

Climate in tourism's research agenda: future directions based on literature review

El clima en la agenda de investigación del turismo:
direcciones futuras basadas en la revisión bibliográfica

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Abstract

One of the major challenges' tourism faces today is climate change, which inevitably involves adjusting many destinations and tourists to new scenarios. For that, a literature review about the link between tourism and climate is mandatory. Therefore, the present paper aims to establish the evolution of the relationship between tourism and climate, since relevant studies were published from 1940 to 2020. A bibliometric analysis using qualitative and quantitative methods were used for measuring the coverage ratio of tourism and climate (change) in spatial-temporal studies. *Web of Science (WoS)* and *Scopus* databases were used to carry out an in-depth analysis based on 889 publications related to tourism climatology. These were synthesized in attributes and codes (e.g. location, journal name, geographic level, methods of analysis, results, implications, and trends). It is true that in the context of tourism research, themes and assumptions give or take a few exceptions, remain constant. Most of the 889 studies analyzed focused on climatological hotspots, such as impacts of climate change on tourism (28.4%) and urban and bioclimatic comfort of tourists in affected destinations (13.2%), with a lower coverage of tourism-related topics such as policies of climate change in tourism (6.1%) or strategies and concrete options to re-enable tourist destinations for climate change (0.2%). The research methods, procedures and results can contribute to advance tourism climatology to a new phase of theoretical and practical application for tourism planning.

Keywords: tourism climatology; climate change; tourism studies; bibliometric.

Resumen

Uno de los mayores desafíos que afronta el turismo en la actualidad es el cambio climático, que inevitablemente implica adecuar muchos destinos y turistas a los nuevos escenarios. Para ello, es imprescindible una revisión bibliográfica sobre el vínculo entre el turismo y el clima. En esta línea, el presente trabajo tiene como objetivo establecer la evolución de la relación entre turismo y clima que se publicaron desde 1940 hasta 2020. Se ha realizado un análisis bibliométrico mediante métodos cualitativos y cuantitativos para medir la tasa de cobertura del turismo y el clima (cambio climático incluido) en estudios espaciotemporales. Se utilizaron las bases de datos *Web of Science (WoS)* y *Scopus* para realizar un análisis en profundidad basado en 889 publicaciones relacionadas con la climatología turística. Estas se sintetizaron en atributos y códigos (por ejemplo, ubicación, nombre de la revista, nivel geográfico, métodos de análisis, resultados, implicaciones y tendencias). Es cierto que, en el contexto de la investigación turística, los temas y las hipótesis, con algunas excepciones, han permanecido constantes. La mayoría de

los 889 estudios analizados se centraron en temas climatológicos clave, como impactos del cambio climático en el turismo (28,4%) y el confort urbano y bioclimático de los turistas en los destinos afectados (13,2%), mientras que han tenido una menor cobertura temas relacionados con el turismo, como las políticas del cambio climático en el turismo (6,1%) o las estrategias y opciones concretas para reactivar los destinos turísticos para el cambio climático (0,2%). Los métodos, procedimientos y resultados de la investigación pueden contribuir al avance de la climatología turística hacia una nueva fase de aplicación teórica y práctica para la planificación turística.

Palabras clave: climatología turística; cambio climático; estudios de turismo; bibliometría.

1 Introduction

Tourism industry is one of the fastest growing sectors in the world (UNWTO, 2019). Despite that, one should bear in mind that climatic and meteorological conditions are undoubtedly connected to tourism's performance in different geographical areas (de Brum Ferreira, 1990; Eugenio-Martin & Campos-Soria, 2010; Gómez-Martín, 2005; Machete et al., 2014; Matzarakis, 2013; Matzarakis et al., 2010; McKercher et al., 2015; Ritty & Scott, 2015; Steiger et al., 2019). This particular context further confirms the need to understand in greater detail the milestones of this relationship, contrary to the more simplistic and descriptive views on climate and meteorology in traditional studies of prospective and tourism analysis. This approach can contribute with practical applications for tourism planning, and/or projects.

According to Petticrew (2001) a systematic review offers a coherent and reproducible set of studies that limit the potential for biases for researchers and experts in the process of selecting the literature to use in their research. In addition, recognition of tourism and climate (change) studies will make it easier and more useful to redefine and redirect adaptation strategies, and the potential impacts of the latter.

Most studies in tourism climatology evaluate dominant paradigms (Dann, 1997), methodological development (Dann, Nash & Pearce, 1988), and the epistemological foundations of tourism knowledge (Botterill, 2001). Despite the fact that other thematic areas such as resident/tourist perspective have been increasingly the subject of analysis, it still seems to fall short (e.g. Nunkoo, Smith & Ramkissoon, 2013; Prayag, Hassibi & Nunkoo, 2019).

Taking these facts into consideration we focused on a thematic that has evolved quickly and that deserves quick answers. The ongoing pandemic period has accelerated this need. For that, the main objectives of this study are to:

- (i) carry out a scientific-metric analysis of publications on tourism and climate from 1940 to December 2020;
- (ii) analyze the methods, data and emerging trends;
- (iii) identify the main challenges and future studies in tourism climatology.

Although there were some studies on the evolution of the subject over the last century (e.g. Hernandez & Ryan, 2011; Kaján & Saarinen, 2013; de Freitas, 2017; Steiger et al., 2017; Stewart, Liggett & Dawson, 2017; Verbos, Altschuler & Brownlee, 2017; Fang, Yin & Wu, 2018; Hoogendoorn & Fitchett, 2018; Loehr & Becken, 2021), none of them contemplated all the geographic scales of analysis, as well as the methods and techniques employed and principal directions for applied studies in the future. The present paper considers these missing issues and can shed a light on whether the studies conducted correspond to the destinations at higher risk of climate impacts. The lack of action by the tourism sector has emphasized the need for changes in the paradigm to face the climate crisis (Hall, 2019; Loehr & Becken, 2021). This paradigm shift can be sustained in the generation and practice of scientific knowledge (e.g. work areas, methods and territories under analysis) linked to the 6th level of evolution of studies. This change assumes the combination of the main theoretical and applied contributions to climate assessment in specific territories.

Besides our analysis being relevant for the diagnosis of the thematic that needs deeper and further analysis (namely in the ongoing pandemic and in the near future – in a possible post-COVID 19 pandemic). Furthermore, politicians and other organizations quickly need data about the linkage between tourism and climate to implement practical and faster solutions.

The present paper is structured as follows. The introduction is followed by a section on methods and data which provides a description of the approach defined in this article. Section three presents the quantitative evolution of the papers in an annual, thematic, and country-based analysis. Next, emerging research problems, potential fields of research, and discussion are presented. These are followed by the conclusions of the article.

2 Methods and data

2.1 Database collection

This section focuses on the international scientific literature on tourism and climate, found in the multidisciplinary *WoS* and *Scopus* databases. These papers were searched through a combination of Boolean operators (AND and OR) for different keywords related to tourism, climate change, weather and meteorology based on the following expression: tourism AND weather OR climate OR climatology OR biometeorology OR climate change OR mitigation and adaptation. This process was repeated for the various keywords. Besides, many of the articles received in TRINET electronic information source (e-mail reference base for the dissemination of tourism research content and information) were about tourism, climate, and climate change. In this sense, we always confirmed whether the article was already part of our list or it was indexed in one of the two main databases.

The aim of the review focuses on empirical studies or papers dealing with conceptual and structural models published in peer reviewed journals. Multisector studies that have little or no relation to tourism climatology were excluded, after an analysis of the core of the scientific publication. Of the 3298 articles initially identified using bibliographic review software (*Citespace* and *Sitkis*), this review resulted in 889 publications that were included in the study. All articles were analyzed individually through the title, abstract, keywords, and in some cases the article body to assess whether it was effectively related to the object of study.

The investigation has covered a period of 80 years, between 1940 and 2020 (the first identified study dating back from 1949 by Deasy). Other papers, beyond the review criteria, were, occasionally, mentioned throughout the research. Content analysis, which is often used to measure trends and identify developmental patterns against concepts (Lu & Nepal, 2009), has also been used in this article.

Our study differs from the others already published on the thematic. A quantitative and qualitative analysis was performed for the collected articles. To this end, the main analysis of relative and absolute frequencies was identified. A content analysis was also carried out based on each of the articles, identifying the main contributions and challenges that each one may have for the evolution of the tourism climatology.

2.2 Production and analysis process

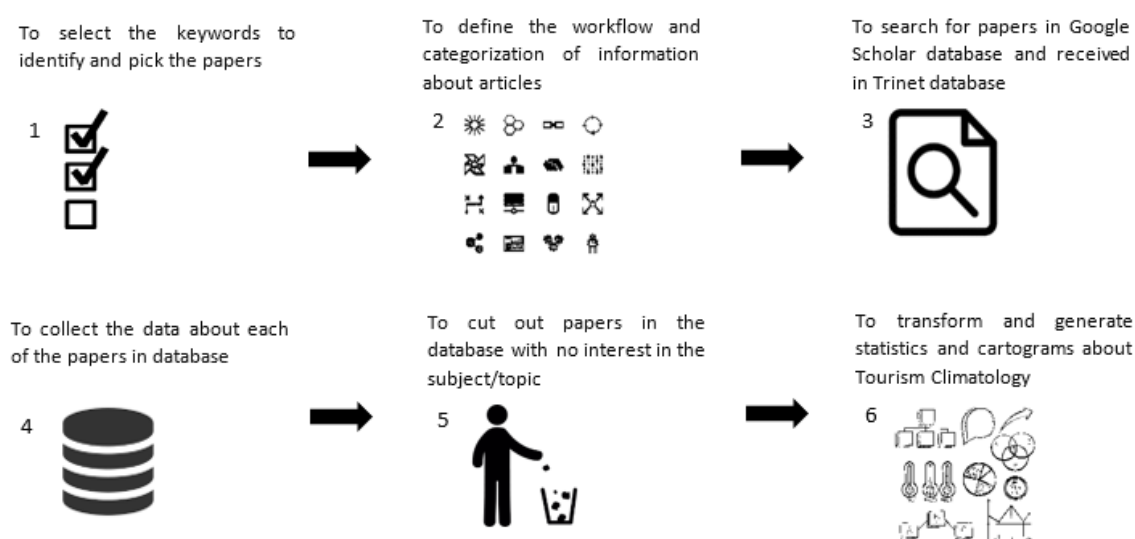
In this research, the analysis on tourism and climate focuses on identifying the foundations of research in tourism and climate, and to identify the main research premises to be developed in the medium and long term.

The data was categorized into: weather station data; campaign measurements; measurements at fixed locations; questionnaire of residents or tourists; Delphi method; focus group; interviews (semi-structured, structured and unstructured); bibliography/documents; and secondary data.

Regarding the approach variables, they were subdivided into different sets, which in turn subdivided the categories closest to climate assessment, climate change or the perspective of comfort and intervention in tourism.

Figure 2 describes the methodology used for creating a content analysis about tourism climatology. This process consisted of 6 steps: (1) select the keywords to identify and pick the papers to use in literature review; (2) subsequently, define the workflow and major categorization of the data used in papers and (3) search for papers; (4) collect the papers in a database, (5) finally, cut out the repeated papers, eliminated errors or omissions, and those that have no interest in the subject; (6) transform them, generating descriptive statistics and cartograms about the subject.

Figure 1. Step-by-step flow chart showing the procedure designed to obtain the data for literature review on tourism climatology



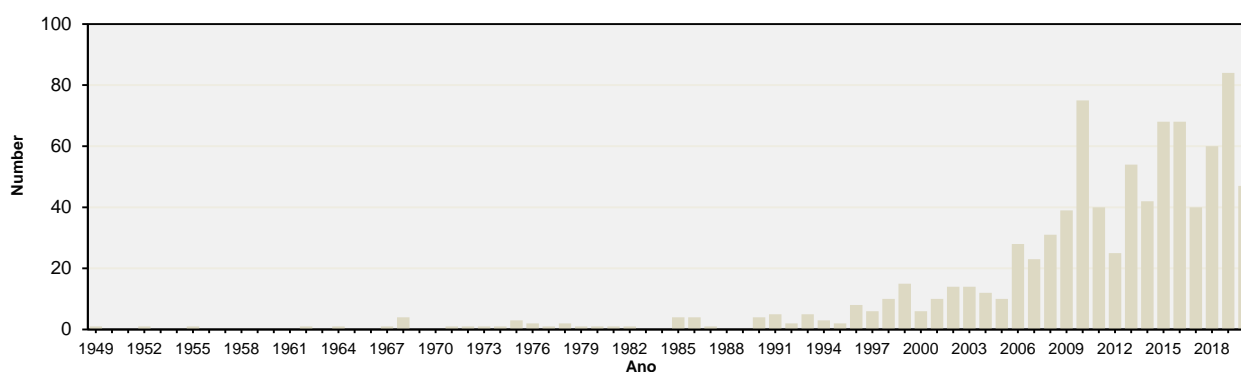
Source: authors' own elaboration

3 Results

3.1 Evolution of tourism climatology research

Climate and tourism studies, and the creation of the tourism climatology research subarea, are still taking their first steps. It is obvious that here has been an increase in the number of papers published (Figure 3) since 1949 [with the publication of Deasy (1949)]. This first study was descriptive in nature, seeking to highlight the climatic conditions of Luce County (in Michigan, USA) for tourism practice.

Figure 3. Evolution of published papers about tourism climatology



Source: authors' own elaboration

Table 1 summarizes the main advances and determining events related to the evolution of this research subarea, with periods of significant growth and other periods of scientific crisis. The field of research in tourism climatology emerged in the period between 1949 and 1959 and focused on general data about climate territories (e.g. Deasy, 1949; Clause & Guérout, 1955). However, the type of studies that were published during this period did not have major impacts on the academic community, possible to show through the reduced number of citations they have in the scientific literature.

During the 1960s and 1970s, at an early stage of concern for environmental sustainability, there was a global investment in weather and climate research that provided researchers with an opportunity to assess how climate affects a set of economic activities. This group of activities included tourism, namely growing tourist areas (de Freitas, 2017) such as urban destinations of Europe and America (e.g. Poulter, 1962; Fergusson, 1964; Green, 1967; Davis, 1968; Heurtier, 1968; Terjung, 1968). Much of the research carried out in this period seems to have been motivated by the usefulness of climate-meteorological information in planning and management processes in the tourism, leisure, and recreation sectors. Nevertheless, this second phase was

based on a limited number of studies and almost concerned with European cities (namely, London – e.g. Poulter, 1962) and regarding the tourism capacity during the summer season of urban destinations.

A growth period began in 1971, but it was relatively limited until 1983 (Perry, 1971; Crowe, 1975; Pigram & Hobbs, 1975; Masterton, 1982). The moderate investment in scientific production is likely to have resulted from the uncertainty created by different world crises between the 1970s and the early 1980s (de Freitas, 2017). During this period, studies gave preference to coastal destinations and the ability to attract tourists, namely the studies carried out on the French and Mediterranean Atlantic coast of Spain and Greece (e.g. Besancenot, Mouiner & De Lavenne, 1978). These studies reveal the attractive capacity of these destinations for the practice of bathing and the pleasure for tourists in colder climates, particularly from northern Europe. On the other hand, it is essentially based on the assessment of the climatic suitability of tourism destinations through classifications of weather types.

A new surge of literature on the subject occurred in the early 1990s, with an increase motivated by potential usefulness (and expectations) for impact analysis and climate change mitigation measures (de Freitas, 1990; Höppe & Seidl, 1991; Uysal, Fesenmaier & O'Leary, 1994; López Palomeque, 1996). In part, this new trend was governed by the change in the Planetary Energy Balance caused by the emission of greenhouse gases with anthropic origin. This period was supported by several studies carried out on a national scale, which demonstrated the urgency of establishing a tourism policy agenda capable of tackling climate change.

Table 1. Main advances and evolution of tourism climatology since the 1940's

| Period | Designation | Main advances and determining events | Areas of publication | Principal authors | N. of papers |
|------------------------|--|---|--|--|--------------|
| <i>Up to 1970</i> | <i>Emergence of the thematic</i> | First approach (Deasy, 1949) | Climate, Geography, Tourism | (Deasy, 1949; Clausse & Guérout, 1955; Poulter, 1962; Fergusson, 1964; Green, 1967; Davis, 1968; Terjung, 1968; Heurtier, 1968) | 10 |
| <i>1971 – 1983</i> | <i>Crisis and uncertainty period</i> | Oil crisis (1973) | Environmental Science, Sport Science, Climate (change), Regional Studies, Geography, Tourism | (Perry, 1972; Adams, 1973; Pigram & Hobbs, 1975; Mayo, 1976; Miossec, 1977; Besancenot, Mouiner & De Lavenne, 1978) | 16 |
| <i>1984 – 1995</i> | <i>Slow progress period</i> | Brundtland Report (Brundtland, 1987); 1 st Assessment report of IPCC (IPCC, 1990); 2 nd Assessment report of IPCC (IPCC, 1995) | Environmental Science, Environmental Engineering, Climate (change), Geography, Tourism | (Mieczkowski, 1985; de Freitas, 1990; Yau & Chan, 1990; Smith, 1990; Farrel & Runyan, 1991; Smith, 1993; Cullingford, 1995; Whetton, Haylock, & Galloway, 1996) | 30 |
| <i>1996 – 2008</i> | <i>Usefulness and expectation period</i> | Kyoto Protocol (1997); International Society of Biometeorology established Commission on Climate, Tourism and Recreation (1998); 3 rd Assessment report of IPCC (2001); Djerba Declaration on Climate Change and Tourism (2003); NATO and EU Science Foundation Workshops on Climate and Tourism (2004); JOST Special Issue on climate change (2006); WMO established Expert Team on Climate and Tourism (2006); Davos declaration on climate change and tourism (2007); 4 th Assessment report of IPCC (2007); UNEP / Oxford U. Capacity Building Workshop for Developing Nations, Oxford (2008); PATA CEO Climate Change Challenge, Bangkok (2008); East Carolina U. Workshop on Weather-Climate Information Application, Greenville (2008) | Environmental Science, Building and construction, Climate (Change), Development (Social Sciences), Earth-Surface Processes, Ecology, Economics, Energy, Environmental Engineering, Regional Studies, Geography, Technology and Innovation Management, Production Systems, Sociology, Tourism, Transports Systems | (Gössling, 2002; Gössling et al., 2002; Lise & Tol, 2002; Beniston, 2003; Hamilton, Maddison, & Tol, 2005; Saarinen, 2006; Amelung, Nicholls & Viner, 2007) | 187 |
| <i>2009 to present</i> | <i>Robustness period</i> | Report for the 2 nd conference on climate change and tourism (Davos, 2007); 3 rd World Climate Conference – Tourism Sector White Paper (2009); Renewal of WMO Expert Team and new mandate (2009); WTTC (2009) – Leading the challenge on climate change; 5 th Assessment report of IPCC (2013); | Environmental Science, Anthropology, Aquatic Science, Arts and Humanities, Biochemical, Genetics and Molecular Biology, Atmospheric Science, Earth and Planetary Science, Sports Science, Climate (Change), Computer Sciences Applications, Cultural Studies, Decisions Sciences, Development, Law, Earth Surface Processes, Ecology, Economics, Energy, Engineering, Aerospace Engineering, Production and Industrial Engineering, Food Science, Geography, Technology and Innovation Management, Management Information Systems, Marketing, Multidisciplinary, Business and International Management, Oceanic Engineering, Renewable Energy, Production Systems, Tourism | (Dwyer et al., 2009; Barr et al., 2010; Scott, Petters & Gössling, 2010; Gössling et al., 2011; Buckley, 2012; Gössling et al., 2012a, 2012b; Lee & Brahmarsrene, 2013; Gössling & Peeters, 2015; Lenzen et al., 2018; Miro-Pérez & Olcina Cantos, 2020) | 642 |

Source: authors' own elaboration

Also, in the late 1990s, new concepts and methods of analysis were applied to a diversity of topics such as: (i) the climatic-meteorological conditions as limiting/enhancing tourism; (ii) the concepts and methodologies in tourism climatology; (iii) the economic effects of climate on tourism; and (iv) the adaptation and mitigation of tourism (and tourists) to variability and climate change (de Freitas, 2017). It should be noted that the number of publications increased significantly until 2011. One of the factors contributed to this can be the relevance attributed to tourism impacts in Fourth Assessment Report of IPCC (Scott, Hall & Gössling, 2016a). In the past 10 years, there has been a substantial increase in published articles. Of this matter, the following issues were most relevant: (i) the use of integrative indices for the assessment of climatic potential, namely with the creation and application of various analysis instruments based on software - for example, CTIS (e.g. Matzarakis, 2014; Rodríguez-Algeciras et al., 2020; Nastos & Matzarakis, 2020) or Rayman (e.g. Matzaraki, Rut & Mayer, 2007; Lin & Matzarakis, 2011) and the assessment of adaptation and mitigation indicators in the face of climate change (Muller & Weber, 2008; Seetanah & Fauzel, 2019). The most studied destinations in this period were related to the continents of Europe, Oceania and America.

The main works in tourism climatology were related to the ISBCCTR (International Society of Biometeorology's Commission on Climate, Tourism and Recreation), constituted in November 1999 in Sydney, Australia, at the 15th Congress of the International Society of Biometeorology (de Freitas, 2017), to promote research in climatology and to consolidate the conceptual framework on climate-tourism relations. Authors who were related to the foundation or who are disciples or worked with the founders during their career are the main scientific producers in tourism climatology. In fact, the co-founders of the group were Chris de Freitas (University of Auckland, New Zealand) and Andreas Matzarakis (University of Freiberg, Germany), later joined by Daniel Scott of the University of Waterloo (Canada). The more relevant studies were mainly due to the formation of this group that there is currently a marked increase in research on climatology and tourism (e.g. Grigorieva, Matzarakis & de Freitas, 2010, de Freitas, 2017; Gössling, Scott & Hall, 2018; Gössling & Scott, 2018). Other authors in the last 11 years have been relevant to the evolution of the scientific field, namely S. Gössling, C. M. Hall or S. Becken (e.g. Scott & Becken, 2010; Becken, 2013a; Gössling, Scott & Hall, 2018; Gössling & Scott, 2018), above all by seeking to establish international standards on the climatic vulnerability of international destinations and global readjustment policies.

Between 2009 and 2020, the causal relationship between tourism and climate was particularly evident comparing to previous periods. Many of the articles published in this period are

accompanied by the evolution of the institutional reports produced on the thematic (e.g. WTTC, 2009; Davos Declaration, 2007; Bigano et al., 2008). Other reports are important for tourism studies, namely cruise tourism (Transport & Environment, 2019), tourism destination planning (Espon Climate, 2011) and climate strategies (Losada et al., 2014).

It should be noted that it is expected that new studies that emerge during the near future will seek to integrate a perspective of connection between environmental measures and economic stimuli after COVID-19, in the assumption of theoretical and practical studies based on a third-order stage (Hall, 2011; Hall, Scott & Gössling, 2020) and a sixth level of evolution of studies, associated with the readaptation in the assessment and management of tourism destinations in the face of climate change. It is essential to improve analysis in countries with well-documented literature, but with high levels of vulnerability (e.g. Mediterranean), as well as to develop these issues in developing destinations, whose work has been increasing in recent years. Several countries still show very high levels of vulnerability regarding their adaptive capacity (in Africa, the Middle East and South Asia). In order to face these vulnerabilities, it is essential to increase data triangulation techniques, which combine the relationship between traditional methods (namely of assessing the instruments of adaptation policy in the face of climate change in tourism) and the carrying out of questionnaire surveys, techniques of listening to specialists and microclimate measurements, to assess the vulnerability of the destination, through a symbiosis between the perspective of several stakeholders (political agents, tourists and residents).

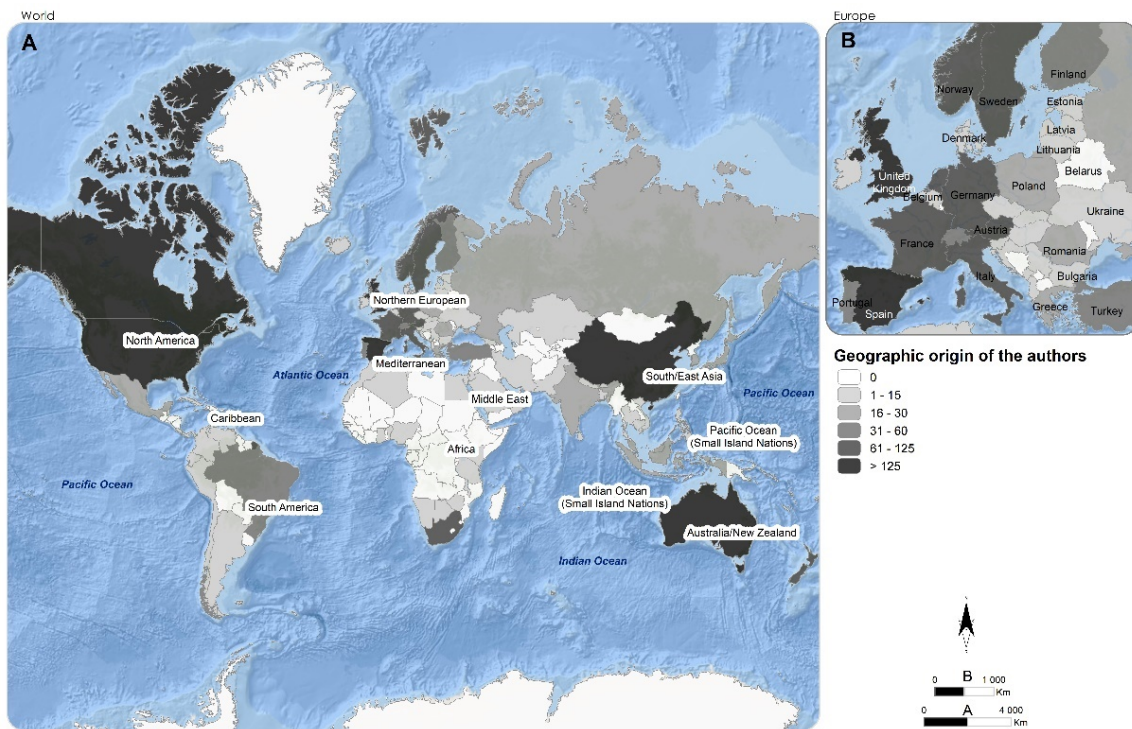
3.2 Territorial evolution: balance between the origin and application of investigation

The geographic evolution of the studies must be seen according to several dimensions, namely the geographical origin of the authors of the studies (according to academic affiliation), the places where the studies are applied and the levels of citation that are associated by geographical area. The network of countries that publish work on tourism and climate represents the weight of research institutions, the availability of funding for research and the proportion of institutional networks that focus on climate-tourism research (Fang & Wu, 2018). Seven countries stand out in the origin of the main authors dedicated to studies in tourism climatology with more than 100 authors: United States (n=325 – 11.6%), Australia (n=249 – 8.9%), China (n=207 – 7.4%), United Kingdom (n=188; 6.7%), Spain (n=169; 6.0%), Canada (n=128; 4.6%) and Germany (n=113; 4.0%) (Figure 4).

It was found a distinction between countries in relation to authors' collaboration. Most of studies (64.4%) were carried out with intra-country collaboration, e.g. Cuba or Algeria (Figure 5a). On

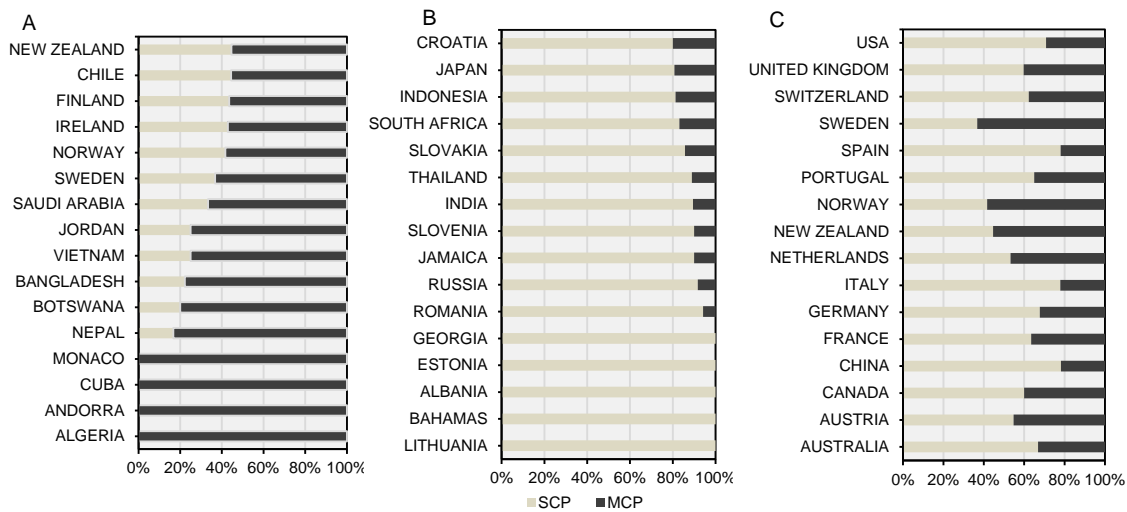
the contrary, studies about Georgia, Estonia, Albania or Lithuania were carried out exclusively by foreign researchers (Figure 5b). In some countries such as South Africa or Croatia, with high levels of publication, is significant the work carried out in collaboration with authors from several countries. Among the most relevant countries in the publication's framework, besides Spain, China or Australia having a prominence of studies carried out with the collaboration of authors of the same nationality or institutional affiliation in the same country, others such as New Zealand or Sweden are associated with a greater participation of different nationalities in the production of articles (Figure 5C).

Figure 4. Geographic origin of the authors of tourism, weather, and climate (change) studies since 1940



Source: authors' own elaboration

Figure 5. Authors' production - the intra-country (SCP) and inter-country (MCP) collaboration indices. Most MCP index (A), Most SCP index (B) and more productive countries (C)



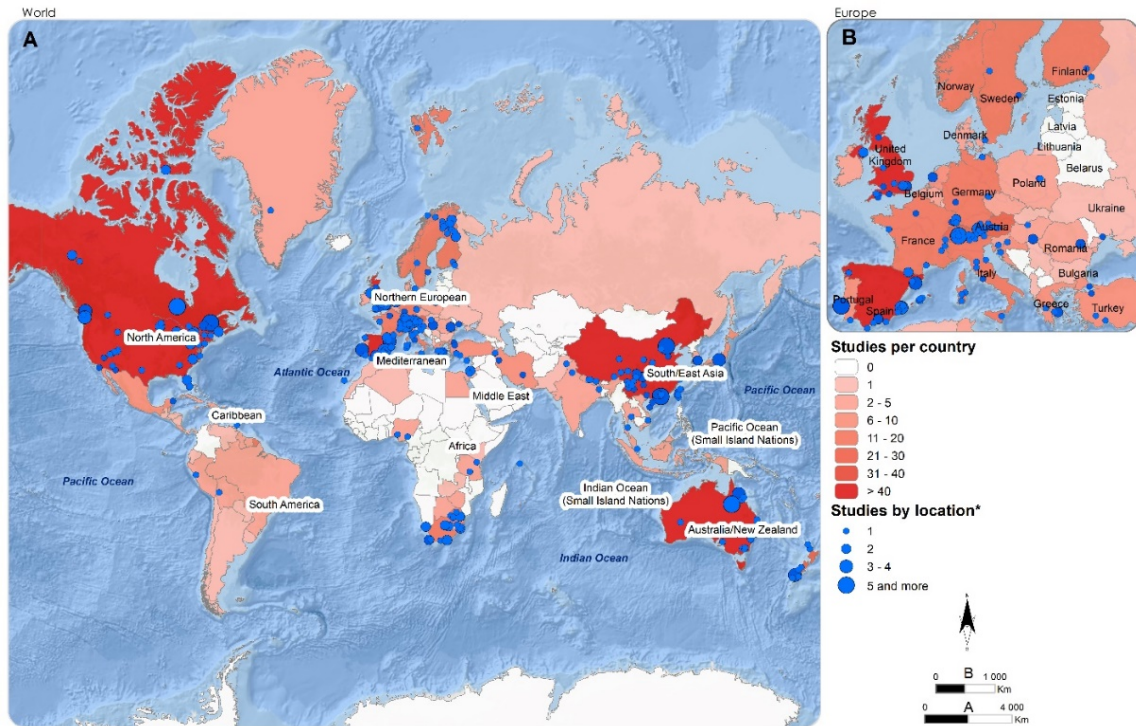
Source: authors' own elaboration

The countries with the largest number of authors of the publications correspond, in many of the cases, to those with the highest number of citations as well.

While in the Northern Hemisphere and Oceania (in South Hemisphere) publications are significantly relevant (Figure 6), other countries do not appear to be so 'proactive' – not just theoretically – above all in what regards the enforcing of policies and theories (namely in Africa or the Middle East). The greater relevance of tourism on an international scale can be explained by the knowledge and involvement of the various entities. This practice improves the identification of tourist potential and the capacity to adapt to the climate. Anyway, these studies undergo constant changes due to the development of knowledge and a focus on territorial action.

Since most of the research is carried out at national, and sometimes regional level (Figure 7), there is a tendency to narrow down the scale of survey. Although local level, more pragmatic, studies have increased in recent years, they seem to have somewhat steadied without the necessary empirical support. We chose to analyze the category 'parks' because they occupy 4.5% of the total studies and they are an important category in terms of the studies that are carried out on a more detailed scale. It is above all national parks, a protected area, usually of great extension, which has as its basic objective the preservation of natural ecosystems of great ecological relevance and scenic beauty.

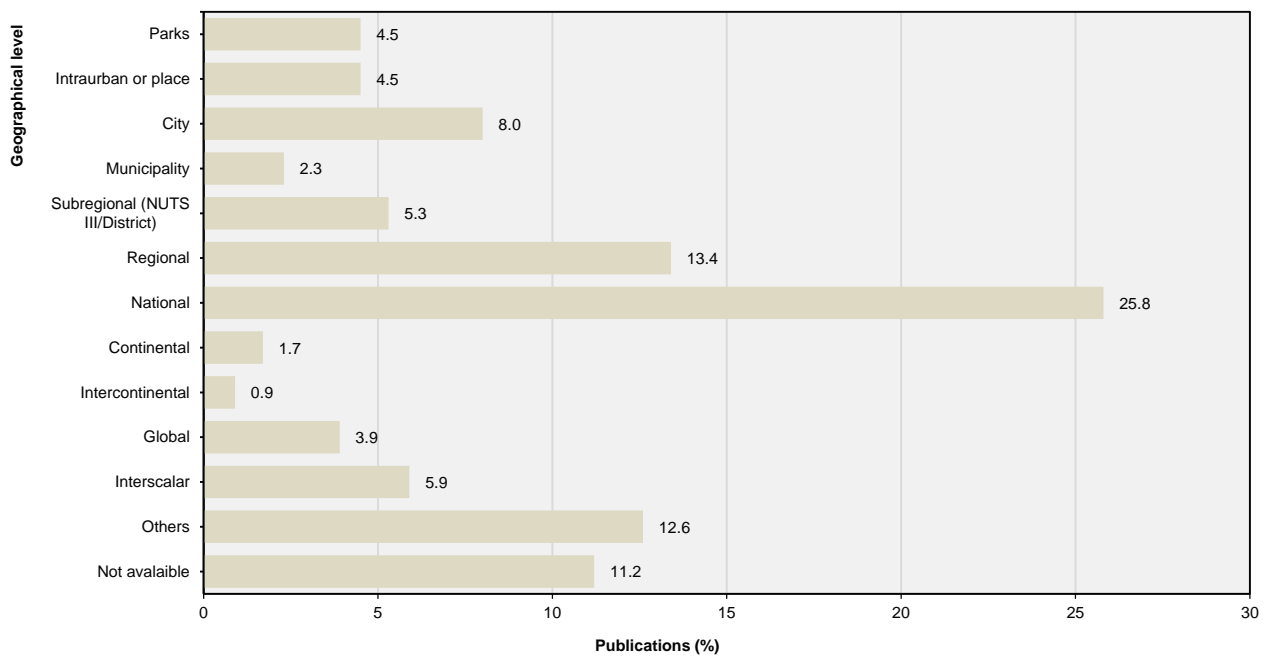
Figure 6. Distribution of tourism, weather, and climate (change) studies since 1940



*some of these studies do not have specific location because it is realized at national scale.

Source: authors' own elaboration

Figure 7. Geographical level of studies identified in tourism climatology

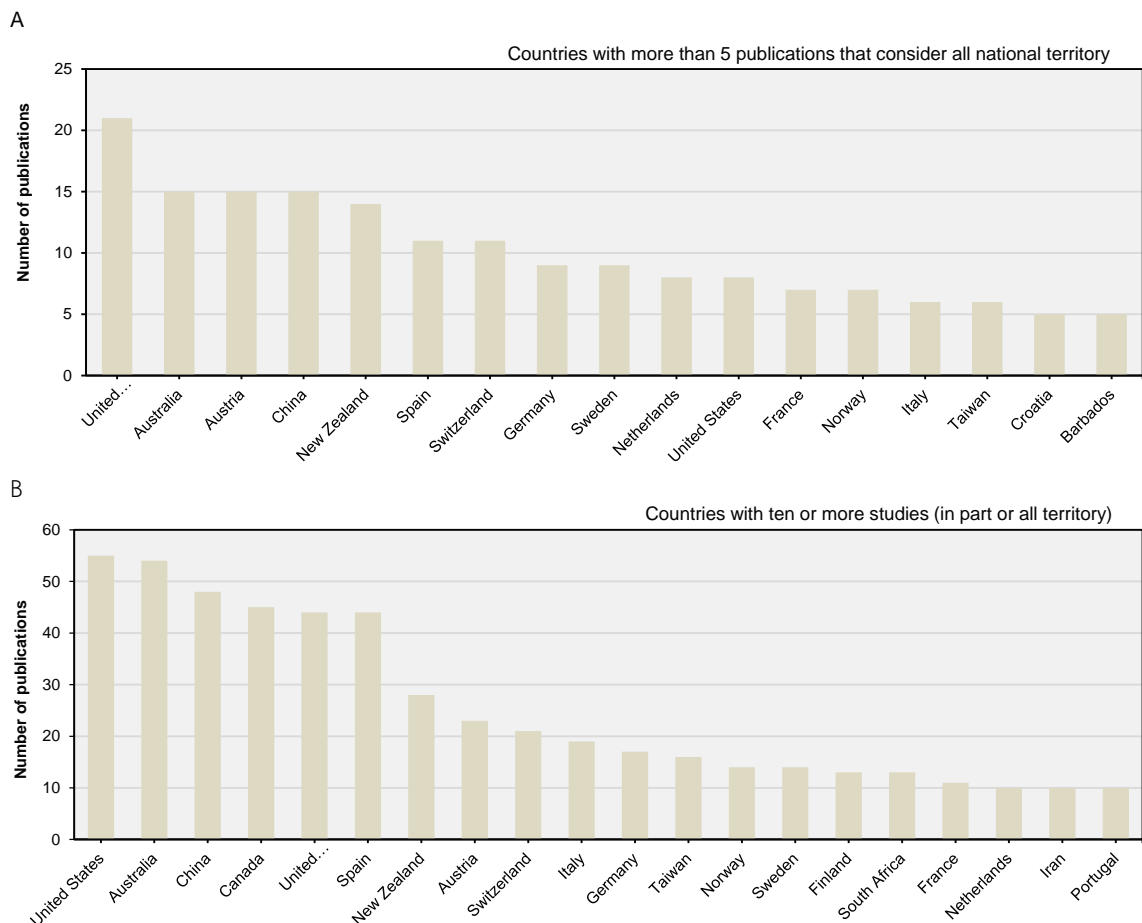


Source: authors' own elaboration

Figure 8 shows countries with more than 5 publications that consider all national territory, and with ten or more studies (in part of territory – e.g. city, sub-regional – or all national territory) (B) since 1940. Major studies applied to the national territory have more expression in United Kingdom (n=21), Australia, Austria and China (n=15) and New Zealand (n=14 - Figure 8A). The distribution of studies carried out by all on any geographical within national scale differs slightly. The US ranks as the country with the higher number of studies (n= 55); Australia have 54 publications, and China 48; Spain and United Kingdom share the fifth position, with 44 publications each (Figure 8B).

Figure 8. Contribution to papers published by country.

(A) countries with more than 5 publications that consider all national territory since 1940 and (B) countries with ten or more studies

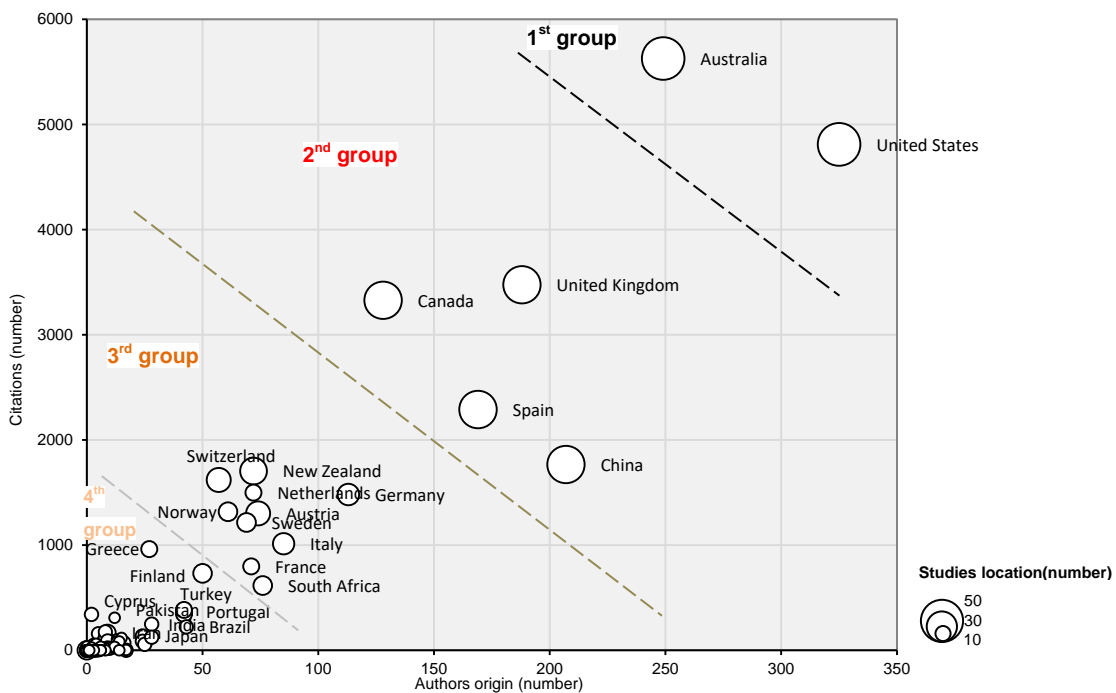


Source: authors' own elaboration

Four groups of countries are distinguished in terms of production for tourism climatology (Figure 9). Group 1 constituted of the USA and Australia, with high involvement of authors, high production levels and a high dedication of studies to the national context; group 2 with four

countries – Canada, China, United Kingdom and Spain - although with less production and dedication to authors than group 1, expresses a significant relevance, visible by the number of citations and works published about the countries. The 3rd group presents a variety of sufficient studies dedicated to tourism and climate, showing the contributory capacity of some research centers and a smaller capacity for citation and number of authors dedicated to the theme. In fact, note the dedication of studies to South Africa, although the origin of authors and the number of citations is quite modest. The 4th group presents some emerging countries in publications (namely Portugal, Finland, or Greece). Most studies are highlighted by: (i) the history that countries and tourist destinations have in the practice of tourism, namely in European countries, or (ii) the size of important research groups that analyze and evaluate tourism in various dimensions.

Figure 9. Relation between authors origin, citations and studies location of tourism, weather, and climate (change) studies since 1940



Source: authors' own elaboration

In Australia, a large part of the investigations evaluating the relationship between tourism and climate are associated with two Australian universities (Griffith University and Queensland). Doing a quantitative analysis of the main authors, the investigations are essentially associated with Susanne Becken and related to sustainable tourism, energy use and greenhouse emissions, the perception of tourists, environmental policies, and risk management in tourism destinations (e.g.

Hendrikx et al., 2013; Hopkins et al., 2013; Le et al., 2019). In China and the USA, which have a large corpus of researchers, the investigations carried out focus on environmental/climatic and tourism models to assess behavior in the tourist destination. It should be noted that the Chinese Academy of Sciences is the main funding entity for studies on tourism and climate change, originated in China, and which contributes to the capacity that institutions in these countries have had to strengthen themselves on the international scene.

3.3 Topics and research approaches in the scientific area

Among the most used approaches in climatology and tourism studies is the analysis of climate change impacts and consequences (28.4% of the studies – Table II).

The existing works focus mainly on tourist demand, instead of trying to analyze the valorisation of attractions (Becken & Simons, 2002; Hamilton, 2003; Bujosa, Riera & Torres, 2015; Kilungu et al., 2019). In addition, the aim of a large part of the studies is to assess the relationship between tourism and climate as a common element, not tourism's susceptibility to general atmospheric conditions (Boodhoo, 2003; de Freitas, 2003; Matzarakis, 2006; Grilli et al., 2020). This alone allows us to understand how climate data is used by traders or decision-makers (de Freitas, 2003; Gössling & Scott, 2018).

Table 2. Main investigation approaches, principal authors, and number of publications since 1940

| Tourism and climatology studies | Authors with higher number of citations and date of publication | Number of selected publications | Proportion in the reviewed literature (%) |
|---|---|---------------------------------|---|
| Expert-based climate/environmental and tourism assessment | (Gomez Martin, 2005; Scott, Lemieux & Malone, 2011; Fang & Yin, 2015; Zhang & Wu, 2015; Scott et al., 2016; Lanquar, 2017; Fitchett, Robinson & Hoogendoorn, 2017; Craig & Feng, 2018). | 26 | 3,0 |
| Climate/environmental and tourism assessment based on stated preferences through surveys | (Williams, Dousa & Hunt, 1997; Frew & Winter, 2010; Hübner & Gössling Gössling, 2012; Abegg & Steiger, 2016; Hewer, Scott & Gough, 2017; Demiroglu, Dannevig & Aall, 2018) | 71 | 8,3 |
| Climate/environmental and tourism assessment based on revealed preferences through the ratio of indices | (Vera Rebollo, 1985; Hui & Yuen, 2002; Fernández-Morales, 2003; Peeters & Schouten, 2006; Kuo & Chen, 2009; Falk & Vieru, 2017; Perkins, 2018) | 28 | 3,3 |
| Multidisciplinary climate/environmental assessment and tourism | (Crowe, 1975; Higham & Hinch, 2002; Becken, Simmons & Frampton, 2003; Becken, 2004; Paget, Dimanche & Mounet, 2010; Scott, Peeters & Gossling, 2010; Dawson et al., 2010; Saurí et al., 2013; Rosselló & Santana-Gallego, 2014) | 50 | 5,8 |
| Policies - Climate Change/Environment and Tourism | (Baum & Hagan, 1999; Kent, Newnham & Essex, 2002; Belle & Bramwell, 2005; Gossling, Peeters & Scott, 2008; Gossling, 2009; Font et al., 2006; Hall, 2013; Archer et al., 2014; Olcina Cantos & Vera Rebollo, 2016; Scott et al., 2016; Moyle et al., 2018; Pandy & Rogerson, 2018) | 52 | 6,1 |
| Impacts and consequences - Climate change and tourism | Koenig & Abegg, 1997; Maddison, 2001; Elsasser & Burki, 2002; Benistom, 2003; Berritella et al., 2005; Hamilton, Maddison & Tol, 2005; Amelung, Nicholls & Viner, 2007; Gössling et al., 2012; Becken, 2012; Gössling & Buckley, 2016; Jacob et al., 2018) | 243 | 28,4 |
| Mitigation - Climate Change/Environment and Tourism | (Lerner & Haber, 2000; Scott, McBoyle & Mills, 2003; Gössling et al., 2007; Brower, Brander & Van Beukering, 2008; Barr et al., 2010; Gössling, Scott & Hall, 2013; Burch et al., 2014; Gössling, Scott & Hall, 2015; Michailidou, Vlachokostas & Moussiopoulos, 2016; Higham et al., 2016; Nalau et al., 2017) | 62 | 7,2 |
| Thermal comfort and tourism | (Höppe & Seidl, 1991; Green, 1967; Zhang & Wang, 2013; Park, Tuller & Jo, 2014; Lin, Yang & Matzarakis, 2015; Roshan, Yousefi & Błazęjczyk, 2017; Ge et al., 2017; Salata et al., 2017; Unger, Skarbit & Gál, 2018; Miro-Pérez & Olcina-Cantos, 2020) | 114 | 13,3 |
| Evolution of tourism and climate studies | (Viner, 2006; Becken, 2013; Kaján & Saarineen 2013; Ruhanen et al., 2015; Hashemkhani et al., 2015; Bramwell, 2015; Verbos, Altschuler & Brownlee, 2017; de Freitas, 2017; Stewart, Liggett & Dawson, 2017; Steiger et al., 2017; Fang, Yin & Wu, 2018; Hoogendoorn & Fitchett, 2018) | 36 | 4,2 |
| Environmental and/ or tourism modelling | (McEniff, 1992; Kelly & Williams, 2007; Schianetz, Kavanagh & Lockington, 2007; Blanco, Lozano & Rey-Maqueira, 2009; Bows, Anderson & Peeters, 2009; Boley, 2015; Hopkins, 2015; Martínez-Ibarra, 2015; Amelung et al., 2016; Bec, McLennan & Moyle, 2016; Li, Song & Li, 2017; Zhang & Zhang, 2018) | 96 | 11,2 |
| Rehabilitation and requalification of tourist spaces | (Weisner & Schernewski, 2013; Falk & Hagsten, 2016) | 2 | 0,2 |

Source: authors' own elaboration

In turn, by analyzing the approaches used according to the developmental periods of tourism climatology, the following can be inferred:

- (i) the tendency to emphasize analysis on climate change impact; and
- (ii) the re-emergence of bioclimatic comfort studies in tourism. It should be noted, moreover, that thermal comfort studies assumed significant relevance in a period prior to 1970, although they were clearly generalist, whereas Post-2009 studies showed a much more appropriate relationship with the study territory, be it global (where studies that aim to ensure a mixed assessment of impacts and consequences and sectoral mitigation measures remain) or local, which aims to understand the ambitions and perceptions of those who interfere in the territory (thermal comfort studies and a climate-tourist assessment analysis based on climate preferences).

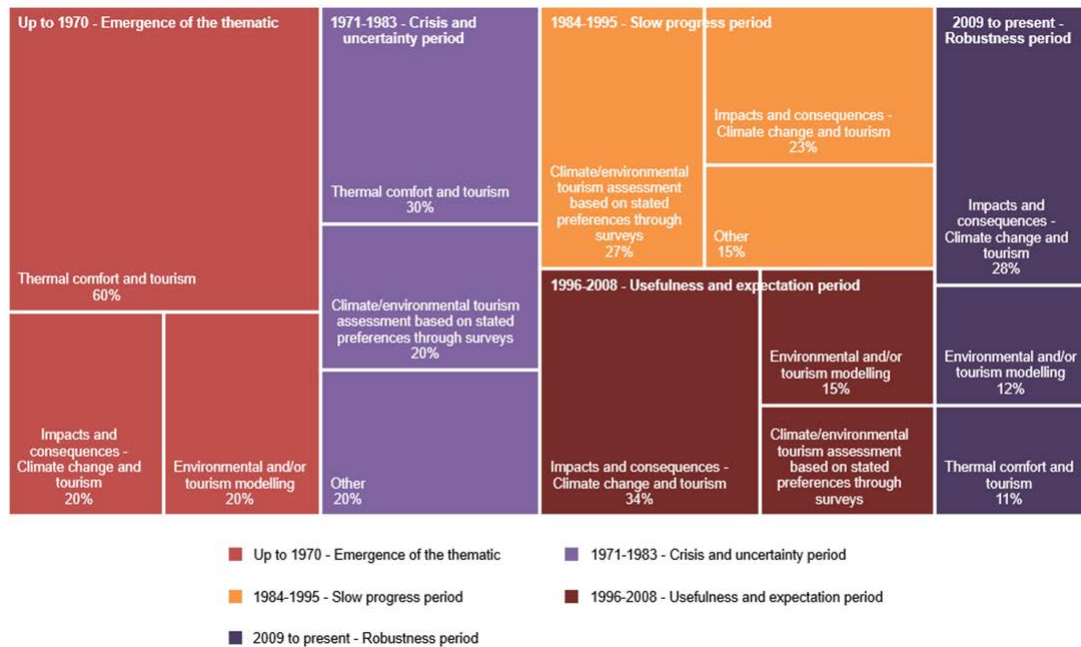
Despite the efforts to determine and assess tourists' suitability based on weather conditions, the application of a set of methods that do not reflect tourists perceived or experienced time and, therefore, have not been verified, i.e., they are based on purely subjective criteria (de Freitas, 2003; de Freitas et al., 2004; Loehr & Becken, 2021), is still recurrent. In this context, one of the basic requirements is the use of observation methods, with the purpose of gauging tourists' answers, needs, reactions and expectations as far as climatic issues are concerned (de Freitas, 2003; Gómez-Martín, 2005; Georgopoulou et al., 2019). In addition to these problems, there are others that expose the disregard for the role that climate and atmospheric conditions play in tourism activity and are still responsible for the theoretical and conceptual deficit on the climate-tourism field (de Freitas, 2001; de Freitas, 2001; de Freitas & Matzarakis, 2005; Hall, 2019; Loehr & Becken, 2021).

The factors that explain the slow development of tourism climatology are diverse. The main explanation reflects the spontaneity and instrumentalization of tourism development, as well as the climatic homogeneity that characterizes mass tourism typical destinations.

Figure 10 summarizes the evolution of theoretical approaches by time periods, and it shows two trends: (i) predominance of studies on thermal comfort and tourism until 1983; and (ii) an increase in impact assessment studies on climate change and tourism since 1997. This increase may be due to new information and knowledge on the reality of climate change prevalent in IPCC reports and mitigation policies and being implemented in different territories. There has been a trend towards conducting thermal comfort and tourism studies (11%) since 2009. In

general terms, the understanding of research approaches allows, among other things, to gauge general perspectives, and to learn how to pursue the most appropriate research projects.

Figure 10. Main investigation approaches of publications for period



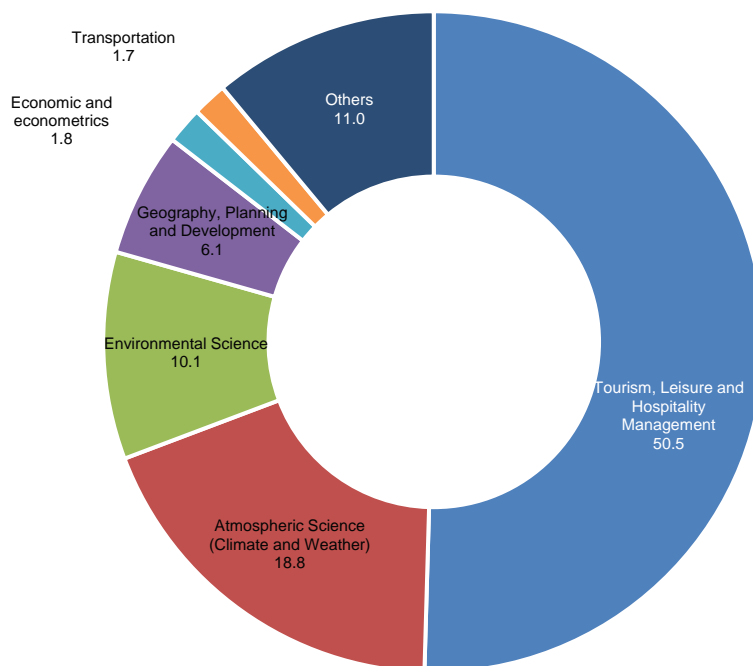
Source: authors' own elaboration

Tourism, leisure, and hospitality management (50.5%) is the most relevant scientific area of publication (Figure 11). A growth that has been intensified since 2000 is caused by the assumption of journals such as *Journal of Sustainable Tourism* (n=102), *Tourism Management* (n=62) and *Current Issues in Tourism* (n=43). Other journals in expansion and with a prestigious impact factor have also increased the number of articles dedicated to the theme, which is among the top 15 international journals that have published articles in the scientific field. In 2020, there is a clear trend towards the emergence of studies that seek to relate the situation of COVID-19 with the contexts of climate change and environmental susceptibility to better manage destinations and to establish a third-order change respects the most sustainable form of tourism.

3.4 Keywords and updates

Once tourism climatology was regarded as an investigation subarea of tourism research, it seemed to excel in the articulation of sustainability policies and domains. It is important to analyze the textual content of the research papers presented. We decided to investigate the words used in the keywords, article titles and abstracts.

Figure 11. Thematic approaches of publication in tourism, weather and climate (change) since 1940



Source: authors' own elaboration

Note that, globally, the keywords climate change ($n=286$), tourism ($n=156$), adaptation ($n=76$), sustainable tourism ($n=49$) and weather ($n=35$) appear as the most mentioned in articles of this subarea of knowledge. On the other hand, although these studies are mainly focused on the domain of climate ($n=33$) and sustainability ($n=30$) assessment, the relevance given to seasonality issues ($n=25$), mitigation ($n=21$) and resilience ($n=19$) cannot be neglected (Figure 12).

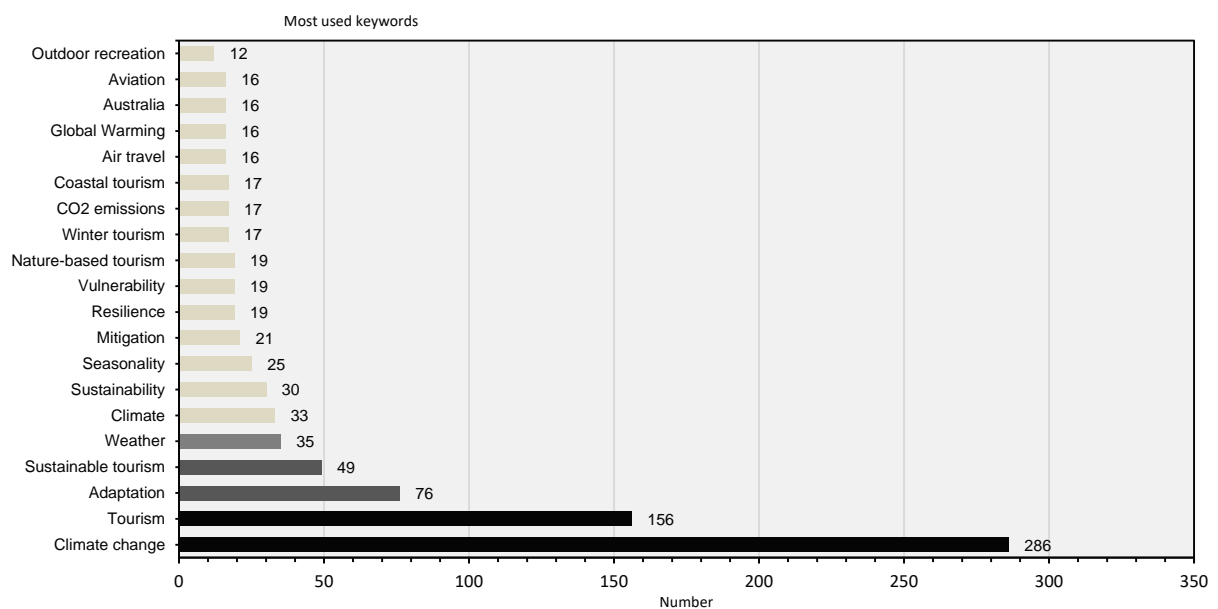
If we look at the trend since 1984, there is a clear evolution towards adaptation of the territories to changes. In this regard, there was a direct relationship between the evolution of keywords in tourism climatology and climate change adaptation and mitigation.

- (i) 1984–1996 (slowdown) - The articles sought to assess the capacity of the territory, especially Sun and Sea tourism destinations, in what concerns local meteorology and climatology. For this purpose, the attitudes of tourists were considered; beach climate (33%), attitudes (17%), beaches (17%), carrying capacity and integrated development (16%) are amongst the most relevant keywords.
- (ii) 1997–2008 (usefulness and expectation) - The ability of territories to adapt to their underlying vulnerability has become a basic premise in publications in the late 20th century. In the case of climate-tourism symbiosis, this evolution was marked by an accentuation in specific areas,

including sustainable tourism (29%), adaptation (21%), sustainability (17%) and seasonality (14%).

(iii) 2009–2020 (robustness) - Despite being a precursor of the trends observed since 1997, the relevance of new themes in tourism climatology is not discarded. In fact, ‘adaptation’ (37%) is assumed to be the most relevant keyword, mainly thanks to successive IPCC reports, where tourism has been granted special attention in recent years, particularly since 2007. The word ‘weather’ has been a constant choice in articles published since 1997 and has essentially to do with the determination with which authors aim to move from global to local analysis in the effective assessment of tourists’ comfort (weather=17%).

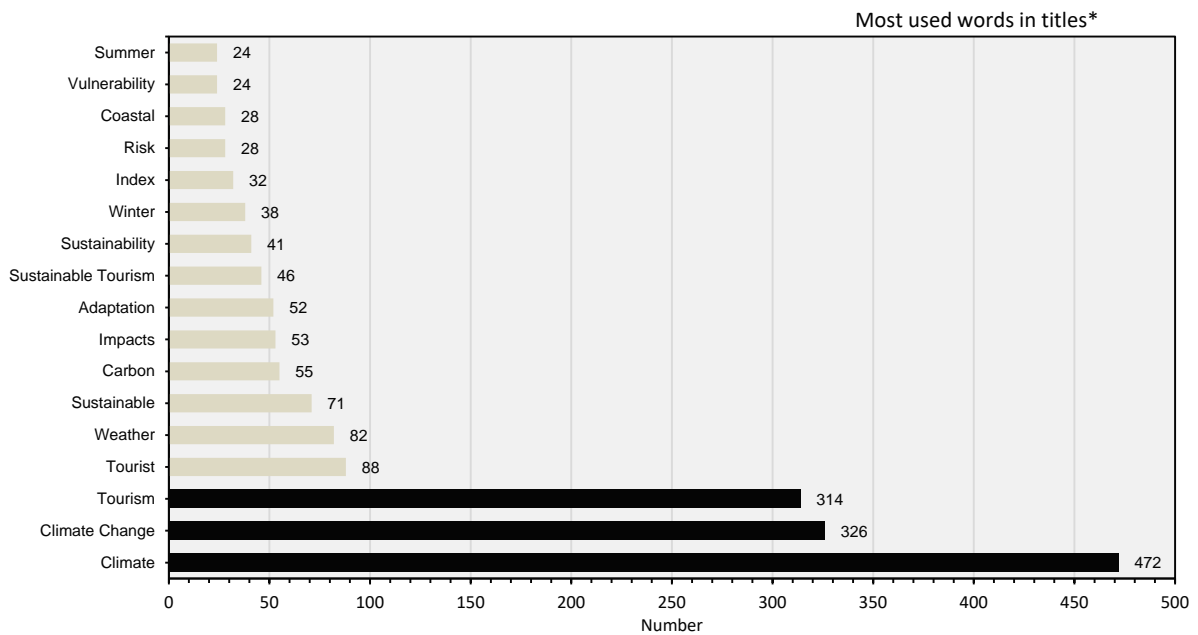
Figure 12. Keywords used in publications about tourism climatology, since 1940



Source: authors’ own elaboration

The titles of the works correspond to a large extent to the level of relevance of the keywords presented, highlighting yet other indicators that prove to be fundamental to studies in tourism. In this context, we highlight the research focus on ‘tourists’ (one of the key stakeholders in the tourism process) (n=88), research centered on neutralizing ‘carbon’ (n=55) and the relevance of ‘impacts’ (n=53) in this scientific domain (Figure 13).

Figure 13. Words used in title publications about tourism climatology, since 1940

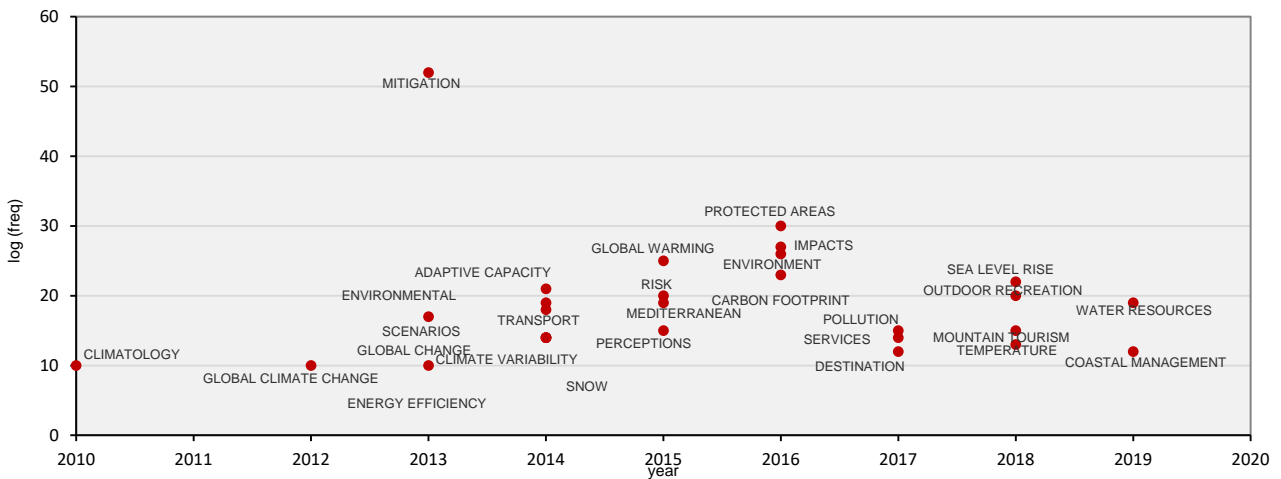


Source: authors' own elaboration

In fact, this perspective is possible to agree with the abstracts submitted to the main journals in the last ten years, where the research clearly focuses on the problems of climate change (global change, global climate change, climate variability, risk, carbon footprint) and the ability to destination management (outdoor recreation, coastal management, adaptive capacity, perceptions – Figure 14).

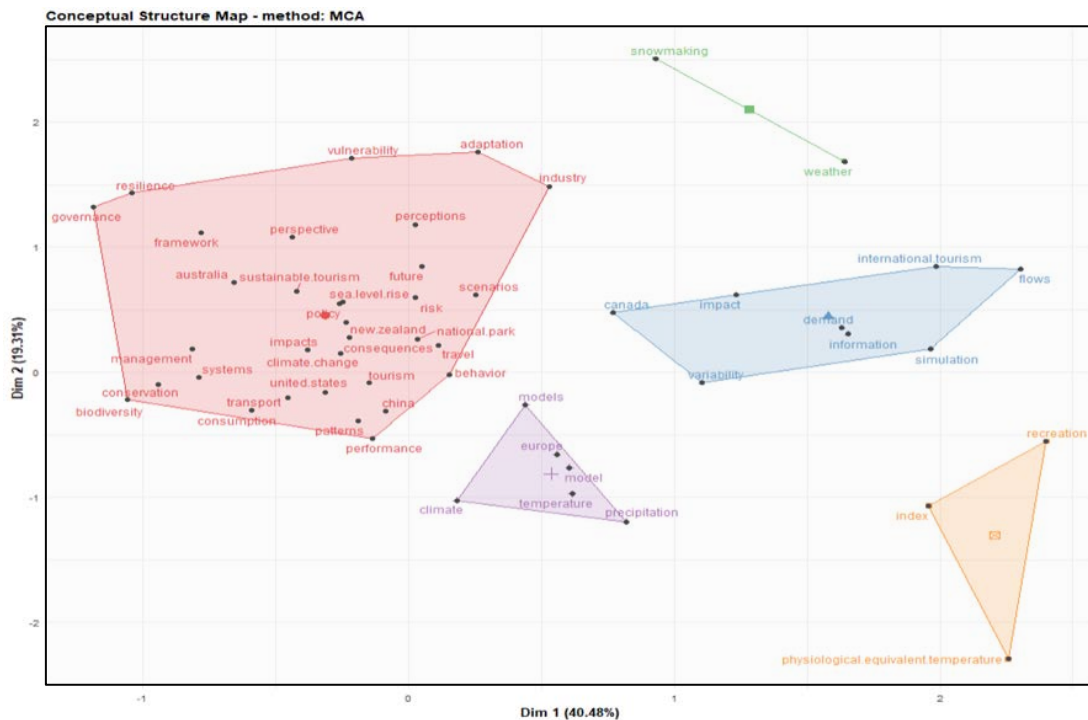
In a cluster analysis based on the Multicriteria Analysis Method (MCA) of the studies is possible to identify four research clusters that correspond to the conceptual structure map: (1) a first central group for observing the impacts and mitigating climate change in the context of anticipating future tourism scenarios (Rosselló & Santana-Gallego, 2014; Peeters et al., 2019); (2) in the establishment of models for tourism climatology centered on physical parameters, such as temperature and precipitation, with Europe becoming the most studied geographic area (Dubois & Ceron, 2006; Endler & Matzarakis, 2010); (3) the studies dedicated to the simulation of demand based on international tourism flows, in which one tries to face the scenarios of impacts and climate variability (Amelung, Nicholls, & Viner, 2007; Falk, 2013; Katircioglu, Cizreliogullari, & Katircioglu, 2019) ; and (4) the research associated with outdoor recreation, through the use of indices, as occurs with the Physiological Equivalent Temperature (PET) (Farajzadeh & Matzarakis, 2012; Matzarakis, Rammelberg & Junk, 2013) (Figure 15).

Figure 14. Words used in abstracts publications about tourism climatology, since 2010



Source: authors' own elaboration

Figure 15. Conceptual Structure map based on words used in publications (title, abstract and keywords) about tourism climatology, since 1940



Source: authors' own elaboration

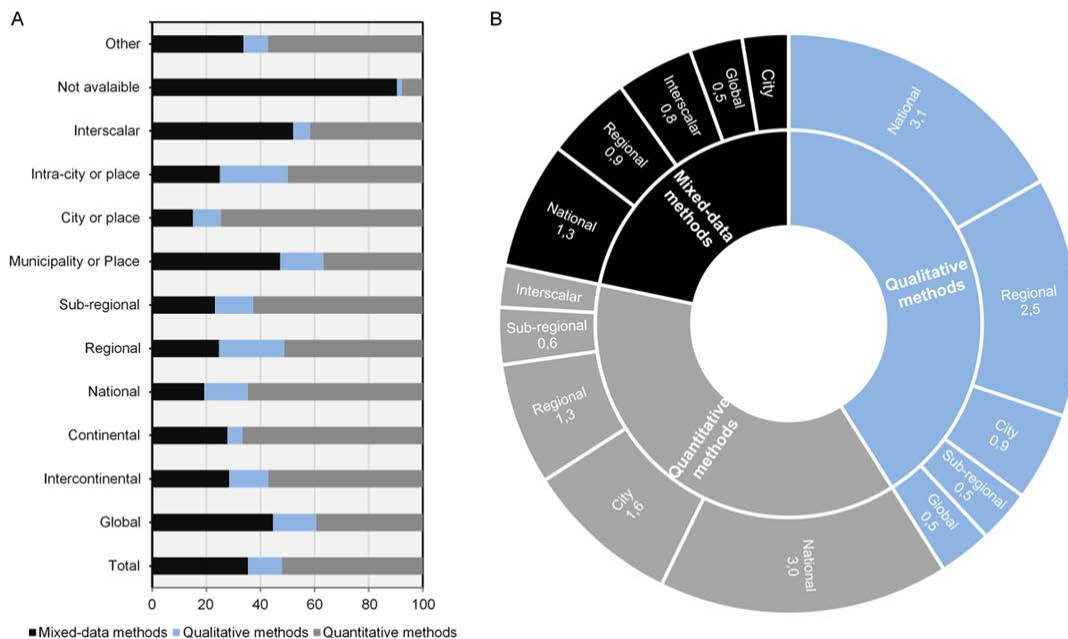
3.5 Methods and principal data used in studies

Following Nunkoo et al. (2013), we chose to categorize the articles according to methodological dimension (qualitative, quantitative, or mixed). Additionally, studies were distinguished according to their practical nature, based on the approach employed and the data. Cross-tables were used

to determine the most appropriate research approaches for each typology, and various analysis graphs were drawn.

It should be noted that, despite this effort to apply studies on a local scale, 52.1% (n=463) of them had quantitative data, while 35.5% (n=315) had a mixed-data and 12.4% (n=110) qualitative dimension (Figure 16A). Although in most cases tourism approaches use mixed-type data, quantitative data has a significant weight, especially when there is a positive variation in their insertion in the analysis performed in the various studies. Between 2009 and 2020, 22% (n=199) of the studies were considered to have quantitative data. It is relevant to mention that mixed methods are usually the most used because they allow for a more precise/detailed assessment.

Figure 16. Methods used in tourism climatology studies, per geographic level (A) and most important geographic level per type of method (B)



Source: authors' own elaboration

For all types of data, studies are mainly conducted at national level (29.8% - quantitative; 30.9% - qualitative; 13.0% - mixed) (Figure 16B) with the predominance of studies dedicated to gauging the impacts of tourism climate change and potential mitigation measures. The United Kingdom, Australia and the USA are the most relevant in conducting these studies. Quantitative studies are used for urban (city) scale studies (16.0% - with special regard to the cities of Beijing, Québec,

Barcelona, or Atenas), qualitative studies at regional scale (24.5%), and mixed data studies are used for global studies (whose geographic scale was not evaluated) (5.4%).

Studies on tourism and climate are essentially based on previous documents, bibliographic analysis (37.1%), and statistical data from international and national entities (24.9%). Primary data is less relevant in the studies performed, although its application needs to be considered for valuing microscale studies or detailed studies (Table III).

The methods depend on the type of data collected, but it is worth mentioning the use of methods that tend to be positivist, associated with the current science paradigm. The analytical methods here refer to statistical analysis and in some of the spatial cases used to establish the relationship between the variables under analysis. It should be noted that this article does not aim to provide the mathematical history of such analytical methods, being beyond the main objective of this article. It is suggested that readers consult mathematical literature to obtain detailed information on the methods presented.

As in these studies, secondary data predominate, it should be noted that a large part of them are dedicated to content analysis, others, to regression models based on meteorological data (time series regression models) (e.g. Toglhofer, Eigner & Prettenhaler, 2011; Lenzen et al., 2018; Miro-Pérez & Olcina Cantos, 2020) or co-integration techniques (e.g. Liu et al., 2019) and many others, in several statistics associated with the comparison between statistical data of tourism demand and climatic conditions. Note the relevance of chi-squared test (e.g. Rankin, Ballantyne & Pickering, 2015) or ordinary least squares (OLS) regression (e.g. Azam, Alam & Hafeez, 2018).

In the case of the use of questionnaires, it depends on the application that is made, but to the traditional statistics, correlation and cross-tabulation (e.g. de Freitas, 2015; Jopp et al., 2015), Principal Component Analysis (e.g. March, Saurí & Olcina Cantos, 2014), confirmatory factor and exploratory factor analysis (e.g. Horng et al., 2013), structural equation models (e.g. Wang et al., 2018) or MANOVA and ANOVA (e.g. Jeuring, 2017) are added another type of statistics, namely in the establishment of optimal climates in thermal comfort in tourism, using probit regression techniques (e.g. Cahyanto & Pennington-Gray, 2015).

Table 3. Type of data in tourism and climatology, since 1940

| Type of data | Proportion in literature review* | Authors with higher number of citations and date of publication |
|-------------------------------------|----------------------------------|---|
| Secondary data | | |
| Bibliography and documents analysis | 37,1 | (Farrell & Runyan, 1991; Elsasser & Burki, 2002; Gössling, 2002; Benistom, 2003; De Freitas, 2003; Gomez-Martín, 2005; Scott, Peeters, & Gossling, 2010; Gössling et al., 2012; Becken, 2013; Gössling & Peeters, 2015; Olcina Cantos & Vera Rebollo, 2016; Cetin et al., 2018; Hoogendoorn & Fitchett, 2018) |
| Meteorological Data (Stations) | 18,4 | (Mieczkowski, Z. 1985; De Freitas, 1990; Najjar et al., 2000; Spagnolo & De Dear, 2003; Scott, McBoyle, & Schwartzentruber, 2006; Scott, McBoyle, & Minogue, 2007; Martínez-Ibarra, 2011; Farajzadeh & Matzarakis, 2012; Goh, 2012; Eludoyin et al., 2014; Mereu et al., 2016; Chen & Matzarakis, 2018; Perkins, 2018; López, 2019; Miro-Pérez & Olcina Cantos, 2020) |
| Secondary data (Statistics,...) | 24,9 | (Gössling, 2002; Gössling et al., 2002; Hamilton, Maddison, & Tol, 2005; Dubois & Ceron, 2006; Amelung, Nicholls, & Viner, 2007; Gössling et al., 2012; Lee & Brahmasrene, 2013; Gössling & Peeters, 2015; Scott et al., 2016; Azam, Alam, & Hafeez, 2018; Lenzen et al., 2018) |
| Primary data | | |
| Questionnaires | 16,3 | (Mayo, 1976; Lerner & Haber, 2000; Becken & Simmons, 2002; Becken, Simmons, & Frampton, 2003; De Freitas, Scott & McBoyle, 2008; Barr et al., 2010; Mair, 2011; Luthe, Wyss, & Schuckert, 2012; Gössling & Buckley, 2016; Toimil et al., 2018; Thomas & Benjamin, 2018) |
| Interviews | 12,9 | (Lerner & Haber, 2000; Higham & Hinch, 2002; Becken, 2004; Bicknell & Mcmanus, 2006; Gössling et al., 2009; Cohen & Higham, 2011; Dickinson, Lumsdon, & Robbins, 2011; Becken, 2013; Higham et al., 2016; Higham, Reis & Cohen, 2016; Parsons et al., 2018; Tervo-Kankare, Kaján, & Saarinen, 2018; Gómez-Martín, Armesto López & Cors Iglesias, 2017) |
| Microclimatic measurements | 1,9 | (De Freitas et al., 1985; Schiller, 2001; Jehn & Jehn, 1979; Chronopoulos et al., 2012; Abreu-Harbich, Labaki, & Matzarakis, 2014; Oliveira, Vaz, & Andrade, 2014; De Freitas, 2015; Zeng & Dong, 2015; Ruty & Scott, 2014; Novas et al., 2017; Lindner-Cendrowska & Błażejczyk, 2018) |
| Delphi technique | 0,6 | (Lee & Huang, 2014; Mikulić et al., 2016; Dawson et al., 2016) |
| Focus group | 0,3 | (Barr et al., 2010; Frew & Winter, 2010; Hares, Dickinson, Wilkes, 2010) |
| Other primary data | 3,3 | (Chan & Lam, 2003; Chan et al., 2008; Riddington et al., 2009; Dwyer et al., 2009; Rubio et al., 2011; Gómez-Martín & Martínez-Ibarra, 2012; Gómez-Martín, Armesto-López & Amelung, 2016; Gössling, 2017) |

Source: authors' own elaboration

The interviews, the Delphi technique and focus group are mainly associated with content analysis or univariate statistics (Lee & Huang, 2014; Frew & Winter, 2010), whereas microclimate measurements are responsible for the origin of thermal comfort indexes (Tourism Climate Indexes). Part of these indices seek to integrate the relationship between the results of these microclimate measurements and the results of surveys applied to tourists, through thermal sensation votes (TSV) and thermal preference votes (TPV) (e.g. Lindner-Cendrowska & Błażejczyk, 2018).

4 Discussion and practical implications

4.1 Research challenges

The increase in the number of published articles is not enough to fully assess the stage of evolution of a given scientific domain. The diversity of scientific areas, geographical distribution, scope of the approaches used, and research methods are relevant for measuring their level of development. Studies continue to fit mainly into scientific journals focused on travel (e.g. *Tourism Review*, *Journal of Sustainable Tourism*, *Tourism Management*), even though some can also be found in journals on climate and climate change (e.g. *International Journal of Biometeorology*, *International Journal of Climatology*), environmental economics (e.g. *Energy Economics*, *Ecology and Society*, *Economy Geography*) or Production Systems (e.g. *Journal of Cleaner Production*). This diversity of publications reflects the relationship between geography and environmental sciences (e.g. Elsasser & Messerli, 2001); transports (e.g. Barr et al., 2010); territorial planning (Archer et al., 2014); sociology (Urry, 2008) and economics (Rosselló-Nadal, 2014).

The publications under review reflect a paradigmatic diversity. The focus of investigations is nonetheless centered on clearly positivist (quantitative methods) or at least biased quantitative (QUANT-QUAL) investigations. Although atmospheric, environmental, biophysical and/or economic modelling is used (e.g. Provencher & Bishop, 1997; Bigano et al., 2008; Filimonau et al., 2013; Amelung et al., 2016), the studies are essentially representative of documentary analysis (e.g. Farrell & Runyan, 1991; Elsasser & Burki, 2002; Gössling, 2002; Hamilton, Maddison, & Tol, 2005; Gössling et al., 2012; Gössling & Peeters, 2015; Azam, Alam & Hafeez, 2018; Lenzen et al., 2018). On the other hand, we are beginning to see more studies based on behavioral analysis of tourists, in particular destinations or potential behaviors in extreme weather situations (e.g. Mayo, 1976; Becken & Simmons 2002; Becken, Simmons, & Frampton, 2003; De Freitas, Scott & McBoyle, 2008; Mair, 2011a; Luthe, Wyss & Schuckert, 2012; Gössling & Buckley, 2016; Toimil et al., 2018; Thomas & Benjamin, 2018).

Other methods are fundamental for implementing better sectoral and territorial policies have been added to the debate, namely the use of interviews (e.g. Lerner & Haber, 2001; Becken, 2004; Bicknell & Mcmanus, 2006; Gössling et al., 2009; Dickinson, Lumsdon & Robbins, 2011; Becken, 2013b; Higham et al., 2016; Parsons et al., 2018; Tervo-Kankare, Kaján & Saarinen, 2018), focus groups (e.g. Barr et al., 2010; Frew & Winter, 2010; Hares, Dickinson & Wilkes, 2010) or the Delphi technique (e.g. Lee & Huang, 2014; Mikulić et al., 2017; Dawson et al., 2016).

The evolution of research in tourism climatology depends to the coexistence of research using different methods and paradigms and the complexity and overcoming of simplistic ideas in this field of research. Some research carried out in the last decade seeks to demystify some ideas, contributing to the valorization of scientific knowledge (e.g. Scott & Ritty, 2010; Weaver, 2011; Weir, 2017).

There is still room for developing more sophisticated research approaches that address multi-sectoral and multi-territorial aspects with the involvement of different actors. The study shows a significant increase in research on tourism policies and climate change, even though just a few effectively evaluate the recourse to primary sources.

In general terms, there are some challenges in tourism climatology research:

1. social inequalities between the global north and south in climate policies for tourism (e.g. studies in Africa, Frey, & George, 2009; Peeters, 2009; Eludoyin et al., 2014; Dillimono & Dickinson, 2015; Dube & Nhamo, 2018).
2. the impact of mass tourism and climate response to its potential effects (Martínez-Ibarra, 2011).
3. tourism's carbon footprint including transport or other resources (McKercher et al., 2010; Mair, 2011b; Vaske, Jacobs, & Espinosa, 2015; León & Araña, 2016; Gössling & Scott, 2018).
4. Tourism response to third-order change in the face of the problems that emerged with the pandemic by COVID-19 and the need to articulate intervention strategies in the territory that contribute to greater sustainability in the destination in a situation of health crisis (Hall, Scott & Gössling, 2020).

4.2 Future directions and managerial implications

This study demonstrates that the investigation to be carried out in the coming years comprises a 6th level of publications, which should strive for the integration of multiple data sources and methodological triangulation. This paper mentions major contemporary ways to observe and predict situations in tourism and climatology in different spatial scales. Note that there is a wide variety of studies, ranging from the individual architectural design of a building, the analysis of an entire city, the impact generated in a region, to the role of cities and residents in predictability and reaction to climate variability. For example, even in cities where investigation is advanced in the analysis of climate risks, the content of the analysis is based only on quantitative analysis of the associated costs (Hunt & Watkiss, 2011). In future, it must change.

The data demonstrates its relevance not only in global analyses of climate readiness, but also in situations of extreme weather events or situations of severe heat stress. The following are key factors for the next 10 years, as part of the 2030 agenda: (i) greater attention to the understudied regions or cities; (ii) new methods and use of data to measure climate and weather effects on tourism; (iii) scale issues; (iv) and both educating and raising awareness among tourism communities and agencies.

a) Greater Attention to the Understudied Regions or Cities

In 2010, Scott & Becken criticized the geographical concentration of research on tourism climatology (Scott & Becken, 2010). Regardless of this shortcoming, there is an indication that researchers are seeking to narrow down this gap. For example, the number of publications which address climate change issues in developing destinations has increased (although still slowly) and, even more encouraging, there is also a higher number of researchers in these countries who contribute to the growing body of knowledge. In any case, some areas deserve attention because of the problems identified by agents and stakeholders or because they are referenced in various reports.

A study by Deutsche Bank (2008) showed that, according to tourism decision-makers, countries in the northern hemisphere are the ones that benefit most from climate change. The same trend does not apply to the southern hemisphere. Among the countries they consider most affected by climate change are those in the Mediterranean basin, namely Portugal, Greece, and Turkey (in Europe and in transition to Asia), Morocco and Tunisia (in Africa), and Australia and New Zealand.

Considering the distribution of the most susceptible/vulnerable elements, it is possible to infer which areas need urgent action and those where intervention is still slow. Scott, Hall, & Gössling (2016) identified Australia and New Zealand, Europe, and Small Islands (Pacific and Indian) as the most critical. Still, there are a few for which knowledge of susceptibility/vulnerability to extreme situations is still unknown. In a study by Scott et al. (2019), was created an index that measures the vulnerability of destinations (the Climate Change Vulnerability Index for Tourism - CVIT), assigning scores to adaptive capacity and regional vulnerability results. Vulnerability hotspots are found mainly in countries in the southern hemisphere (Africa, Middle East, and South Asia).

Besides, global north and south production dynamics have somewhat been fading out, whereas researchers from areas with a smaller number of papers have been gaining some prominence.

Some of the publications in China reveal this latest trend, although their research is still mostly limited to other disciplines, and to the analysis of tourism and energy or greenhouse gas emissions (Yang et al., 2008; Yang, 2010; Zhang & Zhang, 2018). Becken (2013b), for instance, identified the absence of articles about the melting of the Himalayan glaciers, increased water restrictions and associated extreme weather events. In our research, it was observed that an important part of the African countries does not have any studies and the focus are mainly on the Northern Hemisphere.

From a practical point of view, it is also crucial that future research pays attention to other geographical areas, whose susceptibility deserves special attention, not only because of climate change effects, but also areas susceptible to health-related issues or forest fires, such as the Portuguese territory (e.g. Pedrógão Grande wildfire in June 2017 killed vacationers on their way back from river beaches, or the Amazon mega wildfire which brought the international community to tears, which, in both cases, affected tourism capacity at different scales).

b) New methods and use of data to measure climate and weather effects on tourism

Concerning data, it was verified with this investigation that most studies carried out in tourism climatology use secondary data, namely bibliography and documental analysis and statistics from international sources. Trying to increase the coverage of data used, the following are essential: (i) ensure that the data used corresponds to or translates the tools and methods for ongoing research; (ii) ensure that the data format can be used by a broad range of practitioners without compromising the completeness or accuracy of the scientific analysis; and (iii) ensure that metadata accurately describes instruments, location, quality assurance and resources, and control documentation ensures validation under protocol standards. Still, there are a few other fundamental practices for carrying out studies on tourism climatology, such as (i) analyzing the contents of the various IPCC reports and rethinking ways of readapting territories, and conducting studies on tourism; (ii) creating a dataset for long term periods, instead of limited short term campaigns, with equal territorial representativeness; (iii) creating and validating operational (national) and urban (internal and external) weather networks for a balance between resolution and practicality, including instrument networks based on surface analysis (air and surface temperature and air humidity); vertical profiles (inside and outside the urban boundary layer) of temperature, humidity, wind, turbulent flows, radiation, precipitation, air quality (gases and particles), reflection and refraction; (iv) undertaking measurement studies for the validation of quantitative simulations on anthropogenic effects and directly related activities on a variety of

scales (from the effects of daily international or national aircraft movements, to a square scale, where tourists spend part of their time); and (v) using remote sensing and environmental studies for both macro and micro scale assessment (specially for particle distribution analysis, UHI area formation) and other smaller, mobile and accessible instruments. The use of these sources with other more traditional sources (surveys to assess visitor perceptions of the destination) is an opportunity for further evolution in the field, enabling the design of models on a fine or coarse grain scale.

c) Scale issues

The variety of scales and their potential impact on research are determinant for defining and solving any issues. The lack of articulation between the various scales is noted in different studies and most of them either just offer a general review of the ability to affect territories, or an often-simplistic analysis of the problems in different geographical areas. Studies in tourism climatology are still not carried out on very fine scales (large scale), being carried out at national and regional levels. On the other hand, the use of diverse analyses and practices in cities – regions are important in the construction of the necessary indications for the climate change considerations within the strategic planning (Barton, 2009).

To understand global tourism needs, as well as perceptions on climate-affected destinations, and the kind of actions to take in the short and medium run, we need to articulate more refined studies.

This kind of criticism concerns particularly the subjectivity of some articles and the non-holistic view of others, especially when there is the possibility of selecting different activities in the same destination. Recent studies have affirmed the existence of predominant climatic characteristics (such as precipitation) (de Freitas et al., 2008), but little is known about implications on a bigger picture or tourist behavior depending on certain sociodemographic characteristics, notably nationality (Morgan et al., 2000; Bigano et al., 2006; Scott et al., 2008; Martínez-Ibarra et al., 2019).

When choosing to address tourism climatology from an integrative perspective, it is essential to rethink scale analysis since fundamental issues such as water availability or the susceptibility of certain geographical areas to sea level rise, and their influence on tourism, have not been properly assessed yet. When it comes to tourism in coastal areas, it is essential to promote integrative studies, because they allow you to assess different tourism segments, such as ‘beach’ and urban (cultural) tourism. It would be interesting, for example, to consider the body’s high

exposure to atmospheric elements related to activities which are dependent on certain weather conditions, whether it be outdoor travel or getting a tan. Figure 17 summarizes the main research methods and objectives for interconnection assumptions of climate assessment in tourism.

d) Educating and raising awareness among tourism communities and agencies

Authors such as Olcina Cantos & Vera Rebollo (2016) refer to the importance of education for the risk and for climate change. More initiatives and practices in the territories are needed, with direct implications on the knowledge-learning effect. The openness and awareness on the part of communities, as well as the presence of proper means essential to tourism, are pivotal aspects for devising a strategy that may include weather and climate action. Although there are approaches with a clear weight in the scientific literature on tourist climatology, it is essential to rethink what are the potential paths for investigations in the future. Here are a few examples of ways to achieve those goals:

1. Raise awareness among media and agencies for the dissemination of tourism destinations (e.g. agency capacity and means of disclosure of the operability and prices according to recurrent risks of extreme phenomena in certain areas - monsoons in Asia, hurricanes in coastal areas of North America, Honduras, Haiti).
2. Make the media aware of meteorological information and the most sustainable climate needs and possible actions.
3. Encourage dialogue among various scientific areas (traditional and emerging) and the need for scale awareness.
4. Add responses to tourists' increasing knowledge on their travels' carbon footprint.
5. Improve public education and communicating the perception of health and extreme heat risks using simpler language and access to the whole community.
6. Promote collaboration among stakeholders for the development of information systems regarding tourism climatology.
7. Create active voices within the scientific community for the valorization of local 'slow climate change' in post-COVID 19 economic stimulus packages, as poorly directed investments will cause greater damage caused by climate change.

Figure 17. Objective and subjective dimensions in tourism climatology
 – methods, instruments, purposes, and landmarks

| Dimension | Method | Instruments | Purpose | Landmarks |
|---|--|--|--|--|
| OBJECTIVE | Preliminar studies (Bibliography and documents) | International reports (WTO, IPCC,...) Satellite images Recognition routes Weather station reports Tourist supply and demand data Observations Models | Physical and social characteristics (tourist dimension) of the case study and benchmarking Sampling criteria Measurement date and time Global thermal index: Physiological Equivalent Temperature (PET) and Tourism Comfort Index (TCI) | Meteorological and climatic-tourism reports Fieldwork criteria (date and time of measurements) Physical and territorial, social, and productive description Sampling profile Climatic-meteorological mapping |
| | Microclimate measurements | Portable meteorological monitoring equipment (thermometers, anemometers, ...) Fisheye lens camera | Air temperature, solar radiation, wind speed, relative humidity, and globe temperature Mean radiant temperature (MRT) Cloud cover conditions Local comfort index | Impact of urban geometry on bioclimatic comfort Microclimatic mapping Validation of numerical simulations Current mean radiant temperature (MRT) Thermal comfort index in standard situation |
| SUBJECTIVE | Surveys | Semi-structured questionnaire and Tourist Based Responses (TBR) | Current thermal sensation and comfort level Climatic-meteorological preferences in different situations | Thermal sensation vote (TSV) - thermal sensation Standard thermal comfort level Behavioral / psychological adaptation Climate preferences |
| ASSESSMENT BASED ON OBJECTIVE AND SUBJECTIVE DIMENSIONS | Observation and prediction | Theories of thermal comfort and tourism climatology Questionnaire for Delphi method, interviews or similars Data modeling | Adaptation techniques in the face of climate preferences and the context of climate variability Parametric analysis for different scenarios | Microclimate map for the case study Impact of urban geometry on thermal comfort Comparative analysis |

Source: authors' own elaboration

5 Conclusions

Nowadays climate change is recognized as a relevant fact that influences, and will continue to influence, several tourism segments and a considerable number of destinations. For that, this theoretical study with 889 publications can play an essential role in the development of several science fields and help companies that work in tourism activity and need to adapt to new challenges.

On one hand, it can help to understand how investigation, which deals with climate and tourism, has evolved in last decades and what are the missing and predicted thematic that tourism activity will need in the near future to be investigated and analyzed. Several scientific fields will benefit with this kind of approach, i.e., Tourism, Climatology, Economy, Geography or Marketing.

Presenting new perspectives regarding the development and application of theories and work implementations for future studies organizations are involved in lowering carbon foot, politicians (that need more clear and objective data) and companies (e.g. of transport, catering, and accommodation) that need to readjust to the pandemic period.

Finally, this study hopes to contribute to future research being developed in more holistic perspectives and with the combination of different data sources and methods.

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