**Victoria Weather Analysis**

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# 1. Introduction

Overtime, the planet has been subject to changing global temperatures with more erratic and unstable climates. The Intergovernmental Panel on Climate Change (IPCC) has reported that global surface temperatures have increase by approximately 1.1°C since the pre-industrial era, with significant regional variation in impacts (IPCC, 2023). Canada has experienced warming at nearly twice the global average, making it one of the fastest-warming countries in the world (Bush & Lemmen, 2019). This rapid warming has already led to visible consequences across the country, including rising sea levels, more extreme weather events, and increased wildfire risk. To dig deeper into this, I decided to investigate Victoria B.C. Canada, to see if my hometown as well has faced the consequences of climate change in recent, and past years. The study I have conducted is an in-depth analysis of temperature patterns in Victoria across four time periods: 1974-1979, 1984-1989, 2009-2014, and 2019-2024. My aim is to determine whether there have been statistically significant changes in temperatures over time. By analyzing long-term datasets from the Government of Canada, this project seeks to address several key questions: Is there significant temperature difference over time? Are there differences between the early and recent periods? What temperature patterns can be observed seasonally? What might future temperature trends look like?

# 2. Data Sources and Methodology

## 2.1 Data collection

The data was sourced from the Government and Canada's official climate and weather section, focusing on daily average temperatures from weather stations within Victoria. Some variation exists in data availability between stations, so I treated each station (e.g., 1018611 and 1018633) as data from the general Victoria area, and validated trends that were consistent across them.

## 2.2 Data processing

The data was cleaned by removing missing values, then it was used to calculate monthly and seasonal averages. Each year had a "period group" and then I created new columns for season, year, and moth using lubridate. This was used to conduct seasonal aggregation to examine changes across Winter, Spring, Summer, and Fall.

## 2.3 Statistical Methods

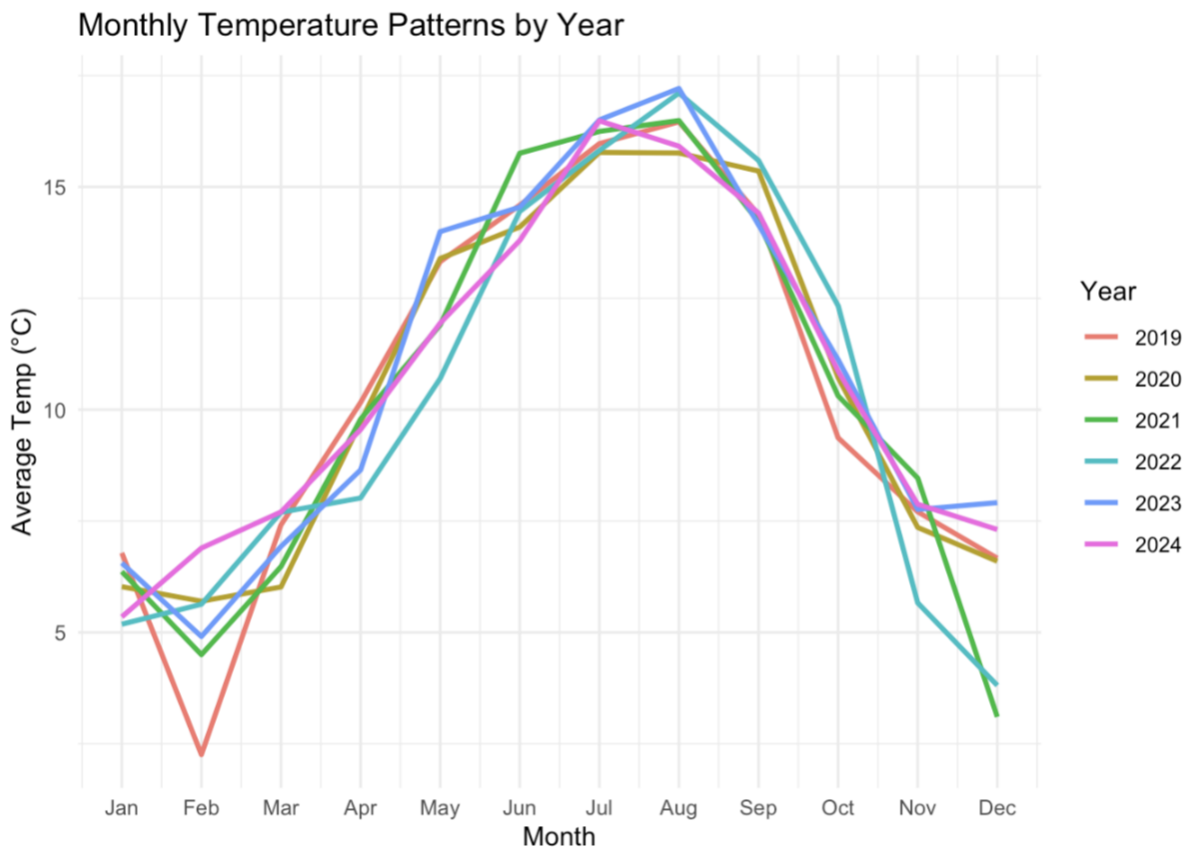
To analyze temperature trends over time, I applied several statistical techniques. Linear regression models were used to estimate temperature changes relative to time, both as simple models and enhanced models accounting for seasonal patterns. Two-sample t-tests were conducted to compare average temperatures between different periods, testing whether observed differences were statistically significant. Additionally, I performed a Breush-Pagan test for heteroskedasticity to check whether the variance of residuals was constant across time, ensuring the reliability of regression inferences. Temperature anomaly detection was done by calculating z-scores for monthly average temperatures to identify months that deviated unusually from the average, flagging potential outliers. Finally, I projected monthly average temperatures for the next ten years using the fitted linear regression model to provide a look into temperature trends in Victoria.

# 3. Results

## 3.1 Monthly Average Temperature Trends (2019-2024)

Analysis of monthly average temperatures from 2019 through 2024 revealed the expected seasonal pattern, with warmer temperatures in summer months and cooler temperatures in wintertime. The initial linear regression model that related average temperature to fractional year time yielded no statistically significant trend as seen in Figure 1. ($p = 0.585$), suggesting temperature averages remained stable during this short timeframe. The low explanatory power (adjusted R^2 = -0.0099) indicated that this simple model did not capture seasonal fluctuations. Introducing seasonality explicitly by adding sine and cosine terms corresponding to monthly cycles improved model performance drastically. This explained 92% of temperature variance (adjusted R^2 = 0.93) and confirmed seasonal variation is the dominant factor in monthly temperature changes. The estimated year effect remained non-significant, implying no detectable warming or cooling trend.

**Figure 1.**



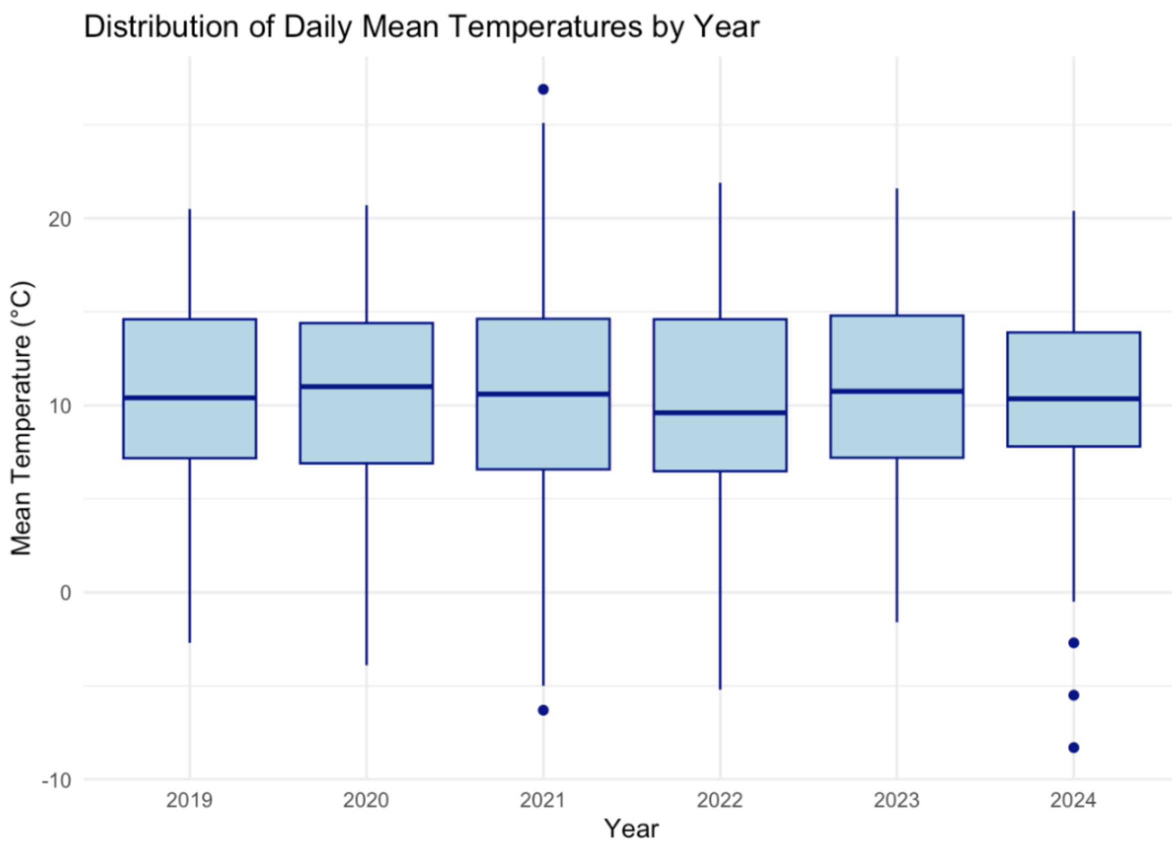

## 3.2 Comparison Between 2019 and 2024

A focused comparison between 2019 and 2024 average temperatures using a Welch two-sample t-test found no significant difference ($p = 0.88$). Mean monthly temperatures in 2019 and 2024 were very close (approximately 10.4°C), reinforcing the finding of stability in recent years. This result is consistent with regression models indication that short-term trends are difficult to detect against seasonal variation and natural variability.

### 3.3 Temperature Distribution Over Years

Boxplots visualizing the distribution of daily mean temperatures from 2019 to 2024 as seen in Figure 2., illustrated variability within and between years but not clear upward or downward trend. Temperature ranges remained relatively stable across years, with typical summer highs and winter lows. Monthly temperature patterns also consistently displayed expected annual cycles.

**Figure 2.**



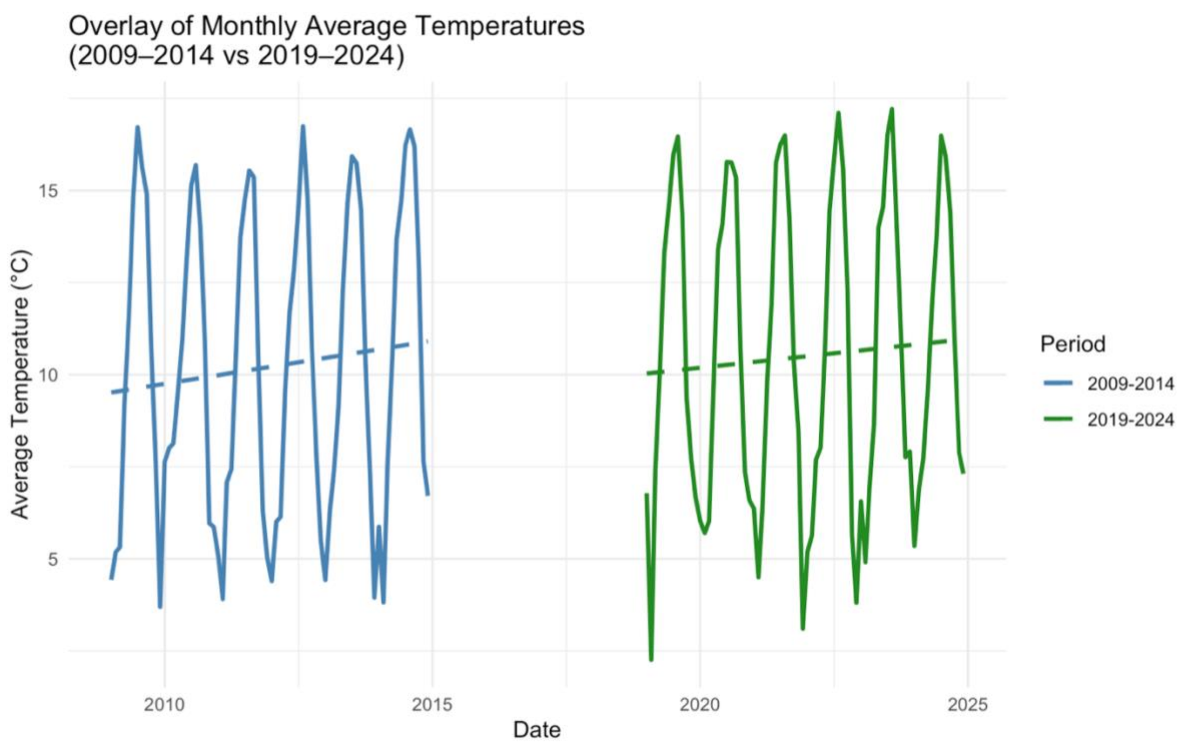

### 3.4 Anomaly Detection

By calculating z-scores for monthly average temperatures, the study searched for potential anomalies. Months with temperature vales deviating significantly from typical patterns. No months from 2019 to 2024 exhibited z-scores beyond +- 2, suggesting that not extreme temperature anomalies happened in this period. This further confirms the relative climatic stability observed in recent data.

### 3.5 Long-term Trends: 2009-2014 vs 2019-2024

Extending the analysis to earlier recent years (2009-2014) revealed similar patterns. Linear regression over this period also failed to detect significant temperature trends (p = 0.41). When comparing monthly averages from 2009-2014 and 2019-2024 as seen in Figure 3., distributions overlapped extensively, and no statistically significant difference was found, indicating that short-term fluctuations mask any recent trends.

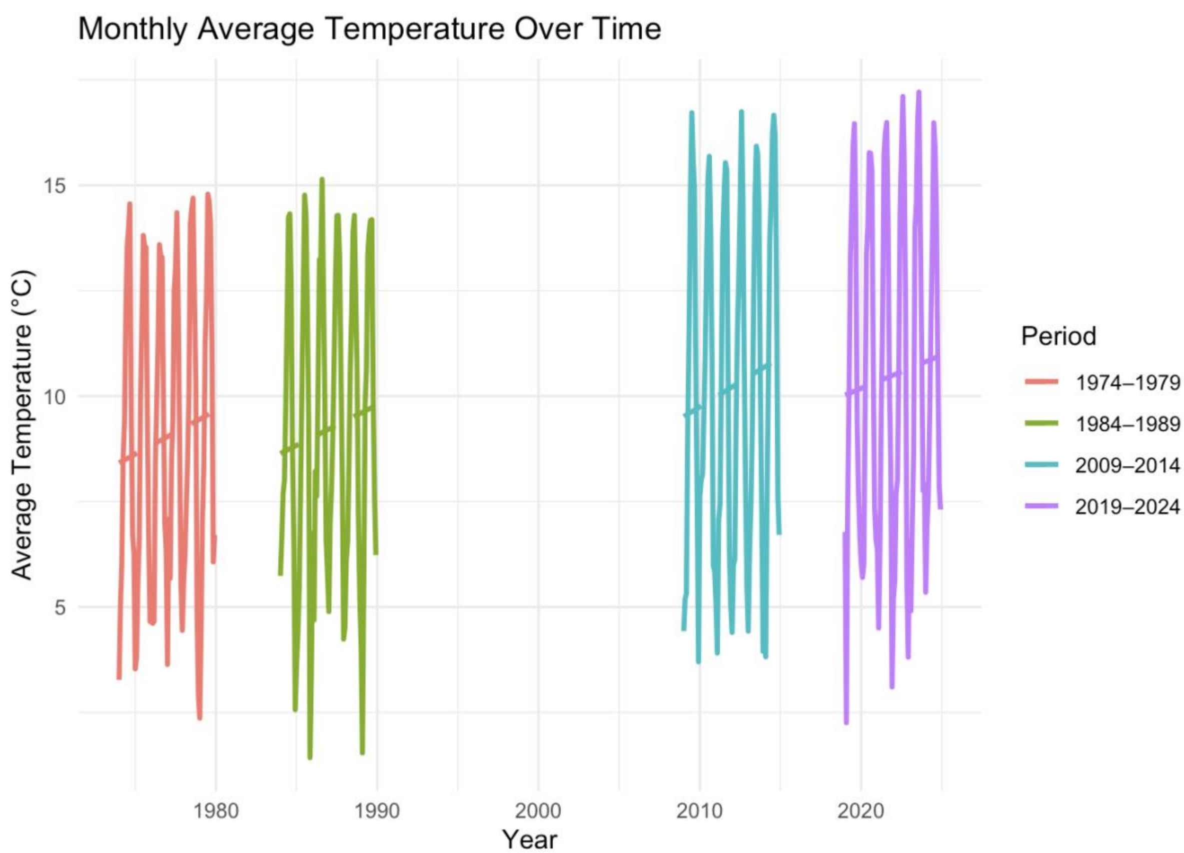
**Figure 3**.



### 3.6 Earlier vs Later Period Comparison (1974-1989 vs 2009-2024)

Comparing two broader timeframes, that being the earlier half decades of the 1970s and 1980s against the later half decades from 2009 and 2019. This revealed a different story completely. Average monthly temperature increased 9.12°C to 10.35°C in the later period as seen in Figure 4. A Welch two-sample t-test confirmed this increase was statistically significant ($p = 0.009$) (reject null-hypothesis), suggesting a clear warming trend over approximately 40 years. This long-term warming is consistent with global observations of changing temperatures attributed to climate change.

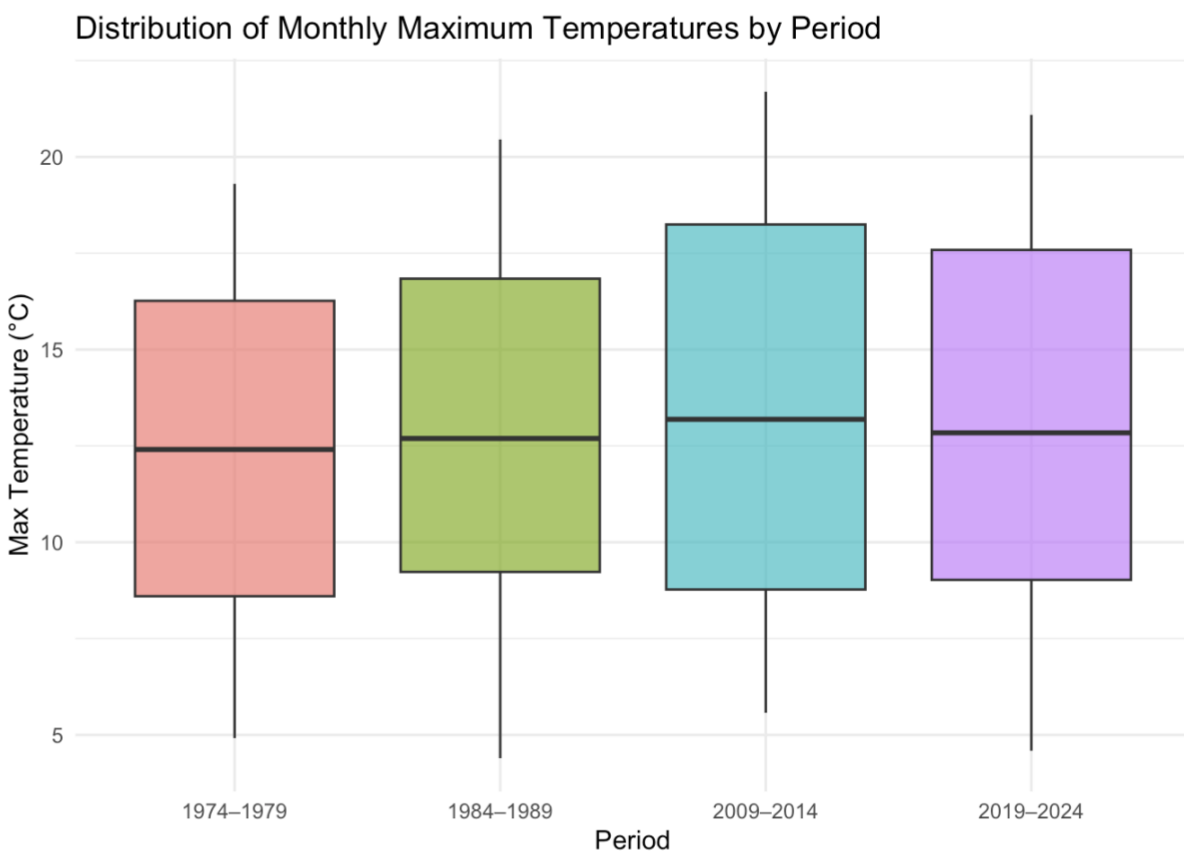
**Figure 4.**



### 3.7 Maximum Temperatures Over Time

Analysis of monthly maximum temperatures corroborated with the warming trend, with average monthly maximum rising from 12.6°C in the earlier period to 13.3°C in the recent period as seen in Figure 5. This supports the conclusion that Victoria has experienced increased summer temperatures over time.

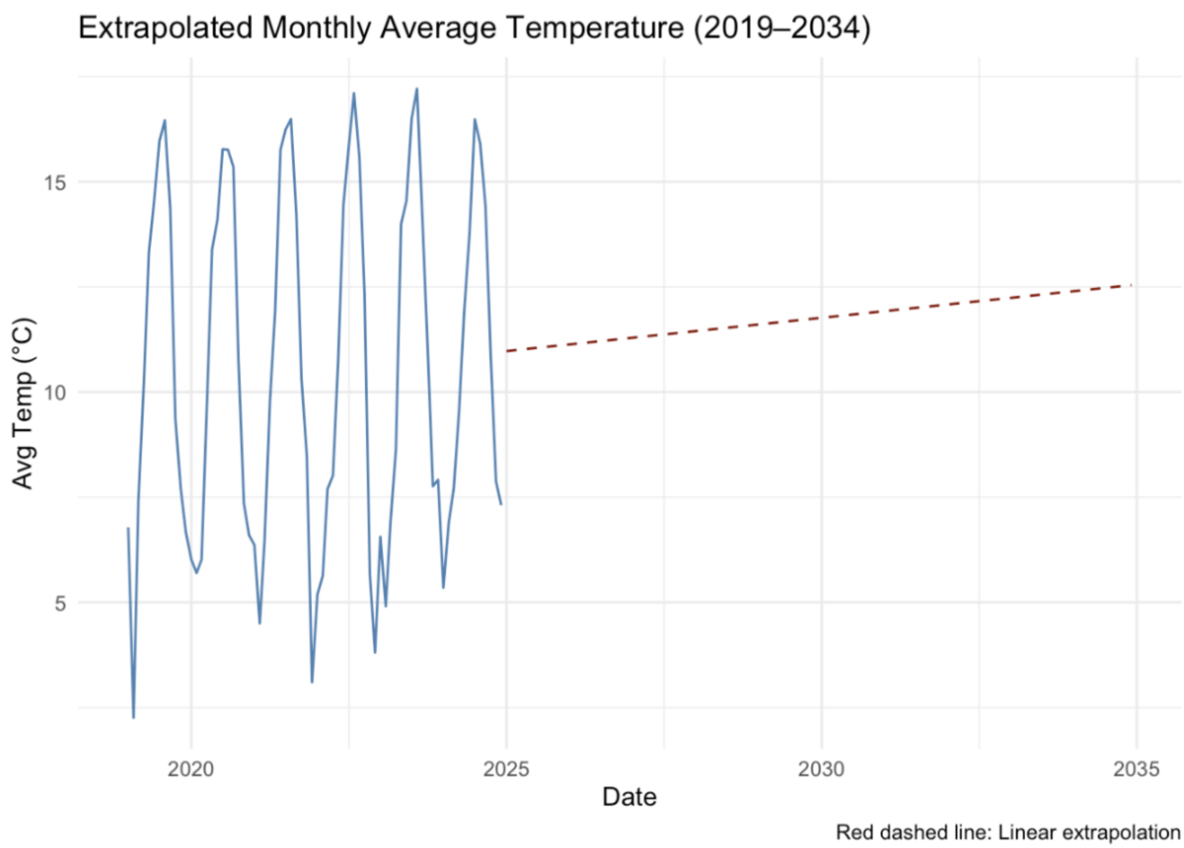
**Figure 5.**




### 3.8 Future Temperature Projections (2025-2034)

Using the linear model fit to recent data, temperature forecasts were projected for the next ten years (2025-2034). The extrapolation of the data suggested a slight continued increase in monthly temperatures as seen in Figure 6. However, the short-term data and natural variability imply that these projections have uncertainty.

**Figure 6.**




## 4. Discussion

The results of this analysis provide evidence for a warming trend in Victoria, BC, over the last several decades, consistent with global climate change patterns. Seasonal temperature cycles remain the dominant drive of temperature variation on a monthly scale. However, the statistically significant increase in average and maximum temperatures between the 1970s-1980s and the

2000s-2020s indicates that the local climate has shifted towards warmer conditions. Short-term analyses within the last decade did not reveal any significant trends, which reflects the challenge of detect climate change, and the gradual change of temperatures. The absence of major anomalies may suggest that extreme temperature events have not increased in recent years, although Victoria is a very mild climate. These findings have important implications for regional environmental management, urban planning, and climate adaptation strategies. A warming climate could affect ecosystems, increase demand for cooling infrastructure, and alter rainfall patterns.

## 5. Conclusion

This study has analyzed temperature data from multiple periods to assess historical climate trends in Victoria, British Columbia. While short-term trends within recent years showed little change, the comparison of earlier and later decades revealed a clear warming trend in average monthly temperatures. Maximum temperatures have similarly increased. The results show the importance of long-term climate data for detecting meaningful changes in local climate conditions. They also align with the climate change patterns observed worldwide. Continued monitoring and climate research will be essential to inform not only Victoria but similar coastal cities facing climate change.

**Bibliography**

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