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The Trend of Temperature Changes in Chongqing Under Global Warming

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Abstract:

Under the condition of global warming, the temperature in Chongqing has been continuously rising, and the forest fires in Chongqing in 2022 have attracted the attention of all sectors of society. Based on this, this article will analyze the daily temperature and sudden weather changes in Chongqing from 1982 to 2024, study the causes of the sudden temperature changes, and the ways in which they occur. This paper uses data from the past 43 years and plots to show the trend changes of temperature in Chongqing. It is found that the temperature in Chongqing rises, falls, and then rises again, and the temperature in Chongqing is compared with the climate in Sichuan. In addition, the number of days with temperatures above 28℃ over the past 43 years was analyzed, and the highest values were specifically analyzed. The factors that led to the sudden increase in temperature were identified, and the two most important ones were: the impact of urbanization and the topography of Chongqing itself. Measures for change were proposed in response. Specific measures for change can be achieved through intelligent maintenance to increase the probability of identifying problems, or by implementing carbon neutrality and carbon reduction to lower greenhouse gas emissions.

Keywords: Temperature Variability; Urban Heat Island; Climate Change Adaptation

1. Introduction

Nowadays, global warming has drawn widespread attention from society. The report of the Intergovernmental Panel on Climate Change (IPCC) shows that the global temperature is rising by 1.1℃, and all regions will face unprecedented climate change [1]. From sea level rise, frequent extreme weather events, to the rapid melting of sea ice, these changes not only affect human activities but also increase the frequency of heat waves. The current global temperature rise has also increased the risk of the climate system‘s critical value, and will cause at least half of the world‘s population to face severe water shortage for at least one month each year, while also accelerating the spread of diseases. Meanwhile, this phenomenon has hindered the increase of agricultural productivity in the middle and low latitudes, and the high tem-

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peratures in Chongqing in recent years have also drawn widespread attention from all sectors of society.

Temperature changes have a significant impact on all aspects of human life.Notably, Antarctica is the region experiencing the most rapid warming globally, while East Asia has also seen a relatively pronounced warming trend. Coastal provinces and municipalities are confronted with risks such as seawater intrusion driven by sea-level rise and flood disasters. The permafrost area is shrinking drastically due to rapid temperature increases, with over 80% of the existing permafrost projected to disappear. Against the backdrop of global warming, Chongqing has also been significantly impacted, as evidenced by the extensive attention drawn to the massive wildfires that occurred in 2022. In the wake of long-time changes,scholars have conducted in-depth research and analysis on climate change in Chongqing. Wu Hongfa employed anomaly analysis, linear trend estimation, the Mann-Kendall method, and the difference information method in the grey system theory. He selected the data from the Shapingba Meteorological Station in Chongqing from 1958 to 2007 for analysis and obtained that the temperature in Chongqing experienced a process of first cooling and then warming in the past fifty years. However, sudden temperature changes occurred in January 1977 and January 1984 [2]. Yu Yunhe and Qu Shujun employed the empirical function fitting method to analyze the long-term trend changes of temperature, and the Morlet wavelet analysis tool to analyze the periodic changes of temperature. They selected the temperature data provided by the National Climate Center from 1956 to 2005 and concluded that some months in spring, summer, and autumn showed a cooling trend, while the warming was mainly manifested in late autumn and winter [3]. Zhou Hao, Li Geng, and Cheng Bingyan selected the observation data of 34 ground meteorological observation stations in Chongqing from 1960 to 2005. They comprehensively applied methods such as linear trend estimation, variation coefficient, wavelet analysis, and M-K mutation test for analysis. They concluded that the trend has been stable with a slight increase in the past 46 years, and the multi-year average temperature is 17.5℃. They also concluded that the changes are phased and corresponding. The periodic characteristics are prominent. The above-mentioned research analyzed the temperature changes in Chongqing over the past few decades and proposed possible causes, but lacked an analysis of the temperature in Chongqing after its rapid development [4].

This article will select daily data from 1982 to 2024, a total of 43 years, and use the methods of drawing graphs and reading literature to summarize and analyze the trend of temperature changes in Chongqing and its causes. The purpose of this study is to investigate the weather changes in Chongqing over the past 43 years and the causes of the sudden changes.

2. Temperature Change

2.1

All weather data in this article were obtained from NASA POWER, with the coordinates selected as 29.57 north latitude and 106.59 east longitude [5].

A comparison of the daily temperature data between 1982 and 2024 shows that there has been a significant increase in temperature. The number of days with a temperature above 28℃ in 2024 is 64, which is far greater than the 13 days in 1982. As can be seen from Fig. 1, in 2024, the duration of high-temperature weather will be prolonged, while that of low-temperature weather will be shortened. According to the data, the temperature in Chongqing rises the most in spring and autumn.

2.2

The following study examines the number of days with temperatures above 28℃ from 1982 to 2024. The horizontal axis represents all the years from 1982 to 2024, and the vertical axis represents the total number of days with temperatures above 28℃.

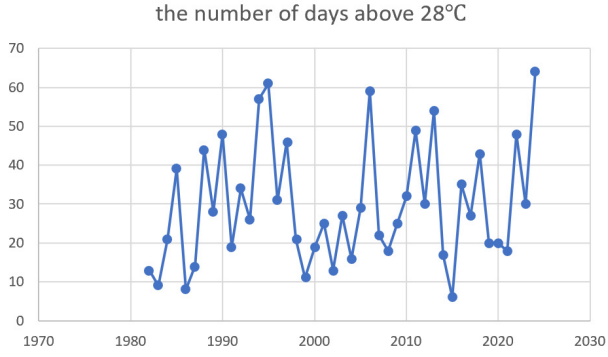

Fig. 1 The number of days above 28℃ in Chongqing (Photo/Picture credit: Original).

As can be seen from Fig. 1, before 2000, it experienced a period of rise, reached the peak, then suddenly dropped, and reached the peak again between 2000 and 2010. After that, it dropped sharply again. After several sharp fluctuations, it reached the highest number of days with a temperature above 228℃ for nearly 43 years, which was 64 days.

From this, it can be seen that the warming in Chongqing started relatively late and is not completely in step with the global trend in terms of time rhythm and extremity.

This is also closely related to the economic development and urbanization of Chongqing. Between 1990 and 2000, a strong El Niño caused the peak to be warmer.

At the same time, the subtropical high pressure is stronger and more westward, and the cold air is weaker, which leads to an increase in warm winters and high temperatures in summer, including the side effects of rapid industrial development. In 2006, a drought occurred, also due to the rise in temperature. In 2013, abnormal atmospheric circulation, combined with the terrain of Chongqing and the urban effect, led to high temperatures.

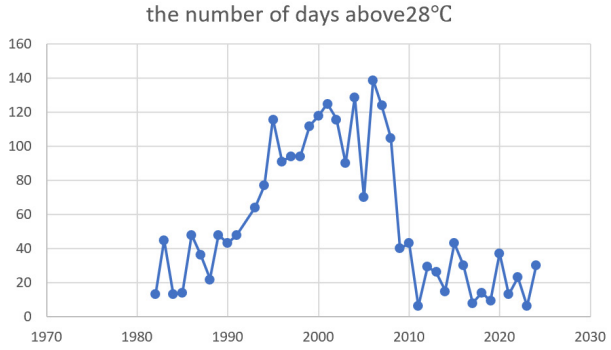

Fig. 2 The number of days above 28℃ in Sichuan (Photo/Picture credit: Original).

2.3

In Fig. 2, the horizontal axis represents the years, and the vertical axis shows the total number of days with a temperature above 28℃ each year.

Here, the data of Sichuan from 1982 to 2024 is presented for comparison with that of Chongqing. It can be seen that the trend in Sichuan was a sharp rise followed by a sharp decline. The period with the most days was concentrated from 1990 to 2010, and then it dropped sharply after that, reaching the lowest number of days in 2010.

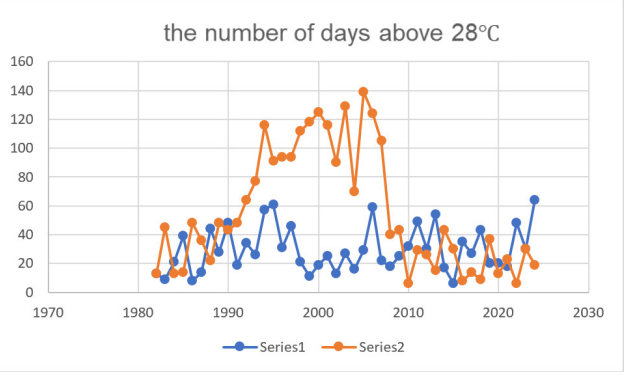

Fig. 3 A comparison between Sichuan and Chongqing (Photo/Picture credit: Original).

2.4

Fig. 3 represents Chongqing, and Series represents Sichuan. It can be seen that between 1990 and 2010, Sichuan was far larger than Chongqing. During this period, Sichuan was affected by global warming, and the temperature rose accordingly. Moreover, the relatively high sea surface temperature in the equatorial Central and Eastern Pacific has also led to an increase in temperature in Sichuan. The rise in sea surface temperature in the tropical western Pacific will cause the position of the subtropical high-pressure system to move further north, resulting in less total rainfall in the Sichuan-Chongqing region and causing the temperature in Sichuan to rise. This includes the rapid economic development of Sichuan Province, a sharp increase in the number of factories, a significant rise in the number of cars, and an increase in the content of greenhouse gases such as carbon dioxide in the atmosphere, which has led to a rise in temperature. Meanwhile, in the process of urbanization, the unreasonable use of land has led to extensive damage to the ecological environment and an increase in the urban thermal dynamic effect.

After 2010, the number of days in Chongqing has been greater than that in Sichuan, and there is still an upward trend. The reason why Chongqing surpassed Sichuan was that at this time, Chongqing's economy was also in a period of rapid development. The establishment of factories led to excessive carbon dioxide emissions and the production of greenhouse gases. Coupled with the natural terrain of Chongqing, the temperature rose. Including the abnormal atmospheric circulation in 2013, Chongqing was affected by the northerly and westward position of the Western Pacific subtropical high. The Western Pacific subtropical has continuously stabilized most of the southern part of China, causing these areas to be continuously subject to abnormal subsidence movements, restricting convection, reducing summer rainfall, persistently high temperatures, and autumn droughts [6]. This also verifies that Chongqing's economic development was late and out of step with global warming, including the impact of global atmospheric circulation on the Chongqing region.

3. Cause Analysis

It can be seen from this that there are many reasons influencing the temperature changes in Chongqing. The main causes among them are: the impact of urbanization, Chongqing's own topography, carbon dioxide emissions, rapid industrial development, and the problem of being affected by atmospheric circulation. This article mainly analyzes the influence of Chongqing's own topography and urbanization.

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Chongqing is located in the southwest of China, at the upper reaches of the Yangtze River. It is mainly composed of mountains and hills, with complex and diverse landforms. To the east and south are the Wushan and Dalou mountainous areas, while to the west are hills and plains. The Yangtze River runs through the entire area, forming the Three Gorges. Karst landforms are widely distributed. However, due to its own terrain, the SO2 gas produced by human activities is difficult to disperse. Chongqing's basin topography facilitates solar heat accumulation while inhibiting dissipation due to orographic blocking and limited air circulation. The Daba Mountains in the north block the southward movement of cold air and also prevent the heat within the basin from spreading northward. The Wushan Mountains in the east restrict the eastward dissipation of heat. The Dalou Mountains in the south act as a barrier, preventing the moist air from the South China Sea from penetrating deeper and also trapping the heat. Such a closed terrain causes the heat brought by solar radiation to accumulate continuously within the basin and is difficult to diffuse outward through atmospheric circulation, thus resulting in a relatively high temperature. More than 96% of Chongqing is mountainous and hilly. The undulating mountains block the deep penetration of the wind. The weak wind environment further weakens the convection and exchange of air, preventing heat from being carried away by the wind and intensifying the persistence of high temperatures.

Another factor influencing the temperature changes in Chongqing is the impact of urbanization. Under natural conditions, the river valleys and hilly areas of Chongqing are mainly covered with vegetation and water bodies. However, after urbanization, these areas have been covered with artificial materials, which have a high heat absorption capacity and a low heat dissipation efficiency, resulting in a significant increase in surface temperature. In addition, the large amount of waste heat generated in industrial production processes, as well as heat source activities such as air conditioning and heating in residents' daily lives, have further strengthened the urban thermal environment. Bai Yingying and others conducted a profound analysis of this. During the rapid urbanization development stage, the number of hot and high-temperature days in the region has increased. Just through the detection of 9 stations, it can be seen that the main urban area has experienced the most prominent changes in hot and high-temperature weather. In cities, common materials such as cement and concrete produce a large amount of carbon emissions, as well as steel and aluminum. Traditional asphalt also absorbs a large amount of solar radiation, which greatly promotes the „urban heat island effect", while high-density stone has a higher heat melting capacity and releases heat at night. Beibei is a city with relatively obvious urbanization. According to statistics, the number of registered residents in Beibei reached 634,700 in 2012. The per capita GDP increased from 9,093 yuan in 2001 to 45,663 yuan in 2012, and the floor area of buildings also increased by 230%. Such a sharp increase in population, economic development, and building construction has led to an increase in greenhouse gas emissions, causing cities to generate a large amount of heat but have weak heat dissipation capacity, and the urban heat island effect has been continuously strengthened. Another factor is the heat brought by industry and the heat sources from daily life.

All these are reflected in the continuous strengthening of the urban heat island effect, the increase in the number of high-temperature days, the frequent occurrence of extreme high temperatures, and the emergence of mountain heat islands.

4. Change the Way

Greening the city, planting more vegetation, strictly protecting Geleshan, Nanshan, and Tieping Mountain, strictly prohibiting the development of mountain forest land, and smart maintenance can be carried out. Compared with manual maintenance, intelligent maintenance makes more effective use of water resources, reduces surface runoff and water accumulation, and also lowers labor costs. For instance, a variety of unmanned devices have been employed for innovative applications. In the Silihe Riverside Park, an unmanned lawn mower with a shape similar to a „large sweeping robot" has been introduced. Compared with manual lawn mowing, this not only reduces operational safety risks but also cuts down on human input by over 30%. At the same time, both air and ground inspections were carried out, and the efficiency of problem detection increased by 50%.

For the low-carbon development of cities, the top-level design can be improved, and a multi-scale carbon sink task decomposition mechanism can be established around the „dual carbon" goals. Establish a measurement system, build a multi-level measurement system, and utilize AI technology; Promote low-carbon design, select native tree species, advance natural green Spaces, and promote three-dimensional greening and the use of suitable trees for specific sites. Deepen low-carbon construction, promote the localization of materials, select durable building materials, and extend their service life. Promote low-carbon management, innovate maintenance systems, implement ecological maintenance, and promote mechanical photovoltaic functions to reduce carbon emissions from maintenance. Promoting new energy vehicles and devel-

oping rail transit tools, for instance, Shenzhen has been the best city in promoting new energy vehicles in recent years. It has built a complete industrial chain covering areas such as complete vehicles, electric batteries, motor and electronic control, intelligent cockpits, autonomous driving, charging infrastructure, and the automotive aftermarket. Only by planning first and positioning the industry can the path be made clearer. Subsequently, the layout was upgraded, and the industrial ecosystem and the development platform grew strongly.

Strictly filter the gas emissions from the factory and try to filter out most of the harmful gases. Carry out carbon neutrality and carbon reduction to cut down on greenhouse gas emissions.

5. Conclusion

This study analyzes the temperature change trends in Chongqing from 1982 to 2024. The results indicate that although Chongqing has experienced a significant overall warming trend, it exhibits a fluctuating pattern of "warming-cooling-warming." Over the 42-year period, the region reached three peaks in the number of days with temperatures exceeding 28℃. The primary drivers of Chongqing's temperature rise are urbanization, global warming, and its unique topographical conditions. Urbanization leads to an increase in surface temperatures: massive heat emissions from industrial activities create an urban thermal environment, while common urban construction materials absorb substantial amounts of heat, exacerbating the "urban heat island effect." Furthermore, these accumulated heat fluxes are trapped by Chongqing's terrain and unable to dissipate outward, resulting in continuous heat accumulation and a buildup of hot air in the region. Against this backdrop, global warming affects every region worldwide, which further contributes to the temperature increase in Chongqing. This study only focuses on temperature data from a single region (Chongqing) without considering temperature changes in other areas, leading to certain inherent errors that may cause significant deviations in future temperature predictions. Numerous uncertain factors influence Chongqing's temperature, reflecting the limitations of this research. For more accurate temperature predictions in Chongqing, additional factors need to be incorporated, such as the intensity of global warming, human impacts on the environment, and natural disasters. In future research, convolutional neural networks (CNNs) could be employed to analyze satellite cloud imagery and other remote sensing data for extracting cloud characteristics and inferring weather changes. Alternatively, high-resolution datasets could be utilized to develop temperature prediction models.

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