Journal of Geoscience and Environment Protection, 2017, 5, 11-22
http://www.scirp.org/journal/gep
ISSN Online: 2327-4344
ISSN Print: 2327-4336

Study and Analysis of Meteorological Effect on Shanghai Sheshan National Tourist Resorts in Shanghai

Yuliang Rong[1,2], Xia Zhang[3], Qianshan He[4]

[1]Songjiang Meteorological Service of Shanghai, Shanghai, China
[2]Shanghai Typhoon Institute, Shanghai, China
[3]Shanghai Meteorological Technology Services Center, Shanghai, China
[4]Minhang Meteorological Service of Shanghai, Shanghai, China
Email: axiong110@163.com

How to cite this paper: Rong, Y.L., Zhang, X. and He, Q.S. (2017) Study and Analysis of Meteorological Effect on Shanghai Sheshan National Tourist Resorts in Shanghai. *Journal of Geoscience and Environment Protection*, **5**, 11-22.
https://doi.org/10.4236/gep.2017.57002

Received: April 28, 2017
Accepted: July 8, 2017
Published: July 11, 2017

Abstract

In this paper, the main meteorological disasters in the Sheshan National Tourist and Vacation Areas are analyzed by using the climate data from 1955 to 2014, such as average temperature, relative humidity, wind speed, insolation duration. The influences of meteorological parameters on this area are studied with the climate comfort evaluation and meteorological disaster climate trend. It is found that the major meteorological disasters in this area including fog, typhoon, storm, wind, thunderstorms and high temperature, were occurred in different periods with higher frequency from May to October. Nineteen comfortable ten-day periods in a year are suitable for tourist activities, during March and May, late September and the end of December. And seventeen ten-day periods in a year are not suitable for tourist activities, from January to February and from June to the middle of September. Some suggestions for tourism weather service on the basis of these results are listed in the conclusion.

Keywords

Tourism Weather, Climate Comfort, Meteorological Disasters

1. Introduction

Weather and climate are directly or indirectly related with tourism activities. Tourism activities are conducted in certain weather or climate environment, and the selection of proper weather and climate is one of the important motivations for traveling [1]. The comfort and duration of tourism climate have an impact on tourist project development, operational decisions and seasonal duration, for example, ecological tourism on mountains, leisure tourism on islands, river drifting, ski tourism and so on are often affected by climate changes [2]. Meanwhile, unexpected meteorological disaster during tourism tends to hinder normal tourism activities or cause losses to tourism industry [3] [4]. Scholars at home and abroad conducted studies on weather, climate and tourism and achieved a number of results. In 1966, W. H. Terjung proposed the concept and classification scheme of climate comfort index [5]. Wall believed that the ski resorts located at Georgia Canyon, Ontario, Canada might disappear due to climate changes [6]. The study conducted by Coombes indicated that with the rise in air temperature, the demand for tourism in the littoral areas would increase [7]. Ma Lijun, *et al.* analyzed the spatial and temporal distribution of tourism comfort in Shaanxi Province and divided tourism comfort periods by establishing tourism climate comfort index [8]. Wang Jinlian, *et al.* combined the characteristics of tourism meteorological disaster in Huangshan Mountain Scenic Spotto built the meteorological disaster prevention system for tourism in scenic spots [9].

As the only natural mountain resorts in Shanghai, Songjiang Sheshan National Tourist Resorts (referred to as "resorts") possess their special weather and climate features. This paper utilized the statistical data of Songjiang District for 60 years to assess the climate comfort of the resorts on the scale of every ten days in each month and conducted statistical analysis on the tourism meteorological disaster in the resorts. It is of great significance in enhancing local tourism meteorological service capability, achieving sustainable development of tourism, protecting tourism resources and life and property safety as well as promoting the meteorological tourism service level of Shanghai as an international metropolis.

2. Overview of Study Area

2.1. Overview of Tourism Resource

The resorts (121˚49'E, 31˚05'N) is located in Northwestern Songjiang District in the southwestern Shanghai, with a planning area of 64.08 square kilometers and a core area of 10.88 square kilometers. The famous Sheshan national forest park is located in the resorts, including 12 peaks such as Eastern and Western Sheshan Hills, Tianma Hill, Fenghuang Hill and Small Kunshan Hill. In addition, the resorts consist of more than 20 tourist attractions and entertainment venues, e.g. Happy Valley Shanghai, Chenshan Botanical Garden, Tianma Circuit, Sheshan Film & Television Base and Guangfulin Cultural Site. Among the tourist attractions and entertainment venues, there are four 4A national scenic spots, two high-standard international golf clubs, one international circuit and four star-rated hotels. See Table 1 for details.

2.2. Overview of Climate

The resorts is located in the Yangtze River Delta Plain and the bottom of Taihu

Table 1. Main scenic spots in holiday resorts.

Type	Name	Festivals & Events
Ecology & Humanity	Sheshan National Forest Park (4A)	Cuisine & Culture Festival of Bamboo Shoots, Catholic Pilgrims, Forest Tour Festival, Mountaineering in the Double Ninth Festival
Leisure & Entertainment	Shanghai Sculpture Park (4A) Happy Valley Shanghai (4A) Playa Maya	Summer Carnival Season, IceMusic Festival, Halloween Carnival
Popular Science Base	Chenshan Botanical Garden (4A) Shanghai Astronomical Museum Earthquake Science Museum	International Orchid Show, Lawn Music Festival
Leisure & Sports	Sheshan Golf Club Tianma Country Club Shanghai Tianma Circuit	Annual Racing

Lake Basin, which belongs to the northern subtropical monsoon region with four distinctive seasons and plentiful rain. It is hot and humid in summers, while it is cold and dry in winters. The annual average temperature is 16.2˚C, and the annual precipitation is 1168.2 mm.

3. Data and Methods

3.1. Data Resource

Located in Northwestern Songjiang District, the resorts are 4 km away from Songjiang National Meteorological Observatory. In order to guarantee the integrity and reliability of data, all data used by the research institute were the observational data of Songjiang National Meteorological Observatory from 1955 to 2014, including the factors such as average temperature, relative humidity, wind speed, sunshine duration and meteorological disaster data, etc. The data are of high accuracy and credibility.

3.2. Study Method

This study introduced the method combining climate comfort evaluation with meteorological disaster and climate trend analysis to analyze the meteorological influence on the resorts. In the climate evaluation based on the studies of Ma Lijun, *et al.* [10], wind effect index (k) is applied to replace wind chill index (WCI). In the end, tourism comfort index (C) integrating temperature-humidity index (THI), wind effect index (k) and index of cloth loading (ICL) for analysis on the resorts.

3.2.1. Temperature-Humidity Index (THI) [11]

Temperature-humidity index (THI) was proposed by a Russian scholar, which was initially known as effective temperature with the calculation formula:

$Et = Td - 0.55(1-f)(Td-58)$. Where, Td is centigrade temperature. Through the integration of temperature and humidity, temperature-humidity index reflects the heat exchange between human body and ambient environment. When the Fahrenheit temperature is converted to centigrade temperature, the calculation formula is as follows:

$$\mathrm{THI} = (1.8t+32) - 0.55(1-f)(1.8t-26) \tag{1}$$

where, t is Celsius temperature (˚C) and f is relative humidity (%). On the basis of extensive experiments, it can be divided into 9 grades as per the size of temperature-humidity index value (shown in Table 2).

3.2.2. Wind Effect Index (k) [12]

Wind effect index (k) was evolved from wind chill index. $\mathrm{WCI} = (33-t)(9.0+10.9\sqrt{V}-V)$. Wind effect index takes heat dissipation of body surface and heat gain of human body after solar radiation into consideration. It reflects the heat exchange between body surface and ambient environment, *i.e.* heat exchange rate per unit area of body surface (positive value represents heat absorption and negative value represents heat dissipation). Its calculation formula is as follows:

$$K = -(10\sqrt{V}+10.45-V)(33-t)+8.55S \tag{2}$$

where, t is Celsius temperature (˚C), V is wind speed (m/s), and S is sunshine duration (h/d). It can be divided into 9 grades as per the size of wind effect index value (shown in Table 2).

3.2.3. Index of Cloth Loading (ICL) [13]

Index of cloth loading (ICL) was proposed by an Australian scholar named Freitas. He considered the fact that people changed uncomfortableness brought

Table 2. The classification of THI, K and ICL.

THI		K		ICL			Level
Range	Human Sense	Range	Human Sense	Range	Dressing	Level	Assignment
<40	Extremely Cold	≤−1000	Extremely Cold and Windy	>2.5	Woolen Sweater	e	1
40 - 45	Cold	−1000 - −800	Cold and Windy	1.8 - 2.5	Thick Outwear	d	3
45 - 55	Slightly Cold	−800 - −600	Slightly Cold and Windy	1.5 - 1.8	Common Winter Dress	c	5
55 - 60	Cool	−600 - −300	Cool and Windy	1.3 - 1.5	Winter Jacket or Bunting	b	7
60 - 65	Pleasantly Cool	−300 - −200	Comfortable and windy	0.7 - 1.3	Casual Shirt	A	9
65 - 70	Warm	−200 - −50	Warm and Windy	0.5 - 0.7	Summer Wear	B	7
70 - 75	Slightly Hot	−50 - 80	Slightly Hot and Windy	0.3 - 0.5	Short-sleeved Cardigan	C	5
75 - 80	Muggy	80 - 160	Hot and Windy	0.1 - 0.3	Frivolous and Breathable Dress	D	3
>80	Extremely Muggy	≥160	Extremely Hot and Windy	<0.1	Mini-skirt or Walking Shorts	E	1

by climate through wearing different clothes. This model is broadly used in practical studies. Its calculation formula is as follows:

$$\text{ICL} = (33 - t)/0.155H - (H + aR\cos\alpha)\Big/\left(0.62 + 19.0\sqrt{V}\right)H \tag{3}$$

where, t is Celsius temperature (˚C); H represents 75% of metabolic rate of human body, and its unit is W/m^2. This study took the metabolic rate under light activity content, so H = 87 W/m^2; a represents the solar radiation absorption by human body, and here it took 0.06; R represents the solar radiation received by land per unit area in the vertical sunlight, and its unit is W/m^2; a is solar elevation angle. The average condition was taken and the latitude was set as β. The solar elevation angle of different regions in summer is 90 − β + 23˚26', the solar elevation angle of different regions in winter is 90 − β − 23˚26' and the solar elevation angle of different regions in spring and autumn is 90 − β; V is wind speed (m/s). On the basis of extensive experiments, it can be divided into 9 grades as per the size of cloth loading index value (shown in Table 2).

3.2.4. Comprehensive Tourism Comfort Index (C) [10]

Climate is a complex system, including solar radiation, atmospheric temperature, atmospheric humidity, wind speed and other climate factors. According to the studies made by Ma Lijun, *et al.*, based on temperature-humidity index, wind effect index and index of cloth loading, and according to the actual conditions of the local area, the feelings of tourist towards temperature-humidity index, wind effect index and index of cloth loading could be determined and divided into 5 different comfort grades, namely most comfortable, comfortable, relatively uncomfortable, uncomfortable and extremely uncomfortable, using 9, 7, 5, 3 & 1 for quantitative calibration. The three tourism climate comfort grading standards, namely temperature-humidity index, wind effect index and index of cloth loading as well as body feeling, grade symbols and assigned value for rating are shown in Table 2. On this basis, marking by experts can be adopted to determine the weights of sub-indexes and establish a new comprehensive evaluation model for tourism climate comfort. Its calculation formula is as follows:

$$C = 0.6X_{\text{THI}} + 0.3X_K + 0.1X_{\text{ICL}} \tag{4}$$

where, C is tourism comfort index; X_{THI}, X_K and X_{ICL} are grading assigned values of temperature-humidity index, wind effect index and index of cloth loading; 0.6, 0.3 & 0.1 are eight coefficients of sub-indexes. The tourism comfort index can be divided into four grades (see Table 3).

Table 3. The classification of climate comfort index.

Level	Range
Comfortable	$6 \le C \le 9$
relatively comfortable	$5 \le C < 6$
relatively uncomfortable	$3 < C < 5$
uncomfortable	$1 \le C \le 3$

4. Results and Analysis

4.1. Analysis on Climatic Comfort Degree for Tourism

Temperature-humidity index, wind effect index and index of cloth loading were separately calculated according to Formula (1), (2) and (3), corresponding to respective grade symbols and assigned values. And then Formula (4) was applied to calculate tourism comfort index C within a year on a ten-day scale. See Table 4 for results. It could be seen that the comfort index of 10 periods of every ten days in each month in Sheshan National Tourist Resorts was ≥6, corresponding to the comfortable level; the comfort index of 9 periods of every ten days in each month reached relatively comfortable level; the comfort index of 9 periods of every ten days in each month was relatively uncomfortable level; the comfort index of 8 periods of every ten days in each month was uncomfortable level. Therefore, there was comfortable climate in the period of 19 periods of every ten days in each month all year round, which was suitable for tourism activities. It could be seen from Figure 1 that the tourism comfort of the resorts throughout the year took on the shape of "M". The lower comfort in cold weather in January and February was unsuitable for tourism activities; comfortable climate from March to May was suitable for travelling; the temperature rise in early and mid-June lowered comfort; with the further rise in temperature, solar radiation and humidity enhanced from late June to Mid-September, and the comfort decreased to the uncomfortable level, which was unsuitable for tourism activities; From late September, the clear and refreshing weather in the resorts would last till late December, and the higher comfort was suitable for tourism activities.

4.2. Characteristics of Major Meteorological Disaster for Tourism

According to the statistical data from 1955-2014, meteorological disasters nearly appeared every year. The main tourism meteorological disasters in the resorts included heavy fog, typhoon, rainstorm, gale, thunderstorm and high temperature.

Table 4. The monthly variation of climate comfort index.

time	early		mid		late	
Jan	dbc	4.4	dbd	4.2	dbd	4.2
Feb	dbd	4.2	dbc	4.4	dbc	4.4
Mar	cAc	6.2	cAb	6.4	cBb	5.8
Apr	bBA	7.2	bCA	6.6	ACA	7.8
May	ADA	7.2	BEA	5.4	BEA	5.4
Jun	CEB	4.0	CEC	3.8	DEC	2.6
Jul	DED	2.4	EEE	1.0	EEE	1.0
Aug	EEE	1.0	DED	2.4	DED	2.4
Sep	DEC	2.6	CEB	4.0	BEB	5.2
Oct	BDA	6.0	ADA	7.2	ADA	7.2
Nov	bCb	6.4	cBb	5.6	cBc	5.6
Dec	cBb	5.8	dAc	5.0	dAc	5.0

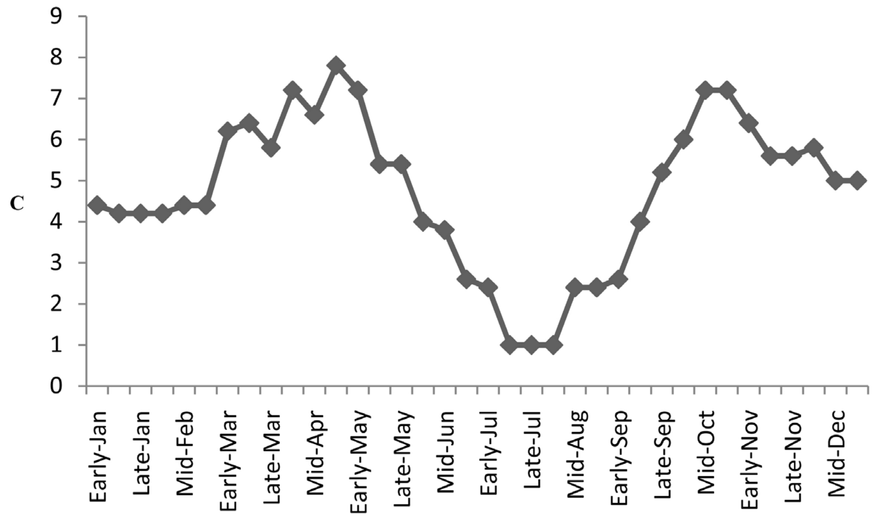

Figure 1. The ten-day variation of climate comfort index.

All meteorological disasters had different timeframe (see **Table 5**), which mainly occurred from May to October. It could be seen from **Figure 2**, the occurrence of heavy fog was most frequent, and thunderstorm the second. These disasters will cause great harm to tourism environment, tourism facilities as well as lives and properties of tourists.

4.2.1. Climatic Feature of Heavy Fog

Heavy fog meteorologically refers to a kind of weather phenomenon that plenty of water droplet floating in the air, often in milk white results in horizontal visibility less than 1000 m. Located in the eastern coastal region, the resorts is the wooded hill in the city with a large relative humidity in the air, which is a place prone to heavy fog. According to the statistical data, the number of annual average foggy days was up to 30 days. It could be seen that fog appeared each month throughout the year, mostly in October-April. The influence of heavy fog on tourism is poor visibility and threat to the safety of trips and tourism trails. Meanwhile, heavy fog also has an impact on normal tourism activities. For instance, the heavy fog on 3 January, 1999 caused a traffic accident of rear-end collision of 6 cars on Shanghai-Hangzhou Expressway, one of the main roads near the scenic spot, and a person was injured. On 20-21 January, 2003, heavy fog lasted in Shanghai. The visibility in Songjiang District was only 50 meters, so all the expressways were closed till 11 o'clock at noon.

4.2.2. Climatic Feature of Thunderstorm

Thunderstorm refers to the electric discharge phenomena generated in cumulonimbus clouds or between clouds or between clouds and ground. According to the observational statistic data from 1955-2014, thunderstorm was likely to occur each month throughout the year, mostly from early summer till early autumn, namely from June to September. The number of annual average thunderstorm days was 24 days. The maximum number of thunderstorm days was 45 days (in 1956) while the minimum number was 1 day (1971 and 1978). Thun-

Table 5. The influence period of different meteorological disasters.

Disaster names	Heavy fog	Thunderstorm	Gale	High temperature	Rainstorm	Typhoon
Influence period	Full yea	Jun to Sep	Full year	May to Sep	Jun to Sep	May to Oct

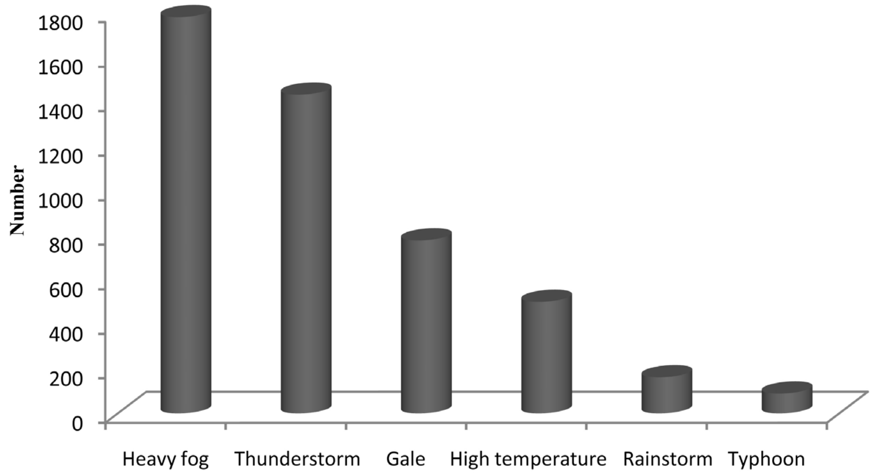

Figure 2. The frequency distribution of main meteorological disasters.

derstorm days mainly concentrated in June and August in which the average number was respectively 7 days 6 days. But the average number of thunderstorm days was less than one day from October to February. The first thunderstorm day in each year occurred on 24 March on average, and the earliest first thunderstorm day was 12 January (1966) while the latest was 18 July (1970). The final thunderstorm day in each year occurred on 21 September on average, and the earliest final thunderstorm day was 3 June (1971) while the latest was 19 December (1979). Thunderstorm had obvious daily variation. Thunderstorm mainly occurred at 15 - 17 o'clock and least in 6 - 10 o'clock in a day. The tourism projects and attractions in the resorts are mostly located in wooden hill and open grassland. Scenic spots and recreation facilities are principally exposed. Some facilities are even equipped with metal handrails. In addition, under the influence of terrain, thunderstorm or gale weather often occurred in the scenic region, posing a large threat to tourism facilities and lives and properties of tourists. For example, a house near the scenic region was struck by lightning on 23 June, 2001, resulting in 11 people injured and 3 severely injured. On 29 August, 2003, thunderstorm occurred in the scenic region where a 800-year-old gingko tree was broken by lightning, resulting in heavy losses.

4.2.3. Climatic Feature of Gale

Any wind at an instantaneous wind speed of 17.0 m/s or above is meteorologically known as gale. According to the observational statistic data gale was likely to occur all the year round. Gale together with other disastrous weather (e.g. thunderstorm, snowstorm, hail, rainstorm, etc.) invaded and results in more damage. The number of average gale days was 13 days, and the maximum number of gale days was 61 days (1963) and the least was zero (1989, 1993 and 2003). From the perspective of interannual variance, the mid 1960s could be deemed as a divide. There were more gale days before that time, but gales occurred less and less after that time. Particularly, there were few gale days in the 1990s, which might be related to the urbanization effect near the observation station. Gale has a negative impact on the vehicle driving and the safe operation of the special entertainment equipments and the scenic region as well as the safety of tourists and trees. For instance, on 2 July 2008, influenced by severe convection weather, strong wind of 10 level occurred in the scenic region, resulting in fallen trees and damaged houses in different degree. Therefore, the scenic region was closed for some time and the tourism income was sharply decreased.

4.2.4. Climatic Feature of High Temperature

The day with daily maximum temperature ≥35˚C is meteorologically known as a high temperature day. It could be seen from Figure 3 that the overall variation trend of the number of high temperature days in Songjiang District was concave-down. The year 1980 was a demarcation point, and the number of annual high temperature days in 1980-2014 showed an apparent increasing tendency. The number of annual average high temperature days was 8 days. The earliest high temperature day occurred on 20 May (1963) while the latest occurred on 21 September (2005). The maximum number of high temperature days was up to 42 days (2013), while there was no high temperature occurred respectively in 1968, 1972 and 1999. The high temperature days were mainly distributed in July and August, and there were maximum high temperature days in July, accounting for nearly 60% of the total number of high temperature days. High temperature

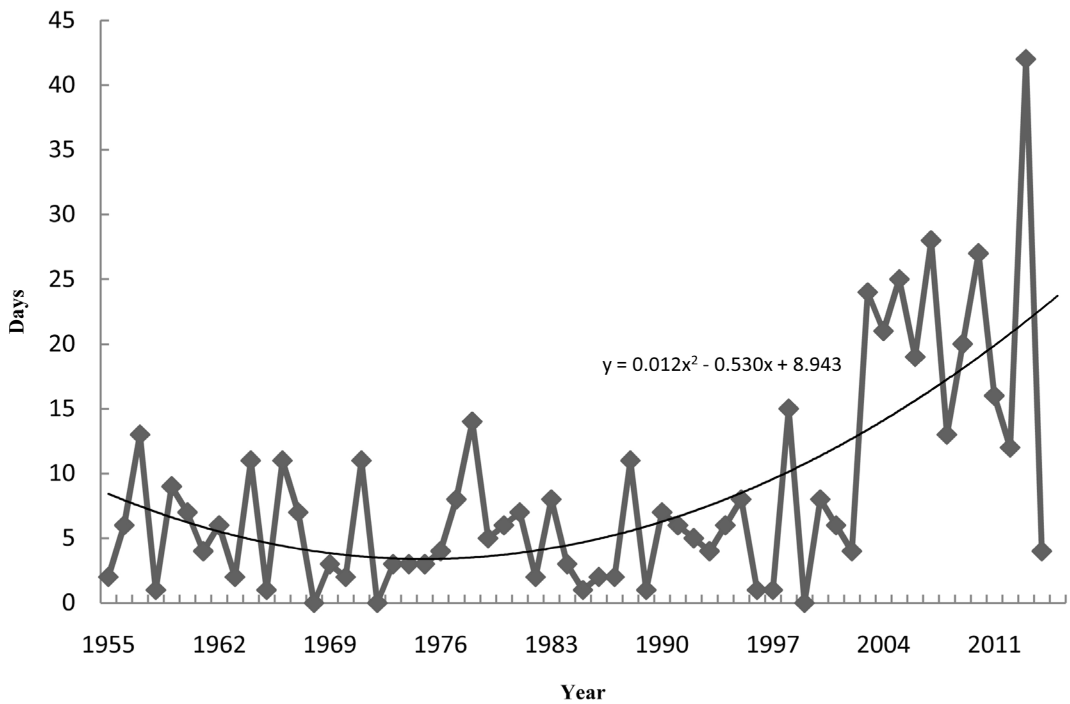

Figure 3. Monthly variations of high temperature averaged from 1955 to 2014.

lowers the comfort index in outdoor activities, and the number of tourists was influenced. For example, in 2013, the number of days with a temperature ≥35.0˚C was up to 24 days while the number of days with a temperature ≥37.0˚C was 26 days. The extreme maximum temperature broke the historic record and reaches 41.2˚C. According to the data from tourism sector, the total number of tourists in July and August decreased by almost 30% compared with a year earlier, resulting in a greater impact on tourism income.

4.2.5. Climatic Feature of Rainstorm

The heavy rainfall with 24-hour precipitation of 50 mm or above was meteorologically known as rainstorm. According to the statistical data, the number of annual average rainstorm days was 3 days, and the maximum number of rainstorm days was 10 days (1999) and there was no rainstorm in some years. Rainstorm usually occurred from mid-June to mid-July and from mid-August to early September. There was generally no rainstorm from late November to mid-March. Rainstorm principally floods or destroys roads, affects traffic and does harm to life and property safety of tourists. Secondly, rainstorm tends to trigger meteorological derived disasters such as flood, landslide or debris flow, harming life and property safety of tourists. For instance, influenced by Meiyu Front, rainstorm occurred in the scenic region on 18 June 2011. The daily precipitation reached 127.5 mm, resulting in partial landslide. Influenced by Typhoon Fitow, the storm precipitation in the scenic region exceeded 300 mm on 2 - 8 October 2013, resulting in the destroy of partial roads up the hill by rush of water and seriously impacting the normal operation of the scenic spot.

4.2.6. Climatic Feature of Typhoon

According to the statistical data, there were 89 typhoons affecting Songjiang District. The number of annual average typhoon was 1.5, and the maximum number of typhoon was 4 and the least was 0. There were 70 typhoons accompanied by strong wind of 8 levels and above, accounting for 86% of the total number; there were 40 typhoons accompanied by rainstorm, accounting for 49% of the total number; there were 35 typhoons affecting wind and rain, accounting for 43% of the total number. The typhoons affecting Songjiang basically occurred from May to October. The maximum number of typhoons occurred in July, August and September, accounting for 87% of the numbers of typhoons throughout the year, particularly in August, accounting for 38% of the numbers of typhoons throughout the year. Typhoon often brings wind and rain, which has a negative impact on the vehicle driving, the safe operation of the scenic spot and the safety of tourists. For example, influenced by Typhoon Haikui, the storm precipitation in the scenic region reached 100 mm on 7 - 9 August 2012. Strong wind of Level 9 - 10 blew, resulting in damaged houses in different degree and fallen trees.

5. Discussion and Conclusion

This study utilized the climatological data from 1955-2014 to analyze the meteorological influence of tourism climate comfort and tourism meteorological disaster on the resorts. It is of great significance in enrichment of tourism meteorological service products, improvement of refined meteorological service level, promotion of technological content in meteorological service and implementation of meteorological disaster prevention and reduction. The major results are as follows:

1) The main tourism meteorological disasters in the resorts include heavy fog, typhoon, rainstorm, gale, thunderstorm and high temperature. All meteorological disasters have different timeframe, which mainly occurred from May to October. In order to conduct tourism meteorological disaster prevention, the meteorological authority needs to enhance and improve tourism meteorological monitoring and early warning capabilities, promote the scientific and technical support for tourism meteorological operation, strengthen cross-sectoral interaction, improve meteorological prevention mechanism, emphasize on popular science propaganda and facilitate sustainable development of tourism.

2) The comfortable climate occurs in the resorts in 19 periods of every ten days in each month all the year round, which was suitable for tourism activities. The timeframe of comfortable climate was distributed in March-May and mid-September to late December. Among the above timeframe, although comfortable climate appears from late September to late December, which is a reason prone to haze, the meteorological authority needs to make monitoring and early warning of haze and hint air quality. There are totally 17 periods of every ten days in each month unsuitable for tourism activities in January and February and from June to mid-September. The cold weather in January and February lowers comfort, which is unsuitable for travelling. The hot weather from June to mid-September also lowers comfort, but this season is suitable for launching aquatic sports. For these reasons, the meteorological authority shall cooperate with the tourism sector to give a reminder of appropriate projects when it provides comfort product service at the same time.

3) There are much more meteorological factors affecting tourism comfort, e.g. rainfall and sudden meteorological disasters. Thus the meteorological authority shall strengthen the weather forecast accuracy and monitoring and early warning of meteorological disasters when it provides comfort service at the same time.

References

[1] Wu, Z.-W. (2001) Climatology of Tourism. China Meteorological Press, Beijing, 30-31.

[2] Ma, L.J., Sun, G.N., Li, L.F., *et al*. (2008) Correlative Analysis of Climate Comfort and Monthly Variation of Tourists in Haikou City. *Resources Science*, **30**, 1754-1759.

[3] Ma, L.J., Sun, G.N., Li, L.F., *et al*. (2010) A Study on the Influence of Extreme Weather and Climate on Tourism: A Case on Snowstorm in 2008. *Resources Science*, **32**, 107-112.

[4] Li, F. (2009) A Comparative Study on the Effect of Tourism Crisis Events with Dif-

ferent Nature Based on Background Line: A Case Study of Four Tourism Crisis Events in China. *Tourism Tribune*, **24**, 73-78.

[5] Terjung, W.H. (1966) Physiologic Climates of the Contentious United States: A Bioclimatic Classification Based on Man. *Annals of the Association of American Geographers*, **5**, 141-179. https://doi.org/10.1111/j.1467-8306.1966.tb00549.x

[6] Wall, G. (1998) Implications of Global Climate Change for Tourism and Recreation in Wetland Areas. *Climate Change*, **40**, 371-389. https://doi.org/10.1023/A:1005493625658

[7] Coombes, E.G. and Jones, A.P. (2010) Assessing the Impact of Climate Change on Visitor Behavior and Habitat Use at the Coast: A UK Case Study. *Global Environmental Change*, **20**, 303-313. https://doi.org/10.1016/j.gloenvcha.2009.12.004

[8] Ma, L.J., Sun, G.N., Li, F.L., *et al.* (2007) Evaluation of Tourism Climate Comfortableness in Shanxi Province. *Resources Science*, **29**, 40-44.

[9] Wang, J.L., Hu, S.F., Liu, A.P., *et al.* (2014) The Tourism Meteorological Disasters System in Huangshan Scenic Area: A Case Study of Lighting Monitoring and Early Warning System. *Scientia Geographica Sinica*, **34**, 60-66.

[10] Ma, L.J., Sun, G.N., Wang, J.J., *et al.* (2009) Evaluation of Tourism Climate Comfortableness of Coastal Cities in the Eastern China. *Progress in Geography*, **28**, 713-722.

[11] Liu, Q.C., Wang, Z. and Xu, S.Y. (2007) Climate Suitability Index for City Tourism in China. *Resources Science*, **29**, 133-141.

[12] Fan, Y.-Z. and Guo, L.-X. (1998) The Climate Suitability of Tourism at the Coastline Destinations of China. *Journal of Natural Resources*, **13**, 306-311.

[13] De Freitas, C. (1979) Human Climates of Northern China. *Atmospheric Environment*, **13**, 71-77. https://doi.org/10.1016/0004-6981(79)90246-4