Visualising Global Temperature Trends

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1. Abstract

This project examines and displays global temperature changes from 1880 to 2016 using data from GCAG (Global Climate Analysis Group) and GISTEMP (NASA's Global Surface Temperature dataset). The goal is to look at long-term warming trends, seasonal changes, and short-term variations using Python-based visuals. We use different methods, including monthly averages, moving averages (12-month and 60-month), heatmaps, and stacked bar charts, to show both short-term changes and long-term climate trends. The results indicate a clear rise in global temperatures, with recent decades (2000-2016) showing notable warming. The analysis highlights how effective data visualization is for presenting evidence of climate change.

2. Introduction

Background:

Climate change and global warming are among the most important issues of the 21st century. Understanding temperature variations over time is essential for policymakers, scientists, and the general public. Here data driven visualisations provide intuitive insights into long-term patterns and anomalies and comparing multiple sources validates consistency in climate observations.

Technology Involved:

- pandas & NumPy for data handling
- Matplotlib & seaborn for static plots

The main goal is to show historical global temperature changes, identify seasonal and long-term warming patterns, and present the findings in a way that improves public understanding of climate dynamics.

List of topics that I received training on during the first two weeks of internship:

1. Basics of Python: Data, Variables, Loop, Data Structures, Class, Functions.
2. Object Oriented Programming
3. NumPy, Pandas
4. Overview of Machine Learning, Regression Analysis and LLM Fundamentals
5. Communication Skills.

3. Project Objective

- To visualize monthly average global temperature anomalies from the GCAG and GISTEMP datasets.

- To apply 12-month moving averages to show long-term warming trends by smoothing out short-term changes.
- To extend smoothing with a 60-month moving average to better capture significant climate changes.
- To create seasonal heatmaps for the last 50 years and the last 20 years, highlighting seasonal variations and climate shifts.
- To build a stacked bar chart that displays monthly and yearly variations over 50 years, connecting seasonal cycles with long-term climate warming.

4. Methodology

Data Collection:

The dataset includes global temperature anomalies from 1880 to 2016 recorded by:

- GCAG (Global Climate Analysis Group)
- GISTEMP (NASA GISS Surface Temperature Analysis)

Analysis Workflow:

a) **Monthly Average Temperature Trends:**
It plots monthly average anomalies for both sources on the same graph and compares them to validate consistency across the two independent datasets.

b) **12-Month Moving Average Plot:**
It computed a rolling 12-month moving average for both datasets. This smoothing technique reduced seasonal fluctuations and highlighted underlying trends.

c) **60-Month Moving Average Plot (GISTEMP):**
This approach further smoothed the data to focus on structural, long-term climate trends. It reveals persistent warming patterns and remove all short-term noise.

d) **Seasonal Temperature Heatmap:**
It examines seasonal variations to identify shifts in anomaly distributions across months using red color for warmer month and blue color for cooler month.

e) **Stacked Bar Chart**
It aggregates monthly temperatures anomalies for each year and construct stacked bars with 12 colour coded segments representing months.

GitHub Link:

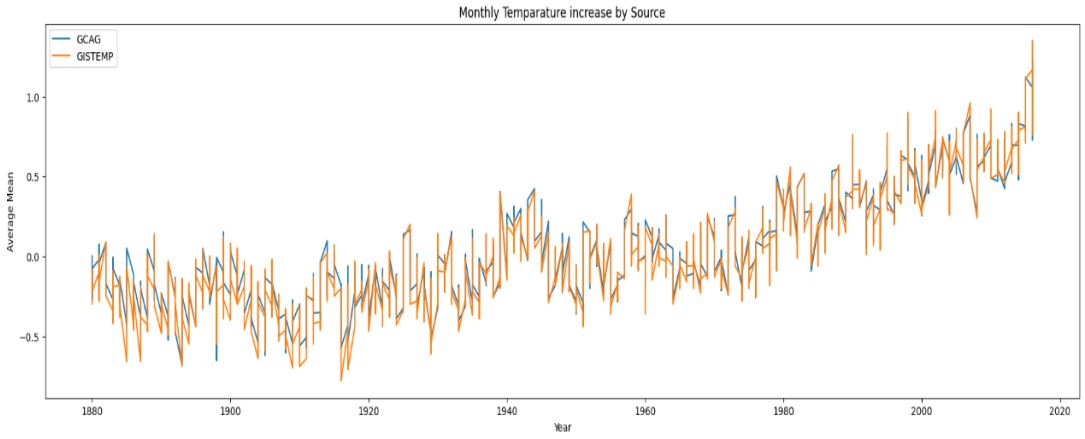
All codes developed for this project are available at:

- GitHub Link

5. Data Analysis and Results

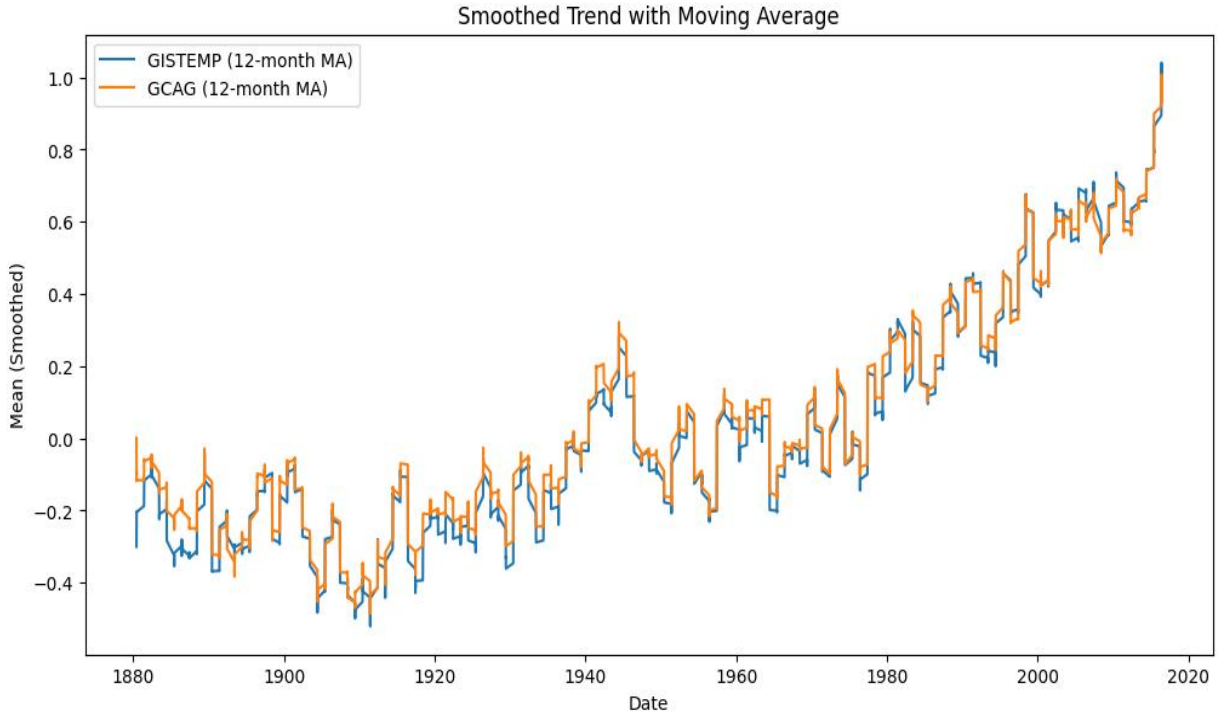
I. Monthly Temperature Trends

The first plot compared GCAG and GISTEMP datasets from 1880 to 2016. Both datasets show strong similarities, with a clear warming trend, especially after 1970.



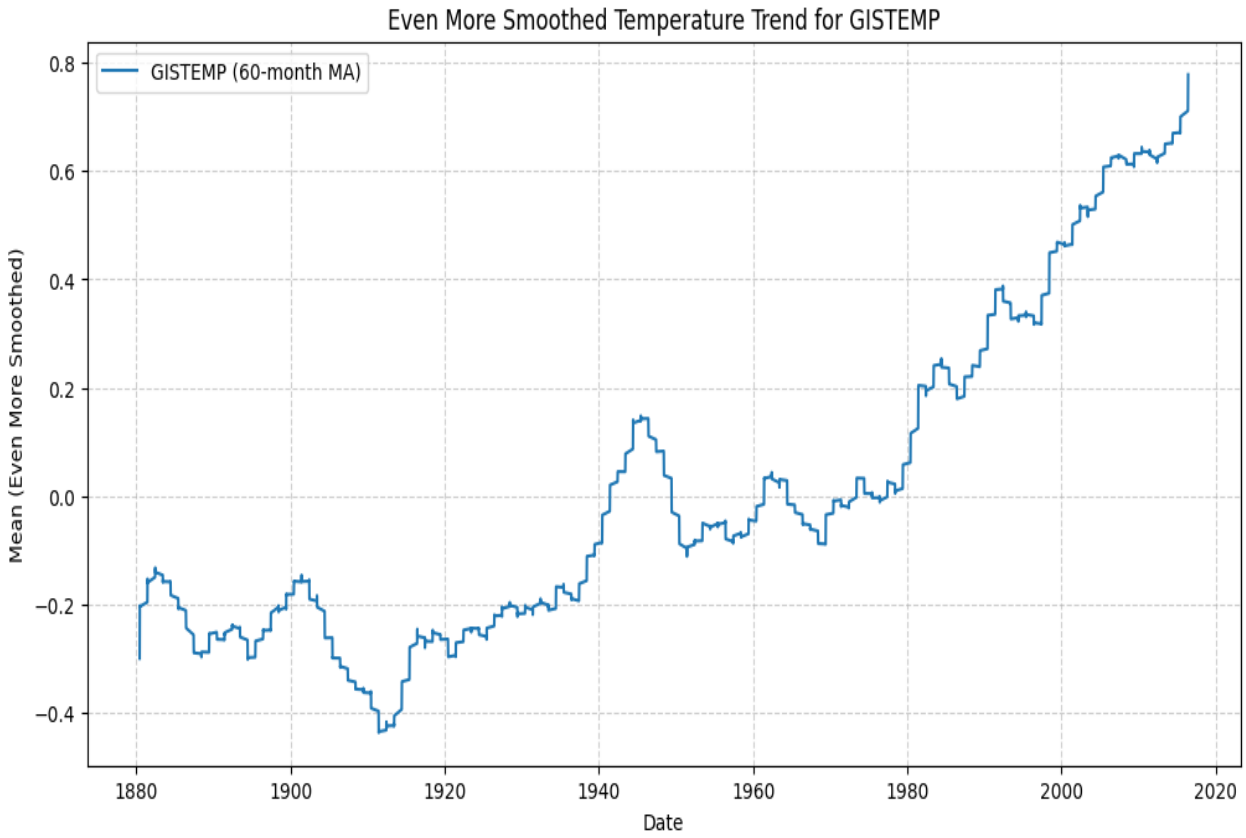
II. Smoothed Temperature Trend (12-Month Moving Average)

The second plot used a 12-month moving average. It reduced seasonal noise and showed a steady increase in anomalies after 1960. The rise accelerated in the 21st century.



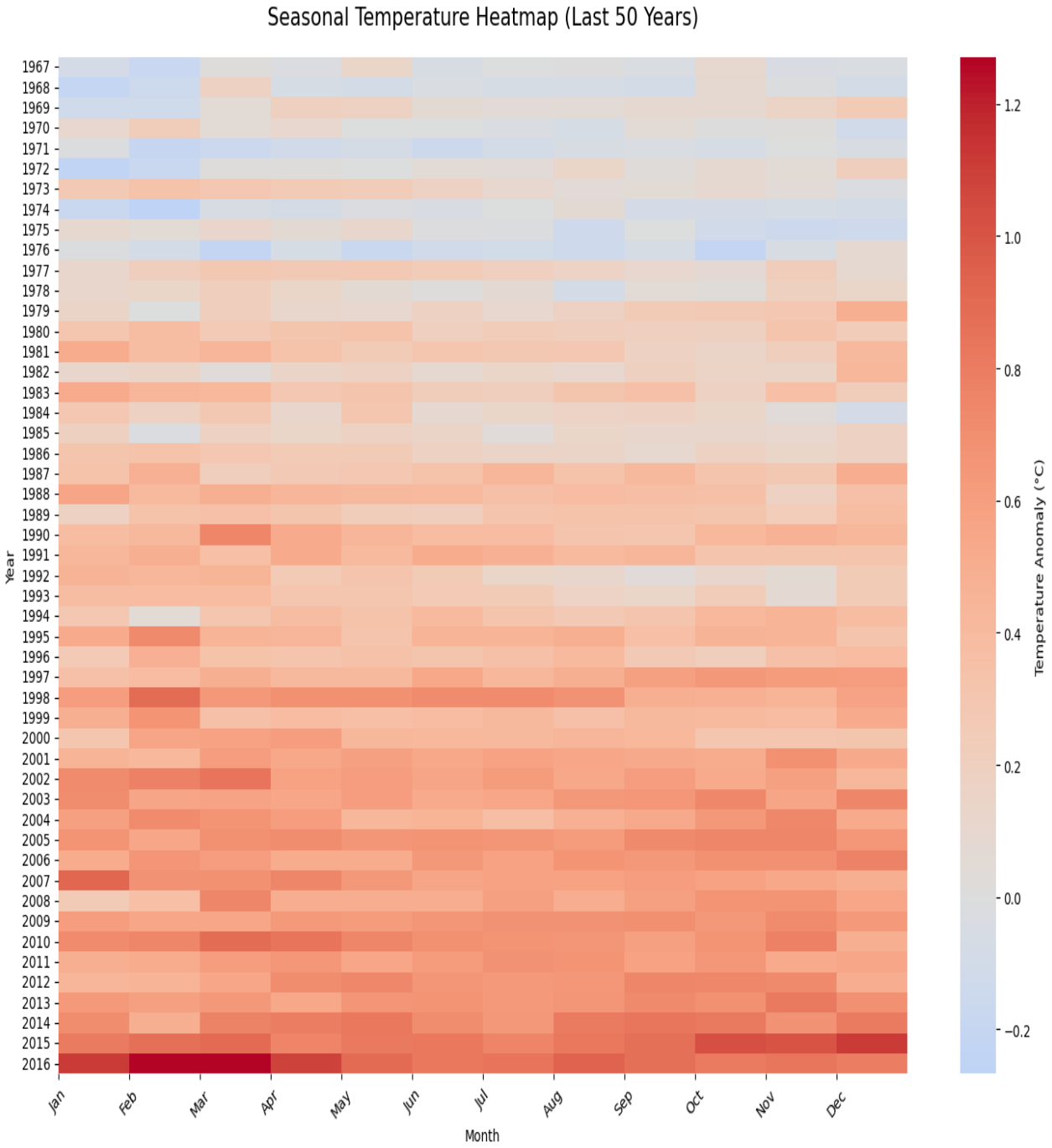
III. Long-Term Smoothed Trend (60-Month Moving Average, GISTEMP)

The third plot applied a 60-month average on GISTEMP data. The trend highlights stable early 20th century temperatures, followed by significant increase from the late 20th century onwards.



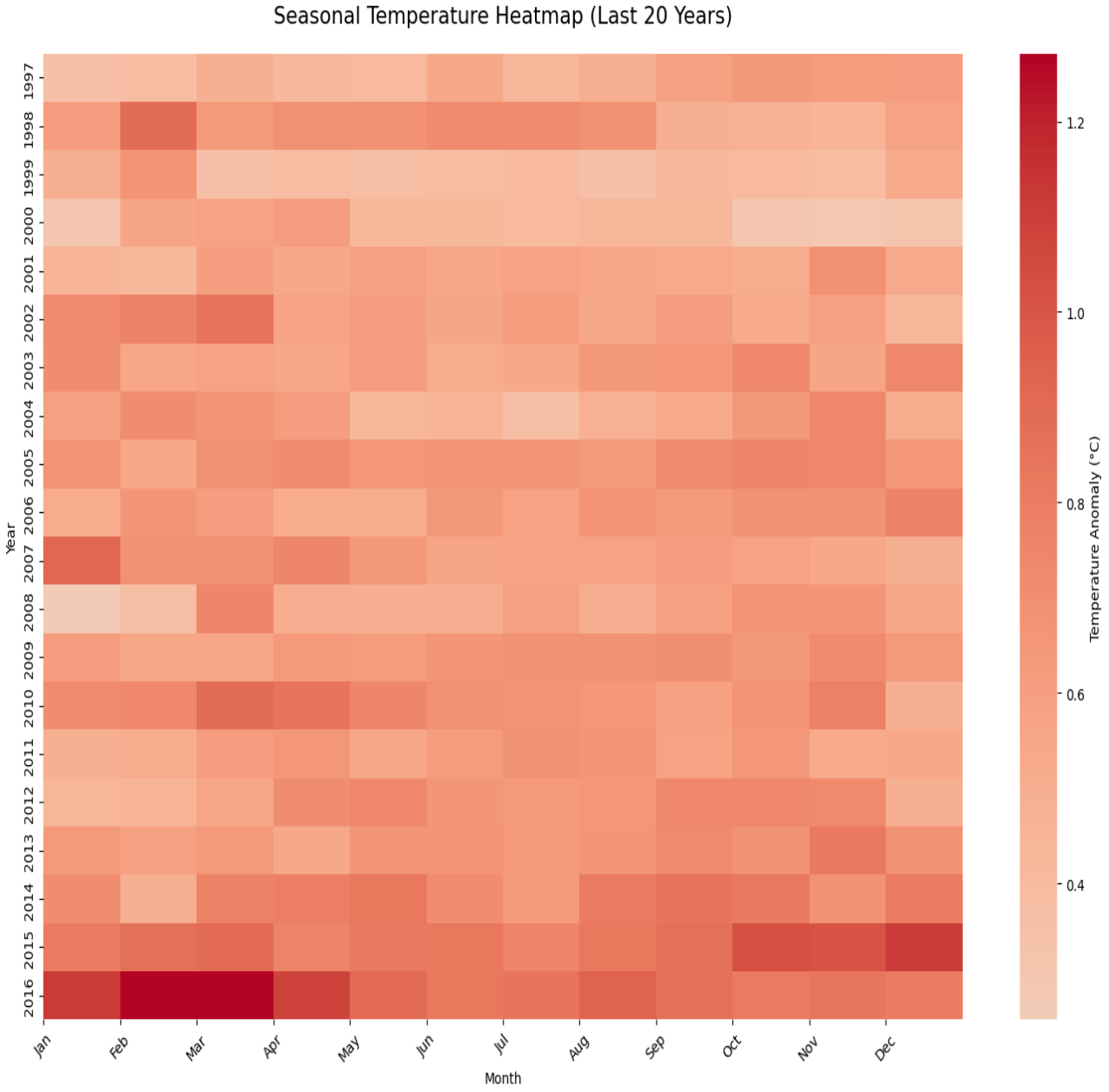
IV. Seasonal Temperature Heatmap (1967–2016)

The heatmap provides a visual representation of monthly temperature anomalies over the last 50 years (1967–2016). Each row corresponds to a year, and each column corresponds to a month (January–December). The colours represent temperature anomalies: blue for cooler-than-average months and red for warmer-than-average months. The heatmap explicitly demonstrates the shift from a primarily cooler climate in the 1960s–1980s to a warmer climate in the 2000s–2010s. Seasonal cycles are still present, but the average baseline temperature anomaly has shifted upward, confirming that global warming continues to endure.



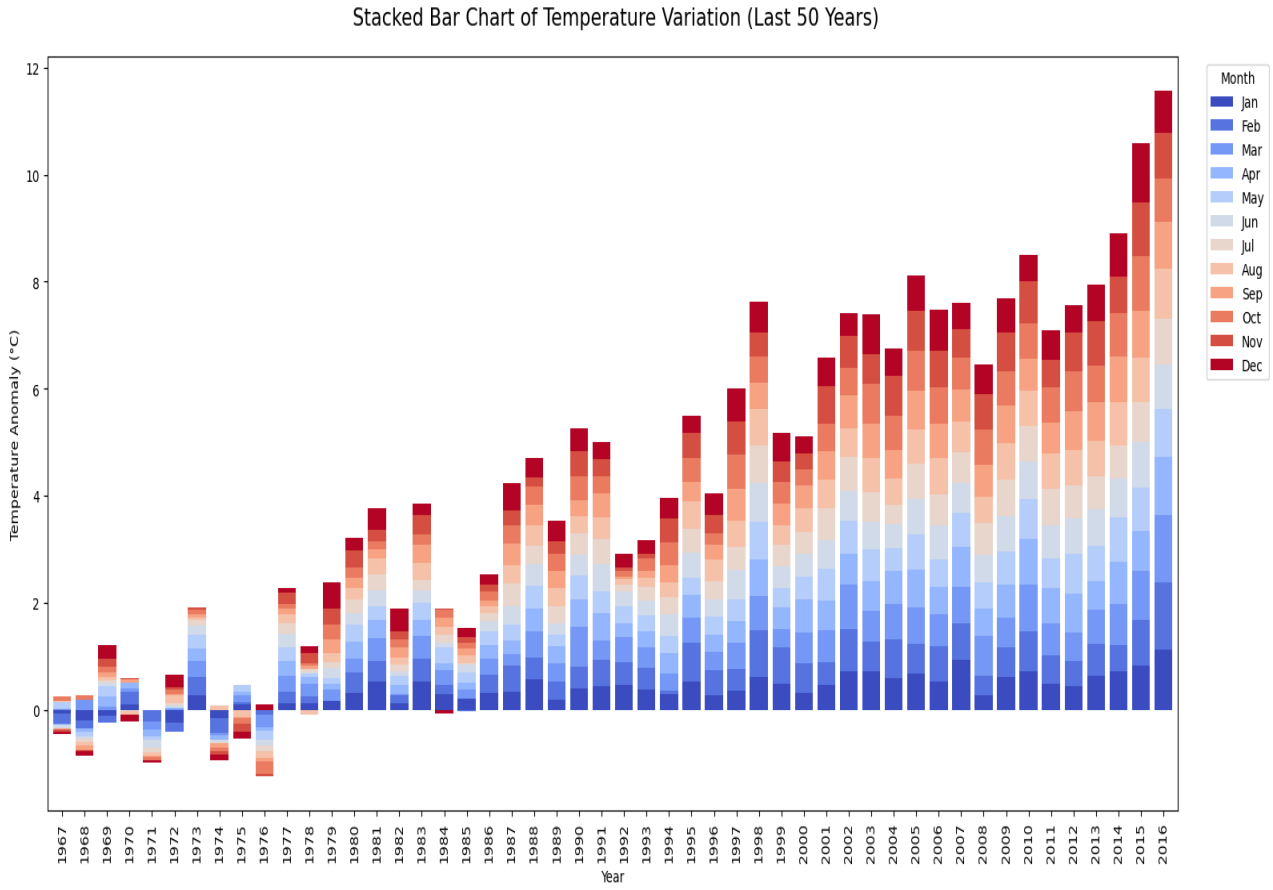
V. Seasonal Temperature Heatmap (1997–2016)

This heatmap provides a detailed view of seasonal temperature anomalies over the past 20 years. It shows that warming has evolved to be consistently and increasingly stronger, and widespread throughout all months, and record high temperatures in the mid-2010s. Seasonal cycles are still visible, but there is an unambiguous shift in the underlying trend towards a warm climate baseline.



VI. Stacked Bar Chart (1967–2016)

The stacked bar chart summarizes monthly temperature anomalies for every year from 1967 to 2016. Each bar stands for one year, with a segmented, 12-color display representing the months (January-December). The total bar height represents the annual mean anomaly, while the distribution of colours demonstrates the seasonal cycle within each year. It reinforces the evidence of progressive warming across all seasons, with a marked rise in annual mean temperatures since the late 20th century.



6. Conclusion

The project “Visualising Global Temperature Trends” effectively illustrates the utilization of data analysis and visualisation using python to investigate long-term and seasonal climate patterns with historical temperature anomaly datasets (GCAG and GISTEMP). Through the use of various methods, including moving averages, heatmaps, and stacked bar charts, the project illustrates short-term variability and long-term warming trends. It confirms that global temperatures have been steadily rising since the late 19th century, with a pronounced acceleration in the last few decades.

Key finding:

- Strong consistency between GCAG and GISTEMP dataset strengthens the base for global warming.
- Analysis reveals a persistent upward shift in temperature anomalies, particularly evident from the 1970s onward.
- Seasonal heatmaps show a transition from cooler anomalies (1960s–1980s) to warmer anomalies (2000s–2010s).

- The stacked bar chart supports seasonal cycles while also showing an upward long-term trend in annual mean temperature and serves as a simple way to communicate climate change to scientific and public audiences alike.

7. APPENDIXES

Appendix A- References

- NASA GISS Surface Temperature Analysis (GISTEMP)
- National centers for Environmental Information (GCAG)

Appendix B –GitHub Link

- https://github.com/routachandrashekhar-ship-it/IDEAS_Autumn_Internship.git