

Hamilton, Jacqueline M.; Tol, Richard S. J.

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THE IMPACT OF CLIMATE CHANGE ON TOURISM IN GERMANY, THE UK AND IRELAND: A SIMULATION STUDY

Jacqueline M. Hamilton^{a,c} and Richard S.J. Tol^{a,b,d,e}

^a *Research unit Sustainability and Global Change, Hamburg University and Centre for Marine and Atmospheric Research, Hamburg, Germany*

^b *Economic and Social Research Institute, Dublin, Ireland*

^c *Forest Economics, Department of Wood Science, Hamburg University, Hamburg, Germany*

^d *Institute for Environmental Studies, Vrije Universiteit, Amsterdam, The Netherlands*

^e *Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA, USA*

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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

1. 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 and 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.

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), 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. Germany, Ireland and the UK account for 24.5% of all international tourists. 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).

Amelung *et al.* (in press) is the only paper that is similar to ours, in the sense that their analysis is global with a reasonable amount of regional detail. However, Amelung *et al.* (in press) use a tourism attractiveness index that is based on biophysical principles, rather than on tourist behaviour. Also, their analysis is restricted to the supply side of tourism, ignoring the demand side.

The paper is structured as follows. Section 2 presents the model used. Section 3 shows selected results at the national and regional level. Section 4 concludes.

2. The model

The model consists of one component predicting tourism flows between countries and domestic tourism in countries. This is described in Section 2.1. A second component which scales national tourist numbers down to the regions of Germany, Ireland and the UK is described in Section 2.2.

2.1. 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). Further details, including papers and model code, can be found at <http://www.uni-hamburg.de/Wiss/FB/15/Sustainability/htm.htm>.

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; for arrivals, the R^2 is always greater than 93%, for departures, 79%; the model was calibrated independently of these observations.

The model shows that 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 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.

As all models, HTM has several shortcomings. Its resolution is crude. It does not distinguish seasons, nor classifies tourists by age and income. Spatially, the model is restricted to countries. This paper only improves on the last shortcoming by downscaling to regions.

2.2. 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.¹ 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 $C.O=3.5\%$, 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.

3. Results

3.1 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 figure 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 Figure 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

¹ 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.

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 figure 4 is similar to that depicted in Figure 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 3 holidays per person per year in 1995, compared to 2 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.

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 figure 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 (figure 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.

3.2. Regional level

Germany

Currently, the regional distributions of domestic and international tourists in Germany are different, as can be seen in Figure 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, with a 13.5% market share, is the largest market. The cities of Berlin (5%) 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.

The impact of climate change on domestic and international tourism by 2080 is shown in Figures 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 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 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 Figure 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 Edinburgh. Other significant markets are the Highlands and Islands and Surrey, East and West Sussex (4.5% and 4.1% respectively). 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 Figures 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.

Ireland

For Ireland regional data was only available for international arrivals. The main market is the South West with just over a quarter of all tourists visiting there. Apart from the relatively small markets of the Midlands (2.7%) and Mid East (4.9%), the other regions have market shares of between 10% and 17%. See

figure 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.² 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.

4. 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 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. 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,

² Note that the absolute size of the domestic market is seven times that of the international market.

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. As tourism is so important economically, this justifies further research to alleviate the caveats listed above.

Acknowledgements

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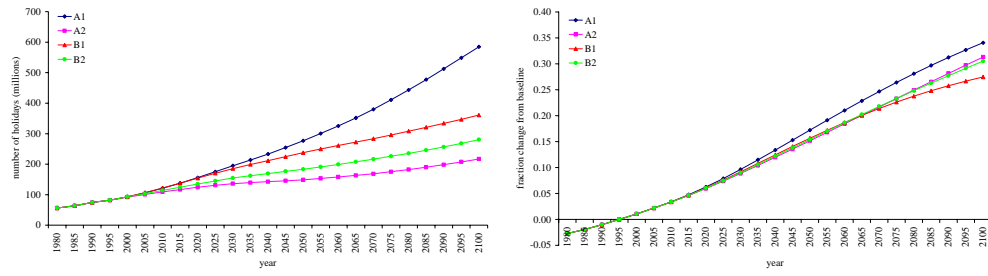


Figure 1. The number of domestic tourist trips in Germany (left panel) and the relative impact of climate change (right panel) according to the four SRES scenarios.

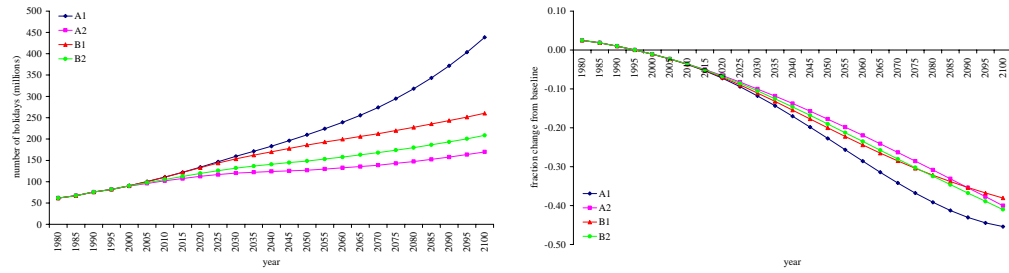


Figure 2. The number of international tourist departures from Germany (left panel) and the relative impact of climate change (right panel) according to the four SRES scenarios.

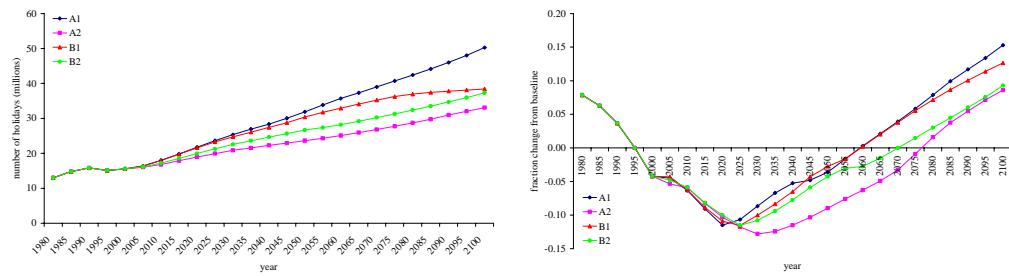


Figure 3. The number of international tourist arrivals in Germany (left panel) and the relative impact of climate change (right panel) according to the four SRES scenarios.

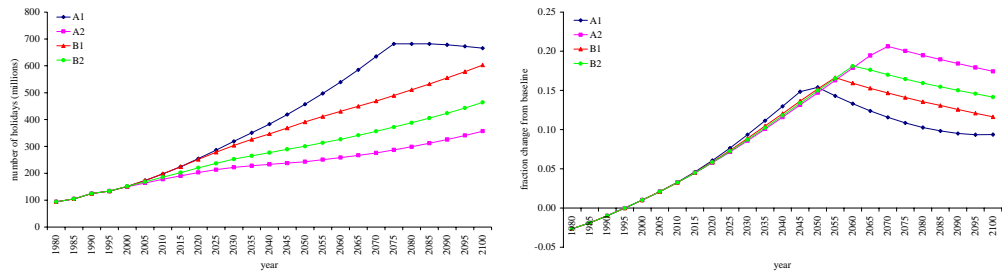


Figure 4. The number of domestic tourist trips in the United Kingdom (left panel) and the relative impact of climate change (right panel) according to the four SRES scenarios.

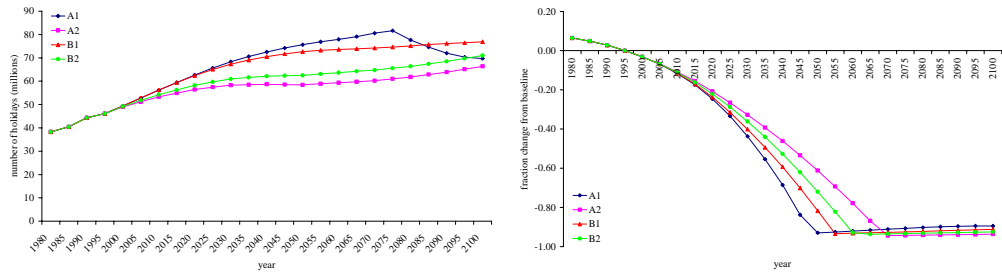


Figure 5. The number of international tourist departures from the United Kingdom (left panel) and the relative impact of climate change (right panel) according to the four SRES scenarios.

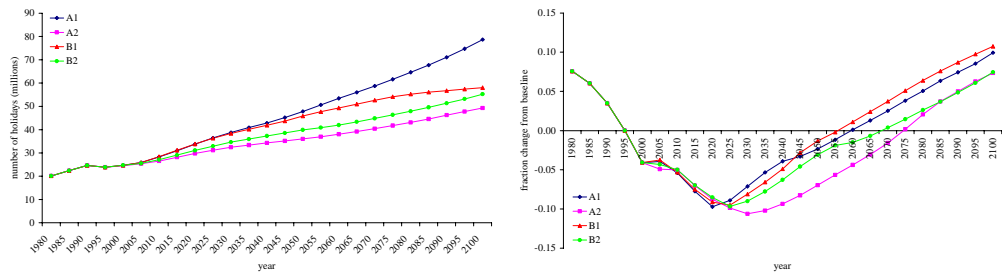


Figure 6. The number of international tourist arrivals in the United Kingdom (left panel) and the relative impact of climate change (right panel) according to the four SRES scenarios.

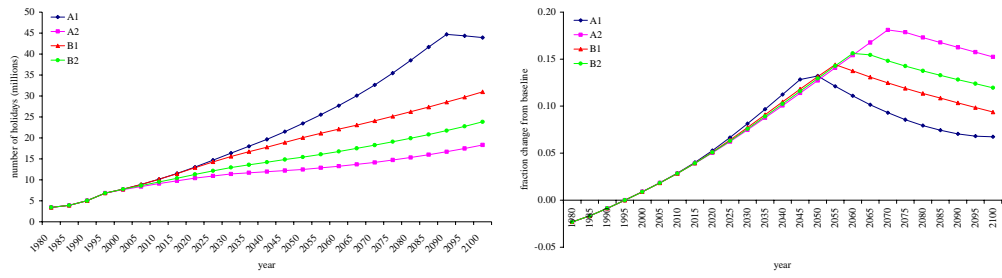


Figure 7. The number of domestic tourist trips in Ireland (left panel) and the relative impact of climate change (right panel) according to the four SRES scenarios.

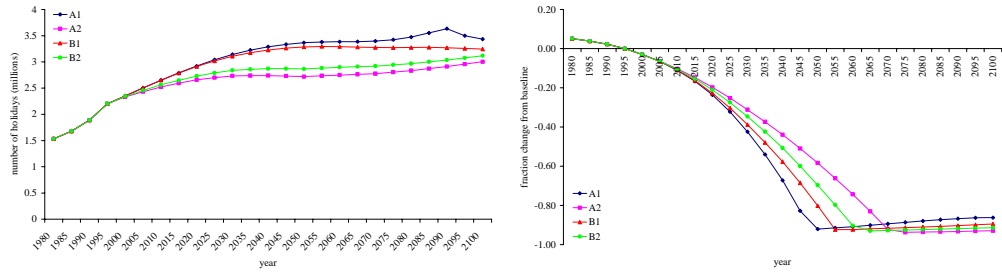


Figure 8. The number of international tourist departures from Ireland (left panel) and the relative impact of climate change (right panel) according to the four SRES scenarios.

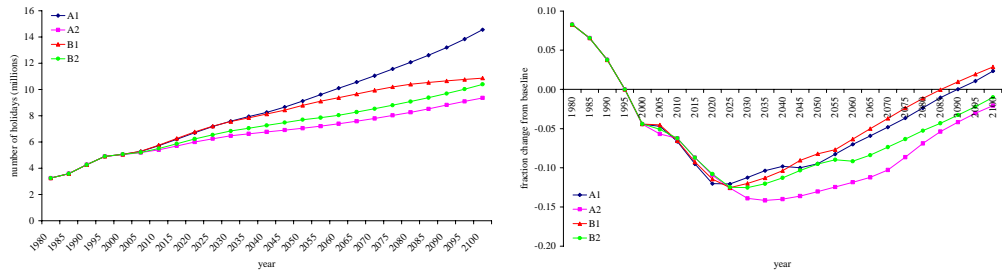


Figure 9. The number of international tourist arrivals in Ireland (left panel) and the relative impact of climate change (right panel) according to the four SRES scenarios.

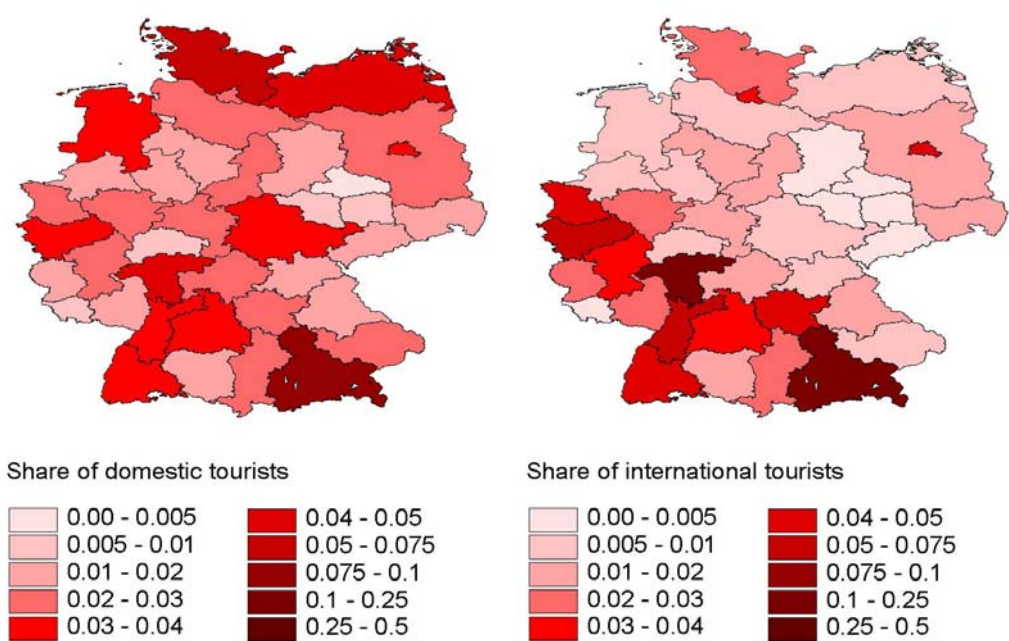


Figure 10. Regional share of tourism in 1995, for domestic (left) and international (right) tourists in Germany.

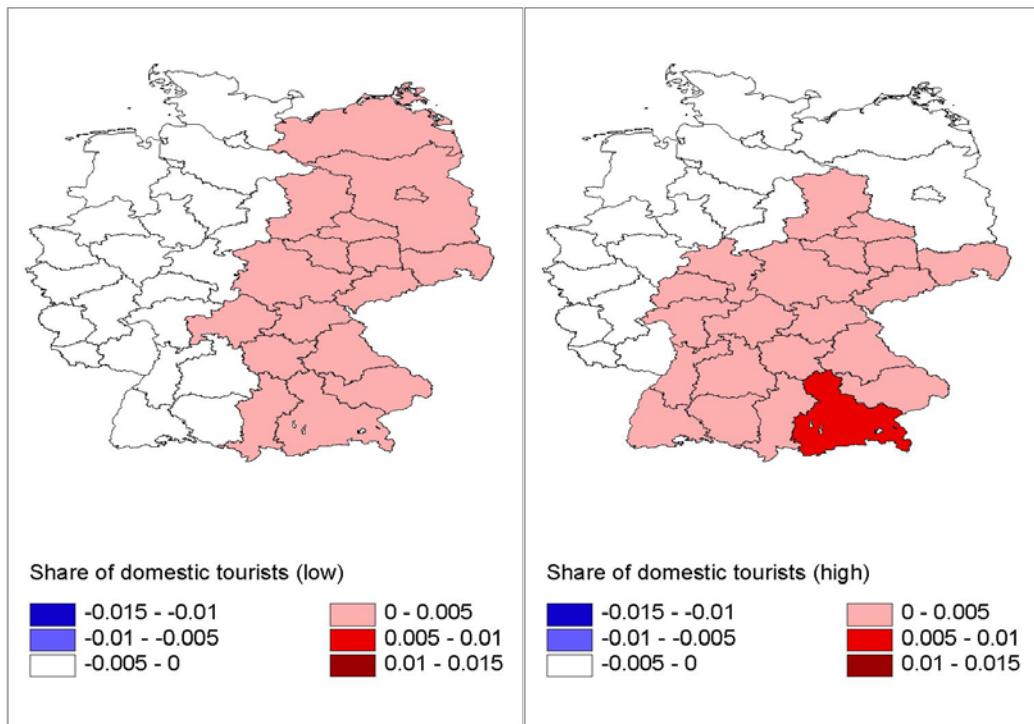


Figure 11. The change in the regional share of domestic tourism between 1995 and 2080 in Germany under two alternative climate change scenarios, viz. B1 (left) and A1 (right).

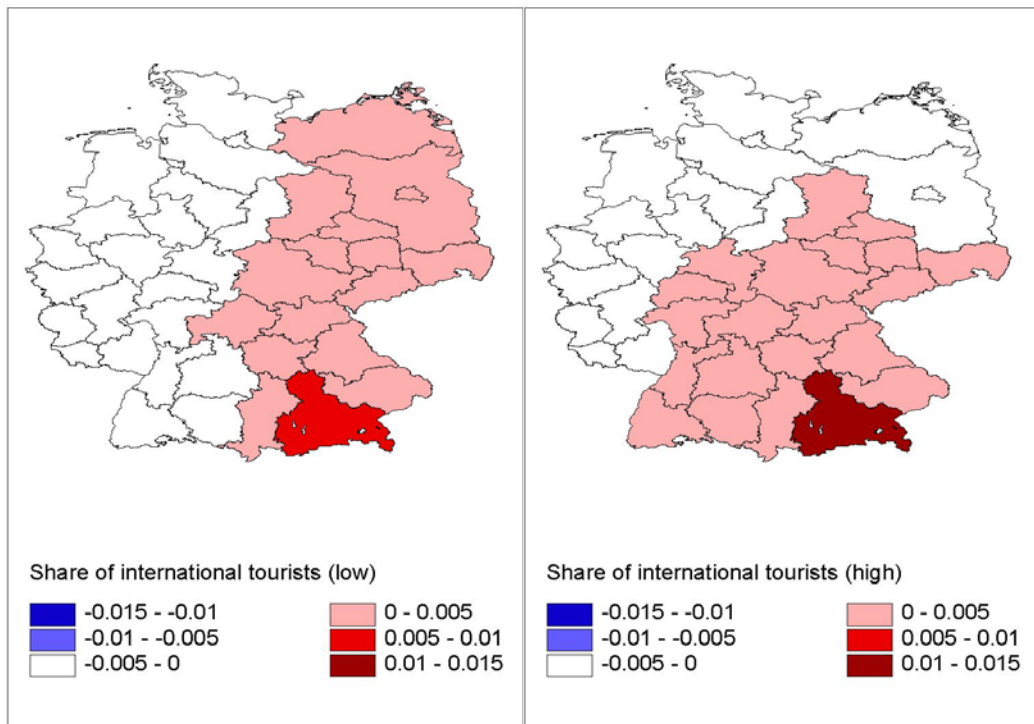


Figure 12. The change in the regional share of international tourism between 1995 and 2080 in Germany under two alternative climate change scenarios, viz. B1 (left) and A1 (right).

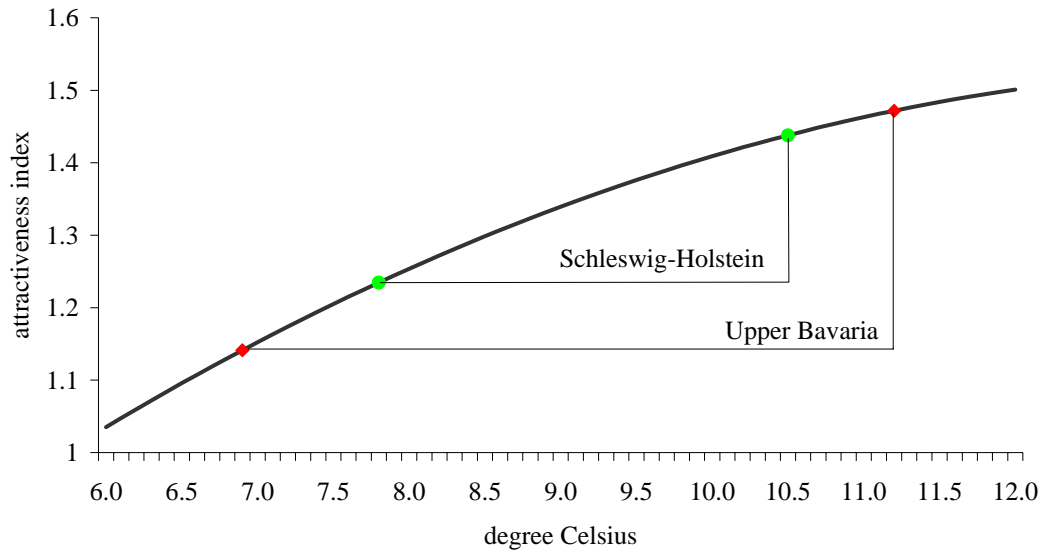


Figure 13. The change in the tourism attractiveness index for Schleswig-Holstein and Upper Bavaria between 1995 and 2080 for the A1 scenario.

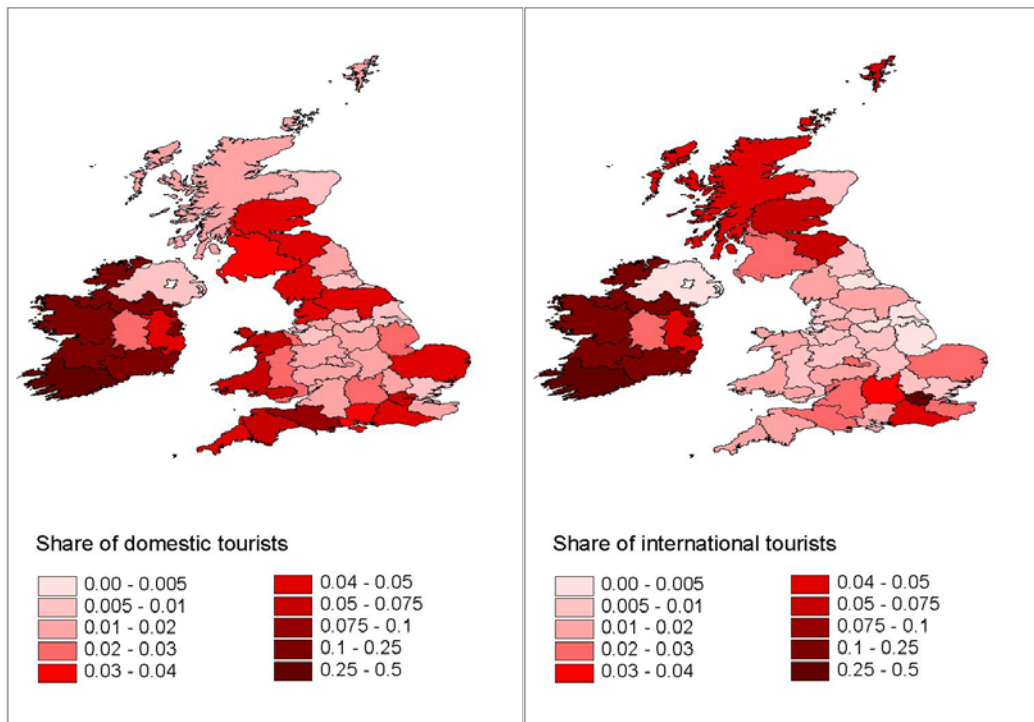


Figure 14. Regional share of domestic (left panel) and international (right panel) tourists per region in 1995.

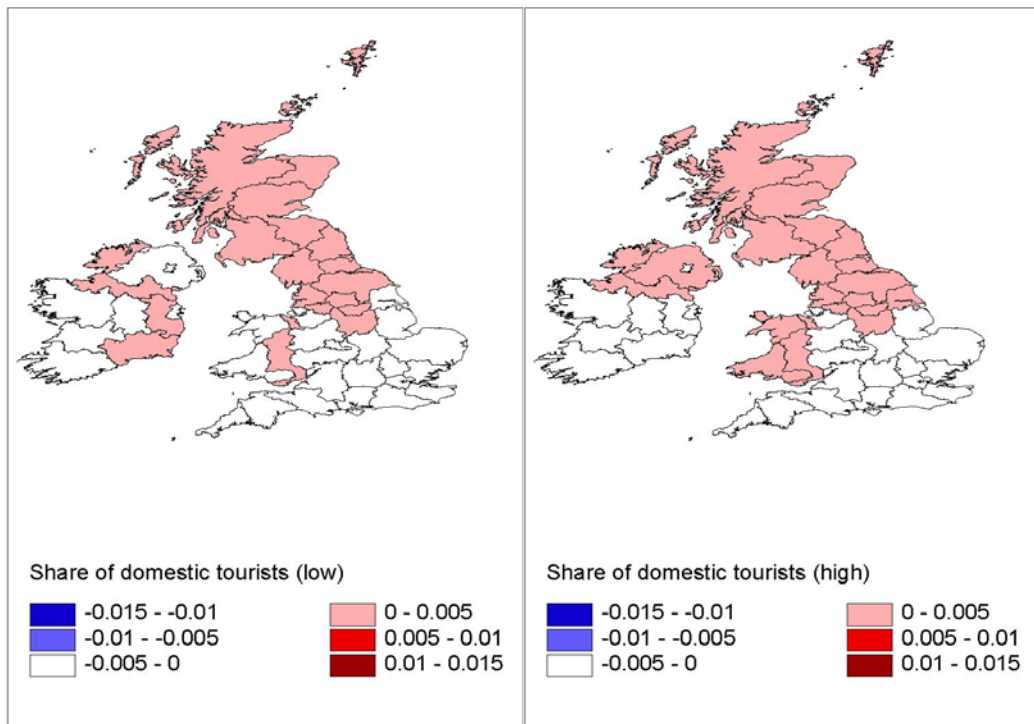


Figure 15. The change in regional share of domestic tourism between 1995 and 2080 in the British Isles under two alternative climate change scenarios (low, left panel; high right panel).

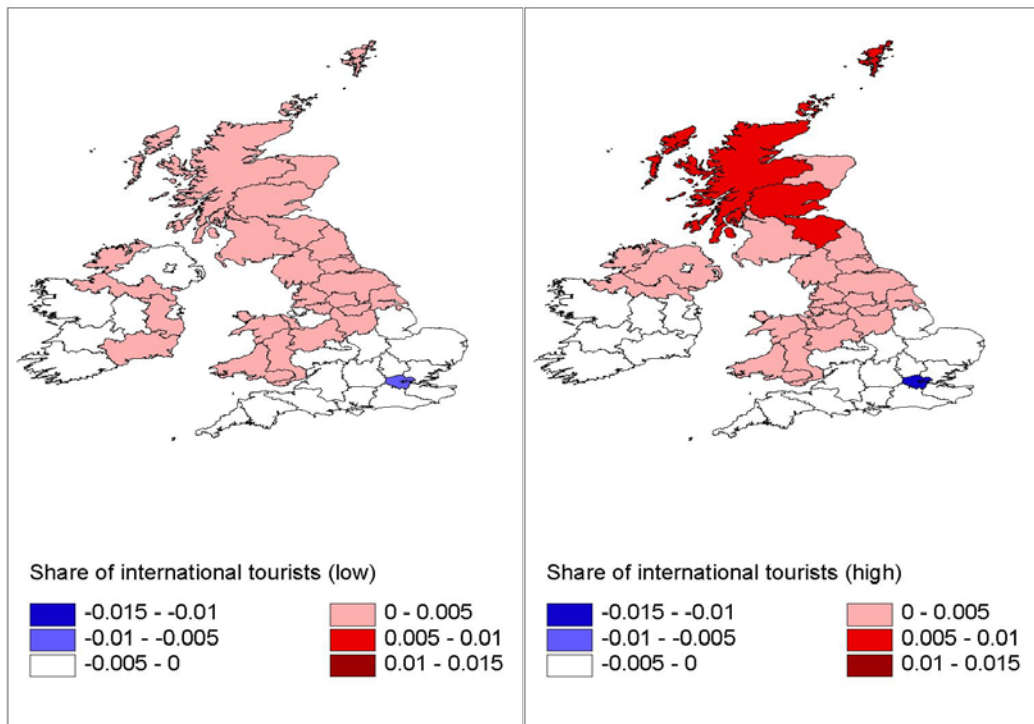


Figure 16. The change in regional share of international tourism between 1995 and 2080 in the British Isles under two alternative climate change scenarios (low, left panel; high right panel).