Climate Variability and Change Analysis: Pretoria

# 1. Introduction

Pretoria, situated in Gauteng Province, has undergone significant urban development over the past six decades. Studying climate variability here  
provides insights into both regional climate trends and the influence of microenvironmental changes such as urbanization.

# 2. Methodology

We used TerraClimate data (1964–2024) for monthly temperature and precipitation. Data was processed using Python (pandas, seaborn, matplotlib).  
Seasonal grouping, anomaly detection, and extreme event classification were applied.

# 3. Results

The following visualizations illustrate key trends in temperature, precipitation, seasonal variation, and extreme events:

Figure: Annual Temperature Trends

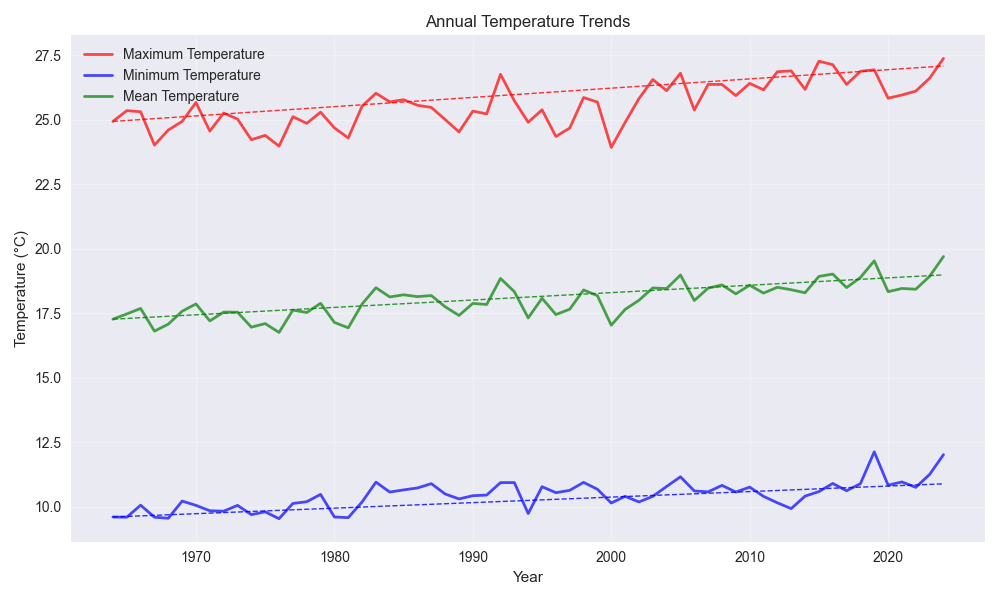


Figure: Annual Precipitation Trend

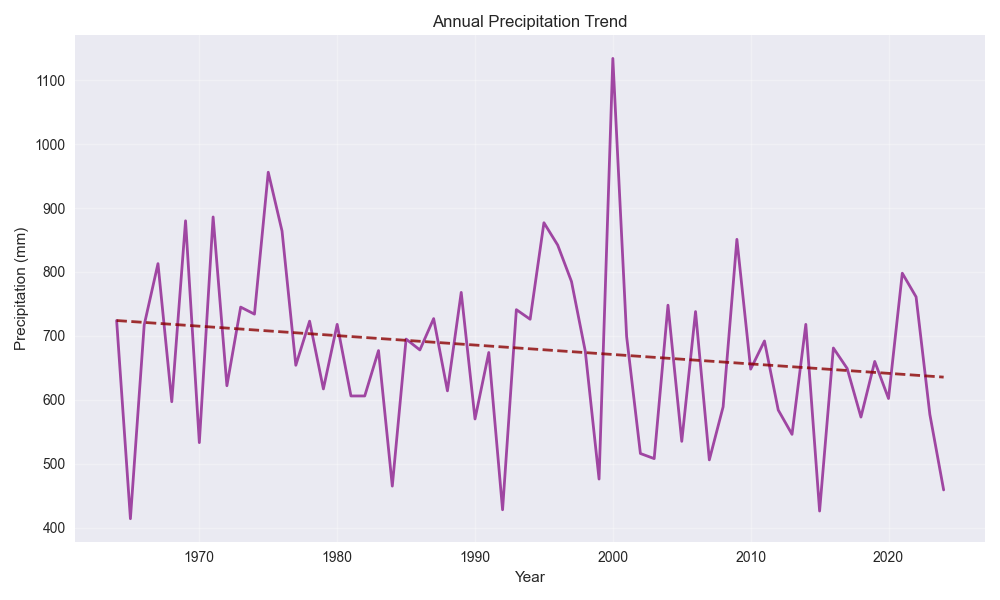


Figure: Diurnal Temperature Range

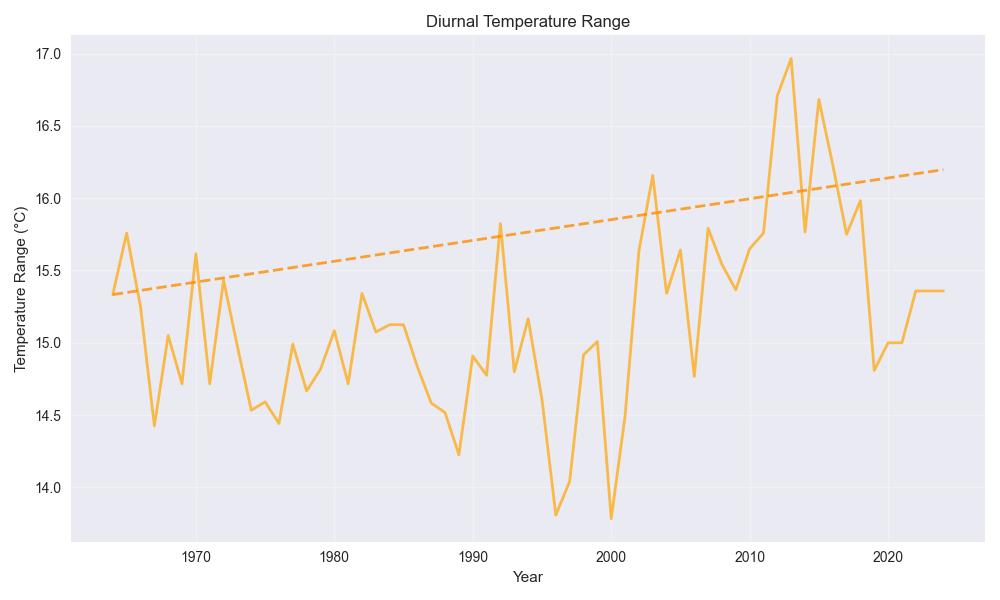


Figure: 10-Year Moving Averages

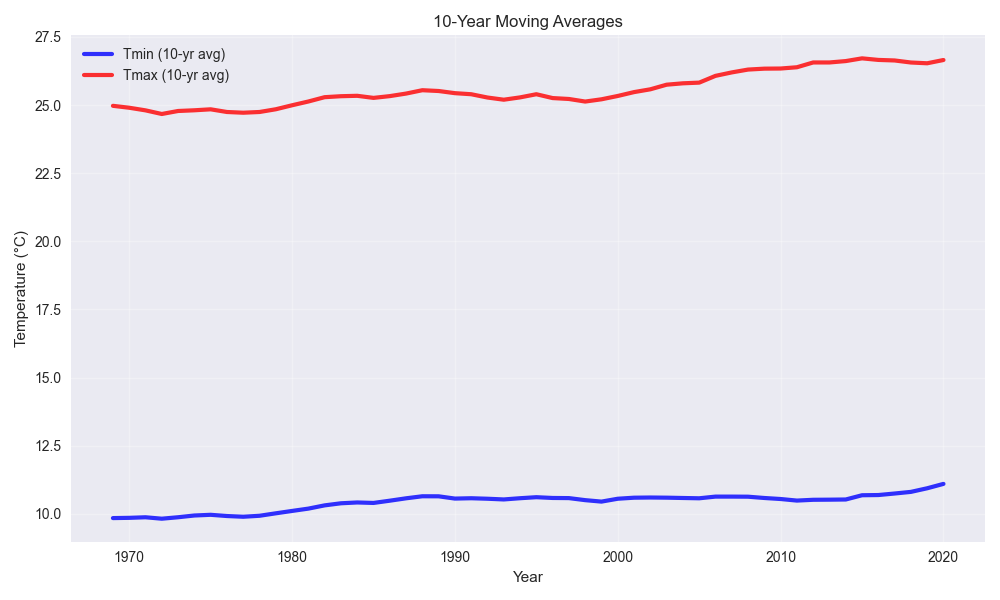


Figure: Summer Temperature Trends

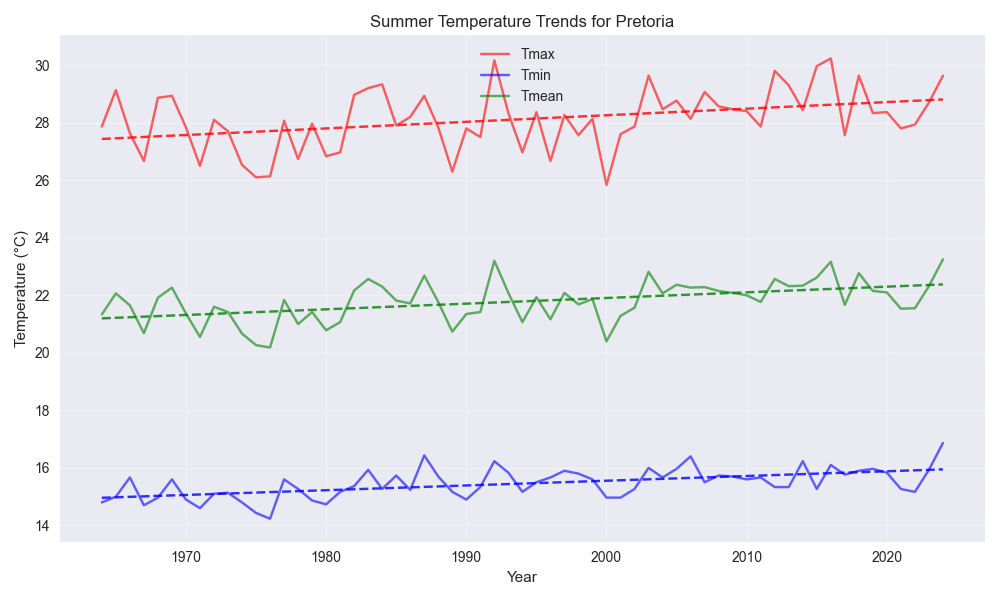


Figure: Autumn Temperature Trends

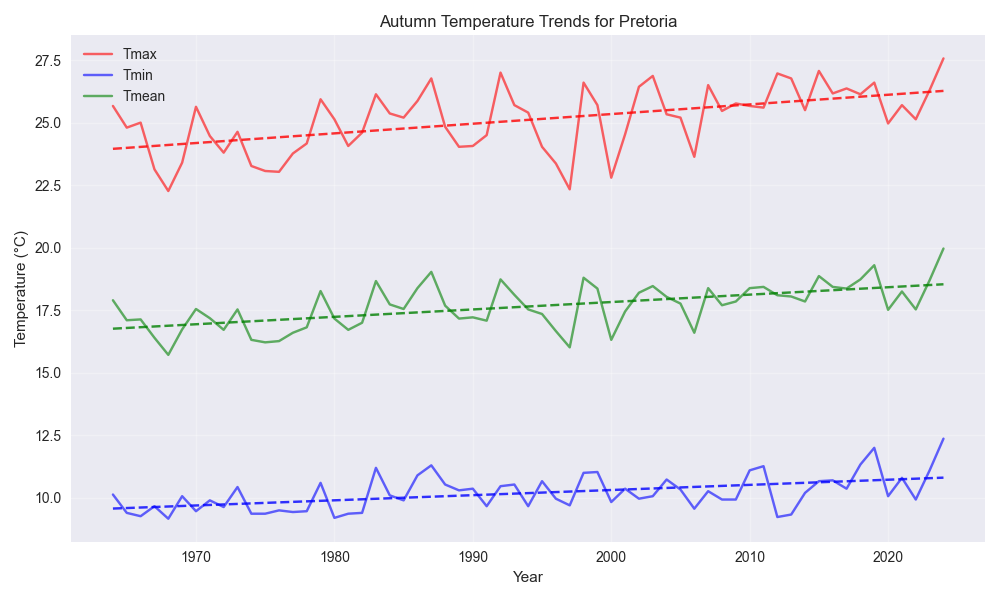


Figure: Winter Temperature Trends

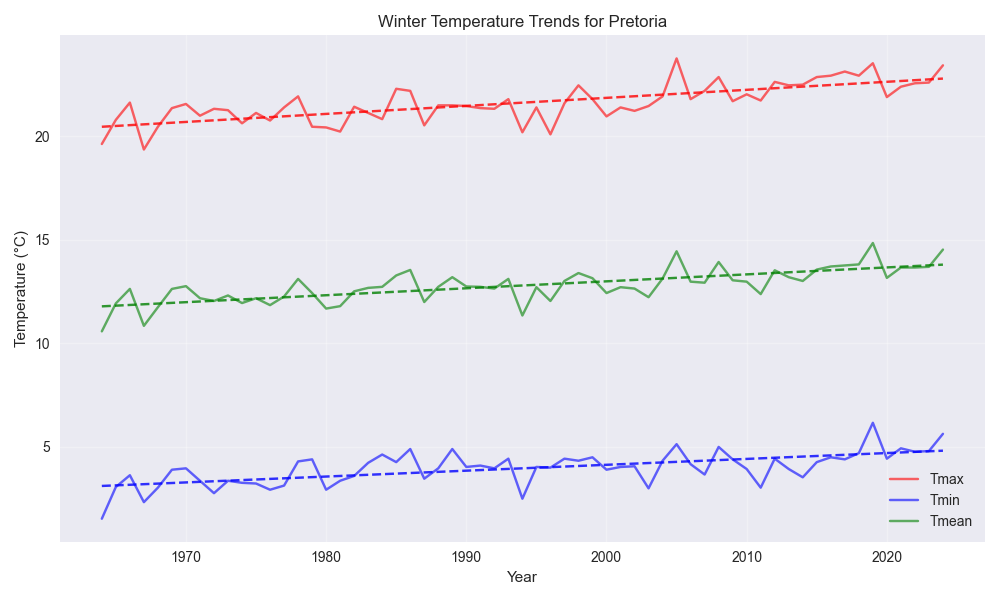


Figure: Spring Temperature Trends

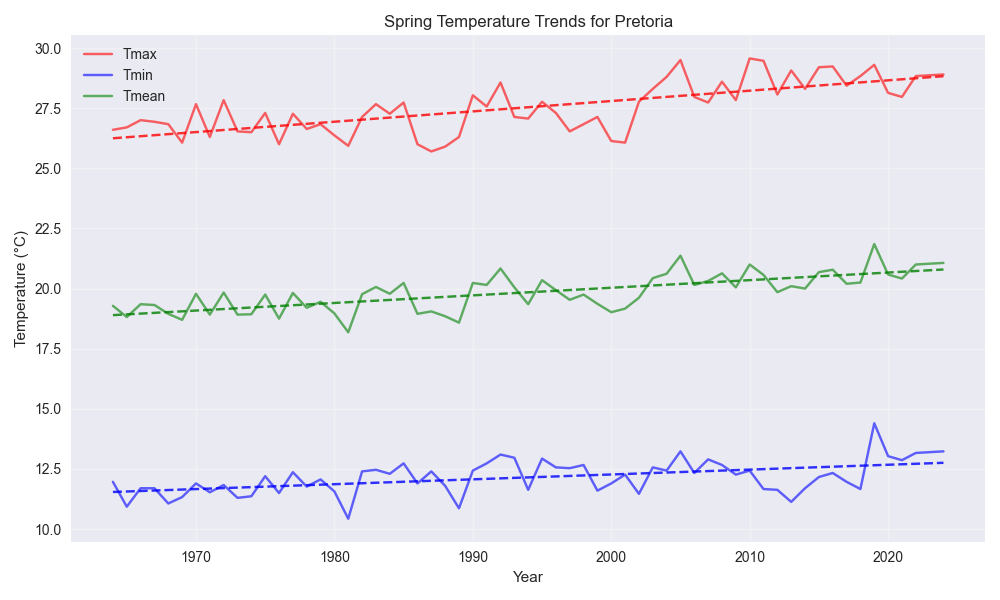


Figure: Seasonal Tmax Distribution

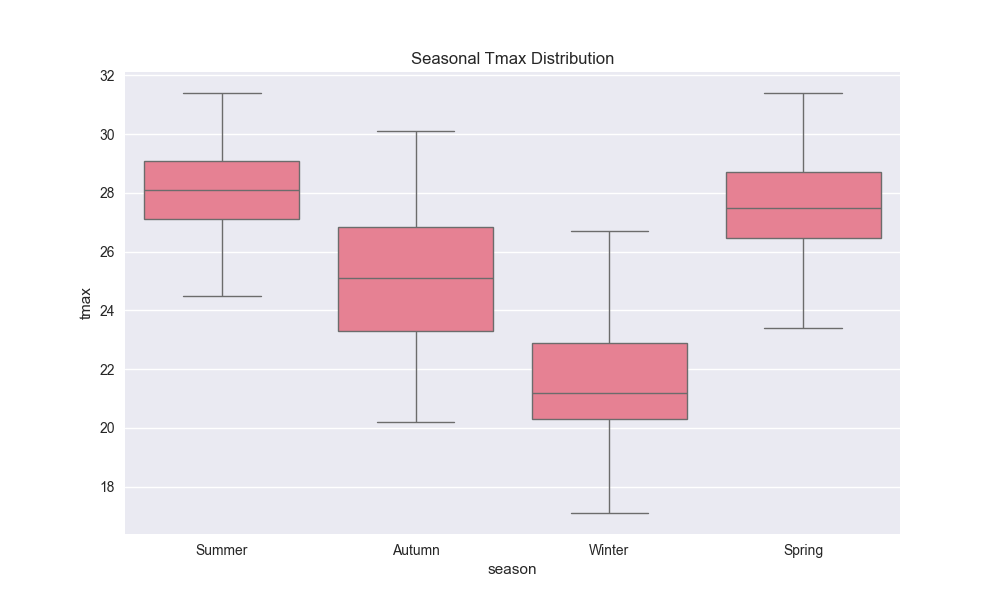


Figure: Extreme Temperature Events per Year

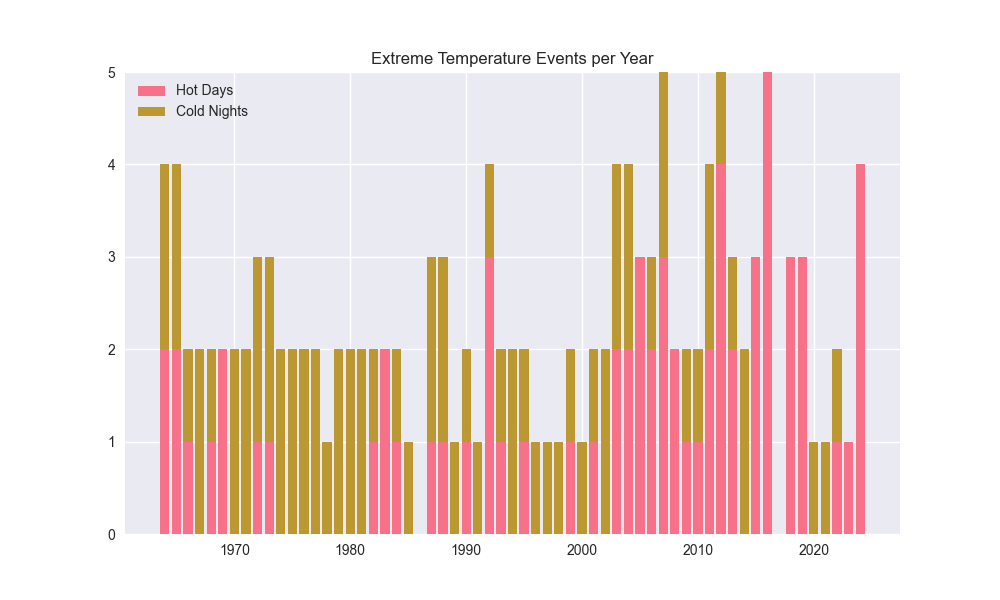


Figure: Annual Precipitation Anomalies

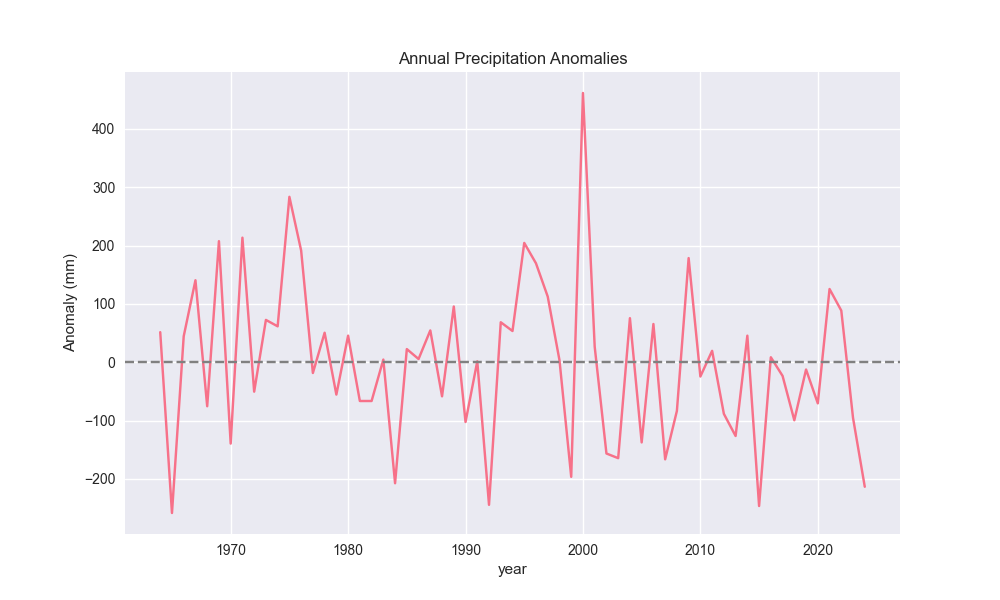


Figure: Minimum Temperature Trends by Period

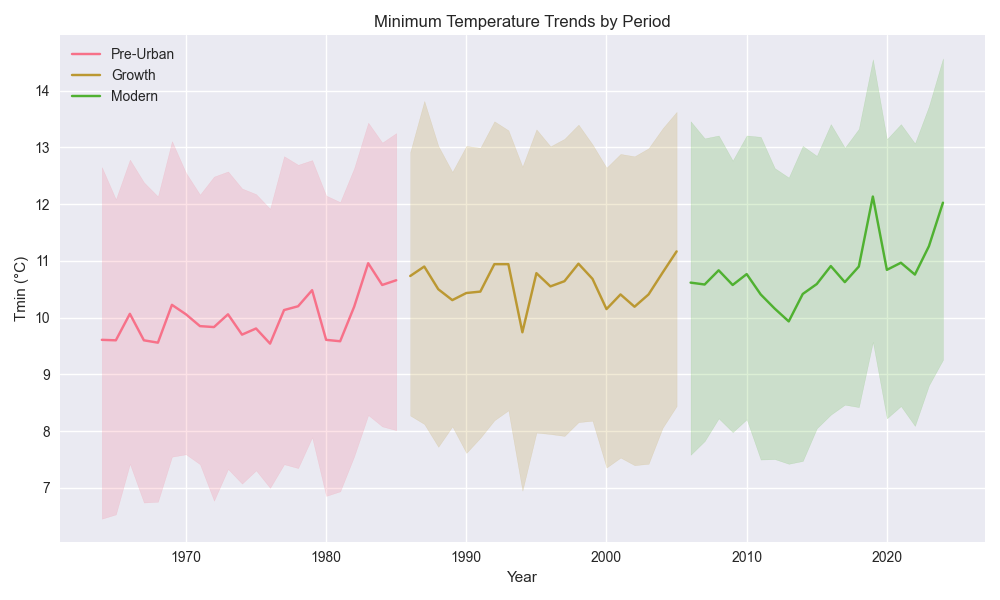
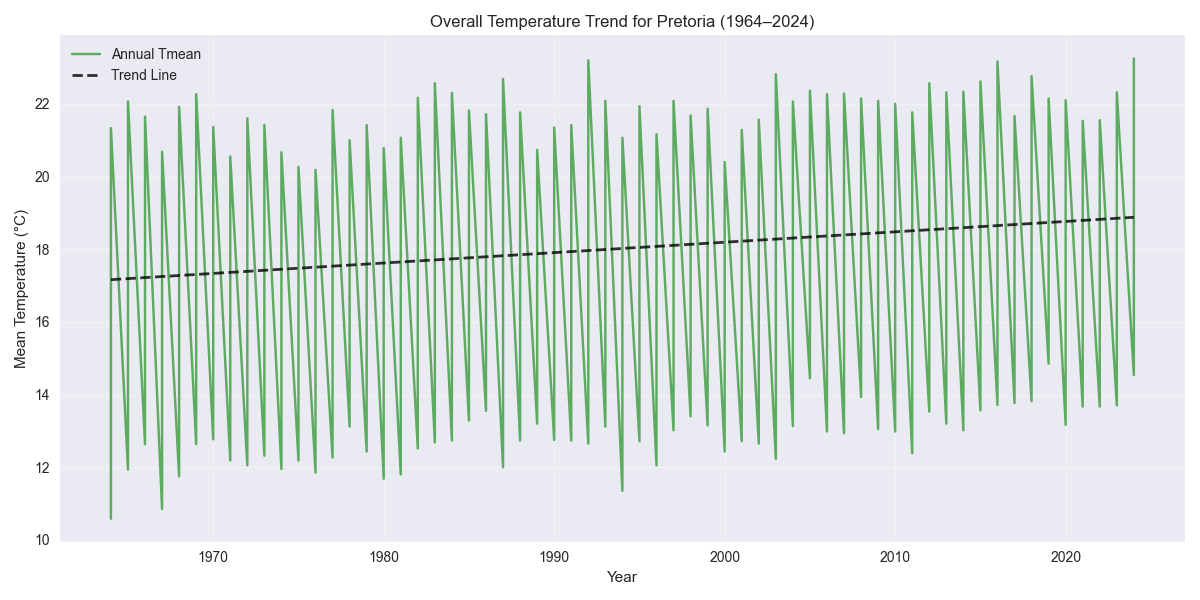


Figure: Overall Temperature Trend



## Seasonal Temperature Trends Summary

|  |  |  |  |
| --- | --- | --- | --- |
| Season | Variable | Trend (°C/decade) | Significant |
| Summer | tmax | 0.229 | Yes |
| Summer | tmin | 0.165 | Yes |
| Summer | tmean | 0.197 | Yes |
| Autumn | tmax | 0.386 | Yes |
| Autumn | tmin | 0.206 | Yes |
| Autumn | tmean | 0.296 | Yes |
| Winter | tmax | 0.388 | Yes |
| Winter | tmin | 0.284 | Yes |
| Winter | tmean | 0.336 | Yes |
| Spring | tmax | 0.43 | Yes |
| Spring | tmin | 0.202 | Yes |
| Spring | tmean | 0.316 | Yes |

## Summary of Temperature Trends

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Trend (°C/decade) | P-value | Significant | R² | Period |
| TMAX | 0.358 | 0.0000 | Yes | 0.511 | 1964-2024 |
| TMIN | 0.214 | 0.0000 | Yes | 0.478 | 1964-2024 |
| TMEAN | 0.286 | 0.0000 | Yes | 0.586 | 1964-2024 |

## Microenvironmental Analysis Summary

|  |  |  |
| --- | --- | --- |
| Indicator | Value | Interpretation |
| Minimum Temperature Trend | 0.214°C/decade | Consistent with urban heat island effects |
| Temperature Range Trend | 0.144°C/decade | Stable or increasing range |
| Tmin Trend (Early Period (1964-1985)) | 0.364°C/decade | Period-specific warming |
| Tmin Trend (Growth Period (1986-2005)) | 0.009°C/decade | Period-specific warming |
| Tmin Trend (Modern Period (2006-2024)) | 0.549°C/decade | Period-specific warming |

# 4. Discussion

The warming trend is most pronounced post-2000, coinciding with rapid urban expansion. Seasonal shifts suggest increased summer Tmax variability.  
The rise in hot days and reduction in cold nights reflect broader warming patterns, potentially amplified by local land cover changes.

# 5. Conclusion

Pretoria’s climate has warmed significantly, with notable changes in seasonal patterns and extreme events. These findings underscore the need for  
localized climate adaptation strategies and further research into microenvironmental influences.