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Rising Summer Temperatures in Guangzhou: Trends, Risks, and Responses

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Abstract. Global warming is significantly altering the patterns of extreme weather events, with extreme heat exerting an especially urgent impact on densely populated urban agglomerations. This paper focuses on Guangzhou, a core city in China's Pearl River Delta (PRD), as a representative case. Based on monthly maximum temperature data from 1970 to 2020 provided by the U.S. National Oceanic and Atmospheric Administration (NOAA), this study analyzes the long-term characteristics of summer high temperatures in this region. It shows that over the past 51 years, the average summer (June-August) maximum temperature in Guangzhou has exhibited a significant upward trend, with a linear warming rate of approximately 0.25°C per decade. Further research reveals that warming is asynchronous across the summer months, with August showing the most pronounced warming rate. This trend serves as the fundamental climatic background for the increasingly frequent and intensified extreme high-temperature events in the PRD region. Integrating existing literature, this paper demonstrates that continued warming poses compound risks to regional public health, the ecological environment, and socio-economic functioning through multiple pathways, such as intensifying the urban heat island effect, altering the ecology of infectious disease vectors, and increasing the potential for photochemical pollution.

Keywords: Extreme High Temperature, Guangzhou, Pearl River Delta (PRD), Climate Warming, Compound Risk

1. Introduction

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) definitively states that human-induced climate warming has led to a systematic increase in the frequency, intensity, and duration of extreme high-temperature events on a global scale [1]. This conclusion is supported by robust physical evidence of rising global greenhouse gas concentrations and changes in energy budgets [2]. This risk is not evenly distributed geographically. Low-latitude, rapidly urbanizing coastal areas, due to their inherently hot and humid climates and high population and economic exposure, are particularly vulnerable "hotspots." The Pearl River Delta (PRD) region, a mega-urban agglomeration in China and globally, is a typical example of such risk.

Recent observational studies confirm that South China is one of the regions in China with the most significant trend of extreme high temperatures, with increases in the number of high-temperature days and the duration of persistent high-temperature events among the highest

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nationally [3]. More complexly, the impacts of high temperatures extend far beyond direct heat stress. For instance, empirical research in Guangzhou shows that the occurrence of daytime heatwaves significantly increases the incidence of dengue fever approximately two months later, revealing how climate warming profoundly reshapes the regional epidemiological landscape by affecting vector organisms [4]. Furthermore, a case study in Shijiazhuang, a city in North China, confirmed that persistent extreme high temperatures are a key meteorological driver for triggering severe near-surface ozone pollution [5]. This mechanism demands heightened vigilance in the PRD region, which also experiences high emissions and intense solar radiation.

Although existing studies have revealed high-temperature risks in the PRD from different perspectives, a clear, long-term, observation-based regional-scale warming trend is the physical cornerstone for understanding and predicting all associated impacts. This study aims to utilize 51 years of monthly temperature data from the Guangzhou station to quantify the long-term evolution characteristics of summer high temperatures in the core area of the PRD. It further synthesizes existing scientific evidence to systematically elaborate on the cascading challenges posed by this warming, ultimately providing data-based decision-making references for local government adaptive governance, consistent with IPCC's recommendations on region-specific climate adaptation strategies [6].

2. Study area, data and methods

2.1. Study area

This study focuses on Guangzhou, a core city in the PRD. Guangzhou features a South Asian subtropical monsoon climate, characterized by long, hot, and rainy summers. As a regional center, rapid urbanization has led to pronounced urban heat island effect. This renders its temperature changes reflective of both regional climate background and intense human activity influences, making it an ideal site for analyzing the combined effects of climate warming and urbanization. As a major economic hub of China, Guangzhou's economic development is inevitably influenced by climatic change. A comprehensive understanding and effective management of climate conditions are essential for fostering the city's economic progress

2.2. Data source

The monthly maximum temperature data for Guangzhou station used in this study comes from the Global Historical Climatology Network dataset provided by the U.S. National Oceanic and Atmospheric Administration (NOAA). To ensure sufficient data length for identifying climate trends, the period from January 1970 to December 2020 was selected, encompassing 51 complete years.

2.3. Analytical methods

All analyses were conducted in Microsoft Excel, with the main steps as follows:

1. Data Aggregation: Extract the monthly maximum temperature values for June, July, and August each year, calculate their arithmetic mean, and define it as the "Annual Summer Average Maximum Temperature." This serves as a comprehensive indicator of the overall summer heat level, consistent with IPCC's recommended metrics for regional heat trend analysis [2].

2. Trend Analysis: Perform linear regression analysis on the time series of the "Annual Summer Average Maximum Temperature" from 1970 to 2020 to model its long-term change trend. Trend

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significance is evaluated by calculating the coefficient of determination (R^2).

3. Monthly Comparison: Independently model linear trends to the monthly temperature series for June, July, and August to compare monthly differences in warming rates.

4. Literature Synthesis: Integrate and discuss the quantitative trends derived from data analysis with findings from existing academic literature on the mechanisms underlying high-temperature impacts on health, environmental, and socio-economic.

3. Results

3.1. Significant upward trend in summer average maximum temperature

The analysis (Figure 1) indicate that between 1970 and 2020, the summer average maximum temperature (June-August mean) in Guangzhou exhibited a distinct upward trend. The linear regression model indicates that the warming rate for the summer mean temperature during this period was approximately 0.25°C per decade—higher than the global average summer warming rate reported by IPCC [2]. This long-term warming trend is statistically significant (R^2 = 0.65). Specifically, in the 1970s, the typical level of Guangzhou's summer mean temperature fluctuated around 32.0°C. By the 2010s, the typical value had steadily risen above 33.0°C. This change demonstrates that the baseline summer heat level in the PRD has been systematically elevated by over 1.0°C in the past fifty years.

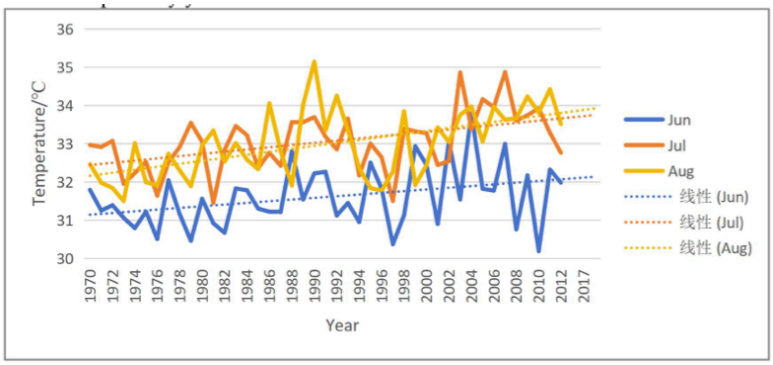


Figure 1. Trends of average summer maximum temperature in Guangzhou from 1970 to 2020

3.2. Differentiated characteristics of warming rates across summer months

Independent trend analysis of individual summer months reveals an important detail: summer warming is not uniformly distributed. As shown in Figure 2, June, July, and August all exhibit warming trends, but the warming rate for August is significantly higher than those in June and July. Calculations show that the linear warming rate for August can reach approximately 0.30°C per decade, while the rates for June and July are about 0.22°C and 0.23°C per decade, respectively. This indicates that against the backdrop of global warming, warming in late summer (transitioning to autumn) is more pronounced, potentially indicating an extension or change in the structure of the hot season.

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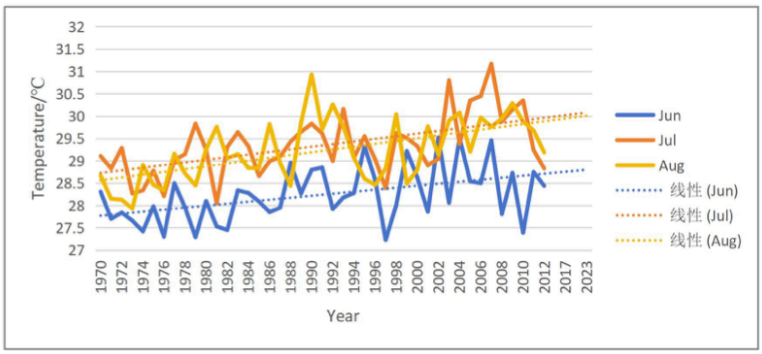


Figure 2. Comparison of maximum temperature trends for summer months (June, July, August) in Guangzhou, 1970-2020

The sustained summer warming trend in Guangzhou revealed by this study represents a distinct regional manifestation of global warming signal [2]. This trend is physically consistent with the globally observed increases in greenhouse gas concentrations and changes in energy budgets. For the PRD, rapid urbanization acts as a key regional amplifier of the greenhouse effect. Changes in the urban underlying surface, including increased impervious surfaces and reduced green spaces, drive the urban heat island effect and further amplify local regional warming The observed elevation in summer mean temperature constitutes the fundamental climatic background for the intensification of all extreme high-temperature events—a warmer summer results in a higher starting point, more energy, and potentially longer durations for heatwaves.

4. Discussion

4.1. From climate trend to compound risks

Sustained warming translates into tangible risks through multiple pathways:

The first is Amplified Health Risks. Rising baseline temperatures directly broaden the vulnerable population and time windows for heat-related illnesses (e.g., heatstroke, cardiovascular diseases). More critically, they create a more favorable environment for vector-borne diseases. The lagged association between heatwaves and dengue fever outbreaks found by Ouyang et al. in Guangzhou is fundamentally due to high temperatures accelerating the mosquito reproductive cycle and virus amplification within mosquitoes [4]. This study's findings indicate this risk driver is continuously strengthening.

The second is Intertwined Environmental Risks. As revealed by Jin et al. in Shijiazhuang, high temperature, strong solar radiation, and stable weather conditions are conductive to the formation of photochemical smog (represented by ozone) [5]. The PRD, as a major manufacturing base, has high emissions of ozone precursors. Sustained summer warming, especially the rapid warming in August, indicates a substantial increase in the meteorological risk of high-intensity, persistent ozone pollution events in the future, resulting in "high temperature-pollution" compound exposure. This is consistent with IPCC's assessment of compound environmental risks under global warming [1].

The third is Social and Economic Pressures. Warming directly increases summer cooling energy consumption, imposing peak challenges on urban power grids and exacerbating carbon emissions. Simultaneously, outdoor labor productivity declines, and prolonged high temperatures accelerate the aging of infrastructure such as roads and power grids, leading to widespread economic costs. This aligns with the IPCC's projections of socio-economic vulnerabilities to climate change [6].

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4.2. Implications of rapid warming in august

The faster warming observed in August holds significant indicative significance. It may be related to circulation changes during the weakening or retreat of the South China Sea summer monsoon, the abnormal persistence of the subtropical high in autumn, or different manifestations of the urbanization effect in late summer. This suggests that climate risk in the PRD are not only reflected in overall summer warming but may also be accompanied by changes in the temporal structure of the hot season, such as an extension into autumn. This could present new challenges to agricultural phenology, ecosystems, and traditional seasonal disaster prevention and mitigation arrangements.

5. Conclusions

This paper, through the analysis of 51 years (1970-2020) of monthly temperature data from the Guangzhou station, provides robust evidence that summer high temperatures in the core area of the PRD exhibit a significant long-term strengthening trend. The summer average maximum temperature has risen at a rate of approximately 0.25°C per decade, with warming being particularly rapid in August. This trend is the result of the combined effects of global warming and local urbanization processes. It constitutes the fundamental climatic background for the increased frequency and intensity of extreme high-temperature events in the region and, through multiple pathways in health, environment, and socio-economics, catalyzes increasingly severe compound climate risks.

Recommendations To address these challenges, three key recommendations are proposed: first, optimize heat mitigation and resilience planning by incorporating the 0.25°C per decade summer warming trend and August's highest warming rate into urban planning, expanding urban green spaces and reducing impervious surfaces to alleviate the urban heat island effect; second, establish a compound risk early warning mechanism that integrates health, meteorological, and environmental protection departments to issue targeted warnings for high-temperature-related risks such as dengue fever and ozone pollution; third, strengthen protection for vulnerable groups including the elderly and outdoor workers, enhance access to cooling facilities and implementing heat protection subsidy policies. These recommendations are consistent with IPCC's guidance on adaptive governance for urban agglomerations.

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