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Climate-Comfortable Period Dataset in Mainland of China (1961−2010)

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Abstract: Climate-comfortable period (CCP) is a temporal index that evaluates the climate based on human thermal comfort. Climate-comfortable information is of significance for architectural designs, public health, tourism developments, and others. Based on daily meteorological data from 775 basic weather stations in mainland China from 1961 to 2010 provided by the China Meteorological Science Data Sharing Service Network, this study used the Temperature Humidity Index (THI) and Wind Effect Index (WEI) modified to fit the representative climatic comfort in mainland of China since the 1960s. The dataset included: (1) the annual average CCP in the provinces (1961-2010); (2) the annual average CCP of 341 prefecture-level cities (1961-2010); (3) the annual average CCP of 775 sites (1961-2010), and the variations between them from 1961-1985 to 1986-2010. The data were stored in Excel format with a volume of 87.5 KB after compression.

Keywords: **climatic comfort; human thermal comfort; weather comfortable; wind effect index; temperature humidity index; tourism climatology**

1 Introduction

Climatic comfort is a bioclimatic indicator that reflects the consciousness of the body's satisfaction with the thermal environment and is a measure of people's level of physical comfort or discomfort within different meteorological environments[1]. It is an important factor that influences human activities and environments[2–4]. Differences in climatic comfort directly influence the length of the regional climate-comfortable period (CCP) as well as seasonal changes thereof. These changes are of substantial significance to architectural design[5–6] and public health[7–8], especially to the pattern of seasonal tourist flows[9–10] as well as the development of vacation destinations[11–12]. Over the past century, the existence of global

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warming has achieved indisputable scientific consensus[13–16] and differential regional responses[13, 17]. In particular, China occupies a vast territory with diverse geographical features; therefore, the impacts of climate change on the different regions and fields are varied [18–19]. The dataset started from the CCP, and analysis of its spatial patterns and evolving characteristics can improve basic understanding of human-environment interaction related to global climate change. It can also be helpful for providing scientific understanding of human settlements construction and human activity adaptation.

2 Metadata of Dataset

The CCP metadata for mainland China from 1961 to 2010[20] is summarized in Table 1. It includes the dataset's full name, short name, authors, year, spatiotemporal resolution, as well as data format, size, files, publisher, and sharing policy, etc.

Table 1 Metadata summary of the climate-comfortable period dataset for Mainland China (1961–2010)

Items	Description
Dataset full name	Climate-Comfortable Period Dataset in Mainland of China (1961–2010)[21]
Dataset short name	CCP_China_1961-2010
Authors	Zhang, W. J. M-7497-2017, Population Research Institute，East China Normal University, wjzhang2017@hotmail.com Li, S. M-6399-2017, School of Geographic Sciences, East China Normal University, sli@geo.ecnu.edu.cn Tan, L. E-9388-2018, Nanjing Institute of Geography & Limnology, Chinese Academy of Sciences, ltan@niglas.ac.cn Sun, M. S. F-2032-2018, School of Geographic Sciences, East China Normal University, meishu00706@163.com
Geographical region	Mainland China
Year	1961–2010
Temporal resolution	Season
Spatial resolution	1 km×1 km
Data format	.xlsx
Data size	87.5 KB
Data files	(1) the annual average CCP in the provinces (1961-2010); (2) the annual average CCP of 341 prefecture-level cities (1961-2010); (3) the annual average CCP of 775 sites (1961-2010), and the variations between them from 1961–1985 to 1986-2010
Foundation(s)	Ministry of Science and Techonlogy of P. R. China (2012CB955803); National Social Science Foundation of China (12AJY008)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing, 100101, China
Data sharing policy	Data from the Global Change Research Data Publishing & Repository includes metadata, datasets (data products), and publications (in this case, in the Journal of Global Change Data & Discovery). Data sharing policy includes: (1) Data are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use Data subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute Data subject to written permission from the GCdataPR Editorial Office and the issuance of a Data redistribution license, and; (4) If Data are used to compile new datasets, the 'ten per cent principal' should be followed such that Data records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset [22]

3 Methods

3.1 Data sources

Daily data from 824 basic meteorological stations in mainland China collected from 1951 to 2010 was provided by the China Meteorological Science Data Sharing Service Network. Two stations were deleted because one only provided seasonal observations and the other lacked sunshine hours. In order to protect the continuity and integrity of the data, this study chose data from 1961 to 2010, and 775 stations that were built before 1961 were selected in this study.

3.2 Algorithm

Generally, most CCP studies use month-scale data. However, this scale is too long to precisely chart the intra- or inter- regional differences, especially those related to global climate change. This study chose to use day-scale data for better precision than the month-scale data used in previous studies. The comfort levels were evaluated using the Temperature Humidity Index (THI) and the Wind Effect Index (WEI), while the evaluation standards were modified.

$$\mathrm{THI} = t - 0.55(1 - 0.01\mathrm{RH})(t - 14.5) \tag{1}$$

$$\mathrm{WEI} = -(10\sqrt{v} + 10.45 - v)(33 - t) + (200 * S)/D \tag{2}$$

In the equations, t is the temperature (°C), RH is the relative humidity (%), v is the wind speed (m/s), S is the sunshine hours (h), and D is the day length (h). Based on daily data from 775 weather stations from 1961 to 2010 (Table 2), the number of combined comfortable days accounted for 70.2% in the single model WEI and 76.5% in the single model THI. This result shows that the two indices are consistent with each other when used to define the comfortable level.

Table 2 Model combination of the THI and WEI for evaluating the CCP in China

Index	Comfort threshold	Comfort sample numbers		Ratio
		Combined model	Single model	
THI, ℃	[16.0，24.0）	3,321,690	4,342,437	76.5%
WEI, kcal/m^2·h	[-300，-50）		4,731,446	70.2%

Note: The number of samples was calculated based on daily meteorological data from 775 basic stations in mainland China from 1961 to 2010.

ArcGIS was used to identify the Tyson polygons at each meteorological site, and at the country and province scales, respectively. According to the size of the Tyson polygonal area, each station was given a corresponding weight to obtain a more stable and reasonable weighted average of the CCP across the country and the provinces.

3.3 Data analysis

This study used the linear tendency estimation method commonly used in meteorology and climatology to analyze the changing trends of the CCP over time. A sliding average CCP of 10 years was used for data from 1961 to 2010, and 41 corresponding sliding averages were calculated at each site (773 sites with no missing slip data in the annual, autumn, and winter, and 774 in the spring and summer). Then, a one-dimensional linear regression equation for the sliding average CCP and the corresponding time series was established (3):

$$x_i = at_i + b \qquad (i\text{=}1,2,\cdots,41) \qquad (3)$$

In the equation, x_i is the average of the CCP (days) for a station during period i, t_i is the time series corresponding to x_i, and a is the linear tendency rate (linear tendency factor), usually $a \times 10$ (days/10 years). The coefficient a can be estimated using the least-squares method; the positive or negative value represents an increasing or decreasing trend and the magnitude of the value reflects the rate of the increase or decrease. The significance of the regression coefficient a was tested by the correlation coefficient r [23]. In addition, this study also calculated the difference of the CCP (the average for 1986-2010 minus the average for 1961-1985) and conducted a cross-validation analysis with the results of the linear tendency estimation method.

4 Results and validation

4.1 Data products

(1) the annual average CCP of provinces (1961-2010) (CCP_China_1961-2010_ Tab.1); (2) the annual average CCP of 341 prefecture-level cities (1961-2010) (CCP_China_1961-2010_ Tab.2); (3) the annual average CCP of the 775 sites (1961-2010); and the changes from 1961-1985 to 1986-2010 (CCP_ China_ 1961-2010_ Tab.3). For example, the CCP of the 31 provinces (cities) in China are shown in Table 3.

Table 3 Provincial rankings of the average annual and seasonal CCP in mainland of China (1961-2010)

Province	Year		Spring		Summer		Autumn		Winter	
	CCP	Ranking	CCP	Ranking	CCP	Ranking	CCP	Ranking	CCP	Ranking
Yunnan	159.0	1	44.2	1	65.4	1	41.8	1	7.6	4
Guizhou	118.9	2	34.5	7	48.9	9	33.7	11	1.8	7
Hainan	118.1	3	28.5	13	1.2	31	32.6	14	55.9	1
Fujian	106.5	4	42.5	3	15.6	25	41.3	2	7.1	5
Guangdong	105.2	5	42.6	2	2.9	30	36.6	7	23.0	2
Guangxi	104.1	6	40.2	4	8.2	28	40.0	3	15.8	3
Chongqing	103.8	7	38.4	5	26.2	18	39.0	4	0.2	10
Shaanxi	93.1	8	21.9	21	53.1	7	18.0	22	0.0	15
Beijing	93.0	9	25.6	16	44.1	11	23.2	18	0.0	15
Liaoning	92.0	10	14.3	25	59.4	3	18.4	21	0.0	15
Shanxi	90.5	11	18.9	23	58.0	5	13.5	24	0.0	15
Zhejiang	90.4	12	33.6	8	17.3	24	38.6	5	0.9	9
Hubei	88.9	13	32.2	10	23.3	21	33.2	12	0.1	12
Jiangxi	88.0	14	35.2	6	14.8	26	35.6	8	2.3	6
Hunan	87.9	15	32.5	9	19.2	23	35.0	9	1.1	8
Tianjin	87.2	16	26.2	14	32.7	15	28.3	17	0.0	15
Henan	87.0	18	29.8	11	27.2	17	30.0	15	0.0	15
Jiangsu	86.6	19	25.7	15	26.2	19	34.6	10	0.0	15
Shanghai	86.5	20	24.2	17	23.7	20	38.4	6	0.2	10
Hebe	85.1	21	22.1	20	42.7	12	20.2	19	0.0	15
Anhui	82.9	22	29.1	12	20.5	22	33.1	13	0.1	12
Ningxia	81.2	23	14.6	24	56.7	6	9.8	25	0.0	15
Shandong	87.0	17	23.7	18	34.0	14	29.3	16	0.0	15

(*To be continued on the next page*)

(***Continued***)

Province	Year		Spring		Summer		Autumn		Winter	
	CCP	Ranking	CCP	Ranking	CCP	Ranking	CCP	Ranking	CCP	Ranking
Jilin	80.3	24	8.6	28	62.8	2	8.9	26	0.0	15
Xinjiang	79.2	25	22.5	19	40.1	13	16.6	23	0.0	15
Gansu	70.5	26	13.0	26	48.6	10	8.9	27	0.0	15
Inner Mongolia	69.9	27	9.8	27	52.8	8	7.3	28	0.0	15
Heilongjiang	68.9	28	5.4	29	58.3	4	5.2	29	0.0	15
Sichuan	68.6	29	19.3	22	29.9	16	19.2	20	0.1	12
Qinghai	12.6	30	0.3	30	11.9	27	0.4	30	0.0	15
Tibet	8.2	31	0.3	31	7.5	29	0.4	31	0.0	15

4.2 Data analysis

According to the THI (Equation 1) and WEI (Equation 2) and the corresponding comfort threshold criteria (Table 2), we calculated the average CCP in mainland China using two different weighted models (Table 4).

Table 4 Annual average CCP for mainland China from 1961 to 2010 (days)

Weighted models	CCP (days)				
	Year	Spring	Summer	Autumn	Winter
Area-weighted average	71.3	18.0	35.2	16.5	1.6
Direct average	86.0	23.4	36.3	23.2	3.1

Based on the analysis of Figures 1 and 3, the annual average CCP of 25 provinces (cities) exceeded the national average (71.3 days). Among them, Yunnan ranked first (159 days)

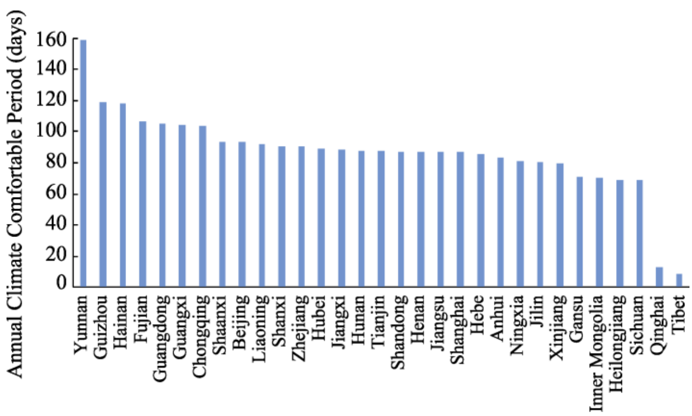

Figure 1 Annual average CCP of the Provinces (Cities) from 1961 to 2010

throughout the year, which was approximately 40 days longer than values obtained for Guizhou. Also, Yunnan occupied the highest ranking for spring, summer, and autumn, while the seasonal advantage was not obvious in Guizhou. Hainan ranked third, especially in winter (55.9 days). The climate ranked as uncomfortable in Tibet and Qinghai with 8.2 days and 12.6 days, respectively.

4.3 Data validation

Using ordinary kriging interpolation in the ArcGIS software with a grid point scale of 1 km

×1 km, the linear tendency rate and the evolution of the CCP in China can be seen in Figure 2a and Figure 2b respectively. The warmer tones (reddish) indicate increased CCP, and the colder tones (bluer) indicate reduced CCP. Both methods provided similar results and formed an interactive verification indicating that the CCP in most regions showed an increasing trend from 1961 to 2010.

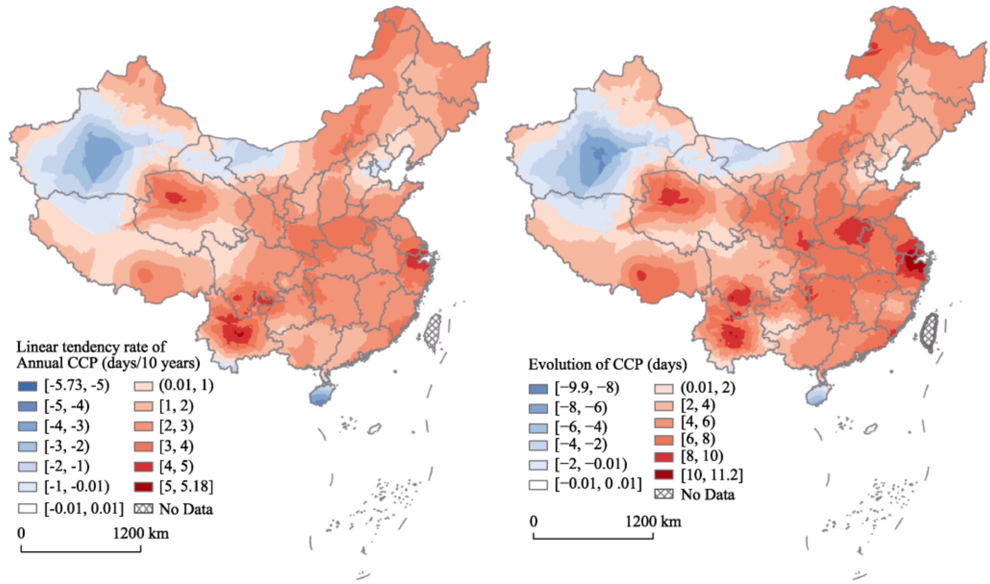

Figure 2 Spatial evolution of the annual average CCP in mainland China from 1961 to 2010.

5 Discussion and Summary

The studied dataset focused more on the characteristics of the CCP and aimed to provide a basic understanding of the relationship between humans and the land for regional responses to global climate change. Based on this basic understanding of the CCP, follow-up research can further explore its possible impact and enrich the associated research on population distribution, industrial diffusion, tourism development, and other related activities. In addition, follow-up research could further measure the "uncomfortable period" and combine the information to carry out "humanistic influence" research and enrich the associated practical topics.

Author Contributions

Li, S. made the overall design of the dataset, including setting the models and algorithms. Zhang, W. J. contributed to data processing and manuscript writing. Tan, L. was responsible for collecting the raw data and Sun, M. S. was responsible for the data screening and preprocessing.

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