunshine duration to the astronomic maximum, Vv = wind speed, Δ = difference between the means for 1982–2011 and 1951–1980.
Source: own elaboration through AEMET data

Table 2. As per Table 1, but showing the mean climate in August.

	OC	NW	MD	SU	MS	MN	NE	CN
Tm (°C)	19.3	20.3	23.4	26.2	25.1	24.4	22.1	23.6
ΔTm (°C)	+1.4	+1.0	+1.2	+0.9	+0.7	+1.6	+1.6	+1.6
Tx (°C)	23.5	28.0	30.8	33.8	29.4	29.2	29.3	27.2
ΔTx (°C)	+1.0	+1.2	+1.2	+0.7	+0.4	+1.6	+1.5	+0.7
Pt (mm/month)	64.3	19.9	14.1	6.5	4.4	33.1	28.4	2.0
ΔPt (mm/month)	–3.4	+6.1	+1.9	+0.2	+0.5	–5.3	–0.5	–0.5
Pd (day/month)	10.6	4.3	2.9	1.2	1.0	4.5	5.3	0.7
ΔPd (day/month)	+0.7	+1.4	+0.8	+0.4	+0.5	+0.2	+0.8	+0.4
Ss (%)	49.5	73.1	78.5	79.2	75.7	68.0	69.2	68.5
Vv (m/s)	3.1	2.8	2.4	3.2	4.2	3.0	3.1	6.0

Source: own elaboration through AEMET data

Secondly, precipitation-climate is most frequently characterised by monthly or annual totals of precipitation. However, in considering tourists' climate requirements, the duration of precipitation is at least as important as its abundance. It is likely that the number of hours with precipitation would reveal a very close connection to tourism requirements, but that kind of data is seldom available. In this study, monthly precipitation totals and monthly mean numbers of precipitous days are examined.

According to Eugenio-Martin and Campos-Soria (2010) Pt = 60mm and Pd = 10 are critical thresholds in tourists requirements. Although strict thresholds should be avoided, these numbers are used as key values in the characterisation of precipitation-climate. Table 1 shows that only on the oceanic coast (and in the Pyrenees, not shown), does wet climate occur in Spain. In most parts of the country the annual mean Pt is only 35-50 mm, and in the southeastern part, as well as in the Canaries, it is less than 30 mm. The mean Pt for August is even smaller than the annual average. In summer there is very seldom any precipitation in most parts of Spain, and it is only in the extreme north that the August Pd reaches a value of 10 or slightly higher.

The average changes of Pt and Pd between 1951-1980 and 1982-2011 are also examined. Interestingly, while Pd slightly increased, the annual mean Pt declined all over the country. The degree of change detected in Pt is small, generally between –12 and –2 % of the averages for 1951-1980 (not shown), except in CN where this ratio is –27%. Note that, due to the sporadic occurrences of heavy precipitation events, the temporal changes of Pt detected might be explained by random fluctuations, at least partly, with particular reference to the Pt in August.

As a consequence, the precipitation-climate of Spain is generally very favourable from the point of view of tourists' requirements.

In terms of sunshine duration, Spain is a sunny country. The annual mean relative sunshine duration generally exceeds 50% except in the extreme North, where the typical Ss is around 40%. The August values are even higher than the annual means, and in Southern Spain they reach 75 – 80%. In the last decades a very slight increase (not shown) appears in the Ss. The large amount of sunshine in Spain all year round is a natural tourist attraction.

Finally, high winds are not favourable for outdoor programmes and therefore 6-8 m/s is generally considered to be the upper limit for good weather. Tables 1 and 2 show that both for August and the annual means, Vv is generally much lower than the threshold for good weather. Exceptions are the Canaries and some specific geographical locations, e.g. Gibraltar, as well as the Atlantic coast (mostly in winter), the Ebro valley and in certain sections of the eastern Mediterranean (not shown). Note that wind often has great spatial variability. A typical example appears in the case study of the hot spell in Volos (Greece): The heat was alleviated by a sea-breeze at the beaches, but the sea-breeze did not reach the observing station of the resort (Papanastasiou et al., 2010). Consequently, the Vv data that is presented in Tables 1 and 2 is not sufficient to provide a full characterisation about the wind-climate in Spain.

Taking the information on climatic variables as a whole, it can be concluded that Spain has a very good climatic potential for tourism from the point of view of tourism requirements. In the extreme north the most favourable season is the summer, in the interior it is the spring or the autumn, while the Canaries and the southern Mediterranean have rather pleasant weather all year round.

4. Joint analysis of hotel tourism data and climatic data

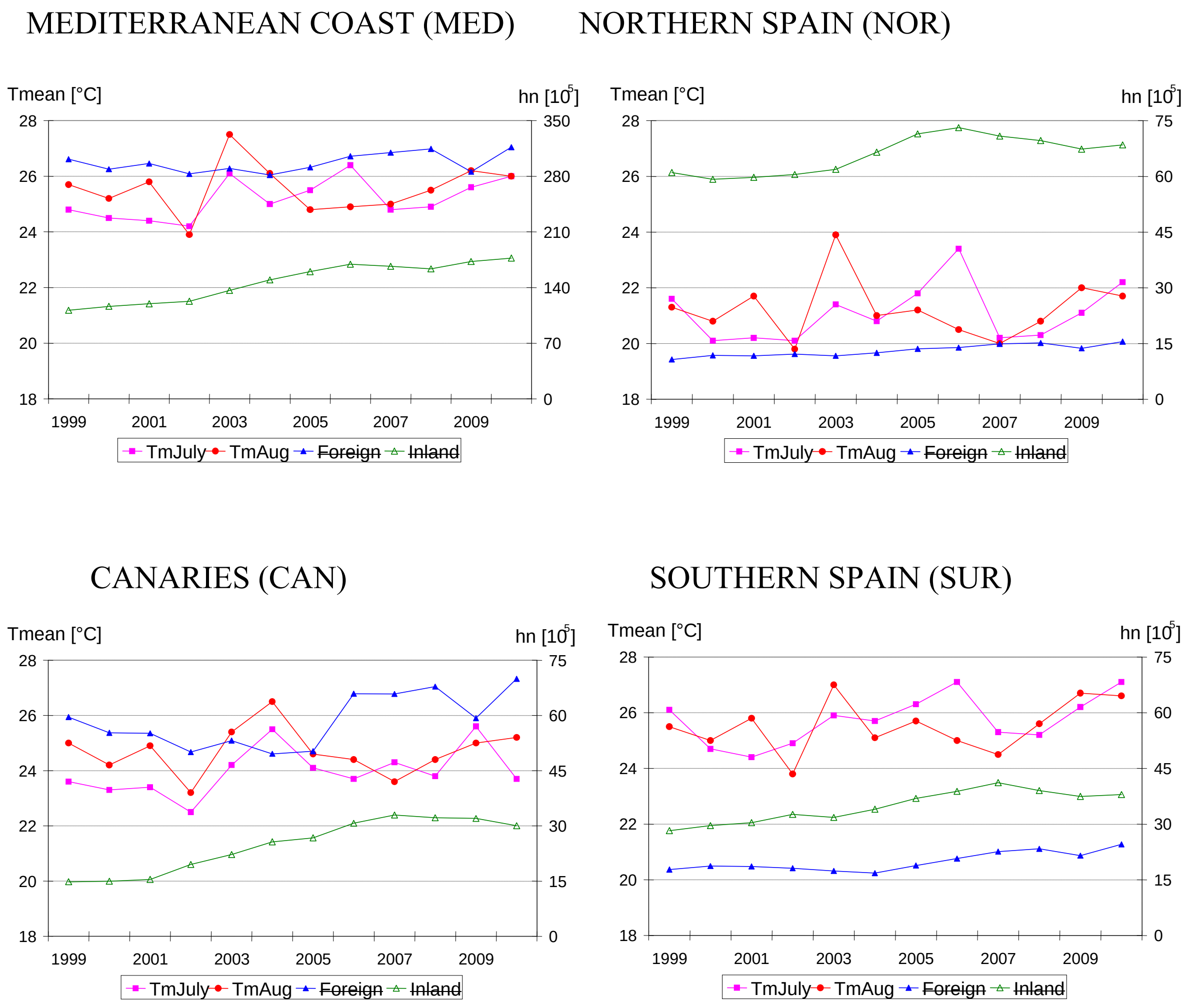
Climate may have a direct impact on tourism through its three distinct aspects, i.e. thermal, physical and aesthetic (Scott et al., 2009). As has been shown in Sect. 3, the mean characteristics for physical and aesthetic aspects are favourable in Spain with very few exceptions. Under the present climate, only the temperature can be considered a factor whose variability might substantially influence tourism activity, since the other climatic properties are mostly favourable (not taking account here specific activities, such as skiing, for example).

Hotel tourism (HN) in July and August is examined together with the monthly mean temperatures of July and August. The period of two summer months were chosen for two reasons: i) this period is generally the peak season for tourism, ii) high summer temperatures in Spain occur mostly in July or August and they may have unfavourable impact on tourism. The negative impact of high temperatures is likely to intensify with the progress of climate change or with the occurrence of extreme hot spells.

The HN data of the 52 Spanish provinces was sorted into four classes: a) provinces with a coastline on the Mediterranean (MED); b) northern Spain, without a coastline on the Mediterranean (NOR); c) central and southern Spain without a coastline on the Mediterranean (SUR) and d) Canaries (CAN). Note that Granada was sorted under SUR instead of MED, because its coastline is relatively short and the main tourist attraction of that province is its capital, which is quite far from the sea.

Fig. 1 shows the time evolution of July-August HN between 1999 and 2010 for the four main regions. First, its characteristics are evaluated without examining any connections with temperature. Five such characteristics seem to be important: i) hotels in Spain as a whole have more international visitors in summer than domestic ones, but this does not apply to all of the regions examined. ii) tourism in MED is overwhelmingly more intensive than in the other regions (note that in Fig.2a the scale of HN differs from that of 2b–2d). iii) beach tourism in Spain is particularly popular with international visitors, since the HN of MED + CAN account for about 90% of the total HN for them. The same ratio for domestic tourists is only around 65%, although its tendency is increasing. iv) the predominant overall tendency of HN between 1999 and 2010 is towards a slight increase and, in none of the areas examined, is there any tendency at all to a decrease. v) the increase of domestic tourism is larger than that of international tourism and domestic beach tourism experienced the most intense increase.

Fig. 1. Time evolution of overnights spent (HN) in July and August together with the variation of temperature (1999-2010)



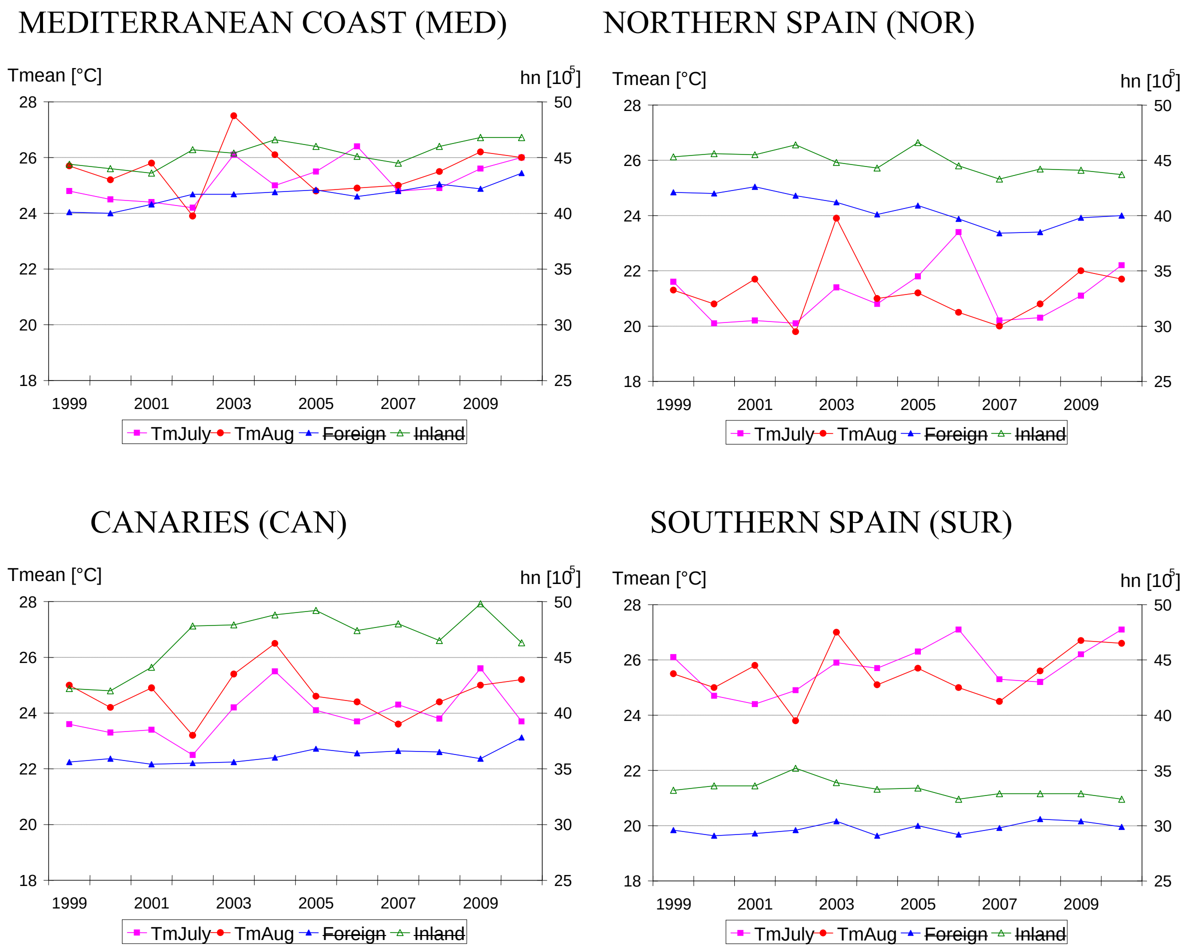
Source: own elaboration through AEMET and Spanish Statistical National Institute data

The climatic trend and its impact is not evident in a period of only 12 years, but the impact of extreme hot spells can be analysed. Assuming that hot weather distracts potential tourists, a decrease of HN is expected in connection with occurrences of extreme hot spells. Note that climatic anomalies often impact on the tourism activity of the following year rather than that of the anomalous period (Lise and Tol, 2002). An outstandingly extreme hot spell struck the Iberian Peninsula (and all of Western Europe) in August 2003. In Spain, that hot spell was most severe on the Eastern Mediterranean coast and the Balearic Islands, while it was absent in CAN. For instance in Barcelona, daily mean temperatures were higher than 30°C on ten consecutive days, an event which is unprecedented and whose probability remains very low for a long time in spite of the slight tendency towards warming. July 2006 was also extremely hot in the whole of Spain except for CAN, the summer of 2004 was extremely hot only in CAN, and that of 2010 only in SUR. The general lesson of Fig. 2 is that the impact of extreme hot spells on hotel tourism is very little if any. From 2003 to 2004, 3% (5%) decrease of HN is observed for international visitors in MED (SUR), and no other decrease of HN can be observed in relation with extreme hot spells. Even the decreases specified are well within the general spread of the data.

Protection against heat stress may imply that, in a hot climate, the ratio of summer visitors declines relative to the visitors during other seasons. To explore this type of argument, the number of visitors in July and August (HN of July and August) is examined in proportion to the total number of visitors during the half year of summer months (HN between May and October). Note that although this ratio also depends on the freedom of choosing a holiday period, the regional differences of the ratio do not. Fig. 2 presents the ratio of relative mid-summer HN (HNrm). Fig. 2 shows that i) HNrm is mostly between 40 and 50%, except in SUR and for international visitors in CAN, ii) HNrm is always higher for domestic visitors than for international ones, iii) the tendency between 1999 and 2010 increases for MED and CAN, is near zero for SUR (although a slight decline appears in domestic visitors) and declines for NOR, iv) extreme hot spells had no significant impact on the time evolution of HNrm.

One feature of the results in Fig. 2 confirms the predicted HNrm–temperature relationship, namely that HNrm is lowest in the region with the hottest summer climate (SUR). However, the spatial difference of the observed tendencies is surprising: HNrm declines only in the region with the lowest summer heat (NOR) and it rises or stagnates in the other regions. Our findings coincide with the results of other studies. Coshall (2009) analysed the holiday destination choices of people resident in England. He found that i) the number of English visitors to Spain increased, ii) the increasing trend was not influenced at all by the extreme hot event of August 2003, iii) when English citizens spend their holidays in Spain the concentration towards summer months clearly increases, while this seasonal concentration is less significant or does not tend to increase in many other destinations.

Fig. 2. Time evolution of relative midsummer rate of overnights spent (HNrm), together with the variation in temperature (1999-2010)



Source: own elaboration through AEMET and Spanish Statistical National Institute data

In Table 3, as a complement to the graphical analysis above, the correlation coefficients of the intertemporal temperature variations of both July and August have been calculated, as well as the demand indicators for the peak summer months, taking the absolute and relative values as used previously. However, this correlation analysis needs to be approached with caution given the low number of observations available. Consequently, the results should be viewed in terms of an initial exploratory analysis. Firstly, there is scarcely any evidence of an inverse correlation between temperature and tourism flows in Spain during the period analysed. In fact, the only significant result arises when a correlation is made between the region with the hottest August temperature and the domestic market. Secondly, the correlation tends to be either positive or without significance.

Table 3: Temperature Correlation Coefficients versus tourism flows in Spanish regions and midsummer months, 1999-2011

		Mid-Summer Overnight	Relative Mid-Summer Overnight	
	International	Domestic	International	Domestic
T-July				
MED	0.2486	0.6396*	0.4633*	0.4549*
NOR	0.1987	0.5181*	-0.2528	-0.2383
CAN	-0.0409	0.5029*	-0.1760	-0.0096
SUR	0.3217	0.4228*	0.1815	-0.0022
T-Aug				
MED	-0.0296	0.0561	0.1036	0.1656
NOR	-0.1379	-0.1227	0.2308	-0.0767
CAN	0.0976	0.5565*	0.0214	0.0957
SUR	0.1763	-0.6092*	0.5521*	-0.3912*

Note: *significant at a level of 5%
Source: own elaboration through AEMET and Spanish Statistical National Institute data

A possible explanation for this result is the different kinds of tourism existents in Spain.
Climate requirements and climate impacts are diverse according to the different kinds of tourism activity; therefore they are discussed further separately, mainly with its interaction to the required optimum temperature

A) Urban

Using statistical examinations, Lise and Tol (2002) find that 21°C is the general optimum temperature for tourism activities. When they examine the optimum for inhabitants of distinct European countries, the results are spread between 21 and 24°C. These results coincide closely with those of an international survey (Scott et al., 2009) in which 22.5°C was found to be the mean tourists' requirement for urban tourism. Based on these results, we believe that the consequences arising from general climate requirements can be applied equally to a wide range of tourism activities, e.g. sight-seeing, shopping and rural tourism. Note that in cultural programmes the tourists' comfort may depend on the actual programme, e.g. the climate requirements are different for visiting ancient monuments in a sunlit environment than for attending an evening open air concert.

The direct impacts of climate change are clearly positive from autumn to spring, but the increasing temperature is unfavourable for summer tourism in most parts of Spain (see also Perch-Nielsen et al., 2010). The overall impact may depend on how freely potential visitors can choose their holiday period.

B) Open air sport tourism

The climate requirements for open air sports sometimes differ substantially from the general requirements. The optimum temperature is generally lower, but for light sports the difference is small, e.g. in the survey mentioned by Scott et al. (2009). 20.5°C was found to be the optimum temperature for mountain tourism, i.e. a value that is lower only by 2°C than the optimum for urban tourism. Hereafter, we deal only with two special tourism activities in this section, namely beach tourism and ski tourism. These tourism activities are selected due to their popularity, economic importance and strong dependence on climate.

C). Beach tourism

“The Mediterranean is currently the world’s most popular and successful tourist destination” (Perry, 2006). In a survey of international visitors to Catalonia (Gómez Martín, 2004), it was found that 61% of them go to beaches outside Barcelona, 35% of them to Barcelona itself (they may prefer either urban tourism, beach tourism or a combination), and only 4% of them choose a destination far away from the seaside. The curiosity of this imbalance discovered in tourism activities is that, in Catalonia, a chain of high mountains (part of the Pyrenees) also exists, with attractive small towns and villages. Our data (Fig. 1) also shows that the vast majority of international tourists visit Spain to spend their time partly or fully at beach resorts of the Mediterranean or Canaries.

It is known that the optimal climate for beach tourism is warmer than for other tourism activities (Freitas, 1990, Hamilton et al., 2005, etc.). However, it is not easy to quantify the bias from the general thermal optimum. Various methods can be applied for the assessment: (i) calculation of the thermal balance of the body, (ii) *in-situ* and *ex-situ* surveys, (iii) watching the behaviour of beach-users with web-camera, (iv) expert assessments.

The thermal balance calculation of the body is theoretically the most objective way (Becker, 1998, Staiger et al., 2012, etc.), however, the large data-demand of these methods and the unavoidable use of subjectively set parameters seriously limit the practical use of these methods. In *in-situ* surveys, beach users are interviewed on the spot on their feelings about temperature. For instance, in an *in-situ* survey, Gómez Martín (2006) found that 22-28°C is the most pleasant temperature for the beach users of Catalonia. A partly similar result was obtained in the international *ex-situ* survey of Scott et al. (2009), i.e. 26.8°C was the average optimum temperature for the people interviewed. The latter values show that surveys prove a bias of only a few degrees from the general optimum temperature. By contrast, web-camera observations show the most intensive use of beaches is during the time of more elevated temperatures (Ibarra, 2011). However, it is only an apparent contradiction. The use of the beach under hot conditions does not prove that users would not prefer it to be less hot. On the other hand, the observed data of beach users’ habits fits in poorly with the results of the surveys. Our results illustrate that the seasonal concentration on the hottest month is a clearly increasing trend (Fig. 2) and that this trend is specific to HN in beach resorts. Relying on web-camera observations, Ibarra (2011) reported that for the second most popular beach in the world, that of Benidorm, more people take their holiday during the hottest month (August) than during the seasons declared to be those with an optimum temperature. Summer visitors to Benidorm could choose less hot and more easily accessible Mediterranean resorts from a wide selection lying north of Benidorm. (Benidorm is very far away from Spain’s two largest international airports which are in Madrid and Barcelona, and also very far from the French border.) Web-camera data also shows that the beaches in Benidorm were intensively used during the hottest hours of the day in August (Ibarra, 2011).

One objective result that comes out of further discussion on thermal requirements and heat tolerance is that above a daily maximum temperature of 30.5ºC, the rate of mortality dynamically increases. Given that the daily temperature range at the seaside is small, above 30°C Tx-s are usually paired with warm nights (22-25°C, or sometimes even warmer). These conditions might cause serious heat stress even for healthy people. However, the use of air conditioners may avoid a great deal of the heat impact. Consequently, the importance of pleasant natural thermal conditions is substantially greater for low-cost tourists than for hotel users.

Some studies communicate that the focus of summer tourist flow will shift to the northern part of Europe with the progression of global warming (Perch-Nielsen et al., Amelung and Moreno, 2012, etc.). However, the authors cannot accept this conclusion because the observed data of beach users’ habits does not support their presumed sensitivity to heat stress. There are two further arguments: a) the temperatures of the North Sea and the Baltic Sea will still not very pleasant even after a 2-4°C warming; b) the optimal temperature depends on the home-climate (Lin and Matzarakis, 2011), thus with a warming climate, a positive shift in thermal requirements can be expected.

As resulting we can notice a differentiate temperature range depending on the tourism typology, and the highest optimal temperature occurs in beach tourism, the most common in Spain
Therefore, it can be concluded that climate is often not the dominant factor in holiday planning, and hot climate and hot spell occurrences in particular have less impact on hotel users’ holiday planning than what could be predicted from heat comfort and heat stress calculations. Note that air conditioning is generally provided in Spanish hotels, and thus the presented results cannot be extrapolated to climatic impacts on low cost tourism.

5. Future climate and the risk of extreme events. Indirect climatic impacts on tourism.

The anthropogenic climate change, known also as global warming, is perhaps the most frequently discussed topic in natural sciences. Looking through the main statements of the IPCC (2007), one can see that a series of unpleasant or even dangerous changes are predicted for the distant future if the increase of greenhouse gas concentration in the atmosphere is not stopped. On the other hand, over the next few decades, the effects seem to be relatively minor. Making projections for the next 50 years, even with further intense emissions (A2 scenario of IPCC), the most likely degree of warming is 1.5–2.0 °C, while a rise in sea level of 10-25 cm is anticipated. Given that this study focuses on the analysis of present and near future climatic conditions, the global warming effects might seem to be insignificant. However, the picture is not so simple on a regional scale and, moreover, the analysis of observational data (Sect. 3) tends to show that the climate of Spain is already experiencing the first unfavourable changes (e.g. the increase in summer temperature).

We have some knowledge about the tendencies of climate change, but climate predictions have substantial uncertainty. The best scientific tools are the global circulation models (GCM), regional circulation models (RCM) and the comparison of model results with observed climatic data.

The observed data suggests that warming is at least twice as fast in Spain as the global average. However, the difference observed between the regional and global means cannot be extrapolated into the future. The examination of historical data proves that the climate has irregular fluctuations both on a global and regional scale (not shown), with these fluctuations usually having a positive correlation, although their temporal trends may differ substantially. Even in the era of global warming, not all the observable temporal changes belong to that phenomenon. This fact makes it particularly difficult to predict the future climate.

The main climate research centres in the world develop mathematical models which describe the physical and chemical processes of the atmosphere, often together with the processes in the ocean and at the polar ice sheets. These models can reproduce past changes and predict future states of the atmosphere quite well, but developers struggle with the fact that such a model never can include all the important details of real atmospheric processes. For this reason, the predictions of individual GCMs and RCMs often differ substantially. Yet, for practical purposes, the coincidences between the results of different models are more important, namely all the GCMs currently used show that warming will continue, and all the models suggest that in the Mediterranean region, in common with many other subtropical regions of the world, the summer precipitation will decrease.

Using a multi-model experiment with 13 GCMs, Cattiaux et al. (2011) have predicted that the difference in mean warming between 1961-2000 and 2045-2065 for the mid-latitude areas between 10°W and 30°E (a great part of Europe and the western Atlantic) will be 1.9°C in spring and around 2.6°C for the other seasons. In another experiment (Déqué et al., 2011), European warming between 1961-1990 and 2021-2050 was examined with 13 RCM-GCM pairs. Its results indicate greater warming for summers than for winters in the Iberian Peninsula and generally throughout Europe. The mean warming predicted for Spain is 2.0°C. In the same study, a significant decrease of summer precipitation is predicted for Spain and for most of the Mediterranean region. As for winter precipitation in Spain, an increase is predicted, but with less statistical significance than for the summer decline.

The characteristics of precipitation-climate are particularly important for Spain, because the possible increase of aridity may cause serious problems in different ways, initially through the decline of freshwater stocks. One cause of the predicted precipitation decline in summer is clear to the researchers, i.e. it is due to the northwards shift of mid-latitude storm-tracks in a warmer climate. On the other hand, the uncertainty of winter precipitation is related to the persistence and dominant position of regional anticyclones, the characteristics of which are very unpredictable. Precipitation-climate also has other influential factors; see more discussions about them in, for example, Scheff and Frierson (2012), and Hoerling et al. (2011).

On the other hand, a favourable characteristic of the Spanish climate is that tropical storms do not develop in the region. However, mid-latitude cyclones sometimes cause very high winds, particularly on the oceanic coast. Among the other climatic extremes, mention is made of hot spells, cold spells, heavy precipitation and drought. These events may have direct and indirect impacts on tourism, but the occurrence of extreme events under the present climate is rare and their intensity is usually tolerable, thus their overall effect is relatively small. A particular problem related to climate change is that even with a small shift in climatic means, the frequency or intensity of extreme events might substantially change: first of all, together with the rise in mean temperature, the frequency and intensity of cold spells decrease, while those of hot spells increase (Cattiaux et al., 2011); and second, the frequency of heavy rain events is likely to increase for thermodynamic reasons, though regional circulation changes might neutralise the thermodynamic potential. The results of Sect. 3 suggest that in Spain the precipitation intensity is decreasing, since in the last three decades less precipitation fell on more precipitous days than in the earlier section of the observed data. However, for a more profound evaluation, the examination of the distribution function of precipitation amounts is needed. That was done by García et al. (2007) for the Iberian Peninsula, using daily precipitation data of the period 1958-1997 for 35 raingauge stations. Their results show that while the frequency of heavy rain events decreases in general, there are several regional and seasonal exceptions. More interestingly, the general tendency is reversed in trends for very rare extreme precipitation events, (events with an estimated return period of 20 years) i.e. there are more trends showing increases rather than the opposite. García et al. (2007) note that the results must be interpreted with caution due to the shortness of the examined period. However, Homar et al. (2010) obtained similar results with the examination of precipitation data from the Balearics for the period 1951-2006. To sum up, the frequency of the most heavy (rare) extreme precipitation events is likely to increase in Spain. Note that heavy rains have little impact on tourism, so long as they do not result in flooding.

- Generally, no change is predicted for the frequency of storms in connection with global warming, but in reality this means that either a decline or an increase is possible.
- The frequency and intensity of drought events will increase, firstly due to decreasing precipitation (Sect. 4.1), secondly due to increased evaporation in a warmer climate and thirdly because the duration of dry periods (series of days without precipitation or with an insignificant amount of precipitation) are likely to lengthen (Sánchez et al., 2011). The increasing trends in the frequency and intensity of drought events are not only predictions, but they also characterise the present and near past climate, as has already been shown and analysed for the entire Mediterranean region by, for example, Hoerling et al. (2011).

Freitas writes in a book review (2009) that "Climate change occurs much more slowly than socio-economic factors related to tourism." Although this is absolutely right when taking only the mean climatic tendencies into consideration when planning for short or medium-long periods, the problem of climate change is that new extreme events may appear with characteristics that beat any earlier records. This is what happened in the summer of 2003 throughout a large part of western and south-western Europe (Perry, 2006). The question of whether such a record-breaking extreme event could or could not have occurred without global warming cannot be answered with full certainty, because scientific tools have limited ability in determining the roles of specific influential factors in distinct climate and weather events. However, the authors believe that the question posed has little practical importance. The point is that with changing climate, society should be prepared to deal with the most frequent and intense occurrences of certain kinds of extreme climatic events, regardless of whether such events can or cannot occur in an imaginary climate with a constant greenhouse effect.

Climate may influence the capacity, the prices (through the costs of maintenance), and even the aesthetic characteristics of tourist destinations. Indirect impacts can be positive or negative on tourism, but unfortunately the most important indirect impacts of the predicted regional climate change in Spain are negative. The positive indirect impacts can be summed up as follows:

(i) Together with the tendency towards general warming, the frequency and intensity of cold spells decrease. At low geographical altitudes the occurrence of snow and ice also decreases. These changes reduce heating costs, favour winter transport and reduce the costs related to cleaning roads and of other public services.
(ii) Mild springs and autumns may lengthen the seasons of the resorts which will tend to make the business more economically viable.
(iii) An increase in sea temperature may attract even more beach users, and the duration of the beach-season will lengthen.
(iv) Hot summer weather in the lowlands may favour mountain resorts (Serquet and Rebetez, 2011) since many people search for places with a pleasant climate for open air leisure activities.

On the other hand, the most serious negative indirect impacts are related to the increasing frequency and severity of drought events. Unfortunately, Spanish freshwater stocks are highly sensitive, because the ratio between water use and accessible freshwater is high. In the central and southern parts of Spain this ratio is higher than in most other parts of the Mediterranean region (Arnell et al., 2011, Ridoutt and Pfister, 2010). Mention has already been made of the fact that it is precisely these regions of Spain that are prone to suffer from severe droughts even in the present climate. In spite of these facts, evaluation of the relative vulnerability of the Spanish freshwater supply is diverse in international studies. Perch-Nielson (2010) reported relatively low vulnerability, (the eleventh best position among 51 countries), because Perch-Nielson judged Spain to have a very favourable adaptation capacity (the third best following Australia and New Zealand). Note that Perch-Nielson used data from before the economic crisis. A very different picture is presented by Gössling et al. (2012) in which the relative vulnerability of the Spanish water supply occupies a clearly bad position among the 55 countries examined. It has been mentioned that episodes of critical freshwater shortage have already occurred in Spain (e.g. in Mallorca, Perry, 2006). Freshwater scarcity can be serious on several distinct levels, which are discussed further in Sect. 8. Another group of negative impacts is related to the maintenance of high quality beaches. These impacts are also important, since several beaches are already overcrowded (Sardá et al., 2009) or their quality is under the expected level (Roca et al., 2009). The list of unfavourable climatic impacts is as follows:

(i) Droughts may have further indirect impacts through the increasing prices of freshwater, deterioration of landscapes (due to the death of the vegetation or dried-up streams), and the increased risk of forest fires.

(ii) Hot spells cause an enhanced use of air-conditioners that increases the costs, and could also overload the national grid (Perry, 2006, Vine, 2012).
(iii) Hot spells elevate the risk of forest fires.
(iv) Drought and hot spells may cause substantial natural and economic loss which ultimately may lead to the decline of popular tourist destinations.
(v) Rising temperatures of natural water is unfavourable for water quality (Beuitez-Gilabert et al., 2010). New diseases and epidemics might appear.
(vi) A specific problem is the cementation of beach sediments (Vousdouskas et al., 2009). This is a natural formation of beach rocks from fine sediment and it adversely affects beach quality. It has been demonstrated (Vousdouskas et al., 2009) that rising temperatures intensify this process. Rocky beaches are less safe and thus less valuable than sandy beaches without stones and rocks in the bathing area.
(vii) Rising sea levels contribute to coastal erosion which raises the cost of beach maintenance.
(viii) Increasing frequency of extreme precipitation events may contribute to coastal erosion.
(ix) The maintenance of ski resorts becomes more risky with the growing uncertainty of snow availability.

6. Conclusions

In this study two main areas have been explored. Firstly, the climatic potential of Spain and its regions has been assessed according to a variety of climate vectors. To do this, it was necessary to perform the intensive task of the standardization and the spatial and temporal vetting of the climatic data obtained from the various weather stations positioned throughout the country. Finally, it was felt that the data provided by 71 of those stations offered a reasonable level of representation across the territory. The climate vectors used were temperature, with various indicators, precipitation, sunshine hours and wind speed. Evaluating this information has revealed that the climatic potential of Spain is good except for the temperature levels in the summer, which would be above the established levels of comfort.

Secondly, and given the previous result obtained by temperature indicators, a study was made of the hypothesis regarding an inverse relationship between temperature increases and tourism flows in Spain during the available period. For this, data was used on overnight stays in hotels during the months of July and August, which are the busiest months and those which, to a great extent, are able to provide this correlation for the period 1999-2011. Additionally, the analysis was split between four climatic regions. The results show that, despite the increase in temperatures, the number of overnight stays spent in Spanish hotels generally increased both for international and domestic visitors. The increase is, in fact, higher in the hottest months (July and August) than at other times of the year. Thus, the data shown in the study generally refutes the hypothesis of declining tourist demand due to rising temperatures in the Mediterranean.

However, the indirect climate impacts themselves, together with the rising number of visitors (and thus the more intensive use of natural resources) is a challenge for tourism management. Although the mean warming tendency is small, the risk of certain extreme climatic events will increase and they are generally not predictable well in advance. The development of drought events is gradual and therefore the appearance of harsh conditions is often foreseeable a few months in advance. By contrast, extreme hot spells and heavy rain events are less predictable.

Many studies point out the importance of regulation in the tourism sector (Jang, 2011, Guizzardi and Mazzocchi, 2010, etc.). It is particularly important for Spain, because in this country tourism activity is high, the natural resources are sometimes scarce and, according to our current knowledge, global warming will have significant unfavourable impacts. The future changes cannot be quantified with adequate certainty, but the extreme climatic events of the current climate may be used as models for future states (see e.g. Pickering, 2011). The climate-related indirect impacts do not affect popular tourist destinations equally, since both the vulnerability and the possibilities of adaptation depend on local conditions. Guizzardi and Mazzocchi (2010) point out the necessity of strategic planning on a local level.

An essential point of strategic planning in tourism is that executable plans are needed for responding well to unusually unfavourable conditions. Such conditions might occur for climatic or non-climatic reasons, or due to a combination of climatic and non-climatic reasons. Few things could cause such serious harm to tourism as a situation in which tourists remain without electricity or freshwater supply due to the exhaustion of those resources. For Spain in general, the freshwater resource seems to be the most fragile point in strategic planning. In Spain, 32% of the renewable freshwater was used in 2000, a ratio which indicates high vulnerability (Gössling et al., 2012). The freshwater consumption of tourism was 12% of the domestic consumption over the same period. This ratio is the fifth highest among the 55 countries examined, with higher ratios only occurring in Mauritius, Cyprus, Malta and Barbados. Note that Gössling et al. took account of only the direct freshwater consumption of tourism; the water that was used for the products consumed by tourists was not considered.

At present the security of the freshwater supply is probably lower than it was in 2000, since tourism has grown and the climate has gradually tended to be drier. A critical point for strategic planning is that stakeholders and managers are interested in the further growth of the tourism industry, but the *per capita* water consumptions of tourists is higher than that of the local residents. Gössling et al. (2012) give advice how the *per capita* water consumption of the tourist sector could be reduced. Such regulations might be unavoidable in the future, but the secondary signs of water scarcity, and even information about it, might deter some affluent visitors. Ultimately, regulations may include restrictions for the expansion of tourism to assure the freshwater needs of local residents and to avoid the danger of the exhaustion of the freshwater stock. One aspect of introducing such a regulation is that the maintenance of luxury tourism could be favoured, since 80% of the profit is produced by 20% of the visitors (Kozak and Martin, 2012). However, this problem is more complex, because: i) in luxury tourism, freshwater consumption is very much higher than in low cost tourism (e.g. the *per capita* consumption in a 4 star hotel is approximately two times higher than in a 2 star hotel, Gössling et al., 2012); ii) The maintenance of high quality service for diverse cost-categories has also ethical, social and political implications which also form part of the image of a country. Nevertheless, local adaptation may include restrictions that harmonise better with local conditions and are not characteristic of the general operation of the tourism sector.

Our main conclusion is that the indirect impacts of climate change and the expansion of tourism is a big challenge for tourism management in Spain. High level regulation is needed based on strategic planning for tourism. The strategic planning and regulation system must serve to be able to prepare for extreme events, to be sensitive to the demands of the tourists and local residents, include the continuous training of employees within the tourist sector, and to be transparent to the public.

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