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Assessing Present and Future Climate Conditions for Beach Tourism in Jardines del Rey (Cuba)

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Abstract: This study assesses, adapting the weather types method, the suitability of the climate in Jardines del Rey (Cuba) for the practice of sun and beach tourism over the period 1991–2014, and the potential future impacts of climate change on this form of tourism on the basis of outputs from the PRECIS-Caribbean Regional Climate Model for the period 2021–2050. The methodology applied makes a classification of daily situations according to the most frequent combinations of climatological variables in tropical areas while focusing on a very specific segment of the tourism market (sun and beach tourism) and taking into account the behaviour of beach users and bioclimatic criteria. The results indicate that the distribution of weather types at the destination during the period 1991–2014 was highly consistent with the monthly distribution of tourists in Cuba, highlighting the existence of a low season from May to October and a high season between November and April. The future scenarios project an improvement in climate conditions for the practice of sun and beach tourism. This improvement is not based on a spectacular increase in favourable weather types compared to unfavourable ones, but rather on a better distribution of both.

Keywords: weather types method; sun and beach tourism; tourism behaviour; climate change; Cuba

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1. Introduction

Coastal tourism is widely considered the most important segment in the tourism industry worldwide and “sun and beach” tourism is its most important variant [1–3]. This is especially true in many island states, in which “sun and beach” tourism has become the main business activity, generating substantial income and profits and boosting general economic development [4,5]. One example is the Caribbean, in which the increasing importance of this sector is manifested in figures provided by the UNWTO: 25.7 million international tourists visited the Caribbean subregion in 2018, generating an income of USD 32 billion. These highly significant figures translate into market shares within the Americas region of 11.9% and 9.6%, respectively [6]. These islands’ main resources in terms of tourist attractions are their climate and beaches, which means that climate change could pose a serious threat to all of them (although the exact situation varies greatly from state to state). The *IPCC Fifth Assessment Report* concluded that [7] (p. 1628) “for the SRES A2 and B2 scenarios, the PRECIS regional climate model projects an increase in temperature across the Caribbean of 1 °C to 4 °C compared to a 1960–1990 baseline, with increasing rainfall during the latter part of the wet season from November to January in the northern Caribbean (i.e., north of 22° N) and drier conditions in the southern Caribbean linked to changes in the Caribbean Low Level Jet with a strong tendency to drying in the traditional wet season from June to October" [8–10]. These projections suggest that the Caribbean island states as a whole, whose economies are highly vulnerable to changes in the climate, could be subject to serious impacts that could put their medium- and long-term development in jeopardy [11–18].

In this context, evaluating the climate potential for sun and beach tourism is a key task and a first step on the way to estimating the direct impacts of climate change on the tourism sector in general and on certain specific regions in particular [19–21]. In the academic field of tourism climatology, the sun and beach segment of the tourism sector has been the subject of a large number of potentiality assessments due to its high dependence on weather conditions [22–24] and its leading role within the wide range of available tourism products worldwide. Many of the research papers that have assessed the potential of climates for sun and beach tourism have tried to measure or quantify it using climate tourism indexes such as the Tourism Climate Index [25–29], the Climate Index for Tourism [30], the Climate Tourism Information Scheme [31–34], the Beach Climate Index [35], the Beach Utility Index [36] and the Holiday Climate Index [37], among others. However, relatively few assessments have been made of the tourism potential of a particular climate using the weather types method, in spite of the fact that it is based on the true state of weather and more accurately reflects the nature of the atmospheric medium by rejecting both the exclusive use of one single climate element and the use of potentially misleading average values (instead using the daily figure, which is real and tangible for people) [23,38–47]. It is important to point out that the results obtained from the application of the different assessment proposals have also depended on the procedures used to calculate the suitability thresholds for the different atmospheric variables. At times, these procedures have been based on expert opinion [27,39,48]. On other occasions, procedures have been based on bioclimatic criteria [49–52], declared preferences (stated preferences approaches using surveys or interviews) [23,43,53–59] and/or revealed preferences (tourist behavioural observation) [46,51,60,61]. The sun and beach tourist destinations that have most frequently been the subject of this kind of research are in the Mediterranean, Pacific and Caribbean Lesser Antilles regions. Research has focused, above all, on assessing the potential of these areas for this kind of tourism and on calculating their suitability thresholds for the different atmospheric variables (Table 1).

Table 1. Daily climatic (ideal/unacceptable) threshold conditions for beach tourism.

Region	Tempretuare		Precipitation (mm or h)		Sun (h)/Could Conditions (%)		Wind (m s^{-1})		Source
	Ideal	Unacceptable	Ideal	Unacceptable	Ideal	Unacceptable	Ideal	Unacceptable	
Spain	22–28	<16; >33	0 h	>3 h	>11 h	≤5 h	<8	>12	Gómez-Martín (2006) [43]
Canada	27	-	-	-	25%	-	≤2.5	-	Scott, et al. (2008) [62]
New Zealand	25	-	-	-	-	-	≤2.5	-	Scott, et al. (2008) [62]
Sweden	29	-	-	-	0%	-	≤2.5	-	Scott, et al. (2008) [62]
Belgium	28	-	-	-	>8 h/0%	-	≤2.5	-	Moreno (2010) [63]
Europe	27–32	<22; >37	0 h	≥2 h	25%	≥75%	≤2.5	≥11.4	Rutty & Scott (2010) [64]
Germany	27–3225–32	<22; >36 <22; >34	0 h	≥2.5 h	25%	≥75%	≤2.5	≥11.4	Wirth (2010) [65]
Spain	28–31	-	0 h	-	>75%	-	<8	-	Martínez-Ibarra (2011) [46]
Spain	29.5–31	<20.8	0 h 0 mm	>1 h >1 mm	>80%	<30%	<8–10	>12	Gómez-Martín & Martínez-Ibarra (2012) [60]
Caribbean	27–30	<23; >34	<15 min	≥2 h	25%	≥75%	≤2.5	≥11.4	Rutty & Scott (2013) [55]
Greece	28–32	<22; >39	0 h	≥2.5 h	25%	≥75%	≤2.5	-	Georgopoulou (2019) [36]

The objective of this research was to assess, adapting the weather types method, the suitability of the climate in Jardines del Rey (Cuba) for the practice of sun and beach tourism and how this might be affected by climate change. The Greater Antilles, the Caribbean region in which this area is located, has been a subject of little research in the tourism climatology field to date [66], a situation that needs to be remedied. The Cuban tourist region of Jardines del Rey a group of Keys which, together, form the eastern part of the Sabana-Camagüey Archipelago, situated to the north of the island of Cuba just off the coast of the central provinces. The climate conditions in Jardines del Rey may be considered representative of the tourist regions in the north of the island of Cuba, which specialize in sun and beach tourism (Table 2).

Table 2. Monthly mean values in Jardines del Rey (meteorological station of Cayo Coco, Cuba).

Variables	January	February	March	April	May	June	July	August	September	October	November	December
Precipitations (mm)	41.0	35.9	32.6	50.6	132.1	133.4	82.9	101.8	145.0	165.8	90.6	45.7
Maximum Temperature (°C)	25.9	26.6	27.3	28.5	29.6	30.8	31.5	31.8	31.4	29.9	27.7	26.5
Environmental Temperature (°C)	23.4	23.6	24.3	25.4	26.5	27.7	28.6	28.5	27.9	27.2	25.6	24.2
Wind Speed (km/h)	13.3	12.6	13.1	12.3	9.4	7.8	8.1	8.1	8.6	10.1	13.8	13.8
Duration of Sunlight (h)	7.5	8.6	9.3	10.1	9.1	8.1	9.3	9.1	8.3	7.8	6.7	7.3
Cloud Cover (okts)	3.9	3.3	3.4	3.5	4.2	4.7	4.1	4.4	4.7	4.5	4.3	4.3

Together with Varadero and Polo Turístico Norte de Holguín, Jardines del Rey has become one of the most popular tourist destinations on the island with various large resorts, such as Cayo Coco and Cayo Guillermo, that are well known internationally for sun and beach tourism. With its 4.7 million foreign tourists, Cuba is the second most important tourist destination in the Caribbean region after the Dominican Republic [6,67]. Tourism has become one of the most important drivers of the island's economy and the second largest source of income after the sale of professional services abroad, contributing 10% of the gross domestic product (GDP) and creating more than half a million jobs. This situation explains the interest in studying the direct impacts of climate change on tourism on the island, as the resulting information could provide a starting point from which to develop new strategies that would enable this key economic sector to adapt to future climate scenarios.

2. Materials and Methods

2.1. Weather Types Method Approach

The studies carried out in the field of tourism climatology using the weather types method have focused, above all, on two meanings of this term. The first meaning is based on the concept of synoptic weather type defined by Pédelaborde [68], which refers to a well-defined meteorological situation with its weather, air masses and centres of action. The second meaning is based on the physionomic concept defined by Hufty [69], which understands weather type as the everyday combination of climatological variables. As occurs with the various climate tourism indexes [62,70,71], the weather types method also has a number of limitations, which have been resolved to a greater or lesser degree through the different contributions made by researchers in this field.

The first studies in the field of tourism climatology that used weather types, in the sense defined by Hufty [69], were those of Masterton, Crowe and Baker [47], Gates [42] and Crowe and McKay and Baker [41]. Their proposals established favourable and unfavourable weather types for up to six types of tourism/tourism activities. This segmentation, together with the inclusion of comfort as a factor for consideration (measured using the Humidex), was an important step forward that highlighted the complex nature of research in the field of tourism climatology. In spite of these advances and of the easy interpretation of the graph-based calendars, the proposals made by these authors had three weaknesses. The first was related to the fact that the thresholds established for some of the atmospheric variables were not exact (in particular, those for the state of the sky), while the second was related to the lack of any empirical comparison or checking. The third, and most important, weakness was related to the binary method of classifying weather types as either suitable or unsuitable, which did not allow for different levels of suitability in the favourable weather types.

Besancenot, Mounier and de Lavenne [40], once again using the approach presented by Hufty [69], proposed a classification of favourable and unfavourable weather types (in different degrees) for the practice of tourism in general, which considered the main atmospheric demands of the tourist in terms of enjoyment, comfort and safety. This approach to the classification of the weather types allowed them to individualize the most relevant, everyday combinations of the main types of climate experienced by tourists in different atmospheric contexts (temperate, tropical, polar and subpolar latitudes), which was a fundamental issue given that the environmental conditions of the tourist destination have a strong influence on tourists' expectations and behaviour. In spite of these strengths, this proposal also had a number of limitations. The first limitation was the fact that the proposal assessed weather types for the practice of tourism in general, and as a result neglected the fact that each tourism activity requires specific atmospheric conditions for its practice. The second limitation was the fact that it established the suitability thresholds on the basis of expert opinion. Numerous research studies have followed these original guidelines of Besancenot, Mounier and de Lavenne [40], including, among others, those conducted by the authors of [38,66,72]. The work of all these authors has served as an inspiration for the different research studies that have tried to overcome some of the limitations referred to above. In the case of Mediterranean climates, these include the studies by Gómez-Martín [23,43,73], which introduced the preferences of tourists, as expressed in surveys, in the ranking of the weather types and in the establishment of thresholds for the atmospheric variables, as well as those by Martínez-Ibarra [45,46], which took into account the behaviour of sun and beach tourists.

Barbière [39], referring to both meanings of weather types mentioned above, based his proposals for tourism climatology on the impossibility of separating the weather experienced by tourists from the mechanisms that produce it, presenting a very useful feature, namely a classification of different levels of suitability. The lack of segmentation in Barbière's classification, the lack of any empirical checking of the levels of suitability established, the fact that the multidimensional variable "comfort" was only considered in passing and the complexity and difficulty involved in interpreting the results led to this proposal being largely unsuccessful.

All these studies, conducted over the course of several decades, created a base on which to develop new proposals that tried to correct the main weaknesses detected while making the most of their innumerable strengths, so allowing great strides to be made in the field of tourism climatology.

2.2. Methodology

The weather types method applied here makes a classification of daily situations according to the most frequent combinations of climatological variables. This classification is then subjected to an analysis of frequencies within the context of the particular tourist destination, in this case, Jardines del Rey in Cuba. To this end, in this study, we used a modified version of the original classification of weather types for tropical climates proposed by Besancenot [48], the main differences being that we focused on a very specific segment of tourist demand and that we decided not to refer to expert opinion when establishing the suitability thresholds for the atmospheric variables under consideration. In this way, the new classification enabled us to assess climate potential (present and future) for the practice of sun and beach tourism at the selected destination, taking into account tourist behaviour as observed in previous research and bioclimatic criteria. Hence, this adaptation overcomes the inherent limitations in the original method, first with regard to the universal nature or lack of segmentation in the weather types proposal (the typology presented here is specific for the sun and beach segment of the tourism market), and second, in the sense that the original list was based on the authors' criteria, whereas the list we used was linked to empirical observations (the hierarchization of the variables and the establishment of favourable and unfavourable thresholds in the typology presented here are referenced to the behaviour of sun and beach tourists and to bioclimatic criteria).

In this way, the weather types established take into account the needs of tourists in terms of comfort, enjoyment and safety. Each of these three tourism climate needs is associated with one of the three facets of climate conceptualized by Perry [74] and De Freitas [22] when analysing its effect on tourism: The aesthetic facet, the thermal facet and the physical facet (Table 3). The set of parameters used to assess these needs were as follows: Daily amount of sunshine (hours), cloud cover at 13:00 (oktas of cloud cover), duration of daily precipitations (hours) or the amount of daily precipitation (mm), maximum daily temperature (°C), wind speed at 13:00 (m/s). Values for various indexes were also calculated, including the Wind Chill Index proposed by Siple and Passel to measure the cooling power of the wind (W/m^2), Thom's thermal discomfort index (°C) and the humidity comfort index (hPa), calculated at the hottest time of day (in practice at 13:00 every day).

Table 3. Needs of tourists and facets of the climate.

Needs of Tourists	Effect on Tourists	Climate Facets	Atmospheric Variables Involved
Enjoyment	Psychological	Aesthetic	Sunshine, Cloud Cover, Visibility, Fog, Length of the Day, etc.
Comfort	Physiological	Thermal	Air Temperature, Humidity, Wind Speed, Solar Radiation, etc.
Safety	Mechanical	Physical	Wind Speed, Amount and Duration of Precipitation, UV Index, etc.

Source: Based on [22,23,48,74,75].

In this study, we used the results of previous research, in which the behaviour of sun and beach tourists in the Iberian Peninsula was observed using nonintrusive techniques, as a reference [60]. The authors of [60] analysed the density of use of beaches (via webcam) and how this varied in line with changes in the different atmospheric parameters. The results suggested that the variables that most affect the use of beaches are sunshine, precipitation, maximum temperature and thermal comfort. It is therefore essential to consider these parameters in the new classification. Sun and beach tourists have also shown themselves to be more tolerant to high temperatures and heat discomfort than other segments of tourist demand. This suggests that the thresholds for these parameters should be broadened, while respecting the bioclimatic recommendations at all times. This finding was also noted in various different research studies on this segment of the tourism market on the basis of preferences declared in surveys [23,35,43,57,62–65,70]. Regarding thresholds, the analysis of the density of use of Spanish beaches in relation to a range of different atmospheric parameters revealed that "the optimal thresholds for going to the beach were: a maximum temperature between 28.83 and 31 °C; a maximum Physiological Equivalent Temperature (PET) of between 34.5 and 38.8 °C; a percentage of solar radiation at 13:00 of at least 50%; a wind speed at 13:00 of <8 m/s (or, at the most, <10 m/s); and no rainfall or, at the most, <1 mm/d or a rainfall event with a duration of <60 min" [60] (p. 135). The densities of use of the beaches under a range of different weather conditions were also calculated [60].

By combining the bioclimatic criteria with the evidence obtained by observing the behaviour of sun and beach tourists, we were able to adjust some of the thresholds proposed by Besancenot in his original classification [48]. This adjusted classification is shown in Table 4. It is important to clarify that using the behaviour of tourists on Spanish beaches as a reference introduced a small degree of bias, as both the country of origin of the beach users (mostly Spanish and European tourists, followed by American tourists) and the particular destination (Mediterranean beaches followed by tropical beaches) may have affected their behaviour and their expectations regarding weather and climate.

Table 4. Classification of tropical weather types for sun and beach tourism.

	Type 1. Very Good Comfortable Weather	
Enjoyment, Comfort and Safety	I > 7 or Nb < 3 D = 0 or P = 0 29.5 ≤ Tx ≤ 31 2 ≤ V ≤ 8	175 ≤ K < 700 15 ≤ THI ≤ 26.4 U ≤ 26.5
	Type 2. Comfortable Weather but Partially Overcast	
Relative Displeasure	3 < I ≤ 7 or 3 ≤ Nb < 6 D = 0 or P = 0 23.5 ≤ Tx ≤ 31 2 ≤ V ≤ 8	175 ≤ K < 1049 15 ≤ THI ≤ 26.4 U ≤ 26.5
	Type 3. Comfortable Weather but with a Brief Rain Shower	
	I > 3 or Nb < 6 0 < D < 1.5 or 0 < P < 2 23.5 ≤ Tx ≤ 31 2 ≤ V ≤ 8	175 ≤ K < 1049 15 ≤ THI ≤ 26.4 U ≤ 26.5
	Type 4. Good Weather with Strong Winds	
	I > 3 or Nb < 6 D = 0 or P = 0 23.5 ≤ Tx ≤ 31 8 < V < 10	175 ≤ K < 1049 15 ≤ THI ≤ 26.4 U ≤ 26.5
	Type 5. Good Cool Weather	
Relative Discomfort	I > 3 or Nb < 6 D = 0 or P = 0 20.8 ≤ Tx ≤ 23.5 2 ≤ V ≤ 8	K ≥ 700 15 ≤ THI ≤ 26.4 U ≤ 26.5
	Type 6. Good Hot and Sultry Weather	
	I > 3 or Nb < 6 D = 0 or P = 0 31 ≤ Tx ≤ 33 2 ≤ V ≤ 8	0 < K < 349 26.5 ≤ THI ≤ 29.9 26.5 < U < 31.3
Absolute Discomfort and/or Displeasure	Type 7. Bad Weather, Unfavourable for Sun and Beach Tourism	
	All other kinds of weather (includes the effects of severe hydrometeorological events)	

Description legend of tropical weather types: I: duration of sunlight (h); Nb: cloud cover at 13:00 (okts of cloud cover); D: duration of daily precipitations (h); P: height of daily precipitations (mm); Tx: maximum temperature (°C); V: wind speed at 13:00 (m/s); K: cooling power of the wind (W/m^2); THI: Thom's thermal discomfort index (°C); U: humidity comfort index (hPa).

In this way, bearing in mind the results of past observations of the behaviour of sun and beach tourists [60], as well as the variant introduced by the bioclimatic criteria, according to which the optimum maximum temperatures are those within the 16–33 °C range (16 °C is the point at which the body mechanisms that defend us against the cold are triggered and someone who is wearing light clothes and is not moving begins feeling cold; 33 °C is the point at which the body, with exposed bare skin, is at risk of not being able to let heat flow out to the exterior), maximum temperature values were set in the proposed classification. A threshold of 29.5–31 °C was established for Type 1, which meets the conditions considered as optimum and guarantees the maximum density of use of the beaches (density of use 3, according to the aforementioned study). For Types 2, 3 and 4, the threshold was set between 23.5 °C and 31 °C, allowing for densities of use of the beaches of over 0.5. For Type 5 (good cool weather), the threshold values were reduced to 20.8–23.5 °C. For Type 6 (good hot sultry weather), the threshold values were in the 31–33 °C range.

Bearing in mind the information obtained by observing the behaviour of sun and beach tourists [60], as well as the length of the day and the maximum possible hours of sunshine in the study area (which ranges from 10 h 46 min on 21 December to 13 h 31 min on 21 June), it was decided that the minimum amount of sunshine compatible with maximum enjoyment is 7 h (Type 1). This minimum limit can be reduced to 3 h of sunshine/day for the weather types with good weather and the occasional drawback (Types 3, 4, 5 and 6). The threshold was set at $3 < I \leq 7$ h for Type 2 (good weather with partial cloud cover). The threshold for Type 7 (bad weather unsuitable for sun and beach tourism) was set at less than 3 h/day.

The effect of rain on the enjoyment and safety of tourist activities is well known, especially in the case of outdoor activities such as sunbathing on the beach. Rain in excess of certain thresholds may act as a limiting factor, capable of eclipsing all other favourable elements and creating, by itself, an impression of poor weather. According to the observed behaviour of sun and beach tourists, the maximum rainfall thresholds are 1 mm or 60 min per day. Given the climate characteristics of the destination in this study, which has a humid, tropical climate with a rainy season in the summer, the aforementioned thresholds were extended to 2 mm or 90 min per day. Weather Types 1, 2, 4, 5 and 6 do not allow for any rainfall at all over the period 0.00–24.00 h. Type 3 (comfortable weather with a brief period of rain) allows for precipitations lasting less than 1.5 h a day or in amounts of up to 2 mm per day. Finally, rainy days can be classified as Type 7, when precipitation levels exceed the thresholds for Type 3. Days in which there are extreme hydrometeorological events were also classified as weather Type 7.

Regarding wind speed, it was observed that the most favourable weather types for sun and beach tourism (Types 1, 2, 3, 5 and 6) had light wind speeds of less than 8 m/s. For Type 4 (good weather with strong winds), wind speeds between 8 and 10 m/s were considered acceptable. Finally, on Type 7 days, considered unsuitable for sun and beach tourism, wind speeds may be even higher than on windy days (Type 4).

Regarding comfort indices, although there are more complete, integrative proposals as reported in reviews by De Freitas & Grigorieva [76] and Potchter et al. [77], we decided to continue using the Wind Chill Index proposed by Siple and Passel (W/m^2), Thom's thermal discomfort index (°C) and the Humidity Comfort Index (hPa), proposed in Besancenot's classification [48], although the original optimum favourable thresholds were altered to take into account the fact that sun and beach tourists are more tolerant to thermal discomfort (Tables 5 and 6). In this way, Type 1 accepts comfort conditions of 175 W/m^2 $\leq$ K < 700 W/m^2, 15 °C $\leq$ THI $\leq$ 26.4 °C and U $\leq$ 26.5 °C. Types 2, 3 and 4 have thresholds of 175 W/m^2 $\leq$ K < 1049 W/m^2, 15 °C $\leq$ THI $\leq$ 26.4 °C and U $\leq$ 26.5 °C. Type 5 has K values of K $\geq$ 1049 W/m^2, 15 °C $\leq$ THI $\leq$ 26.4 °C and U $\leq$ 26.5 °C. For Type 6 (good hot and sultry weather), the following conditions applied: 0 W/m^2 < K < 349 W/m^2, 26.5 °C $\leq$ THI $\leq$ 29.9 °C and 26.5 °C < U < 31.3 °C.

Table 5. Siple and Passel Index: Cooling power of the wind (K) and comfort conditions.

K	Comfort Conditions	Value
0–174	Hot Discomfort	−2
175–349	Hot Subcomfort	−1
350–699	Neutral Comfort	0
700–1049	Cold-Subcomfort	+1
+1050	Cold Discomfort	+2

Table 6. Thom's thermal discomfort index and comfort conditions.

THI	Comfort Conditions
≥ 30	Torrid
26.5 to 29.9	Very Hot
20.0 to 26.4	Hot
15.0 to 19.9	Comfortable
13.0 to 14.9	Cool
−1.7 to 12.9	Cold
−9.9 to −1.8	Very Cold
≤−9.9	Extremely Cold

The proposed weather types classification was applied for the whole year. It was calculated on a daily basis and presented in graphs on a monthly scale.

2.3. Data

In line with the above, this study presents the distribution of the climate conditions for tourism at the Jardines del Rey Cuban tourist region for the base period and for a future period based on outputs from the PRECIS-Caribbean Regional Climate Model for SRES A2 and B2 [9,78–81]. In the *IPCC Fifth Assessment Report* (IPCC, 2014), four new scenarios were defined, referred to as Representative Concentration Pathways (RCP). These cover a broader range than the emissions scenarios (SRES) used in previous assessments by the IPCC, in that they consider climate policies and evaluate a wider range of emissions. The projections provided by the AR4 and AR5 are not directly comparable because they are based on different collections of scenarios, but both are consistent with each other. The projections allow some comparison only between the scenarios that are close in terms of volume and rate of emission (in climate forcing terms, RCP 8.5 is consistent to SRES scenario A2/A1FI and RCP 6.0 is consistent to B2).

Regarding the data used, the base period 1991–2014 was defined on the basis of observations from meteorological station 78,339 in Cayo Coco. This station belongs to the Coastal Ecosystems Research Centre (Centro de Investigaciones de Ecosistemas Costeros or CIEC), which provides information to the national stations network of the Cuba Meteorology Institute (INSMET). We also considered the primary variables involved in the classification of weather types, based on the daily data outputs from the PRECIS-Caribbean Regional Climate Model, which, in turn, used boundary data generated by the Echam-4 General Circulation Model in future climate scenarios A2 and B2 (Big Caribbean domain, 50×50 km, 1961–2100). The model output point (22° N–78° W) corresponds with the location of the meteorological station. A total of 19,723 days was analysed, 8766 of which were from the base period and 10,957 were from the future period 2021–2050. A total of 138,061 pieces of data were used to calculate the parameters that are really covered by the weather type, as well as to enable the correction of the output from the model and the calculation of the bioclimatic indices for the future period.

The output data from the PRECIS-Caribbean Regional Climate Model were processed using the Microsoft Excel program in order to verify the accuracy of the model, which can be idealized as a simple comparison of the prediction made by the model and the real weather using the years from the base period (1991–2014).

$$\text{Accuracy} = \text{Prediction by the Model} - \text{Real Weather} \tag{1}$$

Some of the daily outputs for scenarios A2 and B2 were different from the real values measured by the station (the wind force and relative humidity were lower in the model output and the temperature values were higher than the real temperature). The variables were therefore adjusted to bring them as close as possible to the real value by means of a bimonthly coefficient.

In order to determine whether there were any statistically significant differences between the variables from the model, the corrected variables and those from the station, we decided to carry out the Multiple Sample Comparison procedure, which was designed to compare two or more independent samples of data using the Statgraphics program. The result corroborated the null hypothesis that there are statistically significant differences between the station data and those modelled by PRECIS. Therefore, we decided to determine a coefficient (bimonthly) to adjust the values of the model to bring the values closer to the climatic reality. The graphs and the analyses of the data were prepared using Excel and MatLab.

The coefficient was made by taking the data from the base period of the model and the station. Once the coefficient was determined and the model outputs were adjusted, the new values obtained were submitted to rule out the existence of statistically significant differences. The adjusted values complied with the condition, as they did not present statistically significant differences from those of the station. Therefore, the coefficients were taken to adjust the model values for the 2021–2050 period, so that the prediction that was made as close to the future climate scenario in the area.

3. Results

We now show the results for the base period 1991–2014 of the application of the tropical weather types classification for sun and beach tourism. We then present the results for the period 2021–2050, generated by the PRECIS-Caribbean Regional Climate Model for SRES A2 and B2.

3.1. Classification of the Weather Types in Jardines del Rey (1991–2014)

The results for the base period (Figure 1) show that weather types 1, 2, 3 and 4 predominated in the period November to April. These weather types were also recorded in May and October, although in smaller numbers. Of these four weather types, Type 1 (ideal weather) was the most frequently recorded weather type in the period November to April, with an average of 31% of the days. February was the only month in which there were more days with Type I weather than with Type 7 weather: 37.8% compared to 32.4%, respectively. Of weather Types 2, 3 and 4 (good weather with a relative degree of unpleasantness), the type that appeared most frequently during the period November to April was Type 4, good weather with strong winds.

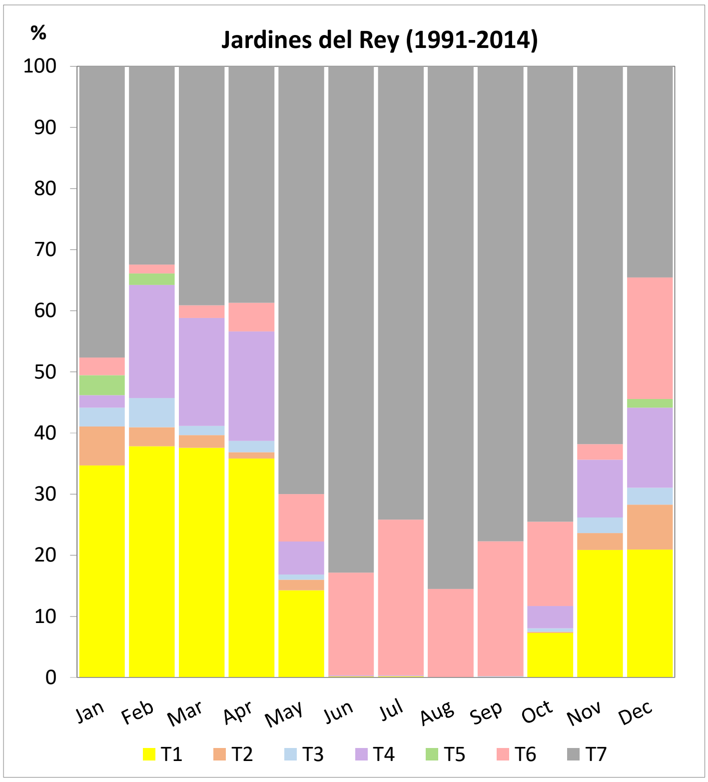

Figure 1. Annual distribution of weather types in Jardines del Rey (1991–2014).

Type 7 weather, unsuitable for sun and beach tourism, was recorded in every single month of the year. Within the period analysed (1991–2014), 60% of days registered this weather type. The months with the highest numbers of days with Type 7 weather were June, July, August, September and October (between 74.2% and 85.5%), the months classified as "low season" for tourism in Cuba.

The least frequent weather type was Type 5 (relative discomfort due to cool weather), at around 0.5%, with just 48 days in the 24-year analysis period. These cool temperatures were recorded in January, February and December. These are winter months, a period when Cuba is affected by frontal systems. By contrast, Type 6 (relative discomfort due to heat) weather occurred all year round. From June to

September, about 6 days a month (20%) were classified as Type 6, and significant percentage levels can also be observed in October and December. These nonideal Type 6 bioclimatic conditions at the Jardines del Rey region in the period June–October, in which there is a relative degree of discomfort due to heat, can combine with other days that are totally unfavourable for sun and beach tourism (Type 7), due to a high degree of heat-related discomfort, strong winds or heavy rain. These factors explain why this period is classified as "low season."

The distribution of favourable weather types at the Jardines del Rey region over the period 1991–2014 shows a high correlation with the monthly distribution of tourists during the same period (R = 0.92 and R^2 = 0.84, a significant correlation given that the p value is less than 0.01) (Figure 2). This finding validates the classification proposed here. When establishing the weather types, the classification takes into consideration the climatic characteristics of the region, the behaviour of tourists based on an analysis of their visits to (Spanish) beaches and bioclimatic criteria.

	Xi	**Yi**
	Favourable Weather Types (%)	**Tourist (%)**
January	52.4	10.5
February	67.6	10.7
March	60.9	12.0
April	61.3	9.8
May	30.0	6.7
June	17.2	6.5
July	25.8	7.7
August	14.5	6.7
September	22.3	5.1
October	25.5	6.0
November	38.2	8.0
December	65.4	10.4
Covariance XY = 37.99		
Standard Deviation X = 19.26		
Standard Deviation Y = 2.16		
Pearson Correlation Coefficient XY = 0.9149		

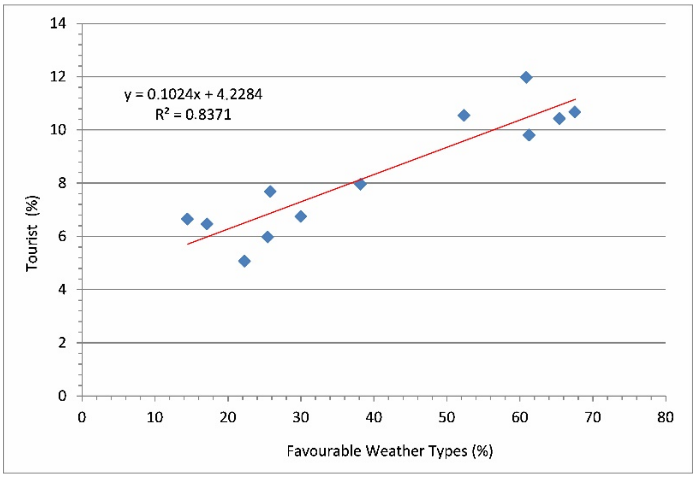

Figure 2. Monthly distribution of favourable weather types (1991–2014) and monthly distribution of tourists in Cuba (1991–2014). Source: The data series from which the monthly distribution of tourists in Cuba for the period 1991–2014 was calculated are from the Cuban Statistics Office (Oficina de Estadísticas de Cuba).

3.2. Classification of Weather Types in Jardines del Rey (2021–2050)

The classification of weather types for future scenarios A2 and B2 showed notable differences compared to the base period (Figure 3). Although the overall percentage values for the days with favourable (Types 1, 2, 3, 4, 5 and 6) and unfavourable (Type 7) weather types are very similar to those recorded for the period 1991–2014, there are important variations in their monthly distribution. Favourable weather types for sun and beach tourism will occur more frequently in the future over the period November to April, with average values of around 70% for both scenarios A2 and B2. These values contrast with the figure of around 57% for the period 1991–2014. January and February stand out in these new future scenarios, because over 90% of the days have favourable weather types for sun and beach tourism. According to these scenarios, the number of days in which the weather will be suitable for sun and beach tourism will increase significantly during the high season, which, for the Jardines del Rey region, runs from November to April.

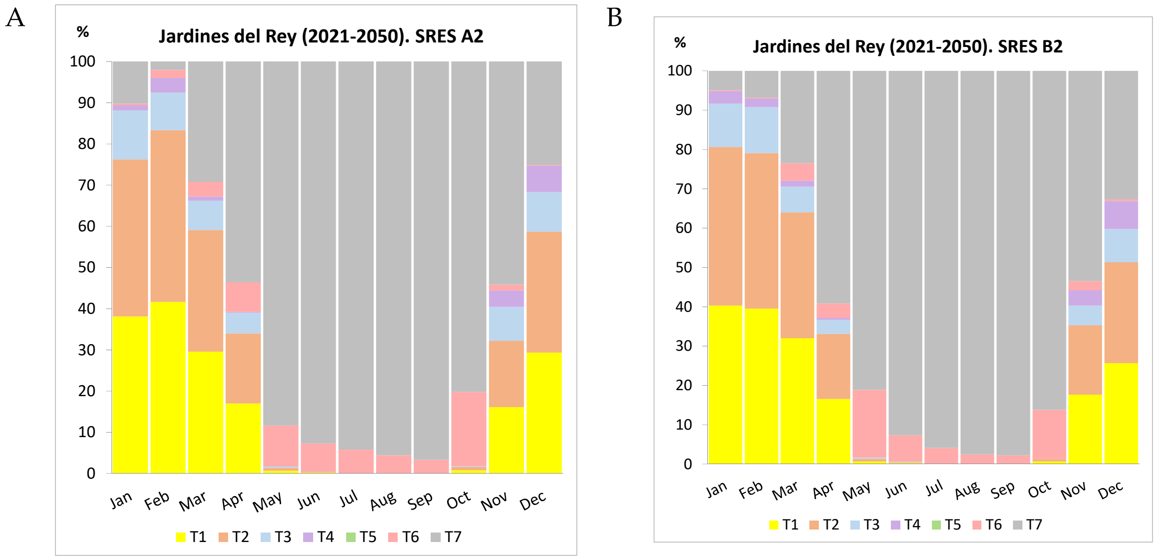

Figure 3. Annual distribution of weather types in Jardines del Rey (2021–2050, scenarios A2 and B2). (**A**) scenario A2 (**B**) scenario B2.

The weather types that will most increase in November–April are Type 2 and Type 4. During the low season between May and October, Type 6 will occur about half as frequently as during the base period.

For the period 2021–2050 (scenarios A2 and B2), Type 7, which is unfavourable for sun and beach tourism, remained the dominant weather type between June and September, scoring even higher than in the period 1991–2014, such that around 95% or 96% of the days during the period 2021–2050 will have weather Type 7 compared to the 80% figure recorded during the base period. Further development of sun and beach tourism at the region during the summer months (June to September) will be difficult due to the fact that temperature and humidity levels will remain high during this part of the year. The months of May and October, which, during the base period, recorded 70% and 74.5%, respectively, of days with unfavourable weather, now show values in the 80–90% range, and can therefore be added to the months considered unsuitable for sun and beach tourism at the region. The trend toward Type 7 weather conditions was more pronounced in scenario B2.

4. Discussion and Conclusions

Climate change will have serious direct repercussions for island destinations whose economies are centred on sectors that are highly dependent on the climate. This highlights the need for accurate assessments of the future potential of tourism in light of these changes, so as to be able either to adapt tourist activities at these regions to new calendars or to develop new tourism products that can make the most of new opportunities provided by the climate for particular forms of tourism [23,82]. Assessments of the potential of the climate for tourism purposes are therefore practical tools that can provide useful information on which important decisions for the management of tourism destinations can be based [82].

In this context, the weather types method (representative of the so-called synthetic approach in tourism climatology research) is an interesting alternative to the various climate tourism indexes (more typical of the separative approach) which have mainly been used in most of the assessments carried out to date of the potential of the climate for particular kinds of tourism. In this study, we used an adapted version of the weather types method proposed by Besancenot in 1991 to present a classification of tropical weather types for sun and beach tourism. This adapted version enabled us to take advantage of the main strengths of Besancenot's original version, while, at the same time, overcoming some of its inherent limitations. These limitations have also been and continue to be a feature of some of the indexes frequently used in the field of tourism climatology [70,71]. In this sense, the classification presented here has enabled us to:

(a) Work with the daily combination of different climate variables that, together, make up the weather, not as an abstract concept but as the daily atmospheric situation experienced by tourists. This means that tourists can identify the proposed weather types as real situations, which are currently being recorded or will be recorded at the destination. Hence, tourists can discover their frequency in numbers of days a month (a value that is easy for all to understand). This is a significant difference compared to the climate tourism indexes traditionally used in the field of tourism climatology, which offer global suitability values for a particular tourism activity that are easy to understand but are rarely associated with real atmospheric situations.
(b) Contextualize the proposal within a regional climate framework. In a particular climate context (in our case, tropical climates), the daily weather conditions are generally reduced to a limited number of weather types, which are specific to and characteristic of the place. In this way, the established weather types take into account the main defining features of the climate of the region.
(c) Take into account tourists' needs in terms of enjoyment, comfort and safety in the classification of the weather types. This was done either through the selection of the weather variables to be included in the weather types, or via the differentiation and hierarchization between favourable (which meet these needs in full or in part) and unfavourable weather types (which do not meet some or any of these needs).
(d) Take into account the segmentation of the tourism market, in this case manifested in the choice of the type of tourism to be studied: Sun and beach. The method adapted well to more detailed segmentation, an aspect of fundamental importance given the current situation of the hypersegmentation of the tourism market. This will be an important future line of research in the field of tourism climatology.
(e) Take empirical comparisons into account when establishing the order of the different weather types in the classification and when establishing the thresholds for the atmospheric variables considered for the different weather types. In this case, the practical comparison took into account the behaviour of sun and beach tourists observed in previous research [60]. The fact that this previous research was conducted in a different climate context (medium latitudes/Mediterranean climate) introduced a small degree of bias into the current study in that both the origin of the users of the beaches and the destination could have affected the behaviour and the weather expectations of the tourists. This limitation should be resolved in future research by observing and measuring the behaviour of tourists on Cuban beaches.
(f) Consider the bioclimatic aspects as rational criteria that can impose limits on certain thresholds on the basis of the *unsuitable* behaviour of tourists in weather situations in which their comfort or safety are compromised. These bioclimatic aspects were taken into account via the maximum temperature and comfort index values included in the weather types. In future research, these comfort indexes could be complemented by other more complete indexes, such as Physiological Equivalent Temperature (PET).

The classification of weather types applied in this study enabled us to find out more about the climate potential for tourism purposes of Jardines del Rey (Cuba) for the base period (1991–2014) and for a future period (2021–2050) based on outputs from the PRECIS-Caribbean Regional Climate Model for scenarios SRES A2 and B2. The results obtained from the application of this method provide extremely useful data for a touristic region that has been studied very little in the scientific literature on this subject to date. The results showed, for example, that the distribution of weather types at the destination during the period 1991–2014 was highly consistent with the monthly distribution of tourists in Cuba ($R = 0.92$ and $R^2 = 0.84$, a significant correlation at level 0.01). Two clearly distinct periods can be identified. The first, which ran from May to October, was not ideal for sun and beach tourism, due to the discomfort produced by the high temperatures and the high relative humidity and due to the fact that it coincided with the rainy period and the hurricane season in the Caribbean. These conditions, which were covered by weather Types 6 and 7 (those which occurred most frequently in the summer months) help explain, from a climate point of view, why less tourists visited the region during the summer. The second period, which ran from November to April, was generally favourable for sun and beach tourism at this region and largely coincided with the period classified as "high season." Of the days in this period, 57% were suitable for sun and beach tourism and the most frequent weather type was Type 1 (ideal for sun and beach activities).

The future scenarios (2021–2050 period) indicated an improvement in the climate conditions for sun and beach tourism in Jardines del Rey, which was slightly more pronounced in scenario A2 than in B2. This improvement was not based on a spectacular increase in the favourable weather types compared to the unfavourable ones, but rather in a better distribution of both. In this way, the projection showed the same differentiation between the high and low seasons, but with a polarization of the weather conditions in each: There will be an increase in the number of days that are favourable for sun and beach tourism during the high season (average values will be over 70% of the days) and, in particular, in the number of days with the most suitable weather types (Types 1 and 2). At the other end of the scale, there will also be an increase in the number of days that are not suitable for sun and beach tourism during the low season. This seems to be the result, above all, of changes in the main comfort indices assessed, with a predicted decrease in the cooling power of the wind and an increase in Thom's thermal discomfort index during this period.

The future improvement in climate conditions for the practice of sun and beach tourism in Jardines del Rey (Cuba) must be taken into account in the management of tourism at the region, in terms of the flows of visitors, the model for development of tourism products at the destination and the way the region is marketed.

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References

1. Hall, C.M. Trends in ocean and coastal tourism: The end of the last frontier? *Ocean. Coast. Manag.* **2001**, *44*, 601–618. [CrossRef]
2. Honey, M.; Krantz, D. *Global Trends in Coastal Tourism*; Center on Ecotourism and Sustainable Development: Washington, DC, USA, 2007.
3. UNWTO. *Tourism and the Sustainable Development Goals*; UNWTO: Madrid, Spain, 2015.

4. McElroy, J.L. Tourism development in small islands across the world. *Geogr. Ann. Ser. B Hum. Geogr.* **2003**, *85*, 231–242. [CrossRef]
5. UNWTO. *Challenges and Opportunities for Tourism Development in Small Island Developing States*; UNWTO: Madrid, Spain, 2012.
6. UNWTO. *International Tourism Highlights, 2019 Edition*; UNWTO: Madrid, Spain, 2019.
7. IPCC. *Climate Change 2014–Impacts, Adaptation and Vulnerability: Regional Aspects*; Cambridge University Press: Cambridge, UK, 2014.
8. Campbell, J.D.; Taylor, M.A.; Stephenson, T.S.; Watson, R.A.; Whyte, F.S. Future climate of the Caribbean from a regional climate model. *Int. J. Climatol.* **2011**, *31*, 1866–1878. [CrossRef]
9. Taylor, M.A.; Whyte, F.S.; Stephenson, T.S.; Campbell, J.D. Why dry? Investigating the future evolution of the Caribbean Low Level Jet to explain projected Caribbean drying. *Int. J. Climatol.* **2013**, *33*, 784–792. [CrossRef]
10. Whyte, F.S.; Taylor, M.A.; Stephenson, T.S.; Campbell, J.D. Features of the Caribbean Low Level Jet. *Int. J. Climatol.* **2008**, *28*, 119–128. [CrossRef]
11. Cashman, A.; Cumberbatch, J.; Moore, W. The effects of climate change on tourism in small states: Evidence from the Barbados case. *Tour. Rev.* **2012**, *67*, 17–29. [CrossRef]
12. Clayton, A. Climate change and tourism: The implications for the Caribbean. *Worldw. Hosp. Tour. Themes* **2009**, *1*, 212–230. [CrossRef]
13. Emmanuel, K. Shifting tourism flows in a changing climate: Policy implications for the Caribbean. *Worldw. Hosp. Tour. Themes* **2014**, *6*, 118–126. [CrossRef]
14. Mackay, E.A.; Spencer, A. The future of Caribbean tourism: Competition and climate change implications. *Worldw. Hosp. Tour. Themes* **2017**, *9*, 44–59. [CrossRef]
15. Moore, W.R. The impact of climate change on Caribbean tourism demand. *Curr. Issues Tour.* **2010**, *13*, 495–505. [CrossRef]
16. Robinson, S.A. Adapting to climate change at the national level in Caribbean small island developing states. *Isl. Stud. J.* **2018**, *13*, 79–100. [CrossRef]
17. Scott, D.; Simpson, M.C.; Sim, R. The vulnerability of Caribbean coastal tourism to scenarios of climate change related sea level rise. *J. Sustain. Tour.* **2012**, *20*, 883–898. [CrossRef]
18. Stancioff, C.E.; Stojanov, R.; Kelman, I.; Němec, D.; Landa, J.; Tichy, R.; Prochazka, D.; Brown, G.; Hofman, C.L. Local Perceptions of Climate Change Impacts in St. Kitts (Caribbean Sea) and Malé, Maldives (Indian Ocean). *Atmosphere* **2018**, *9*, 459. [CrossRef]
19. Gómez-Martín, M.B. Weather, climate and tourism a geographical perspective. *Ann. Tour. Res.* **2005**, *32*, 571–591. [CrossRef]
20. Gómez-Martín, M.B. Retos del turismo español ante el cambio climático. *Investig. Geográficas* **2017**, *67*, 31–47. [CrossRef]
21. Scott, D.; McBoyle, G.; Schwartzentruber, M. Climate change and the distribution of climatic resources for tourism in North America. *Clim. Res.* **2004**, *27*, 105–117. [CrossRef]
22. De Freitas, C.R. Tourism climatology: Evaluating environmental information for decision making and business planning in the recreation and tourism sector. *Int. J. Biometeorol.* **2003**, *48*, 45–54. [CrossRef]
23. Gómez-Martín, M.B. An evaluation of the tourist potential of the climate in Catalonia (Spain): A regional study. *Geogr. Ann. Ser. APhys. Geogr.* **2004**, *86*, 249–264. [CrossRef]
24. Martínez-Ibarra, E.; Gómez-Martín, M.B. Progress in tourism climatology. In *Tourism and Developments—Issues and Challenges*; Mihalič, T., Gartner, W.C., Eds.; Nova Science: New York, NY, USA, 2013; pp. 121–138.
25. Amelung, B.; Viner, D. Mediterranean tourism: Exploring the future with the tourism climatic index. *J. Sustain. Tour.* **2006**, *14*, 349–366. [CrossRef]
26. Fitchett, J.M.; Robinson, D.; Hoogendoorn, G. Climate suitability for tourism in South Africa. *J. Sustain. Tour.* **2017**, *25*, 851–867. [CrossRef]
27. Mieczkowski, Z. The tourism climatic index: A method of evaluating world climates for tourism. *Can. Geogr./Le Géographe Can.* **1985**, *29*, 220–233. [CrossRef]
28. Perch-Nielsen, S.L.; Amelung, B.; Knutti, R. Future climate resources for tourism in Europe based on the daily Tourism Climatic Index. *Clim. Chang.* **2010**, *103*, 363–381. [CrossRef]
29. Yu, D.D.; Rutty, M.; Scott, D.; Li, S. A comparison of the holiday climate index: Beach and the tourism climate index across coastal destinations in China. *Int. J. Biometeorol.* **2020**, 1–8. [CrossRef]

30. De Freitas, C.R.; Scott, D.; McBoyle, G. A second generation climate index for tourism (CIT): Specification and verification. *Int. J. Biometeorol.* **2008**, *52*, 399–407. [CrossRef] [PubMed]
31. Lin, T.P.; Matzarakis, A. Tourism climate and thermal comfort in Sun Moon Lake, Taiwan. *Int. J. Biometeorol.* **2008**, *52*, 281–290. [CrossRef] [PubMed]
32. Matzarakis, A. Transfer of climate data for tourism applications—The climate-tourism/transfer-information-scheme. *Sustain. Environ. Res.* **2014**, *24*, 273–280.
33. Matzarakis, A.; Nastos, P. Analysis of tourism potential for Crete Island, Greece. *Glob. Nest J.* **2011**, *13*, 142–150.
34. Nastos, P.T.; Matzarakis, A. Present and Future Climate—Tourism Conditions in Milos Island, Greece. *Atmosphere* **2019**, *10*, 145. [CrossRef]
35. Morgan, R.; Gatell, E.; Junyent, R.; Micallef, A.; Özhan, E.; Williams, A.T. An improved user-based beach climate index. *J. Coast. Conserv.* **2000**, *6*, 41–50. [CrossRef]
36. Georgopoulou, E.; Mirasgedis, S.; Sarafidis, Y.; Hontou, V.; Gakis, N.; Lalas, D.P. Climatic preferences for beach tourism: An empirical study on Greek islands. *Theor. Appl. Climatol.* **2019**, *137*, 667–691. [CrossRef]
37. Demiroglu, O.C.; Saygili-Araci, F.S.; Pacal, A.; Hall, C.M.; Kurnaz, M.L. Future Holiday Climate Index (HCI) Performance of Urban and Beach Destinations in the Mediterranean. *Atmosphere* **2020**, *11*, 911. [CrossRef]
38. Andrade, H.; Alcoforado, M.J.; Oliveira, S. Methodologies to assess the effects of climate on tourism: Weather type and individual perception. In *Development in Tourism Climatology*; Commission on Climate and Recreation, International Society of Biometeorology: Freiburg, Germany, 2007; pp. 74–79.
39. Barbière, E.B. O factor climatico nos sistemas territoriais de recreaçao (Le facteur climatique et les bases régionales du tourisme). *Rev. Bras. Geogr. Rio Jan.* **1981**, *43*, 145–265.
40. Besancenot, J.P.; Mounier, J.; de Lavenne, F. Les conditions climatiques du tourisme, littoral. *Norois* **1978**, *99*, 357–382. [CrossRef]
41. Crowe, R.B.; Mckay, G.A.; Baker, W.M. *Le Climat de l'Ontario et Son Influence Sur Le Tourisme et Les Loisirs de Plein Air. Volume I, Objectif et Définitions Des Saisons. Volume II Eté. Volume III. Hiver*; Publications en Météorologie Appliquée. REC-1-73; Environnement Canada, Service de l'Environnement Atmosphérique: Toronto, ON, Canada, 1977.
42. Gates, A.D. *Le Climat Des Maritimes en Fonction du Turisme et Des Loisirs de Plein Air*; Environment Canada/Atmospheric Environment: Toronto, ON, Canada, 1975.
43. Gómez-Martín, M.B. Climate potential and tourist demand in Catalonia (Spain) during the summer season. *Clim. Res.* **2006**, *32*, 75–87. [CrossRef]
44. Machete, R.; Lopes, A.; Gómez-Martín, M.B.; Fraga, H. Tourism and climate in Lisbon. An assessment based on weather types. *Finisterra* **2014**, *49*, 153–176. [CrossRef]
45. Martínez-Ibarra, E. Tipos de tiempo para el turismo de sol y playa en el litoral alicantino. *Estud. Geográficos* **2008**, *69*, 135–155.
46. Martínez-Ibarra, E. The use of webcam images to determine tourist–climate aptitude: Favourable weather types for sun and beach tourism on the Alicante coast (Spain). *Int. J. Biometeorol.* **2011**, *55*, 373–385. [CrossRef]
47. Masterton, J.M.; Crowe, R.B.; Baker, W.M. *Tourism and Outdoor Recreation Climate of the Prairie Provinces*; Environment Canada/Atmospheric Environment: Toronto, ON, Canada, 1975.
48. Besancenot, J.P. *Clima y Turismo*; Masson: Barcelona, Spain, 1991.
49. Blazejczyk, K.; Matzarakis, A. Assessment of bioclimatic differentiation of Poland based on the human heat balance. *Geogr. Pol.* **2007**, *80*, 63–82.
50. De Freitas, C.R. Assessment of human bioclimate based on thermal response. *Int. J. Biometeorol.* **1985**, *29*, 97–119. [CrossRef]
51. De Freitas, C.R. Recreation climate assessment. *Int. J. Climatol.* **1990**, *10*, 89–103. [CrossRef]
52. Höppe, P.R.; Seidl, H.A.J. Problems in the assessment of the bioclimate for vacationists at the seaside. *Int. J. Biometeorol.* **1991**, *35*, 107–110. [CrossRef]
53. Denstadli, J.M.; Jacobsen, J.K.S.; Lohmann, M. Tourist perceptions of summer weather in Scandinavia. *Ann. Tour. Res.* **2011**, *38*, 920–940. [CrossRef]
54. Lohmann, M.; Kaim, E. Weather and holiday destination preferences image, attitude and experience. *Tour. Rev.* **1999**, *54*, 54–64. [CrossRef]
55. Rutty, M.; Scott, D. Differential climate preferences of international beach tourists. *Clim. Res.* **2013**, *57*, 259–269. [CrossRef]

56. Rutty, M.; Scott, D. Thermal range of coastal tourism resort microclimates. *Tour. Geogr.* **2014**, *16*, 346–363. [CrossRef]
57. Rutty, M.; Scott, D. Bioclimatic comfort and the thermal perceptions and preferences of beach tourists. *Int. J. Biometeorol.* **2015**, *59*, 37–45. [CrossRef]
58. Rutty, M.; Scott, D. Comparison of Climate Preferences for Domestic and International Beach Holidays: A Case Study of Canadian Travelers. *Atmosphere* **2016**, *7*, 30. [CrossRef]
59. Scott, D.; Rutty, M.; Amelung, B.; Tang, M. An inter-comparison of the holiday climate index (HCI) and the tourism climate index (TCI) in Europe. *Atmosphere* **2016**, *7*, 80. [CrossRef]
60. Gómez-Martín, M.B.; Martínez-Ibarra, E. Tourism demand and atmospheric parameters: Non-intrusive observation techniques. *Clim. Res.* **2012**, *51*, 135–145. [CrossRef]
61. Rutty, M.; Scott, D.; Matthews, L.; Burrowes, R.; Trotman, A.; Mahon, R.; Charles, A. An Inter-Comparison of the Holiday Climate Index (HCI: Beach) and the Tourism Climate Index (TCI) to Explain Canadian Tourism Arrivals to the Caribbean. *Atmosphere* **2020**, *11*, 412. [CrossRef]
62. Scott, D.; Gössling, S.; de Freitas, C.R. Preferred climates for tourism: Case studies from Canada, New Zealand and Sweden. *Clim. Res.* **2008**, *38*, 61–73. [CrossRef]
63. Moreno, A. Mediterranean tourism and climate (change): A survey based study. *Tour. Plan. Dev.* **2010**, *7*, 253–265. [CrossRef]
64. Rutty, M.; Scott, D. Will the Mediterranean become "too hot" for tourism? A reassessment. *Tour. Hosp. Plan. Dev.* **2010**, *7*, 267–281. [CrossRef]
65. Wirth, K. Auswirkungen des Klimawandels Auf Den Tourismus Im Mittelmeerraum Prognosen Ahand Einer Umfrage in Munchen. Master Thesis, Ludwig Maximilian Universitat Munchen, Munich, Germany, 2010.
66. Batista-Tamayo, L.M.; Matos-Pupo, F. La aptitud climática del destino turístico Jardines del Rey (Cuba). Los tipos de tiempo. In *El clima entre el mar y la montaña, IV Congreso de la Asociación Española de Climatolgía*; García Codrón, J.C., Diego Liaño, C., Fdez. de Arróyabe Hernáez, P., Garmendia Pedraja y, C., Rasilla Álvarez, D., Eds.; Santander: Boadilla del Monte, Spain, 2004; pp. 561–570.
67. Rutty, M.; Richardson, R.B. Tourism Research in Cuba: Gaps in Knowledge and Challenges for Sustainable Tourism. *Sustainability* **2019**, *11*, 3340. [CrossRef]
68. Pédelaborde, P. *Le Climat du Bassin Parisien: Essai D'une Méthode Rationnelle de Climatologie Physique*; MT Génin: Paris, France, 1957; Volume 1.
69. Hufty, A. Les types de temps dans le Québec méridional–Méthode pédagogique de description des climats. *Cah. Géographie Du Québec* **1971**, *15*, 29–52. [CrossRef]
70. Dubois, G.; Ceron, J.P.; Dubois, C.; Frias, M.D.; Herrera, S. Reliability and usability of tourism climate indices. *Earth Perspect.* **2016**, *3*, 2. [CrossRef]
71. Matthews, L.; Scott, D.; Andrey, J. Development of a data-driven weather index for beach parks tourism. *Int. J. Biometeorol.* **2019**, 1–14. [CrossRef]
72. Balafoutis, C.; Maheras, P. The Climatic Conditions of the Coastal Areas at Thessaloniki during the high touristic period. *Sci. Ann. Fac. Sci. Univ. Thessalon.* **1983**, *23*, 89–97.
73. Gómez-Martín, M.B. Duración y características de la estación climático-turística estival en Cataluña. *Estud. Geográficos* **2003**, *64*, 623–653. [CrossRef]
74. Perry, A. Climate and weather information for the package holiday-maker. *Weather* **1993**, *48*, 410–414. [CrossRef]
75. Martínez-Ibarra, E.; Gómez-Martín, M.B.; Armesto-López, X.A.; Pardo-Martínez, R. Climatic preferences for tourism: Perceptions about ideal and unfavorable conditions for hiking in Spain. *Atmosphere* **2019**, *10*, 646. [CrossRef]
76. De Freitas, C.R.; Grigorieva, E.A. A comprehensive catalogue and classification of human thermal climate indices. *Int. J. Biometeorol.* **2015**, *59*, 109–120. [CrossRef] [PubMed]
77. Potchter, O.; Cohen, P.; Lin, T.P.; Matzarakis, A. Outdoor human thermal perception in various climates: A comprehensive review of approaches, methods and quantification. *Sci. Total Environ.* **2018**, *631*, 390–406. [CrossRef] [PubMed]
78. Centella-Artola, A.; Bezanilla-Morlot, A.; Leslie, K. *A Study of the Uncertainty in Future Caribbean Climate Using the PRECIS Regional Climate Model*; Technical Report; Community Caribbean Climate Change Center: Belmopan, Belize, 2008; p. 16.

79. Centella-Artola, A.; Taylor, M.A.; Bezanilla-Morlot, A.; Martinez-Castro, D.; Campbell, J.D.; Stephenson, T.S.; Vichot, A. Assessing the effect of domain size over the Caribbean region using the PRECIS regional climate model. *Clim. Dyn.* **2015**, *44*, 1901–1918. [CrossRef]
80. Martínez-Castro, D.; Borrajero-Montejo, I.; Bezanilla-Morlot, A.; Centella-Artola, A. La ocurrencia de ciclones tropicales en el Caribe y México y el calentamiento global. Aplicación de un modelo climático regional. *Ciencias La Tierra Y El Espacio* **2011**, *12*, 17–30.
81. Taylor, M.A.; Centella, A.; Charlery, J.; Bezanilla, A.; Campbell, J.; Borrajero, I.; Stephenson, T.; Nurmohamed, R. The Precis Caribbean Story: Lessons and Legacies. *Bull. Am. Meteor. Soc.* **2013**, *94*, 1065–1073. [CrossRef]
82. Gómez-Martín, M.B.; Armesto-López, X.A.; Martínez-Ibarra, E. Tourists, weather and climate. Official tourism promotion websites as a source of information. *Atmosphere* **2017**, *8*, 255. [CrossRef]