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Analysis of air temperature change trends and their impacts in Australia

Xican Xu

Xinhua Academy, Hefei, Anhui, 230088, China

xxcan1023@gmail.com

Abstract. Global climate change has become a major challenge of our time, affecting ecosystems, weather patterns, and human activities across the globe. In this paper, we analyze the causes and effects of climate change by looking at Australia, in particular, summer temperature trends in the Melbourne region over the past 20 years. By examining historical data and considering the current situation, this paper makes recommendations to address these challenges. The relevant data shows a general increase in average summer temperatures in Melbourne and across Australia from 2003 to 2023. The main factors contributing to these fluctuations include global climate change, human activity, and urbanization. Continued temperature increases are primarily caused by global warming, exacerbated by increased greenhouse gas emissions from human activities and the urban heat island effect. The impacts of climate change on Melbourne and Australia are multifaceted, affecting public health, water management, energy demand, ecosystems, and agriculture. After analyzing Australia's overall climate, this paper proposes measures to improve it, such as reducing greenhouse gas emissions, increasing urban resilience, improving public health security, protecting and restoring ecosystems, and promoting scientific research and education.

Keywords: Climate change, Air temperature, Urban heat island effect, Australia.

1. Introduction

Global climate issues have become a major challenge of our time, and climate change is affecting ecosystems, weather patterns, and human activities around the world. This paper describes Australia, which is located in the Southern Hemisphere, between the South Pacific Ocean and the Indian Ocean (including mainland Australia and Tasmania), but the climate varies throughout the country, such as a tropical desert climate with low rainfall in the western highlands and inland deserts, a tropical savanna climate with high rainfall in the north, and a temperate broadleaf forest climate with temperate forests in the eastern New England Ranges. The Melbourne region selected for this paper is an important city in south-eastern Australia with a warm summer and cool winter climate.

This paper uses Melbourne as a case study to examine the significant climate changes that have occurred there over the past 20 years. This study gathers and scrutinizes these changes, offering the government and stakeholders potential solutions. The Intergovernmental Panel on Climate Change (IPCC) report reveals that human activities have led to an increase in greenhouse gas emissions, potentially contributing to the persistent high temperatures in Australia [1]. Trancoso and colleagues analyzed heatwaves in Australia and found that the intensity of heatwaves has continued to increase in

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a variety of scenarios in the past, present, and future,Their study emphasizes that heatwaves in Australia are becoming more frequent and intense with global warming. Coupled with an increase in extreme weather events, there is an urgent need to address Australia's climate [2].

2. Research Methods

The focus of this paper is to analyze temperature trends across Australia, and the Melbourne region has been selected as a case study for detailed examination. The impact of climate change on Australia as a whole is assessed through a comparative analysis of data from Melbourne and Australia as a whole. A combination of quantitative research and literature review was used to analyze past academic studies and data collected from environmental monitoring reports over the past 20 years (2003-2023). Linear models were added to examine temperature trends, and descriptive statistics were used to analyze the occurrence of extreme weather events nationally and in Melbourne.

2.1. Research objectives

This study aims to analyze seasonal temperature changes in Melbourne and Australia from 2003 to 2023. It also explores potential causes of these changes, including climate change, human activities, and urbanization. It also provides recommendations for the Australian government and local authorities.

2.2. Regional Description

Melbourne's climate is characterized by its variability, often experiencing four seasons in one day. Summers can be hot, with temperatures occasionally exceeding 40°C, while winters are mild but can be chilly at night, with temperatures sometimes dropping below 5°C. The city's proximity to the coast significantly influences its climate, resulting in moderate temperatures compared to inland Australia [3].

Beyond Melbourne, Australia's climate diversity is vast. The tropical north experiences a wet and dry season, with heavy monsoon rains from November to April. The central regions are arid, with a desert climate and extreme temperatures that can exceed 50°C during the day and plummet at night. The southern coastal areas, including cities such as Adelaide and Perth, enjoy a Mediterranean climate with hot, dry summers and mild, wet winters. Tasmania, further south, has a temperate maritime climate with mild summers and cool, wet winters. This climatic diversity across Australia highlights the complexity of studying temperature trends and their impacts on different regions [4].

3. Data analysis

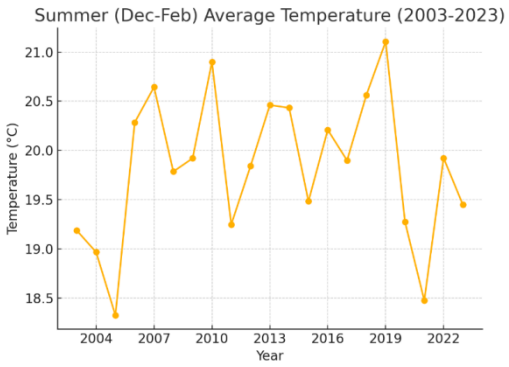

Figure 1. Average summer temperatures in Melbourne (2003-2023) [5]

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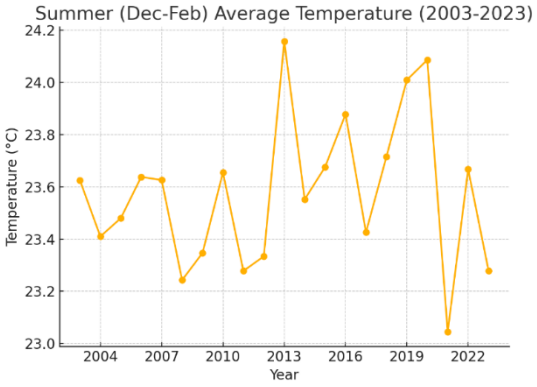

Figure 2. Average summer temperatures in Australia (2003-2023) [5]

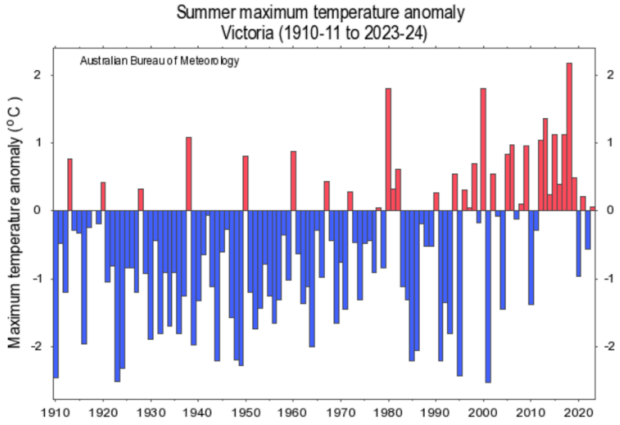

Figure 3. Maximum summer temperature changes in Victoria (2003-2023), compared to the 1991-2020 average of 27.4℃ [6]

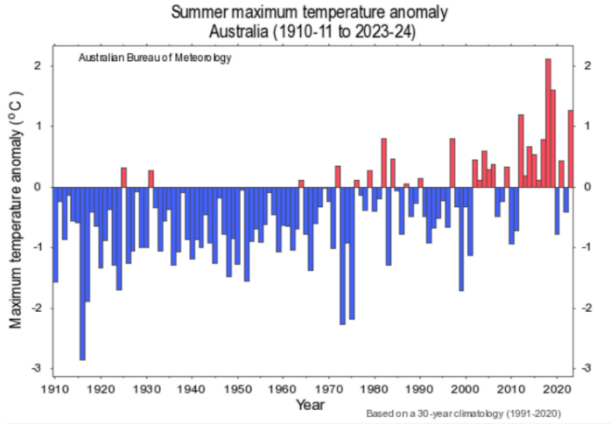

Figure 4. Maximum summer temperature changes in Australia (2003-2023), compared to the 1991-2020 average of 34.7℃ [6]

Analysis of Melbourne and Australia's summer average temperature data reveals the following trends:

Rising Temperature Trend: From 2003 to 2023, both Melbourne and Australia's summer average and maximum temperatures show an upward trend. Melbourne's summer temperature rose from 19.186℃

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in 2003 to 19.447℃ in 2023, while Australia's overall summer temperature decreased from 23.625℃ to 23.279℃.

Temperature Fluctuations: Despite the overall rising trend, there are significant annual temperature fluctuations. For example, Melbourne's summer temperature peaked at 20.9℃ in 2010 but dropped to 19.247℃ in 2011. Australia's overall data shows similar fluctuations, demonstrating the complexity and variability of the climate system.

Extreme Weather Events: Since 2000, there has been an upward trend in maximum temperatures in Victoria and Australia, with 2019 being the hottest and driest year in the past 20 years.

4. Causes and measurements

4.1. Causes of Temperature Changes

There are three principal factors that contribute to fluctuations in temperature. Global warming, in particular, is a significant driver of rising temperatures in Melbourne and Australia. Should the current trajectory persist, it is likely that temperatures will continue to rise, leading to an increase in the frequency and severity of heatwaves and other extreme weather events [2]. Human activities are a significant contributing factor to the observed temperature changes. Industrialization, rapid transportation development and excessive energy consumption have all increased greenhouse gas emissions. From 2000 to 2023, Australia's greenhouse gas emissions have increased significantly, contributing to the acceleration of global warming [7]. The release of considerable quantities of CO2, methane and other greenhouse gases by human activities traps heat in the atmosphere, thereby contributing to global warming. Furthermore, the process of urbanization exerts a significant influence on temperature change. The expansion of Melbourne has resulted in a heat island effect, whereby urban areas are warmer than surrounding suburbs [8]. This phenomenon can be attributed to an increase in building density, a reduction in vegetation, and an enhancement of heat retention in urban environments.

4.2. Measures and Recommendations

It is incumbent upon local governments to develop and implement policies that will reduce greenhouse gas emissions, promote the use of renewable energy sources such as solar and wind power, improve the energy efficiency of buildings and reduce reliance on fossil fuels. These measures are critical to mitigating climate change. It is imperative that governments consider how to make urban planning more environmentally friendly. Effective urban planning can mitigate the urban heat island effect and increase the resilience of cities to climate change. Green building technologies, such as reflective materials and green roofs, can reduce heat absorption and improve energy efficiency. In addition, increasing urban green spaces and vegetation cover can help lower urban temperatures. It is also imperative to safeguard natural ecosystems in order to preserve biodiversity and enhance climate security. The restoration of natural habitats, including wetlands, forests, and coastal areas, has the potential to mitigate the occurrence of extreme weather events. Furthermore, raising public awareness about climate change and encouraging low-carbon lifestyles can help to slow global warming. Education campaigns can facilitate the promotion of environmental awareness, water conservation, waste reduction, and the utilization of public transport.

5. Conclusion

This paper analyzes detailed data on summer temperatures in Melbourne and, in the context of Australia's overall climate trends, finds that summer temperature rises are not just found in some areas but are widespread across many parts of Australia. Climate change, human activity, and urbanization were all found to be contributing factors. This study primarily uses secondary data as its data source, which limits the depth and breadth of the data analysis. The paper's analysis primarily focuses on temperature change trends, but there is a lack of in-depth discussion on the impact of temperature changes on specific aspects. For example, while the paper discusses the impact of climate change on public health, energy demand, and ecosystems, it lacks detailed case studies and comprehensive data

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support. Furthermore, there is a paucity of analysis of other climate factors, such as precipitation and wind speed, which may exert a significant influence on climate change and temperature trends. Should conditions allow in the future, field observations will be conducted to obtain primary data. Future writing will also incorporate analyses of other climate factors, like precipitation and wind speed, to investigate their correlation with temperature changes. Additionally, in-depth analyses of the impact of temperature changes on specific aspects will be conducted, providing detailed cases and data support. For example, changes in the incidence of specific diseases or the impact of high temperatures on certain energy usage patterns may be analyzed. In the face of a complex and changing climate, the government must take proactive steps to mitigate the risk of warming and ensure the sustainability of Australia's natural environment, social and economic development, and human health.

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