VU VRIJE UNIVERSITEIT AMSTERDAM

VU Research Portal

The impact of climate change on tourism in Germany, the UK and Ireland: a simulation study

Hamilton, Jacqueline; Tol, Richard

published in
Regional Environmental Change
2007

DOI (link to publisher)
10.1007/s10113-007-0036-2

document version
Publisher's PDF, also known as Version of record

Link to publication in VU Research Portal

citation for published version (APA)
Hamilton, J., & Tol, R. (2007). The impact of climate change on tourism in Germany, the UK and Ireland: a simulation study. *Regional Environmental Change*, *7*(3), 161-172. https://doi.org/10.1007/s10113-007-0036-2

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

E-mail address:
vuresearchportal.ub@vu.nl

Download date: 28. Mar. 2024

Reg Environ Change (2007) 7:161–172
DOI 10.1007/s10113-007-0036-2

ORIGINAL ARTICLE

The impact of climate change on tourism in Germany, the UK and Ireland: a simulation study

Jacqueline M. Hamilton · Richard S. J. Tol

Received: 3 August 2006 / Accepted: 7 May 2007 / Published online: 25 July 2007
© Springer-Verlag 2007

Abstract We downscale the results of a global tourism simulation model at a national resolution to a regional resolution. We use this to investigate the impact of climate change on the regions of Germany, Ireland and the UK. Because of climate change, tourists from all three countries would spend more holidays in the home country. In all three countries, climate change would first reduce the number of international arrivals—as Western European international tourist demand falls—but later increase numbers—as tourism demand from increasingly rich tropical countries grows. In Ireland and the UK, the regional pattern of demand shifts is similar to the international one: tourism shifts north. In Germany, the opposite pattern is observed as the continental interior warms faster than the coast: tourism shifts south.

Keywords International tourism · Domestic tourism · Climate change · Regional impacts

J. M. Hamilton (✉)
Research Unit Sustainability and Global Change,
Hamburg University and Centre for Marine and Atmospheric Research, Hamburg, Germany
e-mail: jacqueline.hamilton@zmaw.de

R. S. J. Tol
Economic and Social Research Institute,
Dublin, Ireland

R. S. J. Tol
Institute for Environmental Studies,
Vrije Universiteit, Amsterdam, The Netherlands

R. S. J. Tol
Engineering and Public Policy,
Carnegie Mellon University,
Pittsburgh, PA, USA

Introduction

Climate is a crucial resource for tourism. Climate change would have a profound impact on tourism. This was largely ignored in earlier impact studies (Smith et al. 2001)—but a series of papers has emerged recently (for reviews see Scott et al. 2005; Hamilton 2006; Hamilton and Tol 2004). These studies of the impacts of climate change on tourism either investigate the fate of a single region—ignoring the wider context of national and international competition for tourists—or study tourism at the national level—ignoring that tourists tend to be highly spatially concentrated. This study is a first step towards reconciling the local and global aspects of the impacts of climate change on tourism.[1]

We use an econometric simulation model of domestic tourism in countries and of international tourist flows between 207 countries (Bigano et al. 2005). We combine that model with the subnational data-sets of domestic and international tourism of Bigano et al. (2004),[2] and we develop a downscaling method that is consistent with the assumptions in the country model. We apply this to Germany, the UK and Ireland; these are countries for which we have good data and with which we are familiar. There are notable differences between the three countries: Germany is large, and its climate is part maritime and part

[1] Note that weather and climate are different. Climate is what you expect, and weather is what you get. Climate, that is the expected weather, is important for planned holidays. Weather is important for behaviour during holidays, and for spontaneous (short) trips, although it may also distort climate perceptions.

[2] Both domestic and international tourism data include holidays, business travel, visits to friends and relatives, and pilgrimage. Tourists stay at least 24 h at their destination, and at most 365 days. Note that labour migrants, particularly seasonal ones, often masquerade as tourists.

continental; Great Britain is large, and its climate is maritime but with a pronounced north–south gradient; Ireland is small with a fairly homogenous maritime climate; the island of Ireland is shared between the Republic of Ireland and the UK. The differences between these three countries allow for speculative extrapolation to the regional impacts of climate change on tourism in other countries. Germany, Ireland and the UK account for 24.5% of all international tourist departures. However, the innovation of this paper lies in the regional downscaling within the countries. Together, the three countries receive 7.5% of all international arrivals, and they generate 6.3% of all domestic tourists (Bigano et al. 2004).

The paper is structured as follows. The second section presents the model used. The third section shows selected results at the national and regional level. The fourth section concludes.

The model

The model consists of one component predicting tourism flows between countries and domestic tourism in countries. This is described in the second part of this section. A second component which scales national tourist numbers down to the regions of Germany, Ireland and the UK is described in the third part of this section. But first we will discuss the advantages and limitations of this approach in the following section.

Advantages and limitations of simulating tourism flows

The Hamburg Tourism Model (HTM) was developed based on the identification of several gaps in the existing literature on the impact of climate change on tourism. Existing studies have looked only at particular countries, particular environments or particular activities. Often these studies examined either inbound tourism, outbound tourism or domestic tourism. This means that substitution between destinations and between domestic and outbound tourism had been completely overlooked. Substitution, however, is a vital issue, as climate change will occur globally and not just in particular countries or regions. In addition, there is the issue of climate as a push factor, which is related to substitution. Not only can the attractiveness of a country's climate be a factor in the decision to take a holiday there or in the decision when to have a holiday there, the climate, or rather the relative attractiveness of the climate, of the origin country is also a factor in influencing whether to have a domestic holiday or to travel abroad. The HTM tries to fill these gaps by estimating the demand to travel from all countries of the world, estimating the shares of domestic travel and international travel and estimating the demand for each of the countries in the world. In comparison with traditional demand estimation, which typically uses only economic indicators, the HTM uses environmental indicators such as area, length of coastline and temperature to predict demand.

The limitations of the HTM have been discussed in other articles using the simulation model (Hamilton et al. 2005a, b; Bigano et al. 2005) as well as in review articles (Bigano et al. 2006; Goessling and Hall 2006a, b). These can be summarised as follows. The tourism data used is problematic. Ideally, we should use monthly data broken down by trip purpose. Unfortunately, such data is only available for a few countries and even then it is incomplete. The World Tourism Organisation, which compiles the national tourism data used to produce the core equations of the HTM, also uses the same data to make forecasts until 2020 (WTO 2001). For some of the countries in the HTM data for arrivals or departures had to be estimated. Another limitation is that climate is only proxied by temperature in the equations that run the HTM. Climate is of course more complex than just temperature and tourists are not just interested in temperature. The complexity of climate and the interdependency of the various variables used to measure climate make it difficult to include more than one variable in a statistical analysis. Temperature, however, is the one variable that is statistically significant in all econometric studies of climate and tourism demand, and also the one variable that is always available in climate data sets—whether historical data or projections. A case study of German leisure tourists found that only 12% of tourists did not find temperature important (Hamilton and Lau 2005). Moreover, climate assessments using the Tourism Climate Index such as that by Amelung et al. (2007) also rely heavily on temperature data. The temperature data used in the HTM studies is the average for the whole country, which is an improvement on other studies where data for capital cities has been used. Another problem with HTM, indeed with any simulation model of social phenomenon, is that the future drivers of demand are uncertain. The scenarios used to drive the HTM include changes in population size and in GDP. While these factors are known to influence demand, other factors such as disposable household income and available leisure time may also affect demand. Unfortunately, data on such factors is only available for some countries and there are no long-term scenarios; therefore, these aspects cannot be modelled at present. The impact of random events, such as acts of terrorism or natural disasters, can, of course, not be modelled by the HTM.

There are several other shortcomings of the HTM. Its resolution is crude. It does not distinguish seasons, nor classifies tourists by age, income or trip purpose. Spatially, the model is restricted to countries. This paper only improves on the last shortcoming by downscaling to regions.

Amelung et al. (2007) is the only paper that is similar to ours, in the sense that their analysis is global with a reasonable amount of regional detail. Using a tourism climate index and two scenarios of climate change, they find that climatically ideal conditions for tourism are likely to shift towards the poles. Furthermore, they find that some destinations will see their peak season move away from the summer to the shoulder seasons and that destinations at higher latitudes could experience a longer summer season. Their analysis is, however, restricted to the supply side of tourism and the reaction of demand to the predicted changes in the supply of the tourism product (i.e., climatic attractiveness) is only speculated upon by Amelung et al. (2007). The tourism climate index used is mostly based on biophysical principles of human comfort. Other aspects of climate that have been decided to be important for tourists without any empirical evidence are also included. While the index may capture climate in a more complex way than the HTM does, the index ratings of the suitability for tourism are set arbitrarily and are again not based on empirical studies.

Tourism flows at the national level

We use version 1.2 of the Hamburg Tourism Model (HTM), an econometric simulation model of tourism flows in and between 207 countries. Version 1.0 is described by Hamilton et al. (2005a), version 1.1 by Hamilton et al. (2005b) and 1.2 by Bigano et al. (2005). The econometrics are inspired by Maddison (2001), Lise and Tol (2002) and Hamilton (2003), while the data are as in Bigano et al. (2004).

HTM works as follows. The number of tourists that a country generates depends on the size of the population and of average income. The share of domestic in total tourism depends on the climate in the home country and on per capita income. Climate is proxied by the annual mean temperature. A number of other variables, such as country size, were included in the estimation, but these factors are held constant in the simulation. International tourists are allocated to all other countries on the basis of a general attractiveness index, climate, per capita income in the destination countries, and the distance between origin and destination. Again, other explanatory variables were included in the regression for reasons of estimation efficiency, but these are held constant in the simulation. The number of international tourists to a country is the sum of international tourists from the other 206 countries. See Bigano et al. (2005) for further details.

The core equations are estimated using 1995 data, and the model is further calibrated, so that the model almost perfectly reproduces the observations on the number of domestic tourists, international arrivals, and international departures. More convincingly, the model also reproduces international arrivals and departures for the years 1980, 1985 and 1990. Data from these years were not used to calibrate the model. The correlation between observed and modelled international arrivals in 1995 is almost perfect. For the other years, the correspondence between observations and modelled values is never below 92%. For 1985, 1990 and 1995 the correspondence between observations and model results for international departures is between 91 and 94%. Only for 1980 does this drop to 79%. See Bigano et al. (2005) for more information on validation.

The Hamburg Tourism Model and its results depend on a number of parameters, each of which is uncertain. Hamilton et al. (2005a) present sensitivity analyses of the effect of changing the distance parameter (travel costs) and the income elasticity. They find that changing these parameters has a major effect on the baseline results but only a minor effect on the impact of climate change on international tourism. Similar sensitivity analyses are carried out for domestic tourism (Bigano et al. 2005). Changing the parameters for temperature and the scenarios of climate change has a greater impact on the results (Bigano et al. 2005; Hamilton et al. 2005a, b). Another issue is the saturation point of demand. Currently demand saturates at 12 trips per person per year. Hamilton et al. (2005b) find that changing the saturation point for international trips affects the absolute numbers of international tourists but the relative impact of climate change is similar.

The model shows that with climate change countries at higher latitudes and altitudes will become more attractive to tourists, to both domestic tourists and those from abroad. Tourists from the north west of Europe currently dominate international tourism,—the Germans, the Irish and the British together account for 25% of the international tourist market—which implies that the world total of international tourist numbers initially falls because of climate change. The model also shows that the effect of climate change is much smaller than the combined effects of population and economic growth, at least for most countries.

Downscaling

The Hamburg Tourism Model operates at a national scale, tracing domestic tourism in 207 countries and international tourism flows between those countries. In addition to analyses at the national level, the data presented in Bigano et al. (2004) allows us to look at a finer spatial resolution. For the majority of the regions, the resolution of the data is at the NUTS2 level. For Germany, this coincides with the administrative regions (Regierungsbezirke) within the larger states. The smaller states, however, are represented at the NUTS1 level, which is equivalent to the federal state (Bundesland). In total there are 40 regions. For the UK, we

have data for 34 NUTS2 regions and London and Northern Ireland (both NUTS1). For Ireland, we have data for 8 NUTS2 regions, which are equivalent to the regional authorities.

We cannot increase the resolution of the model. Although we have data on where tourists go at a regional resolution, we do not have data on where they are from. This prevents us from re-estimating the empirical relationships that underlie HTM.

Instead, we downscale the national results of HTM to the 84 regions. The downscaling method distributes the national numbers of domestic and international tourists over the constituent regions. For the year 1995, this allocation is identical to the observed distribution.[3] We split the allocation into a climate component, C, and an "all other factors" component, O. For instance, 3.5% of all international tourists in Germany visit Stuttgart (and its surroundings). The climate component equals $C = 0.22T - 0.00791T^2$. The other component is set such that $CO = 3.5\%$, that is, $O = 0.035/(0.22T_{1995} - 0.00791T_{1995}^2)$. The values of C and O are calculated for every region. O is held constant over the simulation period. As the values of C change due to climate change, the market share will alter.

As the climate varies from north to south and from east to west, even a uniform warming of the British Isles and Germany would lead to a regionally differentiated pattern of climate change impacts on tourism. However, a uniform warming is not expected. We use the regional climate change scenarios from ATEAM for Germany and from UKCIP for the British Isles.

Results

National level

Germany

Figure 1 shows the annual number of domestic holidays taken by German tourists according to four alternative scenarios without climate change (left panel), as well as the impact of climate change on these numbers (right panel). In all scenarios, depending on the assumed population and economic growth, domestic holidays increase considerably over the century: by the end of the century they have increased by a factor of 2 (scenario A2) or by a factor of 10 (scenario A1). Climate change increases the number of domestic holidays taken by Germans by 25% (scenario B1) or up to 35% (scenario A1); the greater climate change is, the greater the effect on tourism is.

The development, through the century, of international departures by German tourists is shown in Fig. 2. The pattern is much the same as for domestic holidays. In the A1 scenario, total tourism demand (domestic plus international holidays) almost saturates at the (assumed) maximum of one holiday a month. Figure 2 also shows the effect of climate change. As total tourism demand is independent of climate, the effect of climate change on international departures is practically the mirror image of the impacts on domestic holidays shown in Fig. 1. Climate change would lead to a strong shift in German tourism away from foreign destinations towards domestic ones. (Note that Germany is a big country. Holiday makers do not necessarily stay close to home.)

Figure 3 shows the development of international arrivals of tourists in Germany. Without climate change, numbers increase but not as rapidly as domestic tourist numbers. This is primarily because population growth in Eastern Europe (a major source of tourists to Germany) is assumed to be slower than in Western Europe. Climate change would first reduce the number of international arrivals—as tourists from the main source markets prefer a holiday in the improved climate at home—but later it would increase these numbers—as Germany acquires a more pleasant climate relative to the countries of Southern Europe.

The UK

The development of domestic holidays in the UK shown in Fig. 4 is similar to that depicted in Fig. 1 for domestic holidays in Germany. For the UK, however, we see that in the A1 scenario saturation sets in before the end of the century. The British were already taking on average three holidays per person per year in 1995, compared to two holidays per person per year in Germany. Climate change would increase domestic holidays in the UK, but later in the century, the relative increase falls as the UK becomes too hot.

Figure 5 shows international departures from the UK. Again the pattern is similar to that seen for Germany, but departures saturate in the A1 scenario. Climate change reduces international departures almost to zero.

International arrivals to the UK grow less rapidly than domestic tourism. The development of arrivals through the century is qualitatively similar to that depicted for Germany, but the difference is smaller as Eastern Europeans are less dominant in UK arrivals. Due to climate change, international arrivals first fall and then rise (Fig. 6).

[3] Note that we have regional data for domestic and international tourists for the UK, but international tourists only for Ireland; in the latter case, we assume that domestic tourists have the same regional preferences as international tourists.

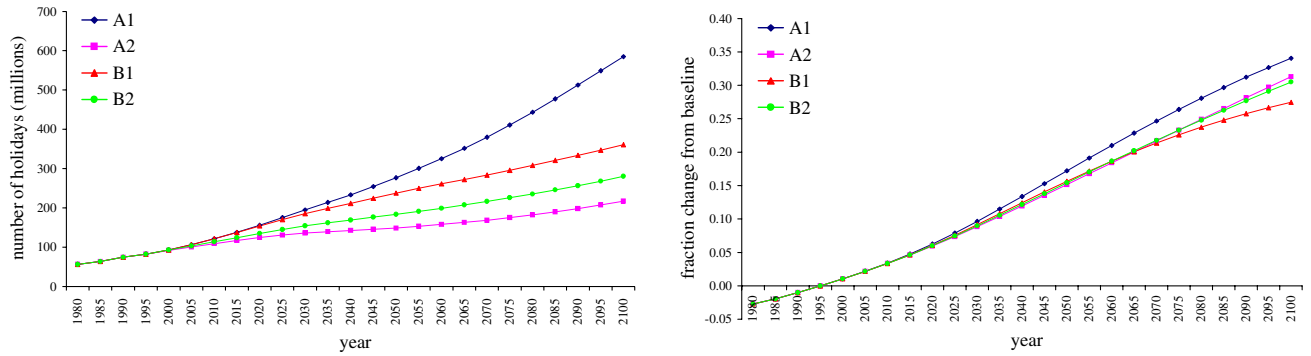


Fig. 1 The number of domestic tourist trips in Germany (*left panel*) and the relative impact of climate change (*right panel*) according to the four SRES scenarios

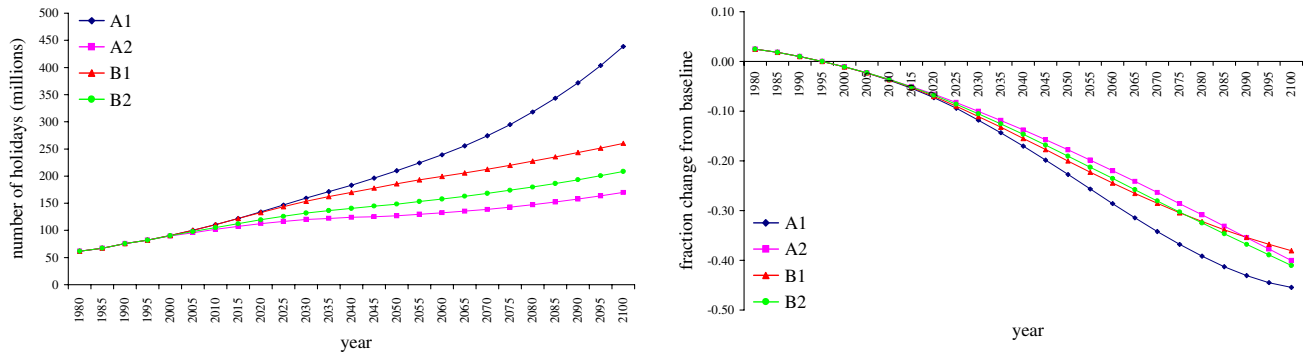


Fig. 2 The number of international tourist departures from Germany (*left panel*) and the relative impact of climate change (*right panel*) according to the four SRES scenarios

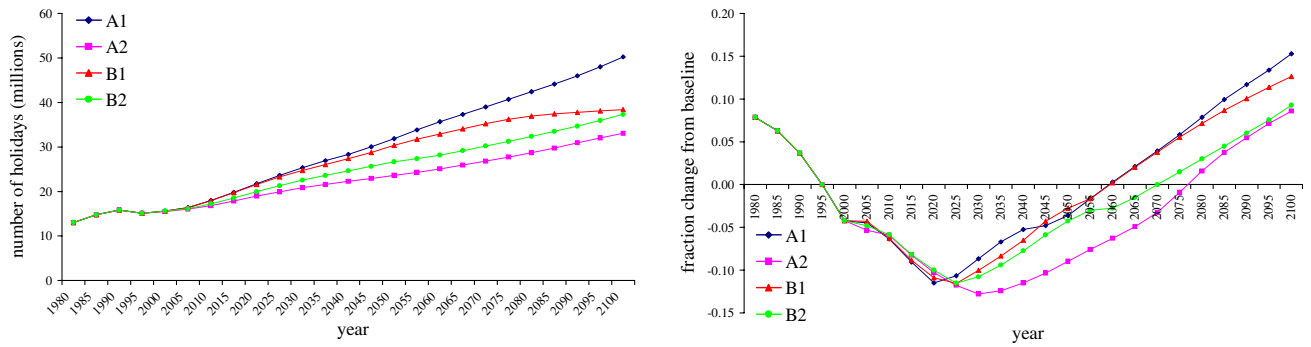


Fig. 3 The number of international tourist arrivals in Germany (*left panel*) and the relative impact of climate change (*right panel*) according to the four SRES scenarios

Ireland

In general the results for Ireland are similar to those for Germany and the UK. Figure 7 shows domestic holidays in Ireland, where the pattern is the same as for the UK, although saturation comes a bit later in the A1 scenario, as Ireland starts off slightly poorer than the UK. The impact of climate change is as in the UK. The development of international departures from Ireland shown in Fig. 8 is almost the same as for the UK; the little blip in the A1 scenario is at the point where tourism demand saturates. The impact of climate change is as in the UK. The pattern of international arrivals to Ireland follows that of the UK (Fig. 9). The impact of climate change is qualitatively as in the UK, but the increase in arrivals is less fast, as Ireland draws a larger share of its tourists from Western Europe.

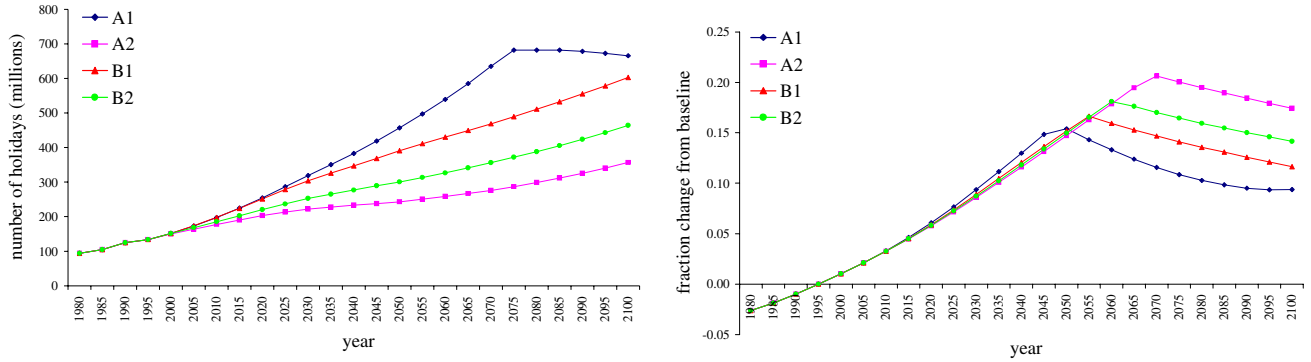


Fig. 4 The number of domestic tourist trips in the UK (*left panel*) and the relative impact of climate change (*right panel*) according to the four SRES scenarios

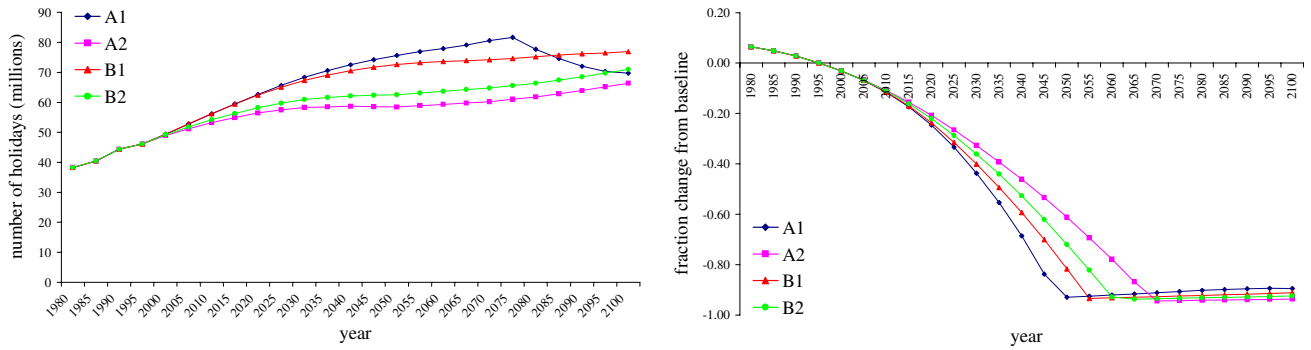


Fig. 5 The number of international tourist departures from the UK (*left panel*) and the relative impact of climate change (*right panel*) according to the four SRES scenarios

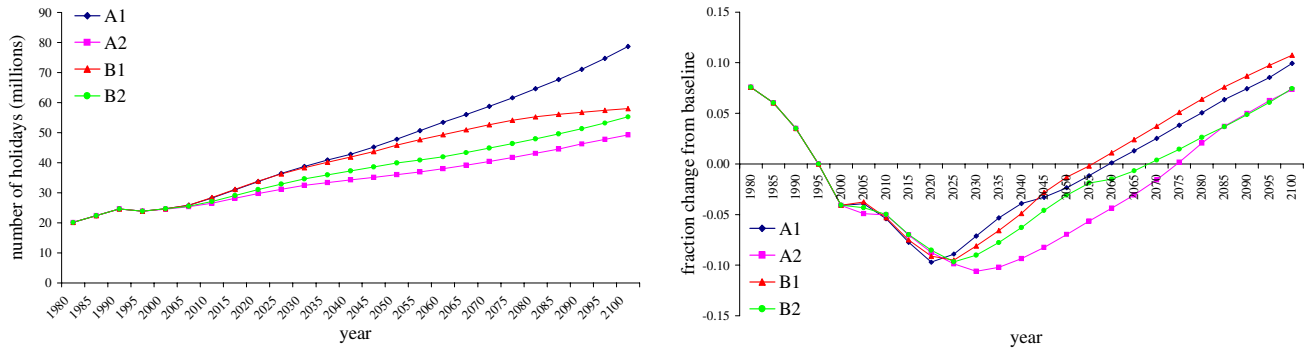


Fig. 6 The number of international tourist arrivals in the UK (*left panel*) and the relative impact of climate change (*right panel*) according to the four SRES scenarios

Regional level

Germany

Currently, the regional distributions of domestic and international tourists in Germany are different, as can be seen in Fig. 10. International tourists are concentrated in the south and south west of the country (with the exception of the relatively unpopular regions of Saarland and Giessen). Upper Bavaria, which includes the city of Munich, the Alps and many other natural as well as cultural attractions, has the largest market share (13.5%). The cities of Berlin (5%)

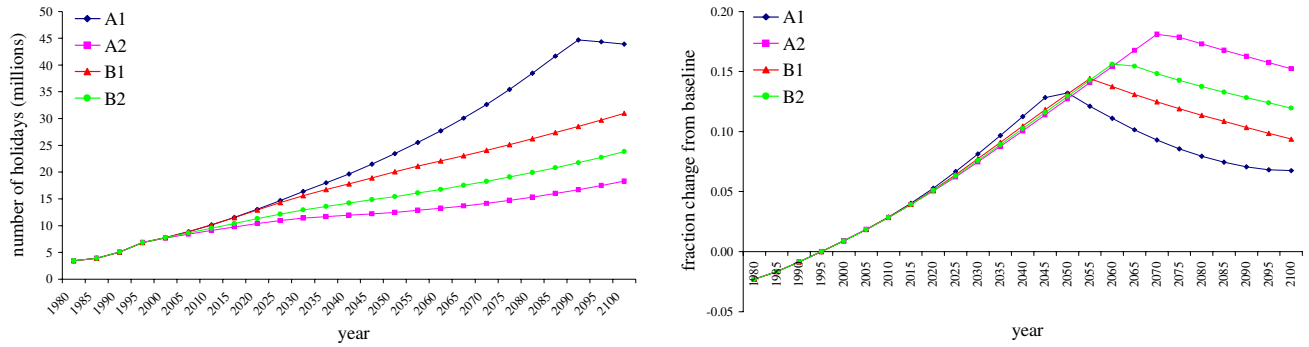


Fig. 7 The number of domestic tourist trips in Ireland (*left panel*) and the relative impact of climate change (*right panel*) according to the four SRES scenarios

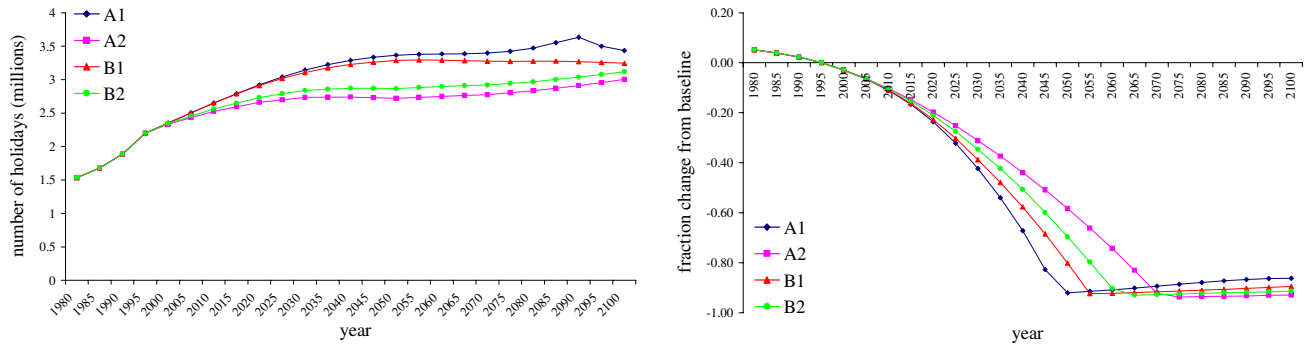


Fig. 8 The number of international tourist departures from Ireland (*left panel*) and the relative impact of climate change (*right panel*) according to the four SRES scenarios

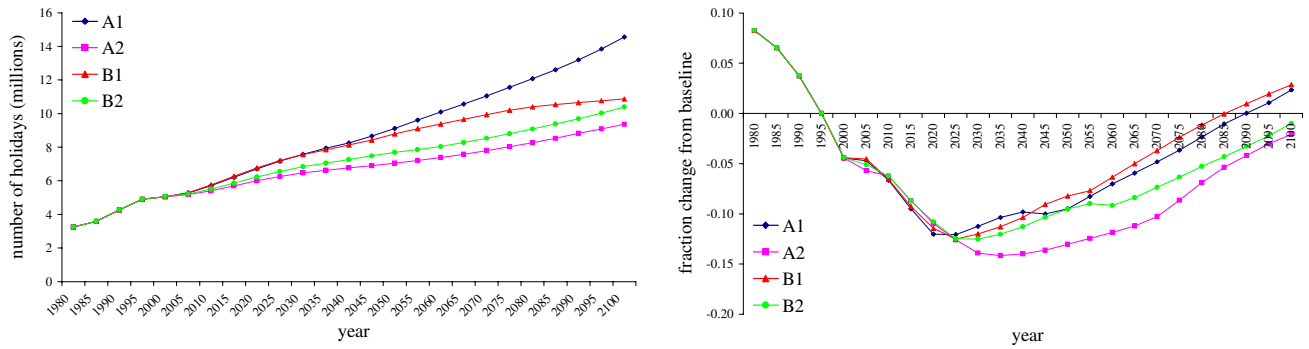


Fig. 9 The number of international tourist arrivals in Ireland (*left panel*) and the relative impact of climate change (*right panel*) according to the four SRES scenarios

and Hamburg (3.3%) are the main markets in the rest of the country. Domestic tourists are spread more or less evenly over the country. Again, the largest market is Upper Bavaria with a 7.9% market share. In addition, the two coastal states of Schleswig-Holstein (5.2%) and Mecklenburg-Vorpommern (4.5%) are significant markets. These two coastal regions have extensive beaches, several islands and four National Parks.

The impact of climate change on domestic and international tourism by 2080 is shown in Figs. 11 and 12, respectively. For all scenarios (only A1 and B1 are depicted), and for both domestic and international tourists, the pattern is the same: the southeast of Germany increases its market share. Depending on the scenario, different regions increase their market share: the northeast of Germany gains slightly under the low scenario

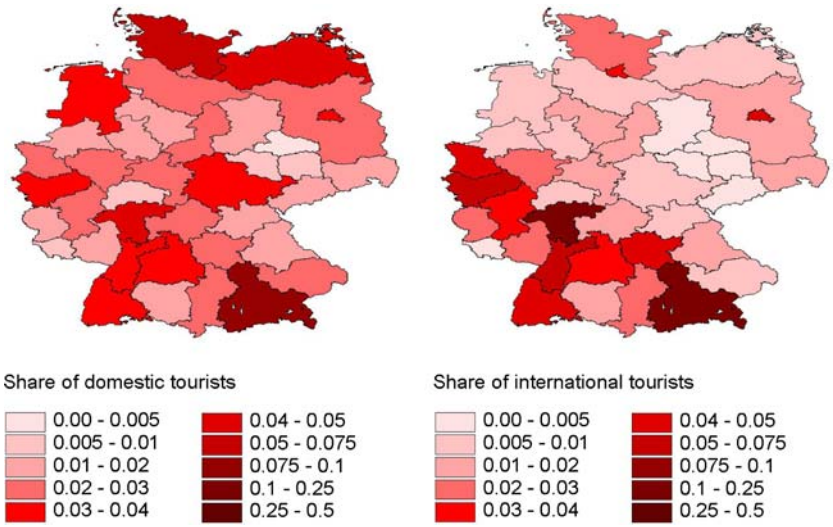


Fig. 10 Regional share of tourism in 1995, for domestic (*left*) and international (*right*) tourists in Germany

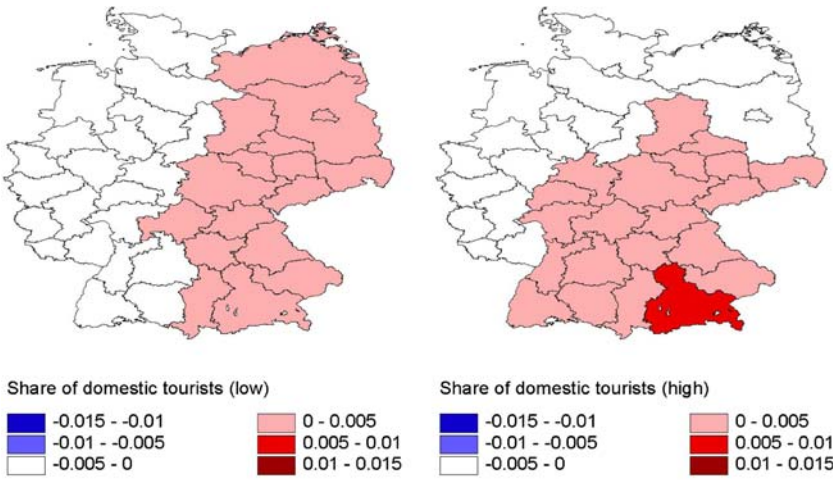


Fig. 11 The change in the regional share of domestic tourism between 1995 and 2080 in Germany under two alternative climate change scenarios, viz., B1 (*left*) and A1 (*right*)

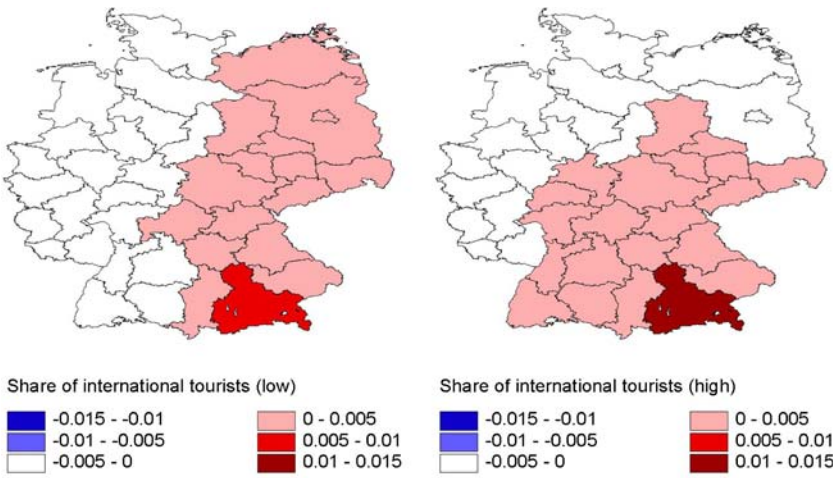


Fig. 12 The change in the regional share of international tourism between 1995 and 2080 in Germany under two alternative climate change scenarios, viz., B1 (*left*) and A1 (*right*)

and the southwest gains under the high scenario. In particular the increase for Upper Bavaria is more pronounced for international tourists, and for the A1 and A2 (not shown) scenarios. Compared to the other regions where the change in market share is not greater than half a percent, Upper Bavaria sees a gain of just more than

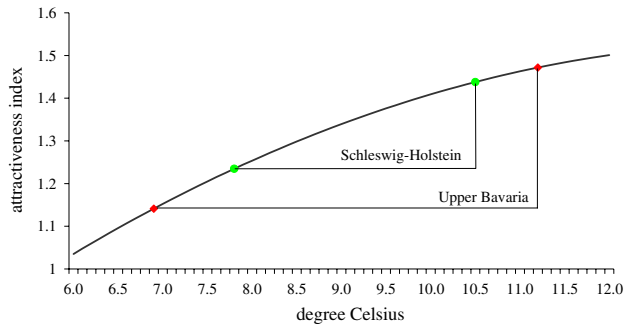


Fig. 13 The change in the tourism attractiveness index for Schleswig-Holstein and Upper Bavaria between 1995 and 2080 for the A1 scenario

1% of the international tourist market under the high scenario. The result runs counter to expectations. With climate change, tourists may be expected to seek cooler destinations, suggesting a poleward shift (Bigano et al. 2005; Hamilton et al. 2005a). This expectation is naïve, however. The explanation is that warming will not be homogenous over Germany. All over the country, the climatic attractiveness for tourists will improve. However, the continental interior will warm faster than the seaboard. Figure 13 shows the change in the climate attractiveness index for Schleswig-Holstein and Upper Bavaria, at opposite ends of the country. Both places will become more attractive to tourists, but Upper Bavaria faster so.

The UK

The current distribution of domestic and international tourists over the UK is shown in Fig. 14. International tourists are concentrated in Southern England and Southern and northwest Scotland. In the base year 1995 London had the largest market share, with 45% of all international tourists spending their holiday there. The second largest market was Eastern Scotland (6.74%), which includes the city of Edinburgh. Other significant markets are the Highlands and Islands, which includes the islands of Skye, Mull and Arran and Loch Ness and Surrey, East and West Sussex (4.5 and 4.1%, respectively), which includes Brighton and Eastbourne and other traditional seaside resorts. Compared to the distribution of international tourists, domestic tourists are spread evenly across the UK. The largest market is Dorset and Somerset with 8% of domestic tourism in 1995. West Wales and The Valleys (7.5%) is the second most important region followed by London, East Anglia, Cornwall, Eastern Scotland and North Yorkshire.

The impact of climate change on domestic and international tourism by 2080 is shown in Figs. 15 and 16, respectively. For all scenarios (only A1 and B1 are depicted), and for both domestic and international tourists, the general pattern is the same: the south of England has a reduced market share, while Scotland, the north of England and Wales have an increased market share. For the A1 and A2 scenarios, however, the pattern is more pronounced. The pattern is even more pronounced for international tourists. Figure 16 shows the change in market share by 2080 for the low and the high scenario. For the low scenario the changes are on the whole less than 0.5%, although London's market share falls by 0.53%. For the high scenario, we see again that for the majority of regions the change is not greater than half a percent. The exceptions are London with a drop of 1.19% in the high scenario and the regions of Highlands and Islands and East Scotland with market share increases of 0.54 and 0.66%, respectively.

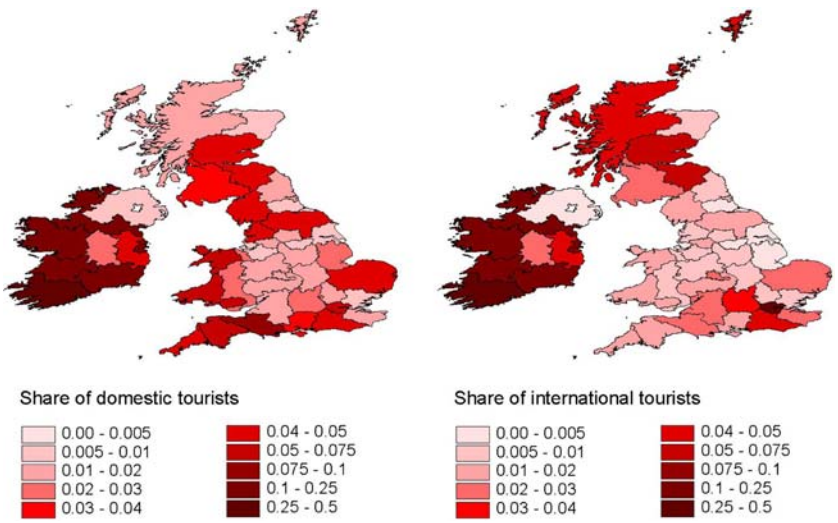


Fig. 14 Regional share of domestic (*left panel*) and international (*right panel*) tourists per region in 1995

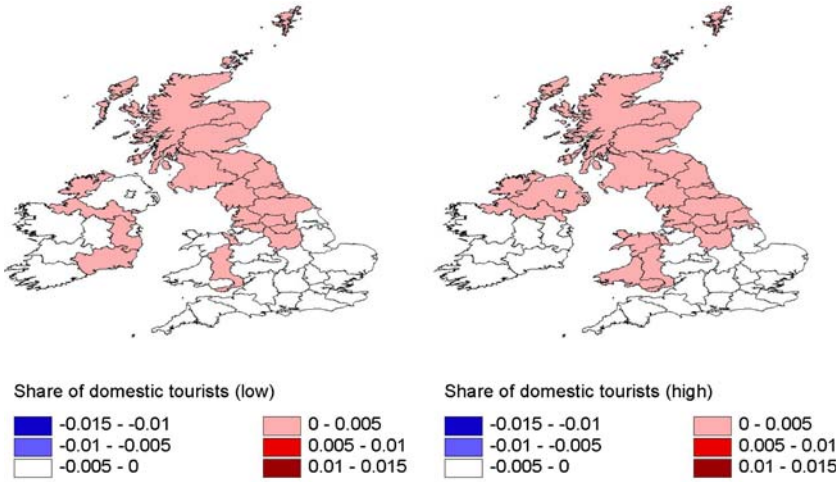


Fig. 15 The change in regional share of domestic tourism between 1995 and 2080 in the British Isles under two alternative climate change scenarios (low *left panel*, high, *right panel*)

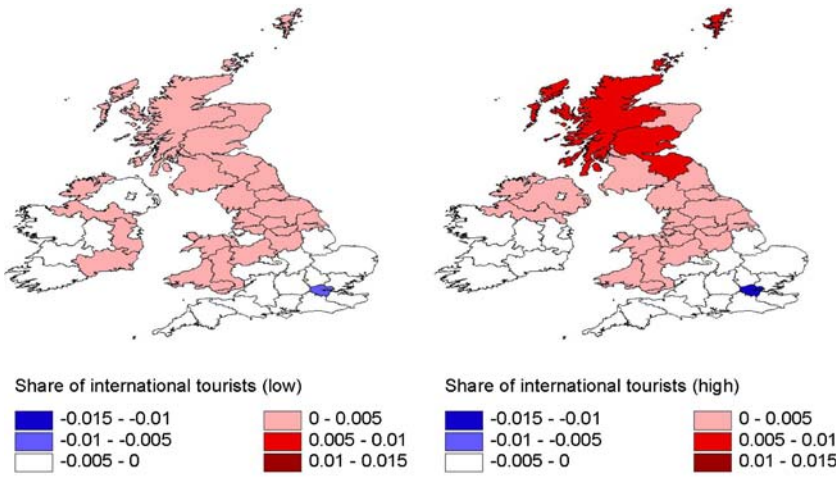


Fig. 16 The change in regional share of international tourism between 1995 and 2080 in the British Isles under two alternative climate change scenarios (low *left panel*; high *right panel*)

Ireland

For Ireland regional data was only available for international arrivals. The main market is the South West, featuring the Blarney Stone and the Ring of Kerry, with just over a quarter of all tourists visiting there. The Georgian capital Dublin, with its pubs, museums and shops, is the second market, with a share of 17%. Apart from the relatively small markets of the Midlands (2.7%) and Mid East (4.9%), the other regions have markets shares of between 10% and 15% (see Fig. 14). As the distribution of domestic tourists is assumed to be the same as that of international tourists, the results discussed below apply for both.[4] Nevertheless, it must be borne in mind that the distribution of international and domestic tourists is not likely to be homogenous.

In Ireland, for the low climate change scenario, for both domestic and international tourists, the border counties and the eastern seaboard (but not Dublin) become slightly more attractive, and the rest of country slightly less so. The change is less than a tenth of a percent. Under the high scenario tourists will increasingly visit the border counties, and the rest of the country will see a slight reduction in market share. Again the changes in market share are not higher than a tenth of a percent, except for the Borders which gain by almost a fifth of a percent. As climate change is largely homogenous over the relatively small island of Ireland, the spatial reallocation of tourists is small.

Discussion and conclusion

Previous studies of the impact of climate change show that there would be a shift of tourism towards the poles—if data and model are resolved at the country

[4] Note that the absolute size of the domestic market is seven times that of the international market.

level. At a finer resolution, this is not necessarily the case as shown here for Germany. On the other hand, the global trend holds for the UK and Ireland. Not only does the regional topography of countries have to be taken into consideration, but also the regional climate change scenarios, which may not necessarily predict homogenous changes over the country. Particularly, the continental interior is likely to warm faster than the ocean board—which explains the difference between Germany on the one hand and Ireland and the UK on the other.

Here we have presented the regional effect of climate change as changes in market share. On the whole these changes are relatively small. This is particularly the case for Ireland, as both climate and climate change are fairly homogenous there. Nonetheless, changes of, for example, half a percent or quarter of a percent can still be of considerable significance in absolute numbers. This is particularly so for domestic tourism. For example, in Germany in the base year of 1995 there were 80 million domestic tourism trips. A change of half a percent leads to an increase or a reduction of 400,000 tourists per year. Although the regional changes caused by climate change may be significant in absolute terms, the increase in tourism caused by population and economic growth will be more important.

All models have weaknesses. The model simulates the development of total tourism demand by country, changes in destination choice, and hence tourism demand in countries and regions. What is not considered in the model is the capacity of countries and regions to meet demand. We assume that Say's Law holds, that is, supply will meet demand. Apart from capacity restrictions, some countries may not be willing to meet the demand. Further limitations of the model are the focus on annual flows as opposed to seasonal flows. With the availability of better tourism data in the near future the model could be extended to simulate monthly or quarterly flows of tourists. We further assume that tastes and technologies are constant. These limitations are shared between the regional and national versions of the model. At the regional resolution, the major shortcoming is that destination is regional but origin is national. This reflects the lack of data rather than an inherent limitation of the model. The implication is that our measure of distance, an important variable in destination choice, is distorted, particularly for domestic tourism. All this is deferred to future research, as is the replication of the analysis presented here for all other countries.

In previous studies, we showed that the impact of climate change on national tourism is substantial. Here, we show that regional patterns do not follow trivially from national patterns—particularly in large countries. As tourism is so important economically, this justifies further research to alleviate the caveats listed above.

Acknowledgments Discussions with Andrea Bigano, David Maddison and Katrin Rehdanz and comments by two anonymous referees helped to improve the paper. Jenny Behm, André Krebber and Nele Leinert helped with the data. Financial support by the EC-DG Research (DINAS-Coast) and the Hamburg University Innovation Fund is gratefully acknowledged. All errors and opinions are ours.

References

Amelung B, Nicholls S, Viner D (2007) Implications of global climate change for tourism flows and seasonality. J Travel Res 45(3):285–296

Bigano A, Hamilton JM, Lau M, Tol RSJ, Zhou Y (2004) A global database of domestic and international tourist numbers at national and subnational level. Fondazione Eni E. Mattei Working Papers 3.05, Milano, Italy

Bigano A, Hamilton JM, Tol RSJ (2005) The impact of climate change on domestic and international tourism: a simulation study. Research Unit Sustainability and Global Change Working Paper FNU-58, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg

Bigano A, Hamilton JM, Maddison DJ, Tol RSJ (2006) Prediction tourism flows under climate change—an editorial comment on Goessling and Hall. Clim Change 79(3–4):175–180

Goessling S, Hall CM (2006a) Uncertainties in predicting tourist flows under scenarios of climate change. Clim Change 79(3–4):163–173

Goessling S, Hall CM (2006b) Uncertainties in predicting tourist flows: common ground and research needs—a reply to Bigano et al. Clim Change 79(3–4):181–183

Hamilton JM (2003) Climate and the destination choice of German tourists. Research Unit Sustainability and Global Change Working Paper FNU-15 (revised). Hamburg University and Centre for Marine and Climate Research, Hamburg

Hamilton JM (2006) Tourism, climate change and the coastal zone. University of Hamburg Faculty of Economic and Social Sciences Doctoral Thesis, Hamburg. Retrieved from http://www.sub.uni-hamburg.de/opus/volltexte/2006/3062/

Hamilton JM, Lau MA (2005) The role of climate information in tourist destination choice decision-making. In: Gössling S, Hall CM (eds) Tourism and global environmental change. Routledge, London

Hamilton JM, Tol RSJ (2004) The impacts of climate change on tourism and recreation. Research Unit Sustainability and Global Change Working Paper FNU-52. Hamburg University and Centre for Marine and Climate Research, Hamburg

Hamilton JM, Maddison DJ, Tol RSJ (2005a) Climate change and international tourism: a simulation study. Global Environ Change 15(3):253–266

Hamilton JM, Maddison DJ, Tol RSJ (2005b) The effects of climate change on international tourism. Clim Res 29:255–268

Lise W, Tol RSJ (2002) Impact of climate on tourism demand. Clim Change 55(4):429–449

Maddison DJ (2001) In search of warmer climates? The impact of climate change on flows of British tourists. Clim Change 49:193–208

Scott D, Wall G, McBoyle G (2005) The evolution of the climate change issue in the tourism sector. In: Hall CM, Higham J (eds) Tourism, recreation and climate change. Channel View Publications, Clevedon, pp 44–60

Smith JB, Schellnhuber HJ, Mirza MMQ, Fankhauser S, Leemans R, Lin E, Ogallo L, Pittock B, Richels RG, Rosenzweig C, Tol RSJ, Weyant JP, Yohe GW (2001) Vulnerability to climate change and reasons for concern: a synthesis. In: McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White KS (eds) Climate change 2001: impacts, adaptation, and vulnerability. Cambridge University Press, Cambridge, pp 913–967

WTO (2001) Tourism 2020 vision—Europe. World Tourism Organisation, Madrid