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The Impact of Arctic Climate on Tourist Destination Choice

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1. Executive Summary

We examine the determinants of holiday destination choice for tourists from 182 countries over a fifteen year time period. Our sample is much larger than that used by previous studies. The results are similar. Tourists prefer to stay relatively close to their home country. They like countries that have a long coast and lots of heritage. Tourists dislike poverty, and tourists from richer countries have a greater aversion to poverty. Tourists prefer politically stable countries (all else being equal). Tourists like countries with high precipitation. Tourists like it hot, but not too hot. Tourists from warmer origins have stronger climate preferences.

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. 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 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.

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

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2. The Impact of Climate on Tourist Destination Choice

2.1. Introduction

Climate is a key variable in the destination choice of tourists (Becken and Hay, 2007;Wall and Badke, 1994). Mass tourism continues to be about sun, sea, sand and safety (Aguiló et al., 2005). The older literature on tourism assumed that climate was constant, and thus not particularly interesting (Hamilton and Tol, 2007). Climate is changing, however, and will continue to change. It is now generally acknowledged that tourism will change with the climate, but there is remarkably little agreement how climate change would affect tourists and tourism resorts. This paper contributes a statistical analysis of more and newer data than what was used before.

Studies of the impact of climate change on tourism come in three flavours. Some papers consider biophysical indicators, either at a local (Lin and Matzarakis, 2008; Lopes et al., 2011) or a global scale (Amelung et al., 2007). Unfortunately, such indicators have yet to be validated (Gomez-Martin, 2006). Other papers study the impact of climate change on particular resorts or areas (Abegg and Elsasser, 1996; Scott et al., 2007), thus omitting the competitive nature of destinations. We therefore follow the tradition of the third flavour of research, and study where tourists go and why.

(Maddison, 2001) estimates the impact of climate change on the destination choice of British tourists and finds that British tourists are attracted to climates with an average maximum temperature of 30.7°C. (Lise and Tol, 2002) find that tourists originating in OECD countries prefer a temperature (in the warmest month) of 21°C at their holiday destination and that this preference 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 individual needs. (Bigano et al., 2006) analyse forty-five countries over the same, single time period and find that tourists have an optimal annual mean temperature of 16.2°C ± 2·0.5 °C irrespective of the climate of their origin country. However, tourists originating in warmer climates tend to be more particular about their destination choice.

(Bigano et al., 2007;Hamilton et al., 2005a;Hamilton et al., 2005b) use these econometric results to construct a global tourism simulation model to examine the effect of climate change on tourism. Two interesting findings emerge from these studies. Firstly, international tourist arrivals will fall in hotter countries and rise in colder countries under a climate change scenario. This will drive tourists to higher latitudes and altitudes. Secondly, tourists from North-Western Europe, the main origin of international tourists at present, would be more inclined to spend their holiday in their home country, so that the total number of international tourists falls. However, the fall in the number of international tourists brought about by climate change would be negated by population and economic growth. In the worst affected countries, climate change slows down the rate of growth in the tourism sector, but the overall size of the sector remains constant. (Eugenio-Martin and Campos-Soria, 2010) also find that a better climate in the country of origin implies a higher probability of travelling domestically and a lower probability of travelling abroad and that *"tourists who live in regions with a poor climate are more willing to accept destinations with a similar climate than tourists who are already living in destinations with a good climate".*

This paper extends on previous work by (Bigano et al., 2006) by introducing a wider array of countries along with a time dimension. The purpose of this paper is to assess the determinants of holiday destination choice for 182 countries analysed across a fifteen year period (1995-2009). (Bigano et al., 2006) used 45 countries and one year of data. The paper is organised as follows. Section 2 outlines the data sources used for each of the variables included in the analysis. Section 3 details the findings for 182 countries, as well as the results of pooled regression analysis. Section 4 provides an interpretation of the optimal temperature and precipitation results. Section 5 discusses and concludes on the findings of the study.

2.2. The data

This section describes the data sources for the variables used in the analysis. For the dependent variable, tourism data for each country is taken from the UN World Tourism Organisation (WTO). (WTO, 2011) defines a *visitor* as *"a traveller taking a trip to a main destination outside his/her usual environment, for less than a year, for any main purpose other than to be employed by a resident entity in the country or place visited."* On the other hand, *"a visitor* (*domestic, inbound or outbound*) *is classified as a tourist if his/her trip includes an overnight stay."* As different countries use varying methods of recording tourist arrivals, four measures were used. Tarrbor measures tourist arrivals by recording the number of *tourists* arriving at the *border* of a given country. Varrbor measures the number of *visitor* arrivals at the *border* of a given country (tourists plus day-trippers). Tarrall measures the number of tourist arrivals at all *accommodation* types and Tarrhot measures the number of tourist arrivals at *hotels* and similar types of accommodation.

A number of explanatory variables are used in the regression below. GDP per capita, length of coastline and area are taken from the CIA World Factbook[1]. Political stability is from the political stability and absence of violence measure as reported by the World Bank[2]. This measure examines the perception of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including domestic violence and terrorism. The political stability index ranges in value from -2.5 to 2.5, with -2.5 indicating the worst level of governance, 0 as the average level and 2.5 as the best governance level. The number of world heritage sites is taken from UNESCO[3]. Distance between countries is calculated as the great circles distance between capital cities according to the Times Atlas (Times,1994).

The model contains both time variant and time invariant independent variables. GDP per capita and political stability are time variant. The other variables such as distance, area, coastline, temperature, precipitation and the number of world heritage sites remain constant over the analysed time period. Temperature and precipitation are constant because we are interested in the impact of the expected weather (or climate) on tourist destination choice, rather than the

[1] https://www.cia.gov/library/publications/the-world-factbook/
[2] http://info.worldbank.org/governance/wgi/index.asp
[3] http://whc.unesco.org/en/list

effect of the actual weather. GDP per capita is used as a proxy for economic well-being. Average annual temperature in degrees Celsius and average annual precipitation in millimetres are used as climate indicators (New et al. 2002). We assume that tourists dislike extremes in both temperature and precipitation and so we have also included temperature squared and precipitation squared as explanatory variables. The number of world heritage sites is used as a measure of the cultural attractiveness of a destination country. Area is included because larger countries are assumed to have a greater amount of attractive features and can accommodate a greater number of people. Distance is used as a proxy for time travel and cost, both of which are expected to deter tourists. Coastline length is included because tourists tend to be attracted to sea and political stability is included because instability deters tourists.

2.3. The results

We estimate the following destination choice model for all countries of origin:

$$(1)\quad \text{In}\left(Y_{d,o,t}\right) = \alpha_{o,t} + \beta_{1,o,t}T_d + \beta_{2,o,t}T_d^2 + \beta_{3,o,t}\,P_d + \beta_{4,o,t}P_d^2 + \beta_{5,o,t}\,A_d + \beta_{6,o,t}\,\text{In}\left(G_{d,t}\right) + \beta_{7,o,t}C_d + \beta_{8,o,t}PS_{d,t} + \beta_{9,o,t}W_d + \beta_{10,o,t}D_{10,o,t} + \varepsilon_{o,t}$$

Where;

- $Y_{d,o,t}$ is the dependent variable, denoting the number of tourist arrivals into a given country *d* from a country *o* at time *t*
- T_d is the average annual temperature of each destination country in degrees Celsius
- P_d is the average annual level of precipitation of each destination country in millimetres
- A_d is the total area of each destination country including both land and sea
- $G_{d,t}$ is the GDP per capita of each destination country in each year measured in US dollars
- C_d is the length of the coastline of each destination country measured in kilometres
- $PS_{d,t}$ is a political stability and absence of violence measure for each destination country in each year, as reported by the World Bank
- W_d is the number of UNESCO world heritage sites located in each destination country
- D_d is the distance from each country of origin to each destination country measured in kilometres

Equation (1) was estimated separately for each country and for each year. The parameter estimates were then combined using Bayes' rule, with an arbitrary result as prior and the rest as data. This procedure is conceptually identical to a random effects panel estimator. While there is a loss of efficiency, there is a gain in flexibility as we can fix parameter estimates over space $\beta_{i,o,t}=\beta_{i,t}$ as well as over time $\beta_{i,o,t}=\beta_{i,o}$. For example

$$(2)\ \beta_{i,o} = \sigma_{i,o}^2 \sum_t \frac{\beta_{i,o,t}}{\sigma_{i,o,t}^2}$$

$$(3)\ \sigma_{i,o}^2 = \sum_t \frac{1}{\sigma_{i,o,t}^2}$$

where $\sigma_{i,o,t}$ is the standard error the parameter $\beta_{i,o,t}$. Equations (2) and (3) follow from the assumption of Normal errors in Equation (1).

More importantly, we can apply (2) and (3) to nonlinear transformations of the parameters. This would impose a non-linear restriction on the parameters in a panel estimator, which is difficult.

2.3.1 Pooled regression results

Pooled OLS regressions ($\beta_{i,o,t}=\beta_i$) were conducted and the results are illustrated in Table 1 below. Table 1 includes results for four different tourist measures. Tourist includes just Tarrbor as the measure for Y_i (tourist arrivals). Tourist 2 includes both Tarrbor and Varrbor, Tourist 3 includes Tarrbor, Varrbor and Tarrall and Tourist 4 includes all measures; Tarrbor, Varrbor, Tarrall and Tarrhot.

The coefficients on the linear and quadratic temperature terms are positive and negative respectively, which suggests that tourists have an optimal temperature. The range of t-statistics across the 4 models is 43.90 to 52.32 (linear) and -43.98 to -52.99 (quadratic). Precipitation has varying effects across the four models. The parameter has the expected negative effect on tourist arrivals and is significant at the 1% level under the Tourist 3 and Tourist 4 models, indicating that higher rainfall amounts discourage tourists (range of t-statistics, linear -4.88 to 6.60, quadratic 5.61 to 12.09). However, an insignificant effect is found under the Tourist model and a positive and significant effect is seen under the Tourist 2 model. In line with other studies, such as (Bigano et al. 2006), tourists prefer to visit wealthier countries as shown by the positive coefficient for GDP per capita in all four models. Again, GDP per capita is significant at the 1% level across the four models (range of t-statistics 33.80 to 48.02).

Table 1: Pooled OLS regression results *(standard error in brackets)*

	Tourist	Tourist 2	Tourist 3	Tourist 4
Temperature	0. 375 (0.008) ***	0. 282 (0.006)***	0. 269 (0.005)***	0.247 (0.005)***
Temperature Squared	-0.012 (0.0003)***	-0.009 (0. 0002)***	-0.009 (0.0002)***	-0.008 (0.0002)***
Precipitation	0.00008 (0.00006)	0.0001 (0. 00006)*	-0.0004 (0.00006)***	-0.0002 (0.00005)***
Precipitation Squared	1.58e-07 (1.91E-08)***	1.57e-07 (1.82e-08)***	9.86e-08 (1.76e-08)***	2.03e-07 (1.68e-08)***
Area	1.23e-07 (5.88E-09)***	1.27e-07 (4.95e-09)***	1.12e-07 (4.35e-09)***	9.08e-08 (4.30e-09)***
World Heritage Sites	0.070 (0.001)***	0. 079 (0. 001)***	0.086 (0.001)***	0.089 (0.001)***
GDP per capita	0.489 (0.014)***	0.577 (0. 013)***	0.595 (0.012)***	0.551 (0.012)***
Political Stability	-0.100 (0.015)***	-0.163 (0.014)***	-0.105 (0.014)***	-0.054 (0.013)***
Coastline	0.00002 (5.54E-07)***	0.00001 (3.91e-07)***	0.00001 (3.54e-07)***	0.00001 (3.51e-07)***
Distance	-0.0002 (2.55E-06)***	-0.0002 (2.36e-06)***	-0.0003 (2.11e-06)***	-0.0002 (2.05e-06)***
R^2	0.24	0.25	0.27	0.25
N	67378	75564	91496	97691

* p < 0.1; ** p < 0.05; *** p < 0.01

Tourists also favour safer destinations as indicated by the negative effect of political stability and absence of violence index which is significant at the 1% level (range of t-statistics -4.01 to -11.55). The number of world heritage sites, the length of coastline in the destination country and the area of the destination country are all found to have a positive effect on the number of tourist arrivals. The range of t-statistics across the four models is 44.96 to 67.96 (#WHS), 28.66 to 30.59 (Coastline) and 20.96 to 25.82 (Area). Distance to the destination country has a negative effect and is significant at the 1% level in all cases, implying that tourists are deterred by longer travel times and expected higher travel cost. While the pooled OLS models exhibit relatively low explanatory power with an R^2 value of 0.24 - 0.27 across the four models, the R^2 values of the individual country regression models are much higher.

2. 3.2 Country-of-origin regression results

Above, we pool all estimates. Here, we consider differences between the countries of origin, pooling over time only ($\beta_{i,o,t}=\beta_{i,o}$). We focus our analysis on the *Tourist* model. Given the number of the countries in this analysis, results are discussed by continent.[4]

The temperature parameters are jointly significant at the 5% level in most countries. However, some exceptions include: Andorra, Latvia, Cambodia, Bhutan, Jamaica, Bermuda and Puerto Rico. The relationship between temperature and the number of tourists has the expected inverted U-shape in the majority of countries apart from Russia, Bosnia and Herzegovina, Lao, Maldives and Barbados. Precipitation has varying effects across the five continents. The coefficients on the linear and quadratic terms are negative and positive respectively in most European and Oceania countries. However, some interesting exceptions include the UK, Germany, Italy, Spain and Switzerland. No clear pattern emerges in the case of Asia, Africa and America and the parameter is insignificant in about half of the African countries examined.

Area has a positive effect and is significant at the 5% level in almost all countries which suggests that larger countries attract more tourists. The parameter is insignificant in the Netherlands, Austria, Albania, Czech Republic, Slovakia, Lao, Somalia, Madagascar, Puerto Rico and Bermuda. The number of world heritage sites is positive and significant in Europe, Oceania and the Americas apart from Liechtenstein, Monaco, Republic of Moldova, Guadeloupe, Antigua & Barbuda and Fiji where a negative and significant relationship is found. Countries in Asia show positive and negative effects depending on the country of origin, with no discernible pattern. The parameter is positive and significant for roughly two thirds of the African countries included in the analysis. GDP per capita in the destination country has a positive effect and is significant at the 5% level in almost all European countries except for Andorra, Moldova and Liechtenstein where an insignificant result is found. Similar results are found in the Americas, Oceania and Asia. This conforms to previous studies (Bigano et al. 2006) which found that, in general, tourists do not like to witness poverty. Not surprisingly, the parameter is positive and significant in less than half of the African countries examined.

Political stability appears to have mixed effects across European countries. The parameter is negative and significant for countries such as France, Germany, UK, Spain, Italy and Belgium. However, we find a positive and significant effect in countries such as Luxembourg, Croatia, Slovakia, Slovenia and Turkey. The parameter is insignificant in Ireland, Austria, Switzerland, Portugal and Denmark. Political stability has a negative effect (and is significant at the 5% level) for most Asian countries along with the Americas and Oceania. This is in agreement with the assumption that tourists are attracted to more stable countries. No clear pattern emerges in Africa, with roughly half the countries showing an insignificant effect. Coastline has a positive and significant effect on tourist arrivals for most of the countries included in the analysis while distance has a clear negative effect and is significant at the 5% level in almost all countries apart

[4] Continents are defined as: Europe, Asia (Middle East), Africa, The Americas and Oceania. We include Russia and Turkey in Europe.

https://www.cia.gov/library/publications/the-world factbook/fields/2145.html?countryName=&countryCode=&regionCode=y

from Macedonia, Liechtenstein, Andorra and Eritrea where a positive and significant result is found. This suggests that international tourists are deterred by long distance holidays.[5]

2.3.3 Time-dependent results

Here, we consider differences over time, pooling over countries only ($\beta_{i,o,t}$=$\beta_{i,t}$). Again, we focus our analysis on the *Tourist* model. Results are presented in Table A1.

Temperature and temperature squared are significant at the 1% level across all years. The relationship between temperature and the number of tourist arrivals is also found through all the years, with a large positive coefficient for temperature and a very small negative coefficient for temperature squared. The number of world heritage sites has a large positive effect on tourist numbers and is significant in all years apart from 1995. Similarly, GDP per

capita is positive and significant in all years except 2008 and 2009. However, the size of the GDP parameter varies over time. A very small positive effect is found from 2000-2009; all other years show a moderate/strong positive effect on tourist numbers.

The area and length of coastline in the destination country have a very small positive effect on tourist numbers throughout all years. Interestingly, political stability is insignificant in most years apart from 1997, 1999, 2004 and 2005 where a small negative and significant result is found. The linear and quadratic precipitation terms are jointly significant at the 1% level in 1995, 1996, 1997, 2007 and 2008. Mixed effects are found in these years. The parameters are positive and negative respectively in 1995, 1996 and 1997. However, the opposite is the case in 2007 and 2008. Distance to the destination country has a negative, but very small negative impact on tourist arrivals and the parameter is significant at the 1% level across all years.

2.4. Interpretation

As previously stated, we assume that tourists dislike extremes in both temperature and precipitation, and so we have included temperature squared and precipitation squared as explanatory variables. The optimal temperature is calculated as follows:

$$(4)\quad T^{opt} = -\frac{\beta_1}{2\beta_2}$$

Optimal precipitation is calculated in the same way using β_3 and β_4 from Equation (1). The standard deviation of the optimal temperature is approximated using the first-order Taylor approximation:

$$(5)\quad \sigma_T^2 = \frac{1}{4\beta_2^2}\sigma_1^2 + \frac{\beta_1^2}{4\beta_2^4}\sigma_2^2 - \frac{\beta_1}{4\beta_2^3}\sigma_{1,2}$$

We can see from Figure 1a that the optimal temperature varies between 14.60°C and 15.69°C across the four models; a difference that is not significantly different. Figure 1b shows that optimal precipitation ranges from -1871 to 619 millimetres per year. This suggests that countries

[5] The complete set of results can be found here - http://www.esri.ie/UserFiles/publications/WP423/WP423.xlsx

with high levels of precipitation are not as attractive to tourists compared to those with low precipitation levels.

Figure 1a: Optimal temperature for each tourist model using the pooled regression results

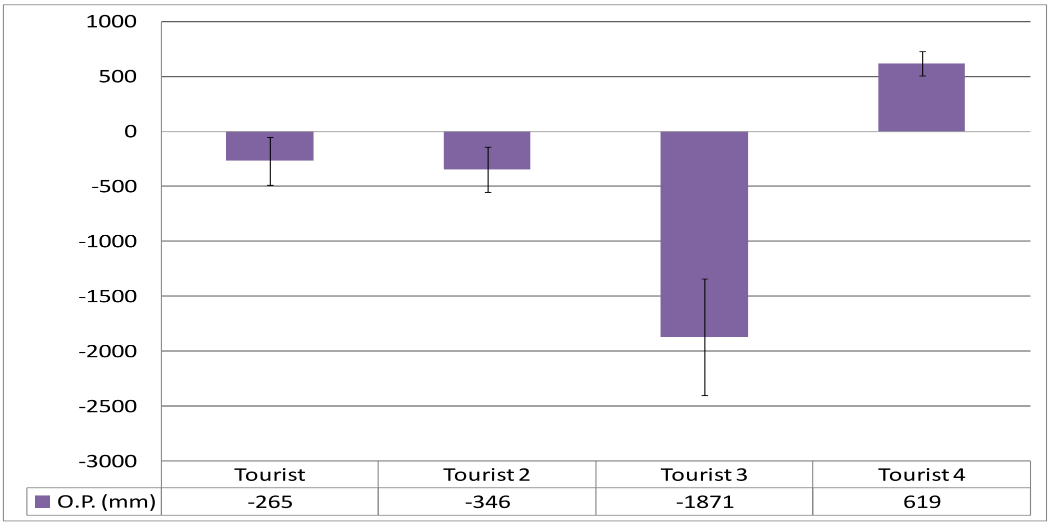


Figure 1b: Optimal precipitation for each tourist model using the pooled regression results

At a country level, the optimal temperatures seem to be largely significant and the global average optimal temperature of 15.49°C ± 0.20 is in line with previous studies. Such temperatures are found in countries such as Argentina, Greece, Portugal, Spain, Italy, Monaco, Lebanon and Taiwan. When we examine the optimal precipitation for each country of origin, we find that the global average optimal precipitation is 1,420mm ± 30.83. This precipitation level is found in countries such as Peru, New Caledonia and Dominican Republic. Surprisingly, countries such as Spain, Italy, France, Germany, Portugal and even Ireland are found to be too dry.

To examine the relative importance of temperature against precipitation in determining destination choice, high resolution temperature and precipitation data (New et al., 2002) is used to construct a composite indicator:

(6) $C_c = e^{\beta_1 T_c + \beta_2 T_c^2 + \beta_3 P_c + \beta_4 P_c^2}$

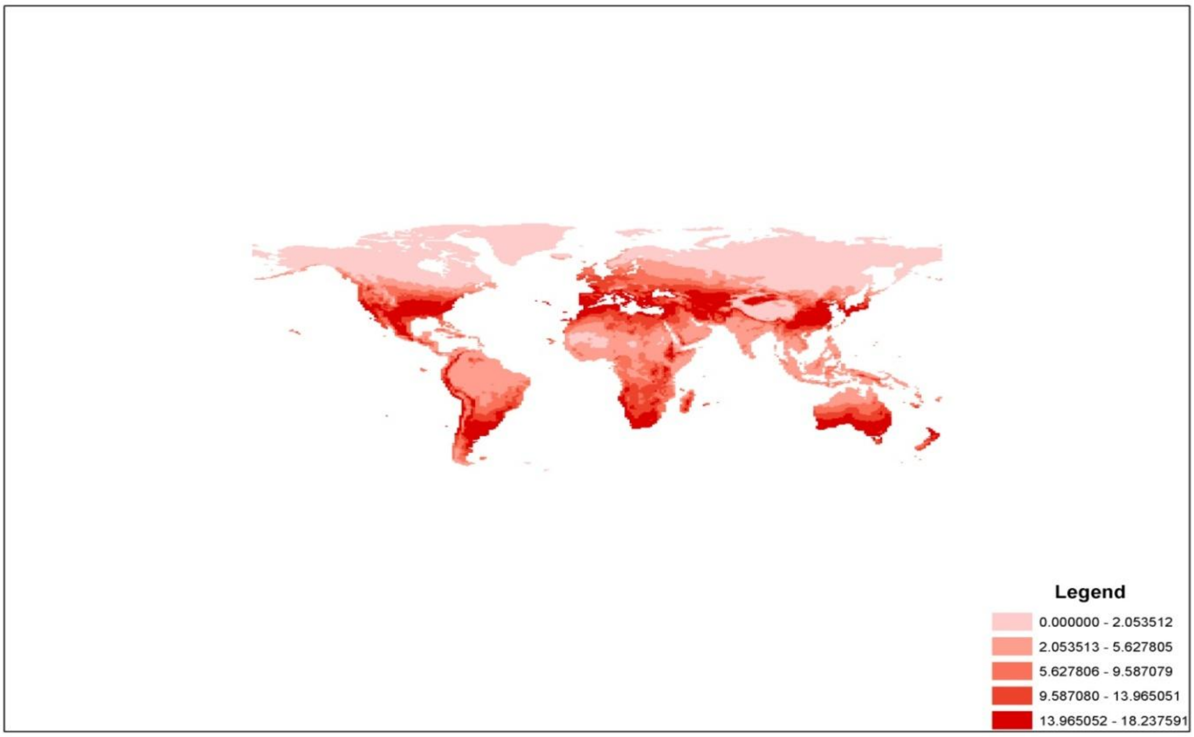


Figure 2: Map showing composite indicator of temperature and precipitation

The results are presented in Figure 2. What we find is that temperature is a much stronger determinant of tourism demand relative to precipitation. Under current climate conditions, the Mediterranean is a very attractive destination for international tourists. Other attractive regions include the African highlands, South Australia and South Africa. Korea and Lebanon should in principle be attractive to international tourists; however, this is unlikely to be the case in reality. Interestingly, California appears to be an attractive destination, however, Florida does not. Unattractive regions include northern Canada and Russia.

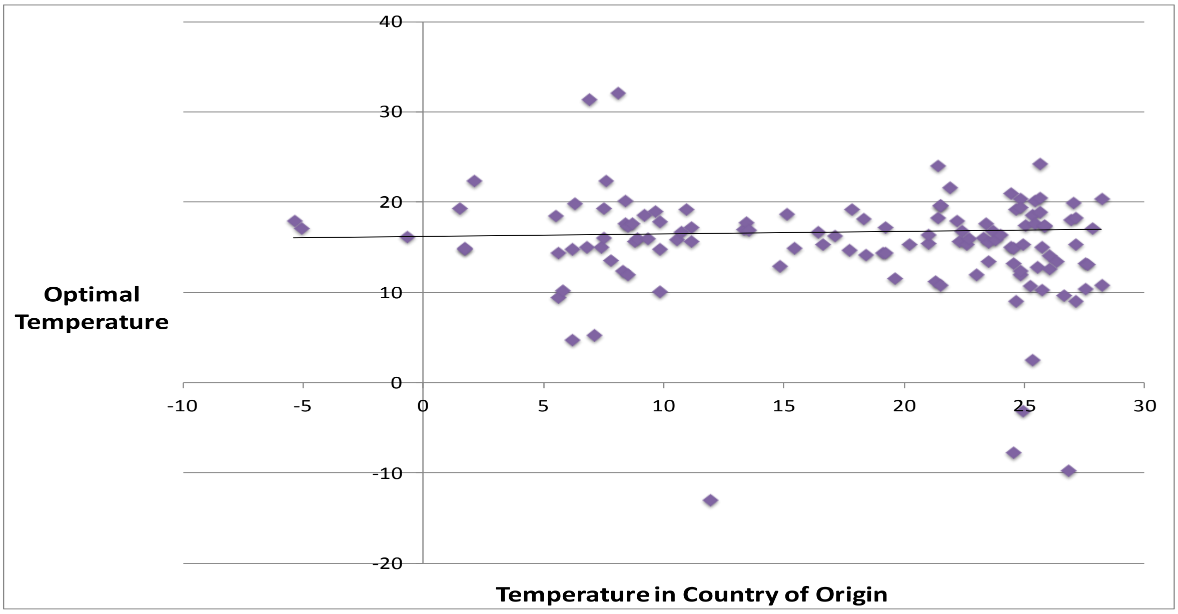


Figure 3: The optimal temperature for the countries of origin; countries of origin are ranked (from lowest to highest) according to their temperature.

Figure 3 shows the relationship between the optimal holiday temperature and the temperature in the country of origin. Similar to earlier studies (Bigano et al. 2006), we find that no relationship exists. In other words, the optimal temperature is independent of what tourists are used to.

Figure 4 shows the relationship between the temperature squared parameter from Equation (1) and the difference between the temperatures in the country of origin and the global average optimal temperature. While all tourists prefer a similar optimal temperature, tourists coming from hotter climates have stronger preferences than those coming from colder climates. That is to say, *"regions with poorer climate show higher flexibility in terms of destination choice"* (Eugenio-Martin and Campos-Soria 2010).

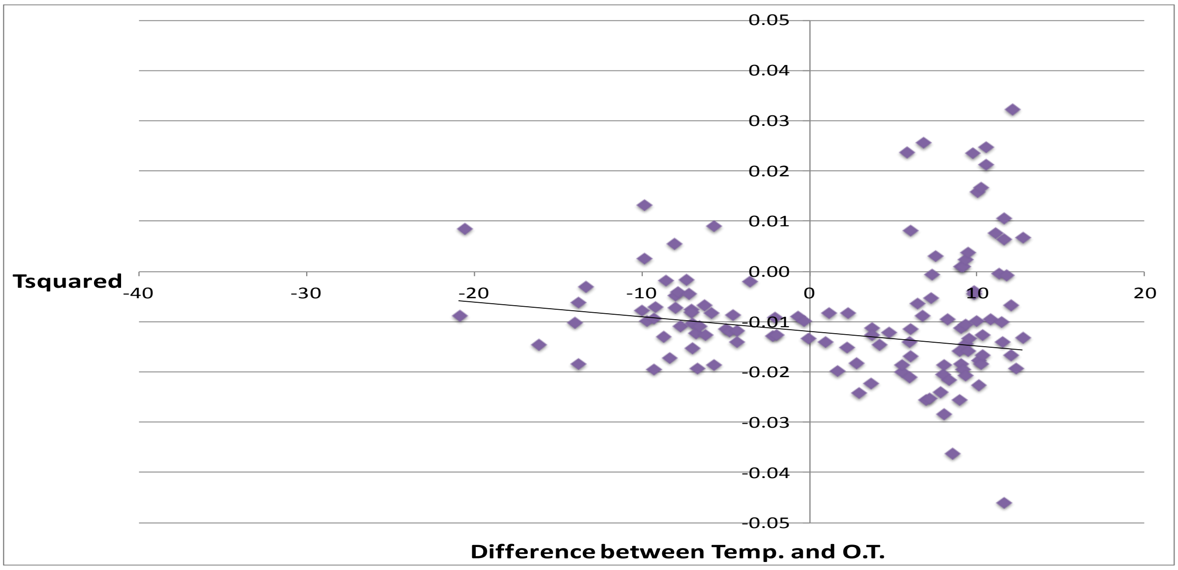


Figure 4: The coefficient of temperature squared in Equation (1) for the countries of origin against the difference between the temperature in the country of origin and the optimal temperature for that country.

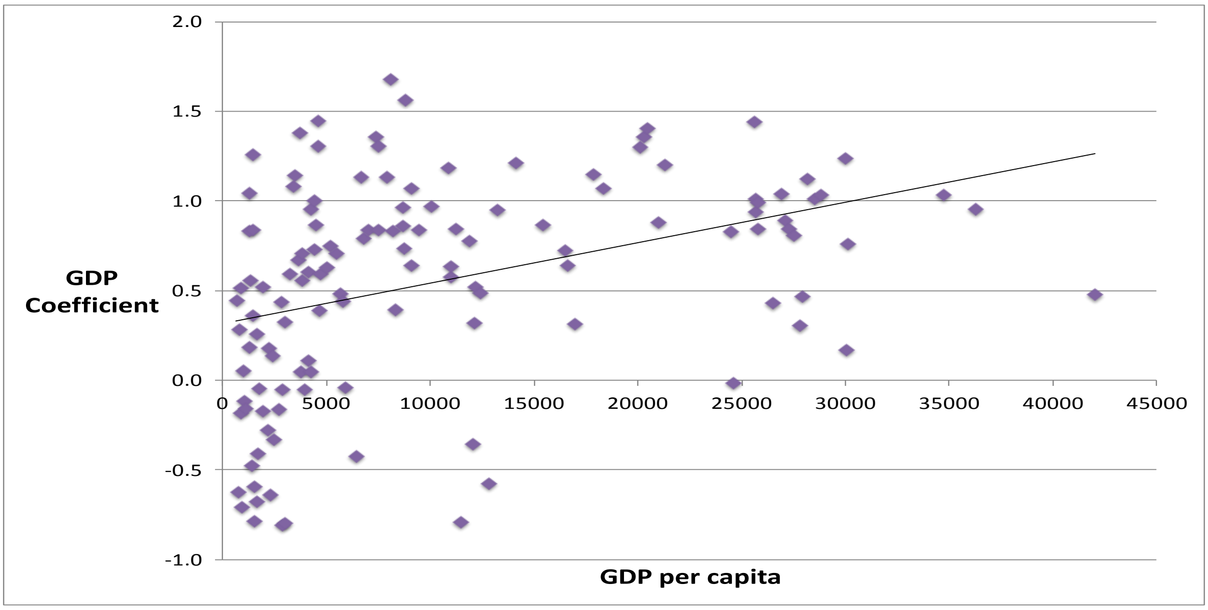


Figure 5: The coefficient of GDP per capita from equation (1) for the countries of origin; countries of origin are ranked (from lowest to highest) according to their GDP per capita.

Figure 5 shows the relationship between GDP per capita in the countries of origin and the GDP parameters from Equation (1). Here we see a clear pattern. Tourists originating in rich countries are more opposed to witnessing poverty compared to those originating in poor countries. Again, this conforms to earlier analysis (Bigano et al. 2006) which found that *"people from poor countries are less deterred by poverty, they can less afford holidays in rich countries, and they may not be allowed to travel there".* To examine whether tourists from stable countries are more sensitive to instability, we graph the coefficient of political stability from Equation (1) for all countries of origin against the average political stability index for each country in Figure 6 below.

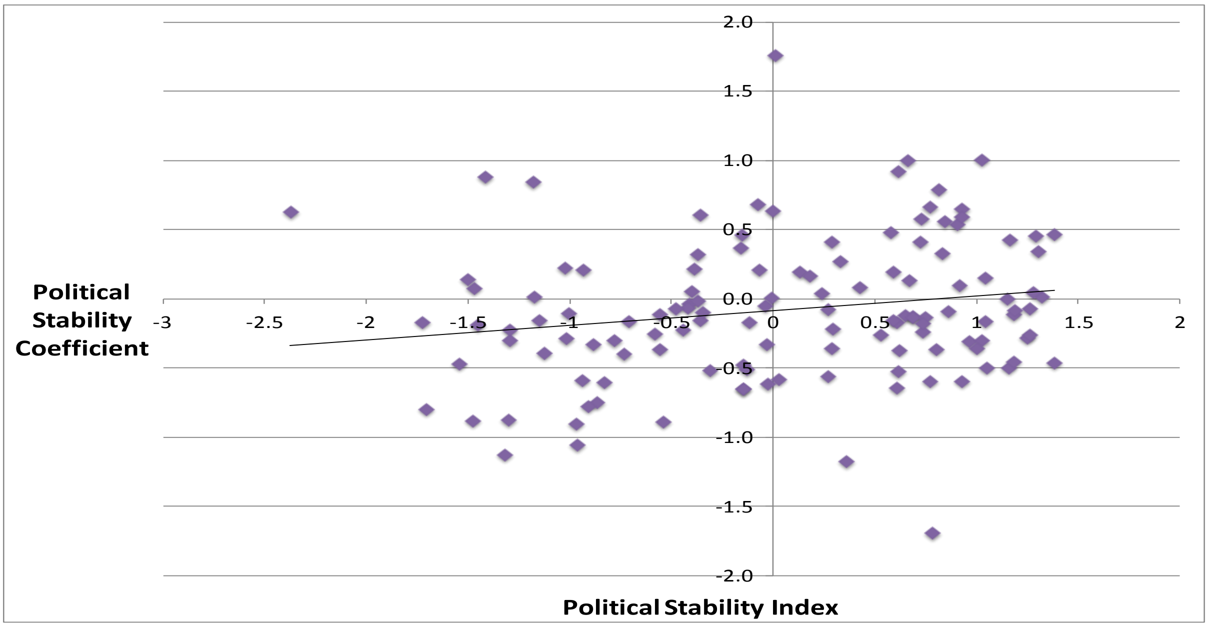


Figure 6: The coefficient of political stability from equation (1) for the countries of origin; countries of origin are ranked (from lowest to highest) according to their political stability.

We find that tourists originating in stable countries do not necessarily have a stronger preference for travelling to stable destinations. This is a surprising result as it suggests that tourists originating in countries such as Sri Lanka and Pakistan have the same preference for travelling to politically stable countries as those originating in Finland and Luxembourg.

2.5. Conclusions

This paper examines the determinants of holiday destination choice for tourists from 182 countries over a fifteen year time period. We find that destination choice is explained by the socio-economic characteristics of the tourist's country of origin as well as climate variables. Tourists originating in rich countries are more averse to witnessing poverty compared to those originating in poor countries. Tourists from politically stable countries do not necessarily have a stronger preference for travelling to stable destinations. We find that temperature is a much stronger determinant of destination choice than is precipitation. As a result, the Mediterranean is a very attractive holiday destination under current climate conditions, along with the African highlands, South Australia and South Africa. Korea and Lebanon should in principle be attractive to international tourists; however, this is unlikely to be the case in reality. The average optimal holiday temperature of 15.49°C ± 0.20 is found to be independent of the tourists' country of origin. In other words, tourists travelling from Canada and Russia prefer the same temperature at their destination choice to those originating in Mali and Maldives. However, when we examine the quadratic temperature term, we find that tourists travelling from colder climates are more flexible in their temperature preference compared to those coming from hot climates.

There are a number of caveats to these results. We ignore heterogeneity – in purpose of travel, season of travel, composition of the group of travellers, their budget, and their taste. This is as a result of the paucity of the data at the global level. Questions of heterogeneity are better investigated with micro-data. We use national data, both for origin and destination. We not only give equal weight to small and large countries, we also assume that each country is homogeneous. We use explanatory variables that are readily available. There are two puzzling results. Tourists appear to like rain. Introspection suggests that tourists really like lush environments (which requires rain) but prefer to visit them when it is dry (whereas we use total annual precipitation rather than the chance of rain during the tourist season). Tourists also appear to like political instability. This is again probably due to omitted variable bias. Tourists probably do not care much about political instability; it is their personal safety that matters. The fourth main caveat is that we use distance as a proxy for travel time and travel cost.

Nonetheless, our results confirm what other studies have found with much fewer data. Such robustness across studies suggests that the above caveats are unlikely to overturn the main thrust of our results. The average tourist has clear and well-defined climate preferences. Climate change is thus likely to shift the geographic pattern of tourism.

Table A1: Time Dependent Regression Results: 1995-2001 ***(standard error in round brackets)***

	1995	1996	1997	1998	1999	2000	2001
Temperature	0.819 (0.053)***	0.686 (0.054)***	0.492 (0.052)***	0.243 (0.032)***	0.353 (0.031)***	0.483 (0.028)***	0.369 (0.031)***
Temperature^2	-0.024 (0.002)***	-0.019 (0.002)***	-0.015 (0.002)***	-0.007 (0.001)***	-0.011 (0.001)***	-0.016 (0.0009)**	-0.012 (0.001)***
Precipitation	0.002 (0.000)***	0.001 (0.000)***	0.001 (0.000)***	0.0005 (0.000)**	0.000012 (0.002)	-0.00008 (0.0002)	0.0002 (0.0002)
Precipitation^2	-5.10e-07 (8.49e-08)***	-2.36e-07 (8.51e-08)***	-2.28e-07 (8.36e-08)***	-1.87e-09 (7.22e-08)	0.000 (7.12e-08)	2.29e-07 (6.85e-08)***	1.34e-07 (6.94e-08)
Area	2.80e-07 (3.10e-08)***	1.71e-07 (2.63e-08)***	9.28e-08 (2.30e-08)***	8.03e-08 (2.22e-08)***	0.000 (2.23e-08)***	1.30e-07 (2.20e-08)***	1.34e-07 (2.20e-08)***
#WHS	0.014 (0.009)	0.048 (0.008)***	0.061 (0.006)***	0.068 (0.006)***	0.071 (0.006)***	0.074 (0.006)***	0.073 (0.006)***
GDP	0.576 (0.067)***	0.495 (0.069)***	0.694 (0.065)***	0.802 (0.059)***	0.650 (0.058)***	0.336 (0.055)***	0.502 (0.060)***
Political Stability	0.005 (0.073)	-0.175 (0.072)**	-0.325 (0.068)***	-0.091 (0.062)	-0.176 (0.060)***	0.060 (0.058)	0.010 (0.059)
Coastline	0.00005 (3.29e-06)***	0.00005 (3.49e-06)***	0.00004 (3.43e-06)***	0.00002 (2.51e-06)***	0.00003 (2.45e-06)***	0.00002 (1.81e-06)***	0.00001 (2.00e-06)***
Distance	-0.0002 (0.000)***	-0.0002 (0.000)***	-0.0002 (0.000)***	-0.0002 (0.000)***	-0.0002 (9.62e-06)***	-0.0002 (9.11e-06)***	-0.0002 (9.38e-06)***
R^2	0.27	0.24	0.24	0.26	0.27	0.26	0.25
N	3211	3566	3955	4277	4645	5450	5005

* p < 0.1; ** p < 0.05; *** p < 0.01

Table A1: Time Dependent Regression Results: 2002-2009 ***(standard error in brackets)***

	2002	2003	2004	2005	2006	2007	2008	2009
Temperature	0.344 (0.032)***	0.412 (0.032)***	0.331 (0.032)***	0.309 (0.032)***	0.370 (0.030)***	0.357 (0.031)***	0.414 (0.029)***	0.530 (0.055)***
Temperature^2	-0.012 (0.001)***	-0.014 (0.001)***	-0.011 (0.001)***	-0.010 (0.001)***	-0.013 (0.001)***	-0.012 (0.001)***	-0.014 (0.0009)***	-0.016 (0.002)***
Precipitation	0.0004 (0.0002)	0.0002 (0.0002)	0.0001 (0.0002)	-0.0002 (0.0002)	-0.0003 (0.0002)	-0.0005 (0.0002)**	-0.0009 (0.0003)***	0.0007 (0.0003)
Precipitation^2	9.88e-08 (6.97e-08)	8.96e-08 (6.99e-08)	1.21e-07 (7.19e-08)	2.51e-07 (6.96e-08)***	2.83e-07 (6.89e-08)***	3.15e-07 (6.90e-08)***	5.46e-07 (7.95e-08)***	2.33e-07 (9.34e-08)**
Area	1.29e-07 (2.23e-08)***	1.31e-07 (2.23e-08)***	1.19e-07 (2.25e-08)***	1.02e-07 (2.21e-08)***	1.03e-07 (2.16e-08)***	1.09e-07 (2.16e-08)***	1.24e-07 (2.16e-08)***	8.40e-08 (2.41e-08)***
#WHS	0.073 (0.006)***	0.064 (0.006)***	0.069 (0.006)***	0.077 (0.006)***	0.078 (0.006)***	0.076 (0.006)***	0.075 (0.006)***	0.079 (0.006)***
GDP	0.391 (0.059)***	0.293 (0.061)***	0.421 (0.063)***	0.499 (0.060)***	0.278 (0.056)***	0.294 (0.056)***	0.070 (0.054)	0.013 (0.061)
Political Stability	-0.003 (0.058)	0.086 (0.059)	-0.190 (0.066)***	-0.150 (0.062)**	0.077 (0.055)	0.077 (0.053)	-0.018 (0.059)	-0.072 (0.069)
Coastline	0.00001 (2.00e-06)***	0.00002 (1.99e-06)***	0.00001 (2.02e-06)***	0.00001 (1.98e-06)***	0.00001 (1.92e-06)***	0.00001 (1.94e-06)***	0.00002 (1.89e-06)***	0.00008 (7.61e-06)***
Distance	-0.0002 (9.45e-06)***	-0.0002 (9.43e-06)***	-0.0002 (9.60e-06)***	-0.0002 (9.27e-06)***	-0.0002 (9.21e-06)***	-0.0002 (9.20e-06)***	-0.0002 (9.54e-06)***	-0.0002 (.00001)***
R^2	0.24	0.25	0.25	0.26	0.26	0.26	0.26	0.27
N	4955	4801	4713	4928	4957	4930	4620	3365

* p < 0.1; ** p < 0.05; *** p < 0.01

3. Climate Change and Tourism in the Arctic Circle

3.1 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 under a climate change scenario. This may 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 will examine the countries which fall into the Arctic circle, namely Canada, Denmark, Finland, Greenland, Iceland, Norway, Russia, Sweden and the US (Alaska).

Previous literature on tourism assumed that climate was constant and thus unlikely to have an effect on tourist flows (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°C ± 0.2 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 individual 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 sites before they disappear (Lemelin et al, 2010; Denstadi et al, 2011). Tourists may visit a region with an unfavourable climate in order to satisfy their interest in exploring unique areas. 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). 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.

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.

3.2 Data and Methods

3.2.1 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. 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

$$\ln N_g \propto \alpha_1 T_g + \alpha_2 T_g^2 + \alpha_3 P_g + \alpha_4 P_g^2 \quad (1)$$

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

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

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) which examined 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.

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

3.2.2 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, version 1.4 (Tol, 2010). The Hamburg model 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.

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

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 given by the Hamburg model 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.

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

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.

Table 2: Details of climate models and tourism scenarios used

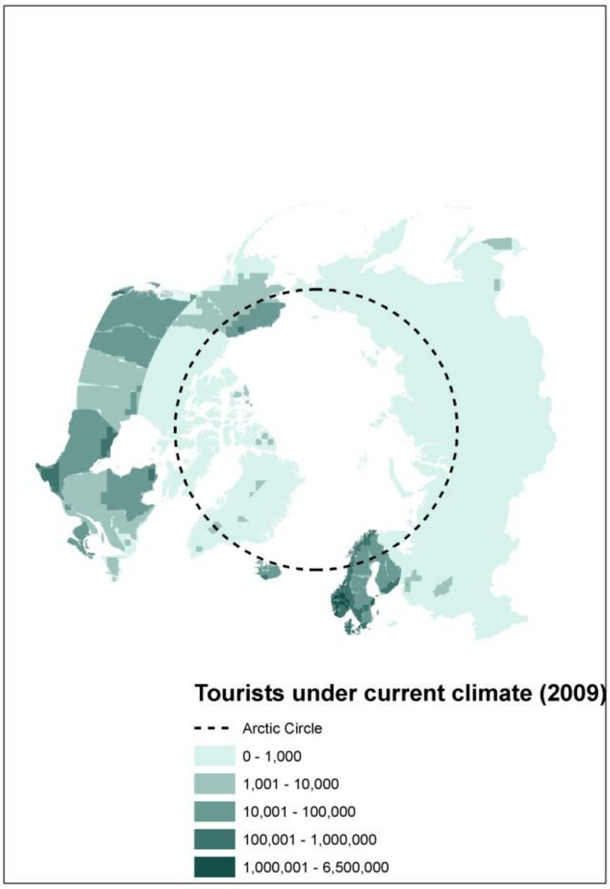
TYN SC 2.0 Climate Model	**Hamburg Tourism Model**
PCM_B2 (low climate change scenario)	B2 with and without climate change
CGCM2_B1 (medium climate change scenario)	B1 with and without climate change
HadCM3_A2 (high climate change scenario)	A2 with and without climate change

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 above. 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.

3.3 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 slightly less clear pattern emerges with respect to precipitation. However, levels of precipitation do seem to be lower closer to the pole. Figure 1 presents grid level tourist numbers in 2009 under current climate conditions.

Figure 1: Maps showing 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 below 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 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

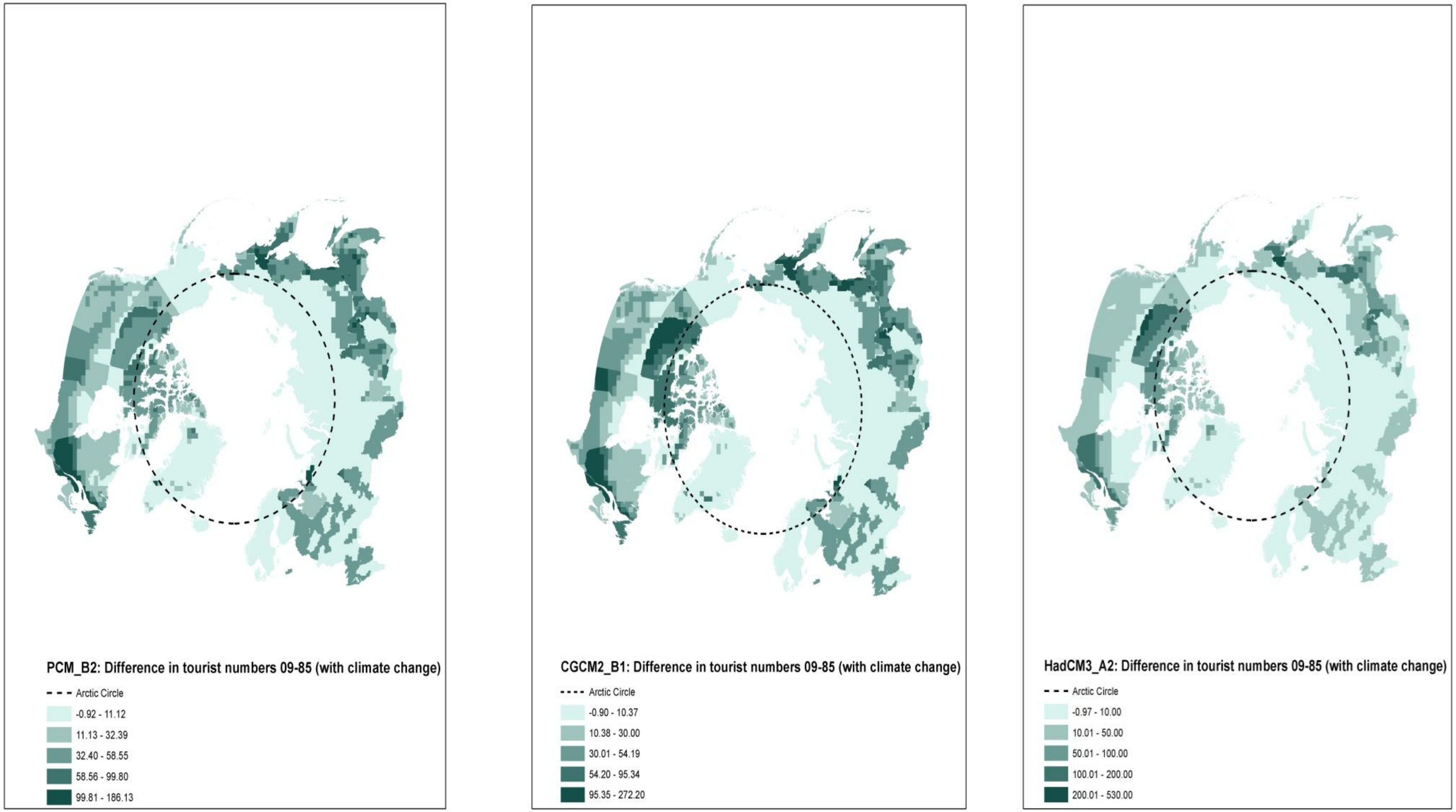


Figure 3 illustrates the difference in grid level tourist numbers between each of the scenarios with climate change and without. For example, the Hamburg tourism scenario *B2 without climate change* is combined with the 2009 grid level climate data in order to simulate grid level tourist numbers in 2085 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.

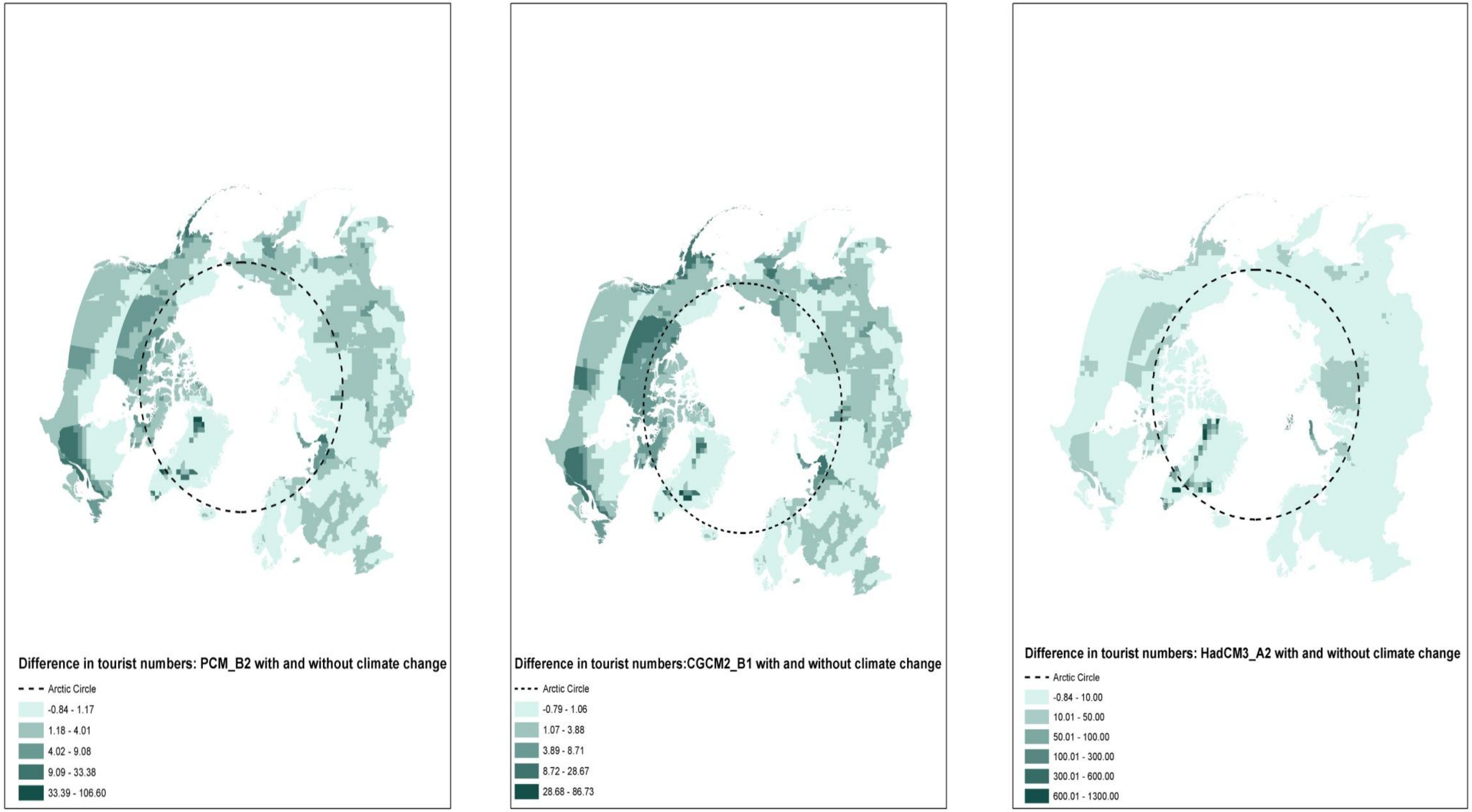
3.4 Conclusions

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.

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



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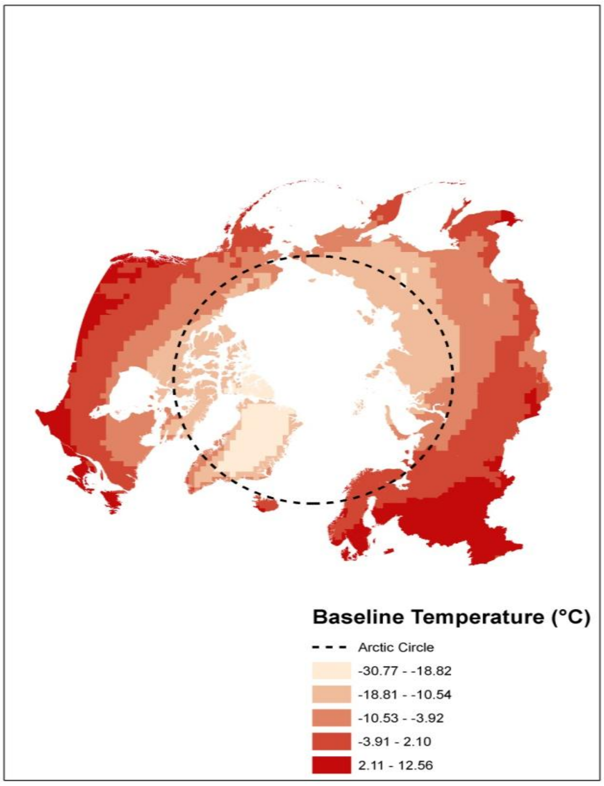
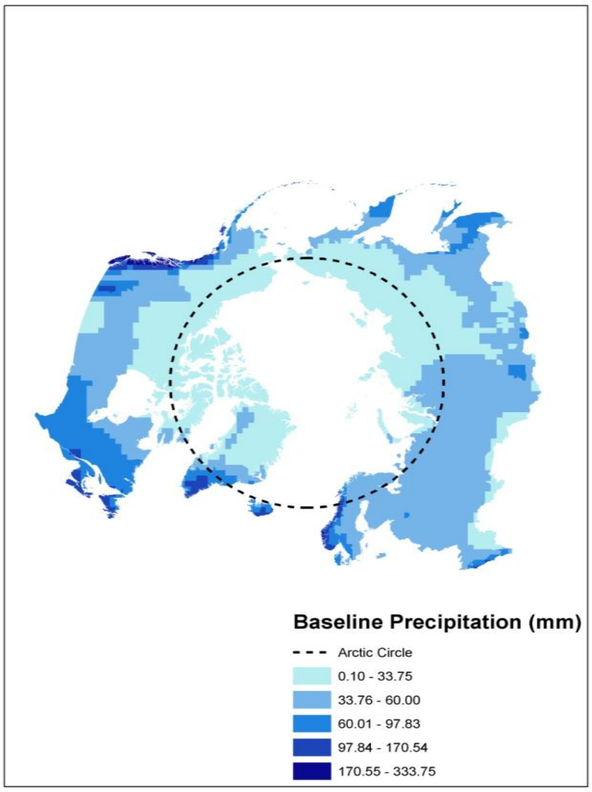
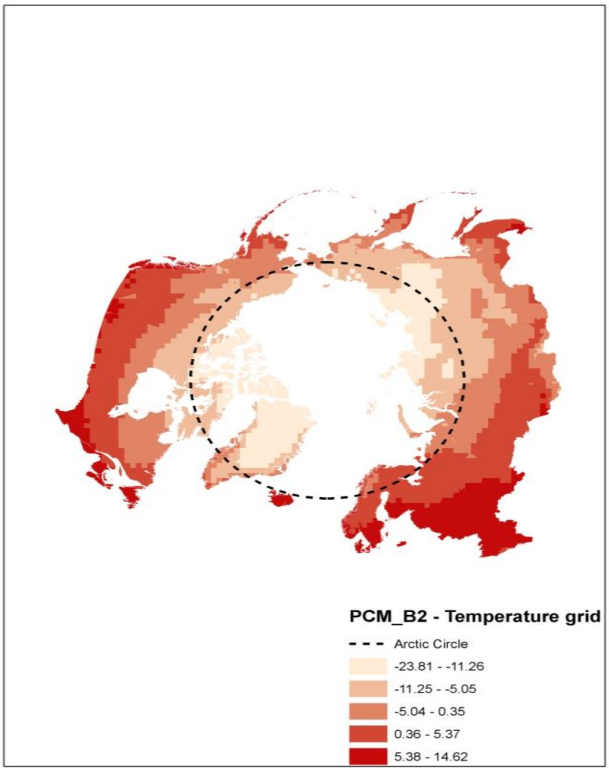
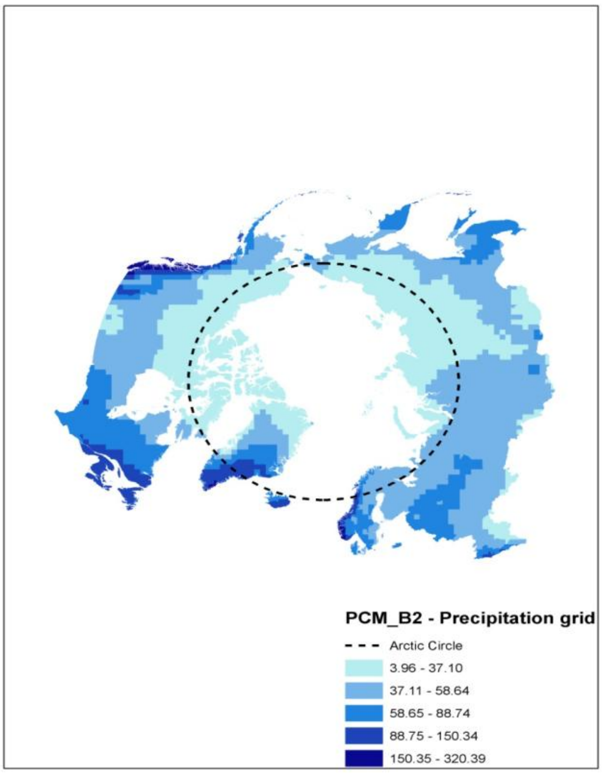
Appendix A: Grid level temperature (°C) and precipitation (mm) in current period



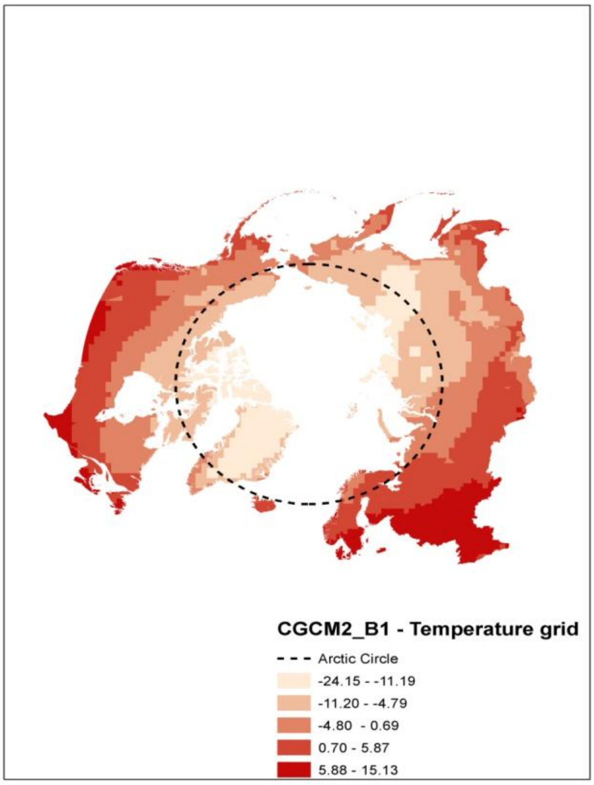


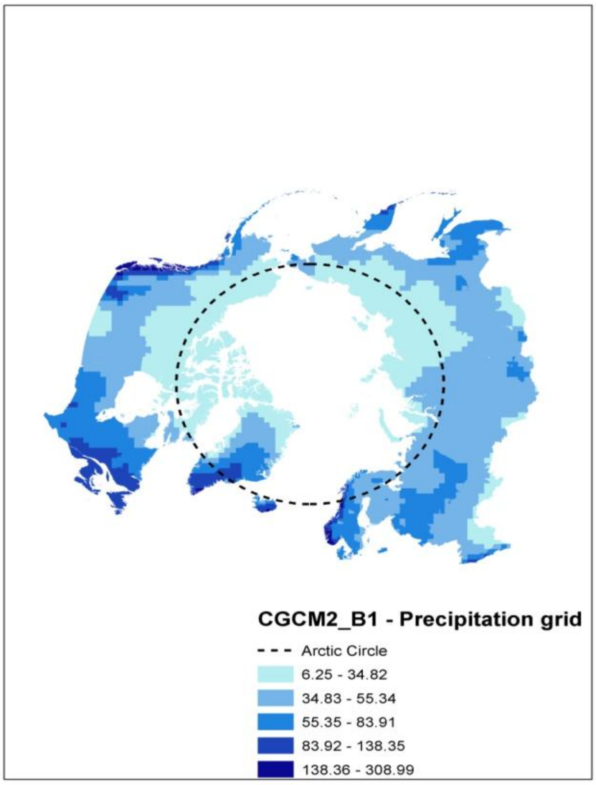
Appendix B1: Grid level temperature (°C) and precipitation (mm) under PCM_B2 scenario (low climate change scenario)



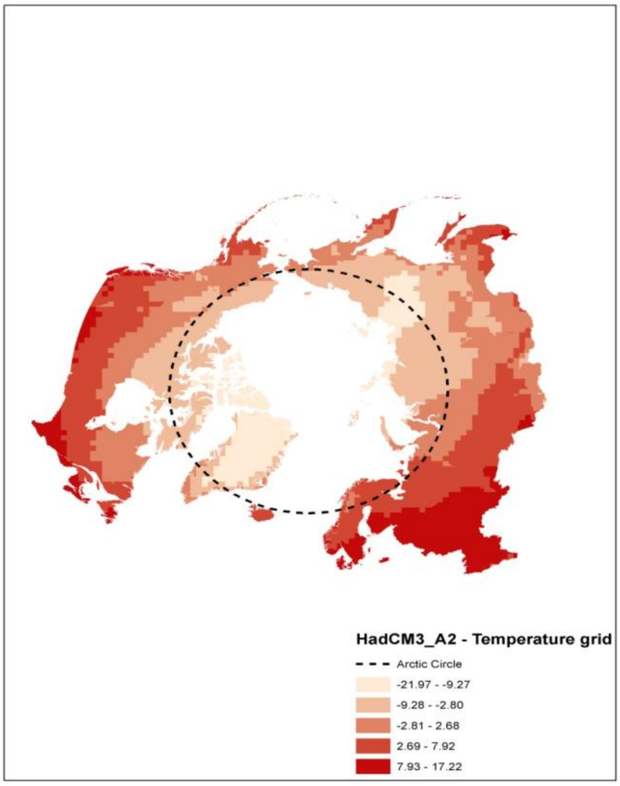


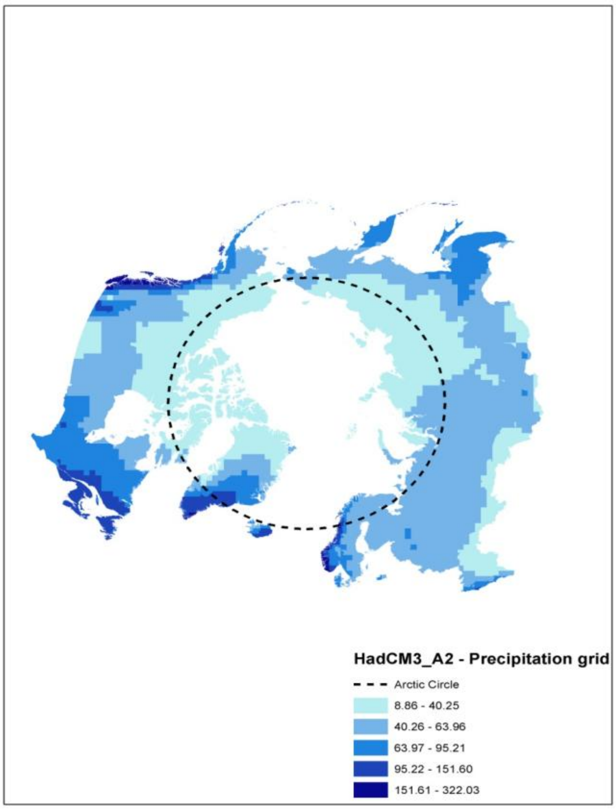
Appendix B2: Grid level temperature (°C) and precipitation (mm) under CGCM2_B1 scenario (medium climate change scenario)





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




HadCM3_A2 - Precipitation grid
Arctic Circle
8.86 - 40.25
40.26 - 63.96
63.97 - 95.21
95.22 - 151.60
151.61 - 322.03