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Climate Change and Tourism in the Arctic Circle

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Abstract: We estimate grid level tourist numbers to Arctic Circle countries under a number of climate change scenarios. At present, the highest tourism volumes are found in Canada and most of the Scandinavian countries. In general, it appears that tourists are attracted to regions with better infrastructure and nicer cities. Under each climate change scenario, Russia sees a significant increase in tourist numbers because Russia is big, its climate is expected to show some improvement and it is relatively close to the growing markets of South and East Asia. A growth in tourist numbers is also projected for Canada and Alaska. While our simulations do not show a re-distribution of tourists within the Arctic under climate change, the volume is likely to increase.

JEL Classification: Q54, L83

Key Words: climate change; tourism; destination choice; arctic

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1. Introduction

Tourist flows are strongly influenced by climatic conditions (Wall and Badke, 1994; Becken and Hay, 2007). According to NSIDC (2012) *"a small temperature increase at the poles leads to a still greater warming over time, making the poles the most sensitive regions to climate change on earth".* As a result, climate change could have a potentially big impact on Arctic tourism. Previous studies (Bigano et al. 2007, Hamilton et al 2005a, Hamilton et al 2005b and Hamilton and Tol 2007) have suggested that international tourist arrivals will fall in hotter countries and rise in colder countries, relative to a scenario without climate change. This would result in a redistribution of tourists to higher latitudes and altitudes providing a valuable opportunity to further develop tourism in the Arctic Circle. For the purpose of this paper, we examine the countries which fall partly into the Arctic circle, namely Canada, Denmark, Finland, Greenland, Iceland, Norway, Russia, Sweden and the US (Alaska).

Previous literature on tourism implicitly assumed that climate was constant and thus not interesting (Hamilton and Tol, 2007). However, climate is changing and will continue to change. Climate change scenarios project increases in both global averaged temperature and precipitation. According to the IPCC (2001), the average global temperature response for 2071-2100 relative to 1961-1990 could range from +0.9°C to +4.5°C. The average precipitation increase for 2071-2100 relative to 1961-1990 is projected to be in the range of 1.2% to 6.8%. It is now generally thought that tourism will change with the climate, but there is little consensus on how climate change would affect the tourism industry. (Maddison, 2001; Lise and Tol, 2002) estimate the impact of climate change on destination choice and find that tourists prefer a temperature of between 21°C and 31°C at their destination choice. Tol and Walsh (2012) examine the determinants of holiday destination choice for tourists from 182 countries over a fifteen year time period. They find that the average optimal holiday temperature of 15.5 ± 0.2 °C is largely independent of the tourists' country of origin. Consequently, climate change will have a significant impact on tourism demand as tourists will travel to different holiday destinations at different times of the year to seek out the climate that meets their needs.

Tourism in the Arctic Circle has been described as *"last chance"* or *"doom"* tourism as tourists increasingly seek to experience the world's most endangered landscapes before they disappear (Lemelin et al, 2010; Denstadi et al, 2011). In a micro analysis of Vesterålen in Norway, Denstaldi et al (2011:935) found that *"depending on tourist motivations and activities and their adaptive capabilities, weather should not necessarily be considered a major barrier in high latitude destinations".* These findings are echoed by Jacobsen et al (2011) in a similar study of Vesterålen and Svalbard. Tourists may also visit a region with an unfavourable climate in order to satisfy their interest in exploring unique areas, or gain bragging rights in exotic holiday contests. In a classic tragedy of the commons, tourists contribute to the destruction of the very attractions they visit through the emission of greenhouse gases (Dawson et al, 2010).

Changes in the patterns of seasonality have also been examined in relation to tourism both globally and regionally. Yu et al (2009) developed a tourism climate index based on hourly weather data to examine the effect of climate change on the seasonality of weather for tourism in two destinations in Alaska; King Salmon and Anchorage. They found that climate change is likely to have mixed effects on the opportunities for tourism, depending on location, geography and activity. They found that the summer season in King Salmon is lengthening while the winter ski season in Anchorage was found to end earlier over the period analysed. Scott et al (2004) used Mieczkowski's (1985) tourism climate index to study the distribution of climate resources in North America under a baseline scenario (1961-1990) and two climate change scenarios (2050s and 2080s). Scott et al (2004:116) found that *"a substantive redistribution of climate resources for tourism was possible as a result of projected climate change".* The authors noted a northward shift in climates under the climate change scenarios resulting in a lengthening of the summer season in Canada and deterioration in the summer climate in regions such as Los Angeles. Amelung et al (2007:289) conducted a similar study of tourism comfort at a global grid level under present and future climates. They found a *"pronounced poleward movement in tourism comfort...such that, by the 2080s, the most ideal conditions for tourism activity in the northern hemisphere will have shifted to Northern Europe and Canada".*

The purpose of this paper is to examine the tourism attractiveness of the Arctic Circle countries under current and future climate conditions. The paper is organised as follows. Section 2 outlines the data sources and methods used in the analysis. Section 3 details the results of the analysis and Section 4 discusses and concludes on the findings of the study.

2. Data and Methods

2.1 Current period

The first part of this paper examines tourist flows to Arctic countries in 2009 under current climate conditions. We use grid level average annual temperature in degrees Celsius and average annual precipitation in millimetres as climate indicators (New et al., 2002). Tourism data are obtained at a regional level (state, province, etc.). Data are taken from a number of sources, details of which are given in Table 1.

There are some issues with the data. We were unable to obtain tourism data for the National Park region of Greenland. As a result, the tourist flows into Greenland will be somewhat underestimated. In addition, some countries report the arrival of tourists only, while other countries report the arrival of non-residents for all purposes. Unfortunately, it is not possible to correct for this.

In order to see where the tourists are likely to go within each region, we downscale the regional tourism data to the grid as follows:

The natural logarithm of tourism numbers *N* in grid-cell g are proportional to

$$\ln N_g \propto \alpha_1 T_g + \alpha_2 T_g^2 + \alpha_3 P_g + \alpha_4 P_g^2 \tag{1}$$

We know the number of tourists in region r. Therefore, the number of tourists in cell g is:

$$N_g = \frac{N_r}{\sum_{g \in c} e^{\alpha_1 T_g + \alpha_2 T_g^2 + \alpha_3 P_g + \alpha_4 P_g^2 * A_g}} e^{(\alpha_1 T_g + \alpha_2 T_g^2 + \alpha_3 P_g + \alpha_4 P_g^2) * A_g} \tag{2}$$

where:

- N_g is the number of tourist arrivals into grid cell g
- N_r is the number of tourist arrivals into region r
- T_g is the average annual temperature in degrees Celsius in grid cell g
- P_g is the average annual precipitation in millimetres in grid cell g
- A_g is the area of grid cell g in square kilometres.

Equation (2) is evaluated separately for each grid cell. The parameters are adopted from Tol and Walsh (2012) who examine the holiday destination choice for 182 countries over a fifteen year time period (1995-2009). Greenland and Alaska were not included in the Tol and

Walsh analysis. To overcome this we use Iceland parameters for Greenland and Canada parameters for Alaska. The area of the grid cell is included as a weight as grid size varies strongly near the pole.

2.2 Future period

The second part of the paper simulates future tourist flows under a number of climate scenarios. Tourism projections are taken from the Hamburg Tourism Model (HTM), version 1.4 (Tol, 2010). HTM provides international tourist flows between 207 countries in order to analyse how the current pattern of tourist flows changes under population growth, economic growth and climate change scenarios (Hamilton et al., 2005a; Hamilton et al., 2005b). For the purpose of this paper, we examine total international arrivals into the Arctic countries in 2085 under six tourism scenarios; B1 (with and without climate change), B2 (with and without climate change) and A2 (with and without climate change). There are some shortcomings with this dataset. Unfortunately, it does not include data on tourist arrivals into Greenland or Alaska. To overcome this, we apply the proportional change in arrivals into Iceland between 2009 and 2085 to the 2009 data which we have for Greenland and Alaska.

$$N_{c,t+1} = \left[\left(N_{i,t+1} - N_{i,t}\right) \div N_{i,t} + 1\right] \times N_{c,t} \quad (3)$$

where:

- $N_{c,t+1}$ is the total number of tourist arrivals into country c where c is either Greenland or Alaska at time $t+1$ where $t+1$ is 2085.
- $N_{i,t+1}$ is the number of tourist arrivals into Iceland at time $t+1$
- $N_{i,t}$ is the number of tourist arrivals into Iceland at time t where time t is 2009
- $N_{c,t}$ is the number of tourist arrivals into country c at time t

The data from HTM are at a national level. Before downscaling to the grid (as we did for the baseline period), we first apply the proportional change in the national numbers to the base year regional data.

$$N_{r,t+1} = \left[\left(N_{c,t+1} - N_{c,t}\right) \div N_{c,t} + 1\right] \times N_{r,t} \quad (4)$$

where:

- $N_{r,t+1}$ is the number of tourist arrivals into region r at time $t+1$ where $t+1$ is 2085
- $N_{c,t+1}$ is the number of tourist arrivals into country c at $t+1$
- $N_{c,t}$ is the number of tourist arrivals into country c at time t where time t is 2009
- $N_{r,t}$ is the number of tourist arrivals into region r at time t

This allows us to estimate regional tourist numbers in 2085. We then further downscale the regional data to the grid using Equation (2) above.

Climate data are taken from the Tyndall Centre for Climate Change Research. We adopt the TYN SC 2.0 data set which provides monthly grid level data of modelled climate from 2001-2100 (Mitchell et al, 2004). The data covers the global land surface at a 0.5 degree resolution. For each grid cell, we calculate the average temperature in degrees Celsius and the average precipitation in millimetres for the period of interest; 2070-2099. TETYN is used to access the data. This is a tool developed for extracting climatic parameters from Tyndall datasets (Solymosi et al., 2008). We employ three climate scenarios in this analysis – these are detailed in Table 2. In order to show the results of the simulation, the data are entered into a Geographic Information System for spatial analysis. Results of the analysis are presented in

Section 3 and all GIS analysis was undertaken using ArcGIS 10.1. The projection used for the maps is North Pole Lambert Azimuthal Equal Area.

3. Results

Grid level climate in the current period is given in Appendix A. As expected, temperatures increase as you move further away from the pole. A less clear pattern emerges with respect to precipitation. However, levels of precipitation tend to be lower closer to the pole. Figure 1 presents grid level tourist numbers in 2009 under current climate conditions.

High tourism volumes are found in Canada and most of the Scandinavian countries. In Canada, tourists are particularly concentrated around Ontario, Northwest Territories and Alberta. In Norway, Sweden, Denmark and Finland, tourist numbers are highest around the capital cities. At present, tourist numbers into Russia are very low relative to the other countries. A factor which may be contributing to this is the perceived difficulty of accessing Russia as a tourist. It appears that tourists are generally attracted to regions with better infrastructure and nicer cities.

Grid level climate under each of the scenarios is presented in Appendix B. Across the three scenarios; the general climate pattern is consistent. However, the level of both temperature and precipitation increases as you move from a low climate change scenario (PCM) to a high scenario (HadCM3). Also, when compared to the base period, the level of both climate variables is increasing.

Figure 2 presents three maps showing the difference between grid level tourist numbers in 2009 under current climate conditions and grid level tourist numbers in 2085 under projected climate conditions. For example, the grid level climate projections from PCM_B2 are combined with scenario *B2 with climate change* from the Hamburg Tourism Model. Grid level tourist numbers are simulated using Equation (2) above. From this, we calculate the difference in tourist numbers from 2009-2085. The greatest difference in tourist numbers is under the climate scenario HadCM3_A2 which is a high climate change scenario. This significant change in climate over the period is expected to result in substantial increases in tourist numbers into certain regions. One of the most significant changes from the base period is the projected increase in tourist numbers into certain parts of Russia. This could be explained by the fact that Russia is big, its climate is projected to improve with respect to variables that influence tourists and it is relatively close to the growing markets of South and East Asia. A growth in tourist numbers is also projected for Canada. As one might expect, Ontario, Northwest Territories and Alberta are projected to experience high levels growth under all three climate scenarios. These would be traditionally popular areas for tourism. Interestingly, a large increase in tourist numbers is also projected for Nunavut. However, tourist numbers into Nunavut in 2009 were significantly lower than other territories and thus the volume of tourists into the region is expected to remain relatively low.

Tourist numbers into Alaska are also projected to increase between the two periods. This growth is likely to be strongest in the region around King Salmon and Anchorage, which is interesting given the findings by Yu et al in 2009. Yu et al (2009) developed a tourism climate index to examine the changes in weather patterns in these two regions between 1941 and 2005. They found that *"overall weather conditions for sightseeing in King Salmon have improved significantly...at the same time, though warming is likely to shorten the total time for skiing each year at Anchorage, it is also likely to improve the quality of the winter season"*. The simulations presented in this paper suggest that these regions will become increasingly popular under climate change conditions. Overall, while we are not observing a re-distribution of tourists within the Arctic, the volume is certainly likely to increase.

Figure 3 illustrates the difference in grid level tourist numbers between each of the scenarios with climate change and without. For example, the Hamburg tourism scenario *B2 without climate change* is combined with the 2009 grid level climate data in order to simulate grid level tourist numbers in 2085 under current climate conditions using Equation (2) above. On the other hand, the Hamburg tourism scenario *B2 with climate change* is combined with the PCM_B2 scenario climate data to simulate tourist numbers in 2085 under climate change conditions. The difference between the two is then calculated. Unsurprisingly, the greatest difference between the models is seen under the climate model HadCM3 which projects the greatest amount of climate change. Similar patterns emerge in this case. Russia, Canada and parts of Alaska experience strong increases in tourist numbers while arrivals into the Scandinavian countries increase but to a lesser extent.

4. Conclusions

This paper estimates grid level tourist numbers to Arctic Circle countries under a number of climate change scenarios. A baseline estimate is also presented which examines the attractiveness of these countries under current climate conditions. At present, the highest tourism volumes are found in Canada and most of the Scandinavian countries. In Canada, tourists are particularly concentrated around Ontario, Northwest Territories and Alberta, while in Scandinavia tourist numbers are highest around the capital cities. Currently, tourist numbers into Russia are very low relative to the other countries which may be driven by the perceived difficulty of access to Russia. Generally, it appears that tourists are attracted to regions with better infrastructure and nicer cities.

Climate change scenarios project increases in both global averaged temperature and precipitation. According to the IPCC (2001), the average global temperature response for 2071-2100 relative to 1961-1990 could range from +0.9°C to +4.5°C. The average precipitation increase for 2071-2100 relative to 1961-1990 is projected to be in the range of 1.2% to 6.8%.

Under each climate change scenario, Russia sees a significant increase in tourist numbers. This could be explained by the fact that Russia is big, its climate is expected to show some improvement and it is relatively close to the growing markets of South and East Asia. A growth in tourist numbers is also projected for Canada. As one might expect, Ontario, Northwest Territories and Alberta experience high levels growth under all three climate scenarios. These would be traditionally popular areas for tourism. Interestingly, a large increase in tourist numbers is seen in Nunavut. However, tourist numbers into Nunavut in 2009 were significantly lower than other territories and thus the volume of tourists into the region remains relatively low. Overall, while the simulations do not show a re-distribution of tourists within the Arctic under climate change, the volume is likely to increase.

A number of caveats apply. We assumed Say's Law: Supply of tourism facilities (transport, hotels, etc) will follow demand. We ignored climate-change induced changes in the seasonality of tourism, and we did not consider heterogeneity among tourists. We omitted other aspect of climate change, such as the reliability of snow cover or blue skies, and kept constant all other determinants of tourism supply and demand bar income and population size. These issues are deferred to future research. We would expect that important may well be affected, but the overall pattern is robust to the simplifications made here: Climate change greatly increases the number of tourists in the Arctic.

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Table 1: Description of 2009 tourism data

Country	Description	# Regions	Source
Denmark, Finland, Sweden	Nights spent by non-residents in hotels and similar accommodation in 2009 by NUTSII	Denmark -5 Finland - 5 Sweden - 8	Eurostat
Greenland	Number of non-resident guests in 2009	5	Statistics Greenland
Iceland	Arrivals into all types of accommodation in 2009	8	Statistics Iceland
Canada	Total visitors (not including business visitors) staying 1+ nights in 2009	13	Statistics Canada
Russia	Number of visitors sent by travel companies to Russia	81	Rosstat
Norway	Guest nights in all accommodation types	19	Statistics Norway
Alaska	Total Number of out-of-state visitors to Alaska May - Sept 2009	1	State of Alaska

Table 2: Details of climate models and tourism scenarios used

TYN SC 2.0 Climate Model	Hamburg Tourism Model
PCM_B2 (low climate change scenario)	B2 with and without climate change
CGCM2_B1 (medium climate change scenario)	B1 with and without climate change
HadCM3_A2 (high climate change scenario)	A2 with and without climate change

Figure 1: Maps showing grid level tourist numbers in 2009 under current climate conditions

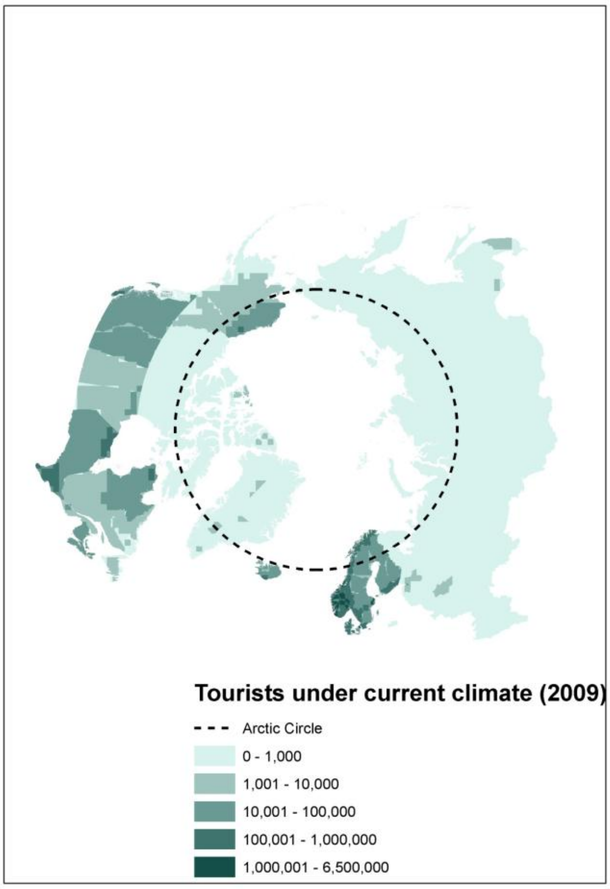


Figure 2: Maps showing the difference in tourist numbers at grid level between 2009 and 2085 under 3 scenarios: PCM_B2 and B2 with climate change, CGCM2_B1 and B1 with climate change and HadCM3_A2 and A2 with climate change

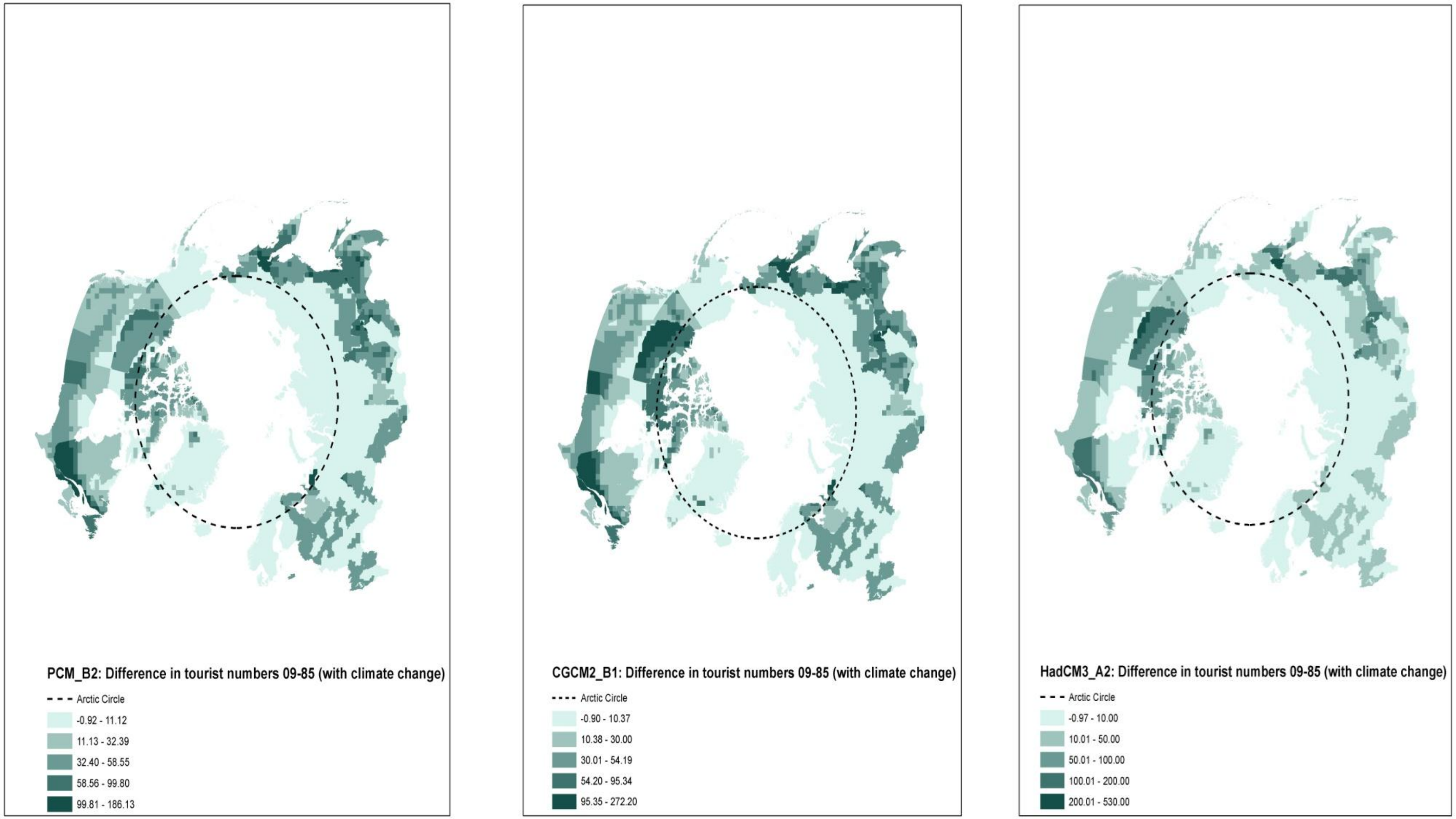
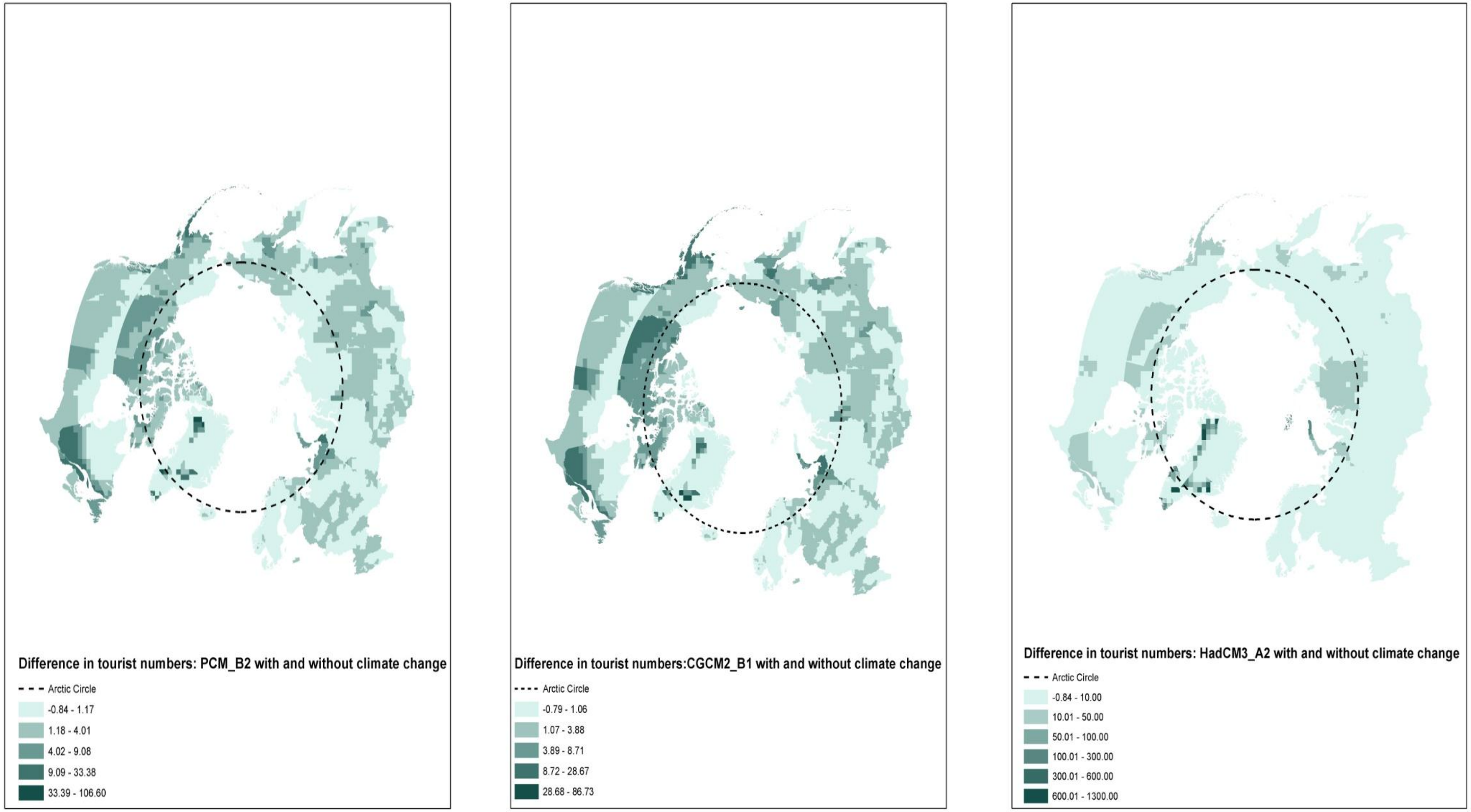
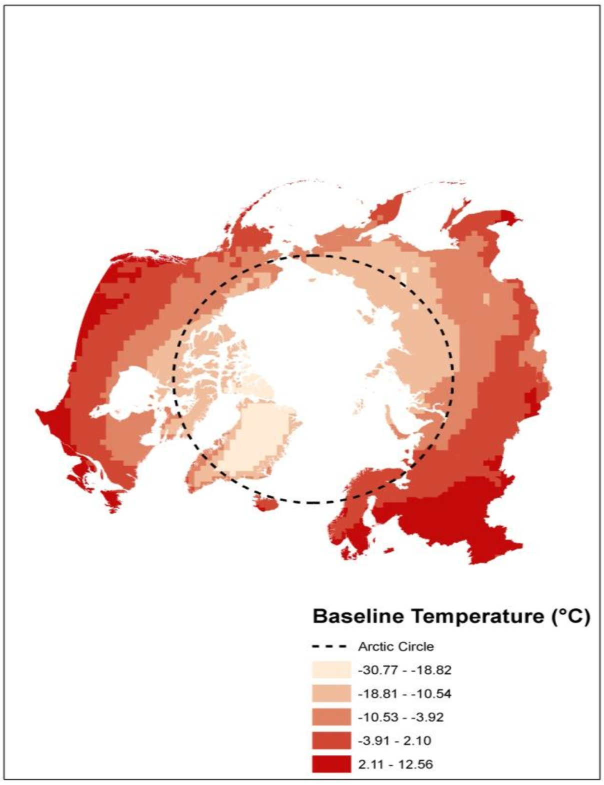
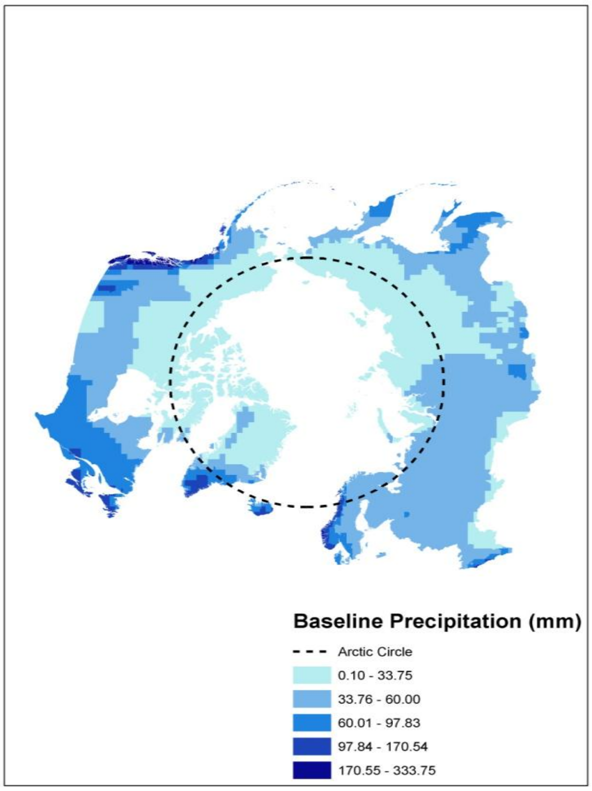


Figure 3: Maps showing the difference in tourist numbers at grid level between each of the scenarios with and without climate change.

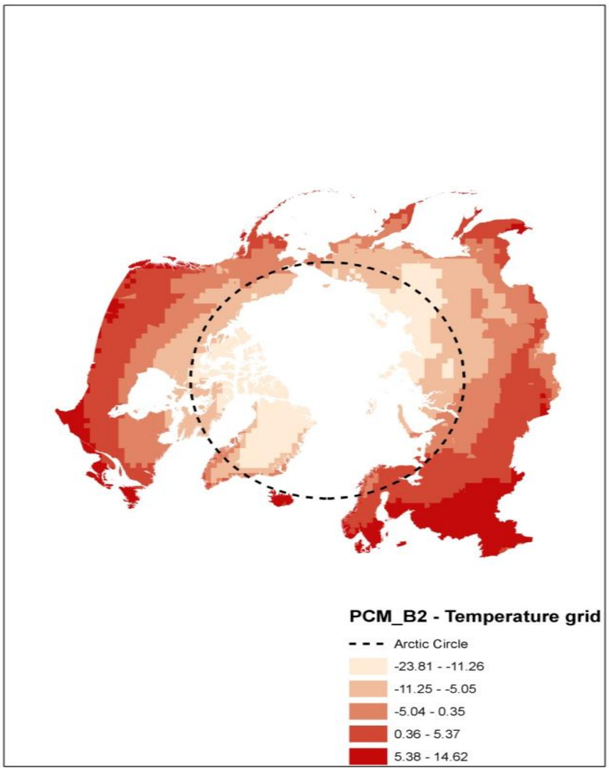


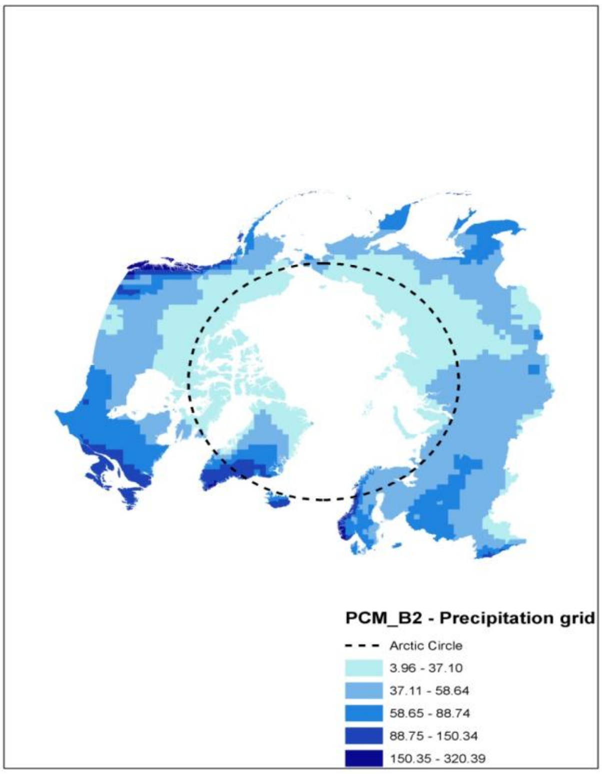
Appendix A: Grid level temperature (°C) and precipitation (mm) in current period



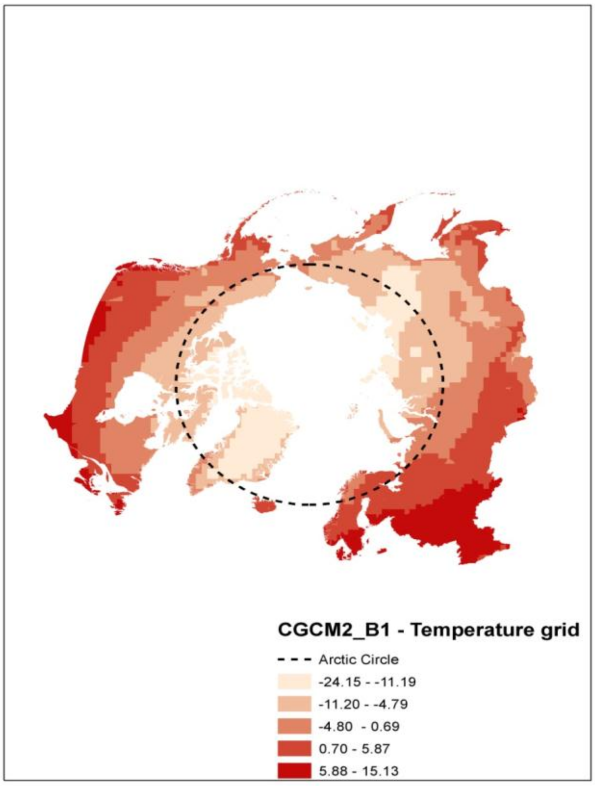


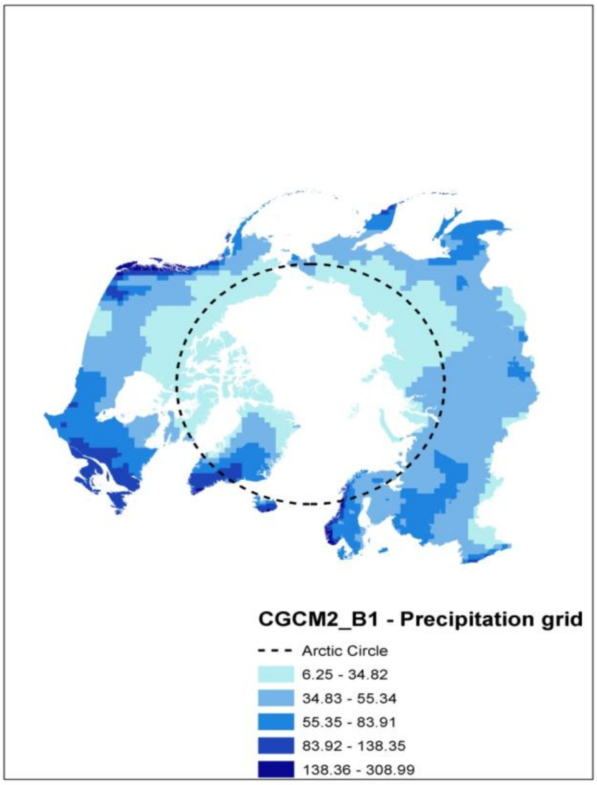
Appendix B1: Grid level temperature (°C) and precipitation (mm) under PCM_B2 scenario (low climate change scenario)





Appendix B2: Grid level temperature (°C) and precipitation (mm) under CGCM2_B1 scenario (medium climate change scenario)





Appendix B3: Grid level temperature (°C) and precipitation (mm) under HadCM3_A2 scenario (high climate change scenario)