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Review

Geobibliography and Bibliometric Networks of Polar Tourism and Climate Change Research

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Abstract: In late 2019, the Intergovernmental Panel on Climate Change (IPCC) released their much-awaited Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC). High mountain areas, polar regions, low-lying islands and coastal areas, and ocean and marine ecosystems, were separately dealt by experts to reveal the impacts of climate change on these regions, as well as the responses of the natural and human systems inhabiting or related to these regions. The tourism sector was found, among the main systems, influenced by climate change in the oceanic and cryospheric environments. In this study, we deepen the understanding of tourism and climate interrelationships in the polar regions. In doing so, we step outside the climate resilience of polar tourism paradigm and systematically assess the literature in terms of its gaps relating to an extended framework where the impacts of tourism on climate through a combined and rebound effects lens are in question as well. Following a systematic identification and screening on two major bibliometric databases, a final selection of 93 studies, spanning the 2004–2019 period, are visualized in terms of their thematic and co-authorship networks and a study area based geobibliography, coupled with an emerging hot spots analysis, to help identify gaps for future research.

Keywords: polar tourism; climate change; Arctic; Antarctic; SROCC; geobibliography

1. Introduction

Climate change and the tourism system show mutual interactions that manifest themselves primarily as environmental change impacts affecting tourism and mostly travel induced emissions driving warming. In this context, the two polar regions, the Arctic and the Antarctic, are in an increasing need of study as, on the one hand, they are subject to amplified impacts and, on the other, are increasing in popularity as tourism destinations with associated touristic products. These changes are serving to (re)structure socio-economic developments/dependencies on tourism while simultaneously encouraging further emissions from long distance travels as well as other increased environmental pressures, but also awareness. In this paper, we aim for a systematic review of state-of-the-art literature and identify research gaps on the relationship of climate change and polar tourism. For this purpose, we have surveyed scholarly bibliometric databases for peer-reviewed articles and revealed trending topics, spatial and thematic clusters, and co-authorships. The assessment is further discussed according to an extended framework that takes account of issues on not only climate change vulnerability, but also the paradoxes among environmental awareness, development, and climatic and wider environmental consequences stemming from ever-increasing tourism activities in the two polar regions, the Arctic and the Antarctic.

2. Polar Regions and Climate Change: An Intergovernmental Panel on Climate Change (IPCC) Perspective

The Earth's two polar regions on its global north and south, namely the Arctic and the Antarctic, have varying delineations and landmarks (Figure 1). The Arctic is typically described as the circumpolar area north of the Arctic Circle that is currently offset at the 66°33′ N latitude. The North Pole is positioned at the center of this zone and intersection of all longitudes at the 90° N latitude. While no land exists at this point and its surroundings, the sea ice is the dominant formation around this zone. There are also the two shifting North Magnetic and Geomagnetic North poles [1], the latter of which is a major determinant of the Aurora Borealis, the "northern lights" phenomenon, which is a major northern tourist attraction [2]. Other physical features that delineate the Arctic are the tree line, the July 10 °C isotherm, and the permafrost cover [3]. However, these phytogeographical and climatic borders and the permafrost thaws are also shifting poleward in line with global warming, all shrinking the Arctic extent [4]. On the human side, however, definitions manifest themselves expanding the Arctic extent to as south as 50° N latitude along the Aleutian archipelago of the Bering Sea [5,6]. Such initiatives and designations become critical as primarily the eight nations of the region, USA, Canada, Russia, Denmark, Norway, Sweden, Iceland, and Finland, compete and cooperate for the resource-rich Arctic seabed and the increasingly navigable Arctic routes, while also a significant number of indigenous peoples exist in the area [7].

Unlike the maritime Arctic, the Antarctic region is mostly covered by a landmass, mainly the continent of Antarctica, at the heart of the South Pole. The continent is further characterized by a high-rise landscape with an average elevation of 2400 m and mostly covered by an ice sheet, exceeding 4000 m at its peak ice dome Argus. The katabatic winds blowing on the glacial slopes with an average speed of 130 kph and gusts of 290 kph contribute to the continent's being one of the harshest and the most inaccessible regions on the planet. Contrary to its cryospheric surface, Antarctica is indeed a cold desert with minimal precipitation, but one that has had the coldest temperatures ever recorded, such as the −89 °C measured at Russia's Vostok research station on 21 July, 1983.

Scientific research is the primary raison d'être for human existence on Antarctica. According to the Antarctic Treaty signed in 1959, the Antarctic region is defined as continental Antarctica along with all oceanic and insular areas and ice shelves south of the 60° S latitude. The treaty articles supersede any national territorial claims and prevent the region from exploitation for extractive industries as well as military presence while strongly encouraging international research networks. Today there are around a hundred stations in this transnational space, some active year-round and some during summers only, belonging to 43 different countries. Researchers and support staff, together with an increasing number of visitors, make up the few thousands of human population, as there are no indigenous peoples or previous settlers here. Other definitions [3] of the Antarctic region include the broader biogeographical perspective by Udvardy [8] who proposed to cluster the Antarctic realm as Marielandia on the west of the continent and Maudlandia on the east, and as far as the subantarctic islands (Insulantarctica) and New Zealand (Neozealandia), reaching 37°S latitude in the north. From a climatological point of view, the Antarctic Polar Front, i.e., the Antarctic Convergence zone, forms a natural delineation for the Antarctic region where the cold polar waters meet the warmer oceans [3].

Polar regions are typically characterized by the polar climate, i.e., according to Köppen–Geiger classification; the ice cap climate (EF) where the average temperature never exceeds 0 °C and the tundra climate (ET) where the average temperature of the warmest month can reach 10 °C and leads to treeless vegetation such as lichens. Most of Antarctica falls into the EF zone with exceptions of ET for the Antarctic Peninsula in the west of the continent. In the southerly parts of the Arctic, boreal (subarctic) climates (Köppen–Geiger classes of Dfc, Dfd, Dsc, Dsd, Dwc and Dwd) are also commonly observed. Early projections show that the dominant ice cap climate, e.g., in the case of Iceland, could be replaced by the subpolar oceanic climate (Cfc), which is currently only dominant around the southern shores of the island, including Reykjavik, the country's main urban center, by the end of the century [9], according to the former A1FI fossil-intensive emissions scenario of the Intergovernmental Panel on

Climate Change (IPCC) [10]. The recent state of the art Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC) by the IPCC [4], having one of its six chapters dedicated for the polar regions [11], on the other hand, reveals the latest observed and projected changes and impacts as well as the systemic responses to these.

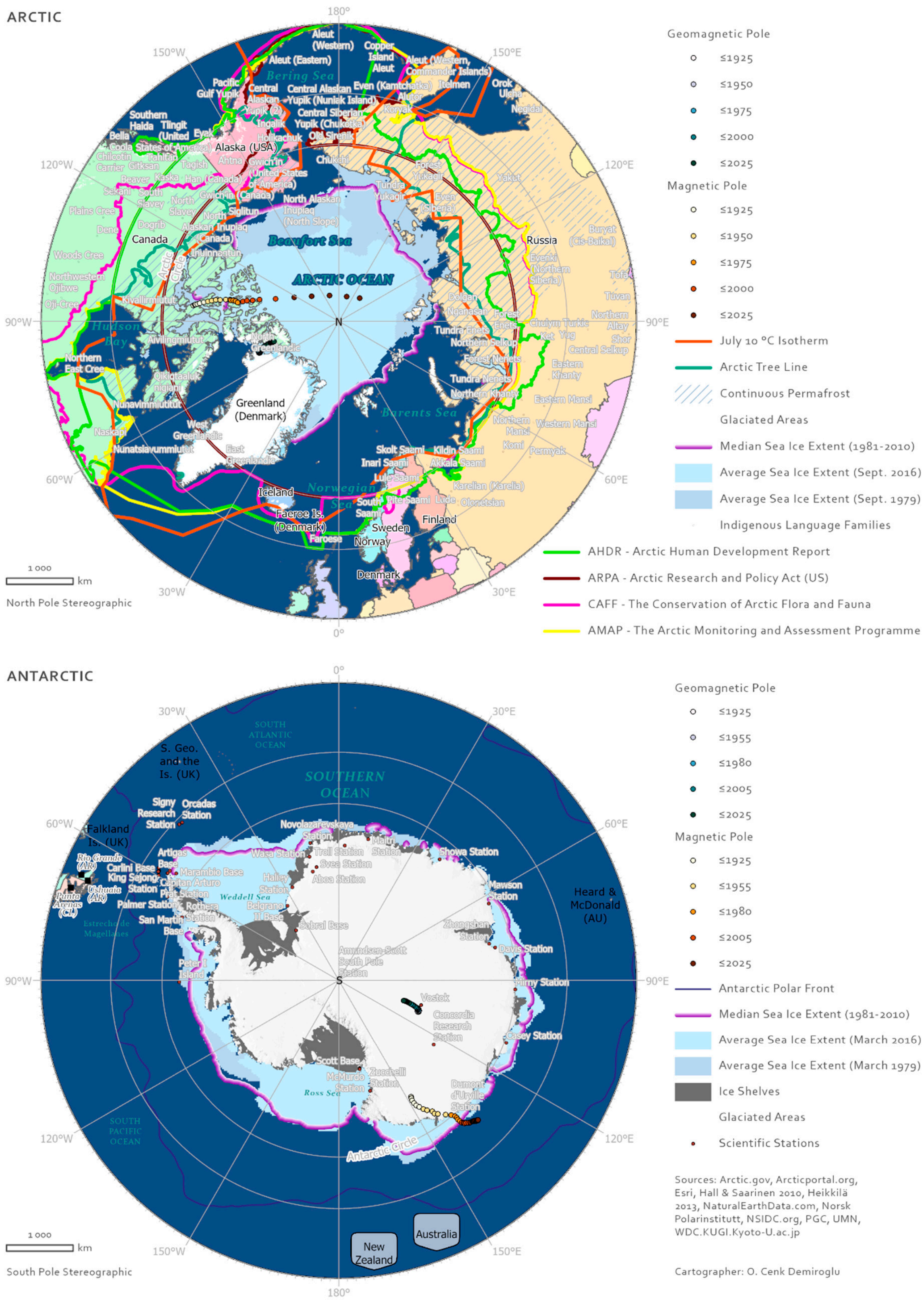


Figure 1. Geographies of the Arctic and the Antarctic Regions.

The SROCC [4] underlines, with 66–100% probability, the increase in Arctic surface air temperature of the last two decades as double that of the global average, attributed to amplified warming resulting from feedback mechanisms of the disappearing sea ice and snow cover. Arctic sea ice extent has, with 90–100% probability, decreased at all times during 1979–2018, causing extreme waves as well. Arctic June snow cover lost 2.5 million km^2 of its extent during 1967–2018 and the Greenland Ice Sheet lost its mass at an average rate of 278 ± 11 Gt/year during 2006–2015. Permafrost thaw accelerated, adding the risk of an exponential contribution to greenhouse gas emissions, including methane with its high warming potential. In the Antarctic, loss of ice sheet mass was at an average rate of 155 ± 19 Gt/year during 2006–2015 while the sea ice extent showed no considerable trend for the past observations. Mass losses of both the Greenland and Antarctic ice sheets, however, resulted in an accelerated sea level rise (95–100% probability). Oceanic thermal expansion is another cause of sea level rise as well. The Southern Ocean accounts for most of the heat gain, especially at its upper layers above 2000 m depth. Projections show that surface air temperatures will continue rising, still leading all components of the cryosphere—glaciers, ice sheets, permafrost, snow cover, (Arctic) sea ice—to diminish as amplified by feedback mechanisms. By the second half of the century, the change will become more differentiated, according to the Representative Concentrations Pathways (RCPs), as the (lack of) mitigation efforts will start paying off (or not) to determine the trajectories leading to the ultimate incremental radiative forcing by the end of the century, with major implications for the ecosystems, human systems, and ecosystem services [4].

Polar tourism is counted among the main social-ecological systems facing the impacts of and responding to climate change, according to the SROCC [4]. The chapter on polar regions [11] highlights the impacts of diminishing sea ice as a positive one that brings in cruise and, to a lesser extent, yacht tourism opportunities, especially in Alaska, Svalbard, Greenland, Arctic Canada, some of the sub-Antarctic islands, and the Antarctic Peninsula, due to improved accessibility. Combined with the "last chance (to see) tourism" trend, which has recently manifested itself more with the snowballing interest in endangered polar habitats and species, e.g., sea ice and polar bears, participation in seaborne travel to and within polar regions has increased. Projected changes such as increased undersaturation, acidification, and the loss of polynyas imply an increased risk to survival, but also a greater curiosity, for the fauna of interest. Besides the polar chapter, the high mountains chapter of the SROCC [12], along with its supplement [13], is also indicative of climate change and polar tourism relationships, as studies on mountains in Alaska (USA), Yukon (Canada), and Nordic Europe are covered in these sections. Here, glacier tourism is often mentioned, again in a "last chance" tourism fashion and regarding adaptation needs, in e.g., Iceland and Norway. The extensive coverage on ski tourism comes with implications for relative resilience of high altitude and high latitude destinations. Overall, the SROCC concludes that positive consequences exist for polar tourism especially in the form of last chance products, acknowledging that regulations and policies are needed to adapt to climatic changes and climate change induced tourism growth itself. Spatial research gaps regarding climate change impacts on tourism in the Russian Arctic, Greenland, Arctic Canada, and continental Antarctica are also addressed.

It is the aim of this paper to contribute to the efforts of the IPCC in the SROCC [4] with a thorough and extended analysis of the literature on climate change and polar tourism. So far, the SROCC [4] synthesis on this topic entails 30 articles, seven reports and a couple of other publications. Main themes were impacts on cruise tourism, emergence of last chance tourism and adaptation needs to these trends. Furthermore, a recent general review on polar tourism by Stewart et al. [14] identifies 262 studies on the topic, among which 20 articles are assessed under the "global change" category, relating to travel emissions, climate change perceptions of supply and demand, and impacts on various products and destinations, with a major emphasis on the cruise tourism industry. The review adds a mitigation aspect to the topic by highlighting polar tourism impacts on the climate, which were not explicitly covered by the SROCC in a tourism context but with respect to commercial shipping and land use. In this study, we also step outside the climate resilience of polar tourism paradigm and systematically assess the literature in terms of its thematic and spatial gaps relating to an extended framework where the impacts of tourism on climate are also in question together with a rebound [15] and combined effects lens that accounts for post-adaptation and post-mitigation consequences.

3. Materials and Methods

In order to deliver a comprehensive review on the topic of polar tourism and climate change systematically and through meta-analyses, we have initially followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [16], which offer a four phase flow diagram for assessment of studies (Figure 2). Accordingly, a total of 244 records, filtered for review, and research articles with full texts in English, were identified with the following Boolean strings on the two leading academic bibliometric databases Scopus (1) and Web of Science (WoS) (2):

TITLE-ABS-KEY((Antarctic* OR Arctic OR polar) AND “climate change” AND touris*) (1)

TS = ((Antarctic* OR Arctic OR polar) AND “climate change” AND touris*) (2)

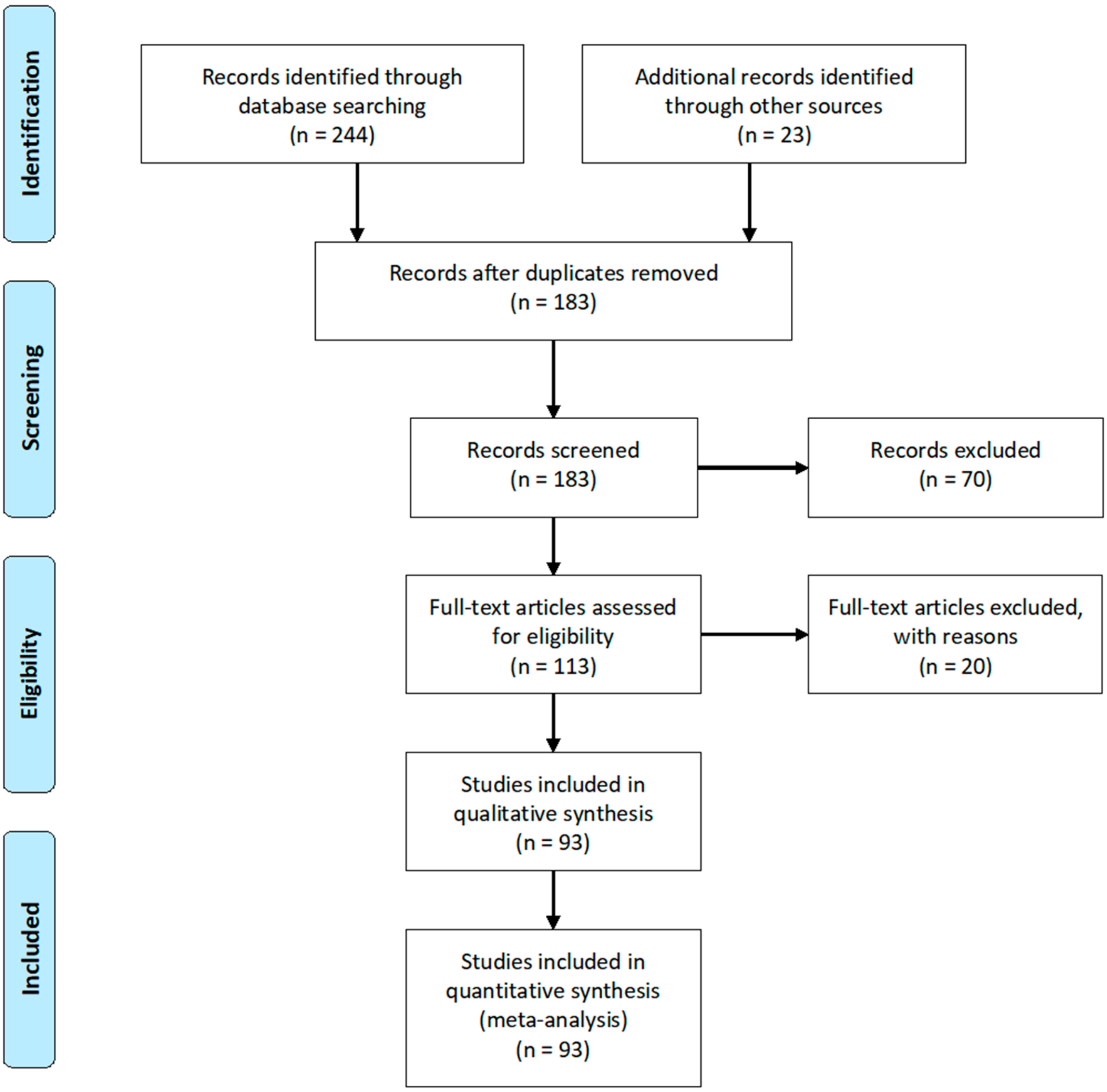


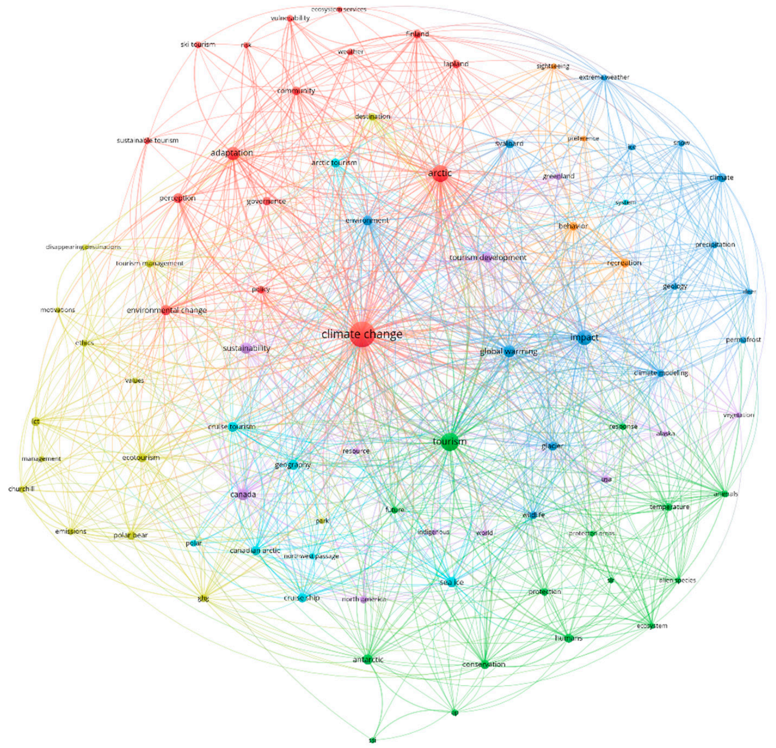
Figure 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Flow Diagram [16] for Systematic Review of Polar Tourism and Climate Change.

The query strings helped identify peer-reviewed Anglophone articles that include the terms "Antarctic(a)/Arctic/polar", "tourism/tourist(s)/touristic" and "climate change" in their titles, abstracts or author and indexed keywords. The limitations on publication type and language help hold this review comparable to that of Stewart et al. [14], who regarded journal articles as the main objective "currency" in the field of polar tourism, but also refrain it from being as comprehensive as the ski tourism and climate change review of Steiger et al. [17], which included books and chapters as well, and were able to cover research carried out in numerous languages.

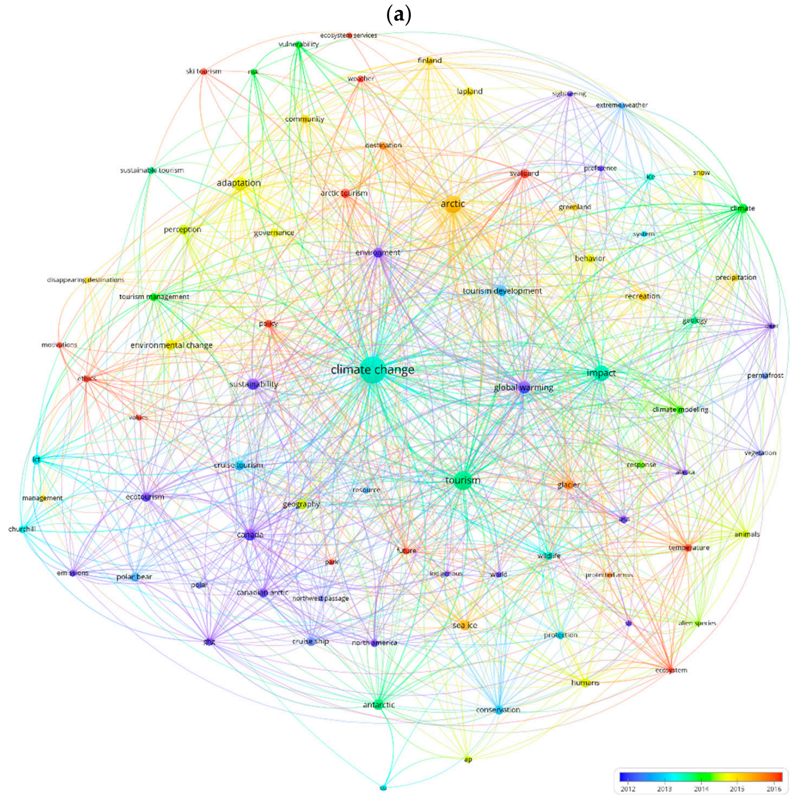
In our query, 126 records were returned by Scopus and 118 by WoS; 23 other articles [18–40] considered as relevant to the topic were further included. Fifteen of these additional articles [19–23,26–29,33–37,39] were already covered by either the SROCC [4] or the Stewart et al. review [14]. The rest [18,24,25,30–32,38,40] was familiar to the authors but were not captured by the queries for several reasons such as missing databases, journal language, and spatial scope, i.e., not described as polar but northern. Together with these additions and after removal of 84 duplicate records between Scopus and WoS, the final count of records to be screened was 183. At this stage, 70 studies retrieved from the two search systems were excluded, based on abstract screening. Most of these studies were related to life sciences, where the disturbing, invasive and pathogenic consequences of climate change, as well as those of increasing human presence (partly due to climate change), are analyzed. While these studies were excluded, those more explicitly related to polar tourism and climate change topic, such as the Goudier Island study [41], where declines in breeding pairs of Gentoo penguins were attributed to both increasing temperatures and visitors, were part of the eligible articles to be assessed. Before a qualitative synthesis, the number of eligible articles was reduced down to 93, as 20 papers were deemed relevant to common polar issues other than climate change, such as governance and environmental problems, with only some minor reference to tourism.

The final list of 93 articles [18–110] were held subject to different thematic and meta- analyses. In order to mine the emerging themes as well as the scholarly relationships, VOSviewer 1.6.14 was utilized. The software helps map bibliometric networks based on texts, keywords, citations and authorships [111]. Keyword co-occurrence and co-authorship maps were the meta-analyses realized for this review–the latter intended for revealing the implications associated with degrees of research collaboration and inclusivity. Prior to analyses, Scopus and WoS results were merged in EndNote X9 and exported in the RIS (Research Information Systems) file format. Both analyses required careful curation of the input data. Regarding authors, identical name styles between records were ensured by edits in EndNote X9. Keywords, on the other hand, were handled using the thesaurus file option of VOSviewer. Here, synonyms (e.g., "aves/birds") and different spellings of the terms (e.g., "behavior/behaviour") were standardized. Generalization and simplification were also aimed here, by, for instance, merging "species conservation", "habitat conservation" and "heritage conservation" under the term "conservation" only. This was also needed to increase the visibility of 613 individual key terms in the final map. Critical keywords such as "global warming" and "climate change", "Arctic/Antarctic tourism", and "polar tourism", however, were left, as they are to account for academic trends in constructing these phenomena and concepts. The thesaurus also allowed for omitting irrelevant keywords–such as "Italy" which appeared due to studies [64,69] that compared Svalbard to Venice. Both the RIS file for publications and the text file for a thesaurus of the keywords are provided as Supplementary Materials.

Use of the thesaurus reduced the total number of keywords in all 93 articles from 613 to 408. Furthermore, the co-occurrence analysis was limited to keywords with a minimum count of three to avoid any clutter in the visualization and to disregard unconnected nods (n: 18) as well as rather discorporate, isolated terms. These omissions led to the use of 84 keywords in the final co-occurrence analysis (a minimum count limitation of two, instead of three, would have resulted in the use of 142 keywords). In the co-authorship analysis, no omission was applied, and the mapping involved all 93 studies and their 250 authors. Here, a fractional, rather than full, counting method was preferred. This ensured that an author's weight in a study is adjusted according to the total number of authors for that study, providing a simple prevention of any overrepresentation [112]. Each analysis yielded two layouts, based on a LinLog/modularity normalization method, showing clusters and time trends of keyword co-occurrence (Figure 3) and co-authorships (Figure 4).

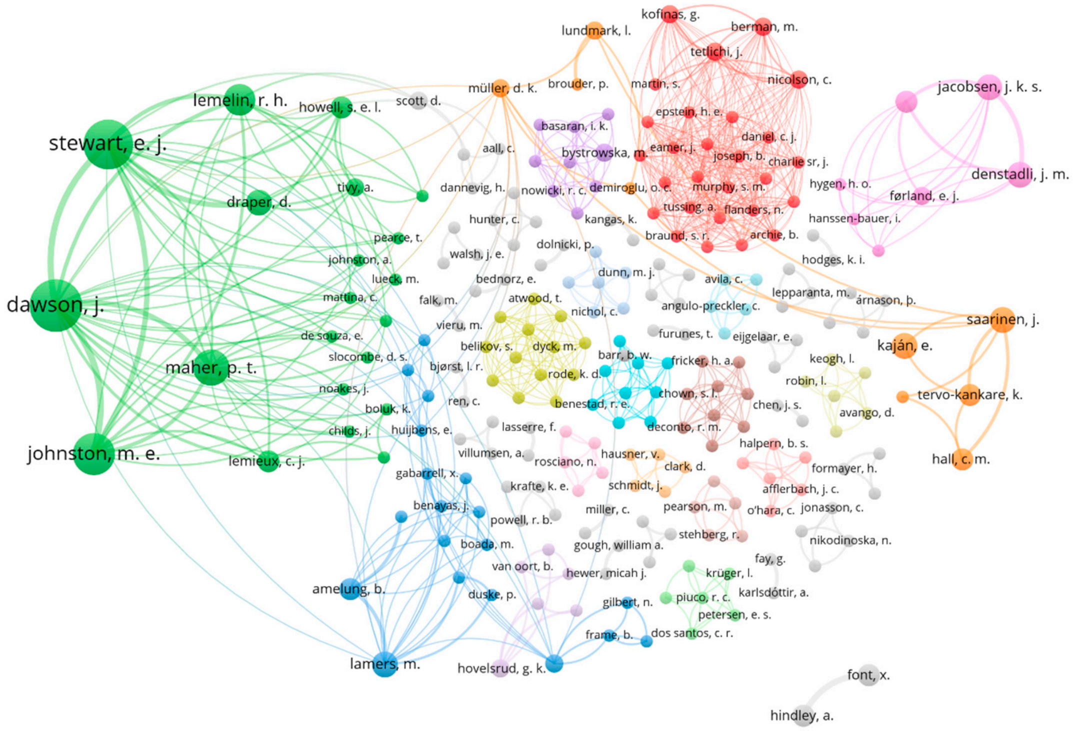


(**a**)

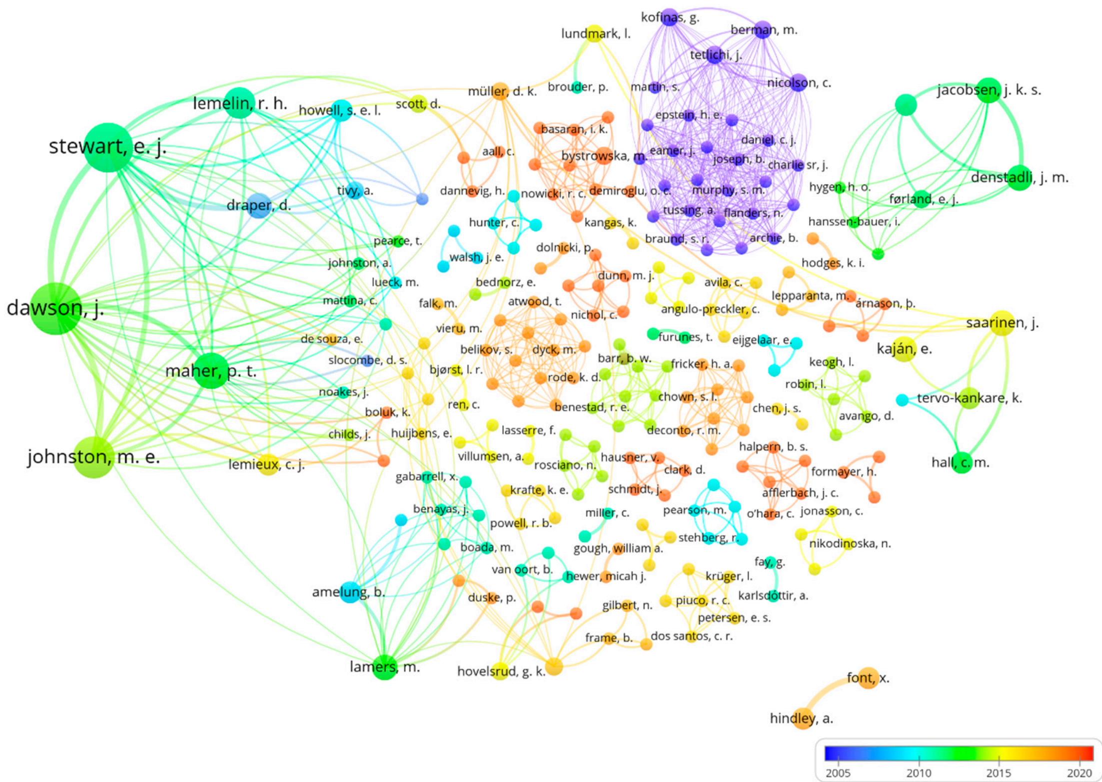


(b)

Figure 3. Clusters (**a**) and Trends (**b**) of Polar Tourism and Climate Change Research Keywords.



(a)



(b)

Figure 4. Schools (**a**) and Trends (**b**) of Polar Tourism and Climate Change Research Co-authorship.

A final analysis to help the synthesis of the literature was realized through construction of a "geobibliography"—a methodological approach that was first applied to ski tourism and climate change literature [113,114]. The geobibliography simply locates studies on a global map, according to their spatial scopes of interest. Its labelling, symbology, and attribute data can indicate information regarding study contents and meta-data. The final product contributes to the visualization of spatial and other contextual gaps in the literature. In this study, the main analysis involved the authors independently sorting the papers in terms of their themes along the extended framework of climate change and polar tourism interrelationships (climate impacts on tourism, tourism impacts on climate, adaptation, mitigation, combined and rebound effects), geographical scopes (Arctic/Antarctic and sub-regions), and tourism/recreation types in question (cruise tourism, winter tourism, ecotourism, etc.) until a mutual agreement was reached. A similar procedure was pursued to categorize the studies by the perspectives of their subjects, i.e., policy, business, visitors, and community. However, the results of this secondary category (Table 1) were held implicit in the geobibliography. Otherwise, the sub-regions of the studied cases were carefully identified as they acted as geolocators. Generalist studies were assigned with representative points for their regions, whereas those encompassing multiple case areas and/or multiple themes were repeatedly pinned on the map. Thus, those studies encompassing specific multiple case sites have a higher representation on the geobibliography, and it should be noted that no distinction/weighting as to how deeply a case location is studied was made. Symbol icons were arranged to represent the main tourism/recreation types discussed in the articles whereas the symbol colors referred to the themes. The final geobibliography was created as both an interactive [115] (Figure 5) and a static map (Figure 6). The interactive map was created using Google My Maps, thus, this can be updated as the literature expands. The static map was created from a KML export of the Google My Map into ArcGIS Pro software to overlay a heat map symbology that displays research density and to further engage in an emerging hot spots analysis. Regarding the latter purpose, a space-time cube was created to aggregate case study locations within their clusters with their publication years setting the annual intervals [116].

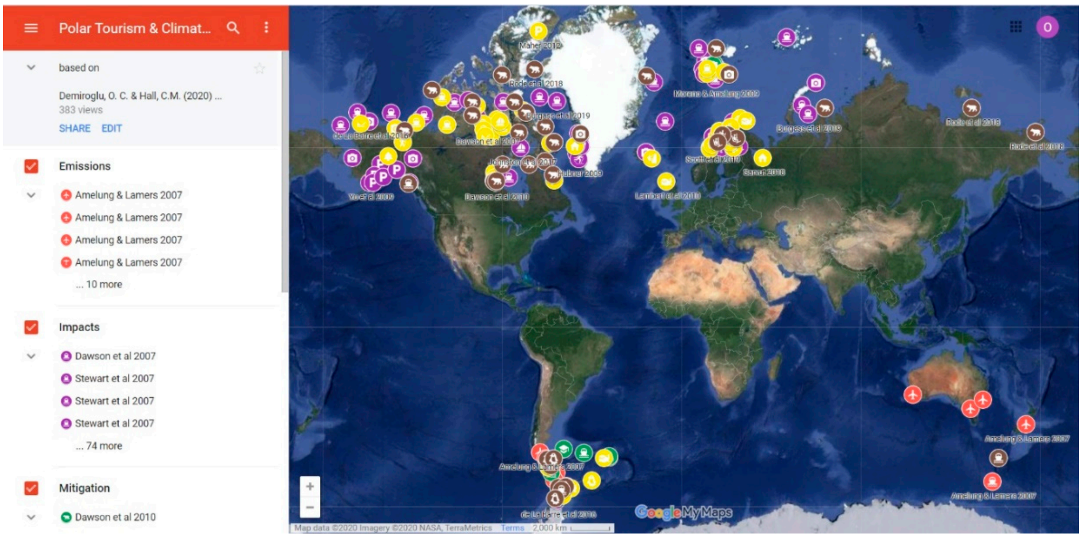


Figure 5. A Screenshot of the Interactive Map [115] for Polar Tourism and Climate Change Geobibliography.

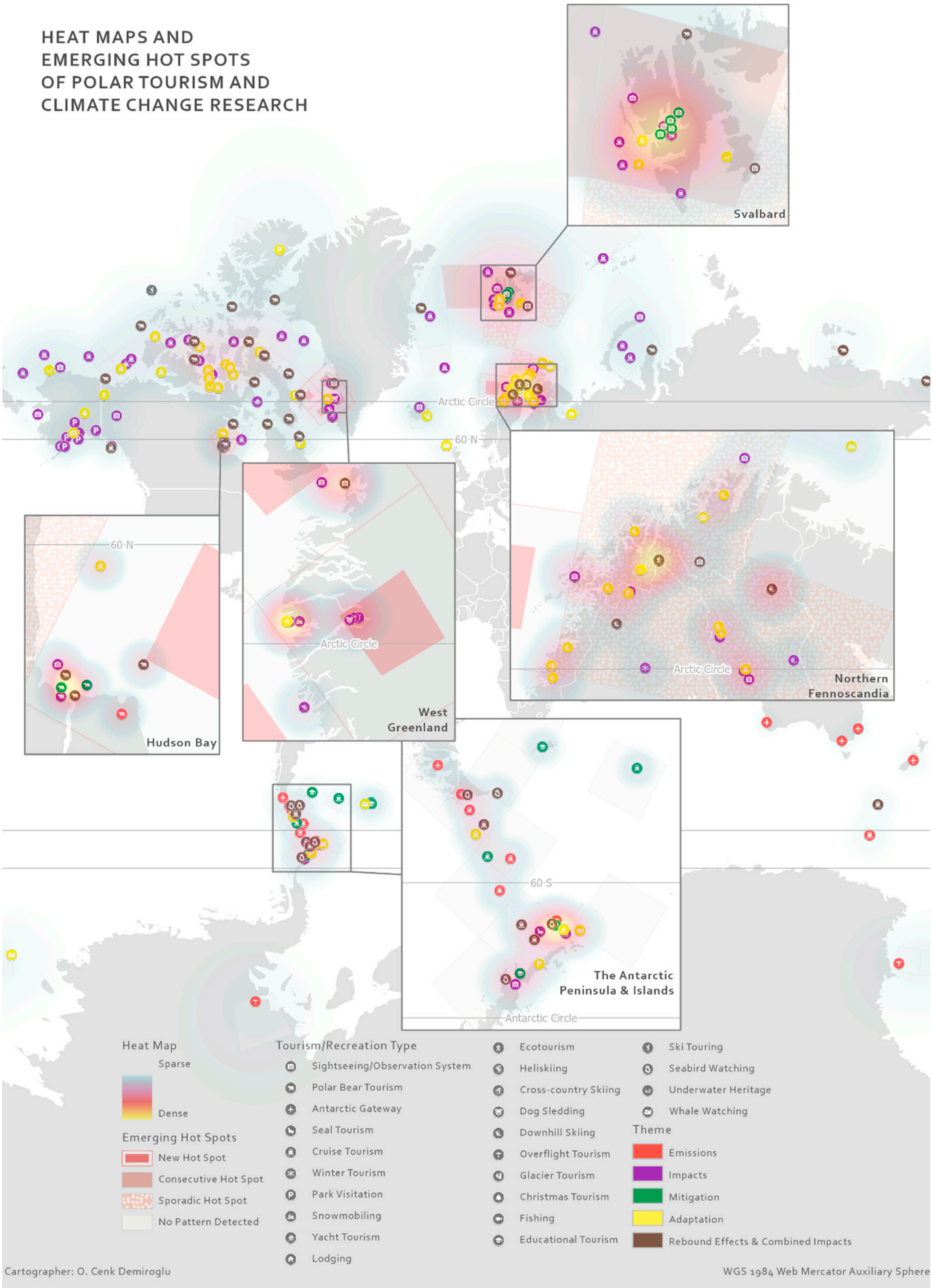


Figure 6. Analytical Map for Polar Tourism and Climate Change Geobibliography.

4. Results

The 93 synthesized articles are published in 51 different journals. Among them, some spatially focused on polar regions, such as *Polar Record* (n: 8) [27,29,49,72,75,84,91,94], *Arctic* (n: 6) [36,44,48,104,105,110] and *Polar Geography* (n: 5) [34,62,79,82,90], and others thematically focused on tourism, such as *Journal of Sustainable Tourism* (n: 7) [18,28,53,54,60,64,102] and *Current Issues in Tourism* (n: 5) [31,33,69,76,86], as well as those with specific spatial and tourism foci, i.e., *Scandinavian*

Journal of Hospitality and Tourism (n: 5), are prominent. Thematically climate focused journal coverage is uncommon except for one article [73] from *Climate Research*. Further thematical, temporal, spatial, and social analyses of polar tourism and climate change research are elaborated below.

4.1. Bibliometric Networks

The 84 keywords that were used at least three times in the 93 articles agglomerate into six clusters according to their distances to each other (Figure 3a), yielding 1259 links. The largest cluster with 20 items (red) stems from a wider theme on climate change adaptation of Arctic tourism from all the policy [53,56], community [53,56,71,76,77], business [33,39,53,56,80,101,106], and visitor [38,56] perspectives. Cluster 2 (n: 16, green) covers mostly combined impacts of climate change and polar tourism, with a spatial focus on the Antarctic [41,92,96,109]. Clusters 3 (blue) and 4 (yellow), with 15 items each, center around the issues of cruise tourism in North America [35,53,74,85,90,103–105], the Antarctic [60,61,104] and Svalbard [48] and the direct impacts on recreational activities in the cryospheric environments of Nordic Europe [57,68,108], respectively. The fifth cluster (n: 13, violet) highlights the highly debated topic of "last chance" tourism [31,40,43,51,54,60,67] with its paradoxical position on care and damage, especially in the example of polar bear watching [51,54,88]. From a temporal perspective (Figure 3b), some trending keywords and themes become prominent based on their average bibliographical ages. Firstly, a transition into "climate change" from "global warming" is observed, in line with the general trends. The pioneering research from Canada [44,51,54,59,81,103–105], on the other hand, has relatively aged, while other hot topics such as European Arctic tourism [50,57,66], especially activity-specific tourism types like ski tourism [21,33,56,106], emerge.

Despite some debate on treating co-authorship as a proxy for research collaboration [117], these networks are still good indicators of scholarly peer cooperation on the thematical and geographical levels. In the case of polar tourism and climate change research, whereas 250 individual authors are identified for the 93 studies (Figure 4), the set with the most links (n: 172) has only 53 items, signaling a lack of direct collaboration among scholars (without accounting for citations). A significant cluster (dark green, n: 21) is formed among mostly Canada affiliated researchers, some of whom [19,20,26,27,30,31,34–36,51–54,67,74,75,86,103–105] bear the highest total link strengths based on the number of articles they have contributed to. Some other researchers such as de la Barre [20], Lamers [20,82], Scott [33,54], and Müller [20,56] play key roles in linking this cluster with European counterparts. The Supplementary Materials can be used to highlight each node's (author or keyword) individual links with the others.

The full account of co-authorships also provide us with a true visualization of the temporal evolution of polar tourism and climate change research that covers a time span from the publication year 2004 to 2019 (Figure 4b). Indeed a larger cluster (n: 27) that consists of two related and extensive studies [44,81] from North America represents the first stone of this paradigm, but lacks co-authorship links to all other items in the entire network. This might be due to the multi-scenario approach of these studies, where tourism is only one component analyzed without much reference to climate change. That being said, many of the newer co-authors [39,41,47,48,79,90,101,102] also seem isolated from the main sets, while some others [33,41,56,67,79] have formed their connections with the well-linked pioneers.

4.2. Geobibliography

The geobibliography [115] has pinned the studies (searchable by citation information) according to their local scopes, listed by publication years and further categorized by layers (with a turn on/off option) of the five themes, i.e., emissions, impacts, mitigation, adaptation, and rebound effects and combined impacts, where multiple representations for multi-thematic studies were allowed. The studies are also classified according to the tourism type examined–again, studies on different tourism types were repeatedly pinned with respective icons. From a macroregional perspective, 73 of the 93 studies focus on the Arctic [19,21–23,25–39,43–45,47–59,62–74,76–83,85,87,89,90,94,99–103,105–108,110,112,117], 15 on the Antarctic [40–42,60,61,75,84,86,91–93,95,96,98,109], and five are bipolar [20,24,88,97,104]. Heat maps (Figure 6) showing the density of studies, multiplied by their themes and tourism type cases, indicate that main clusters are found around northern Fennoscandia (Kilpisjärvi [76–78,87,106,107]), Svalbard [20,32,43,46–48,57,64,66,68–70,73,79,82,88,99,108], West Greenland (Sisimiut [94,101]), Hudson Bay (Churchill [20,25,31,32,51,54,67,90]), and the Antarctic Peninsula and islands (South Shetland Islands [40,42,60,75,83,88,91,92,95,104]).

As noted earlier, some studies yield denser results when they refer to different tourism types and case locations or polar tourism and climate change research themes within smaller regions. An example to the first group is the study by Schrot et al. [101], where the impacts of climate change (only one frequency of research themes) on downhill skiing (two spots), ski-touring (one spot), heliskiing (one spot), cross-country skiing (four spots), dog sledding (two spots), and snowmobiling (one spot) in West Greenland are researched, multiplying the study's representation by 11 times on the map. When the tourism types and/or case locations are not specified, as in the Northern Sweden study [18] that categorizes "winter tourism" as activity-based and venue-based with almost no finer detail, the cartographic representation becomes limited. Moreover, some pan-Arctic studies (e.g., [20,32,47]) and even those extending beyond the polar limits, as in the case of Australian gateway cities to the Antarctic [42], are sparsely spread on a wider region. Regarding the second group, the multi-thematic studies, Eijgelaar et al. paper [60] provides a good example as it was sorted by authors into three categories, thus, represented with a frequency of three.

When it comes to the mining of spatiotemporal patterns over the geobibliography, three different outcomes are obtained: "new hot spots", "consecutive hot spots" and "sporadic hot spots" (Figure 6) [116]. The new hot spots, which are locations that become statistically significant in the final time step (2019), are found along Churchill and West Greenland. In West Greenland, the Schrot et al. study [101] contributes to this pattern by adding on to the older studies [62,72,94]. In Churchill, where polar bear tourism is a unique selling proposition for both watching [31,32,49,51,54,67] and sport hunting [49,59] interests, Groulx et al. [67] establish the new hot spot by revisiting the polar bear tourism issues from a last chance perspective after almost a decade of interruption since the earliest studies [31,51]. This result is a showcase for how emerging hot spots analyses can help capture trends undetected by bibliometric networks, as "Churchill" was not temporally highlighted due to its bibliographical age in the keyword co-occurrence map (Figure 3b). The consecutive hot spots over Svalbard, on the other hand, indicate an agglomeration trend for studies over the recent years. The sporadic hots spots found in Northern Fennoscandia (Lapland) then refer to a pattern where the clustering takes effect only during some of the years, including 2019.

Last but not least, thematic categorization of the geobibliography presents some important findings regarding research foci and gaps. Numbers of the single studies that belong to the research themes of impacts, adaptation, emissions, mitigation, and rebound effects and combined impacts are 28 [18,20,21,25,27,33,36,47,48,52,55,57,58,62,63,65,66,68,72,73,87,88,91,95,101,105,108,110], 40 [19,22,23,26,28–30,33–35,37–39,43,44,49,50,53,56,71,74,76,77,79–85,89,90,94,97,98,100,102–104,106], 4 [42,54,60,61], 11 [54,60,64,67,69,70,75,86,93,94,99], and 16 [24,31,32,40,41,45,46,51,56,59,60,78,92,96,107,109]; respectively. Only five studies [33,54,56,60,94] are identified to be multi-thematic. At the second tier, however, 30 single studies [19–23,27,32,34,35,37,40,42,44,45,50,51,53,56,59,61,62,69,70,81,85,90,92,96,100,103] are found to have multiple perspectives. The studies are further distinguished by a matrix of their themes and perspectives on Table 1.

Table 1. Polar Tourism and Climate Change Research Articles by Themes and Perspectives.

Theme/Perspective	Policy	Business	Visitors	Community [1]
Emissions	[42,61]	[19,49]	[42,54,60,61]	n/a
Impacts	[20,27,47,52,62,66, 91]	[18,20,21,25,27,33, 36,48,55,68,87,88, 95,101,105]	[20,21,57,58,63,65, 72,73,108,110]	[20,62]
Mitigation	[69,70,99]	[94]	[54,60,64,67,69,70, 75,86,93]	n/a
Adaptation	[19,23,26,34,35,37, 43,44,53,56,74,79, 81,83–85,96,98,100, 103,104]	[22,23,28,29,33–35, 37,39,50,53,56,80, 82,85,90,94,100,103, 104,106]	[22,30,38,50,56,89, 103,104]	[19,35,44,49,50,53, 56,71,76,77,81,90, 102–104]
Rebound Effects & Combined Impacts	[24,45,56,59,92,96]	[32,40,45,51,56,59]	[40,46,51,56,60,92, 96,107,109]	[31,32,40,41,56,59, 78,92,96]

[1] Classification for some community studies [32,41,92,96] follows a libertarian extension approach [118].

Consistent with the keyword co-occurrence map results (Figure 3a), the largest thematic group stems from adaptation research and is mostly focused on the Arctic, whilst only a couple of recent studies [84,98], as well as a couple of earlier bipolar studies [97,104], consider the Antarctic as their scopes, all following a policy perspective. In the Arctic, demand side studies form the least interest, while diverse tourism types are in question. Likewise, impact assessment research also has a couple of bipolar [20,88] and a couple of direct studies [91,95] on the Antarctic. Overall, the perspectives of impact studies are more business-oriented. It is also worth mentioning that the recently published few studies on the under-researched, at least in the Anglophone literature, Russian Arctic are found only within the impacts and adaptation research domain. Besides the two pan-Arctic studies [20,47], Gawor and Dolnicki [66] inform us about the expansion of the Russian Arctic National Park, covering parts of Novaya Zemlya and Franz Josef Land, and implications of climate change on intensifying cruise tourism tailored around wildlife (birds, walruses, polar bears) watching and excursions to the North Pole by nuclear icebreakers or helicopters. Sarvut [100], on the other hand, introduces a design concept for (potential) tourism infrastructure's adaptation to sea level rise and permafrost thaw. The study resembles that of Qu et al. [94], who, in Greenland, proposed sustainable (with renewable energy and waste water management) mobile accommodation units for the sake of adapting to shifting cryospheric attractions, as well as to contribute to mitigation efforts.

Studies on emissions and mitigation are fairly limited. Early emissions studies [42,60,61] are realized for the Antarctic, accounting for carbon footprints of air travel via gateway cities, overflight tourism and cruise tourism. In the Arctic, the only emissions study [54] was carried out for polar bear tourism in Churchill, including carbon costs of accommodation and on-site activities, such as tundra vehicle and helicopter trips, in addition to air access to the destination. Although carbon footprint studies have been interrupted for about a decade at the time of preparing this paper, mitigation studies have emerged more recently, with a particular focus on tourist behavior in Svalbard [64,69,70], Churchill [54,67] and the Antarctic [60,75,86].

The final thematic category that completes the extended framework of climate change and polar tourism research deals with what occurs beyond direct mutual effects (emissions and impacts) of tourism and climate change and the responses (mitigation and adaptation) of the tourism system. This tertiary sphere manifests itself as increased negative (not only climatic but also wider environmental) impacts or emissions resulting from (mal-)adaptation and (mal-)mitigation responses [15]. In this context, studies that either explicitly or implicitly focus on the so-called "last chance tourism" provide interesting examples for the Arctic [31,45,46,51] and the Antarctic [60]. Indeed, last chance tourism itself can be considered as an industry adaptation to the relatively positive impacts of climate change, such as increased publicity and improved accessibility. It may even lead to a "positive" rebound effect through its claimed awareness influence on visitors and post-visit transformation to mitigation behavior, although research [40,46] shows this outcome not to succeed as desired. Moreover, increased emissions due to long haul flights to the polar destinations may prove last chance tourism to be a form of maladaptation. Local natural, economic, and social impacts on the destination may also turn out to be negative. On the contrary, climate policy-led mitigation and conservation measures may already stress the usual business, as observed in the conflicts between polar bear conservation versus the sport hunting tourism sustained by the local communities in Nunavut [59].

Increased tourism activity to the relatively fragile polar ecosystems, triggered by last chance motives or the ever-rising common publicity, bear with them the risk of combined impacts—on-site impacts that are caused by climatic changes and the visits themselves. The geobibliography displays a handful of studies on this matter. Most of this research may be placed on a "community" perspective. Here it should be noted that, on a continuum from instrumentalism to conservation and further to libertarian extension [118], one may question who the actual stakeholders within a community are, especially in the uninhabited polar areas. This article follows the libertarian extension approach and treats all non-human inhabitants of the destinations as part of local stakeholders. In this context, penguins and other seabirds of the Antarctic [41,92,96] and polar bears of the Arctic [32] have all been studied so far in terms of their exposure and sensitivity to changing climatic conditions and human presence and interactions.

5. Discussion and Conclusions

This study systematically reviewed and provided meta-analyses for 93 articles [18–110] related to polar tourism and climate change research. Among these studies, only 12 [19–22,26,27,29,33–35,39,77] were included in the SROCC by the IPCC [4], all covering impacts and/or adaptation themes and focusing mainly on the Arctic. The polar tourism review by Stewart et al. [14] had only two items [19,103] common with the SROCC but 15 [19,23,34,36,37,42,43,52,54,57,60,61,65,103,105] with this review—the difference to the SROCC mainly stemming from the wider approach to the climate change issue by including tourism emissions and mitigation themes. In any case, polar tourism and climate change research appears to be a relatively young field with the oldest articles from 2004 [44,81], while polar tourism research itself is dated back to 1980 [14] and climate change and tourism research has been evolving since 1986 [119], taking peer-reviewed articles as the base. In fact, the pioneering Anglophone articles in 1986 were all related to the more specific literature on ski tourism and climate change [17]. As for the future of polar tourism and climate change research, there are many thematic and spatial gaps to be fulfilled, guided by the meta-analysis results of this review and other major sources. Yet it should be reminded that some studies [18–40] reviewed here were only able to be manually added to the corpus, alerting for a need for better semantics that will yield more inclusive results beyond those of the authors' rather subjectively determined search string (1, 2) keywords. For this purpose, further operationalization of comprehensive polar tourism definitions (see e.g., [3,14]) could be a major departure point.

The theme-perspective matrix (Table 1) can be used as an indicator to determine research gaps, while the geobibliography [115] adds to that the diversity of tourism types studied and the spatiotemporal trends (Figure 6). Accordingly, emissions studies are quite limited and outdated despite the criticality of this theme given the remoteness of polar destinations to major markets and consequent footprints. While air travel is the main component of tourism system's increasing contribution to global emissions [120,121], the relatively negligible aggregate emissions of the cruise industry become highly critical due to its most carbon-intensive per capita footprints [121]. Therefore, in a growing polar "last chance" tourism market where cruises are the main carriers, more research is needed to quantify the warming effects from tourism and the following vicious cycle that leads to more "last chance" publicity and further to more emissions and so on. Coupled with the myth of "last chance" tourism's transformative capacity to gear the visitors towards climate change awareness and mitigation behavior, such a paradox reminds us about the need for multi-thematic studies, not least the type of research that is categorized as "rebound effects and combined impacts" in this review. This category also calls for more research regarding biosecurity in polar areas given the potential for the introduction of alien biota that may become invasive [122–125], as the combined impacts of climate change, environmental change and increasing tourism presence become more visible.

Multi-perspectives are evidently knitted in polar tourism and climate change research, except for community perspectives on emissions and mitigation. These signal an opportunity to bridge indigenous knowledge and indigenous tourism of the Arctic and research mobility (and even "research tourism") of the Antarctic. As depicted on Figure 1, the Arctic has a wider extent in terms of human geography, in contrast to its ongoing physical shrinkage, including tourism geographies such as in Nordic Europe where "Arctification" [126] emerges to reconstruct northern images. Importantly, such research may also need to consider the perceptions and expectations of the growing tourism markets for polar tourism. Such trends have broad implications, but especially in relation to national policies on regional development with different sectoral approaches involving not only tourism but also other conventional and potential industries, such as mining, which may share transport and other infrastructure with tourism [127]. Thus, future research will need to address the political dynamics and socioeconomic interests stemming from polar and sub-polar governance and longstanding competition between gateways [128–130].

The SROCC highlights "last chance" tourism and cruise tourism as specific to polar regions, but also reviews ski tourism and glacier tourism literature relevant to polar geographies. In the future, more tourism types can be assessed in terms of climate change impacts, including emerging areas of interest such as heritage tourism. Coastal polar areas vulnerable to sea level rise or the inlands vulnerable to permafrost thaw can be examined in relation to different tourism types and may be especially important for ecotourism attractions and cultural heritage sites [131,132]. In their global assessment of tourism vulnerability to climate change, Scott et al. [133] find tourism in the Arctic countries (not necessarily the Arctic regions within these countries) to be among the least vulnerable to climate change. This holistic study, however, misses results for Greenland and Antarctica. The SROCC [4] (p. 51), on the other hand determines, based on observations, the present impacts of climate change on tourism as positive for the Arctic Ocean (medium confidence) and the Southern Ocean (low confidence), both positive and negative for Iceland (low confidence), and negative for Fennoscandia and Alaska (low confidence), while the conditions for Antarctica, the Russian Arctic, Arctic Canada, and Greenland are left inconclusive due to lack of studies under their review. Thus, when it comes to impact assessment and adaptation research, there is plenty of room to understand the contrasting results and to fill in the spatial and the confidence gaps in terms of not only the observed trends but also the projected scenarios. At this stage, the geobibliography may serve as a practical checklist board.

Expanding the polar tourism and climate change literature will also require larger interest from scholars and better connectedness among them. So far, the co-authorship maps indicate few clusters of scholars within certain geographical concentrations. Initiatives such as the International Polar Tourism Research Network (IPTRN) do and could still act as important platforms to engage researchers from the underrepresented areas such as the Russian Arctic and the Global South as well as to encourage a more holistically multi-thematic and pan-polar paradigm.

This study improved the geobibliography methodology previously applied to ski tourism and climate change literature [113,114], in addition to employing bibliometric network analyses. Such GIS and network-based visualization tools and techniques are gaining in popularity for conducting systematic reviews and meta-analyses. In contrast to the ski tourism application, the geobibliography constructed for this study used multiple layers to display the categorization of research themes and employed point symbologies to distinguish among the tourism types studied. Further developments may include a layer hierarchy, for instance to organize the articles under each theme by their perspective attributes. In addition, non-article publications can also potentially be included to provide a broader assessment of research and scholarship, including from academic traditions that publish substantially in books and chapters, as well as government and agency reports. Regarding bibliometric networks, studies can be mapped by citations, in addition to co-authorship and keyword co-occurrence maps. Moreover, co-authorship layouts can be based on actual geographic coordinates according to author affiliations at the time of each publication. These efforts, except for addition of non-article publications and visualization of citation networks, however, will require alternative platforms as the current versions of VOSviewer and Google My Maps applications used in this study were limited for these purposes. Last but not least, the risk of misrepresenting certain study locations should be highlighted, as the geobibliographical technique used here involved a (sometimes over-) simplification of the spatial scopes into specific points. Alternatively, introducing polygon or mixed symbologies can be attempted to avoid some misreading due to such potential spatial inaccuracies.

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