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Analysis of Tourism Climate Resources in Mile City

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Abstract

This study utilizes meteorological station data from Mile City (1991-2020) to analyze the effects of temperature, humidity, and wind efficiency index on human thermal perception and heat dissipation. The results demonstrate that Mile City offers year-round travel suitability with excellent climatic resources. April and October are particularly ideal for tourism due to synergistic interactions between temperature-humidity conditions and wind efficiency. January, February, March, May, and September also prove suitable for travel, as wind efficiency during winter months enhances comfort perception while transitional seasons optimize tourism experiences through coordinated temperature-humidity-WEI adjustments. Notably, March shows only a 1.3-point difference in wind efficiency index compared to the optimal travel month. For travelers planning June-August visits, light summer retreats are recommended as high temperatures and humidity may cause discomfort, though this remains within acceptable thresholds. The temporal distribution analysis of Mile City's tourism climate comfort provides valuable insights for travel planning and supports sustainable development of the local tourism industry.

Keywords

Mile City, Temperature and Humidity Index, Wind Efficiency Index, Tourism Climate Resources

1. Introduction

In response to the 20th National Congress of the Communist Party of China and the rural revitalization strategy, Mile City has actively advanced its "Tourism-Driven Development" initiative. To meet the public's rising demand for a better life, the city has shifted tourism from single attractions to integrated destination experiences, building a holistic tourism system of "One Core, Five Zones, Four

Corridors" and exploring integrated models combining cultural, agritourism, wellness, sports and eco-tourism. Mile's tourism revenue has kept growing in proportion to its GDP and service sector output.

Given that Mile's unique climate greatly impacts its tourism planning and development—and climate analysis is vital for destinations relying on natural and ecological resources—this study uses 1991-2020 meteorological data and statistical mapping to visualize Mile's monthly average temperature, extreme temperature range, relative humidity and sunshine duration. Based on the temperature-humidity index model in Human Settlements Climate Comfort Evaluation Standard (GB/T 27963-2011), it also quantitatively calculates the city's monthly temperature-humidity index and wind-efficiency index.

The study aims to comprehensively analyze the advantages and limiting factors of Mile's tourism climate resources: it provides visitors with scientific, detailed climatic information to help adjust itineraries and improve travel experiences; meanwhile, its quantitative results and summaries serve as climatological evidence for Mile's sustainable tourism development and efficient resource utilization, offering theoretical and data support for formulating scientific policies and targeted measures in local tourism management.

2. Literature Review on Tourism Climate Research

2.1. Basic Theoretical Research on Tourism Climate Resources

Tourism climate resources—specialized assets from long-term climatic processes—fall under meteorological resources, with specific value attributes, clear functions and relatively stable states. In modern tourism, travelers usually prioritize checking destination climate when planning itineraries. Climate elements impact travel experiences in four key ways: directly affecting tourism comfort; guiding seasonal travel distribution and destination choice; potentially posing safety risks; and participating in the formation and evolution of tourism landscapes. Thus, systematic research on these resources and their rational development is crucial for sustainable tourism growth.

Mile City's tourism industry demonstrates rapid development momentum, with its proportion in local GDP steadily increasing year by year (**Table 1**) (Wei et al., 2023; Liu, 2023). Developing tourism has become a key strategic initiative for alleviating fiscal burdens and advancing rural revitalization. With the sequential development of tourism projects like Dongfengyun Characteristic Town and Hushui Water World, coupled with continuous improvements in transportation infrastructure, Mile City's tourism dominance within Honghe Prefecture is becoming increasingly evident. Against this backdrop, comprehensive exploration of Mile City's tourism climate resources carries positive practical and theoretical implications for further tapping local tourism potential, optimizing product supply models, enhancing service quality, and ultimately driving high-quality advancement in the city's tourism sector.

Climate is essentially the most critical natural tourism resource—nearly all world-renowned resorts attract visitors with pleasant climates (Li, Zhang, & Bai, 2019). A suitable climate is both a basic requirement for regional tourism development and a primary factor in tourism decision-making (Liu, He, & Ye, 2021). Research on climate comfort for optimizing climatic tourism resources (Chen et al., 2024) is valuable for scientifically guiding travel decisions (Yan et al., 2013).

Tourism climate comfort evaluation stems from climate comfort assessment, which uses standards or models to comprehensively evaluate meteorological parameters affecting human comfort during tourism (Zhu et al., 2023). International scholars began exploring this field in 1920, pioneering work in theories, modeling and applications, and developing empirical models (e.g., effective temperature, wet-bulb blackball index, human comfort meteorological index, temperature-humidity index, wind chill index) for diverse objectives (Zhang et al., 2022a). Domestic research started in the 1980s: scholars explored the history, core concepts and applicability of models developed over the century (Yan et al., 2013), and conducted extensive studies on model optimization (Wei et al., 2021), improvement (Zhu et al., 2023) and practical use. Empirical model research has long dominated China's tourism climate comfort evaluation. Domestic scholars have carried out such evaluations at different spatial scales [national (Rong et al., 2024; Liu, Feng, & Tian, 2020), provincial, city/county, specific attractions (Zhang et al., 2022b; Cao & Lu, 2021; Pan et al., 2018; Xiang, 2015; Cheng et al., 2017)] and time scales (Yu & Wang, 2021; Zhang, 2020), achieving fruitful results.

Table 1. Proportion of tourism revenue in GDP of Mile City in each year (data from the work report of Mile City government).

A particular year	2021	2022	2023	2024
Number of tourists (10,000) in Mile City	1001	1173	1504	1779.3
Mile City GDP (100 million)	496.1	524.7	532.2	558
Total tourism revenue of Mile City (100 million)	109.2	127.3	161.4	217.4
Total tourism revenue as a percentage of GDP	22.01%	24.26%	30.33%	38.96%

2.2. International Research Status

Paul Peeters et al. used a problem-oriented review to assess climate change mitigation research in sustainable tourism literature. While climate change has become a global existential environmental crisis and tourism emissions keep rising—making it expected to be central to sustainable tourism studies—rigorous system boundaries, lack of shared definitions, and incomplete data in tourism research appear to hinder methods for evaluating tourism's role in climate mitigation (Peeters, Çakmak, & Guiver, 2024). Valizadeh Mansoor et al. studied climate change's impacts on outdoor tourists via the Outdoor Tourism Climate Index (OTCI) survey, using the Change Factor (CF) method to statistically downscale Global Climate Models (GCM) (Valizadeh & Khoorani, 2022). Kayal Mohamed argues that international tourism is a major economic sector with steady, substantial growth in developed and developing countries, yet it is unstable due to factors including climate change. He illustrated its environmental and socio-economic impacts using criteria like tourist arrivals, and outlined how climate phenomena interact with international tourism's commercial aspects. He further explained why destinations must adapt to climate change risks and opportunities, to show tourists the need to prepare for climate change challenges (Kayal, 2023).

2.3. Domestic Research Status

Recent studies have assessed tourism climate resources in various Chinese regions. An analysis of Hanzhong City's air quality and meteorological data aimed to evaluate its ecotourism climate resources (Zheng, Meng, & Huang, 2024). Research in Wuwei City utilized the Universal Thermal Climate Index (UTCI) to examine the spatiotemporal distribution of tourism climate comfort (Hu & Li, 2023). A comprehensive model integrating multiple indices was developed to assess tourism climate comfort in Guangdong Province (Deng et al., 2023). Similarly, a spatiotemporal analysis of tourism climate comfort was conducted for Luoyang over a 50-year period (Ran, 2023).

2.4. Summary of Domestic and Foreign Tourism Climate Research Literature

In research evolution, domestic and international tourism climate studies have built a "theoretical exploration—model construction—regional application" system. However, three gaps remain: Mainstream evaluation models, mostly developed for specific regional climates, lack sufficient cross-regional applicability testing; future research could compare different climate zones to enhance generalizability. Most studies focus on static tourism comfort assessments, with insufficient attention to long-term dynamic changes under climate change; subsequent work should use longer time-series data and scenario simulations to explore trends and drivers. Current research emphasizes natural meteorological factors but inadequately integrates humanistic-social elements (tourist preferences, facility configurations, policy regulation); future studies should add multi-dimensional variables to build a comprehensive evaluation system, providing practical support for precise tourism resource development, spatial optimization, and scientific planning.

3. Overview of Mile City

Details of Mile City are shown in **Table 2** (Wei, Ma, & Li, 2023; Liu, 2023).

Table 2. Mile City introduction (2023).

Category	Details
Geographic Location	Southeastern Yunnan, northern Honghe Prefecture
Coordinates	103˚04′ - 103˚49′ E, 23˚50′ - 24˚39′ N

Continued

Proximity to Kunming	- 120 km (high-speed rail available)
Tourism Honors (2023)	China's Top Ten Premium Sports Tourism Leisure Districts; National Top 100 Counties with Tourism Development Potential
Tourist Volume (2023)	Exceeded 10 million visitors
Tourism Revenue (2023)	Surpassed RMB 17 billion
National 4A Scenic Areas	Dongfengyun Scenic Area, Jinping Mountain, Taiping Lake International Ecological Tourism Resort, Keyi Town, Huchuan Ecological Park (sub-attractions: Huchuan Half-Mountain Hot Spring, Huchuan Water World)
Key Development Projects	Huchuan Water Village → national tourist resort; Dongfengyun → 5A upgrade; Yunnan Red Wine Winery, Honghe Water Village, Bailong Cave → 4A preparation
Climate Type	Subtropical plateau monsoon climate
Annual Temperature	17.5˚C (mild winters, cool summers, small fluctuations)
Seasonal Characteristics	Dry winter/spring (continental monsoon), humid summer/autumn (marine monsoon); long sunshine hours, rare frost/snow
Annual Humidity	- 74%
Wind Speed	- 2 m/s

4. Research Method

4.1. Technology Roadmap

The specific technical route of this paper is shown in **Figure 1**.

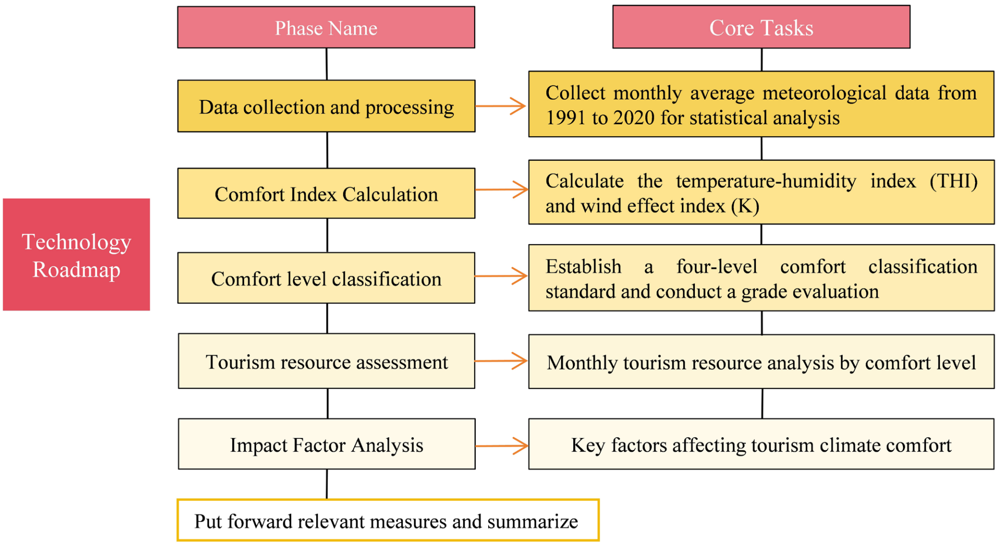

Figure 1. Technology roadmap.

4.2. Data Sources and Processing

1) This study utilizes monthly meteorological data (temperature, relative humidity, wind speed, and solar radiation) for Mile City from 1991 to 2020, sourced from the Yunnan Provincial Meteorological Information Center. Monthly averages were calculated using the following formulas:

Daily Mean Temperature:

$$Td = (T\max + T\min)/2\,. \tag{1}$$

Monthly Mean Temperature:

$$Tm = \sum Td/N\,. \tag{2}$$

Monthly Mean Relative Humidity:

$$RHm = \sum RHd/N\,. \tag{3}$$

2) The following method will be used to calculate the actual sunshine hours in Mile City:

① Theoretical sunshine hours: The theoretical sunshine duration (T_0), representing the solar radiation hours receivable by the Earth's surface in the absence of atmospheric interference, serves as the foundation for calculating actual sunshine duration. This calculation involves geographical latitude and solar declination, utilizing the following classical astronomical formula:

$$T_0 = \frac{2}{15}\arccos(-\tan\phi\cdot\tan\delta)\,. \tag{4}$$

Here, T_0 denotes the theoretical available hours at the horizon (unit: h), ϕ represents the geographical latitude of Mile Ci, and δ is the solar declination angle (unit: ˚), which can be calculated using Spencer's formula based on the date.

To calculate the monthly theoretical sunshine duration, sum the daily sunshine hours:

$$T_{month} = \sum_{i=1}^{n} T_{0_i}\,. \tag{5}$$

Here, n is the number of days in the month.

② Establish a function relationship between adjustment coefficient and humidity. Assuming a simple linear negative correlation exists between the monthly adjustment coefficient km and relative humidity RH_m, which forms the core of the model, expressed as:

$$k_m = a - b\cdot RH_m\,. \tag{6}$$

Here, a and b are model parameters to be determined.

③ Parameter optimization and constraints

The parameters a and b are optimized through a mathematical iterative algorithm to determine the monthly km values. This process must satisfy the following two constraints:

Trend consistency constraint: The calculated monthly km values should demonstrate a reasonable negative correlation with their corresponding RH_m values.

Annual total constraint: The annual total sunshine duration derived from the optimized km calculation must approach the target value of 2100 hours.

The annual total sunshine duration calculation formula is:

$$S_{\text{total}} = \sum_{m=1}^{12}(k_m\cdot T_{\text{month}})\,. \tag{7}$$

The optimization objective is to minimize $|S_{\text{total}} - S_{\text{target}}|$.

④ Check whether the seasonal variations of k_m and RH_m align (e.g., low humidity in the dry season corresponds to high k-value, and high humidity in the rainy season corresponds to low k-value).

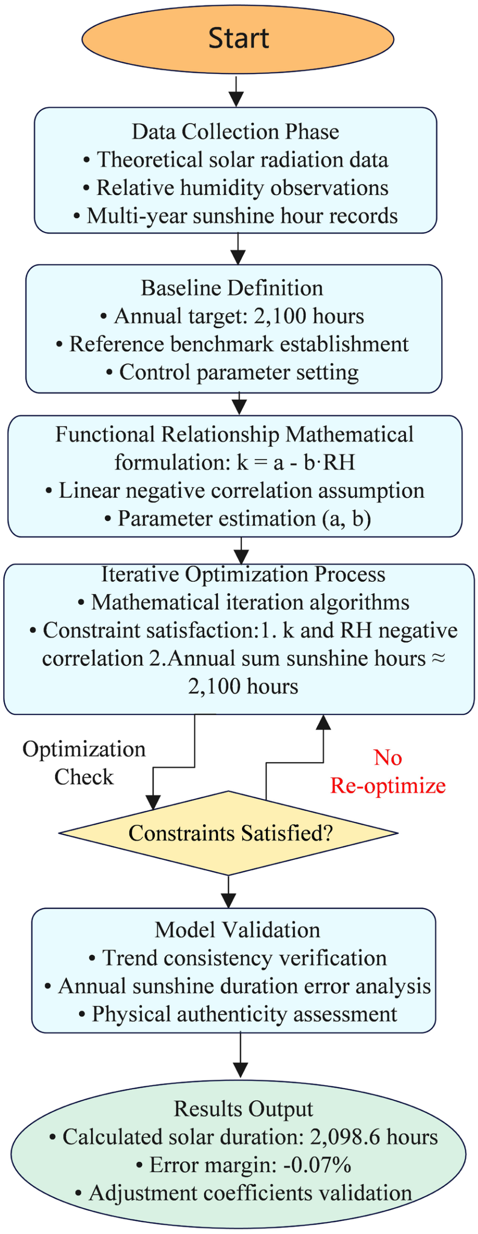

Figure 2. Calculation process of monthly adjustment coefficient.

Calculate the relative error between the final annual total sunshine hours (S_{total}) and the target value (S_{target}) to evaluate the model's overall accuracy. The formula for relative error calculation is as follows:

$$\text{Relative Error} = \frac{|S_{\text{total}} - S_{\text{target}}|}{|S_{\text{target}}|} \times 100\% . \tag{8}$$

The route of the method described in 4.2 (2) is shown in **Figure 2**.

4.3. Temperature and Humidity Index

Temperature and humidity index (THI) quantifies the thermal comfort of environments by integrating temperature and relative humidity through humidity correction. This index evaluates human perception through their interaction with these environmental factors, where higher values indicate more oppressive heat conditions—reflecting actual thermal effects rather than isolated humidity or temperature measurements (Liang, Liu, & Shen, 2025). In plain terms, THI simulates human perceived temperature by adjusting the effect of humidity on the body's heat dissipation capacity, with the core concept being the actual physical sensation of "more stuffy on humid days and more comfortable on dry days at the same temperature". Widely used in meteorology, agriculture, and indoor environment control, THI follows the calculation formula specified in the "Evaluation Standard for Climate Comfort of Human Settlements" (GB/T 27963-2011):

$$THI = 1.8 \times T - 0.55(1-F)(1.8T-26)+32 \tag{9}$$

in Equation (9), THI represents the temperature-humidity index, where T denotes the monthly average temperature (in ˚C) and F indicates relative humidity (in %). Based on research findings regarding tourism climate comfort and human physiological activities, the temperature-humidity index is categorized into nine levels: extremely cold, cold, cool, mild, very comfortable, warm, hot, muggy, and extremely muggy (**Table 3**).

Table 3. Temperature and humidity index classification and human body comfort and suitability for tourism activities.

Level indicators	Scope of indicators	Human body comfort	Tourism comfort
0	THI < 40	Extremely cold, uncomfortable	Unsuitable
1	40 ≤ THI < 45	Very Cold, uncomfortable	Proper arrangements
2	45 ≤ THI < 55	Cold, less comfortable	Essentially suitable
3	55 ≤ THI < 60	Cool and comfortable	suitable
4	60 ≤ THI < 65	Very comfortable	Very suitable
5	65 ≤ THI < 70	Warm and comfortable	suitable
6	70 ≤ THI < 75	Hot and uncomfortable	Essentially suitable
7	75 ≤ THI < 80	Muggy, uncomfortable	Proper arrangements
8	THI ≥ 80	extremely hot, uncomfortable	Unsuitable

4.4. Wind Effect Index

The Wind Effect Index (K), a biometeorological composite evaluation metric, is built on three core meteorological elements: wind speed, temperature, and sunshine duration. Its purpose is to scientifically quantify the human body's physiological comfort under the combined action of these factors, mainly by simulating the heat exchange rate between a unit area of human skin and the external environment within a certain period, thus realizing the quantitative measurement of perceived thermal sensation. In simple terms, K measures actual perceived temperature by combining wind speed's effect on accelerating heat loss from the human body. It explains the common phenomenon that it is colder on windy days and milder on windless days at the same temperature.

A negative K value means the human body dissipates net heat to the surroundings, leading to a subjective feeling of cold; a positive K value indicates the body absorbs heat from the environment, resulting in a subjective feeling of warmth (Liang, Liu, & Shen, 2025). Academically, K systematically integrates meteorological elements, objectively reflects their actual impact on the human thermal balance system, and provides key theoretical basis and data support for constructing scientific indoor climate comfort evaluation systems and promoting accurate public meteorological services.

Table 4. Wind effect index classification and human body comfort and suitability for tourism activities.

Wind efficiency index (K) range	Level of sensitivity	Level	Tourism comfort
<−1000	Very Cold	0	Unsuitable
−1000 - −800	Cold	1	Proper arrangements
−800 - −600	Slightly cold	2	Essentially suitable
−600 - −400	Cool	3	Suitable
−400 - −200	comfortable	4	Very suitable
−200 - −50	warm	5	Suitable
−50 - 80	Slightly hot	6	Essentially suitable
80 - 160	Hot	7	Proper arrangements
>160	Very hot	8	Unsuitable

In terms of calculation method, K's specific formula strictly complies with China's national standard Evaluation of Climate Comfort of Human Settlements (Standard No.GB/T 27963-2011), which is simplified as follows (letters correspond to the subsequent explanation): [K calculation formula: $K = f(V, T, S)$]

$$K = -\left(10\sqrt{V} + 10.45 - V\right) \times \left(33 - T\right) + 8.55 \times S \tag{10}$$

in the calculation model of Equation (10), the parameters are defined as follows: K represents the wind efficiency index, a key indicator for measuring tourism climate comfort; V denotes the average wind speed during the study period, measured in meters per second (m/s); T stands for the average temperature of the corresponding measurement period, measured in degrees Celsius (˚C); S indicates the daily average sunshine duration, measured in hours per day (h/day).

Based on the relevant academic research conclusions on the correlation between tourism climate comfort and human physiological activities, the wind effect index can be divided into 9 different levels. The specific classification criteria and corresponding characteristics of each level are shown in **Table 4** (Ni et al., 2025).

4.5. Comprehensive Evaluation of Temperature Humidity Index and Wind Effect Index

In accordance with the "Evaluation of Climate Comfort in Human Settlements" (GB/T 27963-2011) standard, specific classification levels for Wind Effect Index (K) and Thermal Humidity Index (THI) are presented in **Table 3** and **Table 4** respectively. Within this climate comfort evaluation framework, when discrepancies emerge between Wind Effect Index and THI comfort levels during a given period, the following criteria apply: For seasonal variations, K serves as the primary evaluation metric for winter months, while THI is used for summer months. When monthly average wind speed exceeds 3 m/s, regardless of seasonal variations, K becomes the core evaluation indicator. These standardized procedures are designed to ensure accurate analysis of human settlement climate comfort (Yang et al., 2021).

5. Data Analysis and Results

5.1. Meteorological Condition Analysis of Mile City from 1991 to 2020

Based on the meteorological data of Mile City from 1991 to 2020, the monthly average temperature, average relative humidity and average sunshine hours were calculated first, and then the corresponding charts were generated by EXCEL tool. As shown in **Figure 3**, Mile City's temperature ranged between 0˚C and 36˚C from 1991 to 2020. The hottest months (with air temperatures exceeding 35˚C) were primarily May, June, and July, while the coldest months occurred in December, January, and February. According to **Figure 4**, the city's average temperature during this period (1991-2020) fluctuated between 10.3˚C and 22.9˚C, with minimal annual temperature variations. Combined with **Figure 3** and **Figure 4**, it can be concluded that the months of extreme high temperature and extreme low temperature are basically consistent with the months of average monthly maximum temperature and average monthly minimum temperature, and there is no abnormal temperature phenomenon. According to **Figure 5**, the monthly average relative humidity in Mile City from 1991 to 2020 ranged between 59% and 81%, with relatively high relative humidity in summer. According to **Table 5** and **Figure 6**, from 1991 to 2020, the strong solar radiation in Mile City is concentrated in March to August, among which April has the strongest solar radiation intensity, exceeding 18,000 kJ/m^2 day. This is mainly due to the fact that April in Mile City is in spring, when the rainy season has not completely arrived, the precipitation is relatively small, the weather is mostly sunny, and the solar altitude Angle at noon is large.

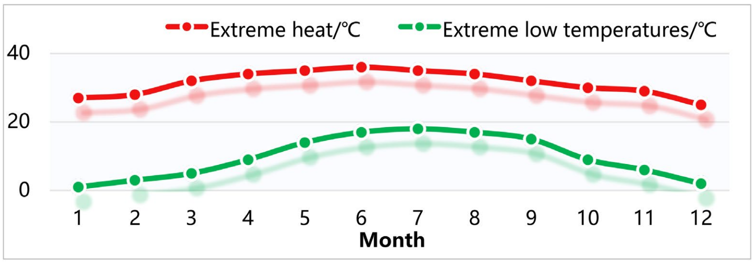

Figure 3. Monthly statistics of extreme average temperature in Mile City (1991-2020).

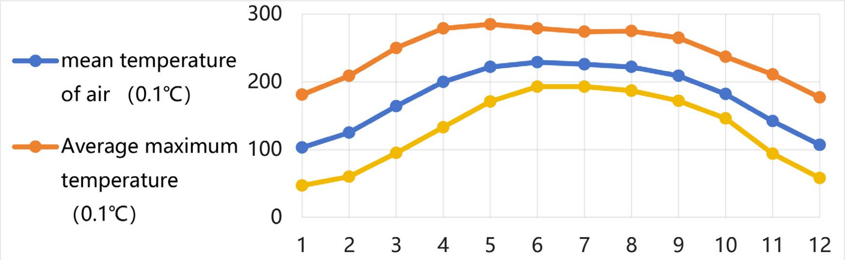

Figure 4. Monthly statistics of average temperature in Mile City (1991-2020).

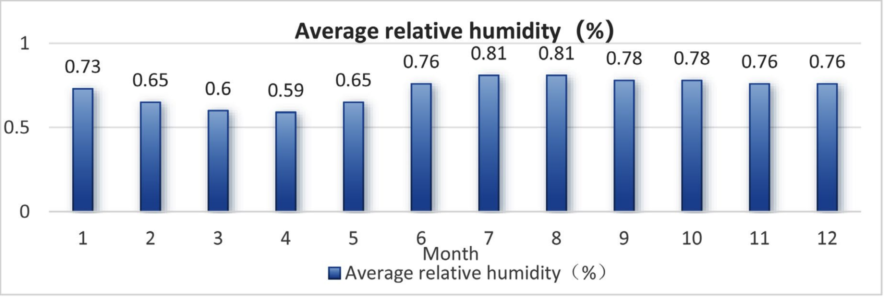

Figure 5. Monthly statistics of average relative humidity in Mile City (1991-2020).

Table 5. Monthly sunshine hours calculated by monthly adjustment coefficient.

Month	1	2	3	4	5	6
Mean monthly solar radiation (KJ·$m^{-2}d^{-1}$)	11,444	13,969	16,630	18,330	17,622	15,962
Monthly adjustment factor (Km)	0.87	0.90	0.92	0.92	0.85	0.75
Theoretical sunshine hours (hour)	5.72	6.98	8.32	9.17	8.81	7.98
Adjust sunshine hours (hour)	5.0	6.3	7.7	8.4	7.5	6.0
Month	7	8	9	10	11	12
Mean monthly solar radiation (KJ·$m^{-2}d^{-1}$)	15,708	16,418	15,032	12,174	11,794	10,604
Monthly adjustment factor (Km)	0.7	0.71	0.77	0.8	0.85	0.84

Continued

Theoretical sunshine hours (hour)	7.85	8.21	7.52	6.09	5.9	5.3
Adjust sunshine hours (hour)	5.5	5.8	5.8	4.9	5.0	4.5

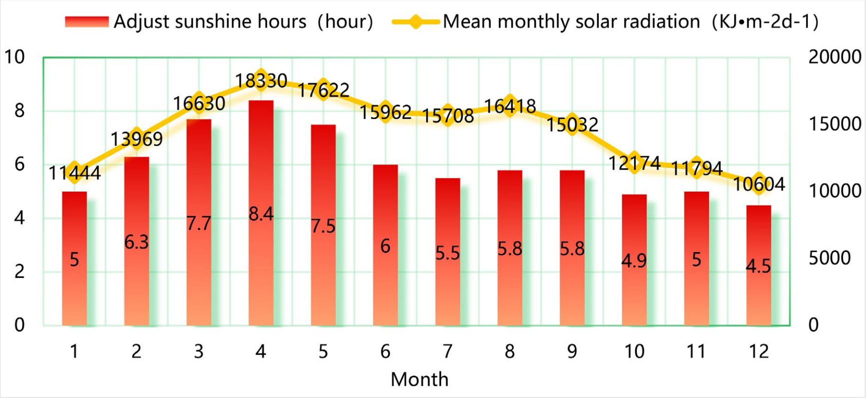

Figure 6. Monthly statistics of average solar radiation and sunshine hours in Mile City (1991-2020).

5.2. Calculation Results of Mile City Temperature and Humidity Index

According to the temperature and humidity index formula, the monthly temperature and humidity index results of the same period are shown in Table 6. Figure 7 shows the monthly variation of THI from 1991 to 2020 (Yang et al., 2021).

Table 6. Monthly calculation results of THI in Mile City (1991-2020).

Monthly calculation results of THI in Mile City from 1991 to 2020						
Month	1	2	3	4	5	6
THI	51.6	55.2	60.7	65.7	69.3	71.2
Month	7	8	9	10	11	12
THI	71.1	70.5	68.2	64	57.6	52.1

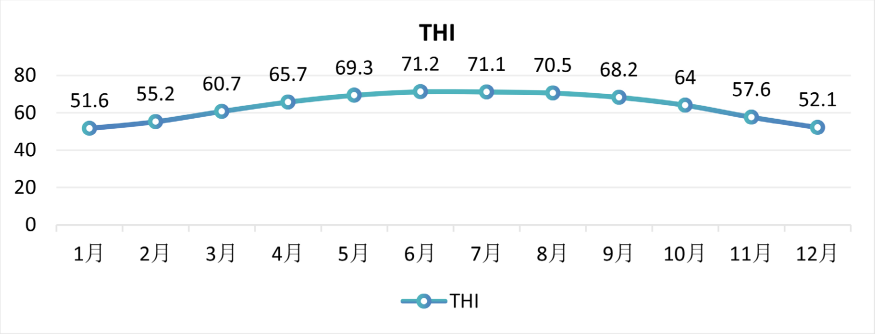

Figure 7. Monthly statistical chart of THI in Mile City (1991-2020).

5.3. Wind Effect Index Calculation Results of Mile City

According to the calculation formula of wind effect index, the monthly wind effect index (K) of Mile City from 1991 to 2020 is calculated as shown in **Figure 8**.

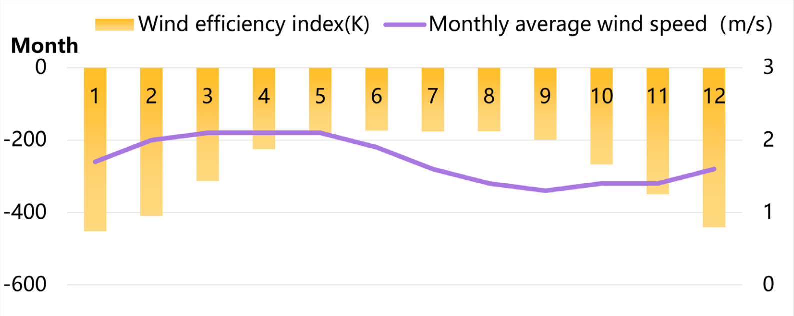

Figure 8. Monthly statistical chart of wind effect index K in Mile City.

5.4. Evaluation of Tourism Climate Comfort in Mile City

Based on the temperature-humidity index (THI) classification principles outlined in the "Evaluation Standard for Climate Comfort in Human Settlements" (GB/T 27963-2011), tourism-friendly months are categorized into four levels: ① Those with THI between 55 - 70 are designated as suitable for tourism; ② those with THI between 45 - 55 or 70 - 75 are considered moderately suitable; ③ months with THI between 40 - 45 or 75 - 80 require thorough climate preparation; ④ and those with THI below 40 or above 80 are classified as unsuitable for tourism.

Based on the wind effect index classification principles outlined in the "Evaluation Standard for Climate Comfort in Human Settlements" (GB/T 27963-2011) and their summarization, tourism comfort months can be categorized into four levels: ① Months with K values between −600 to −300 and −300 to −200 are designated as ideal tourism conditions, offering optimal comfort and peak travel experiences. ② Months with K values between −800 to −600 and −200 to −50 are considered moderately suitable, featuring mild discomfort (slightly cool or warm) that still allows for basic tourism activities. ③ Months with K values between −1000 to −800 and −50 to 80 require thorough climate preparation, as they present extreme discomfort (either too cold or too hot) necessitating additional cold protection or heatstroke prevention measures. ④ Months with K values below −1200 or above 80 are classified as unsuitable for tourism, delivering both physical discomfort and severely diminished travel enjoyment.

According to the data in **Table 7** and **Table 8** and the classification principles, Mile City's most suitable tourism months are April and October. The other suitable months include January, February, March, May, and September. Although March isn't listed as a highly suitable month, its wind effect index is only 13.3 away from −300. Additionally, with relatively low wind speeds in March, people generally feel comfortable in the temperature, making June, July, and August basically suitable for tourism, without the aforementioned ③ or ④ conditions. Calculation results show that Mile City's generally suitable tourism months (as indicated above) are mostly due to a warm climate. However, the THI or K values are very close to the standard thresholds for suitable tourism months. The maximum difference is only 1.2 points in June compared to the standard THI value. Therefore, tourists planning to visit Mile City from May to September should make some preparations for summer cooling, while those visiting in January should bring appropriate warm clothing. There's no need to worry about poor comfort due to severe weather conditions during their trip.

Table 7. Calculation results of temperature and humidity index in summer half year of Mile City (1991-2020).

Month	THI range	Physical comfort	Tourism comfort
5	65 ≤ THI < 70	Warm, comfortable	suitable
6	70 ≤ THI < 75	Hyperthermia and uncomfortable	Essentially suitable
7	70 ≤ THI < 75	Hyperthermia and uncomfortable	Essentially suitable
8	70 ≤ THI < 75	Hyperthermia and uncomfortable	Essentially suitable
9	65 ≤ THI < 70	Warm, comfortable	suitable
10	60 ≤ THI < 65	Very comfortable	Very suitable

Table 8. Calculation results of monthly wind effect index in winter half year of Mile City (1991-2020).

Month	K range	Physical comfort	Tourism comfort
1	−600 ≤ K < −300	Cool	suitable
2	−600 ≤ K < −300	Cool	suitable
3	−600 ≤ K < −300	Cool	suitable
4	−300 ≤ K < −200	comfortable	Very suitable
11	−600 ≤ K < −300	Cool	suitable
12	−600 ≤ K < −300	Cool	suitable

5.5. Factors Affecting Tourism Climate Comfort in Mile City

Temperature, precipitation, wind speed, sunshine duration, evaporation, and relative humidity are key factors influencing the comfort of a tourist's climate. Temperature directly affects how hot it feels to humans, while relative humidity and rainfall influence air moisture levels. Wind speed creates wind chill effects, sunshine duration impacts both temperature perception and sunburn risks, and evaporation is closely tied to humidity. These combined elements play a decisive role in determining tourists' physical experience and comfort level at their destination. The specific impact of the above factors on the climate comfort of Mile City is shown in Table 9.

Through comprehensive analysis, it is evident that Mile City has established a "year-round livable" tourism climate model by leveraging three core climatic advantages: the "health-friendly altitude" (1450 meters, within the human body's physiological adaptation range), the "natural oxygen bar" (negative oxygen ion concentration of 2500 - 3500 per cubic centimeter), and the "three-dimensional climate" (spanning from South Asian tropical to North Asian subtropical vertical climate zones). From the perspective of tourism planning practices, travelers should integrate seasonal characteristics and spatial variations of these climatic elements when selecting destinations and adjusting travel schedules, thereby maximizing comfort and enjoyment in their travel experiences (Liang, Liu, & Shen, 2025).

Table 9. Factors affecting tourism climate comfort in Mile City (Liu, 2023).

Factor	Key Characteristics	Impact on Tourism	Seasonal Features
Temperature	Annual avg: 17.8˚C; Summer: 20˚C - 25˚C (WHO comfort zone); Winter: avg 15˚C, <3 days < 5˚C	Ideal for health tourism; reduces heat stress and cold risks; suitable for all age groups	Not bitterly cold in winter nor scorching hot in summer
Relative Humidity	Annual avg: 45% - 65%; Summer: 60% - 65%; Winter: 25% - 50%; Forest coverage 48.3% enhances air quality	Optimal humidity avoids discomfort; vegetation transpiration improves freshness	Natural humidifier effect with high negative oxygen ions (2500 - 3500 units/cm^3)
Precipitation	Annual avg: ~1000 mm; Rainy season (May-Oct): 80% of rainfall; Dry season: <20 mm/month	Enhances ‘post-rain cooling’ but may require rainy season itinerary adjustments	Convective storms may temporarily disrupt outdoor activities
Wind Speed	Summer: SW winds 1.5 - 2.0 m/s (gentle breeze); Winter: calm, <5 days strong winds (≥8.0 m/s)	Gentle breezes provide natural cooling; minimal wind chill improves year-round comfort	Mountainous terrain blocks cold winds, reducing wind chill effects
Sunshine Hours & Intensity	Annual avg: 2131.4 hours; UV levels 4 - 5; Day-night temp difference: 10˚C - 15˚C	Ample sunshine benefits outdoor activities; UV protection needed for extended exposure	Enables “warm by day, cool by night” unique travel experience
Evaporation Intensity	Summer: 1.2 - 1.5 mm/day; Winter: 2.0 - 2.5 mm/day; Forest microclimates enhance comfort	Balanced evaporation maintains comfort; forests create “moist and refreshing” environment	Forest areas like Keyi Town create pleasant microclimates

5.6. Development and Utilization of Tourism Climate Resources

In order to promote the better development of Maitreya tourism, we can combine the calculation results of suitable/semi-suitable climate in most months of the year, and make breakthroughs from the dimensions of “precise utilization of climate resources + innovative business integration + smart experience upgrading”. The specific methods are as follows (Table 10).

Table 10. Development and utilization measures of tourism climate resources in Mile City.

Category of measures	Specific direction	Detailed measures content
Seasonal custom themed products	Winter and spring (December-April)	Leveraging the ecological foundation of Lake Quan’s hot spring resources and Taiping Lake Forest Oxygen Bar, we have developed a “Hot Spring Wellness + Forest Therapy” integrated tourism product system. This includes core experiences like hot spring baths, forest yoga, and medicinal dietary therapy, complemented by professional services such as health monitoring and traditional Chinese medicine treatments. The “Winter-Spring Folk Culture Festival” features immersive activities including Yi and Axi ethnic costume crafting, hearth cooking demonstrations, and bonfire dance performances. Combined with distinctive rammed-earth homestay facilities, this initiative enhances both cultural immersion and living comfort through dual-value integration.

Continued

Seasonal custom themed products	Summer, autumn, May and September	In core scenic areas like Dongfengyun Art Town and Taiping Lake Ecological Valley, an integrated summer retreat concept combining “Fog Forest Cooling Trails + Waterside Art Spaces” has been developed. This initiative integrates art installations with nighttime light shows, launching themed activities like “Summer Night Art Strolls”. Capitalizing on lakeside water resources, the area offers water-based leisure projects including aquatic challenges, sailing experiences, and paddleboard yoga. The “Outdoor Adventure Carnival” series features mountain off-roading, jungle river tracing, and stargazing camping. Tailored for young travelers, the “Climate Adventure Blind Box” product line has been created, alongside a “One-Day Climate Exploration Route” plan to meet diverse adventure needs.
Smart tourism empowerment	Climate comfortable navigation platform	The “Maitreya Climate Comfort Navigation” mini-program integrates real-time meteorological data including the Thermal Humidity Index (THI) and Wind Effect Index (K), developing algorithm models to precisely recommend the day’s “optimal comfort tour routes” for visitors. Utilizing AR technology, tourists can scan iconic landmarks like Dongfengyun Kaleidoscope Art Museum to instantly access simulated landscape changes across seasons and weather conditions, enhancing interactive experiences and boosting information accessibility during visits.
Cross-border business integration	Climate + food	Developing “Climate-Specific Menu Solutions”: During winter and spring, we introduce “Warmth-Boosting Herbal Hot Pot” series featuring locally sourced medicinal ingredients like Sanqi (Panax notoginseng) and Tianma (Gastrodia elata) blended with organic produce. This is complemented by the “Wellness Food Festival” to enhance brand promotion. In summer and autumn, we create the “Cooling Dai Flavor Market” using tropical fruits like grapes, mangoes, and pomegranates from Mile. Specialized desserts including smoothies, dried fruit preserves, and sour soups are crafted alongside interactive experiences like “Fruit Picking + DIY Cooking” activities, seamlessly integrating culinary enjoyment with agricultural exploration.
Cross-border business integration	Climate + studies	The “Climate and Ecology” themed educational base has been established, featuring a “Climate Detective” research program where students and families use mini weather monitoring devices to collect real-time data on temperature, humidity, wind patterns, and other meteorological parameters at scenic areas. Guided by professional instructors explaining how climatic factors shape Mile’s landscape formation and agricultural development, participants complete hands-on projects like creating “My Mile Climate Report”. This innovative approach seamlessly integrates science education with practical learning experiences.
Marketing and facility upgrades	Off-peak marketing	The “Mile Climate Experience Officer” initiative targets off-seasons like January and September when the climate is ideal but tourism demand remains low. By recruiting tourists to stay free of charge at unique accommodations such as hot spring homestays and stargazing tents, the program encourages participants to share their “comfortable travel experiences during Mile’s off-season” through social platforms like short videos and Xiaohongshu (a popular Chinese social media app). This initiative aims to break down the market’s preconceived notion of “seasonal tourism limitations” and achieve a balanced seasonal distribution of tourist flows.
	Climate adaptation and transformation of infrastructure	To combat summer heat, the scenic area has installed solar-powered cooling pavilions at strategic locations. These systems utilize solar energy to power mini fans and mist sprays, creating refreshing rest areas for visitors. For winter conditions, a “Warm Light Art Gallery” features insulated structures with built-in heaters that regulate temperature. This innovative space showcases seasonal floral displays and cultural exhibits, offering comfortable stays while enhancing visitor experiences across seasons.

6. Conclusion

1) Mile City demonstrates excellent overall climate suitability for tourism, with no months unsuitable for travel throughout the year. From a temporal perspective, both THI and Wind Effect Index (K) show a trend of first increasing then decreasing annually. This reflects a gradual warming followed by cooling in Mile City's climate from the start of the year. However, the annual range of THI remains relatively small, indicating minimal interannual variation in its tourism climate comfort. The most suitable travel months are concentrated at the beginning and end of the year, with April and October being ideal for tourism. During these periods, temperature, humidity, and wind effect work synergistically—optimal temperatures, favorable wind speeds for heat dissipation, and ample sunshine. January, February, March, May, and September also make for pleasant travel conditions, as wind effect during winter months enhances comfort, while transitional seasons balance temperature, humidity, and wind effects to optimize travel experiences. June, July, and August are generally suitable for tourism, though higher summer temperatures and humidity may cause slight heat perception (with June showing the largest gap at just 1.2%). In conclusion, Mile City is well-suited for implementing year-round tourism programs, given its excellent climatic resources.

2) All meteorological factors examined in this study significantly influence Mile City's tourism climate comfort. The analysis reveals distinct priority rankings: Temperature emerges as the primary determinant, directly shaping perceived body temperature levels that critically affect comfort perception. High relative humidity intensifies thermal discomfort, lowering comfort thresholds. Precipitation disrupts outdoor tourism activities, substantially constraining travel experience quality. While wind speed and sunshine duration have limited impact, they remain essential variables in climate comfort evaluation systems. Evaporation's influence remains minimal. When developing tourism itineraries and designing products, comprehensive multi-factor evaluation frameworks should prioritize temperature, relative humidity, and precipitation—the three core elements that most significantly shape climate comfort—to enhance planning precision and scientific validity.

7. Discussion

As solar duration data is classified as confidential information, the sunshine hours used in this study in Mile City were calculated by formula [(4-2) - (4-8)] from 4.2.

Statistical analysis confirmed a significant negative correlation between the adjustment coefficient (k) and relative humidity (RH). During the lowest relative humidity period from March to April, the coefficient peaked at 0.92; however, it dropped to 0.70 - 0.71 during the highest humidity period from July to August. This result perfectly aligns with theoretical model predictions and strongly corresponds to the distinct dry-wet season characteristics in Mile City's climate. 2. Annual Total Solar Duration Verification: The model calculated an annual total solar duration of 2098.6 hours, differing from the target value of 2100 hours by merely

0.07 percentage points. This fully demonstrates the model's outstanding performance in computational accuracy and reliability.

While the relative humidity-based sunshine duration calculation method developed in this study demonstrates high accuracy in Mile City, it still has certain limitations. Firstly, the model solely relies on relative humidity as the core attenuation factor, without explicitly considering key meteorological elements such as cloud cover and aerosol concentration, which may weaken its universality under complex weather conditions. Secondly, the model's regional adaptability requires verification, as its parameters (e.g., linear relationship coefficients) may need adjustment in different climate zones (such as arid or high-altitude areas). Additionally, the terrain shading effect (e.g., mountain ranges or building obstructions) was not incorporated into the model, which may affect the calculation accuracy in local regions. Future improvements can focus on two aspects: First, developing a multi-factor integrated model by incorporating parameters such as cloud cover and precipitation days, and optimizing factor weights through machine learning algorithms (e.g., gradient-boosting decision trees) to enhance the model's overall accuracy. Second, conducting cross-climate zone comparative validation by combining remote sensing data with DEM terrain analysis techniques to clarify the model's applicability boundaries and improve its performance in complex terrain areas.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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